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Republic of Armenia CJSC «ARMHYDROENERGYPROJEKT»

THE UPDATE OF THE EXISTING SCHEMA FOR SMALL HYDRO POWER STATIONS OF THE REPUBLIC OF ARMENIA

(GEF-CS-4/2006)

FINAL REPORT

Yerevan - 2008.

CONTENT

SECTOR 1. INTRODUCTION

The current program - “Energy Development Plan for Small Hydropower Plants in RA” - is carried out by request of Foundation for Armenian Reconstructive Power Engineering and Energy Conservation. The program has been developed under the grant of World Bank (WB) and Global Environment Facility (GEF) (grant GEF-CS-4/2006).

The program is procured by “Armhydroenergyprogect” CJSC. Construction of SHPPs is recognised as national priority within the energy sectior. The development plan for SHPPs, which is the only complete document in the energy sector, was designed in 1997 by “Armhydroenergyprogect”. However, the document does not comply with the current requirements of the sector and fails to reflect the latest changes in hydropower and adjacent sectors (irrigation, water supply). Moreover, the plan does not incorporate currently available technical (water turbines of local and foreign production) and funding options (private means, credits and loans.)

The current project is expected to present the main regulations of the 1997 plan, define the number of incorporated but not appropriated SHPPs, afterwards, update the existing data, taking into consideration the changes in hydrological and hydropower subsections.

The project foresees broadening and updating the plan by exploring and investigating new options for SHPP construction through exploration of river basins and on situ investigations. It is planned to develop this project in two main directions:

- Collection, analysis and ranking of data from appropriate RA organizations
- On-situ investigation of RA river basins in order to collect information on hydro power resources and verification of existing information.

For the objectives of the current project the Client will provide the Contractor the following data: “Updated and verified development plan for Gegharkunik Marz SHPP, RA” (EuropeAid 120653/C/SV/AM) and “Development of geographical and information system for rehabilitated energy sector of Lori Marz, RA” (GEF/WB PPG TF053910).

The updated plan for development of small power plants in Armenia will enforce preparation of business plans and technical and economic substantiations for new SHPPs.

It is expected that this project will contribute to stability of national economy and increase the energy safety level.

SECTION 2. PROJECT: OBJECTIVES AND FUNCTIONING

The The main objective of the present project according to technical specifications (Annex 1), is to update verify and broaden the 1997 plan for development of small power plans in Armenia.

The project also envisages:

1. Collection and analysis of recent (10-15) years' data in hydro-power and adjacent sectors, including hydrology, indicators of mechanical equipment as well as changes in financial sustainability of projects

2. Carry out on-situ investigation of SHPP construction sites under consideration, applying Global Positioning System equipment

3. Calculation of main technical and economic indicators of all SHPPs under consideration

4. Design of SHPPs scheme and general location plan as well as mapping by AutoCAD

5. Mapping of verified and justified SHPP plan according to RA marzes by AutoCAD

6. According to methodology assigned in the Client plan, there are 6 working groups that carry out collection, verification, ranking and appropriate presentation of the corresponding sector data.

7. The collection of on-situ data relating to hydrology and water economy sub categories as well as estimation of hydro power potential were carried out by three working groups. These groups carried out their investigations by means of GPS equipment with succeeding mapping of the collected and analyzed data.

8. Data relating to hydro power sector was collected from water resources and water economy sectors.

9. Taking into consideration the specifications pertaining to all the sectors, presentation modes were developed by means of tables and were agreed upon by corresponding specialists.

10. It is noteworthy that the following institutions were used as sources for program implementation: RA Ministries of Energy Resources, Environmental Protection, Local Governance (Armwatergovcom); RA Committee for Social Services, Hydro-Meteorological and Monitoring State, Water User Unions of RA Marzes and Districts, corresponding international projects and consulting companies as well as various internet resources.

SECTION 3. CURRENT HYDROPOWER POTENTIAL OF RA AND ITS IMPLEMENTATION PROJECTS IN THE NEAREST FUTURE

Armenia is considered a typicaly mountaneous country with complicated and diverse relief. 90% of the coutry is located on the altitude of 1000m and above. All Armenian rivers belong to Kaspian Sea basin and fall into River Kur or its inflow - River Araks, except for those rivers that fall into Lake Sevan from nearest slopes. The source of large hydropwer potential of Armenian rivers is due to their high fall. Water regieme of the rivers is conditioned by uneven flow distribution with spring inundations and severe drought period.

Practically there are no energy carring mineral resources in Armenia. Within this respect the only source of energy, except for alternative energy sources, is hydro-power. The poterntial hydro-power resources of Armenia are estimated 21.8 mlrd. kv.hour, including large and medium rivers – 18.6 mlrd. Kv.h and small rivers - 3.2 mlrd. Kv.h.

The largest energy potential is contained in River Hrazdan with Sevan Lake, Vorotan, Debed, and Araks Rivers.

Presently, only River Debed with its Dzoraget inflow and Araks River are left unused from the hydro-power perspective. There are three hydro power stations designed on Dzoraget and Debet Rivers. HPP Loriberd 1,2 are constructed on Dzoraget River with 65 mwt joint capacity while Shogh HPP is constructed on River Debet with 75 mwt capacity with 200 and 300 mln kwt power production accordingly. The construction of Meghry HPP is planned on River Araks on the border between Iran and Armenia, the HPP will have the capacity of 128 mwt and and 74 mln. Kwt/h energy production.

"Armhydroenergyprogect" designed The Development Plan of Small Hydropower Sector in Armenia in 1991 and updated it in 1997. This plan included the whole territory of the country. According to this plan there should be constructed 325 small HPPs with 274 mwt capacity and 833 mln kwt/h annual energy production.

Thus, the potential hydro power production in Armenia according to country's technical and economic capacities is about 380 mwt capacity and about 1.6 mlrd. Kwt/h production, this amount can cover 25-30% of overall energy demand of the country.

This potential is presented in the Table 1 based on the following indicators.

Table 1. RA Power Potential in the Nearest Future

HPP Name	Initial capacity mwt	Power production mln. Kwt/hour
HPPs in exploitation		
1. Sevan-Hrazdan cascade	556	500
2. Vorotan Cascade	404	1000
3. Dzorashen HPPs	25	70
4. Small HPPs, including SHPPs under construction	75*	244.4
Overall	**1060.0**	**1814.4**
Envisaged HPPs		
1. Megry HPP	128	774
2. Loriberd HPPs	65	200
3. Shnokh HPP	75	300
Middle sized HPP ready for exploitation (Pambak HPP)	20.3	79.2
Small HPPs ready for exploitation	59.6*	207.3*
Small HPPs (included in 1997 plan)	146.9	540.1
Total	**1554.8**	**3915.0**

SECTION 4. PECULARITIES OF SHPP DEVELOPMENT PLAN - 1997

The objective of the development of small hydropower sector is to explore the potential of small rivers. This rivers have strong inclination which detemines exploitation of water resources for extracting hydro power. However, when it comes to water resources, it should be taken into consideration that they are limited and highly unproportional.

In order to determine the potential of small HPPs, 11 river basins were investigated. To use the hydro power potential of the rivers derrivational HPPs will be constructed. It is considerede to construct SHPPs next to existing race channels and reservoirs (close to dams) as well as next to reservoirs and water channels that are in the design state.

For the construction of SHPPs it is planned to use rivers sections that have sighnificant inclination and therefore derivational inclinations are maximally short.

Productive exploitation of water resources is a complex problem where the priority is given to public utitlities as well as technical and irrigation water supply.

Derivation length of desighned SHPPs equals 1.5-5.0 km and therefore the given river section is drained. In order not to drain the river bed according to **СанПи - 3907-85,** the daily average minimal discharge value is accepted as annual envoronmental protection value with 95% guarantee.

Taking into consideration, that during the design period there was no information on irrigation water demand of the particular marzes, the corresponding economic calculations render the discharge for summer i.e. July-August periods as no demand periods which means the SHPPs are closed for the mentioned periods.

Heardworks will be constructed on the river sections where SHPPs' headwoks are located next to dams. The natural river flow is determined based on hydrological data. The discharge of July and August is derived from this flow of indicators and values for environemntal flow and the rest of the flow value is used as energy resource.

In the 1997 hydro power development scheme, the river was divided according to stages based on the following principles:

- ❖ The Headworks of SHPPs were installed after the inflows joined the main river bed.
- ❖ Derivation length was defined according to static pressure of SHPPs, within 40-125m limits, which is conditioned by the type of hydro-turbines which are mainly produced by St. Pitsburg factory **"ÈÍÑÝÒ"** according to standards for unified radius-axis tree types of hydro agregates

Type	Pressure, m	Discharge, m3/sec
PO 115 – 40	40 – 75	1.0; 1.2; 1.4
PO 230 – 40	75 – 125	0.4; 0.6; 0.8
PO 230 – 20	70 – 95	0.12; 0.2; 0.35

- ❖ In case if between the headworks of SHPPs there is no or little lateral flow and there are no water users in the area, then the derivation system of the SHPPs serves as headwork structure for the next one. Under this curcumstances working regieme of SHPPS is highly interdependent.
- ❖ Hydro-economy indicators for SHPPs are defined with 50% average guarantee for the whole year. Average annual water discharge indicators in winter are 5-10 times less than the spring discharge. Thus, it is natural that in order to use the normalised discharge indicators, the design discharge of SHPPs was determined based on the spring 2-3 mouth guarantee indicators.
- ❖ Open channel or closed pipeline were chosen as derivation options, taking into account the pecularities of the given area.
- ❖ There are no reservoirs forseen on SHPPs headworks as the expences are not paid off.

SECTION 5. VERIFICATION, UPDATE AND EXPANTION OF 1997 PLAN

In 1999 hydro-energy sector started its rapid development. This was explained mostly by the growing interest of private investors, particularly in the area of SHPP construction. Therefore, at this period the process of obraining permission from the authorities for construction of SHPPs begun. As a result, technical and economic substantiontion was carried out for SHPPs under question, the outcome was the update of indicators and data of 1997 plan for SHPPs.

As to the present day, out of the number of SHPPs indicated in 1997 plan, the most productive SHPPS are being contructed. The desicion to construct particular SHPPs is based on the large volumes of produced energy as well as favorable conditions for construction. This conditions include such cliteria as the altitude up to 2000m, location near existing highways, corresponding infrastructure and communications.

Based on the technical specifications of the present project, it is nesessary to define and estimate the potential and other properties of the SHPPs that have not been appropriated in order to verufy and update 1997 plan. Therefore, comparative anaysis of 1997 plan and the data of SHPP under exploitation or under the construction has been carried out. Additional comparative anaysis of SHPP design data starting from 1997 from several design insisution of RA has been carried out.

As a result the list of unapropriated SHPPS was compiled together with number of technical and economic properties. The plan of unaproprited SHPPs can be found in the Attachement 1 of the present report together with hydro-power and technical properties. Hydro-power and technical properties are shown on the table 2 below, classified according to main river basins of RA

Table 2. Water Energy and Technical Indicators of Unappropriated SHPPs According to Main RiverBasins

#	RA River Basins	Number of SHPPS in the basin	total allocated power	total average annual production	Capacity coefficient	
			Kwt	mln. Kwt/hour	Hour/year	%
1	Debed	55	17496	57.41	3281.3	37.5
2	Aghstev	51	33360	89.75	2690.3	30.7
3	Akhuryan	9	5495	17.09	3110.1	35.5
4	Kasakh	13	7505	18.41	2453.0	28.0
5	Hrazdan	7	4350	13.22	3039.1	34.7
6	Lake Sevan	15	10075	25.24	2505.2	28.6
7	Azat and Vedi	17	15855	48.65	3068.4	35.0
8	Arpa	0	0	0	0	0
9	Vorotan	3	1650	5.1	3090.9	35.3
10	Vogji	35	14707	47.43	3225.0	36.8
11	Meghri	1	750	2.40	3200.0	36.5
	TOTAL	**206**	**111243**	**324.7**	**2918.8**	**33.3**

According to main RA river basins, the most of unused SHPP potential is contained in Aghstev (about 33 mgw additional energy production with annual 90mln kw per hour) and Debed (about 18 mgw additional energy production with annual 57mln kw per hour) river basins. Azat-Vedi and Vogji river basins also have considerable potential: 49 and 47 mln kw per hour correspondingly.

It is clear that for Tavush Marz the uapropriated maximal potential of SHPPs is about 34mwt of total initial capacity and 90mln Kwt/hour annual capacity. There is a significant potential of Lori and Syunic Marzes with annual production of 57 nad 54 mln kwt/hour accordingly.

The following changes are to be carried out in 1997 plan for unapropriated SHPPs:

1. Hydrological indicators: water supply and irrigation changes besed on observations of the natural river basins during the last decade.
2. Within the values of perspective water supply from water basins.
3. The location plan of headworks, derivation and station section of SHPPs under question can be changed after on-situ investigations for platform location. The change will affect the perspective SHPPs on the given river.
4. From the technical perspective, there will be separate headworks for SHPPs on the same river, so that working regimes of stations are not interdependent.
5. The main static pressure changes of SHPP indicators to be carried out based on technical capacities of local production companies as well as foreign hydrological equipment. The list of factories producing hydrological equipment can be found in Attachement 2.
6. The normative environmental discharge is also subject to change according to RA Governmental Decree # 592 due from May 22, 2003, the enviromental protection discharge is considered the value of river considred as 95% gurantee, 75% form (see Attachement).
7. The planning of new SHPPs not included in 1997 version: on natural water channels, existing and perspectibe water channels, dams and water supply channels.

8. Water economy calculation will be carried out based on survey of local water user unions and after receiving data on water supply requirements. Based on these calculations and data thechnical characteristics of all unapropriated SHPPs will be updated.
9. Main hydraulic equipment of SHPPs will be purchased from CIS countries as well as other foreign countries. Those factories are mainly located in St. Peterburg, Sizran, Ekaterenburg, Kiev, including Check Republic factories “MAVEL”, “ZINK”. Local hydraulic equipment will also be used.
10. The initial price for hydro aggregate equipment is calculated as 250-500 USD (excluding VAT) depending on integration and delivery services.
11. The basis for capital investments into SHPPs is the the booklet: “Price formation analysis and information center” by RA Ministry of Civil Construction as for 01 January 2008.
12. During calculation of investment effectiveness the prime cost for electricity was adopted by RA Social Services regulating commitiee decision N598-Ü as of 30.11.2007 (Attachement):
13. The basis for schematic relocation plan of the SHPPs were the 1:25000 scale maps

Verifications are underway. It will be possible to use the whole potential of SHPPs as a result of ongiong verifications, changes and constant update this will also increase the attractiveness of SHPPs for potential investors.

SECTION 6. SHPP PRODUCTIVITY CHARACTERISTICS

The maximal productive use of hydro potential inluding water basins, irrigation and waer supply will carried out with strict maitenance of environmental norms based on the following princeiples:

6.1. Technical characteristics:

The division of rivers into sections should be carried out

- SHPP headworks will mainly be situated on the sectiond where river inflos already join the main river bed in order to use the the river potential to the fullest.
- River section of SHPP construction should have the inclination exceeding 25m per 1 km which results in short distance derivation.

- The construction sites altitude for SHPPs should be no more that 2600m, taking into consideration the depth of soil freezing (the pipeline is located in a closed trenches, for effective exploitation the depth of covering soil should not exceed 1.5m)
- Main premises will be located news the existing roads, sub-stations, communication systems.
- Taking into consideration that local and foregn factories produce sny type of hydroagregates the technical capabilities allow to act without strict regulations when it comes to SHPP equipment and parameters.

6.2. Finantial characterisitcs.

1. Finantial sustainability and indicators.

- Internal Rate of Return - IRR
- Net Present Value - NPV
- Payback Period - PB

During finatitiol sustainability analysis of NPV value is considered if comparative interest (discount indicator) are 8.10,12,14%, which means that income norm is compared with the mentioned interest rate. The desision on finantiol sustainbility of the project is taken based on ca;culation data and sucseeding analysis.

Thus, if NPV indicator in case of the abovementioned interest rates is negative, it means that the IRR project under question is less than the comparative interest rates. In case if IRR is less than 10% investment pay back period exceeds 10 years. Thus, after the analysis of this data is becomes clear that this project is not attractive for investors.

2. During finantial anaysis of the designed SHPPs the design period is accepted 30-40 years starting from exploitation date of SHPPs, this is the proposed standard according to normative acts and hydro power literature.

3. While calculating finantial sustainability the taxes are calculated according to active RA legislation:

- Profits tax - 20% of the taxable income
- Inventory tax - 0.6% of depreciated cost
- Value Added Tax (VAT), within construction-assembling works and equpment costs: - 20%

4. Prime cost value of 1kwt.h power production (annual exploitation expenses and annual power production ratio.)

5. One of the main criteria for SHPP sustainability is the spacific investments per 1kwt capacity and 1kwt/hour power.

“Armhydroenergyproject” CJSC carried out technical specification and design of mny (about 65) SHPPs, some of them are already in exploitation other are being constructed. According to the above mentioned research the average value for specific investment capacity for 1 kwt for SHPPs constructed on natural flow rivers as well as water supply and irrigation shannels and áreservoirs, is 825 and 470 USD accordingly (without VAT), and the average value for specific investment capacity for 1 kwt of hydro power is 0.225 and 0.12 USD accordingly.

The analyisi shows that the project is proficatble for investors (pay off period is very short) if the specific investment value is less than 0.3 USD per 1kwt/h. (in case of present tariffs).

6. Taking into consideration that armenian rivers are mountaneous then from annual perpectibe they are quite uneven. The SHPPs constructed on rivers like this are working during the spring floods which means only three mounth. The analyisi of the procjects leads to conclusion that using the mentioned potential of hours (Plant Factor) which if more than 3000 hours/year (or more than 34%) is considered productive from finantial point of view.

SECTION 7. MAIN TECHNOLOGICAL SOLUTIONS

7.1. The choice of location scheme for SHPPs

There are 3 types of SHPPs in the updated scheme: derivational, water supply on the inclinations of the water routes and those located next to dams/reservoirs.

a) The derivational SHPPs are planned to construct for using the energy potential of rivers. All SHPP buildings were located on the previously planned section. The main knots of derivational SHPPs are:

- headworks
- derivational water carrier
- station knot
- discharge channel

<u>Headworks</u>

The headworks section consists of:

- concrete water discharge channel, which is constructed for creating the necessary protection level from water supply and the discharge up to 3% probability design flood overflow,

  SHPPs are classified as III category construction (2.06.01-86), therefore, the maximal exceeding capacity of annual design discharge on the river section with the headworks is
    - for the main case 3%,
    - for the verifying case 0.5%.
- water receiving together with waste water tank is forseen for receing design the design discharge,
- waste water tank: for firther water purification,
- diverting cleaning passage for purification of waste water tank sediment.

<u>Derivational Water Carrier</u>

Derivational water carrier is a high pressure copper pipeline that starts from the water receiver and reaches till SHPP, located on the river bank.

It is planned to locate the pipeline in a trench pass which is covered by reverse filling. The pressure pipeline next to station building ramifies towards pipelines leading to hydro aggregate that has automatic gates.

<u>Station Works</u>

Station works include.

- SHPP buildings where hydropower aggregates are located,
- Installation site,
- Outdoor switchgear sub-station.

<u>Discharge channel</u> starts immediately from SHPP building. The processed water discharges into the river by means of the channel.

µ) It is planned to use the SHPPs located on channel inclinations and on the reservoirs with different water level for hydro power purposes.

The main sections of SHPPs are:

- Water receiving section,
- Pressure basin,
- Station section,
- Discharge channel.

·) The SHPPs to be constructed on water supply channels are planned for using the power potential of water channel springs

The main sections of SHPPs are:

- Inflow channel,
- Station knot,
- Discharge channel.

7. 2. Preliminary decisions on energy supply

After the construction of SHPPs, it is planned to incorporate the produced energy into state energy system.

The hydro aggregates located on the SHPP are supplied by synchronic generators. These generators can work within the energy system as well as for separate load, however, are foreseen for working with energy systems. The whole power potential of the station is aimed at supplying energy system.

The station has the following scheme: the generators are linked to one general tire which is linked to transformation. As far as the tension of the network and the SHPP are different, therefore it is planned to locate a transformer near the station building in order to amplify the tension.

SECTION 8. ESTIMATION OF ENVIRONMENTAL IMPACT OF SHPPS

The design resolutions of SHPPs and the environmental influence of planned construction and exploitation works as well as social and economic influence were estimated according RA law “Environmental influence of designed constructions.”[1]

According to investigation carried out on design and construction of SHPPs (up to 10mwt), this kinд of hydro technical constructions are more perspective from environmental point of view as during their construction and exploitation the environmental impact is minimal.

The potential environmental impact and influence have been considerer taking into consideration possible dangerous and unfavorable condition that may comes up during the construction of exploitation of SHPPs.

During SHPP construction and exploitation there is no waste, no toxic waste. The possible influence:
- ❖ Occupation of certain area for SHPP construction
- ❖ Temporary influence of construction works on local flora and fauna
- ❖ Diminishing of the natural flow in the river bed along the derivational pipeline.

The channel excavated for pipeline installation will be covered by soil without altering the natural state on the environment.

SHPP construction does not endanger the valuable vegetative and geological examples. The insignificant extraction of bushes (of no value) is compensated by planting of new trees. By carrying out the reconstructive requirements the location is brought back to its state before the construction. It should be taken into consideration that there is an option for migration of wild species because of construction works. However, the wild animals come back to the old habitat after construction ends. In order to preserve the fish species of the basin a staircase fish channel will be constructed according to RA Minister Committee decision as of 16.12.1991 #687 (see Annex 5).

Water intake for energy purposes will take into consideration environmental filtration which preserves normative water quality and prevents negative conditions for hydromechanics constructions.

There are constructive isolating units in SHPP buildings against the noise from hydro aggregates in the neighborhood.

Therefore it can be concluded that SHPP construction and exploitation will not have a negative effect of the local environment. SHPPs are ecologically clean and safe constructions that have a positive social economic effect.

[1] Accepted 20 Nov. 1995.

SECTION 9. IN-SITU INVESTIGATIONS AND ESTIMATION OF HYDRO POWER POTENTIAL OF RA RIVER BASINS ACCORDING TO MARZES

In-situ investigations were carried out by working groups in 9 marzes and 14 river basins of RA. Location plans of unrealized SHPPs were verified in the result of this investigations and measurements as well as data on irrigation and water supply systems was collected.

The working group specialists carried out the following:

a) Defined hydrologic water meter stations for river network of RA marzes that served as analogues for the SHPP Rivers section hydrological descriptions.
b) Researched currently active observation points, the data includes short description and exploitation timeline as well as general and main data on RA Rivers. The provided data includes water meter station data: average annual flow, maximal and minimal flow with different probabilities. This data is shown in Annex 6.
c) Each working group focused on a giver river basin. The basis for this investigation was the 1997 plan. The main goals were to verify construction options for unrealized SHPPs, location plan as well as existence of current and perspective reservoirs as well as irrigation and water supply channels.
d) Working groups carried out substantial amount of work in determining the data of perspective, existing and designed reservoirs. The specialists used data from State Water Economy Committee as well as from programs on reconstruction and development of reservoirs.
e) During in-situ investigations while choosing construction sites for SHPPs specialists took into consideration geological, geomorphic and other properties of the site.
f) After thorough investigation of the site the geographic properties were defines as well:

    a. Hydro technical working group designed station plan, longitudinal section and other appropriate sections based on SHPP geographical coordinates according to M1:25000 scale maps.

g) After verifying design sections of SHPP headworks was proposed to the working groups to verify average monthly discharge with 25,50,75% probability, and average daily minimum discharge for maximum 3, 0.5% probability and observed 95% guarantee.
h) The working groups conducted collection of characterizing data related with irrigation and water supply system for administrative division of RA (marzes). Inquiries were made to RA Stare Water Economy Committee, Water Users Organizations of appropriate administrative bodies as well as "Grmugh-Koyughi" organizations to clarify detail about water intake for irrigation and water supply water intake from SHPP section works river section.
i) Water energy working groups carried out water economy and energy calculations based on the previous information on SHPPs.
j) Capital investments into SHPP construction were estimated based technical information on each of SHHP as well as "Information Center for Price Formation Analysis" (01.01.2008) of RA Ministry of Urban Construction.
k) Technical substantiation working group carried out technical effectiveness calculation based on SHPP energy and technical properties. The primary cost for the n\power unit was estimated according to RA Social Services Committee decisions as of 30.11.2007. The financial analysis was carried out along two scenarios.
l) The verified schemes were documented through GPS system during in-situ investigations carried out by "Georisk" Research Company.

SECTION 10. GENERAL DESCRIPTION OF RA TERRITORY

The Republic of Armenia is situated in the south of Trans-Caucasus and occupies north-east of Armenian mountain chain. Its northern and eastern parts are surrounded by Small Caucasian mountain chain. The republic occupies 29.8 thousand km^2. Due to its mountainous nature the altitude varies within 4095 and 450m, the average altitude equals 1800m. The country stretches for 360km from north-west to south-east. The ultimate width from west to east does not exceed 200 km.

Northern part of Armenia borders with Georgia, from south - borders with Iran and Turkey - from south-west and west.

Freshwater Sevan is a high altitude lake situated in the geographical center of Armenia, closer to its eastern border. Volcanic section of Aragats Mountain is located to the west from the northern edge of the lake. The highest peak of Aragats is 4095m. The 3000-3500m high mountains divide the republic into several regions that are connected by deep river basins.

It is possible to divide the territory of Armenia into four main relief types that differ by origins and properties such as accumulative, volcanic, tectonic-volcanic, tectonic, and erosive, glacier.

Accumulative type of relief is characteristic of flat territory, which is usually located in the downstream of river basins (Akhuryan, Kasakh, Vedi, etc.). However, volcanic and tectonic type of relief is highly characteristic of Armenia. Thus, well preserved volcanic cones are situated on Aragats massive and on its bordering areas: Geghama, Vardenis, Zangezur mountain chains and Karabakh area. Carved-tectonic, erosive mountains are characteristic at the folded relief borders of Small Caucasus.

Glacier relief is characteristic of high mountainous areas. Particularly, in the areas that were subjected to intensive glacier invasions. After melting, these glaciers form moraine lakes, which represent most typical types of glacier relief.

Types of soil vary greatly. Meanwhile, their distribution in the area is characterized by cincture of high altitude.

There are semi-deserted areas, in the lowest sections of Araks basin, on the altitude of 7000-1000m. In the foothills there are dark brown soils, while fruitful black soils of volcanic origin are characteristic of mountain ravines and intermountain concavities (1500-2200m altitude). In the high altitude regions there are Alpine (2200-3400m) pastures and meadows, underneath there are brown alpine meadows.

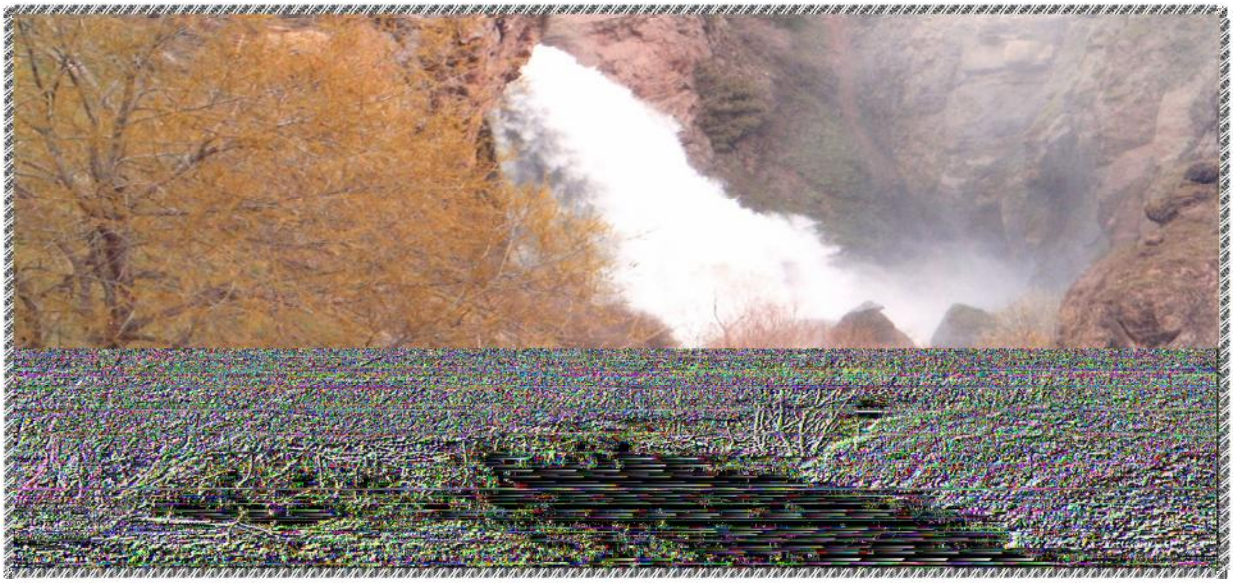
Deserted prairies - with low inclusions of organic substance - are prevailing in the north–west of Ararat valley. Meanwhile, cultivated and irrigated lands are prevailing in the lower parts of Ararat valley, closer to the Araks River bed. On the border of Armavir and Ararat marzes, where ground water level is close to the surface, large areas are occupied by salt-marshes and soils with high salt content. Salt-marshes and soils with high salt content are also present on the marginal areas of Ararat valley, where ground waters are situated deeper from the surface.

At the foothills dark brown soils prevail, which differ from deserted prairies of Ararat valley by higher concentration. Most of the river valleys, including Arpa, Akhuryan, Azat, Meghryget, sit on the dark brown soils, with reach organic composition.

Mountainous prairies are located on the altitude of 1300-2000m sometimes even higher, they occupy large territories of Gyumri plateau, Sevan Lake basin, Zangezur and Nagorno-Karabakh bordering territories. Here, the top soil level is represented by mountainous black earth and its’ subtypes.

The highlands are located above 2200 m and occupy Aragats massive as well as upper section of Geghama, Vardenis and Zangezur mountain chains. Vegetation is represented by thick cover of alpine and sub alpine grass. This kind of vegetation forms a thick cover making it possible to form mountainous meadows in severe climate conditions.

The following types of soil are characteristic for basin of River Kur: mountain-meadows in the upstream; mountain-forests in the downstream changing into forest-prairies and prairies followed by lowlands and turning into black-brown and grey prairie and semi-desert soils.



Armenia has diverse vegetation. Desert vegetation is characteristic of plain lands closer to River Araks. Most of Sub-Araks plain is occupied by absite semi-desert. It includes talus hills in the foothills that spreads over alluvial sections.

The main plant of wormwood semi-desert is fragrant wormwood. Pyramidal poplars and oleasters are typical representatives of wormwood semi-desert landscape. The phrygana type vegetation characteristic of Sub-Araks lowlands and its foot hills is more xerophyte. It is characteristic for land-starved, rocky and stony slopes of Araks ravine foothills of the semi-desert zone, before 1500m altitude. Overwhelming part of phrygana type vegetation is represented by pillow-shaped, dwarfish bushes and small trees. Prairie vegetation is typical for Armenian highlands. Prairies are located on average altitude of 1500-220m and occasionally on 2700m and occupy significant territories.

Forest vegetation occupies comparatively slam niche compared with deserts, semi-deserts, phrygana and prairies. Forests are characteristic to basins of Vorotan, Voggh, Meghriget, Debet, Aghstev and Kur river streams. Forest vegetation is practically absent on low-lands, mountain slopes and ravines. The forests are composed of the following tree types: oak (35%), beech trees (32%) and other (18%).

The Sub-Alpine meadows are located above forest and prairie areas on the altitude of 2200-2800m. Sub-Alpine vegetation can occasionally be observed on lower altitudes of northern slopes. Vegetative structure of Sub-Apine meadows is very diverse: with 120-130 types of plants. Alpine meadows form well defined Alpine zones by occupying significant mountainous areas. These zones are located within 27700-3500m average altitude and are located up to 4090m on Aragats Mountain.

Alpine vegetation forms a thick and short grass cover. The most characteristic elements of this zone are “carpets”. These are distributed over concave relief where earth cover is well developed and has high moisture content. The carpets also consist of dwarfish double-finger-sized grass. Grains exercise secondary role and are characterized by insignificant inclusions of turf. Typical upper Alpine carpets differ by defined colorfulness and are mosaic-like. Alpine meadows and carpets are a perfect summer pastures and execute an important role in cattle-breeding.

SECTION 11. RA CLIMATE CONDITIONS

Armenia has a diverse climate, conditioned by geological location between Black and Caspian Sea, separate elements of strictly divided relief compose mountain chains of Small Caucasus. Strict continental climate of Sub-Araks lowlands is combined with climate of mountainous tundra of Armenian highlands. In winter, high pressure is prevailing and is conditioned by invasions of large masses of cold air coming from the east.

In the beginning of spring the influence of counter cyclone is still quite significant. In the second half of spring the transition of cyclone becomes more frequent. Comparatively moist air warms up during penetration, becoming unstable, which results in precipitations. In summer, low pressure prevails over the area. In the beginning of September, penetration of arctic air is noticeable, which explains first autumnal frostbites.

The main actors of climate formation are sun radiation and atmosphere circulation. The solar radiation is influenced buy latitude and elevation. Air transparency changes with elevation consequently the solar radiation varies within significant range over the given territory. The largest number of sunny days is encountered in July and August; the least amount of solar radiation is encountered in winter months.

Fluctuations of average annual air temperature are from 13.80C (Meghri), to 2.70C (Aragats). From February to March there is a rise in temperature. The highest temperature is usually encountered in July – August. The temperature intensively decreases starting from September. The lowest average monthly temperature is encountered in January and fluctuates within the following range: in the north-east, Gyumry mountain plateau, from 8.7^{0}C (Maralik) up to 12.7^{0}C (Shushanabad), Sevan basin from 4.6^{0}C (Shorgha) up to 9.0^{0}C (Sevan HMS), in the average section of River Araks ravine, starting from 3.5^{0}C (Vedy), up to 6.6^{0}C (Aragats railway).

The borderline of south-east differs by warm winter season. Average air temperature in January fluctuates from 0^{0}C (Ghapan) up to 0.9^{0}C (Meghry). The ultimate lowest temperature is encountered in January and February; the fluctuations are significant starting from 20^{0}C (Shnokh, Meghry), up to 40^{0}C (Shushanabad). The summer is overall warm in River Araks basin and occasionally hot in some of basins (the temperature in July fluctuates within the range of 22-26^{0}C in the downstream and the middle section of River Araks.)

Sevan river Basin and Shirak mountain plain have chilly climate in summer on the altitude of 2000m. For example the average July temperature of Sevan Lake basin is 13-16^{0}C, while in Shirak mountain chain it alters from 14^{0}C (Shushanabad) to 20^{0}C (Gyumry).

The highest air temperature is observed in July and August and fluctuates within 31^{0}C (Shushanabad) up to 42^{0}C (Yerevan, Ararat).

In hydrology the shift from 0^{0}C is of great importance. This shift is related to floods and snow melting. Average daily air temperature of 0^{0}C also defines the beginning of winter or the end of it. On the altitude of 1500-2000m this shift takes place from 20th of March till 5th of April, while on the altitude of 2000m it takes place after the fist decade of April.

The temperature is shifts over 0^{0}C threshold, in autumn on the altitude of 1500-2000m, takes place during second and third decades of November and on 2000m altitude – during the fist decade of November.

The winter lasts for 21 days in Ghapan and 221 days in Aragats highlands. Medium freezing of soil in winter time varies from 18 cm in Yerevan (agro) up to 68cm in Sevan. The minimum 2cm in Yerevan up to 21cm in Sisyan and maximum from 12 up to 169cm in Eratmber. Yearly resilience of water evaporation is at its minimum in winter months in January and February and is at its maximum in July. It decreases with altitude.

In Ararat valley, in the mid-stream of Araks River, its intensity is high in winter and summer: 3.4-4.8mb in January and 11.0-16.5mb in July. Air moisture content - on Shirak mountain plateau, Sevan river basin and northern sections of Zangezur - on January-Fabruary is within 2.5-3.0mb and 11.5-13.0mb in July.

Average monthly moisture content of Araks mid-stream varies within 59-80% in winter (November – March) and within 42-69% in summer season (April-October).

The comparative average moisture content of Sevan lake basin and Shirak mountain plateau is 65% in winter and 45-55% in summer. In the highlands this fluctuations are not significant. The utmost quantity of days with high moisture content (30%) is observed in mid and downstream of Araks River while in case of Sevan Lake Basin the number of days with high moisture content is the smallest.

In summer there is a high moisture shortage especially in dry regions. The highest denominators of this shortage are observed in daytime, especially in the afternoon, and the lowest – at night after the sunset.

The complex relief of the basin and high range of altitudes conditions the presence of significant temperature gradients between high and average mountain ravines as well as over water and land surfaces. This conditions local air circulation as well as mountain ravine winds and breeze over Sevan Lake bank.

Mountain ravine air circulation is developing over Araks River basin, which spreads over Aragats foothills and Geghama Mountains. The wind direction does not have defined annual flow and is defined by the direction of the river ravine.

Northern winds prevail in Shirak mountain plateau. Annual flow of well defined wind can be traced in Araks basin and its inflows: Hrazdan, Arpa as well as Lake Sevan shore line. In winter southern, south-western winds blow in Hrazdan basin while in summer – northern and north-eastern.

In summer western, south-western winds blow in Araks basin while in winter – eastern and north-eastern. Average annual wind flow varies greatly. Thus, in Kapan it equals 1m/sec, while in Sisyan mountain pass 8m/sec. Ararat and Zangezur mountain chain river valleys are characterized by small wind speed up to 2m/sec. Average annual wind flow in Sevan lake basin varies within 1.8 (Gavar), up to 4.5m/sec (Sevan, HMS).

The annual speed of winter flow is well defined on stations located on open mountain plateaus (Eghvard), open ravines, Sevan Lake basin with well developed air circulation.

In summer wind speed strengthens in Shirak mountain plateau and Araks mid-flow. In Sevan River Basin except for Masriki plain the maximum wind speed takes place in winter months (January-February). It is noteworthy, that Sevan Lake Basin is the windiest part within Araks borders. Here the most stable winds are at south-west. This is characteristic from October till April.

The winds blow from mountains to Lake Bank through narrow plain of Argishi River. There are strong winds in summer as well. In the area of Mazra Hydrometer Station mountain winds cause strong waves over the lake surface.

Maximal wind speed is present at Sisyan Mountains, where average monthly values exceed 6-8km/sec. and maximal values reach up to 9m/sec. in February. For the observed territory there is an interconnection between the volume of precipitations and the altitude. The precipitations rise with altitude. In case of cold fronts, which come from west, there are strong precipitations especially on eastern slopes of Ghavakheti mountain chain and northern slopes of Aragats.

When air masses intrude from the east, the main moisture is preserved over eastern slopes of Sevan, Karabakh and Zangezur. The territories located beyond the mentioned mountains have low precipitation rate. Annual precipitations are unevenly distributed. Most part takes place during the warm period: April - October. The minimal precipitation rate is 250-350mm annually in the Araks river basin and nearest territories up to 700-1000m altitude.

In the foothills and Shirak mountain plateau up to 1500m altitude the precipitations are 350-500mm.
On the altitude of 1500-2000m and Sevan Lake basin the amount of precipitations is 400-500mm and over Zangezur mountain chain on the same altitude - 600-900mm.

On the altitude of 2000-2250 meters the amount of precipitations is approximately the same 600-900mm. The dominant part of the precipitations discharges in Shurak mountain plateau, Ararat valley and adjacent foothills. This discharge takes place in Zangezur basin in May and in Lake Sevan basin in June. During the same months amount of precipitations, on the western and south-western banks of Sevan Lake, is 88mm on average and 66mm on eastern and south-eastern banks.

In the middle of River Araks the largest amount of monthly precipitations reaches 46mm, in the upper streams of Kasakh River as well as Hrazdan, Akhryan and Zangezur rivers it reaches 100-1200mm and 95mm in Shirak mountain plateau.

The lowest amount of annual precipitations in Sevan Lake basin and Shirak mountain plateau takes place in January and December while in the downstream of Kasakh, Hrazdan and Araks rivers as well as basins of Zangezur rivers it takes place from August to September. Thus, particularly in the nearest banks of Araks River the average precipitations in August are 8-10mm. The minimum days when precipitations are above 0.1mm are characteristic of Araks valley (80 days are 0.1 and above precipitations).

In the flows of Kasakh and Hrazdan Rivers the number of days with precipitations reaches 138, on Shirak mountain-plateau - 130, Goris area - 121, Sevan basin - 110, Zangezur Mountains about 100.

Large amount of precipitations (10mm and more) are observed on slopes of Zangezur Mountains that are affected by eastern wind flows.

Maximal days with 10-20mm precipitations are more often in summer months, particularly its characteristic for Sevan Lake basin when in case of thunders.

The length of precipitations on Shirak Mountain Plateau is approximately 550-600 hours annually, while on Ararat valley, Zangezur and Sevan Lake basin it is – 400-500 hours.

When the length of precipitations is prolonged its intensity is decreased. The maximal magnitudes of the latter are indicated on the high altitude slopes with strong winds and their adjacent valleys (Goris 3.4mm/minute).

Non-intensive precipitations are observed on Sevan shores and in the middle of River Araks, where it reaches 1.3-1.5mm/min and 1.4-2 mm/min on Shirak mountain plain.

The maximal quantity of precipitations is affected by slope exposition. It increases on slopes exposed to wind (Goris, 42mm) and decreases over slopes with no wind (Shorja, 27mm). Daily maximum precipitations are abruptly decreased over closed mountain valleys.

In Sisian and Eghegnadzor metrological stations its average indication is 24 and 26mm. In the River Araks mid-stream the maximum recorded daily precipitations equals 22mm on average in Shirak – 28m, west shore of Lake Sevan – 33mm while 28mm on the east shore. The daily maximum of precipitations may reach significant indicators on the mountainous west-eastern part of the basin. On the mountainous side of the basin the snow layer is formed annually and may be significantly thick. There is a stable snow layer formed every year on the second decade of December that melts in the end of March of beginning of April, except for Ararat valley and Megry region.

In winter time the average number of days with snow cover varies depending on the location. Thus, on the river upstream it is 135 days, in Shirak- 97 days, north of Zangezur – 85 days, mid-stream of River Araks 45 days, Megry and Kapan – 25 days. The snow cover is one of the most important factors in the formation of spring floods. Maximal evaporation equals 450-500mm annually and is observed at northern regions with high moisture content (Bagratashen, Shnokh, Sevkar, etc.) as well as in the south-east of the Republic (Goris, Khotanan, Kapan). The minimal (400-450mm annually) is observed at regions with low elevation such as Ararat valley (Eghmiatsin, Artashat, Yerevan, etc.) The lowest evaporation of high altitude zones is observed in December: 208mm annually.

SECTION 12. WATER REGIME OF RA RIVERS

Rivers of Armenia belong to basins of Araks and Kur rivers and serve as water suppliers that have mixed feeding, however, the main source is melted snow waters. Ground waters play a significant role in feeding the rivers; rain waters have their contribution depending on the season.

The following stages are important for river water regime: spring floods, which include some part of summer period; rain floods which are added up at the general wave of river floods or are considered a result of autumn drought and summer-autumn, winter drought periods.

The main river channels are conditioned by geographical location and elevation of river basins, their feeding type as well as geographical, hydro-geographical, local and other factors.

However, except for natural factors there is the factor of high elevation zoning that stands out and conditions the magnitude of river basins which constitute water balance and distribution of the flow through annual seasons and the territory.

The elevation of Armenian river basins varies within 1100 m to 3500m and higher, this is why almost all characteristics for hydrological regimes are conditioned by altitude.

Water regime is affected by presence of vast territories with mountainous volcanic rock types with porous structure (mainly andesites, basalts and andesite-basalts).

This rock types change the impact of precipitations, over distribute surface and ground water streams and change the formation conditions even where climate is tedious.

The rivers can be classified into several:
1. mainly snow water feeding
2. snow-rain water feeding
3. mainly melted water and ground water feeding;
4. mainly ground water feeding;
5. rain, snow melting, ground water feeding;
6. snow melting, glacier waters, ground waters and rain water feeding

The given classification does not incorporate the whole diversity of feeding options as their interconnection is not stable but changes with time and depending on elevation zones of river basins. It is not possible to make a strict classification of river basins to fit the above mentioned classification, because most of the rivers have diverse feeding sources depending on the season and location. The correlation of feeding sources does not remain stable while observed during several years.

The most of mountainous river beds belong to those rivers, which feeding is carried out mainly by melted snow. Thus, these rivers feed on the elevation from 1200-1500 meters up to 3000-3500 meters.

Part of the melted waters of mountainous rivers constitutes 50-80% of annual flow. Rain feeding of the rivers is of relatively stable nature and constitutes on average 10-15% of annual river flow, conceding snow water and ground water feeding.

Ground waters are essential for feeding certain rivers, for example River Sevghur mostly depends on ground water feeding.

Spring flooding is one of the main stages of river regime. It is observed as a well defined wave along rivers formed as a result of snow melting, rain waters and ground waters, thus having a mixed origin. The maximal water discharge is observed at this very period. At the simultaneous snow melting the flooding is strong with maximal water levels and takes place within a short period of time, has one uneven wave with sudden intensive rise and smoother fall.

In case of early snow melting and following long spring, the decrease of the snow layer is carried out slowly and melting waters reach the rivers with interruptions which conditions slow and prolonged melting.

Comparatively large inflow volumes (up to 60-80%) during spring floods are observed in the rivers starting on the slopes of Vardenis and Zangezur mountain chains and Karabakh mountains. The minimal inflow of floods (25-35%) is observed in the rivers that mostly depend on ground water feeding.

Rain flow during flooding in different rivers varies greatly and is about 5-25% and in separate cases within 30%. The ground water component of overall spring flow is about 30-40% and in some rivers – 90%. The time of floods and prolongation manly depends on feeding and elevation. This is why floods are not simultaneous. Significant role is played by meteorological conditions, while particular spring properties is of great importance, thus the spring may be standard or prolonged, early or late. The slightly late beginning of spring floods usually coincides with higher air temperature and its stable gradation to higher temperatures in the zones that feed the rivers at the flood start.

For most of the rivers flooding begins in the second decade of March – begging or April, may vary for few days depending on year. The earliest start is in mid march with the rise of water horizons that have low height of river basins.

The prolongation of flooding for many rivers is 20-30 days with slight deviations depending on hydro-meteorological conditions of the given year. For high altitude mountainous rivers that are feeding from melted snow and glaciers this period is prolonged up to 35-45 and sometimes 60 days.

Maximal annual water discharge, except for separate cases is observed during spring floods. The date of maximal water inflow is conditioned by elevation of the main water basin and few other natural variables.

There are tree types of maximal water discharge:

1. melting
2. mixed (snow and rain)
3. rain

In comparison with flood rising, the fall takes longer and is mainly conditioned by the type of river feeding as well as the geological and hydrological properties of water collecting basin and its altitude. For majority of rivers the length of flood falling is 60 days on average, and its end mainly takes place at the end of June or beginning of July.

The length of spring flooding for most of the rivers is about 100 days on average. The rains are often for spring flood season (during the peak or fall); this conditions the mixed nature of the floods.

The readings of short floods, with smooth peaks, when being applied on flood hydrograph give it a comb like shape.

Rains that follow spring floods, during summer-autumn draught, cause most of the rivers to flood. However, these floods are comparatively moderate as strong rains are seldom during this season.

The strength of inundations that take place directly after flood falls is noticeably higher than inundations of summer-autumn draught period and in some cases even exceed the level of floods caused by melting snow. The summer-autumn floods on most of the rivers usually take place as short term inundations. The prolongation of such inundations varies from few hours to one day, however, sometimes, during heavy floods, it could be significant.

The evaporation of precipitation and the degree of instauration by the river bed has a great effect on the volume of rain flow; this is of great significance during summer period.

There are occasional violent mudflows that often have destructive consequences. This takes place as a result of heavy rains over small and medium water carriers of the basin such as Shahverd, Getar, Grvegh, Dalar, Meghriget, Lake Sevan inflows, Debed, Aghstev, Kasakh as well as rivers flowing from Kharabakh and Zangezur mountains.

After the end of inundations, dry regime is established on the rivers which is the longest stage (for most of the rivers, it lasts 8-9 months). This period is divided into to well defined seasons: summer-autumn and winter drought. The feeding and regime of rivers is determined by the volume and origin of ground water flow.

During simmer-autumn draught, rains play a crucial role for river feeding. Accordingly, during winter drought, rivers sometimes receive additional source from melting snow that originate from warm weather. Summer-autumn drought usually lasts up to the beginning of November or Mid-November until river starts to freeze. At this period river feeding partially depends on inundation waters caused by rain. However, rain waters are far less than ground water feeding at the particular period. For most of the rivers the minimal summer outflow is usually observed from the second decade of July to September. However, almost everywhere its volumes are altered by irrigation discharges.

Winter drought is usually established from the end of November to the beginning of December and lasts up until the first spring inundation. The beginning and the end of this period is also strictly conditioned by the altitude if the given territory.

In winter the river discharge is preserved due to the penetration of ground waters into the river bed, therefore, the rivers that do not freeze have low water level and stable flow. The short -term rise of water horizons caused by snow melting is possible only in the downstream of certain rivers (Kasakh, Hrazdan, Araks) as well as on the small water routes by means on reservoirs located on small altitudes.

During winter the draught period lasts about 25-30 days. Winter draught component is about 10-20% of annual water flow.

SECTION 13. INDICATIONS OF HYDROLOGICAL STATIONS

During the last 15 years the destruction of large forest territories brought to environmental changes, these changes explain the drought during 90-tees and 2000-s while for 1998, 1999 floods were typical.

This is why it is not acceptable to calculate the indicators of hydrological stations on RA Rivers until 1988 without taking into consideration the data from recent years.

The definitions of hydrological characteristics should be based on hydro meteorological observations which are officially disseminated by “ArmHydromed” as well as unpublished observations of previous years that can be found at: “State Hydromed Foundation”, archives of various research and design organizations.

When there is no previous data on hydrological observations it is necessary to carry out hydrological observations on the anticipated site. For these purposes the list of water meter stations has been prepared. This list has been submitted to State Hydrometric Service.

According to observation results the following stations are presently in the state of exploitation: r. Tanjut-Vanadzor, r. Eghnajur-Garnalich, r. Azat-Garni, r. Azat-Garni, r. Vedi-Urcadzor, r. Masrik-Tzovak, r. Martuni-Geghhovit and r. Kiranc-Hacharkut.

Factual observations of the above mentioned stations were obtained by “Armhydroenergyproject” CJSC. The observations were used, after normalizing results into natural conditions, for calculation of hydrological characteristics of horizontal sections.

The hydrological conditions of the Small Hydropower Plants (SHPP) design sections are calculated according to 2 schemes for the rivers with developed water use network that alters the natural hydraulic regime of the rivers.

The first design scheme proposes to bring the factual hydrological rows to natural, homogeneous, stable conditions by means of water balance and other methods. Taking into consideration economic factors, there is an adjustment in design values of hydrological characteristics which is based on natural rows of outlets. The numerical value of monthly adjustments includes the difference between agricultural/domestic and natural flows. Design growth of probability is calculated by adjustment distribution curve.

Table 3. List of water meter stations

#	Water meter station	Belongs to Basin	Water collecting surface, km^2	Average elevation of water collecting basin, m.	Observation period.	Flow Norms	
						Water discharge m3/sec.	Water module l/sec, km2
1	2	3	4	5	6	7	8
1.	Chichkhan – Getik	Debed	108	2250	1946-1987y.y.	1.24	11.5
2.	Lernaghur-Lernapat	Debed	77.5	2120	1964-1987y.y.	1.44	18.6
3.	Tandzut - Khndzorut	Debed	102	2120	1946-1987y.y.	1.72	16.9
4.	Chanakhchi - DebedãÇ	Debed	96.1	2010	1959-1957y.y.	1.58	16.4
5.	Dzoraget - Kartnarat	Debed	140	2350	1948-1987y.y.	2.65	18.9
6.	Urut – M. Gorki	Debed	130	1770	1955-1987y.y.	0.90	6.92
7.	Gargar - Kurtan	Debed	123	1680	1960- working	1.22	9.92
8.	Marciget-Atan	Debed	11.0	1820	1952-1963y.y.	0.16	14.5
9.	Alaverdi-Alaverdi	Debed	36.0	1570	1960-1980y.y.	0.27	7.50
10.	Aghstev-Fioletovo	Aghstev	93.4	2081	1948- working	1.42	15.2
11.	Agstev-Dilijan	Aghstev	303	2000	1948- working	3.14	10.4
12.	Bldan-Dilijan	Aghstev	73.5	2060	1970-1987y.y.	0.73	9.93
13.	Shamlukh – Dilijan	Aghstev	54.8	1880	1960-1987y.y.	0.60	10.9
14.	Getik –Chambarak	Aghstev	94.0	2100	1948- working	0.81	8.62
15.	Getik - Alachuk	Aghstev	581	1940	1948- working	3.46	5.96
16.	Paghjur –Getahovit	Aghstev	204	1710	1955-1988y..	2.00	9.80
17.	Kiranc – Achakut	Aghstev	129	1420	1959- working	1.11	8.60
18.	Hakhum – Tsaghkavan	Kur	169	1650	1948- working	1.57	9.29
19.	Karmnrajur	Akhuryan	35.0	2550	1960-1987y.y	0.36	10.3
20.	Heghnaghbur	Akhuryan	83.0	2470	1960-1999y.y.	0.74	8.92
21.	Mantash – Mets Mantash	Akhuryan	38.5 16.6	2790 3150	1961-1972y.y. 1974-1979y.y.	0.89	59.3
22.	Gomur – Meghradzor	Hrazdan	101	2430	1936- working	1.45	14.4
23.	Dalar – Arzakan	Hrazdan	87.0	2110	1936- working.	0.93	10.7
24.	Ulashik	Hrazdan	39.4	2560	1970-1987y.y.	0.81	20.4
25.	Araidet – Aragyugh	Hrazdan	63.8	2060	1949-1987y.y.		
26.	Vardenis – Vardenis	Lake Sevan	110	2680	1927- working	1.69	15.4
27.	Gegharkunik – Sarukhan	Lake Sevan	48.0	2520	1961-1987y.y.	0.34	7.08
28.	Masrik-Tsovak	Lake Sevan	685	2310	1966- working	4.30	6.28
29.	Masrik -Torf	Lake Sevan	473	2330	1953- working	4.16	8.79
30.	Marmuni-Gehgahovit	Lake Sevan	84.5	2640	1955- working	1.84	21.8
31.	Artsvanist- Artsvanist	Lake Sevan	79.8	2540	1950-1987y.y.	0.67	8.40
32.	Azat – Garni	Azat	326	2420	1936-working	5.34	16.4
33.	Vedi-Urcadzor	Vedi	348	2060	1937- working	1.85	5.32
34.	Elegis – Hermon	Elegis	205	2630	1957- working	5.03	24.5
35.	Meghri-Meghri	Meghri	274	2200	1945- working	3.39	12.4
36.	Meghri-Lichk	Meghri	21	2960	1950-1987y.y.	0.71	33.8
37.	Voghji-Kagharan	Voghji	120	2840	1950- working	3.27	27.3
38.	Vachagan – Ghapan	Voghji	35.0	1670	1970-1988y.y.	0.43	12.3
39	Geghi-Geghi	Voghji	195	2640	1950-1987y.y.	4.32	22.2
40.	Khachin-Rozdere	Voghji	266	1710	1959-1980y.y.	2.08	7.82
41.	Vorotan-Gorhaik	Vorotan	179	2760	1943- working	3.31	18.5
42.	Sisian-Arevis	Vorotan	118	2520	1948-1987y.y.	1.85	15.7
43.	Loradzor-Lcen	Vorotan	118	2320	1934-1981y.y.	0.99	8.39

The hydrological rows examined by means of the second design scheme result in domestic flow based on the assumption that the complicated economic structure including the real plan of national economy was there from the very beginning.

The decision about designed hydrological descriptions should be carried out by means of uniform observation set. Evaluation of hydraulic row uniformity is carried out based on genetic and static analysis of the primary data. Conditions for genetic data analysis of river flow formation depend on investigation of physical factors. The latter is conditioned by heterogeneity of primary data.

The design definition of hydraulic characteristics is carried out by means of annual distribution of possible growth, applying safety curve analytic functions in case there is a long term water meter observation data.
Observation period s considered sufficient if the time period is representative and if the relative average square alteration of the investigated hydrological properties does not exceed 10% -per annum and per season, and 20% for maximal and minimal flows.

When there is no sufficient data, the hydrological characteristics of distribution curve as well as main elements of design hydrograph should be brought to multi annum period using data from analogue-stations. Therefore, the exploitation of several fulcrum hydrologic stations, which were stopped before 1988, have been prolonged based on 33-101-2003 requests. When choosing analogue – stations, it is necessary to take into consideration the special links between the observed hydrological descriptions that give numerical description by means of temperature coefficient correlation matrix or by means of stereometric correlation function that shows the dependence of river flow temperature correlation factor on the distance between gravity centers of catchment basins.

The average perennial value of uninvestigated rivers to be estimated based on average elevation of catchment basins with territorial flow relation, acceptable for the investigated river. Based on these very requirements, the network of water meter stations has been developed to be used in further hydrologic calculations.

SECTION 14. GENERAL DIRECTIVES FOR DEFINITION OF DESIGN WATER REGIME

Data from 43 observation stations was used for defining design sections of 100 Armenian SHPP (see the table 3) to define the design hydrologic descriptions including the normal flow, annual flow distribution (25, 50 and 75% guarantee) as well as maximal and minimal flow data.

There are additional observation points used as partial imitations, to obtain the flow norms. The data on flow was obtained from hydrological year-books, XIII volume, I part. Similarities are referred to in construction norms 2.01.14-83. Design hydrological observations are defined according to factual water discharge data from yearbooks that had been brought to natural conditions taking into consideration all of the intakes. Calculation of main hydrological characteristics for headwork sections is carried out based on the following data: catchment basin, river length, average altitude of the basin, standard flow, maximum and minimum flow data (if there is no data on flow volume, the data from similar water meter station is used).

Occasionally, to obtain the normal flow indications, local interdependence curves between flow module and average elevation of the basin are used. This data is shown by means of tables classified according to river basins.

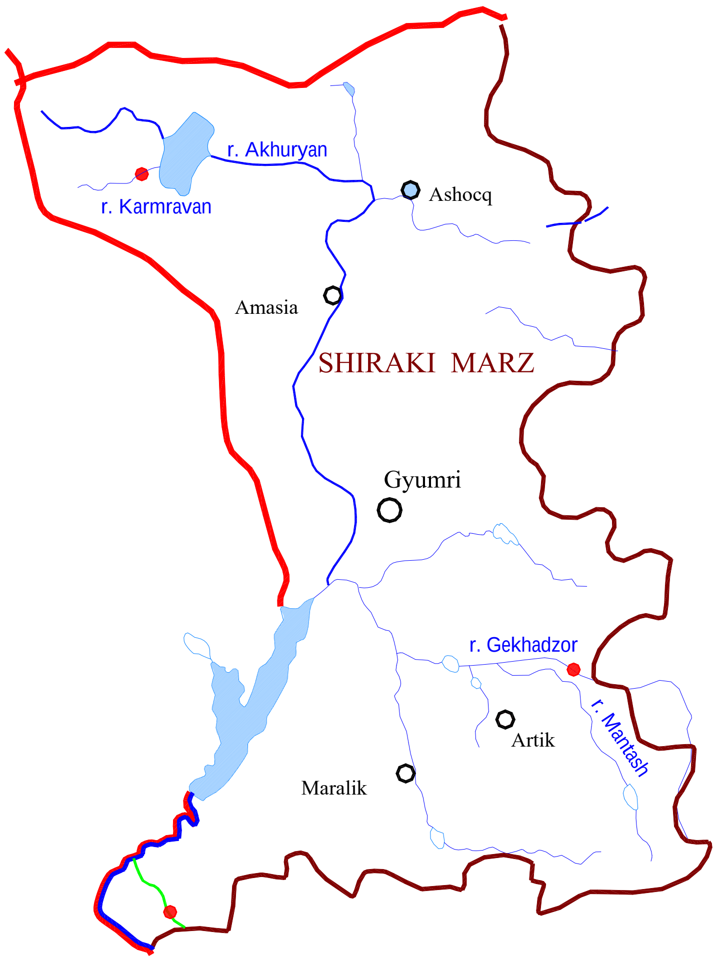
Annual flow distribution is carried out by choosing the design year from annual observational data. Annual distribution is carried out for calendar year. Annual flow distribution tables for SHPP-s' headworks are classified according to river basins.

SECTION 15. SHPP VERIFIED AND UPDATED PLAN FOR RA RIVER BASINS

PART 15. 1 SHIRAK MARZ

AKHURYAN RIVER BASIN

VERIFIED AND UPDATED SCHEME FOR SHPPs



GENERAL INFORMATION

According to 1997 scheme it was planned to construct 14 SHPPs in the Akhuryan River Basin river basin: 2 SHPP near Kaps and Akhuryan reservoirs, 3 SHPPs – on the inclination of Talin channels and 9 derivational SHPPs. Presently Ghradzor SHPP, Akhryan –Talin SHPP (on Talin channel) and derivational Heghnaghur SHPP (on Chingil River) are under construction. Private investors have ordered technical substantiation from SHPPs located new dam. Technical-economic substantiation is being carried out for Talin's right wing channel, which was not incorporated into the earlier plan.

After in situ investigations the water energy indicators of Karmravan (Kizil), Matash, Geghadzor Rivers were verified.

Kaps reservoir construction is planned to construct on Akhuryan River according to Millenium Development Goals program. Kaps reservoir volume is foreseen to be 6.0mln.m^3 (instead of 84mln.m^3). As far as there a re no final data on Kaps reservoir there is any SHPP planned in the neighborhood.

15.1.1. SHORT DESCRIPTION OF AKHURYAN RIVER BASIN

River Akhuryan is the large left inflow of river Araks and falls into the latter at 708km from the river mouth and flows in the western direction. Akhuryan basin is located in the west section of RA but most of the river is flows outside of the borders of the republic.

River length is 186km; catchment basin is 9670$km^{2,}$ average elevation till Haykadzor observation point is 2010m, average inclination of the river is 5.6%, forest – 2%.

The river basin borders with Chorokh river basin from the west (Chaldri mountain chain - 2914), from the north – Kur River basin (Somkheti mountain chain – 3010m), from the north east – Debet River Basin (Khonav mountains – 3202m), from the east Kasakh river basin (Aragats slopes).

The upstream flow of the river starts in Armenia, and afterwards, it serves as national border between Turkey and Armenia.

River Akhuryan starts from Lake Arpy that was turned into a reservoir, on the elevation of 2023m and is located on the lowest point of Ashotsk mountain plateau.

The river mainly flows along deep twisting valley that reaches to wide Shiral mountain plateau that stretches to the west from Aragats.

The valley has a diverse earth cover in the upstream there is mountainous black earth and in the downstream black earth and in the zone of Ani station – brown earth mixed with rocks. Grey earth is observed in the downstream towards the river mouth. The vegetation is not so diverse. There are almost no forests the high elevation mountainous zones are covered by alpine and sub alpine soils. In the downstream the zones are covered by dry, short grass and after Ani station there is almost no grass cover.

The river valley has a wide vessel-like ravine surrounded by low mountains. The slopes of the valley used to be the bottom of dried out lake and currently have a slight indication towards the river, which occasionally bogged and covered by thick grass.

Only near Shurabad the slopes come close and meet the river. The valley width at this point is 1.5-2.0km, with slope height of 10-15m. The nature of the valley changes very strictly, starting from Daliget inflow. The river changes direction from eastern to southern and the mountains come closer and Akhuryan starts to flow along thin, deep, gorge that is full of stones.

The height of the slopes varies from 50m to 300m. The slope inclination is 30 – 60^{ú}, and near Kaps village is varied within 2-3 km the river turn into gorge with vertical slopes.

The valley width in the upstream is 100-500m. The slopes are mild and almost horizontal. Gyumry water line passes parallel to the river on the height of 40-50m.

The valley becomes wider near Gyumry city the mountains become lower and create wide Shirak mountainous plateau.

Starting from Keghach village the river falls into volcanic rock types creating narrow and deep valley. In the begging the slope height is 10-20km and valley width is 0.5km. In the downstream the valley depth reaches 200-300m, and the valley width equals 150-200m. The mountains are located far from the river for about 10km at the river mouth section and the valley becomes terrace-like while the bed of the river valley equals 1 km. The terraces are located on the 40-50m one on top of another. The valley slopes are steep and occasionally parallel, at the begging composed of tuffs and after Ani station – basalt and andeside basalts. There is no vegetation on the slopes and on the river mouth terraces there are fruit gardens and willows. Near village Bakhchalar there are irrigated sections and there are rich fruit gardens and wine yards.

At the beginning the inundation area is double sided stretching for 0.5-0.8km, close to the inhabited areas it becomes narrower and completely disappears. It is moist all year long. The river covers the inundation are when water level rises for 0.-1.4m. In the gorged areas the inundation are disappears. When water covers inundation area it occupies the whole area and occasionally flows along several branches. While this temporary river beds constantly change their location, when the river enters the gorge near Kharkov village the inundation area disappears.

The climate of Akhuryan basin is dry and very continental. The winter is cols for most of the basin, which is the result of constant anti cyclone. In the north the temperature in north is very mild while is the south is it very high. Average annual temperature in Shurabad equals 1.8C, and 9.0C in the north.

15.1.2 GEOLOGICAL COMPOSITION OF AKHURYAN RIVER BASIN

From geological point of view the basin is mainly composed if mountainous volcanic rocks with overwhelming basalts and andesite basalts. The exception is the neighborhood of Shishtapa village with undivided alluvium and talus with underlying lime stones. There are lake – clay layers in Shiral mountain plateau that cover the tuffs.

In the upstream of Akhuryan river on the Voskeghur and Eghnaghur inflow there are quaternary volcanic sedimentary rock types. The volcanic rock types of lower Miocene are represented by andesite-basalts, andesites, dacites liparites etc. These are strong highly permeable cracked rock types.

The quaternary age rock types are represented by talus, proluvial and alluvial sand clays and rock sediments. In the basin of Mantash inflow upper Pliocene volcanic rock types are represented by doleritic and olivine basalts, andesite basalts, partially tuff breccias and tuffs. These are strong highly permeable cracked rock types.

Volcanic rocks are occasionally covered by up to 5m talus and colluvial sediments.

15.1.3. WATER REGIME OF AKHURYAN RIVER BASIN RIVERS AND DESIGHN DATA

The river is of typical mountainous nature while the hydro physical network of the river is highly developed only in the upstream and right side of the midstream section.

The water regime is well developed up to Haikadzor and there is no verified data on the part located in Turkey.

The river has diverse feeding: lake, ground water, surface (snow and rain). Taking into consideration the fact that in 1947 the Arpy Lake was turned into reservoir it has a well defined regulatory characteristic. Thus, it collects spring waters and releases them in summer from irrigation and energy means.

The water regime of the river is described by heavy spring floods and stable droughts that last from July up to March. The floods start at the end of March or begging of April the water horizons rise rapidly and reach their peak at the end of April and begging of May. The rise lasts no more than one month and the fall is milder and more gradual. Spring rains in the upstream do not affect water regime. Winter phenomena are diverse and are presented in all the aspects. The ice sections create a block section that cause water level to raise and sometimes this rise of horizons exceed the levels of spring floods.

The upper stream section of the river completely freezes the ice layer reaches 0,2-0,32m. In the gorge sections there the speed is high there are no ice covers. There are large ice bergs and floating ice that often interferes with Len SHPP exploitation. The same related to the section flowing near Gyumry.

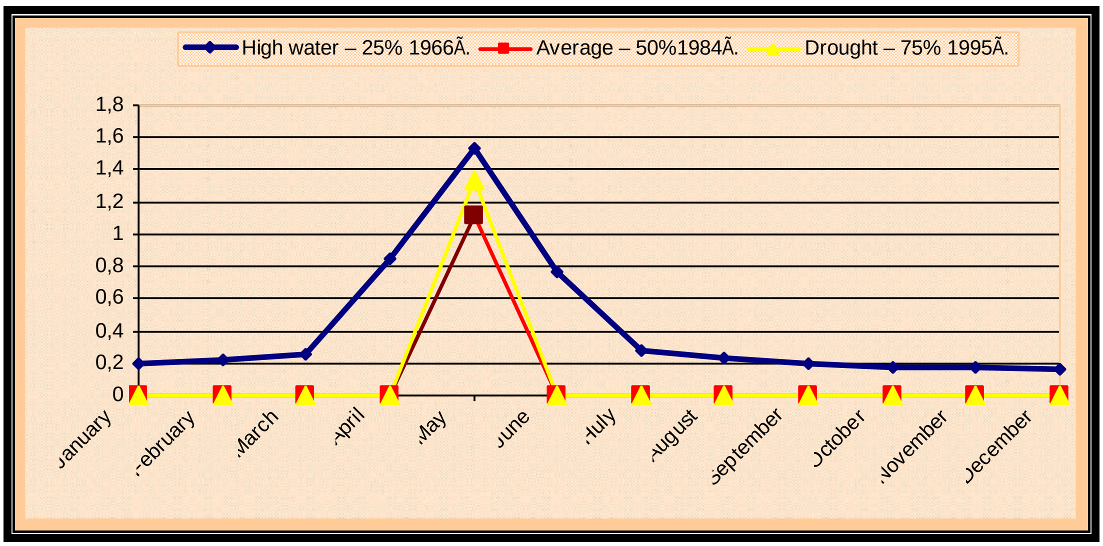
The systematic observations of Akhuryan river basin were carried out from the following observation points. The main hydrological observations are shown on the table 4.

Table. 4. Akhuryan River Basin Discharge Observation Results

Watermeter Station	Distance from the river bed, km.	Average elevation of reservoir, m.	Catchment area, km^2	Exploitation timeline		«0» altitude BS
				started	terminated	
Karmravan-Kizilkend	1.0	2550	35.0	01.01.60	21.12.87	2034.85 BS

For average water flow indicators and annual distribution data the abovementioned observation results were used by rehabilitating the natural state of the river. The Table 2 shows annual distribution of Akhuryan river basin flow for characteristic years.

Graph. 1. Annual Distribution of Akhuryan River Basin Flow (m^3/sec)



15.1.4. TECHNICAL ECONOMIC SPECIFICATION OF SHPPS TO BE CONSTRUCTED ON AKHURYAN RIVER

15.1.4.1. KARMIRAVAN SHPP

INTRODUCTION

According to development scheme it was planned to construct 2 SHPPs on the river. However, as a result of in-situ investigations it is planned to construct one derivational SHPP. Karmravan SHPP uses inclination of River Karmravan from 2225.0 till 2065.0.

The length of derivation from Karmravan River is 2.75km by copper pipeline 530mm in diameter with design pressure of 138.5m and design discharge 0.40m^3/sec. After construction and exploitation Karmravan SHPP will have 0.443mwt capacity and will produce 1.58mln kw/h electricity annually.

SHORT DESCRIPTION OF KARMRAVAN RIVER BASIN

Karmravan (Kizil) river falls into Arpy Lake on the elevation 2020m. The river length is 14.0 km and catchment area is 40km^2, average elevation of the basin is 2550m, with no summer. Karmravan River starts on the elevation of 2800m from Turkish-Armenian national border. The river starts from 2 springs underneath mountain rocks which join and form a stable and strong flow i.e. river Karmravan. The average inclination of the river is 57%. In the upstream the river has northern direction and then turn to the east till it discharges into the lake.

The geological structure of the river basin is represented by volcanic andeside-basalts, covered by black soils.
The vegetation of the river valley is very poor, represented by alpine meadows and different crops mainly grain. The river valley is a V-shape gorge before it reaches village Kizilkend. This gorge has a strong inclination, with rocky slopes that are a result of weathering rocks and the bottom of the valley is covered by rounded stones. Water regime of Karmravan River is characterized by large spring maximum, during the inundation period that starts at the beginning of April. The maximal level of the water is observed during May or June months. The drought period is stable starting from August. There are no autumn floods.

The ice regime of the river is characterized by ice crust of the river banks starting from November until complete freezing in December. The river does not freeze till the very bottom. The average thickness of the ice reaches 20-25cm. The ice starts to move from the begging of April together with floods and the river is free of ice at the end of April. The climate is with short summer and cold winter.

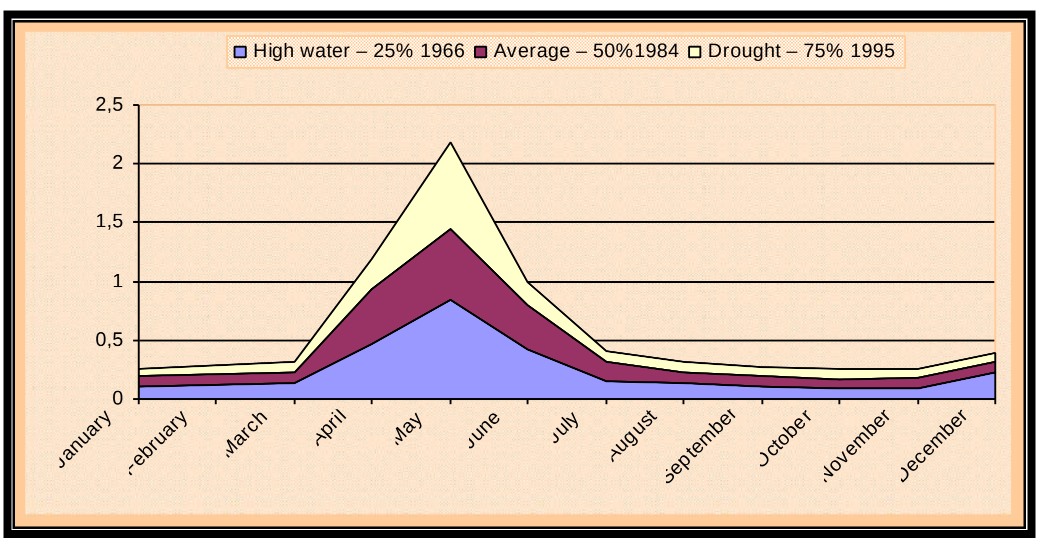
Climate condition data of the SHPP region is based on Amasia meteorological station observations. According to this observations the average annual temperature is 4.1°C, the maximal is +32°C, and the lowest is 36°C. The maximal freezing of the soil is 104cm. The moisture content of the air is 65mb with comparative moisture varying within 61-80%. The quantity of average muli-annual precipitations is 686mm, the maximal case is 43.

Average annual wind speed varies 3.0m/sec, the wind direction is generally northern. With 5% guarantee the maximal wind speed may reach up to 27m/sec.

HYDROLOGY

The observation data from river Karmravan - Kizilkend water-meter station is used to define the hydrological properties of Karmravan SHPP headworks and the design river section.

Graph. 2. Annual Distribution of Karmravan SHPP Water Regime



In the design section of Karmravan SHPP the catchment area is 19.2km^2, average yearly flow value of is 0.20m^3/sec.

The table below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Maximal design discharge for Karmravan SHPP headwork river section for the general case equal 3% - 3.23m^3/sec, for verifying case - 0.5%-3.86m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.029m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Karmravan SHPP is 2225.0m, downstream - 2060.0m. According to data of Shirak Marz WUA there is no water intake for irrigational use from Karmravan River. Karmravan SHPP is derivational SHPP. In order not to drain the river where 2750m derivational pipeline is the environmental discharge is designed according to RA laws and 0.02m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Karmravan SHPP are calculated with 50% guarantee per annum (1975).

Table. 5. Average monthly discharge Geghadzor SHPP (m^3/sec)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Karmravan SHPP (m^3/sec)	0.07	0.07	0.07	0.40	0.40	0.36	0.14	0.07	0.07	0.06	0.07	0.06	
SHPP average monthly capacity (mwt)	0.09	0.09	0.09	0.443	0.44	0.41	0.18	0.09	0.09	0.08	0.09	0.08	
SHPP –average monthly energy production (mln kwt/hour)	0.07	0.06	0.07	0.32	0.33	0.30	0.13	0.07	0.06	0.06	0.06	0.06	1.58

INVESTMENT EFFICIENCY

Capital investments into Karmravan SHPP construction

The capital investments into hydropower station are 569.7 thousand USD (without VAT) and 684 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production by Karmravan SHPP

Annual exploitation expenses for power production on Karmravan SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for Karmravan SHPP (according to 2008 rates)

Expenses	USD thousand
1. Depreciation	18.8
2. Exploitation expenses	
Salary	14.4
Renovation	4.6
Other Expenses	3.0
Total	40.8

Power indicators of Karmravan SHPP

Indicators		Values
Derivation capacity, kwt		443
Average multi annual production of energy, mln kwt/hour		1.58
Capital investments into SHPPS(without VAT), thousand USD		
	USD thousand	569.7
	USD / kwt	1286
	USD / kwt/hour	0.36
Prime cost of power production, cents/kwt hour		2.5

Financial analisis

The construction period for Karmravan SHPP is 12 months while design period is 30 years. Karmravan SHPP financial sustainability is determined by means of investment options:

- Private investments only
- 30% of private capital and 70% credit

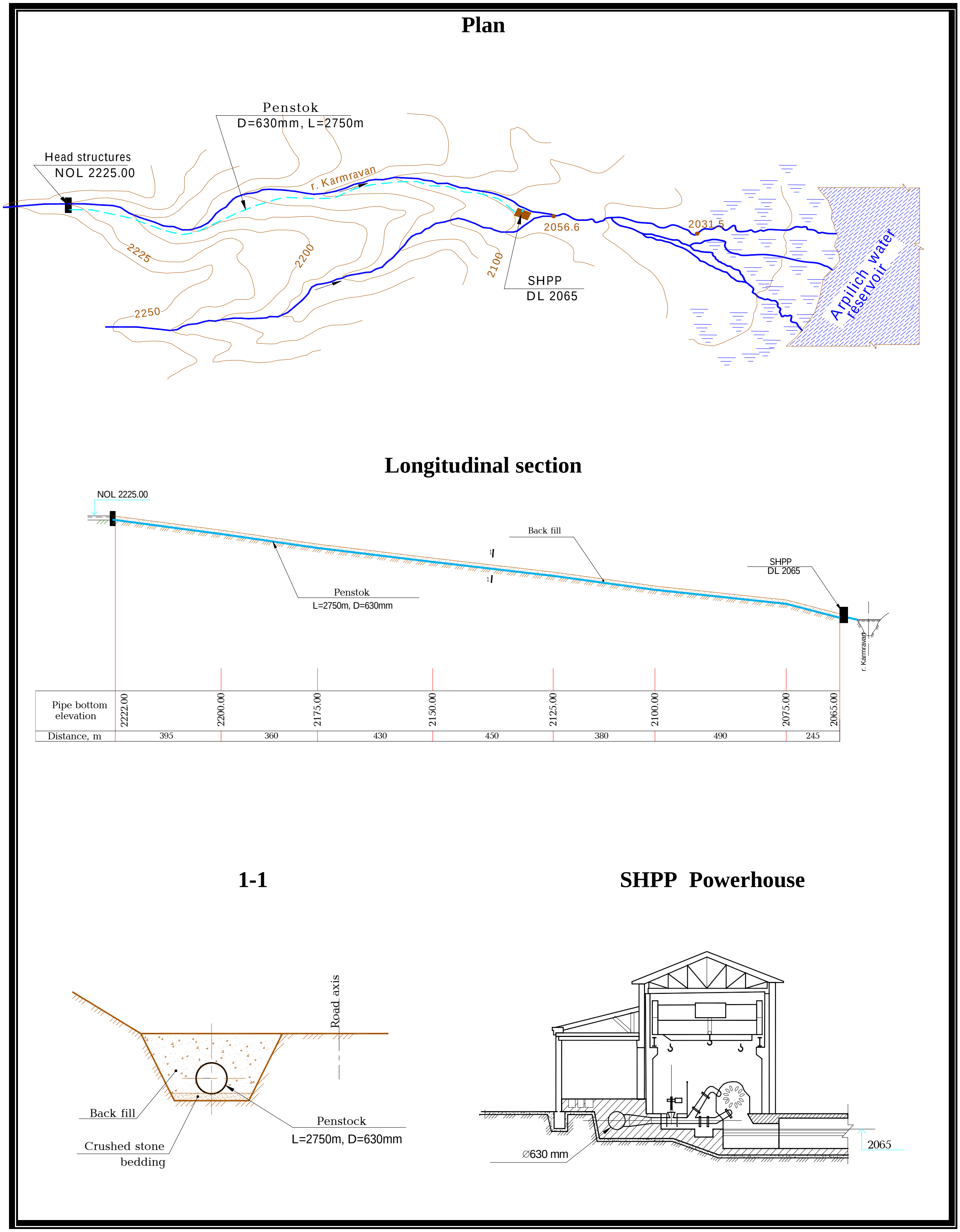
Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 6. Calculation results according to finantial scenarios

INDICATORS		**Scenario 1** 100% fully self - financed option	**Scenario 2** 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		8.5	8.8
NPV, thousand USD			
	8%	29.3	29.3
	10%	-68.1	-29.1
	12%	-141.1	-68.6
	14%	-197.2	-95.9
PB, years (without discount)		10.7	15.3
Deadline for credit return, years			12.0

APPENDIX. 1. KARMRAVAN SHPP



15.1.4.2. MANTASH SHPP

INTRODUCTION

According to development scheme it was planned to construct 5 SHPPs on the river, which were located on the internal bief of, below 2500m till 2000m. The volume of the Mantash reservoir is 7.9mln.m^3, the regulation is seasonal and is constructed for water supply of Artik city and neighboring villages (250l/sec). The water supply pipeline starts immediately from the reservoir.

The on-situ investigations have shown that during the whole period of exploitation there are only few years when the reservoir was filled up completely.

During May-June of the current year the reservoir was half full (due to little precipitations) and the river bed was completely drained.

Thus, due to investigations and calculations it has been decided that it is not appropriate to construct a SHPP on Mantash river as it would be possible to use it only during high water years.

15.1.4.3. GEGHADZOR SHPP

INTRODUCTION

According to development scheme it was planned to construct 1 SHPPs on the river. During in-situ investigations the location of the SHPP was clarified.

It is planned to construct Geghadzor SHPP in the north of RA within vicinity of Geghadzor village, which is from administrative point of view belongs to Aratsotn Marz but is located in the Akhuryan river basin. The station works of Geghadzor SHPP is located above the headworks of water supply pipeline.

Geghadzor SHPP uses inclination of River Geghadzor from 2465.0 till 2365.0. The length of derivation from Geghadzor River is 1.40km by copper pipeline 530mm in diameter with design pressure of 83.0m and design discharge 0.50m^3/sec. After construction and exploitation Geghadzor SHPP will have 332mwt capacity and will produce 1.20mln kw/h electricity annually.

SHORT DESCRIPTION OF GEGHADZOR RIVER BASIN

Geghadzor (Gyuzaldara) river basin is located on the northern part of Aragats volcanic part and belongs to Akhryan river basin. Geghadzor River is the right inflow of Karkachun (Karangu) river and falls 23km from the river mouth. The catchment area of the river is 144km^2, river length is 34km, the average inclinations on the observation point is 123‰, average height of the basin is 2980m, the average inclination is 300‰. Summer cover is absent. The river starts on the western peak of Aragats mountain from 3500m. The river source is represented by two strong springs that flow from basalt cracks. The river flows to the north and afterwards turns to the west and falls in to Karkachu River.

Gaghadzor river valley is a narrow, mountainous and uninhabited gorge with 200-500m slopes with inclination 45-60^0.

There is insignificant vegetation and soil cover. The upstream of the basin is covered with alpine meadow, except for mountain area peaks. Below the Geghadzor River the river falls into mountain plateau with 10-15^0 inclinations.

On the internal streams the slopes are cultivated and at some places used as pastures. The main water carried which is 400mm in diameter starts from the main source and two small water carriers start from left inflow springs, the diameter of these water carriers is 150mm.

There is inundation are only below Geghadzor village. IT is double sided and is covered by grass. Occasionally the width if the inundation area reaches 1-1.5km. The river bed in the upstream is twisted the bottom is stony. The river basin is composed of highly permeable andesite – basalts that filter the river bed. In the downstream there is occasionally no water at all, the more downstream the stronger is permeability.

Geghadzor river water regime is typical mountainous and is characterized by sudden rise, short term peaks and long term falls. The inundation begins at the end of April-begging of May and ends ar August-September.

The draught is stable except for rise of water horizons during winter which is conditioned by icing. There are sometimes strong deformations of the river bed which alters the normal flow: the river freezes till the bottom. All these phenomena follow one another from December-March.

The climatic description of SHPP region have been carried out according to Geghadzor – Artik meteorological station data, According to this data the average annual temperature varies 3-4°C, maximal +29°C, minimal -35°C:

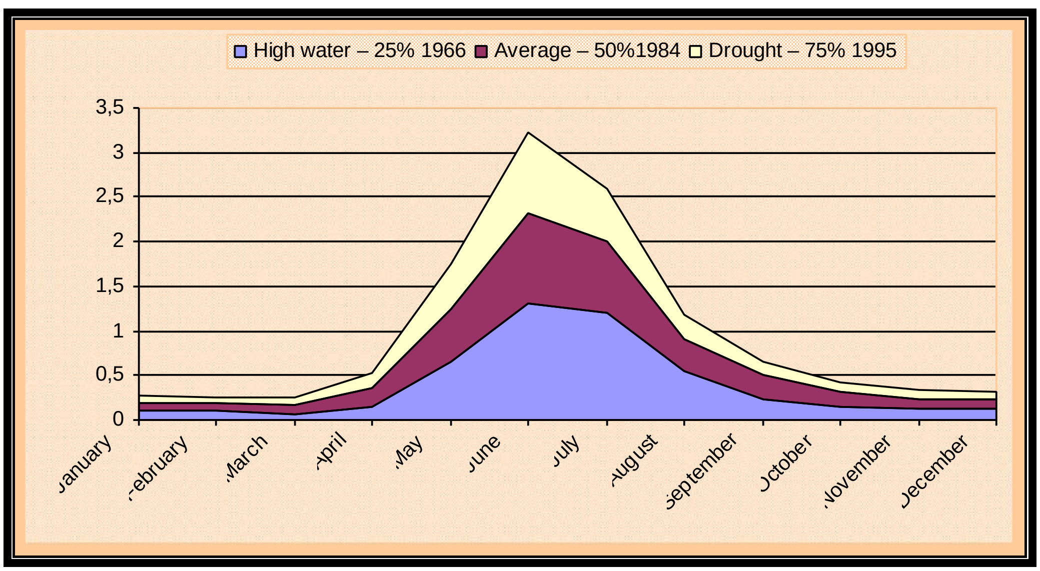
The utmost depth of soil freezing is 115-120cm. Comparative moisture content of the air varies within 73-80%. Average precipitations equal 785mm. Average annual wind speed varies within 3-4m/sec, maximal wind direction is to the east. of wind flow speed with 5%guarantee may reach 30m/sec.

HYDROLOGY

The water regime of Geghadzor river has been investigated in Geghadzor observation point 1936,37, 43, 45-47. The observation data quality is low. The absence of long term and high quality research hinders the definition of flow indicators as there is no observation point in the vicinity.

This is why the only solution is the construction of interdependence curve of regional annual flow module and dependence of average basin elevation. The curve was formed according to data from 11 inflows of Akhuryan and Kasakh River. The curve is quite dependable and the data taken corresponds the dam river section which equals 2.1l/sec.km^2.

Graph. 3. <u>Hydrological properties of design river section for 3 typical years, necessary for the SHPP</u>



The maximal flow is calculated according to extreme intensity equation and the minimal flow is based on factual observations of Geghadzor observation point and recalculated for design river valley of SHPP's headworks. In the design section of Geghadzor SHPP headworks the catchment area is 16.5km^2, average yearly flow value of is 0.35m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Geghadzor SHPP is 2465.0m, downstream - 2365.0m.
According to data of RA State Committee for Water Economy there water intake for irrigation purposes for Geghadzor river is carried out below the station works, and the water demand for the territory till the headworks, according to WUA, is 1.89mln.m^3(60l/sec), annually. Geghadzor SHPP is derivational SHPP. In order not to drain the river where 1400m derivational pipeline is the environmental discharge is designed according to RA laws and 0.014m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Geghadzor SHPP are calculated with 50% guarantee per annum

Table. 7. Average monthly discharge Geghadzor SHPP (m^3/sec)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Geghadzor SHPP (m^3/sec)	0.013	0.007	0.020	0.121	0.500	0.500	0.500	0.296	0.181	0.094	0.047	0.034	
SHPP average monthly capacity (mwt)	0.010	0.006	0.016	0.096	0.332	0.332	0.332	0.222	0.141	0.075	0.038	0.027	
SHPP –average monthly energy production (mln kwt/hour)	0.008	0.004	0.012	0.069	0.247	0.239	0.247	0.165	0.102	0.056	0.027	0.020	1.20

INVESTMENT SUSTAINABILITY

Capital investments into Geghadzor SHPP construction.

The capital investments into hydropower station are 380.5 thousand USD (without VAT) and 317.1 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production by Geghadzor SHPP

Annual exploitation expenses for power production on Geghadzor SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Expenses	USD thousand
1. Depreciation	12.6
2. Exploitation expenses	19.4
Salary	14.4
Renovation	3.0
Other Expenses	2.0
Total	32.0

While power economic indicators have singled out the following levels.

Indicators		Values
Derivation capacity, kwt		332
Average multi annual production of energy, mln kwt/hour		1.195
Capital investments into SHPPS(without VAT),		
	thousand USD	380.5
	USD / kwt	1146.1
	USD / kwt/hour	0.317
Prime cost of power production, cents/kwt hour		2.66

Financial analisis

The construction period for Geghadzor SHPP is 12 months while design period is 30 years.

Geghadzor SHPP financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

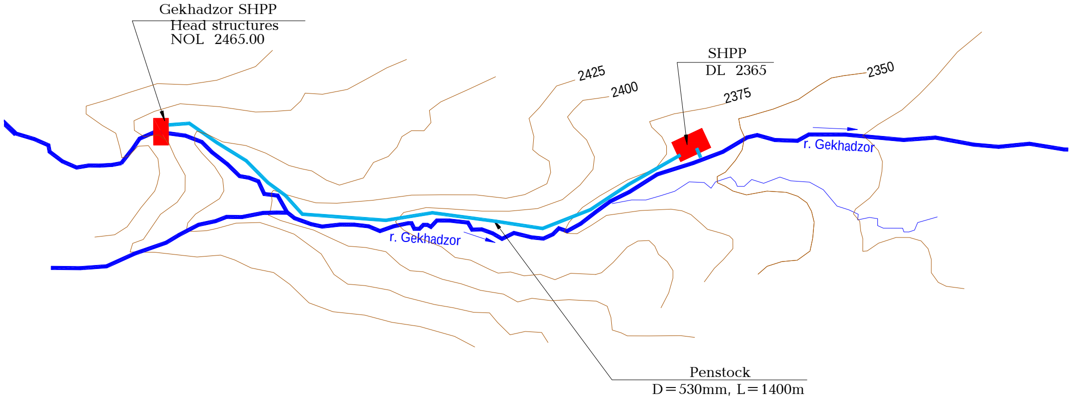
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 8. Calculation results according to finantial scenarios

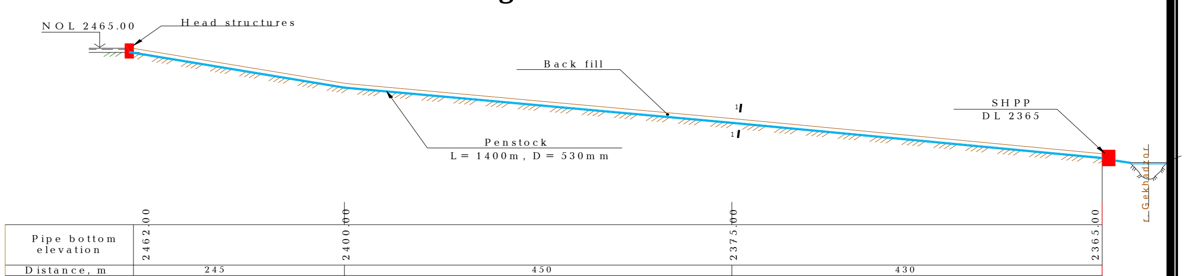
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		7.1	6.3
NPV, thousand USD			
	8%	-31.7	-31.7
	10%	-88.5	-56.9
	12%	-131.0	-73.3
	14%	-163.6	-84.3
PB, years (without discount)		12.3	19.5
Deadline for credit return, years			16.0

APPENDIX.. 2. GEKHADZOR SHPP

Plan



Longitudinal section



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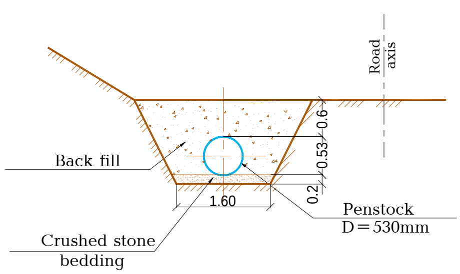
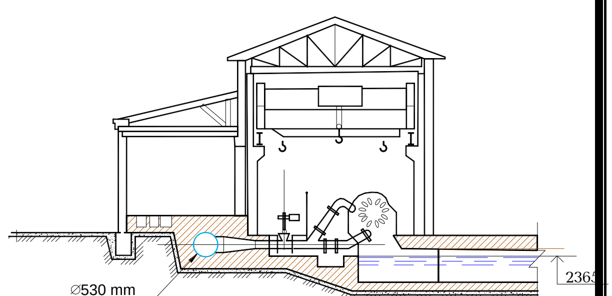


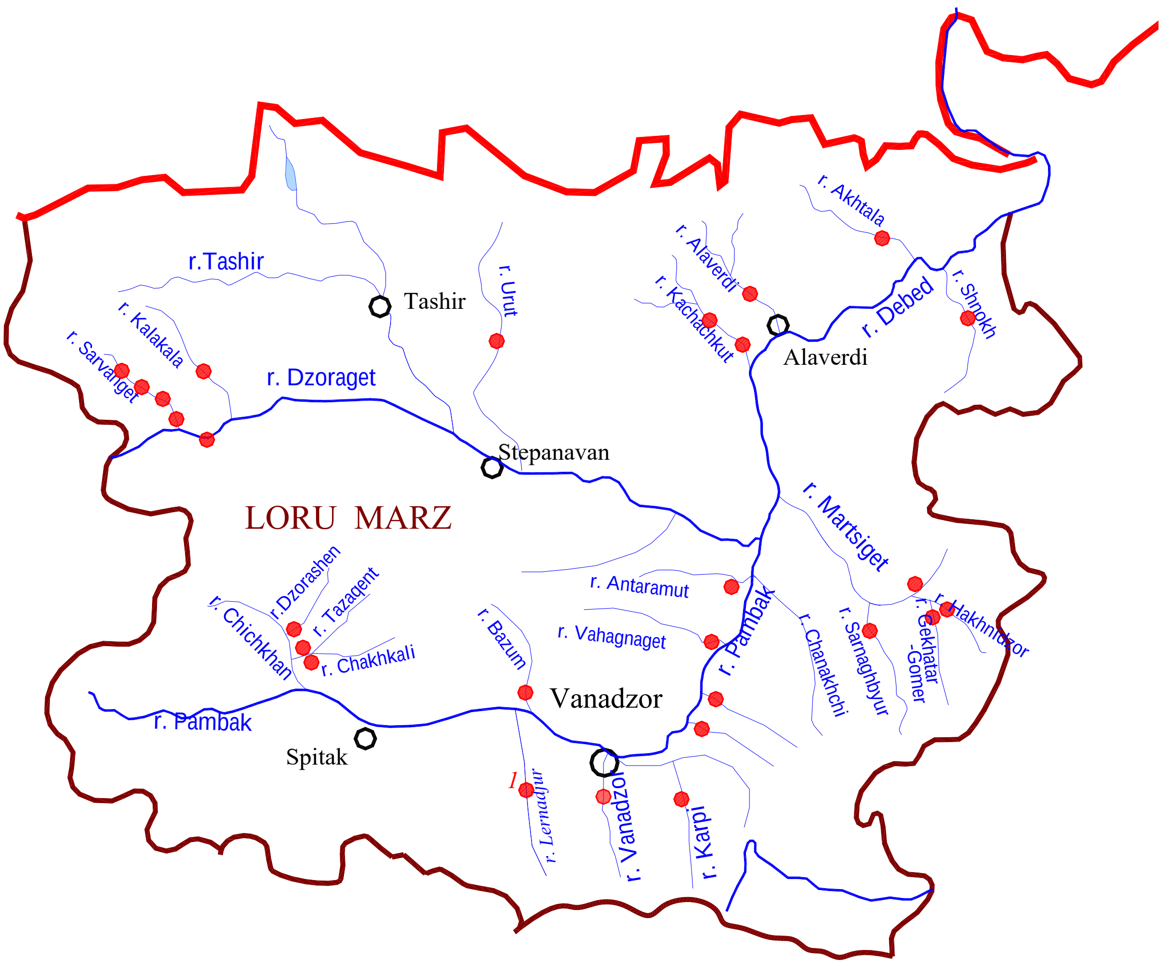
SHPP Powerhouse



PART. 15. 2 LORY MARZ.

DZORAGET, PAMBAK AND DEBED RIVER BASIN.

VERIFIED AND UPDATED SCHEME FOR SHPPs



GENERAL DATA

Out of 30 previously planned SHPPs the following SHPPs have been constructed and are under exploitation: Kurtan (Gargar SHPP), Doraget SHPP-5, Karakala SHPPs 1-7. There is permission for construction of Joltaya SHPPs 1-4, as well as there is a technical substantiation design carried out for Dzoraget 3, 4 SHPPs.

15.2.1. SHORT DESCRIPTION OF DZORAGET RIVER BASIN AND CLIMATIC CONDITIONS

River Dzoraget is the largest left inflow of river Debet and falls into the latter at 84km from the river mouth. The river starts from Ghavakheti mountain chain and flows to east and south-east. River catchment basin is 1460km^2, length is 67km; average elevation of the river basin is 1860m, average inclination of the river is 20%. Dzoraget basin is surrounded by Somkheti mountain chain from the north, Bazumi mountain chain from the south which divides Pambak and Dzoraget river basins and Ghavakheti mountain chain from the west. The highest point of the river basin is Agka Mountain with 3196m elevation. The northern part of the basin as opposed to mountainous western and southern parts is represented by Lori mountain valley with average elevation 1400m. It has a wide valley bottom that has a slight inclination towards south-west and is covered by small lakes and ponds especially its north-west section from which many rivers originate.

The earth cover of the river valley is diverse. The upper section fully consists of sub-alpine, light brown mountain soils. The middle section is represented by black mountain soils and moist prairie black soils that are partially dissolved and thick, here there are also meadow-swamp soils. In the downstream the soils are represented by mountainous and moderately moist, carbonated black soils. There is also weakly developed thin layer of black soils. Moreover there are mountain-forest, prairie soils.

There is a diverse flora of the river basin. It the upstream it is represented by internal alpine meadows. There are large prairies for the internal sections of the basin with occasional swamps and bogged areas. In the downstream there is grain as well as diverse grain vegetation with occasional tragacanth inclusions. There are thick forests composed of different tree types including pine trees, oak trees that are located near Gyulakarak village and in the south of Stepanavan city. There are small forest areas on the northern slopes of Azumi mountain chain.

During last 15-20 years the forest areas strictly decrease due to the fast that they are the main source of heating in those areas. The rest of the area is occupied by grains and technical vegetation. There are fruit trees to the downstream of Stepanavan city.

The river Dzorashen at its source is small uncultivated V-shaped gorge. In the upstream the inclination of the slopes 15-20^0 and their height is 100-150m, which gradually merges into the surrounding mountainous area. The width of the valley in the upper part is 200-3000m. The slopes are covered by alpine and sub-alpine meadows. The in the downstream the river flows along the southern border of Lori valley, that is covered by grass and split by multiple drainage springs. Along the length of the Dzoraget River flow the Lori valley is box-shaped, has an inundation area with middle height, gentle slopes and tidy bottom. The slope inclination is 5-10^0.

Starting from the Stepanavan city the river Dzoraget flows through a deep gorge which upper parts are mountainous and very steep, occasionally almost vertical up to 100m height. Towards downstream the slope inclination decreases reaching 40-50^0, with height of 120-130m. On the separate small sections near the river mouth the valley becomes more like a gorge with slope height of 100-120m.

The inundation area is located on the Lori Mountain plain. The inundation valley is flat with slight inclination towards the river. The river bed is slightly twisting with no considerable branches.

From the climatic point of view the area has a comparatively moist climate, The winter is mild, long with thick snow layer that is present starting from November, /the climatic conditions of the basin are supplied according to the nearest meteorological station ¥1602m data. According to Katnarat meteorological station data the average multi annual air temperature equals 6.5°C, absolute minimum -34°C, and absolute maximum +33°C, the maximal freezing of the soil is 62cm. The absolute air moisture content is 7.8mb, comparative moisture content is 74%.

Average multi-annum precipitations are 879mm. The ten-day snow cover is 1m. Average annual wind speed equals 2.4m/sec; the main wind direction is western. The maximal wind speed with 1% guarantee is 35-36m/sec.

15.2.2. Geological Composition of Dzoraget River

Dozraget river basin has a complicated geological composition with volcanic rock types being the main item. Lori mountain plain is composed of tuffs up to the city of Stepanavan; there are basalts and andesite-basalts in the middle of the basin with occasional granite layers.

The basins of Sarvanget and Chknagh inflows are composed of dark, yellow-grey, occasionally hydro-thermal, cracked and occasionally withered, slightly permeable porphyries, tuff breccias tufts tuffs, lime stones and dolomites.

On foothills of the slopes with low inclination there are contemporary diluvia colluvial sediments, represented by clay-sand and gravely soils that are 2.5m thick. The river bed and the inundation area are represented by 5-6 m of contemporary alluvial sediments consisting of pebbles and rounded rocks.

The basin of Karakala inflow is represented by effusive rock lavas of upper Miocene. They are represented by andesine basalt, dacites, and other rock types that are firm, cracked and highly permeable. The valley slopes are covered by 3-5m of talus sediments. Alluvial sediments are not well developed.

15.2.3. Water Regime and Design Data

River Dzoraget presents a typical mountainous river with seasonal water regime; the river has a mixed feeding: snow, rain, ground waters.

The annual flow distribution is characterized by spring-summer inundations during April July months that are conditioned by heavy precipitations. During the spring inundations the maximal rise of the water level starts from the second half of April and beginning of may. The drought season starts from July that last up to march.

The maximal flow discharge is observed during the spring inundations and is conditioned by snow melting and rains. The periodical observations of the river flow were carried out on the following observation points: Katnarat, Stepanavan, Urut, Tashir, Kurtan water meter stations.

For receiving average flow as well as average annual distribution data the above mentioned rows were used by restoring the natural state of the flow. In order to calculate the design characteristics of the river section for SHPPs the data from the following observation point was used r. Dzoraget-Katnarat and r. Urut-M. Gorky (see the table).

Table. 9. Hydrologic Description of the Analogous Water Meter Stations

#	River-Observation Point	Distance from the river mouth, km	Catchment are of the basin km^2	Average altitude, m	Observation time	Flow norm	
						Water lischarge, m^3/sec	Flow modul, l/sec,km^2
1.	r. Dzoraget-Katnarat	46.0	140.0	2320	1949-1987	2.66	19.0
2.	r. Urut – M. Gorky	5.7	130.0	1770	1955-1975	0.89	6.85

Annual flow distribution based on the data of R. Dzoraget – Katnarat and Urut and M. Gorky_water meter stations for characteristic years is shown on the table 10.

Table. 10. Annual distribution according to R. Dzoraget – Katnarat and Urut and M. Gorky water meter stations / m^3/sec/

Years	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
1. r. Dzoraget - Katnarat													
Water abundant – 25%													
1952y.	0.97	0.88	1.10	5.24	10.1	7.48	3.84	2.12	1.38	1.02	1.08	0.99	3.02
Average– 50%													
1986y.	0.72	0.90	0.92	4.54	6.81	7.20	3.03	1.76	1.40	1.26	1.27	1.28	2.59
Drought – 75%													
1973y.	0.75	0.70	0.58	4.27	6.64	5.57	2.65	1.47	1.07	0.86	1.28	0.75	2.22
2. r. Urut - M. Gorky													
Water abundant – 25%													
1983y.	0.27	0.31	1.02	0.45	3.09	2.49	0.80	1.09	1.07	0.59	1.01	0.47	1.07
Average– 50%													
1998y.	0.34	0.34	0.36	1.25	3.05	2.26	0.70	0.55	0.34	0.30	0.34	0.35	0.85
Drought – 75%													
1997y.	0.34	0.32	0.32	2.09	1.04	1.17	0.71	0.42	0.53	0.60	0.37	0.34	0.69

15.2.4. TECHNICAL ECONOMIC SPECIFICATION OF SHPPS TO BE CONSTRUCTED ON Dzoraget RIVER

15.2.4.1. Dzoraget SHPP-1

Introduction

According to development scheme it was planned to construct 5 SHPPs on the river. As a result of in-situ investigations it was decided to use the potential of combining the derivations of Dzoraget SHPP1 and 2.

The station works of Dzoraget SHPP-1 is located on Dzoraget River 500m from the headworks of Doraget 4 SHPP. Dzoraget SHPP uses inclination of River Dzoraget from 2045.0 till 1910.0. The length of derivation from Dzoraget River is 2900m by copper pipeline 1020mm in diameter with design pressure of 117.1m and design discharge 2.20m^3/sec. After construction and exploitation Dzoraget SHPP will have 2.06mwt capacity and will produce 6.58mln kw/h electricity annually.

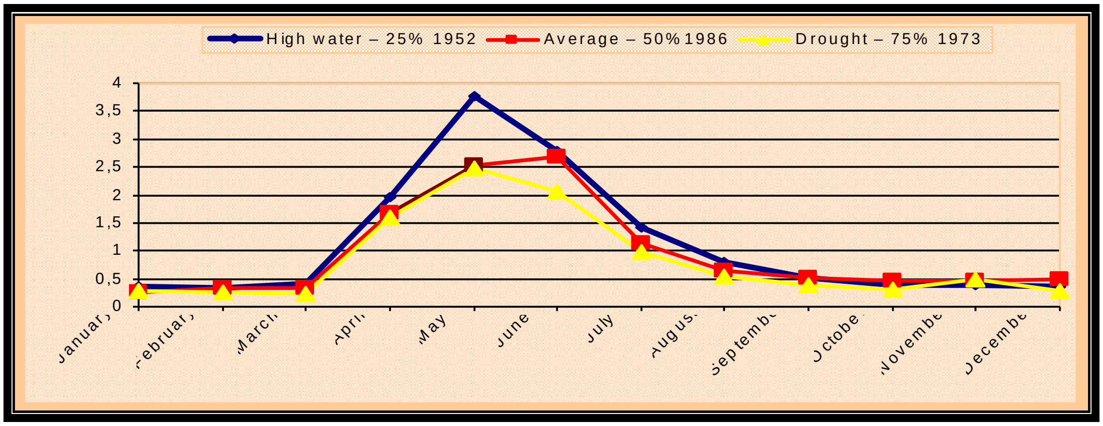
HYDROLGY

The observation data from river r. Dzoraget-Katnarat water-meter station is used to define the hydrological properties of Dzoraget SHPP-1 headworks and the design river section.

In the design section of Dzoraget SHPP-1 the catchment area is 51.1km^2, average yearly flow value of is 1.0m^3/sec. The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Maximal design discharge for Dzoraget SHPP-1 headwork river section for the general case equal 3% - 56.2m^3/sec, for verifying case - 0.5%-35.9m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.227m^3/sec.

Graph. 4. Annual flow distribution



WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Dzoraget SHPP-1 is 2045.0m, downstream - 1910.0m. According to data of Marz's WUA there is no water intake for irrigational use from Dzoraget River. DzoragetSHPP-1 is derivational SHPP. In order not to drain the river where 2900m derivational pipeline is the environmental discharge is designed according to RA laws and 0.17m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Dzoraget-1 SHPP are calculated with 50% guarantee per annum (1986 see table 11).

Table. 11. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Dzoraget SHPP-1 (m^3/sec)	0.10	0.16	0.17	1.52	2.20	2.20	0.96	0.48	0.35	0.30	0.30	0.31	
SHPP average monthly capacity (mwt)	0.11	0.17	0.18	1.54	2.06	2.06	1.01	0.51	0.38	0.32	0.32	0.33	
SHPP –average monthly energy production (mln kwt/hour)	0.08	0.12	0.14	1.11	1.53	1.48	0.75	0.38	0.27	0.24	0.23	0.25	6.58

INVESTMENT SUSTAINABILITY

Capital investments into Dzoraget-1 SHPP construction

The capital investments into hydropower station are 1977.4 thousand USD (without VAT) and 2372.9 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production by Dzoraget-1 SHPP

Annual exploitation expenses for power production on Dzoraget-1 SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		65.3
2. Exploitation expenses		41.0
	Salary	20.2
	Renovation	15.8
	Other Expenses	5.0
Total		106.3

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		2.06
Average multi annual production of energy, mln kwt/hour		6.58
Capital investments into SHPPS(without VAT),		
	thousand USD	1977.4
	USD / kwt	959.4
	USD / kwt/hour	0.30
Prime cost of power production, cents/kwt hour		1.6

Financial analisis

The construction period for Dzoraget SHPP-1 is 12 months while design period is 30 years.

Geghadzor SHPP financial sustainability is determined by means of investment options:

- ❖ Private investments only /Scenario 1/
- ❖ 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

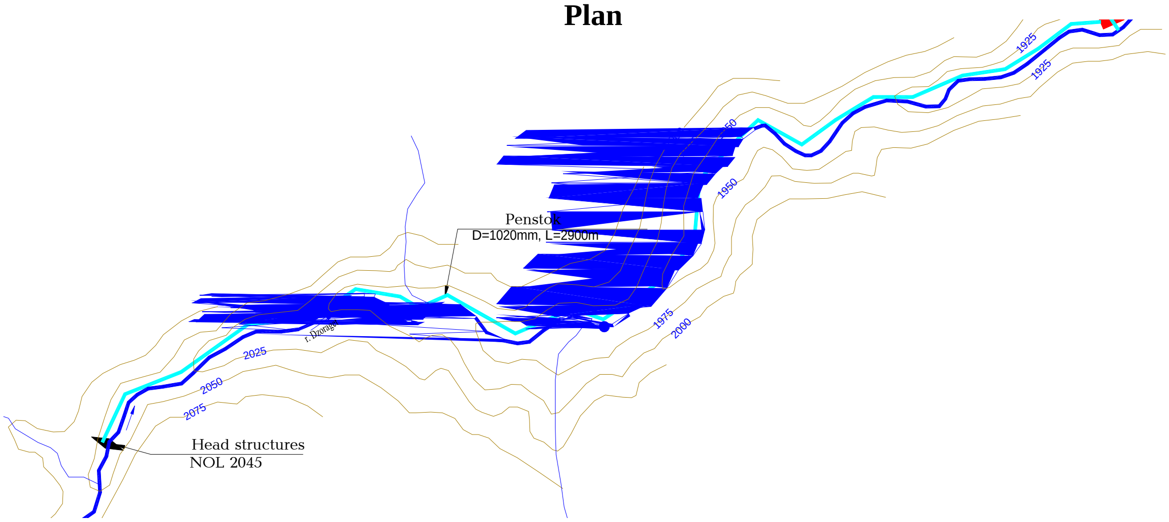
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 12. Calculation Results According to the Finantial Scenarios

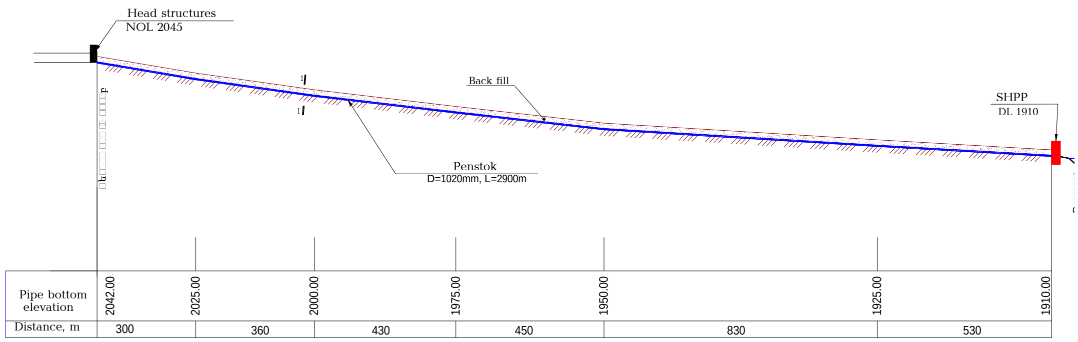
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		12.8	15.3
NPV, thousand USD			
	8%	964.6	967.4
	10%	486.02	579.9
	12%	127.5	303.3
	14%	-147.7	102.25
PB, years (without discount)		7.6	9.4
Deadline for credit return, years			7.0

APPENDIX. 3. DZORAGET SHPP-1

Plan



Longitudinal section



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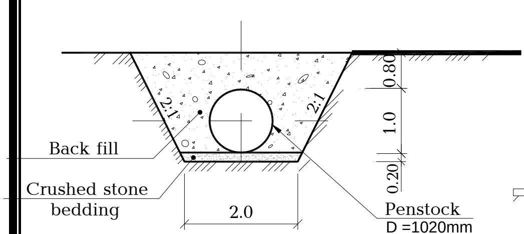
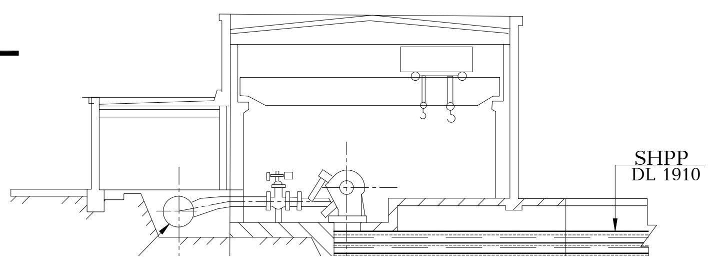


SHPP Powerhouse



15.1.2.2. SARVANGET SHPP-1,2,3,4,

INTRODUCTION

Introduction

Sarvanget SHPPs are located on the inflow of Dzoraget River – Sarvanget.

According to the development scheme it was planned construct 9 SHPPs. After in-situ investigations it was planned to construct derivational SHPP type 4.

Sarmanget SHPPs use the inclination of Sarmanget from 2275.0 elevation up to 1675.0.

Short description of Sarmanget River basin

Sarmanget is the left inflow of Dzoraget that falls into the river 46 km from the river mouth. General length of the river is 13km; catchment area equals 28km^2. It starts from the eastern parts of Khonav mountain slopes from 2550m, in the glacier zone.

River valley is slightly cultivated with a V-Shaped gorge. The slopes are composed from volcanic rock types. They are steep (30-60^0), covered by alpine and sub alpine vegetation layer. In the midstream the river passes through Lori mountain zone, has low shores and the slope steepness decreases up to 20-30^0.

The geological composition of the river basin is represented by basalts and tuffs. The vegetative layer is mainly represented by meadow and mountainous black earth. The river bed twists at the beginning the slopes are very steep 0,2-0,5m high, stony, covered by rounded stones and sand. The inundation are appears where the river turns into a mountain. It is double sided while the bottom is pebble-sand.

Sarvanget water regime is not yet investigated. According to interview data spring inundations start at the end of March and beginning of April, reaching their peak at may and then gradually decrease. The drought starts at the end of June beginning of July and has stable horizons and water discharge. In winter water level is very stable as during that period river feeding is based on ground waters and is extremely stable. The freezing regime is very strict as well. In the upstream the river is frozen from December till March and closer to the river mouth the freezing changes into shoreline ice cover that is comparatively unstable, which means they freeze and then unfreeze during winter.

15.1.2.3. SARVANGET SHPP-1

INTRODUCTION

Introduction

Sarvanget SHPP-1 uses the inclination of Sarvanget River 2275.0 to 2150.0. The length of derivation from Sarvanget River is 2600m by copper pipeline 530mm in diameter with design pressure of 113.4m and design discharge 0.30m^3/sec. After construction and exploitation Sarvanget SHPP-1 will have 275kwt capacity and will produce 0.86mln kw/h electricity annually.

HYDROLGY

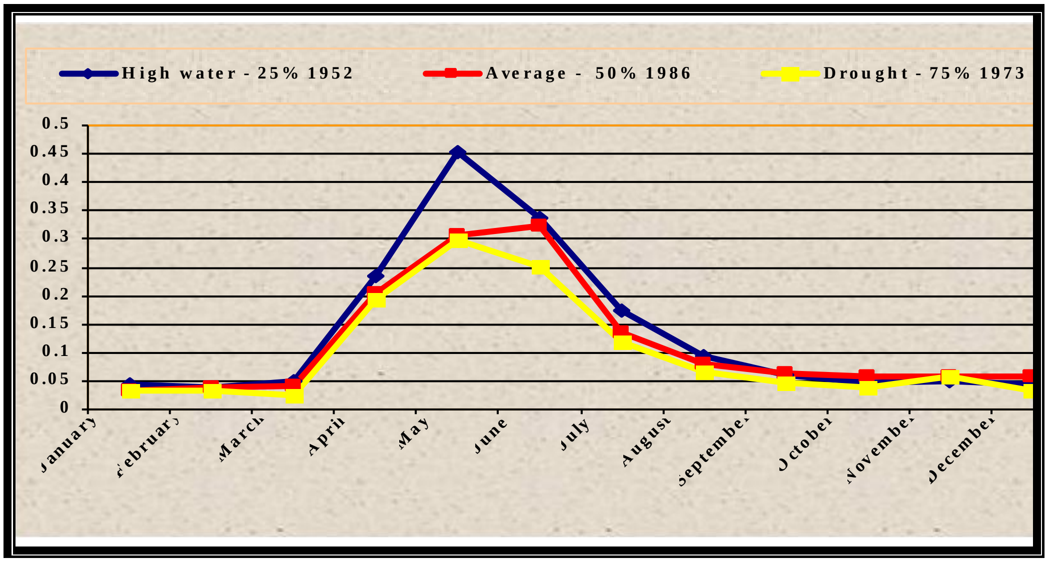
The observation data from river r. Dzoraget-Katnarat water-meter station is used to define the hydrological properties of Sarvanget SHPP-1 headworks and the design river section.

In the design section of Sarvanget SHPP-1 the catchment area is 6.3km^2, average annual flow value of is 0.12m^3/sec.

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Maximal design discharge for Sarvanget SHPP-1 headwork river section for the general case equal 3% - 15.4m^3/sec, for verifying case - 0.5%-24.2m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.016m^3/sec.

Graphic 5. Annual flow distribution



WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Sarvanget-1 SHPP is 2275.0m, downstream - 2150.0m. According to data of Marz's WUA there is no water intake for irrigational use from Sarvanget River. Sarvanget-1 SHPP is derivational SHPP. In order not to drain the river where 2600m derivational pipeline is the environmental discharge is designed according to RA laws and 0.12m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Sarvanget-1 SHPP are calculated with 50% guarantee per annum (1986 see table 13).

Table. 13. Average monthly discharge

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Sarvanget SHPP -1(m^3/sec)	0.02	0.03	0.03	0.19	0.29	0.30	0.12	0.07	0.05	0.05	0.05	0.05	
SHPP average monthly capacity (mwt)	0.020	0.028	0.029	0.185	0.268	0.272	0.122	0.067	0.051	0.045	0.045	0.046	
SHPP –average monthly energy production (mln kwt/hour)	0.015	0.019	0.022	0.133	0.199	0.196	0.091	0.050	0.037	0.033	0.032	0.034	**0.860**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 302.1thousand USD (without VAT) and 362.5 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on Sarvanget-1 SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.
Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		10.0
2. Exploitation expenses		19.4
	14.4	14.4
	3.0	3.0
	2.0	2.0
Total		29.4

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		272
Average multi annual production of energy, mln kwt/hour		0.86
Capital investments into SHPPS(without VAT),		
	thousand USD	302.1
	USD / kwt	1110.5
	USD / kwt/hour	0.35
Prime cost of power production, cents/kwt hour		3.4

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

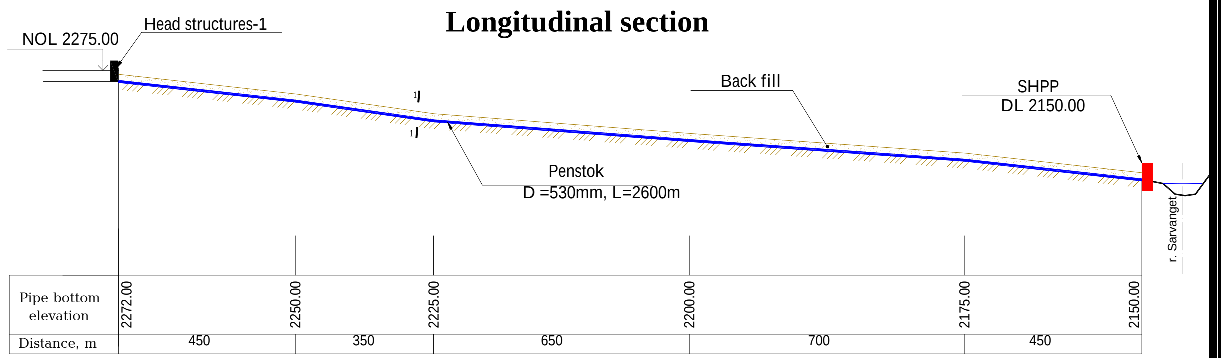
Table, 14. Calculation results according to finantial scenarios

INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		6.5	5.0
NPV, thousand USD			
	8%	-40.9	-40.9
	10%	-83.4	-56.0
	12%	-115.2	-65.8
	14%	-140.0	-72.2
PB, years (without discount)		13.0	22.0
Deadline for credit return, years			

APPENDIX. 4. SARVANGET SHPP -1

Plan

Longitudinal section



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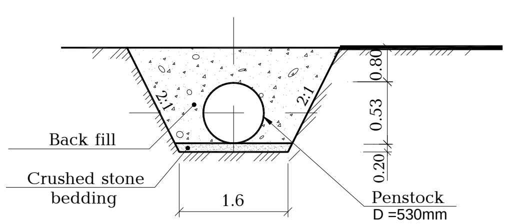
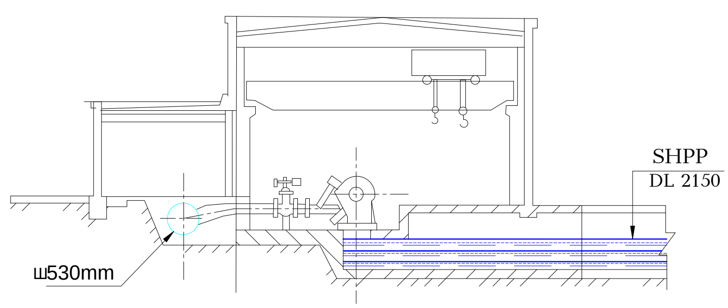
SHPP Powerhouse





Sarvanget SHPP-2

Introduction

Sarvanget SHPP-2 uses the inclination of Sarvanget River 21455.0 to 2000.0. The length of derivation from Sarvanget River is 1800m by copper pipeline 630mm in diameter with design pressure of 132.8m and design discharge 0.60m^3/sec. After construction and exploitation Sarvanget SHPP-2 will have 638kwt capacity and will produce 2.13mln kw/h electricity annually.

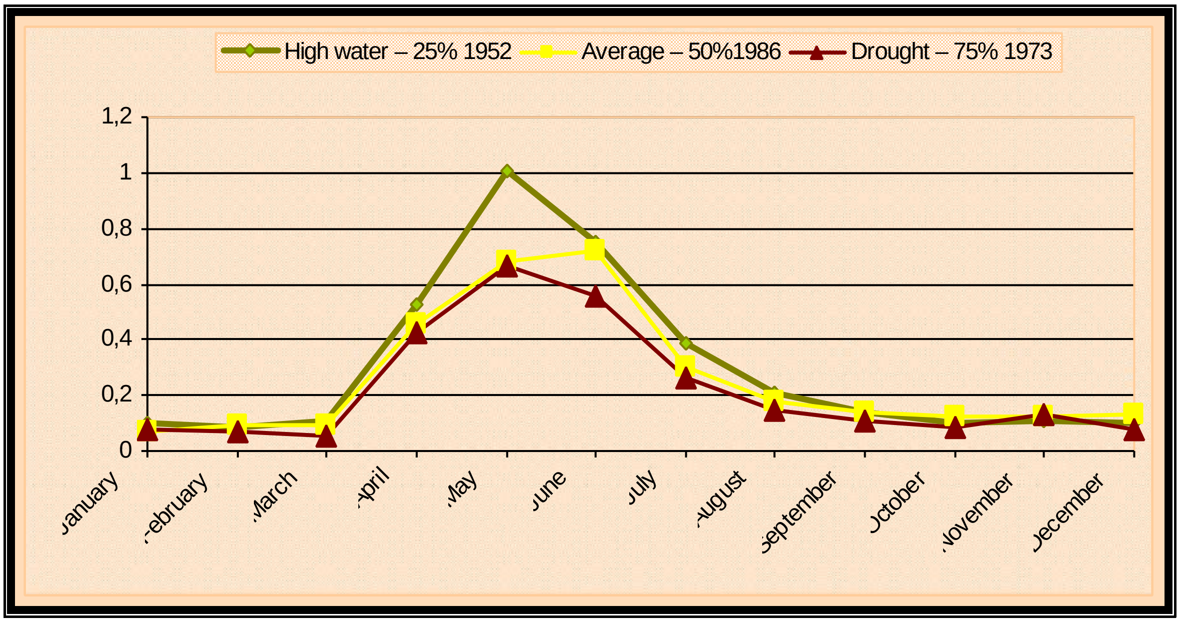
HYDROLGY

The observation data from river r. Dzoraget-Katnarat water-meter station is used to define the hydrological properties of Sarvanget SHPP-2 headworks and the design river section.

In the design section of Sarvanget SHPP-2 the catchment area is 14.0km^2, average annual flow value of is 0.26m^3/sec.

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 6. Annual flow distribution



Maximal design discharge for Sarvanget SHPP-2 headwork river section for the general case equal 3% - 21.2m^3/sec, for verifying case - 0.5%-33.2m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.036m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Sarvanget SHPP-2 is 2145.0m, downstream - 2000.0m. According to data of Marz's WUA there is no water intake for irrigational use from Sarvanget River. Sarvanget SHPP-2 is derivational SHPP. In order not to drain the river where 1800m derivational pipeline is the environmental discharge is designed according to RA laws and 0.027m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of SarvangetSHPP-2 are calculated with 50% guarantee per annum (1986 see table 13).

Table. 15. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Sarvanget SHPP-2 (m^3/sec)	0.05	0.06	0.07	0.43	0.60	0.60	0.28	0.15	0.11	0.10	0.10	0.10	
SHPP average monthly capacity (mwt)	0.052	0.073	0.075	0.474	0.638	0.638	0.314	0.172	0.131	0.115	0.116	0.117	
SHPP –average monthly energy production (mln kwt/hour)	0.039	0.049	0.056	0.341	0.474	0.459	0.234	0.128	0.094	0.085	0.083	0.087	**2.13**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 700.9 thousand USD (without VAT) and 584.1 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	19.3
2. Exploitation expenses	21.1
Salary	14.4
Renovation	4.7
Other Expenses	2.0
Total	40.4

Power indicators of have the following level

Indicators	Values
Derivation capacity, kwt	638
Average multi annual production of energy, mln kwt/hour	2.13
Capital investments into SHPPS(without VAT),	
thousand USD	584.1
USD / kwt	915.6
USD / kwt/hour	0.27
Prime cost of power production, cents/kwt hour	1.9

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

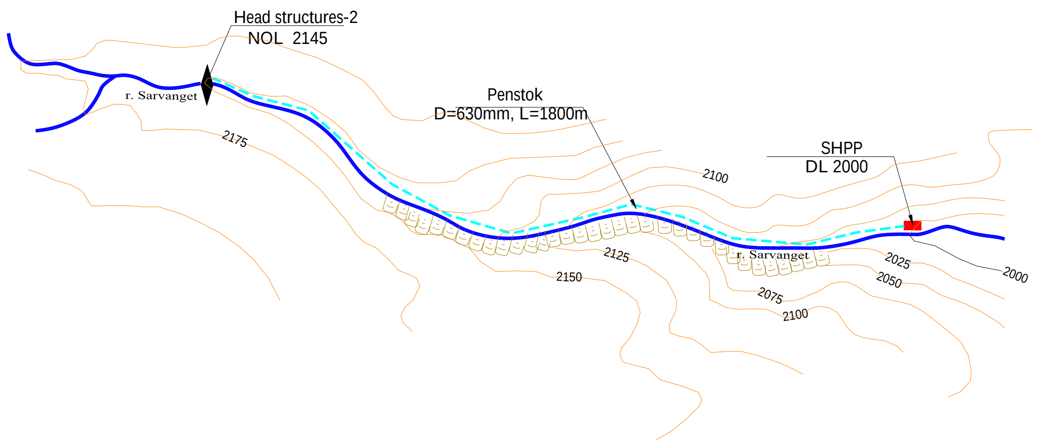
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 16. Calculation results according to finantial scenarios

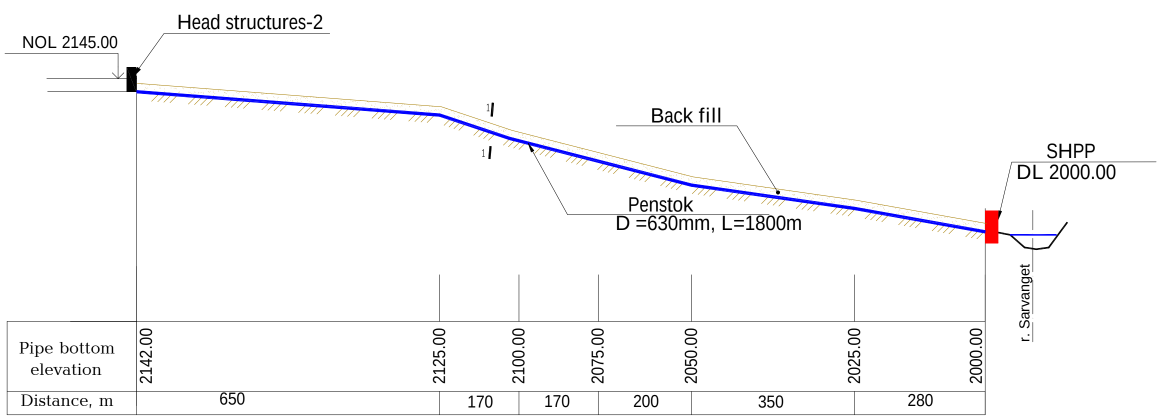
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		13.0	15.5
NPV, thousand USD			
	8%	293.7	293.7
	10%	150.9	177.8
	12%	43.9	95.1
	14%	-38.2	34.9
PB, years (without discount)		7.5	9.3
Deadline for credit return, years			7.0

APPENDIX. 5. SARVANGET SHPP-2

Plan



Longitudinal section



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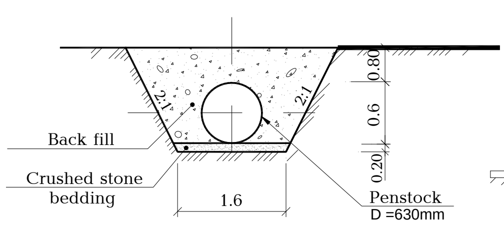
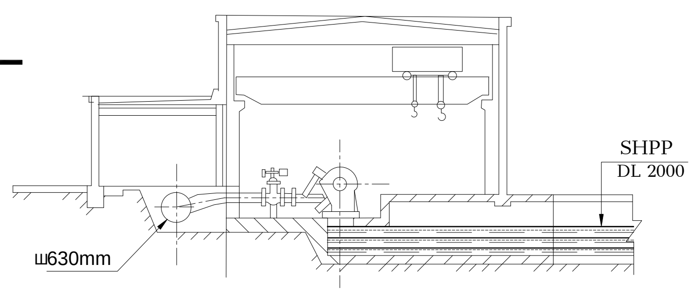


SHPP Powerhouse



Sarvanget SHPP-3

Introduction
Sarvanget SHPP-3 uses the inclination of Sarvanget River 1995.0 to 1835.0. The length of derivation from Sarvanget River is 2300m by copper pipeline 720mm in diameter with design pressure of 150.5m and design discharge 0.70m^3/sec. After construction and exploitation Sarvanget SHPP-3 will have 843kwt capacity and will produce 2.76mln kw/h electricity annually.

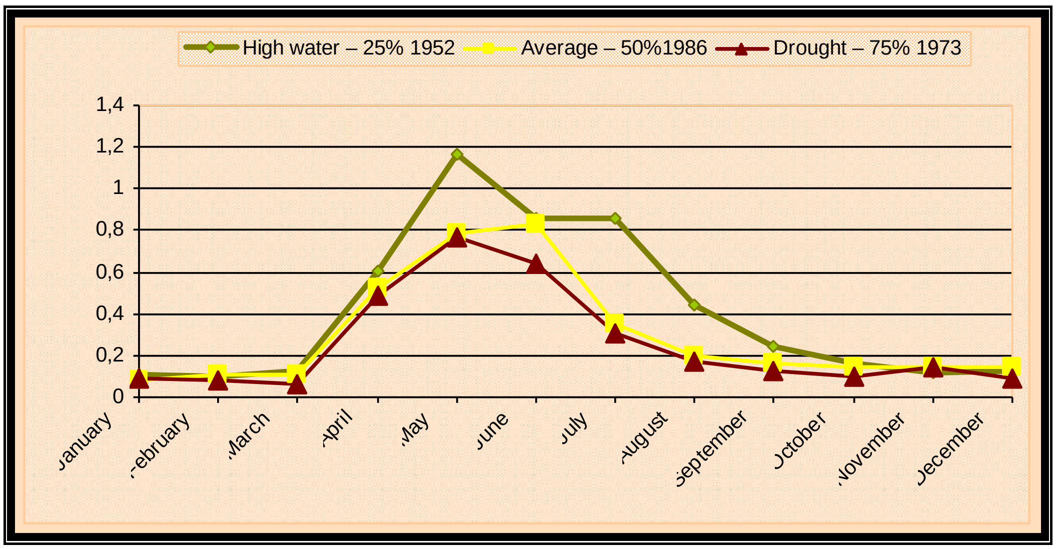
HYDROLGY

The observation data from river r. Dzoraget-Katnarat water-meter station is used to define the hydrological properties of Sarvanget SHPP-3 headworks and the design river section.

In the design section of Sarvanget SHPP-3 the catchment area is 16.1km^2, average annual flow value of is 0.30m^3/sec.

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 7. Annual flow distribution



Maximal design discharge for Sarvanget SHPP-3 headwork river section for the general case equal 3% - 22.4m^3/sec, for verifying case - 0.5%-35.1m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.041m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Sarvanget SHPP-3 is 1995.0m, downstream - 1835.0m. According to data of Marz's WUA there is no water intake for irrigational use from Sarvanget River. Sarvanget SHPP-3 is derivational SHPP. In order not to drain the river where 2300m derivational pipeline is the environmental discharge is designed according to RA laws and 0.031m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Sarvanget SHPP-3 are calculated with 50% guarantee per annum (1986 see table 17).

Table. 17. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Sarvanget SHPP-3 (m^3/sec)	0.05	0.07	0.08	0.49	0.70	0.70	0.32	0.17	0.13	0.11	0.12	0.12	
SHPP average monthly capacity (mwt)	0.067	0.093	0.096	0.610	0.843	0.843	0.401	0.218	0.166	0.146	0.147	0.148	
SHPP –average monthly energy production (mln kwt/hour)	0.049	0.063	0.071	0.439	0.627	0.607	0.298	0.162	0.120	0.108	0.106	0.110	**2.76**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 818.0 thousand USD (without VAT) and 981.6 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	27.0
2. Exploitation expenses	22.9
Salary	14.4
Renovation	6.5
Other Expenses	2.0
Total	49.9

Power indicators of have the following level

Indicators	Values
Derivation capacity, kwt	843
Average multi annual production of energy, mln kwt/hour	2.76
Capital investments into SHPPS(without VAT),	
thousand USD	818.0
USD / kwt	970.3
USD / kwt/hour	0.30
Prime cost of power production, cents/kwt hour	1.8

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- ❖ Private investments only /Scenario 1/

- 30% of private capital and 70% credit /Scenario 2/:

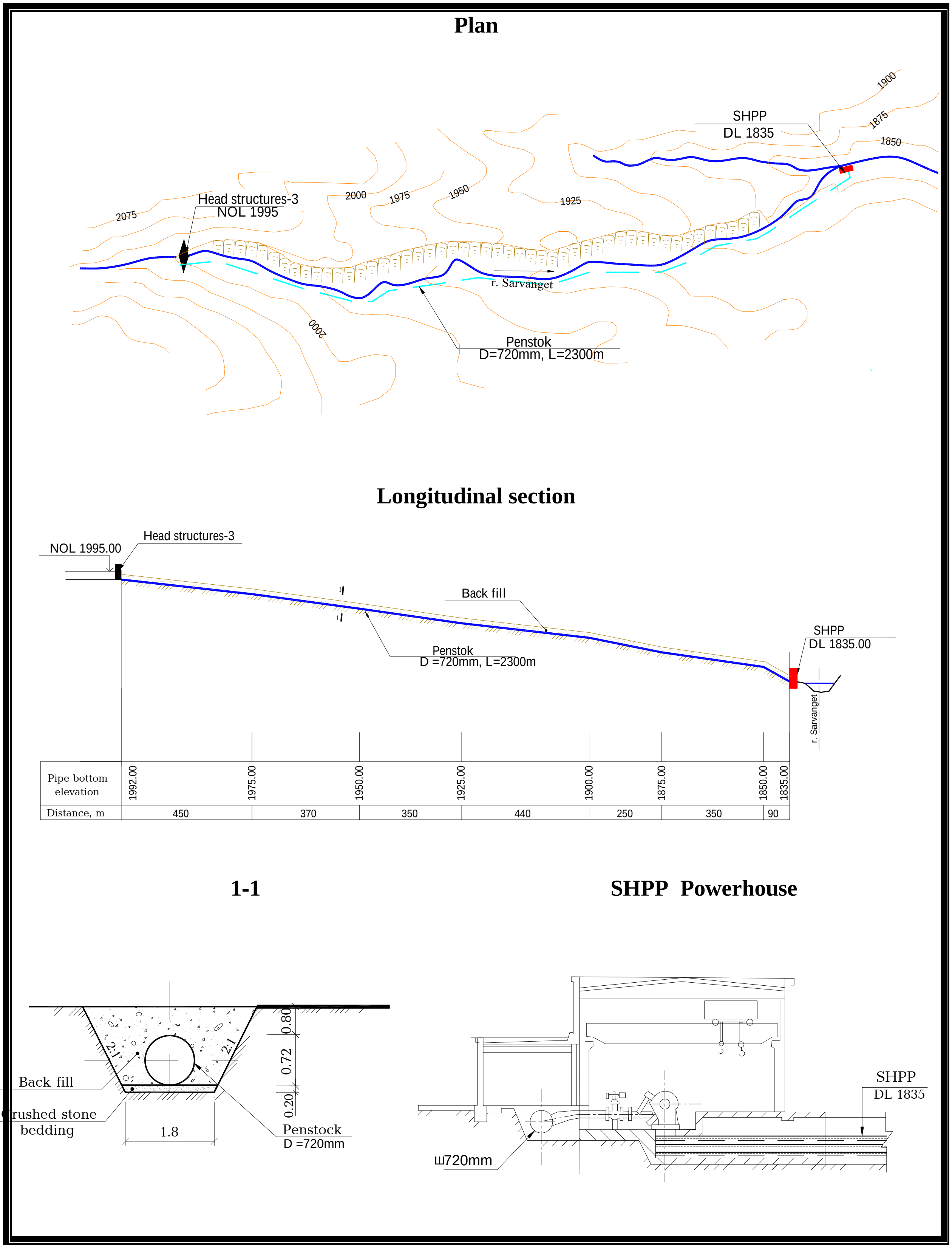
Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 18. Calculation Results Accoring to Finantial Scenarios

INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		12.4	14.9
NPV, thousand USD			
	8%	363.9	363.9
	10%	171.6	213.3
	12%	27.6	106.4
	14%	-83.0	29.1
PB, years (without discount)		7.8	10.0
Deadline for credit return, years			8.0

APPENDIX. 6. SARVANGET SHPP-3



Sarvanget SHPP-4

Introduction

Sarvanget SHPP-4 uses the inclination of Sarvanget River 1830.0 to 1675.0. The length of derivation from Sarvanget River is 2300m by copper pipeline 820mm in diameter with design pressure of 145.4m and design discharge 1.0m^3/sec. After construction and exploitation Sarvanget SHPP-4 will have 1164kwt capacity and will produce 3.73mln kw/h electricity annually.

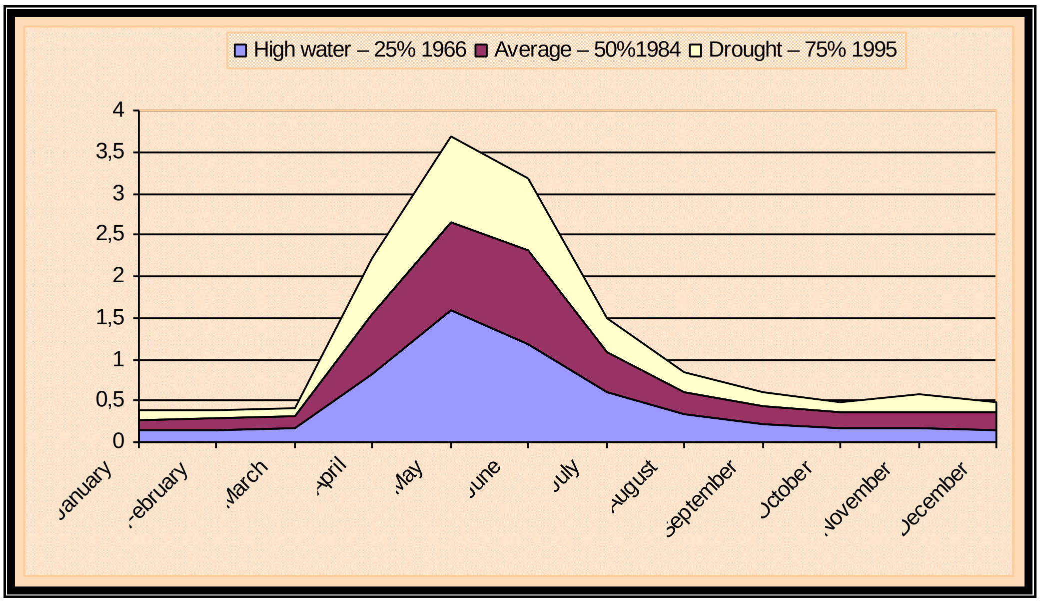
HYDROLGY

The observation data from river r. Dzoraget-Katnarat water-meter station is used to define the hydrological properties of Sarvanget SHPP-4 headworks and the design river section.

In the design section of Sarvanget SHPP-4 the catchment area is 22.0km^2, average annual flow value of is 0.40m^3/sec.

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 8. Annual flow distribution



Maximal design discharge for Sarvanget SHPP-4 headwork river section for the general case equal 3% - 25.4m^3/sec, for verifying case - 0.5%-39.8m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.056m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Sarvanget SHPP-4 is 1830.0m, downstream - 1675.0m. According to data of Marz's WUA there is no water intake for irrigational use from Sarvanget River. Sarvanget SHPP-4 is derivational SHPP. In order not to drain the river where 2300m derivational pipeline is the environmental discharge is designed according to RA laws and 0.042m^3/sec.

All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of SarvangetSHPP-4 are calculated with 50% guarantee per annum (1986 see table 17).

Table. 19. Monthly Water Energy Indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Sarvanget SHPP -4(m^3/sec)	0.07	0.10	0.10	0.67	1.00	1.00	0.43	0.23	0.18	0.16	0.16	0.16	
SHPP average monthly capacity (mwt)	0.088	0.123	0.126	0.809	1.164	1.164	0.532	0.289	0.220	0.193	0.194	0.197	
SHPP –average monthly energy production (mln kwt/hour)	0.065	0.082	0.094	0.582	0.866	0.838	0.396	0.215	0.159	0.144	0.140	0.146	**3.72**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 1046.2 thousand USD (without VAT) and 1255.4 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	41.4
2. Exploitation expenses	28.7
Salary	17.3
Renovation	8.4
Other Expenses	3.0
Total	70.1

Power indicators of have the following level

Indicators	Values
Derivation capacity, kwt	1164
Average multi annual production of energy, mln kwt/hour	3.73
Capital investments into SHPPS(without VAT),	
thousand USD	1046.2
USD / kwt	898.8
USD / kwt/hour	0.28
Prime cost of power production, cents/kwt hour	1.88

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

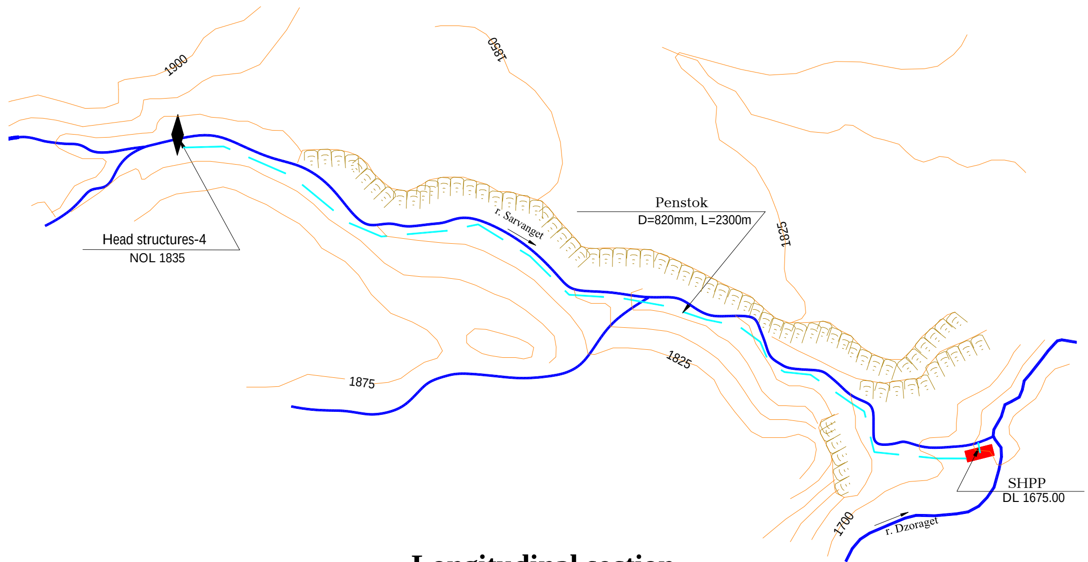
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 20 Calculation results according to finantial scenarios

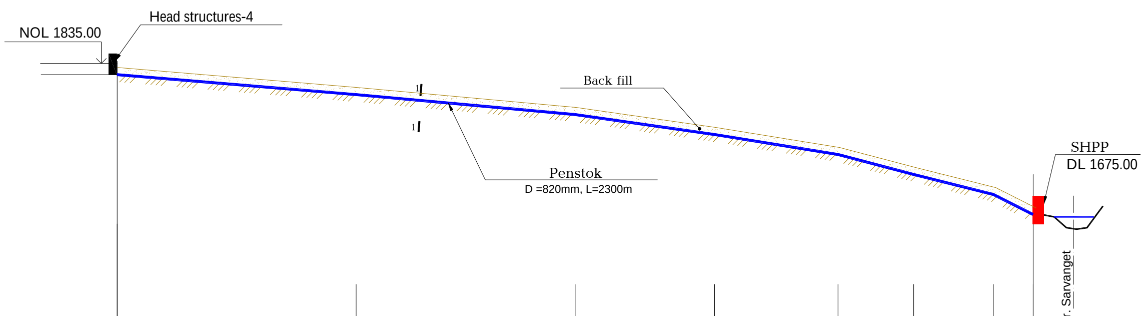
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		13.4	16.1
IRR, %		13.4	16.1
NPV, thousand USD			
	8%	567.0	567.0
	10%	304.5	352.8
	12%	107.9	199.6
	14%	-42.9	88.0
PB, years (without discount)		7.3	9.1
Deadline for credit return, years			7.0

APPENDIX. 7. SARVANGET SHPP 4

Plan

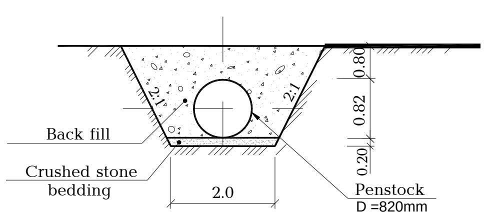


Longitudinal section

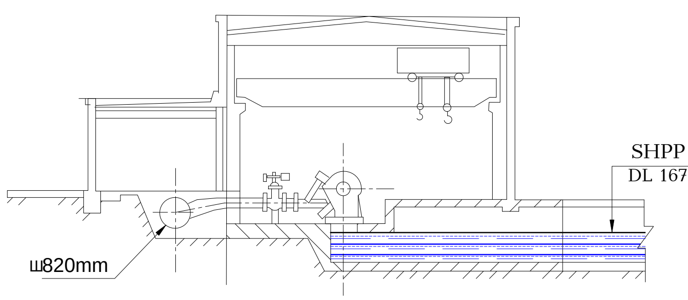


Pipe bottom elevation	1832.00	1825.00	1800.00	1775.00	1750.00	1725.00	1700.00	1675.00
Distance, m	600	550	350	310	190	200	100	

1-1



SHPP Powerhouse



15.2.4.3. KARAKALA SHPP-1

Introduction

Karakala SHPP is located on the inflow of Dzoraget river, Karakala. According to the development scheme it was planned to construct 7 SHPPs on the river. According to in-situ investigations it was found out that the river has no inclination over large territories and there is a SHPP being constructed near Katnarat village. Therefore it was decided to construct only one derivations SHPP on the river.

Karakala SHPP uses the inclination of S Karakala River 1980.0 to 1825.0. The length of derivation from Karakala River is 4875m by copper pipeline 820mm in diameter with design pressure of 140.7m and design discharge 0.80m^3/sec. After construction and exploitation Karakala SHPP will have 901kwt capacity and will produce 3.42mln kw/h electricity annually.

HYDROLGY

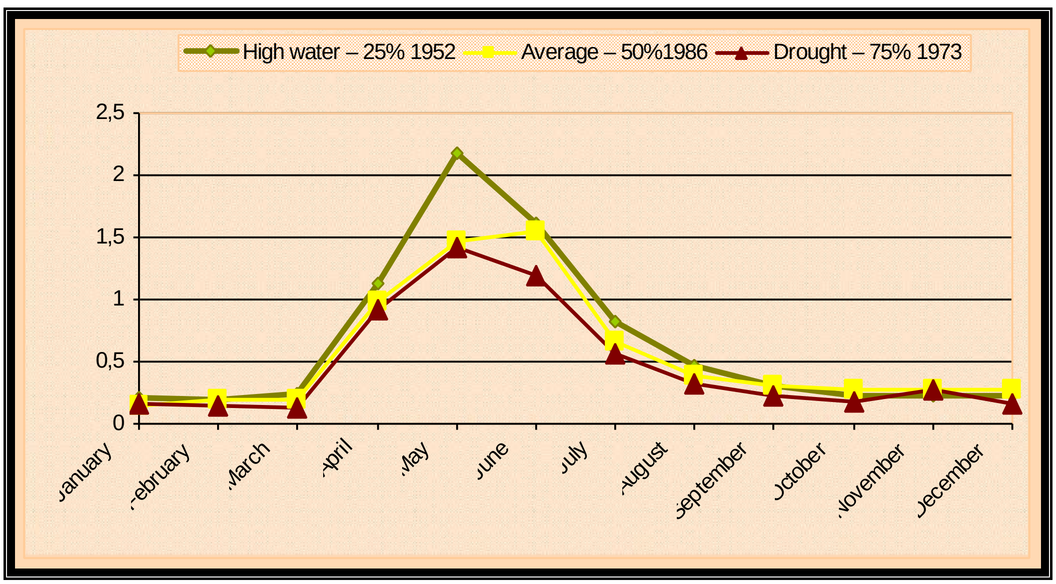
The water regime of Karakala River is not yet investigated. According to interviews spring inundations begin at the end of march and beginning of April reaching their peak in may, afterwards they slowly decrease.

The drought becomes stabilized at the end of June and has a stable horizons and water expenses. In winter water level is very stable due to ground water the glacier regime is very strong. In the upstream the river is frozen from December till March and towards the river mouth there is a shoreline freezing that is comparatively unstable and keep melting and freezing back in winter period.

The maximal discharge of Karakals river is observed during spring floods and are conditioned by snow melting together with heavy rains.

The observation data from river r. Dzoraget-Katnarat water-meter station is used to define the hydrological properties of Karakala SHPP headworks and the design river section. In the design section of Karakala SHPP the catchment area is 37.7km^2, average annual flow value of is 0.60m^3/sec. The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 9. Annual flow distribution /m^3/sec/



Maximal design discharge for Karakala SHPP headwork river section for the general case equal 3% - 31.6m^3/sec, for verifying case - 0.5%-49.6m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.16m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Karakala SHPP is 1980.0m, downstream - 1825.0m. According to data of Marz's WUA there is no water intake for irrigational use from Karakala River. Karakala SHPP is a derivational SHPP. In order not to drain the river where 4875m derivational pipeline is the environmental discharge is designed according to RA laws and 0.12m3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Karakala-1 SHPP are calculated with 50% guarantee per annum (1986 see table 21).

Table. 21. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Karakala SHPP (m^3/sec)	0.03	0.07	0.08	0.80	0.80	0.80	0.54	0.26	0.18	0.15	0.15	0.15	
SHPP average monthly capacity (mwt)	0.04	0.09	0.10	0.90	0.90	0.90	0.64	0.31	0.23	0.19	0.19	0.19	
SHPP –average monthly energy production (mln kwt/hour)	0.03	0.06	0.07	0.65	0.67	0.65	0.47	0.23	0.16	0.14	0.14	0.14	**3.42**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 1165.6 thousand USD (without VAT) and 1398.7 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	38.5
2. Exploitation expenses	30.6
Salary	17.3
Renovation	9.3
Other Expenses	4.0
Total	69.1

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		901
Average multi annual production of energy, mln kwt/hour		3.42
Capital investments into SHPPS(without VAT),		
	thousand USD	1165.6
	USD / kwt	1293.6
	USD / kwt/hour	0.34
Prime cost of power production, cents/kwt hour		2.02

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

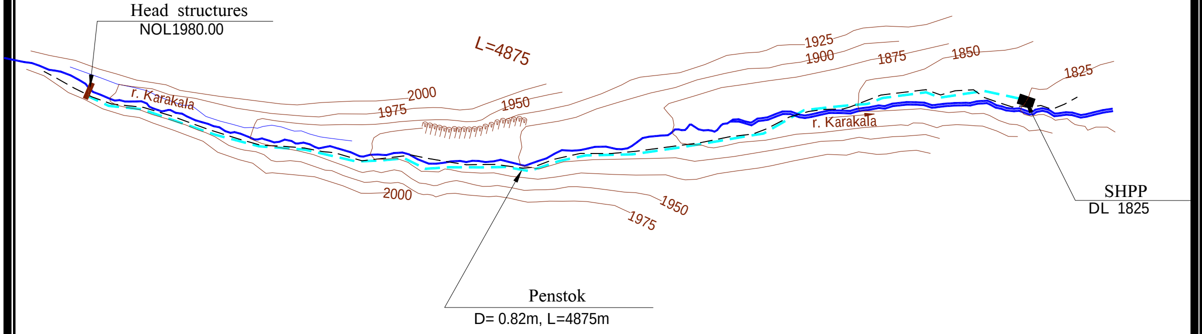
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 22 Calculation results according to finantial scenarios

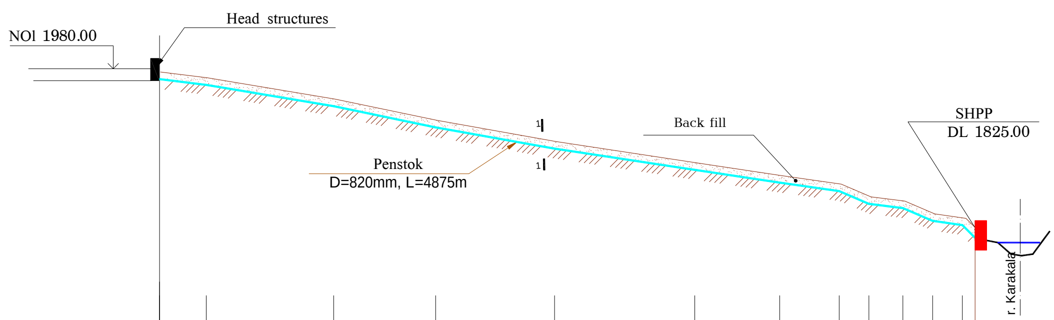
INDICATORS		**Scenario 1** 100% fully self - financed option	**Scenario 2** 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		10.5	11.9
NPV, thousand USD			
	8%	289.9	289.9
	10%	53.1	117.9
	12%	-124.3	-2.27
	14%	-260.4	-87.7
PB, years (without discount)		9.0	11.9
Deadline for credit return, years			9.0

APPENDIX. 8. KARAKALA SHPP

Plan

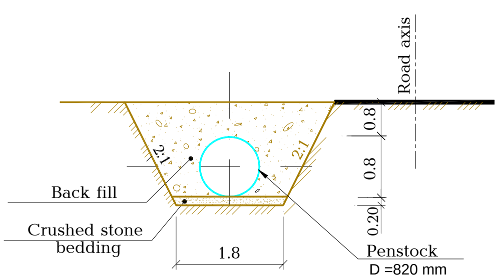


Longitudinal section

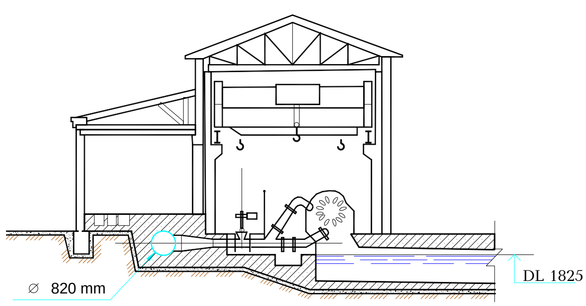


Pipe bottom elevation	1977.00	1975.00	1950.00	1925.00	1900.00	1875.00	1860.00	1850.00	1845.00	1840.00	1835.00	1830.00	1825.00
Distance, m	275.0	760.0	590.0	710.0	820.0	500.0	340	180	200	180	180	80	

1-1



SHPP Powerhouse



15.2.4.3. URUT SHPP

Introduction

Urut SHPP is located on the Urut (Meskhana) inflow of Dzoraget river it is planned to construct 1 SHPP according to development scheme, the localization scheme has been verified based on the results of in-situ investigations. Utut station works will be located before the headworks of Lori water channel, on the river Urut.

Urut SHPP uses the inclination of Urut River 1560.0 to 1500.0. The length of derivation from Urut River is 4800m by copper pipeline 820mm in diameter with design pressure of 52.0m and design discharge 0.60m^3/sec. After construction and exploitation Urut SHPP will have 250kwt capacity and will produce 1.02mln kw/h electricity annually.

Short description of Urut River basin

Urut is the left inflow of Dzoraget that falls into the river 22 km from the river mouth. General length of the river is 29km; catchment area equals 156km^2.

It starts from the southern slopes of Somkheti mountain chain from 1740m. The catchment area is covered by grass and grain cultures the downstream merges into the continuation of Lori mountain plain. In the downstream there is also Lori water channel.

The river valley at the beginning has a V-shape and is 700-800m high in the upper part, the lower parts are 200m wide while the slopes have inclination of 30-40^0. The slopes are covered by meadows. After village Privolnoe the slopes preserve distance from the river bed turning it into wide, slightly inclined bottom. Thus the river is flowing along the valley deeply set into the bottom of the meadow.

The valley is 0.5-1.5km wide has a slight inclination towards the river. In the downstream of Urut River for 2-3km the left bank is bogged and in the downstream of M. Gorky village the river is set into basalts and gradually deepens, turning into deep gorge. The gorge depth is 300-40m in the begging and reaches 80m. The upper width if the gorge exceeds 300m and 200m at the bottom. The slopes are composed of basalts that are naked and occasionally very steep. The inundation area begins from village Privolnoe and lasts till M. Gorky. At the beginning it stretches over the right back and turns into the left bank 3km before village Sverdlov. The inundation area is 100-200m wide.

After the Urut river for 3 km the inundation are is bogged and covered by vegetation. The river bed is twisting especially in the inundation part. The banks are height and steep 0.6-1.0m, and composed of river in wash.
Urut River is typical mountainous river with seasonal water regime. The river has complicated mixed feeding: snow, rain, ground waters.

The rise of water lever starts at the beginning of March due to multiple inundations and reaches its peak in May while the water level fall is very slow and unstable. The drought horizons are stable and start at July or August. The maximum river level amplitude reaches 1m.

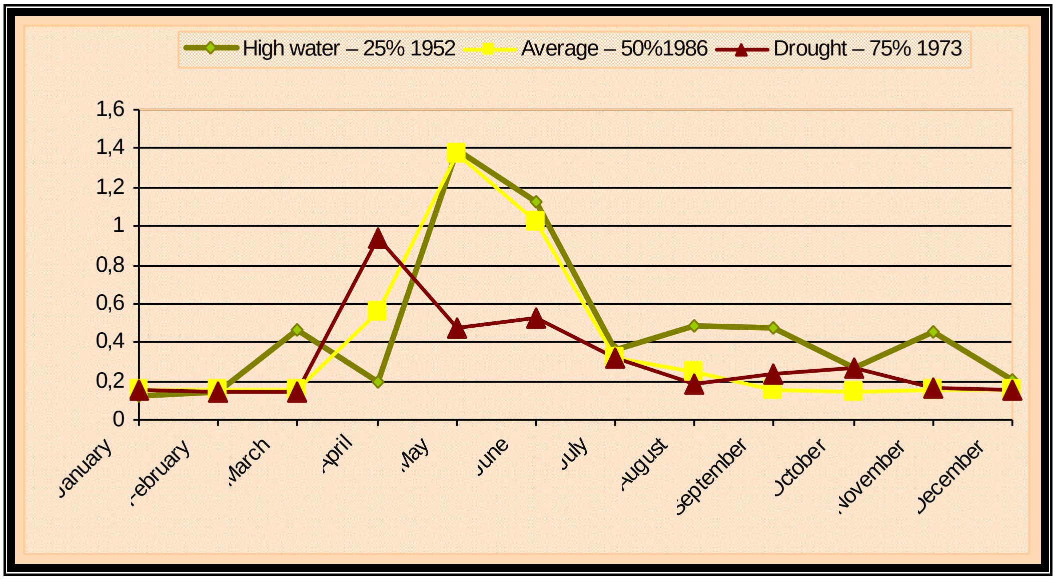
The glacier regime is characterized by freezing in the upstream and is cover on river banks. In case of severe winters the river bed freezes completely up to Privolnov village.

HYDROLGY

The observation data from river r. Urut – M. Gorky water-meter station is used to define the hydrological properties of Urut SHPP headworks and the design river section. In the design section of Urut SHPP the catchment area is 58.5km^2, average annual flow value of is 0.40m$^{3/}$sec.

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 10. Annual flow distribution /m^3/sec/



15.2.4.3. URUT SHPP

Introduction

Urut SHPP is located on the Urut (Meskhana) inflow of Dzoraget river it is planned to construct 1 SHPP according to development scheme, the localization scheme has been verified based on the results of in-situ investigations. Utut station works will be located before the headworks of Lori water channel, on the river Urut.

Urut SHPP uses the inclination of Urut River 1560.0 to 1500.0. The length of derivation from Urut River is 4800m by copper pipeline 820mm in diameter with design pressure of 52.0m and design discharge 0.60m^3/sec. After construction and exploitation Urut SHPP will have 250kwt capacity and will produce 1.02mln kw/h electricity annually.

Short description of Urut River basin

Urut is the left inflow of Dzoraget that falls into the river 22 km from the river mouth. General length of the river is 29km; catchment area equals 156km^2.

It starts from the southern slopes of Somkheti mountain chain from 1740m. The catchment area is covered by grass and grain cultures the downstream merges into the continuation of Lori mountain plain. In the downstream there is also Lori water channel.

The river valley at the beginning has a V-shape and is 700-800m high in the upper part, the lower parts are 200m wide while the slopes have inclination of 30-40^0. The slopes are covered by meadows. After village Privolnoe the slopes preserve distance from the river bed turning it into wide, slightly inclined bottom. Thus the river is flowing along the valley deeply set into the bottom of the meadow.

The valley is 0.5-1.5km wide has a slight inclination towards the river. In the downstream of Urut River for 2-3km the left bank is bogged and in the downstream of M. Gorky village the river is set into basalts and gradually deepens, turning into deep gorge. The gorge depth is 300-40m in the begging and reaches 80m. The upper width if the gorge exceeds 300m and 200m at the bottom. The slopes are composed of basalts that are naked and occasionally very steep. The inundation area begins from village Privolnoe and lasts till M. Gorky. At the beginning it stretches over the right back and turns into the left bank 3km before village Sverdlov. The inundation area is 100-200m wide.

After the Urut river for 3 km the inundation are is bogged and covered by vegetation. The river bed is twisting especially in the inundation part. The banks are height and steep 0.6-1.0m, and composed of river in wash.
Urut River is typical mountainous river with seasonal water regime. The river has complicated mixed feeding: snow, rain, ground waters.
The rise of water lever starts at the beginning of March due to multiple inundations and reaches its peak in May while the water level fall is very slow and unstable. The drought horizons are stable and start at July or August. The maximum river level amplitude reaches 1m.
The glacier regime is characterized by freezing in the upstream and is cover on river banks. In case of severe winters the river bed freezes completely up to Privolnov village.

HYDROLGY

The observation data from river r. Urut – M. Gorky water-meter station is used to define the hydrological properties of Urut SHPP headworks and the design river section. In the design section of Urut SHPP the catchment area is 58.5km^2, average annual flow value of is 0.40m^3/sec.

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Table. 23. Monthly Water Energy Indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Urut SHPP (m^3/sec)	0.13	0.13	0.14	0.54	0.60	0.60	0.30	0.23	0.13	0.12	0.13	0.14	
SHPP average monthly capacity (mwt)	0.06	0.06	0.06	0.23	0.25	0.250	0.14	0.11	0.06	0.06	0.06	0.06	
SHPP –average monthly energy production (mln kwt/hour)	0.04	0.04	0.05	0.17	0.19	0.18	0.10	0.08	0.04	0.04	0.04	0.05	**1.02**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 320.3 thousand USD (without VAT) and 384.3 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	10.6
2. Exploitation expenses	19.0
Salary	14.4
Renovation	2.6
Other Expenses	2.0
Total	29.6

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		250
Average multi annual production of energy, mln kwt/hour		1.02
Capital investments into SHPPS(without VAT),		
	thousand USD	320.3
	USD / kwt	1281.2
	USD / kwt/hour	0.314
Prime cost of power production, cents/kwt hour		2.9

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

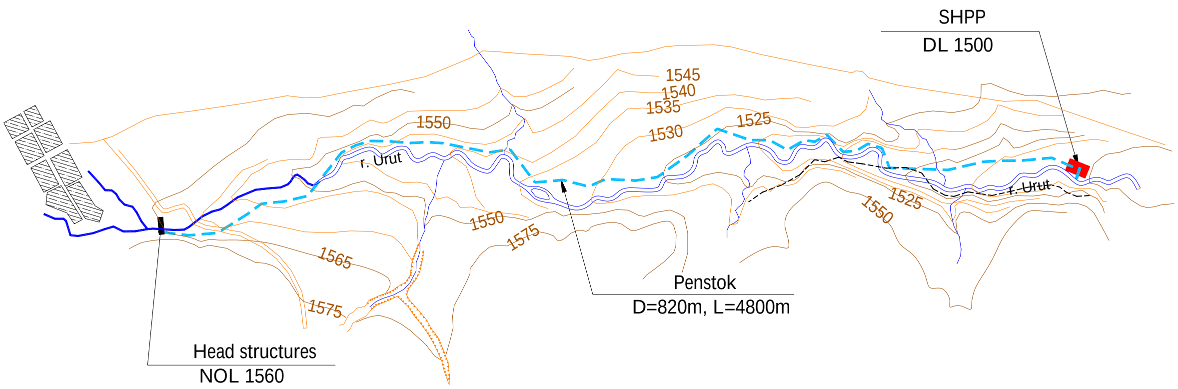
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 24. Calculation Results According to the Finantial Scenarios

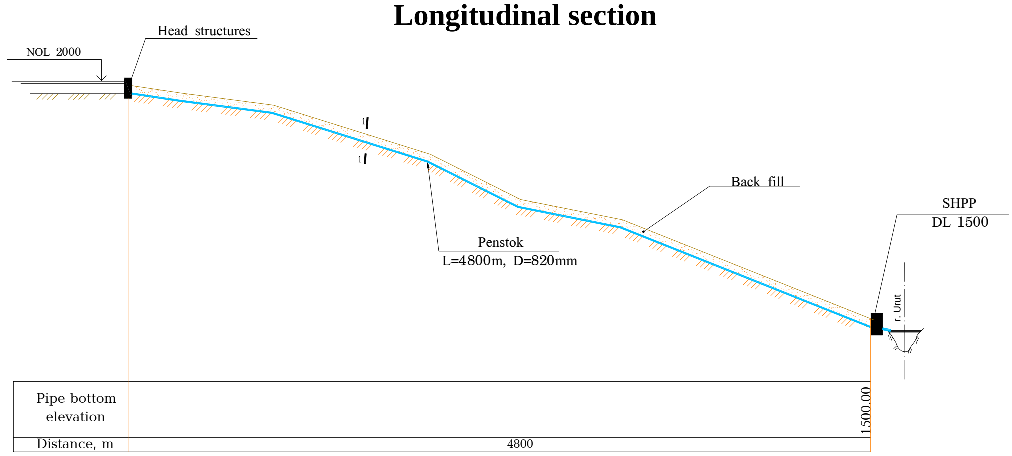
INDICATORS		**Scenario 1** 100% fully self - financed option	**Scenario 2** 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		8.7	9.2
NPV, thousand USD			
	8%	22.9	22.9
	10%	-32.9	-11.0
	12%	-74.8	-34.03
	14%	-106.9	-49.9
PB, years (without discount)		10.5	15.0
Deadline for credit return, years			12.0

APPENDIX. 9. URUT SHPP

Plan



Longitudinal section



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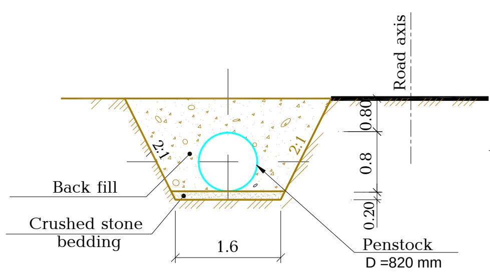
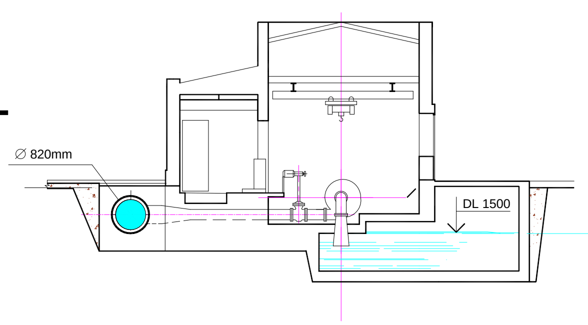
SHPP Powerhouse





15.2.5. SHPPs on Pambak River Basin

15.2.5.1. General Information

There are 28 SHPP to be constructed on Pambak river basin, however, presently only Larnagur SHPP-1 is under exploitation while there is a permission for Chanakhchi SHPP-2 and Lerbaghur 2-3, Karachoban 1-3 SHPPs and technical substantiation design is carried out for Chanakhchi SHPP 1,3.

15.2.5.2. Short Description of Pambak River Basin and Climatic Conditions

River Pambak is one of the large inflows of Debet River. The water Catchment Area of equals 1374km^2, river length is 86km. The water basin is surrounded by Bzovdal mountain chain from the north, Kechut from the west, Pambak from south and Papakar from the east. The Pambak river source is the spring situated over Ghaghur tunnel on elevation of 1810m. There is a dry channel over the spring that is filled only during snow melting and rains. The earth cover of the basin is diverse consisting of forest gray-brown soils. The vegetative layer is also diverse and is quite reach in comparison with other regions of Armenia. The mountain slopes are mostly covered by thick forest starting from town of Vanadzor and rest of the territory is covered by meadows or is well cultivated.

The river valley is mainly represented by a gorge. In the upstream the valley width changes along 10-25km. The bottom is very flat and is 1-5km wide near Spitak town. The slopes are uneven by parallel little gorges and inflow gorges. Starting from Shirakamut station the river valley is crossed by Spitak water channel at several sections that starts from Chichkhan River, the left inflow of Pambak. Sometimes the gorge widens and its bottom width reaches 50-70m creating the conditions for swampy inundation area. The main shores remain rocky and have 50-70^0 inclination. There are protective walls starting from Shirakamut village up to Vanadzor city. At this point the river inclination is strong and the river bed is full of rounded stones that are washed upon by mud flows. At separate river valleys up to the city of Vanadzor the river valley widens and reaches 0.5km.

Just above the city of Vanadzor the right bank of the river moves away from the river bed forming a valley on which the city of Vanadzor is currently is situated. Near the village of Darpas the thick forest starts. Right after the city of Vanadzor the valley becomes narrower and becomes a gorge which thickness in the lower part is 40-50m and in the upstream part is 100-150m. Near the village Megrut the river turns to left cutting through Bzovdan mountain plain and flows through steep rocky gorge, with thick forests on the right bank, till it reaches Dzoraget River. The inclination of the slopes is 60-90^0, the thickness occasionally reaches 300m. The width of the valley bottom is 8-10m and is fully covered by fast flow of water. After the village of Shahali the gorge slopes slightly widen and the valley becomes V-shaped. The slopes are covered by thick bushes and grass cover. After Toumanyan station the valley becomes a deep 20-30m deep gorge, with slope height 40-50m, the slopes are covered by forest and bushes. On the elevation of 300-400m there is a sudden change longitudinal section the mountain plain starts.

The inundation area is present at separate sections and is not very wide. The first time it appears 2km upstream from Daltskhchi village here its width riches 1km. There are small tree groups are separate trees within the inundation area. There are also small swamp areas that are covered by bushes. The inundation area is covered by water when the horizons reach 0.5-1meter. Occasionally inundation water width reaches 1km. There is an inundation area 0.5km below Shirakamut Village, after falling into Chichkhan River. The inundation area is flat there are separate swamp sections. During inundation the river width does not exceed 0.5km.

From the climatic point of view the river Pambak cuts through four climatic zones: mild zones with short cool summers and cold winters to mild-warm with mild winters. The closest meteorological station is Vanadzor on 1350Ùm. According to its data the average annual temperature is 7.6C, maximum us +36C, and minimum is -30C. The maximal soil freezing is 84cm.

The ultimate air moisture content is 8.2, the comparative moisture us 71%, the average precipitation quantity is 610mm, the maximal annual – 967mm, monthly 206mm, daily 61mm. Average ten-day snow cover thickness is 17cm, maximal is 40cm. Average annual wind speed is 1.7 m/sec and maximal guarantee wind speed is 28 m/sec.

15.2.5.3. Geological Composition of Pambac River Valley

The geological composition is complicated and diverse. These are mainly Bazum and Pambak mountain chains. The basin is mainly composed from volcanic rock types. There are tuffs, porphirites, andesites and basalts. There are different types of tuffs except from lavas. The main rock types of the basin are impermeable, however there are permeable filtering masses composed of limestone and sand stones that affect the natural balance of the river. In the basin of Panbighur there are well developed talus-proluvial sediments that cover weathered rock types of Upper Miocene.

The Upper Eocene rock types are well developed in Karachoban, Lernaghurm Vanadzor, Tamghur and Pambak River valley. There are represented by surface weathered, cracked, permeable, porphirites, andesite-dacites, limestone and conglomerates. On the territories with low inclination these rocks are covered by talus prolluvial sediments 3-5m thick. The alluvial sediments are slightly developed with more that 2-3m thickness.

In the river valley of Dzorashen and Tazashen there are the abovementioned Upper Moicene sediments. In the foothills the low inclination areas are composed of slightly permeable or impermeable talus, prolluvial rock types. Antaramut and Chanakhchi river basins from Geological point of view are composed of Upper Jurassic period tuff-sand-stones, clay layers etc. River valley slopes are covered by contemporary talus-proluvial sediments up to 2-3m thick. Alluvial sediments are slightly developed and no more than 2-3m.

15.2.5.4. Pambak river water regime and design data

The hydrographic network of Pambak River is well developed. There are multiple flood channels in the middle section of the basin; however, on average annual basin they do not affect the overall river discharge.

Table. 25. Hydrological data from the similar water meter stations

Ñ/Ñ	River-Observation Point	Distance from the river mouth, km	Catchment are of the basin km^2	Average altitude, m	Observation time	Flow norm	
						Water discharge, m^3/sec	Flow module, l/sec,km^2
1.	r. Chichkhan-Getik	15.0	108	2250	1946-active	1.09	10.1
2.	r. Vordnav-Ghrashen	12.0	13.3	2050	1945-1957	0.095	7.14
3	r. Tandzut-Khndzorut	5.5	102	2120	1945-1963	1798	17.4
4	r. Vanadzor - Vandzor	1.0	41.7	2020	1955-1964	0.579	0.014
5	r. Lernaghur-Lernapat	3.3	77.5	2120	1964-1987	1.45	18.7
6	r. Gargar-Kurtan	4.0	123.0	1680	1955-active	1.25	10.2

The river has a diverse feeding from snow, rain and ground waters. The annual flow distribution is well defined by long term spring inundations and stable drought period. The spring inundations begin in April, while drought period starts in July. The flood peak is usually in May however there is often a short, sudden peak in April too. On table 25 the hydrological characteristics of Pammak river observation points are presented that have been used as analogue from SHPP design river sections.

In order to receive the distribution of average flow indicators the above-mentioned observations were used to reconstruct the natural river flow. The annual distribution of Pambak river basin Rivers for characteristic rivers is shown on the table 26.

Table. 26. Hydrological description of observation points

Years	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Average
1. r. Chichkhan - Getik													
Water abundant – 25%													
1978	0.45	0.50	0.80	3.90	6.60	3.00	1.25	0.90	0.75	0.55	0.55	0.55	1.65
Average – 50%													
1981	0.90	0.64	0.90	2.21	1.86	1.67	0.76	0.76	0.59	0.57	0.55	0.49	0.99
Drought – 75%													
1958	0.50	0.46	0.52	2.05	1.83	1.20	0.70	0.70	0.50	0.50	0.47	0.42	0.82
r. Vordnav-Ghrashen													
Water abundant – 25%													
1956	0.002	0	0	0.23	0.49	0.19	0.14	0.16	0.12	0.004	0.004	0.002	0.11
Average – 50%													
1952	0.010	0.010	0.022	0.31	0.25	0.15	0.16	0.16	0.13	0.042	0.005	0.004	0.10
Drought — 75%													
1946	0.006	0.005	0.006	0.044	0.16	0.20	0.16	0.19	0.14	0	0.028	0.014	0.085
r. Tandzut-Khndzorut													
Water abundant – 25%													
1949	0.85	0.60	0.90	3.01	9.20	5.25	1.08	1.16	0.93	0.91	0.63	0.58	2.09
Average 50%													
1953	0.40	0.54	0.58	2.41	4.84	3.53	3.77	1.96	0.86	0.62	0.63	0.56	1.72
Drought — 75%													
1957	0.38	0.47	1.34	3.53	3.78	3.05	1.97	0.62	0.53	0.42	0.43	0.37	1.41
r. Vanadzor - Vandzor													
Water abundant – 25%													
1956	0.25	0.20	0.37	2.36	2.10	1.54	0.71	0.14	0.17	0.14	0.15	0.12	0.76
Average 50%													
1957	0.10	0.20	0.69	1.65	1.82	1.02	0.76	0.14	0.13	0.12	0.13	0.11	0.57
Drought — 75%													
1962	0.086	0.09	0.34	1.14	1.79	0.44	0.44	0.21	0.13	0.12	0.10	0.10	0.42
r. Lernaghur-Lernapat													
Water abundant – 25%													
1986	0.62	0.77	0.85	2.74	4.77	4.11	1.35	0.75	0.77	1.09	1.14	0.82	1.65
Average – 50%													
1980	0.67	0.74	1.19	2.78	4.28	2.40	1.29	0.81	0.80	0.57	0.58	0.57	1.39
Drought — 75%													
1974	0.49	0.46	0.79	1.52	4.81	2.18	0.89	0.71	0.84	0.60	0.48	0.49	1.19
r. Gargar-Kurtan													
Water abundant – 25%													
1974	0.21	0.29	1.41	4.70	3.53	1.45	0.69	1.10	2.47	0.58	0.38	0.40	1.43
Average – 50%													
1983	0.32	0.27	0.72	1.93	3.18	1.97	1.25	0.65	0.67	0.55	2.77	0.75	1.25
Drought — 75%													
1966	0.33	0.35	0.59	1.89	4.68	1.24	1.01	0.31	0.46	0.54	0.29	0.22	0.99

15.2.5.5. Technical Indicators of Pambak river basin SHPPs

15.2.5.5.1. Dzorashen SHPP

Introduction

According to development scheme it was planned to construct 2 SHPPs on Dzorashen river. As a result of in-situ investigations it was decided to construct one derication SHPP.

Dzorashen SHPP uses inclination of River Dzorashen from 1990.0 till 1880.0. The length of derivation from Dzorashen River is 2750m by copper pipeline 430mm in diameter with design pressure of 92.5m and design discharge 0.20m^3/sec. After construction and exploitation Dzorashen SHPP will have 148mwt capacity and will produce 0.62mln kw/h electricity annually.

Short Description of Dzorashen River

Dzorshen is the left inflow of Chichkhan river and falls into the latter 15km from the river mouth. The chatchment area is 17.35 km^2. The River length is 7.7km. The river starts from springs that originate from the south-western slope of Ashagan Mountain on elevation of 2998m. It has several inflows that are based on solely spring feeding. The river basin is covered by rich meadow vegetation

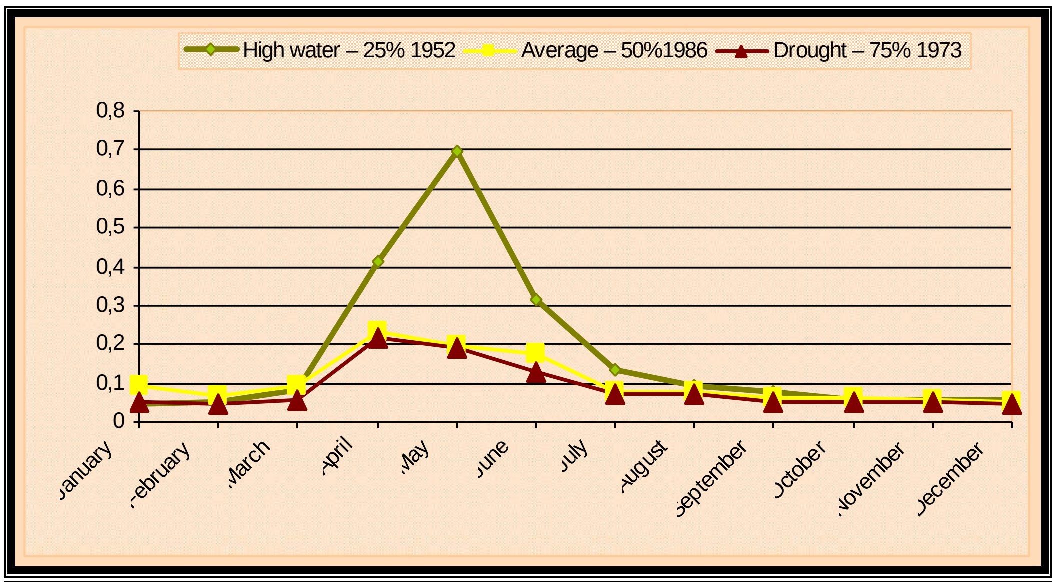
The river valley is flat and after Agkilisa village it turns into a narrow gorge with steeper slopes from the left that from the right. Their average steepness is 400 and more. The valley width in the upper part of this area is 600-800m. The slopes of the valley are covered by sand-clay and clay-sand layer.

The river bed is twisting the banks have slight inclination in the begging and are more steep at the end. The bottom of the river bed is filled with rounded stones, and sand. Occasionally in the inflow sections with lots of water during the flood there are rock deposits that were washed over into the main river bed. Such deposits are on Ghaghur and Dzorshen villages the water regime is characterized by spring inundation that starts at the end of March at beginning of April and is very fast at the end of April. The drought period starts from June and follows by very stable levels. The lowest water level is observed during August-September months during the highest air temperature, afterwards there is a slight increase. In winter there is a rise in water level due to freezing. During winter there is usually icing on the river banks the river completely freezes in the upstream. The freezing starts at the end of November and lasts till March

HYDROLOGY

The observation data from river r. Chichkhan – Getik water-meter station is used to define the hydrological properties of Dzorashen SHPP headworks and the design river section. In the design section of Dzorashen SHPP the catchment area is 11.4km^2, average yearly flow value of is 0.10 m^3/sec.
Maximal design discharge for Dzorashen SHPP headwork river section for the general case equal 3% - 10.2m^3/sec, for verifying case - 0.5%-14.3m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.021m^3/sec.
The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

<u>Graph. 11. Annual flow distribution</u>



WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Dzorashen SHPP is 1990.0m, downstream - 1880.0m. According to data of Marz's WUA there is no water intake for irrigational use from Dzorashen.

Dzorashen SHPP is derivational SHPP. In order not to drain the river where 2750m derivational pipeline is the environmental discharge is designed according to RA laws and 0.016m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Dzorashen SHPP are calculated with 50% guarantee per annum (1981 see table 27).

Table. 27. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Dzorashen SHPP (m^3/sec)	0.079	0.052	0.079	0.200	0.180	0.160	0.064	0.064	0.046	0.044	0.042	0.036	
SHPP average monthly capacity (mwt)	0.068	0.045	0.068	0.148	0.138	0.126	0.055	0.055	0.040	0.038	0.037	0.031	
SHPP –average monthly energy production (mln kwt/hour)	0.05	0.03	0.05	0.11	0.10	0.09	0.04	0.04	0.03	0.03	0.03	0.02	**0.62**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 176.8 thousand USD (without VAT) and 212.2 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	5.83
2. Exploitation expenses	13.5
Salary	10.0
Renovation	1.5
Other Expenses	2.0
Total	19.33

Power indicators of have the following level

Indicators	Values
Derivation capacity, kwt	843
Average multi annual production of energy, mln kwt/hour	2.76
Capital investments into SHPPS(without VAT),	
thousand USD	818.0
USD / kwt	970.3
USD / kwt/hour	0.30
Prime cost of power production, cents/kwt hour	1.8

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

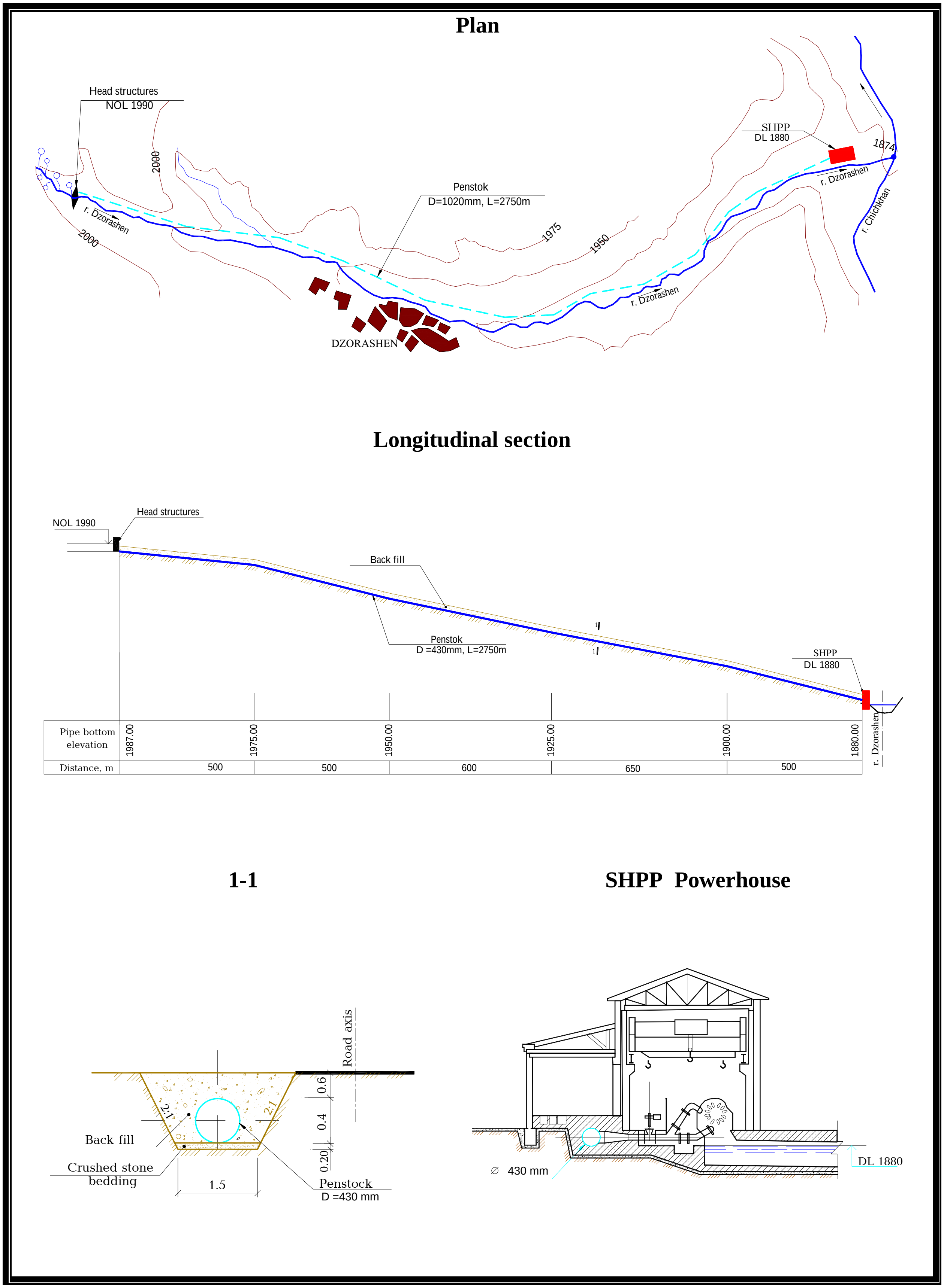
Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 28. Design results according to financial scenarios

INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		8.8	9.3
NPV, thousand USD			
	8%	13.4	13.4
	10%	-17.5	-5.4
	12%	-40.7	-18.2
	14%	-58.5	-27.1
PB, years (without discount)		10.5	12
Deadline for credit return, years			14.9

APPENDIX. 10. DZORASHEN SHPP



15.2.5.5.2. Tazakent SHPP

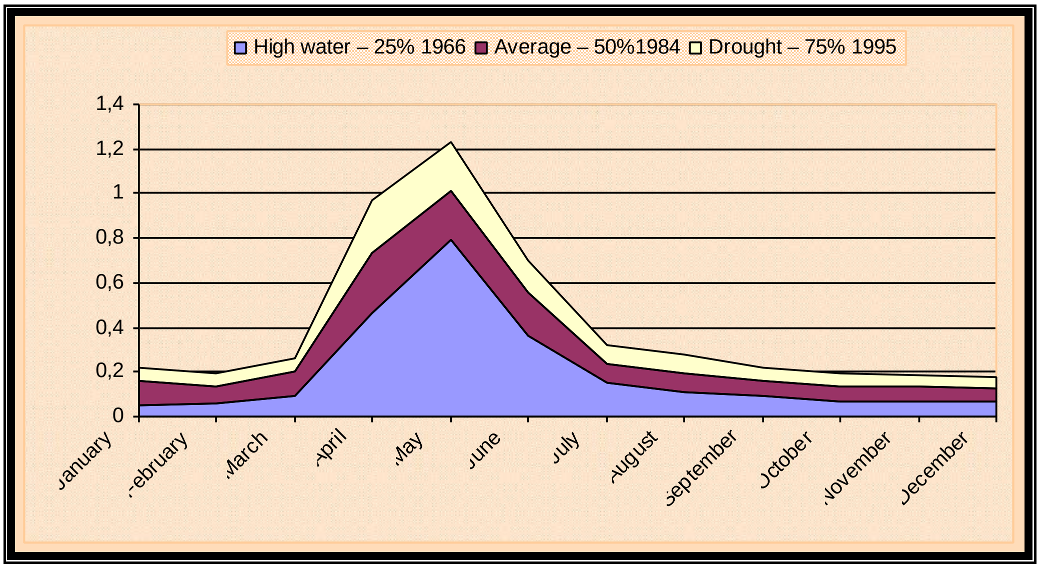
Introduction

Tazakent SHPP uses inclination of River Tazakent from 1900.0 till 1795.0. The length of derivation from Tazakent River is 1425m by copper pipeline 430mm in diameter with design pressure of 186.1m and design discharge 0.20m^3/sec. After construction and exploitation Tazakent SHPP will have 153mwt capacity and will produce 0.68mln kw/h electricity annually.

HYDROLOGY

The observation data from river r. Chichkhan-Getik water-meter station is used to define the hydrological properties of Tazakent SHPP-1 headworks and the design river section. In the design section of Tazakent SHPP-1 the catchment area is 12.9km^2, average yearly flow value of is 0.12/sec.
The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 12. Annual flow distribution



Maximal design discharge for Tazakent SHPP headwork river section for the general case equal 3% - 10.7m^3/sec, for verifying case - 0.5%-15.0m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.024m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Tazakent SHPP is 1900.0m, downstream - 1795.0m. According to data of Marz's WUA there is no water intake for irrigational use from Tazakent River. Tazakent SHPP is derivational SHPP. In order not to drain the river where 1425m derivational pipeline is the environmental discharge is designed according to RA laws and 0.018m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Tazakent SHPP are calculated with 50% guarantee per annum (1981 see table 29).

Table. 29. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Tazakent SHPP (m^3/sec)	0.090	0.059	0.090	0.200	0.200	0.181	0.072	0.072	0.052	0.050	0.048	0.041	
SHPP average monthly capacity (mwt)	0.074	0.049	0.074	0.153	0.153	0.141	0.060	0.060	0.043	0.042	0.040	0.034	
SHPP –average monthly energy production (mln kwt/hour)	0.06	0.03	0.06	0.11	0.11	0.10	0.04	0.04	0.03	0.03	0.03	0.03	0.675

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 171.6 thousand USD (without VAT) and 205.9 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	5.66
2. Exploitation expenses	13.4
Salary	10.0
Renovation	1.4
Other Expenses	2.0
Total	19.1

Power indicators of have the following level

Indicators	Values
Derivation capacity, kwt	153
Average multi annual production of energy, mln kwt/hour	0.675
Capital investments into SHPPS(without VAT),	
thousand USD	171.6
USD / kwt	1121.8
USD / kwt/hour	0.254
Prime cost of power production, cents/kwt hour	2.83

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

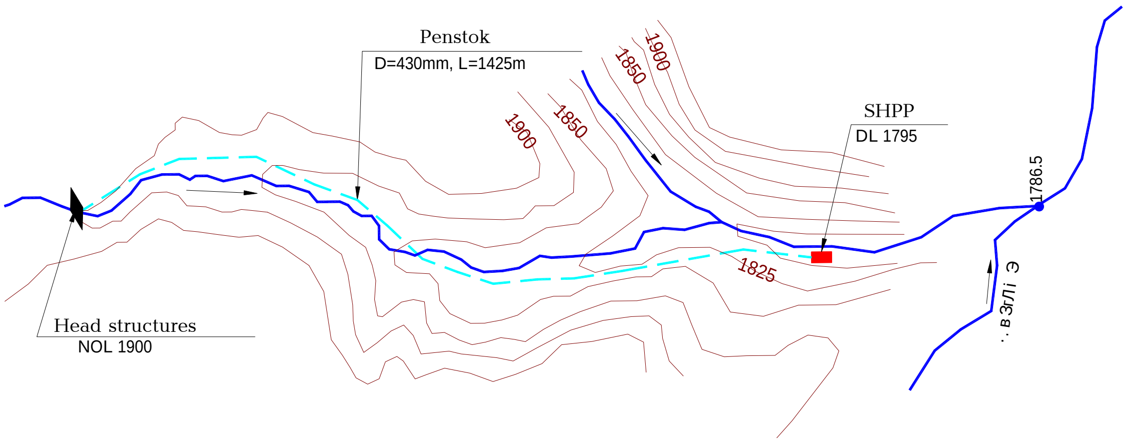
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 30. Design results according to financial scenarios

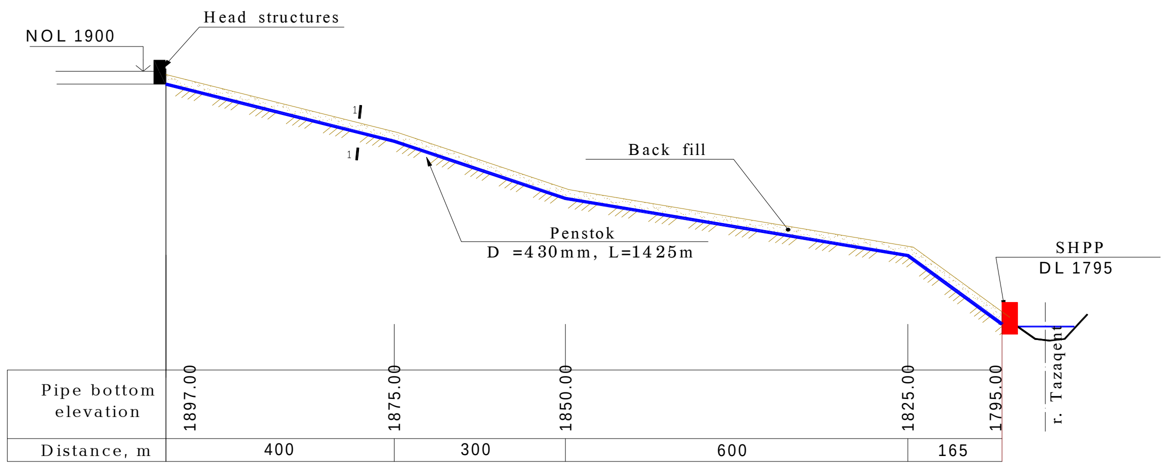
INDICATORS		Scenario 1 100% fully self -financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		6.5	5.0
NPV, thousand USD			
	8%	45.1	45.1
	10%	9.9	19.4
	12%	-16.5	1.42
	14%	-36.8	-11.4
PB, years (without discount)		8.9	11.7
Deadline for credit return, years			9.0

APPENDIX. 11. TAZAQENT SHPP

Plan



Longitudinal section



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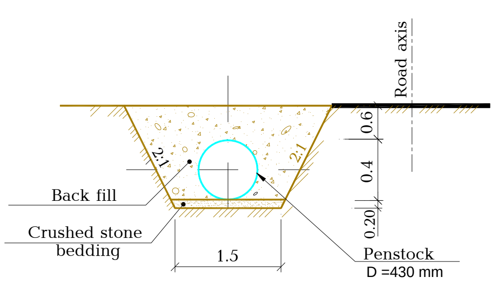
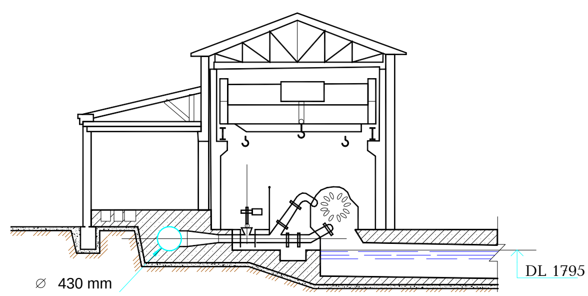


SHPP Powerhouse



15.2.5.5.3. PAMBY SHPP

Introduction

According to development scheme it was planned to construct 2 SHPPs on the river. As a result of in-situ investigations it was decided to construct 1 SHPP on Pamby River.

Pamby (Geduk) SHPP uses inclination of River Pamby from 1865.0 till 1700.0. The length of derivation from Pamby River is 3625m by copper pipeline 430mm in diameter with design pressure of 129.2m and design discharge 0.80m^3/sec. After construction and exploitation Pamby SHPP will have 258kwt capacity and will produce 1.0mln kw/h electricity annually.

Short Description Pamby River Basin

Pamby River is the right inflow of the Pambak River and flows into the latter 143km from the river mouth. The river length is 18km with 92km^2 catchment basin. It starts from the northern slopes of Pambal mountain chain on the elevation of 2120m. There are several small inflows the largest is 6km and falls from the right bank of Vordvan downstream of Ghrashat village.

In the upstream the river valley is a V-shaped gorge with 300-400m high slopes and 30-45^0 inclination. The slopes are slightly inclined news Ghachaghan village the mountains gradually step away and form 1km plateau till Ghrashat village. The mountains are located 1 and more kilometers from the river bed.

Valley slopes are composed of different rock types, covered by sand soil. Near villages there are fruit garden and cultivated areas on the slopes. The inundation area fist appears near Ghachaghan village for 1km and afterwards stretches over both banks with overall 1-2-3 width near Ghrashat village.

The river bank is twisting and sometimes direct. During drought periods the bed splits into 2-3 branches. The river bed consists of split rocks as well as clay and sand stones. Near Ghrashat village there are rounded stones consisting 0.4-0.8m in diameter. The river bed is very deformed.

The river as opposed to neighboring rivers has a long-term drought period, stable horizons and short term inundation that starts in the second half of April and lasts till the end of May.

The general prolongation of inundation is 1.5-2 months. There are very few rain floods during the drought period. The fluctuation of the horizon does not exceed 5-10cm.

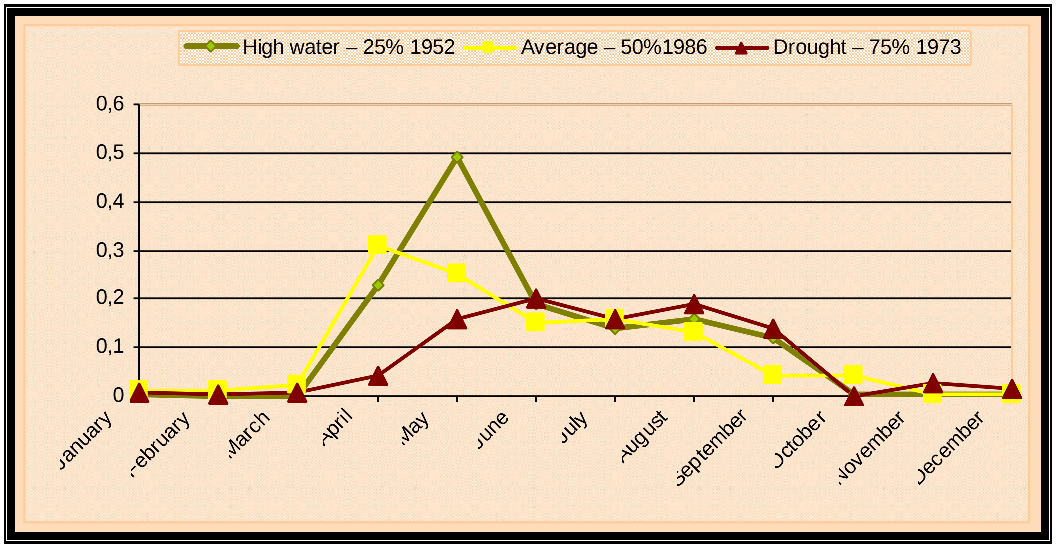
During the winter period there is strong icing that makes the river bed narrow and forms a 20-30cm dam. It is note worthy that during the summer the flow will be less than in winter. The ice remains till the end of February and the beginning of March and instantly melts away. Sometimes the river bank ice covers connect and close the river flow.

HYDROLOGY

The observation data from river r. VordNav-Jrashen water-meter station is used to define the hydrological properties of Pamby SHPP headworks and the design river section. In the design section of Pamby SHPP the catchment area is 13.3km^2, average yearly flow value of is 0.10m^3/sec.

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 13. Annual Distribution of the water flow /m³/sec



Maximal design discharge for Pamby SHPP headwork river section for the general case equal 3% - 6.0m³/sec, for verifying case - 0.5%-12.5m³/sec, the observed average annual discharge value with 95% guarantee equals 0.0004m³/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Pamby SHPP is 1990.0m, downstream - 1990.0m. According to data of Marz's WUA there is no water intake for irrigational use from Pamby River. Pamby SHPP is derivational SHPP. In order not to drain the river where 3625m derivational pipeline is the environmental discharge is designed according to RA laws and 0.0003m³/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Pamby SHPP are calculated with 50% guarantee per annum (1952 see table 31).

Table. 31. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Pamby SHPP (m³/sec)	0.010	0.010	0.022	0.250	0.250	0.150	0.160	0.160	0.130	0.042	0.005	0.004	
SHPP average monthly capacity (mwt)	0.013	0.013	0.029	0.258	0.258	0.182	0.192	0.192	0.161	0.055	0.006	0.005	
SHPP –average monthly energy production (mln kwt/hour)	0.010	0.009	0.021	0.186	0.192	0.131	0.143	0.143	0.116	0.041	0.004	0.004	1.00

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 316.4 thousand USD (without VAT) and 379.7 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		10.4
2. Exploitation expenses		18.4
	Salary	14.4
	Renovation	2.5
	Other Expenses	1.5
Total		28.8

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		258
Average multi annual production of energy, mln kwt/hour		1.00
Capital investments into SHPPS(without VAT),		
	thousand USD	316.4
	USD / kwt	1226.3
	USD / kwt/hour	0.316
Prime cost of power production, cents/kwt hour		2.9

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

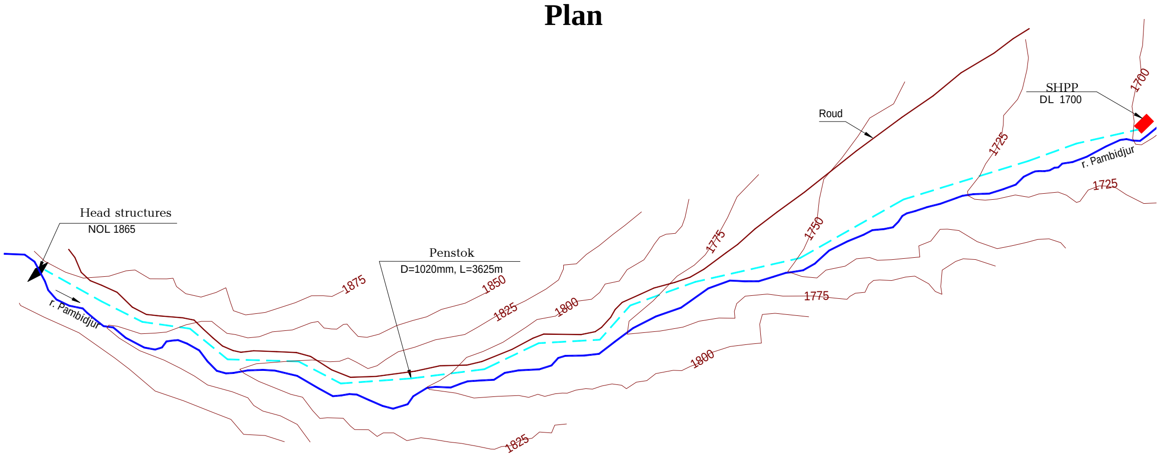
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 32. Design results according to financial scenarios

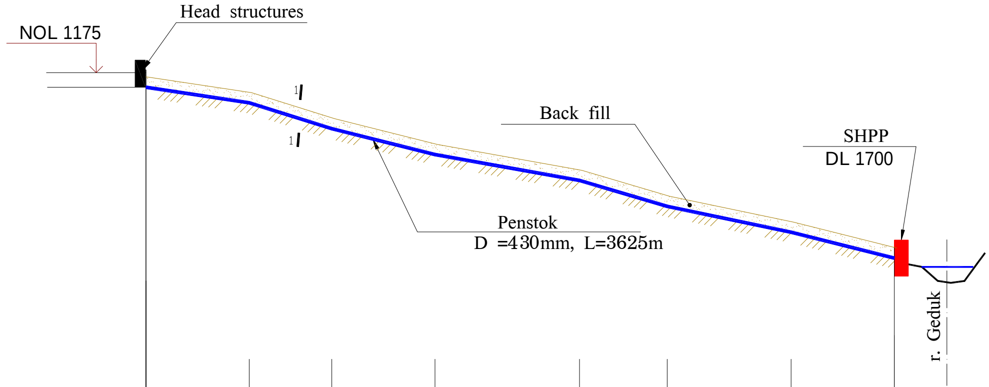
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		8.7	9.2
NPV, thousand USD			
	8%	22.3	22.3
	10%	-32.8	-11.1
	12%	-74.1	-33.9
	14%	-105.8	-49.6
PB, years (without discount)		10.5	12.0
Deadline for credit return, years			15.0

APPENDIX. 12. PAMBI SHPP

Plan

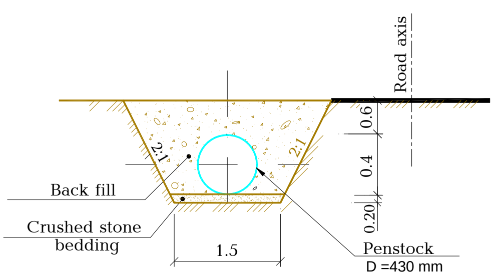


Longitudinal section

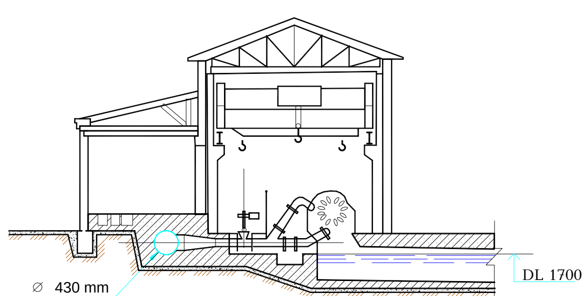


Pipe bottom elevation	1862.00	1850.00	1825.00	1800.00	1775.00	1750.00	1725.00	1700.00
Distance, m	500	400	500	700	425	600	500	

1-1



SHPP Powerhouse



15.2.5.5.4. Bazum SHPP

Introduction

According to development scheme it was planned to construct 2 SHPPs on the river. As a result of in-situ investigations it was decided to construct 1 derivational SHPP.
Bazum SHPP uses inclination of River Bazum from 1500.0 till 1400.0. The length of derivation from Bazum River is 2500m by copper pipeline 7200mm in diameter with design pressure of 92.4m and design discharge 0.60m^3/sec. After construction and exploitation Bazum SHPP will have 443mwt capacity and will produce 1.93mln kw/h electricity annually.

Short Description of Bazum River Basin

River Bazum starts from Bazum mountain chain southern slope, from the foothills of Bzovdal Mountain, at bout 2500m. The river catchment area is 47.2km^2, river length is 17km. The river is the inflow of Pambak River and falls into it 113km from the river mouth.

The river source is a spring that starts underneath a rock slope and a inflow joins it 2km from the source which feeds from melting waters. There are several other inflows that feed from rains and floods. The river valley is composed of mountainous cracked rock types with small amount of vegetation. The river falls vertically into River Pambak from the elevation of 1350m. The river valley is V-shapes with Ý 30-45^0 inclined slopes the right slopes at places have the inclination of 90^0.

The slopes are 300-500m high. In the upstream the valley width is 1-1.5km. After the river turns it becomes smaller up to20-30^0, and in the upstream it does not exceed 2km. The slope height is 200-300m and sometimes it reaches 500m. in the downstream of Bazum village the character of the valley slightly changes, the mountains are further from the river, the slope inclination becomes 15-20^0, and the slope height reaches 100-150m and is 2-3km near Gdanov village while near the river mouth the river flows through Pambak valley.

There is a very poor vegetative cover. The upstream the valley is covered by alpine and sub-alpine meadows after the Bazum village there is cultivated land and grain fields. Near the river mouth 2km from Jdanov village there are fruit (apple, pear) gardens that stretch along the river and are irrigated by the river.

Near Bzovdal village there are small mineral springs. The water is sour with a metallic taste while the surrounding stones have a red coloring. The temperature of these springs is 13.5^{0}C. There is an inundation area only at the river mouth. The inundation area is flat with a slight inclination towards the river. The inundation area spreads over both river banks it fills up when the water rises for 0.8-1.0m.

After the second right inflow the water regime of the river changes and the river bed becomes flatter with steep banks with 0.5-1m height and 0.2-0.3m deep. The river bed width varies within 10-15m. The river bed bottom is covered by rocks and rounded stones.

The inundation begins in March and lasts till the end of May and the beginning of June. The highest levels are observed in the second half of April or the first half of May, which is mainly a result of floods, because there is no snow in the basin by then although there may be some sections remaining in the highest parts of the basin.

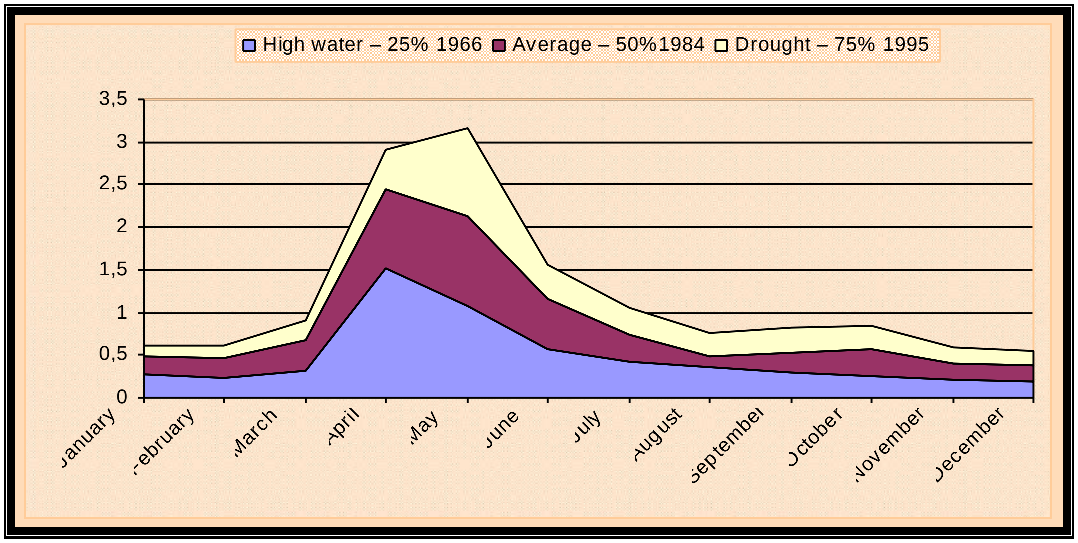
The drought lasts from June till March and sometimes it is interrupted by summer and autumn inundations, which last only for few hours. During this season the rise of the levels does not exceed 20-30cm. During the spring inundation the horizons change up to 1m in the upstream and 2m the downstream.

The winter drought flow exceeds the summer flow. There are no dangerous hydrologic phenomena. The freezing regime is characterized by its instability. The fist ice is observed during the shoreline freezing that may disappear and then appear again. In the upper streams the river by a complete ice cover which carried several meters of snow and in the downstream the shorelines freeze and sometimes hinder the flow of the river. The snow melts at the beginning of February till March.

HYDROLOGY

The observation data from river r. Chichkhan – Getik water-meter station is used to define the hydrological properties of Bazum SHPP headworks and the design river section. In the design section of Bazum SHPP the catchment area is $40.2km^2$, average yearly flow value of is 0.40 m^3/sec.
The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 14. Annual flow distribution



Maximal design discharge for Bazum SHPP headwork river section for the general case equal 3% - 16.9m^3/sec, for verifying case - 0.5%-23.7m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.062m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Bazum SHPP is 1500.0m, downstream - 1400.0m. According to data of Marz's WUA there the water intake for irrigational use from Bazum River is 0.15mln.m^3. Bazum SHPP is derivational SHPP. In order not to drain the river where 1725m derivational pipeline is the environmental discharge is designed according to RA laws and 0.046m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Bazum SHPP are calculated with 50% guarantee per annum (1966 see table 33).

Table. 33. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Bazum SHPP (m^3/sec)	0.152	0.178	0.328	0.600	0.600	0.541	0.252	0.054	0.178	0.272	0.141	0.160	
SHPP average monthly capacity (mwt)	0.121	0.141	0.256	0.443	0.443	0.406	0.199	0.043	0.141	0.214	0.112	0.127	
SHPP –average monthly energy production (mln kwt/hour)	0.090	0.095	0.191	0.319	0.330	0.292	0.148	0.032	0.102	0.159	0.081	0.095	1.93

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 475.9 thousand USD (without VAT) and 571.1thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		15.7
2. Exploitation expenses		20.2
	Salary	14.4
	Renovation	3.8
	Other Expenses	2.0
Total		35.9

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		443
Average multi annual production of energy, mln kwt/hour		1.93
Capital investments into SHPPS(without VAT),		
	thousand USD	475.9
	USD / kwt	1074.3
	USD / kwt/hour	0.246
Prime cost of power production, cents/kwt hour		1.86

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

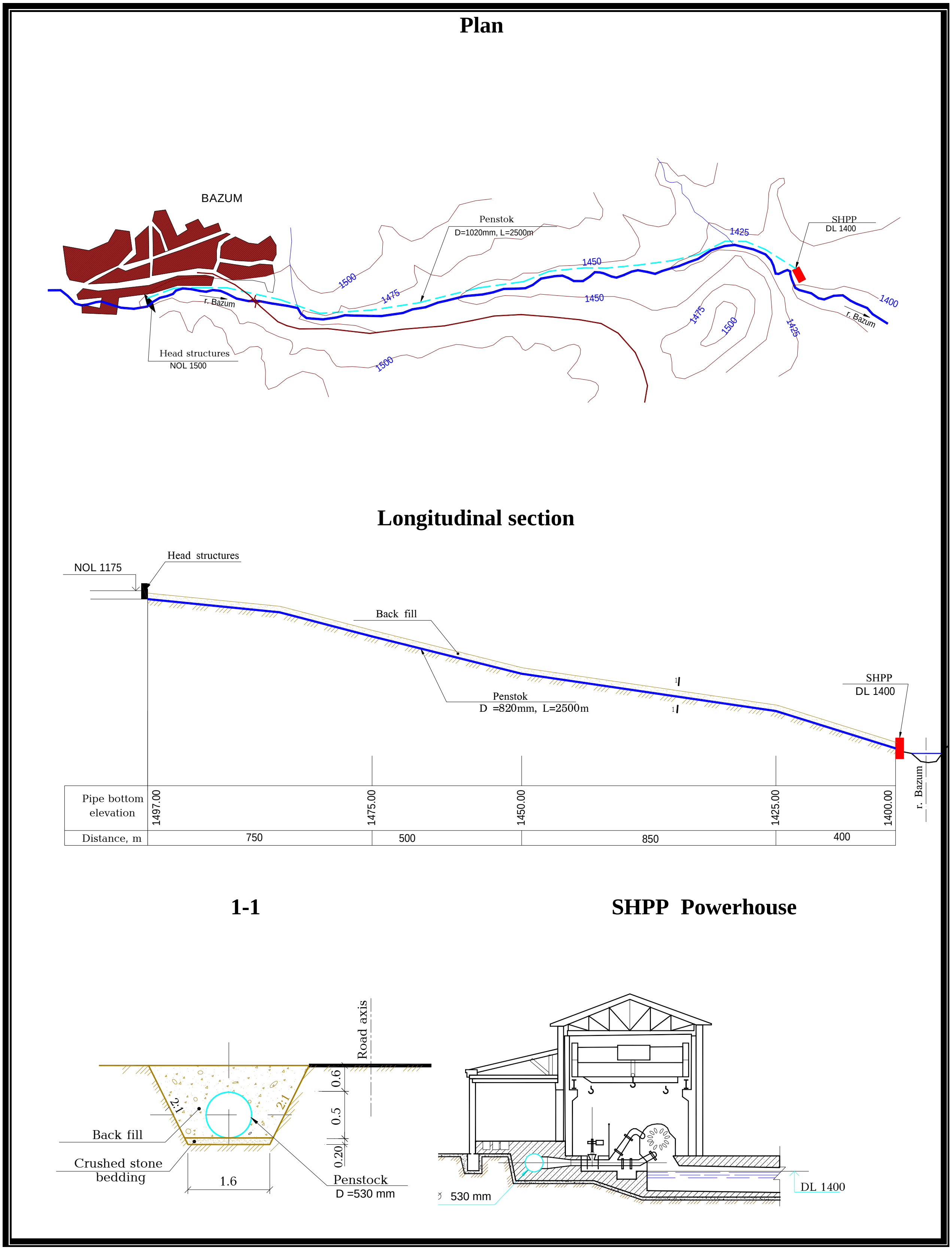
Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 34. Design results according to financial scenarios

INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		12.4	14.9
NPV, thousand USD			
	8%	363.9	363.9
	10%	171.6	213.3
	12%	27.6	106.4
	14%	-83.0	29.1
PB, years (without discount)		7.8	10.0
Deadline for credit return, years			8.0

APPENDIX. 13. BAZUM SHPP



15.2.5.5.5. Vanadzor SHPP

Introduction

According to development scheme it was planned to construct 2 SHPPs on the river. As a result of in-situ investigations it was decided to construct 1 derivational SHPP.

Vanadzor SHPP uses inclination of River Vanadzor from 1650.0 till 1450.0. The length of derivation from Vanadzor River is 2600m by copper pipeline 720mm in diameter with design pressure of 186.1m and design discharge 0.80m^3/sec. After construction and exploitation Vanadzor SHPP will have 1191mwt capacity and will produce 3.63mln kw/h electricity annually.

Short Description of Vanadzor River Basin

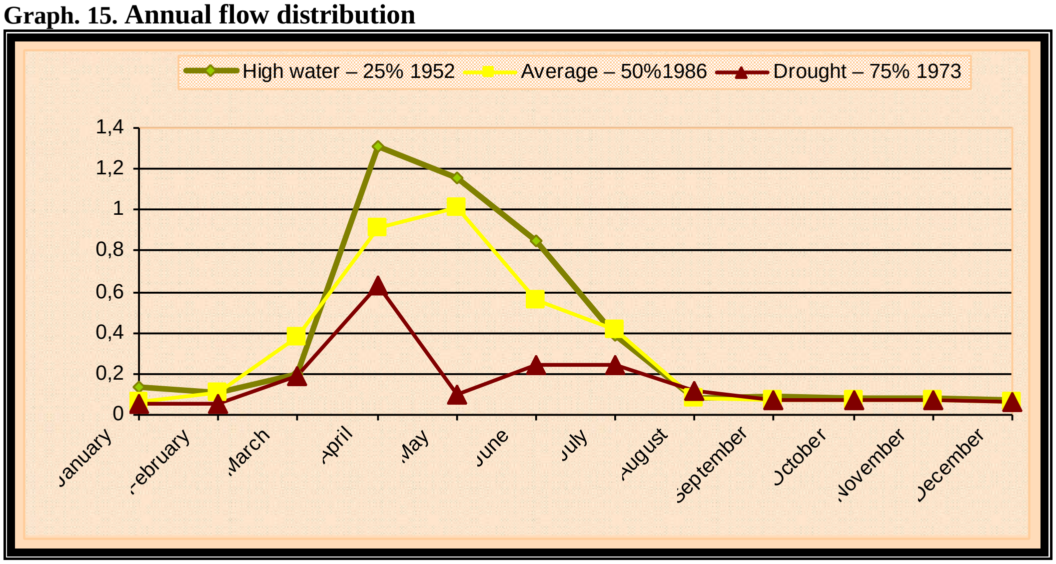
Vanadzor rover is the left inflow of Tandzut River that falls into it 1.7km from the river mouth. The overall catchment area is 104km^2, length is 14km. The river starts from the northern slopes of Pambal mountain chain the foothills of Maimegh Mountain on the elevation of 2300m. The river mouth is situated in the Vanadzor city. In the upstream on the elevation of 1500m the river basin is covered by meadows in the downstream by a thick forest. From geological point of view the river basin is composed of volcanic rock types, andesites and basalts. The river valley is almost flat and is a V-shaped gorge with 100-200m high slopes with 45-60^0 inclination. There is no inundation area. The river bed follows the direction of the valley in the beginning the river bed is quite narrow which causes a strong flow. The width of the river bed during drought period is 2-3m.

In the forest are the inclination is less and it becomes even smaller when flowing through the city. Within the city the river bed becomes deeper and the bank height becomes 1-2m. Then the irrigation channels start. That is why during summer the width of the river reaches 1-1.5m and in winter it is 23m. The river bed is strongly deformed. The spring flood starts in second half of March and reaches its peak May by strong peak sand downfalls. Besides there are also rain floods that sometimes exceed spring peaks. On separate years the precipitations are o often that the there is no deference between spring floods and rain floods. The drought lasts from mid-august till mid-march and is characterized by constant variation of water horizons which however does not exceed 20-30cm, while the annual fluctuations are within 1-2m. Winter phenomena start in December and in March and are distinguished by shoreline freezing and floating ice.

HYDROLOGY

The observation data from river r. Vanadzor - Vanadzor water-meter station is used to define the hydrological properties of Vanadzor SHPP headworks and the design river section. In the design section of Vanadzor SHPP the catchment area is 23.1km^2, average yearly flow value of is 0.35m^3/sec.
The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 15. Annual flow distribution



Maximal design discharge for Vanadzor SHPP headwork river section for the general case equal 3% - 10.5m^3/sec, for verifying case - 0.5%-14.0m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.017m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Vanadzor SHPP is 1650.0m, downstream - 1450.0m. According to data of Marz's WUA the water intake from Vanadzor River is 0.32mln.m^3. Vanadzor SHPP is derivational SHPP. In order not to drain the river where 2600m derivational pipeline is the environmental discharge is designed according to RA laws and 0.01m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Vanadzor SHPP are calculated with 50% guarantee per annum (1986 see table 35).

Table. 35. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Vanadzor SHPP (m^3/sec)	0.04	0.09	0.36	0.80	0.80	0.54	0.40	0.06	0.05	0.05	0.05	0.04	
SHPP average monthly capacity (mwt)	0.06	0.14	0.57	1.19	1.19	0.84	0.63	0.10	0.08	0.08	0.08	0.00	
SHPP –average monthly energy production (mln kwt/hour)	0.05	0.10	0.42	0.86	0.89	0.60	0.47	0.07	0.06	0.06	0.06	0.00	3.63

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 1299.2 thousand USD (without VAT) and 1559.0 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		42.9
2. Exploitation expenses		31.7
	Salary	17.3
	Renovation	10.4
	Other Expenses	4.0
Total		74.6

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		1191
Average multi annual production of energy, mln kwt/hour		3.63
Capital investments into SHPPS(without VAT),		
	thousand USD	1299.2
	USD / kwt	1090.9
	USD / kwt/hour	0.36
Prime cost of power production, cents/kwt hour		2.06

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

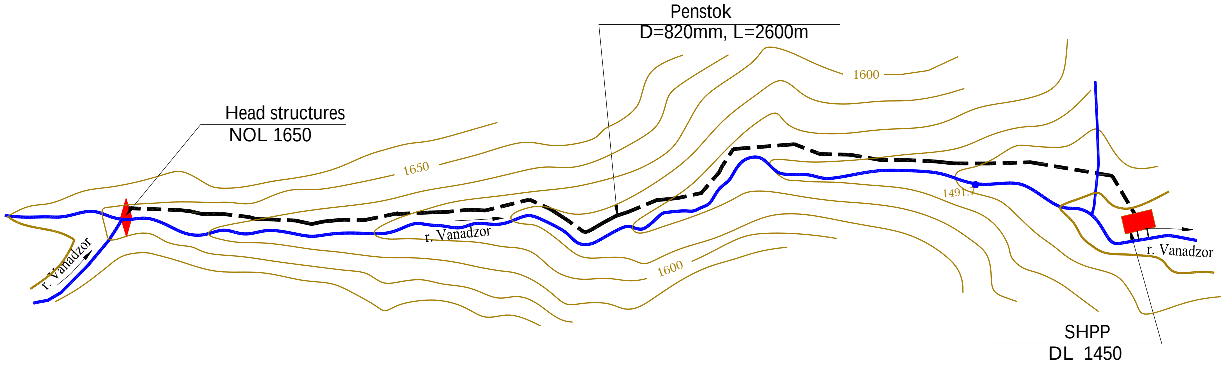
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 36. Design results according to financial scenarios

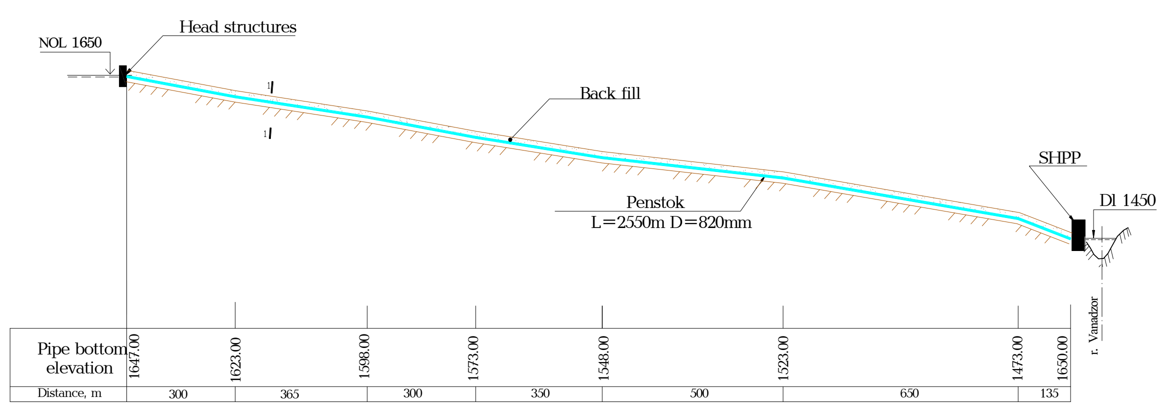
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		10.03	11.2
NPV, thousand USD			
	8%	257.2	257.2
	10%	3.92	82.1
	12%	-185.8	-39.4
	14%	-331.3	-125.2
PB, years (without discount)		9.4	12.7
Deadline for credit return, years			10.0

APPENDIX. 14. VANADZOR SHPP

Plan



Longitudinal section



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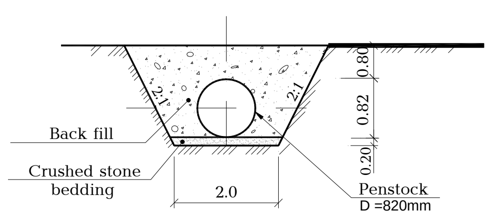
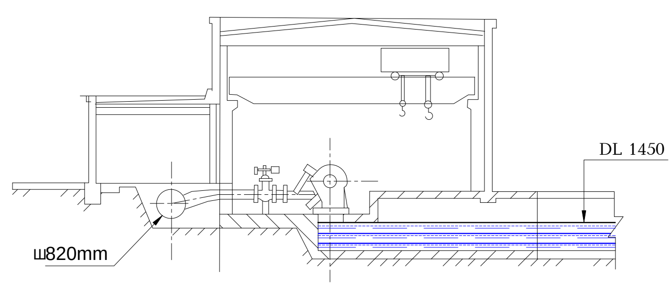


SHPP Powerhouse



15.2.5.5.6. Karby SHPP

Introduction

According to development scheme it was planned to construct 1 SHPPs on the river. As a result of in-situ investigations it was decided to construct 1 derivational SHPP.

Karby SHPP uses inclination of River Karby from 1675.0 till 1485.0. The length of derivation from Karby River is 2900m by copper pipeline 820mm in diameter with design pressure of 178.0m and design discharge 1.0m^3/sec. After construction and exploitation Karby SHPP will have 1424mwt capacity and will produce 5.02mln kw/h electricity annually.

Short Description of Karbi River Basin

Karbi River basin is the left inflow if Tandzut River and falls into the latter 6km from the rier mouth.

The catchment area is 43km^2, river length is 10.5km. The river starts at eastern slope of Maimekh Mountain from 2774m elevation, and the height of the river mouth is 1446m.

The river valley is flat, cultivated and V-shaped. The valley completely consists of volcanic rock types, including dolomites, andesites and porphyrites. In the upstream the river valley is covered by rich alpine meadows and in the downstream – forest section. The slope inclination is 50-60^0, and the height is up to 200m. 1.5-2km from the river source the slope inclination decreases, reaching 40-45^0, while the height is preserved.

There is no inundation area. The river bed is straight and highly cultivated in the upstream. Occasionally the river bed is so inclined that the river forms water falls.

The spring inundations begin at the second half of March and sometimes there is a very intensive rise of horizons which explains the annual peak in April. During the floods there are multiple peaks which give the hydrograph comp-shape readings; there are peaks on June and July on the separate years.

The drought begins in June but is often interrupted by short term rain inundations. In winder due to ice the river bed narrows and the water horizon rises. Sometimes this rise exceeds spring peaks.

The river has a mud flow nature and therefore is a subject to deformations. Winter phenomena are unstable. They stat in December as shoreline ice and end at the beginning of March sometimes there is floating ice. On the upstream there is a complete freezing of the river.

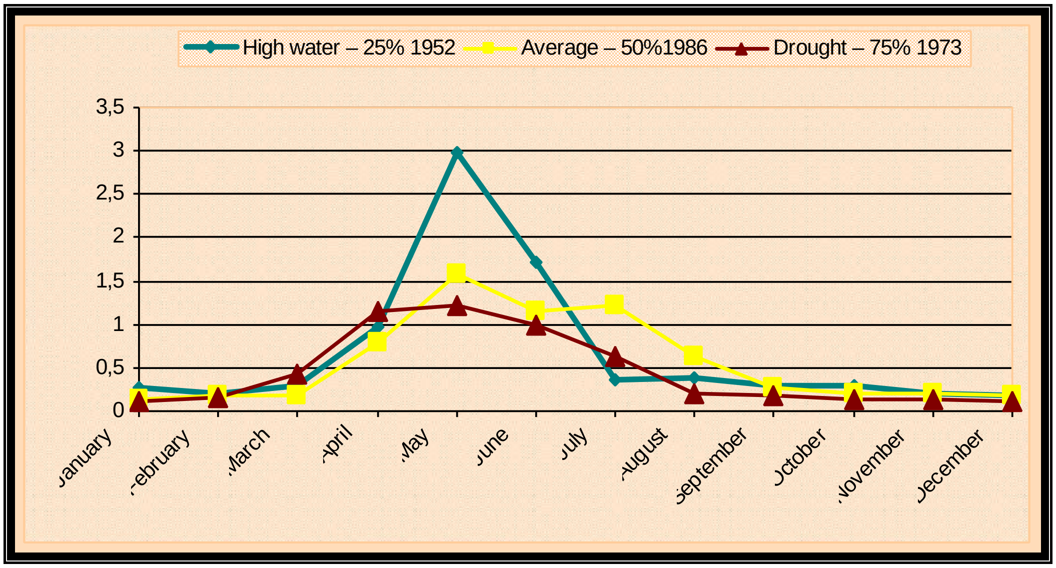
HYDROLOGY

The observation data from Tandzut-Khndzorut water-meter station is used to define the hydrological properties of Karby SHPP headworks and the design river section. In the design section of Karby SHPP the catchment area is 33.2km^2, average yearly flow value of is 0.60m^3/sec.

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Maximal design discharge for Karby SHPP headwork river section for the general case equal 3% - 21.9m^3/sec, for verifying case - 0.5%-31.2m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.058m^3/sec.

Graph. 16. Annual flow distribution



WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Karby SHPP is 1675.0m, downstream - 1485.0m. According to data of Marz's WUA the water intake from Karby River is 1.05mln.m^3 while the water demand is 1.58mln.m^3. Karby SHPP is derivational SHPP. In order not to drain the river where 2900m derivational pipeline is the environmental discharge is designed according to RA laws and 0.04m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Karby SHPP are calculated with 50% guarantee per annum (1986 see table 37).

Table.37. Monthly Water Enegry Indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Karby SHPP (m^3/sec)	0.04	0.09	0.10	0.69	1.00	1.00	1.00	0.45	0.09	0.06	0.12	0.09	
SHPP average monthly capacity (mwt)	0.04	0.09	0.10	0.69	1.00	1.00	1.00	0.45	0.09	0.06	0.12	0.09	
SHPP –average monthly energy production (mln kwt/hour)	0.04	0.09	0.10	0.69	1.00	1.00	1.00	0.45	0.09	0.06	0.12	0.09	12.4

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 1498.1 thousand USD (without VAT) and 1797.7 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		49.4
2. Exploitation expenses		36.2
	Salary	20.2
	Renovation	12.0
	Other Expenses	4.0
Total		85.6

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		1424
Average multi annual production of energy, mln kwt/hour		5.02
Capital investments into SHPPS(without VAT),		
	thousand USD	1498.1
	USD / kwt	1052.0
	USD / kwt/hour	0.30
Prime cost of power production, cents/kwt hour		1.7

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

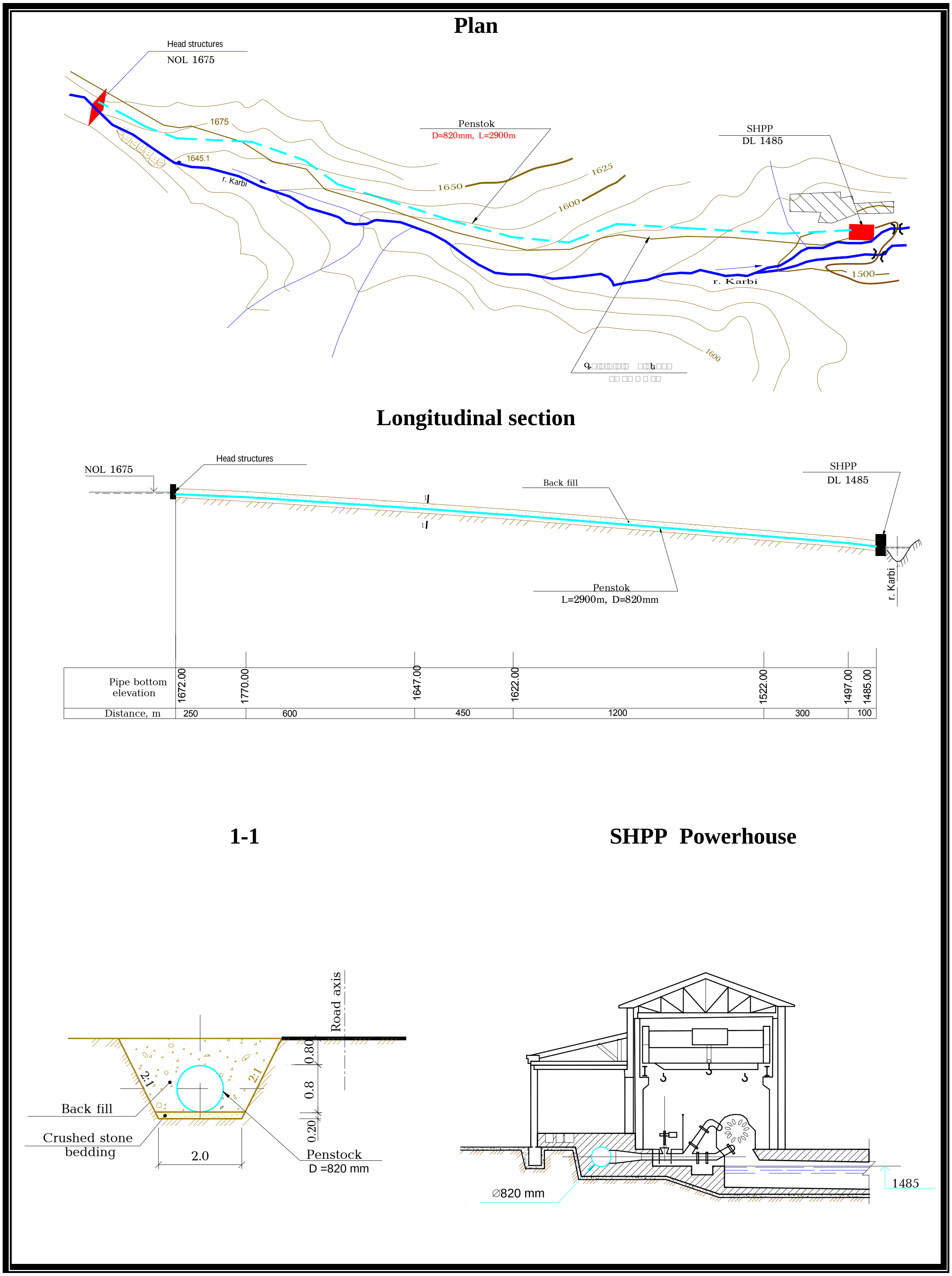
Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 38. Design results according to financial scenarios

INDICATORS		**Scenario 1** 100% fully self - financed option	**Scenario 2** 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		12.5	15.0
NPV, thousand USD			
	8%	677.3	677.3
	10%	323.4	399.7
	12%	58.3	202.6
	14%	-145.2	60.1
PB, years (without discount)		13.0	22.0
Deadline for credit return, years			

APPENDIX. 15. KARBI SHPP



15.2.5.5.7. Pambak SHPP-1,2

Pambak SHPP -1

Introduction

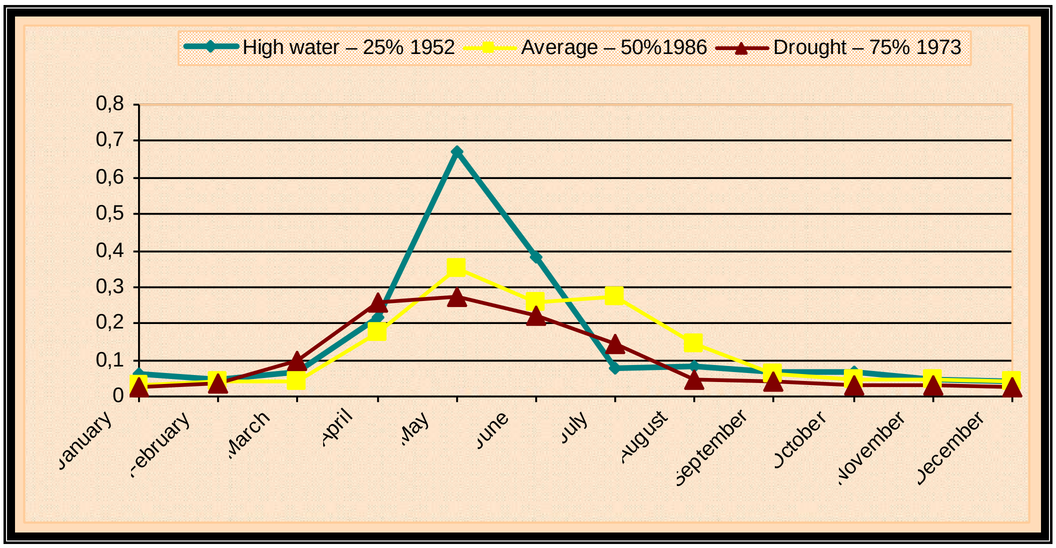
Pambak SHPP-1 is situated on the right bank of Pambak River. According to development scheme it was planned to construct 2 SHPPs on the river. As a result of in-situ investigations it was decided to construct 1 derivational SHPP.

Pambak-1 SHPP uses inclination of River Pambak from 1450.0 till 1250.0. The length of derivation from Pambak River is 1625m by copper pipeline 430mm in diameter with design pressure of 185.2m and design discharge 0.24m^3/sec. After construction and exploitation Pambak-1 SHPP will have 356kwt capacity and will produce 1.28mln kw/h electricity annually.

HYDROLOGY

The observation data from Tandzut-Khndzorut water-meter station is used to define the hydrological properties of Pambak -1 SHPP headworks and the design river section. In the design section of Pambak -1 SHPP the catchment area is 7.45km^2, average yearly flow value of is 0.13m^3/sec.
The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 17. Annual flow distribution



Maximal design discharge for Pambak-1 SHPP headwork river section for the general case equal 3% - 12.1m^3/sec, for verifying case - 0.5%-17.5m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.028m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Pambak SHPP-1 is 1450.0m, downstream - 1250.0m. According to data of Marz's WUA there is no water intake water intake from Pambak River. Pambak SHPP is derivational SHPP. In order not to drain the river where 1625m derivational pipeline is the environmental discharge is designed according to RA laws and 0.021m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of PambakSHPP-1 are calculated with 50% guarantee per annum (1953 see table 39).

Table. 39. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Pambak SHPP -1(m^3/sec)	0.008	0.018	0.021	0.155	0.240	0.236	0.240	0.122	0.042	0.024	0.025	0.020	
SHPP average monthly capacity (mwt)	0.013	0.029	0.034	0.240	0.356	0.351	0.356	0.191	0.067	0.038	0.040	0.032	
SHPP –average monthly energy production (mln kwt/hour)	0.01	0.02	0.02	0.17	0.26	0.25	0.26	0.14	0.05	0.03	0.03	0.02	1.28

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 367.1 thousand USD (without VAT) and 440.5 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		12.1
2. Exploitation expenses		19.4
	Salary	14.4
	Renovation	3.0
	Other Expenses	2.0
Total		31.5

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		365
Average multi annual production of energy, mln kwt/hour		1.28
Capital investments into SHPPS(without VAT),		
	thousand USD	367.1
	USD / kwt	1031.1
	USD / kwt/hour	0.29
Prime cost of power production, cents/kwt hour		2.46

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/

- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

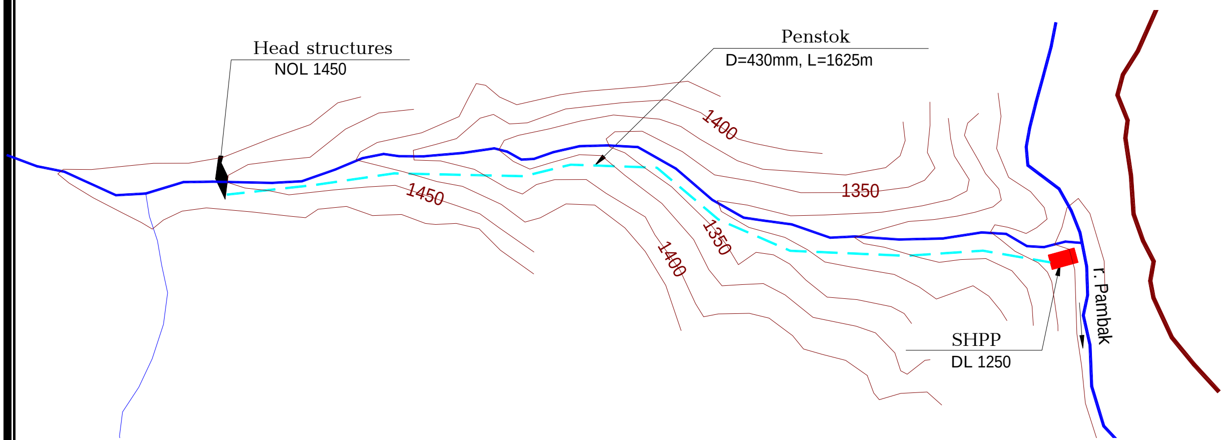
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 40. Design results according to financial scenarios

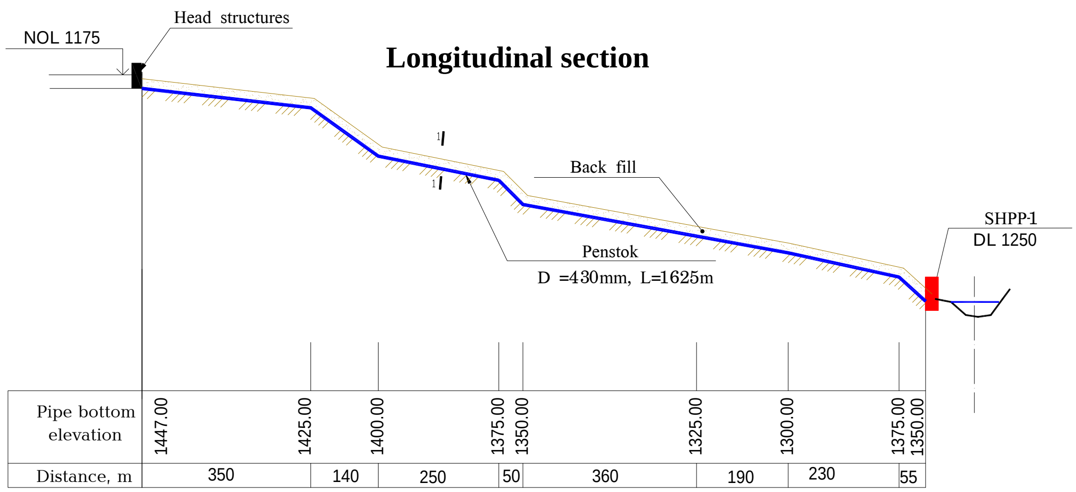
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		6.5	5.0
NPV, thousand USD			
	8%	-40.9	-40.9
	10%	-83.4	-56.0
	12%	-115.2	-65.8
	14%	-140.0	-72.2
PB, years (without discount)		13.0	22.0
Deadline for credit return, years			

APPENDIX. 16. PAMBAK SHPP-1

Plan



Longitudinal section



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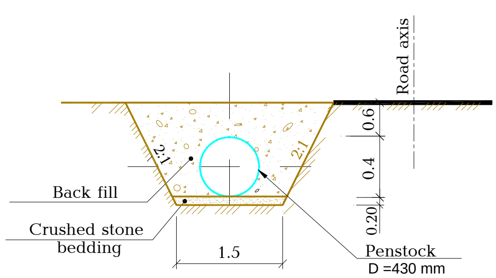
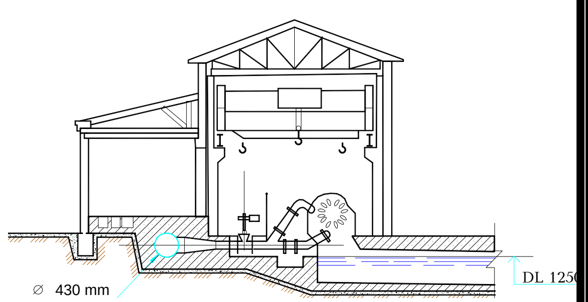


SHPP Powerhouse



Pambak SHPP-2

Introduction

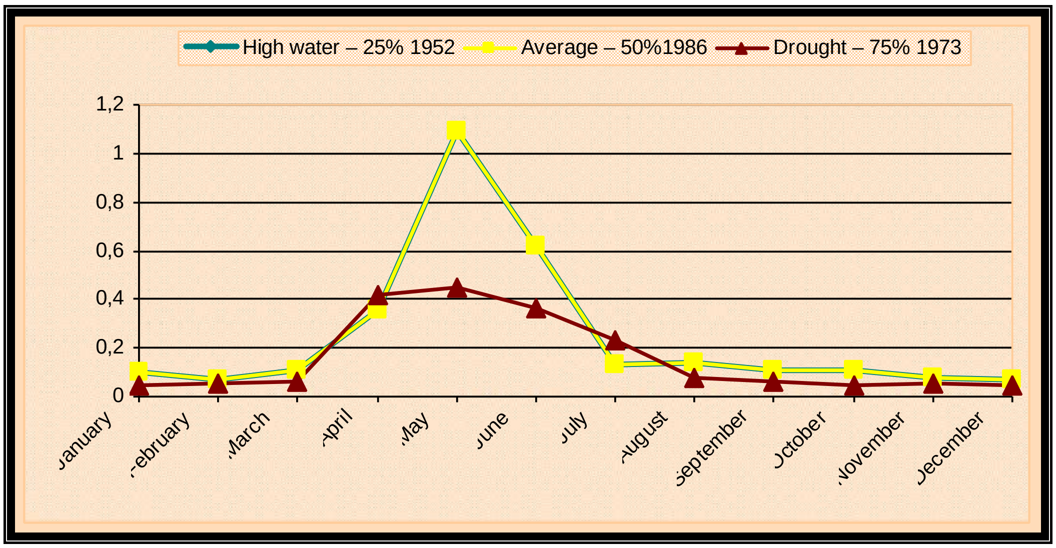
Pambak SHPP-2 is situated on the right bank of Pambak River. According to development scheme it was planned to construct 2 SHPPs on the river. As a result of in-situ investigations it was decided to construct 1 derivational SHPP.

Pambak SHPP-1 uses inclination of River Pambak from 1450.0 till 1195.0. The length of derivation from Pambak River is 1570m by copper pipeline 530mm in diameter with design pressure of 242.7m and design discharge 0.40m^3/sec. After construction and exploitation Pambak-2 SHPP will have 777kwt capacity and will produce 2.73 mln kw/h electricity annually.

HYDROLOGY

The observation data from Tandzut-Khndzorut water-meter station is used to define the hydrological properties of PambakSHPP-2 headworks and the design river section. In the design section of PambakSHPP-2 the catchment area is 12.1km^2, average yearly flow value of is 0.40m^3/sec.
The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 18. Annual flow distribution



Maximal design discharge for Pambak-2 SHPP headwork river section for the general case equal 3% - 14.6m^3/sec, for verifying case - 0.5%-21.2m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.045m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Pambak SHPP-2 is 1450.0m, downstream - 1195.0m. According to data of Marz's WUA there is no water intake from Pambak River. PambakSHPP-2 is a derivational SHPP. In order not to drain the river where 1570m derivational pipeline is the environmental discharge is designed according to RA laws and 0.034m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Pambak SHPP-2are calculated with 50% guarantee per annum (1953 see table 41).

Table. 41. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Pambak SHPP-2 (m^3/sec)	0.013	0.030	0.034	0.251	0.400	0.384	0.400	0.198	0.068	0.040	0.041	0.032	
SHPP average monthly capacity (mwt)	0.027	0.061	0.069	0.502	0.777	0.748	0.777	0.399	0.139	0.082	0.084	0.065	
SHPP –average monthly energy production (mln kwt/hour)	0.020	0.041	0.052	0.362	0.578	0.539	0.578	0.297	0.100	0.061	0.060	0.049	2.73

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 771.4 thousand USD (without VAT) and 925.7 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	25.5
2. Exploitation expenses	26.5
Salary	17.3
Renovation	6.2
Other Expenses	3.0
Total	52.0

Power indicators of have the following level

Indicators	Values
Derivation capacity, kwt	777
Average multi annual production of energy, mln kwt/hour	2.73
Capital investments into SHPPS(without VAT),	
thousand USD	771.4
USD / kwt	992.8
USD / kwt/hour	0.21
Prime cost of power production, cents/kwt hour	1.9

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:
- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

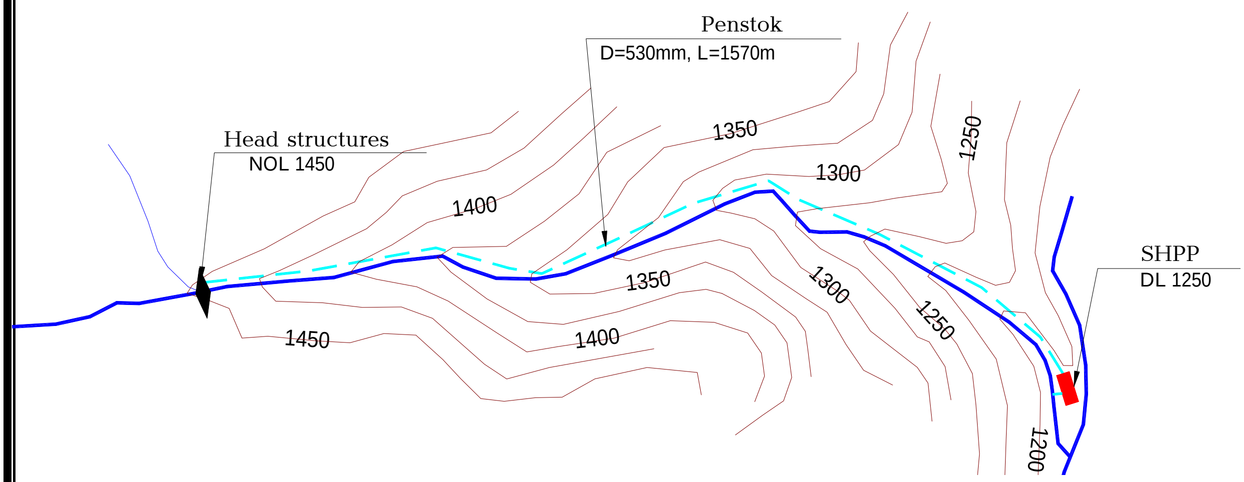
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 42. Design results according to financial scenarios

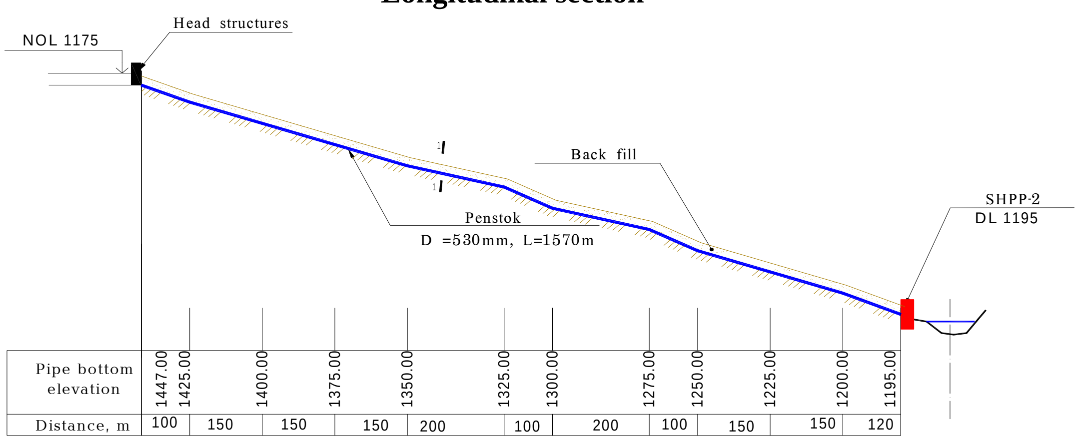
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		12.6	14.9
NPV, thousand USD			
	8%	-40.9	-40.9
	10%	-83.4	-56.0
	12%	-115.2	-65.8
	14%	-140.0	-72.2
PB, years (without discount)		7.7	9.5
Deadline for credit return, years			7.0

APPENDIX. 17. PAMVAK SHPP-2

Plan



Longitudinal section



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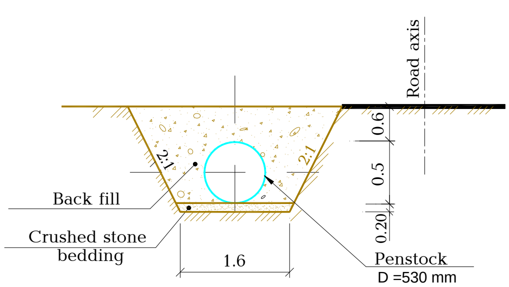
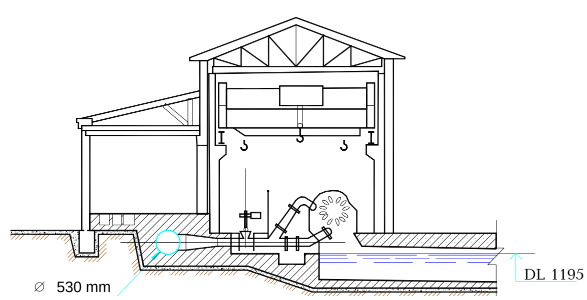


SHPP Powerhouse



15.2.5.5.8. Vahagnaget SHPP

Introduction

According to development scheme it was planned to construct 3 SHPPs on the river. As a result of in-situ investigations it was decided to construct 1 derivational SHPP.

Vahagnaget SHPP uses inclination of River from 1205.0 till 1025.0. The length of derivation from Vahagnaget is 3200m by copper pipeline 530mm in diameter with design pressure of 154.9m and design discharge 0.40m^3/sec. After construction and exploitation Vahagnaget SHPP will have496kwt capacity and will produce 2.68 mln kw/h electricity annually.

Short Description of Vahagni River Basin

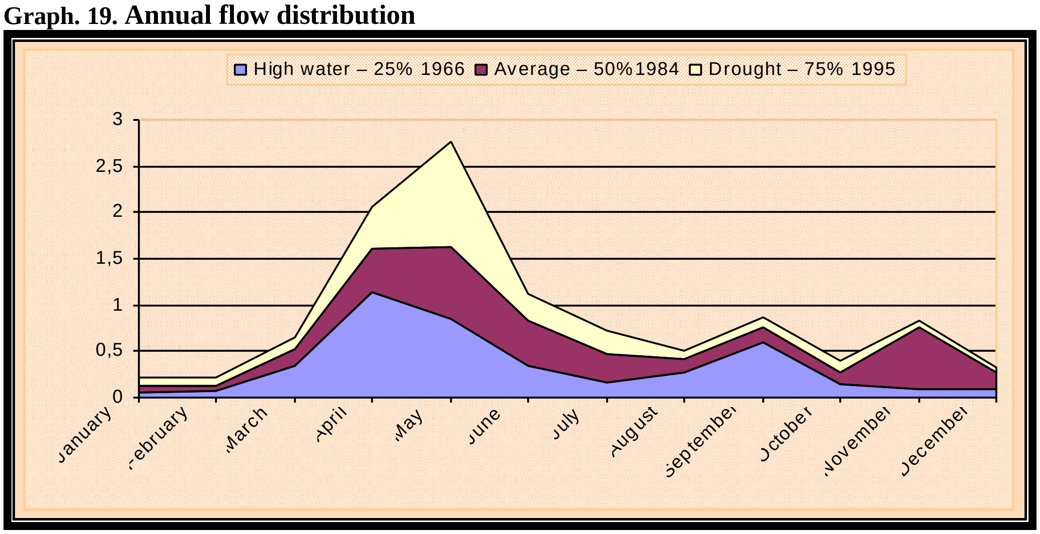
Vahagni River discharges into River Pambak 94km from the river mouth. The catchment area is 39km^2, river length is 19.5km. Several small inflows discharge into the river. The river starts from eastern slope of Bzovdali mountain chain on the elevation 2000m, from a small spring between rocks. The river basin is not inhabited and is covered by a thick forest where there were once wild animals. The area is V-shaped and flows through a rock bed with sand stone in wash. The slope inclination is 45^0. The left banks covered with grass with separate trees. The most significant inflow discharges 1.5km from the source and 2km below the source river enters a thick forest that fully cover the slopes that turn into a 5m wide gorge. River inclinations are very strong with 10m falls. The height of the slopes varies within 50-200m. Some times the gorge bottom widens till 40-50m with swamp areas.

During inundations the river covers the bottom of the gorge, rising up to 1-1.5m. There is no inundation area. The river bed is slightly twisting by is mainly straight. During the drought period river width is 1.5-2.0m. There are often in washes of rounded slopes and different soils which are covered by thick grass and bushes, here the river width reaches 2-3m and depth till 25cm. River regime is characterized by spring inundations that starts at the end of March and the begging of April and lasts till July. Usually during the drought the river discharge is insignificant: in the upstream - 3-5l, mid-stream - 25-40l, in the river mouth – 50l. During inundation the river discharge grows significantly while in winter the river completely freezes but not till the bottom, the flow is small but is always present.

HYDROLOGY

The observation data from Gargar-Kurtan water-meter station is used to define the hydrological properties of Vahagnaget SHPP headworks and the design river section. In the design section of Vahagnaget SHPP the catchment area is 29.8km^2, average yearly flow value of is 0.30m^3/sec.
The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 19. Annual flow distribution



Maximal design discharge for Vahagnaget SHPP headwork river section for the general case equal 3% - 28.8m^3/sec, for verifying case - 0.5%-49.3m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.008m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Vahagnaget SHPP is 1205.0m, downstream – 1025.0m. According to data of Marz's WUA there is no water intake from Pambak River. Vahagnaget SHPP is a derivational SHPP. In order not to drain the river where 3200m derivational pipeline is the environmental discharge is designed according to RA laws and 0.006m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Vahagnaget SHPP are calculated with 50% guarantee per annum (1983 see table 43).

Table. 43. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Vahagnaget SHPP (m^3/sec)	0.072	0.059	0.168	0.400	0.400	0.400	0.297	0.151	0.156	0.127	0.400	0.176	
SHPP average monthly capacity (mwt)	0.103	0.085	0.236	0.496	0.496	0.496	0.394	0.213	0.220	0.180	0.496	0.246	
SHPP –average monthly energy production (mln kwt/hour)	0.077	0.057	0.175	0.357	0.369	0.357	0.293	0.158	0.158	0.134	0.357	0.183	2.676

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 553.6 thousand USD (without VAT) and 664.3 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	18.3
2. Exploitation expenses	20.8
Salary	14.4
Renovation	4.4
Other Expenses	2.0
Total	39.1

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		496
Average multi annual production of energy, mln kwt/hour		2.68
Capital investments into SHPPS(without VAT),		
	thousand USD	553.6
	USD / kwt	1116.1
	USD / kwt/hour	0.21
Prime cost of power production, cents/kwt hour		1.46

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

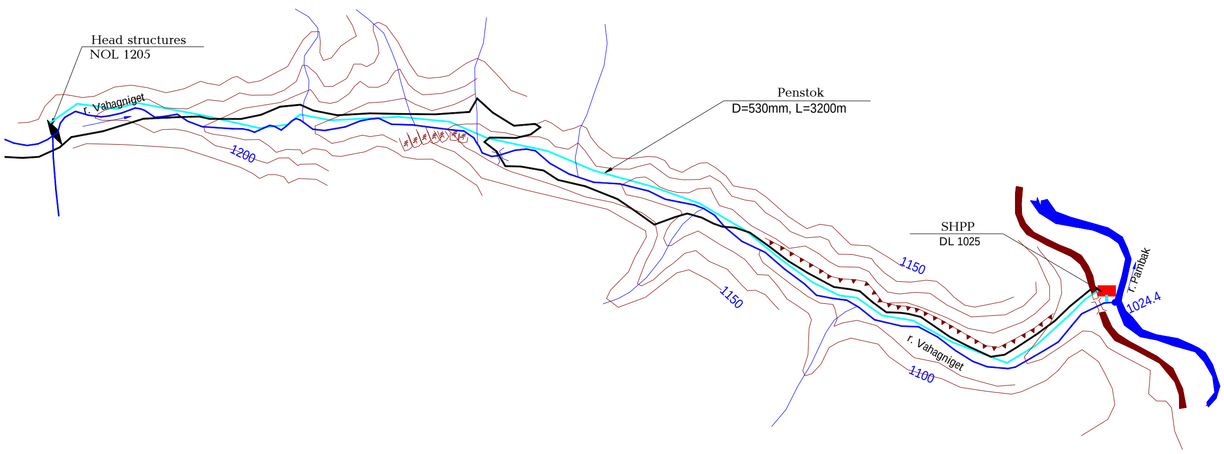
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 44. Design results according to financial scenarios

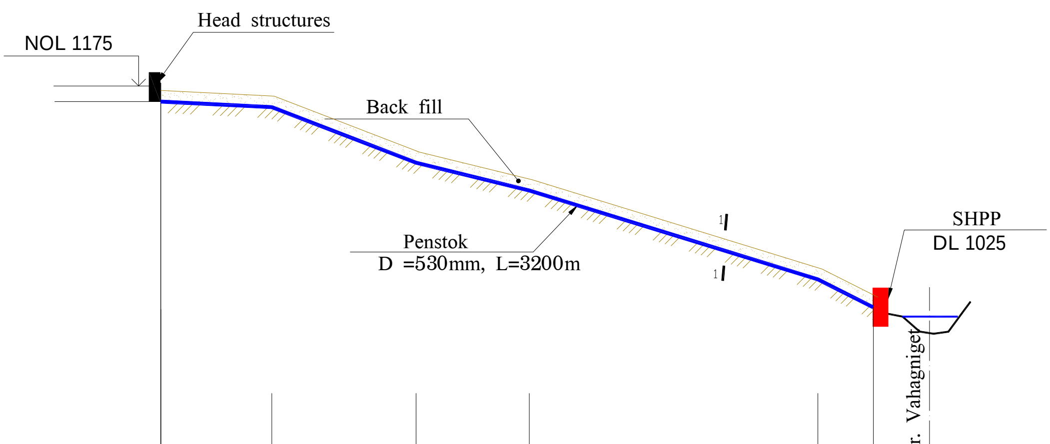
INDICATORS		**Scenario 1** 100% fully self -financed option	**Scenario 2** 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		18.1	23.2
NPV, thousand USD			
	8%	587.6	587.6
	10%	401.9	421.7
	12%	262.9	300.9
	14%	156.2	211.01
PB, years (without discount)		5.5	6.4
Deadline for credit return, years			5.0

APPENDIX. 18. VAHAGNIGET SHPP

Plan



Longitudinal section



Pipe bottom elevation	1202.00	1175.00	1125.00	1100.00	1050.00	1025.00
Distance, m	500	650	500	1300	250	

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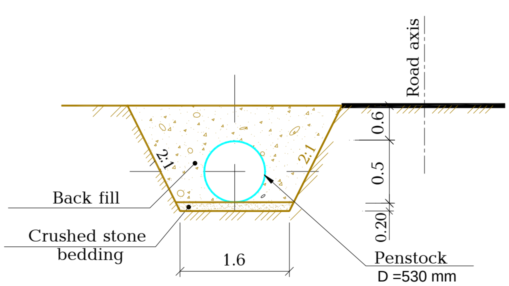
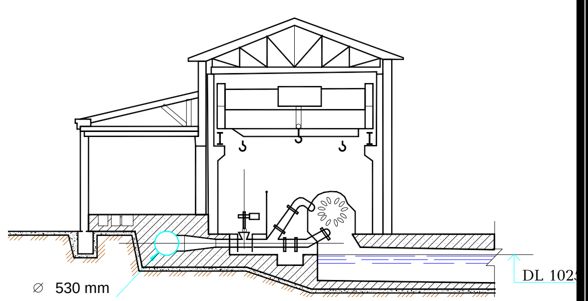


SHPP Powerhouse



15.2.5.5.9. Antaramut SHPP

Introduction

According to development scheme it was planned to construct 2 SHPPs on Antaramut river. As a result of in-situ investigations it was decided to construct one derication SHPP.

Antaramut SHPP uses inclination of River Antaramuy from 1100.0 till 950.0. The length of derivation from Dzorashen River is 2600m by copper pipeline 530mm in diameter with design pressure of 134.3m and design discharge 0.35m^3/sec. After construction and exploitation Antaramut SHPP will have 376mwt capacity and will produce 1.89mln kw/h electricity annually.

Short Description of Antaramut River basin

Antaramut River falls into Pambak River 86km from the river mouth. The river catchmet area is 30km^2, length is 12km. It starts from a small spring near Kolegeran village on the northern slope of Teokesan Mountain on the left 1800m and flows to the east till discharging into river Pambak on the elevation of 930m near Tumanyan station.

In the upstream the valley is represented by a gorge. Near Kolageran village where the valley is narrow its width is more that 200m and slop height is 890-100m. But when the gorge becomes wider its width reaches 1.5km with 200m slopes.

Near the spring the valley slopes are covered by high grass after which the river enters forest gorge where the trees are close to river bank. There are small water falls 1.2m high. The forest ends near Kolegeran village. 1km in the downstream from the village the slope becomes steep (45-60^0), and 3km downstream again steep with 100m high and in the upper part 200-300m wide.

The river bed is even and mountainous along the whole length, in the upstream it is covered by rocks and huge rounded stones – up to 2m in diameter. The depth near the river mouth reaches 15-230cm the river width reaches up to 1.5m and speed till 1m/sec.

Water regime is characterized by relatively small horizon rise in March and the stable drought begins in July. The highest water horizons reach 0.5m and on abundant years it my reach 1-1.5m and in the most narrow areas it reaches 2m.

There is icing of river banks from the beginning of December till February and in the upstream the river completely freezes.

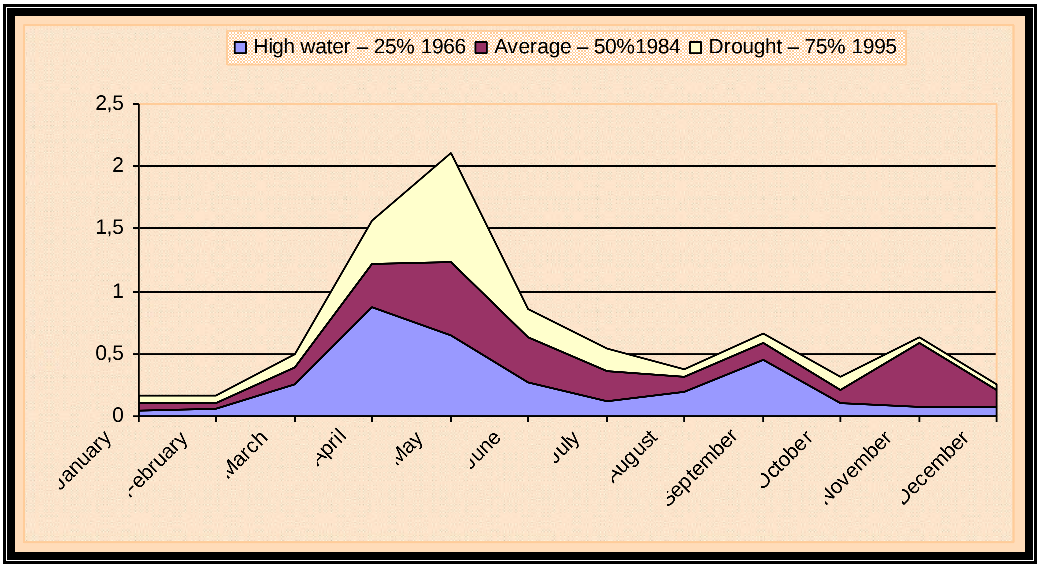
HYDROLOGY

The observation data from river r. Gargar - Kurtan water-meter station is used to define the hydrological properties of Antaramut SHPP headworks and the design river section. In the design section of Antaramut SHPP the catchment area is 22.7km^2, average yearly flow value of is 0.23 m^3/sec.

Maximal design discharge for Antaramut SHPP headwork river section for the general case equal 3% - 25.8m^3/sec, for verifying case - 0.5%-44.2m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.006m^3/sec.

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 20. Annual flow distribution



WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Antaramut SHPP is 1500.0m, downstream - 1400.0m. According to data of Marz's WUA there is no water intake for irrigational use from Antaramut. Antaramut SHPP is derivational SHPP. In order not to drain the river where 2600m derivational pipeline is the environmental discharge is designed according to RA laws and 0.0045m3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Antaramut SHPP are calculated with 50% guarantee per annum (1983 see table 45).

Table. 45. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Antaramut SHPP (m^3/sec)	0.055	0.046	0.129	0.350	0.350	0.350	0.227	0.116	0.120	0.098	0.350	0.134	
SHPP average monthly capacity (mwt)	0.065	0.054	0.152	0.376	0.376	0.376	0.260	0.137	0.142	0.116	0.376	0.158	
SHPP –average monthly energy production (mln kwt/hour)	0.05	0.04	0.11	0.27	0.28	0.27	0.19	0.10	0.10	0.09	0.27	0.12	1.89

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 439.1 thousand USD (without VAT) and 526.9 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		14.5
2. Exploitation expenses		19.9
	Salary	14.4
	Renovation	3.5
	Other Expenses	2.0
Total		34.4

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		376
Average multi annual production of energy, mln kwt/hour		1.89
Capital investments into SHPPS(without VAT),		
	thousand USD	363.9
	USD / kwt	213.3
	USD / kwt/hour	106.4
Prime cost of power production, cents/kwt hour		1.82

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

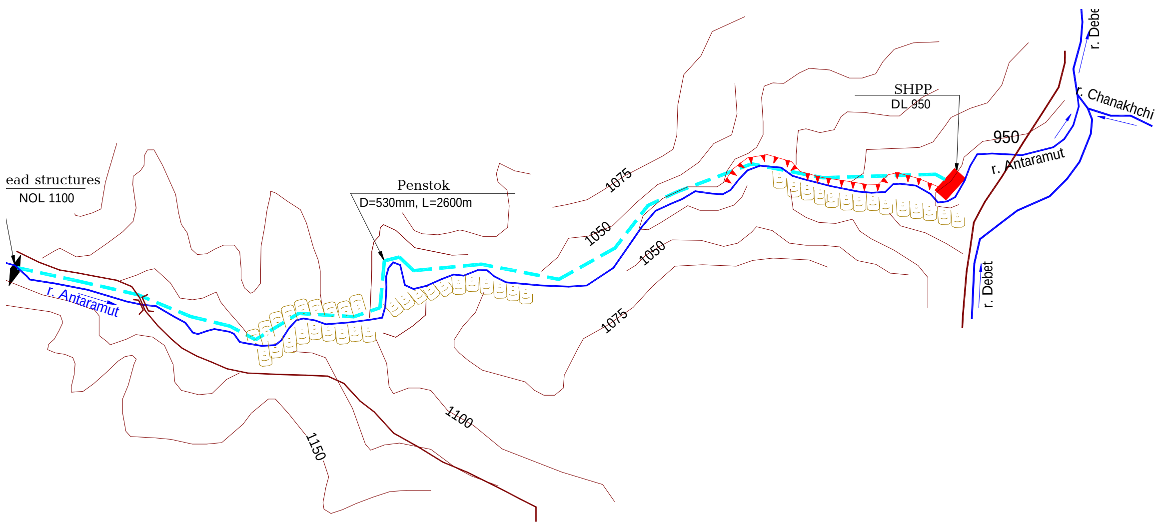
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 46. <u>Design results according to financial scenarios</u>

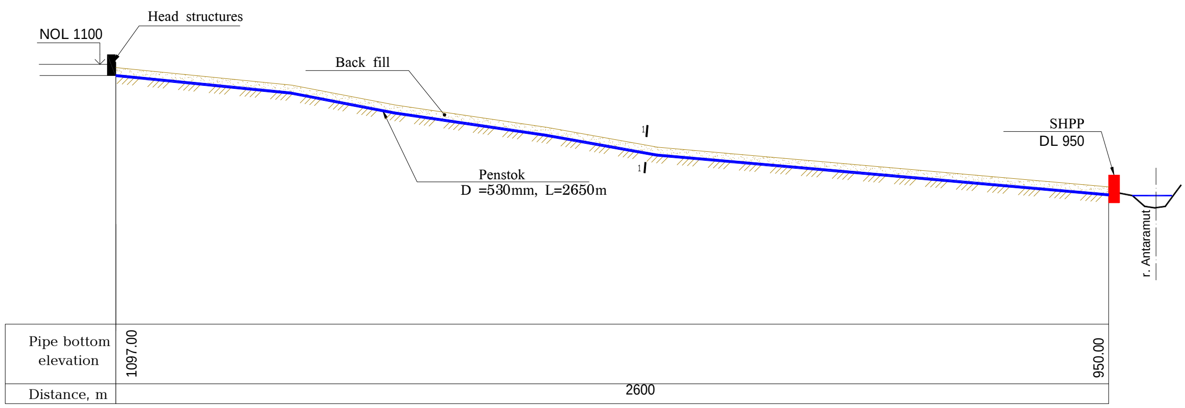
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		12.4	14.9
NPV, thousand USD			
	8%	323.9	323.9
	10%	199.8	217.8
	12%	106.8	141.2
	14%	35.5	84.9
PB, years (without discount)		6.5	7.9
Deadline for credit return, years			6.0

APPENDIX. 19. ANTARAMUT SHPP

Plan



Longitudinal section



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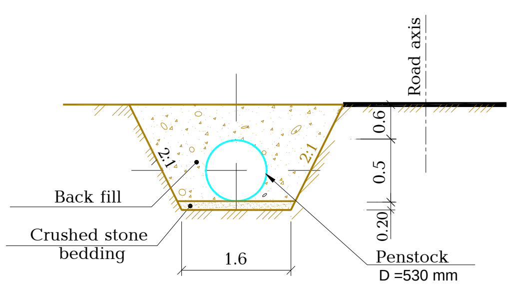
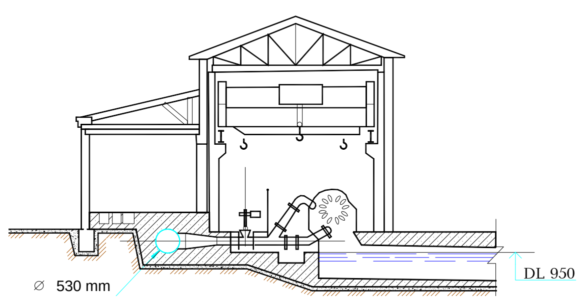


SHPP Powerhouse



15.2.5.5.10. Chakhkali SHPP

Introduction

According to development scheme there were no SHPP to construct on Chakhkali River. As a result of in-situ investigations it was decided to construct one SHPP.

Chakhkali SHPP uses inclination of River Chakhkali from 1950.0 till 1795.0. The length of derivation from Chakhkali River is 2350m by copper pipeline 430mm in diameter with design pressure of 131.8m and design discharge 0.25m^3/sec. After construction and exploitation Chakhkali SHPP will have 148mwt capacity and will produce 0.62mln kw/h electricity annually.

Short Description of Chakhkal River

Chakhkal river falls into River Chichkhan 11km from the river mouth. River length is 8km catchment area is 35.2km^2.

Chakhkal river starts from springs that are situated on eastern slopes of Chibukhli mountains on elevation of 2560m. In the beginning the river flows in south-west direction and after inflow of the right significant inflow it turns for 90^0-to the south up to Chichkhn River. There are multiple small and big rivers falling into the river.

15.2.5.5.10. Chakhkali SHPP

Introduction

According to development scheme there were no SHPP to construct on Chakhkali River. As a result of in-situ investigations it was decided to construct one SHPP.

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Short Description of Chakhkal River

Chakhkal river falls into River Chichkhan 11km from the river mouth. River length is 8km catchment area is 35.2km^2.

Chakhkal river starts from springs that are situated on eastern slopes of Chibukhli mountains on elevation of 2560m. In the beginning the river flows in south-west direction and after inflow of the right significant inflow it turns for 90^0-to the south up to Chichkhn River. There are multiple small and big ricers falling into the river.

Almiost all inflow have ground water feeding. The basin is covered by rich alpine meadows. In the beginning the river valley is flat and turns into V-shaped gorge afterwards. The slopes are composed of grey tuff.

Near the river mouth that is situated 50m below Chichkhan river waterfall the river cuts through grey tuff layer creating steep and high walls that look like gates releasing the river. Valley slopes have 30-35^0 inclination and in the end 70-80^0. The slopes consist of sand stone sand tuffs.

There is no inundation area. The river bed is composed of rounded stones, sand and on the right side there are piles of rounded stones and rocks. The river flow has a insignificant speed in the upstream which increases closer to the main river bed. Spring inundations start at the end of March and last will July while peak takes place in the mid-may.

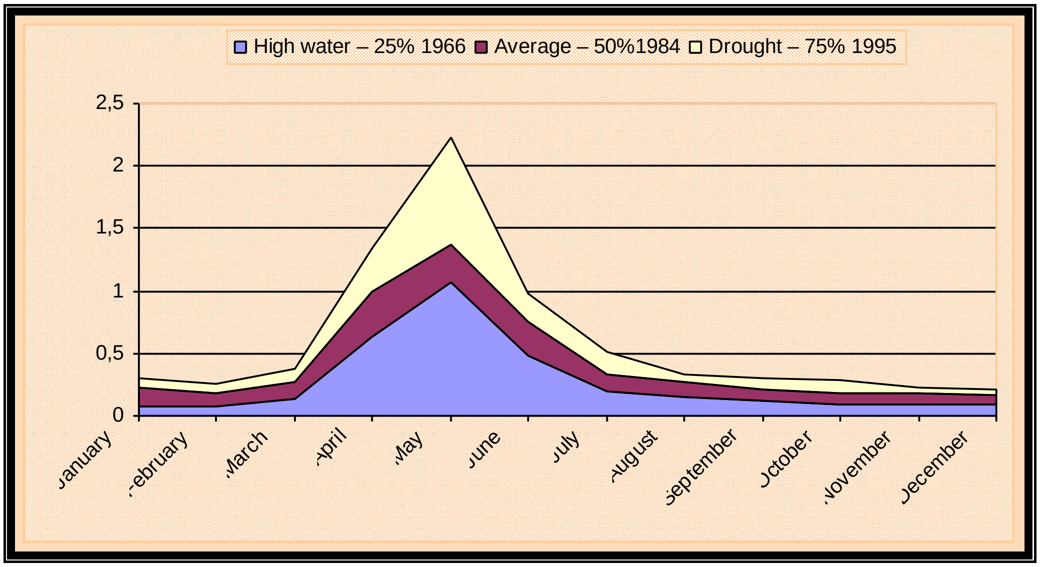
The drought period from July till March while there is a rise of horizons up to 20-30cm, due to winter phenomena. In winter the shoreline freezes. The ise forms in December and incese of very severe winter even in November and lasts till February.

HYDROLOGY

The observation data from river r. Chichkhan – Getik water-meter station is used to define the hydrological properties of Chakhkali SHPP headworks and the design river section. In the design section of Chakhkali SHPP the catchment area is 17.5km^2, average yearly flow value of is 0.10 m^3/sec.

Maximal design discharge for Chakhkali SHPP headwork river section for the general case equal 3% - 12.2m^3/sec, for verifying case - 0.5%-17.2m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.033m^3/sec. The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 21. Annual flow distribution



WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Chakhkali SHPP is 1950.0m, downstream - 1795.0m. According to data of Marz's WUA there is no water intake for irrigational use from Chakhkali. Chakhkali SHPP is derivational SHPP. In order not to drain the river where 2350m derivational pipeline is the environmental discharge is designed according to RA laws and 0.025m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Chakhkali SHPP are calculated with 50% guarantee per annum (1981 see table 47).

Table. 47. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Chakhkali Karmravan SHPP (m^3/sec)	0.121	0.079	0.121	0.250	0.250	0.245	0.098	0.098	0.070	0.067	0.064	0.055	
SHPP average monthly capacity (mwt)	0.145	0.096	0.145	0.264	0.264	0.260	0.119	0.119	0.086	0.082	0.079	0.068	
SHPP –average monthly energy production (mln kwt/hour)	0.108	0.065	0.108	0.19	0.196	0.187	0.088	0.088	0.062	0.06	0.061	0.057	1.26

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 285.5 thousand USD (without VAT) and 342.6 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	9.42
2. Exploitation expenses	14.3
Salary	10.0
Renovation	2.3
Other Expenses	2.0
Total	23.7

Power indicators of have the following level

Indicators	Values
Derivation capacity, kwt	264
Average multi annual production of energy, mln kwt/hour	1.26
Capital investments into SHPPS(without VAT),	
thousand USD	285.5
USD / kwt	1081.3
USD / kwt/hour	0.23
Prime cost of power production, cents/kwt hour	1.88

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- ❖ Private investments only /Scenario 1/
- ❖ 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

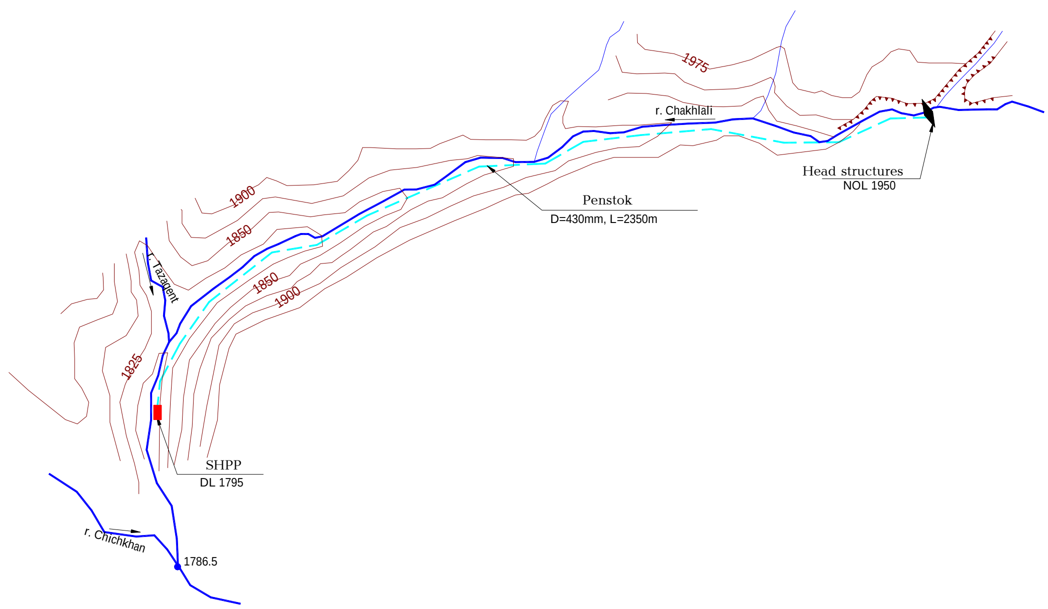
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 48. Design results according to financial scenarios

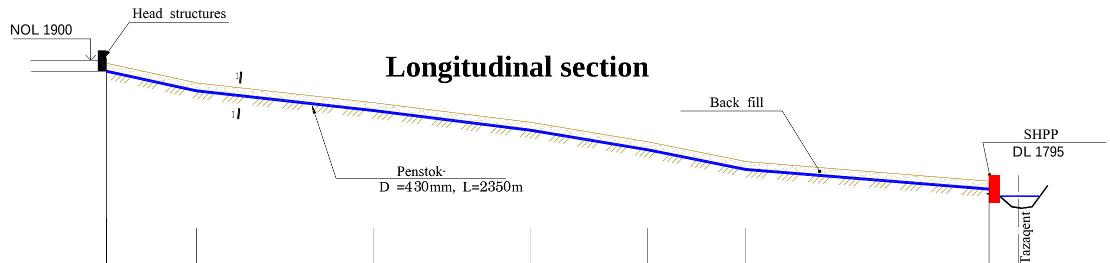
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		15.2	18.9
NPV, thousand USD			
	8%	213.1	213.1
	10%	131.9	143.7
	12%	71.2	93.6
	14%	24.6	56.7
PB, years (without discount)		6.5	7.8
Deadline for credit return, years			6.0

APPENDIX. 20. CHAKHKALI SHPP

Plan



Longitudinal section



Pipe bottom elevation	1947.00	1925.00	1900.00	1875.00	1850.00	1825.00	1795.00
Distance, m	230	450	400	300	250	620	

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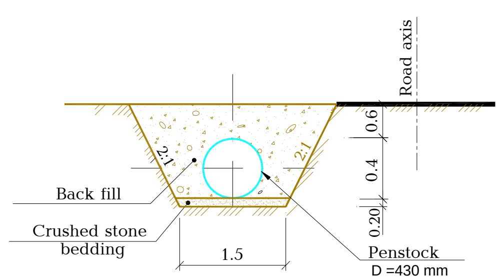
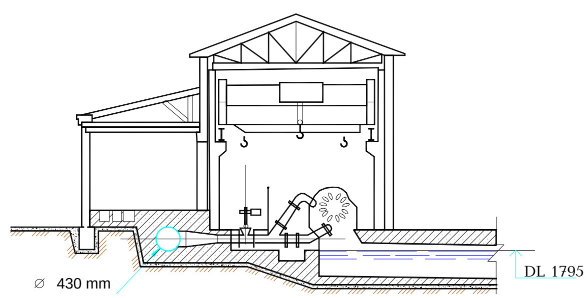


SHPP Powerhouse



15.2.6. Updated and Verified Scheme for Debed River Basin

15.2.6.1. General Information

Out of 22 SHPP planned to construct on Debet River basin only Aghir (Haghpat 1.2) SHPPs1-3 are constructed and Martsiget SHPP 1, 2 has a construction permission.

As a result of in-situ investigations the unappropriated SHPP indicators were verified and observed as well as new locations were investigated on Marciget river basin.

15.2.6.2. Short Description of Debed River Basin and Climatic Conditions

Debed River basin is located in the centre of eastern part of Armenia. The catchment area is 3790km^2, river length is 176km, average elevation - 1650m, average inclination - 12%, forest area - 17%.

River Debed is the largest inflow of Khrami River and is formed in a result of joining of Pambak and Dzoraget rivers on the elevation of 880m. The river basin is surrounded Somkheti Mountains from the north and Pambak mountain chain from the south. Bazumi mountain chain is situated between Pambak and Dzoraget rivers. Both rivers have a well developed river network, while the river net of Debed River is less developed and acquires a valley like nature closer to its borders. The flow of Pambak and Dzoraget rivers is constantly growing in the downstream and after they join the flow becomes slower.

The hydrograph encounters multiple peaks in spring as well as in autumn; rises and downfalls follow each other very actively.

The flow is unstable and extremely strong it often washes down rocks and on separate years part of the inflows turn into mudflow channels which results in emergency floods.

The earth cover is diverse. The upper mountainous zones are rich in brown mountain-meadow lands. Lori mountain plain is covered by humus black earth while the Pambak river valley and Debed river right bank are covered by grey forest black earth. In the Alaverdu area the left part of Debed valley is covered by grey-brown carbonated earth and lies above the sedimentary soil.

There is a rich vegetative cover in the basin. The Slopes are mainly covered by forests while the rest of the land consists of meadows or cultivated lands. River banks are mainly occupied by fruit gardens, gardens and different grain types.

The mountain valley represents a steep (30-40^{û}), high (200-300m), stony, narrow and deep canyon. After the Airum station the mountains becomes lower and wider while the slope inclination becomes decreases (15-20^{û}), the height does not exceed 50m.

The valley slopes are separated by multiple inflow gorges. After Sadalhlu village the river flows into Bokhalu ravine and the valley becomes 1.5-2.0km wider and ill defend. The inundation is absent at the beginning and appears only on the valley area. It is double sided and stretches 0.5-2.0km. And has a insignificant inclination.

The river bed is slightly twisting while the banks are 1.0-3.0m high, steep and rocky. The river bed is composed of stones and sand. There are large rounded stones 1.5-3.0 in diameter. River bed width is 2.0-3.0m. The installed water meter station is Shnogh on the elevation of 656m. According to the information provided by the latter the average annual temperature is 11°C, the maximal - +23.5°C, and minimal -0.5°C. The maximal freezing of the soil 50cm. Average annual precipitations add up to 535mm, maximum is 73mm.

The maximal air moisture content is 10.5mb, comparative moisture content is 70%, average annual precipitations 550mm, maximal annual - 836mm, monthly-162mm, daily – 70mm. Average 10 day snow cover moisture content is 7cm, maximum is 16cm. Average annual wind speed is 1.5m/sec, and maximum is 2%, guaranteed wind speed is 25 m/sec.

15.2.6.3. Geological composition of Debed river basin

The geological composition of the basin is diverse. It presents impermeable basic rock types due to which the surface feeding of the river prevails; this explains the presence of thick river network.

The river basin mainly consists of mountainous volcanic rocks there are diorites, porphyrites, andesited and basalts. There are also different kinds of tuffs.

The exception is the northern part of Lori mountain plain that is composed of thick layer of sandy soil which once have been a bottom of a lake and Borchalu valley that was covered by alluvium.

From a geological point of view Kachahkut, Alaverdi, Akhtala, Aknet (Kistum), Vardadzor inflows are composed of Lower Jurrasiv porphyrites, half-tuffs and tuff breccias as well as tuff sands and layered tuffs. These are weathered, hydrothermal, slightly permeable rocks.

The foothill sections and their slopes are covered by 2-3m thick talus and prolluvial sediments.

In the basins of Poghosaghbuyr, Teghut and Shnorh inflows there are granite rocks of chalk age: diorites, granodiorites and granites. These rock types are weathered on the top, cracked, partially deformed, short and slightly permeable.

The above mentioned rocks located on slightly inclined relief of valley slopes ire covered by 2-5m thick deluvial-proluvial layer. The alluvial sediments are thin and undeveloped.

The river basins of Marc, Sarnakhbuyr, Akhnidzor, and Lorut are composed of Middle Eocene sedimentary rocks. These are represented by weathered, slightly permeable porphytrited, andesite-basalts, lime stones and conglomerates. These rocks are covered by weathered talus prolluvial sediments – 3-5m thick. Alluvial sediments are not very well developed and their thickness does not exceed 2-3m.

15.2.6.4. Deved River Water Regieme and Desighn Date

The river chain is very well developed: the multiple inflows flow from the both sides and create a relief by creating a significant deformation on the middle flow of the river.

The water regime is well investigated. Water horizons start rising in March and continue doing do till mid-July. Inundation process is characterized by number of peaks and lows while the rise period is shorter than the fall period. He annual peak takes place in second half of April or beginning of May.

The drought period on river Debed starts from July and lasts till March. The winter drought is lower that summer-autumn one, the same concerns river level and amplitude. The river has a mixed feeding: rain, ground water and snow. The periodical observations of water discharge on Debed is carried out from several points.

The average flow data and annual distribution of SHPPs the data from r. Marciget=Tumanyan and r. Alaverdi-Alaverdi water meter stations are used by restoring the natural flow of the river. Marciget Toumanyan wate meter station is the analogue for Marciget River and its inflows while Alaverdi-Alaverdi station for design section of Snogh, Akhtala rivers' SHPPs.

The table 49 shows the hydrological descriptions that were used for analogue SHPP design river sections.

Table. 49. Hydrological descriptions for observation points

NN	River-Observation Point	Distance from the river mouth, km	Catchment are of the basin km^2	Average altitude, m	Observation time	Flow norm	
						Water discharge, m^3/sec	Flow Module, l/sec, km^2
1.	Marciget-Toumanyan	0.03	251	1720	1938 working		
2.	r. Alaverdi-Alaverdi	0.80	36.0	1570	1960-1980	0.26	7.2

Annual flow distribution based on the data of R. Marciget-Toumanyan and r. Alaverdi-Alaverdi water meter stations for characteristic years is shown on the table 50.

Table. 50. Annual flow distribution according to rivers m3/sec

years	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	average
1. Marciget-Toumanyan													
Water abundant – 25%													
1983	0.61	0.30	2.10	3.93	7.14	5.84	3.61	3.30	1.95	1.46	2.18	1.43	2.82
Average – 50%													
1991	0.47	0.67	4.15	7.08	5.98	4.73	1.44	1.01	0.69	0.62	0.69	0.89	2.37
Drought — 75%													
1992.	0.74	0.52	1.44	4.41	5.01	5.11	2.29	1.02	0.80	0.78	0.57	0.53	1.94
2. r. Alaverdi-Alaverdi													
Water abundant – 25%													
1979	0.078	0.069	0.11	0.58	0.71	1.38	0.67	0.27	0.12	0.077	0.099	0.15	0.36
Average – 50%													
1973	0.075	0.065	0.087	0.39	0.28	0.91	0.37	0.083	0.073	0.081	0.083	0.096	0.22
Drought — 75%													
1971	0.034	0.042	0.18	0.86	0.25	0.24	0.078	0.057	0.056	0.045	0.035	0.038	0.12

15.2.6.5. Technical Specification for Debed River Basin SHPPs

15.2.6.5.1. Aghnidzor SHPPs

Introduction

According to development scheme it was planned to construct 2 SHPPs on Aghnidzor River. As a result of in-situ investigations it was decided to construct 2 derivational SHPP.
Aghnidzor SHPP-1 station works is located near Aghnidzor village. Aghnidzor SHPP-1 uses inclination of River Aghnidzor from 1535.0 till 1435.0. The length of derivation from Aghnidzor River is 2000m by copper pipeline 530mm in diameter with design pressure of 86.9m and design discharge 0.35m^3/sec. After construction and exploitation Aghnidzor SHPP will have 243mwt capacity and will produce 0.84mln kw/h electricity annually.

Short Description of Aghnidzor River Basin

Aghnidzor River is the left inflow of Marciget and falls into the latter 19.0km from the river mouth. General area of the catchment basin is 61km^2, river length is 14.0km, general inclination is 84%, average elevation is 1950m, and forest coverage equals 55%. The river starts from Dalidagh mountain northern side. The source is represented by small spring that starts from mountain slopes on the elevation of 2460m.

River basin in the upstream is covered by sub-alpine meadows, thick forest starts below 2000m. In the whole river basin there is only one village – Akhnidzor. Before that village the river flows in northern direction and afterwards turns to north-east and at 1280m falls into Marciget. The valley along the river length is V-shaped and the width varies 400 – 1000m.

The valley width in the lower section is 20-50m while the slope inclination is 45^{û}. The slopes, especially in the upstream are covered by bushes. There is no inundation area. The river bed is absolutely straight and cultivated while the shoreline is steep and have a well developed, 0.5-1.0m high borderline. In the upstream there are several waterfalls. The river cannot be crossed along the whole length due to steep slopes there are no bridges.

The water regime of Aghnidzor river is very much alike the water regime of Martciget river the spring inundations start at the end of March reaching their peak at the beginning April and then slowly decrease. The drought period starts at the end of June and beginning of July has stable horizons and water discharge.

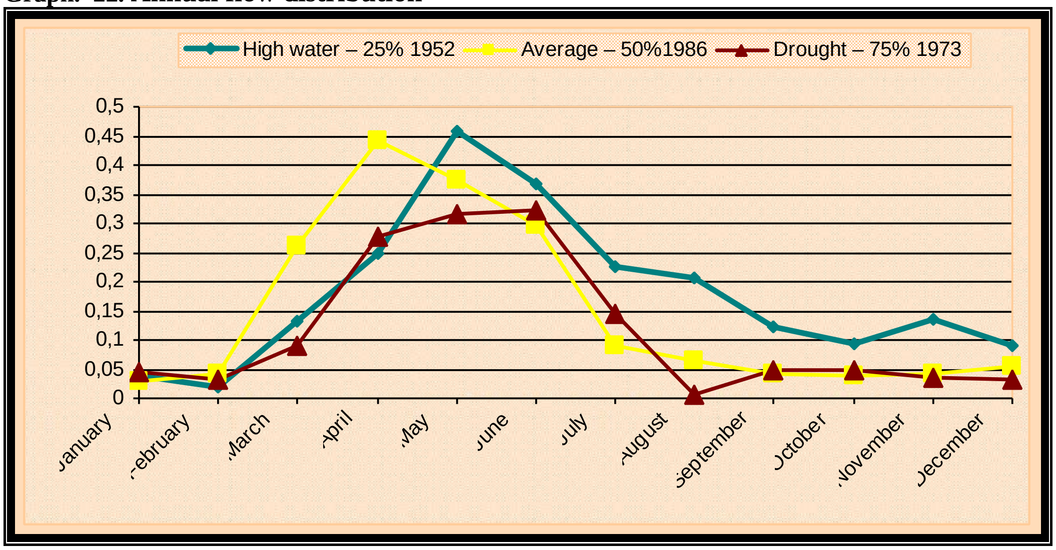
The maximal discharge of Aghnidzoris observed during spring inundations and is conditioned by snow meting together with heavy rains. The water quality is used for drinking and irrigation of cultivated areas close to the shoreline.

HYDROLOGY

The observation data from river r. Marciget-Toumanyan water-meter station is used to define the hydrological properties of Aghnidzor SHPP – 1 headworks and the design river section. In the design section of Aghnidzor SHPP – 1 the catchment area is 15.7km^2, average yearly flow value of is 0.15 m^3/sec.

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 22. Annual flow distribution



Maximal design discharge for Aghnidzor SHPP – 1 headwork river section for the general case equal 3% - 22.3m^3/sec, for verifying case - 0.5%-32.2m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.013m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Aghnidzor SHPP – 1 is 1535.0m, downstream - 1435.0m. According to data of Marz's WUA there is no water intake for irrigation or water supply from Aghnidzor River. Aghnidzor SHPP – 1 is derivational SHPP. In order not to drain the river along the 2000 meters of derivation the environmental discharge is designed according to RA laws and 0.01m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Aghnidzor SHPP – 1 are calculated with 50% guarantee per annum (1991 see table 57).

Table. 51. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Aghnidzor SHPP-1 (m^3/sec)	0.02	0.03	0.25	0.35	0.35	0.29	0.08	0.05	0.03	0.03	0.03	0.05	
SHPP average monthly capacity (mwt)	0.015	0.026	0.186	0.243	0.243	0.209	0.064	0.042	0.026	0.023	0.026	0.037	
SHPP –average monthly energy production (mln kwt/hour)	0.011	0.017	0.139	0.175	0.181	0.150	0.047	0.031	0.019	0.017	0.019	0.027	0.835

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 293.4 thousand USD (without VAT) and 352.1 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		9.7
2. Exploitation expenses		18.4
	Salary	14.4
	Renovation	2.5
	Other Expenses	1.5
Total		28.1

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		243
Average multi annual production of energy, mln kwt/hour		0.835
Capital investments into SHPPS(without VAT),		
	thousand USD	293.4
	USD / kwt	1207.6
	USD / kwt/hour	0.35
Prime cost of power production, cents/kwt hour		3.36

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:
- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

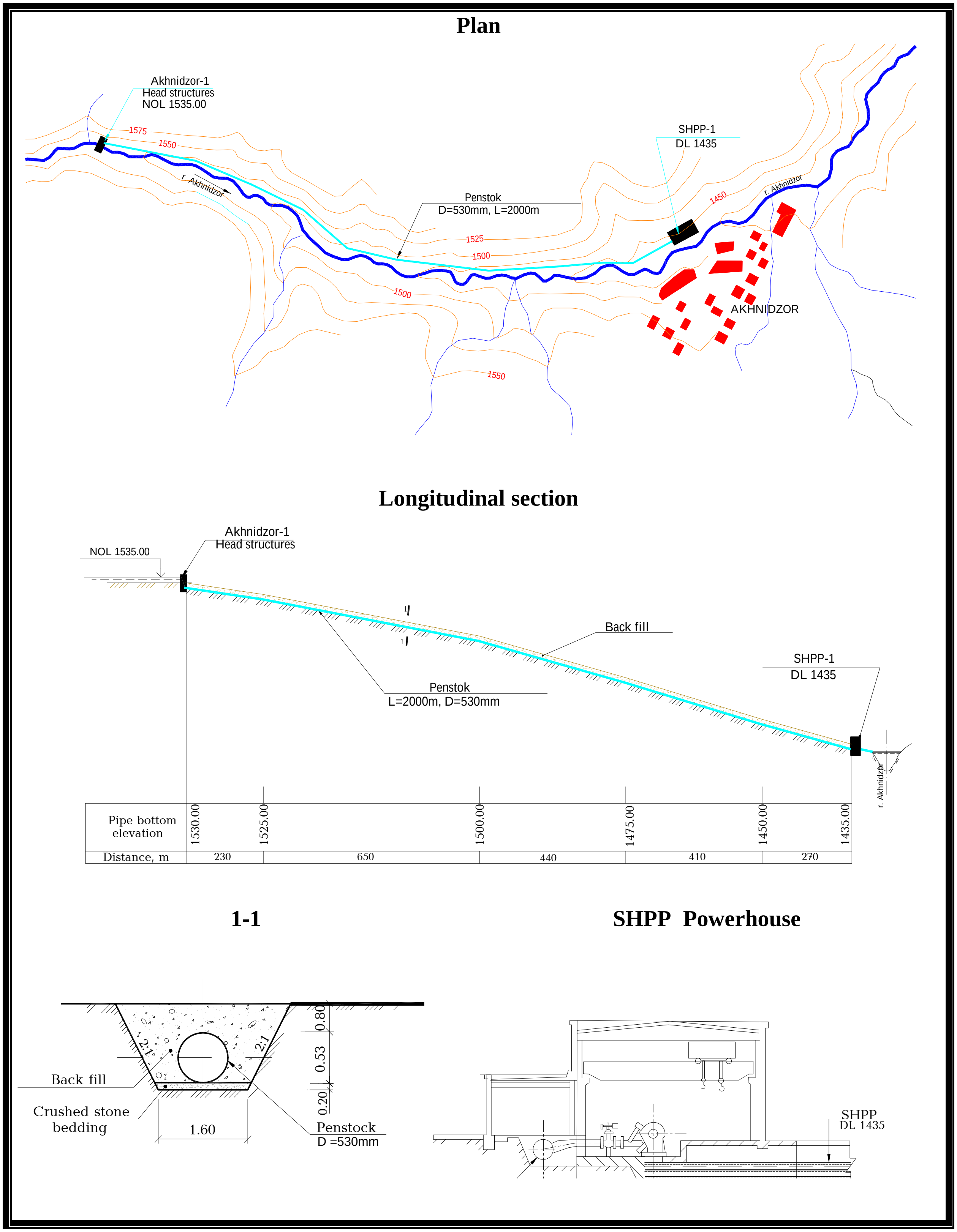
Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 52. Design results according to financial scenarios

INDICATORS		Scenario 1 100% fully self -financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		6.65	5.3
NPV, thousand USD			
	8%	-35.9	-35.9
	10%	-77.8	-51.8
	12%	-109.1	-62.1
	14%	-133.2	-68.9
PB, years (without discount)		12.8	
Deadline for credit return, years			21.3

APPENDIX. 21. AGHNIDZOR SHPP-1



15.2.6.5.2. Aghnidzor SHPP-2, Martc SHPP

Introduction

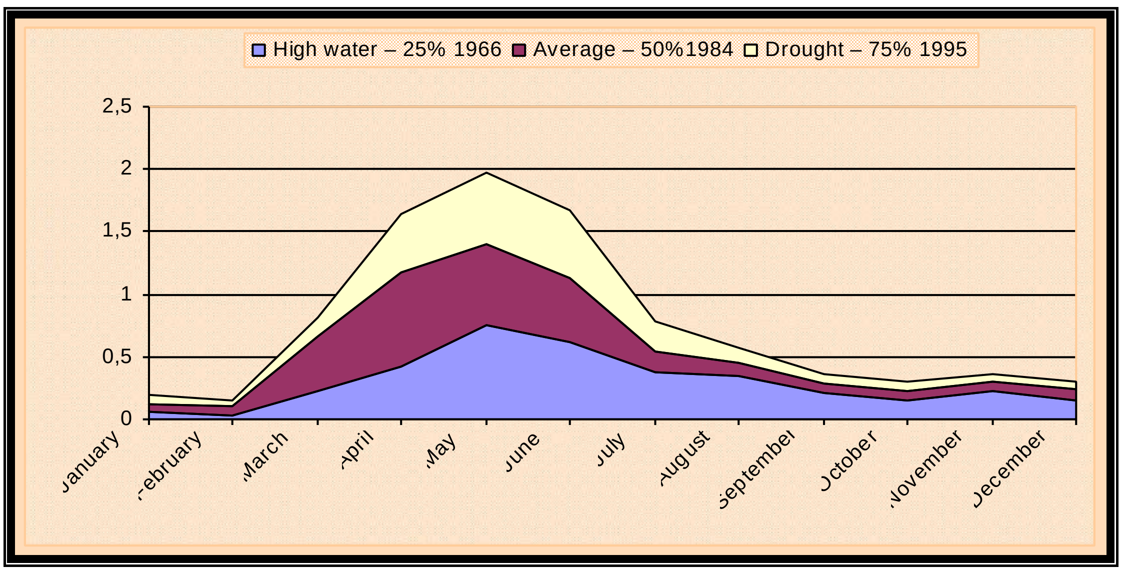
It is planned to construct 2 combined SHPPs with one station work unit on Martcidet and its inflow Aghnidzor River. Aghnidzor headworks will be located on Aghnidzor River right below Aghnidzor village, while Martc SHPP works will be located in the upstream of Martciget River. The hydroagregates of Aghnidzor SHPP-2 and Martc SHPP will be located within one station work unit.

Aghnidzor SHPP-2 uses inclination of River Aghnidzor from 1400.0 till 1300.0 while Matc SHPP – 1966-1300. The length of derivation from Aghnidzor River is 3000m by copper pipeline 720mm in diameter with design pressure of 90.0m and design discharge 0.60m^3/sec. The length of derivation from Marciget River is 2100m by copper pipeline 720mm in diameter with design pressure of 59.0m and design discharge 0.60m^3/sec. After construction and exploitation the SHPPs will have 715mwt capacity and will produce 2.332mln kw/h electricity annually.

HYDROLOGY

The observation data from river r. Marciget-Toumanyan water-meter station is used to define the hydrological properties of the SHPPs headworks and the design river section. In the design section of Aghnidzor SHPP – 2 the catchment area is 26.7km^2, average yearly flow value of is 0.25 m^3/sec.
The graphic below shows hydrological properties of design river section for Aghnidzor SHPP-2 for 3 typical years.

<u>Graph. 23. Annual flow distribution</u>



The catchment area of Marts SHPP design section is 25.8km^2, flow norm is 0.25m^3/sec.

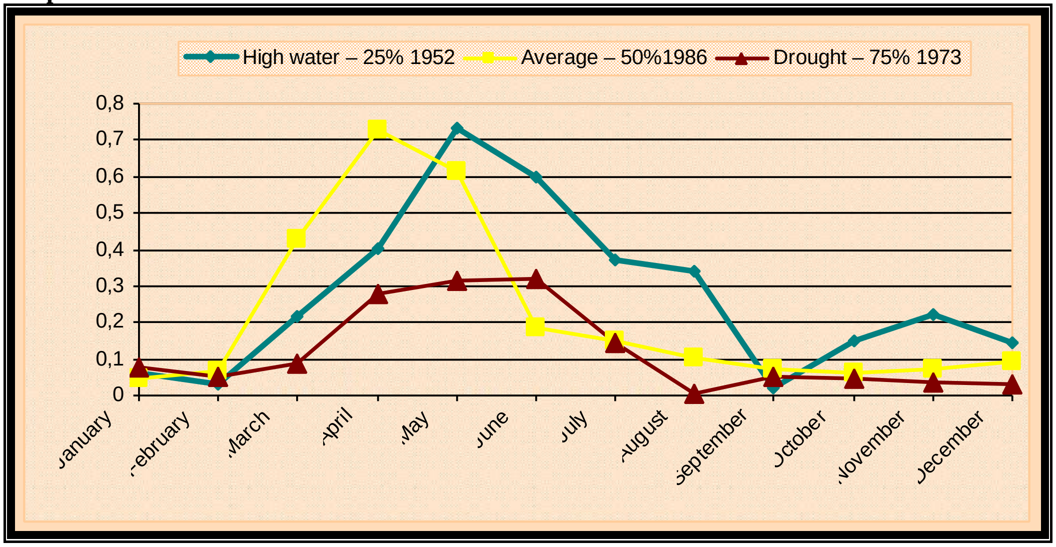
The graphic below shows hydrological properties of design river section for Marc SHPP for 3 typical years.

The SHPPs are of derivational type and are classified as type III constructions (ÑÍèÏ 2.06.01-86).

The dischage in the headwork section is the following:

Fir #1 headworks (Aghnidzor) and #2 headworks (Matciget) for the general case equal 3% - 27.6m^3/sec and 39.8 m^3/sec accordingly and for verifying case - 0.5%-27.2m^3/sec, and 39.2 m^3/sec, accordingly.

Graph. 24. Annual flow distribution for Marc River



The observed average annual discharge value for the design river sections is considered with 95% guarantee and average daily discharge is equals 0.032m^3/sec and 0.031 m3/sec, accordingly.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Aghnidzor SHPP – 2 is 1400.0m, downstream - 1300.0m; Matc SHPP is 1366m and 1300m.

According to data of Marz's WUA there is no water intake for irrigation or water supply from Aghnidzor of Martc Rivers. Aghnidzor SHPP – 2 is derivational SHPP. The pressure derivation represents a metal pipeline. In order not to drain the river along the 3000 meters of derivation the environmental discharge is designed according to RA laws and 0.024m^3/sec.

Table. 53. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Aghnidzor SHPP-2 (m^3/sec)	0.03	0.05	0.42	0.60	0.60	0.48	0.13	0.08	0.05	0.04	0.05	0.07	
SHPP average monthly capacity (mwt)	0.021	0.038	0.318	0.432	0.432	0.359	0.103	0.066	0.039	0.034	0.039	0.057	
SHPP –average monthly energy production (mln kwt/hour)	0.015	0.025	0.237	0.311	0.322	0.258	0.076	0.049	0.028	0.025	0.028	0.042	1.418

Marts SHPP derivation section along the 3000 meters has the calculated the environmental discharge is designed according to RA laws and 0.023m^3/sec.

Martc and Aghnidzor natural flow without including environmental flow values can be used for energy purposes. Hydro-power properties of Aghnidzor SHPP – 2 are calculated with 50% guarantee per annum (1991 see table 53 for Aghnidzor and Table 54 for Martc).

Table. 54. Monthly water energy indicators for Martc

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Martc SHPP(m^3/sec)	0.03	0.05	0.40	0.60	0.59	0.46	0.13	0.08	0.05	0.04	0.05	0.07	
SHPP average monthly capacity (mwt)	0.013	0.024	0.203	0.283	0.280	0.229	0.066	0.043	0.025	0.022	0.025	0.036	
SHPP –average monthly energy production (mln kwt/hour)	0.010	0.016	0.151	0.204	0.209	0.165	0.049	0.032	0.018	0.016	0.018	0.027	0.914

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 916.3 thousand USD (without VAT) and 1099.6 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	30.2
2. Exploitation expenses	34.3
Salary	23.0
Renovation	7.3
Other Expenses	4.0
Total	64.5

Power indicators of have the following level

Indicators	Values
Derivation capacity, kwt	715
Average multi annual production of energy, mln kwt/hour	2.332
Capital investments into SHPPS(without VAT),	
thousand USD	916.3
USD / kwt	1281.6
USD / kwt/hour	0.39
Prime cost of power production, cents/kwt hour	2.76

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:
- ❖ Private investments only /Scenario 1/
- ❖ 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

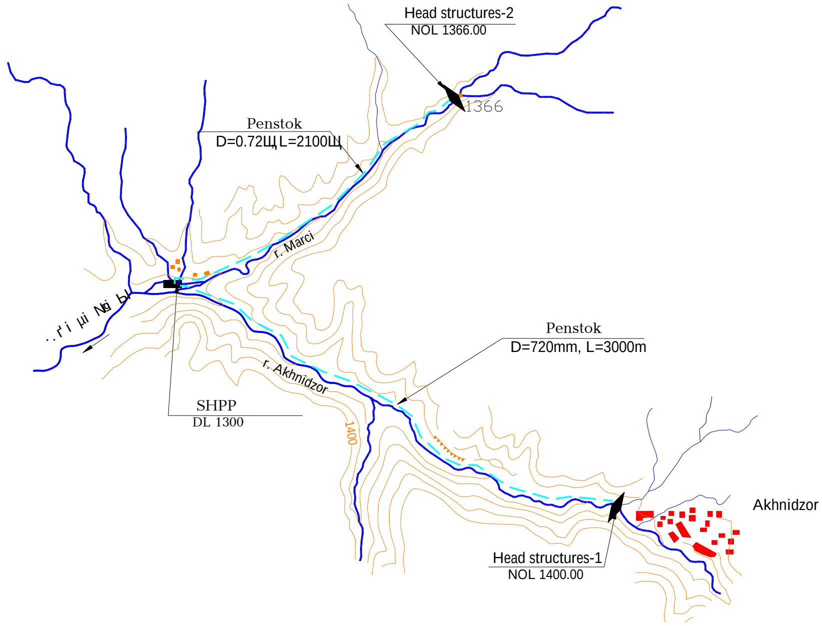
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 55. Design results according to financial scenarios

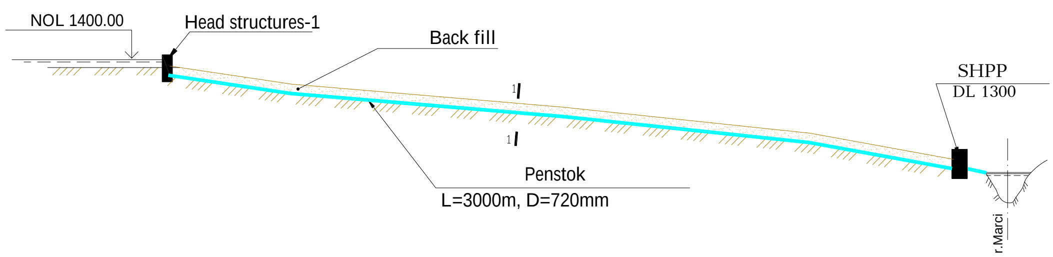
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		7.58	7.2
NPV, thousand USD			
	8%	-36.1	-36.1
	10%	-170.3	-107.4
	12%	-286.6	-154.8
	14%	-368.9	-186.8
PB, years (without discount)		11.7	18.0
Deadline for credit return, years			14.0

APPENDIX. 22.AGHNIDZOR-2 and MARTC SHPP

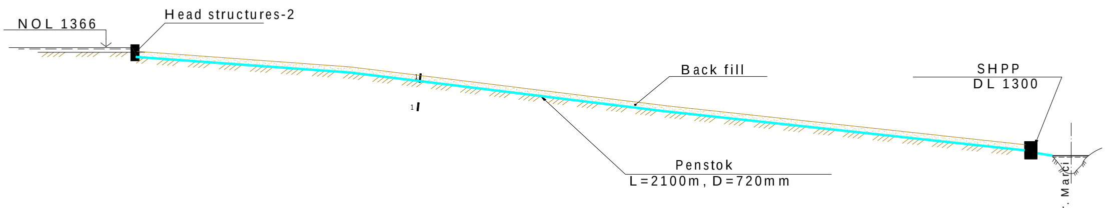
Plan



Longitudinal section-1



Longitudinal section-2



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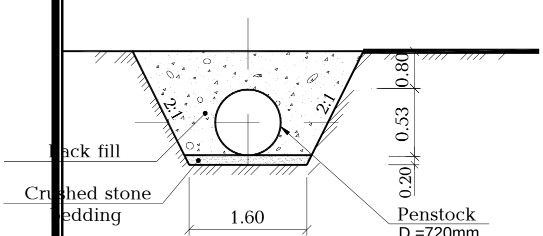
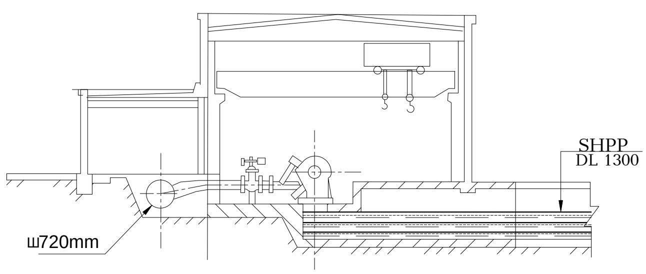


SHPP Powerhouse



15.2.6.5.3. Geghatar Gomer SHPP

Introduction

According to development scheme it was planned to construct 1 SHPP on Geghatar Gomer river. As a result of in-situ investigations the location for SHPP was specified.

Geghatar Gomer SHPP uses inclination of River Geghatar Gomer from 1485.0 till 1410.0. The length of derivation from Geghatar Gomer is 1300m by copper pipeline 630mm in diameter with design pressure of 65.4m and design discharge 0.60m^3/sec. After construction and exploitation Geghatar Gomer SHPP will have 314kwt capacity and will produce 0.60mln kw/h electricity annually.

hort Descriptionof Geghatar Gomer River Basin

Geghatar Gomer River is the left inflow of Akhnidzor River that falls into the latter 1km from the river mouth. The catchment area is 30,7km2, river length is 12km, general inclination is 90% and average height 2002m, forest area is 52%.

The river starts from eastern slopes of Airnikar Mountain (2782m), on the elevation of 2480m, from the Dzor Lake shore. The river starts from several springs on the mountain slopes which are most probably connected with the Lake. In the beginning the river has a northern direction which changes into north-western then north again and flows in that direction till the river mouth.

There are several small inflows and large springs falling into the river along the way. In the upstream the river basin is covered by sub alpine and alpine meadows, the thick forest starts form the elevation of 1900-2000m, and stretches till the river mouth.

The river valley along the length is V-shaped, its thickness is about 20-30m and in the upstream 400-800, the slope inclination is 10-450m and more. There is no inundation area along the river bed is twisting and not well cultivated in the beginning. The banks are steep with well defined borderline, 1m high. There are waterfalls in the upstream flow of the river.

Water regime is defined by inundations that starts at the second half of March, with multiple sudden peaks and downfalls, reaches its maximum in Maynad has an uneven flow. The drought takes place in August-September.

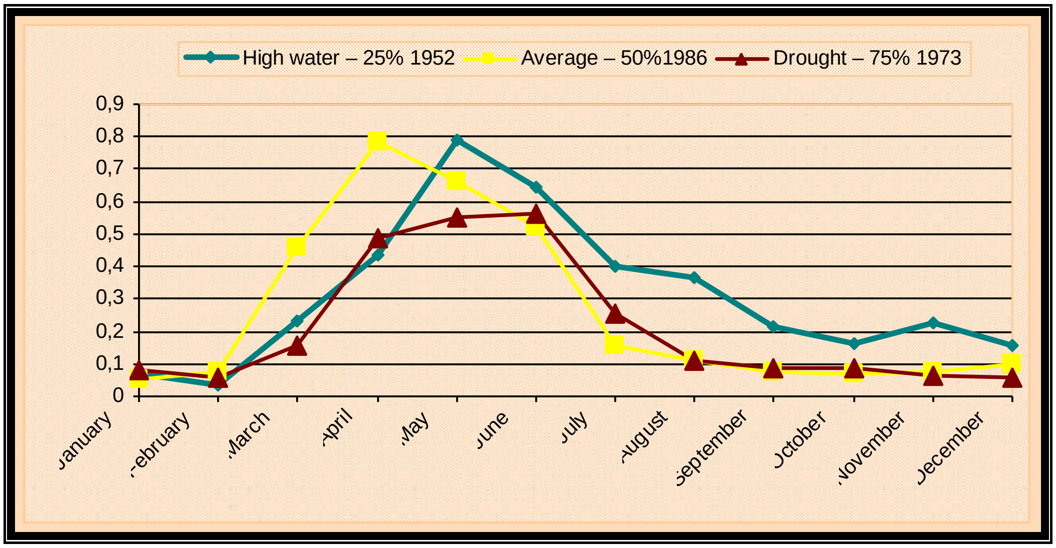
During separate years the peaks are later in July and even October. Due to multiple rains the river discharge is high and sometimes exceeds that of Akhnidzor river.

The winter regime is defined by shoreline ice in December – January. There is no ice flow in the river. Water quality is good and can be used for drinking and technical purposes.

HYDROLOGY

The observation data from river r. Martsiget - Tumanyan water-meter station is used to define the hydrological properties of Geghatar Gomer SHPP headworks and the design river section. In the design section of Geghatar Gomer SHPP the catchment area is 27.7km^2, average yearly flow value of is 0.26 m^3/sec.
The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 25. Annual flow distribution



Maximal design discharge for Geghatar Gomer SHPP headwork river section for the general case equal 3% - 28.3m^3/sec, for verifying case - 0.5%-40.4m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.033m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Geghatar Gomer SHPP is 1485.0m, downstream - 1410.0m. According to data of Marz's WUA there is no water intake for irrigation or water supply from Geghatar Gomer. Geghatar Gomer SHPP is derivational SHPP. In order not to drain the river along the 1300 meters of derivation the environmental discharge is designed according to RA laws and 0.025m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Geghatar Gomer SHPP are calculated with 50% guarantee per annum (1991 see table 56).

Table. 56. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Geghatar Gomer SHPP (m^3/sec)	0.03	0.05	0.43	0.60	0.60	0.50	0.13	0.09	0.05	0.04	0.05	0.07	
SHPP average monthly capacity (mwt)	0.016	0.029	0.242	0.314	0.314	0.272	0.080	0.052	0.031	0.026	0.031	0.044	
SHPP –average monthly energy production (mln kwt/hour)	0.012	0.020	0.180	0.226	0.234	0.196	0.059	0.039	0.022	0.019	0.022	0.033	1.061

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 337.5 thousand USD (without VAT) and 405.0 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		11.1
2. Exploitation expenses		18.6
	Salary	14.4
	Renovation	2.7
	Other Expenses	1.5
Total		29.7

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		843
Average multi annual production of energy, mln kwt/hour		2.76
Capital investments into SHPPS(without VAT),		
	thousand USD	818.0
	USD / kwt	970.3
	USD / kwt/hour	0.30
Prime cost of power production, cents/kwt hour		1.8

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

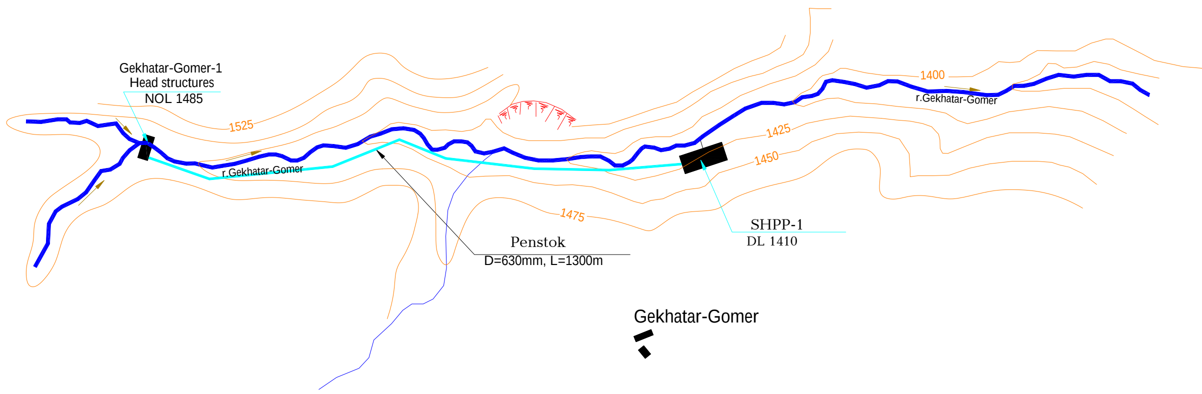
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 57. **Design results according to financial scenarios**

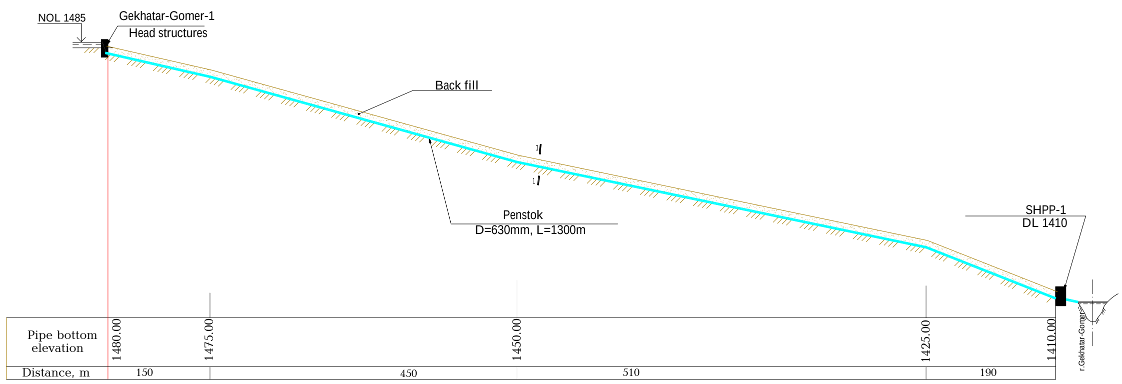
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		8.9	9.6
NPV, thousand USD			
	8%	30.3	30.3
	10%	-29.6	-6.7
	12%	-74.1	-32.0
	14%	-108.8	-49.5
PB, years (without discount)		10.3	14.7
Deadline for credit return, years			11.0

APPENDIX. 23. GEKHATAR GOMER-1 SHPP

Plan



Longitudinal section



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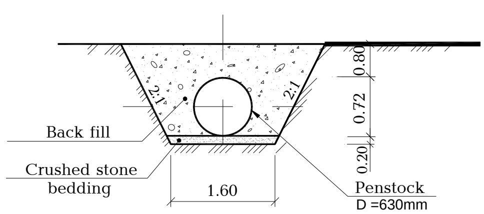
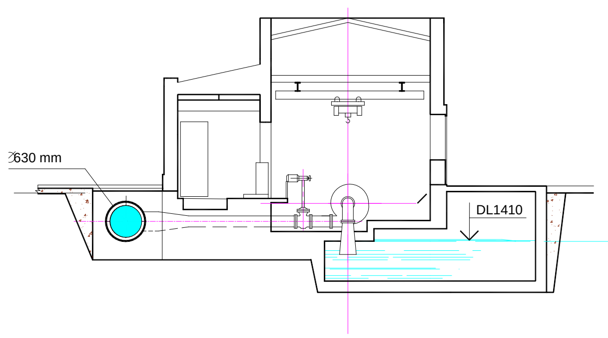


SHPP Powerhouse



15.2.6.5.4. Sarnakhbyur SHPP

Introduction

According to development scheme it was planned to construct 1 SHPPs on Sarnakhbyur River. As a result of in-situ investigations the location of headworks was determined while the station works were shifted lower till discharging into Matciget.

Sarnakhbyur SHPP uses inclination of River Sarnakhbyur from 1350.0 till 1160.0. The length of derivation from Sarnakhbyur River is 3000m by copper pipeline 820mm in diameter with design pressure of 176.4m and design discharge 1.0m^3/sec. After construction and exploitation Sarnakhbyur SHPP will have 1411kwt capacity and will produce 4.82mln kw/h electricity annually.

Short Description of Sarnakhbyur River basin

River Sarnakhbuyr is the left inflow of Marciget River, and falls into the latter 10.6km from the river mouth. The catchment area is 55.2km^2, river length is 17.0km. The rive starts to the north of Airitash peak, from 2400m. The river starts from several springs that flow from a crack on andesite –basalts.

At the beggining the river has a north-west direction till the eastern slopes of Dalibash mountain western slopes and afterwards is goes straight towards west and then north-west and north east and falls into Marciget. On its way the river receives several inflow and springs.

In the beginning on the elevation 2400-1880m the river basin is covered by thick alpine and sub-alpine meadows, after the river basin is fully covered by thick forest.

The river valley is represented by a narrow V-shaped gorge. The valley thickness in the upstream is 500-1000m, while in the downstream up to 50m,.

The slope inclination is 45^0 and more. The valley forest is composed of different trees including oak, average thickness of trees is 0.5-1m. There are some fruit trees including apple, pear and other.

The river regime is characterized by one inundation that starts at the second half of March and after multiple peaks and falls reaches its peak in May; the fall also has even flow. The Drought period starts in August-September. On separate years the inundation peaks take place in July and Even August. Due to heavy rains the river is quite water abundant.

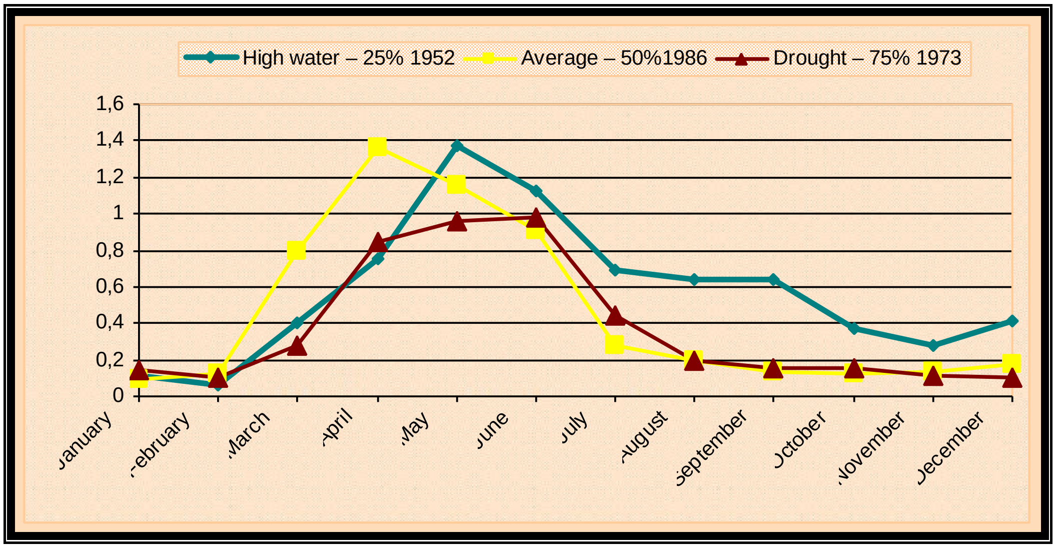
The winter regime lasts from December to January. Water quality is high, and can be used for drinking and technical purposes.

HYDROLOGY

The observation data from river r. Marciget-Toumanyan water-meter station is used to define the hydrological properties of Sarnakhbyur SHPP – 1 headworks and the design river section. In the design section of Sarnakhbyur SHPP – 1 the catchment area is 48.3km2, average yearly flow value of is 0.50 m^3/sec.
The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Maximal design discharge for Sarnakhbyur SHPP – 1 headwork river section for the general case equal 3% - 34.9m^3/sec, for verifying case - 0.5%-50.3m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.058m^3/sec.

Graph. 26. Annual flow distribution



WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Sarnakhbyur SHPP is 1350.0m, downstream - 1160.0m. According to data of Marz's WUA there is no water intake for irrigation or water supply from Sarnakhbyur River. Sarnakhbyur SHPP is derivational SHPP. In order not to drain the river along the 3000 meters of derivation the environmental discharge is designed according to RA laws and $0.04m^3$/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Sarnakhbyur SHPP are calculated with 50% guarantee per annum (1991 see table 58).

Table. 58. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Sarnakhbyur SHPP (m^3/sec)	0.05	0.09	0.76	1.00	1.00	0.87	0.24	0.15	0.09	0.08	0.09	0.13	
SHPP average monthly capacity (mwt)	0.08	0.14	1.10	1.41	1.411	1.25	0.36	0.23	0.14	0.12	0.14	0.20	
SHPP –average monthly energy production (mln kwt/hour)	0.06	0.09	0.82	1.02	1.05	0.90	0.27	0.17	0.10	0.09	0.10	0.15	4.82

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 1331.7 thousand USD (without VAT) and 1598.0 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		43.9
2. Exploitation expenses		34.9
	Salary	20.2
	Renovation	10.7
	Other Expenses	4.0
Total		78.8

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		1411
Average multi annual production of energy, mln kwt/hour		4.82
Capital investments into SHPPS(without VAT),		
	thousand USD	1331.7
	USD / kwt	943.8
	USD / kwt/hour	0.276
Prime cost of power production, cents/kwt hour		1.63

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- ❖ Private investments only /Scenario 1/
- ❖ 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

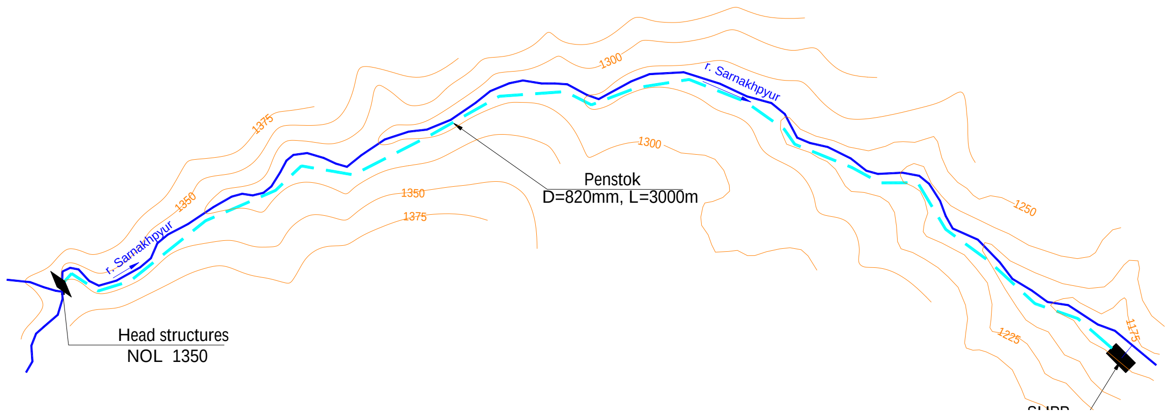
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 59. Design results according to financial scenarios

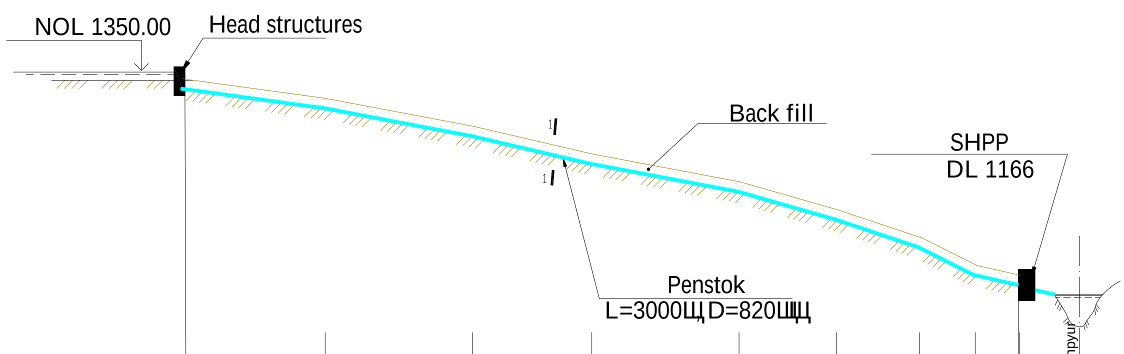
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		13.7	16.7
NPV, thousand USD			
	8%	771.1	771.1
	10%	429.0	490.4
	12%	172.7	289.4
	14%	-23.9	142.7
PB, years (without discount)		7.1	8.9
Deadline for credit return, years			7.0

APPENDIX. 24. SARNAKHBYUR SHPP

Plan



Longitudinal section



Pipe bottom elevation	1347.00	1325.00	1300.00	1275.00	1250.00	1225.00	1200.00	1175.00	1166.00
Distance, m	500	530	430	530	350	300	200	160	

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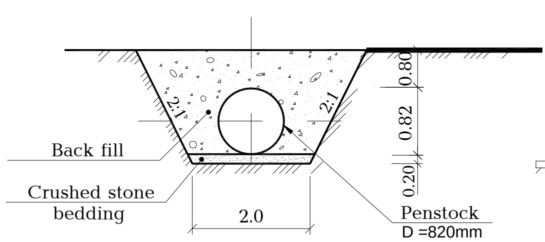
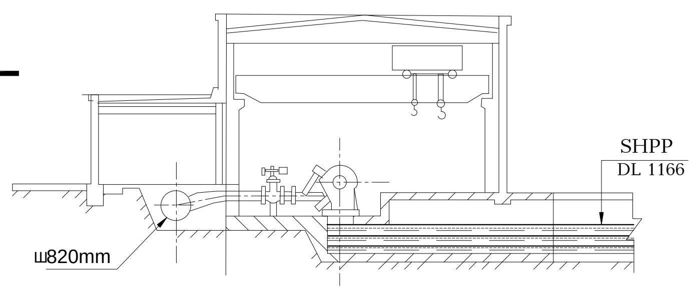


SHPP Powerhouse



15.2.6.5.5. Akhtala SHPP

Introduction

According to development scheme it was planned to construct 4 SHPPs on Akhtala river. As a result of on-situ investigations it was decided to construct 1 derivational SHPP on a particular river section.

Akhtala SHPP uses inclination of River Akhtala from 740.0 till 620.0. The length of derivation from Aghnidzor River is 2450m by copper pipeline 530mm in diameter with design pressure of 109.1m and design discharge 0.40m^3/sec. After construction and exploitation Akhtala SHPP will have 323kwt capacity and will produce 1.33mln kw/h electricity annually.

Short Description of Akhtala River Basin

Akhtala river is the left inflow of River Debed and falls into the latter 49km from the river mouth. The general water catchment area is 48.4km^2, river length is 14.0km. The river starts from Lalvar peak -1587m.

The river basin is composed of volcanic rock types that are covered by skeleton lands. The whole river valley is covered by forest. The forest is mainly deciduous with different tree types.

The river stars from different springs that multiply as the river flows further and in 2km an inflow falls into it after which water volumes of the river doubles.

The river valley is not cultivated at the beginning and has gently slopes with 20-30^0 inclination. Afterwards, the river goes deeper and flows along a deep gorge there borders are well defined as the depth is 50-60, width- no more than 20m, and length is 3km.

Near village Akhtala slope inclination decreases, becomes wider and merges with surrounding relief. Near the river mouth the river flows along a wide inundation part. The length of inundation area is 2km form the river mouth; it is double sided and is inclined towards the river. The width is 40-50m.

River regime has heavy inundations conditioned by melting snow or rains, there is a drought period during summer and winter period there are moderate rain floods in autumn. The inundation starts in March and ends in June and lasts no more than 100 days.

During the drought period the flow strictly diminishes and only in autumn as a result of rains the water becomes muddy and the flow becomes heavier.

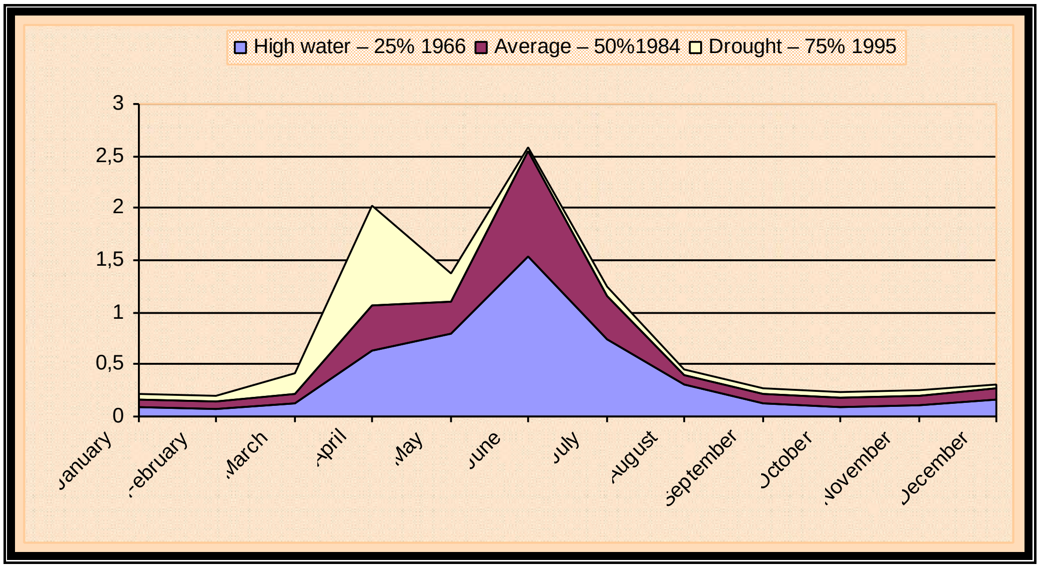
In winter the flow strictly diminishes and never ends. The horizons vary within 0.5-1.5m, and during rain floods the river rises for 0.2-0.3m. There are no winter phenomena in the river. There is occasional shoreline ice.

HYDROLOGY

The observation data from river r. Marciget-Toumanyan water-meter station is used to define the hydrological properties of Akhtala SHPP headworks and the design river section. In the design section of Akhtala SHPP the catchment area is 401km^2, average yearly flow value of is 0.25 m^3/sec.

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 27. Annual flow distribution



Maximal design discharge for Akhtala SHPP headwork river section for the general case equal 3% - 51.5m^3/sec, for verifying case - 0.5%-97.6m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.0168m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Akhtala SHPP is 740.0m, downstream - 620.0m. According to data of Marz's WUA there is no water intake for irrigation or water supply from Akhtala River. Akhtala SHPP is derivational SHPP. In order not to drain the river along the 2450 meters of derivation the environmental discharge is designed according to RA laws and 0.013m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Akhtala SHPP are calculated with 50% guarantee per annum (1973 see table 60).

Table. 60. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Akhtala SHPP (m^3/sec)	0.071	0.059	0.084	0.400	0.299	0.400	0.399	0.079	0.068	0.077	0.079	0.094	
SHPP average monthly capacity (mwt)	0.068	0.057	0.080	0.323	0.261	0.323	0.322	0.076	0.065	0.074	0.076	0.090	
SHPP –average monthly energy production (mln kwt/hour)	0.051	0.038	0.060	0.232	0.194	0.232	0.240	0.056	0.047	0.055	0.054	0.067	1.33

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 381.1 thousand USD (without VAT) and 457.3 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		12.6
2. Exploitation expenses		17.0
	Salary	12.0
	Renovation	3.0
	Other Expenses	2.0
Total		29.6

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		323
Average multi annual production of energy, mln kwt/hour		1.83
Capital investments into SHPPS(without VAT),		
	thousand USD	381.1
	USD / kwt	1204.6
	USD / kwt/hour	0.29
Prime cost of power production, cents/kwt hour		2.23

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

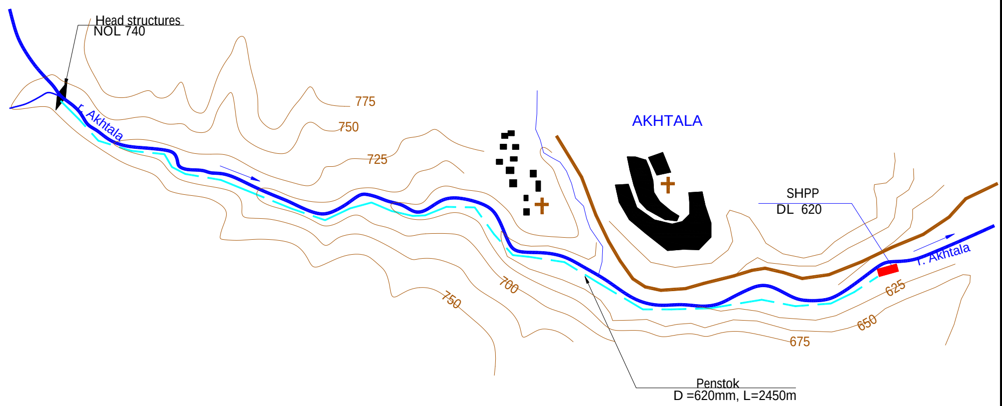
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 61. Design results according to financial scenarios

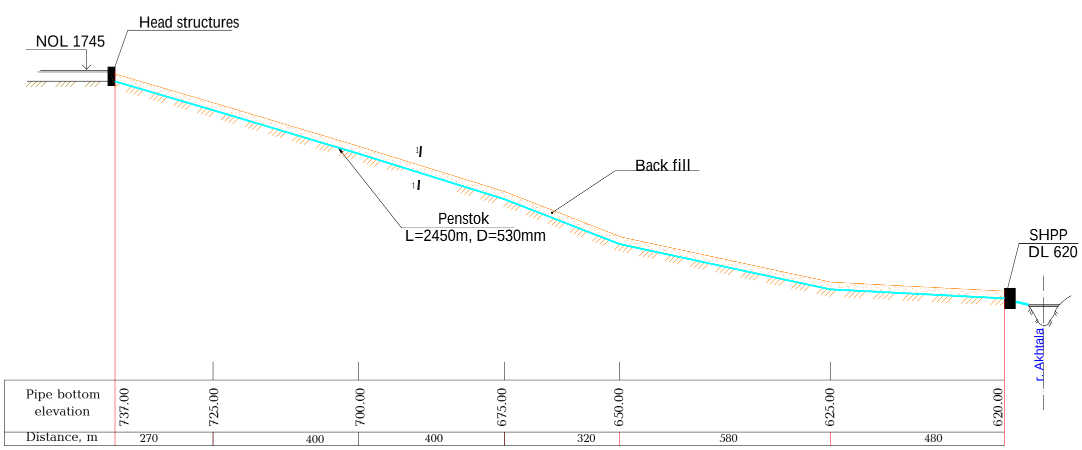
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		11.5	13.3
NPV, thousand USD			
	8%	132.3	132.3
	10%	48.8	68.2
	12%	-13.8	22.9
	14%	-61.8	-9.6
PB, years (without discount)		8.4	10.7
Deadline for credit return, years			8.0

APPENDIX. 25. AKHTALA SHPP

Plan



Longitudinal section



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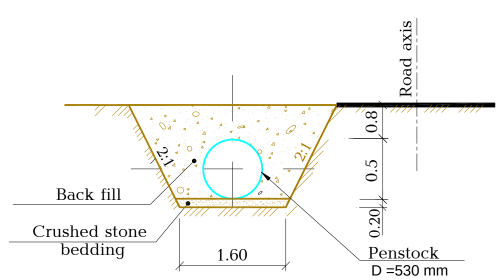
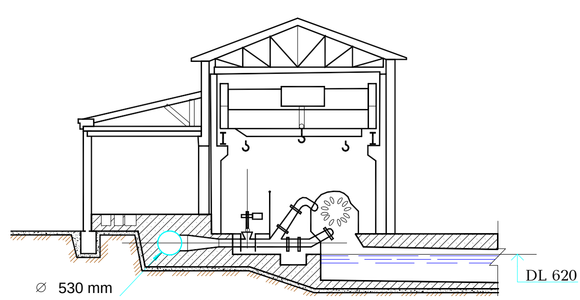


SHPP Powerhouse



15.2.6.5.6. Alaverdi SHPP

Introduction

According to development scheme it was planned to construct 2 SHPPs on Alaverdi River. As a result of in-situ investigations it was decided to construct 1 derivational SHPP.

Alaverdi SHPP uses inclination of River Alaverdi from 885.0 till 740.0. The length of derivation from Alaverdi River is 1650m by copper pipeline 430mm in diameter with design pressure of 130.0m and design discharge 0.24m^3/sec. After construction and exploitation Alaverdi SHPP will have 249 kwt capacity and will produce 0.84mln kw/h electricity annually.

Short Description for Alaverdi River

Alaverdi river is the left bank inflow for Debed River and falls into it 65km from the river mouth. The catchment are of the basin is 36.0km^2, river length is 10.3km. Alaverdi River starts from a group of springs that flow from underneath mountain rock types eastern slope Lalvar mountain (2556m). The river basin is composed of mountain rock types that are covered by skeleton lands. There are multiple small springs in the basin that fall into the river. The upper section of the basin is covered by meadows and below on the elevation of 1700m there is a thick forest, mainly composed of oak trees and many fruit trees.

The forest ends below 1000m and gardens, private lads and cultivated areas start. River valley is a V-shaped gorge which is the continuation of surrounding mountainous territory. The slope inclination is 30-450 degrees. The slopes are covered by grass then by forest till go down till the river bed. After the 7th km of the flow the forest ends and slopes become naked. There are copper mines. There is no inundation area. The river bed is straight , covered by rounded stones. River slopes are high (0.5-1.0m) and very steep. The rive banks and river bed are composed of stones of different degree of polishing and different sizes.

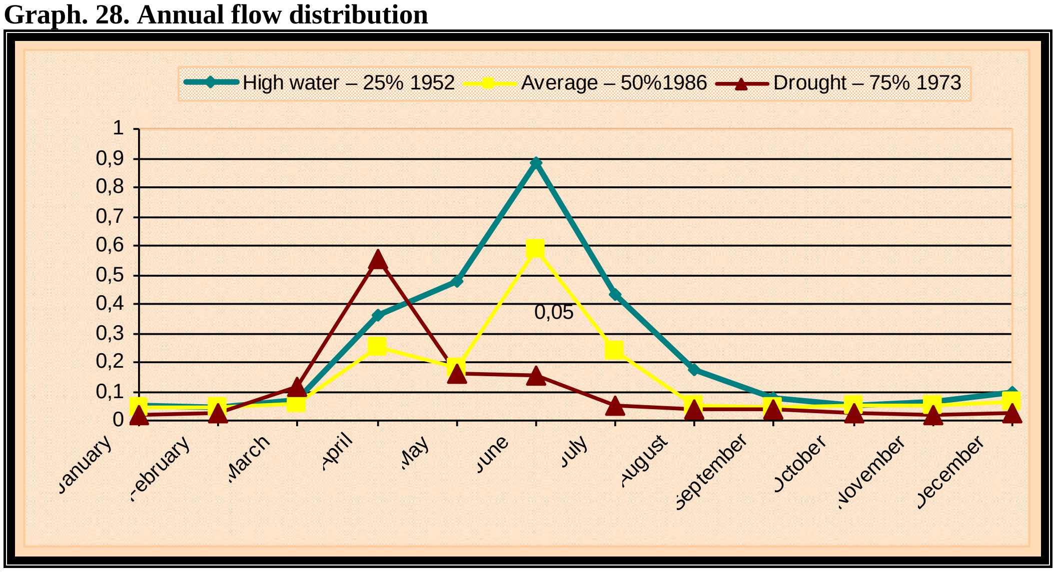
The river regime is characterized by short term, strong inundations 90-100days (April-June) and drought period interrupted by short term rain floods. This results in constant variation of water horizon's. The glacier phenomena are not very often and are well defined only by shoreline ice in the upper streams.

HYDROLOGY

The observation data from river r. Alaverdi-Alaverdi water-meter station is used to define the hydrological properties of Alaverdi SHPP headworks and the design river section. In the design section of Alaverdi SHPP the catchment area is 23.1km^2, average yearly flow value of is 0.15 m^3/sec.

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 28. Annual flow distribution



Maximal design discharge for Alaverdi SHPP headwork river section for the general case equal 3% - 41.2m^3/sec, for verifying case - 0.5%-78.0m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.097m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Alaverdi SHPP is 885.0m, downstream - 740.0m. According to data of Marz's WUA there is no water intake for irrigation or water supply from Alaverdi River. Alaverdi SHPP – 1 is derivational SHPP. In order not to drain the river along the 1650 meters of derivation the environmental discharge is designed according to RA laws and 0.007m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Alaverdi SHPP – 1 are calculated with 50% guarantee per annum (1973 see table 62).

Table. 62. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Alaverdi SHPP (m^3/sec)	0.041	0.035	0.049	0.240	0.173	0.240	0.230	0.046	0.040	0.045	0.046	0.055	
SHPP average monthly capacity (mwt)	0.047	0.040	0.057	0.249	0.190	0.249	0.241	0.053	0.046	0.052	0.053	0.063	
SHPP –average monthly energy production (mln kwt/hour)	0.035	0.027	0.042	0.180	0.141	0.180	0.180	0.040	0.033	0.039	0.038	0.04	0.98

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 287.9 thousand USD (without VAT) and 345.5 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	9.5
2. Exploitation expenses	15.8
Salary	12.0
Renovation	2.3
Other Expenses	1.5
Total	25.3

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		249
Average multi annual production of energy, mln kwt/hour		0.98
Capital investments into SHPPS(without VAT),		
	thousand USD	287.9
	USD / kwt	1156.3
	USD / kwt/hour	0.29
Prime cost of power production, cents/kwt hour		2.58

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

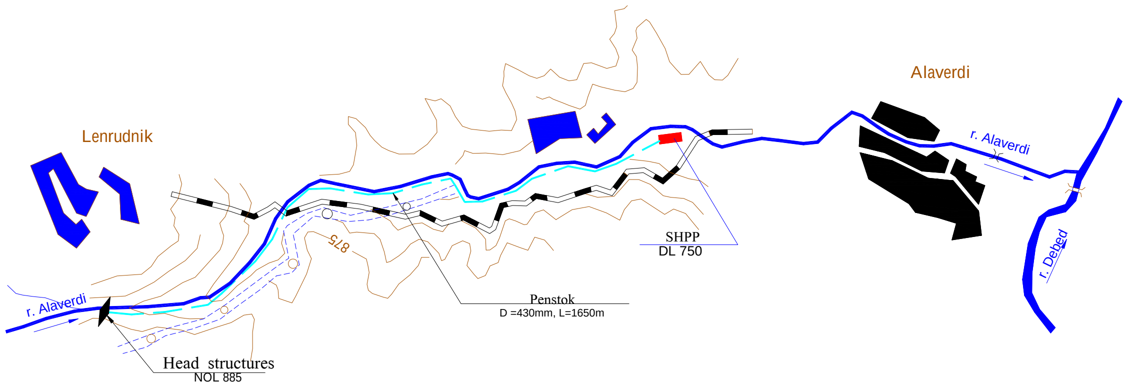
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 63. Design results according to financial scenarios

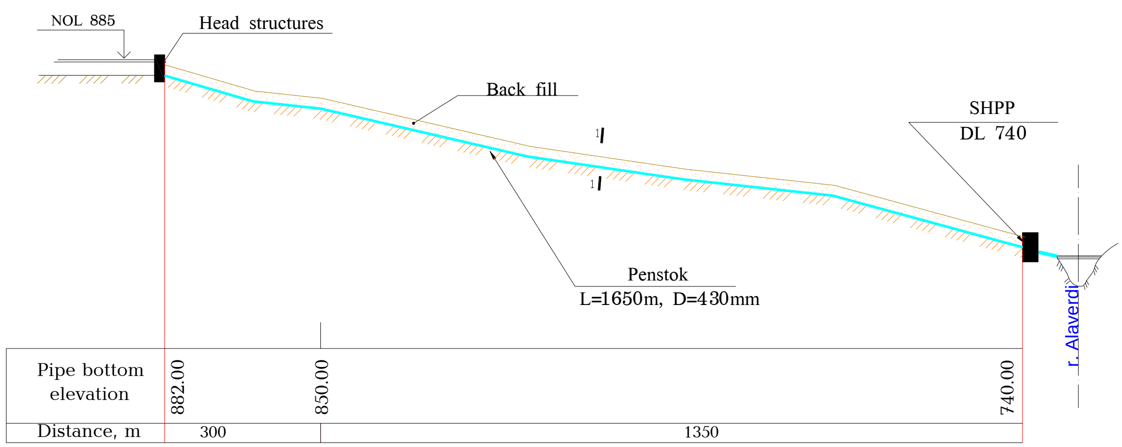
INDICATORS		**Scenario 1** 100% fully self - financed option	**Scenario 2** 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		10.2	11.6
NPV, thousand USD			
	8%	63.0	63.0
	10%	5.9	23.2
	12%	-36.9	-4.5
	14%	-69.7	-24.0
PB, years (without discount)		9.2	12.5
Deadline for credit return, years			10.0

APPENDIX. 26. ALAVERDI SHPP

Plan



Longitudinal section



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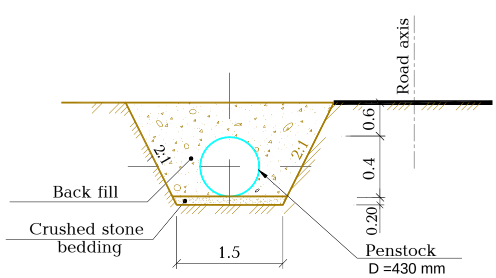
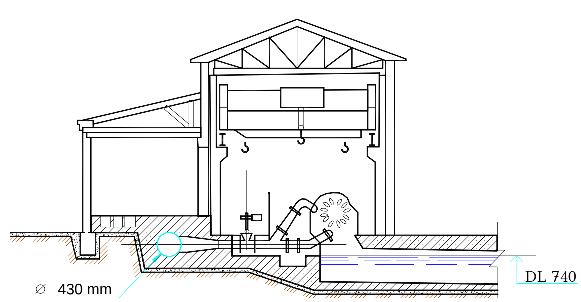


SHPP Powerhouse



15.2.6.5.7. Shnokh SHPP

Introduction

According to development scheme it was planned to construct 2 SHPPs on Shnokh river. As a result of in-situ investigations it was decided to construct 1 derivational SHPP after Shnokh and Gyulab rivers mix.

Shnokh SHPP uses inclination of River Aghnidzor from 1050.0 till 850.0. The length of derivation from Shnokh River is 1350m by copper pipeline 630mm in diameter with design pressure of 190.9m and design discharge 0.60m^3/sec. After construction and exploitation Shnokh SHPP will have 916kwt capacity and will produce 3.43mln kw/h electricity annually.

Short Description of Shnokh River Basin

Shnokh River is the upstream inflow of Debed river, and falls into the latter 48km from the river mouth. Thecatchment area is 116km, river length is 13km. Shnokh river starts from the western slopes of Papakar mountain chain, near Dzikatar mountain (1656m). The river has two inflows: Gulyab and Teghut. The river basin is represented by mountainous location with multiple inflows and gorges, composed of clay earth and mountain rock types. Almost the whole basin is covered by thick forest. The river plateau is represented by a narrow V-shaped gorge. The valley sloped are high, inclined (20-45^0), occasionally steep with small gorges through which spring waters fall into the river.

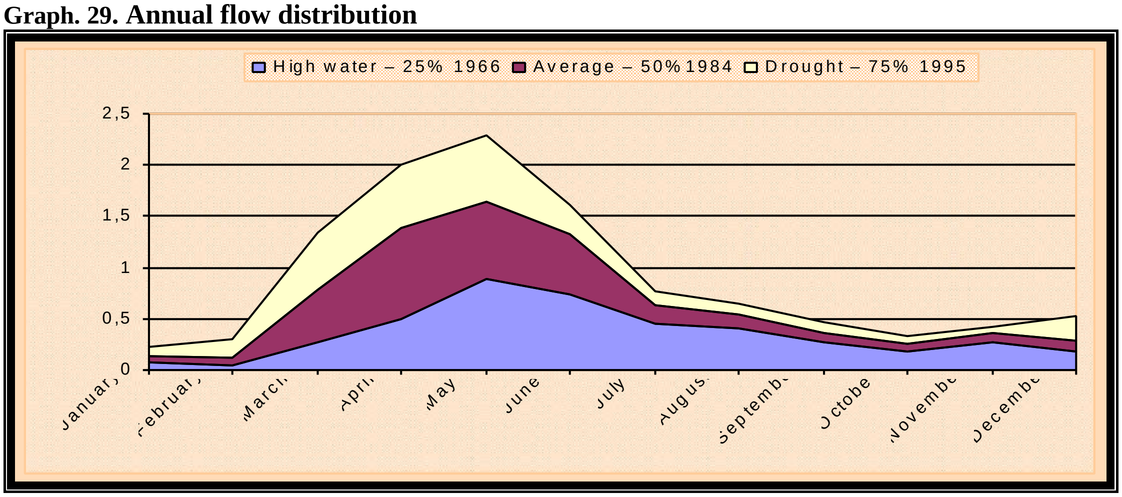
Above 900m the slopes are covered by thick forest, tree diameter is 0.3-1.0m. Below 900m the slopes are covered by fruit gardens and different cultures. Uncultivated lands are indicated by small dots and covered by meadows and are plough-lands. 3km from the river mouth the valley slopes keeping the previous inclination and elevation stand further from the river mouth create a mild ladder type relief that rises over the drought level for 1.5-3.0m.

There is an inundation area only at the river mouth for 3km, it stretches over both river banks. The inundation area is covered by large stones and rounded stones 20-30cmin diameter. Close to the river mouth the river splits into 3-4 branches that that join and then split again. Water regime is characterized by one inundation, March-June/July. In September-October there are short term rain inundations which are sometimes very internsive.

HYDROLOGY

The observation data from river r. Marciget-Toumanyan water-meter station is used to define the hydrological properties of Shnokh SHPP headworks and the design river section. In the design section of Shnokh SHPP catchment area is 31.5km^2, average yearly flow value of is 0.30 m^3/sec.
The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 29. Annual flow distribution



Maximal design discharge for Shnoch SHPP headwork river section for the general case equal 3% - 29.4m^3/sec, for verifying case - 0.5%-42.3m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.013m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Shnokh SHPP is 1050.0m, downstream - 850.0m. According to data of Marz's WUA there is no water intake for irrigation or water supply from Shnokh River. Shnokh SHPP is derivational SHPP. In order not to drain the river along the 1650 meters of derivation the environmental discharge is designed according to RA laws and 0.01m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Shnokh SHPP are calculated with 50% guarantee per annum (1991 see table 64).

Table. 64. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Shnokh SHPP (m^3/sec)	0.049	0.074	0.511	0.600	0.600	0.584	0.171	0.117	0.077	0.068	0.077	0.102	
SHPP average monthly capacity (mwt)	0.078	0.118	0.790	0.916	0.916	0.894	0.273	0.187	0.123	0.109	0.123	0.163	
SHPP –average monthly energy production (mln kwt/hour)	0.058	0.080	0.588	0.660	0.682	0.644	0.203	0.139	0.089	0.081	0.089	0.121	3.43

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 872.6 thousand USD (without VAT) and 10047.1 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	28.8
2. Exploitation expenses	31.2
Salary	20.2
Renovation	7.0
Other Expenses	4.0
Total	60

Power indicators of have the following level

Indicators	Values
Derivation capacity, kwt	916
Average multi annual production of energy, mln kwt/hour	3.43
Capital investments into SHPPS(without VAT),	
thousand USD	872.6
USD / kwt	952.6
USD / kwt/hour	0.254
Prime cost of power production, cents/kwt hour	1.75

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

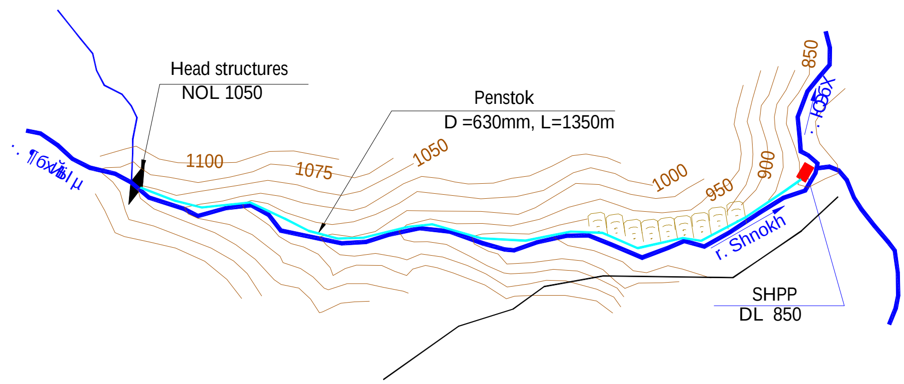
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 65. Design results according to financial scenarios

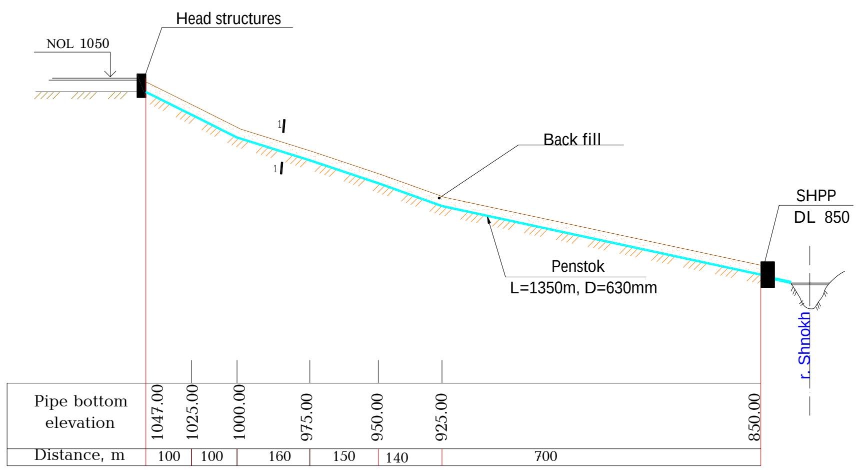
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		14.3	17.2
NPV, thousand USD			
	8%	562.0	562.0
	10%	328.6	364.5
	12%	153.8	222.2
	14%	19.6	117.8
PB, years (without discount)		6.9	8.3
Deadline for credit return, years			6.0

APPENDIX. 27. SHNOKH SHPP

Plan



Longitudinal section



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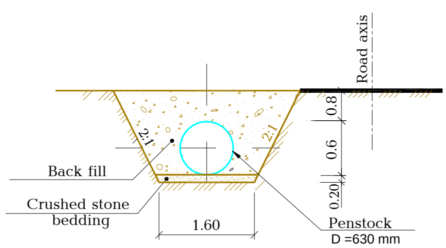
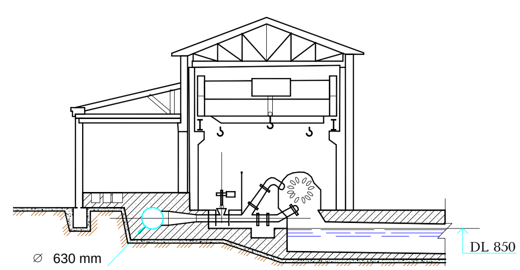


SHPP Powerhouse



15.2.6.5.8. Kachachkut SHPP-1.2

Kachachkut SHPP-1

Introduction

According to development scheme it was planned to construct 5 SHPPs on Kachachkut River. As a result of in-situ investigations it was decided to construct 2 derivational SHPP.

Kachachkut SHPP-1 uses inclination of River Kachachkut from 1270.0 till 1035.0. The length of derivation from Kachachkut River is 2200m by copper pipeline 430mm in diameter with design pressure of 227.0m and design discharge 0.15m^3/sec. After construction and exploitation Kachachkut SHPP will have 272mwt capacity and will produce 0.99mln kw/h electricity annually.

Short Description of Kachachkut River Basin

The river is the left inflow of Debed River basin and alls into it 70km from the river mouth on te distance of 70km. The catchment basin area is 55.0km^2, while the river length is 11.0km.

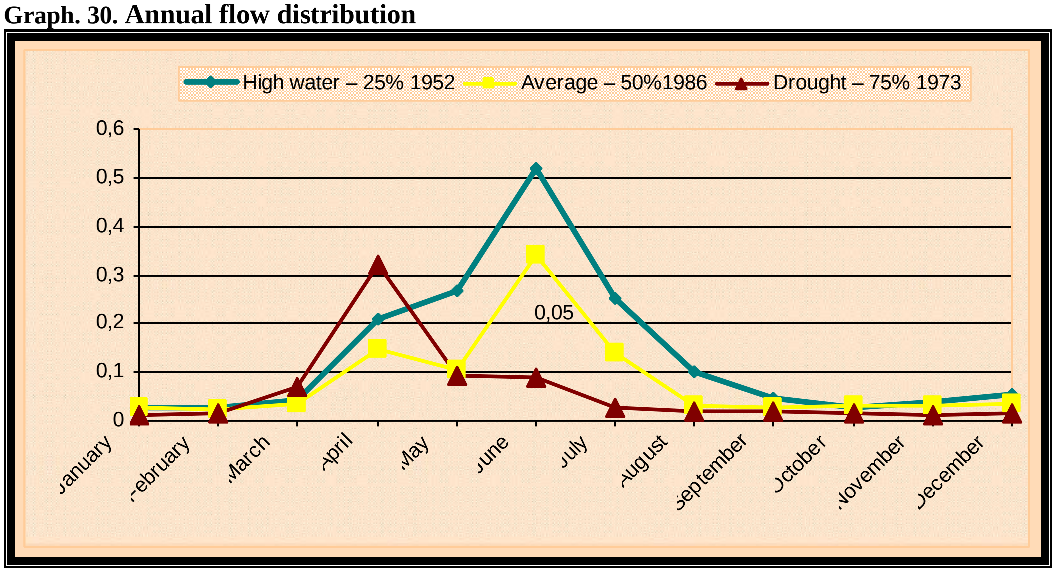
The river Kachakachut starts from the southern slopes of Leghan Mountain (2530m). The river basin is composed of volcanic rocks that are covered by skeletal soils. The basin vegetation is represented by meadows in the upstream and thick forest in the lower sections. There are various springs in the basin. The river valley is represented as a V-shaped gorge in the beginning which slopes gradually merge with surrounding mountain slopes. The slopes are steep (30-45^0), and only near river mouth their inclination slightly decreases but the gorge shape remain the same. Here the forest ends and the slopes are covered by gardens and cultivated lands.

There is no inundation are the river bed is straight not very cultivated in the beginning and5-6 km from the source it goes to the bottom of the alley getting deeper for 0.5-1m. The slopes are very steep. River Water Regime is classified as unstable. The inundation date is 100-120 days starting from the end of March till June July. The drought starts in July and lasts till March. There is almost no winter phenomenon, excluding shoreline ice that happens only during very cold winters.

HYDROLOGY

The observation data from river r. Alaverdi-Alavberdi water-meter station is used to define the hydrological properties of Kachachkut SHPP – 1 headworks and the design river section. In the design section of Kachachkut SHPP – 1 the catchment area is 13.5km^2, average yearly flow value of is 0.10 m^3/sec.
The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 30. Annual flow distribution



Maximal design discharge for Kachachkut SHPP headwork river section for the general case equal 3% - 33.2m^3/sec, for verifying case - 0.5%-63.0m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.057m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Kachachkut SHPP – 1 is 1270.0m, downstream - 11035.0m. According to data of Marz's WUA there is no water intake for irrigation or water supply from Kachachkut River. Kachachkut SHPP – 1 is derivational SHPP. In order not to drain the river along the 2200 meters of derivation the environmental discharge is designed according to RA laws and 0.004m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Kachachkut SHPP – 1 are calculated with 50% guarantee per annum (1973 see table 66).

Table. 66. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Kachachkut SHPP-1(m^3/sec)	0.024	0.020	0.029	0.142	0.101	0.150	0.135	0.027	0.023	0.026	0.027	0.032	
SHPP average monthly capacity (mwt)	0.045	0.038	0.054	0.259	0.187	0.272	0.247	0.051	0.043	0.049	0.051	0.060	
SHPP –average monthly energy production (mln kwt/hour)	0.034	0.025	0.041	0.186	0.139	0.196	0.184	0.038	0.031	0.036	0.037	0.045	0.99

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 328.5thousand USD (without VAT) and 394.2 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	10.8
2. Exploitation expenses	16.6
Salary	12.0
Renovation	2.6
Other Expenses	2.0
Total	27.4

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		272
Average multi annual production of energy, mln kwt/hour		0.99
Capital investments into SHPPS(without VAT),		
	thousand USD	328.5
	USD / kwt	1207.7
	USD / kwt/hour	0.33
Prime cost of power production, cents/kwt hour		2.76

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- ❖ Private investments only /Scenario 1/
- ❖ 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

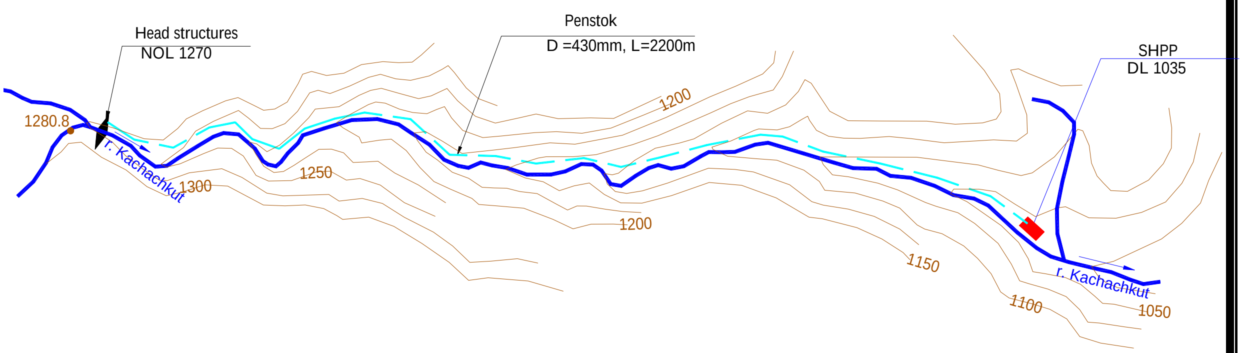
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 67. <u>Design results according to financial scenarios</u>

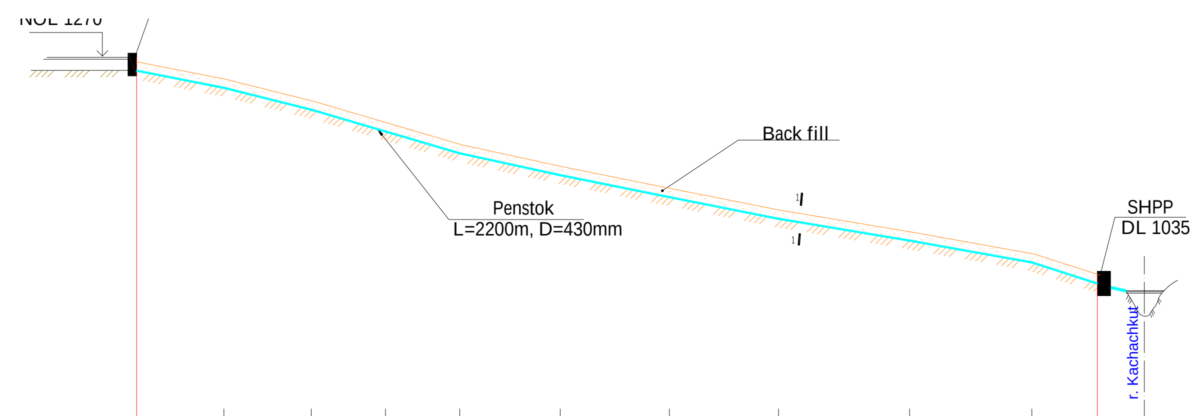
INDICATORS		**Scenario 1** 100% fully self - financed option	**Scenario 2** 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		8.7	9.2
NPV, thousand USD			
	8%	22.9	22.9
	10%	-34.3	-11.9
	12%	-77.1	-35.3
	14%	-110.0	-51.6
PB, years (without discount)		10.5	15.0
Deadline for credit return, years			12.0

APPENDIX. 28. KACHACHKUT SHPP-1

Plan

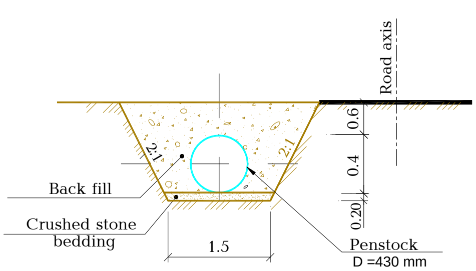


Longitudinal section

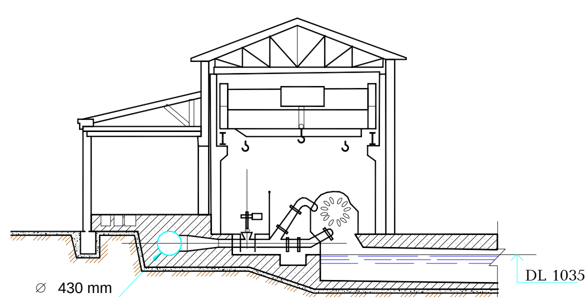


Pipe bottom elevation	1267.00	1250.00	1225.00	1200.00	1175.00	1150.00	1125.00	1100.00	1075.00	1050.00	1035.00
Distance, m	200	200	170	170	230	250	250	300	280	150	

1-1



SHPP Powerhouse



KACHACHKUT SHPP-2

Introduction

Kachachkut SHPP-2 uses inclination of River Aghnidzor from 1025.0 till 825.0. The length of derivation from Kachachkut River is 1975m by copper pipeline 430mm in diameter with design pressure of 162.1m and design discharge 0.35m^3/sec.

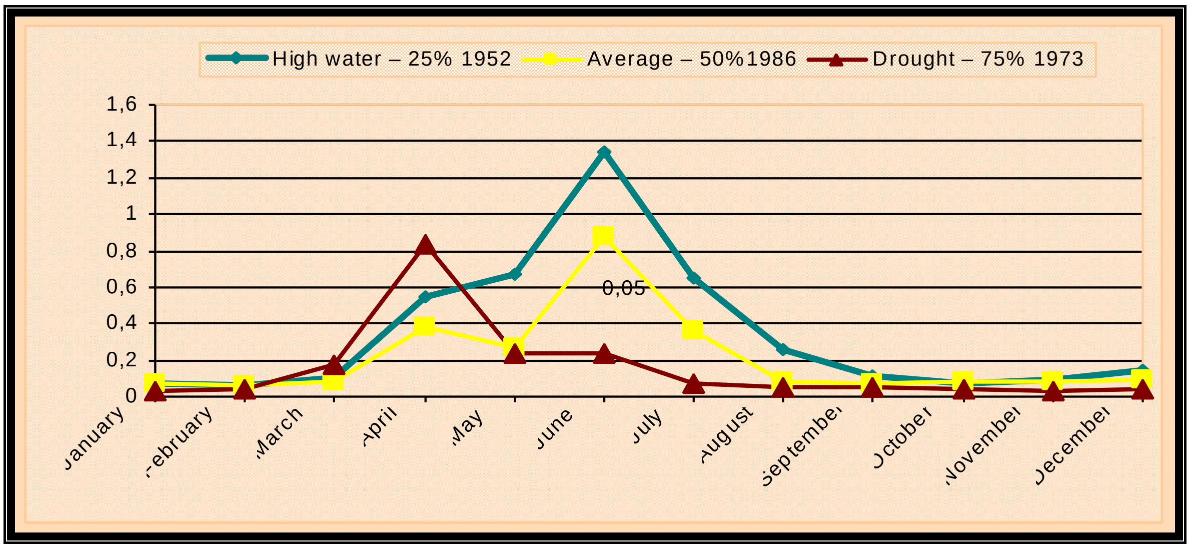
After construction and exploitation Kachachkut SHPP-2 will have 454mwt capacity and will produce 1.89mln kw/h electricity annually.

HYDROLOGY

The observation data from river r. Alaverdi-Alaverdi water-meter station is used to define the hydrological properties of Kachachkut SHPP – 2 headworks and the design river section. In the design section of Kachachkut SHPP – 2 the catchment area is 34.9km^2, average yearly flow value of is 0.22 m^3/sec.

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 31. Annual flow distribution



Maximal design discharge for Kachachkut SHPP – 2 headwork river section for the general case equal 3% - 487.8m^3/sec, for verifying case - 0.5%-92.5m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.0146m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Kachachkut SHPP – 2 is 1025.0m, downstream - 825.0m. According to data of Marz's WUA there is no water intake for irrigation or water supply from Kachachkut River. Kachachkut SHPP – 2 is derivational SHPP. In order not to drain the river along the 1975 meters of derivation the environmental discharge is designed according to RA laws and 0.011m^3/sec.

All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Kachachkut SHPP – 2 are calculated with 50% guarantee per annum (1973 see table 68).

Table. 68. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Kachachkut SHPP-2 (m^3/sec)	0.062	0.052	0.073	0.350	0.260	0.350	0.348	0.069	0.060	0.067	0.069	0.082	
SHPP average monthly capacity (mwt)	0.099	0.083	0.116	0.454	0.372	0.454	0.452	0.110	0.095	0.106	0.110	0.130	
SHPP –average monthly energy production (mln kwt/hour)	0.073	0.056	0.086	0.327	0.277	0.327	0.337	0.081	0.069	0.079	0.079	0.097	1.89

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 520.0 thousand USD (without VAT) and 624.0 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	15.6
2. Exploitation expenses	20.6
Salary	14.4
Renovation	4.2
Other Expenses	2.0
Total	36.2

Power indicators of have the following level

Indicators	Values
Derivation capacity, kwt	454
Average multi annual production of energy, mln kwt/hour	1.89
Capital investments into SHPPS(without VAT),	
thousand USD	520.0
USD / kwt	1145.0
USD / kwt/hour	0.28
Prime cost of power production, cents/kwt hour	1.92

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

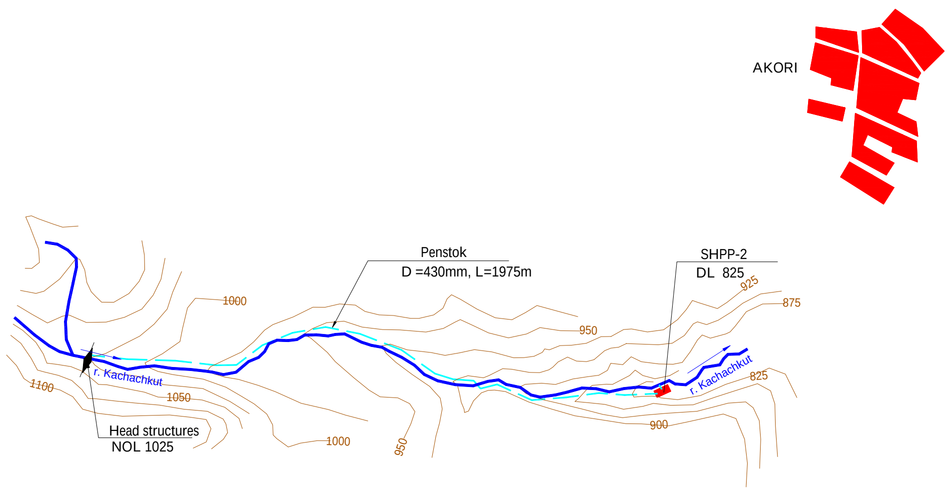
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 69. Design results according to financial scenarios

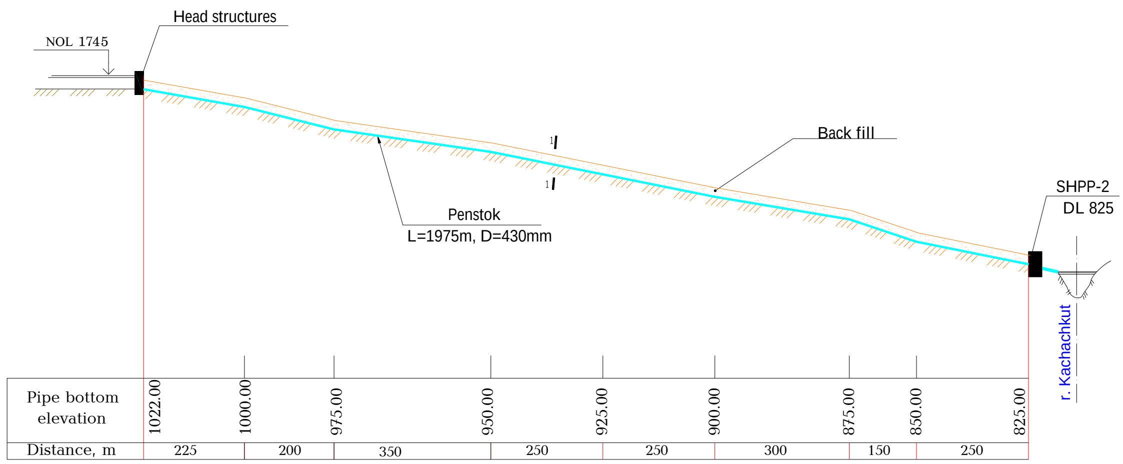
INDICATORS		**Scenario 1** 100% fully self - financed option	**Scenario 2** 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		12.6	15.2
NPV, thousand USD			
	8%	240.7	240.7
	10%	116.9	143.4
	12%	24.2	74.3
	14%	-46.9	24.3
PB, years (without discount)		7.7	9.6
Deadline for credit return, years			8.0

APPENDIX. 29. KACHACHUT SHPP-2

Plan



Longitudinal section



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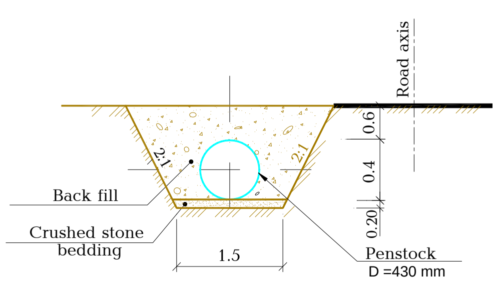
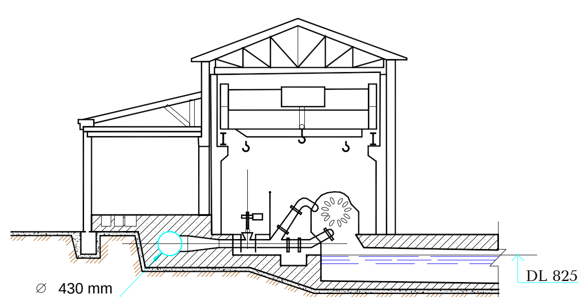


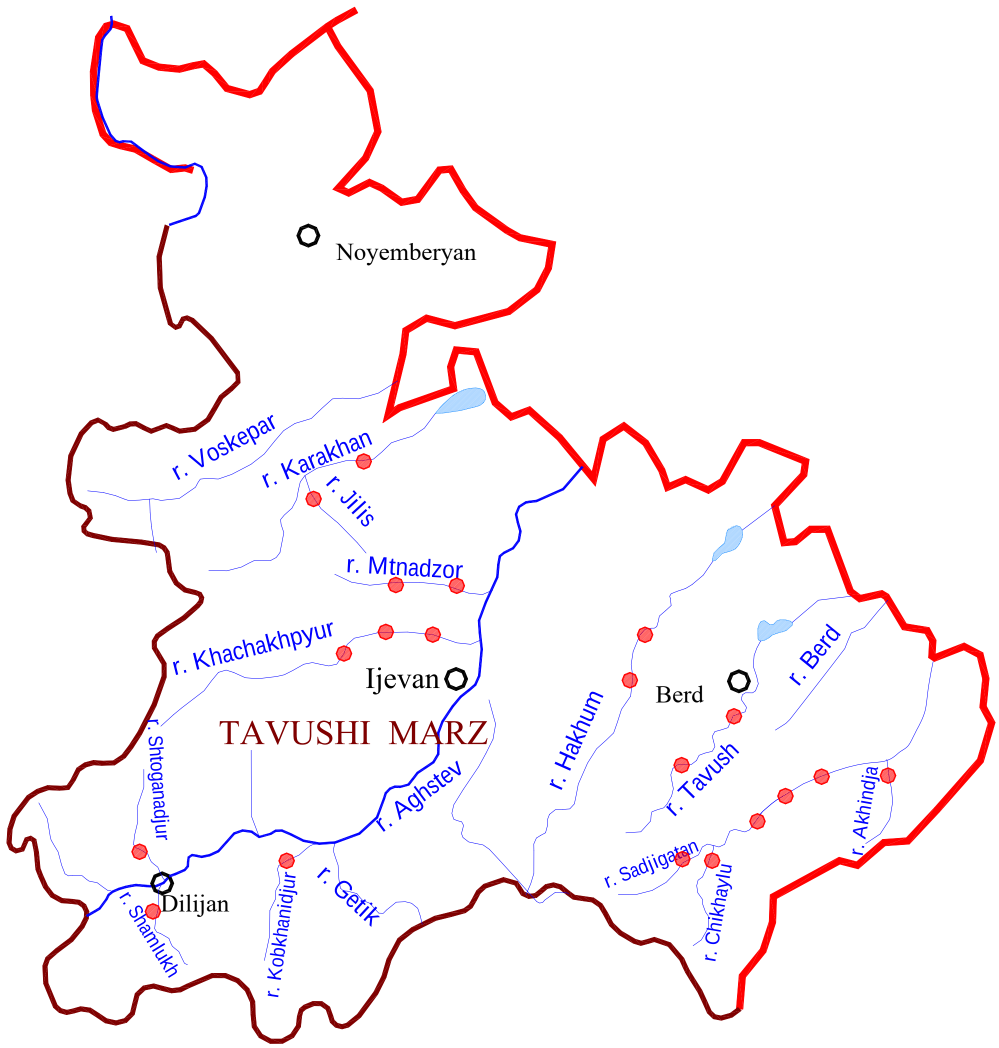
SHPP Powerhouse



PART 15.3. TAVUSH MARZ

AGHSTEV RIVER BASIN

VERIFIED AND UPDATED SCHEME FOR SHPPs



15.3.1. General Information

There are 67 SHPP to be constructed on Aghstev river basin: 3 SHPPs neat Khndzorut, Hakhum and Tavush reservoirs and 64 derivational SHPPs.

Presently Aghstev 1-6, Khachakhbur 11, Poland 1, 2, Getik 1, 2 SHPPs have the construction permission; technical –economic project is prepared for Bldan 1, 2 and Bareber 1,2 SHPPs.

The properties of unappropriated SHPPs and their technical schemes have been verified during the on situ investigations. Thus it has been decided that the SHPPs will be constructed near Hakhum and Tavush reservoirs located on Aghstev River while the construction near Khndzorut SHPP is not appropriate because there is currently being constructed an SHPP which feeds on the reservoir gravity flow.

3 SHPPs were envisaged on Hakhum River, instead, it is planned to construct one station due to the fact that there is an SHPP being constructed on the elevation of 1020m, near Akhsu farm, on 10km long water carrier. The territory from Hakhum river till Tsakhkavan village is not appropriate for construction of hydropower station.

Tavish River SHPPs are located until Berd town bridge (near water meter station) where the irrigation systems begin. 1 SHPP is planned to construct on Hakhingha River and 3 SHPP on Khndzorut till the reservoir starts.

15.3.2. Short Description for Aghstev River Basin and Climatic Conditions

River Aghstev is the largest right inflow of River Kur that falls into the river 788km from the river mouth. General catchment area of the river is 2500km^2, river length is 133km. Average inclination equals 40%, average elevation of the catchment area is 1900m, and forest territory is 28%.

River basin is located in the north-eastern part of Armenia. River basin borders with Kur river from the north, Pambak river from the east, with dividing Babakyari mountain chain, and Kur river inflow from the west, Hrazdan river and Sevan Lake basin from south.

The main flow direction is towards east and in the downstream - north east. From the administrative point of view the river basin flows through different RA marzes and the upper streams in Lori marz but the main part flows through Tavish marz.

River Aghstev is a typical mountainous river. Vegetative layer is composed of alpine meadows in the upstream and a bit bogged while the right slope is covered by forests and the right one covered by moist meadows.

The river valley is a V shaped gorge with plain slopes. It turns into a gorge in the downstream, gets deeper and slope inclination increases and only Near Fioletovo village and Dilijan city gets larger and turns into a flat meadow with 100÷150m width, 30÷40° slope inclination and stays the same till Getik river mouth. In this section it has the width 100÷120m and is occupied by fruit gardens, gardens some part is inundated during the floods.

From the climatic point of view Aghstev River basin is located in two climatic zones.

- ❖ warm long summer;
- ❖ cold winter and moist weather all year round.

Multi annual data for climatic description is presented in the table below.

#	Station	Elevation, m	Observation period	Number of observational years.
1.	Dilijan	1256	1929- working	78
2.	Ijevan	732	1929- working	78
3.	Chambarak	1831	1929- working	78

According to Dlijan, Ijevan and Chambarak meteorological stations average multi-annual air temperature varies within 5.0°C and 10.8°C, absolute minimum - (-19)-(-28)°C, absolute maximum -(+32)-(+39))°C, maximal soil freezing depth is 42-66cm.

The precipitations depend on the elevation and slope exposition. Average multi-annual precipitation quantity is 662mm in Dilijan, 590mm in Ijevan and 599mm in Chambarak. Annual precipitation maximum is 984 in Dilijan, 620mm in Ijevan and 887 in Chambarak. Monthly maximum is 195mm in Dilijan, 145mm in Ijevan, 174 in Chambarak, while the daily is 75mm in Dilijan and Ijevan and 56mm in Chambarak.

Maximal moisture content is 7.0-9.0mb, comparative moisture content is 72-74%. Average annual wind speed equals 2.2-2.8m/sec. 5% guarantee maximal wind flow is 20m/sec in Dilijan, 22m/sec in Ijevan and 15m/sec in Chambarak.

15.3.3. Geological Composition of Aghstev River Basin

The basin is quite diverse from geological point of view. There are sedimentary mountain formations, volcanic rocks of different ages, there are clays and sedimentary rocks. There are porphyrites covered with limestone layer that are in a close interconnection with diabases. Limestones start from Kuibishev village till Paghjur river mouth. There are alluvial sediments in the river basin.

Mid-Jurassic volcanic sedimentary layers are usual for Aghstev river basin. They are represented by porphyrites and andesite basalts that are weathered over the surface, cracked with small and average layers as well as andesite dacites, conglomerates and limestones.

These rocks are covered by contemporary weathered rocks, talus formations and 3-5m alluvial formations in the inundation area.

Khachakhbyur river basin has a similar composition from the geological point of view. Karakhan (Kiranc) inflow basin is composed of mid-Jurassic volcanic sedimentary rocks, porphyrites, tuff-breccias, sandy tuffs and tuff conglomerates and lime stones.

15.3.4. Design Data of Aghstev River Basin

Aghstev River basin water regime has a typical mountainous nature which is a consequence of high altitude and complicated relief. Water regime is characterized by spring floods, the decrease of water level during floods is due to melting of Pambak mountain plateau glaciers. The decrease is extremely prolonged and lasts from April-July.

The inundation peak is registered in May but a short term peak takes place in April. The observations of Aghstev river basin were carried out on the several observation points that are shown on the table 70.

Table. 70. **Design results from observation stations**

Water meter Station	Distance from the river mouth, km	Average elevation of catchment area, m	Catchment area, km^2	Operation period		0 elevation BS, m	Flow norms, m^3/sec
				open	*closed*		
Aghstev-Fioletovo	96	2081	93.4	1948	working	1653.36	1.42
Aghstev -Dilighan	89	2000	303	1948	working	1145.41	3.14
Aghstev -Ijevan	54	1800	1270	1938	working	683.49	10.1
Bldan - Dilijan	0.6	2060	73.5	1970	1987	1297.67	0.73
Shamlukh - Dilighan	0.2	1880	54.8	1960	1987	1224.74	0.60
Getik – Chambarak	42	2100	94.0	1948	working	1816.45	0.81
Getik – Alachukh	1.7	1940	581	1948	working	921.70	3.46
Paghjur –Getahovit	0.5	1710	204	1955	1988	651.46	2.04
Kirantc-Acharkut	3.5	1420	129	1959	working	735,00	1.11
Hakhum-Tsakhkavan	39	1650	169	1948	working	776.37	1.57
Hakhingha – Aygedzor	29	1630	403	1946	working	726.36	3.26
Voskepar-Voskepar	30	1530	184	1946	working	741,56	1.32
Tavush - Berd	17	1490	102	1950	working		0.83

The above mentioned data rows are used for determining average flow indicators and annual flow distribution for reconstruction of natural flow conditions. The table 71 represents annual flow distribution for typical years for Aghstev river basin.

Table. 71. Annual dostribution of Aghstev River Basin for Typical Water Abundant Years m3/sec

Years	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Average
Aghstev-Fioletovo													
Water abundant – 25%													
1950	0.86	0.63	1.86	3.27	6.99	4.48	0.22	0.54	0.48	0.71	0.60	0.54	1.77
Average – 50%													
1984	0.86	0.91	1.32	3.06	2.85	1.51	1.15	0.74	0.65	0.92	0.69	1.52	1.35
Drought – 75%													
1995	0.75	0.75	1.29	3.06	1.84	0.92	0.81	0.61	0.70	0.75	0.83	0.67	1.08
Aghstev -Dilighan													
Water abundant – 25%													
1993	1.01	1.38	2.65	9.06	12.2	6.96	2.32	1.94	1.42	1.36	1.77	1.25	3.61
Average – 50%													
1985	1.35	1.61	2.92	10.1	7.20	4.62	2.35	1.39	1.15	1.28	1.15	1.15	3.03
Drought — 75%													
1955	0.51	0.57	1.54	5.03	7.70	6.20	1.49	1.27	1.92	1.90	1.00	0.82	2.50
Aghstev -Ijevan													
Water abundant – 25%													
1968	3.20	3.25	10.6	38.9	22.3	22.7	12.6	5.60	4.77	3.60	3.20	3.12	11.2
Average 50%													
1969	2.78	2.52	6.37	34.6	39.9	9.32	4.95	3.18	3.40	3.77	2.93	3.01	9.73
Drought — 75%													
1972	1.91	2.04	4.11	17.0	22.4	21.2	8.26	4.33	4.52	3.42	3.94	2.46	7.97
Bldan - Dilijan													
Water abundant – 25%													
1978	0.06	0.34	1.36	2.74	3.23	2.61	0.43	0.19	0.10	0.13	0.09	0.08	0.95
Average 50%													
1986	0.09	0.12	0.47	1.17	2.43	2.79	0.54	0.36	0.19	0.16	0.25	0.13	0.73
Drought — 75%													
1973	0.08	0.21	0.27	1.33	1.55	1.19	0.70	0.18	0.16	0.26	0.51	0.23	0.56
Shamlukh - Dilighan													
Water abundant – 25%													
1960	0.29	0.43	0.40	2.67	1.10	0.99	0.93	0.40	0.36	0.29	0.25	0.19	0.69
Average – 50%													
1965	0.16	0.15	0.44	1.40	0.89	0.90	0.82	0.51	0.33	0.57	0.39	0.33	0.57
Drought — 75%													
1987	0.18	0.28	0.33	1.32	0.89	0.39	0.27	0.30	0.28	0.28	0.38	0.38	0.44
Getik – Chambarak													
Water abundant – 25%													
1982	0.29	0.25	0.44	4.33	1.9	1.11	0.53	0.55	0.41	0.67	0.64	0.38	0.96
Average – 50%													
1966	0.56	0.62	0.68	2.03	2.93	0.7	0.33	0.29	0.29	0.6	0.51	0.46	0.83
Drought — 75%													
1955	0.21	0.25	0.46	2.36	1.38	1.34	0.24	0.18	0.36	0.37	0.22	0.22	0.63
Getik – Alachukh													
Water abundant – 25%													
1985	1.76	1.90	3.46	18.7	9.29	4.27	2.63	1.79	1.40	1.42	0.94	1.02	4.05
Average – 50%													
1964	1.59	1.35	6.53	10.0	8.83	3.85	4.12	2.47	1.26	1.48	1.28	1.26	3.67
Drought — 75%													
2000	1.02	0.90	1.33	10.2	9.06	3.81	0.76	0.57	0.72	1.59	1.22	1.03	2.69
Paghjur –Getahovit													
Water abundant – 25%													
1978	0.20	0.86	2.11	5.82	8.22	8.86	1.58	0.87	0.51	0.39	0.38	0.34	2.51
Average – 50%													
1964	0.68	0.75	2.98	3.55	3.39	3.74	3.95	1.81	1.14	0.95	0.73	0.61	2.02
Drought — 75%													
1979	0.34	0.3	0.71	2.26	2.52	5.22	2.17	0.92	0.45	0.76	0.96	0.82	1.45

Kirantc-Acharkut													
Water abundant – 25%													
2006	0.52	0.62	2.67	3.64	2.23	1.1	0.93	0.61	0.71	0.99	0.66	0.61	1.27
Average – 50%													
1993	0.79	0.89	1.65	2.31	2.44	1.84	0.63	0.47	0.41	0.39	0.5	0.66	1.08
Drought — 75%													
1964	0.20	0.20	1.85	2.55	1.66	1.51	0.83	0.48	0.32	0.30	0.24	0.14	0.86
Hakhum-Tsakhkavan													
Water abundant – 25%													
2006	0.97	1.10	3.80	5.08	3.22	1.74	1.51	1.09	1.22	1.59	1.16	1.09	1.97
Average – 50%													
1993	1.33	1.46	2.46	3.33	3.50	2.71	1.12	0.91	0.83	0.80	0.95	1.16	1.71
Drought — 75%													
1966	0.89	0.87	0.84	2.32	5.23	1.63	0.92	0.72	0.76	0.78	0.74	0.71	1.37
Hakhingha – Aygedzor													
Water abundant – 25%													
2006	1.81	2.07	7.36	9.87	6.23	3.31	2.87	2.04	2.30	3.02	2.17	2.04	3.76
Average – 50%													
1974	0.80	0.72	2.95	9.49	5.45	3.76	2.01	3.92	6.73	1.33	1.17	0.98	3.28
Drought — 75%													
1977	0.61	1.00	1.99	4.29	7.04	8.28	2.32	1.48	1.20	1.21	1.77	0.85	2.67
Voskepar-Voskepar													
Water abundant – 25%													
1986	0.16	0.22	0.53	2.12	6.04	5.99	3.48	2.77	1.60	0.36	0.56	0.26	2.01
Average – 50%													
1981	0.25	0.32	0.50	1.26	3.70	3.13	1.60	2.08	1.44	0.43	0.30	0.20	1.27
Drought — 75%													
1967	0.23	0.20	0.46	2.58	1.56	1.87	1.03	0.45	0.63	0.33	0.78	0.56	0.89
Tavush - Berd													
Water abundant – 25%													
1960	0.11	0.66	0.63	4.75	0.60	1.21	1.89	0.46	0.31	0.29	0.27	0.25	0.96
Average – 50%													
1978	0.19	0.26	0.73	1.87	1.79	1.78	0.55	0.23	0.16	0.31	0.17	0.14	0.68
Drought — 75%													
1987	0.07	0.09	0.23	1.18	0.67	0.71	0.56	0.49	0.37	0.58	0.66	0.33	0.50

15.3.5. Technical Specifications for Aghstev River Basin SHPPs

15.3.5.1. Shamlukh SHPP

Introduction

According to development scheme it was planned to construct 2 SHPPs on Shamlukh river. As a result of in-situ investigations it was decided to construct one derivational SHPP.

Shamlukh SHPP station works will be located until the river reaches Dilijan town and 500m upstream from the river mouth.

Shamlukh SHPP uses inclination of River Shamlugh from 1425.0 till 1275.0. The length of derivation from Shamlukh River is 33250m by copper pipeline 720mm in diameter with design pressure of 135.1m and design discharge 0.70m^3/sec.

After construction and exploitation Shamlukh SHPP will have 0.756mwt capacity and will produce 2.992mln kw/h electricity annually.

Short Description for Shamlugh River Basin

Shamlugh River is the right inflow of Aghstev River and falls into the latter 89km from the river mouth. River length is 11.5km, general chatchment area is 54.5km^2, average inclination is 81.2‰, average elevation is 1880m, and forests occupy 65% of the territory.

The river starts on the elevation of 2464m. River basin is located in the northern part of Armenia. River Shamlugh is a typical mountainous river with complicated relief with multiple inflows.

The river basin has a diverse geological composition. There are many sedimentary rock formations, volcanic rocks, clays. There are porphyries with lime stone layers that are connected with diabases. There are alluvial sediments in the river basin.

Vegetative layer of the upstream is composed of alpine meadows, then bogged and forest areas the right bank is covered by forests while the left bank is moist meadows.

Soil cover is represented by sub alpine mountainous meadows, then mountainous-forest dark brown soil then mountainous black soils, there are dry prairies and brown soils in the downstream.

The river valley in the upstream is represented by not very deep V shaped gorge.

HYDROLOGY

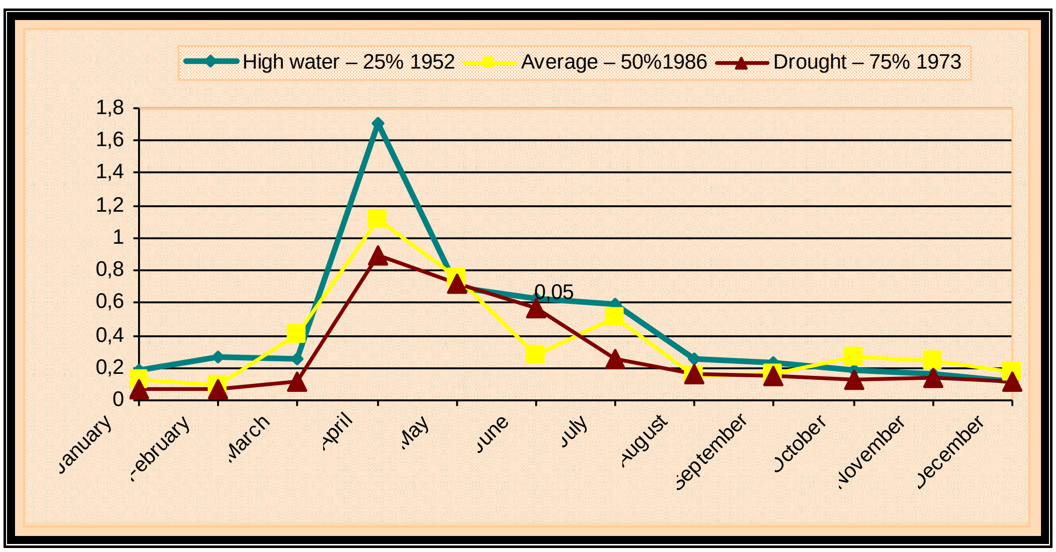
The observation data for 48 years from r. Shamlugh – Dilighan water-meter station is used to define the hydrological properties of Shamlukh SHPP headworks and the design river section.

The graphic below shows the hydrological properties of design river sections.

River Section	Distance from the river mouth, Km	Average Elevation of the Catchment Basin, m.	Catchment basin km^2	Flow Norm, m^3/sec
Shamlukh—design section	4.5	2000	35.1	0.39

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 32. Annual flow distribution



Maximal design discharge for Shamlukh SHPP headwork river section for the general case equal 3% - 15.3m^3/sec, for verifying case - 0.5%-20.9m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.032m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Shamlukh SHPP is 1425.0m, downstream - 1275.0m. According to data of State Water Economy Data there is no water intake for irrigational use from Shamlukh River. Shamlukh SHPP is derivational SHPP. In order not to drain the river where 3325m derivational pipeline is the environmental discharge is designed according to RA laws and $0.024m^3$/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Shamlukh SHPP are calculated with 50% guarantee per annum (2006 see table 72).

Table. 72. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Shamlukh SHPP (m^3/sec)	0.11	0.07	0.39	0.70	0.70	0.26	0.49	0.13	0.14	0.25	0.22	0.16	
SHPP average monthly capacity (mwt)	0.127	0.084	0.449	0.756	0.756	0.303	0.555	0.151	0.163	0.291	0.257	0.186	
SHPP –average monthly energy production (mln kwt/hour)	0.094	0.056	0.334	0.545	0.563	0.218	0.413	0.112	0.117	0.217	0.185	0.139	**2.992**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 721.3 thousand USD (without VAT) and 865.6 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	23.8
2. Exploitation expenses	26.1
Salary	17.3
Renovation	5.8
Other Expenses	3.0
Total	49.9

Power indicators of have the following level

Indicators	Values
Derivation capacity, kwt	756
Average multi annual production of energy, mln kwt/hour	2.99
Capital investments into SHPPS(without VAT),	
thousand USD	721.3
USD / kwt	954.1
USD / kwt/hour	0.24
Prime cost of power production, cents/kwt hour	1.66

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

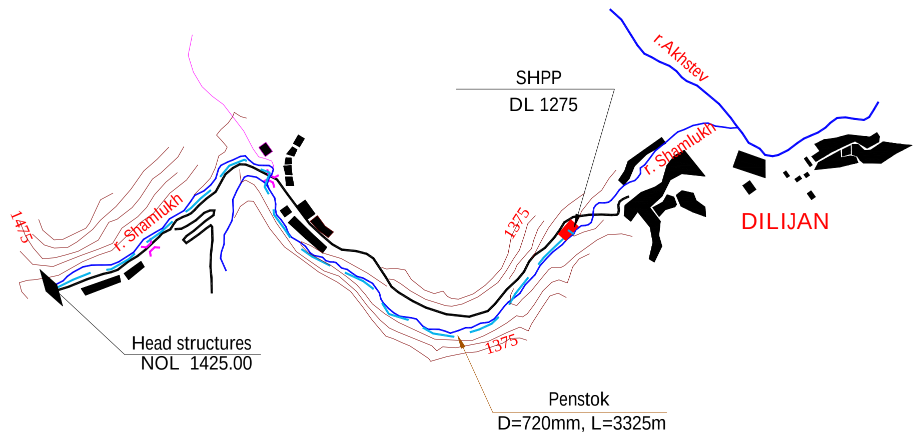
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 73. Design results according to financial scenarios

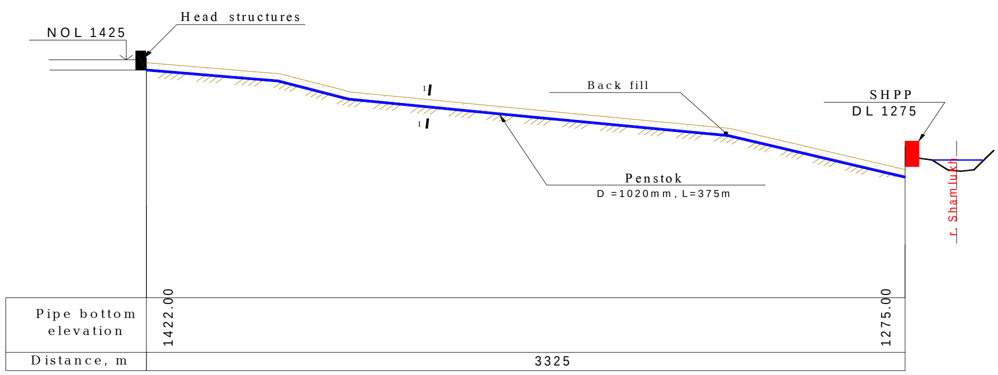
INDICATORS		**Scenario 1** 100% fully self - financed option	**Scenario 2** 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		15.2	18.8
NPV, thousand USD			
	8%	536.4	536.4
	10%	331.8	361.4
	12%	178.6	235.1
	14%	60.95	142.1
PB, years (without discount)		6.5	7.8
Deadline for credit return, years			6.0

APPENDIX. 30. SHAMLUKH SHPP

Plan



Longitudinal section



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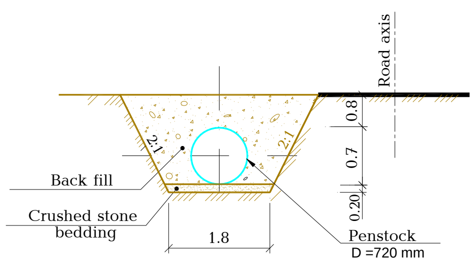
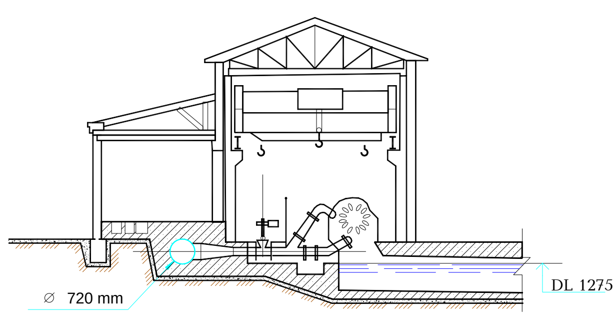


SHPP Powerhouse



15.3.5.2. Shtoganajur SHPP

Introduction

According to development scheme it was planned to construct 2 SHPPs on Shtoganaghur river. As a result of in-situ investigations it was decided to construct one derivational SHPP.

Shtoganaghur SHPP headworks will be located in the nearby of Shamakhyan village.

Shtoganaghur SHPP uses inclination of River Shamlugh from 1350.0 till 1275.0. The length of derivation from Shtoganaghur River is 1550m by copper pipeline 630mm in diameter with design pressure of 64.4m and design discharge 0.60m^3/sec.

After construction and exploitation Shtoganaghur SHPP will have 0.316mwt capacity and will produce 0.845mln kw/h electricity annually.

Short Description of Shtoganajur River Basin

Shtoganajur is the left inflow of Aghstev river and falls into the latter 89km from the river mouth. River length is 11.1km, catchment are is 21.6km^2, average inclination is 81.2%, average elevation of the basin is 1900m, forest coverage 25%.

The river starts at 2800m. River basin is located in the northern part Armenia. The river is typically mountaneous. The basin has a complicated relief with multiple gorges and inflows.

The river basin has a diverse geological composition. There are many sedimentary rock formations, volcanic rocks and clays. There are porphyries with lime stone layers that are connected with diabases. There are alluvial sediments in the river basin.

Soil cover is represented by sub alpine mountainous meadows, then mountainous-forest dark brown soil then mountainous black soils, there are dry prairies and brown soils in the downstream.

Soil cover is represented by sub alpine mountainous meadows, then mountainous-forest dark brown soil then mountainous black soils, there are dry prairies and brown soils in the downstream.

The river valley in the upstream is represented by not very deep V shaped gorge.

HYDROLOGY

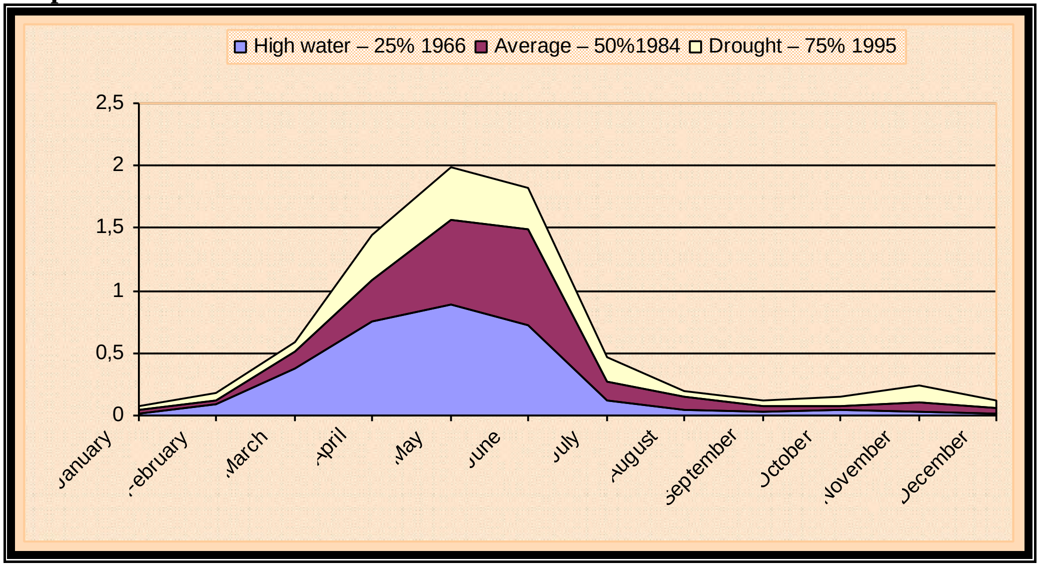
The observation data for 22 years from r. Bldan – Dilighan water-meter station is used to define the hydrological properties of Shtoganaghur SHPP headworks and the design river section.

The graphic below shows the hydrological properties of design river sectios.]

River Section	Distance from the river mouth, Km	Average Elevation of the Catchment Basin, m.	Catchment basin km^2	Flow Norm, m^3/sec
Shtoganaghur --design river section	1.0	2000	20.3	0.21

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP

Graph. 33. Annual flow distribution



Maximal design discharge for Shtoganaghur SHPP headwork river section for the general case equal 3% - 10.4m^3/sec, for verifying case - 0.5%-12.5m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.007m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Shtoganaghur SHPP is 1350.0m, downstream - 1275.0m. According to data of State Water Economy Data there is no water intake for irrigational use from Shtoganaghur River.

Shtoganaghur SHPP is derivational SHPP. In order not to drain the river where 1550m derivational pipeline is the environmental discharge is designed according to RA laws and 0.005m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Shtoganaghur SHPP are calculated with 50% guarantee per annum (2006 see table 74).

Table. 74. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Shtoganaghur SHPP (m^3/sec)	0.02	0.03	0.13	0.32	0.60	0.60	0.15	0.09	0.05	0.04	0.06	0.03	
SHPP average monthly capacity (mwt)	0.012	0.017	0.075	0.182	0.310	0.310	0.086	0.056	0.028	0.023	0.038	0.019	
SHPP –average monthly energy production (mln kwt/hour)	0.009	0.011	0.055	0.131	0.230	0.223	0.064	0.042	0.020	0017	0.028	0.014	**0.845**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 721.3 thousand USD (without VAT) and 865.6 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		23.8
2. Exploitation expenses		26.1
	Salary	17.3
	Renovation	5.8
	Other Expenses	3.0
Total		49.9

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		756
Average multi annual production of energy, mln kwt/hour		2.99
Capital investments into SHPPS(without VAT),		
	thousand USD	721.3
	USD / kwt	954.1
	USD / kwt/hour	0.24
Prime cost of power production, cents/kwt hour		1.66

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

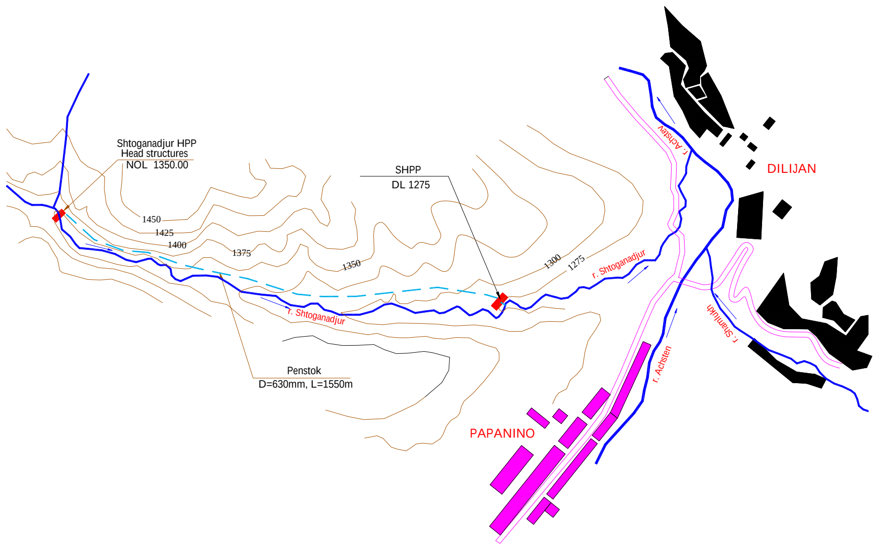
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 75. Design results according to financial scenarios

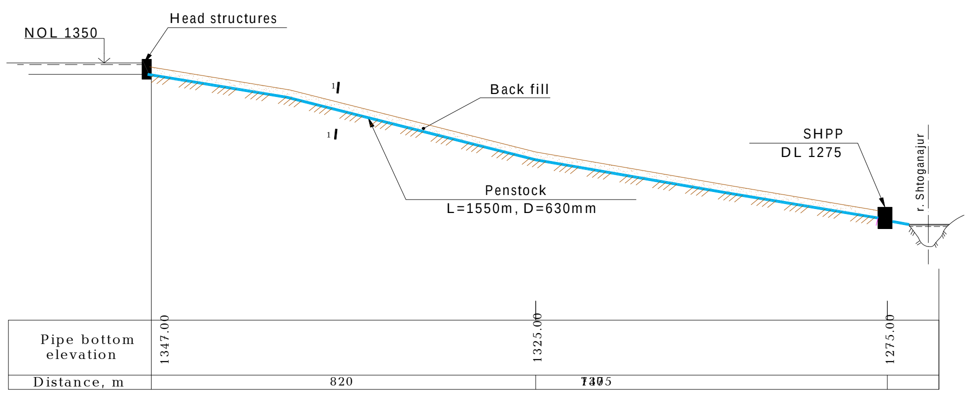
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		15.2	18.8
NPV, thousand USD			
	8%	536.4	536.4
	10%	331.8	361.4
	12%	178.6	235.1
	14%	60.95	142.1
PB, years (without discount)		6.5	7.8
Deadline for credit return, years			6.0

APPENDIX. 31. SHTOGNADJUR SHPP

Plan



Longitudinal section



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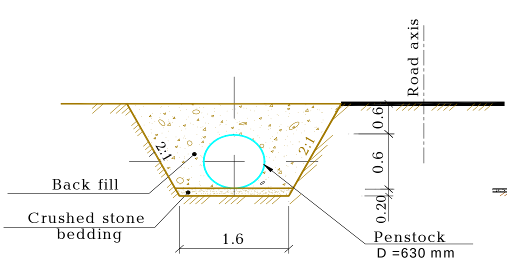
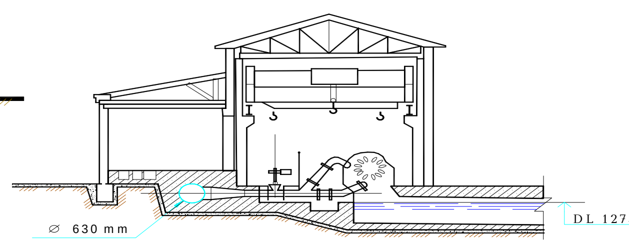


SHPP Powerhouse



15.3.5.3.Mtnadzor SHPP-1,2

Mtnadzor SHPP-1

Introduction

According to development scheme it was planned to construct 4 SHPPs on Mtnadzor river. As a result of in-situ investigations it was decided to construct 2 derivational SHPPs.

Mtnadzor SHPP uses inclination of River Mtnadzor from 1125.0 till 815.0. The length of derivation from Mtnadzor River is 2600m by copper pipeline 430mm in diameter with design pressure of 273.2m and design discharge 0.30m^3/sec.

After construction and exploitation Mtnadzor SHPP will have 0.656mwt capacity and will produce 2.667mln kw/h electricity annually.

Short Description for Mtnadzor River Basin

Mtnadzor River is the left inflow of Aghstev River and falls into the latter 47km from the river mouth. River length is 13.4km, general chatchment area is 28.2km^2, average inclination is 81.2‰, average elevation is 1900m, and forests occupy 75% of the territory.

The river starts from eastern slopes of Gugarats mountain chain: foothills of Kizilikaya mountain foothills on the elevation of 2091.5m. River basin is located in the north-west of Armenia.

River Mtnadzor is a typical mountainous river with complicated relief with multiple inflows. The river basin has a diverse geological composition. There are many sedimentary rock formations, volcanic rocks, clays. There are porphyries with lime stone layers that are connected with diabases. There are alluvial sediments in the river basin.

Vegetative layer of the upstream is composed of alpine meadows, then bogged and forest areas the right bank is covered by forests while the left bank is moist meadows. In the mid stream and downstream there are beech and hornbeam forests.

Soil cover is represented by sub alpine mountainous meadows, then mountainous-forest dark brown soil then mountainous black soils, there are dry prairies and brown soils in the downstream.

The river valley in the upstream is represented by not very deep V shaped gorge.

HYDROLOGY

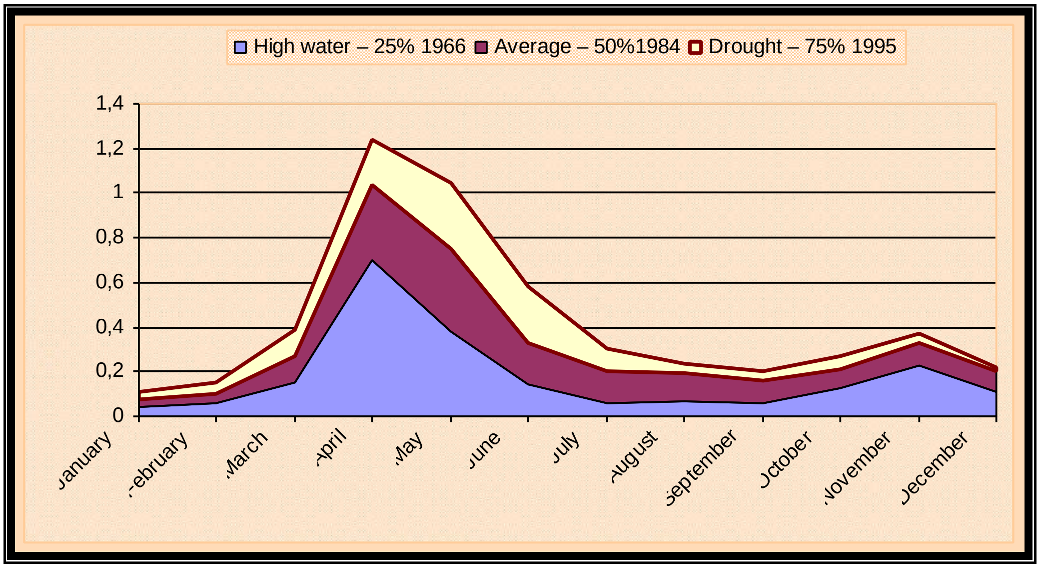
The observation data for 49 years from r. Paghgur – Getahovit water-meter station is used to define the hydrological properties of Mtnadzor SHPP headworks and the design river section.

The graphic below shows the hydrological properties of design river sectios.

River Section	Distance from the river mouth, Km	Average Elevation of the CatchmentBasin,m.	Catchment basin km^2	Flow Norm, m^3/sec
Mtnadzor –design section-1	5.4	1650	15.0	0.14

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 34. Annual flow distribution



Maximal design discharge for Mtnadzor SHPP-1 headwork river section for the general case equal 3% - 29.4m^3/sec, for verifying case - 0.5%-36.1m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.007m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Mtnadzor SHPP-1 is 1125.0m, downstream - 815.0m. According to data of State Water Economy Data there is no water intake for irrigational use from Mtnadzor River. Mtnadzor SHPP-1 is derivational SHPP. In order not to drain the river where 2600m derivational pipeline is the environmental discharge is designed according to RA laws and 0.005m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Mtnadzor SHPP - 1are calculated with 50% guarantee per annum (1993 see table 76).

Table. 76. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Mtnadzor SHPP-1 (m^3/sec)	0.03	0.03	0.12	0.30	0.30	0.19	0.14	0.12	0.10	0.08	0.10	0.08	
SHPP average monthly capacity (mwt)	0.082	0.074	0.280	0.656	0.656	0.438	0.326	0.280	0.233	0.189	0.233	0.197	
SHPP –average monthly energy production (mln kwt/hour)	0.061	0.050	0.208	0.472	0.488	0.615	0.243	0.208	0.168	0.141	0.168	0.146	**2.667**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 612.0 thousand USD (without VAT) and 734.4 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		20.2
2. Exploitation expenses		24.2
	Salary	17.3
	Renovation	4.9
	Other Expenses	2.0
Total		44.4

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		656
Average multi annual production of energy, mln kwt/hour		2.67
Capital investments into SHPPS(without VAT),		
	thousand USD	612.0
	USD / kwt	933.0
	USD / kwt/hour	0.23
Prime cost of power production, cents/kwt hour		1.66

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

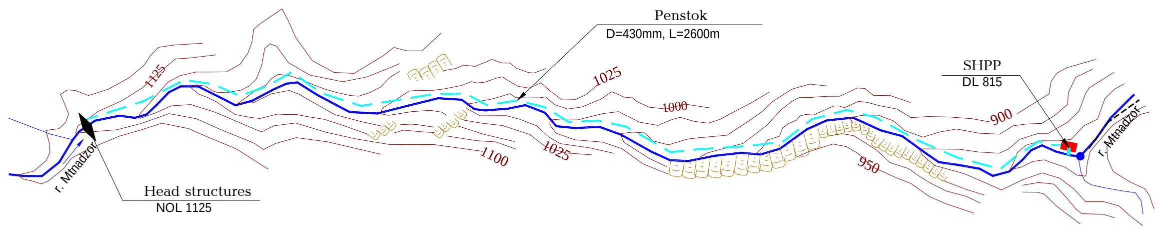
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 77. Design results according to financial scenarios

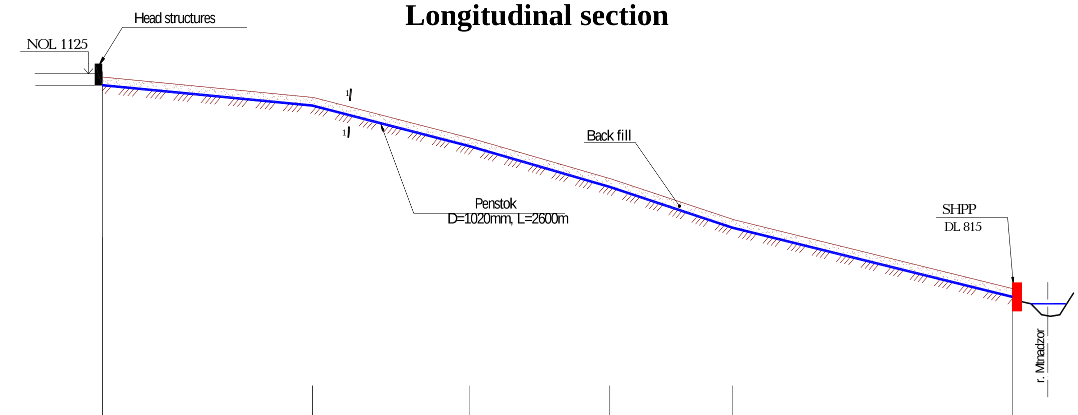
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		15.9	20
NPV, thousand USD			
	8%	498.5	498.5
	10%	317.8	342.9
	12%	182.5	230.5
	14%	78.6	142.5
PB, years (without discount)		6.2	7.5
Deadline for credit return, years			6.0

APPENDIX. 32. MTNADZOR SHPP-1

Plan



Longitudinal section



Pipe bottom elevation	1122.00	1050.00	1000.00	950.00	900.00	815.00
Distance, m	600	450	400	350	800	

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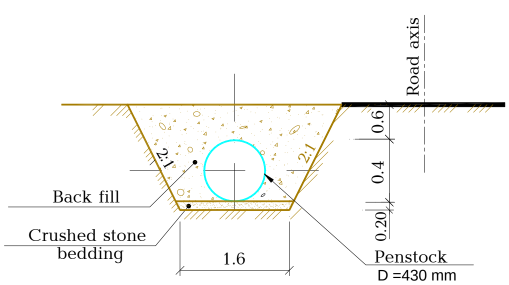
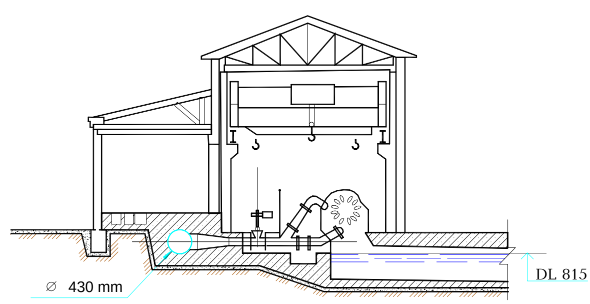


SHPP Powerhouse



Mtnadzor SHPP-2

Introduction

The headworks of Mtnadzor SHPP-2 are located upstream of Lusadzor River before the existing water intake of Mtnadzor River (715m).

Mtnadzor SHPP-2 uses inclination of River Mtnadzor from 810.0 till 720.0. The length of derivation from Mtnadzor River is 1825m by copper pipeline 630mm in diameter with design pressure of 81.4m and design discharge 0.50m^3/sec.

After construction and exploitation Mtnadzor SHPP-2 will have 0.326mwt capacity and will produce 1.252mln kw/h electricity annually.

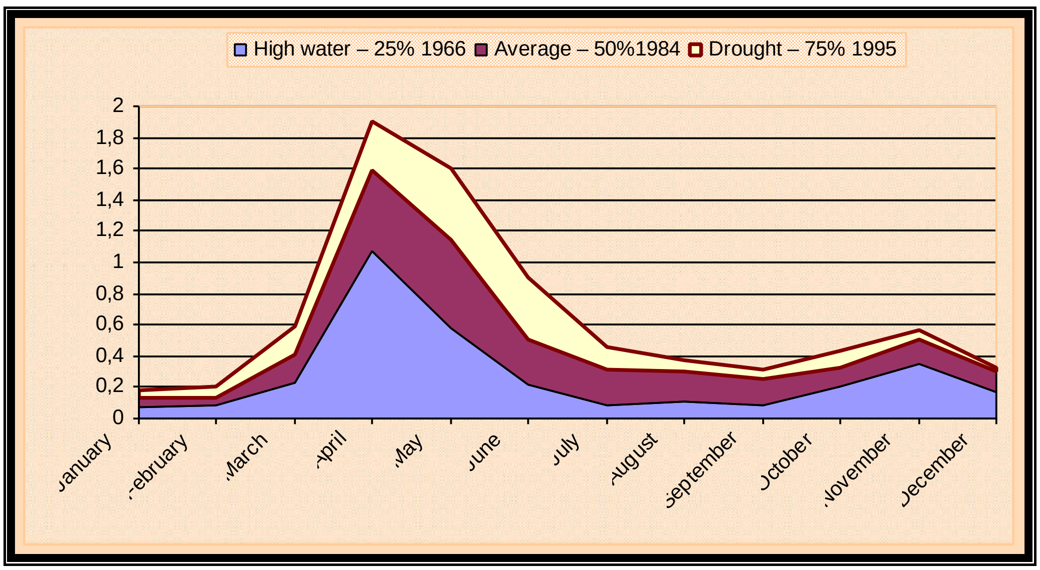
HYDROLOGY

The observation data for 49 years from r. Paghgur – Getahovit water-meter station is used to define the hydrological properties of Mtnadzor SHPP-2 headworks and the design river section. The graphic below shows the hydrological properties of design river sections.

River Section	Distance from the river mouth, Km	Average Elevation of the CatchmentBasin,m.	Catchment basin km^2	Flow Norm, m^3/sec
Mtnadzor –design section-2	3.6	1600	23.0	0.21

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 35. Annual flow distribution



Maximal design discharge for Mtnadzor SHPP-2 headwork river section for the general case equal 3% - 34.8m^3/sec, for verifying case - 0.5%-42.9m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.011m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Mtnadzor SHPP-2 is 810.0m, downstream - 720.0m. According to data of State Water Economy Data there is no water intake for irrigational use from Mtnadzor River. Mtnadzor SHPP-2 is derivational SHPP. In order not to drain the river where 1825m derivational pipeline is the environmental discharge is designed according to RA laws and 0.008m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Mtnadzor SHPP-2 are calculated with 50% guarantee per annum (1993 see table 78).

Table. 78. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Mtnadzor SHPP-2 (m^3/sec)	0.05	0.05	0.17	0.50	0.50	0.28	0.21	0.18	0.15	0.12	0.15	0.12	
SHPP average monthly capacity (mwt)	0.037	0.033	0.122	0.326	0.326	0.197	0.150	0.129	0.108	0.087	0.108	0.087	
SHPP –average monthly energy production (mln kwt/hour)	0.027	0.022	0.091	0.234	0.242	0.142	0.112	0.096	0.078	0.065	0.078	0.065	**1.252**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 381.3 thousand USD (without VAT) and 457.7 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	12.6
2. Exploitation expenses	19.5
Salary	14.4
Renovation	3.1
Other Expenses	2.0
Total	32.1

Power indicators of have the following level

Indicators	Values
Derivation capacity, kwt	326
Average multi annual production of energy, mln kwt/hour	1.25
Capital investments into SHPPS(without VAT),	
thousand USD	381.3
USD / kwt	1169.8
USD / kwt/hour	0.31
Prime cost of power production, cents/kwt hour	2.56

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

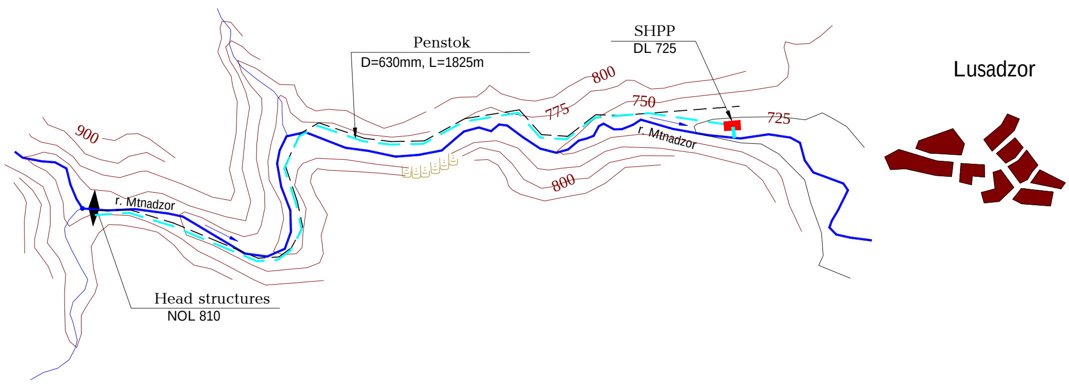
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 79. Design results according to financial scenarios

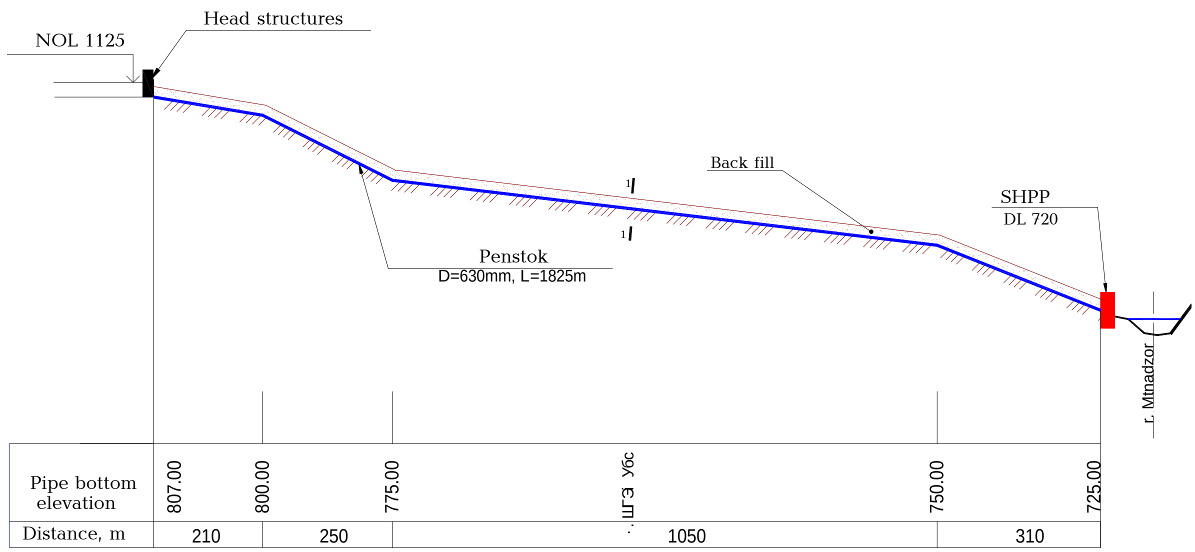
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		10.0	11.1
NPV, thousand USD			
	8%	73.5	73.5
	10%	-0.5	22.4
	12%	-55.9	-13.0
	14%	-98.5	-38.0
PB, years (without discount)		9.4	12.8
Deadline for credit return, years			10

APPENDIX. 33. MTNADZOR SHPP-2

Plan



Longitudinal section



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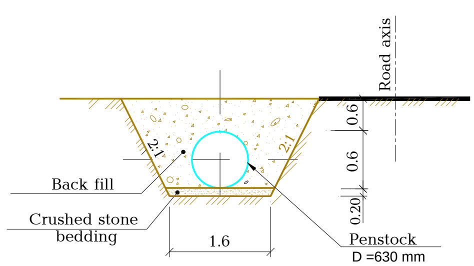
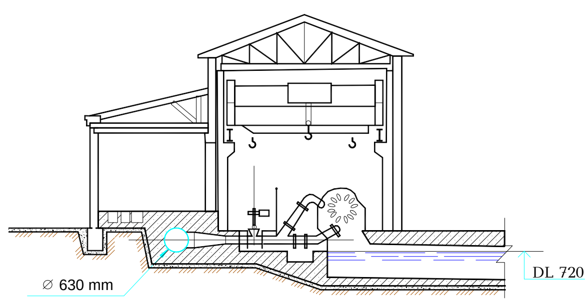


SHPP Powerhouse



15.3.5.5. Koghbanijur SHPP

Introduction

According to development scheme it was planned to construct 3 SHPPs on Koghbanijur river. As a result of in-situ investigations it was decided to construct 1 derivational SHPP.

Koghbanijur SHPP headworks will be located in the nearby of Shamakhyan village before the irrigational water intake.

Koghbanijur SHPP uses inclination of River Koghbanijur from 1240.0 till 1000.0. The length of derivation from Koghbanijur River is 2825m by copper pipeline 530mm in diameter with design pressure of 221.4m and design discharge 0.35m^3/sec.

After construction and exploitation Koghbanijur SHPP will have 0.620mwt capacity and will produce 2.336mln kw/h electricity annually.

Short Description for Koghbanijur River Basin

Koghbanijur River is the right inflow of Aghstev River and falls into the latter 76.7km from the river mouth. River length is 8.5km, general chatchment area is 24.5km^2, average inclination is 81.2‰, average elevation is 1750m, and forests occupy 70% of the territory.

The river starts from slopes of Maimekh mountain foothills on elevation of 2569m. River basin is located in the northern parts of Armenia.

From administrative point of view the river is located in Tavush region. River Koghbanijur is a typical mountainous river with complicated relief with multiple inflows. The river basin has a diverse geological composition. There are many sedimentary rock formations, volcanic rocks, clays. There are porphyries with lime stone layers that are connected with diabases. There are alluvial sediments in the river basin.

Vegetative layer of the upstream is composed of alpine meadows, then bogged and forest areas the right bank is covered by forests while the left bank is moist meadows. In the mid stream and downstream there are beech and hornbeam forests.

Soil cover is represented by sub alpine mountainous meadows, then mountainous-forest dark brown soil then mountainous black soils, there are dry prairies and brown soils in the downstream. The river valley in the upstream is represented by not very deep V shaped gorge.

HYDROLOGY

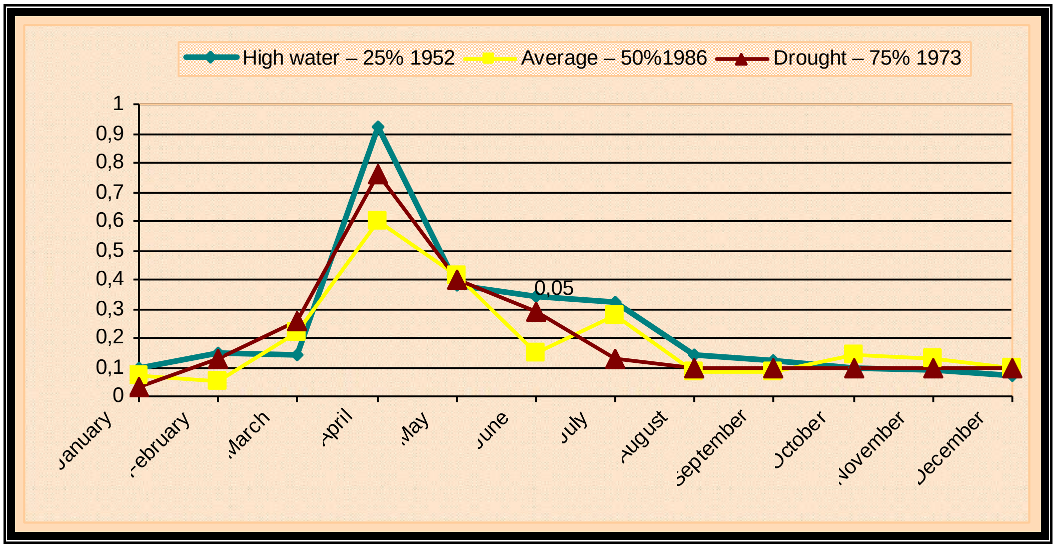
The observation datafor 48 years from r. Shamlugh-Dilijan water-meter station is used to define the hydrological properties of Koghbanijur SHPP headworks and the design river section.

The graphic below shows the hydrological properties of design river sections.

River Section	Distance from the river mouth, Km	Average Elevation of the CatchmentBasin,m.	Catchment basin km^2	Flow Norm, m^3/sec
Shamlugh - design river section	2.4	1900	16.5	0.18

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 36. Annual flow distribution



Maximal design discharge for Koghbanijur SHPP headwork river section for the general case equal 3% - 11.9m^3/sec, for verifying case - 0.5%-16.3m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.017m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Koghbanijur SHPP is 1240.0m, downstream - 1000.0m. According to data of State Water Economy Data there is no water intake for irrigational use from Koghbanijur **River**. Koghbanijur SHPP is derivational SHPP. In order not to drain the river where 2825m derivational pipeline is the environmental discharge is designed according to RA laws and 0.11m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Koghbanijur r SHPP are calculated with 50% guarantee per annum (2006 see table 80).

Table. 80. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Koghbanijur SHPP (m^3/sec)	0.049	0.033	0.179	0.350	0.349	0.119	0.229	0.060	0.065	0.119	0.099	0.076	
SHPP average monthly capacity (mwt)	0.094	0.063	0.337	0.620	0.619	0.226	0.425	0.115	0.124	0.226	0.189	0.145	
SHPP –average monthly energy production (mln kwt/hour)	0.070	0.043	0.250	0.446	0.460	0.163	0.316	0.085	0.090	0.168	0.136	0.108	**2.336**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 695.1 thousand USD (without VAT) and 714.1 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		19.6
2. Exploitation expenses		24.1
	Salary	17.3
	Renovation	4.8
	Other Expenses	2.0
Total		43.7

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		620
Average multi annual production of energy, mln kwt/hour		2.34
Capital investments into SHPPS(without VAT),		
	thousand USD	595.1
	USD / kwt	959.9
	USD / kwt/hour	0.26
Prime cost of power production, cents/kwt hour		1.87

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

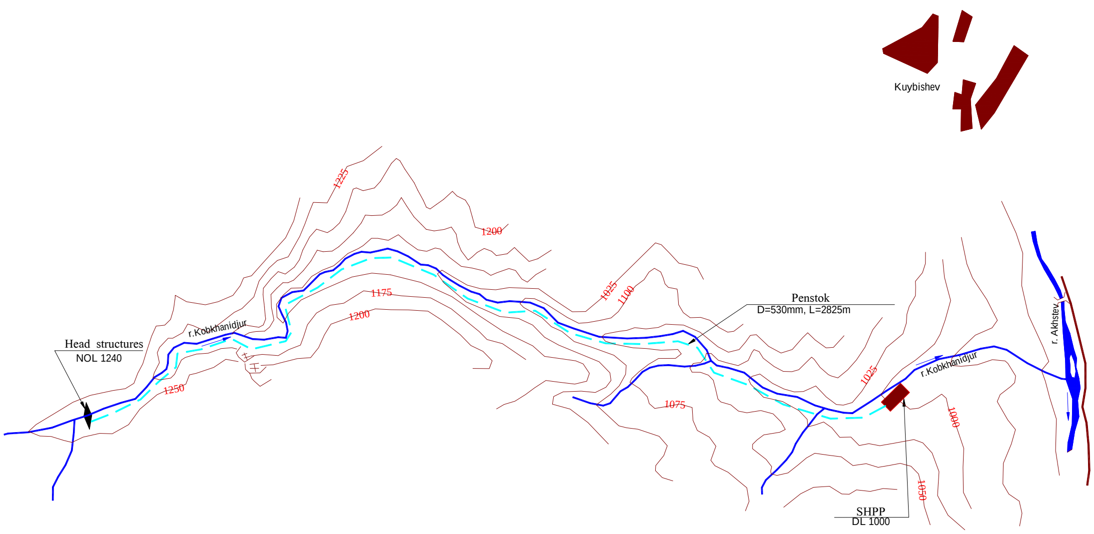
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 81. Design results according to financial scenarios

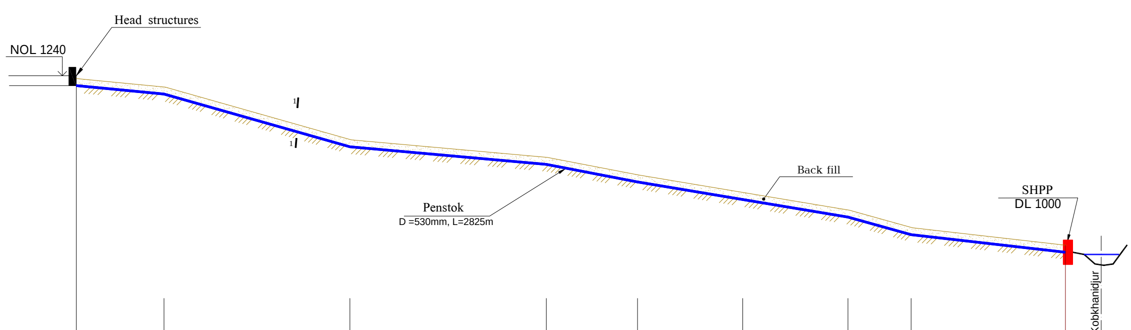
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		13.9	17.0
NPV, thousand USD			
	8%	355.7	355.7
	10%	201.0	228.4
	12%	85.13	137.3
	14%	-3.78	70.7
PB, years (without discount)		7.1	8.8
Deadline for credit return, years			7.0

APPENDIX. 34. KOGHBANIDJUR SHPP

Plan

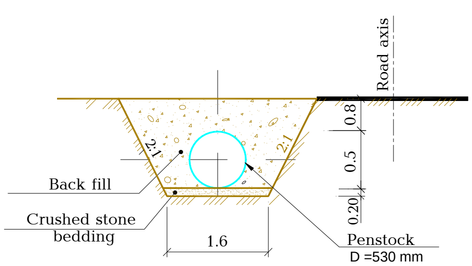


Longitudinal section

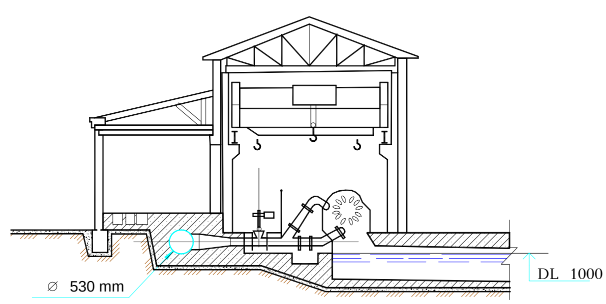


Pipe bottom elevation	1237.00	1225.00	1150.00	1125.00	1100.00	1075.00	1050.00	1025.00	1000.00
Distance, m	380	580	300	430	280	380	380	380	

1-1



SHPP Powerhouse



15.3.5.6. Jilis SHPP

Introduction

According to development scheme it was planned to construct 2 SHPPs on Jilis River. As a result of in-situ investigations it was decided to construct one derivational SHPP.
Ji
lis SHPP uses inclination of River Jilis from 1050.0 till 850.0. The length of derivation from Jilis River is 3600m by copper pipeline 530mm in diameter with design pressure of 179.5m and design discharge 0.34m^3/sec.

After construction and exploitation Jilis SHPP will have 0.488mwt capacity and will produce 2.067mln kw/h electricity annually.

Short Description for Jilis River Basin

Jilis River is the right inflow of Karakhan which is the right inflow of Voskepar River and falls into the latter 8.8km from the river mouth. Jilis river length is 9.8km, general chatchment area is 46.0km^2, average inclination is 1582‰, average elevation is 1400m, and forests occupy 90% of the territory.

The river starts from eastern slopes of Gugarats mountain chain: foothills of Jilis mountain foothills on the elevation of 1916m. River basin is located in the northern part of Armenia. From north, west and east it borders with Karakhan River and its inflows and Aghstev river basin from South, divided by Gugarats mountain chain. The geological composition is represented by middle and upper Jurassic period dacites, tuff breccias, tuff sand stones as well as Quaternary deluvial-alluvial sediments.

The earth cover of the river is diverse consisting of sub-alpine meadows, black soil, some brown mountain soil in the midstream and dark brown soil in the downstream. Jilis river basin has a forest cover which occupies 90% of its territory. In the upstream there are alpine meadows and oak forests in the downstream.

Jilis River is a typical mountainous river. The relief is mountainous with small and large inflows. The valley is a gorge covered by forests and bushes. The slopes consist of basalts covered by forest black soil.

Jilis river bed is straight and consists of large stones, sand stones and and is subject to deformation. During seasonal floods the flow is heavy and brings many in wash material. In winter there is insignificant shoreline ice.

HYDROLOGY

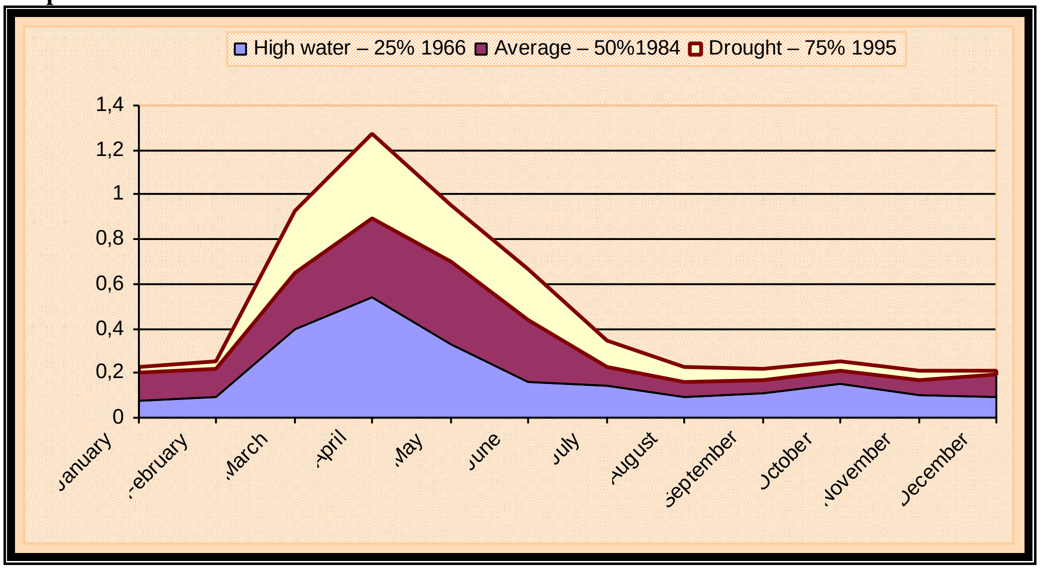
The observation data for 47 years from r. Kirants-Achakut water-meter station is used to define the hydrological properties of Jilis SHPP headworks and the design river section.

The graphic below shows the hydrological properties of design river sectios.

River Section	Distance from the river mouth, Km	Average Elevation of the CatchmentBasin,m.	Catchment basin km^2	Flow Norm, m^3/sec
Jilis - design river section	3.7	1500	19.3	0.17

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 37. Annual flow distribution



Maximal design discharge for Jilis SHPP headwork river section for the general case equal 3% - 12.6m^3/sec, for verifying case - 0.5%-15.7m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.005m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Jilis SHPP is 1050.0m, downstream - 850.0m. According to data of State Water Economy Data there is no water intake for irrigational use from Jilis River. Jilis SHPP is derivational SHPP. In order not to drain the river where 3600m derivational pipeline is the environmental discharge is designed according to RA laws and 0.004m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Jilis SHPP are calculated with 50% guarantee per annum (1993 see table 82).

Table. 82. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Jilis SHPP (m^3/sec)	0.116	0.126	0.246	0.340	0.340	0.276	0.090	0.066	0.057	0.054	0.071	0.096	
SHPP average monthly capacity (mwt)	0.183	0.199	0.372	0.488	0.488	0.412	0.143	0.105	0.091	0.086	0.113	0.152	
SHPP –average monthly energy production (mln kwt/hour)	0.136	0.133	0.277	0.352	0.363	0.296	0.106	0.078	0065	0064	0081	0.113	**2.067**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 533.1 thousand USD (without VAT) and 639.7 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		17.6
2. Exploitation expenses		20.7
	Salary	14.4
	Renovation	4.3
	Other Expenses	2.0
Total		38.3

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		488
Average multi annual production of energy, mln kwt/hour		2.07
Capital investments into SHPPS(without VAT),		
	thousand USD	533.1
	USD / kwt	1092.4
	USD / kwt/hour	0.26
Prime cost of power production, cents/kwt hour		1.85

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

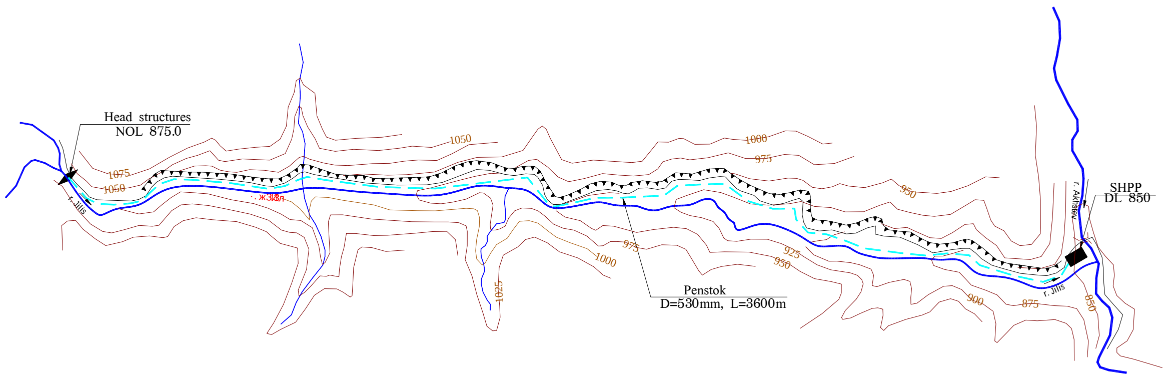
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

<u>Table. 83. Design results according to financial scenarios</u>

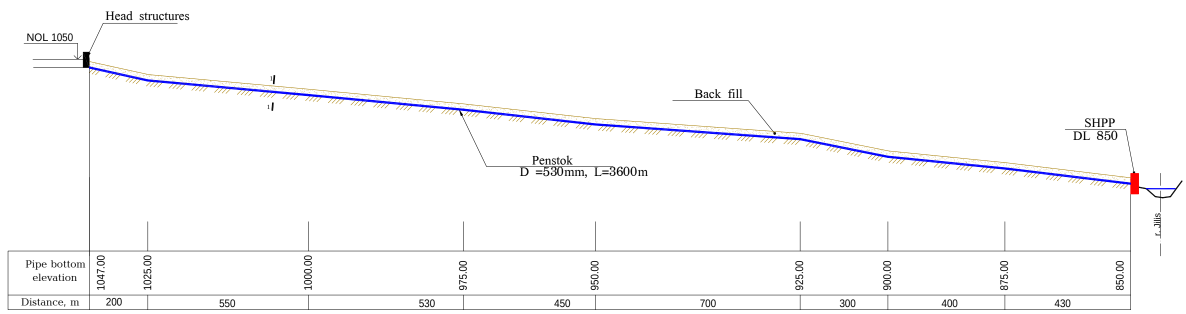
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		13.8	17.0
NPV, thousand USD			
	8%	314.3	314.3
	10%	176.4	201
	12%	73.2	119.9
	14%	-6.08	60.6
PB, years (without discount)		7.1	8.8
Deadline for credit return, years			7.0

APPENDIX. 35. JILIS SHPP

Plan



Longitudinal section



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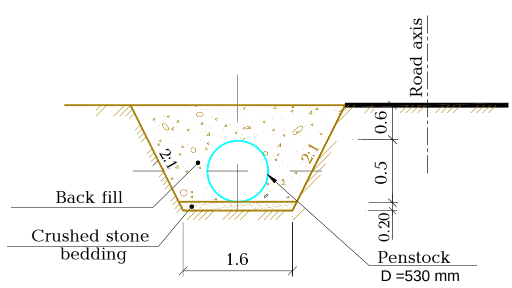
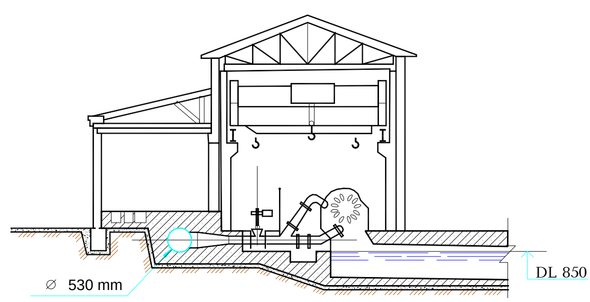


SHPP Powerhouse



15.3.5.7. Kirants SHPP

Introduction

According to development scheme it was planned to construct 8 SHPPs on Karakhants/Kirants/ river. The river flows through forest, there are many historical monuments in the river basin. The location of SHPP was chosen during in-situ investigations do that there is no historical monuments near by and where construction works will harm the forest least.

Headworks of Kirants river are to be located before the bordering Acharkut River. The headworks will be located on Karakhan river right after falling into Jilis inflow, and station works will be located in the nearby of Achakut village.

Kirants SHPP uses inclination of River Karakhan from 840.0 till 730.0. The length of derivation from Karakhan River is 4.25km by copper pipeline1020mm in diameter with design pressure of 94.2m and design discharge 1.60m^3/sec.
After construction and exploitation Kirantc SHPP will have 1.21mwt capacity and will produce 5.83mln kw/h electricity annually.

Short Description for Karakhan River Basin

Karakhan River is the left inflow of Voskepar which is the left inflow of Aghstev River and falls into the latter 17.5km from the river mouth. Karakhan river length is 31km, general chatchment area is 165m^2, average inclination is 1582‰, average elevation is 1400m.

Average inclination of the river is 0.0515, general fall is 1500m, average elevation of catchment basin is 1420m, forests occupy 90% of the territory.

Karakhan river is a typically mountainous river with seasonal water regime, The river has a mixed feeding with snow, rain, ground water. The relief is mountainous with small and large inflow valleys.

The geological composition is represented by middle and upper Jurassic period dacites, tuff breccias, porphyrites, tuff sand stones as well as Quaternary talus-alluvial sediments.

The earth cover of the river is diverse consisting of sub-alpine meadows, black soil, some brown mountain soil in the midstream and dark brown soil in the downstream. Karakhan river basin has a forest cover which occupies 90% of its territory. In the upstream there are alpine meadows and oak forests in the downstream.
During seasonal floods the flow is heavy and brings many in wash material. In winter there is insignificant shoreline ice.

HYDROLOGY

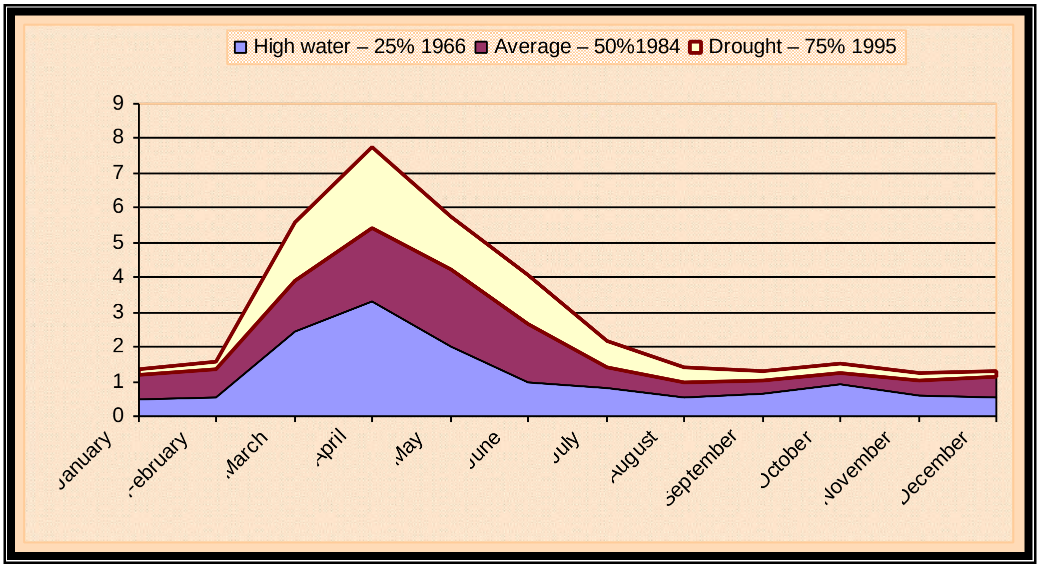
The observation data for 47 years from Kirants-Achakut water-meter station is used to define the hydrological properties of Kirants SHPP headworks and the design river section.

The graphic below shows the hydrological properties of design river sections.

River Section	Distance from the river mouth, Km	Average Elevation of the CatchmentBasin,m.	Catchment basin km^2	Flow Norm, m^3/sec
Karakhan- design river section	5.5	1530	117.2	1.01

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 38. Annual flow distribution



Maximal design discharge for Kirants SHPP headwork river section for the general case equal 3% - 230m^3/sec, for verifying case - 0.5%-27.7m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.032m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Kirants SHPP is 840.0m, downstream - 730.0m. According to Ijevan WUO data there is 1.32mln.m^3 water intake for irrigational use from Kirants River. Kirants SHPP is derivational SHPP. In order not to drain the river where 4250m derivational pipeline is the environmental discharge is designed according to RA laws and 0.03m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Kirants_SHPP are calculated with 50% guarantee per annum (1993 see table 84).

Table. 84. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Kirants SHPP (m^3/sec)	0.69	0.78	1.47	1.60	1.60	1.54	0.44	0.30	0.24	0.32	0.42	0.57	
SHPP average monthly capacity (mwt)	0.59	0.66	1.14	1.21	1.21	1.18	0.38	0.26	0.21	0.28	0.37	0.49	
SHPP –average monthly energy production (mln kwt/hour)	0.44	0.45	0.85	0.87	0.90	0.85	0.29	0.19	0.15	0.21	0.26	0.37	**5.83**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 1435.1 thousand USD (without VAT) and 1722.1 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		47.4
2. Exploitation expenses		30.5
	Salary	17.3
	Renovation	9.2
	Other Expenses	4.0
Total		77.9

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		1212
Average multi annual production of energy, mln kwt/hour		5.83
Capital investments into SHPPS(without VAT),		
	thousand USD	1435.1
	USD / kwt	1184.1
	USD / kwt/hour	0.246
Prime cost of power production, cents/kwt hour		1.34

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

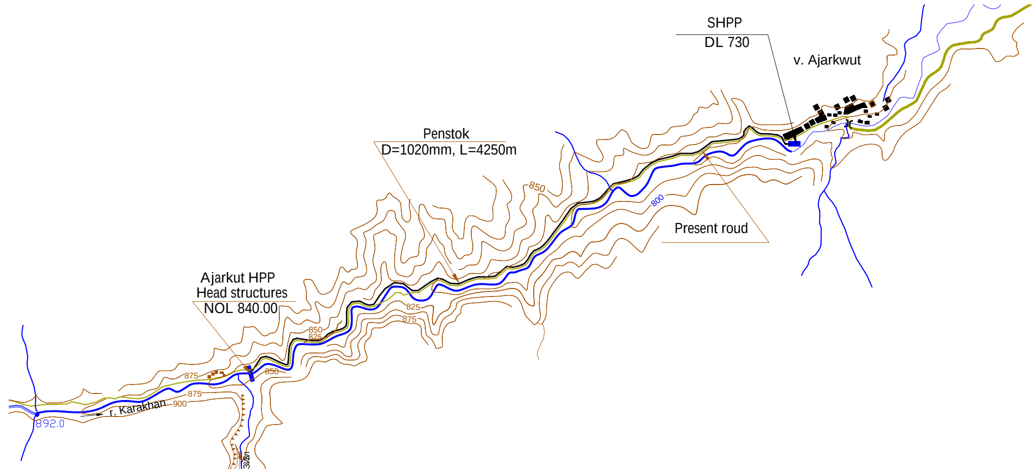
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 85. Design results according to financial scenarios

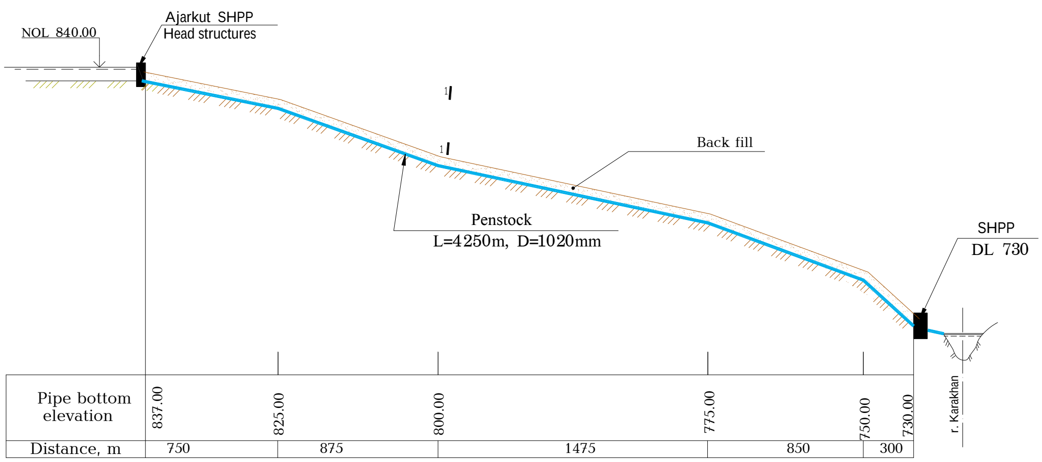
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		20.4	16.1
NPV, thousand USD			
	8%	1201.1	1201.1
	10%	772.3	831.2
	12%	451.0	563.5
	14%	204.5	365.9
PB, years (without discount)		6.1	7.4
Deadline for credit return, years			6.20

APPENDIX. 36. KIRANTS SHPP

Plan



Longitudinal section



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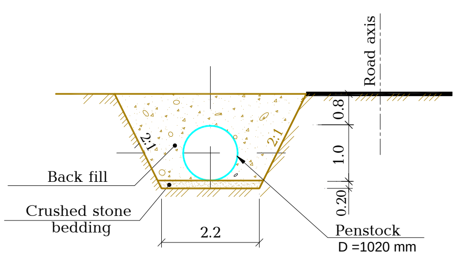
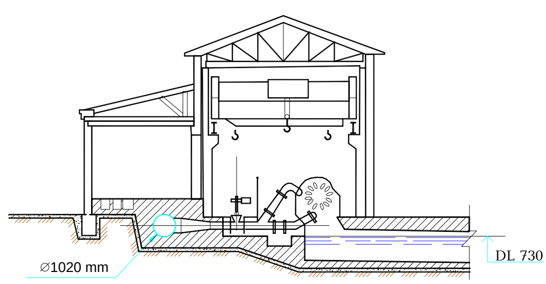


SHPP Powerhouse



15.3.5.8. Khachakhbyur-1,2,3

Khachakhbyur SHPP-1

Introduction

According to development scheme it was planned to construct 11 SHPPs on Khachakhbyur river. As a result of in-situ investigations it was decided to construct 3 derivational SHPP.

It is planned to construct Paghghur reservoir on Khachakhbyur river, the working volume of the reservoir is 3.0mln.m^3 and Normal Maximum Operating Level is 1450. The reservoir will supply water to Ijevan town. The SHPPs on the river will be located below the reservoir, therefore in water economy calculations the existence of the reservoir will be taken into consideration.

Enokavan Irrigational system feeds from Khachakhbyur river, therefore all the design sections of SHPPs will be located before the water intake.

Khachakhbyur SHPP-1 uses inclination of River Khachakhbyur from 1400.0 till 1255.0. The length of derivation from Khachakhbyur River is 2000m by copper pipeline 920mm in diameter with design pressure of 59.6m and design discharge 1.50m^3/sec.

After construction and exploitation Khachakhbyur SHPP-1 will have 1.606mwt capacity and will produce 7.301mln kw/h electricity annually.

Short Description of Khachakhbyur River Basin

Paghgur (Khachakhbyur) River is the left inflow of Aghstev River and falls into the latter 41km from the river mouth. River length is 31km, general chatchment area is 205km2, average inclination is 44‰, average elevation is 1710m, and forests occupy 23% of the territory.

The river starts from slopes of one of the eastern slopes of Gugarats mountain – the foothills of Khan-Bulak mountain on the elevation of 1990m. River basin is located in the north-west parts of Armenia. River Khachakhbyur is a typical mountainous river with complicated relief with multiple inflows. The river basin has a diverse geological composition. There are many sedimentary rock formations, volcanic rocks, clays. There are porphyries with lime stone layers that are connected with diabases. There are alluvial sediments in the river basin.

Vegetative layer of the upstream is composed of alpine meadows, then bogged and forest areas the right bank is covered by forests while the left bank is moist meadows. In the mid stream and downstream there are beech and hornbeam forests.

Soil cover is represented by sub alpine mountainous meadows, then mountainous-forest dark brown soil then mountainous black soils, there are dry prairies and brown soils in the downstream. The river valley in the upstream is represented by not very deep V shaped gorge.

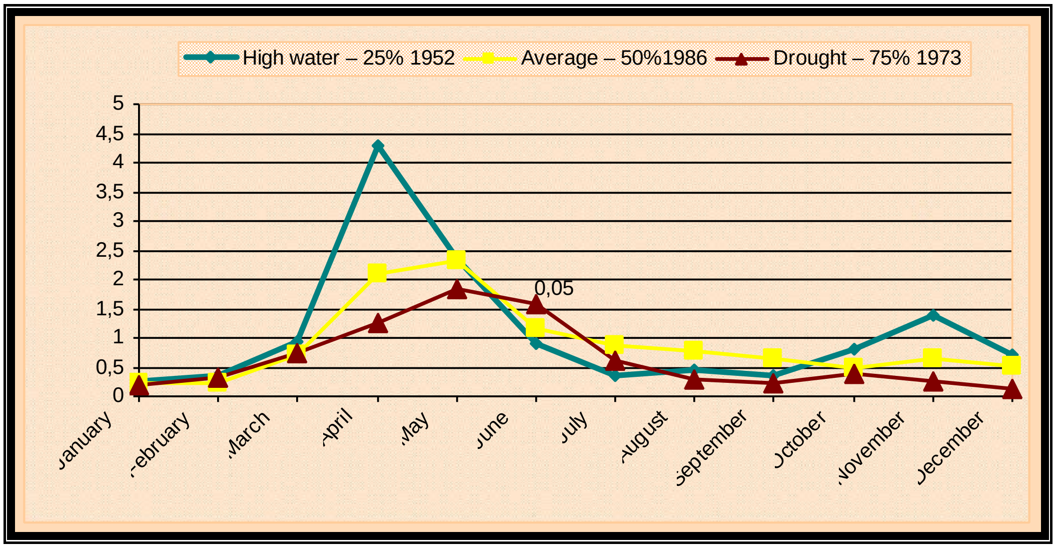
HYDROLOGY

The observation datafor 49 years from r. Paghjur-Getahovit water-meter station is used to define the hydrological properties of Khachakhbyur SHPP-1 headworks and the design river section.
The graphic below shows the hydrological properties of design river sectios.

River Section	Distance from the river mouth, Km	Average Elevation of the CatchmentBasin,m.	Catchment basin km^2	Flow Norm, m^3/sec
Khachakhbyur --design river section 1	16.0	2000	92.8	0.87

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 39. Annual flow distribution



Maximal design discharge for Khachakhbyur SHPP-1 headwork river section for the general case equal 3% - 60.9m^3/sec, for verifying case - 0.5%-74.9m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.045m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Khachakhbyur SHPP-1 is 1400.0m, downstream - 1255.0m. There is no water intake for irrigational use from Khachakhbyur River. Paghjur reservoir volume 30mln.m^3 is taken into conaideration in water enrgy calculations, it is planned to fill the reservoir in spring. Khachakhbyur SHPP-1 is derivational SHPP. In order not to drain the river where 2000m derivational pipeline is the environmental discharge is designed according to RA laws and 0.034m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Khachakhbyur SHPP-1 are calculated with 50% guarantee per annum (1993 see table 86).

Table. 86. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Khachakhbyur SHPP-1 (m^3/sec)	0.21	0.19	0.68	1.50	1.50	1.14	0.85	0.74	0.60	0.47	0.60	0.50	
SHPP average monthly capacity (mwt)	0.239	0.215	0.772	1.609	1.609	1.260	0.957	0.838	0.683	0.536	0.683	0.570	
SHPP –average monthly energy production (mln kwt/hour)	0.177	0.145	0.574	1.158	1.197	0.907	0.712	0.623	0.492	0.399	0.492	0.424	**7.301**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 1545.0 thousand USD (without VAT) and 1854.0 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		51.0
2. Exploitation expenses		40.4
	Salary	23.0
	Renovation	12.4
	Other Expenses	5.0
Total		91.4

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		1609
Average multi annual production of energy, mln kwt/hour		7.30
Capital investments into SHPPS(without VAT),		
	thousand USD	1545.0
	USD / kwt	960
	USD / kwt/hour	0.21
Prime cost of power production, cents/kwt hour		1.25

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:
- ❖ Private investments only /Scenario 1/
- ❖ 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

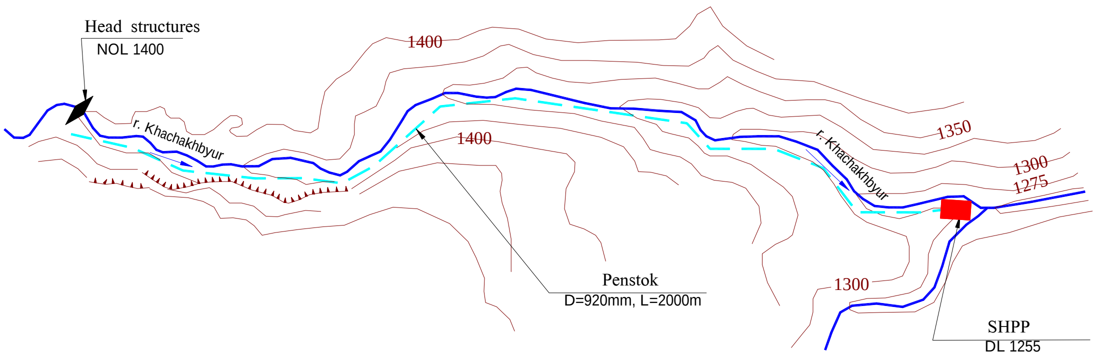
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 87. Design results according to financial scenarios

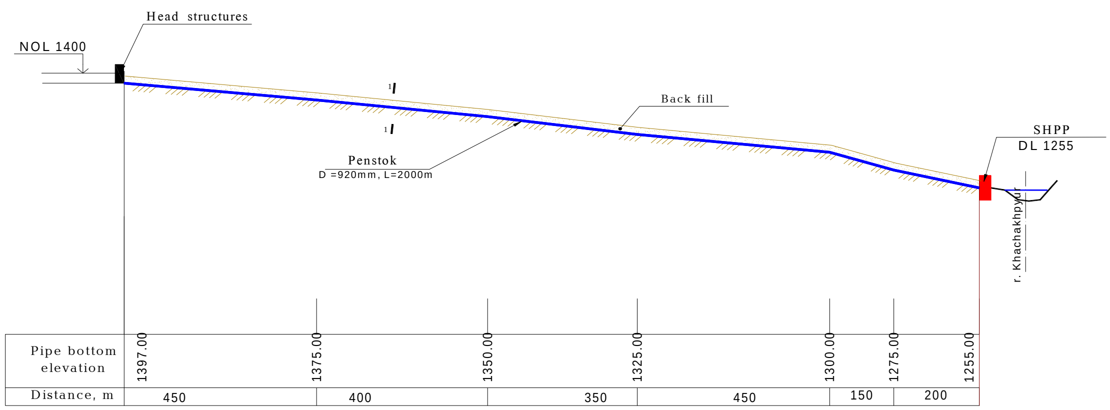
INDICATORS		Scenario 1 100% fully self -financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		18.6	24
NPV, thousand USD			
	8%	1718.3	1718.3
	10%	1187.5	1242.7
	12%	789.8	895.9
	14%	484.6	637.7
PB, years (without discount)		5.3	6.3
Deadline for credit return, years			5.0

APPENDIX. 37. KHACHAKHPYUR SHPP-1

Plan



Longitudinal section



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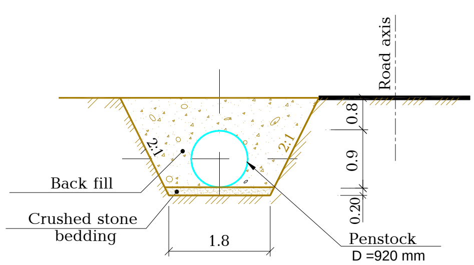
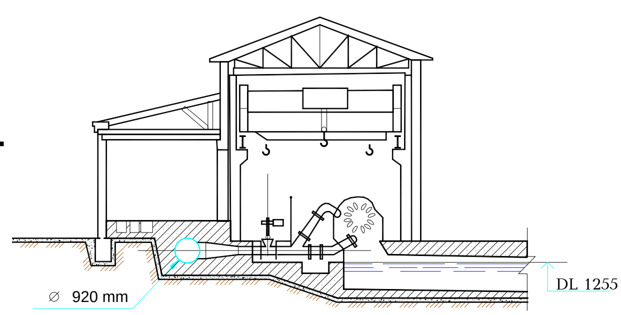


SHPP Powerhouse



Khachakhbyur SHPP-2

Introduction

Khachakhbyur SHPP-2 uses inclination of River Khachakhbyur from 1255.0 till 1110.0. The length of derivation from Khachakhbyur River is 2200m by copper pipeline 1220mm in diameter with design pressure of 130.75m and design discharge 2.80m^3/sec.

After construction and exploitation Khachakhbyur SHPP-2 will have 2.929mwt capacity and will produce 12.382mln kw/h electricity annually.

HYDROLOGY

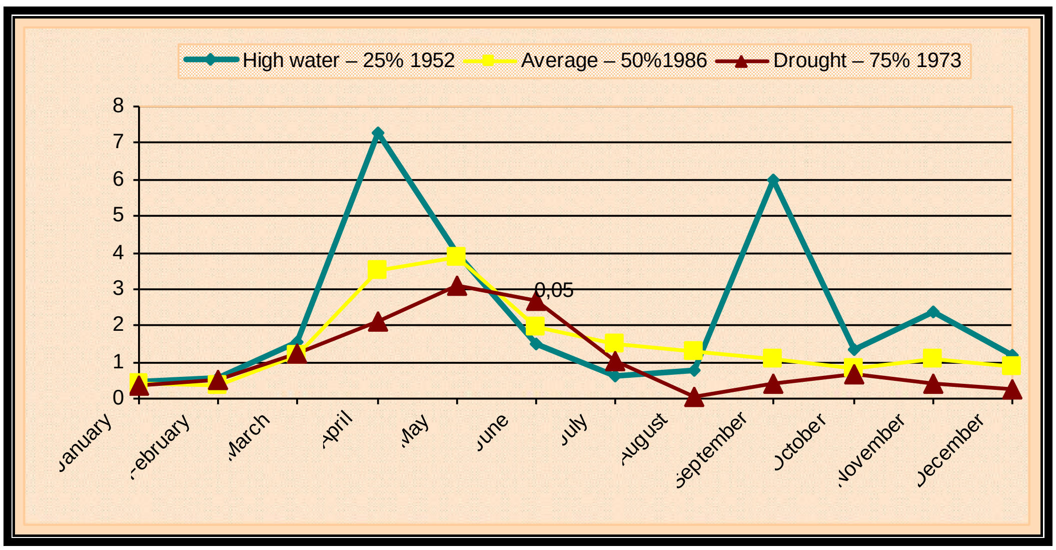
The observation data for 49 years from r. Paghjur-Getahovit water-meter station is used to define the hydrological properties of Khachakhbyur SHPP-2 headworks and the design river section.

The graphic below shows the hydrological properties of design river sections.

River Section	Distance from the river mouth, Km	Average Elevation of the CatchmentBasin,m.	Catchment basin km^2	Flow Norm, m^3/sec
Khachakhbyur --design river section 2	11.5	1890	156.7	1.456

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 40. Annual flow distribution



Maximal design discharge for Khachakhbyur SHPP-2 headwork river section for the general case equal 3% - 75.1m^3/sec, for verifying case - 0.5%-92.3m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.077m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Khachakhbyur SHPP-2 is 1255.0m, downstream - 1110.0m. There is no water intake for irrigational use from Khachakhbyur River. Paghjur reservoir volume 30mln.m^3 is taken into consideration in water energy calculations, it is planned to fill the reservoir in spring. Khachakhbyur SHPP-2 is derivational SHPP. In order not to drain the river where 2200m derivational pipeline is the environmental discharge is designed according to RA laws and 0.058m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Khachakhbyur SHPP-2 are calculated with 50% guarantee per annum (1993 see table 88).

Table. 88. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Khachakhbyur SHPP-2 (m^3/sec)	0.34	0.31	1.15	2.80	2.80	1.91	1.42	1.24	1.00	0.79	1.00	083	
SHPP average monthly capacity (mwt)	0.383	0.349	1.275	2.929	2.929	2.075	1.565	1.372	1.112	0.882	1.112	0.926	
SHPP –average monthly energy production (mln kwt/hour)	0.285	0.235	0.949	2.109	2.179	1.494	1.164	1.021	0.801	0.656	0.801	0.689	**12.382**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 2870.4 thousand USD (without VAT) and 3444.5 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	94.7
2. Exploitation expenses	57.7
Salary	28.8
Renovation	22.9
Other Expenses	6.0
Total	152.4

Power indicators of have the following level

Indicators	Values
Derivation capacity, kwt	2929
Average multi annual production of energy, mln kwt/hour	12.38
Capital investments into SHPPS(without VAT),	
thousand USD	2870.4
USD / kwt	980.0
USD / kwt/hour	0.23
Prime cost of power production, cents/kwt hour	1.23

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

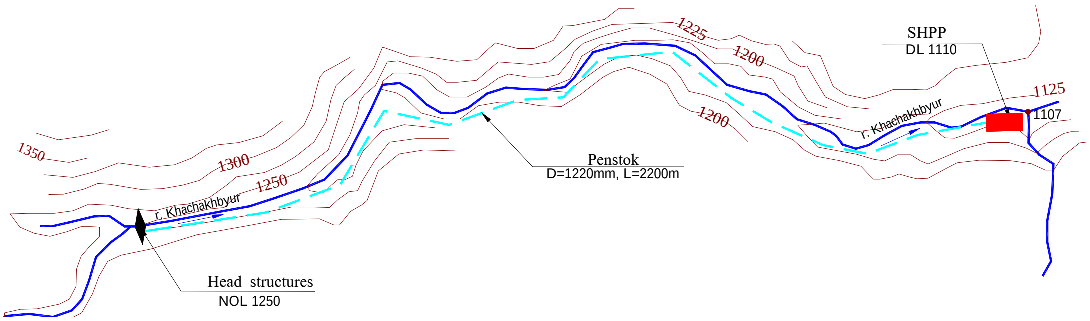
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 89. Design results according to financial scenarios

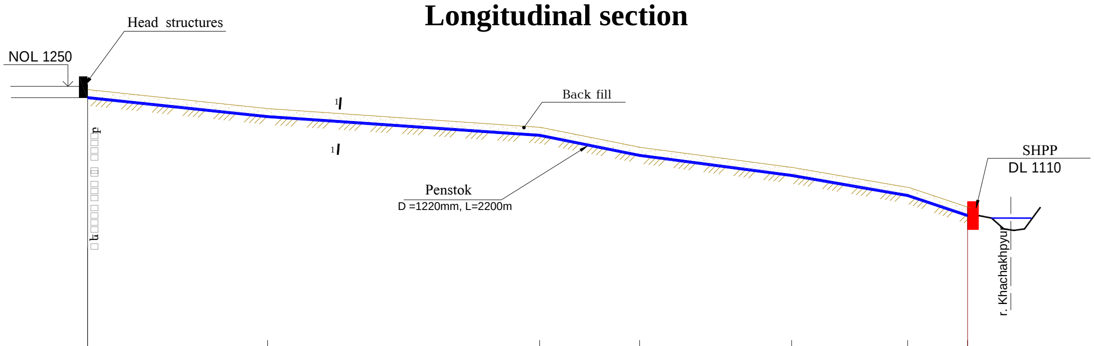
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		21.6	17.3
NPV, thousand USD			
	8%	2779.4	2779.4
	10%	1860.4	1963.0
	12%	1171.8	1368.9
	14%	643.5	927.9
PB, years (without discount)		5.7	6.7
Deadline for credit return, years			5.0

APPENDIX. 38. KHACHAKHPYUR SHPP-2

Plan

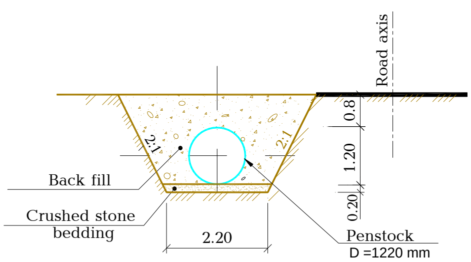


Longitudinal section

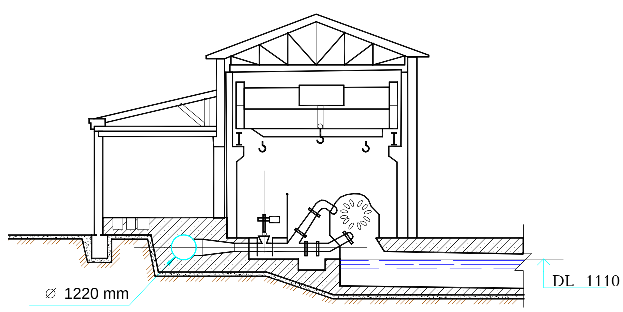


Pipe bottom elevation	1247.00	1225.00	1200.00	1175.00	1150.00	1125.00	1110.00
Distance, m	450	680	250	380	290	150	

1-1



SHPP Powerhouse



Khachakhbyur SHPP-3

Introduction

Khachakhbyur SHPP-3 uses inclination of River Khachakhbyur from 1100.0 till 890.0. The length of derivation from Khachakhbyur River is 2900m by copper pipeline 1220mm in diameter with design pressure of 194.13m and design discharge 3.20m^3/sec.

After construction and exploitation Khachakhbyur SHPP-3 will have 4.970mwt capacity and will produce 20.242mln kw/h electricity annually.

HYDROLOGY

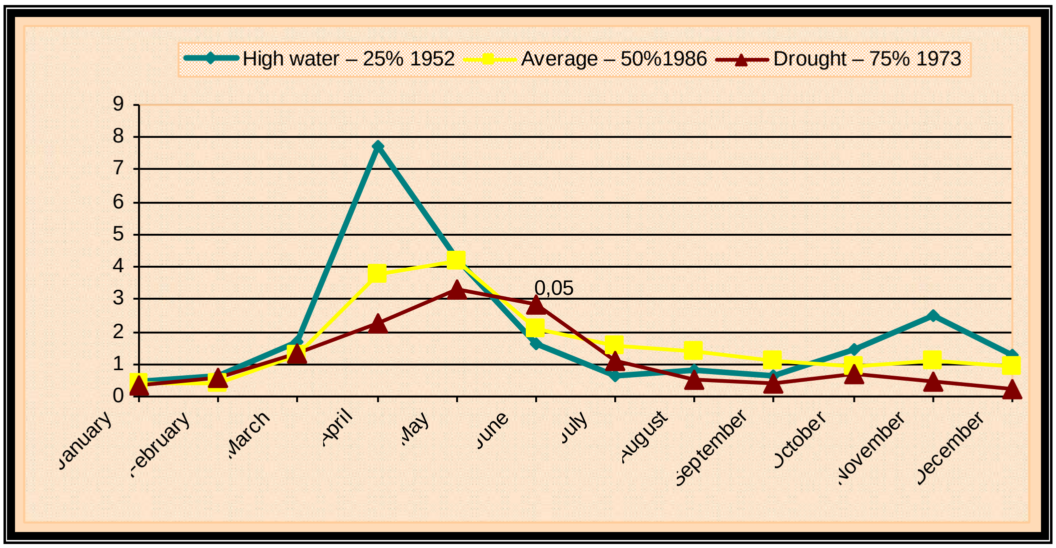
The observation data for 49 years from r. Paghjur-Getahovit water-meter station is used to define the hydrological properties of Khachakhbyur SHPP-3 headworks and the design river section.

The graphic below shows the hydrological properties of design river sectios.

River Section	Distance from the river mouth, Km	Average Elevation of the CatchmentBasin,m.	Catchment basin km^2	Flow Norm, m^3/sec
Khachakhbyur --design river section 3	9.4	1800	167.2	1.56

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 41. Annual flow distribution



Maximal design discharge for Khachakhbyur SHPP-3 headwork river section for the general case equal 3% - 77.1m^3/sec, for verifying case - 0.5%-94.8m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.082m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Khachakhbyur SHPP-3 is 1100.0m, downstream - 890.0m. There is no water intake for irrigational use from Khachakhbyur River. Paghjur reservoir volume 30mln.m^3 is taken into consideration in water energy calculations, it is planned to fill the reservoir in spring. Khachakhbyur SHPP-3 is derivational SHPP. In order not to drain the river where 2900m derivational pipeline is the environmental discharge is designed according to RA laws and 0.062m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Khachakhbyur SHPP-3 are calculated with 50% guarantee per annum (1993 see table 90).

Table. 90. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Khachakhbyur SHPP-3 (m^3/sec)	0.37	0.33	1.23	3.20	3.20	2.05	1.52	1.33	1.07	0.85	1.07	0.89	
SHPP average monthly capacity (mwt)	0.618	0.551	2.039	4.970	4.970	3.333	2.506	2.201	1.778	1.417	1.778	1.483	
SHPP –average monthly energy production (mln kwt/hour)	0.459	0.370	1.517	3.578	3.697	2.400	1.864	1.638	1.281	1.054	1.281	1.106	**20.242**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 4895.5 thousand USD (without VAT) and 5514.6 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	161.5
2. Exploitation expenses	76.0
Salary	28.8
Renovation	39.2
Other Expenses	8.0
Total	237.5

Power indicators of have the following level

Indicators	Values
Derivation capacity, kwt	4970
Average multi annual production of energy, mln kwt/hour	20.24
Capital investments into SHPPS(without VAT),	
thousand USD	4895.5
USD / kwt	985
USD / kwt/hour	0.24
Prime cost of power production, cents/kwt hour	

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

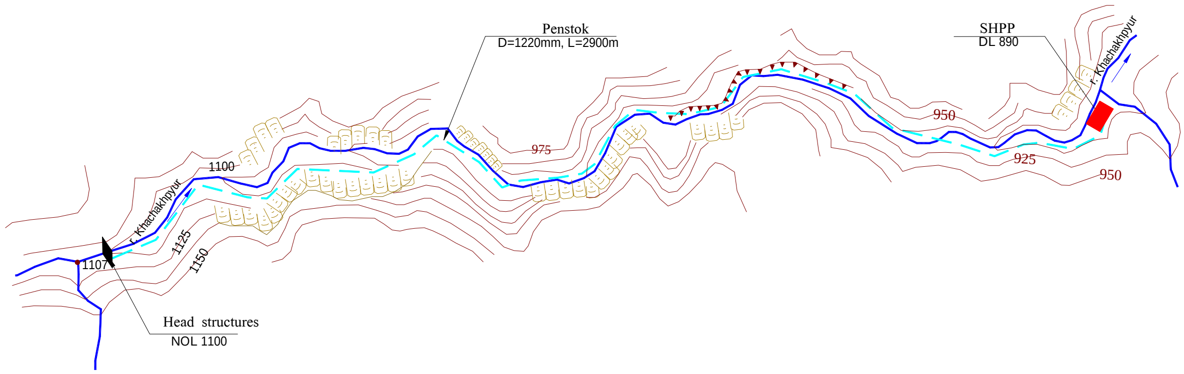
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 91. Design results according to financial scenarios

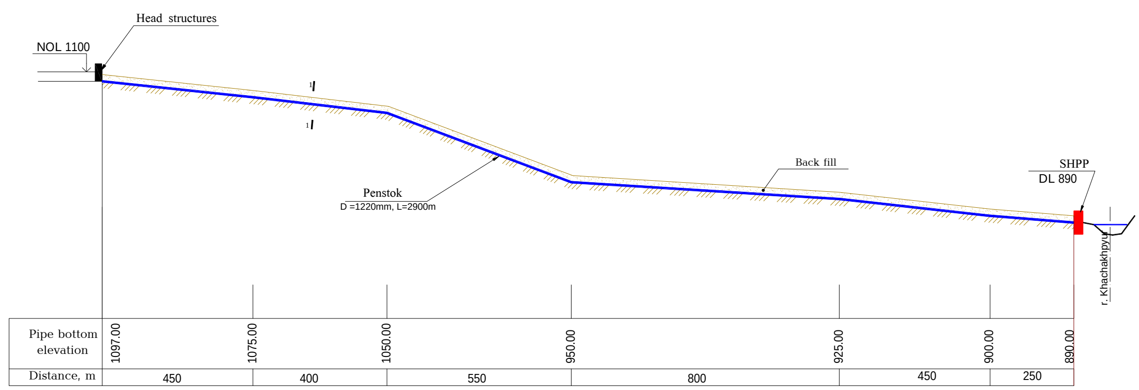
INDICATORS		**Scenario 1** 100% fully self -financed option	**Scenario 2** 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		16.9	20.9
NPV, thousand USD			
	8%	4520.5	4520.5
	10%	2988.8	3263.9
	12%	1841.3	2177.6
	14%	960.8	1445.9
PB, years (without discount)		5.9	6.9
Deadline for credit return, years			5.2

APPENDIX. 39. KHACHAKHPYUR SHPP-3

Plan



Longitudinal section



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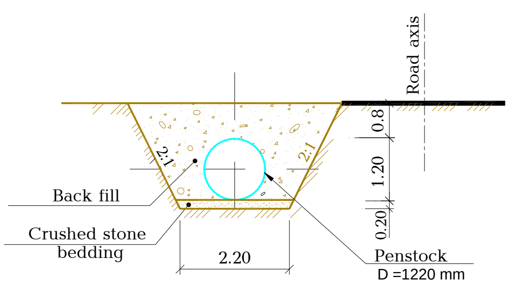
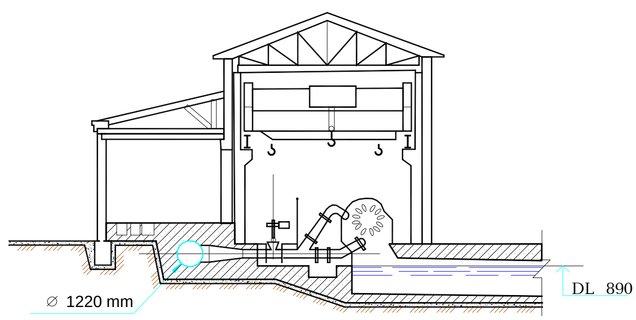


SHPP Powerhouse



15.3.5.9. Hakhum SHPP

Introduction

According to development scheme it was planned to construct 4 SHPPs on Hakhum river. As a result of in-situ investigations it was decided to construct 2 derivational SHPP.

It is planned to construct Hakhum SHPP before the existing Hakhum reservoir.

Hakhum SHPP-1 uses inclination of River Hakhum from 1090.0 till 1025.0. The length of derivation from Hakhum River is 2500m by copper pipeline 920mm in diameter with design pressure of 53.06m and design discharge 1.40m^3/sec.

After construction and exploitation Hakhum SHPP will have 0.594mwt capacity and will produce 2.843mln kw/h electricity annually.

Short Description of Hakhum River Basin

Hakhum River is the right inflow of Kur River and falls into the latter 805km from the river mouth. River length is 32km, general chatchment area near r. Tsakhkavan is 165km2, average inclination is 103‰, average elevation is 1630m, and forests occupy < 5% of the territory.

Hakhum river basin is located in the north-eastern slopes of RA. It borders with river Kur form north, Getik river from south with dividing Murghuz mountain chain, Tavush River from the west and Aghstev River basin from the east. The river starts 2917.0m from Murghuz mountain chain.

The geological composition is represented by middle and upper Jurassic period dacites, tuff breccias, porphyrites, tuff sand stones as well as Quaternary talus-alluvial sediments.

The earth cover of the river is diverse consisting of sub-alpine meadows, black soil, some brown mountain soil in the midstream and dark brown soil in the downstream. In the upstream there are alpine meadows and oak forests in the downstream.

Hakhum River is a typical mountainous river. The relief is mountainous with small and large inflows. The slopes consist of basalts covered by forest black soil. Bottom of the valley is composed of volcanic sediments.

The river bed is straight near Tsakhkavan village; composed of large stones, sands and subject to deformation. During drought river bed merges with valley sloped. During spring and summer rains the river becomes heavy and brings many in wash materials in winter there is some insignificant shoreline icing.

HYDROLOGY

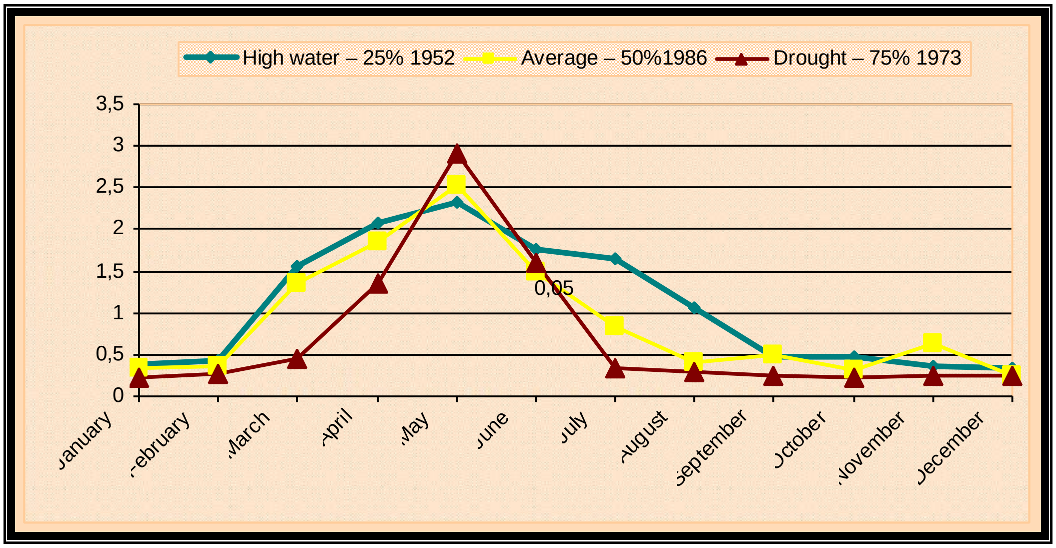
The observation data for 56 years from r. Hakhum-Tsakhkavan water-meter station is used to define the hydrological properties of Hakhum SHPP headworks and the design river section.

The graphic below shows the hydrological properties of design river sections.

River Section	Distance from the river mouth, Km	Average Elevation of the CatchmentBasin,m.	Catchment basin km^2	Flow Norm, m^3/sec
Hakhum - design river section	42.4	1800	99.8	0.88

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 42. Annual flow distribution



Maximal design discharge for Hakhum SHPP headwork river section for the general case equal 3% - 30.6m^3/sec, for verifying case - 0.5%-39.0m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.083m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Hakhum SHPP is 1090.0m, downstream - 1025.0m. According to data of State Water Economy Data the water intake for irrigational use from Hakhum river is 0.74mln.m^3. Hakhum SHPP is derivational SHPP. In order not to drain the river where 2500m derivational pipeline is the environmental discharge is designed according to RA laws and 0.06m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Hakhum SHPP are calculated with 50% guarantee per annum (2004 see table 92).

Table. 92. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Hakhum SHPP (m^3/sec)	0.28	0.31	1.30	1.40	1.40	1.38	0.73	0.30	0.41	0.26	0.57	0.18	
SHPP average monthly capacity (mwt)	0.144	0.160	0.569	0.594	0.594	0.590	0.361	0.156	0.208	0.134	0.287	0.093	
SHPP –average monthly energy production (mln kwt/hour)	0.107	0.107	0.423	0.428	0.442	0.425	0.269	0.116	0.150	0.100	0.207	0.069	**2.843**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 673.8 thousand USD (without VAT) and 808.6 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		22.2
2. Exploitation expenses		21.8
	Salary	14.4
	Renovation	5.4
	Other Expenses	2.0
Total		44.0

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		594
Average multi annual production of energy, mln kwt/hour		2.84
Capital investments into SHPPS(without VAT),		
	thousand USD	673.8
	USD / kwt	1134.3
	USD / kwt/hour	0.24
Prime cost of power production, cents/kwt hour		1.55

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

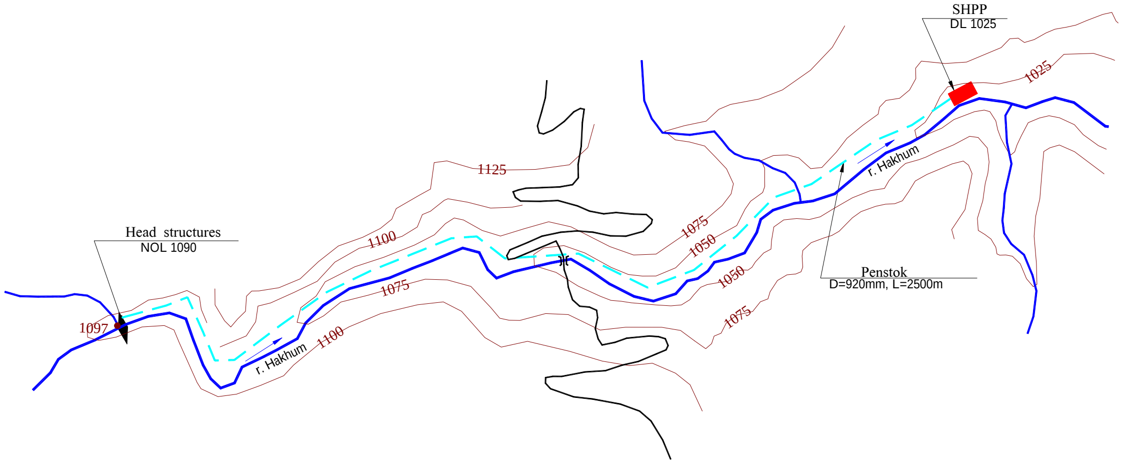
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 93. Design results according to financial scenarios

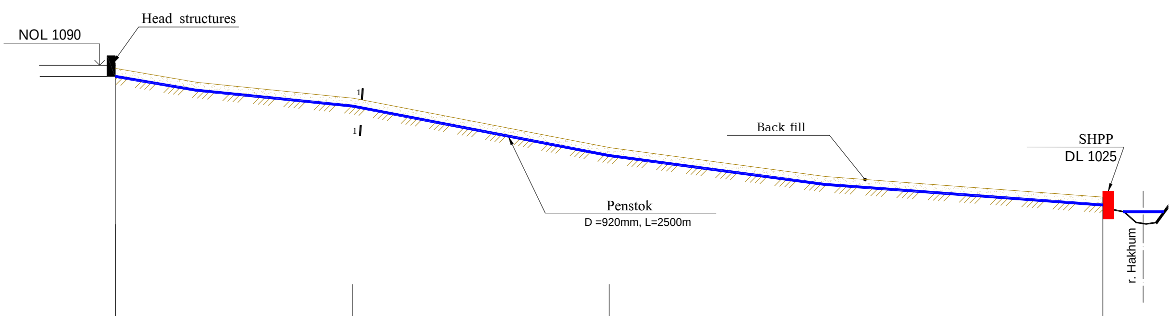
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		15.9	20.0
NPV, thousand USD			
	8%	547.5	547.5
	10%	348.8	376.5
	12%	200.0	252.8
	14%	85.8	161.6
PB, years (without discount)		6.2	7.5
Deadline for credit return, years			6.0

APPENDIX. 40. HAKHUM SHPP

Plan

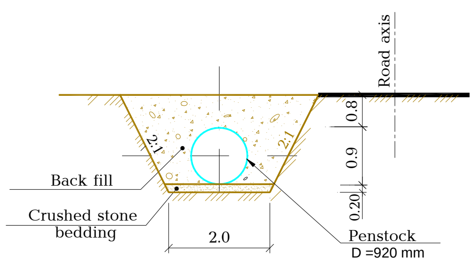


Longitudinal section

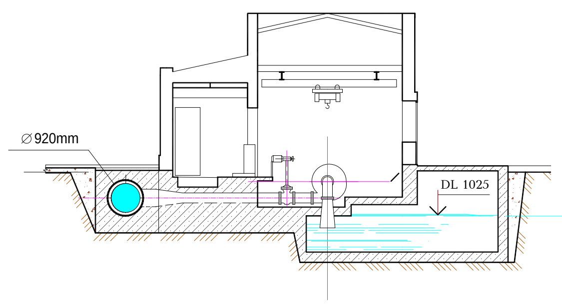


Pipe bottom elevation	1087.00		1075.00		1050.00	1025.00
Distance, m		600		650	1250	

1-1



SHPP Powerhouse



15.3.5.12. Hakhinja SHPP

Introduction

According to development scheme it was planned to construct 2 SHPPs on Hakhinja River. As a result of in-situ investigations it was decided to construct one derivational SHPP.

Hahginja SHPP uses inclination of River Hakhinja from 850.0 till 760.0. The length of derivation from Hakhinja River is 3000m by copper pipeline 1420mm in diameter with design pressure of 80.70m and design discharge 3.60m^3/sec.

After construction and exploitation Hakhinja SHPP will have 2.324mwt capacity and will produce 9.025mln kw/h electricity annually.

Short Description for Hakhinja River Basin

Hakhija River is the right inflow of Tavush River and falls into the latter 24km from the river mouth. Hakhija river length is 47km, general chatchment area is 454km^2, average inclination is 334‰, average elevation is 1630m, and forests occupy 74% of the territory.

Hakhinja River basin is located in the north-eastern part of Armenia It borders with Tavush river from north-south, Getik River from south with dividing Murghuz mountain chain, and river Kur inflow basins from the west. The river starts to the east from Bazkert mountain of Murghus mountain chain. The geological composition is represented by middle and upper Jurassic period dacites, tuff breccias, tuff sand stones as well as Quaternary talus-alluvial sediments.

The earth cover of the river is diverse consisting of sub-alpine meadows, black soil, some brown mountain soil in the midstream and dark brown soil in the downstream. Hakhinja river basin has a forest cover which occupies 74% of its territory. In the upstream there are alpine meadows and oak forests in the downstream.

Hakhinja River is a typical mountainous river. The relief is mountainous with small and large inflows. 29km from the river mouth the Khndzorut inflow discharges into Hakhinja river. The valley is a gorge covered by forests and bushes. The slopes consist of basalts covered by forest black soil. The river bed is composed of volcanic sediments.

Near the village Hakhinja river bed is straight and consists of large stones, sand stones and is subject to deformation. During the drought period river bed merges into the valley slopes. During seasonal floods the flow is heavy and brings many in wash material. In winter there is insignificant shoreline ice.

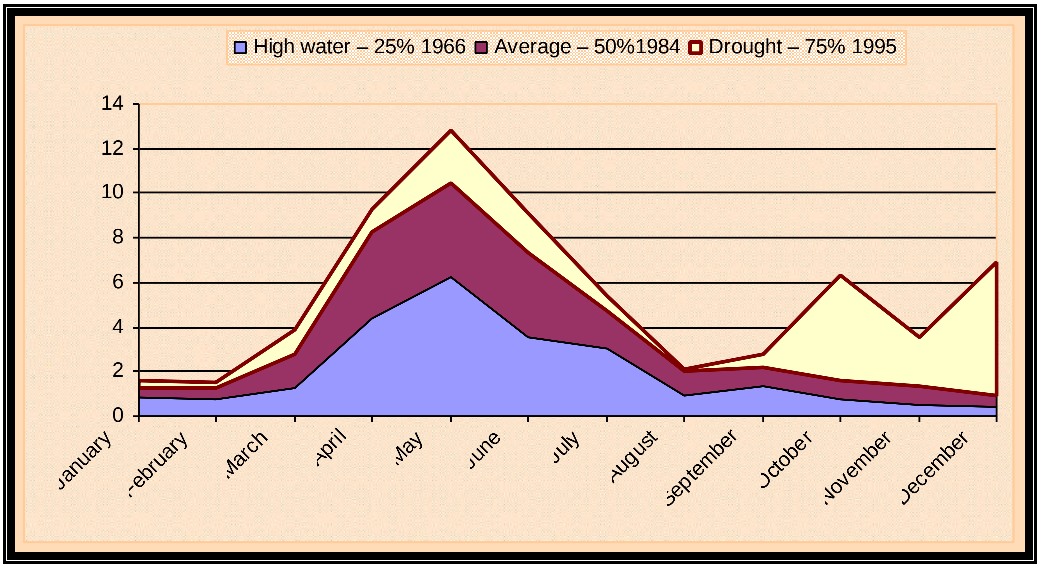
HYDROLOGY

The observation data for 54 years from r. Hakhinja Aigedzor water-meter station is used to define the hydrological properties of Hakhinja SHPP headworks and the design river section.

River Section	Distance from the river mouth, Km	Average Elevation of the CatchmentBasin,m.	Catchment basin km^2	Flow Norm, m^3/sec
Hakhingha - design river section	22.3	1700	222.1	1.66

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 43. Annual flow distribution



Maximal design discharge for Hakhinja SHPP headwork river section for the general case equal 3% - 83.6m^3/sec, for verifying case - 0.5%-119m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.066m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Hakhinja SHPP is 850.0m, downstream - 760.0m. According to data of State Water Economy Data the water intake for irrigational use from Hakhinja River is 1.12mln.m^3. Hakhinja SHPP is derivational SHPP. In order not to drain the river where 3000m derivational pipeline is the environmental discharge is designed according to RA laws and 0.05m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of the SHPP are calculated with 50% guarantee per annum (1991 see table 94).

Table. 94. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Hakhinja SHPP (m^3/sec)	0.38	0.47	1.42	3.60	3.60	3.69	1.59	0.90	0.70	0.83	0.77	0.49	
SHPP average monthly capacity (mwt)	0.273	0.338	1.005	2.324	2.324	2.320	1.122	0.644	0.500	0.594	0.552	0.352	
SHPP –average monthly energy production (mln kwt/hour)	0.203	0.227	0748	1.673	1.729	1.670	0.835	0.479	0.360	0.442	0397	0.262	**9.025**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 2186.1 thousand USD (without VAT) and 2623.3 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		72.1
2. Exploitation expenses		48.5
	Salary	26.0
	Renovation	17.5
	Other Expenses	5.0
Total		120.6

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		2324
Average multi annual production of energy, mln kwt/hour		9.025
Capital investments into SHPPS(without VAT),		
	thousand USD	2186.1
	USD / kwt	940.7
	USD / kwt/hour	0.242
Prime cost of power production, cents/kwt hour		1.34

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

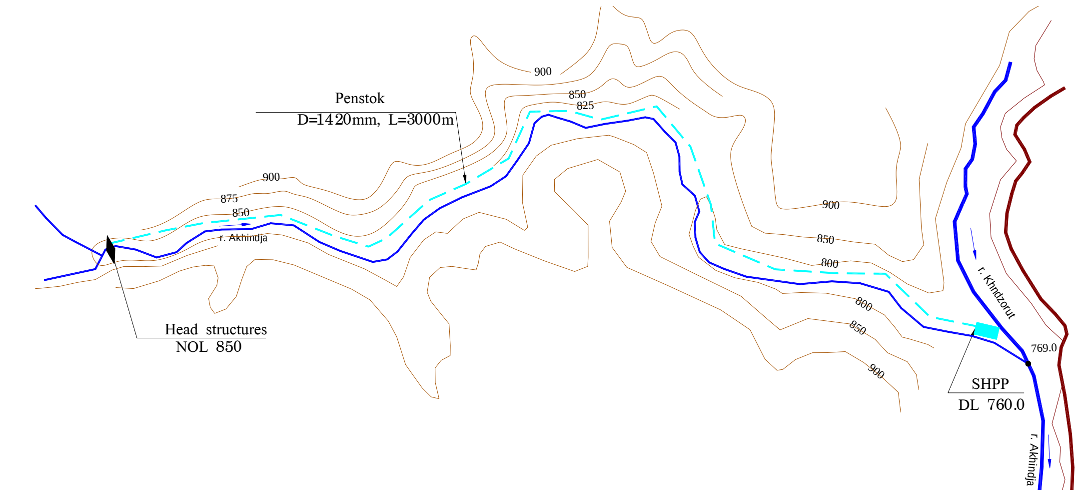
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 95. Design results according to financial scenarios

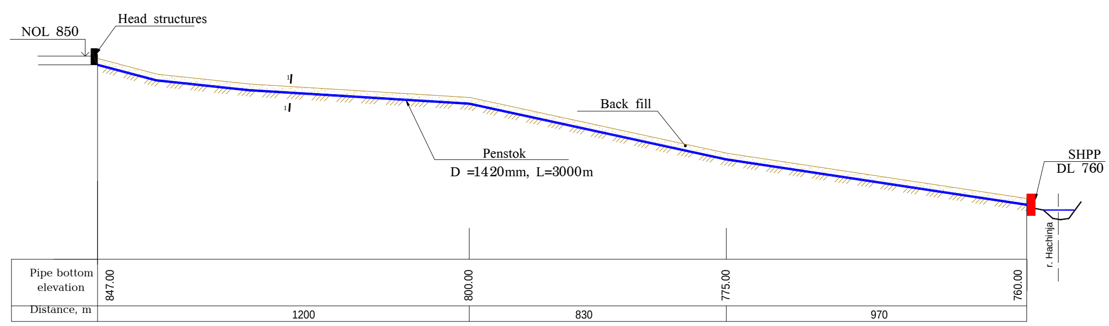
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		16.3	20.6
NPV, thousand USD			
	8%	1880.7	1880.7
	10%	1219.1	1308.8
	12%	723.5	894.9
	14%	343.2	589.2
PB, years (without discount)		6.1	7.3
Deadline for credit return, years			5.7

APPENDIX. 41. HAKHINJA SHPP

Plan



Longitudinal section



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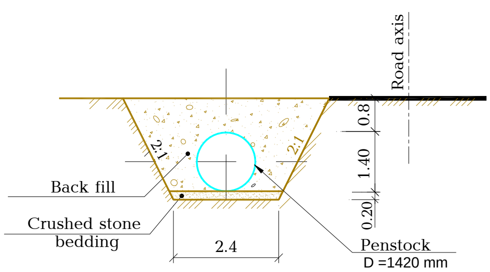
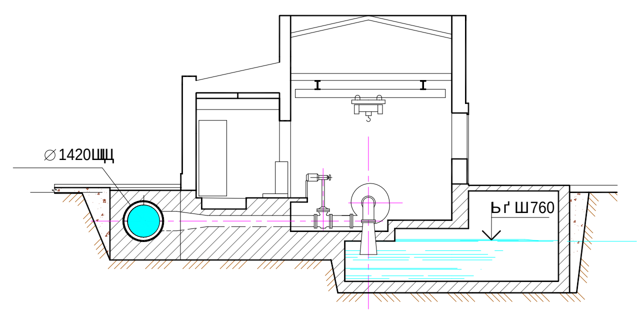


SHPP Powerhouse



15.3.5.13. Khndzorut SHPP-1,2,3

Khndzorut SHPP-1

Introduction

According to development scheme it was planned to construct 5 SHPPs on Khndzorut river. As a result of in-situ investigations it was decided to construct 3 derivational SHPP.

It is planned to construct Khndzorut SHPP before Khndzorut reservoir. Khndzorut SHPP uses inclination of River Khndzorut from 1305.0m till 1205.0m. The length of derivation from Khndzorut River is 2450m by copper pipeline 820mm in diameter with design pressure of 88.9m and design discharge 1.00m^3/sec.

After construction and exploitation Khndzorut SHPP will have 0.711mwt capacity and will produce 2.755mln kw/h electricity annually.

Short Description for Khndzorut River Basin

Khndzorut River is the left inflow of Hakhinja River which discharges into the latter 10km from the river mouth. Khndzorut river length is 29km, general chatchment area is 191.6km^2, average inclination is 86‰, average elevation is 1870m, and forests occupy 75% of the territory.

Khndzorut River basin in the north-eastern section of RA It borders with Tavush River on north and east-south, south Getik River with dividing Maghmuz mountain chain, with west – with Kur River inflows.

The river starts to the east from Bakend mountain of Murghuz mountain chain. slopes of Gugarats mountain chain. The geological composition is represented by middle and upper Jurassic period dacites, tuff breccias, tuff sand stones as well as Quaternary talus-alluvial sediments. The earth cover of the river is diverse consisting of sub-alpine meadows, black soil, some brown mountain soil in the midstream and dark brown soil in the downstream. Hakhinja river basin has a forest cover which occupies 75% of its territory. In the upstream there are alpine meadows and oak forests in the downstream.

Khndzorut River is a typical mountainous river. The relief is mountainous with small and large inflows. The slopes consist of basalts covered by forest black soil. The river bed consists of volcanic sediments.

Khndzorut river bed is straight and consists of large stones, sand stones and and is subject to deformation. During seasonal floods the flow is heavy and brings many in wash material. In winter there is insignificant shoreline ice.

HYDROLOGY

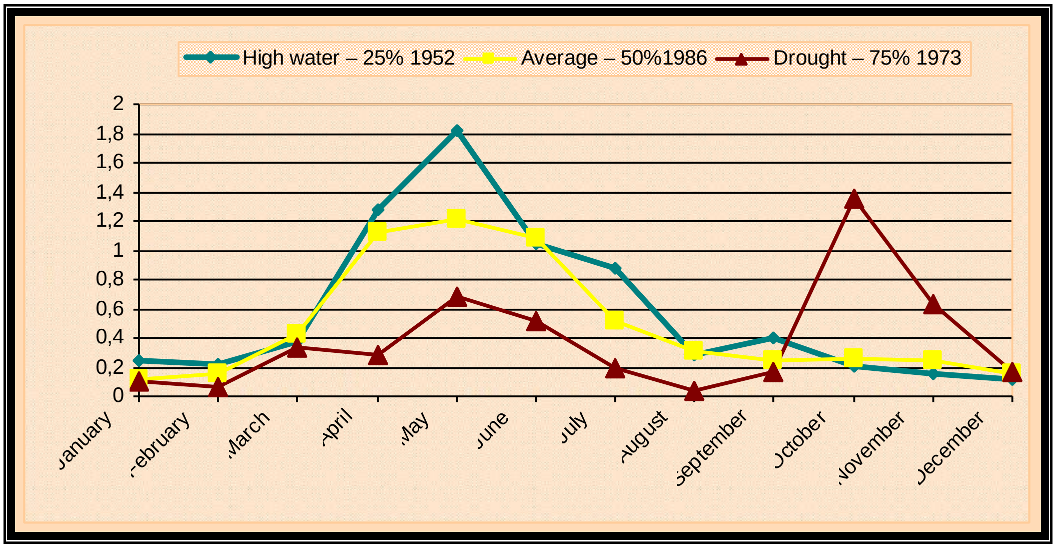
The observation datafor 54 years from r. Hakhingha-Aigedzor water-meter station is used to define the hydrological properties of Khndzorut SHPP-1 headworks and the design river section.

The graphic below shows the hydrological properties of design river sections.

River Section	Distance from the river mouth, Km	Average Elevation of the CatchmentBasin,m.	Catchment basin km^2	Flow Norm, m^3/sec
Khndzorut SHPP-1- design river longitudinals section	15.4	2150	64.4	0.66

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 44. Annual flow distribution



Maximal design discharge for Khndzorut SHPP-1 headwork river section for the general case equal 3% - 50.9m^3/sec, for verifying case - 0.5%-72.7m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.019m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Khndzorut SHPP-1 is 1305.0m, downstream - 1205.0m. According to data of State Water Economy Data the water intake for irrigational use from Khndzorut SHPP-1 is 0.95mln.m^3. Khndzorut SHPP-1 is derivational SHPP. In order not to drain the river where 2450m derivational pipeline is the environmental discharge is designed according to RA laws and 0.014m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Khndzorut SHPP-1 are calculated with 50% guarantee per annum (1991 see table 96).

Table. 96. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Khndzorut SHPP-1 (m^3/sec)	0.11	0.14	0.42	1.00	1.00	1.00	0.41	0.21	0.17	0.25	0.23	0.15	
SHPP average monthly capacity (mwt)	0.085	0.109	0.326	0.711	0.711	0.711	0.325	0.165	0.136	0.195	0.180	0.116	
SHPP –average monthly energy production (mln kwt/hour)	0.063	0.073	0.243	0.512	0.529	0.512	0242	0.123	0.098	0.145	0.129	0.087	**2.755**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 680.2 thousand USD (without VAT) and 816.2 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		22.4
2. Exploitation expenses		25.7
	Salary	17.3
	Renovation	5.4
	Other Expenses	3.0
Total		48.1

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		711
Average multi annual production of energy, mln kwt/hour		2.76
Capital investments into SHPPS(without VAT),		
	thousand USD	680.2
	USD / kwt	956.6
	USD / kwt/hour	0.25
Prime cost of power production, cents/kwt hour		1.75

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

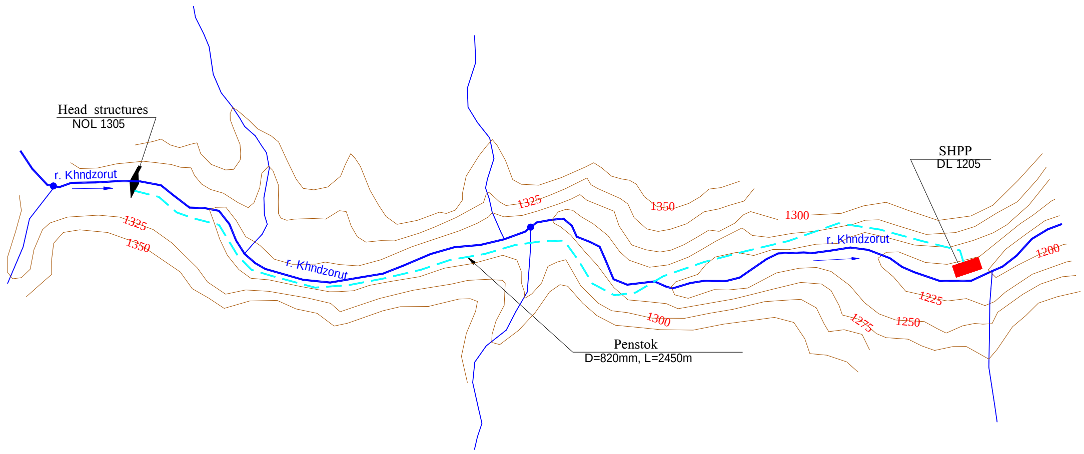
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 97. Design results according to financial scenarios

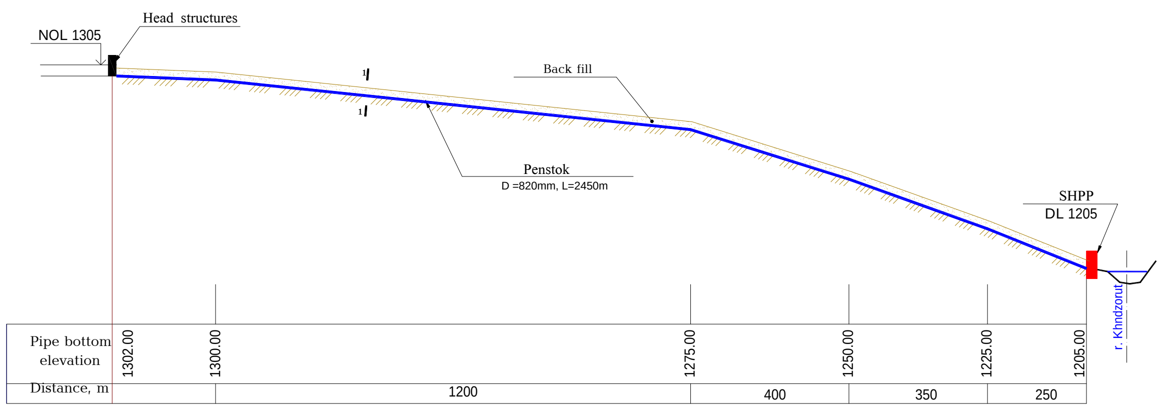
INDICATORS		**Scenario 1** 100% fully self - financed option	**Scenario 2** 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		14.6	17.8
NPV, thousand USD		5.4	5.4
	8%	464.1	464.1
	10%	277.9	305.8
	12%	138.6	191.8
	14%	31.5	108.0
PB, years (without discount)		6.7	8.1
Deadline for credit return, years			6.0

APPENDIX. 42. KHNDZORKUT SHPP-1

Plan



Longitudinal section



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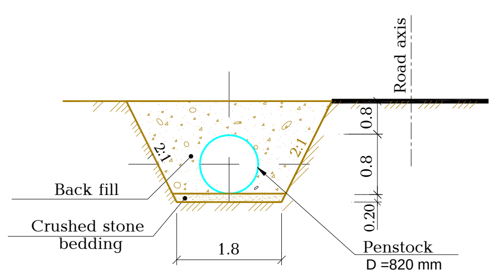
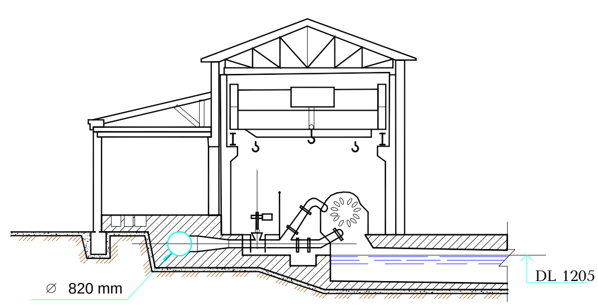


SHPP Powerhouse



Khndzorut SHPP-2

Introduction

Khndzorut SHPP-2 uses inclination of River Khndzorut from 1200m till 1100m. The length of derivation from Khndzorut River is 2500m by copper pipeline 920mm in diameter with design pressure of 91.1m and design discharge 1.20m^3/sec.

After construction and exploitation Khndzorut SHPP will have 0.875mwt capacity and will produce 3.336mln kw/h electricity annually.

HYDROLOGY

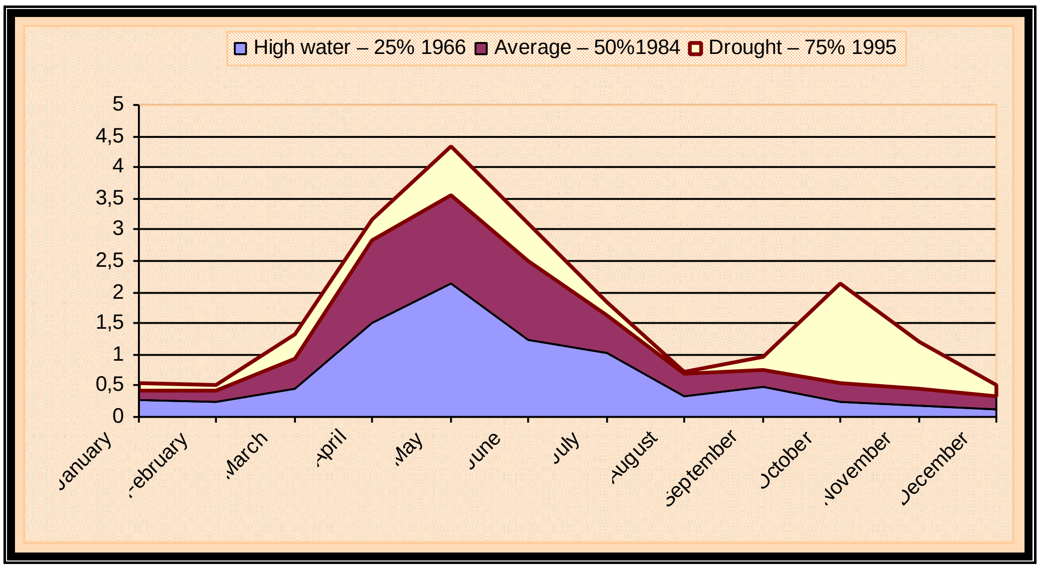
The observation datafor 54 years from r. Hakhingha-Aigedzor water-meter station is used to define the hydrological properties of Khndzorut SHPP-2 headworks and the design river section.

The graphic below shows the hydrological properties of design river sectios.

River Section	Distance from the river mouth, Km	Average Elevation of the CatchmentBasin,m.	Catchment basin km^2	Flow Norm, m^3/sec
Khndzorut SHPP-2- design river longitudinal section	14.2	2100	72.9	0.78

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP

Graph. 45. Annual flow distribution



Maximal design discharge for Khndzorut SHPP-2 headwork river section for the general case equal 3% - 54.3m^3/sec, for verifying case - 0.5%-77.5m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.023m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Khndzorut SHPP-2 is 1200.0m, downstream - 1100.0m. According to data of State Water Economy Data the water intake for irrigational use from Khndzorut SHPP-2 is 0.95mln.m^3. Khndzorut SHPP-2 is derivational SHPP. In order not to drain the river where 2500m derivational pipeline is the environmental discharge is designed according to RA laws and 0.017m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Khndzorut SHPP-2 are calculated with 50% guarantee per annum (1991 see table 98).

Table. 98. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Khndzorut SHPP - 2(m^3/sec)	0.13	0.16	0.48	1.20	1.20	1.19	0.49	0.25	0.21	0.28	0.26	0.17	
SHPP average monthly capacity (mwt)	0.106	0.130	0.381	0.875	0.875	0.869	0.387	0.202	0.166	0225	0.209	0.138	
SHPP –average monthly energy production (mln kwt/hour)	0.079	0.087	0.283	0.630	0.651	0.626	0.288	0.151	0.119	0.168	0.151	0.103	**3.336**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 835.4 thousand USD (without VAT) and 1002.5 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	27.6
2. Exploitation expenses	27.0
Salary	17.3
Renovation	6.7
Other Expenses	3.0
Total	54.6

Power indicators of have the following level

Indicators	Values
Derivation capacity, kwt	875
Average multi annual production of energy, mln kwt/hour	3.34
Capital investments into SHPPS(without VAT),	
thousand USD	835.4
USD / kwt	954.8
USD / kwt/hour	0.25
Prime cost of power production, cents/kwt hour	1.64

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- ❖ Private investments only /Scenario 1/
- ❖ 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

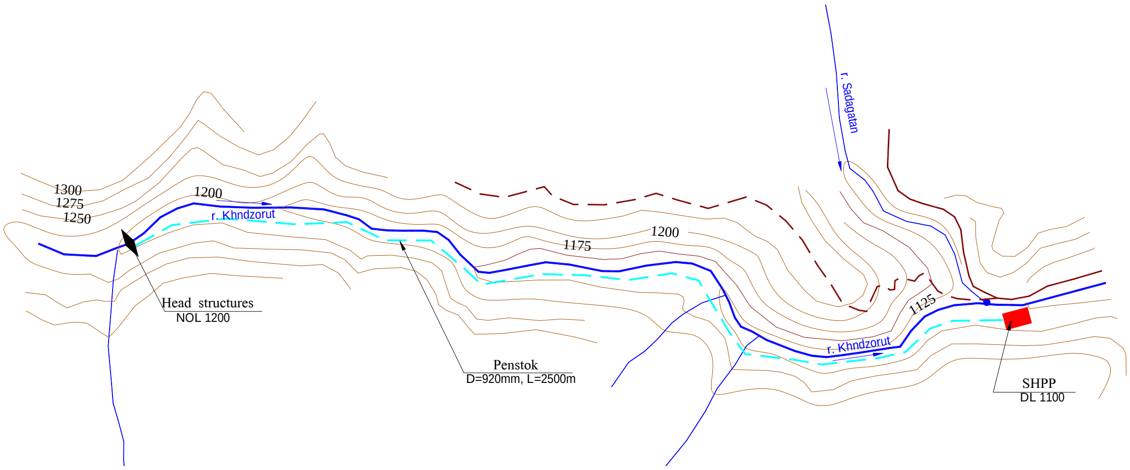
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 99. Design results according to financial scenarios

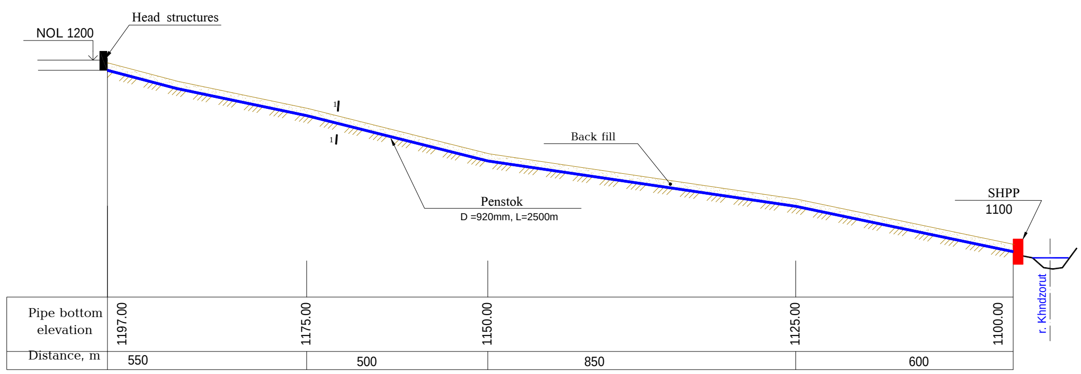
INDICATORS		Scenario 1 100% fully self -financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		14.9	18.2
NPV, thousand USD			
	8%	688.1	588.1
	10%	356.5	390.8
	12%	183.1	248.5
	14%	49.9	143.9
PB, years (without discount)		6.6	8.0
Deadline for credit return, years			6.0

APPENDIX. 43. KHNDZORUT SHPP-2

Plan



Longitudinal section



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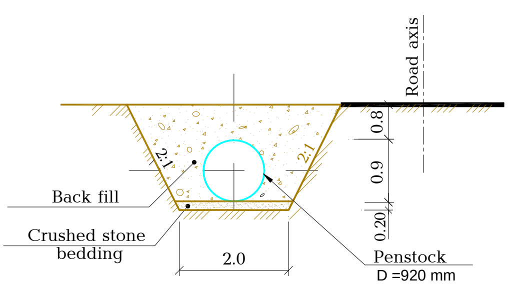
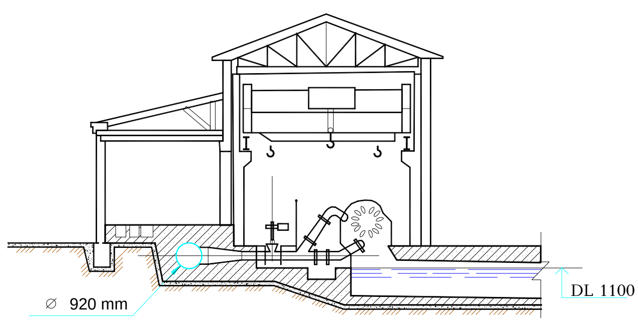


SHPP Powerhouse



Khndzorut SHPP-3

Introduction

Khndzorut SHPP-3 uses inclination of River Khndzorut from 1090.0m till 975.0m. The length of derivation from Khndzorut River is 3750m by copper pipeline 1020mm in diameter with design pressure of 94.07m and design discharge 2.00m^3/sec.

After construction and exploitation Khndzorut SHPP-3 will have 1.505mwt capacity and will produce 6.076mln kw/h electricity annually.

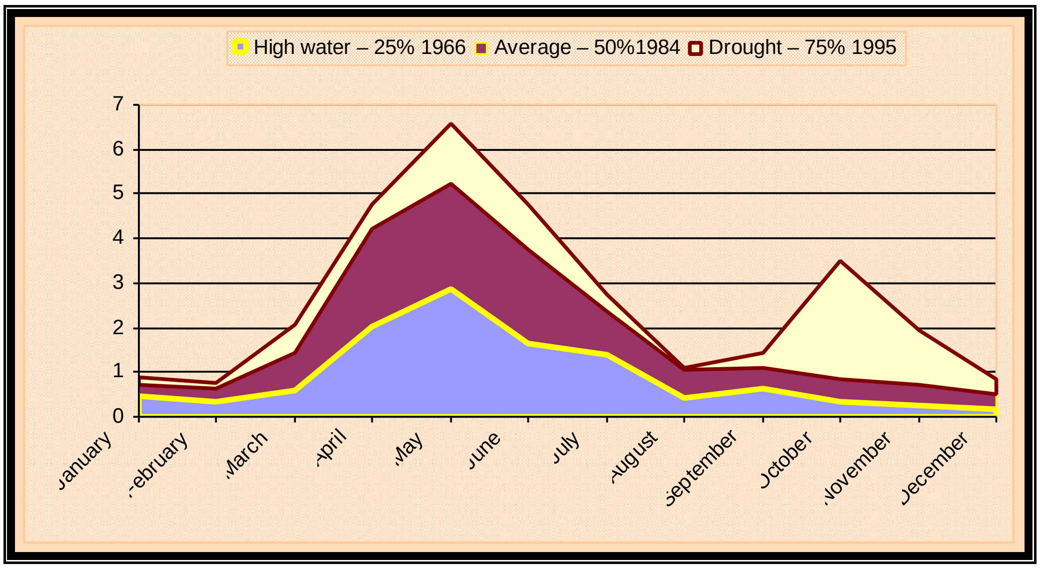
HYDROLOGY

The observation data for 54 years from r. Hakhingha-Aigedzor water-meter station is used to define the hydrological properties of Khndzorut SHPP-3 headworks and the design river section.

The graphic below shows the hydrological properties of design river sections.

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 46. Annual flow distribution



Maximal design discharge for Khndzorut SHPP-3 headwork river section for the general case equal 3% - 66.6m^3/sec, for verifying case - 0.5%-95.0m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.037m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Khndzorut SHPP-3 is 1090.0m, downstream - 975.0m. According to data of State Water Economy Data the water intake for irrigational use from Khndzorut SHPP-3 is 0.95mln.m^3. Khndzorut SHPP-3 is derivational SHPP. In order not to drain the river where 3750m derivational pipeline is the environmental discharge is designed according to RA laws and 0.028m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Khndzorut SHPP-3 are calculated with 50% guarantee per annum (1991 see table 100).

Table. 100. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Khndzorut SHPP-3 (m^3/sec)	0.21	0.26	0.80	2.00	2.00	2.00	0.88	0.48	0.38	0.47	0.43	0.28	
SHPP average monthly capacity (mwt)	0.195	0.240	0.715	1.505	1.505	1.505	0.780	0.439	0.344	0.430	0.394	0.258	
SHPP –average monthly energy production (mln kwt/hour)	0.145	0.161	0532	1.084	1.120	1.084	0.580	0.327	0.248	0320	0.284	0.192	**6.076**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 1482.5 thousand USD (without VAT) and 1779.0 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	48.9
2. Exploitation expenses	38.9
Salary	23.0
Renovation	11.9
Other Expenses	4.0
Total	87.8

Power indicators of have the following level

Indicators	Values
Derivation capacity, kwt	1505
Average multi annual production of energy, mln kwt/hour	6.08
Capital investments into SHPPS(without VAT),	
thousand USD	1482.5
USD / kwt	985.0
USD / kwt/hour	0.24
Prime cost of power production, cents/kwt hour	1.45

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

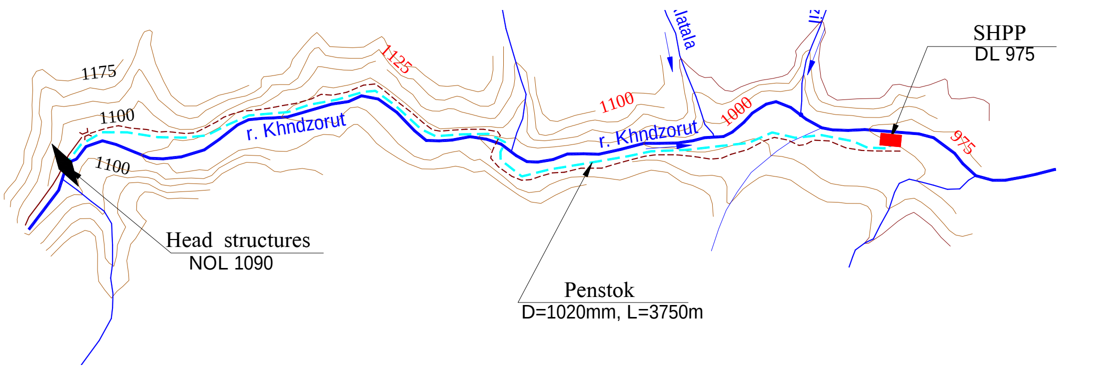
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 101. Design results according to financial scenarios

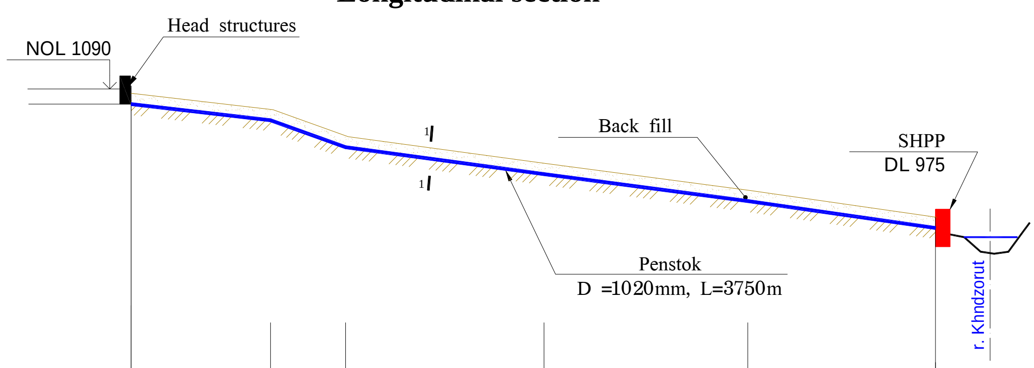
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		15.8	19.9
NPV, thousand USD			
	8%	1199.8	1199.8
	10%	763.6	824.4
	12%	436.7	552.9
	14%	185.8	352.6
PB, years (without discount)		6.2	7.5
Deadline for credit return, years			6.0

APPENDIX. 44. KHNDZORUT SHPP-3

Plan

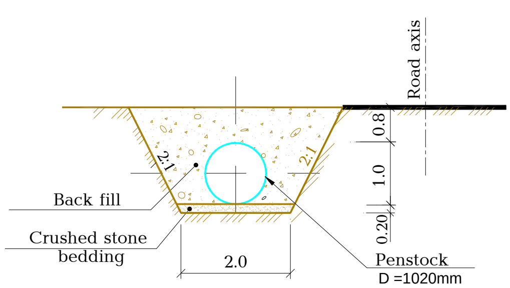


Longitudinal section

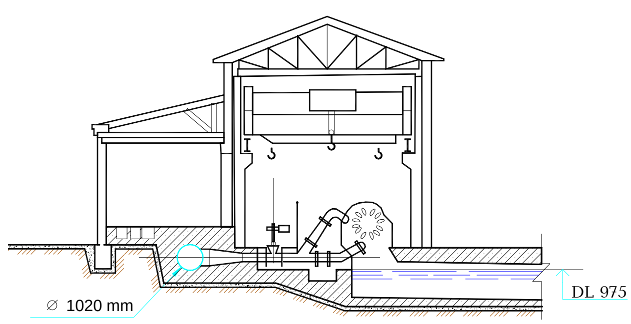


Pipe bottom elevation	1087.00		1075.00		1050.00		1025.00		1000.00		975.00
Distance, m		650		350		925		950		875	

1-1



SHPP Powerhouse



15.3.5.16.Sajagastan SHPP

Introduction

According to development scheme it was planned to construct 1 SHPPs on Sajagastan river. As a result of in-situ investigations the suitable longitudinal section was verified.

Sajagastan SHPP uses inclination of River Sajagastan from 1240.0m till 1125.0m. The length of derivation from Sajagastan River is 2000m by copper pipeline 630mm in diameter with design pressure of 105.55m and design discharge 0.50m^3/sec.

After construction and exploitation Sajagastan SHPP will have 0.422mwt capacity and will produce 1.627mln kw/h electricity annually.

Short Description of Sajagastan River Basin

Sajagastan River is the left inflow of Khndzorut river which discharges into the latter 13km from the river mouth. Sajagastan river length is 13.3km, general chatchment area is 38.7km^2, average inclination is 142‰, average elevation is 2050m, and forests occupy 65% of the territory.

Sajagastan River basin in the north-eastern section of RA It borders with Tavush River from north-south and Chikhalu River from south.

The river starts to the east from Murghuz mountain of Murghuz mountain chain on the elevation of 2993.2. The geological composition is represented by middle and upper Jurassic period dacites, tuff breccias, tuff sand stones as well as Quaternary talus-alluvial sediments. The earth cover of the river is diverse consisting of sub-alpine meadows, black soil, some brown mountain soil in the midstream and dark brown soil in the downstream. Sajagastan river basin has a forest cover which occupies 65% of its territory. In the upstream there are alpine meadows and oak forests in the downstream.

Sajagastan River is a typical mountainous river. The relief is mountainous with small and large inflows. The slopes consist of basalts covered by forest black soil. The river bed consists of volcanic sediments.

Sajagastan river bed is straight and consists of large stones, sand stones and is subject to deformation. During seasonal floods the flow is heavy and brings many in wash material. In winter there is insignificant shoreline ice.

HYDROLOGY

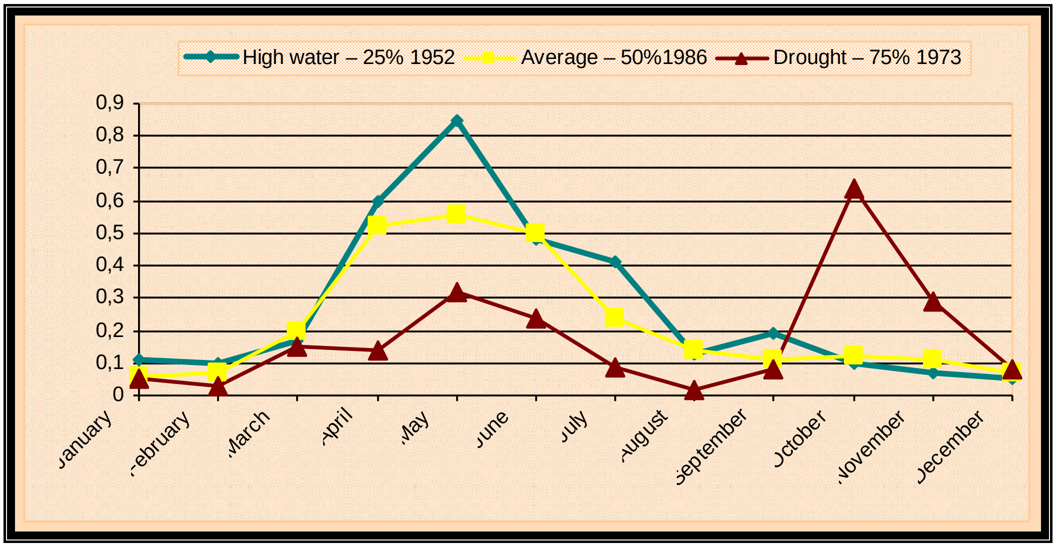
The observation datafor 54 years from r. Hakhingha-Aigedzor water-meter station is used to define the hydrological properties of Sajagastan SHPP-1 headworks and the design river section.

The graphic below shows the hydrological properties of design river sections.

River Section	Distance from the river mouth, Km	Average Elevation of the CatchmentBasin,m.	Catchment basin km^2	Flow Norm, m^3/sec
Sajagastan - design river longitudinals section	2.55	2150	30.0	0.31

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 47. Annual flow distribution



Maximal design discharge for Sajagastan SHPP headwork river section for the general case equal 3% - 37.5m^3/sec, for verifying case - 0.5%-53.6m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.009m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Sajagastan SHPP is 1240.0m, downstream - 1125.0m. According to data of State Water Economy Data there is no water intake for irrigational use from Sajagastan SHPP. Sajagastan SHPP is derivational SHPP. In order not to drain the river where 2000m derivational pipeline is the environmental discharge is designed according to RA laws and 0.007m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Sajagastan SHPP are calculated with 50% guarantee per annum (1991 see table 102).

Table. 102. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Sajagatan SHPP (m^3/sec)	0.05	0.06	0.19	0.50	0.50	0.49	0.23	0.13	0.10	0.11	0.10	0.06	
SHPP average monthly capacity (mwt)	0.049	0.058	0.175	0.422	0.422	0.417	0.210	0.122	0.094	0.103	0.094	0.058	
SHPP –average monthly energy production (mln kwt/hour)	0.036	0.039	0.130	0.304	0.314	0.300	0.157	0.090	0.068	0.077	0.068	0.043	**1.627**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 458.6 thousand USD (without VAT) and 550.3 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		15.1
2. Exploitation expenses		20.1
	Salary	14.4
	Renovation	3.7
	Other Expenses	2.0
Total		35.2

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		422
Average multi annual production of energy, mln kwt/hour		1.63
Capital investments into SHPPS(without VAT),		
	thousand USD	458.6
	USD / kwt	1086.8
	USD / kwt/hour	0.28
Prime cost of power production, cents/kwt hour		2.16

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

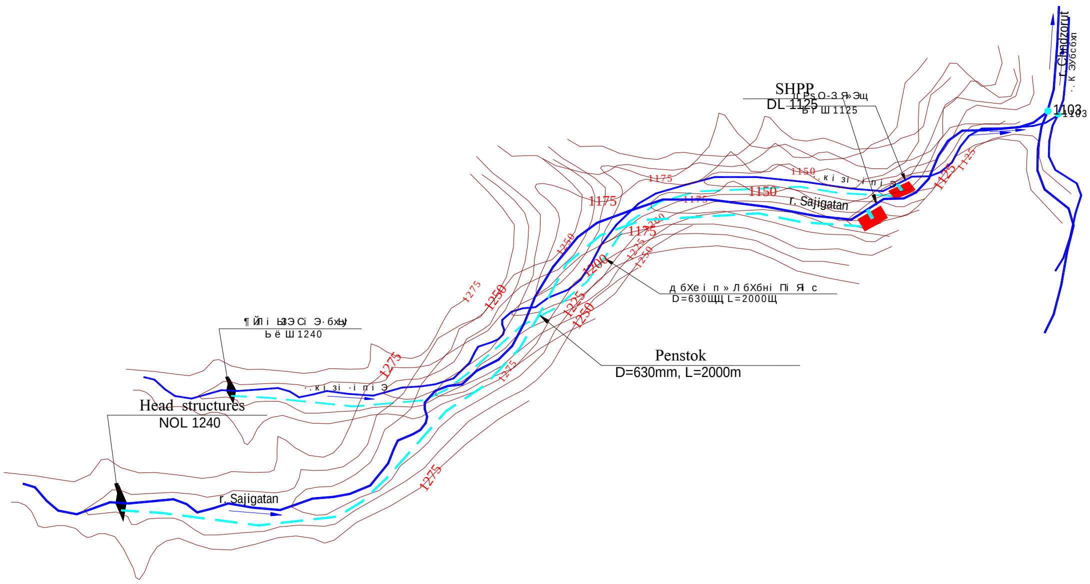
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 103. Design results according to financial scenarios

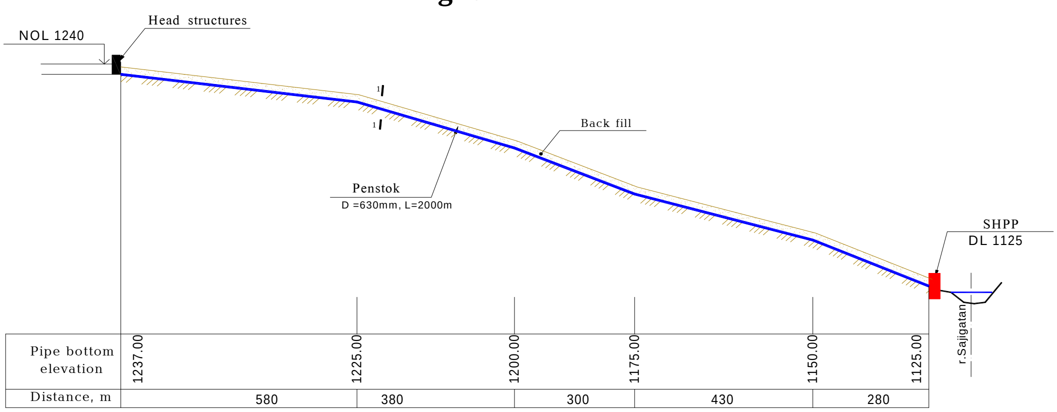
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		11.8	14.0
NPV, thousand USD			
	8%	176.9	177.0
	10%	73.5	96.9
	12%	-3.9	40.3
	14%	-63.4	-0.50
PB, years (without discount)		8.1	10.4
Deadline for credit return, years			8.0

APPENDIX. 45. SAJAGASTAN SHPP

Plan



Longitudinal section



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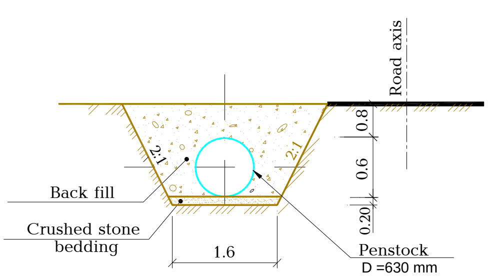
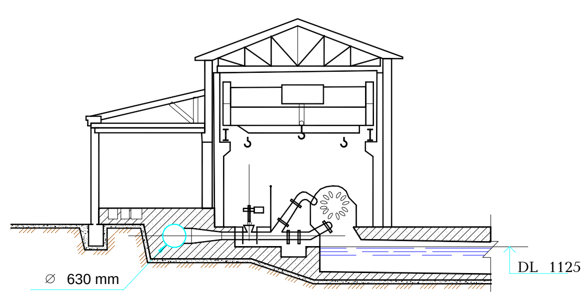


SHPP Powerhouse



15.3.5.17.Chikhailu SHPP

Introduction

According to development scheme it was planned to construct 2 SHPPs on Chikhailu River. As a result of in-situ investigations it was decided to construct one derivational SHPP.

Chikhailu SHPP uses inclination of River Chikhailu from 1580.0 till 1435. The length of derivation from Chikhailu River is 1750m by copper pipeline 530mm in diameter with design pressure of 137.21m and design discharge 0.30m^3/sec. After construction and exploitation Chikhailu SHPP will have 0.329mwt capacity and will produce 1.219mln kw/h electricity annually.

Short Description for Chikhlailu River Basin

Chikhlailu River is the left inflow of Khndzorut River and falls into the latter 10.0km from the river mouth. Chikhlailu river length is 9.8km, general chatchment area is 23.7km^2, average inclination is 170‰, average elevation is 1630m, and forests occupy 35% of the territory.

Chikhailu River basin is located in the north-eastern part of Armenia It borders with Saghagatun river from north-south, Khndzorut River from south. The river starts 2993.2m to the east from Murghus mountain of Murghus mountain chain. The geological composition is represented by middle and upper Jurassic period dacites, tuff breccias, tuff sand stones as well as Quaternary talus-alluvial sediments.

The earth cover of the river is diverse consisting of sub-alpine meadows, black soil, some brown mountain soil in the midstream and dark brown soil in the downstream. Chikhailu river basin has a forest cover which occupies 35% of its territory. In the upstream there are alpine meadows and oak forests in the downstream.

Chikhailu River is a typical mountainous river. The relief is mountainous with small and large inflows. The valley slopes consist of basalts covered by forest black soil. The river bed is composed of volcanic sediments.

Near the village Chikhailu river bed is straight and consists of large stones, sand stones and and is subject to deformation. During the drought period river bed merges into the valley slopes. During seasonal floods the flow is heavy and brings many in wash material. In winter there is insignificant shoreline ice.

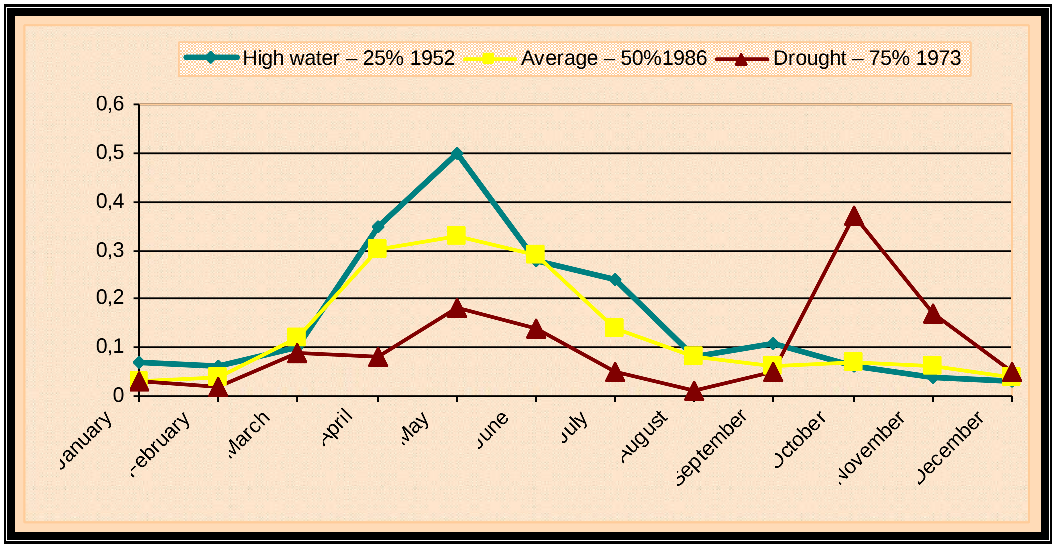
HYDROLOGY

The observation data for 54 years from r. Hakhingha - Aigedzor water-meter station is used to define the hydrological properties of Chikhailu SHPP headworks and the design river section.

River Section	Distance from the river mouth, Km	Average Elevation of the CatchmentBasin,m.	Catchment basin km^2	Flow Norm, m^3/sec
Chikhlailu SHPP- design longitudina section	3.6	2300	17.5	0.18

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 48. Annual flow distribution



Maximal design discharge for Chikhailu SHPP headwork river section for the general case equal 3% - 30.2m^3/sec, for verifying case - 0.5%-43.2m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.005m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Chikhailu SHPP is 1580.0m, downstream – 14355.0.0m. According to data of State Water Economy Data there is no water intake for irrigational use from Chikhailu River. Chikhailu SHPP is derivational SHPP. In order not to drain the river where 1750m derivational pipeline is the environmental discharge is designed according to RA laws and 0.004m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Chikhailu SHPP are calculated with 50% guarantee per annum (1991 see table 104).

Table. 104. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Chikhailu SHPP (m^3/sec)	0.026	0.036	0.116	0.296	0.30	0.286	0.136	0.076	0.056	0.066	0.056	0036	
SHPP average monthly capacity (mwt)	0.030	0.042	0.133	0.325	0.329	0.316	0.156	0.088	0.065	0.076	0.065	0.042	
SHPP –average monthly energy production (mln kwt/hour)	0.022	0028	0099	0234	0245	0.227	0.116	0.065	0.047	0.057	0.047	0.031	**1.219**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 362.2 thousand USD (without VAT) and 434.6 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		11.95
2. Exploitation expenses		19.3
	Salary	14.4
	Renovation	2.9
	Other Expenses	2.0
Total		31.25

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		329
Average multi annual production of energy, mln kwt/hour		1.22
Capital investments into SHPPS(without VAT),		
	thousand USD	362.2
	USD / kwt	1100.8
	USD / kwt/hour	0.297
Prime cost of power production, cents/kwt hour		2.56

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

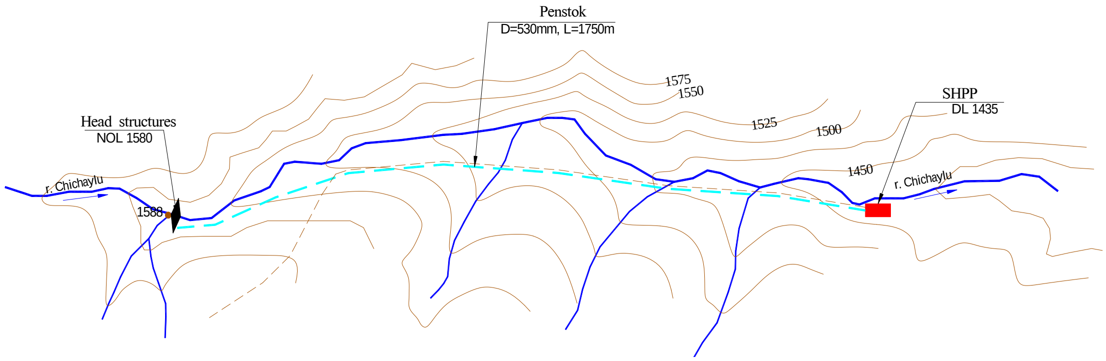
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 105. Design results according to financial scenarios

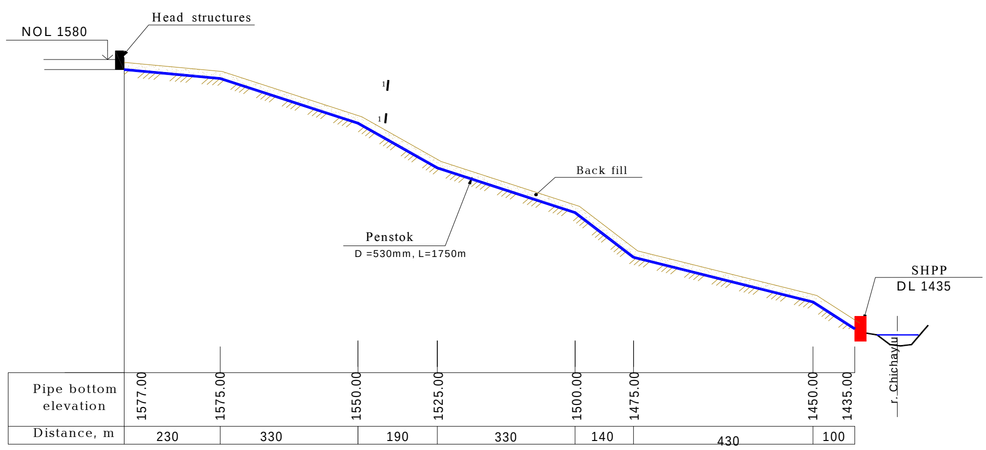
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		10.1	11.5
NPV, thousand USD			
	8%	77.1	77.1
	10%	5.6	27.4
	12%	-47.9	-7.1
	14%	-89.0	-31.5
PB, years (without discount)		9.3	12.6
Deadline for credit return, years			10.0

APPENDIX. 46. CHIKHAILU SHPP

Plan



Longitudinal section



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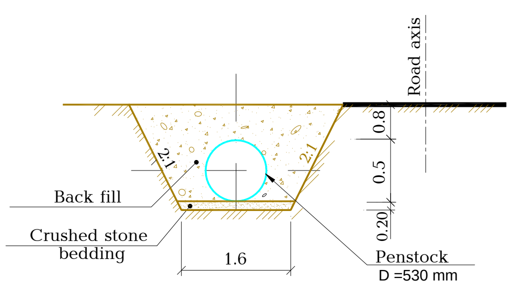
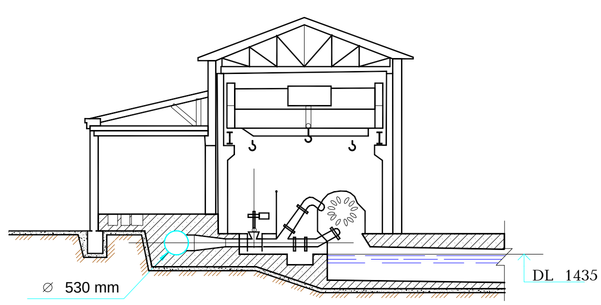


SHPP Powerhouse



15.3.5.18.Tavush SHPP -1,2

Tavush SHPP -1,

Introduction

According to development scheme it was planned to construct 5 SHPPs on Tavush river. As a result of in-situ investigations it was decided to construct 2 derivational SHPP. The SHPP will be constructed before Berd town and Tavush reservoir.

Tavush SHPP-1 uses inclination of River Tavush from 1175.0 till 1065.0. The length of derivation from Tavush River is 3650m by copper pipeline 820mm in diameter with design pressure of 99.3m and design discharge 0.80m^3/sec.

After construction and exploitation Tavush SHPP-1 will have 0.636mwt capacity and will produce 2.06mln kw/h electricity annually.

Short Description of Tavush River Valley

Tavush River is the right inflow of Kut River and falls into the latter 835km from the river mouth. Hakhinga river length is 17km, general chatchment area until Berd is 102km^2, average inclination is 385‰, average elevation is 1490m, and forests occupy < 5% of the territory.

Tavush River basin is located in the north-eastern part of Armenia It borders with Kur river from the north, Getik river from south, Akhingha river from the west and Hakhum river basin from the east. The river starts Murghus mountain chain peak on elevation of 2917.0. The geological composition is represented by middle and upper Jurassic period dacites, tuff breccias, tuff sand stones as well as Quaternary talus-alluvial sediments.

The earth cover of the river is diverse consisting of sub-alpine meadows, black soil, some brown mountain soil in the midstream and dark brown soil in the downstream. Tavush river basin has a forest cover. In the upstream there are alpine meadows and oak forests in the downstream.

Tavush River is a typical mountainous river. The relief is mountainous with small and large inflows. The slopes consist of basalts covered by forest black soil. The river bed is composed of volcanic sediments.

Near the village Tavush river bed is straight and consists of large stones, sand stones and is subject to deformation. During the drought period river bed merges into the valley slopes. During seasonal floods the flow is heavy and brings many in wash material. In winter there is insignificant shoreline ice.

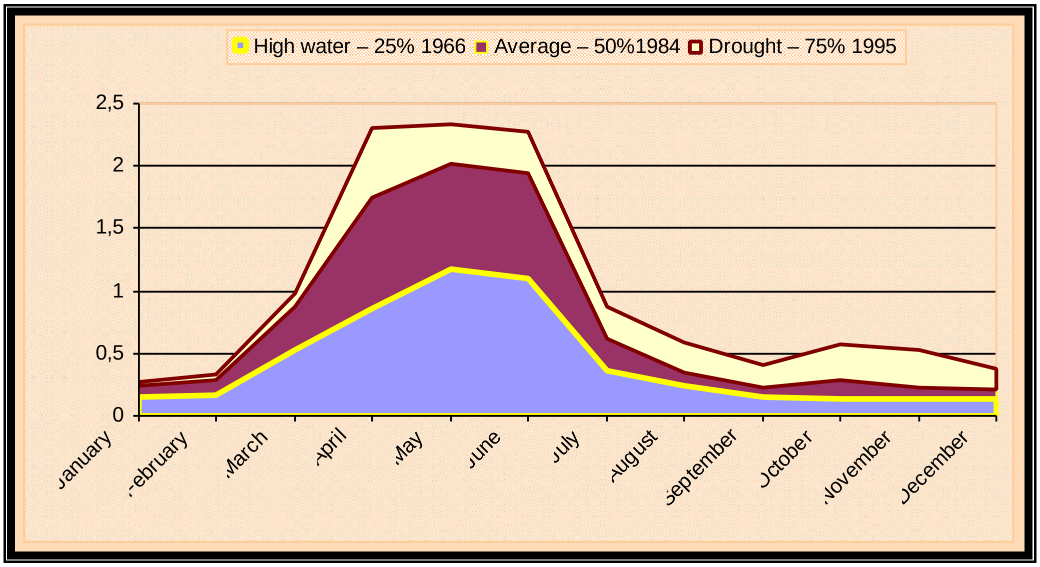
HYDROLOGY

The observation data for 54 years from r. Tavush-Berd water-meter station is used to define the hydrological properties of Tavush SHPP-1 headworks and the design river section.

River Section	Distance from the river mouth, Km	Average Elevation of the CatchmentBasin,m.	Catchment basin km^2	Flow Norm, m^3/sec
Tavush SHPP-1- design longitudinal section	5.1	1550	48.3	0.35

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 49. Annual flow distribution



Maximal design discharge for Tavush SHPP-1 headwork river section for the general case equal 3% - 44.8m^3/sec, for verifying case - 0.5%-84.8m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.017m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Tavush SHPP-1 is 1175.0m, downstream - 1065.0m. According to data of State Water Economy Data the water intake for irrigational use from Tavush River is 0.67mln.m^3. Tavush SHPP is derivational SHPP. In order not to drain the river where 3650m derivational pipeline is the environmental discharge is designed according to RA laws and 0.013m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Tavush SHPP-1 are calculated with 50% guarantee per annum (1978 see table 106).

Table. 106. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Tavush SHPP-1 (m^3/sec)	0.08	0.12	0.34	0.80	0.79	0.78	0.20	0.05	0.03	0.14	0.07	0.05	
SHPP average monthly capacity (mwt)	0.068	0.103	0.291	0.636	0.629	0.625	0.174	0.046	0.023	0.120	0.059	0.050	
SHPP –average monthly energy production (mln kwt/hour)	0.050	0.069	0.217	0.458	0.468	0.450	0.129	0.034	0.016	0.089	0.042	0.037	**2.060**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 743.1thousand USD (without VAT) and 891.7thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		24.5
2. Exploitation expenses		26.2
	Salary	17.3
	Renovation	5.9
	Other Expenses	3.0
Total		50.7

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		636
Average multi annual production of energy, mln kwt/hour		2.06
Capital investments into SHPPS(without VAT),		
	thousand USD	7743.1
	USD / kwt	1160.4
	USD / kwt/hour	0.36
Prime cost of power production, cents/kwt hour		2.46

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

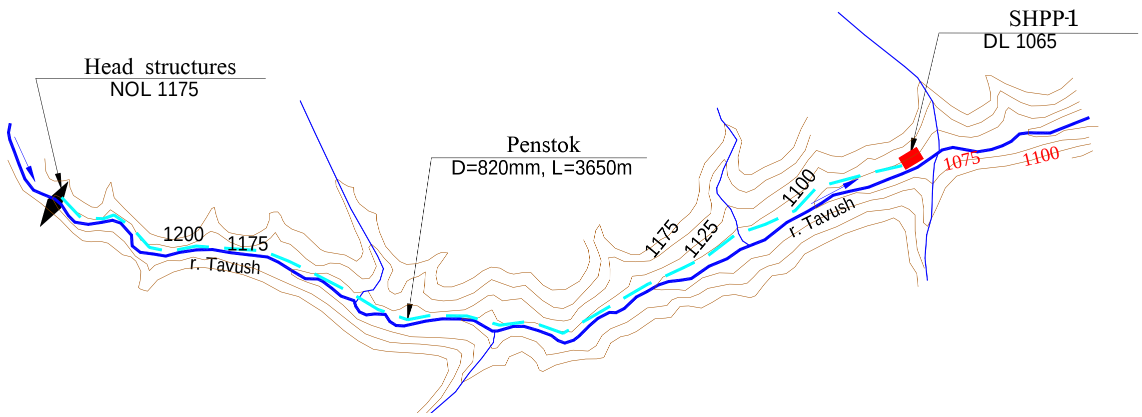
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 107. Design results according to financial scenarios

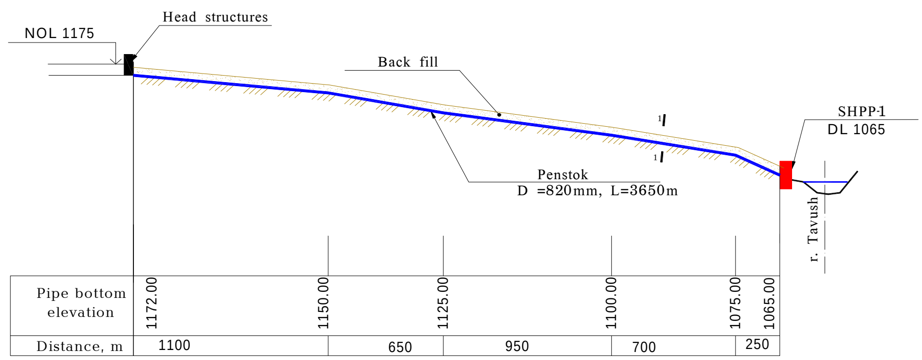
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		8.9	9.5
NPV, thousand USD			
	8%	66.6	66.6
	10%	-65.2	-14.8
	12%	-163.8	-70.4
	14%	-239.5	-109.0
PB, years (without discount)		10.3	14.7
Deadline for credit return, years			12.0

APPENDIX. 47. TAVUSH SHPP-1

Plan



Longitudinal section



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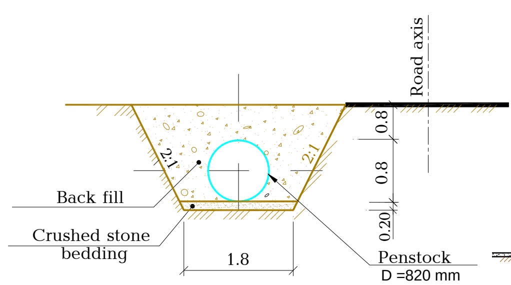
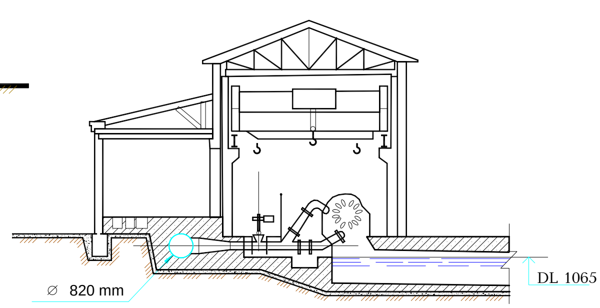


SHPP Powerhouse



Tavush SHPP -2

Introduction

Tavush SHPP-2 uses inclination of River Tavush from 1055.0 till 925.0. The length of derivation from Tavush River is 4425m by copper pipeline 920mm in diameter with design pressure of 119.10m and design discharge 1.00m^3/sec.

After construction and exploitation Tavush SHPP-2 will have 0.95mwt capacity and will produce 3.19mln kw/h electricity annually.

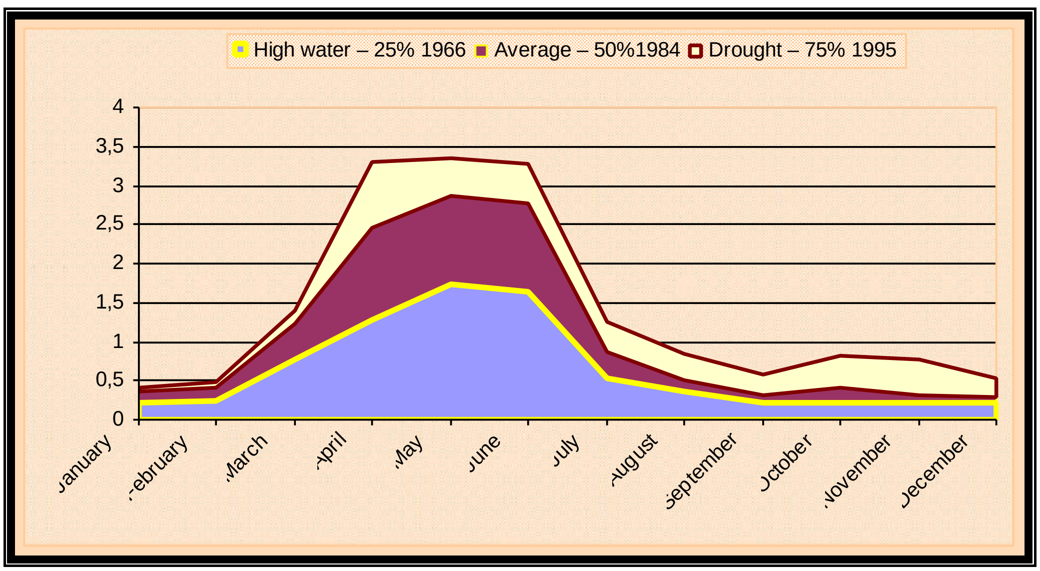
HYDROLOGY

The observation data for 54 years from r. Tavush-Berd water-meter station is used to define the hydrological properties of Tavush SHPP-2 headworks and the design river section.

River Section	Distance from the river mouth, Km	Average Elevation of the CatchmentBasin,m.	Catchment basin km^2	Flow Norm, m^3/sec
Tavush SHPP-1- design longitudinal section	3.2	1500	71.7	0.52

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 50. Annual flow distribution



Maximal design discharge for Tavush SHPP-2 headwork river section for the general case equal 3% - 55.9m^3/sec, for verifying case - 0.5%-106m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.025m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Tavush SHPP-2 is 1055.0m, downstream - 925.0m. According to data of State Water Economy Data the water intake for irrigational use from Tavush River is 0.67mln.m^3. Tavush SHPP is derivational SHPP. In order not to drain the river where 4425m derivational pipeline is the environmental discharge is designed according to RA laws and 0.019m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Tavush SHPP-2 are calculated with 50% guarantee per annum (1978 see table 108).

Table. 108. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Tavush SHPP-2 (m^3/sec)	0.12	0.15	0.44	1.00	1.00	1.00	0.27	0.09	0.05	0.18	0.09	0.07	
SHPP average monthly capacity (mwt)	0.126	0.157	0.451	0.953	0.953	0.953	0.282	0.089	0.052	0.188	0.095	0074	
SHPP –average monthly energy production (mln kwt/hour)	0.093	0.105	0.335	0.686	0.709	0.686	0.210	0.066	0.037	0.140	0.068	0.055	**3.191**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 104.5 thousand USD (without VAT) and 1252.2 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	34.4
2. Exploitation expenses	32.5
Salary	20.2
Renovation	8.3
Other Expenses	4.0
Total	66.9

Power indicators of have the following level

Indicators	Values
Derivation capacity, kwt	953
Average multi annual production of energy, mln kwt/hour	3.19
Capital investments into SHPPS(without VAT),	
thousand USD	1043.5
USD / kwt	1095.0
USD / kwt/hour	0.33
Prime cost of power production, cents/kwt hour	2.1

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

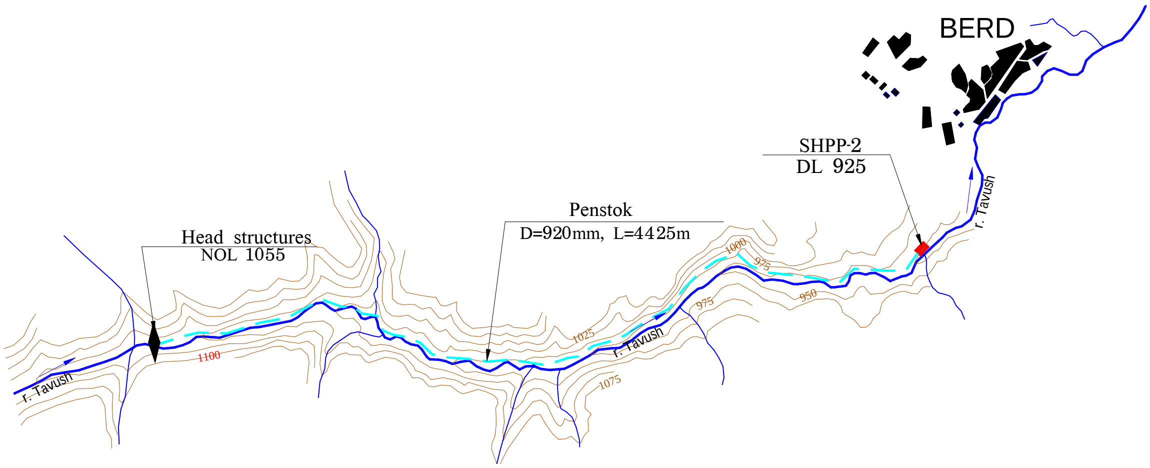
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 109. Design results according to financial scenarios

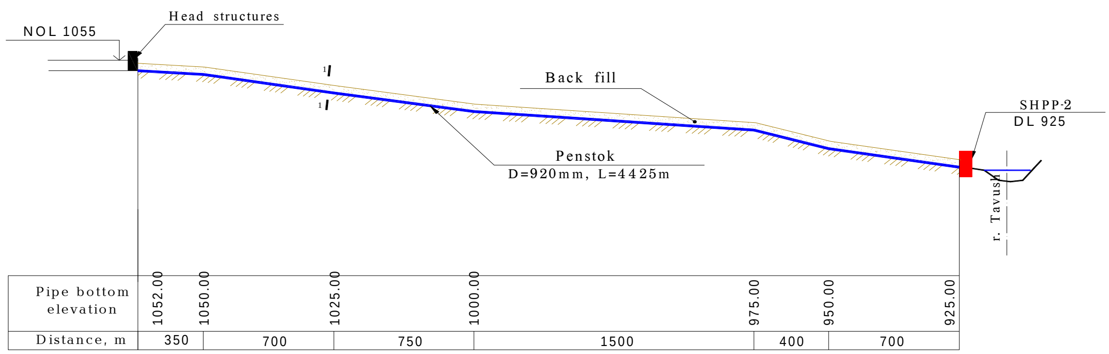
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		10.7	12.2
NPV, thousand USD			
	8%	275.7	275.7
	10%	61.1	119.2
	12%	-99.7	9.6
	14%	-223.0	-68.4
PB, years (without discount)		8.9	11.7
Deadline for credit return, years			9.0

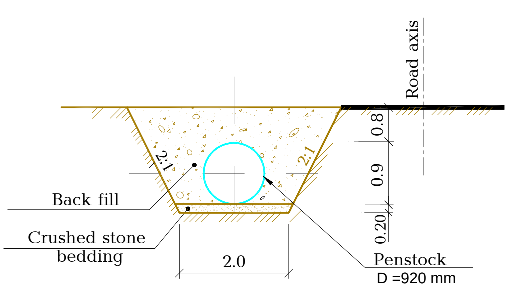
APPENDIX. 48. TAVUSH SHPP-2

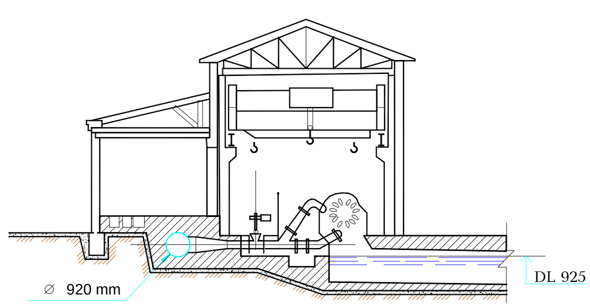
Plan



Longitudinal section



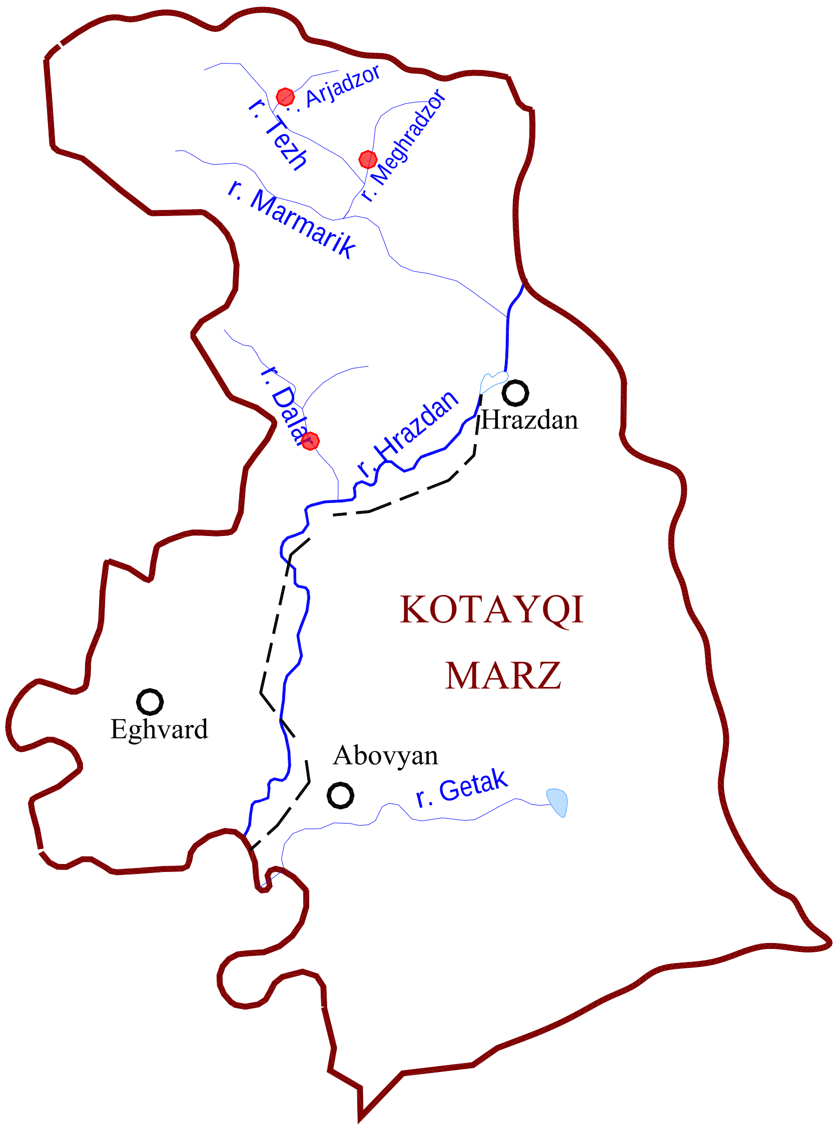




PART 15.4. KOTAYK MARZ

HRAZDAN RIVER BASIN

VERIFIED AND UPDATED SCHEME FOR SHPPs



15.3.1. GENERAL INFORMATION

13 SHPPs were planned in Hrazdan river basin in 1997plan. 1 SHPP on the Kotayk channel inclination and 12 derivational SHPPs. Presently, there is one SHPP on Kotayk channel inclination and one Tegh SHPP, technical-economic support is carried out for Ulashik SHPP.

In the result of in-situ investigations the indicators of prospective SHPPs were updated and the construction options for Arghadzor SHPP were also explored.

15.4.1.1. SHORT DESCRIPTION OF HRAZDAN RIVER BASIN RIVERS AND CLIMATIC CONDITIONS

River Hrazdan is one of the left inflows of river Araks and falls into the latter 629km from the river mouth. River length is 146km; catchment basin is 2560km^2 and 7310 km^2 together with Sevan River basin. Average inclination is 16% and average altitude is 1860m.

Hrazdan River Basin is located in the center of the republic. The river starts from Sevan Lake, on the 1890m altitude. The main direction of the river is east, starting from Ghrarat village in the south and the main inflow of Hrazdan River is Marmarik.

Hrazdan River basin borders with Debet river basin from south which is divided by Pambak mountain chain Mahmer mountain – 3082m, Tegh mountain – 3109m, from the east and south-east together with Kasakh river basin that is separated by Tsakhkunyats mountain chain (Tsakhkunyats mountain – 2851m, from the west Sevan Lake rivers which are divided by Geghama mountain chain Aknasar mountain – 3258.m, from the south, together with Araks river basin, that is divided by Uruts Mountain chain.

The Hrazdan river basin is a typical mountainous basin with complex geography. The earth cover of the basin in the upstream is presented by alpine mountainous earth and sub-alpine light brown soils in the downstream, lower there are dry forests and bushes with typical soil. The vegetative cover of the river basin is extremely diverse, with alpine ravines in the upstream that turns into sub-alpine soils and in the south and forms crop prairies. Hrazdan river valley generally represents a deep, canyon with inclined, rock slopes. River net is well developed from the right bank, forming a peculiar relief and leaves a significant influence on the average river flow.

River Hrazdan is a typical mountainous river with mixed feeding starting from glacier melting and ground water feedings as well as rains. The water regime is conditioned by spring floods that are also conditioned by large masses of melted snow and precipitations. The inundation peak is observed at the second half of May or in July. The maximal discharge is observed during spring – summer floods particularly in April-May. The minimal discharge of the basin is observed during winter as well as summer months.

From the climatic point of view Hrazdan river basin is located in tree climatic zones, starting from dry continental climate to tundra. The planned SHPPs are located at the following zones:

- favorable-warm zone with mild winter,
- favorable-warm zone with mild winter,
- favorable-warm zone with warm long summer and cold winter.

The data used for climatic overview is shown in the Table 1.

#	*Station*	*Altitude, m*	*Observation period*	*Number of years*
1.	Hankavan	1957	1936 - working	72
2.	Aghavnadzor	1761	1953- working	56
3.	Hrazdan	1765	1927- working	81

According to Hankavan, Aghavnadzor, Hrazdan meteorological stations average air temperature is 3.6°C - 4.8°C, absolute low (-33)-(-38)°C, absolute high (+31)- (+33)°C, maximal depth of ground freezing 88-96cm.

The quantity of precipitations is in direct relation from the local altitude and lope elevation as well as slope exposition. Average multi annual precipitations in Hankavan 841 mm, Aghavnadzor 468mm, Hrazdan 688mm. Maximal quantity of annual precipitations in Hankavan is 1070mm, Aghavnadzor 486mm, Hrazdan 929mm, maximal monthly precipitations are: Hankavan 180mm, Aghavnadzor 144mm, Hrazdan 160mm, while daily is Hankavan 86mm, Aghavnadzor 30mm, Hrazdan 64mm.

Absolute moisture content of the air is 6.8-7.0, comparative moisture content is 71-78%.

Average annual wind speed equals 1.5-2.0m/sec. 1% guarantee absolute wind speed in Hrazdan is 29m/sec.

15.4.1.2. GEOLOGICAL COMPOSITION OF VEDI RIVER BASIN

From the Geological point of view Hrazdan river basin is extremely diverse. The upper section of are composed of Mesosoic and secondary granite rock types and in the downstream there are volcanic sedimentary rock types (mainly basalts). Sedimentary rocks are often in this area and different volcanic rock types clays and sedimentary layers. Here there are porphyries that are covered by lime stone that have strong interconnection with diabases.

Most of the rock types form a massive of medium firmness or firm, with cracks and slightly permeable. Occasionally rocks are subject to hydro thermal influence. Contemporary talus sediments are not well developed 3-4meters thick, the river bed is rich in alluvial sediments 5-10m thick.

Contemporary talus and alluvial sediments are not well developed their thickness varies from 2 to 3 meters. Part of the Dalar inflow basin is composed of lime, mergel, sand, slay that are strong or of medium strength with cracks occasionally weathered and have a low permeability. Talus sediments are often here that clay sediments. Dellluvial sediments are not well developed.

15.4.1.3. WATER REGIME OF HRAZDAN RIVER BASIN RIVERS AND DESIGHN DATA

Hrazdan River Basin Rivers present a typical mountainous rivers with seasonal water regime. The rivers have a mixed feeding from snow, rain, ground waters. The main feeding source is melting snow waters with 85% from annual river flow.

Flow distribution within a year is represented by large f\water volumes and long, stable droughts. The spring flooding starts from April and lasts will June and the autumn inundation is not defined and is observed during October and November. The drought period starts during June-July the minimal water discharge is observed during winter as well as summer-autumn droughts. Systematic observations were carried out with main hydrological descriptions shown on table 2.

Water meter Station	*Distance from the river bed, km.*	*Average elevation of reservoir, m.*	*Catchment area, km^2*	*Exploitation timeline*		*«0» altitude BS*	*Normal Flow, m^3/sec.*
				started	*started*		
Dalar-Arzakan	0.1	2110	87.0	1936	2006	1453.11	0.93
Gomut - Meghradzor	2.9	2430	101	1936	2006	2.0УС	1.45
Ulashik - Artavan	12.0	2560	39.4	1970	1987	1891.8ÁC	0.90

In order to obtain annual distribution of average flow indicators and distribution the above mentioned observations are used. Annual distribution if Hrazdan River Basin Rivers is shown on the table below.

Years	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	average
Gomut - Meghradzor													
Abundant – 25%													
1941y.	0.42	0.48	1.01	6.10	7.79	2.10	0.90	0.35	0.29	0.27	0.26	0.28	1.69
Average – 50%													
1990y.	0.48	0.41	1.41	5.92	4.13	1.50	0.57	0.44	0.29	0.24	0.28	0.27	1.33
Drought– 75%													
2001y.	0.24	0.26	1.62	5.64	2.04	1.56	0.68	0.31	0.21	0.21	0.23	0.24	1.10
Dalar-Arzakan													
Abundant – 25%													
1949y.	0.48	0.33	1.10	2.12	4.54	1.89	0.49	0.42	0.41	0.60	0.54	0.34	1.11
Average – 50%													
1984y.	0.25	0.27	0.55	3.35	3.15	1.08	0.42	0.29	0.25	0.26	0.31	0.26	0.87
Drought– 75%													
1975y.	0.27	0.21	0.27	2.75	2.35	0.79	0.39	0.27	0.20	0.24	0.21	0.24	0.27
Ulashik - Artavan													
Abundant – 25%													
1975y.	0.27	0.28	0.32	2.71	3.15	3.20	0.45	0.40	0.40	0.47	0.35	0.29	1.02
Average – 50%													
1972y.	0.25	0.21	0.25	1.56	2.24	2.34	1.01	0.42	0.37	0.38	0.32	0.20	0.80
Drought– 75%													
1983y.	0.35	0.34	0.34	0.81	2.28	1.28	0.55	0.45	0.38	0.33	0.34	0.33	0.65

15.4.2. TECHNICAL ECONOMIC SPECIFICATION OF SHPPS TO BE CONSTRUCTED ON AZAT AND VEDI RIVERS

15.4.2.1. MEGHRADZOR SHPP

INTRODUCTION

According to development scheme it was planned to construct 5 SHPPs on the river. However, as a result of in-situ investigations it is planned to construct one derivational SHPP. Meghradzor SHPP uses inclination of River Meghradzor from 1960.0 till 1810.0. The length of derivation from Meghradzor River is 3800m by copper pipeline 820mm in diameter with design pressure of 124.2m and design discharge 1.00m^3/sec. After construction and exploitation Meghradzor SHPP will have 0.994mwt capacity and will produce 2.78mln kw/h electricity annually.

SHORT DESCRIPTION OF MEGHRADZOR RIVER BASIN

River Meghradzor is the left inflow of river Marmarik. It flows into the river 12km from the river mouth. Length of the river is 15km general catchment area is 104km^2 with average inclination of 87%, and average elevation of the basin that equals 2430m. The river starts from 2800m altitude of Pambak mountain range.

In the upstream river Meghradzor flows in the south-eastern direction and falls into river Marmarik approximately at 1755m. Meghradzor river basin is located in the center of RA to the east from Sevan Lake.

From the geological point of view the upper section of the river basin are composed of mezozoic and secondary granite rock types and the downstream is composed of volcanic sedimentary rock types (mainly basalts). The vegetation is represented by alpine and sub-alpine meadows that turn into forests in the downstream.

Meghradzor river basin is V-shaped with 450 and more inclined slopes. Multiple inflows fall into the river including Tegh, Khurumdzor, Arkhoshan.

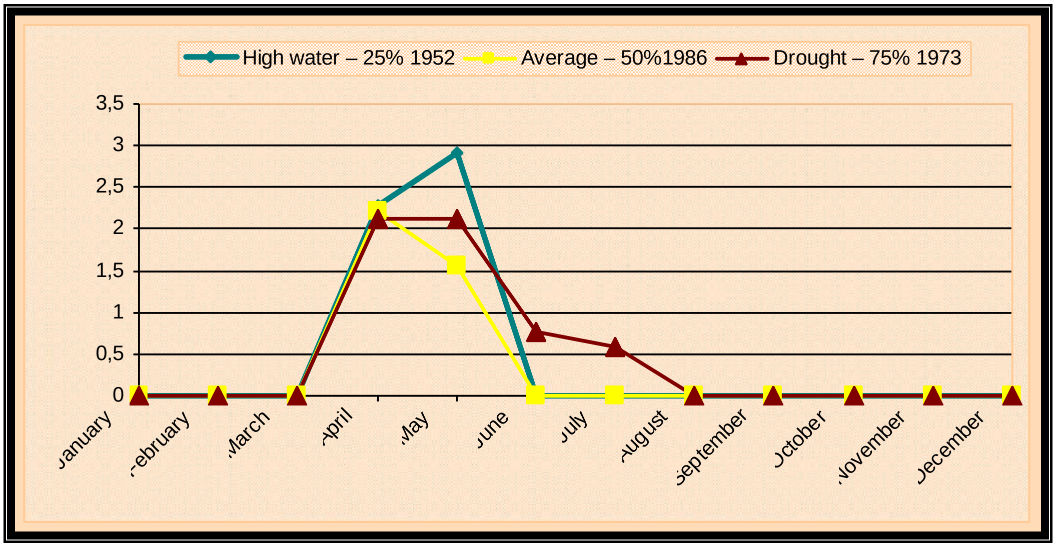
HIDROLOGY

The observation data from 51 year observations of river Gomur and Meghradzor water-meter station is used to define the hydrological properties of Meghradzor SHPP headworks and the design river section. The table below shows hydrological properties of design river section necessary for the SHPP.

River Section	Distance from river mouth, km	Average altitude of the catchment basin, m.	Catchment area, km^2	Flow norms, m^3/sec
Meghradzor - design perpendicular section	5.5	2400	37.9	0.54

Graph shows annual flow distribution of Meghradzor SHPP for the design river section, during tree characteristic years

Graph. 51. Annual flow distribution



Maximal design discharge for Meghradzor SHPP headwork river section for the general case equal 3% - 24.4m^3/sec, for verifying case - 0.5%-39.1m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.008m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Meghradzor SHPP is 1950.0m, downstream - 1810.0m. According to data of “Kotaik” WUO there is no water intake starting from SHPP station works. While the annual water demand is 1.58mln.m^3. Meghradzor SHPP is derivational SHPP. In order not to drain the river where 3800m derivational pipeline is the environmental discharge is designed according to RA laws and 0.006m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Meghradzor SHPP are calculated with 50% guarantee per annum (1990).

Table. 110. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Meghradzor SHPP (m^3/sec)	0.12	0.09	0.47	1.00	1.00	0.50	0.15	0.11	0.05	0.03	0.05	0.04	
SHPP average monthly capacity (mwt)	0.139	0.105	0.517	0.994	0.994	0.548	0.172	0.127	0.060	0.038	0.060	0.049	
SHPP –average monthly energy production (mln kwt/hour)	0.10	0.07	0.38	0.72	0.74	0.39	0.13	0.09	0.04	0.03	0.04	0.04	**2.78**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 1032.3 thousand USD (without VAT) and 1238.8 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		34.1
2. Exploitation expenses		19.6
	Salary	17.3
	Renovation	8.3
	Other Expenses	4.0
Total		63.7

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		994
Average multi annual production of energy, mln kwt/hour		2.78
Capital investments into SHPPS(without VAT),		
	thousand USD	1032.3
	USD / kwt	1038.5
	USD / kwt/hour	0.37
Prime cost of power production, cents/kwt hour		2.3

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

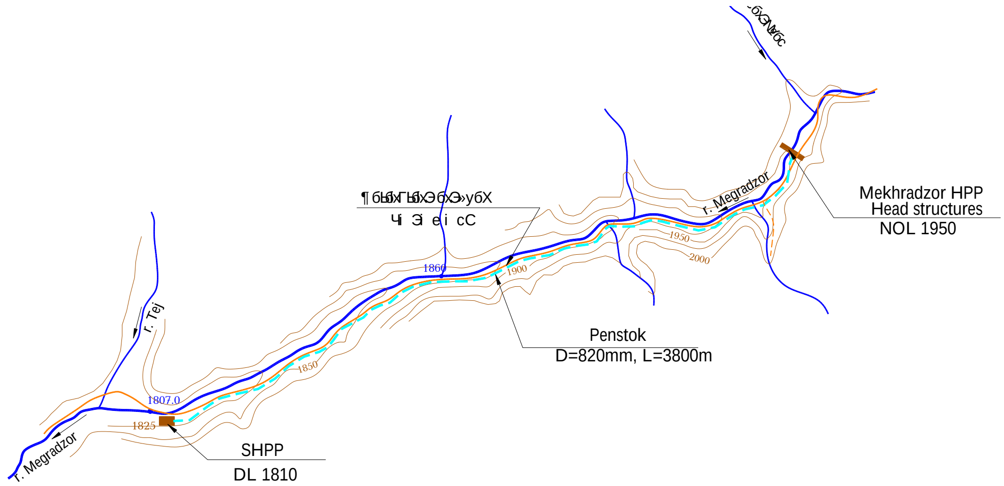
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 111. Design results according to financial scenarios

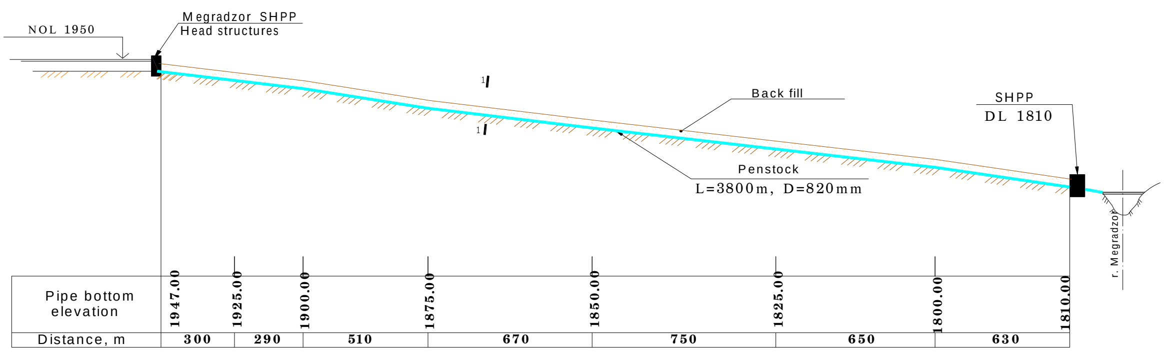
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		9.2	9.9
NPV, thousand USD			
	8%	115.3	115.3
	10%	-71.4	-4.9
	12%	-211.3	-87.3
	14%	-318.6	-144.6
PB, years (without discount)		10.1	14.1
Deadline for credit return, years			11

APPENDIX. 49. MEGRADZOR SHPP

Plan



Longitudinal section



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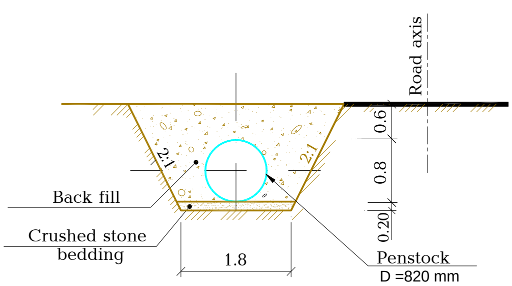
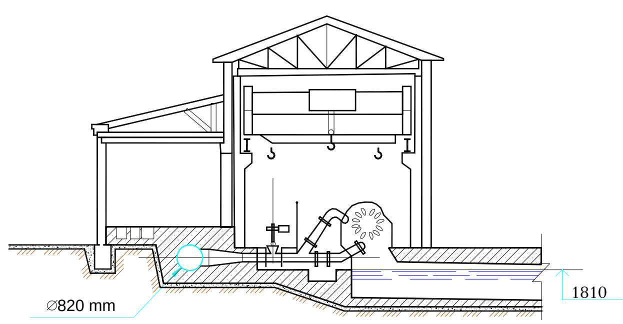


SHPP Powerhouse



15.4.2.2. DALAR SHPP

INTRODUCTION

According to development scheme it was planned to construct 2 SHPPs on the river. However, as a result of in-situ investigations it is planned to construct one derivational SHPP. Dalar SHPP uses inclination of River Dalar from 2000.0 till 1860.0.

The length of derivation from Dalar River is 2400m by copper pipeline 530mm in diameter with design pressure of 124.2m and design discharge 0.35m^3/sec.

After construction and exploitation Dalar SHPP will have 0.348mwt capacity and will produce 0.873 mln kw/h electricity annually.

SHORT DESCRIPTION OF MEGHRADZOR RIVER BASIN

River Dalar is the right inflow of river Hrazdan and falls from its mouth for 88km. Length of the river is 14km general catchment area is 90km^2 with average inclination of 68%, and average elevation of the basin that equals 2110m.

The river starts from several springs on the 2700m altitude of Tsakhkunyats mountain range and flows through V-shape valley to south-west.

Dalar river valley is typical mountainous valley with inflow gorges. The valley is surrounded by Tsakhkunyats mountain chain from the north, and branches of the same chain from west and east while from south it flows into the Hrasdan river valley.

The river valley is V-shape and has rocky slopes.

The geological composition of the basin in the upstream is represented by secondary granite rocks and in the middle stream by volcanic rock types. The grass cover of the river valley is diverse represented by alpine and sub alpine meadows.

The earth cover of the river basin in the upstream is represented by alpine soils and sub alpine brown soils; in the downstream – dry forests, mountainous-forest brown soils.
In winter there are large icebergs that affect river horizon.

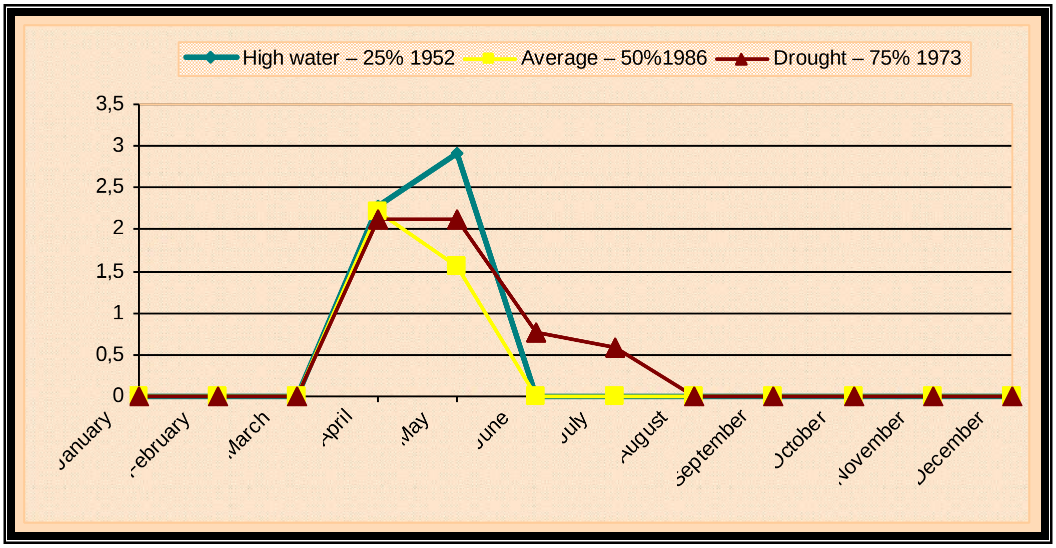
Hydrology

The observation data from 52 year observations of river Dalar Arzakan water-meter station is used to define the hydrological properties of Dalar SHPP headworks and the design river section. The table below shows hydrological properties of design river section necessary for the SHPP.

River Section	Distance from river mouth, km	Average altitude of the catchment basin, m.	Catchment area, km^2	Flow norms, m^3/sec
Dalar-- design perpendicular section	5.4	2350	11.06	0.12

Graph shows annual flow distribution of Dalar SHPP for the design river section, during tree characteristic years.

Graph. 52. Annual flow distribution



Maximal design discharge for Dalar SHPP headwork river section for the general case equal 3% - 11.6m^3/sec, for verifying case - 0.5%-16.4m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.008m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Dalar SHPP is 2000.0m, downstream - 1860.0m. According to data of "Kotaik" WUO there is no water intake starting from SHPP station works. The irrigation channel is located below the SHPP building. Dalar SHPP is derivational SHPP. In order not to drain the river where 2400m derivational pipeline is the environmental discharge is designed according to RA laws and 0.006m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Dalar SHPP are calculated with 50% guarantee per annum (1984).

Table. 112. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Dalar SHPP (m^3/sec)	0.026	0.029	0.064	0.350	0.350	0.134	0.048	0.031	0.026	0.028	0.034	0.028	
SHPP average monthly capacity (mwt)	0.029	0.032	0.071	0.348	0.348	0.147	0.054	0.035	0.029	0.031	0.038	0.031	
SHPP –average monthly energy production (mln kwt/hour)	0.022	0.022	0.053	0.250	0.259	0.106	0.040	0.026	0.021	0.023	0.027	0.023	**0.873**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 350.0 thousand USD (without VAT) and 420.0 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		11.6
2. Exploitation expenses		19.7
	Salary	14.4
	Renovation	3.3
	Other Expenses	2.0
Total		31.3

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		348
Average multi annual production of energy, mln kwt/hour		0.87
Capital investments into SHPPS(without VAT),		
	thousand USD	0.350
	USD / kwt	1005.7
	USD / kwt/hour	0.40
Prime cost of power production, cents/kwt hour		3.6

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

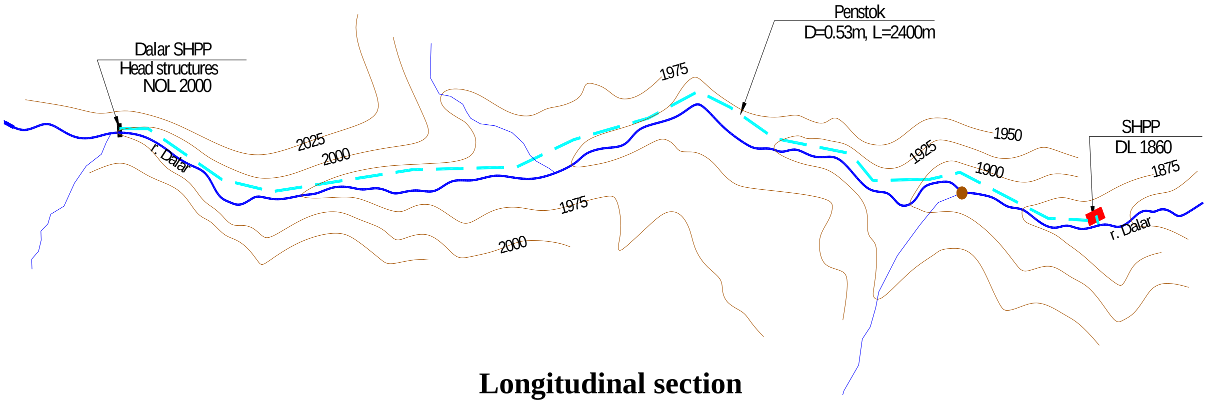
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 113. Design results according to financial scenarios

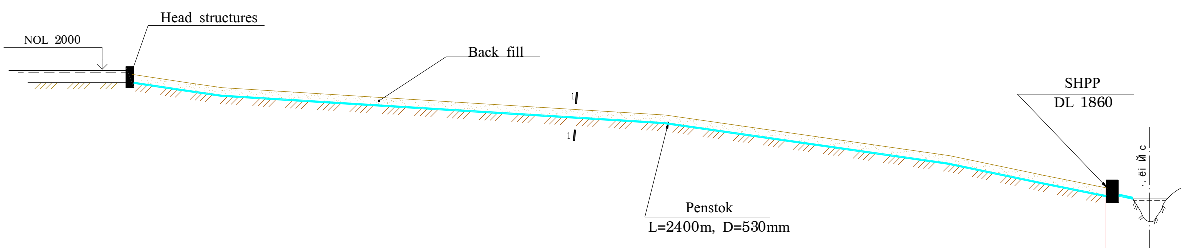
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		2.3	2.8
NPV, thousand USD			
	8%	-81.75	-81.75
	10%	-91.5	-87.7
	12%	-103.2	-91.5
	14%	-109.1	-94.1
PB, years (without discount)		17.0	29.0
Deadline for credit return, years			24.0

APPENDIX. 50. DALAR SHPP

Plan

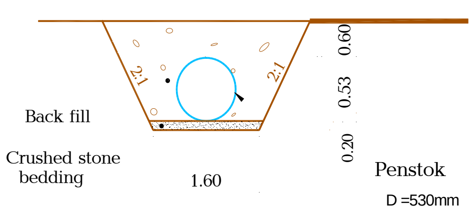


Longitudinal section

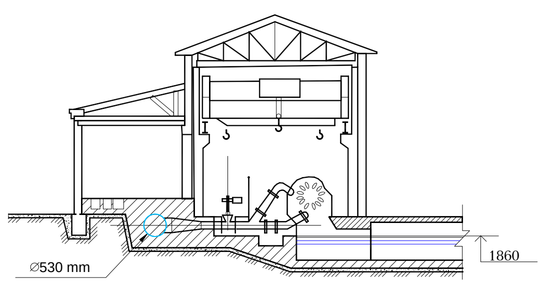


Pipe bottom elevation	2000.00	1975.00	1950.00	1925.00	1900.00	1875.00	1860.00
Distance, m	500	810	350	350	250	150	

1-1



SHPP Powerhouse



15.4.2.3. ARGHADZOR SHPP

ITRODUCTION

According to development scheme it was planned to construct 5 SHPPs on the river. However, as a result of in-situ investigations it is planned to construct one derivational SHPP. Arghadzor SHPP uses inclination of River Arghadzor from 1960.0 till 1810.0. The length of derivation from Arghadzor River is 3800m by copper pipeline 820mm in diameter with design pressure of 124.2m and design discharge 1.00m^3/sec. After construction and exploitation Arghadzor SHPP will have 0.994mwt capacity and will produce 2.78mln kw/h electricity annually.

SHORT DESCRIPTION OF ARGHADZOR RIVER BASIN

Arghadzor River is the left inflow of Tegh River and discharged 24 km from its mouth. The river starts from Pambak mountain chain south Arkhoshan peak on the elevation of 3025m. General catchment area is 21km^2, length is 11km, average elevation of the catchment area equals 2600m.
In the upstream the river Arghadzor flows in south – western direction and falls into Tegh River on 1862.5m.

The average inclination of Arghadzor River is about 0.075, the river basin is strictly curved. Arghadzor river basin is located in the center of RA in the west of Sevan Lake. From the point of view of geologic composition the upper parts are composed of secondary granites and in the downstream volcanic lavas, mainly basalts. The vegetation is represented by alpine and sub-alpine meadows that turn into forests in the downstream.
Arghadzor river basin is V-shaped with 450 and more inclined slopes with multiple inflows fall into the river.

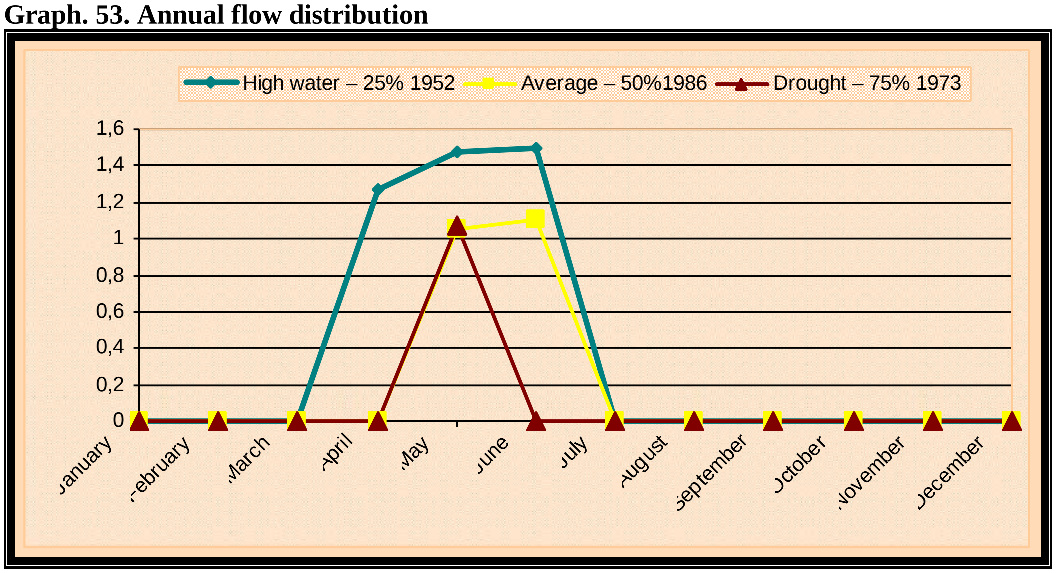
HYDROLOGY

The observation data from 17 year observations of river Ulashik and Arghadzor water-meter station is used to define the hydrological properties of Arghadzor SHPP headworks and the design river section. The table below shows hydrological properties of design river section necessary for the SHPP.

River Section	Distance from river mouth, km	Average altitude of the catchment basin, m.	Catchment area, km^2	Flow norms, m^3/sec
Arghadzor -- design perpendicular section	2.3	2450	18.2	0.38

Graph shows annual flow distribution of Arghadzor SHPP for the design river section, during tree characteristic years

Graph. 53. Annual flow distribution



Maximal design discharge for Arghadzor SHPP headwork river section for the general case equal 3% - 10.4m3/sec, for verifying case - 0.5%-13.2m3/sec, the observed average annual discharge value with 95% guarantee equals 0.033m^3/sec.

WATER ECONIMY AND ENERGY SECTOR

The upstream pool elevation of Arghadzor SHPP is 1987.5m, downstream - 862.5m. According to data of "Kotaik" WUO there is no water intake starting from SHPP station works. Arghadzor SHPP is derivational SHPP. In order not to drain the river where 1200m derivational pipeline is the environmental discharge is designed according to RA laws and 0.025m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Arghadzor SHPP are calculated with 50% guarantee per annum (1972).

Table. 114. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Arghadzor SHPP (m^3/sec)	0.10	0.08	0.10	0.70	0.70	0.70	0.46	0.18	0.15	0.16	0.13	0.07	
SHPP average monthly capacity (mwt)	0.095	0.075	0.095	0.668	0.668	0.668	0.446	0.174	0.145	0.155	0.125	0.065	
SHPP –average monthly energy production (mln kwt/hour)	0.07	0.05	0.07	0.48	0.50	0.48	0.33	0.13	0.10	0.12	0.09	0.05	**2.47**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 638.9 thousand USD (without VAT) and 766.7 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	21.1
2. Exploitation expenses	22.6
Salary	14.4
Renovation	5.2
Other Expenses	3.0
Total	43.7

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		668
Average multi annual production of energy, mln kwt/hour		2.469
Capital investments into SHPPS(without VAT),		
	thousand USD	638.9
	USD / kwt	956.5
	USD / kwt/hour	0.26
Prime cost of power production, cents/kwt hour		1.77

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

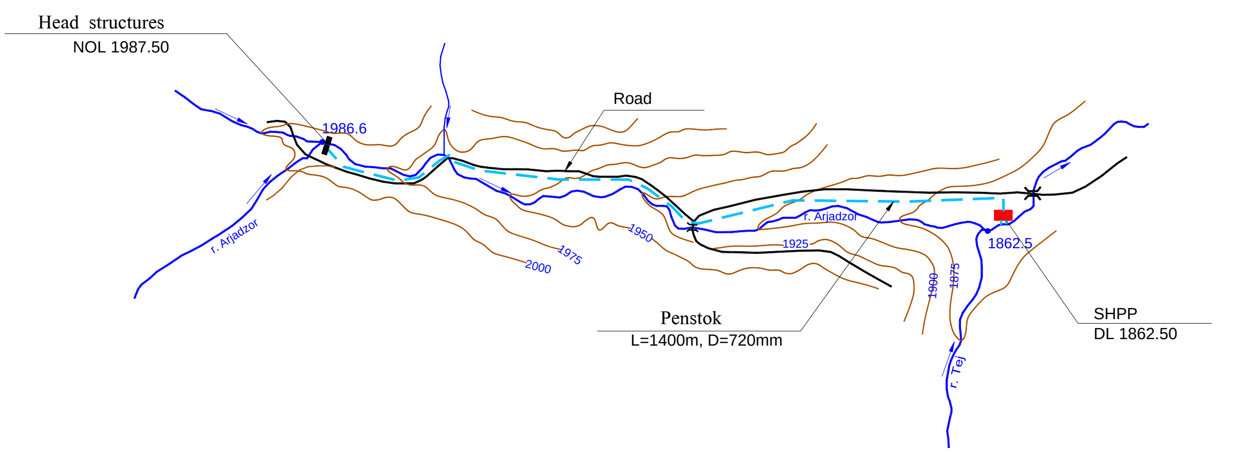
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 115. Design results according to financial scenarios

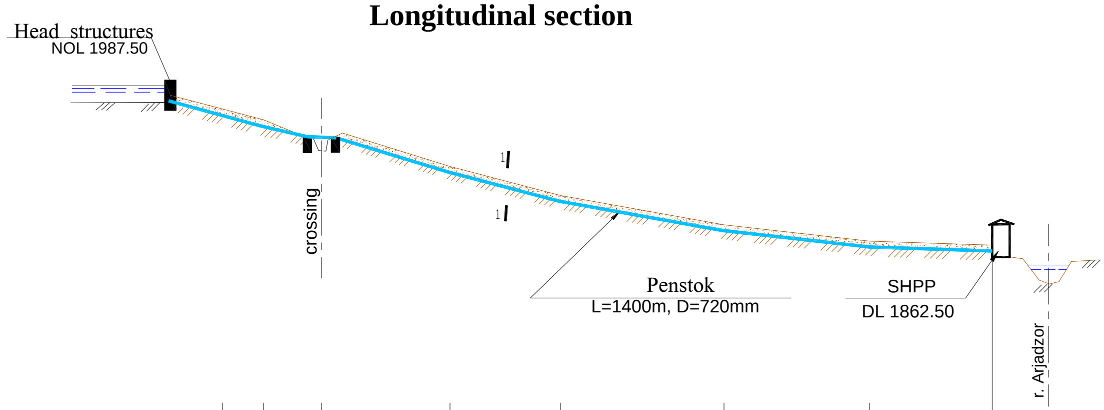
INDICATORS		**Scenario 1** 100% fully self - financed option	**Scenario 2** 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		14.1	17.3
NPV, thousand USD			
	8%	392.6	392.6
	10%	224.8	254.1
	12%	99.1	155.0
	14%	2.62	82.6
PB, years (without discount)		7.0	8.7
Deadline for credit return, years			7.0

APPENDIX. 51. ARJADZOR SHPP

Plan

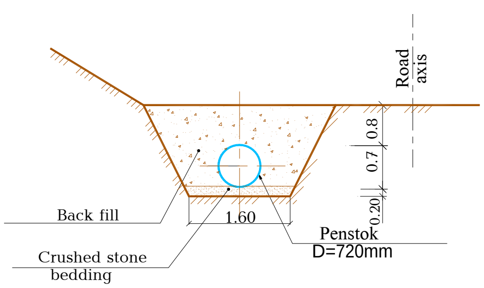


Longitudinal section

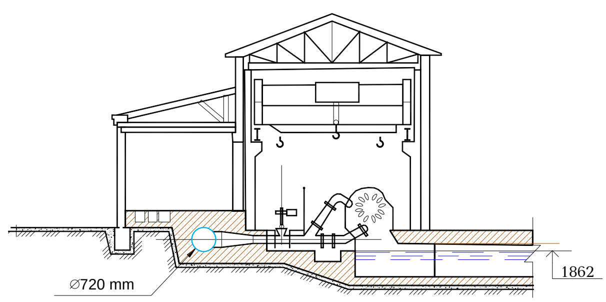


Pipe bottom elevation	1986.00	1985.00	1975.00	1965.00	1950.00	1925.00	1900.00	1875.00	1864.00
Distance, m	80	70	100	230	200	270	250	200	

1-1



SHPP Powerhouse



PART15.5. ARAGATSOTN MARZ

KASAKH RIVER BASIN

VERIFIED AND UPDATED SCHEME FOR SHPPs

15.5.1. GENERAL INFORMATION

Kasakh River Basin 1997 development scheme contemplates construction of 26 SHES: one SHPP - next to Aparan reservoir (next to the dam), another SHPP on river inclination and derivational 24 SHPPs.

Presently, there are one active and two pending SHPPs: Aygezard SHPP on Artashat channel, Ampur and Gegharot SHPPs pending for approval.

Construction options of Aparan SHPPs have been considered during in-situ investigations.

15.5.1.1. Short Description of Kasakh River Basin

Kasakh River is the largest right inflow of River Sevghur that discharges 26m from the river mouth. General catchment area of River Kasakh is 1480km2, and it is 89km long.

The iver starts from several springs that flow from Aragats mountain slopes as well as southern slopes of Pambak mountain chain. The river flows through broad alluvial mountain plain and is not very deep.

The river basin is surrounded by Aragats Mountain from the west and Pambak chain from the north as well as Tsakhkunyats mountain chain from the east.

Kasakh river basin is mainly located on Aparan mountain plateau. Kasakh river bed remains dry for 8 moths a year staring from the river spring up to Arparan city. After inflow of two strong flows the river has a stable flow.

The earth cover of the river bed is mainly carbonated with scarce humus and black earth. In the middle stream the earth cover of the river bed is brown – carbonated, in the downstream it is skeleton, and in the are of the river mouth it is ash black, ancient prolluvial-talus streams.

The vegetative layer if the basin is not very rich composed of medium areas of alpine and sub-alpine ravines as well as pinewoods and foliar woods.

Fruit tree garden and vine yards are located in the irrigated areas of the basin. In the downstream to the south-west of the river there is marsh area and salt lands with no vegetative cover. From the climatic point of view the Kasakh river basin is located in five climatic zones. The zone under investigation, occupies two of them: the first is mild, warm long-term summer and cold winter and the second one with mild and warm summer and mild, cold winter.

In the nearest Ashtarak (1090m) city the meteorological station indicators show the following data: annual average air temperature (11.1°)C, absolute (-29)°C, absolute maximum (+41)°C.

Absolute moisture of the air is 8.7mb, comparative moisture content us ª61%, and this data varies within 49-77% borders. The average multi annum precipitations equal 368mm, maximum daily precipitations are 56mm. The ten day snow cover is 55cm. Annual average wind speed is 1.0m/sec, with eastern wind direction.

15.5.1.2. GEOLOGICAL COMPOSITION OF KASAKH RIVER BASIN

Kasakh river basin is located on volcanic massive. The whole massive is composed of porphyries, tuffs and basalts. There is a alluvial ravine in the upstream which saturates part of the flow. This is the reason why the river bed remains dry most of the year till it reaches Aparan springs.

In the downstream the river basin is composed of diverse, loose Quaternary sedimentary rock types. Akhashan inflow bed is composed of volcanic effusive rock types. They are represented by grey, loose, highly permeable andesites, basalts, dacites and other effusive rock types. The foothills mostly have 5-10m thick layer of dispersed stones.

15.5.1.3. KASAKH RIVER BASIN WATER REGIEME AND DESIGHN DATA

Kasakh River is a typical mountainous River with seasonal water regime. The river has a mixed feeding by means of rain, snow, ground waters. The increase of the river level during spring floods is unstable, starting from the beginning if March strong inundations start as a result of snow melting and heavy precipitations. Inundations start from the second decade of March and continue to June. Kasakh River inundations take place through several peaks that are higher by 2-2.5meters as apposed to dryer periods. The summer and autumn peaks are stable regardless of short term rain inundations.

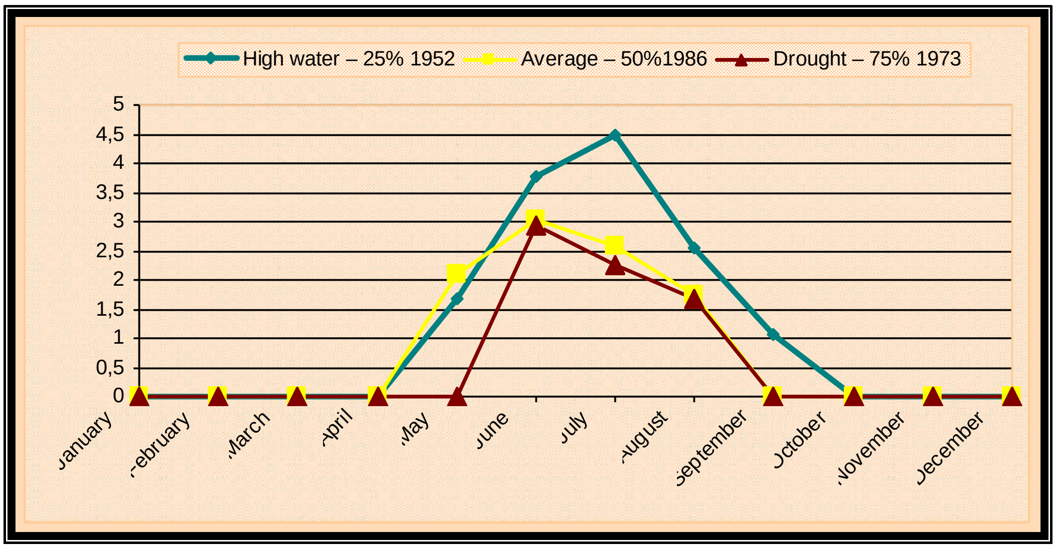
In the upstream of Kasakh River till Ashtarak city starting from the end of November till the beginning of December there are 2m wide ice blocks on the river banks. During January-February the river is covered by thin layer of ice. The river mouth is freezes very rarely.

Systematic observations of Kasakh river discharge were carried out in several different water meter stations.
The observations of river hydrologic properties are shown on the table and are used as analogue for SHPP design river sections.

Water meter station	Distance from the river mouth, km	Average elevation of reservoir, m.	Catchment area, km^2	Exploitation timeline started	started	Exploitation timeline	Normal Flow, m^3/sec
r. Geghahovit-Aragats	13.0	3100	39.6	1929	1994	2092.9	1.00
g. Mantahs-M. Mantash	35.0	2790	38.5	1961	1973	1976.6	

Average flow indicators and number of observaions used for annual flow distribution indicators are used t reconstruct the natural state of the flow. Table 3 shows annual distribution for Kasakh River basin from the watch points of r. Gegharot-Aragats.

Graph. 54. Annual flow distribution



15.5.2.TECHNICAL ECONOMIC SPECIFICATION OF SHPPS TO BE CONSTRUCTED ON RIVER KASAKH BASIN

15.5.2.1ARKHASHAN SHPP-1

INTRODUCTION

According of the design headworks should be located on the altitude of 2065m by means of which the river flow will be transferred to the Byurakan reservoir as planned.

The location of headworks of Arkhashan SHPP-1, 2, 3 is planned before the mentioned flow transfer. Arkhashan SHPP-1 uses inclination of River Arkhashan from 25750m till 2330.0m. The length of derivation from Arkhashan River is 2150m by means of copper pipeline 630mm in diameter and design pressure of 2305m and design discharge 0.60m^3/sec. After construction and exploitation SHPP Arkhashan -1 will have 111mwt capacity and will produce 3.94mln kw/h electricity annually.

SHORT DESCRIPTION OF ARKHASHAN RIVER BASIN

River Arkhashan is the left inflow of Amberd River falls into the latter on the 19th km. The river length is 13km; general catchment area is 32.9km^2. The river starts from Sevan Lake that is located to the south of Aragats mountain peaks on the elevation of 3200m. The lake itself has an elliptical shape that stretches from west to east. The surrounding location is ravine with hills that has no forests but is reach in alpine earth. The soil types that the river basin is composed of are presented by andesite-basalts that are occasionally covered by tuffs. The earth cover is presented by various black earths that are covered by reach vegetative layer. The beginning of the ravine is presented by a small slope that after 400-500m has a V shape ravine with high slopes with 60-70^0 inclination and 400-500m elevations. Occasionally the slopes are horizontal particularly near Amberd with huge hanging rocks.

The inundation ravine along the whole river length is absent. The river bed is very complicated with multiple turnings; the elevation of the river banks is 0.4m and sometimes 0.8m. The river bed is full of large rocks. The annual flow of horizons is described by short-term floods that last 60-80 days with multiple peaks and falls. The beginning of the flood takes place at the eng of April of beginning of May and the drought starts from the begging of June. The floods are usually snow based and vary within 40-50cm. There are no autumn floods. The drought period is very stable and is conditioned only ground water feeding. The flow properties during the draught period do not change. The freezing begins in the end of autumn. The ice cover is very strong which may cause the flow to completely stop.

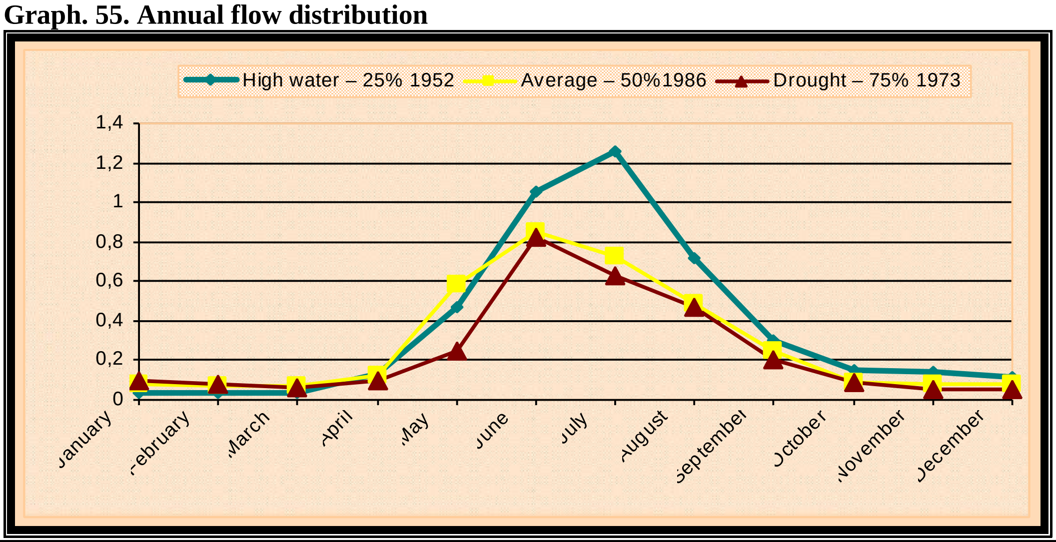
The river has never been studied before and is located in a region with strong permeability. We do not think that it is sensible to locate a water meter station rather in this case we have taken the curve of the module dependent on the average altitude of the river basin that is carried out for Akhuryan and Kasakh river inflows, to get the flow data of those two rivers.

HYDROLOGY

The observation data from r. Geghahovit-Aragats water-meter station is used to define the hydrological properties of Arkhashan -1 SHPP headworks and the design river section. It is noteworthy that the data on the average flow of Arkhashan River are not dependable due to high permeability of Amberd river basin and special in-situ water meter investigations are necessary. The catchment area of Arkhashan SHPP-1 in headworks design area is 13.9km^2 with average multi-annual flow norm 0.30m^3/sec.

Graph shows annual flow distribution of Arkhashan SHPP-1 for the design river section, during tree characteristic years.

Graph. 55. Annual flow distribution



Maximal design discharge for Arkhashan SHPP-1 headwork river section for the general case equal 3%-12.3m^3/sec, for verifying case - 0.5%-18.5m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.035m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Arkhashan SHPP-1 is 2575.0m, downstream - 2330.0m. According to data of RA State Committee for Water Economy there is no water intake starting from SHPP station works.

Arkhashan SHPP-1 is derivational SHPP. In order not to drain the river where 2150m derivational pipeline is the environmental discharge is designed according to RA laws and 0.026m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes.

Hydro-power properties of Arkhashan SHPP-1 are calculated with 50% guarantee per annum (1971).

Table. 116. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Arkhashan SHPP (m^3/sec)	0.053	0.047	0.044	0.100	0.561	0.600	0.600	0.462	0.221	0.061	0.058	0.050	
SHPP average monthly capacity (mwt)	0.104	0.092	0.086	0.196	1.042	1.106	1.106	0.873	0.430	0.119	0.114	0.098	
SHPP –average monthly energy production (mln kwt/hour)	0.077	0.062	0.064	0.141	0.776	0.796	0.823	0.650	0.309	0.089	0.082	0.073	**3.94**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 1015.5 thousand USD (without VAT) and 1218.6thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	33.5
2. Exploitation expenses	35.3
Salary	23.2
Renovation	8.1
Other Expenses	4.0
Total	68.8

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		1106
Average multi annual production of energy, mln kwt/hour		3.94
Capital investments into SHPPS(without VAT),		
	thousand USD	1015.5
	USD / kwt	918.2
	USD / kwt/hour	0.258
Prime cost of power production, cents/kwt hour		1.74

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

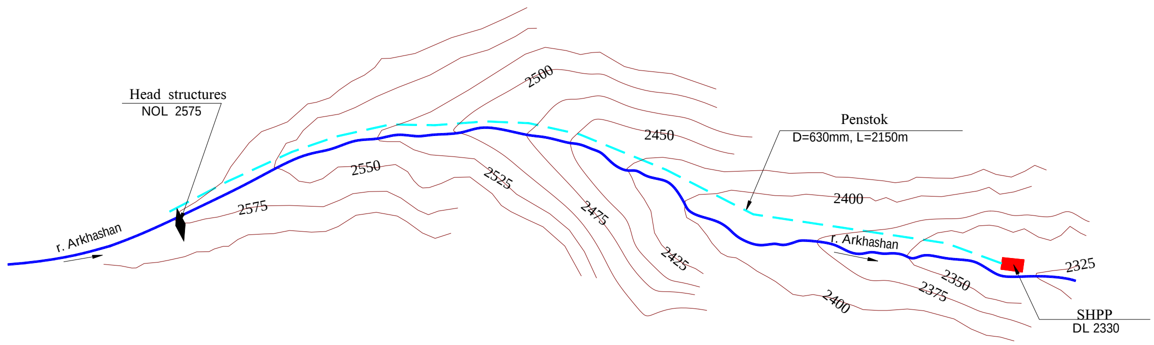
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 117. Design results according to financial scenarios

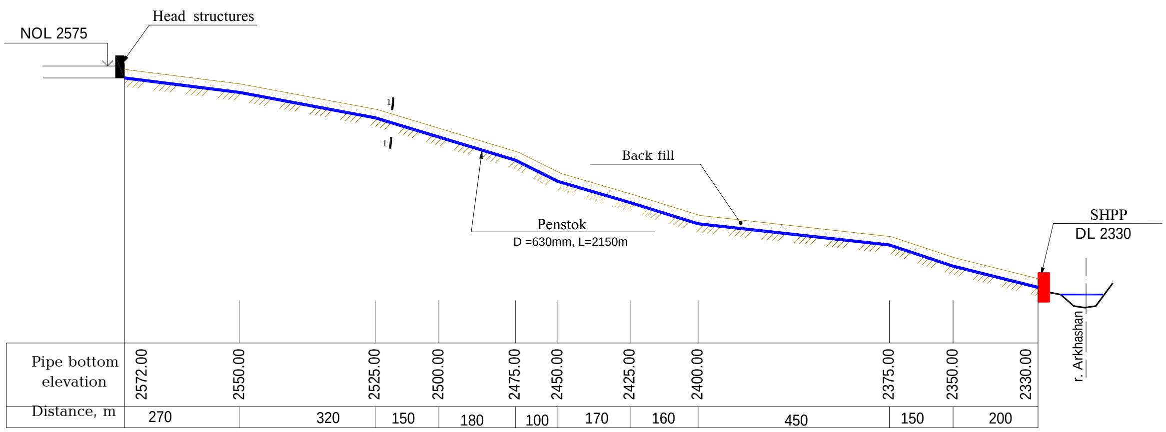
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		14.1	17.5
NPV, thousand USD			
	8%	636.0	638.0
	10%	369.1	415.9
	12%	167.6	256.5
	14%	12.9	140.0
PB, years (without discount)		6.9	8.6
Deadline for credit return, years			7.0

APPENDIX. 52. ARKHASHAN SHPP

Plan



Longitudinal section



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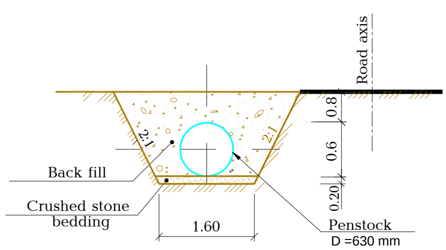
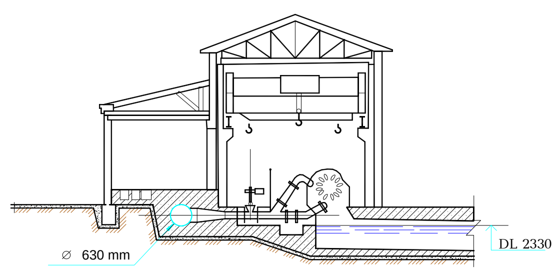


SHPP Powerhouse



15.5.2.2. ARKHASHAN SHPP-2

INTRODUCTION

Arkhashan SHPP-2 uses inclination of River Arkhashan from 2315.0m till 2170.0m.

The length of derivation from Arkhashan River is 1900m by means of copper pipeline 630mm in diameter and design pressure of 127.6m and design discharge 0.70m^3/sec. After construction and exploitation SHPP Arkhashan -2 will have 0.714mwt capacity and will produce 2.54mln kw/h electricity annually.

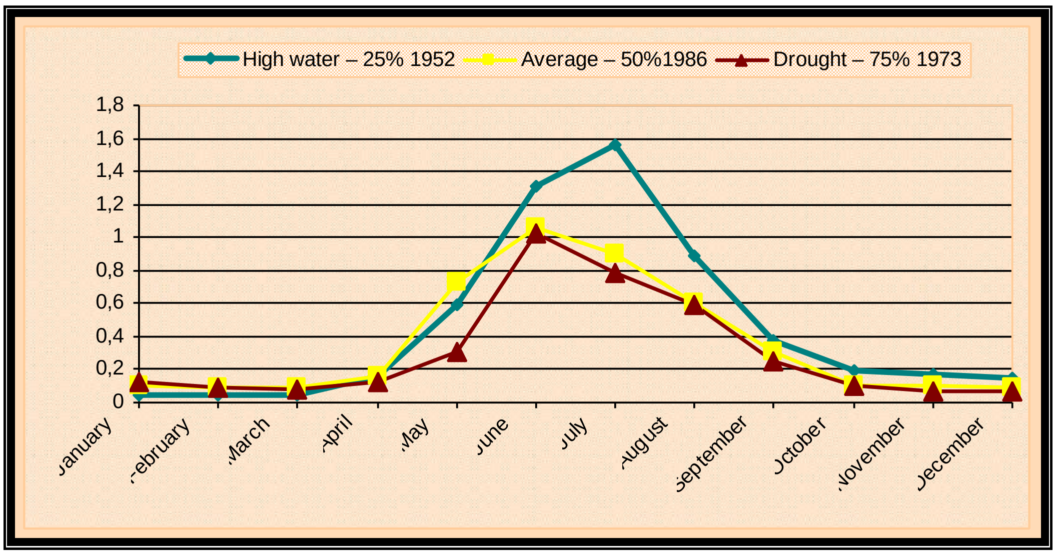
HYDROLOGY

The observation data from r. Geghahovit-Aragats water-meter station is used to define the hydrological properties of Arkhashan SHPP-2 headworks and the design river section.

The catchment area of Arkhashan SHPP-2 in headworks design area is 17.3km^2 with average multi-annual flow norm 0.40m^3/sec.

Graph 1 shows annual flow distribution of Arkhashan SHPP-2 for the design river section, during tree characteristic years.

Graph. 56. Annual flow distribution



Maximal design discharge for Arkhashan SHPP-2 headwork river section for the general case equal 3%-13.4m^3/sec, for verifying case - 0.5%-20.2m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.068m^3/sec.

WATER ECONOMY ENERGY SECTOR

The upstream pool elevation of Arkhashan SHPP-2 is 2315.0m, downstream - 2170.0m. According to data of RA State Committee for Water Economy there is no water intake starting from SHPP station works.

Arkhashan SHPP-2 is derivational SHPP. In order not to drain the river where 1900 m derivational pipeline is the environmental discharge is designed according to RA laws and 0.051m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes.

Hydro-power properties of Arkhashan SHPP-2 are calculated with 50% guarantee per annum (1971).

Table. 118. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Karmravan SHPP (m^3/sec)	0.047	0.040	0.036	0.106	0.679	0.700	0.700	0.557	0.257	0.057	0.054	0.043	
SHPP average monthly capacity (mwt)	0.054	0.046	0.042	0.123	0.699	0.714	0.714	0.597	0.293	0.066	0.063	0.050	
SHPP –average monthly energy production (mln kwt/hour)	0.041	0.031	0.031	0.088	0.520	0.514	0.532	0.444	0.211	0.049	0.045	0.037	**2.54**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 713.1 thousand USD (without VAT) and 855.7 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	23.5
2. Exploitation expenses	31.9
Salary	23.2
Renovation	5.7
Other Expenses	3.0
Total	55.4

Power indicators of have the following level

Indicators	Values
Derivation capacity, kwt	714
Average multi annual production of energy, mln kwt/hour	2.54
Capital investments into SHPPS(without VAT),	
thousand USD	713.1
USD / kwt	998.7
USD / kwt/hour	0.28
Prime cost of power production, cents/kwt hour	2.2

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

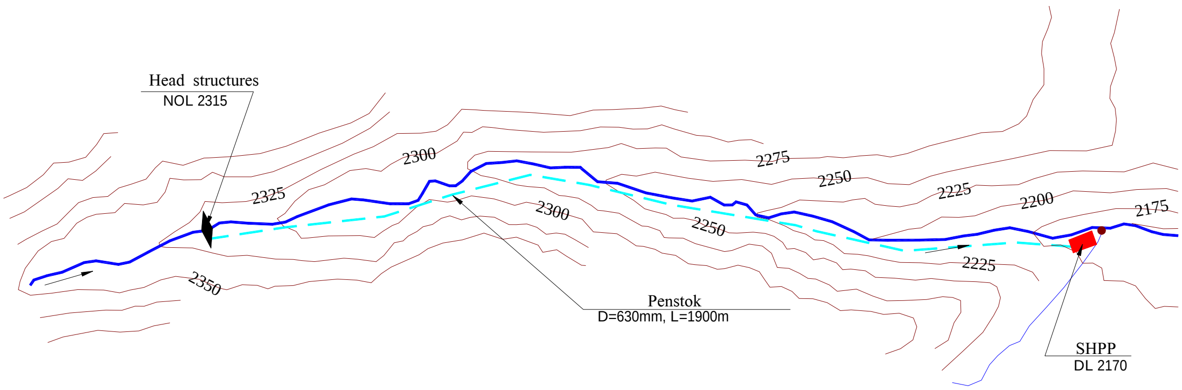
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 119. Design results according to financial scenarios

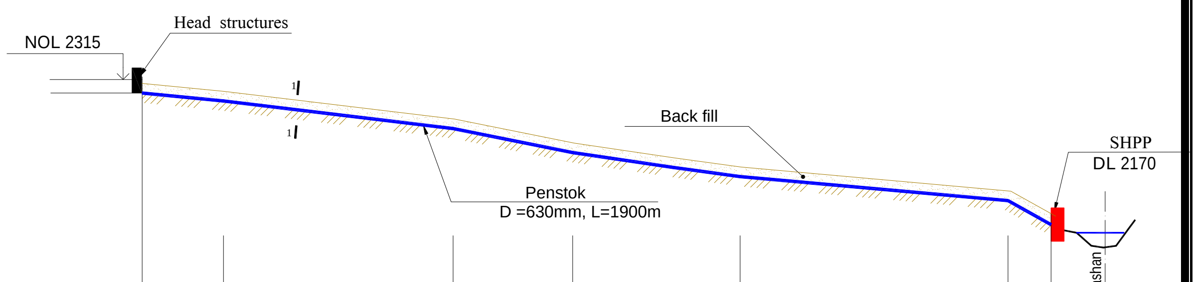
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		11.9	14.0
NPV, thousand USD			
	8%	275.6	275.6
	10%	114.8	151.1
	12%	-5.83	63.0
	14%	-98.2	-0.5
PB, years (without discount)		8.1	9.0
Deadline for credit return, years			8.0

APPENDIX. 53. ARKHASHAN SHPP 2

Plan

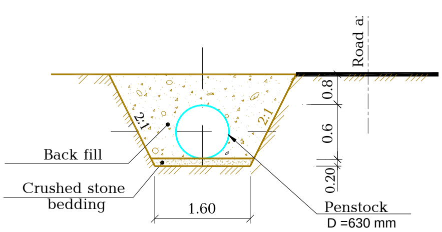


Longitudinal section

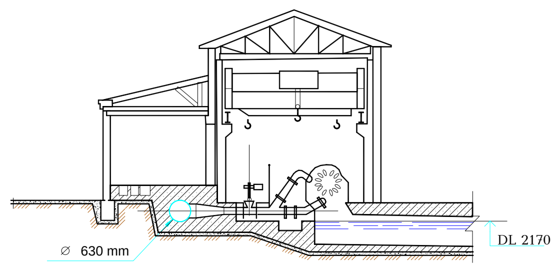


Pipe bottom elevation	2312.00	2300.00	2275.00	2250.00	2225.00	2175.00	2170.00
Distance, m	170	480	250	350	560	90	

1-1



SHPP Powerhouse



15.5.2.2. ARKHASHAN SHPP-3

INTRODUCTION

Arkhashan SHPP-3 uses inclination of River Arkhashan from 2150.0m till 2075.0m.

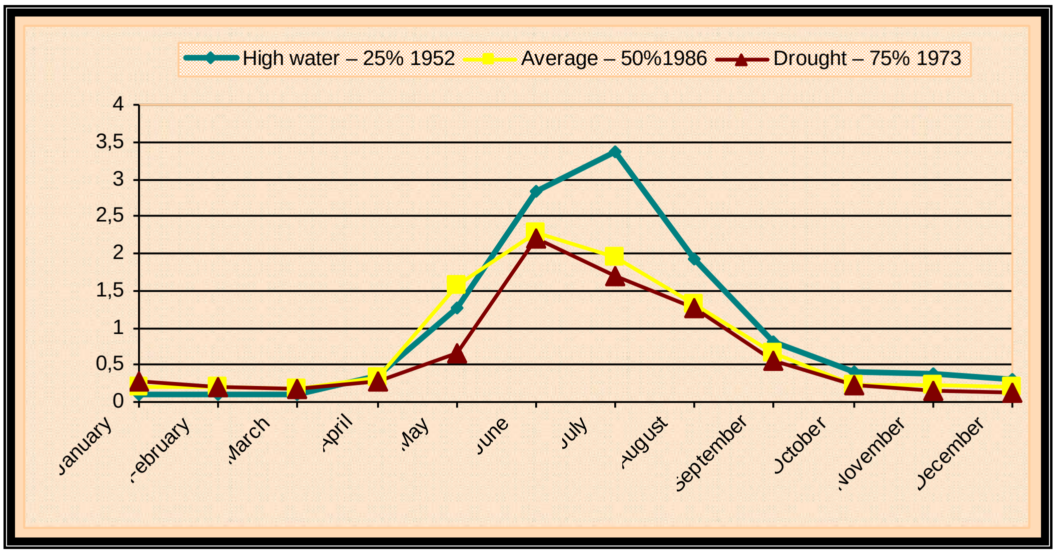
The length of derivation from Arkhashan River is 1000m by means of copper pipeline 920mm in diameter and design pressure of 70.0m and design discharge 1.50m^3/sec. After construction and exploitation SHPP Arkhashan - 3 will have 0.84mwt capacity and will produce 3.14mln kw/h electricity annually.

HYDROLOGY

The observation data from r. Geghahovit-Aragats water-meter station is used to define the hydrological properties of Arkhashan SHPP-3 headworks and the design river section. The catchment area of Arkhashan SHPP-3 in headworks design area is 29.8km^2 with average multi-annual flow norm 0.80m^3/sec.

Graph below shows annual flow distribution of Arkhashan SHPP-3 for the design river section, during tree characteristic years.

Graph. 57. Annual flow distribution



Maximal design discharge for Arkhashan SHPP-3 headwork river section for the general case equal 3%-16.7m^3/sec, for verifying case - 0.5%-25.1m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.086m^3/sec.

WATER ECONOMY AND ENERGI SECTOR

The upstream pool elevation of Arkhashan SHPP-3 is 2150.0m, downstream - 2075.0m.

According to data of RA State Committee for Water Economy there is no water intake starting from SHPP station works.

Arkhashan SHPP-3 is derivational SHPP. In order not to drain the river where 1000 m derivational pipeline is the environmental discharge is designed according to RA laws and 0.065m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes.

Hydro-power properties of Arkhashan SHPP-3 are calculated with 50% guarantee per annum (1971).

Table. 120. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Karmravan SHPP (m^3/sec)	0.146	0.131	0.123	0.274	1.500	1.500	1.500	1.244	0.597	0.168	0.161	0.138	
SHPP average monthly capacity (mwt)	0.088	0.079	0.074	0.164	0.840	0.840	0.840	0.712	0.354	0.101	0.097	0.083	
SHPP –average monthly energy production (mln kwt/hour)	0.065	0.053	0.055	0.118	0.625	0.605	0.625	0.530	0.255	0.075	0.069	0.062	**3.14**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 750.1thousand USD (without VAT) and 900.1 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	24.7
2. Exploitation expenses	30.2
Salary	20.2
Renovation	6.0
Other Expenses	4.0
Total	54.9

Power indicators of have the following level

Indicators	Values
Derivation capacity, kwt	840
Average multi annual production of energy, mln kwt/hour	3.14
Capital investments into SHPPS(without VAT),	
thousand USD	750.1
USD / kwt	893.0
USD / kwt/hour	0.24
Prime cost of power production, cents/kwt hour	1.75

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

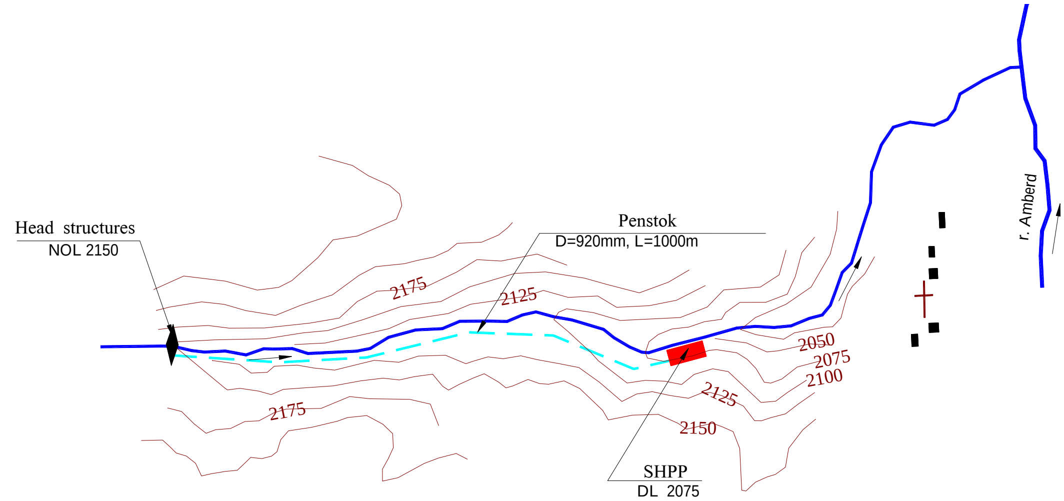
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 121. Design results according to financial scenarios

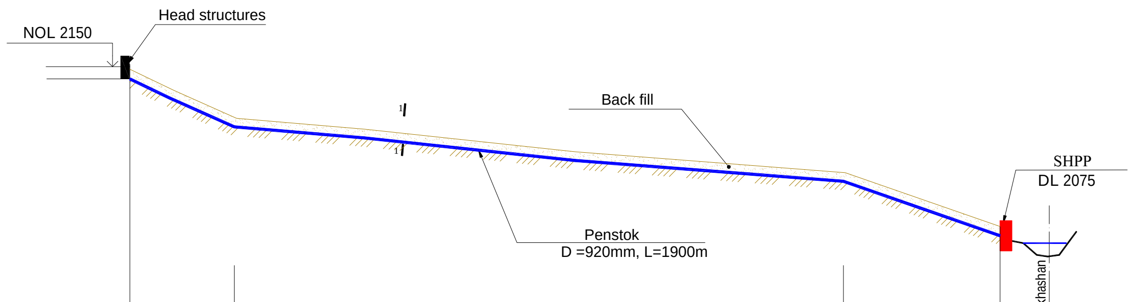
INDICATORS		Scenario 1 100% fully self -financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		15.0	18.5
NPV, thousand USD			
	8%	542.1	542.1
	10%	331.9	362.7
	12%	174.4	233.2
	14%	53.6	138.0
PB, years (without discount)		6.5	8.0
Deadline for credit return, years			6.0

APPENDIX. 54. ARKHASHAN SHPP-3

Plan

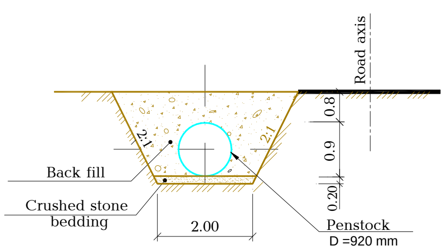


Longitudinal section

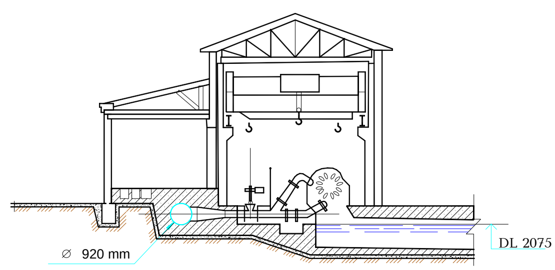


Pipe bottom elevation	2147.00	2125.00	2100.00	2075.00
Distance, m	120	700	180	

1-1



SHPP Powerhouse



15.5.2.4. DUZQENT SHPP

INTRODUCTION

Duzqend SHPP uses inclination of River Duzqend from 2450.0m till 2260.0m.

The length of derivation from Duzqend River is 2200m by means of copper pipeline 630mm in diameter and design pressure of 175.0m and design discharge 0.60m^3/sec. After construction and exploitation SHPP Duzqend will have 0.84mwt capacity and will produce 2.88mln kw/h electricity annually.

SHORT DESCRIPTION OF DUZQEND RIVER BASIN

River Duzqend the right inflow of Kasakh river and falls into the latter on the 89th km. The river length is 25km; general catchment area is 39.2km^2. The original flow of the river is very small; it is more of a mud flow carrier that is activated during rain and snow melting inundations.

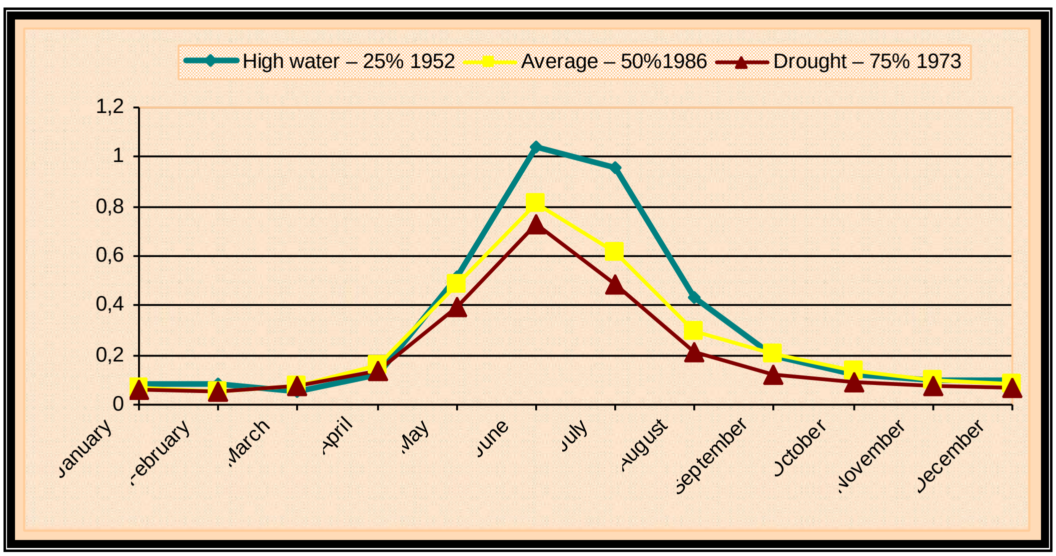
During these seasons the waters are carried towards Kasakh river source that starts where tree small rivers fall into one. Out of the spring flood season this river even dries out and small springs that appear near Duzqend village do not reach River Kasakh.

Hydrology

The observation data from r. Mantash-M. Mantash water-meter station is used to define the hydrological properties of Duzqend SHPP-1 headworks and the design river section. The catchment area of Duzqend SHPP-1 in headworks design area is 16.9km^2 with average multi-annual flow norm 0.26m^3/sec.

Graph shows annual flow distribution of Duzqend SHPP-1 for the design river section, during tree characteristic years.

Graph. 58. Annual flow distribution



Maximal design discharge for Duzqend SHPP-1 headwork river section for the general case equal 3%-27.0m^3/sec, for verifying case - 0.5%-41.1m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.02m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Duzqend SHPP is 2450.0m, downstream - 2260.0m.

According to data of RA State Committee for Water Economy there is no water intake from Arkhashan river starting from SHPP station works.

Duzqend SHPP is derivational SHPP. In order not to drain the river where 2200m derivational pipeline is the environmental discharge is designed according to RA laws and 0.015m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes.

Hydro-power properties of Duzqend SHPP-1 are calculated with 50% guarantee per annum.

Table. 122. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Duzqend SHPP-1 (m^3/sec)	0.055	0.040	0.060	0.141	0.469	0.600	0.598	0.281	0.189	0.119	0.082	0.071	
SHPP average monthly capacity (mwt)	0.084	0.061	0.091	0.213	0.678	0.841	0.838	0.420	0.285	0.180	0.124	0.108	
SHPP –average monthly energy production (mln kwt/hour)	0.062	0.041	0.068	0.154	0.505	0.605	0.624	0.312	0.205	0.134	0.090	0.080	**2.88**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 796.6 thousand USD (without VAT) and 955.9 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	26.3
2. Exploitation expenses	30.6
Salary	20.2
Renovation	6.4
Other Expenses	4.0
Total	56.9

Power indicators of have the following level

Indicators	Values
Derivation capacity, kwt	841
Average multi annual production of energy, mln kwt/hour	2.88
Capital investments into SHPPS(without VAT),	
thousand USD	796.6
USD / kwt	947.2
USD / kwt/hour	0.277
Prime cost of power production, cents/kwt hour	1.98

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

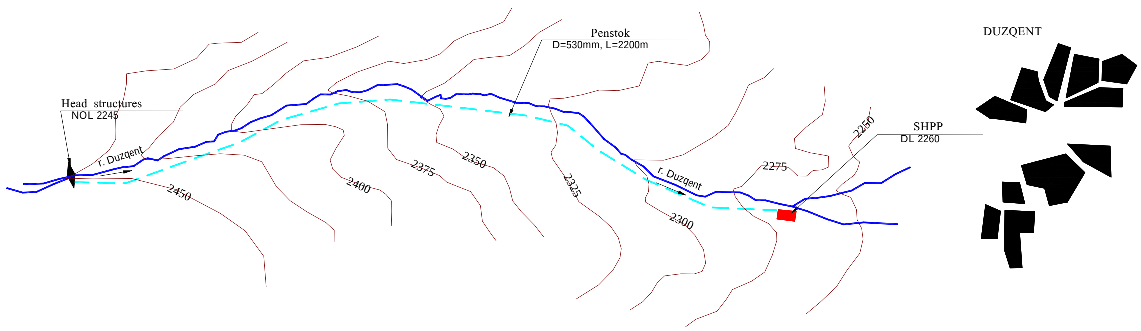
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 123. Design results according to financial scenarios

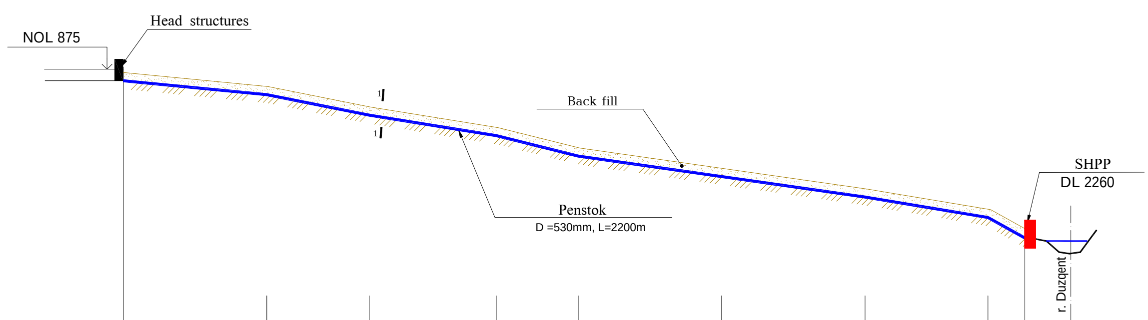
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		12.6	14.9
NPV, thousand USD			
	8%	371.7	371.7
	10%	181.6	218.3
	12%	39.2	109.0
	14%	-70.0	29.7
PB, years (without discount)		7.7	9.6
Deadline for credit return, years			7.2

APPENDIX 55. DUZQENT SHPP

Plan

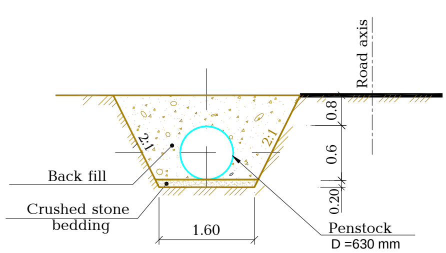


Longitudinal section

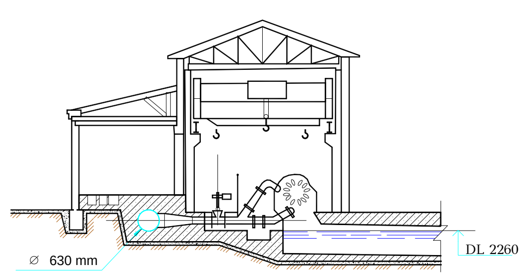


Pipe bottom elevation	2425.00	2400.00	2375.00	2350.00	2325.00	2300.00	2275.00	2260.00
Distance, m	350	250	310	200	350	350	300	90

1-1



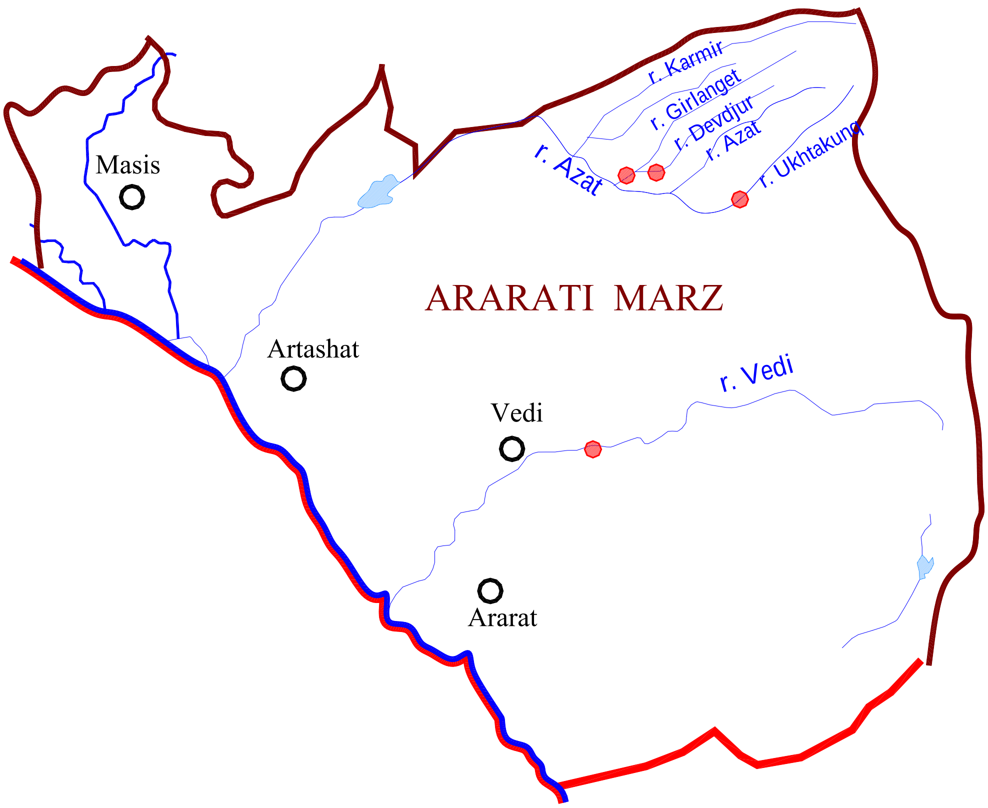
SHPP Powerhouse



PART15.6 ARARAT MARZ

AZAT AND VEDY RIVER BASIN

VERIFIED AND UPDATED SCHEME FOR SHPPs



15.6.1. GENERAL INFORMATION

According to 1997 scheme it was planned to construct 20 SHPPs in the Azat and Vedy river basins: one SHPP on Garni channel inclination and 19 derivational SHPPs. Presently Garni SHPP is under exploitation, while working design is conducted for Gokht SHPP and technical-economic substantiation is carried out for Azat SHPP. The energy potential of Karmir River is not taken into consideration as the acting Geghardalich reservoir is feeding all the way along Karmir River bed. Therefore, construction of SHPPs on the River Karmir is not efficient.

15.6.1.1. SHORT DESCRIPTION OF AZAT RIVER BASIN

River Azat is one of the left inflows of river Araks and falls into the latter at 614km from the river mouth. River length is 65km; catchment basin is 572km^2. River Azat starts from the western slopes of Geghama mountain chain. It springs from in between tree: Aghdahag (2080m), Small Aghdag (3447m) and Big Aghdag (3560m).

River Azat is formed from two small rivers that flow in separate gorges of Geghama Mountains. The river basin borders with Hrazdan River, from the north with Getar (Hrazdan inflow), from the east – Lake Sevan, the water flow is divided by Geghama mountains, while from the south Azat River is divided from River Vedi basin by Geghama mountain chain.

In the upstream the river basin has a strong broken structure as is composed of rock types mainly basalts. The earth cover is very poor and composed of thin layer of black soil. Often the rocks have no soil layer whatsoever. There are no forests and vegetative layer is composed of alpine and sub-alpine ravines. The area has a shape of a V-shape canyon with 45-60^0 slope inclination while the right slope is occasionally very steep and is 300m high and reaches 50m ascending towards Garni. The left slope is lower and flat. Its elevation does not exceed 150-200and with inclination of 45^0.

The width if the ravine bed is 25-50m, it occasionally reaches 250 in width especially in the area of inflows, small canyons. The slopes are covered with meadows and rocks that are the result of weathering of rocks. There are no inundations. The river bed is not cultivated in the beginning and after Kernikerd village it joins the meadow bed. The river banks have slight inclination in the beginning and gradually blend into the meadow landscape and further of the banks become steep.

Closer to Garny, the river bed is very steep and mountainous and on the inside it is represented as a part if Sub-Araks meadow. The vegetative cover of the basin is nether neither diverse nor reach. The alpine meadows of the upstream change into low grass cover in the downstream from Garni village, with the exception of heavily irrigated lands with wine yards and apple tree gardens.

From the south – west till Dzorashen, the river flows in a deep gorge, afterwards in flows into a valley and slowly flows over the cone of brought rock types. The river basin is presented by well cultivated canyon with 45^0 and more steep slopes. Four kilometers from Garni village, the right bank of the river is steep with terraces on the horizontal surfaces there are vineyards and gardens. The left bank is even steeper with deep gorges. The elevation of the right bank is 150m near river Garni and 50-60m near Dzorashen. The left slope stars with 100m and overwhelming 60-70m elevation along the river length.

Valley width varies from 300m, and 1.5km till Dzorashen village. Starting from Dzorashen the valley is not well developed and the river flows along the valley carrying out multiple turnings.

The inundation area appears only after Dzorashen village when the river appears on the valley. Occasionally there are small panoramic areas. The width of inundation area is 100-200m with flat bed. The bed of the inundation is sandy and covered with silt.

In the beginning the river bed occupies the bottom of the whole valley. It has multiple braches and is almost flat. While in the inundation area there are multiple turnings and divided into branches (3-4 and more). In the gorge section the river bed is covered with grass, bushes and separate trees. Here the river bed is slightly deformed and in the inundation bed is composed of sand, small river stones and is strongly deformed.

15.6.1.2. GEOLOGIC COMPOSITION OF AZAT RIVER BASIN

From the geologic point of view the mountains of the basin are composed of volcanic rock types: basalt and andesite basalts. The left bank of the River Garni is composed of multi color megrels and conglomerates while in the Kuru-Self flow basin there is a thin layer andesite-basalt lavas that is broken into separate pieces and stretches in the south-west direction and gradually gets more narrow till it reaches Dzoraget village and gradually disappears. The width of this layer near village Gokht is 2.5km., near Garni village – 1km, and near Dzorashen – it finishes. Near the mentioned villages this layer is represented by impermeable megrels and clay lime stones and near Dzorashen – also by sand stone layers. The earth cover near Garni village is represented with black meadow earth while in the downstream of Garni village by clay and sand stones.

The quality of water in the river is very high and is used by two main water carriers that supply Yerevan and Artashat cities with drinking water.

15.6.1.3 WATER REGIME OF AZAT RIVER BASIN AND DESIGHN DATA

The river regime is characterized with strict fluctuations during flooding and rain floods. The inundations start from the end of March or the beginning of April and reach their peak at the begging of May.

The horizons are uneven with multiple ups and downs, which are conditioned by snow melting in different climatic zones; moreover, there are rains during flooding. The downgrading is more smooth and stable. There are almost no autumn floods. The drought period is characterized by stable horizons and water discharge; this is conditioned by ground water feeding. All through the drought period, which lasts for 9 months the fluctuations of the horizon do not exceed 5 cm.

The river flow is formed due to ground water, snow melting and rain compositions. The two latter take part in the flow formation only during 3 spring-summer months that form about 30% of annual flow and the remaining 70% are the ground waters that are evenly distributed all through the year.

The river module near Garni village is significantly high as opposed to other rivers. This is explained by the fact that the volume of the ground water catchment basin does not coincide with on river basin and exceeds it. Particularly it spreads towards north-west section, incorporating Kur-Selav inflow basin, this explains the low water levels of the latter.

This could be fully understandable if this basin was in a deserted area. However, it is located in the highlands, with annual precipitations of 700-900mm. According to A. P. Sokolov, calculations 55km^2 of Kur- Selaf basin should be considered for Garni observation point. There is water loss in the Garni-Dzorashen section where Azat reservoir is located.

Winter phenomena are defined in various ways. In the upstream of the river starting from December there are ice sections near the river banks. At the end of December they turn into ice cover. A bit further downstream they grow thicker and narrow the river bed. There is occasionally floating ice in the begging of winter.

In the downstream the winter phenomenon does not appear mainly due to warm springs. Embankment ice almost never occurs and melts away rapidly. However, in the further downstream near Dzorashen, before the reservoir was build there had been embankment ice due to slowing down of the river flow. The systematic observations of Azat and Vedi river basin were carried out from r. Azat– r. Garni and Vedi - Urtsadzor observation points. The main hydrological observations are shown on the table.

Water meter station	Distance from the river mouth, km	Average elevation of reservoir, m.	Catchment area, km^2	Exploitation timeline		Exploitation timeline	Normal Flow, m^3/sec
				started	started		
r. Azat– r. Garni	0.1	2110	87.0	1936	2006	1453.11	0.93
Vedi - Urtsadzor	25.0	2060	348	1937	2005		1.99

For average water flow indicators and annual distribution data the abovementioned observation results were used by rehabilitating the natural state of the river. The table 3 shows annual distribution of Azat river basin flow for characteristic years.

Տ ար ի	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	average
r. Azat– r. Garni													
High Water – 25%													
1942y.	3.99	4.09	4.09	6.50	15.9	10.3	5.43	4.52	4.65	4.48	4.74	4.97	6.14
Average – 50%													
1955y.	4.34	4.28	4.16	6.96	13.2	8.69	4.11	3.96	3.92	3.77	3.86	3.76	5.42
Drought– 75%													
1978y.	1.50	1.50	1.94	5.77	14.1	13.8	7.65	2.37	2.28	2.46	1.56	1.83	4.73
Vedi - Urtsadzor													
High Water – 25%													
1972y.	0.85	0.71	0.91	5.58	10.0	4.80	1.33	0.96	0.84	0.79	0.82	0.49	2.34
Average – 50%													
1957y.	0.86	0.87	1.83	4.28	6.07	3.98	1.50	0.76	0.63	0.64	0.84	0.84	1.92
Drought– 75%													
1979y.	0.73	0.95	1.23	3.63	5.82	2.19	0.72	0.54	0.49	0.74	0.88	0.78	1.56

15.6.2. TECHNICAL ECONOMIC SPECIFICATION OF SHPPS TO BE CONSTRUCTED ON AZAT AND VEDI RIVERS

15.6.2.1. GILANLAR SHPP

INTRODUCTION

According to development scheme it was planned to construct 2 SHPPs on the river. However, as a result of in-situ investigations it is planned to construct one derivational SHPP. Gilanlar SHPP uses inclination of River Gilanlar from 1650.0 till 1385.0. The length of derivation from Gilanlar River is 2350m by copper pipeline 530mm in diameter with design pressure of 244.9m and design discharge 0.40m^3/sec. After construction and exploitation Gilanlar SHPP will have 0.784mwt capacity and will produce 2.55mln kw/h electricity annually.

SHORT DESCRIPTION OF GILANLAR RIVER BASIN

River Gilanlar is the right inflow of river Azat. It flows into the river 1.2km from the river mouth. Length of the river is 14km general catchment area is 22.5km^2. The river starts from the springs that appear on the surface from lava cracks on the western slope of Geghama Mountain on the elevation of 2880m. The whole gorge is covered by alpine meadows.

The river starts to flow from east-west. 5km from the river mouth it turns towards south-west and falls into Sevghur near Baiburd village. The river mouth is located on the elevation og 1450m. The river valley is a comparatively wide V-shape open gorge the slopes of which are 40-80m high with 185-30^0 inclination. The river has no inflows. The slopes are covered by meadow vegetation and used for grain crops near the river mouth. There is no inundation valley.

River bed follows the direction of the valley with no branches. The river banks are high and are composed of stones as well as the river bed. The river has significant inclination which becomes more significant near the river mouth. Gilanlar river water regime has a natural regulation. Floods start in March and reach the maximal point in at the and of April and gradually decrease.

The drought begins at the end of June and the beginning of July. Due to small size of the river basin floods are even, with no sudden peaks. The river floods are often but short term. They can be during spring floods and seldom in autumn. The river never dries out or freezes in winter and during the drought period, due to constant inflow of ground water springs. The winter season is characteristic with iced river banks that appears in December and melt in March.

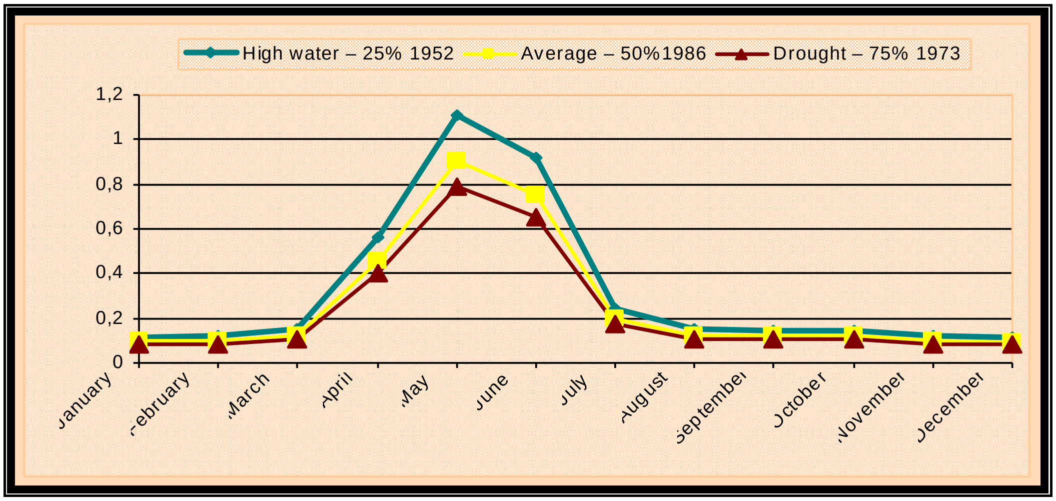
HYDROLOGY

The observation data from river Azat-Garni water-meter station is used to define the hydrological properties of Gilanlar SHPP headworks and the design river section. The table below shows hydrological properties of design river section necessary for the SHPP.

River Section	Distance from river mouth, km	Average altitude of the catchment basin, m.	Catchment area, km^2	Flow norms, m^3/sec
Gilanlar - design perpendicular section	5.5	2400	37.9	0.54

Graph shows annual flow distribution of Gilanlar SHPP for the design river section, during tree characteristic years.

Graph. 59. Annual flow distribution



Maximal design discharge for Gilanlar SHPP headwork river section for the general case equal 3% - 26.1m^3/sec, for verifying case - 0.5%-37.1m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.065m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Gilanlar SHPP is 1650.0m, downstream - 1385.0m. According to data of RA State Committee for Water Economy there is no water intake starting from SHPP station works. Gilanlar SHPP is derivational SHPP. In order not to drain the river where 2350m derivational pipeline is the environmental discharge is designed according to RA laws and 0.05m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Gilanlar SHPP are calculated with 50% guarantee per annum (1955).

Table. 124. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Gilanlar SHPP (m^3/sec)	0.046	0.051	0.072	0.400	0.400	0.400	0.147	0.076	0.069	0.069	0.047	0.045	
SHPP average monthly capacity (mwt)	0.097	0.108	0.152	0.784	0.784	0.784	0.308	0.161	0.146	0.146	0.100	0.095	
SHPP –average monthly energy production (mln kwt/hour)	0.072	0.073	0.113	0.564	0.583	0.564	0.229	0.120	0.105	0.109	0.072	0.071	**2.68**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 750.2 thousand USD (without VAT) and 900.2 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		24.8
2. Exploitation expenses		26.3
	Salary	17.3
	Renovation	6.0
	Other Expenses	3.0
Total		51.1

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		784
Average multi annual production of energy, mln kwt/hour		2.68
Capital investments into SHPPS(without VAT),		
	thousand USD	750.2
	USD / kwt	956.9
	USD / kwt/hour	0.28
Prime cost of power production, cents/kwt hour		1.9

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

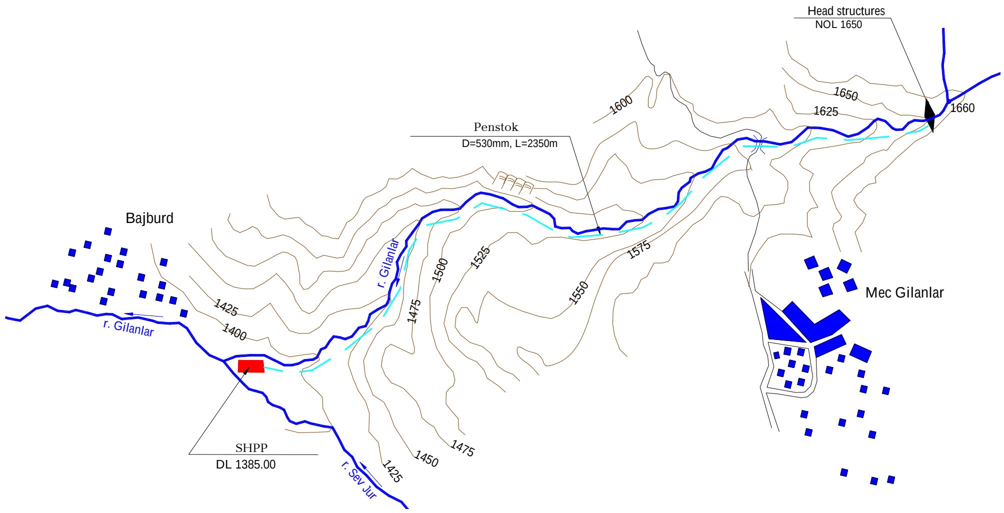
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 125. Design results according to financial scenarios

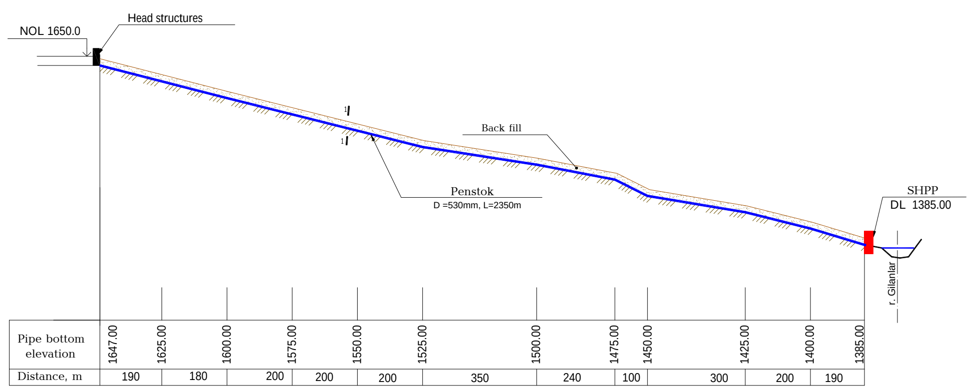
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		12.7	15.0
NPV, thousand USD			
	8%	355.2	355.2
	10%	175.4	210.0
	12%	40.7	106.4
	14%	-62.7	31.1
PB, years (without discount)		7.6	9.5
Deadline for credit return, years			7.0

APPENDIX. 56. GLINLAR SHPP

Plan



Longitudinal section



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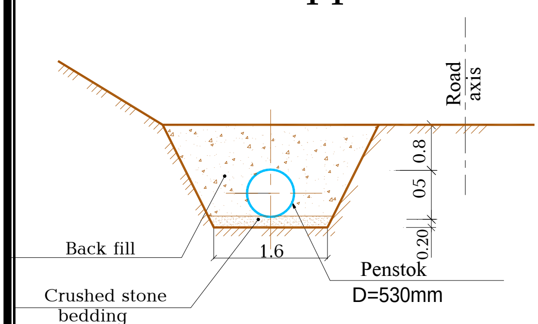
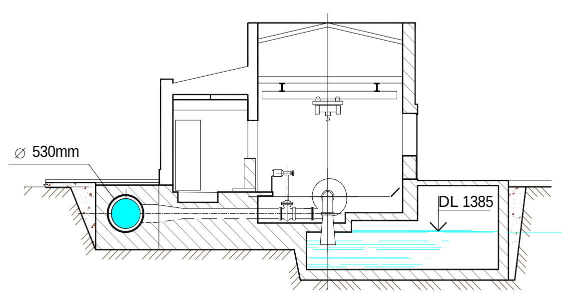


SHPP Powerhouse



15.6.2.2. UKHTAKUNK SHPP

INTRODUCTION

According to development scheme it was planned to construct 2 SHPPs on the river. However, as a result of in-situ investigations it is planned to construct one derivational SHPP. Ukhtakunk SHPP uses inclination of River Ukhtakunk from 1965.0 till 1750.0. The length of derivation from Ukhtakunk River is 3400m by copper pipeline 720mm in diameter with design pressure of 200.4m and design discharge 0.70m^3/sec. After construction and exploitation Ukhtakunk SHPP will have 1.12mwt capacity and will produce 3.84mln kw/h electricity annually.

SHORT DESCRIPTION OF UKHTAKUNK RIVER BASIN

River Ukhtakunk is the right inflow of river Azat. It falls into the river 50km from the river mouth. Length of the river is 19km general catchment area is 58.5km^2. The river starts from the west slopes of Geghama Mountains, in between Mets Aghdag (3560m) and Dznaget (3160m) peaks, approximately on the elevation of 3150m.

The river source is a spring that appears from basalt cracks located in a small gorge. The river valley is composed of basalts and covered by black earth. The vegetation is represented by alpine and sub-alpine meadows. There is no summer.

In the upper section of the river basin there are number of small mountainous lakes. The river gorge is a weakly cultivated gorge with slope inclination 45^0. The valley decreases and the gorge becomes deeper and more narrow. Within 4km the river mildly enters narrow, rocky canyon that is composed of basalts.

River bed is composed of rounded stones and full of large stones and rocks that are carried during floods from the slopes. There are no water flow observations of Ukhtakunk River. The regime is characterized by one flood, stable drought period that is occasionally interrupted by summer rains. The floods start at the beginning of March or April. The peak is during May and the drought period starts at the end of June.

Short occasional rains were observed in summer, occasional measurements during the drought period showed water discharge of 200l/sec. (0.2m^3/sec).

The regime is not well investigated it is know that the river freezes in winter, however not till the very bottom. The water quality is high due to the feeding from springs.

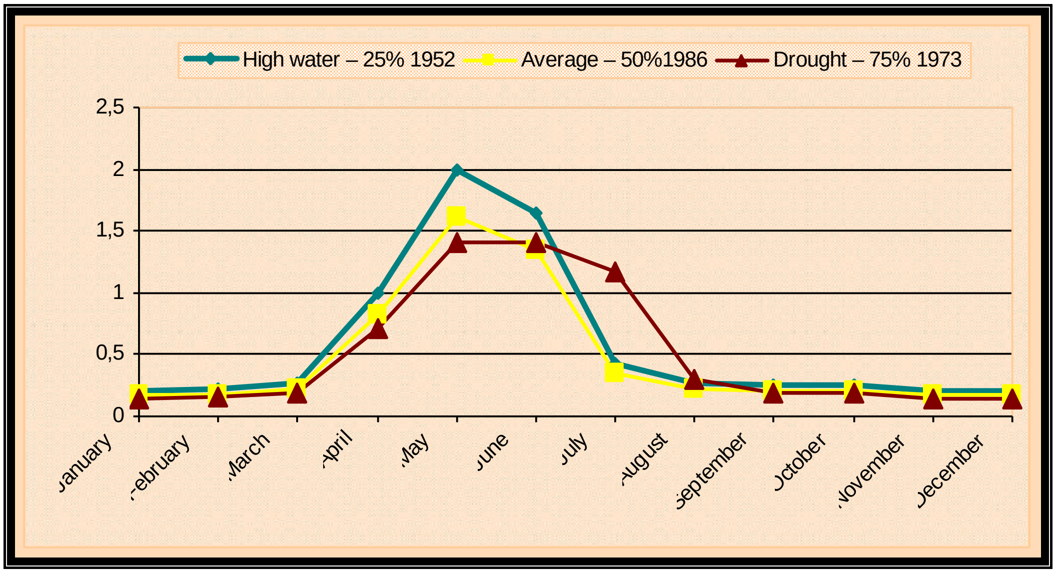
HYDROLOGY

The observation data from river Azat-Garni water-meter station is used to define the hydrological properties of Ukhtakunk SHPP headworks and the design river section. The table below shows hydrological properties of design river section necessary for the SHPP.

River Section	Distance from river mouth, km	Average altitude of the catchment basin, m.	Catchment area, km^2	Flow norms, m^3/sec
Ukhtakunk - design perpendicular section	5.5	2400	37.9	0.54

Graph shows annual flow distribution of Ukhtakunk SHPP for the design river section, during tree characteristic years.

Graph. 60. Annual flow distribution



Maximal design discharge for Ukhtakunk SHPP headwork river section for the general case equal 3% - 33.0m^3/sec, for verifying case - 0.5%-47.8m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.117m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Ukhtakunk SHPP is 1965.0m, downstream - 1750.0m. According to data of RA State Committee for Water Economy there is no water intake starting from SHPP station works. Ukhtakunk SHPP is derivational SHPP. In order not to drain the river where 3400m derivational pipeline is the environmental discharge is designed according to RA laws and 0.088m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Ukhtakunk SHPP are calculated with 50% guarantee per annum (1955).

Table. 126. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Ukhtakunk SHPP (m^3/sec)	0.083	0.090	0.128	0.700	0.700	0.700	0.262	0.135	0.122	0.122	0.084	0.080	
SHPP average monthly capacity (mwt)	0.143	0.155	0.220	1.122	1.122	1.122	0.446	0.232	0.209	0.209	0.144	0.137	
SHPP –average monthly energy production (mln kwt/hour)	0.106	0.104	0.163	0.808	0.835	0.808	0.332	0.172	0.151	0.156	0.104	0.102	**3.84**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 1101.9 thousand USD (without VAT) and 1322.3 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		36.4
2. Exploitation expenses		33.2
	Salary	20.2
	Renovation	9.0
	Other Expenses	4.0
Total		69.6

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		1122
Average multi annual production of energy, mln kwt/hour		3.84
Capital investments into SHPPS(without VAT),		
	thousand USD	1101.9
	USD / kwt	982.1
	USD / kwt/hour	0.287
Prime cost of power production, cents/kwt hour		1.81

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

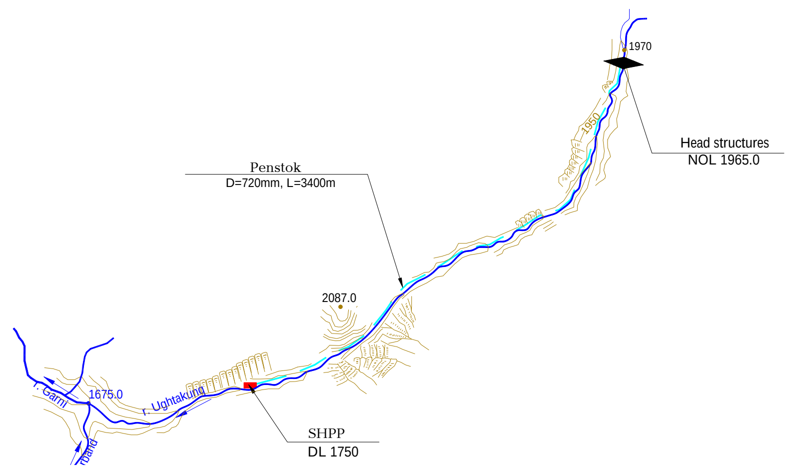
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 127. Design results according to financial scenarios

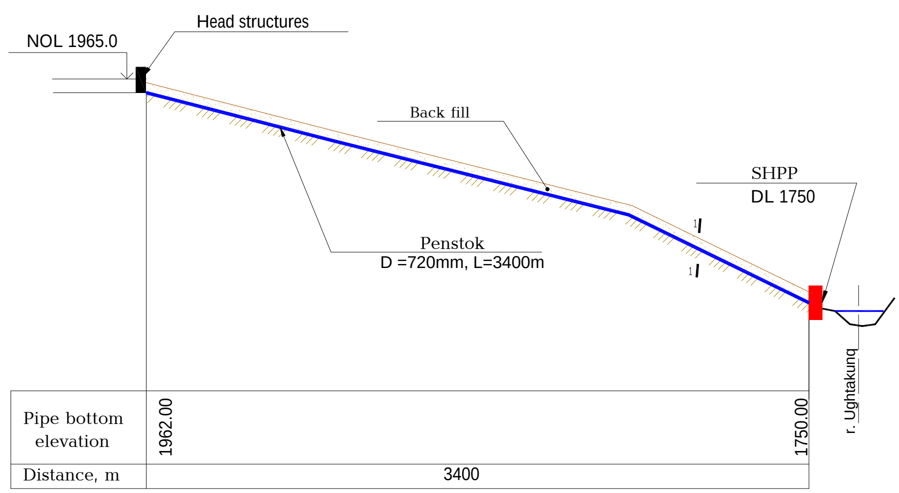
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		12.7	15.1
NPV, thousand USD			
	8%	528.2	528.2
	10%	263.0	313.8
	12%	64.4	160.9
	14%	-88.1	49.8
PB, years (without discount)		7.6	9.5
Deadline for credit return, years			7.0

APPENDIX. 57. UKHTAKUNK SHPP

Plan



Longitudinal section



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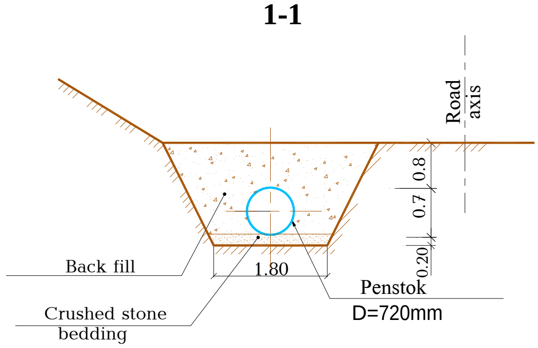
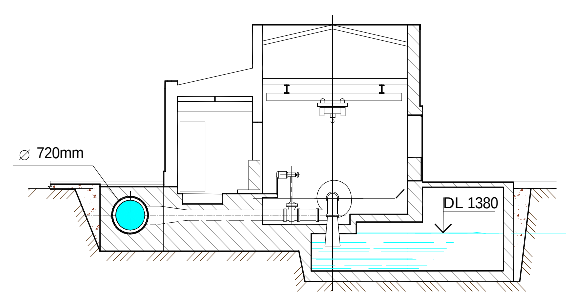


SHPP Powerhouse



15.6.2.3. SEVGHUR SHPP

INTRODUCTION

According to development scheme it was planned to construct 5 SHPPs on the river. However, as a result of in-situ investigations it is planned to construct one derivational SHPP. Sevghur SHPP uses inclination of River Sevghur from 1800.0 till 1550.0. The length of derivation from Sevghur River is 235.4m by copper pipeline 530mm in diameter with design pressure of 235.4m and design discharge 0.50m^3/sec. After construction and exploitation Sevghur SHPP will have 0.94mwt capacity and will produce 2.68mln kw/h electricity annually.

SHORT DESCRIPTION OF SEVGHUR RIVER BASIN

River Sevghur is the right inflow of river Azat. It falls into the river 39.5km from the river mouth. Length of the river is 19km, general catchment area is 57.5km^2. The river starts from the right inflows of Geghama mountain area, from the foothills of Dznaret Mountain (3168m.) The main flow starts at 2800m, from a small spring. In the upper section the bed dries out and fills up only from snow melting and rains.

From the beginning the river follows the direction of the valley and flows in south-west direction. On the 10th km of the flow it changes direction to west until it falls into River Araks.

The catchment basin is composed of volcanic rock types, mainly basalts. The earth is mountainous black, which covers rocks by a thin layer. Often the mountain slopes are completely uncovered. The vegetation of the river mouth is presented by alpine and sub-alpine categories. In the downstream the lands are cultivated. The river valley is has complicated shape that deepens downstream.

Valley slopes are of 30-45^0 inclination mountainous meadows, cultivated near inhabited areas. There is no inundation valley, but there are wider sections that are filled up with water during floods.

HYDROLOGY

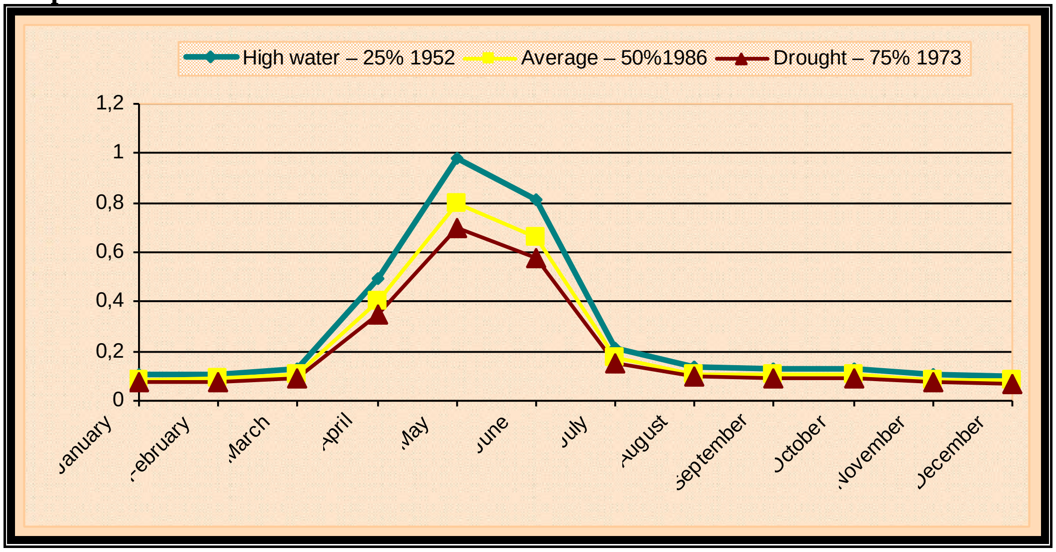
Sevghur river inundation starts at the end of March and begging of April and reaches its peak in the first half of May and in summer horizons are stabilized at the end of June – beginning of July. There are no autumn floods. Winter drought flow exceeds summer flow. The freezing period starts in November and beginning of December. There is no uniform freezing on the river. There are only ice pieces on the embankment that grow larger as winter proceeds. Ice melts without forming ice flow.

The observation data from river Azat-Garni water-meter station is used to define the hydrological properties of Sevghur SHPP headworks and the design river section. The table below shows hydrological properties of design river section necessary for the SHPP.

River Section	Distance from river mouth, km	Average altitude of the catchment basin, m.	Catchment area, km^2	Flow norms, m^3/sec
Sevghur - design perpendicular section	5.5	2400	37.9	0.54

Graph shows annual flow distribution of Sevghur SHPP for the design river section, during tree characteristic years.

Graph. 61. Annual flow distribution



Maximal design discharge for Sevghur SHPP headwork river section for the general case equal 3% - 24.8m^3/sec, for verifying case - 0.5%-36.0m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.058m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Sevghur SHPP is 1800.0m, downstream - 1550.0m. According to data of RA State Committee for Water Economy there is no water intake starting from SHPP station works. Sevghur SHPP is derivational SHPP. In order not to drain the river where 1150 m derivational pipeline is the environmental discharge is designed according to RA laws and 0.044m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Sevghur SHPP are calculated with 50% guarantee per annum (1955).

Table. 128. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Sevghur SHPP (m^3/sec)	0.041	0.045	0.063	0.360	0.500	0.500	0.130	0.067	0.061	0.061	0.042	0.040	
SHPP average monthly capacity (mwt)	0.081	0.089	0.125	0.697	0.941	0.941	0.258	0.133	0.121	0.121	0.083	0.079	
SHPP –average monthly energy production (mln kwt/hour)	0.060	0.060	0.093	0.502	0.700	0.678	0.192	0.099	0.087	0.090	0.060	0.059	**2.68**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 745.36 thousand USD (without VAT) and 894.4 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		24.6
2. Exploitation expenses		27.3
	Salary	17.3
	Renovation	6.0
	Other Expenses	4.0
Total		51.9

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		941
Average multi annual production of energy, mln kwt/hour		2.68
Capital investments into SHPPS(without VAT),		
	thousand USD	745.3
	USD / kwt	792.0
	USD / kwt/hour	0.278
Prime cost of power production, cents/kwt hour		1.66

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

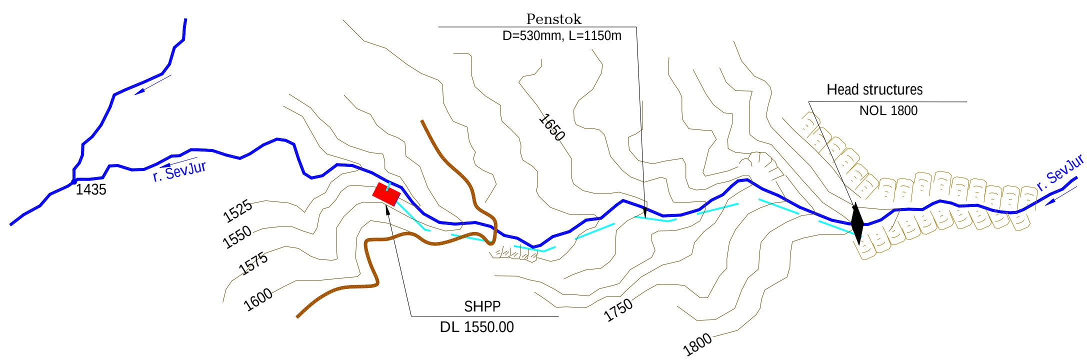
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 129. Design results according to financial scenarios

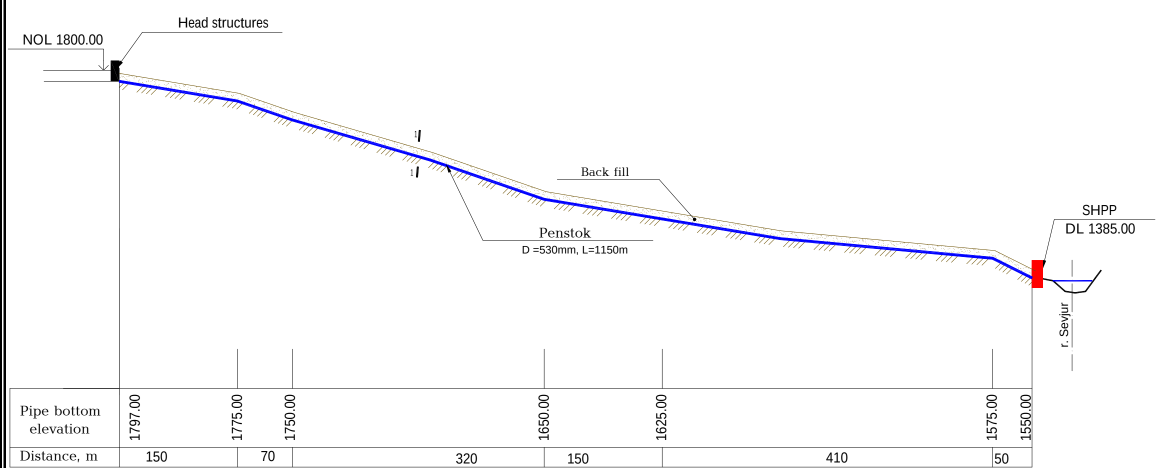
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		13.4	16.3
NPV, thousand USD			
	8%	410.9	410.9
	10%	222.8	257.2
	12%	81.9	147.2
	14%	-26.2	67.0
PB, years (without discount)		7.3	9.0
Deadline for credit return, years			7.0

APPENDIX. 58. SEVGHUR SHPP

Plan



Longitudinal section



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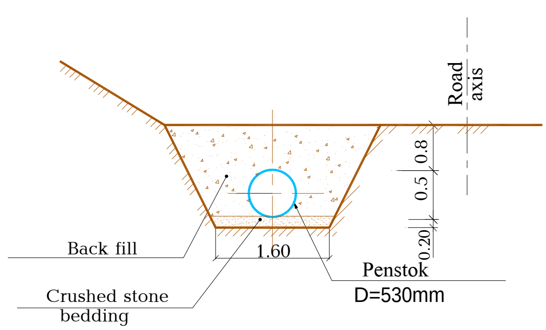
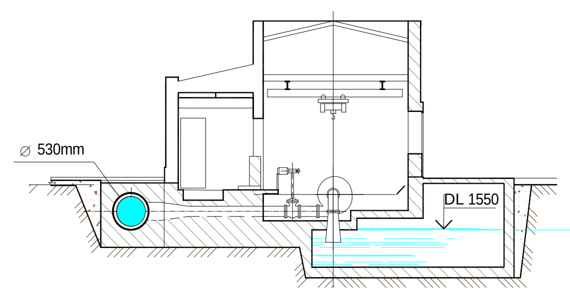


SHPP Powerhouse



15.6.2.4. VEDI SHPP

INTRODUCTION

According to development scheme it was planned to construct 2 SHPPs on the river. However, as a result of in-situ investigations it is planned to construct one derivational SHPP. Vedi SHPP uses inclination of River Vedi from 1460.0 till 1380.0. The length of derivation from Vedi River is 3150m by copper pipeline 1020mm in diameter with design pressure of 73.6m and design discharge 1.20m^3/sec. After construction and exploitation Vedi SHPP will have 0.706mwt capacity and will produce 2.38mln kw/h electricity annually.

SHORT DESCRIPTION OF VEDI RIVER BASIN

River Vedi is the right inflow of river Azat. It falls into the river 600km from the river mouth. The river starts from 2515 altitude. The river source is represented by number of strong springs. Length of the river is 58km general catchment area is 633km^2. In spring during snow melting the source shifts 4-5km upper on the latitude 2700m from the sea level. In the upper sections the river basin presents a mountainous area with multiple lakes and springs. In the begging, the river flows along the meridian till Kelanlu village, after which is turns and flows towards west and changes direction news B-Vedi village towards south-west and falls into river Araks on 809km near Shidlu village. The river has several inflows, most of them are mud flow beds that are activated during floods. The vegetative layer is not rich there are alpine meadows in the upstream on Geghama mountains while in the downstream there are shushes and short dry grass.

After Chimanaget village where river is used for irrigational needs there are gardens. River Vedi valley is composed of two sections, mountainous and ravine. The ravine section is connected to sub-Araks valley. The mountainous part stretches till Vedi city for 44 km, the ravine part – 14 km. The mountainous part is represented by sedimentary rock types that are mainly yellow-grey sand stones, lime stones and clays. In the initial 28km of the flow the river valley is represented by a gouge the slopes of which have the inclination of 30-60^0 they are composed of basalts and covered with grass. After the village Khrabaghkar the valley changes into lower hills that are separate from the river.

In the valley the slopes are covered by gardens and vineyards. Starting from Chimankend village irrigational channels start from both river banks and near the river mouth Buruni irrigational construction is built that mainly feeds of Artashat chennel and Vedi river waters. The inundation valley in the upstream till Khrabaghkar village is absent, and in the downstream there are inundation sections that in the beginning have 50-80m width and at the end 200-300m. The area is occasionally bogged and mainly covered by sand and have insignificant inclination towards the river. After Khrabaghkar village the bed is seldom formed into branches, the river banks are low and the river bed is covered by sand stones. The water regime is characterized by large flood wave that starts in the beginning of April. As a result of snow melting the peak is in the beginning of Amrch and the fall is slow and takes place in June-July. The amplitude of water fluctuations is insignificant and does not exceed 1m, and 0.-0.4m in the widest area. There is no ice regime on the river. During cold winters the upper streams are covered by insignificant ice crust.

GEOLOGICAL COMPOSITION OF VEDI RIVER BASIN

From the geological point of view the river basin is composed of volcanic rock types, basalts and andesite basalts and in the downstream of the basin the river flows through sedimentary rock types of Araks valley. The river basin is significant for its high temperature and little precipitations.

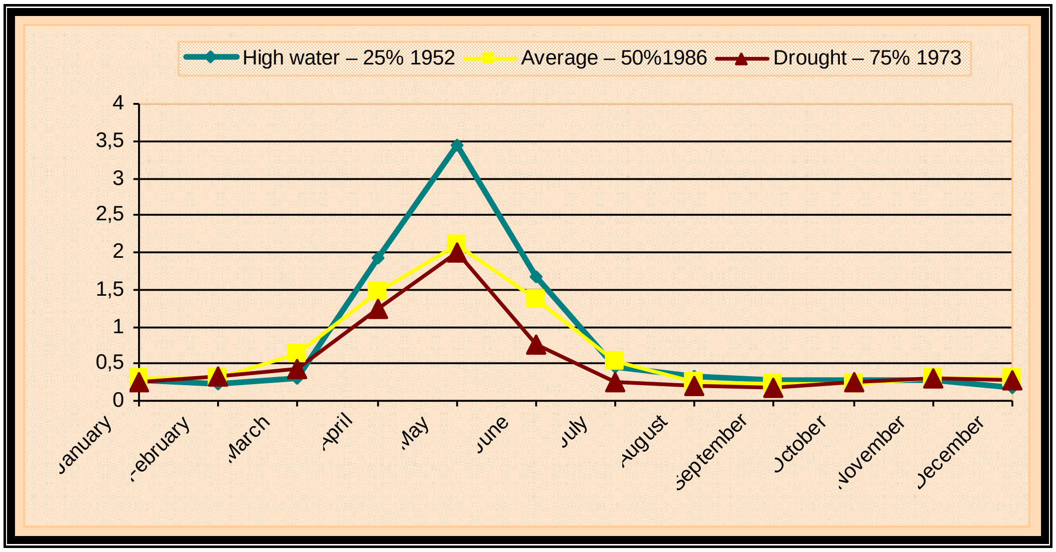
HYDROLOGY

The observation data from river Vedi-Urcadzor water-meter station is used to define the hydrological properties of Vedi SHPP headworks and the design river section. The table below shows hydrological properties of design river section necessary for the SHPP

River Section	Distance from river mouth, km	Average altitude of the catchment basin, m	Catchment area, km^2	Flow norms, m^3/sec
Vedi-design perpendicular section	5.5	2400	37.9	0.54

Graph shows annual flow distribution of Vedi SHPP for the design river section, during tree characteristic years.

Graph. 62. Annual flow distribution



Maximal design discharge for Vedi SHPP headwork river section for the general case equal 3% - 37.9m^3/sec, for verifying case - 0.5%-65.4m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.12m^3/sec.

WATER ECONOMY AND ENERGY SEKTOR

The upstream pool elevation of Vedi SHPP is 1460.0m, downstream - 1380.0m. According to data of RA State Committee for Water Economy there is no water intake starting from SHPP station works. Irrigation channels are located in the downstream of SHPPs building. Vedi SHPP is derivational SHPP. In order not to drain the river where 3150m derivational pipeline is the environmental discharge is designed according to RA laws and 0.09m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Vedi SHPP are calculated with 50% guarantee per annum (1957).

Table. 130. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Vedi SHPP (m^3/sec)	0.16	0.16	0.49	1.20	1.20	1.20	0.38	0.12	0.08	0.08	0.16	0.16	
SHPP average monthly capacity (mwt)	0.102	0.102	0.309	0.706	0.706	0.706	0.241	0.077	0.051	0.051	0.102	0.102	
SHPP –average monthly energy production (mln kwt/hour)	0.076	0.069	0.230	0.508	0.525	0.508	0.179	0.057	0.037	0.038	0.074	0.076	**2.38**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 833.5 thousand USD (without VAT) and 1000.2 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		27.5
2. Exploitation expenses		27.3
	Salary	17.3
	Renovation	7.0
	Other Expenses	3.0
Total		54.8

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		706
Average multi annual production of energy, mln kwt/hour		2.38
Capital investments into SHPPS(without VAT),		
	thousand USD	833.5
	USD / kwt	1180.5
	USD / kwt/hour	0.35
Prime cost of power production, cents/kwt hour		2.3

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

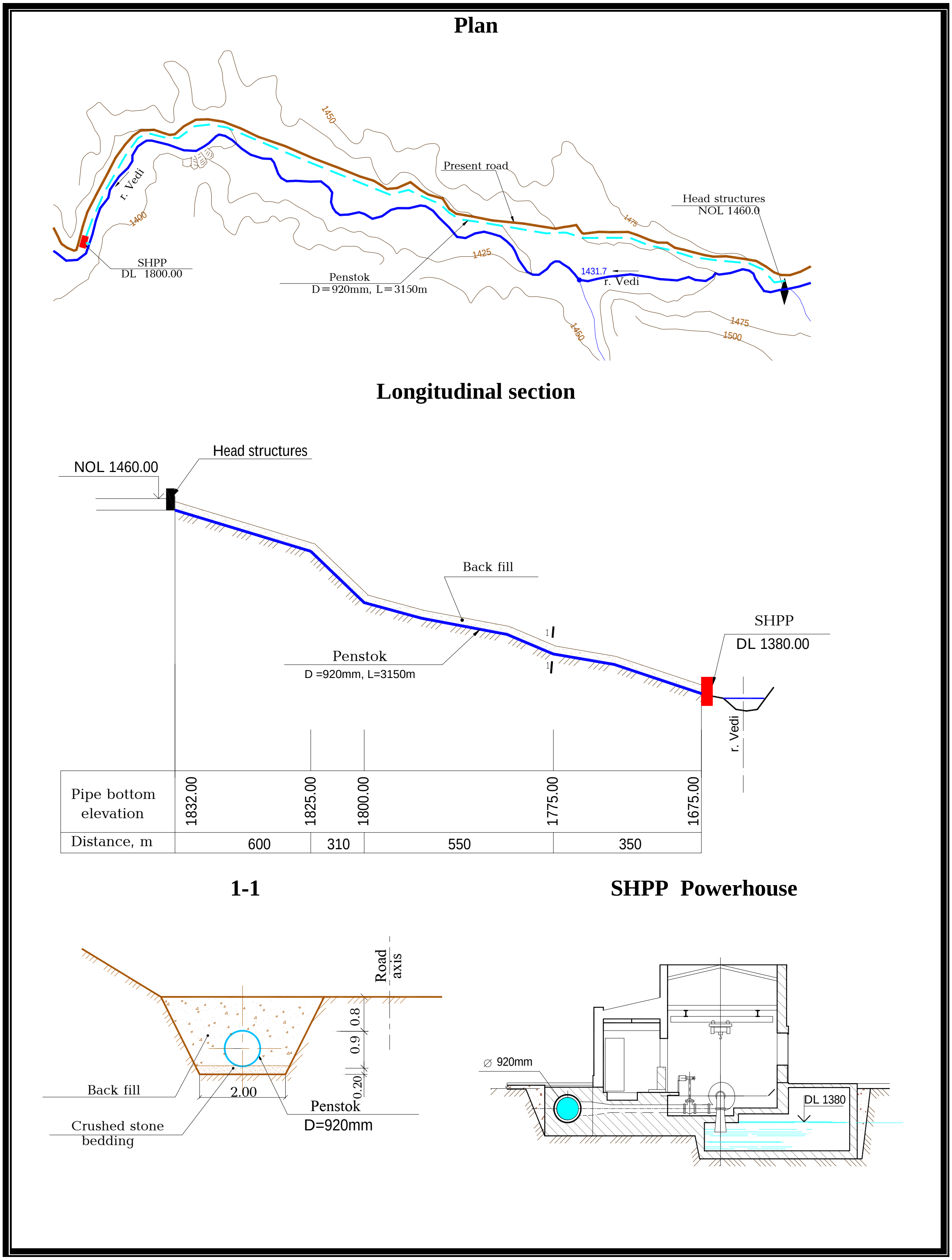
Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 131. Design results according to financial scenarios

INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		9.5	10.6
NPV, thousand USD			
	8%	125.9	125.9
	10%	-30.2	23.5
	12%	-147.1	-47.0
	14%	-236.8	-96.4
PB, years (without discount)		9.8	13.6
Deadline for credit return, years			11.0

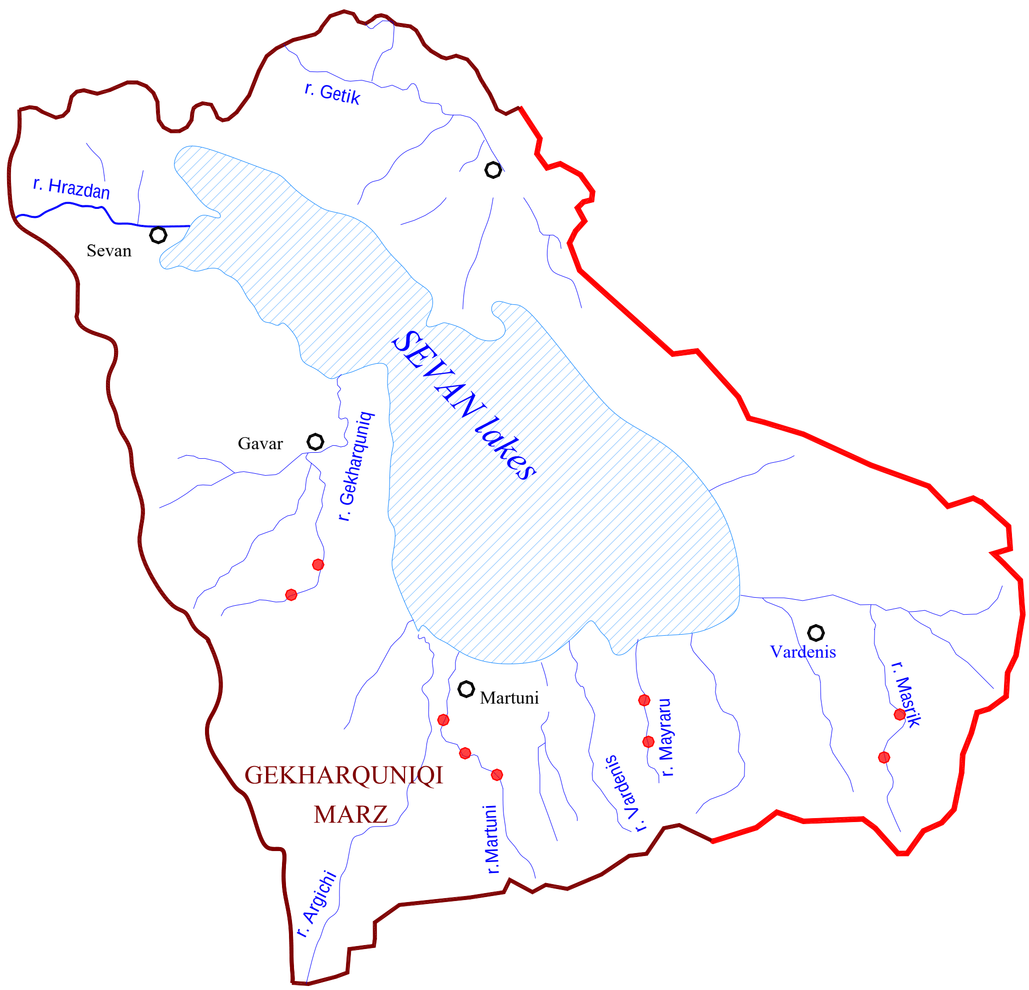
APPENDIX 59. VEDI SHPP



PART 15.7. GEGHARKUNIK MARZ

LAKE SEVAN BASIN

VERIFIED AND UPDATED SCHEME FOR SHPPs



15.7.1. GENERAL INFORMATION

Sevan Basin development scheme contemplates 20 SHES, presently only Argichi and Vardenis SHES have the permission for construction, while technical substantiation design has been carried out for Baidana (Karchakhbyur) SHES.

Local investigations specified properties of not yet appropriated Masrik, Martuni, Gegarkunik, Mairaru SHES-s. Construction of three new SHPPs on River Martuni is being considered.

15.7.2.BRIEF DESCRIPTION OF SEVAN BASIN RIVERS AND CLIMATE CONDITIONS

Lake Sevan basin is located in the north-east of RA. It is represented by large tectonic concavity that has a triangle shape. This concavity is surrounded by Gaghama Mountains from the west, Vardenis Mountains from the south and Areguni and Sevana mountain chains from north-east and east.

The elevation above the sea level of mountains chains surrounding Sevan concavity varies from 500 m to 1800m. Gehgama Mountain volcanic massive is located along meridian and divides Sevan concavity from Ararat Valley.

Total area of Lake Sevan basin is 4890km^2, overall length of water-distributive line of the basin equals approximately 400km. Pambak mountain chain serves as Sevan Lake water-distributive line from north, while Aregun and Sevan mountain chains - with the highest peak 3289.6m - divide the lake from north-west and west, Geghama mountain chain –from the east, Vardenis mountain chain from the south with the highest peak 3454.0m.

Rivers of Sevan basin are characterized as typical mountain rivers. The basin relief is extremely complicated. Water collecting basins of the rivers are strictly divided by mountain-branches, multiple small rivers and canyons which were formed as a result of heavy rains followed by mud-flows.

Basin vegetation is diverse no forest vegetation except for artificial forests of in the nearby of the lake. In the upper sections of the basin there are grain fields and grass fields and parries, closer to the center of the basin there are complex alpine meadows.
Earth cover of the basin and also diverse: in the upper flows it is represented by sub-alpine and brown soil typical for mountain-meadows. In the center of the basin closer to the lake shore exposed soils can be found, in the slightly upper section, mountain- brown and dark prairie soils can be found. Rivers of Sevan basin are used for irrigation and other agricultural purposes.
As for the climate, the site is considered as rigorous all year round. River basin crosses 2 climatic zones.

- Continental zone - warm, long summer and cold winter
- Continental zone – cool and short summer and cold winter.

To describe climate condition the multi-annual data is used, see table 1.

№№ пп	Station	Elevation,m	Observation Period	Number of years under observation
1.	Martuni	1945	1926-in exploitation	81
2.	Yanikh	2334	1929-in exploitation	78

According to Martuni and Yanikh meteorological stations average year temperature varies from 2.7°C to 5.6°C, absolute minimum is (-31)-(-32)°C, absolute maximum (+37)- (+37)°C, maximal depth of soil freezing is 95-105cm.

Precipitations are in direct relation from the particular elevation and slope exposition. Volume of average multi-year precipitations in Martuni is 501 mm, Yanikh - 511mm. Maximal annual precipitation equals 607mm in Martuni and 726mm in Yanikh, maximal quantity of monthly precipitation in Martuni equals 169 mm, Yanikh 176mm while daily volume is 59 mm in Martuni and 49mm – Yanikh respectively. Maximal height of ten-day-snow-cover is 75-105cm.

Absolute air moisture content is 6.0-7.0mb, relative moisture content is 67-72%:

Average wind speed equals 3.2-3.8m/sec. 5% safety line of wind speed equals 25m/sec in Martuni, 29m/sec in Yanikh.

15.7.1.2. GEOLOGICAL COMPOSITION OF LAKE SEVN BASIN

Lake Sevan basin is of complex geologic composition. Its northern part consists of andesite basalt lavas, southern part – sedimentary rock types, mainly limestone. The middle section of the basin consists of thick alluvial sediments.

From geological point of view the basin can be divided into two main sections: north-eastern and south-western. North-east part is composed of Mesozoic and Early Quaternary sedimentary rocks, while south-western section consists of andesite rock types covered by layer of andesite-basalt lava.

From geological point of view Masrik river basin is composed of Quaternary alluvial sediments represented by sand-clay soils. Large layers of the abovementioned soils are covered by contemporary talus compositions that are 3-5m thick.

Gegharkunik River basin is composed of volcanic rock types dating back to Upper Moicen Era, including: andesite basalts, andesites, andesite-dacites, liparites, obsidians, perlites and their fragments. Surface weathered rocks situated at the foothills of most of the slopes that are extremely water-permeable

Water meter station	Distance from the river mouth, km	Average elevation of reservoir, m.	Catchment area, km^2	Exploitation timeline		Exploitation timeline	Normal Flow, m^3/sec
				started	started		
Gegharkunic - Sarukhan	23	2520	48,0	1961	1987	2016.90	0.34
Masrik-Tsovak	0.9	2310	685	1966	2006	1909.44	4.30
Masrik-Torf	5.0	2330	473	1953	1966	1911.52	4.16
Martuni-Geghhovit	7.2	2640	84.5	1955	2006	2049.29	1.84
Artsvanist-Artsvanist	0.5	2540	79.8	1950	1987	1913.86	0.67

Volcanic sedimentary rock types represent River Martuni Basin including vitric tuffs, limestones, marls, sand stones, conglomerates as well as ultramarine intrusive rock types: predotites, pyroxenites, dunites, serpentinite etc. These are rock types of average firmness, and low water permeability.

The ravine slopes with moderate inclination are occasionally covered by covered by talus sediments. Alluvial sediments are not well formed.

15.7.1.3. WATER REGIME AND DESIGN DATA OF LAKE SEVN BASIN

Water regime of Lake Sevan Basin Rivers is of typical mountainous nature which as a consequence results in high elevation and complicated relief. The regime is characterized by spring floods caused by melting snow and rains, which last from May till August due to the feeding from Vardenis and Sevan high mountainous glaciers. The flood peak is usually in June; however there may be a sudden, short term peak in May.

Lake Sevan river basin discharge systemic observations were carried out from the following observation points (see table 2). The above mentioned data rows are used to obtain average water flow and its annual distribution by restoring natural flow. Artsvanist-Artsvanist observation point was used as a model for Mairaru River.

Years	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	average
r. Gegharkunik-Sarukhan													
Abundant – 25%													
1966y.	0.077	0.083	0.27	1.14	2.32	0.54	0.46	0.34	0.055	0.08	0.07	0.088	0.46
Average – 50%													
1981y.	0.13	0.12	0.12	0.36	0.88	1.48	0.52	0.14	0.12	0.13	0.13	0.14	0.36
Daught– 75%													
2004y.	0.091	0.074	0.11	0.16	0.62	0.95	0.39	0.13	0.107	0.103	0.093	0.078	0.24
r.Masrik-Tsovak													
Abundant – 25%													
1990y.	2.25	2.47	2.35	7.79	11.3	6.89	5.12	2.99	3.09	3.51	3.15	3.78	4.56
Average – 50%													
1991y.	3.08	3.31	3.33	6.01	7.30	6.88	4.92	2.80	2.74	3.07	3.26	3.47	4.18
Daught– 75%													
1987y.	1.97	2.19	2.18	6.12	9.34	6.64	4.24	2.46	2.40	2.60	2.44	2.76	3.78
r. Martuni-Geghhovit													
Abundant – 25%													
1982y.	0.62	0.66	1.10	2.76	4.73	6.97	2.54	0.87	0.70	0.80	0.74	0.73	1.93
Average – 50%													
1967y.	0.73	0.72	0.58	0.84	4.54	5.67	3.81	1.72	1.05	0.83	0.83	0.68	1.83
Daught– 75%													
1998y.	0.96	0.99	1.17	3.08	4.56	2.91	1.02	0.71	0.62	0.62	0.66	0.63	1.49
r. Artsvanist-Artsvanist													
Abundant – 25%													
1992y.	0.22	0.41	0.38	0.51	1.72	3.96	1.15	0.21	0.18	0.19	0.21	0.18	0.78
Average – 50%													
1991y.	0.23	0.32	0.26	0.92	1.88	1.89	0.76	0.25	0.19	0.19	0.29	0.27	0.62
Daught– 75%													
1972y.	0.11	0.11	0.14	0.60	0.88	1.25	0.82	0.48	0.09	0.13	0.11	0.16	0.41

15.7.2. TECHNICAL ECONOMIC SPECIFICATION OF SHPPS TO BE CONSTRUCTED ON LAKE SEVAN BASIN

15.7.2.1. MASRIK SHPP-1

INTRODUCTION

Masric SHPP-1 to be located in the north-west of the country on river Masric. Masric SHPP-1 uses inclination of River Masric from 2165.0 till 2090.0. The length of derivation from Masrik River us 2500m by copper pipeline 920mm in diameter with design pressure of 59.6m and design discharge 1.10m^3/sec.After construction and exploitation SHPP Masrik-1 will have 0.595mwt capacity and will produce 3.28mln kw/h electricity annually.

SHORT DESCRIPTION OF MASRIK RIVER BASIN

River Masrik is one of the rivers discharging into Lake Sevan. Length of the river is 30km general catchment area is 793km^2, average inclination equals 198‰, average elevation of the basin is 2310m.

The river starts from western peaks of Zangezur mountain plateau on the elevation of 3427.0m. River basin is located in the north-east of the country.

River Masric is a typical mountainous river. Relief has a complicated relief divided by multiple small inflow canyons. Geographic composition of the basin is also complicated, the whole northern part is composed of andesite basalt lavas while southern part – from sedimentary rock types, mainly limestone. There are alluvial sediments in the middle section of the river basin.

The vegetative layer of the basin is highly diverse, even though there is no forest except for the artificial forest in the nearby of the river. In the upper sections of the basin there are grain crops and lands covered by grass, prairies and alpine meadows further on.

The earth cover of the basin is diverse: in the upstream it is represented by sub alpine high land meadows with natural dark brown soils; in the downstream, shoreline of Lake Sevan, occasionally washed out natural lands can be observed, brown and dry prairie lands are in the upper section.

The upstream section of the river bed is relatively straight further on it occasionally twists but does not split while in the in the middle section river bed splits into several branches which join back before the river discharges into Lake Sevan.

HYDROLOGY

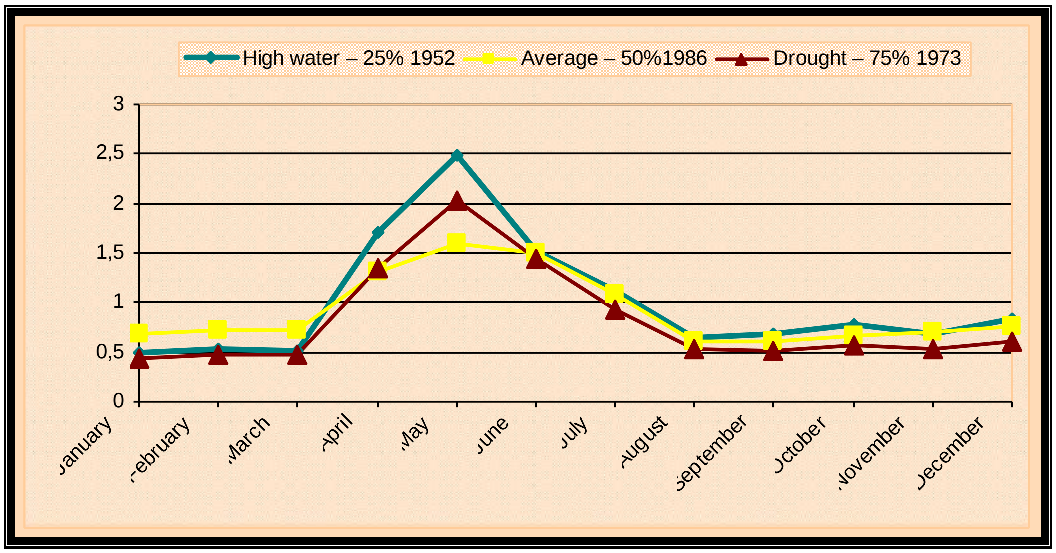
The 54 year long observation data from river Masrik-Tsovak water-meter station is used to define the hydrological properties of Masrik-1 SHPP headworks and the design river section.

The table below shows hydrological properties of design river section necessary for the SHPP.

River Section	Distance from river mouth, km	Average altitude of the catchment basin, m.	Catchment area, km^2	Flow norms, m^3/sec
R. Masrik-design perpendicular section - 1	25.9	2680	113.5	0.91

Graph shows annual flow distribution of Masrik SHPP-1 for the design river section, during tree characteristic years.

Graph. 63. Annual flow distribution



Maximal design discharge for Masrik SHPP-1 headwork river section for the general case equal 3% - 9.86m^3/sec, for verifying case - 0.5%-:13.7m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.19m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Masrik SHPP-1 is 2165.0m, downstream - 2090.0m.

According to “Vardenis” WUC data the water take value, carried out up to SHPP station works section from irrigation channel of Airk inflow, equals 2.42mln, m^3 annually.

Masrik SHPP-1 is derivational SHPP. In order not to drain the river where 2500m derivational pipeline is the environmental discharge is designed according to RA laws and $0.14m^3$/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes.

Hydro-power properties of Masrik SHPP-1 are calculated with 50% guarantee per annum (1991).

Table. 132. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Masrik SHPP-1 (m^3/sec)	0.54	0.58	0.59	1.10	1.10	1.10	0.61	0.14	0.46	0.54	0.57	0.62	
SHPP average monthly capacity (mwt)	0.313	0.338	0.343	0.595	0.595	0.595	0.355	0.085	0.273	0.313	0.333	0.358	
SHPP –average monthly energy production (mln kwt/hour)	0.23	0.23	0.26	0.43	0.44	0.43	0.26	0.06	0.20	0.23	0.24	0.27	**3.28**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 625.7 thousand USD (without VAT) and 750.8 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	20.6
2. Exploitation expenses	22.4
Salary	14.4
Renovation	5.0
Other Expenses	3.0
Total	43.0

Power indicators of have the following level

Indicators	Values
Derivation capacity, kwt	595
Average multi annual production of energy, mln kwt/hour	3.277
Capital investments into SHPPS(without VAT),	
thousand USD	625.7
USD / kwt	1051.8
USD / kwt/hour	0.19
Prime cost of power production, cents/kwt hour	1.3

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:
- ❖ Private investments only /Scenario 1/
- ❖ 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

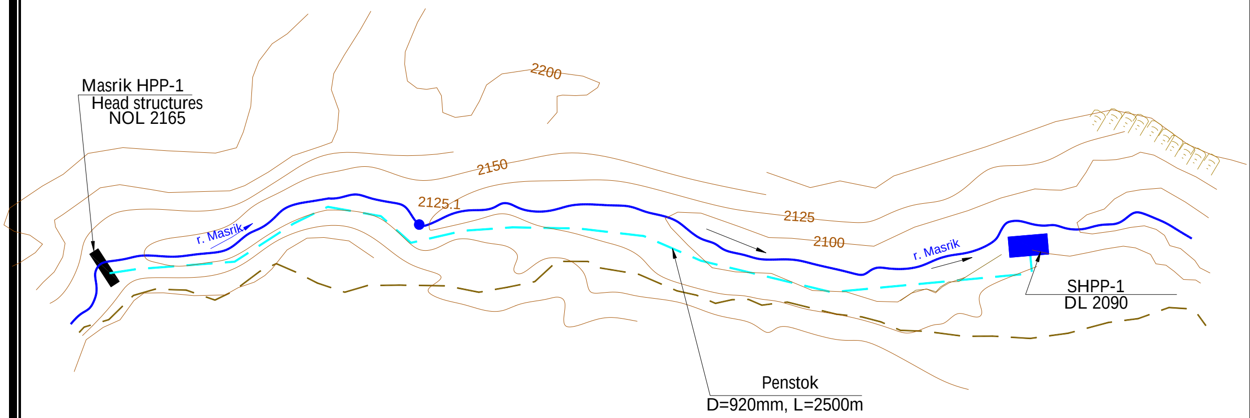
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 133. Design results according to financial scenarios

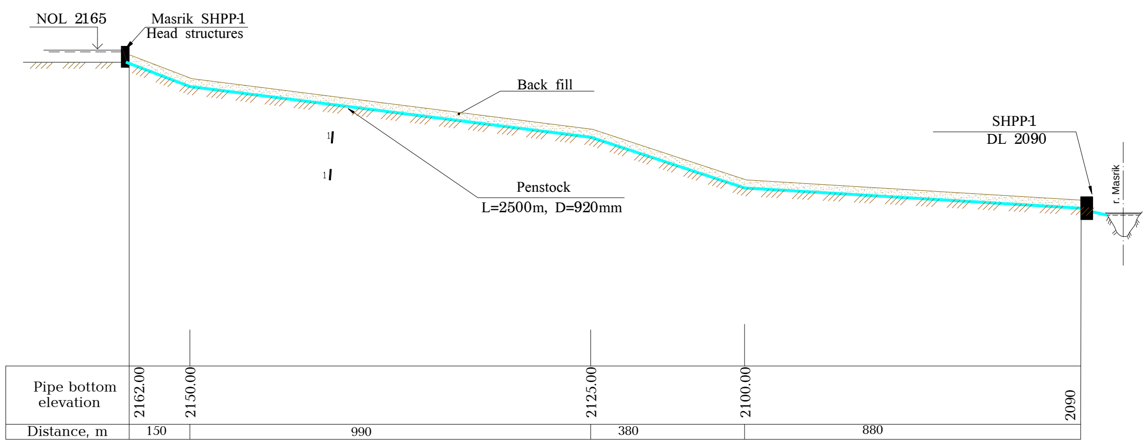
INDICATORS		**Scenario 1** 100% fully self - financed option	**Scenario 2** 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		20.6	26.3
NPV, thousand USD			
	8%	833.2	833.2
	10%	595.9	614.9
	12%	418.1	454.7
	14%	281.7	334.8
PB, years (without discount)		4.8	5.5
Deadline for credit return, years			4.0

APPENDIX 60. MASRIK SHPP-1

Plan



Longitudinal section



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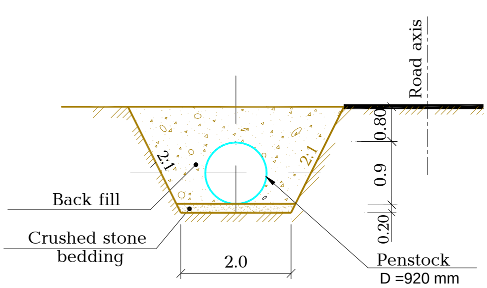
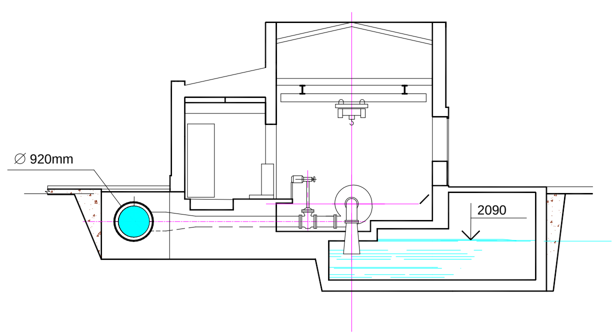


SHPP Powerhouse



MASRIK SHPP-2

INTRODUCTION

Masrik SHPP-2 is to be located in the north-east of the country, on the river Masrik. The SHPP uses the inclination of Masrik River from the elevation 2085.0 up to 2015.0.

The derivation length is 3300m, the diameter of steel pipeline equals 920mm, design pressure is 58.4m, design discharge equals 1.20m^3/sec.

Masrik SHPP-2 will have 0.560mvt capacity after then end of construction and putting into exploitation and produce annually 3.082mln. kwt/hour power.

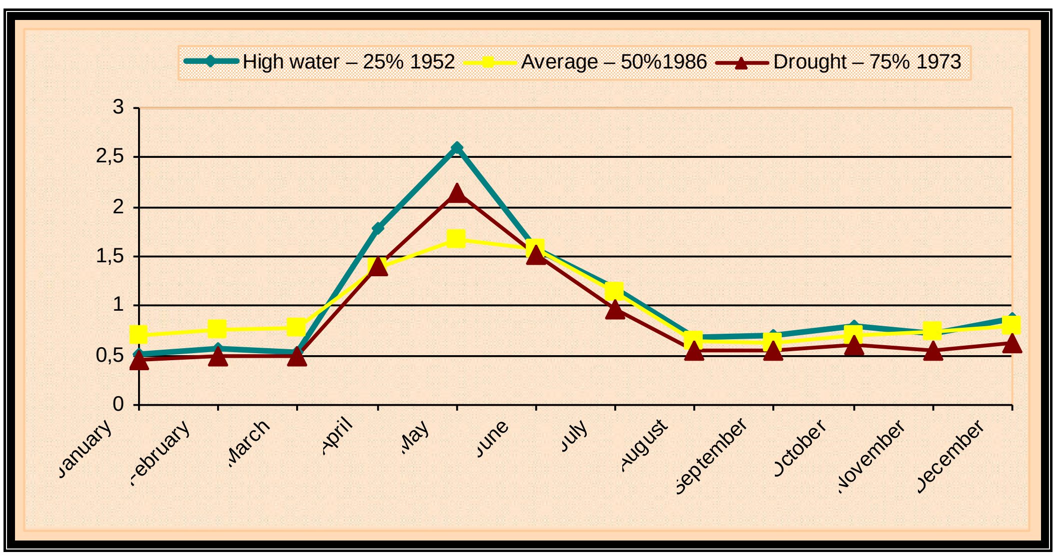
HYDROLOGY

The 54 year long observation data from river Masrik-Tsovak water-meter station is used to define the hydrological properties of Masrik SHPP-2 headworks and the design river section.
The table below shows hydrological properties of design river section necessary for the SHPP.

River Section	Distance from river mouth, km	Average altitude of the catchment basin, m.	Catchment area, km^2	Flow norms, m^3/sec
R. Masrik-design perpendicular section - 2	23.1	2660	120.4	0.95

Graph shows annual flow distribution of Masrik SHPP-2 for the design river section, during tree characteristic years.

Graph. 64. Annual flow distribution



Maximal design discharge for Masrik SHPP-2 headwork river section for the general case equal 3%-10.1m^3/sec, for verifying case - 0.5%-14.0m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.21m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Masrik-2 SHPP is 2085.0m, downstream - 2015.0m.

According to “Vardenis” WUC data, the water take value, carried out up to SHPP station works section from irrigation channel of Airk inflow, equals 2.42mln.m^3 annually.

Masrik SHPP-2 is derivational SHPP. In order not to drain the river where 3300m derivational pipeline is the environmental discharge is designed according to RA laws and 0.14m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes.

Hydro-power properties of Masrik SHPP-2 are calculated with 50% guarantee per annum (1991).

Table. 134. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Masrik SHPP-2 (m^3/sec)	0.54	0.60	0.61	1.20	1.20	1.16	0.64	0.15	0.47	0.54	0.59	0.63	
SHPP average monthly capacity (mwt)	0.29	0.32	0.32	.56	0.560	0.55	0.34	0.08	0.26	0.29	0.32	0.34	
SHPP –average monthly energy production (mln kwt/hour)	0.22	0.21	0.24	0.40	0.42	0.39	0.25	0.06	0.18	0.22	0.23	0.25	**3.082**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 634.8 thousand USD (without VAT) and 761.8 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	20.9
2. Exploitation expenses	22.5
Salary	14.4
Renovation	5.1
Other Expenses	3.0
Total	43.4

Power indicators of have the following level

Indicators	Values
Derivation capacity, kwt	560
Average multi annual production of energy, mln kwt/hour	3.082
Capital investments into SHPPS(without VAT),	
thousand USD	634.8
USD / kwt	1133.5
USD / kwt/hour	0.206
Prime cost of power production, cents/kwt hour	1.4

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

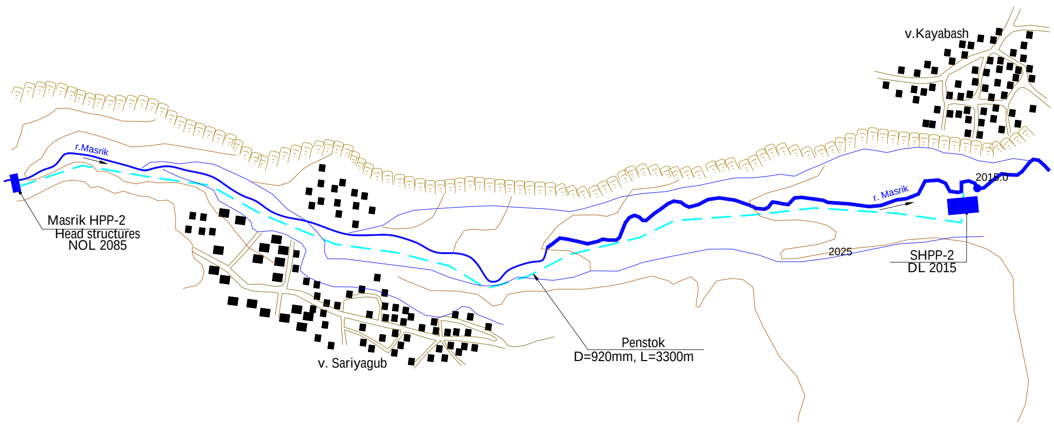
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 135. Design results according to financial scenarios

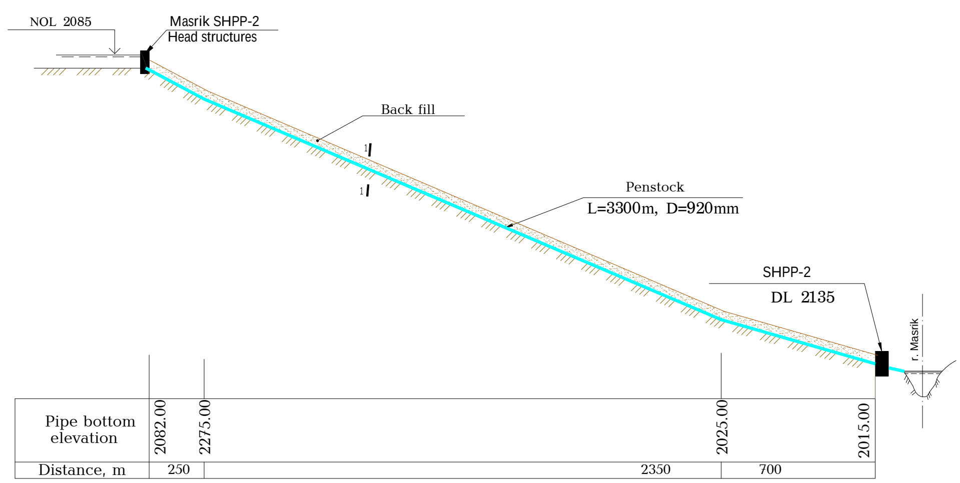
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		18.4	23.7
NPV, thousand USD			
	8%	692.4	692.4
	10%	476.5	499.2
	12%	314.8	358.4
	14%	190.7	253.4
PB, years (without discount)		5.4	6.4
Deadline for credit return, years			5.0

APPENDIX. 61. MASRIK SHPP-2

Plan



Longitudinal section



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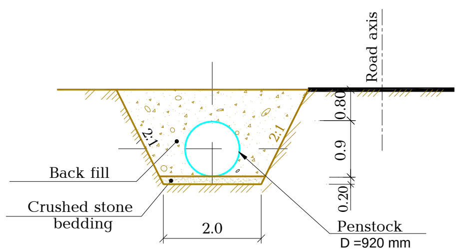
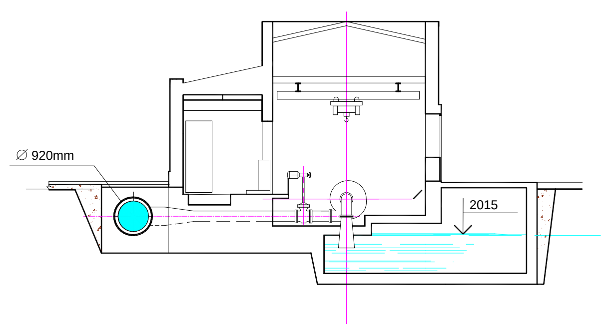


SHPP Powerhouse



15.7.2.2. MARTUNI SHPP-1

ITRODUCTION

Martuni SHPP-1 is to be located in the north-east of the country, on the river Martuni. The SHPP uses the inclination of Martuni River from the elevation 2600.0 up to 2375.0 mark. The derivation length is 4250.0m, the diameter of steel pipeline equals 820mm, design pressure is 205.7m, design discharge equals 1.00m^3/sec. Martuni SHPP-1 will have 1.646 MW productive capacity after the end of construction and putting into exploitation with annual power output of 6.07mln. kW/hour.

SHORT DESCRIPTION OF MARTUNI RIVER BASIN

River Martuni is one of the few rivers discharging into Lake Sevan. Length of the river is 27km, overall catchment area is 98.0km^2, average inclination equals 55.1‰, and average elevation of the basin is 2626m. The river starts from southern peaks of Vardenis mountain plateau, the highest peak is “Vardenis” 3522m. River basin is located in the north-east of the country. Martuni river basin borders with Argichi river from the east, Astghadzor river from west and Elegis river from south. River Masric is a typical mountainous river. It has a complicated relief divided by multiple small canyons formed by river inflows.

Geographic composition of the basin is also complicated, thus, the upstream part is composed of andesite basalt lavas while downstream – from sedimentary rock types, mainly limestone. There are alluvial sediments in the middle section of the river basin.

The vegetative layer of the basin is highly diverse, even in the absence of forests. In the upper sections of the basin there are grain crops and lands covered by grass, prairies and alpine meadows further on.

The earth cover of the basin is also diverse: in the upstream it is represented by sub alpine, high land meadows with natural dark brown soils; in the downstream, shoreline of Lake Sevan, occasionally washed out natural lands can be observed and dry prairie lands - in the upper section.

The upstream section of the river bed is relatively straight, it occasionally twists further on but does not split, while in the in the middle section, the river bed splits into several branches which join back before the river discharges into Lake Sevan.

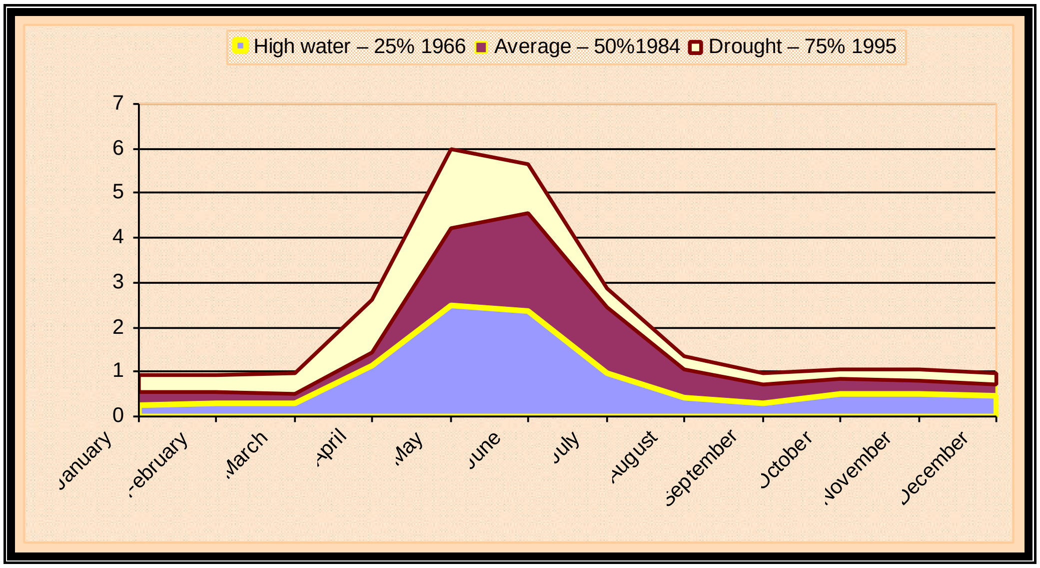
HYDROLOGY

The 52 year long observation data from Martuni-Geghahovit river water-meter station is used to define the hydrological properties of Martuni SHPP-1 headworks and the design river section. The table below shows hydrological properties of design river section necessary for the SHPP.

River Section	Distance from river mouth, km	Average altitude of the catchment basin, m.	Catchment area, km^2	Flow norms, m^3/sec
R. Martuni-design perpendicular section - 1	19.1	2870	28.3	0.71

Graph shows annual flow distribution of Martuni SHPP-1 for the design river section, during tree characteristic years.

Graph. 65. Annual flow distribution



Maximal design discharge for Martuni-1 SHPP headworks river section for the general case equals 3% - 22.1m^3/sec, for verifying case - 0.5%-35.5m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.074m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Martuni-1 SHPP is 2600.0m, downstream – 2375.0m. According to “Martuni” WUC data, the average annual water intake value, carried out up to SHPP station works from the irrigation channel of Martuni river upstream flows, equals 4.36mln.m^3.

Martuni-1 SHPP is derivational SHPP. In order not to drain the river, where 4250m derivational pipeline is, the environmental discharge is designed according to RA laws and equals 0.06m^3/sec. All natural flow including irrigational demands and environmental flow values can be used for energy purposes.

Hydro-power properties of Martuni-1 SHPP are calculated with 50% guarantee per annum (1967).

Table. 136. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Martuni SHPP-1 (m^3/sec)	0.22	0.22	0.16	0.26	1.00	1.00	1.00	0.15	0.14	0.26	0.26	0.20	
SHPP average monthly capacity (mwt)	0.39	0.39	0.29	0.47	1.646	1.65	1.65	0.27	0.25	0.47	0.47	0.36	
SHPP –average monthly energy production (mln kwt/hour)	0.29	0.26	0.21	0.33	1.22	1.18	1.22	0.20	0.18	0.35	0.33	0.27	**6.07**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 1506.7thousand USD (without VAT) and 1808.0 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		49.7
2. Exploitation expenses		36.2
	Salary	20.2
	Renovation	12.0
	Other Expenses	4.0
Total		85.9

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		1646
Average multi annual production of energy, mln kwt/hour		6.07
Capital investments into SHPPS(without VAT),		
	thousand USD	1506.7
	USD / kwt	915.3
	USD / kwt/hour	0.248
Prime cost of power production, cents/kwt hour		1.42

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

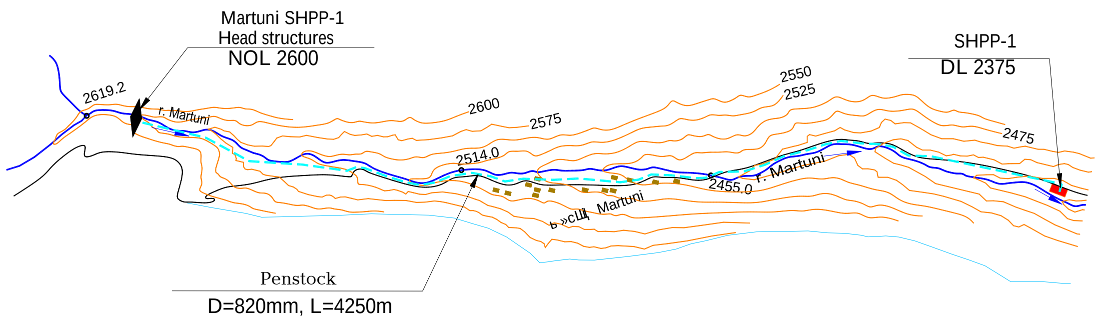
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 137. Design results according to financial scenarios

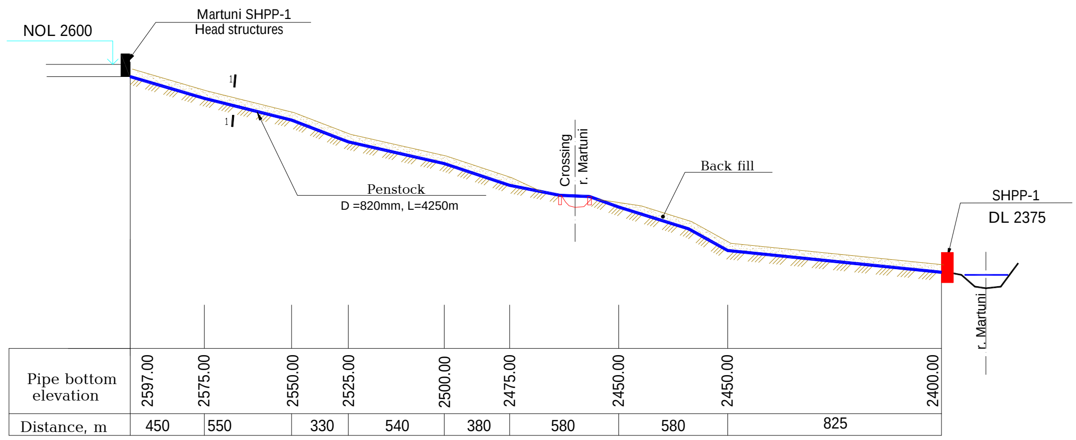
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		15.7	19.7
NPV, thousand USD			
	8%	1198.5	1198.5
	10%	758.4	820.2
	12%	428.7	546.8
	14%	175.8	345.2
PB, years (without discount)		6.3	7.6
Deadline for credit return, years			6.0

APPENDIX 62. MARTUNI SHPP-1

Plan



Longitudinal section



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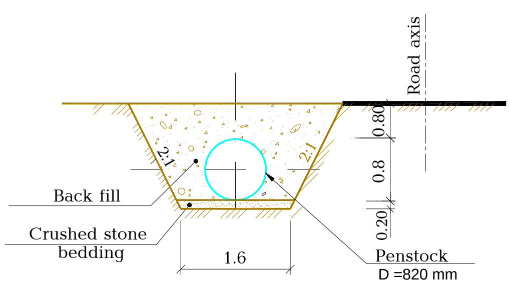
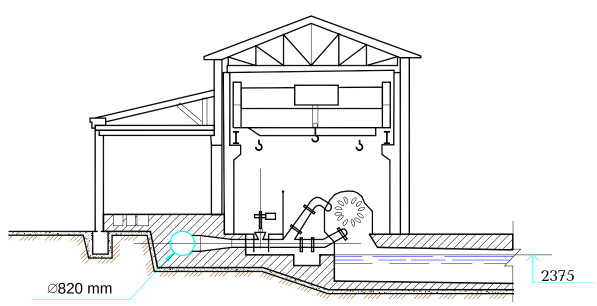


SHPP Powerhouse



MARTUNI SHPP - 2

INTRODUCTION

Martuni SHPP-2 is to be located in the north-east of the country, on the river Martuni. The SHPP uses the inclination of Martuni river from the elevation 2375.0 up to 2190 mark. The derivation length is 4400.0m, the diameter of steel pipeline equals 920mm, design pressure is 164.5m, design discharge equals 1.20m^3/sec. Martuni SHPP-2 will have 1.579 MW productive capacity after the end of construction and putting into exploitation with annual power output of 5.07mln. kW/hour.

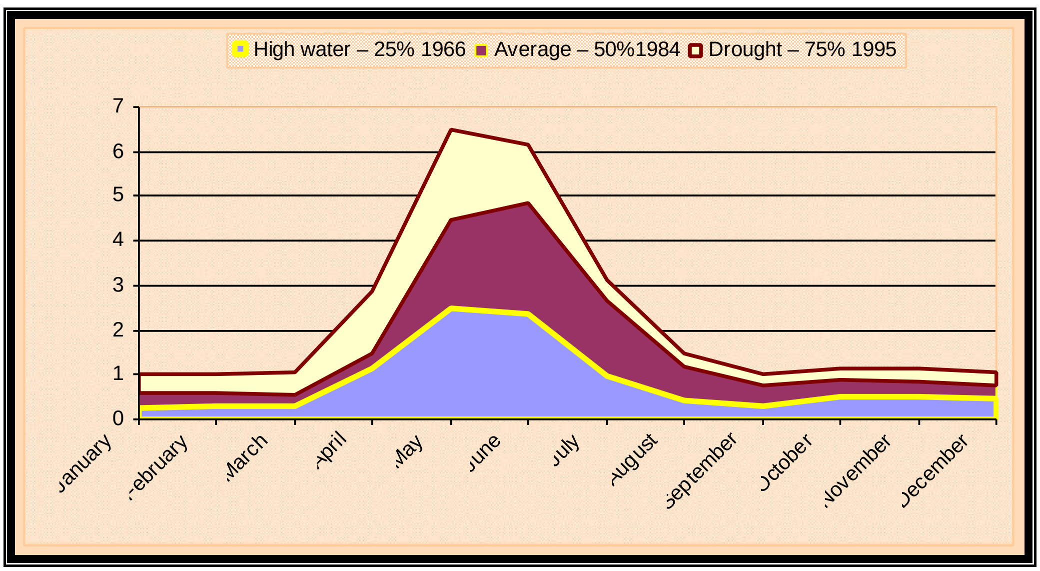
HYDROLOGY

The 52 year long observation data from Martuni-Geghahovit river water-meter station is used to define the hydrological properties of Martuni SHPP-2 headworks and the design river section. The table below shows hydrological properties of design river section necessary for the SHPP

River Section	Distance from river mouth, km	Average altitude of the catchment basin, m.	Catchment area, km^2	Flow norms, m^3/sec
R. Martuni-design perpendicular section - 2	16.9	2850	34.1	0.81

Graph shows annual flow distribution of MartuniSHPP-2 for the design river section, during tree characteristic years.

Graph. 66. Annual flow distribution



Maximal design discharge for Martuni SHPP-2 headworks river section for the general case equals 3%-23.8m^3/sec, for verifying case - 0.5%-38.3m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.089m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of MartuniSHPP-2 is 2370.0m, downstream – 2190.0m.

According to "Martuni" WUC data, the average annual water intake value, carried out up to SHPP-1 station works from the irrigation channel of Martuni river upstream flows, equals 4.36mln,m^3.

Martuni SHPP-2 is derivational SHPP. In order not to drain the river, where 4400m derivational pipeline is, the environmental discharge is designed according to RA laws and equals 0.07m^3/sec. All natural flow including irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Martuni SHPP-2 are calculated with 50% guarantee per annum (1967).

Table. 138. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Martuni SHPP-2 (m^3/sec)	0.24	0.24	0.17	0.29	1.20	1.20	1.20	0.23	0.17	0.28	0.28	0.22	
SHPP average monthly capacity (mwt)	0.34	0.34	0.24	0.42	1.579	1.58	1.58	0.33	0.24	0.40	0.40	0.32	
SHPP –average monthly energy production (mln kwt/hour)	0.26	0.23	0.18	0.30	1.17	1.14	1.17	0.25	0.17	0.30	0.29	0.23	**5.70**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 1576.6 thousand USD (without VAT) and 1891.8 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	52.0
2. Exploitation expenses	36.8
Salary	20.2
Renovation	12.6
Other Expenses	4.0
Total	88.8

Power indicators of have the following level

Indicators	Values
Derivation capacity, kwt	1579
Average multi annual production of energy, mln kwt/hour	5.7
Capital investments into SHPPS(without VAT),	
thousand USD	1576.5
USD / kwt	998.4
USD / kwt/hour	0.277
Prime cost of power production, cents/kwt hour	1.56

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- ❖ Private investments only /Scenario 1/

- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

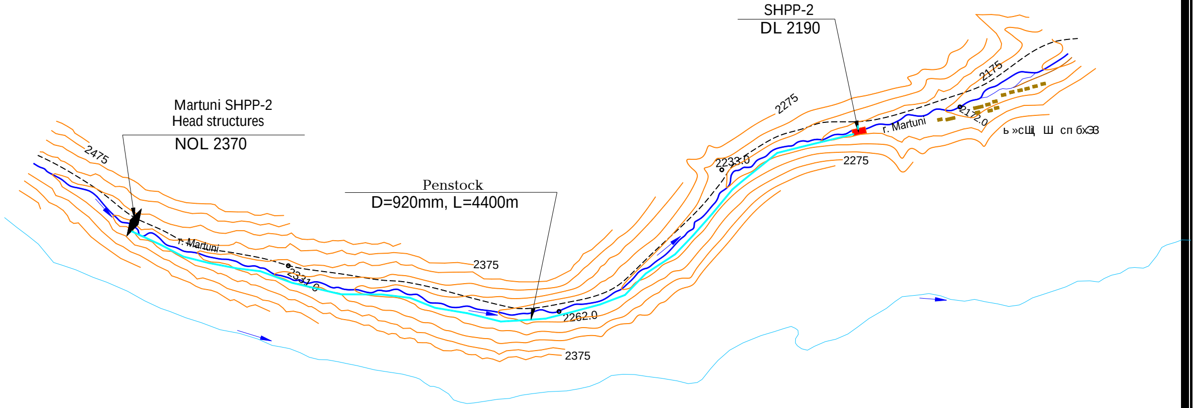
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 139. Design results according to financial scenarios

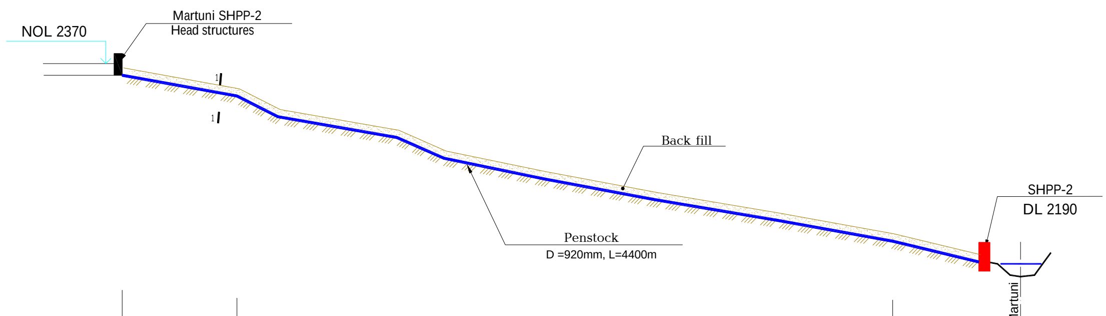
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		13.9	17.1
NPV, thousand USD			
	8%	948.7	948.7
	10%	537.9	610.6
	12%	230.2	368.3
	14%	-6.0	191.3
PB, years (without discount)		7.0	8.8
Deadline for credit return, years			7.0

APPENDIX. 63. MARTUNI SHPP-2

Plan

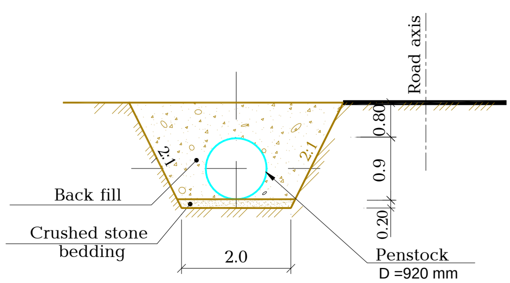


Longitudinal section

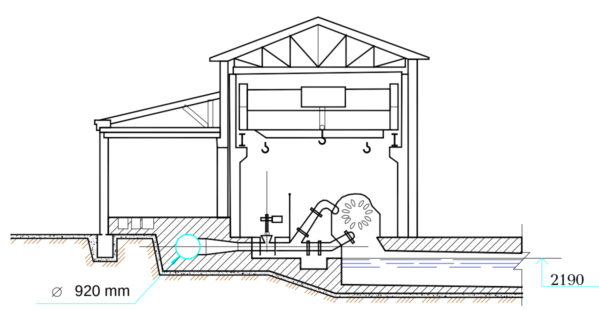


Pipe bottom elevation	2397.00	2375.00	2200.00	2175.00
Distance, m	700	2900	550	

1-1



SHPP Powerhouse



MARTUNI-3 SHPP

INTRODUCDUCTION

Martuni SHPP-3 is to be located in the north-east of the country, on the river Martuni. The SHPP uses the inclination of Martuni river from the elevation 2187.0 up to 2113.0 mark. The derivation length is 2500m, the diameter of steel pipeline equals 1020mm, design pressure is 67.7m, design discharge equals 1.40m^3/sec. MartuniSHPP-3 will have 0.758 MW productive capacity after the end of construction and putting into exploitation with annual power output of 2.29mln. kW/hour.

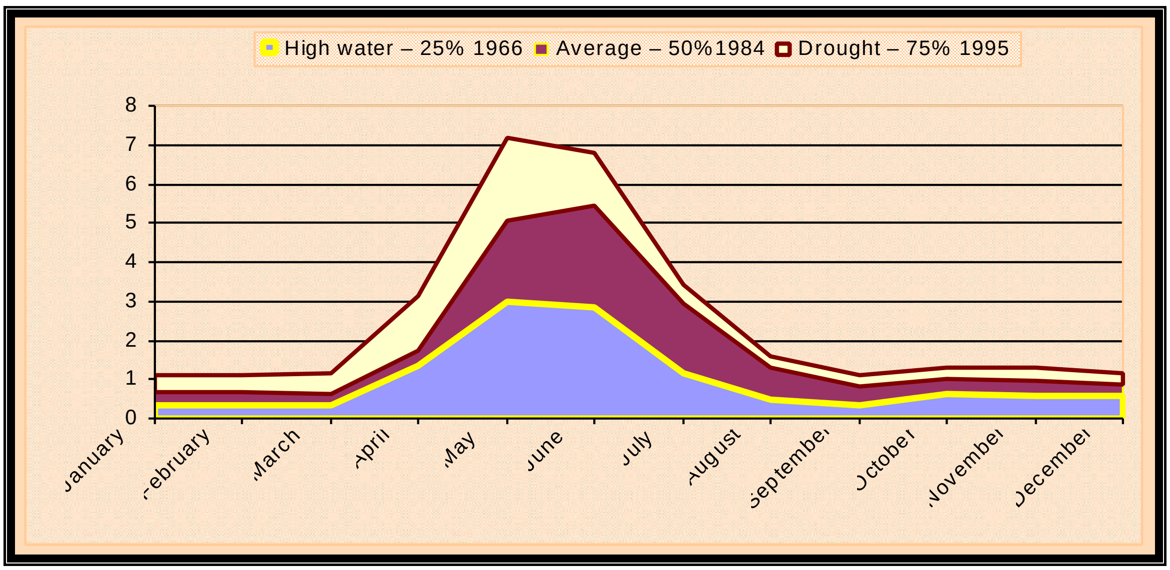
HYDROLOGY

The 52 year long observation data from Martuni-Geghahovit river water-meter station is used to define the hydrological properties of Martuni SHPP-3 headworks and the design river section. The table below shows hydrological properties of design river section necessary for the SHPP.

River Section	Distance from river mouth, km	Average altitude of the catchment basin, m.	Catchment area, km^2	Flow norms, m^3/sec
R. Martuni-design perpendicular section - 3	11.9	2800	37.9	0.85

Graph shows annual flow distribution of Martuni SHPP-3 for the design river section, during tree characteristic years.

Graph. 67. Annual flow distribution



Maximal design discharge for Martuni SHPP-3 headworks river section for the general case equals 3% - 24.9m^3/sec, for verifying case - 0.5%-39.9m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.101m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Martuni SHPP-3 is 2187.0m, downstream – 2113.0m.

According to “Martuni” WUC data, the average annual water intake value, carried out up to SHPP station works from the irrigation channel of Martuni river upstream flows, equals 8.73mln,m^3.

Martuni SHPP-3 is derivational SHPP. In order not to drain the river, where 2500m derivational pipeline is, the environmental discharge is designed according to RA laws and equals 0.0075m^3/sec. All natural flow including irrigational demands and environmental flow values can be used for energy purposes.

Hydro-power properties of Martuni SHPP-3 are calculated with 50% guarantee per annum (1967).

Table. 140. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Martuni SHPP-3 (m^3/sec)	0.27	0.26	0.20	0.32	1.40	1.40	0.88	0.00	0.00	0.31	0.31	0.24	
SHPP average monthly capacity (mwt)	0.16	0.15	0.12	0.19	0.758	0.76	0.50	0.00	0.00	0.18	0.18	0.14	
SHPP –average monthly energy production (mln kwt/hour)	0.12	0.10	0.09	0.13	0.56	0.55	0.37	0.00	0.00	0.13	0.13	0.10	**2.29**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 810.8 thousand USD (without VAT) and 973.0 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		26.7
2. Exploitation expenses		23.9
	Salary	14.4
	Renovation	6.5
	Other Expenses	3.0
Total		50.6

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		758
Average multi annual production of energy, mln kwt/hour		2.29
Capital investments into SHPPS(without VAT),		
	thousand USD	810.8
	USD / kwt	1069.7
	USD / kwt/hour	0.355
Prime cost of power production, cents/kwt hour		2.2

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

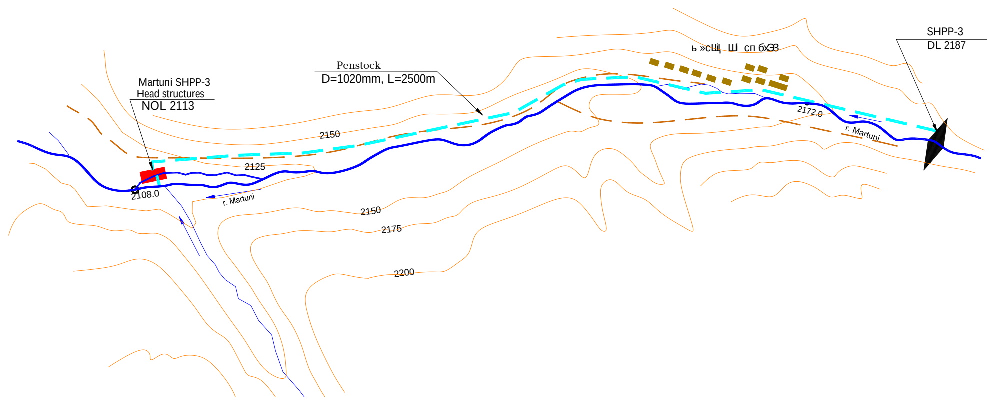
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 141. Design results according to financial scenarios

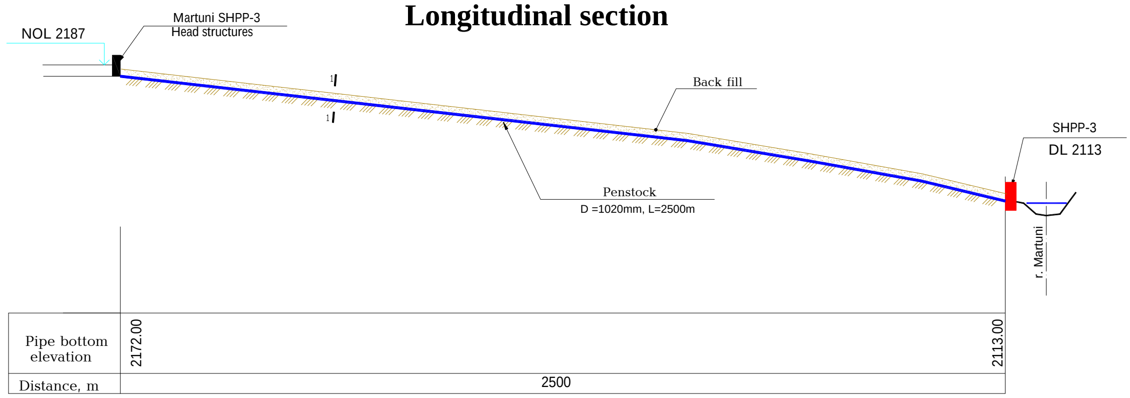
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		9.7	10.7
NPV, thousand USD			
	8%	133.8	133.8
	10%	-19.9	28.9
	12%	-135.0	-43.7
	14%	-223.4	-94.7
PB, years (without discount)		9.7	13.1
Deadline for credit return, years			10.0

APPENDIX. 64. MARTUNI SHPP-3

Plan



Longitudinal section



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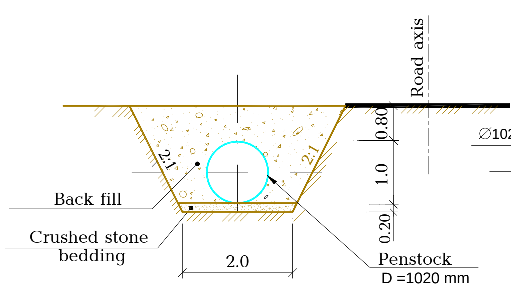
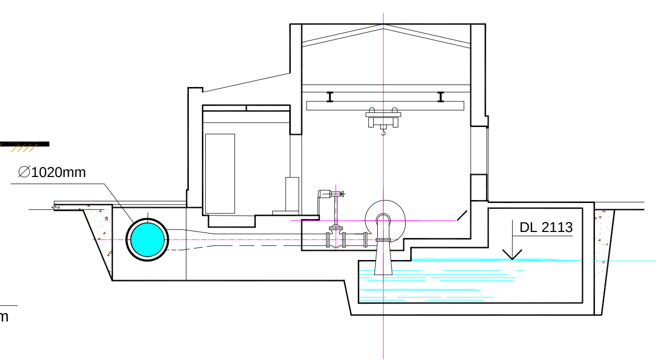


SHPP Powerhouse



15.7.2.3. GEGHARKUNIK SHPP -1

INTRODUCTION

GegharkunikSHPP-1 is to be located in the north-east of the country, on the river Gegharkunik. The SHPP uses the inclination of Gegharkunik river from the elevation 2525.0 up to 2375.0 mark. The derivation length is 2000m, the diameter of steel pipeline equals 430mm, design pressure is 119.1m, design discharge equals 0.30m^3/sec. Gegharkunik-1 SHPP will have 0.286MW productive capacity after the end of construction and putting into exploitation with annual power output of 1.0mln. kW/hour.

SHORT DESCRIPTION OF GEGHARKUNIK RIVER BASIN

River Gegharkunik is the right stream of Gavaraget river which is one of the few rivers falling into Lake Sevan. Gegharkunik river is 31km long with 96.0km^2 overall catchment area, average inclination - 55.1‰ and 2520m average basin altitude. The river starts from one of the southern peaks of Geghama mountain plateau – Gegharkunik mountain foothills, on the altitude of 3092.0m. River basin is located in the north-east of the country. Gegharkunik River is a typical mountainous lake with complicated relief and multiple river streams.

Geographic composition of the basin is also complicated, thus, the northern part is composed of andesite basalt lavas while southern part – from sedimentary rock types, mainly limestone. There are alluvial sediments in the middle section of the river basin. In the upper sections of the basin there are grain crops and lands covered by grass, prairies and alpine meadows further on. The earth cover of the basin is also diverse: in the upstream it is represented by sub alpine, high land meadows with natural dark brown soils; in the downstream, shoreline of Lake Sevan, occasionally washed out natural lands can be observed and dry prairie lands - in the upper section. The upstream section of the river valley has V-shape slopes, with abrupt turns without multiple streams.

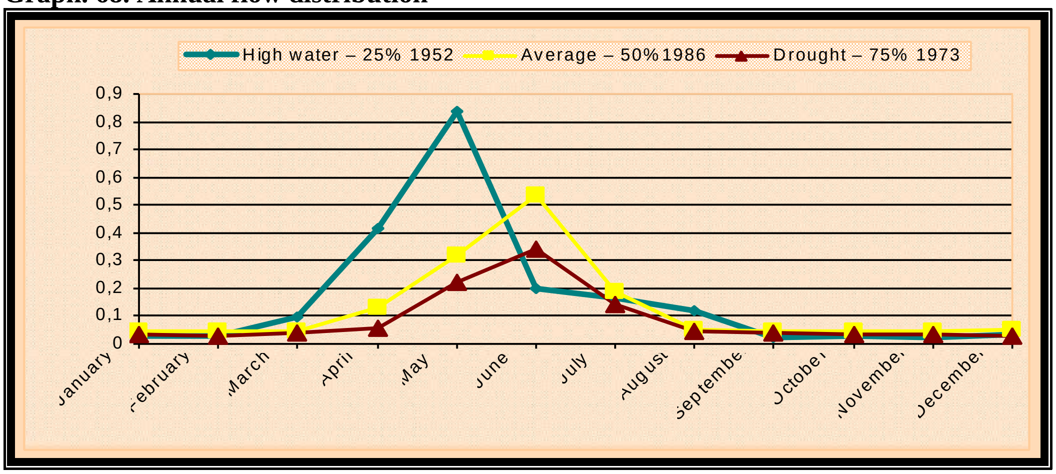
HYDROLOGY

The 39 year long observation data from Gegharkunik - Sarukhan river water-meter station is used to define the hydrological properties of Gegharkunik SHPP-1 headworks and the design river section. The table below shows hydrological properties of design river section necessary for the SHPP

River Section	Distance from river mouth, km	Average altitude of the catchment basin, m.	Catchment area, km^2	Flow norms, m^3/sec
Gegharkunik- design perpendicular section - 1	16.9	2680	17.35	0.12

Graph shows annual flow distribution of Gegharkunik SHPP-1 for the design river section, during tree characteristic years.

Graph. 68. Annual flow distribution



Maximal design discharge for Gegharkunik SHPP-1 headworks river section for the general case equals 3% - 7.07m^3/sec, for verifying case - 0.5%-8.75m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.0004m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Gegharkunik SHPP-1 is 2525.0m, downstream – 2375.0m. According to "Gavar" WUC data, the irrigational water intake is carried out from 3 reservoirs located on Gegharkunik River. The SHPPs (Gegharkunik -1 and 2) to be constructed before the river section of the reservoirs.

Gegharkunik SHPP-1 is derivational SHPP. In order not to drain the river, where 2000m derivational pipeline is, the environmental discharge is designed according to RA laws and equals 0.0004m^3/sec. All natural flow including irrigational demands and environmental flow values can be used for energy purposes.

Hydro-power properties of Gegharkunik SHPP-1 are calculated with 50% guarantee per annum (1981).

Table. 142. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Gegharkunik SHPP-1 (m^3/sec)	0.05	0.04	0.04	0.13	0.30	0.30	0.19	0.05	0.04	0.05	0.05	0.05	
SHPP average monthly capacity (mwt)	0.06	0.05	0.05	0.15	0.286	0.29	0.21	0.06	0.05	0.05	0.05	0.06	
SHPP –average monthly energy production (mln kwt/hour)	0.04	0.04	0.04	0.11	0.21	0.21	0.15	0.04	0.04	0.04	0.04	0.04	**1.00**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 334.4 thousand USD (without VAT) and 401.3 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		11.0
2. Exploitation expenses		19.1
	Salary	14.4
	Renovation	2.7
	Other Expenses	2.0
Total		30.1

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		286
Average multi annual production of energy, mln kwt/hour		1.00
Capital investments into SHPPS(without VAT),		
	thousand USD	334.4
	USD / kwt	1169.3
	USD / kwt/hour	0.33
Prime cost of power production, cents/kwt hour		3.0

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

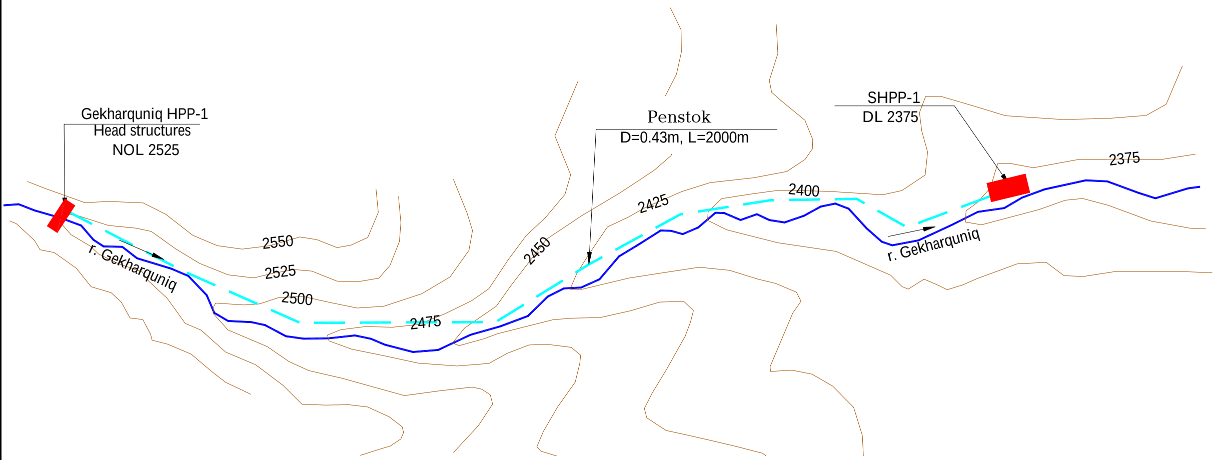
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 143. Design results according to financial scenarios

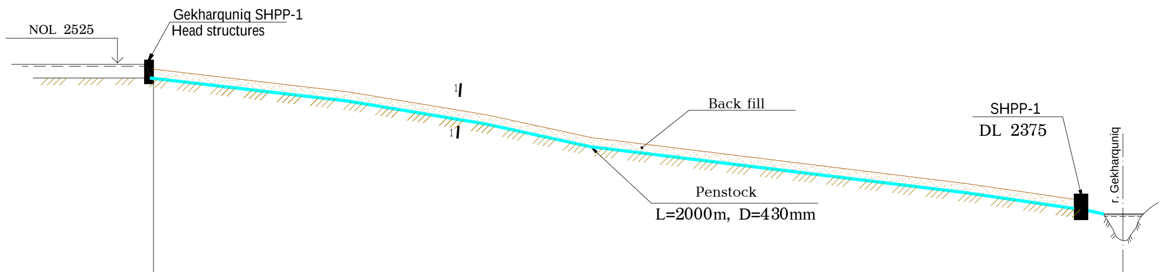
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		8.0	8.0
NPV, thousand USD			
	8%	0.22	0.22
	10%	-54.2	-29.2
	12%	-95.0	-49.0
	14%	-126.3	-62.5
PB, years (without discount)		11.3	16.8
Deadline for credit return, years			14.0

APPENDIX. 65. GEKHARQUNIQ SHPP-1

Plan

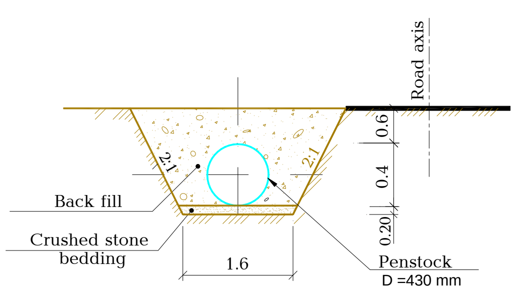


Longitudinal section

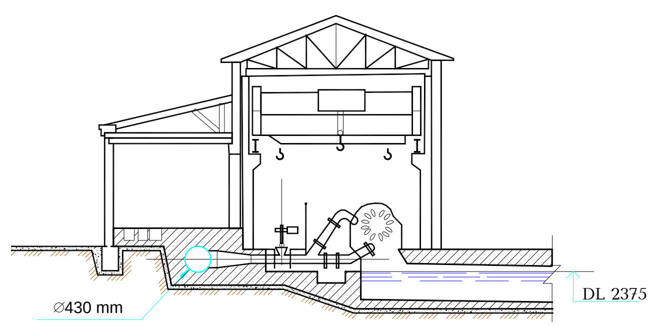


Pipe bottom elevation	2522.00	2500.00	2450.00	2425.00	2400.00	2375.00
Distance, m	430	450	260	310	550	

1-1



SHPP Powerhouse



GEGHARKUNIK SHPP - 2

INTRODUCTION

Gegharkunik SHPP-2 is to be located in the north-east of the country, on the river Gegharkunik. The SHPP uses the inclination of Gegharkunik river from the elevation 2370.0 up to 2210.0 mark. The derivation length is 2130m, the diameter of steel pipeline equals 530mm, design pressure is 141.8m, design discharge equals $0.40m^3$/sec. Gegharkunik SHPP-2 will have 0.454MW productive capacity after the end of construction and putting into exploitation with annual power output of 1.46mln. kW/hour.

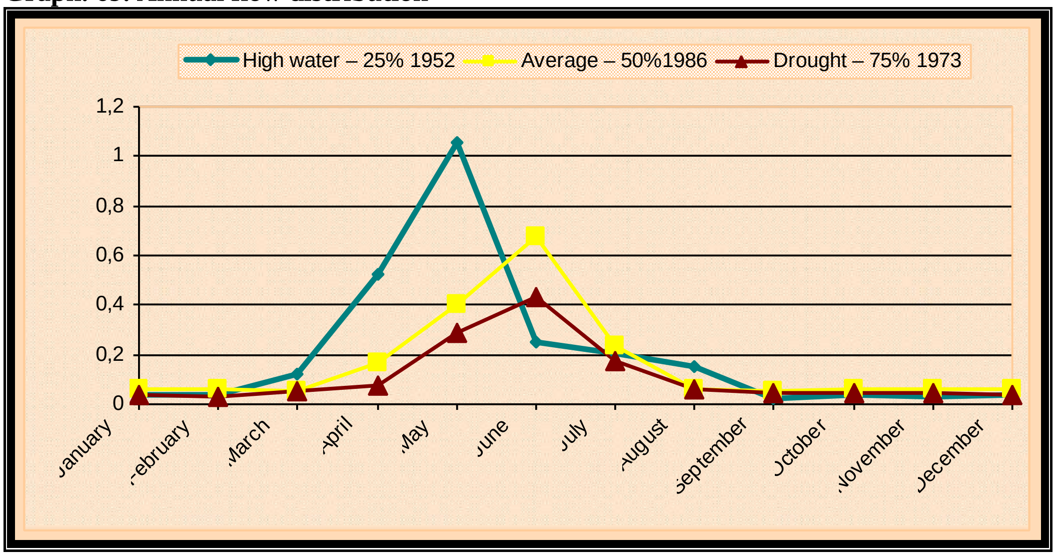
HYDROLOGY

The 39 year long observation data from Gegharkunik - Sarukhan river water-meter station is used to define the hydrological properties of Gegharkunik SHPP-2 headworks and the design river section. The table below shows hydrological properties of design river section necessary for the SHPP.

River Section	Distance from river mouth, km	Average altitude of the catchment basin, m.	Catchment area, km^2	Flow norms, m^3/sec
Gegharkunik- design perpendicular section - 2	14.2	2575	22.4	0.16

Graph shows annual flow distribution of Gegharkunik SHPP-2 for the design river section, during tree characteristic years.

Graph. 69. Annual flow distribution



Maximal design discharge for Gegharkunik SHPP-2 headworks river section for the general case equals 3% - $7.63m^3$/sec, for verifying case - 0.5%-$9.48m^3$/sec, the observed average annual discharge value with 95% guarantee equals $0.0005m^3$/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Gegharkunik -2 SHPP is 2370.0m, downstream – 2210.0m.
According to "Gavar" WUC data, the irrigational water intake is carried out from 3 reservoirs located on Gegharkunik River. The SHPPs (Gegharkunik -1 and 2) to be constructed before the river section of the reservoirs.

Gegharkunik SHPP-2 is derivational SHPP. In order not to drain the river, where 2130m derivational pipeline is, the environmental discharge is designed according to RA laws and equals 0.0005m^3/sec. All natural flow including irrigational demands and environmental flow values can be used for energy purposes.
Hydro-power properties of Gegharkunik SHPP-2 are calculated with 50% guarantee per annum (1981).

Table. 144. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Gegharkunik SHPP-2 (m^3/sec)	0.06	0.06	0.06	0.17	0.40	0.40	0.24	0.06	0.05	0.06	0.06	0.06	
SHPP average monthly capacity (mwt)	0.07	0.07	0.07	0.21	0.454	0.45	0.29	0.08	0.07	0.07	0.07	0.08	
SHPP –average monthly energy production (mln kwt/hour)	0.06	0.05	0.05	0.15	0.34	0.33	0.22	0.06	005	0.05	0.05	0.06	**1.46**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 459.2 thousand USD (without VAT) and 551 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	15.2
2. Exploitation expenses	20.1
Salary	14.4
Renovation	3.7
Other Expenses	2.0
Total	35.3

Power indicators of have the following level

Indicators	Values
Derivation capacity, kwt	454
Average multi annual production of energy, mln kwt/hour	1.46
Capital investments into SHPPS(without VAT),	
thousand USD	459.2
USD / kwt	1011.4
USD / kwt/hour	0.31
Prime cost of power production, cents/kwt hour	2.4

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

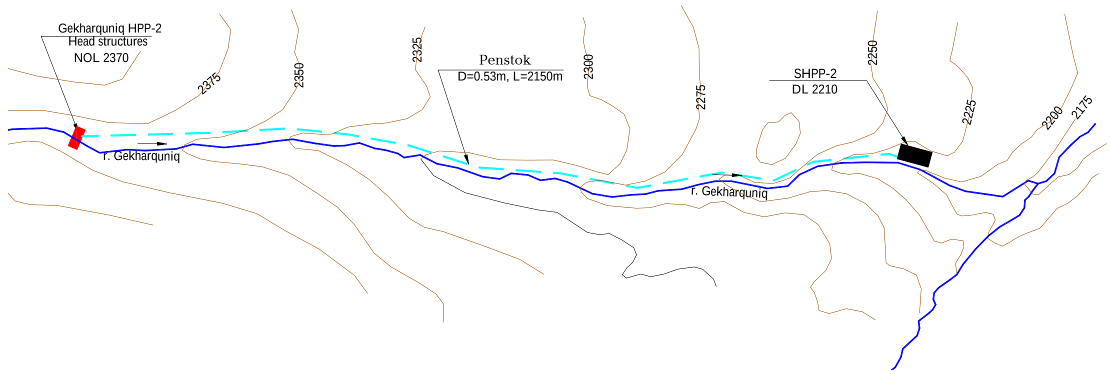
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 145. Design results according to financial scenarios

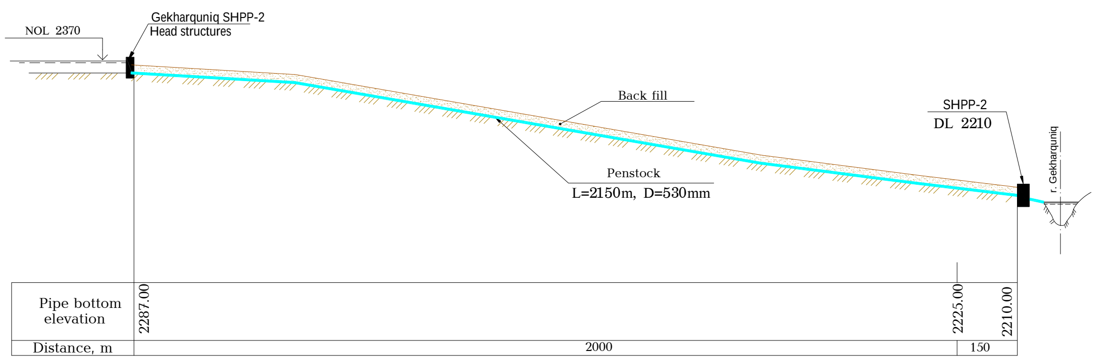
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		10.1	11.5
NPV, thousand USD			
	8%	96.9	96.9
	10%	6.5	34.1
	12%	-61.3	-9.6
	14%	-113.3	-40.5
PB, years (without discount)		9.3	12.6
Deadline for credit return, years			10.0

APPENDIX. 66. GEKHARQUNIQ SHPP-2

Plan



Longitudinal section



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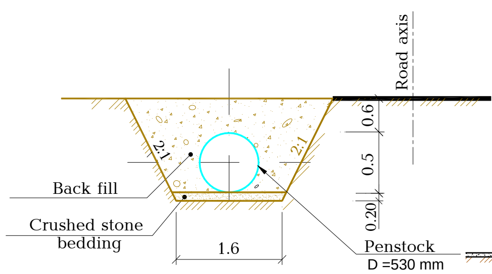
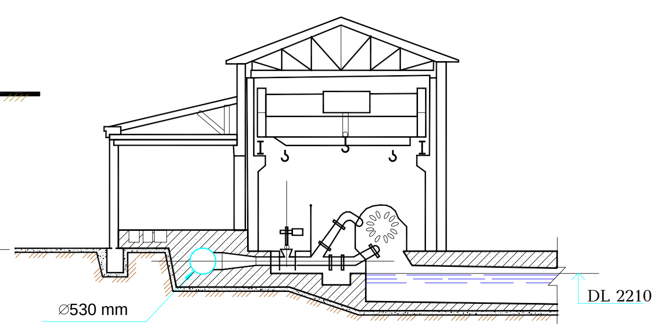


SHPP Powerhouse



15.7.2.4. MAIRARU SHPP -1

INTRODUCTION

Mairaru SHPP-1 is to be located in the north-east of the country, on the river Mairaru. The SHPP uses the inclination of Mairaru River from the elevation 2500.0 up to 2320.0 mark. The derivation length is 1500m, the diameter of steel pipeline equals 630mm, design pressure is 165m, design discharge equals 0.70m^3/sec. Mairaru SHPP-1 will have 0.924MW productive capacity after the end of construction and putting into exploitation with annual power output of 3.13mln. kW/hour.

SHORT DESCRIPTION OF MAIRARU RIVER BASIN

River Mairaru is the right stream of Artcvanist river which is one of the few rivers falling into Lake Sevan. Mairaru River is 19km long with 22.1km^2 overall catchment area, average inclination – 19.2‰ and 2540m average basin altitude. The river starts from one of the southern peaks of Vardenis mountain plateau – Vardenis mountain peak, on the altitude of 3521.5m. River basin is located in the north-east of the country.

Mairaru River is a typical mountainous lake with complicated relief and multiple river streams. As opposed to parallel Karchakhbyur River, Mairaru is a shallow river. Spring floods usually start at the end of March and reach its peak in May and then gradually pass to dry season in August.

Geographic composition of the basin is also complicated, thus, the northern part is composed of andesite basalt lavas while southern part – from sedimentary rock types, mainly limestone. There are alluvial sediments in the middle section of the river basin.

In the upper sections of the basin there are grain crops and lands covered by grass, prairies and alpine meadows further on. The earth cover of the basin is also diverse: in the upstream it is represented by sub alpine, high land meadows with natural dark brown soils; in the downstream, shoreline of Lake Sevan, occasionally washed out natural lands can be observed and dry prairie lands - in the upper section.

The upstream section of the river valley has V-shape slopes, with abrupt turns without multiple streams.

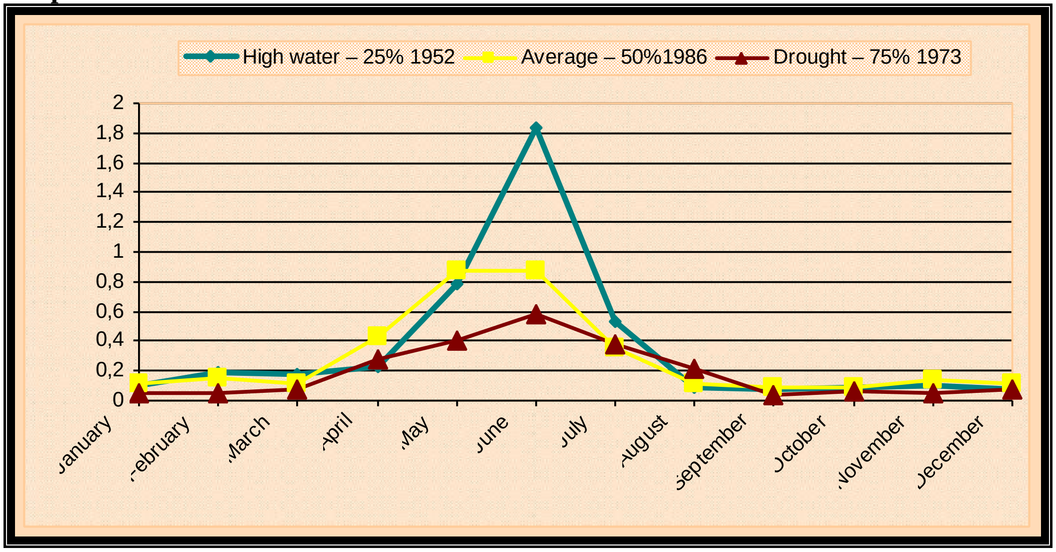
HYDROLOGY

The 41 year long observation data from Artsvanist - Artsvanist river water-meter station is used to define the hydrological properties of Mairaru SHPP-1 headworks and the design river section. The table below shows hydrological properties of design river section necessary for the SHPP.

River Section	Distance from river mouth, km	Average altitude of the catchment basin, m.	Catchment area, km^2	Flow norms, m^3/sec
Mairaru- design perpendicular section - 1	4.5	3000	13.06	0.29

Graph shows annual flow distribution of Mairaru SHPP-1 for the design river section, during tree characteristic years.

Graph. 70. Annual flow distribution



Maximal design discharge for Mairaru SHPP-1 headworks river section for the general case equals 3% - 5.44m^3/sec, for verifying case - 0.5%-8.44m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.0004m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Mairaru SHPP-1 is 2500.0m, downstream – 2320.0m. According to "Vardenis" WUC data, there is no water intake from Mairaru River up to SHPP station works.

Mairaru SHPP-1 is derivational SHPP. In order not to drain the river, where 1500m derivational pipeline is, the environmental discharge is designed according to RA laws and equals 0.0004m^3/sec. All natural flow including irrigational demands and environmental flow values can be used for energy purposes.

Hydro-power properties of Mairaru SHPP-1 P are calculated with 50% guarantee per annum (1991).

Table. 146. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Mairaru SHPP -1(m^3/sec)	0.11	0.15	0.12	0.43	0.70	0.70	0.35	0.12	0.09	0.09	0.14	0.12	
SHPP average monthly capacity (mwt)	0.16	0.21	0.17	0.60	0.924	0.92	0.49	0.17	013	0.13	0.20	0.17	
SHPP –average monthly energy production (mln kwt/hour)	0.12	0.14	0.13	0.43	0.69	0.67	0.37	0.13	0.09	0.10	0.14	0.13	**3.13**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 858.1 thousand USD (without VAT) and 1029.7 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		28.3
2. Exploitation expenses		27.2
	Salary	17.3
	Renovation	6.9
	Other Expenses	3.0
Total		55.5

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		924
Average multi annual production of energy, mln kwt/hour		3.128
Capital investments into SHPPS(without VAT),		
	thousand USD	858.1
	USD / kwt	928.7
	USD / kwt/hour	0.274
Prime cost of power production, cents/kwt hour		1.77

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:
- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

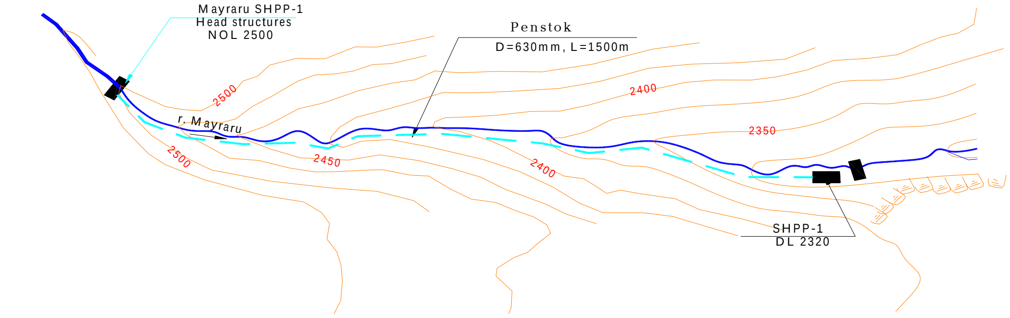
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 147. Design results according to financial scenarios

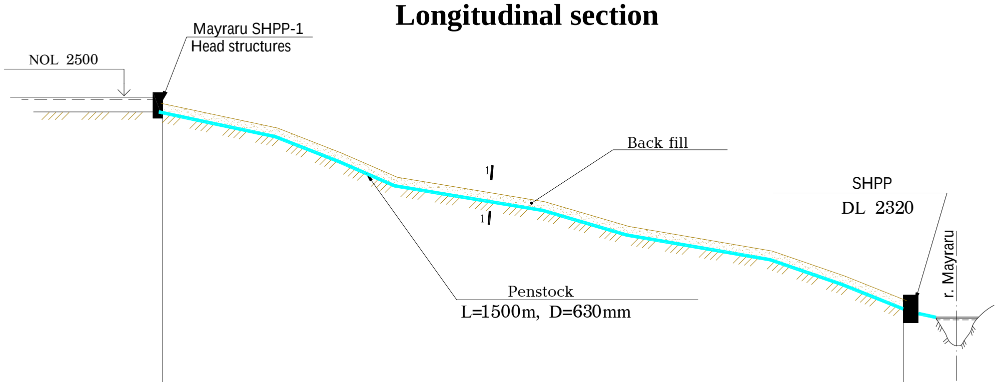
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		13.4	16.1
NPV, thousand USD			
	8%	465.1	465.1
	10%	249.9	289.4
	12%	88.6	163.8
	14%	-35.1	72.2
PB, years (without discount)		7.3	9.1
Deadline for credit return, years			7.0

APPENDIX. 67. MAYRARU SHPP-1

Plan

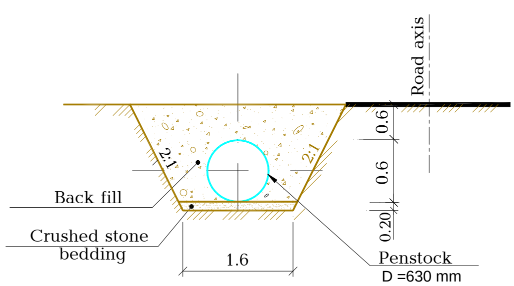


Longitudinal section

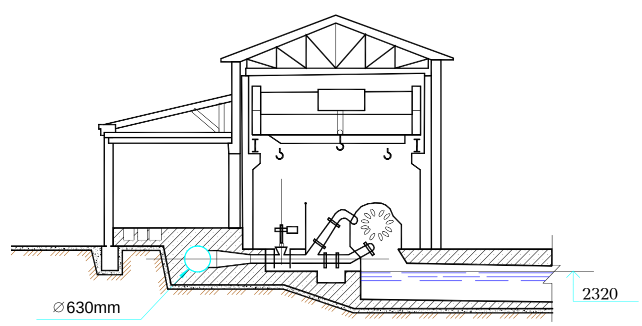


Pipe bottom elevation	2497.00	2475.00	2450.00	2425.00	2400.00	2375.00	2350.00	2325.00	2320.00
Distance, m	225	130	115	300	170	290	145	125	

1-1



SHPP Powerhouse



MAIRARUSHPP-2

INTRODUCTION

Mairaru SHPP-2 is to be located in the north-east of the country, on the river Mairaru. The SHPP uses the inclination of Mairaru river from the elevation 2310.0 up to 2225.0 mark. The derivation length is 1000m, the diameter of steel pipeline equals 720mm, design pressure is 79.2m, design discharge equals 0.80m^3/sec. Mairaru-2 SHPP will have 0.507MW productive capacity after the end of construction and putting into exploitation with annual power output of 1.62mln. kW/hour.

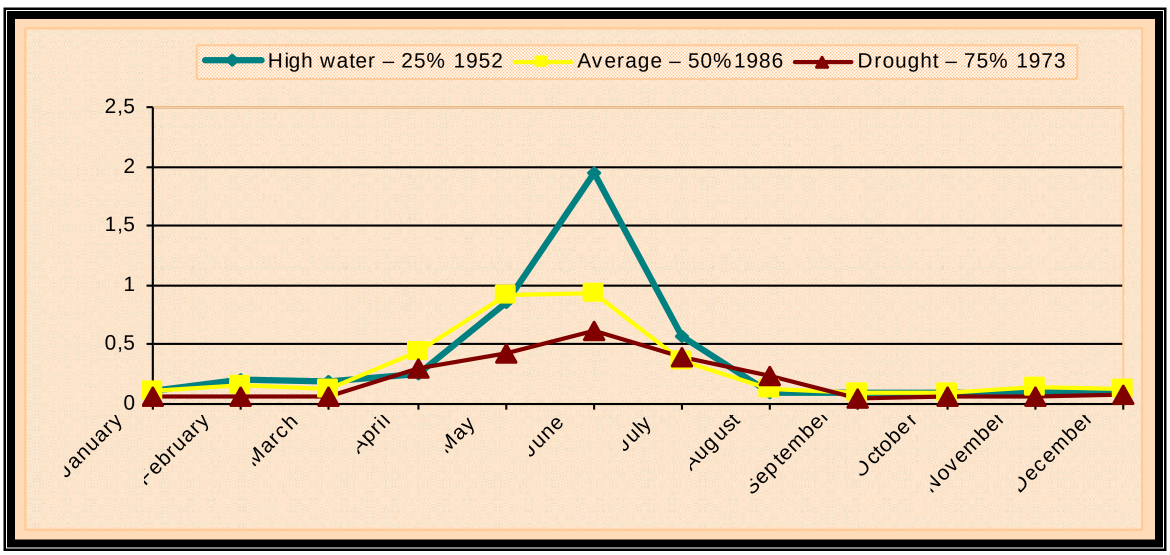
HYDROLOGY

The 41 year long observation data from Artsvanist - Artsvanist river water-meter station is used to define the hydrological properties of Mairaru SHPP-2 headworks and the design river section. The table below shows hydrological properties of design river section necessary for the SHPP.

River Section	Distance from river mouth, km	Average altitude of the catchment basin, m.	Catchment area, km^2	Flow norms, m^3/sec
Mairaru- design perpendicular section - 2	4.5	3000	13.06	0.29

Graph shows annual flow distribution of Mairaru SHPP-2 for the design river section, during tree characteristic years.

Graph. 71. Annual flow distribution



Maximal design discharge for Mairaru SHPP-2 headworks river section for the general case equals 3% - 5.44m^3/sec, for verifying case - 0.5%-8.44m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.0004m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Mairaru SHPP -2 is 23100.0m, downstream – 2225.0m.
According to “Vardenis” WUC data, there is no water intake from Mairaru River up to SHPP station works.

MairaruSHPP-2 is derivational SHPP. In order not to drain the river, where 1500m derivational pipeline is, the environmental discharge is designed according to RA laws and equals 0.0006m^3/sec. All natural flow including irrigational demands and environmental flow values can be used for energy purposes.
Hydro-power properties of Mairaru SHPP -2 are calculated with 50% guarantee per annum (1991).

Table. 148. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Mairaru SHPP-2 (m^3/sec)	0.11	0.16	0.13	0.45	0.80	0.80	0.37	0.12	0.10	0.09	0.14	0.13	
SHPP average monthly capacity (mwt)	0.16	0.21	0.17	0.60	0.924	0.92	0.49	0.17	013	0.13	0.20	0.17	
SHPP –average monthly energy production (mln kwt/hour)	0.12	0.14	0.13	0.43	0.69	0.67	0.37	0.13	0.09	0.10	0.14	0.13	**3.13**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 501.7 thousand USD (without VAT) and 602 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		16.55
2. Exploitation expenses		20.4
	Salary	14.4
	Renovation	4.0
	Other Expenses	2.0
Total		36.95

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		507
Average multi annual production of energy, mln kwt/hour		1.622
Capital investments into SHPPS(without VAT),		
	thousand USD	501.7
	USD / kwt	989.6
	USD / kwt/hour	0.309
Prime cost of power production, cents/kwt hour		2.28

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- ❖ Private investments only /Scenario 1/

- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

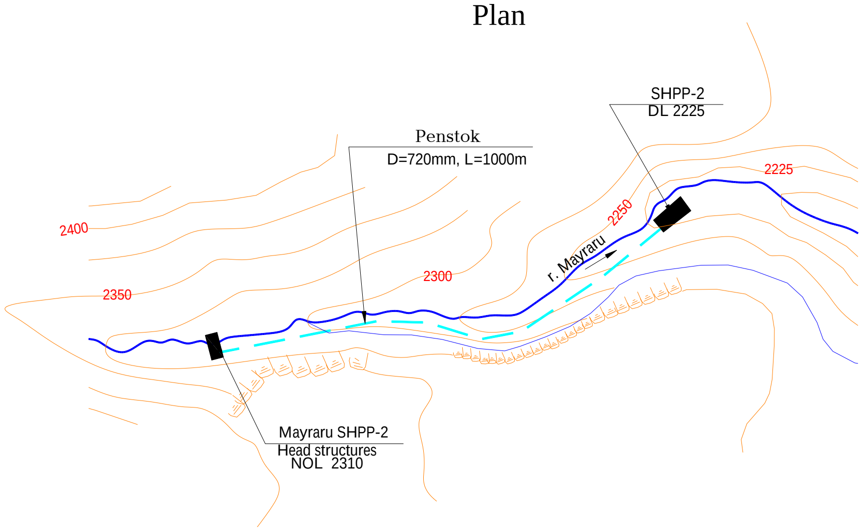
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 149. Design results according to financial scenarios

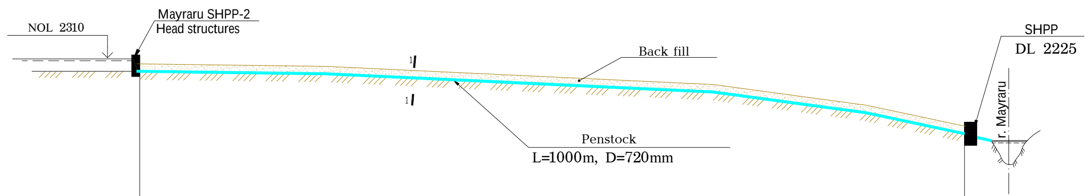
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		10.7	12.2
NPV, thousand USD			
	8%	131.8	131.9
	10%	28.8	56.7
	12%	-48.4	4.1
	14%	-107.7	-33.4
PB, years (without discount)		8.9	11.7
Deadline for credit return, years			9.0

APPENDIX. 68. MAYRARU SHPP-2

Plan



Longitudinal section



Pipe bottom elevation	2307.00	2300.00	2275.00	2250.00	2225.00
Distance, m	225	470	185	120	

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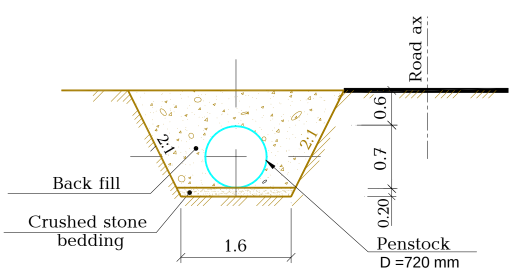
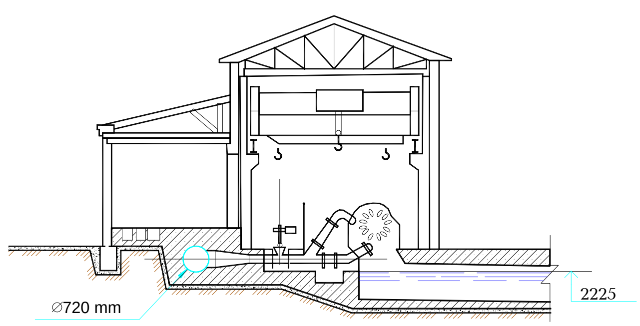


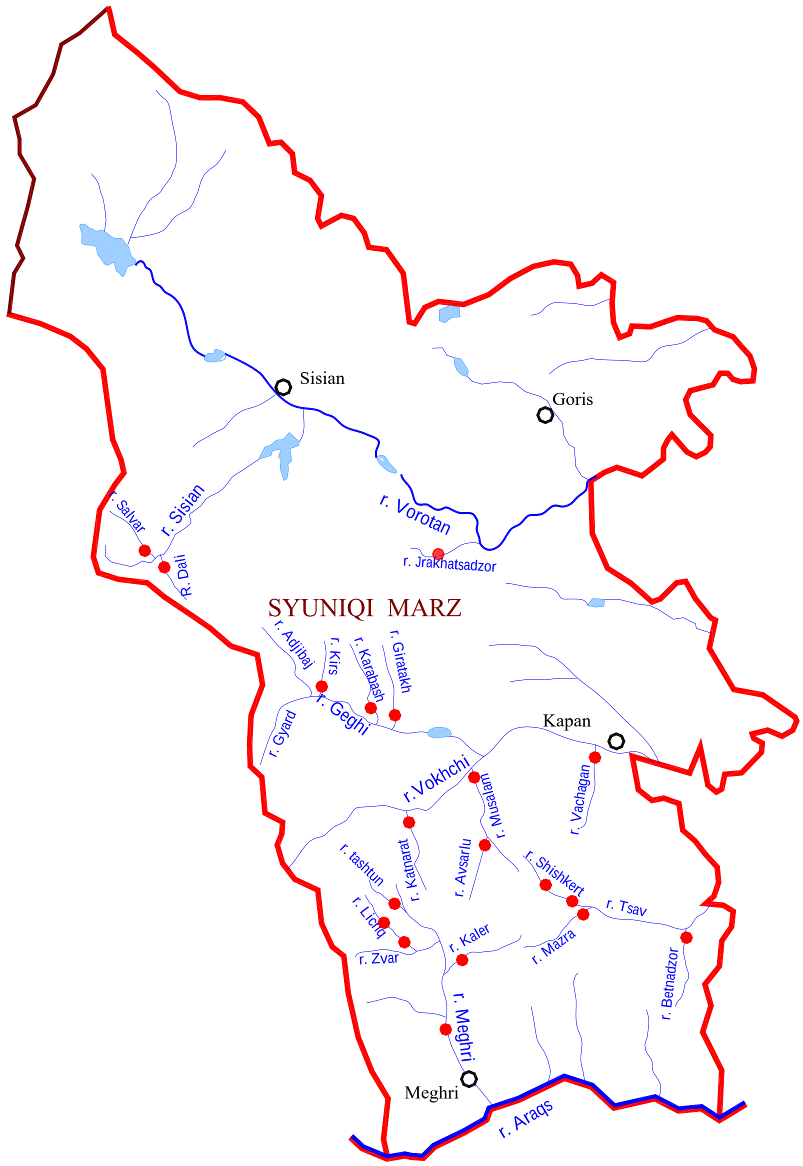
SHPP Powerhouse



PART 15.8. SYUNIK MARZ

VOROTAN, VOGHJI AND MEGHRI RIVER BASINS

VERIFIED AND UPDATED SCHEME FOR SHPPs



15.8.1. Updated and Verified Scheme for Vorotan River Basin

General Information

According to development scheme it was planned to construct 8 SHPPs. Presently, Darbas SHPP -1, 2, Ayriget SHPP, Araglighur SHPP has construction permission. Technical substantiation design is being planned for Vorotan 1, 2 SHPPs, Vorotan-Arpa channel.

In-situ investigations verified unappropriated Jraganidzor SHPP indicators, and the possibility of new SHPP construction on Arevis and Tatev rivers.

15.8.2. Short Description of Vorotan River Basin and Climatic Conditions

River Vorotan is the largest left inflow of River Araks that falls into the river 236km from the river mouth. General catchment area of the river is 5540km^2, river length is 194km. River length on the territory of Armenia is 129km and catchment area 2020km^2, with 21% of average inclination and 2280m of average catchment area elevation.

River basin is located in the north-western part of Armenia. River basin borders with Akera River from the west and north-west, which is the main inflow of Vorotan, afterwards it merges with Araks river basin with dividing Kharabakh mountain plateau (3581m) from north and west, together with Arpa River Basin which is separated by Zangezur mountain chain. The basin also borders with Voghji River Basin, divided by Bargushan mountain chain.

The river basin has a complicated U-shape with main directions from north-west to south-east. River Vorotan is a typical mountainous river. It has a complicated relief with inflow basins; however the inflows are unevenly distributed over the territory of the country. There are no inflows on the left bank, especially in the midstream; instead there are large springs that start from the bank: Shaki, Dzir-Dzor, Urut, etc. Te inflows of the right bank are more evenly distributed.

The river starts from 2 small lakes that are included in the system of Kharabakh mountain chain (3045m). Further on the river accepts multiple inflows.
The river valley is a V shaped, comparatively wide gorge that becomes flatter towards the river mouth. The river valley slopes are mountainous, have inclination of 30^0 and are covered by alpine meadows.

From geological point of view the river valley is composed of volcanic Paleogene rock types: porphyrites, tuff breccias, tuff sand stones that are mainly distributed in the upper stream of the basin. The earth cover is represented by light brown and nor developed national soil. The vegetative layer is mainly prairie type.

There is almost no inundation area in the upper streams; in the wider part of the basin it does not exceed 50-150m.

From climatic point of view the climate is mild with warm and long summers and cold winters. Vorotan river basin is stretches for 3 climatic zones, starting from continental climate will mountainous tundra zones. The planned SHPPs are located in the following zones:

- ❖ Moderate – warm zone with mild winter,
- ❖ Moderate zone – with mild winter,
- ❖ Moderate zone with long summer and cold winter.

The climatic description of the basin is given according to the data of the closes meteorological station 1580m.

№№ пп	Station	Elevation, m	Observation period	Number of observational years.
1.	Sisyan	1580	1931-working	75

According to meteorological station data average multi-annual air temperature equals 6.7^{0}C, absolute minimum equals -37°C, absolute maximum +34°C. Maximal annual precipitations equal 350mm, annual maximum 468mm. Absolute moisture content 7.2mb, comparative moisture content 6.7%. Average thickness of snow cover is 0.3-0.4m.

Average monthly speed equals 3.8m/sec, win speed with 1% probability is 40m/sec.

15.8.3.Vortan River Regieme and Design Data

Vorotan River basin rivers are of typical mountainous nature with seasonal water regime.

The flow distribution of Vorotan River and its inflows is characterized by well developed spring inundations and stable drought periods. The rivers have mixed feeding by snow, rain, ground water.

Due to high zoning snow melting begins on low altitudes then gradually goes up which is conditioned by floods staring from April till July (3-4month). The stable drought period starts from July that lasts till next spring. Spring water abundance with rising horizons starts from the end of March and the beginning of April and ends in July. The maximal level of spring inundations is observed in mid may and is characterized by short term nature (2-3 days.)

The most intensive period in the river basin coincides with heavy rains that result in considerable rise of water horizons and consequentially in emergency floods.

Autumn rain peaks are insignificant. The left section of the river basin has a stable drought area due to ground waters which makes the stabilization of the flow possible.

During the water abundant period the river passes 60% of annual flow while the remaining 40% are the ground water flow during summer and winter periods.

Vorotan river regime is well investigated.

Main hydrological characteristics of Vorotan River and its inflows are shown below.

Water meter station	Distance from the river mouth, km	Average elevation of reservoir, m.	Catchment area, km^2	Exploitation timeline		Exploitation timeline	Normal Flow, m^3/sec
				opened	closed		
Tatev-Tatev	0.04	2140	84.5	1960	1987	963.85БС	1.37
Sisian-Arevis	19	2520	116	1963	1987	1937.56 БС	1.85

The table below shows the annual flow distribution of Vorotan river basin for characteristic years.

year	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Average Annual
Sisyan-Arevis													
Water Abundant – 25%													
1987	1.25	1.29	1.35	2.99	6.29	3.45	2.24	2.08	1.94	1.61	1.53	1.21	2.27
Average– 50%													
1966	0.56	0.66	1.09	4.56	9.19	3.74	0.61	0.41	0.56	0.73	0.47	0.37	1.91
Drought– 75%													
1973	0.29	0.40	0.50	2.40	4.51	3.26	2.33	1.13	0.74	0.54	0.53	0.50	1.43
Tatev-Tatev													
Water Abundant – 25%													
1979	0.52	0.70	1.77	3.97	3.23	3.73	3.03	0.96	0.35	0.57	0.68	0.60	1.68
Average– 50%													
1983	0.59	0.69	0.80	0.93	4.83	3.42	1.02	0.99	0.86	0.70	0.64	0.71	1.35
Drought– 75%													
1972	0.49	0.46	0.59	2.41	3.36	1.88	1.22	0.72	0.91	0.59	0.61	0.62	1.16

15.8.4. Technical Specifications for Vorotan River Basin SHPPs

15.8.4.1 Arevis SHPP-1,2

Arevis SHPP-1

Introduction

Arevis SHPP uses inclination of River Dali from 1960.0m to 1895.0m. The length of derivation from Dali River is 1200m by copper pipeline 820mm in diameter with design pressure of 59.6m and design discharge 1.00m^3/sec. After construction and exploitation Arevis SHPP will have 0.48mwt capacity and will produce 1.381mln kw/h electricity annually.

Short Description for Dali River Basin

Dali River is the right inflow of Sisian River which is the inflow of Vorotan River. River length is 10.5km, general chatchment area is 33.4km^2, average inclination is 141‰, average elevation is 2650m.

River basin is located in the south-eastern part of Small Caucasian mountain chain. It borders with Baghdushan mountain chain from west to south-west. There river basin is located in the southern part of the republic. It borders with Vorotan river inflow basins from north, east and west; Voghji river basin from south divided by Baghdushar mountain chain (Geghakar Mountain – 3348.3m)

From the geological point of view the basin slopes are composed of Oligocene volcanic soils that are comparatively weak cracked and water permeable.

The vegetative layer of the basin in the upstream is mainly alpine and sub alpine that is substituted by bushes and afterwards with forest.

In the upstream the river basin is represented by sub alpine earth. Dali river basin is flat and slopes are covered by meadows and bushes. River Dali is atypical mountainous river that flows though a gorge with 35 -45° slope inclination.

HYDROLOGY

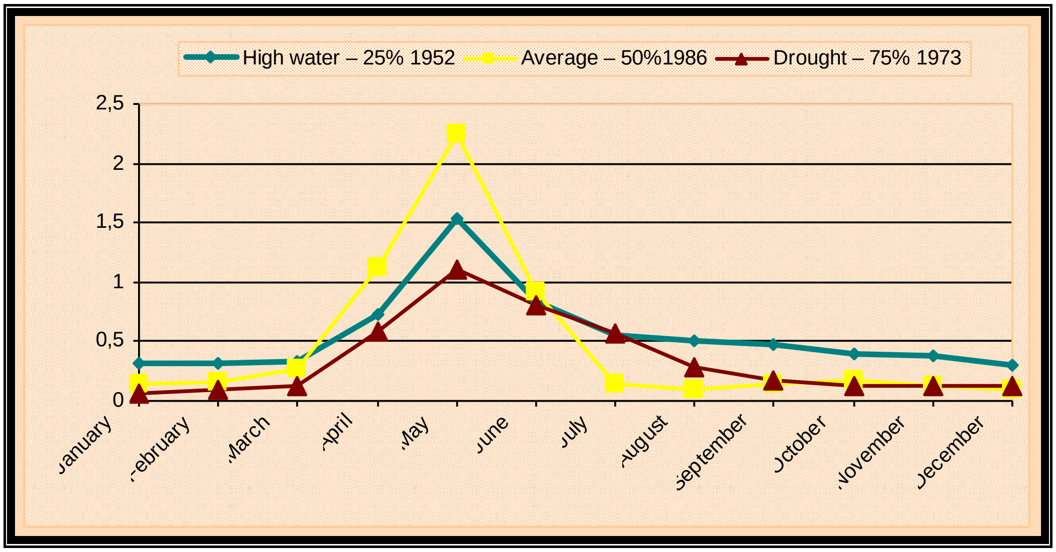
The observation data for 40 years from r. Sisian-Arevis water-meter station is used to define the hydrological properties of Arevis SHPP-1 headworks and the design river section.

The graphic below shows the hydrological properties of design river sections.

River Section	Distance from river mouth, km	Average altitude of the catchment basin, m.	Catchment area, km^2	Flow norms, m^3/sec
R. Dali - longitudinal section-1	2.2	2700	28.4	0.47

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 72. Annual flow distribution



Maximal design discharge for Arevis SHPP-1 headwork river section for the general case equal 3% - 24.5m^3/sec, for verifying case - 0.5%-43.6m^3/sec, the observed average daily discharge value with 95% guarantee equals 0.049m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Arevis SHPP-1 is 1960.0m, downstream - 1895.0m. According to data of State Water Economy Data there is no water intake for irrigational use from Dali River. Arevis SHPP-1 is derivational SHPP. In order not to drain the river where 1200m derivational pipeline is the environmental discharge is designed according to RA laws and 0.04m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Arevis SHPP-1 are calculated with 50% guarantee per annum (1966 see table 150).

Table. 150. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Arevis SHPP-1 (m^3/sec)	0.14	0.16	0.27	1.12	2.25	0.92	0.15	0.10	0.14	0.18	0.12	0.09	
SHPP average monthly capacity (mwt)	0.05	0.06	0.12	0.48	0.48	0.43	0.06	0.03	0.05	0.07	0.04	0.03	
SHPP –average monthly energy production (mln kwt/hour)	0.04	0.04	0.09	0.34	0.35	0.31	0.04	0.02	0.04	0.05	0.03	0.02	**1.381**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 480.3 thousand USD (without VAT) and 576.4 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		15.8
2. Exploitation expenses		20.4
	Salary	14.4
	Renovation	4.0
	Other Expenses	2.0
Total		36.2

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		476
Average multi annual production of energy, mln kwt/hour		1.38
Capital investments into SHPPS(without VAT),		
	thousand USD	180.3
	USD / kwt	1009.3
	USD / kwt/hour	0.348
Prime cost of power production, cents/kwt hour		2.62

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

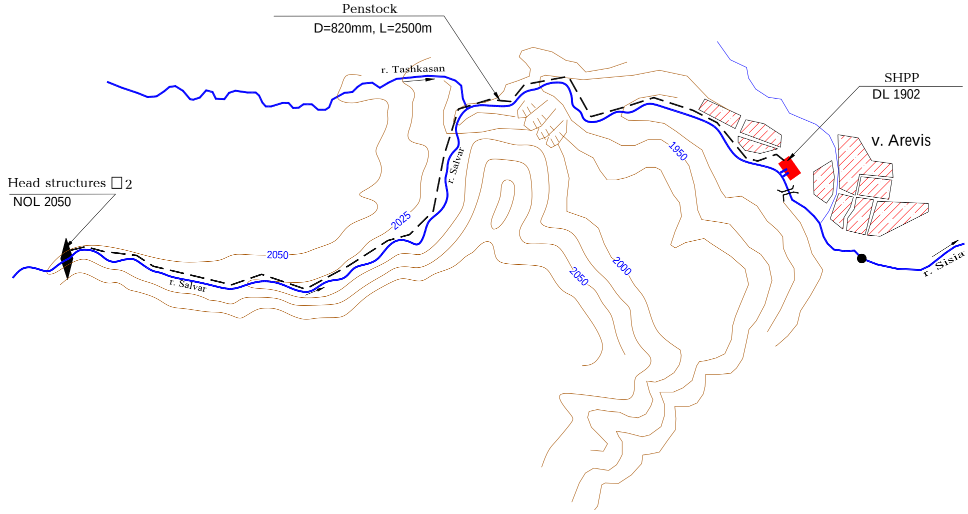
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 151. Design results according to financial scenarios

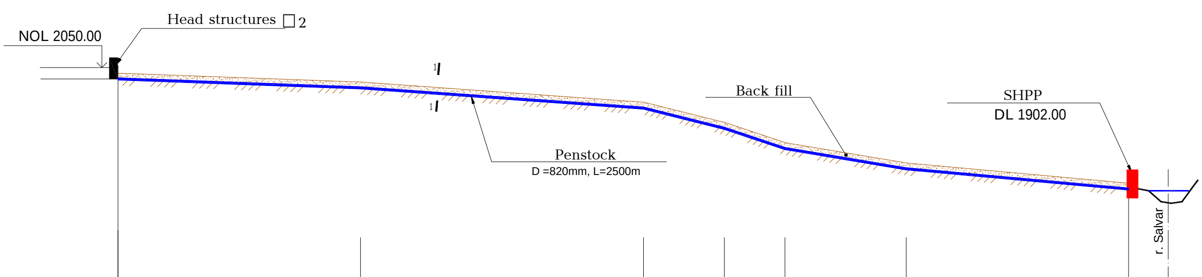
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		8.8	9.3
NPV, thousand USD			
	8%	35.7	35.7
	10%	-48.3	-15.3
	12%	-111.2	-50.1
	14%	-159.4	-74.1
PB, years (without discount)		10.5	15.0
Deadline for credit return, years			14.0

APPENDIX. 69. AREVIS SHPP-2

Plan



Longitudinal section



Pipe bottom elevation	2047.00	2025.00	2000.00	1975.00	1950.00	1925.00	1905.00
Distance, m	600	700	200	150	300	550	

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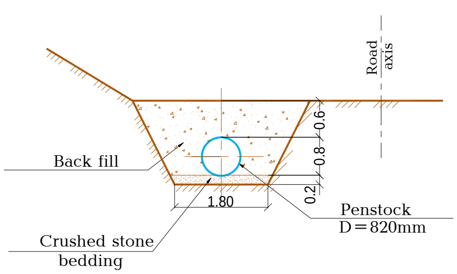
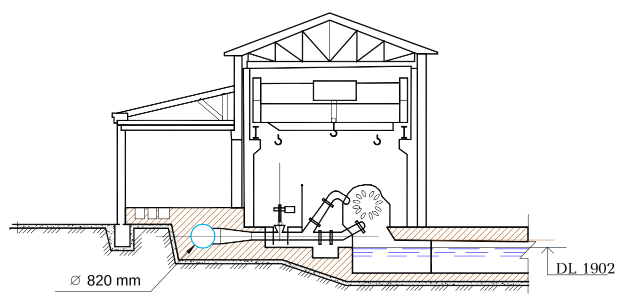


SHPP Powerhouse



Arevis SHPP-2

Introduction

Arevis SHPP-2 is planned to locate on the southern part of RA on the river Salvar. The station works are located before river Salvar discharges into river Sisian.

Arevis SHPP-2 uses inclination of River Salvar from 2050.0 till 1902.0. The length of derivation from Salvar River is 2500m by copper pipeline 820mm in diameter with design pressure of 138.8m and design discharge 0.90m^3/sec. After construction and exploitation Arevis SHPP-2 will have 1.00mwt capacity and will produce 2.890mln kw/h electricity annually.

Short Description for Salvar River Basin

Salvar River is the left inflow of Sisian River which is the right inflow of Vorotan River. River length is 11.0km, general chatchment area is 49.6km^2, average inclination is 229‰, and average elevation is 2550m.

River basin is located in the south-eastern part of Small Caucasian mountain chain. It borders with Baghdushan mountain chain from west to south-west. There river basin is located in the southern part of the republic. It borders with Vorotan river inflow basins from north, east and west; Voghji river basin from south ,divided by Baghdushar mountain chain (Geghakar mountain – 3348.3m)

From the geological point of view the basin slopes are composed of Oligocene volcanic soils that are comparatively weak cracked and water permeable.

The vegetative layer of the basin in the upstream is mainly alpine and sub alpine that is substituted by bushes and afterwards with forest.

In the upstream the river basin is represented by sub alpine earth. Salvar river basin is flat and sloeps are covered by meadows and bushes. River Salvar is a typical mountainous river that flows though a gorge with 55 -65^0 slope inclination.

HYDROLOGY

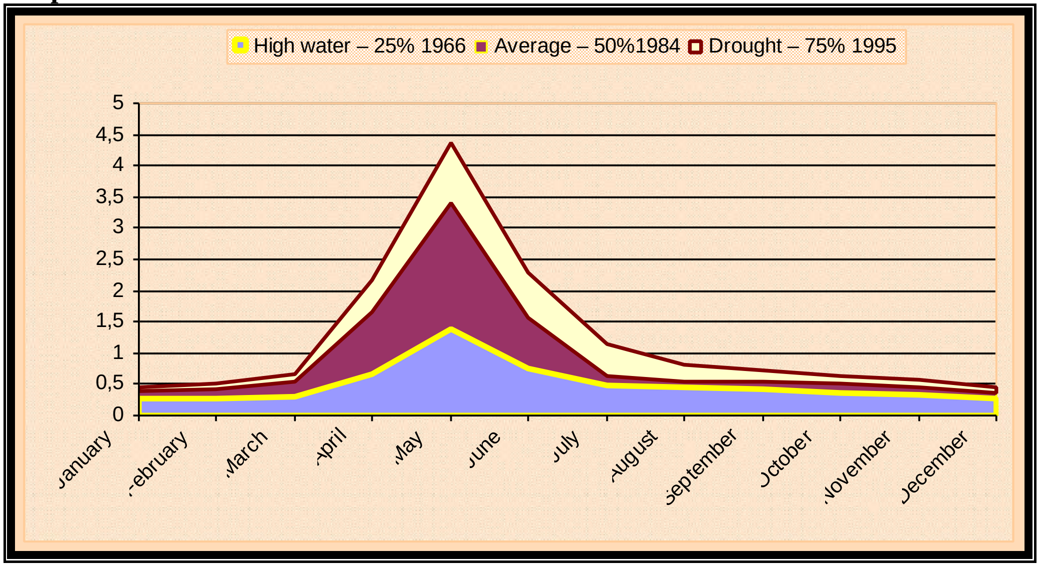
The observation data for 40 years from r. Sisian-Arevis water-meter station is used to define the hydrological properties of Arevis SHPP-2 headworks and the design river section.

The graphic below shows the hydrological properties of design river sections.

River Section	Distance from river mouth, km	Average altitude of the catchment basin, m.	Catchment area, km^2	Flow norms, m^3/sec
R. Salvar-longitudinal section -1	4.2	2650	25.4	0.42

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 73. Annual flow distribution



Maximal design discharge for Arevis SHPP-2 headwork river section for the general case equal 3% - 23.4m^3/sec, for verifying case - 0.5%-41.7m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.044m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Arevis SHPP-2 is 2050.0m, downstream - 1902.0m. According to Syunik Marz "Tolors" WUO there is no water intake for irrigational use from Salvar River. Arevis SHPP-2 is derivational SHPP. In order not to drain the river where 1200m derivational pipeline is the environmental discharge is designed according to RA laws and 0.03m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Arevis SHPP-2 are calculated with 50% guarantee per annum (1966 see table 152).

Table. 152. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Arevis SHPP-2 (m^3/sec)	0.12	0.14	0.24	1.00	2.01	0.82	0.13	0.09	0.12	0.16	0.10	0.08	
SHPP average monthly capacity (mwt)	0.11	0.13	0.25	1.00	1.00	0.89	0.12	0.07	0.11	0.15	0.08	0.06	
SHPP –average monthly energy production (mln kwt/hour)	0.08	0.09	0.18	0.72	0.72	0.64	0.09	0.05	0.08	0.11	0.06	0.04	**2.890**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 964.3 thousand USD (without VAT) and 1157.2 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		31.8
2. Exploitation expenses		29.3
	Salary	17.3
	Renovation	8.0
	Other Expenses	4.0
Total		61.1

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		999
Average multi annual production of energy, mln kwt/hour		2.89
Capital investments into SHPPS(without VAT),		
	thousand USD	964.3
	USD / kwt	965.3
	USD / kwt/hour	0.333
Prime cost of power production, cents/kwt hour		2.1

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- ❖ Private investments only /Scenario 1/
- ❖ 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

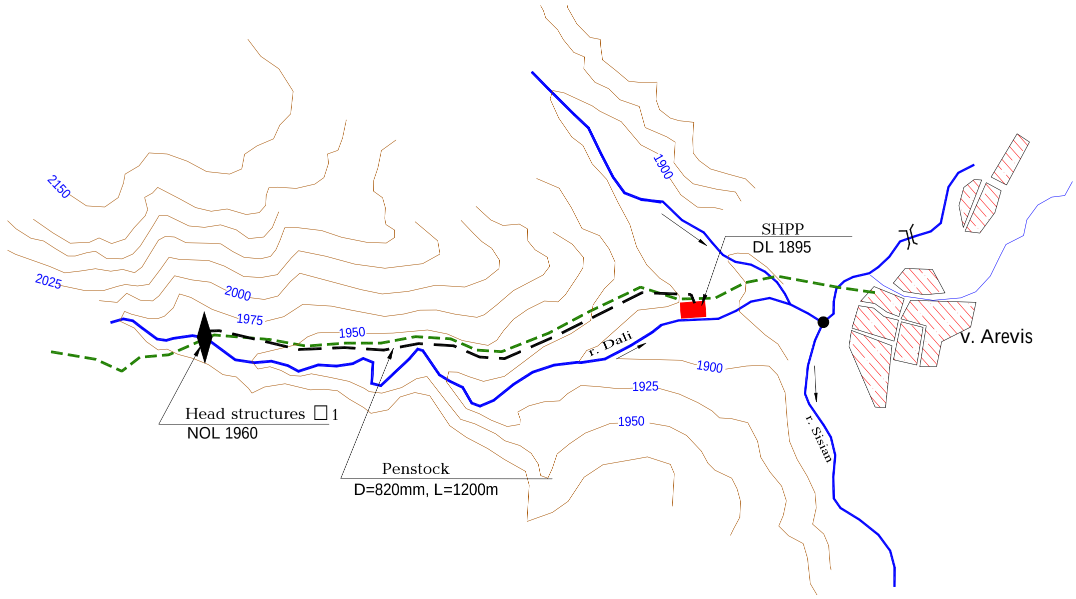
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 153. Design results according to financial scenarios

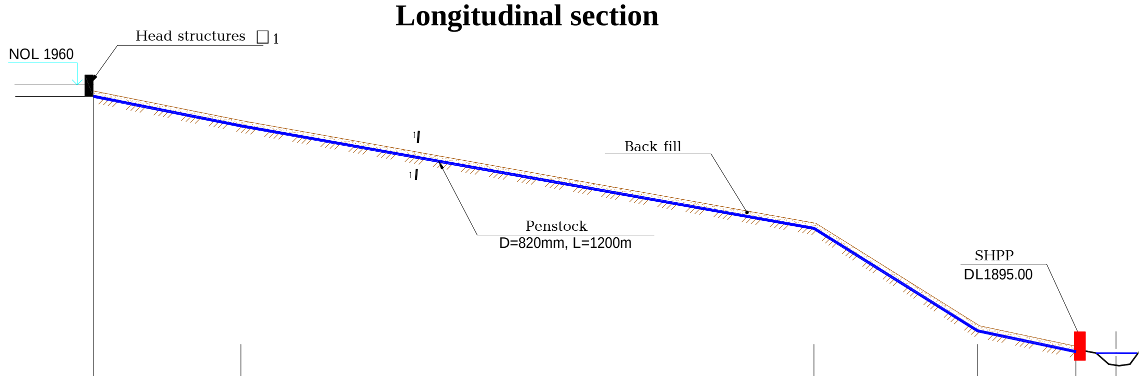
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		10.5	11.8
NPV, thousand USD			
	8%	233.1	233.1
	10%	38.3	92.0
	12%	-107.6	-6.7
	14%	-219.6	-76.7
PB, years (without discount)		9.1	11.9
Deadline for credit return, years			9.0

APPENDIX. 70. AREVIS SHPP-2

Plan

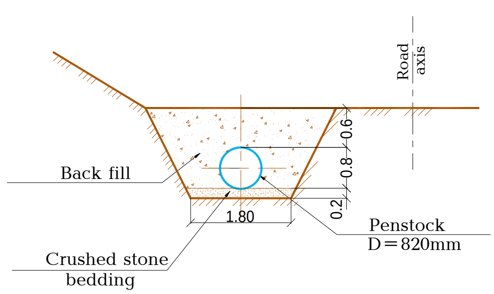


Longitudinal section

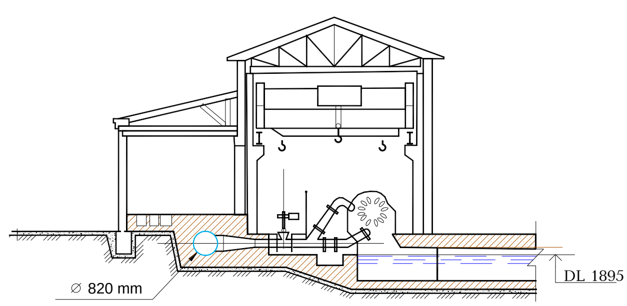


Pipe bottom elevation	1957.00		1950.00		1925.00		1900.00		1895.00
Distance, m		180		700		200		120	

1-1



SHPP Powerhouse



15.8.4.2. Jragatsidzor SHPP

Introduction

Jraghatsidzor SHPP will be located on the southern part f RA. The station works will be located before the Jraghatsidzor River falls into Tatec River.

Jraghatsidzor SHPP uses the river inclination from 16150.0 till 1500.0. The length of derivation from Jraghatsidzor River is 2800m by copper pipeline 720mm in diameter with design pressure of 102.95m and design discharge 0.70m^3/sec.

After construction and exploitation Jraghatsidzor SHPP will have 0.576mwt capacity and will produce 1.905mln kw/h electricity annually.

Short Description of Jraghatsidzor River Basin

Jraghatsidzor River is the left inflow of Satev River which is the inflow of Vorotan River. River length is 9.0km, general chatchment area is 24.2km^2, average inclination is 228‰, average elevation is 2050m. River basin is located in the south-eastern part of Small Caucasian mountain chain. It borders with Baghdushan mountain chain from west to south-west.

There river basin is located in the southern part of the republic. It borders with Vorotan river inflow basins from north, east and west; Voghji river basin from south divided by Baghdushar mountain chain (Geghakar Mountain – 3348.3m)

From the geological point of view the basin slopes are composed of Oligocene volcanic soils that are comparatively weak, cracked and water permeable.

The vegetative layer of the basin in the upstream is mainly alpine and sub alpine that is substituted by bushes and afterwards with forest. In the upstream the river basin is represented by sub alpine earth. Jraghatsidzor river basin is flat and slopes are covered by meadows and bushes.

River Jraghatsidzor is atypical mountainous river that flows though a gorge with 35 -45û slope inclination.

HYDROLOGY

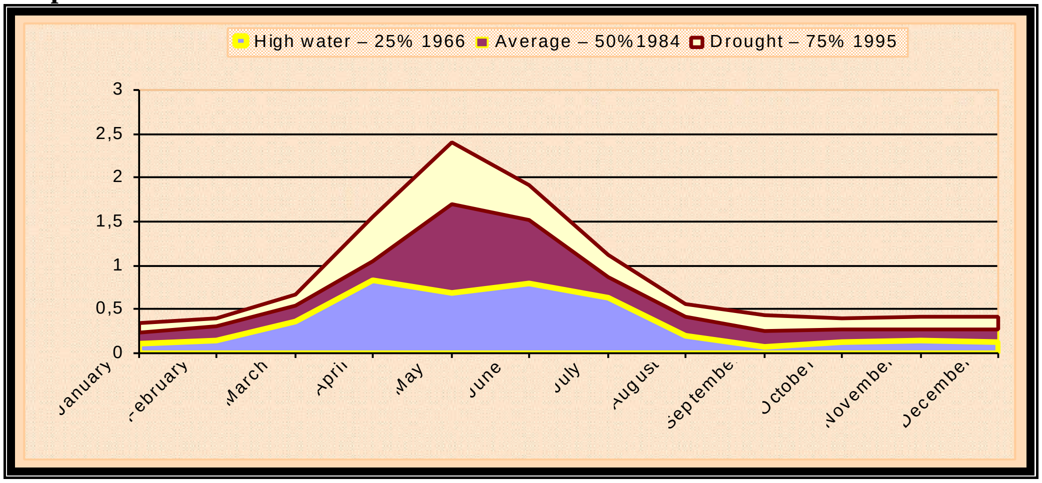
The observation data for 28 years from r. Tatev-Tatev water-meter station is used to define the hydrological properties of Jraghatsidzor SHPP headworks and the design river section.

The graphic below shows the hydrological properties of design river sections.

River Section	Distance from river mouth, km	Average altitude of the catchment basin, m.	Catchment area, km^2	Flow norms, m^3/sec
Jraghatsidzor--longitudinal section-1	3.6	2200	17.8	0.29

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 74. Annual flow distribution



Maximal design discharge for Jraghatsidzor SHPP headwork river section for the general case equal 3% - 15.3m^3/sec, for verifying case - 0.5%-22.3m^3/sec, the observed average dayly discharge value with 95% guarantee equals 0.015m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Jraghatsidzor SHPP is 1615.0m, downstream - 1500.0m. According to data of State Water Economy Data there is no water intake for irrigational use from Jraghatsidzor River. Jraghatsidzor SHPP is derivational SHPP. In order not to drain the river where 2800m derivational pipeline is the environmental discharge is designed according to RA laws and 0.011m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Jraghatsidzor SHPP are calculated with 50% guarantee per annum (1983 see table 154).

Table. 154. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Jraghatsidzor SHPP (m^3/sec)	0.13	0.15	0.17	0.20	1.02	0.72	0.22	0.21	0.18	0.15	0.14	0.15	
SHPP average monthly capacity (mwt)	0.109	0.127	0.145	0.172	0.576	0.576	0.190	0.181	0.154	0.127	0.118	0.127	
SHPP –average monthly energy production (mln kwt/hour)	0.081	0.086	0.108	0.124	0.429	0.415	0.142	0.135	0.111	0.095	0.085	0.095	**1.905**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 554.7thousand USD (without VAT) and 665.666 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		18.3
2. Exploitation expenses		20.9
	Salary	14.4
	Renovation	4.5
	Other Expenses	2.0
Total		39.2

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		576
Average multi annual production of energy, mln kwt/hour		1.905
Capital investments into SHPPS(without VAT),		
	thousand USD	554.7
	USD / kwt	963.0
	USD / kwt/hour	0.29
Prime cost of power production, cents/kwt hour		2.06

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

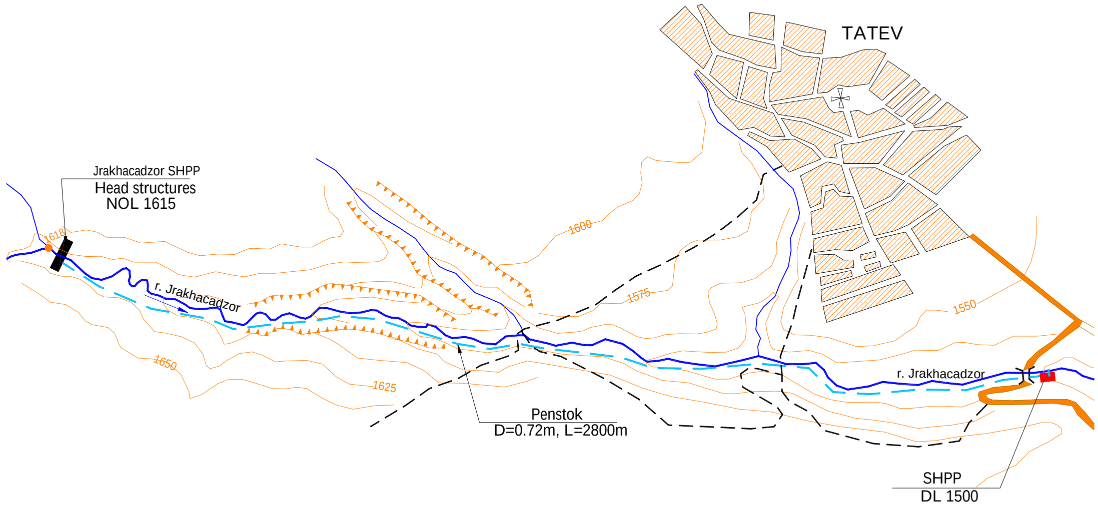
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 155. Design results according to financial scenarios

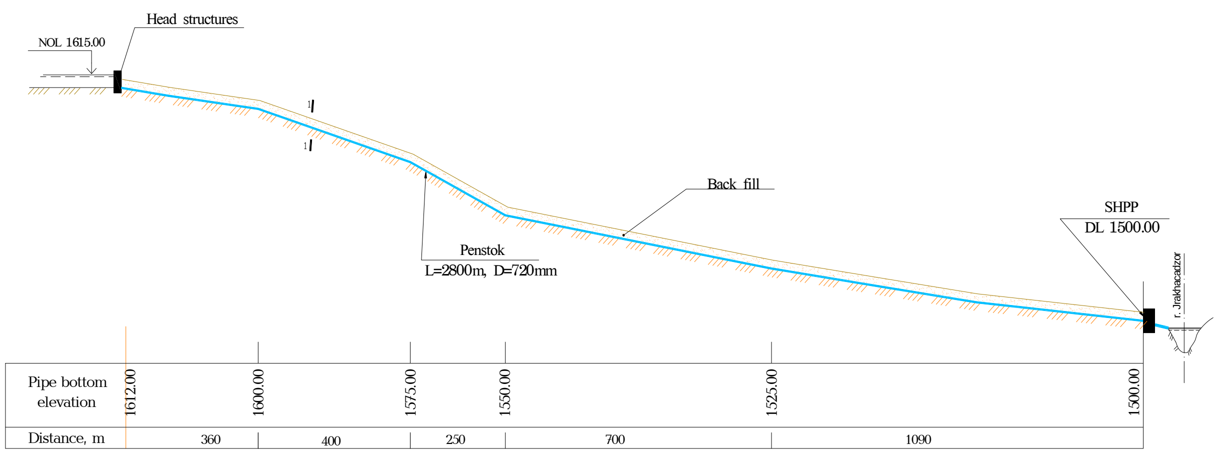
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		11.9	14.0
NPV, thousand USD			
	8%	214.4	214.4
	10%	89.3	117.6
	12%	-4.4	49.0
	14%	-76.3	-0.36
PB, years (without discount)		8.1	10.4
Deadline for credit return, years			8.0

APPENDIX. 71. JRAKHACADZOR SHPP

Plan



Longitudinal section



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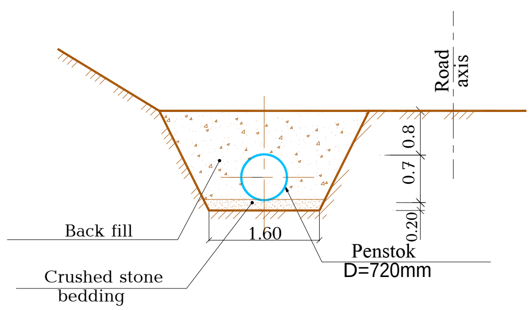
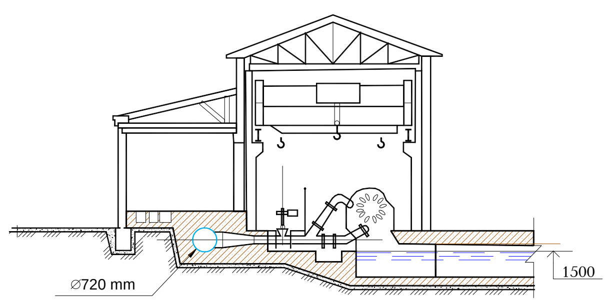


SHPP Powerhouse



15.8.5. Verified and updated scheme for Voghji River Basin SHPPs

15.8.5.1. General Information

According to development scheme it was planned to construct 37 SHPPs. It is planned to get construction permission for 6 SHPP envisaged for Kapan town water supply pipeline on Geghi River Gyuard and Aghibaz.

Construction of 2 SHPPs on Voghji river upstream flows is not appropriate as far as Kagharan administration is planning to construct a reservoir.

Technical substantiation design is carried out for SHPP situated neat Geghi reservoir.

In-situ investigations verified unappropriated SHPP indicators, and the possibility of new SHPP construction on Geghi river and its Kirs inflow.

According to the development scheme of Tsav river basin it is planned to construct 9 SHPPs; currently TSAV rivers 1-4 have the permission fr construction.

In-situ investigations verified unappropriated SHPP indicators, and the possibility of new SHPP construction on Mazra River.

In 90-ties most of the river flow was transferred to Meghriget by means of a pipeline. This makes it impossible to construct previously planned SHPPs on Sakarsu River, due to flow reduction.

The plan for SHPP on the chute of Kagharan Copper-Molybdenum Plant has not been verified since the last investigations, thus, the Plant administration foresees a new plan after which it would be possible to consider construction options for new SHPPs.

15.8.5.2. Short Description of Voghji River Basin and Climatic Conditions

River Voghji is the left inflow of River Araks. River length on the territory of Armenia is 48km and catchment area 933km^2, with 0.038% of average inclination and 2200m of average catchment area elevation.

River basin is located in the southern part of Armenia. River basin borders with Akera River from the west and north-west, which is the main inflow of Vorotan, afterwards it merges with Araks river basin with dividing Kharabakh mountain plateau (3581m) from north and west, together with Arpa River Basin which is separated by Zangezur mountain chain. The basin also borders with Voghji River Basin, divided by Bargushan mountain chain.

Voghji river basin is located in the south of the republic. The river starts from several small ice lakes 3530m. Voghji river basin borders with Vorotan river from north, divided from one another by Bargushat mountain chain (Aramaz mountain-3399m), Nakhijevan rivers from, divided by Zangezur mountain chain Kaputjur Mountain – 3904m, Meghri river basin from south east, divided by Megri mountain chain 2811m and Tsav River basin from Bazats mountain – 3249.3m.

The river basin is uneven with multiple inflow basins and small gorges, many of which were formed in a result of mudflows caused by rains. Voghgi has a typical mountainous nature with complicated physical - geographic conditions.

The geographical composition of Voghji River basin is complicated with volcanic rocks and sedimentary type of stones. The soil cover is diverse but mainly composed of dark brown soils. The forest covers 18% of Voghji river basin.

The vegetative cover is also diverse and different from that of neighboring basins, there are forest in the downstream and meadows in the upstream.

The river valley mainly goes through a deep gorge which becomes flatter near Kajaran city. Left and right banks of the river are mountainous and inclined.

The river has a well developed river network with many mud flow inflows falling into the river brom both banks, creating complicated relief and at the same time leave a significant influence on the average river flow. River Voghji is a typical mountainous river with mixed feeding: now melting snow, ground waters and rains. The water regime is characterized by spring-summer floods. The flood peaks are observed in second half of May or in June. The maximal discharges are observed in spring-summer period in April-May. The minimal discharge is observed in winter as well as in summer droughts.

From the climatic point of view Voghji river basin crosses 6 climatic zones, staring from dry continental to mountainous regime. The SHPPs are located in the following zones.

- Mild-warm zone: mild winter,
- Mild zones with mild winter,
- Mild zone with warm long simmer and cold winter.

For climate description the following multi annual data is used.

№№	Station	Elevation, m	Observation period	Number of observational years.
1.	Majaran	1980	1933-workign	74
2.	Geghi	1558	1948-working	59
3.	Kapan	704	1933-working	71

According to meteorological stations of Kajaran, Gekhi, Kapan data average multi-annual air temperature equals 6.9^0C to 11.9^0C, absolute minimum equals (-19°C) – (-29°C), absolute maximum (+33°C)- (+42°C), the soil freezing maximum is 42-66cm.

The precipitation volume depends on elevation and slope exposition. Average multi-annual precipitation volume in Kapan is 840 mm, Ghekhi-660mm, monthly precipitation volume is 224 mm in Kapan and 124mm in Gekhi, while the daily average is 176 in Kapan and 44mm in Gekhi. The maximal moisture content 7.1-7.3mb, comparative moisture content is 68-71%. Annual average winter speed is 1.0-1.6m/sec. With 5% guarantee in Kapan is 21m/sec and 32m/sec in Gekhi.

15.8.5.3. Voghji River Regime and Design Data

Voghji river is if typical mountainous nature with seasonal water regime. Water regime is characterized by spring snow melting and rain floods which reduce very slowly due to prolonged melting of snow and glaciers in Meghri and Zangezur and lasts from April till July.

The inundation peak usually takes place in May and there is often a short term peak in April.

Voghji river basin discharges according to several observation points are shown on the table below.

Water meter station	Distance from the river mouth, km	Average elevation of reservoir, m.	Catchment area, km^2	Exploitation timeline		Exploitation timeline	Normal Flow, m^3/sec
				started	started		
Voghji-Kagharan	69	2840	120	1950	2006	1755.82	3.27
Kagharan-Ghapan	9.5	1670	35.0	1970	1988	801.08	0.43
Geghi-Geghi	11	2640	195	1950	1987	1539.07	4.32
Khachin-Rozdere	14	1710	266	1959	1980	566.98	2.08

The abovementioned data rows were used to receive average flow indicators and annual distribution to restore the natural flow indicators. Khachin-Rozdere observation point has been an analogue for Shishkerd, Mazra and Bentadzor river sections. Table 3 shows annual distribution of Voghji river basin rivers for typical rivers.

year	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	average
Voghji-Kagharan													
Water Abundant – 25%													
1984	1.53	1.51	1.92	3.51	4.80	15.1	11.9	2.93	1.51	1.45	1.40	1.35	4.08
Average – 50%													
1990	0.69	0.72	0.70	3.03	10.7	12.7	5.14	1.94	0.77	0.71	0.80	0.78	3.22
Drought – 75%													
2005	0.28	0.28	0.29	1.11	7.66	13.1	7.16	1.21	0.29	0.29	0.28	0.28	2.68
Geghi-Geghi													
Water Abundant – 25%													
1985	2.17	2.27	2.54	8.05	16.8	17.2	6.10	2.52	2.06	1.80	1.75	1.66	5.42
Average – 50%													
1970	1.75	1.56	2.08	8.57	10.6	10.5	5.90	3.35	1.93	1.48	1.32	1.29	4.19
Drought – 75%													
1953	1.04	1.04	1.08	3.68	8.82	10.8	7.38	3.27	1.52	1.15	1.03	0.99	3.48
Khachin-Rozdere													
Water Abundant – 25%													
1978	0.87	1.48	3.16	5.59	9.28	9.58	2.23	1.11	0.85	1.10	1.35	1.55	3.18
Average – 50%													
1975	0.89	0.90	2.40	3.43	5.53	1.80	0.58	0.51	0.80	1.64	084	1.70	1.75
Drought – 75%													
1980	0.74	077	3.64	5.23	3.43	088	0.32	0.24	0.45	0.53	0.92	0.51	1.47
Vachagan-Ghapan													
Water Abundant – 25%													
1973	0.097	0.15	0.31	1.23	1.16	0.77	0.47	0.45	0.52	0.21	0.46	0.35	0.52
Average – 50%													
1976	0.30	0.20	0.53	1.42	1.29	0.35	0.17	0.088	0.097	0.10	0.13	0.19	0.41
Drought – 75%													
1982	0.070	0.15	0.33	0.90	0.73	0.35	0.25	0.52	0.11	0.088	0.11	0.13	0.31

15.8.5.4. Technical Specifications for Vighji River Basin SHPPs

15.8.5.4.1.Betnadzor SHPP
Introduction

It is planned to locate Betnadzor SHPP in the southern part of RA. The SHPP uses inclination of River Betnadzor from 875.0 till 750.0. The length of derivation from Betnadzor is 1700m by copper pipeline 530mm in diameter with design pressure of 111.7m and design discharge 0.40m^3/sec.
After construction and exploitation Betnadzor SHPP will have 0.36mwt capacity and will produce 1.531mln kw/h electricity annually.

Short Description for Betnadzor **River Basin**

Betnadzor River is the right inflow of Tsav River which is the left inflow of Araks River and discharges into the latter 251km from the river mouth. River length is 6.3km, general chatchment area is 43.2km^2, average inclination is 49‰, average elevation is 1600m, and forest coverage is 95%.

River basin is located in the south. The river starts from Meghri mountain passage, Khosup Mountain on the elevation of 2269.5m.

Bentadzor river basin borders with Tsav river basin from north east, and west and Araks river basin from south divided by the southern part of Meghri mountain chain.

The river basin is formed by multiple gorges and mountain as well as multiple river and inflow basins, many of which were formed by mud flows caused by heavy rains.

Bentadzor river basin is a typical mountainous river basin conditioned by its physical -geographical conditions. The geographical composition is also complicated with volcanic rock types, clays and sedimentary layers.

Earth cover is of diverse nature; however, river basin is covered by dark brown soils and dark forest earth cover.

The vegetation is rich, diverse and differs from neighboring basins. In the downstream the vegetation is mainly composed of forests and in the upstream it is represented by alpine meadows.

HYDROLOGY

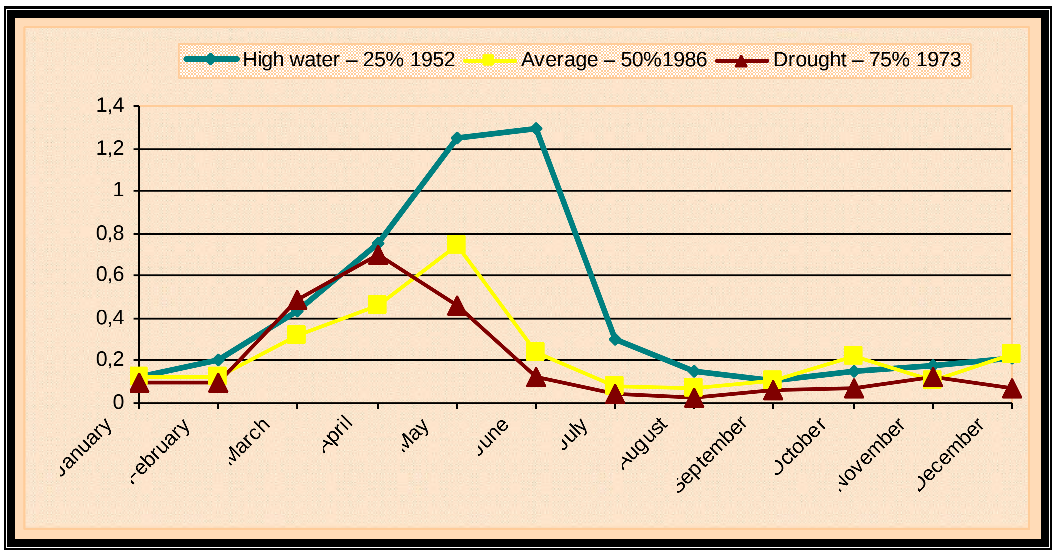
The observation data for 21 years from r. Khachin - Rozdere water-meter station is used to define the hydrological properties of Betnadzor SHPP headworks and the design river section.

The graphic below shows the hydrological properties of design river sections

River Section	Distance from river mouth, km	Average altitude of the catchment basin, m.	Catchment area, km^2	Flow norms, m^3/sec
R.Betnadzor - longitudinal section	2.0	1625	41.99	0.32

The graphic below shows the hydrological properties of design river sections

Graph. 75. Annual flow distribution



Maximal design discharge for Betnadzor SHPP headwork river section for the general case equal 3% - 31.8m^3/sec, for verifying case - 0.5%-44.0m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.028m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Betnadzor SHPP is 875.0m, downstream - 750.0m. According to data of State Water Economy Data there is no water intake for irrigational use from Dali River. Betnadzor SHPP is a derivational SHPP. In order not to drain the river where 1700m derivational pipeline is the environmental discharge is designed according to RA laws and 0.02m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Betnadzor SHPP are calculated with 50% guarantee per annum (1975 see table 156).

Table. 156. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Betnadzor SHPP (m^3/sec)	0.10	0.10	0.30	0.40	0.40	0.22	0.06	0.05	0.09	0.20	0.09	0.21	
SHPP average monthly capacity (mwt)	0.10	0.10	0.28	0.36	0.36	0.213	0.06	0.05	0.09	0.19	0.09	0.20	
SHPP –average monthly energy production (mln kwt/hour)	0.07	0.07	0.21	0.26	0.27	0.15	0.04	0.04	0.06	0.14	0.06	0.15	**1.53**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 386thousand USD (without VAT) and 463.2 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	12.7
2. Exploitation expenses	19.5
Salary	14.4
Renovation	3.1
Other Expenses	2.0
Total	32.2

Power indicators of have the following level

Indicators	Values
Derivation capacity, kwt	357
Average multi annual production of energy, mln kwt/hour	1.53
Capital investments into SHPPS(without VAT),	
thousand USD	386
USD / kwt	1081.2
USD / kwt/hour	0.25
Prime cost of power production, cents/kwt hour	2.1

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

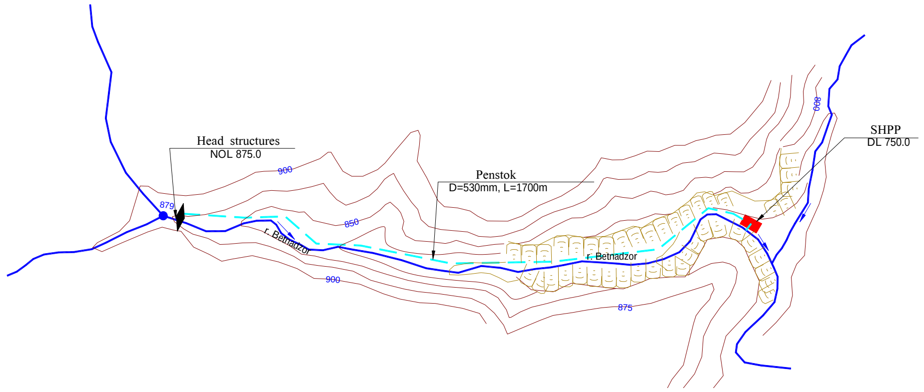
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 157. Design results according to financial scenarios

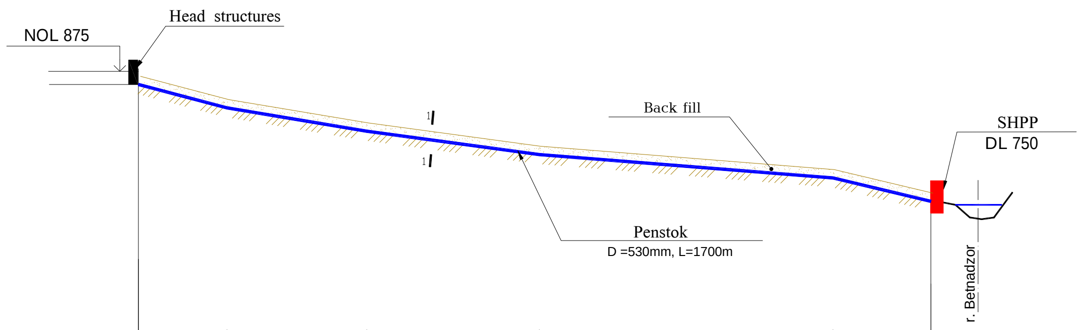
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		13.2	15.9
NPV, thousand USD			
	8%	204.4	204.4
	10%	108.4	126.2
	12%	36.4	70.2
	14%	-18.4	29.5
PB, years (without discount)		7.4	9.2
Deadline for credit return, years			7.0

APPENDIX. 72. BETNADZOR SHPP

Plan

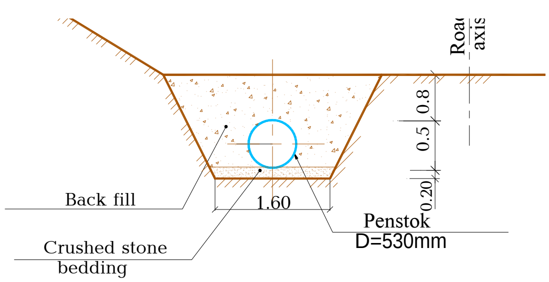


Longitudinal section

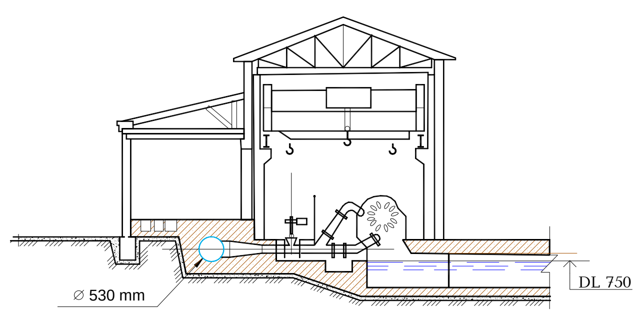


Pipe bottom elevation	872.00	850.00	825.00	800.00	775.00	750.00
Distance, m	600	550	350	310	190	

1-1



SHPP Powerhouse



15.8.5.4.2. Shishkert SHPP -1,2

Shishkert SHPP -1

Introduction

Shishkert SHPP-1 uses inclination of River Shishkert from 1575.0 till 1415.0. The length of derivation from Shishkert River is 2100m by copper pipeline 720mm in diameter with design pressure of 145.2m and design discharge 0.90m^3/sec.
After construction and exploitation Shishkert SHPP-1 will have 1.05mwt capacity and will produce 4.20mln kw/h electricity annually.

Short Description for Shishkert River

Shishkert River is the left inflow of Tsav River which is the left inflow of Araks River and discharges into the latter 251km from the river mouth. Shishkert River length is 13.3km, general chatchment area is 45.7km^2, average inclination is 40‰, average elevation is 3200m, and forest coverage is 40%.
River basin is located in the south. The river starts from Meghri mountain passage, Khosup Mountain on the elevation of 2829.5m.

Bentadzor river basin borders with Tsav river basin from south, east and west and Voghji river inflow basins from north.

The river basin is formed by multiple gorges and mountain as well as multiple river and inflow basins, many of which were formed by mud flows caused by heavy rains.

Shishkert river basin is a typical mountainous river basin conditioned by its physical -geographical conditions. The geographical composition is also complicated with volcanic rock types, clays and sedimentary layers.

Earth cover is of diverse nature; however, river basin is covered by dark brown soils and dark forest earth cover.

The vegetation is rich, diverse and differs from neighboring basins. In the downstream the vegetation is mainly composed of forests and in the upstream it is represented by alpine meadows.

HYDROLOGY

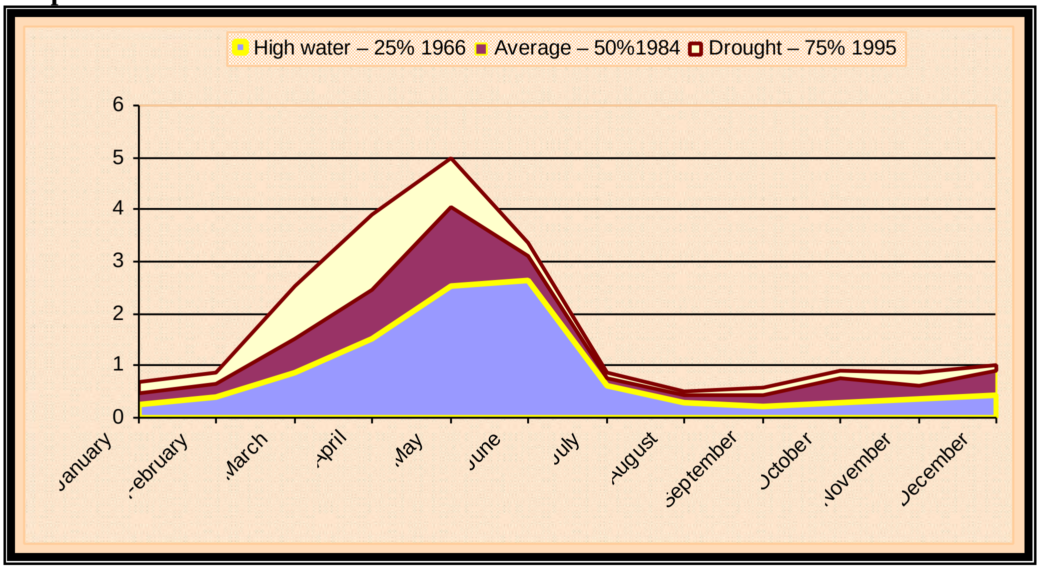
The observation data for 21 years from r. Khachin -Rozdere water-meter station is used to define the hydrological properties of Shishkert SHPP-1 headworks and the design river section.

The graphic below shows the hydrological properties of design river sections.

River Section	Distance from river mouth, km	Average altitude of the catchment basin, m.	Catchment area, km^2	Flow norms, m^3/sec
R. Shishkert 1- longitudinal section	3.8	2420	34.2	0.58

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 76. Annual flow distribution



Maximal design discharge for Shishkert SHPP-1 headwork river section for the general case equal 3% - 29.3m^3/sec, for verifying case - 0.5%-40.5m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.058m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Shishkert SHPP-1 is 1575.0m, downstream - 1415.0m. According to data of WUO there is no water intake for irrigational use from Dali River. Shishkert SHPP-1 is derivational SHPP. In order not to drain the river where 2100m derivational pipeline is the environmental discharge is designed according to RA laws and 0.04m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Shishkert SHPP-1 are calculated with 50% guarantee per annum (1975 see table 158).

Table. 158. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Shishkert SHPP-1 (m^3/sec)	0.20	0.21	0.62	0.90	0.90	0.45	0.12	0.10	0.18	0.41	0.19	0.43	
SHPP average monthly capacity (mwt)	0.25	0.27	0.76	1.05	1.05	0.56	0.15	0.13	0.23	0.51	0.24	0.54	
SHPP –average monthly energy production (mln kwt/hour)	0.19	0.18	0.56	0.75	0.78	0.40	0.11	0.10	0.17	0.38	0.17	0.40	**4.20**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 1367.3 thousand USD (without VAT) and 1640.8 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		45.1
2. Exploitation expenses		31.3
	Salary	17.3
	Renovation	11.0
	Other Expenses	3.0
Total		76.4

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		1045
Average multi annual production of energy, mln kwt/hour		4.20
Capital investments into SHPPS(without VAT),		
	thousand USD	1367.3
	USD / kwt	874.2
	USD / kwt/hour	0.32
Prime cost of power production, cents/kwt hour		1.8

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

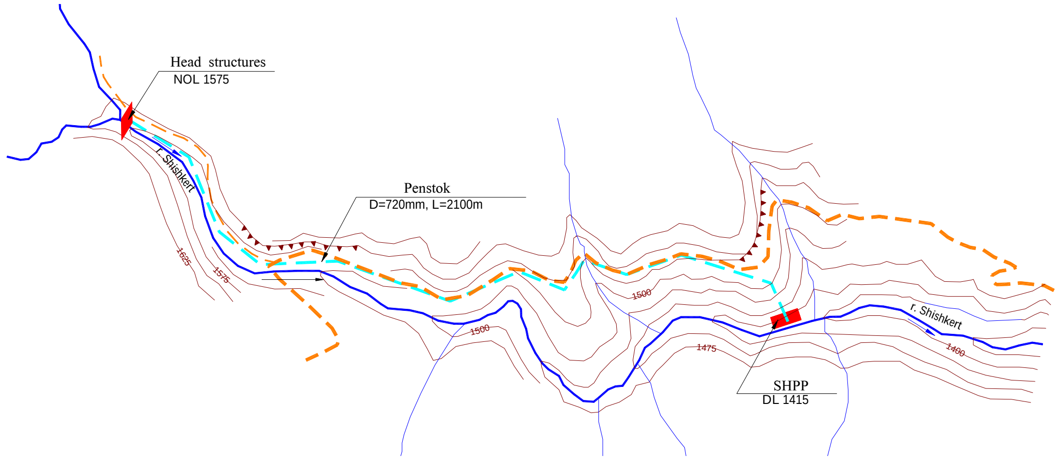
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 159. Design results according to financial scenarios

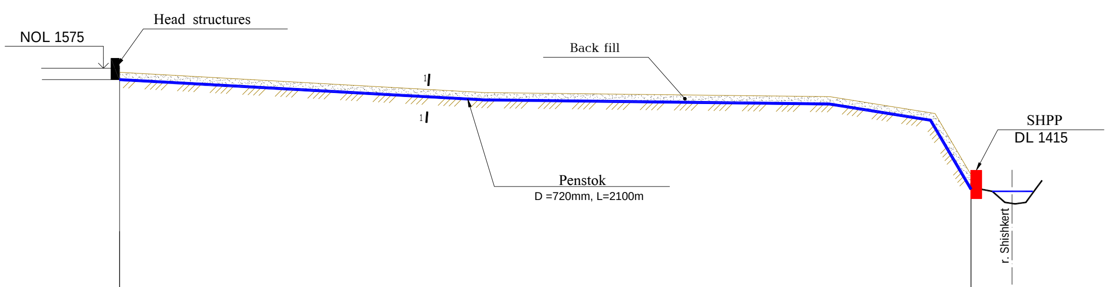
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		11.5	13.3
NPV, thousand USD			
	8%	472.0	472.0
	10%	172.8	242.5
	12%	-51.4	80.4
	14%	-223.4	-36.1
PB, years (without discount)		8.4	10.7
Deadline for credit return, years			8.0

APPENDIX. 73. SHISHKERT SHPP-1

Plan

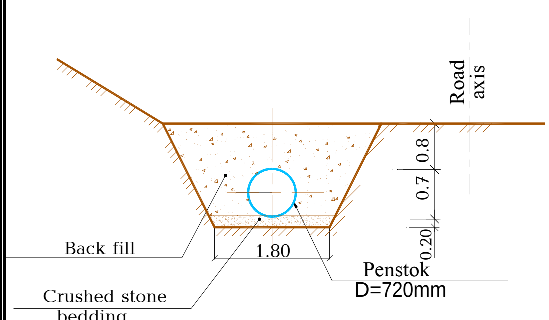


Longitudinal section

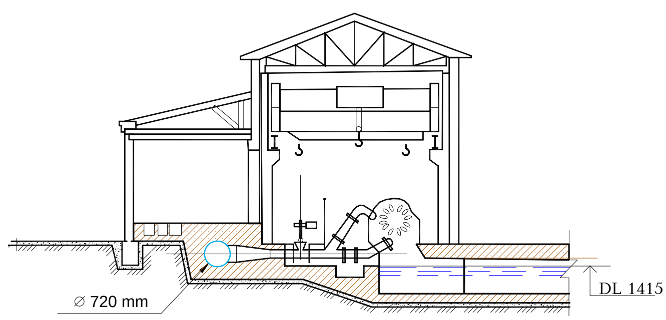


Pipe bottom elevation	1572.00	1525.00	1520.00	1500.00	1415.00
Distance, m	900	850	200	100	

1-1



SHPP Powerhouse



Shishkert SHPP-2, Mazra SHPP

Introduction

IT is planned to construct 2 SHPPs of Tsav River's Shishkert and Mazra inflows, with ine station works. Shishkert SHPP-2 will be located on Shoshkert inflow which is the left inflow of Tsav River. Shishkert SHPP-2 used the derivation of river Shishkert from 1400.0 till 1220.0. The length of derivation from Shishkert River is 2300m by copper pipeline 720mm in diameter with design pressure of 163.8m and design discharge 0.90m^3/sec.

After construction and exploitation Shishkert SHPP-2 will have 1.18mwt capacity and will produce 4.77mln kw/h electricity annually.

Mazra SHPP is planned to be located on River Mazra which is the right inflow of Tsav River. Mazra SHPP uses inclination of River Mazra from 1400.0 tyo 1220.0. The length of derivation from Salvar River is 1050m by copper pipeline 720mm in diameter with design pressure of 172.9m and design discharge 0.90m^3/sec. Mazra SHPP will have 1.24mwt capacity and will produce 4.86mln kw/h electricity annually.

Short Description of Mazra River Basin

Mazra River is the right inflow of Tsav River which is the left inflow of Araks River and discharges into the latter 251km from the river mouth. Mazra river length is 6.3km, general chatchment area is 43.7km2, average inclination is 49‰, average elevation is 2200m, and forest coverage is 71%.

River basin is located in the south. The river starts from Meghri mountain passage, Khosup Mountain on the elevation of 2825.5m.

Mazra river basin borders with Tsav river basin from north, east, and west and Araks river basin from south divided by the southern part of Meghri mountain chain.

The river basin is formed by multiple gorges and mountain as well as multiple river and inflow basins, many of which were formed by mud flows caused by heavy rains.

Mazra river basin is a typical mountainous river basin conditioned by its physical -geographical conditions. The geographical composition is also complicated with volcanic rock types, clays and sedimentary layers.

Earth cover is of diverse nature; however, river basin is covered by dark brown soils and dark forest earth cover.

The vegetation is rich, diverse and differs from neighboring basins. In the downstream the vegetation is mainly composed of forests and in the upstream it is represented by alpine meadows.

HYDROLOGY

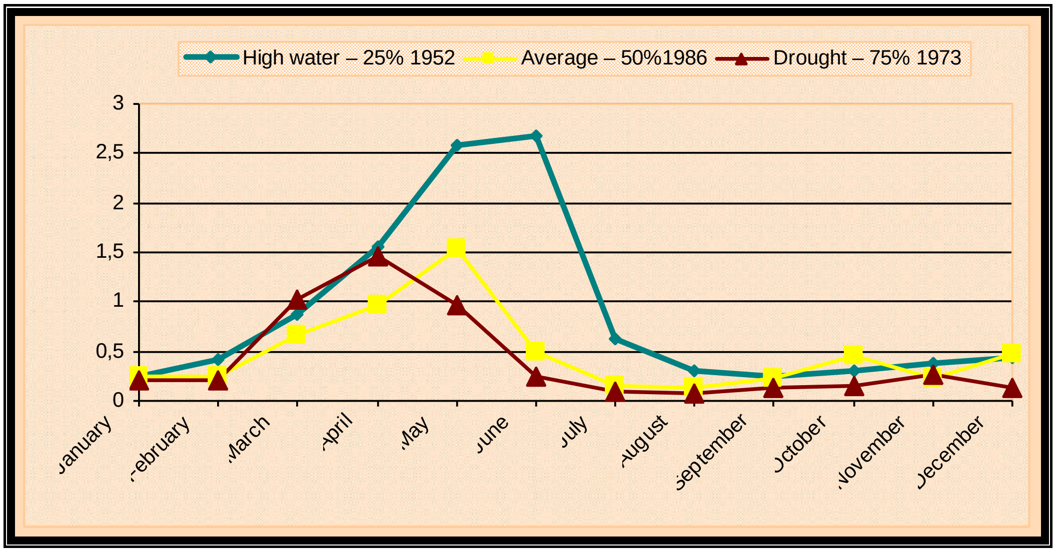
The observation data for 21 years from r. Khachin-Rozdere water-meter station is used to define the hydrological properties of Shishkert SHPP-2 and Mazra SHPP headworks and the design river section.

The graphic below shows the hydrological properties of design river sections.

River Section	Distance from river mouth, km	Average altitude of the catchment basin, m.	Catchment area, km^2	Flow norms, m^3/sec
R. Mazra-longitudinal section	1.0	2200	43.53	0.57
R. Shishkert 2-longitudinal section	1.9	2325	38.8	0.59

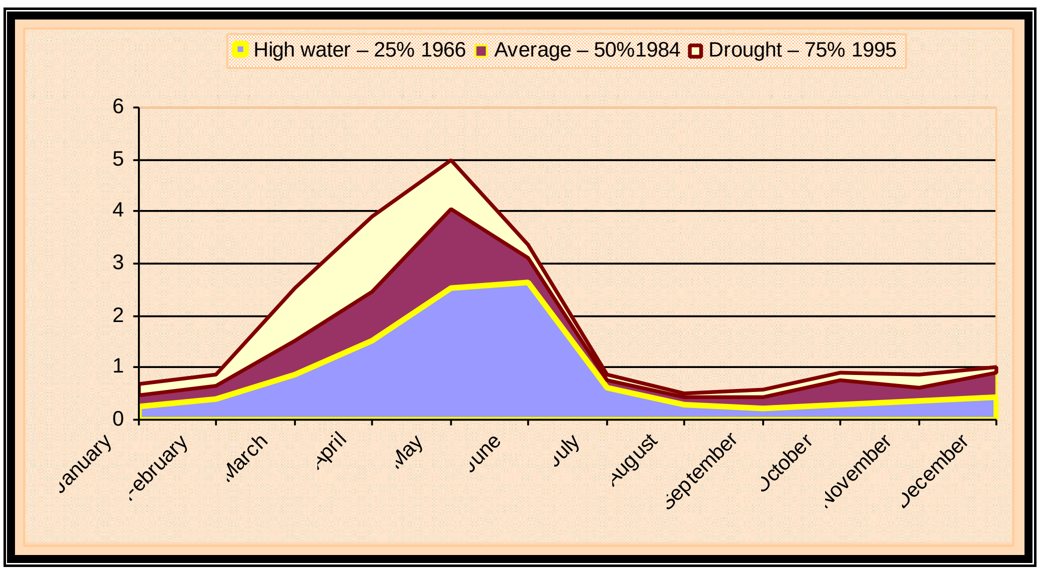
The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the Shishkert SHPP-2.

Graph. 77. Annual flow distribution



The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the Mazra SHPP.

Graph. 78. Annual flow distribution



Maximal design discharge for Shishkert SHPP-2 headwork river section for the general case equal 3% - 30.8.4m^3/sec, for verifying case - 0.5%-42.6m^3/sec, and for Mazra3% - 32.2 m3/sec, 0.5% - 44.6 m3/sec.
The observed average daily minimum discharge value for Shishkert SHPP-2 with 95% guarantee equals 0.059m3/sec and for Mazra SHPP 0.58% m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Shishkert SHPP-2 is 1400.0m, downstream - 1220.0m and 1400-1220 for Mazra SHPP. According to Syunik Marz “Kapan” WUO there is no water intake for irrigational use from Shishkert and Mazra Rivers.

Mazra SHPP-2 is derivational SHPP. In order not to drain the river where 2300m derivational pipeline is the environmental discharge is designed according to RA laws and 0.04m^3/sec.

Mazra river has 1050m derivational pipeline is the environmental discharge is designed according to RA laws and 0.04m^3/sec.

All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Shishkert SHPP-2 and Mazra SHPPs are calculated with 50% guarantee per annum (1975 see table 160 and 161).

Table. 160. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Shishkert SHPP - 2(m^3/sec)	0.21	0.21	0.63	0.90	0.90	0.46	0.12	0.10	0.18	0.42	0.19	0.43	
SHPP average monthly capacity (mwt)	0.30	0.30	0.87	1.18	1.18	0.65	0.17	0.14	0.26	0.59	0.27	0.61	
SHPP –average monthly energy production (mln kwt/hour)	0.22	0.20	0.64	0.85	0.88	0.47	0.13	0.11	0.19	0.44	0.20	0.45	**4.77**

Table. 161. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Mazra SHPP (m^3/sec)	0.20	0.21	0.62	0.90	0.90	0.45	0.12	0.10	0.18	0.41	0.19	0.43	
SHPP average monthly capacity (mwt)	0.29	0.30	0.88	1.24	1.24	0.64	0.17	0.14	0.26	0.59	0.27	0.61	
SHPP –average monthly energy production (mln kwt/hour)	0.21	0.20	0.65	0.90	0.93	0.46	0.13	0.11	0.19	0.44	0.20	0.46	**4.86**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 2033.8 thousand USD (without VAT) and 2440.6 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	67.1
2. Exploitation expenses	50.1
Salary	28.8
Renovation	16.3
Other Expenses	5.0
Total	117.2

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		2424
Average multi annual production of energy, mln kwt/hour		9.63
Capital investments into SHPPS(without VAT),		
	thousand USD	2033.8
	USD / kwt	839.0
	USD / kwt/hour	0.21
Prime cost of power production, cents/kwt hour		1.22

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

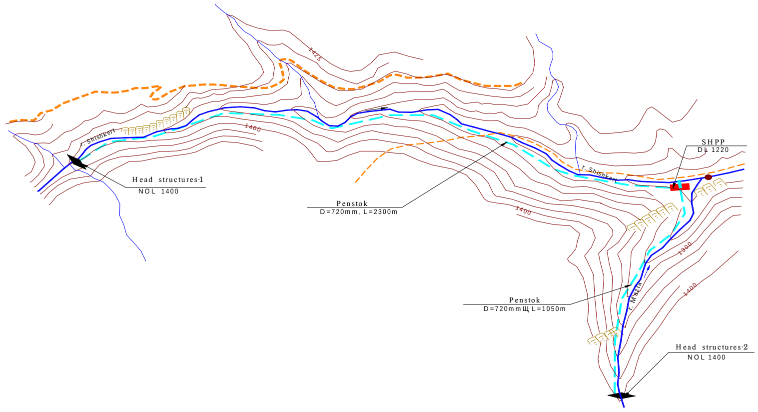
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 162. Design results according to financial scenarios

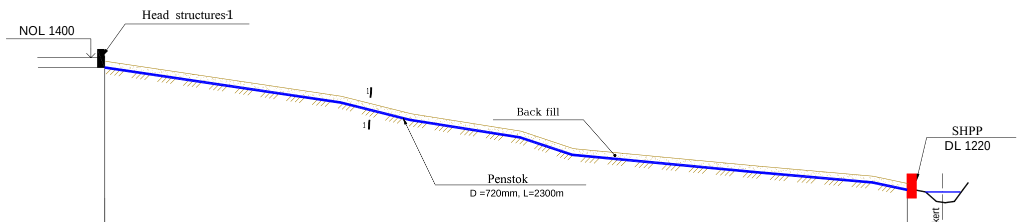
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		18.8	24.3
NPV, thousand USD			
	8%	2300.8	2300.8
	10%	1595.7	1668.4
	12%	1067.4	1207.2
	14%	662.1	863.6
PB, years (without discount)		5.3	6.3
Deadline for credit return, years			5.0

APPENDIX. 74. SHISHKERT SHPP-2 & MAZRA SHPP

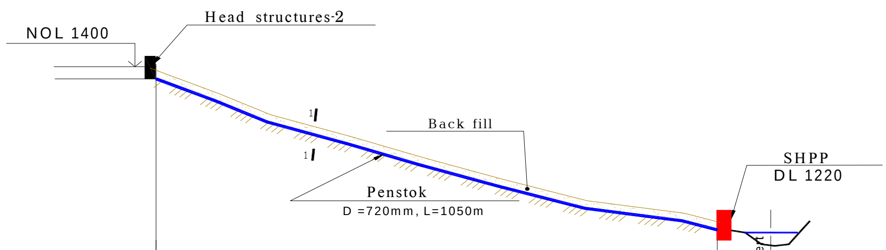
Plan



Longitudinal section



Pipe bottom elevation	1397.00	1375.00	1350.00	1325.00	1300.00	1275.00	1250.00	1220.00
Distance, m	350	325	200	315	150	530	430	



Pipe bottom elevation	1397.00	1375.00	1350.00	1325.00	1300.00	1275.00	1250.00	1220.00
Distance, m	110	100	150	140	150	160	250	

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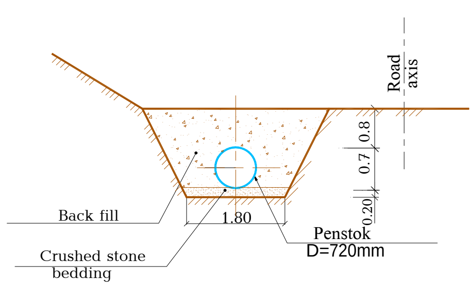
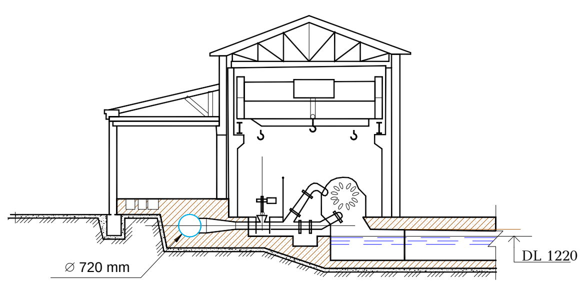


SHPP Powerhouse



15.8.5.4.4.Kirs SHPP

Introduction

Kirs SHPP is planned to locate on the southern part of RA. Kirs SHPP uses inclination of River Kirs from 1667.6 till 1576.0. The length of derivation from Kirs River is 2000m by copper pipeline 1020mm in diameter with design pressure of 79.7m and design discharge 2.00m^3/sec.After construction and exploitation Kirs SHPP will produce 4.64mln kw/h electricity annually.

Short Description for Kirs River Basin

Kirs River is the left inflow of Geghi River that is the left inflow of Voghji River that falls into the latter 56m from the river mouth.River length is 15.0km, general chatchment area is 52.0km^2, average inclination is 55‰, average elevation is 2510m, and forest coverage is 2%.

Kirs River basin is located to the south of the republic; it starts from Khustup mountain of Baghushat mountain passage on the elevation of 3350m. It borders with Vorotan river basin from north with dividing Baghushat mountain chain (Geghasar 3348m), and Voghji River basin from west, east and south. The river basin is formed by multiple gorges and mountain as well as multiple river and inflow basins, many of which were formed by mud flows caused by heavy rains.

Kirs River is a typical mountainous river. The relief is complicated with inflow basins. The geological composition of the basin is volcanic consisting of basalt lavas, andeside basalts and tuffs. Vegetation of the basin is not very rich. The upper streams are represented by alpine and sub-alpine meadows; there are oak and leaf forests. The earth cover is represented by alpine and, dry-prairie, dark brown soils. Mountain forest soils are prevailing near the river mouth.

HYDROLOGY

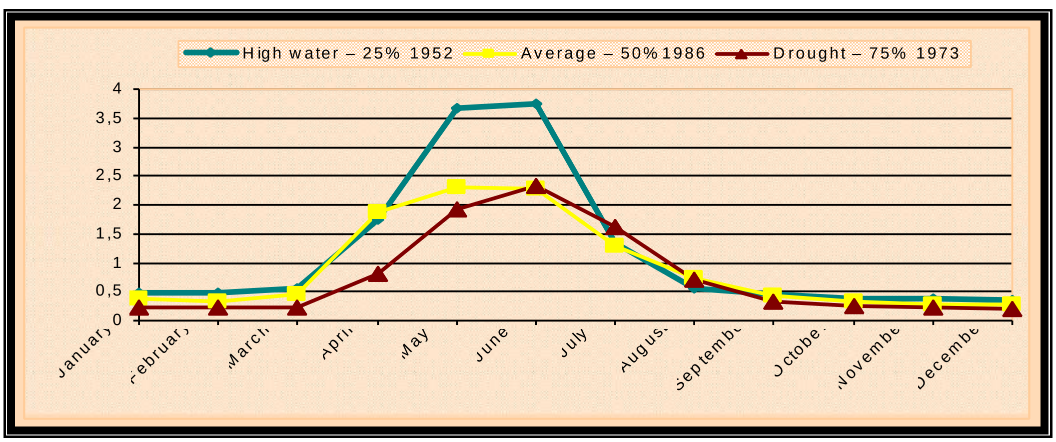
The observation data for 38 years from r. Gekhi-Gekhi water-meter station is used to define the hydrological properties of Kirs SHPP headworks and the design river section.

The graphic below shows the hydrological properties of design river sections.

River Section	Distance from river mouth, km	Average altitude of the catchment basin, m.	Catchment area, km^2	Flow norms, m^3/sec
R. Kirs-longitudinal section	1.9	2550	48.4	0.94

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 79. Annual flow distribution



Maximal design discharge for Kirs SHPP headwork river section for the general case equal 3% - 45.4m^3/sec, for verifying case - 0.5%-75.8m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.12m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Kirs SHPP is 1667.6m, downstream - 1576.0m. According to Syunik Marz WUO there is no water intake for irrigational use from Kirs River. Kirs SHPP is derivational SHPP. In order not to drain the river where 2000m derivational pipeline is the environmental discharge is designed according to RA laws and 0.09m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Kirs SHPP are calculated with 50% guarantee per annum (1970 see table 163).

Table. 163. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Kirs SHPP (m^3/sec)	0.29	0.25	0.36	1.78	2.00	2.00	1.19	0.64	0.33	0.23	0.20	0.19	
SHPP average monthly capacity (mwt)	0.21	0.18	0.26	1.17	1.28	1.28	0.83	0.46	0.24	0.17	0.15	0.14	
SHPP –average monthly energy production (mln kwt/hour)	0.16	0.12	0.19	0.84	0.95	0.92	0.62	0.34	0.17	0.12	0.10	0.10	**4.64**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 1192.2 thousand USD (without VAT) and 1430.6 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	23.8
2. Exploitation expenses	26.1
Salary	17.3
Renovation	9.5
Other Expenses	4.0
Total	49.9

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		39.3
Average multi annual production of energy, mln kwt/hour		30.8
Capital investments into SHPPS(without VAT),		
	thousand USD	1192.2
	USD / kwt	934.4
	USD / kwt/hour	0.257
Prime cost of power production, cents/kwt hour		70.1

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

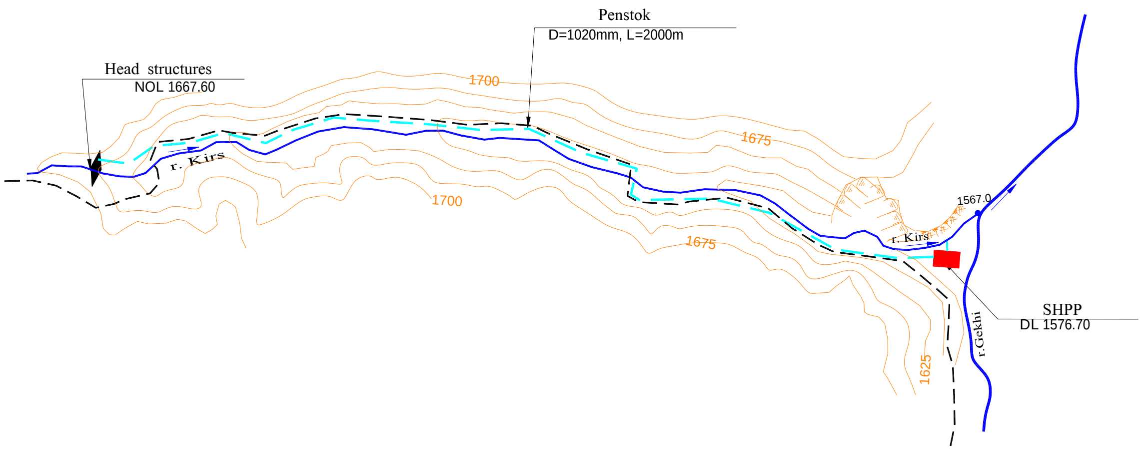
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

<u>Table. 164. Design results according to financial scenarios</u>

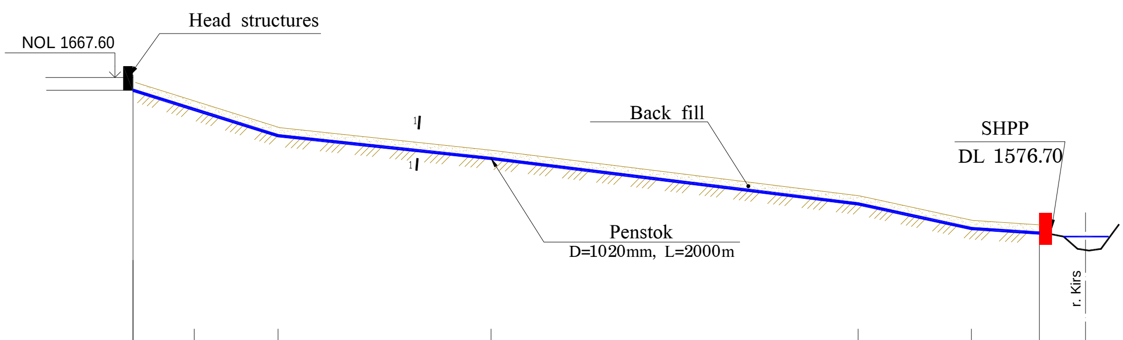
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		15.0	18.4
NPV, thousand USD			
	8%	850.8	850.8
	10%	518.4	567.4
	12%	269.4	362.9
	14%	78.4	212.5
PB, years (without discount)		6.6	8.0
Deadline for credit return, years			6.0

APPENDIX. 75. KIRS SHPP

Plan



Longitudinal section



Pipe bottom elevation	1664.60	1675.00	1650.00	1625.00	1600.00	1575.00	1576.70
Distance, m	135	185	470	810	250	150	

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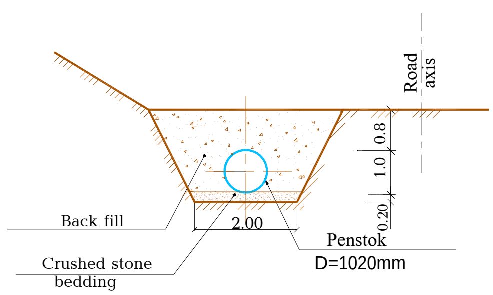
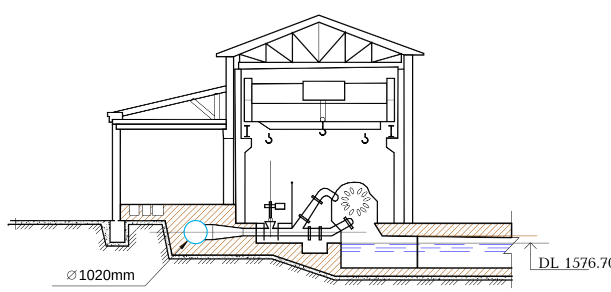


SHPP Powerhouse



15.8.5.4.5.Karabash SHPP

Introduction

Karabash SHPP is planned to locate on the southern part of RA. SHPP uses inclination of River Karabash from 1520.0 1340.0 till 1902.0. The length of derivation from Karabash River is 1200m by copper pipeline 530mm in diameter with design pressure of 165.4m and design discharge 0.50m^3/sec.
After construction and exploitation Karabash SHPP will have 0.662mwt capacity and will produce 2.34mln kw/h electricity annually.

Short Description for Karabash River Basin

Karabash River is the left inflow of Geghi River that is the left inflow of Voghji River that falls into the latter 56m from the river mouth.

Karabash River length is 10.0km, general chatchment area is 16.3km^2, average inclination is 55‰, average elevation is 2300m, and forest coverage is 1%.

Karabash River basin is located to the south of the republic; it starts from Tarkatar mountain of Baghushat mountain passage on the elevation of 3277m. It borders with Vorotan river basin from north with dividing Baghushat mountain chain (Geghasar 3348m), and Voghji River basin from west, east and south. The river basin is formed by multiple gorges and mountain as well as multiple river and inflow basins, many of which were formed by mud flows caused by heavy rains.

Karabash River is a typical mountainous river. The relief is complicated with inflow basins. The geological composition of the basin is volcanic consisting of basalt lavas, andesite basalts and tuffs.

Vegetation of the basin is not very rich. The upper streams are represented by alpine and sub-alpine meadows; there are oak and leaf forests.

The earth cover is represented by alpine and, dry-prairie, dark brown soils. Mountain forest soils are prevailing near the river mouth.

HYDROLOGY

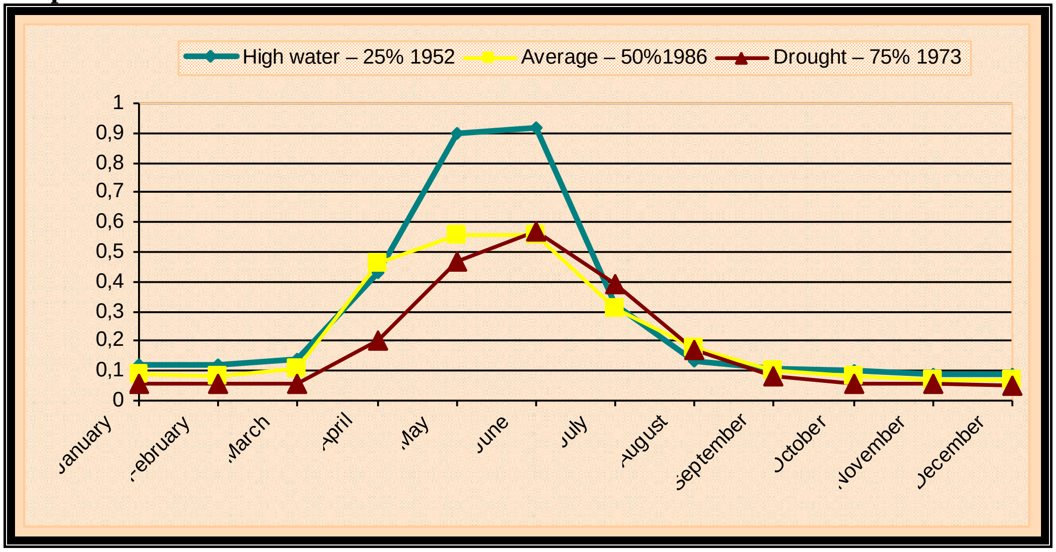
The observation data for 38 years from r. Geghi-Geghi water-meter station is used to define the hydrological properties of Karabash SHPP headworks and the design river section.

The graphic below shows the hydrological properties of design river sections.

River Section	Distance from river mouth, km	Average altitude of the catchment basin, m.	Catchment area, km^2	Flow norms, m^3/sec
R. Karabash-longitudinal section	2.2	2420	14.6	0.23

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 80. Annual flow distribution



Maximal design discharge for Karabash SHPP headwork river section for the general case equal 3% - 23.2m^3/sec, for verifying case - 0.5%-38.7m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.028m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Karabash SHPP is 1520.0m, downstream - 1340.0m. According to Syunik Marz “Tolors” WUO there is no water intake for irrigational use from Karabash River. Karabash SHPP is derivational SHPP. In order not to drain the river where 1200m derivational pipeline is the environmental discharge is designed according to RA laws and 0.09m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Karabash SHPP are calculated with 50% guarantee per annum (1970 see table 165).

Table. 165. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Karabash SHPP (m^3/sec)	0.069	0.059	0.089	0.439	0.500	0.500	0.289	0.159	0.079	0.059	0.049	0.049	
SHPP average monthly capacity (mwt)	0.099	0.085	0.128	0.592	0.662	0.662	0.405	0.227	0.114	0.085	0.070	0.070	
SHPP –average monthly energy production (mln kwt/hour)	0.074	0.057	0.095	0.427	0.492	0.476	0.301	0.169	0.082	0.063	0.051	0.052	**2.34**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 613.4 thousand USD (without VAT) and 736.1 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		20.2
2. Exploitation expenses		25.2
	Salary	17.3
	Renovation	4.9
	Other Expenses	3.0
Total		45.4

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		662
Average multi annual production of energy, mln kwt/hour		2.34
Capital investments into SHPPS(without VAT),		
	thousand USD	613.4
	USD / kwt	926.5
	USD / kwt/hour	0.26
Prime cost of power production, cents/kwt hour		1.94

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

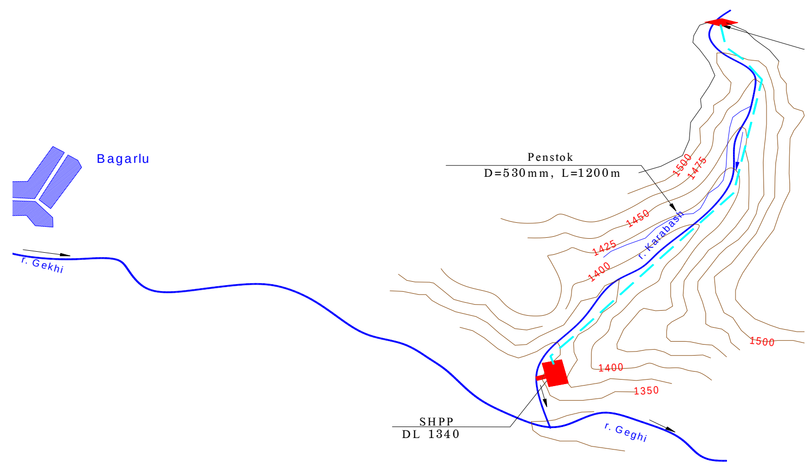
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 166. Design results according to financial scenarios

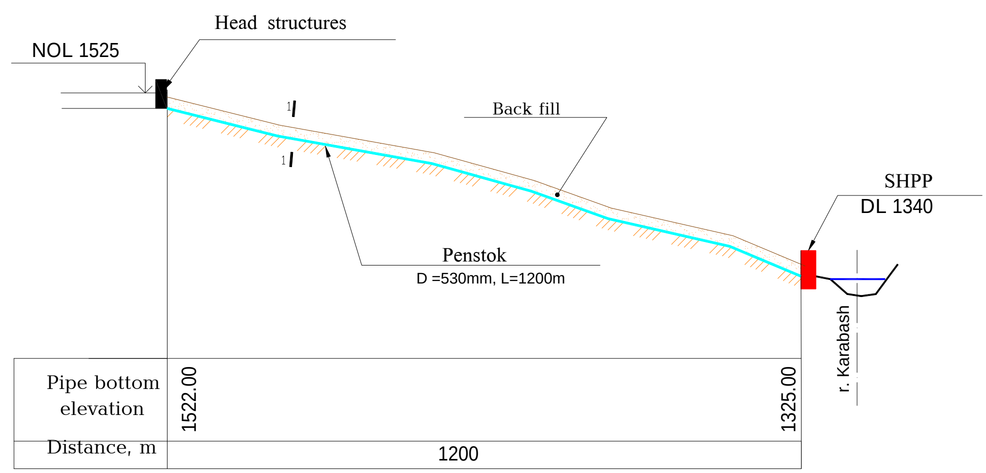
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		13.3	16.0
NPV, thousand USD			
	8%	330.3	330.3
	10%	176.7	205.0
	12%	61.7	115.5
	14%	-26.5	50.22
PB, years (without discount)		7.3	9.1
Deadline for credit return, years			7.0

APPENDIX. 76. KARABASH SHPP

Plan



Longitudinal section



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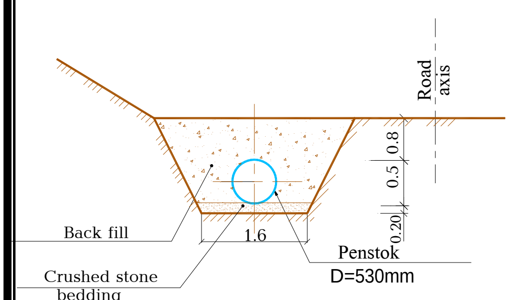
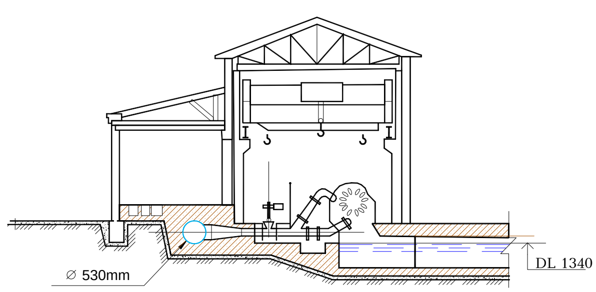


SHPP Powerhouse



15.8.5.4.6. Giratagh SHPP

Introduction

Giratagh SHPP will be located on the southern part f RA. Giratagh SHPP uses the river inclination from 1450 till 1280. The length of derivation from Giratagh River is 1750m by copper pipeline 630mm in diameter with design pressure of 158.16m and design discharge 0.60m^3/sec.

After construction and exploitation Giratagh SHPP will have 0.759mwt capacity and will produce 2.71mln kw/h electricity annually.

Short Description for Kirs River Basin

Giratagh River is the left inflow of Voghji River abd falls into the latter 53km from the river mouth. Giratagh River length is 11.0km, general chatchment area is 22.7km^2, average inclination is 55‰, average elevation is 2510m, and forest coverage is 2%. Giratag River basin is located to the south of the republic; it starts from Khustup mountain of Tarkatar mountain passage on the elevation of 3277m. It borders with Vorotan river basin from north with dividing Baghushat mountain chain (Geghasar 3348m), and Voghji River basin from west, east and south. The river basin is formed by multiple gorges and mountain as well as multiple river and inflow basins, many of which were formed by mud flows caused by heavy rains

Kirs River is a typical mountainous river. The relief is complicated with inflow basins. The geological composition of the basin is volcanic consisting of basalt lavas, andesite basalts and tuffs. Vegetation of the basin is not very rich. The upper streams are represented by alpine and sub-alpine meadows; there are oak and leaf forests. The earth cover is represented by alpine and, dry-prairie, dark brown soils. Mountain forest soils are prevailing near the river mouth.

HYDROLOGY

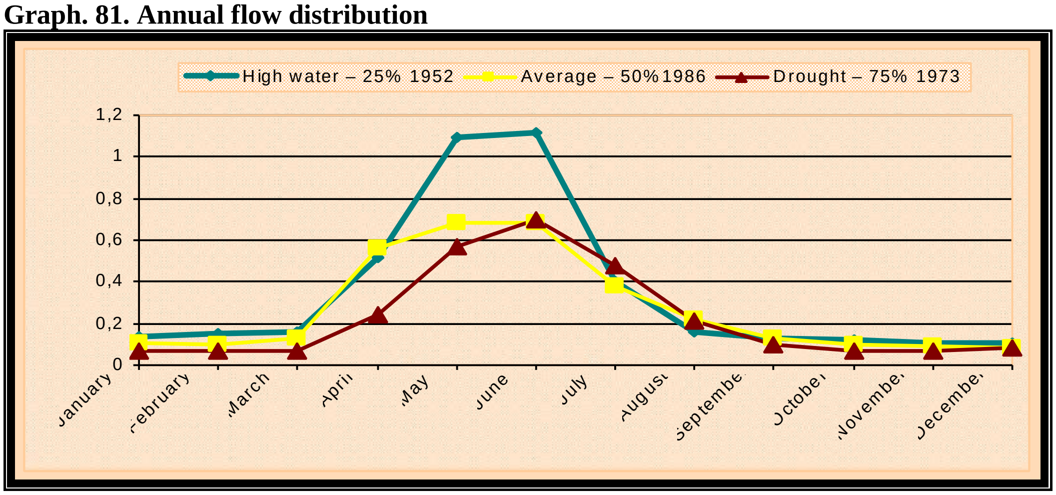
The observation data for 38 years from r. Geghi-Geghi water-meter station is used to define the hydrological properties of Giratagh SHPP headworks and the design river section.

The graphic below shows the hydrological properties of design river sections.

River Section	Distance from river mouth, km	Average altitude of the catchment basin, m.	Catchment area, km^2	Flow norms, m^3/sec
¶.¶Çñ³Ã³Õ---- longitudinal section	2.5	2350	17.9	0.28

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 81. Annual flow distribution



Maximal design discharge for Giratagh SHPP headwork river section for the general case equal 3% - 25.1m^3/sec, for verifying case - 0.5%-41.9m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.034m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Giratagh SHPP SHPP is 1450.0m, downstream - 1280.0m. According to data of marz WUO there is no water intake for irrigational use from Giratagh SHPP River. Giratagh SHPP SHPP is derivational SHPP. In order not to drain the river where 1750m derivational pipeline is the environmental discharge is designed according to RA laws and 0.026m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Giratagh SHPP SHPP are calculated with 50% guarantee per annum (1970 see table 167).

Table. 167. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Giretagh SHPP (m^3/sec)	0.085	0.075	0.105	0.535	0.600	0.600	0.355	0.195	0.105	0.075	0.065	0.055	
SHPP average monthly capacity (mwt)	0.115	0.101	0.142	0.687	0.759	0.759	0.47	0.262	0.142	0.101	0.088	0.074	
SHPP –average monthly energy production (mln kwt/hour)	0.085	0.068	0.105	0.494	0.565	0.547	0.350	0.195	0.102	0.075	0.063	0.055	**2.71**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 734.76 thousand USD (without VAT) and 881.6 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	24.2
2. Exploitation expenses	26.2
Salary	17.3
Renovation	5.9
Other Expenses	3.0
Total	50.4

Power indicators of have the following level

Indicators	Values
Derivation capacity, kwt	759
Average multi annual production of energy, mln kwt/hour	2.71
Capital investments into SHPPS(without VAT),	
thousand USD	734.7
USD / kwt	987.9
USD / kwt/hour	0.27
Prime cost of power production, cents/kwt hour	1.86

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:
- ❖ Private investments only /Scenario 1/
- ❖ 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

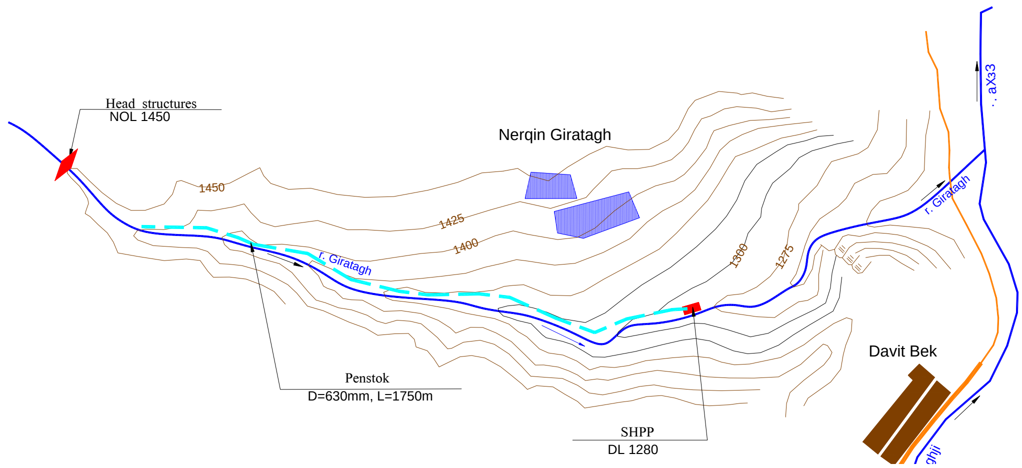
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 168. Design results according to financial scenarios

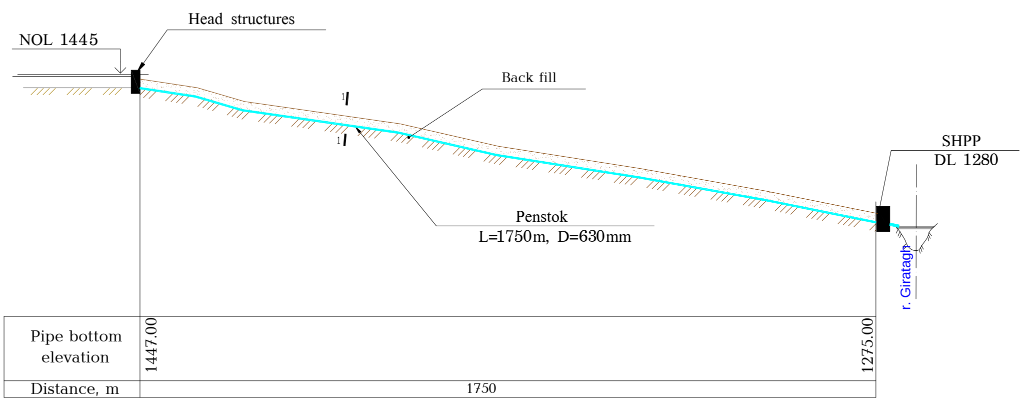
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		13.2	15.8
NPV, thousand USD			
	8%	384.9	384.9
	10%	202.8	236.6
	12%	66.3	130.7
	14%	-38.4	53.6
PB, years (without discount)		7.4	9.2
Deadline for credit return, years			7.0

APPENDIX. 77. GIRATAGH SHPP

Plan



Longitudinal section



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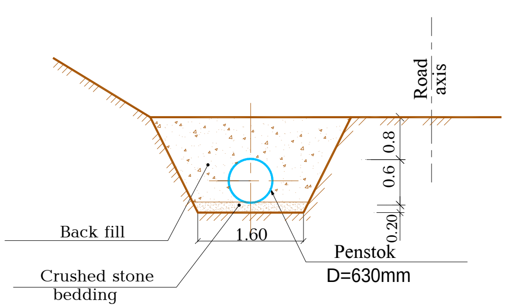
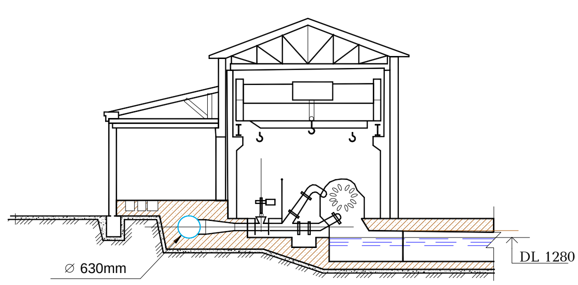


SHPP Powerhouse



15.8.5.4.7. Katnarat SHPP

Introduction

Katnarat SHPP will be located on the southern part f RA. Katnarat SHPP uses the river inclination from from 1740.0 till 1505.0. The length of derivation from Katnarat River is 2000m by copper pipeline 530mm in diameter with design pressure of 219.32m and design discharge 0.40m^3/sec.
After construction and exploitation Katnarat SHPP will have 0.662mwt capacity and will produce 2.42mln kw/h electricity annually.

Short Description for Katnarat River Basin

Katnarat River is the right inflow of Voghji River that falls into the latter 64m from the river mouth. River length is 7.5km, general chatchment area is 19.8km^2, average inclination is 159‰, average elevation is 2100m, and forest coverage is 3%. Katnarat River basin is located to the south of the republic; it starts from Meghri mountain passage on the elevation of 2692m. It borders with Voghji river basin from east and west and Meghri river basin from south.. The river basin is formed by multiple gorges and mountain as well as multiple river and inflow basins, many of which were formed by mud flows caused by heavy rains.

Katnarat River is a typical mountainous river. The relief is complicated with inflow basins. The geological composition of the basin is volcanic consisting of basalt lavas, andesite basalts and tuffs. Vegetation of the basin is not very rich. The upper streams are represented by alpine and sub-alpine meadows; there are oak and leaf forests. The earth cover is represented by alpine and, dry-prairie, dark brown soils. Mountain forest soils are prevailing near the river mouth.

HYDROLOGY

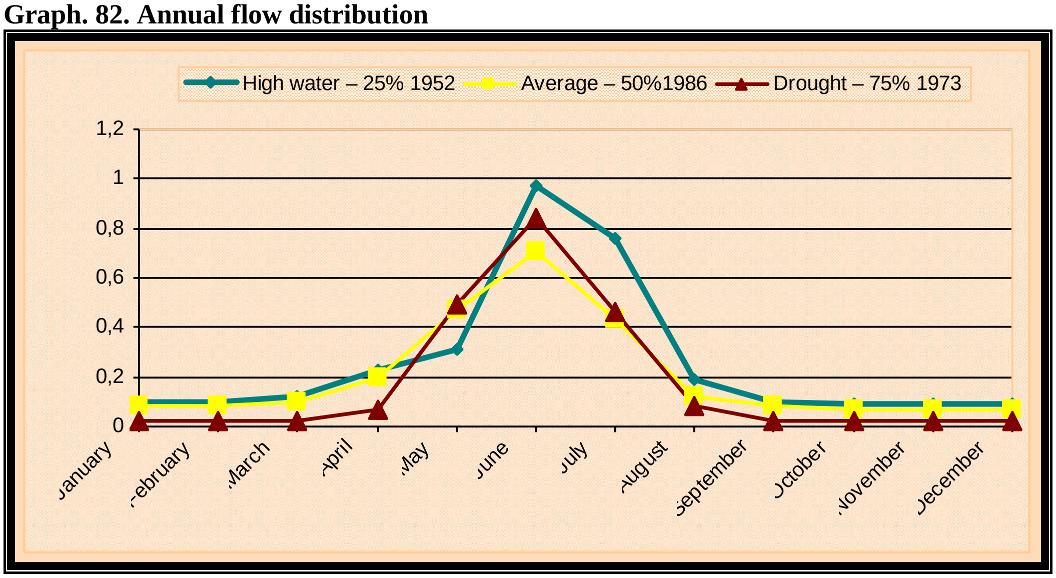
The observation data for 57 years from r. Voghji - Kajaran water-meter station is used to define the hydrological properties of Katnarat SHPP headworks and the design river section.

The graphic below shows the hydrological properties of design river sections.

River Section	Distance from river mouth, km	Average altitude of the catchment basin, m.	Catchment area, km^2	Flow norms, m^3/sec
R. Katnarat-- longitudinal section-	2.3	2220	15.3	0.21

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 82. Annual flow distribution



Maximal design discharge for Jraghatsidzor SHPP headwork river section for the general case equal 3% - 23.2m^3/sec, for verifying case - 0.5%-38.3m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.034m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Katnarat SHPP is 1740.0m, downstream - 1505.0m. According to data of WUO there is no water intake for irrigational use from Katnarat River. Katnarat SHPP is derivational SHPP. In order not to drain the river where 2000m derivational pipeline is the environmental discharge is designed according to RA laws and 0.026m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Katnarat SHPP are calculated with 50% guarantee per annum (1990 see table 169).

Table. 169. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Katnarat SHPP (m^3/sec)	0.052	0.053	0.074	0.174	0.400	0.400	0.400	0.400	0.094	0.054	0.045	0.046	
SHPP average monthly capacity (mwt)	0.0.98	0.100	0.139	0.323	0.702	0.702	0.702	0.176	0.101	0.085	0.086	0.085	
SHPP –average monthly energy production (mln kwt/hour)	0.073	0.067	0.103	0.232	0.522	0.505	0.522	0.131	0.073	0.063	0.052	0.063	**2.242**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 690.7 thousand USD (without VAT) and 828.8 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	22.8
2. Exploitation expenses	25.8
Salary	17.3
Renovation	5.5
Other Expenses	3.0
Total	48.6

Power indicators of have the following level

Indicators	Values
Derivation capacity, kwt	702
Average multi annual production of energy, mln kwt/hour	2.42
Capital investments into SHPPS(without VAT),	
thousand USD	690.7
USD / kwt	983.9
USD / kwt/hour	0.29
Prime cost of power production, cents/kwt hour	2.01

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

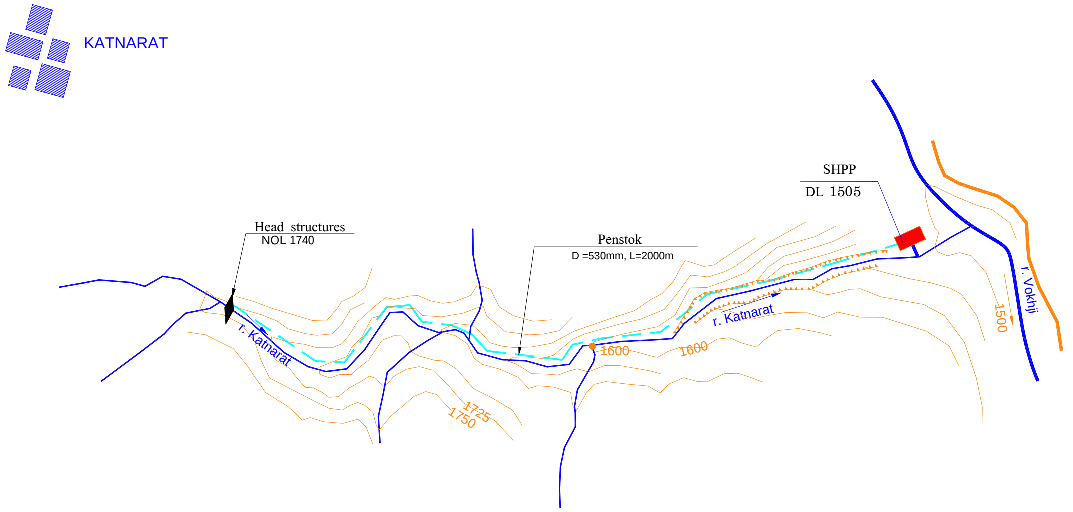
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 170. Design results according to financial scenarios

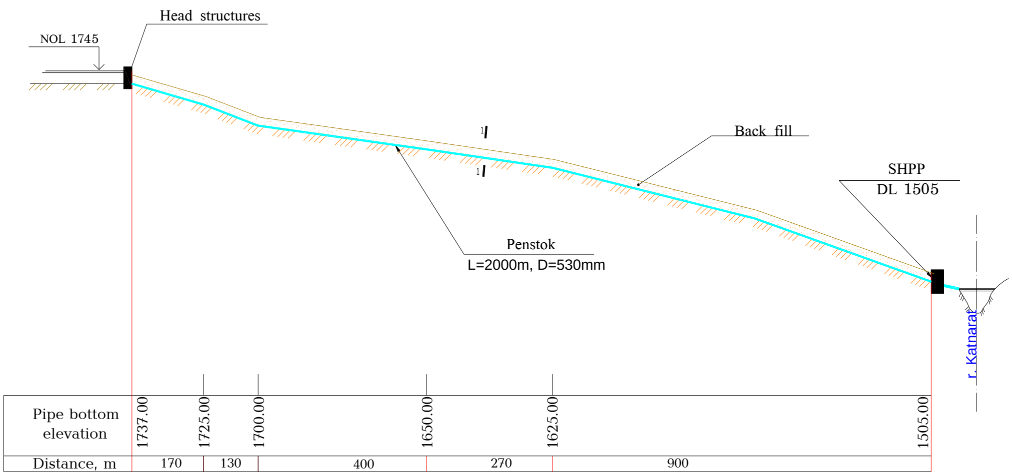
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		12.2	14.5
NPV, thousand USD			
	8%	290.7	290.7
	10%	131.0	166.2
	12%	11.4	78.0
	14%	-80.4	14.3
PB, years (without discount)		7.9	10.1
Deadline for credit return, years			8.0

APPENDIX. 78. KATNARAT SHPP

Plan



Longitudinal section



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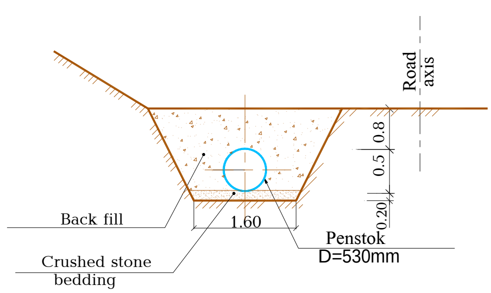
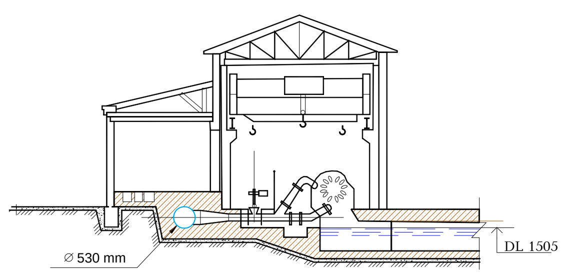


SHPP Powerhouse



15.8.5.4.8. Avsarlu SHPP

Introduction

Avsarlu SHPP will be located on the southern part f RA. Avsarlu SHPP uses the river inclination from from 1750.0 till 1545.0. The length of derivation from Avsarlu River is 2150by copper pipeline 630mm in diameter with design pressure of 185.29m and design discharge 0.70m^3/sec.After construction and exploitation Avsarlu SHPP will have 0.36mwt capacity and will produce 3.68mln kw/h electricity annually.

Short Description for Avsarlu River Basin

Avsarlu River is the left inflow of Musalam River that is the inflow of Voghji River that falls into the latter 4.0m from the river mouth. River length is 10.0km, general chatchment area is 22.8km^2, average inclination is 159‰, average elevation is 2400m, and forest coverage is 71%.

Avsarlu River basin is located to the south of the republic; it starts from Baghats mountain of Meghri mountain passage on the elevation of 3246m. It borders with Voghji river basin from west, east and north, Meghri River basin from south. The river basin is formed by multiple gorges and mountain as well as multiple river and inflow basins, many of which were formed by mud flows caused by heavy rains.

Avsarlu River is a typical mountainous river. The relief is complicated with inflow basins. The geological composition of the basin is volcanic consisting of basalt lavas, andesite basalts and tuffs. Vegetation of the basin is not very rich. The upper streams are represented by alpine and sub-alpine meadows; there are oak and leaf forests. The earth cover is represented by alpine and, dry-prairie, dark brown soils. Mountain forest soils are prevailing near the river mouth.

HYDROLOGY

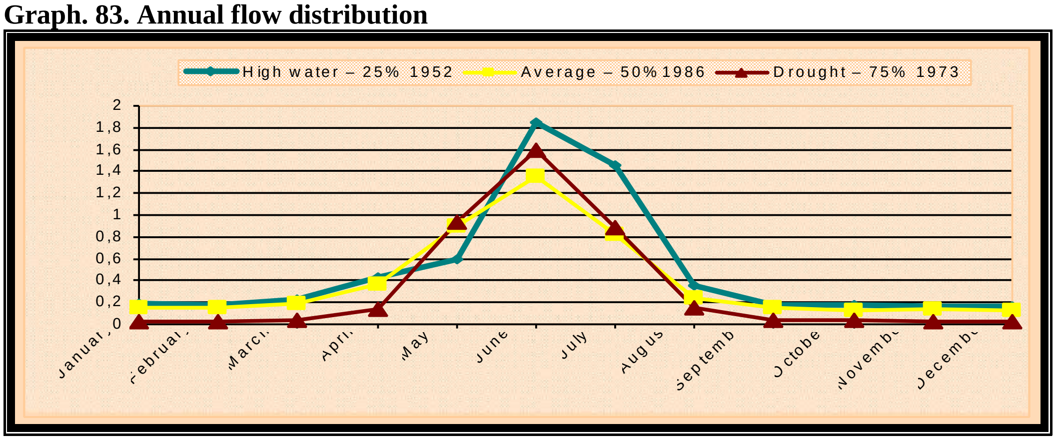
The observation data for 57 years from r. Voghji - Kajaran water-meter station is used to define the hydrological properties of Avsarlu SHPP headworks and the design river section.

The graphic below shows the hydrological properties of design river sections.

River Section	Distance from river mouth, km	Average altitude of the catchment basin, m.	Catchment area, km^2	Flow norms, m^3/sec
¶ Avsarlu - longitudinal section	2.3	2220	21.4	0.40

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 83. Annual flow distribution



Maximal design discharge for Avsarlu SHPP headwork river section for the general case equal 3% - 27.6m^3/sec, for verifying case - 0.5%-45.7m^3/sec, the observed average annual discharge value with 95% guarantee equals 0.071m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Avsarlu SHPP is 1750.0m, downstream - 1545.0m. According to marz's WUO there is no water intake for irrigational use from Avsarlu River. Avsarlu SHPP is derivational SHPP. In order not to drain the river where 2150m derivational pipeline is the environmental discharge is designed according to RA laws and 0.053m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Avsarlu SHPP are calculated with 50% guarantee per annum (1990 see table 171).

Table. 171. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Avsarlu SHPP (m^3/sec)	0.097	0.097	0.137	0.317	0.700	0.700	0.700	0.187	0.097	0.077	0.087	0.077	
SHPP average monthly capacity (mwt)	0.159	0.159	0.224	0.509	1.038	1.038	1.038	0.304	0.159	0.126	0.142	0.126	
SHPP –average monthly energy production (mln kwt/hour)	0.118	0.107	0.166	0.367	0.772	0.747	0.772	0.227	0.114	0.094	0.103	0.094	**3.68**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 721.3 thousand USD (without VAT) and 865.6 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		33.1
2. Exploitation expenses		32.3
	Salary	20.2
	Renovation	8.1
	Other Expenses	4.0
Total		65.4

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		1038
Average multi annual production of energy, mln kwt/hour		3.68
Capital investments into SHPPS(without VAT),		
	thousand USD	1002.0
	USD / kwt	965
	USD / kwt/hour	0.27
Prime cost of power production, cents/kwt hour		1.78

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:
- ❖ Private investments only /Scenario 1/
- ❖ 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

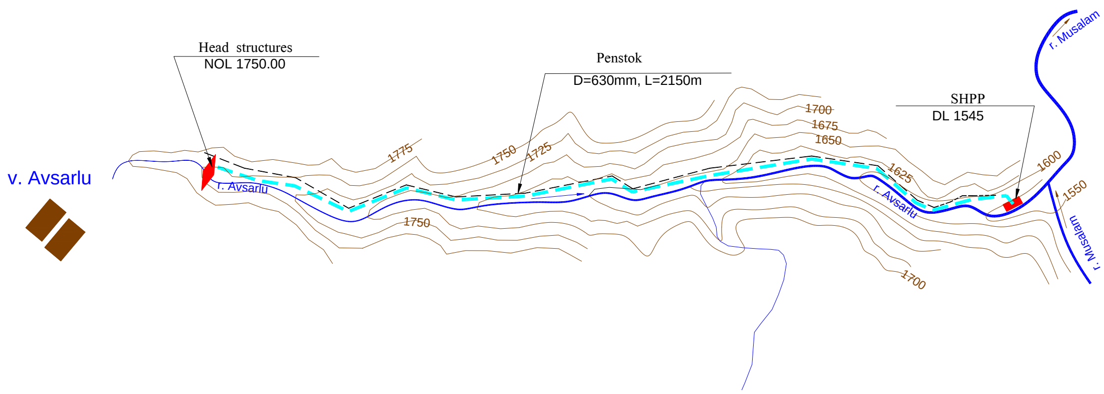
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 172. Design results according to financial scenarios

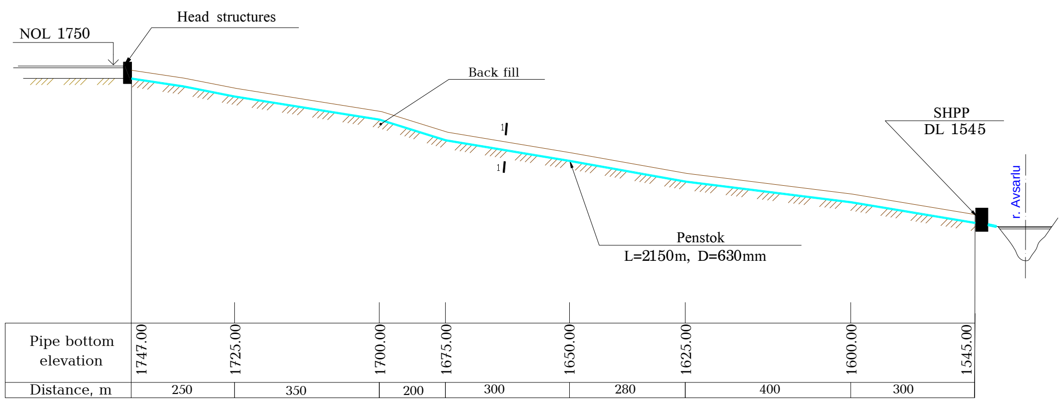
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		13.4	16.2
NPV, thousand USD			
	8%	551.5	551.5
	10%	298.8	344.9
	12%	109.4	197.2
	14%	-35.8	89.5
PB, years (without discount)		7.3	9.04
Deadline for credit return, years			7.0

APPENDIX. 79. AVSARLU SHPP

Plan



Longitudinal section



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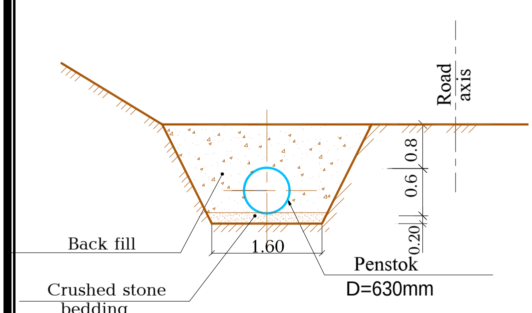
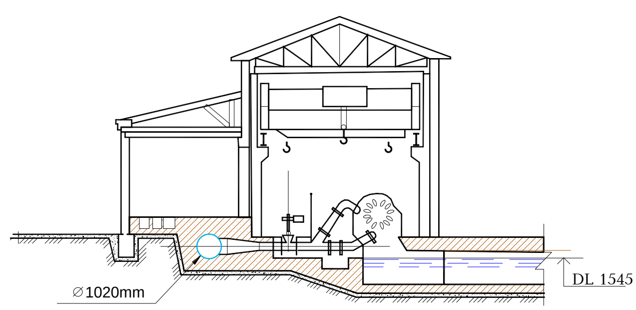


SHPP Powerhouse



15.8.5.4.9. Musalam SHPP

Introduction

Musalam SHPP will be located on the southern part of RA. Musalam SHPP uses the river inclination from 1535.0 till 1345.0. The length of derivation from Musalam River is 3400by copper pipeline 820mm in diameter with design pressure of 169.76m and design discharge 1.20m^3/sec.
After construction and exploitation Musalam SHPP will have 1.63mwt capacity and will produce 6.25mln kw/h electricity annually.

Short Description for Musalam River Basin

Musalam River is the left inflow of Voghji River falls into the latter 59m from the river mouth. River length is 16.0km, general chatchment area is 58.0km^2, average inclination is 122‰, average elevation is 2300m, and forest coverage is 26%.

Musalam River basin is located to the south of the republic; it starts from Baghats mountain of Meghri mountain passage on the elevation of 3246m. It borders with Voghji river basin from north, west and east and Meghri River basin from south. The river basin is formed by multiple gorges and mountain as well as multiple river and inflow basins, many of which were formed by mud flows caused by heavy rains. Musalam River is a typical mountainous river. The relief is complicated with inflow basins. The geological composition of the basin is volcanic consisting of basalt lavas, andeside basalts and tuffs. Vegetation of the basin is not very rich. The upper streams are represented by alpine and sub-alpine meadows; there are oak and leaf forests. The earth cover is represented by alpine and, dry-prairie, dark brown soils. Mountain forest soils are prevailing near the river mouth.

HYDROLOGY

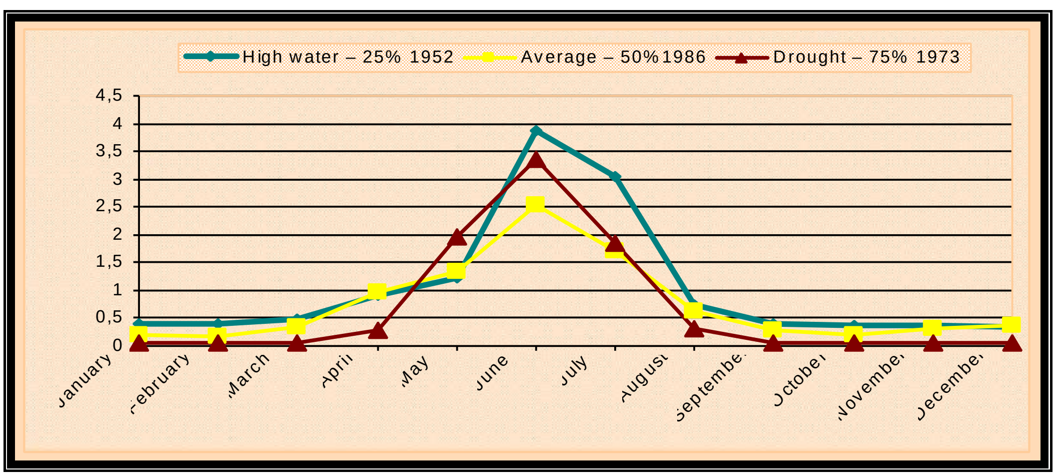
The observation data for 57 years from r. Voghji - Kajaran water-meter station is used to define the hydrological properties of Musalam SHPP headworks and the design river section.

The graphic below shows the hydrological properties of design river sections.

River Section	Distance from river mouth, km	Average altitude of the catchment basin, m.	Catchment area, km^2	Flow norms, m^3/sec
Musalam - longitudinal section	3.8	2400	60.6	0.84

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 84. Annual flow distribution



Maximal design discharge for Musalam SHPP headwork river section for the general case equal 3% - 37.6m^3/sec, for verifying case - 0.5%-61.8m^3/sec, the observed average daily discharge value with 95% guarantee equals 0.014m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Musalam SHPP is 1535.0m, downstream - 1345.0m. According to marz's WUO there is no water intake for irrigational use from Musalam River. Musalam SHPP is derivational SHPP. In order not to drain the river where 3400m derivational pipeline is the environmental discharge is designed according to RA laws and 0.105m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Musalam SHPP are calculated with 50% guarantee per annum (1990 see table 173).

Table. 173. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Musalam SHPP (m^3/sec)	0.10	0.08	0.24	0.76	1.20	1.20	1.20	0.53	0.18	0.09	0.22	0.28	
SHPP average monthly capacity (mwt)	0.14	0.11	0.36	1.10	1.63	1.63	1.63	0.78	0.27	0.13	0.33	0.42	
SHPP –average monthly energy production (mln kwt/hour)	0.11	0.08	0.26	0.79	1.21	1.17	1.21	0.58	0.19	0.10	0.23	0.31	**6.25**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 1641.5 thousand USD (without VAT) and 1969.8 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	54.2
2. Exploitation expenses	43.9
Salary	25.9
Renovation	13.0
Other Expenses	5.0
Total	98.1

Power indicators of have the following level

Indicators	Values
Derivation capacity, kwt	1630
Average multi annual production of energy, mln kwt/hour	6.25
Capital investments into SHPPS(without VAT),	
thousand USD	1641.5
USD / kwt	1007.0
USD / kwt/hour	0.26
Prime cost of power production, cents/kwt hour	

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

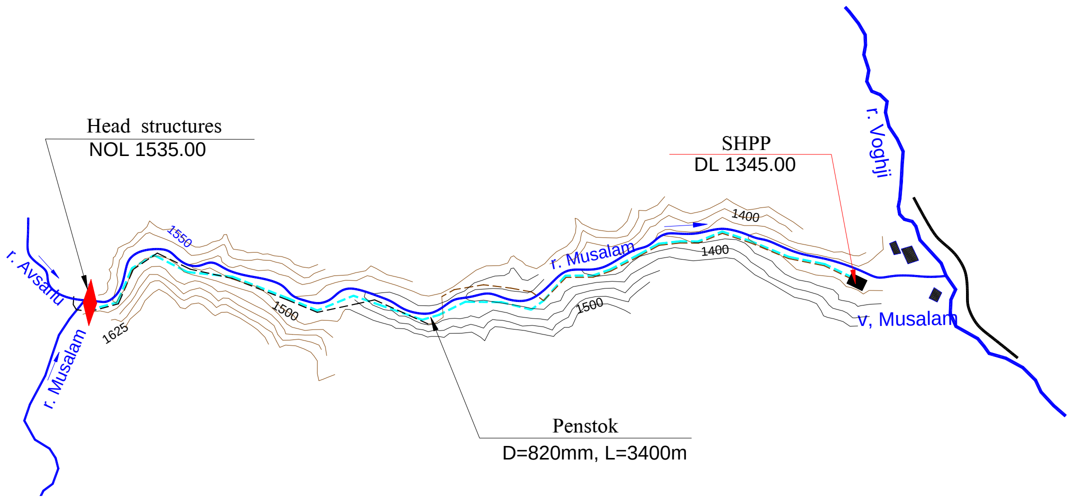
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 174. Design results according to financial scenarios

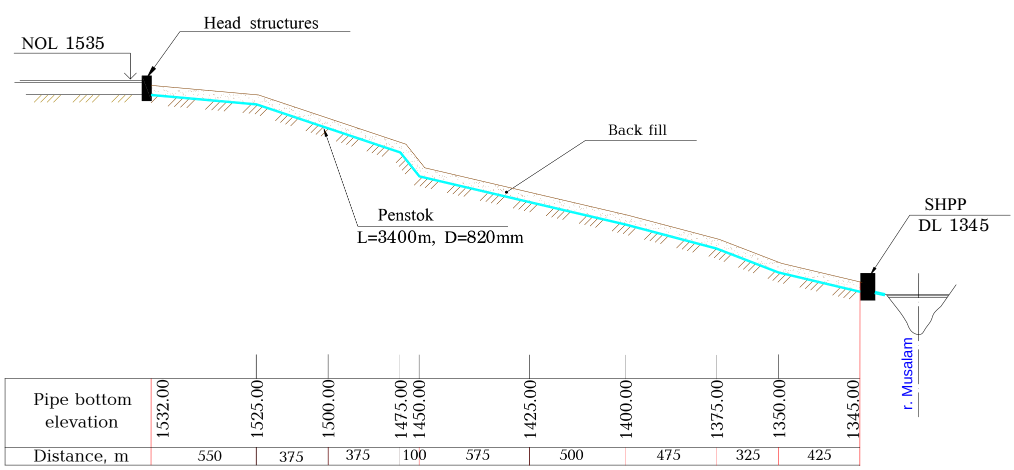
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		14.5	17.6
NPV, thousand USD			
	8%	1091.2	1091.2
	10%	646.7	714.0
	12%	313.6	442.3
	14%	58.1	365.5
PB, years (without discount)		6.8	8.2
Deadline for credit return, years			6.2

APPENDIX 80. MUSALAM SHPP

Plan



Longitudinal section



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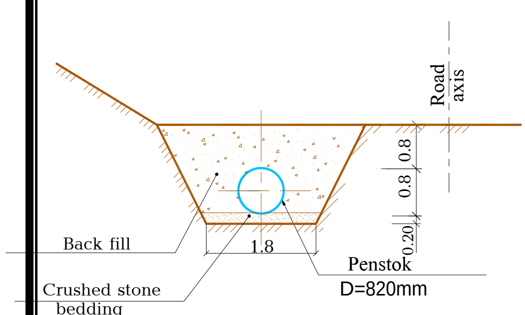
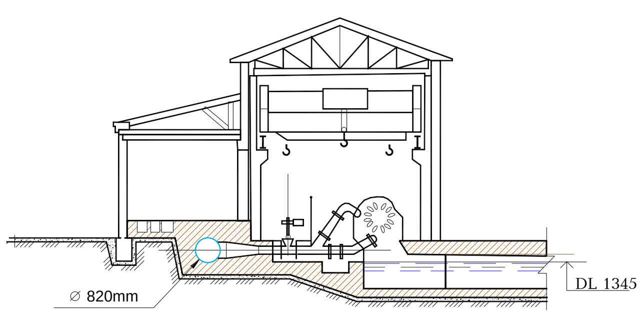


SHPP Powerhouse



15.8.5.4.11. Vachagan SHPP

Introduction

Vachagan SHPP will be located on the southern part f RA. Vachagan SHPP uses the river inclination from from 975.0 till 845.0. The length of derivation from Vachagan River is 2500m by copper pipeline 720mm in diameter with design pressure of 118.2m and design discharge 0.75m^3/sec.
After construction and exploitation Vachagan SHPP will have 0.709mwt capacity and will produce 2.52mln kw/h electricity annually.

Short Description of Vachagan River Basin

Vachagan River is the right inflow of Voghji River that falls into the latter 43m from the river mouth. River length is 11.0km, general chatchment area is 35.0km^2, average inclination is 481‰, average elevation is 1640m, and forest coverage is 75%. Vachagan River basin is located to the south of the republic. It starts from Khustup mountain of Meghri mountain passage on the elevation of 3201m. From administrative point of view Vachgan river is completely located in Syunic Marz. It borders with Voghji river basin from north and west Meghri river basin from east, with dividing Meghri mountain chain (Khustup mountain – 3201.0m), and Tsav River basin from south divided by western part of Meghri mountain chain (Baghats Mountain – 3249.3m). The river basin is formed by multiple gorges and mountain as well as multiple river and inflow basins, many of which were formed by mud flows caused by heavy rains.

Vaachagan River is a typical mountainous river with complicated. The geological composition of the basin is volcanic consisting of clays and sedimentary layers. The earth cover is not very rich represented by dark brown and dark forest earth. The vegetative layer is rich and differs from the neighboring basins in the downstream the vegetative layer is mainly represented by forest and alpine meadows in the upstream.

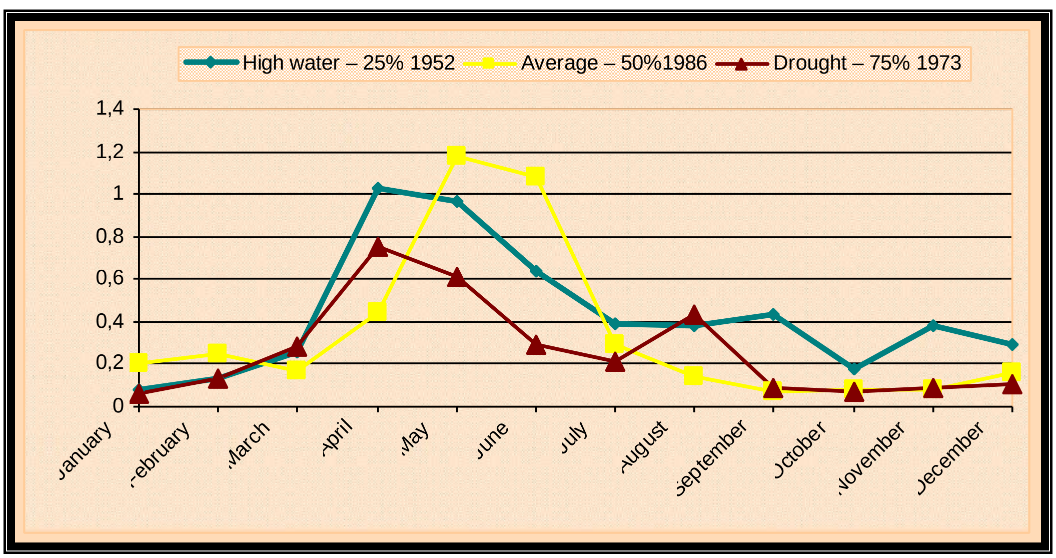
HYDROLOGY

The observation data for 24 years from r. Vachagan-Ghapan water-meter station is used to define the hydrological properties of Vachagan SHPP headworks and the design river section.

River Section	Distance from river mouth, km	Average altitude of the catchment basin, m.	Catchment area, km^2	Flow norms, m^3/sec
Vachagan - longitudinal section	3.9	2100	29.2	0.36

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 85. Annual flow distribution



Maximal design discharge for Vachagan SHPP headwork river section for the general case equal 3% - 15.3m^3/sec, for verifying case - 0.5%-22.3m^3/sec, the observed average dayly discharge value with 95% guarantee equals 0.015m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Vachagan SHPP is 957.0m, downstream - 845.00m. According to data of WUO there is no water intake for irrigational use from Vachagan River. Vachagan SHPP is derivational SHPP. In order not to drain the river where 2500m derivational pipeline is the environmental discharge is designed according to RA laws and 0.011m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Vachagan SHPP are calculated with 50% guarantee per annum (1976 see table 175).

Table. 175. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Vachagan SHPP (m^3/sec)	0.079	0.079	0.289	0.750	0.750	0.299	0.359	0.379	0.089	0.149	0.189	0.059	
SHPP average monthly capacity (mwt)	0.082	0.082	0.296	0.709	0.709	0.306	0.365	0.385	0.092	0.154	0.195	0.061	
SHPP –average monthly energy production (mln kwt/hour)	0.061	0.055	0.220	0.511	0.528	0.221	0.272	0.286	0.067	0.115	0.141	0.046	**2.52**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 766.7 thousand USD (without VAT) and 920.0 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	25.3
2. Exploitation expenses	26.5
Salary	17.3
Renovation	6.2
Other Expenses	3.0
Total	51.8

Power indicators of have the following level

Indicators	Values
Derivation capacity, kwt	709
Average multi annual production of energy, mln kwt/hour	2.52
Capital investments into SHPPS(without VAT),	
thousand USD	766.7
USD / kwt	10810.3
USD / kwt/hour	0.30
Prime cost of power production, cents/kwt hour	2.05

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:
- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

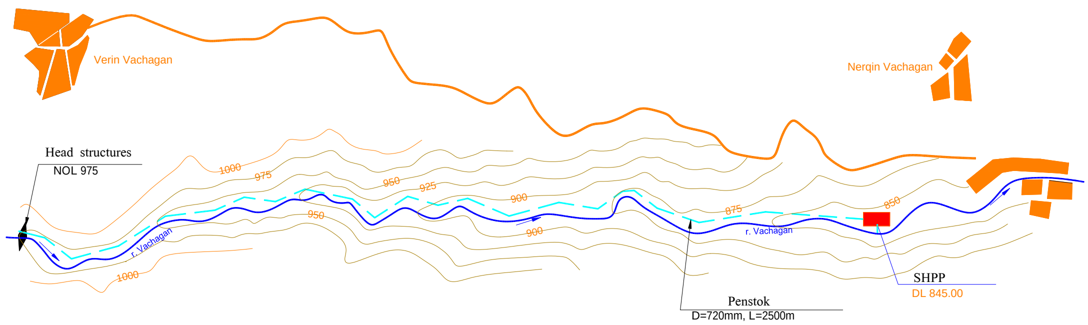
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 176. Design results according to financial scenarios

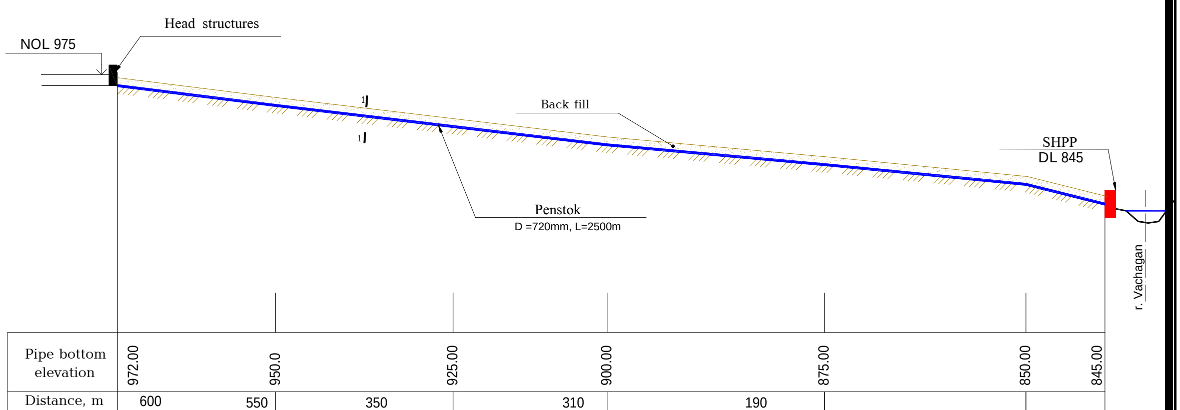
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		11.4	13.2
NPV, thousand USD			
	8%	264.0	264.0
	10%	96.3	135.4
	12%	-29.3	44.6
	14%	-125.7	-20.7
PB, years (without discount)		8.4	10.7
Deadline for credit return, years			8.0

APPENDIX. 81. VACHAGAN SHPP

Plan



Longitudinal section



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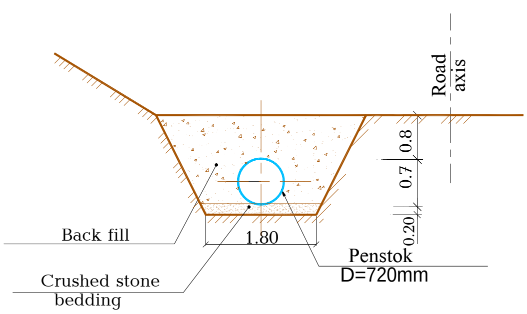
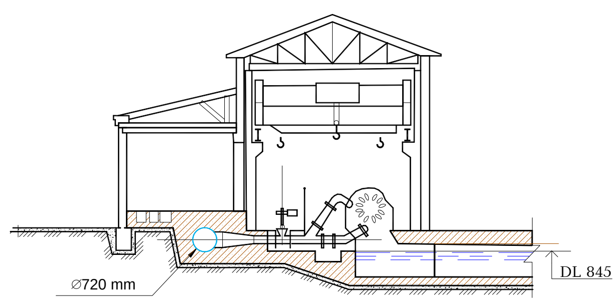


SHPP Powerhouse



15.8.6. Short Description of Megri River Basin and Climatic Conditions

River Meghriget is the left inflow of River Araks that falls into the river 312km from the river mouth. General catchment area of the river is 336km^2, river length is 36km, with 16% of average inclination and 2200m of average catchment area elevation.

The river starts from a number of springs coming out of basalt stones on elevation of 3240 on Debaklu mountain passage.

Meghrigaet basin borders with Voghji river basin that is divided by Meghri mountain chain (2811m), Tsav River basin from the east, small inflow basins of Araks mountain chain from south east, and Nekhichevan river basins from the west that are divided by Zangezur mountain chain (with the highest Kapighig peak – 3904m, that is out of the borders and Saridara – 3750 within the border).

The geographical composition of Voghji River basin is complicated with volcanic rocks and sedimentary type of stones. The vegetative cover is diverse with sub-alpine meadows in the upstream and alpine meadows in the downstream; there are thick forest further on to the downstream with Georgian and eastern oaks.

There is an absite semi-desert in the Araks valley. The earth cover of the desert is represented by grey earth and occasionally with high salt content, in the downstream. Mountain-forest earth is further upstream that are followed by light brown soils and sub alpine meadows and then, alpine meadows.

River waters are used for water supply and irrigation.

From the climatic point of view the river basin crosses 6 climatic zones, staring from dry continental to mountainous regime. The SHPPs are located in the II, III and IV zones.

- ❖ Mild-warm zone: mild winter,
- ❖ Mild zones with mild winter,
- ❖ Mild zone with warm long simmer and cold winter.

№№	Station	Elevation, m	Observation period	Number of observational years.
1.	Meghri	627	1930 – working	77
2.	Lichk	1769	1936 - working	71

As far as Meghri Station is located on the elevation of 627m it can reflect only Leghvaz SHPP climatic conditions, and for the rest of the SHPP the data is approximate. Lichk is the only an observation point that reflect precipitation data only.

Temperature for mountainous regions is very different and depends on elevation, type of relief, and slope exposition. Multi annual average temperature in Meghri is 14.1^{o}C. The coldest month is January 1.4^{o}C, the warmest – July - 26.1^{o}C. Maximal minimum is (-18^{o}C), absolute maximum is – (41^{o}C). Average quantity of warm days in a yeas us 277. Air moisture content depends on temperature regime, quantity of precipitations and physical-geographical conditions. Average annual

The moisture content mainly depends on water regime, quantity of precipitations and physical-geographical properties of the region. Evaporation flexibility equals 10.3 mb. Average multi annual comparative moisture content is 60%. Precipitations depend upon elevation and slope exposition. Averge annual precipitations in Meghri are 283mm, and 768mm in Lichk.

Average annual precipitation in Megri are 402mm, monthly 113mm, daily – 40mm. Average 10-day thickness of snow cover is 5cm in Meghri, 52cm in Lichk while maximum is 27 and 97cm, accordingly. The winds penetrate from north and from Araks river. Average annual speed of wind in Meghri is 1.6m/sec. The over main wind direction is eastern.

15.8.6.1. Geological composition of Meghri river basin

From geological point of view Meghriget river basin is composed of different lave kinds, mainly basalts. V-shaped gorges are covered by talus. There are significant tectonic shifts. River basin is fully composed of intrusive rock types: Eocene-Oligocene granites, granite – diorites, granite-syenites, and monzonites. River valley sloes are composed of weakly developed talus and alluvial sediments.

In the inundation area there are alluvial sediments 2-3m thick. On Vanadzor and Vaik inflows there are similar granite rock types.

15.8.6.2. Meghriget Water Regime and Design data

Meghri river is a typical mountainous river which is a consequence of high elevation and complicated relief. Water regime is melting-rain inundations which slow decrease is conditioned by feeding from high altitude glaciers and usually lasts from April till July. Te inundation peak is usually in May but usually there is a short term peak in April. The observations of the river flow were carried out from two observation points: Meghri and Lichk water meter stations.

The above mentioned indicators are used for determining annual distribution of average river flow by recovering the natural condition of the flow. Observation point Lichk is an analogue for Lichk-1,2 and Tashtun SHPPs and Meghri Observation point for Leghvaz and Vank SHPPs. The below are the hydrological characteristics of observation points that were used as analogue for design river sections of SHPPs.

NN	Water meter Station	Distance from the river mouth, km	Average elevation of catchment area, m	Average Elevation of the river basin	Observation period	Flow Norm	
						Water discharge m^3/sec	Flow module, $l/sec,km^2$
1.	Meghri-Meghri	Araks	274	2200	1946-2001	3.37	12.3
2.	Lichk-Lichk	Meghri	21.0	2960	1950-1987	0.70	33.3

The table below shows the annual flow distribution of Meghri and Lichk water meter stations for characteristic years.

Years	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Average
1. Meghri-Meghri													
Water Abundant – 25%													
1964	1.36	1.42	4.70	7.98	13.6	6.80	3.17	3.11	2.49	1.55	1.27	1.13	4.05
Average – 50%													
1957	1.15	1.22	2.19	3.88	6.45	10.7	5.23	2.44	1.53	1.42	1.53	1.31	3.25
Drought – 75%													
1950	0.82	1.05	1.80	3.63	4.77	7.70	5.59	2.05	0.90	1.00	0.91	0.73	2.58
2. Lichk-Lichk													
Water Abundant – 25%													
1958	0.13	0.13	0.17	0.61	1.97	2.91	1.99	0.89	0.34	0.16	0.15	0.14	0.80
Average Ý – 50%													
1974	0.13	0.13	0.18	0.37	1.99	2.85	1.37	0.57	0.48	0.16	0.13	0.11	0.70
Drought — 75%													
1980	0.10	0.10	0.20	0.52	1.50	2.56	1.48	0.47	0.24	0.10	0.09	0.08	0.62

15.8.6.3. . Technical Specifications for Meghriget River Basin SHPPs

15.8.6.3.1. Leghvaz SHPP on Meghriget River

Introduction

Leghvaz SHPP will be located on River Meghtiget. The headworks will be located 200m downstream from Vardanisdzor SHPP (Meghriget SHPP 5.6), the station works will be located near Leghvaz Village. Leghvaz SHPP uses Meghriget river inclination from 935.0 till 865.0. The length of derivation from Leghvaz River is 1625m by copper pipeline 1220mm in diameter with design pressure of 61.1m and design discharge 3.20m^3/sec.

After construction and exploitation Leghvaz SHPP will have 1.56mwt capacity and will produce 7.01mln kw/h electricity annually.

HYDROLOGY

The observation data for 77 years from r. Meghri-Meghri water-meter station is used to define the hydrological properties of Jraghatsidzor SHPP headworks and the design river section.

The graphic below shows the hydrological properties of design river sections.

River Section	Distance from river mouth, km	Average altitude of the catchment basin, m.	Catchment area, km^2	Flow norms, m^3/sec
Meghri-- longitudinal section	10.6	2285.0	246.0	2.90

The table below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Table. 177. Annual flow distribution

Years	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Average
Water Abundant – 25%													
1964	1,22	1,28	4,23	7,18	12,2	6,12	2,85	2,80	2,24	1,40	1,14	1,02	3,64
Average – 50%													
1957	1,04	1,10	1,97	3,49	5,80	9,63	4,71	2,20	1,38	1,28	1,38	1,18	2,92
Drought – 75%													
1950	0,74	0,94	1,62	3,27	4,29	6,93	5,03	1,84	0,81	0,90	0,82	0,66	2,32

Maximal design discharge for Leghvaz SHPP headwork river section for the general case equal 3% - 46.8m^3/sec, for verifying case - 0.5%-77.96m^3/sec, the observed average dayly discharge value with 95% guarantee equals 0.048m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Leghvaz SHPP is 935.0m, downstream – 865.0.0m. According to data of WUO there is water intake for irrigational use from Leghvaz River for Agarak Factory industrial needs, Meghri city and village domestic needs, as well as in irrigational needs:

- ❖ Industrial water supply - 7.2mln.m^3
- ❖ Domestic water supply - 3.5mln.m^3
- ❖ Irrigational water supply - 2.5mln.m^3

Leghvaz SHPP is derivational SHPP. In order not to drain the river where 1625m derivational pipeline is the environmental discharge is designed according to RA laws and 0.036m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Leghvaz SHPP are calculated with 50% guarantee per annum (1957 see table 178).

Table. 178. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Leghvaz SHPP (m^3/sec)	0.49	0.55	1.39	2.75	3.20	3.20	3.20	1.10	0.58	0.71	0.83	0.64	
SHPP average monthly capacity (mwt)	0.27	0.31	0.76	1.39	1.56	1.56	1.56	0.61	0.32	0.39	0.46	0.36	
SHPP –average monthly energy production (mln kwt/hour)	0.20	0.21	0.56	1.00	1.16	1.13	1.16	0.45	0.23	0.29	0.33	0.27	**7.01**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 1600 thousand USD (without VAT) and 1920.0 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		52.8
2. Exploitation expenses		39.2
	Salary	20.2
	Renovation	13.0
	Other Expenses	6.0
Total		92.0

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		1564
Average multi annual production of energy, mln kwt/hour		7.01
Capital investments into SHPPS(without VAT),		
	thousand USD	1600
	USD / kwt	1023
	USD / kwt/hour	0.23
Prime cost of power production, cents/kwt hour		1.31

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

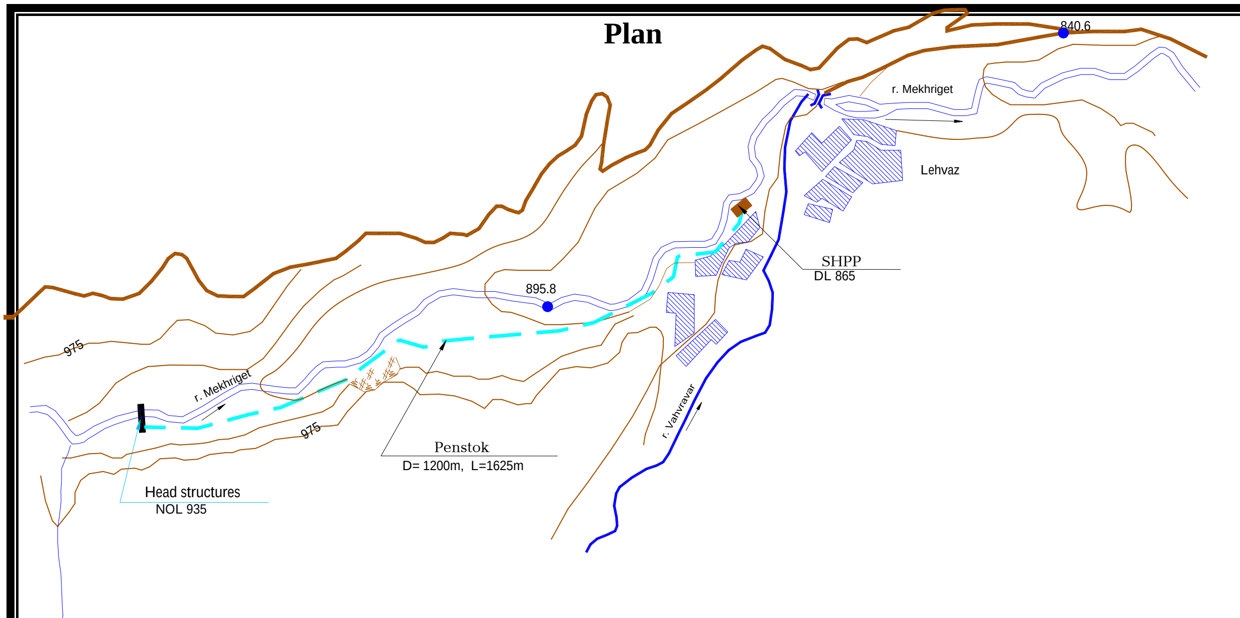
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 179. Design results according to financial scenarios

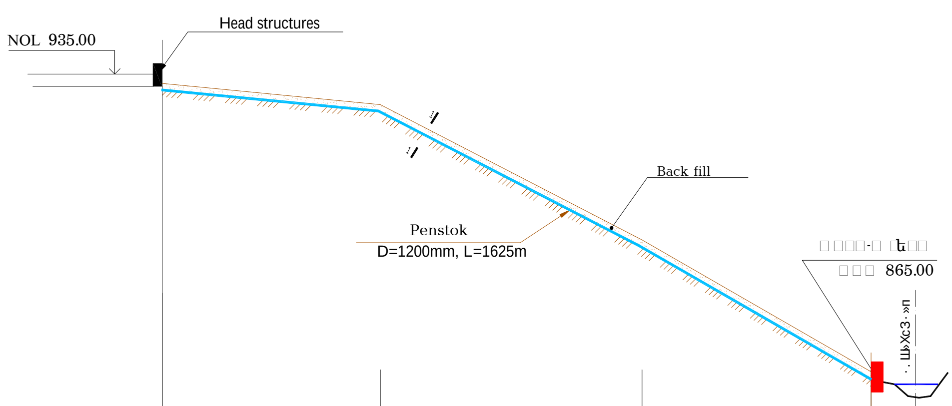
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		17.3	21.6
NPV, thousand USD			
	8%	1538.0	1536.0
	10%	1027.5	1084.7
	12%	645.1	755.0
	14%	351.7	510.0
PB, years (without discount)		5.5	6.8
Deadline for credit return, years			5.0

APPENDIX. 82. LEGHVAZ SHPP

Plan



Longitudinal section



Pipe bottom elevation	932.00		925.00		900.00		867.00
Distance, m		500		600		525	

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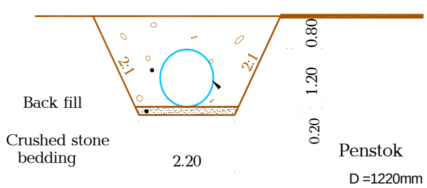
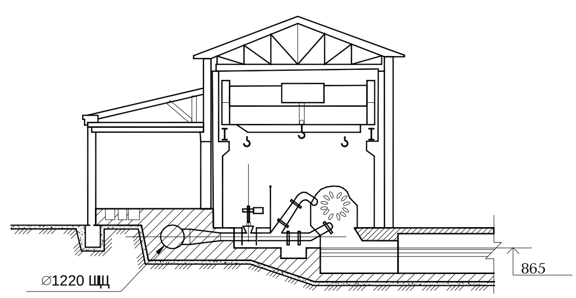


SHPP Powerhouse



15.8.6.3.1 Lichk SHPP-1 on Lichk River

Introduction

Lichk SHPP is planned to locate on Lichk river. The sation works will me located nnear the river mouth till reaching Airi (Zvar) River. Lichk SHPP uses inclination of River Lichk from 1705.0 till 1610.0. The length of derivation from Lichk River is 1200m by copper pipeline 920mm in diameter with design pressure of 88.4m and design discharge 1.50m^3/sec.

After construction and exploitation Lichk SHPP will have 1.06mwt capacity and will produce 3.12mln kw/h electricity annually.

Short Description for Lichk River Basin

Lichk River is the right inflow of Meghri River that discharges into the latter 20.5m from the river mouth.

River length is 14.0km, general chatchment area is 44.8km^2, average inclination is 135‰, average elevation is 2600m, and forest coverage is 14%. River flows in south-eastern direction.The neighboring territory is with large hills and gorges, small rivers. The geological composition consists of different lavas: mainly basalts. Vegetative cover is represented by alpine and sub-alpine meadows that turn into a thick forest.

HYDROLOGY

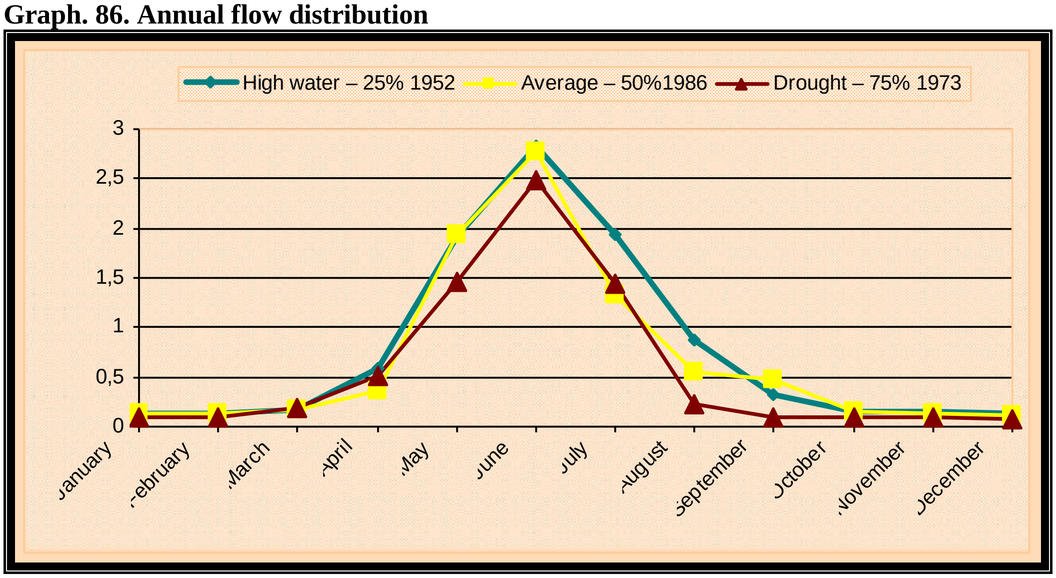
The observation data for 71 years from r. Lichk - Lichk water-meter station is used to define the hydrological properties of Lichk SHPP-1 headworks and the design river section.

The graphic below shows the hydrological properties of design river sections.

River Section	Distance from river mouth, km	Average altitude of the catchment basin, m.	Catchment area, km^2	Flow norms, m^3/sec
R. Lichk - longitudinal section -1	3.4	20.4	2950	0.70

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 86. Annual flow distribution



Maximal design discharge for Lichk SHPP-1 headwork river section for the general case equal 3% - 7.05m^3/sec, for verifying case - 0.5%-8.32m^3/sec, the observed average daily discharge value with 95% guarantee equals 0.008m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Lichk SHPP-1 is 1705.0m, downstream - 1610.0m. According to "Meghri" WUO there is no water intake for irrigational use from Lichk River. Lichk SHPP-1 is derivational SHPP. In order not to drain the river where 1200m derivational pipeline is the environmental discharge is designed according to RA laws and 0.006m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Lichk SHPP-1 are calculated with 50% guarantee per annum (1974 see table 180).

Table. 180. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Lichk SHPP-1 (m^3/sec)	0.07	0.07	0.11	0.30	1.50	1.50	1.27	0.49	0.41	0.09	0.07	0.05	
SHPP average monthly capacity (mwt)	0.05	0.05	0.08	0.23	1.061	1.06	0.92	0.37	0.31	0.07	0.05	0.04	
SHPP –average monthly energy production (mln kwt/hour)	0.04	0.00	0.06	0.16	0.79	0.76	0.68	0.27	0.22	0.05	0.04	0.03	**3.12**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 1045.8 thousand USD (without VAT) and 1255.0 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	34.5
2. Exploitation expenses	29.8
Salary	17.3
Renovation	8.5
Other Expenses	4.0
Total	64.3

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		1061
Average multi annual production of energy, mln kwt/hour		3.12
Capital investments into SHPPS(without VAT),		
	thousand USD	1045.8
	USD / kwt	985.7
	USD / kwt/hour	0.33
Prime cost of power production, cents/kwt hour		2.06

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

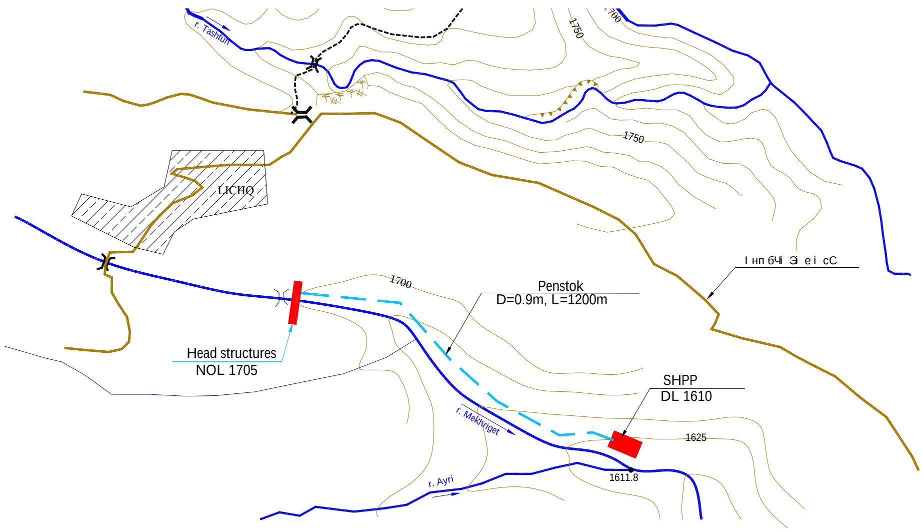
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 181. Design results according to financial scenarios

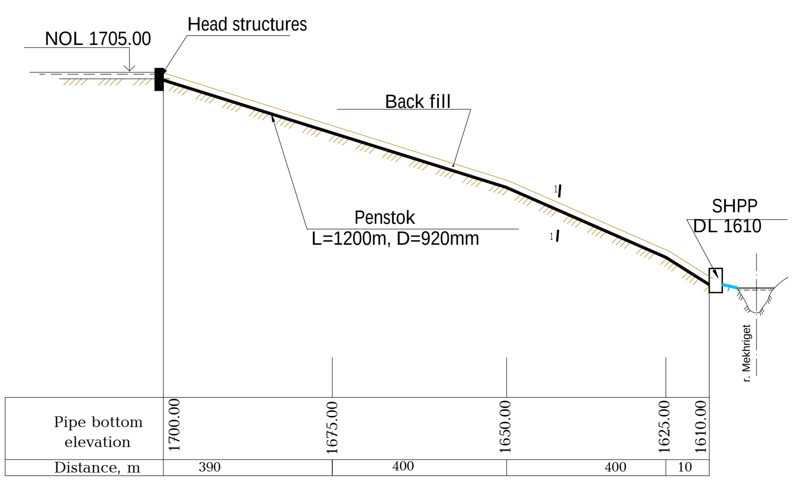
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		10.6	12.0
NPV, thousand USD			
	8%	263.7	263.7
	10%	50.7	108.9
	12%	-108.9	0.59
	14%	-231.4	-76.4
PB, years (without discount)		9.0	11.8
Deadline for credit return, years			9.0

APPENDIX. 83. LICHK SHPP-1

Plan



Longitudinal section



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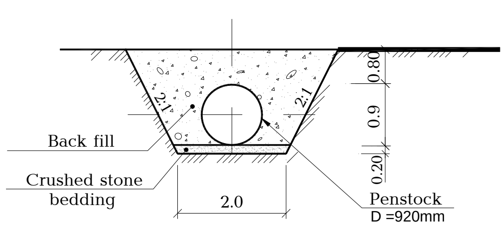
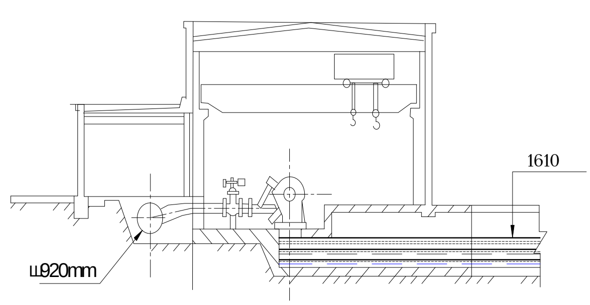


SHPP Powerhouse



Lichk SHPP-2 on Meghriget

Introduction
HYDROLOGY

Lichk SHPP-2 is planned to locate on Mechriget River. It is planned to construct a 1.4mln.m reservoir near the SHPP within Millennium Challenge Campaign.

The head works will me located near the river mouth till reaching Airi (Zvar) River after falling into Meghriget river and station works will be located after the Lichk reservoir.

Lichk SHPP-2 uses inclination of River Meghriget from 1605.0 till 1465.0. The length of derivation from Lichk River is 1950m by copper pipeline 1020mm in diameter with design pressure of 129.1m and design discharge 2.0m^3/sec.

After construction and exploitation Lichk SHPP-2 will have 2.066mwt capacity and will produce 5.52mln kw/h electricity annually.

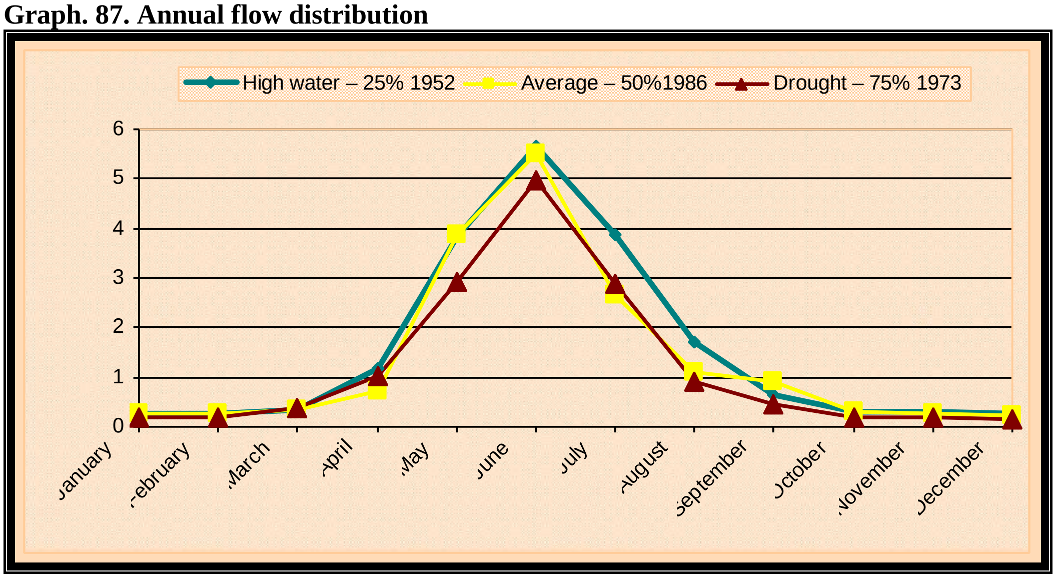
The observation data for 71 years from r. Lichk - Lichk water-meter station is used to define the hydrological properties of Lichk SHPP-2 headworks and the design river section.

The graphic below shows the hydrological properties of design river sections.

River Section	Distance from river mouth, km	Average altitude of the catchment basin, m.	Catchment area, km^2	Flow norms, m^3/sec
R. Lichk - longitudinal section -2	2.0	40.7	2680.0	1.40

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 87. Annual flow distribution



Maximal design discharge for Lichk SHPP-2 headwork river section for the general case equal 3% - 9.18m^3/sec, for verifying case - 0.5%-10.8m^3/sec, the observed average daily discharge value with 95% guarantee equals 0.155m^3/sec.

Water Economy and Energy Sector

The upstream pool elevation of Lichk SHPP is 1605.0m, downstream – 1465.0.0m. According to “Meghri” WUO there is water intake for irrigational use from Meghriget River for Agarak Plant industrial needs, Meghri city and village domestic needs, as well as it is used for seasonal regulation of Lichk reservoir – 1.4mln.m^3 annually:

- ❖ Industrial water supply -- 7.2mln.m^3
- ❖ Domestic water supply -- 3.5mln.m^3

Lichk SHPP-2 is derivational SHPP. In order not to drain the river where 1950m derivational pipeline is the environmental discharge is designed according to RA laws and 0.012m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Lichk SHPP-2 are calculated with 50% guarantee per annum (1974 see table 182).

Table. 182. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Lichk SHPP-2 (m^3/sec)	0.00	0.00	0.00	0.26	2.00	2.00	1.98	0.52	0.41	0.00	0.00	0.00	
SHPP average monthly capacity (mwt)	0.00	0.00	0.00	0.29	2.066	2.07	2.05	0.58	0.46	0.00	0.00	0.00	
SHPP –average monthly energy production (mln kwt/hour)	0.00	0.00	0.00	0.21	1.54	1.49	1.52	0.43	0.33	0.00	0.00	0.00	**5.52**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 1828.7 thousand USD (without VAT) and 2194.4 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses	USD thousand
1. Depreciation	60.3
2. Exploitation expenses	40.8
Salary	20.2
Renovation	14.6
Other Expenses	6.0
Total	101.1

Power indicators of have the following level

Indicators	Values
Derivation capacity, kwt	2066
Average multi annual production of energy, mln kwt/hour	5.52
Capital investments into SHPPS(without VAT),	
thousand USD	721.3
USD / kwt	954.1
USD / kwt/hour	0.24
Prime cost of power production, cents/kwt hour	1.83

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:
- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

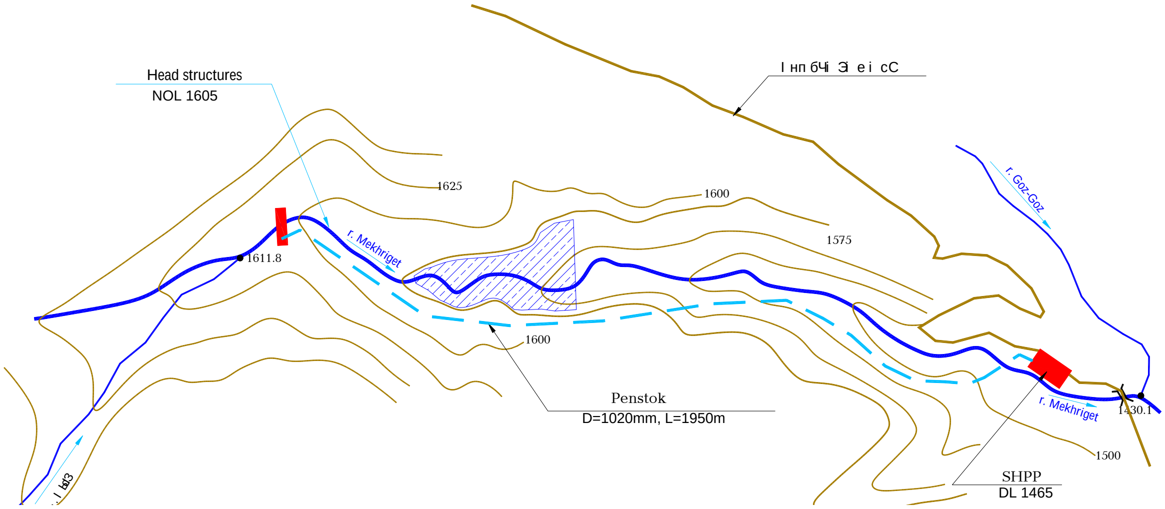
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 183. Design results according to financial scenarios

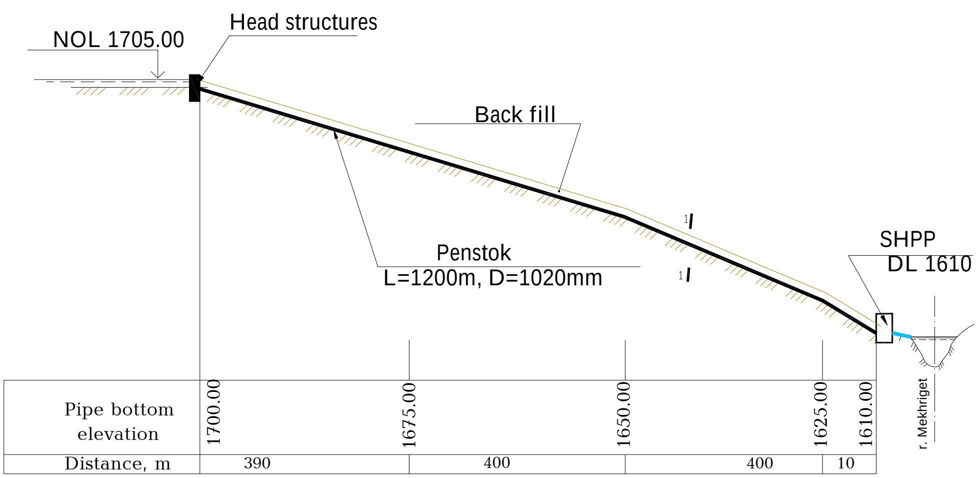
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		11.5	13.3
NPV, thousand USD			
	8%	637.3	637.3
	10%	236.2	329.4
	12%	-64.4	111.8
	14%	-295.0	-44.5
PB, years (without discount)		8.4	10.7
Deadline for credit return, years			8.0

APPENDIX. 84. LICHK SHPP-2

Plan



Longitudinal section



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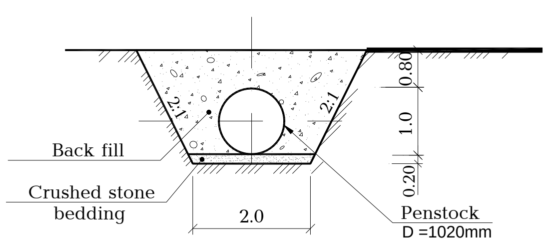
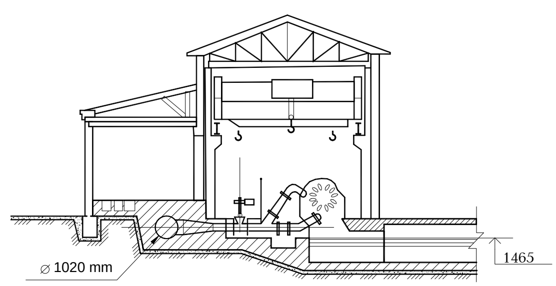


SHPP Powerhouse



15.8.6.3.2. Tashtun SHPP

Introduction

Tashtun SHPP will be located on River Tashtun. This SHPP was not included in the development plan. The working group found a construction for the SHPP after on-situ investigation.

Tashtun SHPP uses Tashtun river inclination from 1795.0 till 1680.0.

The length of derivation from Tashtun River is 1350m by copper pipeline 630mm in diameter with design pressure of 105.6m and design discharge 0.60m^3/sec.

After construction and exploitation Tashtun SHPP will have 508mwt capacity and will produce 1.56mln kw/h electricity annually.

Short Description for Tashtun **River Basin**

Tashtun River is the left inflow of Meghriget River and falls into the latter 22km from the river mouth.

River general chatchment area is 69.3km^2, average inclination is 132‰, average elevation is 2600m.

The forest coverage of the river is insignificant; the river flow direction is towards south-west. The area under description is mountainous with multiple inflows basins and gores.

River valley has a V-shape from upstream till water discharge.

The geological composition is represented by volcanic rocks, mainly basalt. The vegetation, especially in the upstream is alpine, sub-alpine that turned into mountain-leaf forest in the downstream.

The soils are presented by mountainous meadows. The annual flow of the river is formed by ground-spring and surface flows. Ground-water springs are the main source and participate in the flow formation during the while year round and decrease in winter because of freezing of the upper soil layers.

In spring the feeding mainly depends on melting snow, while in summer - on rain. Kajaran meteorological station is near the investigated territory, it is located in the Voghji river basin on the similar (1980m). The average ait temperature is 5.7°C. The absolute minimum is (-29°C), absolute maximum is (+33°C). The maximal freezing depth is 100cm. The comparative air moisture content is 70%. Average annual precipitations are 768mm, daily maximum is 66cm. Average thickness of ten-day snow layer is 91cm and snow freezing depth is 100cm.

HYDROLOGY

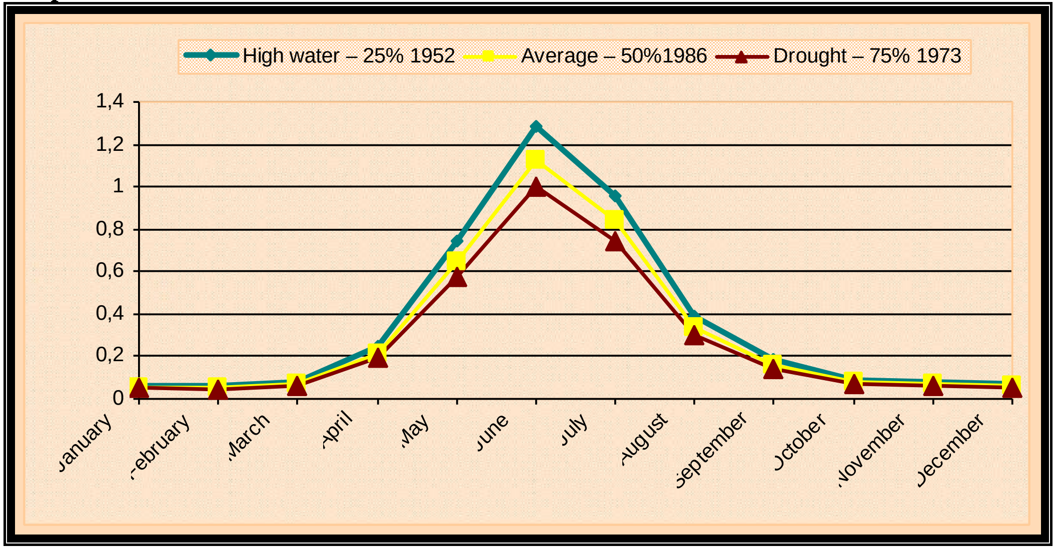
The observation data for 71 years from r. Lichk-Lichk water-meter station is used to define the hydrological properties of Tashtun SHPP headworks and the design river section.

The graphic below shows the hydrological properties of design river sections.

River Section	Distance from river mouth, km	Average altitude of the catchment basin, m.	Catchment area, km^2	Flow norms, m^3/sec
R. Tashtun-- longitudinal section	1.6	2575	16.5	0.30

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 88. Annual flow distribution



Maximal design discharge for Tashtun SHPP headwork river section for the general case equal 3% - 6.40m^3/sec, for verifying case - 0.5%-7.50m^3/sec, the observed average dayly discharge value with 95% guarantee equals 0.063.m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Tashtun SHPP is 1795.0m, downstream – 1680.0.0m. According to data of "Meghri" WUO there is no water intake from Tashtun River.

Tashtun SHPP is derivational SHPP. In order not to drain the river where 1350m derivational pipeline is the environmental discharge is designed according to RA laws and 0.056m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Tashtun SHPP are calculated with 50% guarantee per annum (1974 see table 184).

Table. 184. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Tashtun SHPP (m^3/sec)	0.02	0.01	0.03	0.18	0.60	0.60	0.60	0.30	0.12	0.04	0.03	0.02	
SHPP average monthly capacity (mwt)	0.02	0.00	0.03	0.16	0.508	0.51	0.51	0.27	0.11	0.04	0.03	0.02	
SHPP –average monthly energy production (mln kwt/hour)	0.01	0.00	0.02	0.12	0.38	0.37	0.38	0.20	0.08	0.03	0.02	0.01	**1.62**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 520.0 thousand USD (without VAT) and 624.0 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		17.2
2. Exploitation expenses		22.9
	Salary	14.4
	Renovation	4.5
	Other Expenses	4.0
Total		40.1

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		508
Average multi annual production of energy, mln kwt/hour		1.62
Capital investments into SHPPS(without VAT),		
	thousand USD	520.0
	USD / kwt	1023.6
	USD / kwt/hour	0.32
Prime cost of power production, cents/kwt hour		2.47

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- Private investments only /Scenario 1/
- 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

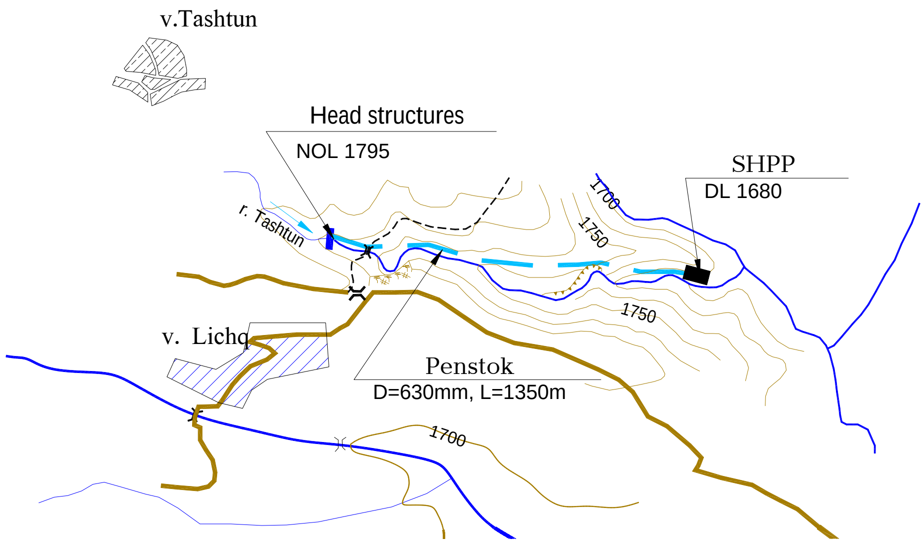
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

Table. 185. Design results according to financial scenarios

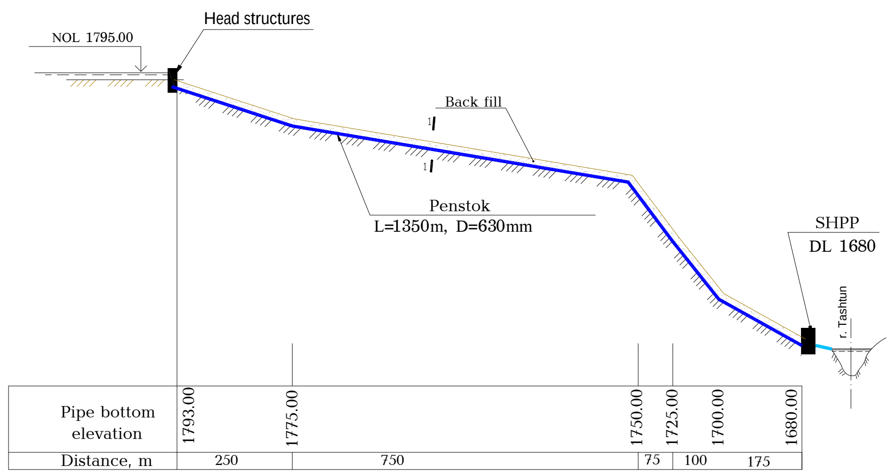
INDICATORS		**Scenario 1** 100% fully self - financed option	**Scenario 2** 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		9.8	10.9
NPV, thousand USD			
	8%	91.4	91.4
	10%	-8.1	23.2
	12%	-82.6	-24.0
	14%	-139.6	-57.3
PB, years (without discount)		9.6	12.9
Deadline for credit return, years			10.0

APPENDIX. 85. TASHTUN SHPP

Plan



Longitudinal section



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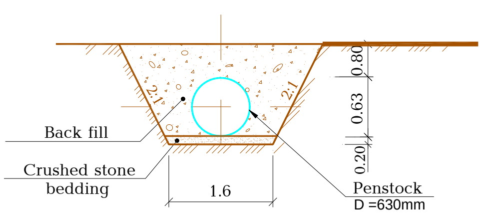
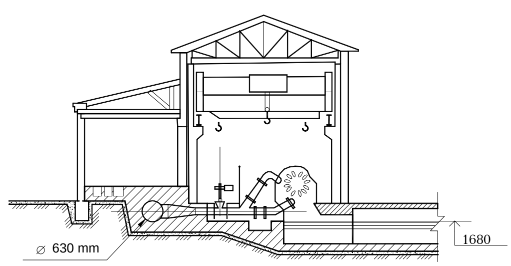


SHPP Powerhouse



15.8.6.4.1. Vank SHPP on River Kaler

Introduction

Vank SHPP will be located on River Kaler. The headworks will be located before the river Kaler falls into Meghriget River. Vank SHPP uses Kaler river inclination from 1700.0 till 1420.0. The length of derivation from Kaler River is 2900m by copper pipeline 720mm in diameter with design pressure of 264.5m and design discharge 0.80m^3/sec.

After construction and exploitation Vank SHPP will have 1.69mwt capacity and will produce 4.95mln kw/h electricity annually.

Short Description of KAler River basin

Kaler (Vaik) River is the left inflow of Meghriget River and falls into the latter 20km from the river mouth.

River length is 11.0km; general chatchment area is 32.5km^2. The river start from a number of inflows that come out on northern part of Bughbughan mountain (3219m) from basalt cracks 2700-2720 above the sea level. The general direction of the river is towards south-west.

River basin is shapes by multiple inflows and small rivers with their basin sand gorges, these were created iin the result of snow melting and heavy rains. The geological composition is conditioned by lavas.

The vegetative cover is alpine and sub alpine meadows that turn into bushes and small forests (Near Vaik village). Te earth cover is represented by mountainous meadow lands. The river flow is shaped by ground waters and surface waters. The ground waters have effect on flow formation the whole year round, slightly decreasing during summer drought. Snow melting waters feed the river during spring floods and rain – during spring and autumn.

River valley has a V-shape with 40-500 inclination and well cultivated valley. Slopes are composed of basalts and weak rocks in steep areas that are covered by clay-sand and sand stones. In the upstream the slopes are covered by grass and in the downstream – trees and gardens.
There is not inundations area. River bed is twisting and turning. The river banks are steep, 1.5 m high.

The river slopes and river bed are composed of rocks. The rounded stones are washed along the river bed; the river bed is subjected to deformation. Spring inundations start in March and reach their peak in May. The decrease is milder. The drought period is established in July-August. There are no autumn floods, but summer inundations are very heavy. The summer drought is more severe than the winter one.

There are no winter phenomena on the river except for insignificant ice on the river bank.

HYDROLOGY

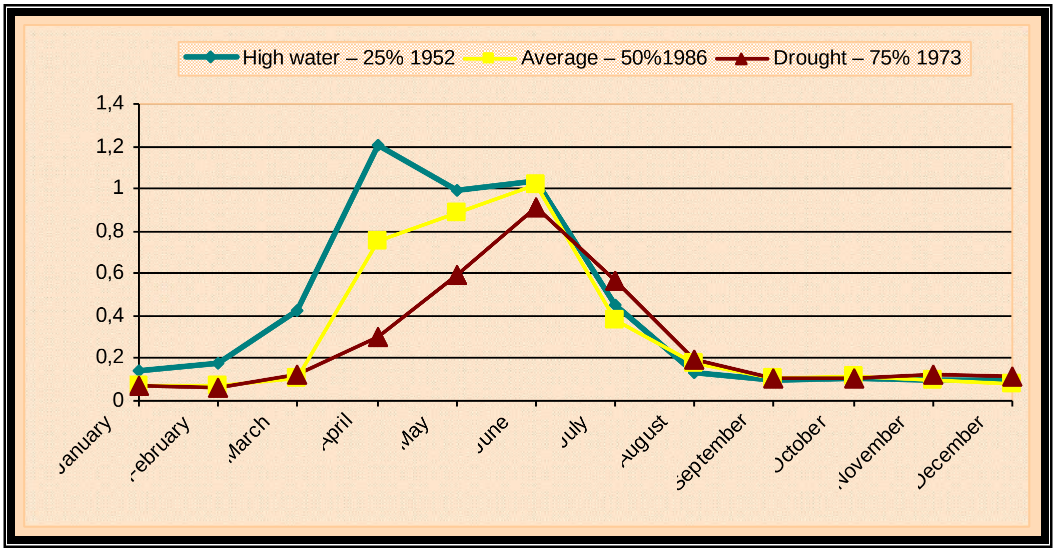
The observation data for 77 years from r. Meghri-Meghri water-meter station is used to define the hydrological properties of Vank SHPP headworks and the design river section.

The graphic below shows the hydrological properties of design river sections.

River Section	Distance from river mouth, km	Average altitude of the catchment basin, m.	Catchment area, km^2	Flow norms, m^3/sec
Kaler-- longitudinal section	2.8	2480	29.3	0.35

The graphic below shows hydrological properties of design river section for 3 typical years, necessary for the SHPP.

Graph. 89. Annual flow distribution



Maximal design discharge for Vank SHPP headwork river section for the general case equal 3% - 20.0m^3/sec, for verifying case - 0.5%-33.2m^3/sec, the observed average dayly discharge value with 95% guarantee equals 0.058m^3/sec.

WATER ECONOMY AND ENERGY SECTOR

The upstream pool elevation of Vank SHPP is 1700.0m, downstream – 1420.0.0m. According to data of WUO there is no water intake from River Kaler.

Vank SHPP is derivational SHPP. In order not to drain the river where 2900m derivational pipeline is the environmental discharge is designed according to RA laws and 0.04m^3/sec. All natural flow without irrigational demands and environmental flow values can be used for energy purposes. Hydro-power properties of Vank SHPP are calculated with 50% guarantee per annum (1959 see table 178).

Table. 186. Monthly water energy indicators

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	total
Average monthly discharge Karmravan SHPP (m^3/sec)	0.03	0.03	0.06	0.71	0.80	0.80	0.34	0.13	0.06	0.08	0.06	0.04	
SHPP average monthly capacity (mwt)	0.07	0.07	0.14	1.52	1.693	1.69	0.75	0.30	0.14	0.17	0.13	0.09	
SHPP –average monthly energy production (mln kwt/hour)	0.05	0.05	0.10	1.09	1.26	1.22	0.56	0.22	0.10	0.12	0.10	0.07	**4.95**

INVESTMENT EFFECIENCY

Capital investments

The capital investments into hydropower station are 1573.2 thousand USD (without VAT) and 1887.7 thousand USD with VAT.

Annual Exploitation Expenses - Prime Cost of Power Production

Annual exploitation expenses for power production on the SHPP are composed of depreciation expenses and exploitation expenses. Depreciation is accepted as linear with 3.3% annually.

Annual exploitation expenses for 2008 rates are as following:

Expenses		USD thousand
1. Depreciation		51.9
2. Exploitation expenses		40.8
	Salary	20.2
	Renovation	12.6
	Other Expenses	8.0
Total		92.7

Power indicators of have the following level

Indicators		Values
Derivation capacity, kwt		1693
Average multi annual production of energy, mln kwt/hour		4.95
Capital investments into SHPPS(without VAT),		
	thousand USD	1573.2
	USD / kwt	929.2
	USD / kwt/hour	0.317
Prime cost of power production, cents/kwt hour		1.87

Financial analisis

The construction period for the SHPP is 12 months while design period is 30 years.

Financial sustainability is determined by means of investment options:

- ❖ Private investments only /Scenario 1/
- ❖ 30% of private capital and 70% credit /Scenario 2/:

Prime cost for selling electric power is accepted as 5.4cents per kwt/hour. Credit percents are accepted as 10% annually.

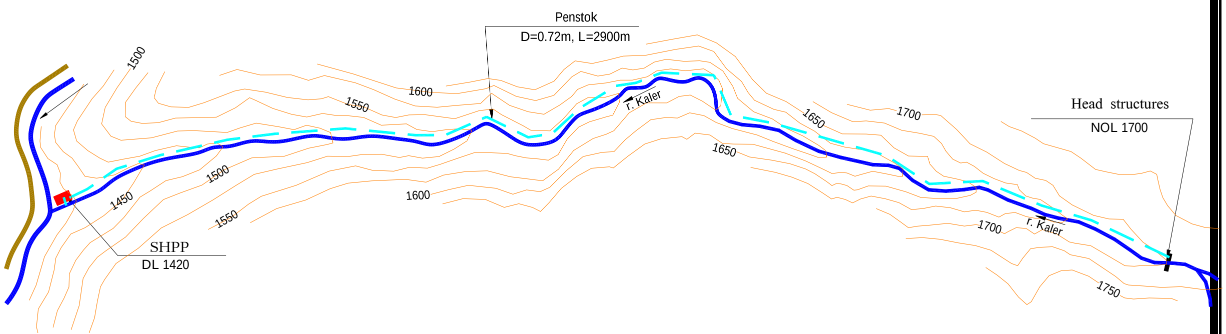
The results for financial sustainability based on the main option -30% of private capital and 70% credit – are shown on the table below.

<u>Table. 187. Design results according to financial scenarios</u>

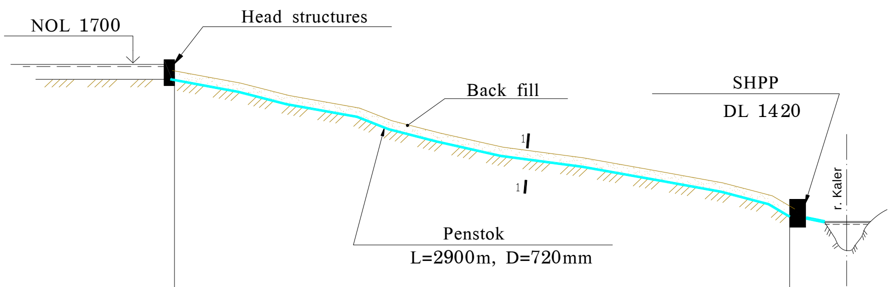
INDICATORS		Scenario 1 100% fully self - financed option	Scenario 2 30% capital & 70% credit
Prime cost cent, kwr/hour Indicators		5.4	5.4
IRR, %		11.5	13.4
NPV, thousand USD			
	8%	556.5	556.6
	10%	210.1	290.3
	12%	-49.5	102.1
	14%	-248.7	-33.1
PB, years (without discount)		8.3	10.7
Deadline for credit return, years			8.0

APPENDIX. 86. VANQ SHPP

Plan



Longitudinal section



Pipe bottom elevation	1697.00	1675.00	1650.00	1625.00	1600.00	1575.00	1550.00	1525.00	1500.00	1475.00	1450.00	1420.00
Distance, m	300	230	330	150	230	300	380	330	325	225	100	

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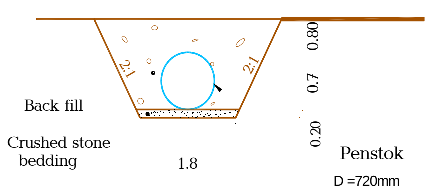
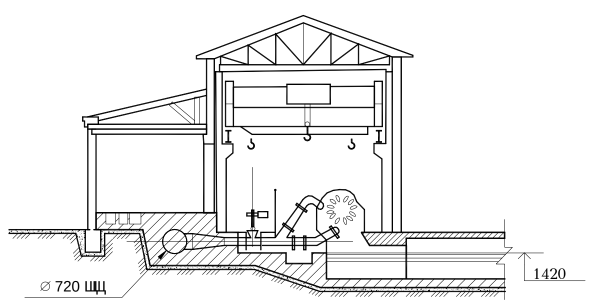


SHPP Powerhouse



SECTION 16. Approipriation of water supply system's hydropotential

According to technical specifications one of the main goals of the present program is to define successful appropriation standards. There is no water supply channels in 1997 SHPP plan.

In order to define the hydro potential of water supply system, during the development we made an inquiry from the Water Economy Committee of RA Ministry of Local Administration to obtain the technical data for water systems of RA. The answer was that the private water supplier of the republic are remaining passive to submit the required information (see Annex 7)

At the same time during the works, private investors asked to design a SHPP for supplying water to Agarak CMP (Copper Molybdenum Plant). The technical substations have been carried out for this project. The technical indicators for the SHPP are show in the table below.

Foundation for Reconstructive Energy Sector and Enerjy Saving supplied the below mentiopned data through WB related ti water supply saystems and SHPP design primary data indicators

No	Name of the Water Carrier	Diameter (mm)	Location Site	Water quantity (l/sec)	Design Pressure(m)	Design capacity (kWt)	Distance from the network (km)	Necessary investment (AMD)
1	Mukhuturyan-Goris	500	1-st extinguishing basin	200	36.8	55.0	4.5	32,045,000.0
		500	2-nd extinguishing basin	200	22.1	35.0	2.5	18,785,000.0
2	Chanakhchi Cogeneration Plant -Kapan	300	1-st extinguishing basin	60	147.5	60.0	1.0	17,680,000.0
3	Jenmanis-Vedi	300	6-th extinguishing basin	30	620.0	145.0	2.5	43,095,000.0
4	Artashavan – Ashtarak	600	1-st extinguishing basin	120	28.7	46.2	0.5	12,420,200.0
5	Makravan Abovyan	700	2-nd extinguishing basin	450	23.3	70.0	2.5	26,520,000.0
		600	3-rd extinguishing basin	360	27.4	85.0	4.3	37,791,000.0
		600	Water Channel	250	26.4	80.0	0.5	19,890,000.0
6	Mantash-Artiki Cogeneration Plant	500	1-st extinguishing basin	250	169.0	295.8	11.0	113,991,800.0
		500	2-nd extinguishing basin	250	224.2	392.4	8.0	122,080,400.0
		500	Cogeneration Plant	250	196.6	344.1	0.1	76,488,100.0
7	Mantash-Gyughakan	500	1-st extinguishing basin	160	203.9	228.4	9.0	90,256,400.0
		500	Cogeneration Plant	160	203.9	228.4	4.0	68,156,400.0
	Total					**2,065.3**		**679,199,300.0**

SECTION 17. Conclusion

Working groups carried out on-situ investigations in 9 marzes and 14 river basins, have updated and verified localized schemed of unappropriated SHPPs and their technical properties.

As a result of recent updates and verification works, it has become possible to estimate the power potential of SHPP and estimate exploitation possibilities. Therefore, general estimation if SHPP increased their attractiveness for investors.

The following SHPPs are planned to be put under exploitation in RA marzes:

Shirak marz - 2 derivational, 1 next to a dam, 1 on irrigational channel
Lori marz - 32 derivational, 1 on a water channel
Tavish marz - 21 derivational, 1 on irrigation channel, 1 SHPP next to a dam
Aragatsotni marz - 4 derivational
Kotayk marz - 4 derivational
Ararat marz - 5 derivational
Gegharkunic Marz - 10 derivational, 1 on irrigational channel
Vayots dzor marz - 4 derivational
Syunik Marz - 24 derivational, 1 next to dam, 1 irrigational channel and 1 water supply water line.

In the investigated river basins the general quantity of SPPPs equals 115, which is the half of the quantity planned by 1997 scheme. As far as there is no indication of pressure limit for SHPP it is possible to create 2-3 stations and have one SHPP with 5km derivation length.

According to pressure scheme there are high indicators for water economy for SHPPs.
This fact is explained by two preconditions.
a)- every station have been designed with new headworks that gives an opportunity to use the energy of the neighbouring flows and correspondingly increase power production,
b)- average value has been accepted for hydropower equipment turbines and generator efficiency coefisient, the value equals 8.0 in 1997 plan as opposed to standard 7.5.

According top RA main river basins research results in 1997 plan as well as in the updates scheme the maximal potential in the following river basins Aghstev (23.3mwt, annual 2.5mln.kw/howr power production), Debed (20.4mwt, annual 73.6mln. kwt/hour power production) and Vogghy (14.3mwt with annual 60.4mln. kwt/hour production).

Below are the technical properties of SHPPs classified according to the river basins.

	RA river Basin	Quantity if SHPPs in the basin	Installed Capacity	General average annual production	Annual working hours	Plant factor
			mwt	Mln. kwt/hour	Hour/year	%
1	Debed	33	24.8	90.8	3670	41.9
2	Aghstev	23	33.7	129.8	3843	43.9
3	Akhuryan	4	11.0	27.7	2521	28.8
4	Kasakh	4	3.5	12.5	3570	40.8
5	Hrazdan	4	4.3	13.2	3089	35.3
6	Sevan Lake	11	9.7	43.3	4466	51.0
7	Azat and Vedi	5	5.0	18.7	3728	42.6
8	Arpa	4	12.2	35.5	2908	33.2
9	Vorotan	5	10.3	42.7	4131	47.2
10	Voghgy	14	19.0	76.2	4009	45.8
11	Meghri	8	13.3	49.7	3724	42.5
	Total	**115**	**146.9**	**540.1**	**3677**	**42.0**

The total number of SHPPs in RA marzes river basins and their technical specifications are presented on table 1.3.

The following are the main factors for estimating industrial sustainability:

- Internal Rate of Return - IRR
- Net Present Value – NPV in case of certain comparative percentage
- capital investments into 1kwt hour power.

The table 4 shows the SHPP list with final options that are classified according to IRR decrease in case of financing with one’s own means.

Water Energy Indicators of Updated and Verified SHPPs on the territory of RA									
#	SHPP Names	Upstream Elevation, m	Downstream Elevation m	Derivation Length, m	Derivation Diameter, m	Design Pressure, m	Design Discharge m^3/sec	Initial Capacity kWt	Annual power Production, mln. kWt/hour
1	2	3	4	5	6	7	8	9	10
	Akhuryan River Basin								
1	Karmravan SHPP (Kizil)	2225.0	2065.0	2750.0	0.53	138.5	0.40	443	1.58
2	Geghadzor SHPP	2465.0	2365.0	1400.0	0.53	83.0	0.50	332	1.20
3	Near-Dam SHPP next to Akhuryan reservoir*	1452.0	1407.9	430.0	3.00	40.0	29.00	9900	23.00
4	Karakert SHPP on Talin channel*	1232.6	1133.7	2250.0	0.53	66.0	0.69	312	1.93
	Shirak Marz Total							**10987**	**27.70**
	Dzorakert river basin								
1	Dzorakert SHPP-1(1.2)	2045.0	1910.0	2900.0	1.02	117.1	2.20	2061	6.58
2	Dzorakert SHPP -2(3.4)*	1905.0	1727.0	4000.0	1.22	167.5	2.20	2950	10.30
3	Sarvanget SHPP-1	2275.0	2150.0	2600.0	0.53	113.4	0.30	272	0.86
4	Sarvanget SHPP -2	2145.0	2000.0	1800.0	0.63	132.8	0.60	638	2.13
5	Sarvanget SHPP -3	1995.0	1835.0	2300.0	0.72	150.5	0.70	843	2.76
6	Sarvanget SHPP -4	1830.0	1675.0	2300.0	0.82	145.4	1.00	1164	3.73
7	Karakala SHPP -1(5.6)	1980.0	1825.0	4875.0	0.82	140.7	0.80	901	3.42
8	Urut(Meskhana) SHPP	1560.0	1500.0	4800.0	0.82	52.0	0.60	250	1.02
	Pambak River Basin								
9	Dzorashen SHPP	1990.0	1880.0	2750.0	0.43	92.5	0.2	148	0.621
10	Tazakent SHPP	1900.0	1795.0	1425.0	0.43	95.9	0.2	153	0.675
11	Pambi (Geduk) SHPP	1865.0	1700.0	3625.0	0.43	129.2	0.25	258	1.00
12	Bazum SHPP	1500.0	1400.0	2500.0	0.72	92.4	0.6	443	1.93
13	Vanadzor SHPP	1650.0	1450.0	2600.0	0.72	186.1	0.8	1191	3.63
14	Karbi SHPP	1675.0	1485.0	2900.0	0.82	178	1.0	1424	5.02
15	Pambak (no name) SHPP-1	1450.0	1250.0	1625.0	0.43	185.2	0.24	356	1.28
16	Pambak (no name) SHPP -2	1450.0	1195.0	1570.0	0.53	242.7	0.4	777	2.73
17	Vahagnaget SHPP	1205.0	1025.0	3200.0	0.53	154.9	0.4	496	2.68
18	Antaramut SHPP	1100.0	950.0	2600.0	0.53	134.3	0.35	376	1.89
19	Chakhkali SHPP	1950.0	1795.0	2350.0	0.43	131.8	0.25	264	1.26
20	Legranjur SHPP *	1870.0	1770.0	2100.0	0.72	86.7	0.8	555	2.38

1	2	3	4	5	6	7	8	9	10
21	Chanakhchi SHPP -1*	1265.0	1139.0	1950.0	1.02	115.0	1.80	1550	6.3
22	Chanakhchi SHPP -3*	1034.0	930.0	2600.0	1.22	95.0	2.00	1300	5.7
23	Trchkan SHPP on Chichkhan River*	1834.0	1760.0	2400.0	1.22	67.8	2.00	1085	4.09
	Debed River Basin								
24	Akhnidzor SHPP -1	1535.0	1435.0	2000.0	0.53	86.9	0.35	243	0.84
25	Akhnidzor SHPP -2	1400.0	1300.0	3000.0	0.72	90.0	0.6	715	2.33
	Marts SHPP	1366.0	1300.0	2100.0	0.72	59.0	0.6		
26	Geghatar Gomer SHPP -1	1485.0	1410.0	1300.0	0.63	65.4	0.6	314	1.06
27	Sarnakhbyur SHPP	1350.0	1160.0	3000.0	0.82	176.4	1.0	1411	4.82
28	Sarnakhbyur t SHPP -1	1270.0	1035.0	2200.0	0.43	227.0	0.15	272	0.99
29	Sarnakhbyur SHPP -2	1025.0	825.0	1975.0	0.43	162.1	0.35	454	1.89
30	Alaverdi SHPP	885.0	740.0	1650.0	0.43	130.0	0.24	249	0.98
31	Shnokh SHPP	1050.0	850.0	1350.0	0.63	190.9	0.60	916	3.43
32	Akhtala SHPP	740.0	620.0	2450.0	0.53	100.8	0.40	323	1.33
33	Narek and Heghine SHPP on Airum HPP-Zeitun Haghtanak¦ irrigational channel*	521.7	494.5	250.0	1.22	24.6	2.00	394	1.16
	Total for Lori Marz							**24746**	**90.81**
	Aghstev River Basin								
1	Bldan SHPP *	1400.0	1293.0	2700.0	0.72	84.5	1.00	680	2.65
2	Getik SHPP -3*	1330.0	1000.0	13500.0	1.42	283.0	4.00	9000	31.40
3	Shamlukh SHPP	1425.0	1275.0	3325.0	0.72	135.1	0.70	756.0	2.99
4	Shtoganajur SHPP	1350.0	1275.0	1550.0	0.63	64.5	0.60	310.0	0.85
5	Kobkhanjur SHPP	1240.0	1000.0	2825.0	0.53	221.4	0.35	620.0	2.34
6	Khachakhbyur SHPP -1	1400.0	1255.0	2000.0	0.92	134.1	1.50	1609.0	7.30
7	Khachakhbyur SHPP -2	1250.0	1110.0	2200.0	1.22	130.8	2.80	2929.0	12.38
8	Khachakhbyur SHPP -3	1100.0	890.0	2900.0	1.22	194.1	3.20	4970.0	20.24
9	Mtnaghur SHPP -1	1125.0	815.0	2600.0	0.43	273.2	0.30	656.0	2.67
10	Mtnaghur SHPP -2	810.0	720.0	1825.0	0.63	81.4	0.05	326.0	1.25
11	Jilis SHPP	1050.0	850.0	3600.0	0.53	178.3	0.35	488.0	2.07
12	Karakhan SHPP (Kirants)	840.0	730.0	4250.0	1.02	94.7	1.60	1212	5.83
13	Hakhum SHPP -1	1090.0	1025.0	2500.0	0.32	53.1	1.40	594	2.84
14	Tavush SHPP -1	1175.0	1065.0	3650.0	0.82	99.3	0.80	636	2.06
15	Tavush SHPP -2	1055.0	925.0	4425.0	0.92	119.1	1.00	953	3.19
16	Chichkhailu SHPP	1580.0	1435.0	1750.0	0.53	137.0	0.30	329	1.22
17	Sajigatan SHPP	1240.0	1125.0	2000.0	0.63	105.6	0.50	422	1.63

1	2	3	4	5	6	7	8	9	10
18	Khndzorut SHPP -1	1305.0	1205.0	2450.0	0.82	88.9	1.0	711	2.76
19	Khndzorut SHPP -2	1200.0	1100.0	2500.0	0.92	91.2	1.2	875	3.34
20	Khndzorut SHPP -3	1090.0	975.0	3750.0	1.02	94.7	2.0	1505	6.08
21	Akhnja SHPP	850.0	760.0	3000.0	1.42	80.7	3.6	2324	9.03
22	Vonkepar SHPP on irrigational pipeline*	1203.2	905.0	10000.0	0.72	266.3	0.50	1065	2.48
23	Spitak Lich SHPP next to Spitak Lich reservoir*	727.0	715.0	500.0	2x1.42	10.0	10.00	800	3.20
	Tavush Marz Tota							**33779**	**129.77**
1	Arkhashan SHPP -1	2575.0	2330.0	2150.0	0.63	230.6	0.6	1106	3.94
2	Arkhashan SHPP -2	2315.0	2170.0	1900.0	0.63	127.6	0.7	714	2.54
3	Arkhashan SHPP -3	2150.0	2075.0	1000.0	0.92	70.0	1.5	840	3.14
4	Duskend SHPP	2450.0	2260.0	2200.0	0.63	175.1	0.6	841	2.879
	Total Aratsotn Marz							**3501**	**12.50**
	Hrazdan River Basin								
1	Meghradzor SHPP	1950.0	1810.0	3800.0	0.82	124.2	1.00	994	2.78
2	Tsakhkamarg SHPP on Ulashik River*	2260.0	1905.0	5550.0	0.8	340.1	0.80	2270	7.1
3	Arjadzor SHPP	1987.5	1862.5	1400.0	0.72	119.2	0.70	668	2.47
4	Dalar SHPP	2000.0	1860.0	2400.0	0.53	124.2	0.35	348	0.87
	Kotaik Marz Total							**4280**	**13.22**
	Azat River Basin								
1	Azat SHPP *	1190.0	1120.0	3350.0	1.42	62.8	3.00	1510	7.21
2	Gilankar SHPP	1650.0	1385.0	2350.0	0.53	244.9	0.40	784	2.68
3	Sevjur SHPP	1800.0	1550.0	1150.0	0.53	235.4	0.50	941	2.68
4	Ukhtakunk SHPP	1965.0	1750.0	3400.0	0.72	200.4	0.70	1122	3.84
	Vedi River Basin								
5	Vedi SHPP	1460.0	1380.0	3150.0	0.92	69.4	1.2	666	2.32
	Total Ararat Basin							**5023**	**18.73**
	Sevan Lich Basin								
1	Masiv SHPP -1	2165.0	2090.0	2500.0	0.92	67.6	1.10	595	3.28
2	Masrik SHPP -2	2085.0	2015.0	3300.0	0.92	58.4	1.20	560	3.08
3	Gegharkunik SHPP -1	2525.0	2375.0	2130.0	0.43	119.1	0.30	286	1.00

1	2	3	4	5	6	7	8	9	10
4	Gegharkunic SHPP -2	2370.0	2210.0	2150.0	0.53	141.8	0.40	454	1.46
5	Martuni SHPP -1	2600.0	2375.0	4250.0	0.82	205.7	1.00	1646	6.07
6	Martuni SHPP -2	2370.0	2190.0	4400.0	0.92	164.5	1.20	1579	5.70
7	Martuni SHPP -3	2187.0	2113.0	2500.0	1.02	67.7	1.40	758	2.29
8	Mairaru SHPP -1	2500.0	2320.0	1500.0	0.63	165.0	0.70	924	3.13
9	Mairaru SHPP -2	2310.0	2225.0	1000.0	0.72	79.2	0.80	507	1.62
10	Karchakhbuyr SHPP ensemble on Baidara river*	2700.0	2000.0	10700.0	0.53	575.0	0.45	2000	13.10
11	Gavar SHPP on irrigational channel*			330.0	1.22	13.6	2.90	380	2.54
	Gegharkunikmarz Total							**9698**	**43.27**
	Arpa River Basin								
1	Arpa 1-5 SHPP*	2500.0	2200.0	3900.0	1.02	270.0	2.00	4300	12.00
2	Elis SHPP on Elis River*	2352.0	2212.0	3270.0	1.42	127.9	4.00	4196	12.83
	SHPP on Soghmalu inflow*	2298.0	2212.0	1540.0	0.72	79.3	0.70	455	1.51
3	Karakala SHPP -1 on Karakala River*	2400.0	2210.0	2050.0	0.63	167.7	0.70	940	2.60
	SHPP-2 on the right inflow*	2415.0	2210.0	1150.0	0.30	183.1	0.15	220	0.60
4	Karakala SHPP -3*	2023.0	1803.0	3300.0	0.82	186.5	1.40	2090	5.94
	Vayuts Dzor Marz: Total							**12201**	**35.48**
	Vorotan River Basin								
1	Vorotan SHPP -1*	2208.0	2150.0	9000.0	1.62	117.8	6.0	5860	25.0
2	Jraghadzor SHPP	1615.0	1500.0	2800.0	0.72	102.9	0.7	576	1.91
	Sisyan river basin								
3	Arevis SHPP *	1870.0	1730.0	6200.0	1.22	120.9	2.5	2420	11.50
4	Arevis SHPP -1(vtak)	1960.0	1895.0	1200.0	0.82	59.7	1.0	476	1.38
5	Arevis SHPP -2(vtak)	2050.0	1902.0	2500.0	0.82	138.8	0.9	999	2.89
	Voghji River Basin								
1	Katnarat SHPP	1750.0	1505.0	2000.0	0.53	219.3	0.4	702	2.42
2	Avsarlu SHPP	1750.0	1545.0	2150.0	0.63	185.3	0.7	1038	3.68
3	Musalam SHPP	1535.0	1345.0	3400.0	0.82	169.8	1.2	1630	6.25
4	Kirs SHPP	1667.6	1576.7	2000.0	1.02	79.7	2.0	1276	4.64
5	Karabash SHPP	1520.0	1340.0	1200.0	0.53	165.4	0.5	662	2.34

1	2	3	4	5	6	7	8	9	10
6	Giratakh SHPP	1450.0	1280.0	1750.0	0.63	158.2	0.6	759	2.71
7	Vachagan SHPP	975.0	845.0	2500.0	0.72	118.2	0.8	709	2.52
8	SHPP next to Gekhi Reservoir *	1402.0	1332.5	401.0	1.22	65.0	3.0	1560	9.79
9	SHPP on Geghi –Eghvard water carrier*	1330.4	1130.0	8400.0	0.53	168.2	0.2	330	1.61
10	Geghi-2 SHPP *	1325.0	1260.0	3000.0	1.42	51.2	4.5	1840	9.13
11	Voghji SHPP-1 (Jrakhor SHPP-1)	1240.3	1140.0	600.0	1.62	97.8	6.0	4690	15.8
	Tsav River Basin								
12	Shishkert SHPP -1	1575.0	1415.0	2100.0	0.72	143.8	0.90	1045	4.20
13	Shishkert SHPP -2	1400.0	1220.0	2300.0	0.72	162.3	0.90	2424	9.63
	Mazra SHPP	1400.0	1220.0	1050.0	0.72	172.6	0.90		
14	Bentadzor SHPP	875.0	750.0	1700.0	0.53	110.9	0.40	355	1.53
	Meghri River Basin								
1	Lichk SHPP -1	1705.0	1610.0	1200.0	0.92	88.4	1.50	1061	3.12
2	Lichk SHPP 2	1605.0	1465.0	1950.0	1.02	129.1	2.00	2066	5.52
3	Tashtun SHPP – left inflow	1790.0	1680.0	1350.0	0.63	105.9	0.60	508	1.56
4	Tashtun SHPP -1 on Tashtun river*	2050.0	1723.0	4750.0	0.72	307.4	0.70	1720	5.97
5	Vardanidzor SHPP on river Meghri*	1125.0	940.0	4100.0	1.42	175.8	3.20	4500	15.40
6	Leghvaz SHPP	935.0	865.0	1625.0	1.22	61.1	3.20	1564	7.01
7	Vank SHPP (Kaler)	1700	1570	2900	0.73	119.8	0.80	767	2.26
8	Karchevan SHPP Agarak Copper Molybdenum Plant water supply channel*	1294.0	950.0	2000.0	0.53	324.2	0.45	1170	8.90
	Syunik Marz: Total							**42707**	**168.67**
	Total for RA territory							**146904**	**540.14**

*) Technical economic substantiation for this SHPPs are ordered by private investors

Economic exponents of verifies and updated SHPPs

#	SHPP	Initial Capacity kWt	Power production Mln.kWt/hour	Annual production/hours	Plant factor, %	Capital Investments Thousand USD	Specific Capital Investments		Annual exploitation expenses Thousand USD	Power prime cost	IRR, %		NPV					
							USDkWt	USD/kWt hour		10%	Credit 10 %	Private Capital	Credit, 10%			Private Capital		
													8%	10%	12%	8%	10%	12%
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
	Akhuryan River Basin																	
1	Karmravan SHPP (Kizil)	443	1.58	3557.6	40.6	570.0	1286.7	0.360	40.8	2.5	8.8	8.5	29.3	-29	-69	29.3	-68	-141
2	Geghadzor SHPP	332	1.20	3599.4	41.1	380.5	1146.1	0.318	32.0	2.66	6.3	7.1	-31.7	-57	-73	-32	-89	-161
3	SHPP Next to Akhuryan Reservoir*	9900	23.00	2323	26.5	5490	557	0.240	293.0	1.27		11.2				564	-333	-1008
4	Karakert SHPP in Talin channel*	312	1.93	6185.9	70.6	238.5	758	0.120	27.3	1.4	22.7	17.9	170	124	85.7	166	107	62.3
	Shirak Marz: Total	**10987**	**27.70**			**6679.0**												
	Dzoraget River Basin																	
1	Dzoraget SHPP -1(1.2)	2061	6.58	3192.6	36.4	1977.4	959.5	0.300	106.3	1.6	15.3	12.8	967	580	303	965	486	128
2	Dzoraget SHPP -2(3.4)*	2950	10.30	3491.5	39.9	1985.0	673	0.190	108.9	1.05	23.7	16.2	1257	1148	827	1089	631	286
3	Sarvanget SHPP -1	272	0.86	3161.8	36.1	302.1	1110.5	0.350	29.4	3.4	5.0	6.5	-40.9	-56	-66	-41	-83	-115
4	Sarvanget SHPP -2	638	2.13	3338.6	38.1	584.1	915.6	0.270	40.4	1.9	15.5	13.0	294	178	95.1	294	151	43.9
5	Sarvanget SHPP -3	843	2.76	3274.0	37.4	818	970.3	0.280	49.9	1.8	14.9	12.4	364	213	106	364	172	27.6
6	Sarvanget SHPP -4	1164	3.73	3204.5	36.6	1046.2	898.8	0.280	70.1	1.88	16.1	13.4	567.0	353	200	567	305	107.9
7	Karakala SHPP -1(5.6)	901	3.42	3795.8	43.3	1165.6	1293.6	0.340	69.1	2.02	11.9	10.5	290	118	-2.3	290	53.1	-124
8	Urut (Meskhana) SHPP	250	1.02	4080.0	46.6	320.3	1281.2	0.310	29.6	2.9	9.2	8.7	22.9	-11.0	-34.0	22.9	-32.9	-74.8
	Pambak River Basin																	
9	Dzorashen SHPP	148	0.621	4195.9	47.9	176.8	1195	0.285	19.3	3.11	9.3	8.8	13.4	-5.4	-18	13.4	-18	-40.7
10	Tazakent SHPP	153	0.675	4411.8	50.4	171.6	1121.8	0.254	19.1	2.83	12.2	10.6	45.1	19.4	1.43	45.1	9.9	-16.5
11	Pamby (Gedurk) SHPP	258	1.00	3876.0	44.2	316.4	1226.3	0.316	28.2	2.9	9.2	8.7	22.3	-11	-34	22.3	-33	-74.1
12	Bazum SHPP	443	1.93	4356.7	49.7	475.9	1074.3	0.246	35.9	1.86	17.2	14.3	306	198	121	306	179	83.4
13	Vanadzor SHPP	1191	3.63	3047.9	34.8	1299.2	1090.9	0.360	74.6	2.06	11.2	10.0	257	82.1	-39	257	3.92	-186
14	Karbi SHPP	1424	5.02	3525.3	40.2	1498.2	1052	0.300	85.6	1.7	15.0	12.5	677	400	203	677	323	58.3
15	Pambak (no name) SHPP -1	356	1.28	3595.5	41.0	367.1	1031.1	0.287	31.5	2.46	12.4	10.8	101	45.3	6.3	101	24.9	-32.2
16	Pambak (no name) SHPP -2	777	2.73	3513.5	40.1	771.4	992.8	0.210	52	1.9	14.9	12.6	362	213	107	362	178	39.6
17	Vahagnaget SHPP	496	2.68	5403.2	61.7	553.6	1116.1	0.207	39.1	1.46	23.2	18.1	588	422	301	588	402	263
18	Antaramut SHPP	376	1.89	5026.6	57.4	439.1	1167.7	0.232	34.4	1.82	18.7	15.2	324	218	141	324	200	107

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
19	Chakhkali SHPP	264	1.26	4772.7	54.5	285.5	1081.3	0.227	23.7	1.88	18.9	15.2	213	144	93.6	213	132	71.2
20	Lernajur SHPP *	555	2.38	4288.3	49.0	623.6	1123.6	0.260	51.3	2.15	14.2	12.0	137	59.6	5.4	107	0.7	-78.7
21	Chanakhchi SHPP -1*	1550	6.3	4065	46.4	2010	1300	0.320										
22	Chanakhchi SHPP -3*	1300	5.7	4385	50.1	2000	1540	0.350										
23	Trchkan SHPP on Chichkhan River*	1085	4.09	3765	43.0	847.4	780.9	0.207	52.4	1.28	17.7	14.5		365	224		332	158
	Debed River Basin																	
24	Akhnidzor SHPP -1	243	0.84	3456.8	39.5	293.4	1207.6	0.350	28.1	3.36	5.3	6.7	-35.9	-52	-62	35.9	-78	-109
25	Akhnidzor SHPP -2 Marts SHPP	715	2.33	3258.7	37.2	916.3	1281.6	0.390	64.5	2.76	7.2	7.58	-36.1	-107	-155	-36	-170	-287
26	Geghatar Gomer SHPP -1	314	1.06	3375.8	38.5	337.5	1074.9	0.320	29.7	2.8	9.6	8.9	30.3	-6.7	-32	30.3	-30	-74.4
27	Sarnakhbyur SHPP	1411	4.82	3416.0	39.0	1331.7	943.8	0.276	78.8	1.63	16.7	13.7	771	490	289	771	429	173
28	Sarnakhbyur t SHPP -1	272	0.99	3639.7	41.5	328.5	1207.7	0.330	27.4	2.76	9.2	8.7	22.9	-12	-35	22.9	-34	-77.1
29	Sarnakhbyur SHPP -2	454	1.89	4163.0	47.5	520	1145	0.276	36.2	1.92	15.2	12.6	241	143	74.3	241	117	24.2
30	Alaverdi SHPP	249	0.98	3939.8	45.0	287.9	1156.3	0.293	25.3	2.58	11.6	10.2	63	23.2	-4.5	63	5	-36.9
31	Shnokh SHPP	916	3.43	3744.5	42.7	872.6	952.6	0.254	60.0	1.75	17.2	14.3	562	365	222	562	329	154
32	Akhtala SHPP	323	1.33	4108.4	46.9	381.1	1204.6	0.293	29.6	2.23	13.3	11.5	132	68.2	22.9	132	18.8	-13.8
33	Narek and Heghine SHPP on Airum HPP-Zeitun Haghtanak¦ irrigational channel*	394	1.16	2944	33.6	165.0	420.0	0.140	16.8	1.45	18.2	14.4		75.8	48.3		63.7	30.3
	Total for Lori Marz	**24746**	**90.81**			**25468.5**												
	Aghstev River Basin																	
1	Bldan SHPP *	680	2.65	3897	44.5	484.0	712.0	0.180	25.0	0.94								
2	Getik SHPP -3*	9000	31.40	3488.9	39.8	6722.0	746.9	0.2	344.6	1.10		14.8					2847	1433.8
3	Shamlukh SHPP	756.0	2.99	3955.0	45.1	721.3	954.1	0.241	.49.9	1.66	18.8	15.2	536	361	235	536	332	179
4	Shtoganajur SHPP	310.0	0.85	2725.8	31.1	348.0	1122.5	0.411	30.7	3.60		5.1				-89	-131	-163
5	Kobkhanjur SHPP	620.0	2.34	3767.7	43.0	595.1	959.9	0.255	43.7	1.87	17.0	13.9	356	228	137	356	201	85
6	Khachakhbyur SHPP -1	1609.0	7.30	4537.6	51.8	1545.0	960.0	0.210	91.4	1.25	24.0	18.6	1718	1243	896	1718	1188	790
7	Khachakhbyur SHPP -2	2929.0	12.38	4226.7	48.2	2870.4	980.0	0.230	152.4	1.23	21.6	17.3	2779	1963	1369	2779	1860	1177
8	Khachakhbyur SHPP -3	4970.0	20.24	4072.4	46.5	4895.5	985.0	0.240	237.5	1.17	20.9	16.9	4521	3164	2178	4521	2989	1841
9	Mtnadzor SHPP -1	656.0	2.67	4065.5	46.4	612.0	933.0	0.230	44.4	1.66	20.0	15.9	499	343	231	499	318	183
10	Mtnadzor SHPP -2	326.0	1.25	3840.5	43.8	381.3	1169.8	0.305	32.1	2.56	11.1	10.0	73.5	22.4	-13.0	73.5	-0.5	-55.9
11	Jilis SHPP	488.0	2.07	4235.7	48.4	533.1	1092.4	0.258	38.3	1.85	17.0	13.8	314	201	120	314	176	73.2
12	Karakhan SHPP (Kirants)	1212	5.83	4810.2	54.9	1435.1	1184.1	0.246	77.9	1.34	20.4	16.1	1201	831	564	1201	772	451.0
13	Hakhum SHPP -1	594	2.84	4786.2	54.6	673.8	1134.3	0.237	44.0	1.55	20.0	15.9	548	377	253	548	349	200.0
14	Tavush SHPP -1	636	2.06	3239.0	37.0	743.1	1168.4	0.360	50.7	2.46	9.5	8.9	67	-15	-70	67	-65	-164
15	Tavush SHPP -2	953	3.19	3348.4	38.2	1043.5	1095.0	0.327	66.9	2.10	12.2	10.7	276	119	10	276	61	-99.7
16	Chichkhailu SHPP	329	1.22	3705.2	42.3	362.2	1100.8	0.297	31.3	2.56	11.5	10.1	77	27	-7	77	6	-47.9
17	Sajigatan öÐ¾Î	422	1.63	3855.5	44.0	458.6	10.86.8	0.281	35.2	2.16	14.0	11.8	177	97	40	177	74	-3.9

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
18	Khndzorut SHPP -1	711	2.76	3874.8	44.2	680.2	956.6	0.247	48.1	1.75	17.8	14.6	464	306	192	464	278	138.5
19	Khndzorut SHPP -2	875	3.34	3812.6	43.5	835.4	954.8	0.250	54.6	1.64	18.2	14.9	588	391	249	588	357	183.1
20	Khndzorut SHPP -3	1505	6.08	4037.2	46.1	1482.5	985.0	0.244	87.8	1.45	19.9	15.8	1200	824	553	1200	764	436.7
21	Akhnja SHPP	2324	9.03	3883.4	44.3	2186.1	940.7	0.242	120.6	1.34	20.6	16.3	1881	1309	895	1881	1219	723.5
22	Vonkepar SHPP on irrigational pipeline*	1065	2.48	2328.6	26.6	445.6	418.4	0.180	43.7	1.76	8.2	7.8	5.1	-35		-8.7	-80	
23	Spitak Lich SHPP next to Spitak Lich reservoir*	800	3.20	4000	45.7	650.0	812.5	0.200										
	Tavush Marz Total	**33770**	**129.77**			**30703.8**												
	<u>Kasakh River Basin</u>																	
1	Arkhashan SHPP -1	1106	3.94	3564.2	40.7	1015.5	918.2	0.258	68.8	1.7	17.5	14.1	638.0	416	257	638	369	167.6
2	Arkhashan SHPP -2	714	2.54	3561.6	40.7	713.1	998.7	0.280	55.4	2.2	14.0	11.9	275.6	151	63	276	115	-5.7
3	Arkhashan SHPP -3	840	3.14	3733.3	42.6	750.1	893.0	0.240	54.9	1.8	18.5	15.0	542.1	363	233	547	332	174.4
4	Duskend SHPP	841	2.879	3423.3	39.1	796.6	947.2	0.277	56.9	2.0	14.9	12.6	371.7	218	109	372	182	39.2
	Total Aratsotn Marz	**3501**	**12.50**			**3275.3**												
	<u>Hrazdan River Basin</u>																	
1	Meghradzor SHPP	994	2.78	2796.8	31.9	1032.3	1038.5	0.370	63.7	2.30	9.9	9.2	115	-4.9	-87	115	-71	-211
2	Tsakhkamarg SHPP on Ulashik River*	2270	7.10	3128	35.70	1637.0	721.0	0.23	91.9	1.29		13.3					462.4	155.2
3	Arjadzor SHPP	668	2.47	3697.6	42.2	638.9	956.5	0.260	43.7	1.77	17.3	14.1	393	254	155	393	225	99.1
4	Dalar SHPP	348	0.87	2500.0	28.5	350.0	1005.7	0.470	31.3	3.58	2.5	2.3	-81.8	-88	-92	-82	-92	-103
	Kotaik Marz Total	**4280**	**13.22**			**3658.2**												
	<u>Azat River Basin</u>																	
1	Azat SHPP *	1510	7.21	4774.8	54.5	1646.0	1090.0	0.23	86.5	1.2	19.1	13.7		678	434		524	205.4
2	Gilankar SHPP	784	2.68	3412.0	38.9	750.2	956.9	0.280	51.1	1.90	15.0	12.7	355.2	210	106	355	175	40.7
3	Sevjur SHPP	941	2.68	2848.0	32.5	745.3	792.0	0.278	51.9	1.94	16.3	13.4	410.9	257	147	411	223	81.9
4	Ukhtakunk SHPP	1122	3.84	3422.5	39.1	1101.9	982.1	0.287	69.60	1.8	15.1	12.7	528.2	314	161	528	263	64.4
	<u>Vedi River Basin</u>																	
5	Vedi SHPP	666	2.32	3483.5	39.8	833.5	1180.5	0.350	54.8	2.30	10.6	9.5	125.9	23.5	-47.0	126	-30	-147
	Total Ararat Basin	**5023**	**18.73**			**5076.9**												
	<u>Sevan Lich Basin</u>																	
1	Masrik SHPP -1	595	3.28	5507.6	62.9	625.7	1051.8	0.190	43.0	1.3	26.3	20.6	833	615	455	833	596	418
2	Masrik SHPP -2	560	3.08	5503.6	62.8	634.8	1133.5	0.206	43.4	1.4	23.7	18.4	692	499	358	692	477	315
3	Gegharkunik SHPP -1	286	1.00	3503.5	40.0	334.4	1169.3	0.330	30.1	3.0	8.0	8.0	0.2	-29.2	-49.0	0.2	-54.2	-95.0

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
4	Gegharkunic SHPP -2	454	1.46	3220.3	36.8	459.2	1011.4	0.310	35.3	2.4	11.5	10.1	96.9	34.1	-9.6	96.9	6.5	-61.3
5	Martuni SHPP -1	1646	6.07	3687.7	42.1	1506.7	915.3	0.248	85.9	1.42	19.7	15.7	1199	820	547	1199	758	429
6	Martuni SHPP -2	1579	5.70	3609.9	41.2	1576.5	998.4	0.277	88.8	1.56	17.1	13.9	949	611	368	949	538	230
7	Martuni SHPP -3	758	2.29	3021.1	34.5	810.8	1069.7	0.354	50.6	2.2	10.7	9.7	134	28.9	-44	134	-20	-135
8	Mairaru SHPP -1	924	3.13	3385.3	38.6	858.1	928.7	0.274	55.5	1.77	16.1	13.4	465	289	164	465	250	88.6
9	Mairaru SHPP -2	507	1.62	3199.2	36.5	501.7	989.6	0.309	36.95	2.28	12.2	10.7	132	56.7	4.1	132	28.8	-48.4
10	Karchakhbuyr SHPP ensemble on Baidara river*	2000	13.10	6550	74.8	2022	1010	0.150	122.0	0.92	22.7	18.2		858	599		855	553
11	Gavar SHPP on irrigational channel*	380	2.54	6684.2	76.3	302.8	797	0.120	23.0	0.90	21.6	17.0	357.0	204	142	296	189	117.0
	Gegharkunikmarz Total	**9689**	**43.27**			**9632.7**												
	<u>Arpa River Basin</u>																	
1	Arpa 1-5 SHPP*	4300	12.00	2791	31.9	4200.0	977.0	0.35										
2	Elis SHPP on Elis River*	4196	12.83	3058	34.9													
	SHPP on Soghmalu inflow*	455	1.51	3319	37.9	3572.6	768.1	0.25	180.8	1.3	19.0	15.8		1839	1185		1829	1026
3	Karakala SHPP -1 on Karakala River*	940	2.60	2766	31.6													
	SHPP-2 on the right inflow*	220	0.60	2727	31.1	1000.0	862.0	0.31										
4	Karakala SHPP -3*	2090	5.94	2842	32.4	1670.0	797.0	0.28										
	Vayuts Dzor Marz: Total	**12201**	**35.48**			**10442.6**												
	<u>Vorotan River Basin</u>																	
1	Vorotan SHPP -1*	5860	25.0	4266	48.7	5340.0	912	0.210	219.3	0.88	16.7	13.4	2851	1826		2974	1590	
2	Jraghadzor SHPP	576	1.91	3316.0	37.9	554.7	963.0	0.290	39.2	2.06	14.0	11.9	214.4	118	49.0	214	89.3	-4.4
	<u>Sisyan river basin</u>																	
3	Arevis SHPP *	2420	11.50	4752.07	54.25	2720	1124	0.240	142.2	1.21		15.7					1364	770
4	Arevis SHPP -1(vtak)	476	1.38	2899.2	33.1	480.30	1009.00	0.348	36.20	2.62	9.30	8.80	35.70	-15.3	-50.1	35.7	-48.3	-111
5	Arevis SHPP -2(vtak)	999	2.89	2892.9	33.0	964.30	965.30	0.330	61.10	2.10	11.80	10.50	233.1	92.0	-6.7	233	38.3	-108
	<u>Voghji River Basin</u>																	
1	Katnarat SHPP	702	2.42	3443.0	39.3	690.7	983.9	0.286	48.6	2.01	14.5	12.2	291	166	78	291	131	11.4
2	Avsarlu SHPP	1038	3.68	3545.3	40.5	1002	965	0.272	65.4	1.78	16.2	13.4	552	345	197	552	299	109
3	Musalam SHPP	1630	6.25	3834.4	43.8	1641.5	1007.0	0.262	98.1	1.57	17.6	14.5	1091	714	442	1091	647	314
4	Kirs SHPP	1276	4.64	3636.4	41.5	1192.2	934.3	0.257	70.1	1.51	18.4	15.0	851	567	363	851	518	269
5	Karabash SHPP	662	2.34	3533.2	40.3	613.4	926.6	0.262	45.4	1.94	16	13.3	330	205	116	330	177	61.7
6	Giratakh SHPP	759	2.71	3563.9	40.7	734.7	987.9	0.272	50.4	1.86	15.8	13.2	385	237	131	385	203	66.3
7	Vachagan SHPP	709	2.52	3555.7	40.6	766.7	1081.3	0.304	51.8	2.05	13.2	11.4	264	135	44.6	264	96.3	-29.3

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
8	SHPP next to Geghi reservoir*	1560	9.79	6275.6	71.6	949.0	608	0.100	66.5	0.68	32.4	24.0	1250	944	718	1249	913	659
9	SHPP on Geghi-Eghvard irrigational pipeline *	330	1.61	4878.8	55.7	240.4	728.5	0.150	24.7	1.5	17.4	14.4	102	62.6	33.7	92.2	43.8	6.7
10	Geghi-2 SHPP *	1840	9.1	4962.0	56.6	1625.0	882.0	0.178	99.0	1.08	24.45	19.2		979	690		906	567.5
11	Vighji Ð¾Î-1 (Jrakhor HPP-1)	4690	15.8	3369	38.5	3313.2	706.0	0.210	187.7	1.19	20.7	17.1		2120	1431		2114	1301
	Tsav River Basin																	
12	Shishkert SHPP -1	1045	4.20	4019.1	45.9	1367.3	874.2	0.320	76.4	1.8	13.3	11.5	472	243	80.4	472	173	-51.4
13	Shishkert SHPP -2 Mazra SHPP	2424	9.63	3974.4	45.4	2033.8	839.0	0.210	117	1.22	24.3	18.8	2301	1668	1207	2301	1596	1067
14	Bentadzor SHPP	355	1.53	4309.9	49.2	386.0	1081.2	0.250	32.2	2.1	15.9	13.2	204	126	70.2	204	108	36.4
	Meghri River Basin																	
1	Lichk SHPP -1	1061	3.12	2940.6	33.6	1045.8	985.7	0.330	64.3	2.06	12.0	10.6	264	109	0.59	264	50.7	-109
2	Lichk SHPP 2	2066	5.52	2671.8	30.5	1828.7	885.1	0.330	101.1	1.83	13.3	11.5	637	329	112	637	236	-64.4
3	Tashtun SHPP – left inflow	508	1.56	3070.9	35.1	520.0	1023.6	0.320	43.6	2.7	10.9	9.8	91.4	23.2	-24.0	91.4	-8.1	-82.6
4	Tashtun SHPP -1 on Tashtun river*	1720	5.97	3471	39.6	1494.0	870	0.250	88.4	1.50	17.2	12.5		474	283		320	55.9
5	Vardanidzor SHPP on river Meghri*	4500	15.40	3422	39.1	3510.6	780	0.230	186.0	1.21		14.5					1374	663
6	Leghvaz SHPP	1564	7.01	4482.1	51.2	1600.0	1023.0	0.230	92.0	1.31	21.6	17.3	1538	1085	755	1538	1028	645
7	Vank SHPP (Kaler)	767	2.26	2946.5	33.6	1573.2	929.2	0.317	92.7	1.87	13.4	11.5	557	290	102	557	210	-49.5
8	Karchevan SHPP Agarak Copper Molybdenum Plant water supply channel*	1170	8.90	7607	86.8	501.3	428.5	0.060	43.7	0.5	32.0	31.5		681	523		659	490
	Syunik Marz: Total	**42707**	**168.67**			**38688.8**												
	Total for RA territory	**146904**	**540.14**			**133625.8**												

*) Technical economic substantiation for this SHPPs are ordered by private investors

SHPP Design classification according to income internal norm decrease IRR

#	SHPP	Initial Capacity	Annual power production	Annual production/hours	Plant factor, %	Capital Investments	Specific Capital Investments		Annual exploitation expenses thous. USD	Power prime cost	IRR, %		NPV, thousabd USD					
											Credit	Private Capital	Credit,, 10%			Private Capital		
		kWt	Mln.kWt/hour			Thousand USD	USDkWt	USD/kWt hour		10%	10%		8%	10%	12%	8%	10%	12%
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	Masrik SHPP -1	595	3.28	5507.6	62.9	625.7	1051.8	0.190	43.0	1.3	26.3	20.6	833.2	614.9	454.7	833.2	595.9	418.1
2	Shishkert SHPP -1, Mazra SHPP	2424	9.63	3972.8	45.4	2033.8	839	0.210	117	1.22	24.3	18.8	2301	1668	1207	2301	1596	1067
3	Khachakhbyur SHPP -1	1609.0	7.30	4537.6	51.8	1545.0	960.0	0.210	91.4	1.25	24.0	18.6	1718.3	1242.7	895.9	1718.3	1187.5	789.8
4	Masrik SHPP -2	560	3.08	5503.6	62.8	634.8	1133.5	0.206	43.4	1.4	23.7	18.4	692.4	499.2	358.4	692.4	476.5	314.8
5	Vahagnaget SHPP	496	2.68	5403.2	61.7	553.6	1116.1	0.207	39.1	1.46	23.2	18.1	587.6	421.7	300.9	587.6	401.9	262.9
6	Khachakhbyur SHPP -2	2929.0	12.38	4226.7	48.2	2870.4	980.0	0.230	152.4	1.23	21.6	17.3	2779.4	1963.0	1368.9	2779.4	1860.4	1176.8
7	Leghvaz SHPP	1564	7.01	4482.1	51.2	1600.0	1023.0	0.230	92.0	1.31	21.6	17.3	1538	1084.7	755	1538	1027.5	645.1
8	Khachakhbyur SHPP -3	4970.0	20.24	4072.4	46.5	4895.5	985.0	0.240	237.5	1.17	20.9	16.9	4520.5	3163.9	2177.6	4520.5	2988.8	1841.3
9	Akhinja SHPP	2324	9.03	3883.4	44.3	2186.1	940.7	0.242	120.6	1.34	20.6	16.3	1880.7	1308.8	894.9	1880.7	1219.1	723.5
10	Karakhan SHPP (Kirants)	1212	5.83	4810.2	54.9	1435.1	1184.1	0.246	77.9	1.34	20.4	16.1	1201.1	831.2	563.5	1201.1	772.3	451.0
11	Mtnajur SHPP -1	656.0	2.67	4065.5	46.4	612.0	933.0	0.230	44.4	1.66	20.0	15.9	498.5	342.9	230.5	498.5	317.8	182.5
12	Hakhum SHPP -1	594	2.84	4786.2	54.6	673.8	1134.3	0.237	44.0	1.55	20.0	15.9	547.5	376.9	252.8	547.5	348.8	200.0
13	Khndzorut SHPP -3	1505	6.08	4037.2	46.1	1482.5	985.0	0.244	87.8	1.45	19.9	15.8	1199.9	824.4	552.9	1199.9	763.6	436.7
14	Martuni SHPP -1	1646	6.07	3687.7	42.1	1506.7	915.3	0.248	85.9	1.42	19.7	15.7	1198.5	820.2	546.8	1198.5	758.4	428.7
15	Antaramut SHPP	376	1.89	5026.6	57.4	439.1	1167.7	0.232	34.4	1.82	18.7	15.2	323.9	217.8	141.2	323.9	199.8	106.8
16	Chakhkali SHPP	264	1.26	4772.7	54.5	285.5	1081.3	0.227	23.7	1.88	18.9	15.2	213.1	143.7	93.6	213.1	131.9	71.2
17	Shamlukh SHPP	756.0	2.99	3955.0	45.1	721.3	954.1	0.241	.49.9	1.66	18.8	15.2	536.4	361.4	235.1	536.4	331.8	178.6
18	Arkhashan SHPP -3	840	3.14	3733.3	42.6	750.1	893.0	0.240	54.9	1.8	18.5	15.0	542.1	362.7	233.2	547.1	331.9	174.4
19	Kirs SHPP	1276	4.64	3636.4	41.5	1192.2	934.3	0.257	70.1	1.51	18.4	15.0	850.8	567.4	362.9	850.8	518.4	269.4
20	Khndzorut SHPP -2	875	3.34	3812.6	43.5	835.4	954.8	0.250	54.6	1.64	18.2	14.9	588.1	390.8	248.5	588.1	356.5	183.1
21	Khndzorut SHPP -1	711	2.76	3874.8	44.2	680.2	956.6	0.247	48.1	1.75	17.8	14.6	464.1	305.8	191.8	464.1	277.9	138.5
22	Musalam SHPP	1630	6.25	3834.4	43.8	1641.5	1007.0	0.262	98.1	1.57	17.6	14.5	1091.2	714	442.3	1091.2	646.7	313.6
23	Bazum SHPP	443	1.93	4356.7	49.7	475.9	1074.3	0.246	35.9	1.86	17.2	14.3	305.9	198.2	120.7	305.9	178.7	83.4
24	Shnikh SHPP	916	3.43	3744.5	42.7	872.6	952.6	0.254	60.0	1.75	17.2	14.3	562	364.5	222.2	562	328.6	153.8
25	Arkhashan SHPP -1	1106	3.94	3564.2	40.7	1015.5	918.2	0.258	68.8	1.7	17.5	14.1	638.0	415.9	256.5	638.0	369.1	167.6
26	Arjadzor	668	2.47	3697.6	42.2	638.9	956.5	0.260	43.7	1.77	17.3	14.1	392.6	254.2	155	392.6	224.8	99.1
27	Kobkhanijur SHPP	620.0	2.34	3767.7	43.0	595.1	959.9	0.255	43.7	1.87	17.0	13.9	355.7	228.4	137.3	355.7	201.0	85.1
28	Martuni SHPP -2	1579	5.70	3609.9	41.2	1576.5	998.4	0.277	88.8	1.56	17.1	13.9	948.7	610.6	368.3	948.7	537.9	230.2
29	Jilis SHPP	488.0	2.07	4235.7	48.4	533.1	1092.4	0.258	38.3	1.85	17.0	13.8	314.3	201.0	119.9	314.3	176.4	73.2
30	Sarnakhbyur SHPP	1411	4.82	3416.0	39.0	1331.7	943.8	0.276	78.8	1.63	16.7	13.7	771.1	490.4	289.4	771.1	429	172.7
31	Sarvanget SHPP-4	1164	3.73	3204.5	36.6	1046.2	898.8	0.280	70.1	1.88	16.1	13.4	567.0	352.8	199.6	567.0	304.5	107.9
32	Secjur SHPP	941	2.68	2848.0	32.5	745.3	792.0	0.278	51.9	1.94	16.3	13.4	410.9	257.2	147.2	410.9	222.8	81.9

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
33	Mairaru SHPP -1	924	3.13	3385.3	38.6	858.1	928.7	0.274	55.5	1.77	16.1	13.4	465.1	289.4	163.8	465.1	249.9	88.6
34	Avsarlu SHPP	1038	3.68	3545.3	40.5	1002	965	0.272	65.4	1.78	16.2	13.4	551.5	344.9	197.2	551.5	298.8	109.4
35	Karabash SHPP	662	2.34	3533.2	40.3	613.4	926.6	0.262	45.4	1.94	16	13.3	330.3	205	115.5	330.3	176.7	61.7
36	Goratakh SHPP	759	2.71	3563.9	40.7	734.7	987.9	0.272	50.4	1.86	15.8	13.2	384.9	236.6	130.7	384.9	202.8	66.3
37	Betnadzor SHPP	355	1.53	4309.9	49.2	386.0	1081.2	0.250	32.2	2.1	15.9	13.2	204.4	126.2	70.2	204.4	108.4	36.4
38	Sarvanget SHPP -2	638	2.13	3338.6	38.1	584.1	915.6	0.270	40.4	1.9	15.5	13.0	293.7	177.8	95.1	293.7	150.9	43.9
39	Dzoraget SHPP -1(1.2)	2061	6.58	3192.6	36.4	1977.4	959.5	0.300	106.3	1.6	15.3	12.8	967.4	579.9	303.3	964.6	486	127.5
40	Gilanlar SHPP	784	2.675	3412.0	38.9	750.2	956.9	0.280	51.1	1.90	15.0	12.7	355.2	210.0	106.4	355.2	175.4	40.7
41	Ukhtakunk SHPP	1122	3.84	3422.5	39.1	1101.9	982.1	0.287	69.60	1.8	15.1	12.7	528.2	313.8	160.9	528.2	263.0	64.4
42	Pambak (no name) SHPP -2	777	2.73	3513.5	40.1	771.4	992.8	0.210	52	1.9	14.9	12.6	362.2	213.3	107.2	362.2	177.7	39.6
43	Kachachkut SHPP -2	454	1.89	4163.0	47.5	520	1145	0.276	36.2	1.92	15.2	12.6	240.7	143.4	74.3	240.7	116.9	24.2
44	Duzkend SHPP	841	2.879	3423.3	39.1	796.6	947.2	0.277	56.9	2.0	14.9	12.6	371.7	218.3	109.0	371.7	181.6	39.2
45	Karbi SHPP	1424	5.02	3525.3	40.2	1498.2	1052	0.300	85.6	1.7	15.0	12.5	677.3	399.7	202.6	677.3	323.4	58.3
46	SArvanget SHPP -3	843	2.76	3274.0	37.4	818	970.3	0.280	49.9	1.8	14.9	12.4	363.9	213.3	106.4	363.9	171.6	27.6
47	Katnarat SHPP	702	2.42	3443.0	39.3	690.7	983.9	0.286	48.6	2.01	14.5	12.2	290.7	166.2	78	290.7	131	11.4
48	Arkhashan SHPP -2	714	2.54	3561.6	40.7	713.1	998.7	0.280	55.4	2.2	14.0	11.9	275.6	151.1	63.0	275.6	114.8	-5.7
49	Jraghatcadzor SHPP	576	1.91	3316.0	37.9	554.7	963.0	0.290	39.2	2.06	14.0	11.9	214.4	117.6	49.0	214.4	89.3	-4.4
50	Sajigatun SHPP	422	1.63	3855.5	44.0	458.6	10.86.8	0.281	35.2	2.16	14.0	11.8	177.0	96.9	40.3	176.9	73.5	-3.9
51	Akhtala SHPP	323	1.33	4108.4	46.9	381.1	1204.6	0.293	29.6	2.23	13.3	11.5	132.3	68.2	22.9	132.3	18.8	-13.8
52	Shishkert SHPP -1	1045	4.20	4019.1	45.9	1367.3	874.2	0.320	76.4	1.8	13.3	11.5	472	242.5	80.4	472	172.8	-51.4
53	Lichk SHPP 2	2066	5.52	2671.8	30.5	1828.7	885.1	0.330	101.1	1.83	13.3	11.5	637.3	329.4	111.8	637.3	236.2	-64.4
54	Vank SHPP (Kaler)	767	2.26	2946.5	33.6	1573.2	929.2	0.317	92.7	1.87	13.4	11.5	556.6	290.3	102.1	556.6	210.1	-49.5
55	Vachagan SHPP	709	2.52	3555.7	40.6	766.7	1081.3	0.304	51.8	2.05	13.2	11.4	264	135.4	44.6	264	96.3	-29.3
56	Pambak(no name) SHPP -1	356	1.28	3595.5	41.0	367.1	1031.1	0.287	31.5	2.46	12.4	10.8	101.1	45.3	6.3	101.1	24.9	-32.2
57	Tavush SHPP 2	953	3.19	3348.4	38.2	1043.5	1095.0	0.327	66.9	2.10	12.2	10.7	275.7	119.2	9.6	275.7	61.1	-99.7
58	Mairaru SHPP -2	507	1.62	3199.2	36.5	501.7	989.6	0.309	36.95	2.28	12.2	10.7	131.9	56.7	4.1	131.8	28.8	-48.4
59	Tazaget SHPP	153	0.675	4411.8	50.4	171.6	1121.8	0.254	19.1	2.83	12.2	10.6	45.1	19.4	1.43	45.1	9.9	-16.5
60	Lichk SHPP -1	1061	3.12	2940.6	33.6	1045.8	985.7	0.330	64.3	2.06	12.0	10.6	263.7	108.9	0.59	263.7	50.7	-108.9
61	Karakala SHPP -1(5.6)	901	3.42	3795.8	43.3	1165.6	1293.6	0.340	69.1	2.02	11.9	10.5	289.9	117.9	-2.27	289.9	53.1	-124.3
62	Arevis SHPP -2(inflow)	999	2.89	2892.9	33.0	964.30	965.30	0.330	61.10	2.10	11.80	10.50	233.10	92.00	-6.70	233.10	38.3	-107.6
63	Alaverdi SHPP	249	0.98	3939.8	45.0	287.9	1156.3	0.293	25.3	2.58	11.6	10.2	63	23.2	-4.5	63	5	-36.9
64	Chichkhailu SHPP	329	1.22	3705.2	42.3	362.2	1100.8	0.297	31.3	2.56	11.5	10.1	77.1	27.4	-7.1	77.1	5.6	-47.9
65	Gegharkunic SHPP -2	454	1.46	3220.3	36.8	459.2	1011.4	0.310	35.3	2.4	11.5	10.1	96.9	34.1	-9.6	96.9	6.5	-61.3
66	Vanadzor SHPP	1191	3.63	3047.9	34.8	1299.2	1090.9	0.360	74.6	2.06	11.2	10.0	257.2	82.1	-39.4	257.2	3.92	-185.8
67	Mtnajur SHPP -2	326.0	1.25	3840.5	43.8	381.3	1169.8	0.305	32.1	2.56	11.1	10.0	73.5	22.4	-13.0	73.5	-0.5	-55.9
68	Tashtun SHPP	508	1.56	3070.9	35.1	520.0	1023.6	0.320	43.6	2.7	10.9	9.8	91.4	23.2	-24.0	91.4	-8.1	-82.6
69	Martuni SHPP -3	758	2.29	3021.1	34.5	810.8	1069.7	0.354	50.6	2.2	10.7	9.7	133.8	28.9	-43.7	133.8	-19.9	-135.0
70	Vedi SHPP	666	2.32	3483.5	39.8	833.5	1180.5	0.350	54.8	2.30	10.6	9.5	125.9	23.5	-47.0	125.9	-30.2	-147.1
71	Meghradzor SHPP	994	2.78	2796.8	31.9	1032.3	1038.5	0.370	63.7	2.30	9.9	9.2	115.3	-4.9	-87.3	115.3	-71.4	-211.3

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
72	Geghatar Gomer SHPP -1	314	1.06	3375.8	38.5	337.5	1074.9	0.320	29.7	2.8	9.6	8.9	30.3	-6.7	-32	30.3	-29.6	-74.4
73	Tavush SHPP -1	636	2.06	3239.0	37.0	743.1	1168.4	0.360	50.7	2.46	9.5	8.9	66.6	-14.8	-70.4	66.6	-65.2	-163.8
74	Dzorashen SHPP	148	0.621	4195.9	47.9	176.8	1195	0.285	19.3	3.11	9.3	8.8	13.4	-5.4	-18.2	13.4	-17.5	-40.7
75	Arevis SHPP -1(inflow)	476	1.38	2899.2	33.1	480.30	1009.00	0.348	36.20	2.62	9.30	8.80	35.70	-15.30	-50.10	35.70	-48.3	-111.2
76	Urit (Meskhana) SHPP	250	1.02	4080.0	46.6	320.3	1281.2	0.310	29.6	2.9	9.2	8.7	22.9	-11.0	-34.0	22.9	-32.9	-74.8
77	Pambi(Geduk) SHPP	258	1.00	3876.0	44.2	316.4	1226.3	0.316	28.2	2.9	9.2	8.7	22.3	-11.1	-33.9	22.3	-32.8	-74.1
78	Kachachkut SHPP -1	272	0.99	3639.7	41.5	328.5	1207.7	0.330	27.4	2.76	9.2	8.7	22.9	-11.7	-35.3	22.9	-34.3	-77.1
79	Karmravan SHPP (Kizil)	443	1.58	3557.6	40.6	570.0	1286.7	0.360	40.8	2.5	8.8	8.5	29.3	-29.1	-68.6	29.3	-68.1	-141.1
80	Gegharkunic SHPP -1	286	1.00	3503.5	40.0	334.4	1169.3	0.330	30.1	3.0	8.0	8.0	0.2	-29.2	-49.0	0.2	-54.2	-95.0
81	Akhnidzor SHPP -2, Marc SHPP	715	2.33	3258.7	37.2	916.3	1281.6	0.390	64.5	2.76	7.2	7.6	-36.1	-107.4	-154.8	-36.1	-170.	-286.6
82	Geghadzor SHPP	332	1.20	3599.4	41.1	380.5	1146.1	0.318	32.0	2.66	6.3	7.1	-31.7	-56.9	-73.3	-31.7	-88.5	-161
83	Akhnidzor SHPP -1	243	0.84	3456.8	39.5	293.4	1207.6	0.350	28.1	3.36	5.3	6.7	-35.9	-51.8	-62.1	35.9	-77.8	-109.1
84	Sarvanget SHPP -1	272	0.86	3161.8	36.1	302.1	1110.5	0.350	29.4	3.4	5.0	6.5	-40.9	-56	-65.8	-40.9	-83.4	-115.2
85	Shtonaganajur SHPP	310.0	0.85	2725.8	31.1	348.0	1122.5	0.411	30.7	3.60		5.1				-88.9	-131.	-162.6
86	Dalar SHPP	348	0.87	2500.0	28.5	350.0	1005.7	0.470	31.3	3.58	2.5	2.3	-81.8	-87.7	-91.5	-81.75	-91.5	-103.2

SHPP Design classification according to Plant factor, %

#	SHPP	Initial Capacity Ïìï	Annual power production Mln.kWt/hour	Annual production/hours	Plant factor, %	Capital Investments Thousand USD	Specific Capital Investments		Annual exploitation expenses thous. USD	Power prime cost 10%	IRR, %		NPV, thousabd USD					
											Credit, 10%	Private Capital	Credit, 10%			Private Capital		
							USDkWt	USD/kWt hour					8%	10%	12%	8%	10%	12%
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	Masrik SHPP- 1	595	3.28	5507.6	62.9	625.7	1051.8	0.190	43.0	1.3	26.3	20.6	833.2	614.9	454.7	833.2	595.9	418.1
2	Masrik SHPP-2	560	3.08	5503.6	62.8	634.8	1133.5	0.206	43.4	1.4	23.7	18.4	692.4	499.2	358.4	692.4	476.5	314.8
3	Vahagnaget SHPP	496	2.68	5403.2	61.7	553.6	1116.1	0.207	39.1	1.46	23.2	18.1	587.6	421.7	300.9	587.6	401.9	262.9
4	Antaramut SHPP	376	1.89	5026.6	57.4	439.1	1167.7	0.232	34.4	1.82	18.7	15.2	323.9	217.8	141.2	323.9	199.8	106.8
5	Karahkan SPP (Kirants)	1212	5.83	4810.2	54.9	1435.1	1184.1	0.246	77.9	1.34	20.4	16.1	1201.1	831.2	563.5	1201.1	772.3	451.0
6	Hakhum SHPP-1	594	2.84	4786.2	54.6	673.8	1134.3	0.237	44.0	1.55	20.0	15.9	547.5	376.9	252.8	547.5	348.8	200.0
7	Chakhali SHPP	264	1.26	4772.7	54.5	285.5	1081.3	0.227	23.7	1.88	18.9	15.2	213.1	143.7	93.6	213.1	131.9	71.2
8	Khachakhbyur SHPP-1	1609.0	7.30	4537.6	51.8	1545.0	960.0	0.210	91.4	1.25	24.0	18.6	1718.3	1242.7	895.9	1718.3	1187.5	789.8
9	Leghvaz SHPP	1564	7.01	4482.1	51.2	1600.0	1023.0	0.20	92.0	1.31	21.6	17.3	1538	1084.7	755	1538	1027.5	645.1
10	Tazaqent SHPP	153	0.675	4411.8	50.4	171.6	1121.8	0.254	19.1	2.83	12.2	10.6	45.1	19.4	1.43	45.1	9.9	-16.5
11	Bazum SHPP	443	1.93	4356.7	49.7	475.9	1074.3	0.246	35.9	1.86	17.2	14.3	305.9	198.2	120.7	305.9	178.7	83.4
12	Betnadzor SHPP	355	1.53	4309.9	49.2	386.0	1081.2	0.250	32.2	2.1	15.9	13.2	204.4	126.2	70.2	204.4	108.4	36.4
13	Djilis SHPP	488.0	2.07	4235.7	48.4	533.1	1092.4	0.258	38.3	1.85	17.0	13.8	314.3	201.0	119.9	314.3	176.4	73.2
14	Khachakhbyur SHPP-2	2929.0	12.38	4226.7	48.2	2870.4	980.0	0.230	152.4	1.23	21.6	17.3	2779.4	1963.0	1368.9	2779.4	1860.4	1176.8
15	Dzorashen SHPP	148	0.621	4195.9	47.9	176.8	1195	0.285	19.3	3.11	9.3	8.8	13.4	-5.4	-18.2	13.4	-17.5	-40.7
16	Karchachkot SHPP-2	454	1.89	4163.0	47.5	520	1145	0.276	36.2	1.92	15.2	12.6	240.7	143.4	74.3	240.7	116.9	24.2
17	Akhtala SHPP	323	1.33	4108.4	46.9	381.1	1204.6	0.293	29.6	2.23	13.3	11.5	132.3	68.2	22.9	132.3	18.8	-13.8
18	Urut (Meskhana) SHPP	250	1.02	4080.0	46.6	320.3	1281.2	0.310	29.6	2.9	9.2	8.7	22.9	-11.0	-34.0	22.9	-32.9	-74.8
19	Khachakhbyur SHPP-3	4970.0	20.24	4072.4	46.5	4895.5	985.0	0.240	237.5	1.17	20.9	16.9	4520.5	3163.9	2177.6	4520.5	2988.8	1841.3

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
20	Mtnadjur SHPP-1	656.0	2.67	4065.5	46.4	612.0	933.0	0.230	44.4	1.66	20.0	15.9	498.5	342.9	230.5	498.5	317.8	182.5
21	Khndzorut SHPP -3	1505	6.08	4037.2	46.1	1482.5	985.0	0.244	87.8	1.45	19.9	15.8	1199.9	824.4	552.9	1200	763.6	436.7
22	Shishkert SHPP-1	1045	4.20	4019.1	45.9	1367.3	874.2	0.320	76.4	1.8	13.3	11.5	472	242.5	80.4	472	172.8	-51.4
23	Shishkert SHPP-2,Mazra SHPP	2424	9.63	3972.8	45.4	2033.8	839	0.210	117	1.22	24.3	18.8	2301	1668	1207	2301	1596	1067
24	Shamlukh SHPP	756.0	2.99	3955.0	45.1	721.3	954.1	0.241	.49.9	1.66	18.8	15.2	536.4	361.4	235.1	536.4	331.8	178.6
25	Alaverdy SHPP	249	0.98	3939.8	45.0	287.9	1156.3	0.293	25.3	2.58	11.6	10.2	63	23.2	-4.5	63	5	-36.9
26	Akhindja SHPP	2324	9.03	3883.4	44.3	2186.1	940.7	0.242	120.6	1.34	20.6	16.3	1880.7	1308.8	894.9	1881	1219.1	723.5
27	Phambi (Geghuk) SHPP	258	1.00	3876.0	44.2	316.4	1226.3	0.316	28.2	2.9	9.2	8.7	22.3	-11.1	-33.9	22.3	-32.8	-74.1
28	Khndzorut SHPP -1	711	2.76	3874.8	44.2	680.2	956.6	0.247	48.1	1.75	17.8	14.6	464.1	305.8	191.8	464.1	277.9	138.5
30	Mtnadjur SHPP-2	326.0	1.25	3840.5	43.8	381.3	1169.8	0.305	32.1	2.56	11.1	10.0	73.5	22.4	-13.0	73.5	-0.5	-55.9
31	Musalam SHPP	1630	6.25	3834.4	43.8	1641.5	1007.0	0.262	98.1	1.57	17.6	14.5	1091	714	442.3	1091.2	646.7	313.6
32	Khndzorut SHPP-2	875	3.34	3812.6	43.5	835.4	954.8	0.250	54.6	1.64	18.2	14.9	588.1	390.8	248.5	588.1	356.5	183.1
33	Karakala SHPPÎ-1(5.6)	901	3.42	3795.8	43.3	1165.6	1293.6	0.340	69.1	2.02	11.9	10.5	289.9	117.9	-2.27	289.9	53.1	-124.3
34	Kobkhanidjur SHPP	620.0	2.34	3767.7	43.0	595.1	959.9	0.255	43.7	1.87	17.0	13.9	355.7	228.4	137.3	355.7	201.0	85.1
35	Shnokh SHPP	916	3.43	3744.5	42.7	872.6	952.6	0.254	60.0	1.75	17.2	14.3	562	364.5	222.2	562	328.6	153.8
36	Arkhashan SHPP-3	840	3.14	3733.3	42.6	750.1	893.0	0.240	54.9	1.8	18.5	15.0	542.1	362.7	233.2	547.1	331.9	174.4
37	Chikhaylu SHPP	329	1.22	3705.2	42.3	362.2	1100.8	0.297	31.3	2.56	11.5	10.1	77.1	27.4	-7.1	77.1	5.6	-47.9
38	Archadzor SHPP	668	2.47	3697.6	42.2	638.9	956.5	0.260	43.7	1.77	17.3	14.1	392.6	254.2	155	392.6	224.8	99.1
39	Martuni SHPP-1	1646	6.07	3687.7	42.1	1506.7	915.3	0.248	85.9	1.42	19.7	15.7	1198.5	820.2	546.8	1199	758.4	428.7
40	Kachachkut SHPP-1	272	0.99	3639.7	41.5	328.5	1207.7	0.330	27.4	2.76	9.2	8.7	22.9	-11.7	-35.3	22.9	-34.3	-77.1
41	Kirs SHPP	1276	4.64	3636.4	41.5	1192.2	934.3	0.257	70.1	1.51	18.4	15.0	850.8	567.4	362.9	850.8	518.4	269.4
42	Martuni SHPP-2	1579	5.70	3609.9	41.2	1576.5	998.4	0.277	88.8	1.56	17.1	13.9	948.7	610.6	368.3	948.7	537.9	230.2
43	Gegadzor SHPP	332	1.20	3599.4	41.1	380.5	1146.1	0.318	32.0	2.66	6.3	7.1	-31.7	-56.9	-73.3	-31.7	-88.5	-161
44	Pambak(no name) SHPP -1	356	1.28	3595.5	41.0	367.1	1031.1	0.287	31.5	2.46	12.4	10.8	101.1	45.3	6.3	101.1	24.9	-32.2
45	Arshakhan SHPP-1	1106	3.94	3564.2	40.7	1015.5	918.2	0.258	68.8	1.7	17.5	14.1	638.0	415.9	256.5	638.0	369.1	167.6
46	GiratakhSHPP	759	2.71	3563.9	40.7	734.7	987.9	0.272	50.4	1.86	15.8	13.2	384.9	236.6	130.7	384.9	202.8	66.3
47	Arkhashan SHPP-2	714	2.54	3561.6	40.7	713.1	998.7	0.280	55.4	2.2	14.0	11.9	275.6	151.1	63.0	275.6	114.8	-5.7
48	Karmravan SHPP(Kizil)	443	1.58	3557.6	40.6	570.0	1286.7	0.360	40.8	2.5	8.8	8.5	29.3	-29.1	-68.6	29.3	-68.1	-141.1
49	Vachagan SHPP	709	2.52	3555.7	40.6	766.7	1081.3	0.304	51.8	2.05	13.2	11.4	264	135.4	44.6	264	96.3	-29.3
50	Avsarlu SHPP	1038	3.68	3545.3	40.5	1002	965	0.272	65.4	1.78	16.2	13.4	551.5	344.9	197.2	551.5	298.8	109.4

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
51	Karabash SHPP	662	2.34	3533.2	40.3	613.4	926.6	0.262	45.4	1.94	16	13.3	330.3	205	115.5	330.3	176.7	61.7
52	Karbi SHPP	1424	5.02	3525.3	40.2	1498.2	1052	0.300	85.6	1.7	15.0	12.5	677.3	399.7	202.6	677.3	323.4	58.3
53	Pambak(no name) SHPP - 2	777	2.73	3513.5	40.1	771.4	992.8	0.210	52	1.9	14.9	12.6	362.2	213.3	107.2	362.2	177.7	39.6
54	Gegharquniq SHPP-1	286	1.00	3503.5	40.0	334.4	1169.3	0.330	30.1	3.0	8.0	8.0	0.2	-29.2	-49.0	0.2	-54.2	-95.0
55	Vedi SHPP	666	2.32	3483.5	39.8	833.5	1180.5	0.350	54.8	2.30	10.6	9.5	125.9	23.5	-47.0	125.9	-30.2	-147.1
56	Akhnidzor SHPP-1	243	0.84	3456.8	39.5	293.4	1207.6	0.350	28.1	3.36	5.3	6.7	-35.9	-51.8	-62.1	35.9	-77.8	-109.1
57	Katnarat SHPP	702	2.42	3443.0	39.3	690.7	983.9	0.286	48.6	2.01	14.5	12.2	290.7	166.2	78	290.7	131	11.4
58	Dusqent SHPP	841	2.879	3423.3	39.1	796.6	947.2	0.277	56.9	2.0	14.9	12.6	371.7	218.3	109.0	371.7	181.6	39.2
59	Ukhtakunq SHPP	1122	3.84	3422.5	39.1	1101.9	982.1	0.287	69.60	1.8	15.1	12.7	528.2	313.8	160.9	528.2	263.0	64.4
60	Sarnaakhbyur SHPP	1411	4.82	3416.0	39.0	1331.7	943.8	0.276	78.8	1.63	16.7	13.7	771.1	490.4	289.4	771.1	429	172.7
61	Gilanlar SHPP	784	2.675	3412.0	38.9	750.2	956.9	0.280	51.1	1.90	15.0	12.7	355.2	210.0	106.4	355.2	175.4	40.7
62	Mayraru SHPP-1	924	3.13	3385.3	38.6	858.1	928.7	0.274	55.5	1.77	16.1	13.4	465.1	289.4	163.8	465.1	249.9	88.6
63	Geghatar Gomer SHPP-1	314	1.06	3375.8	38.5	337.5	1074.9	0.320	29.7	2.8	9.6	8.9	30.3	-6.7	-32	30.3	-29.6	-74.4
64	Tavush SHPP-2	953	3.19	3348.4	38.2	1043.5	1095.0	0.327	66.9	2.10	12.2	10.7	275.7	119.2	9.6	275.7	61.1	-99.7
65	Sarvanget SHPP-2	638	2.13	3338.6	38.1	584.1	915.6	0.270	40.4	1.9	15.5	13.0	293.7	177.8	95.1	293.7	150.9	43.9
66	Djraghac SHPP	576	1.91	3316.0	37.9	554.7	963.0	0.290	39.2	2.06	14.0	11.9	214.4	117.6	49.0	214.4	89.3	-4.4
67	Sarvanget SHPP-3	843	2.76	3274.0	37.4	818	970.3	0.280	49.9	1.8	14.9	12.4	363.9	213.3	106.4	363.9	171.6	27.6
68	Akhnidzor SHPP-2	715	2.33	3258.7	37.2	916.3	1281.6	0.390	64.5	2.76	7.2	7.6	-36.1	-107.4	-154.8	-36.1	-170.3	-286.6
69	Tavush SHPP-1	636	2.06	3239.0	37.0	743.1	1168.4	0.360	50.7	2.46	9.5	8.9	66.6	-14.8	-70.4	66.6	-65.2	-163.8
70	Gegharquniq SHPP-2	454	1.46	3220.3	36.8	459.2	1011.4	0.310	35.3	2.4	11.5	10.1	96.9	34.1	-9.6	96.9	6.5	-61.3
71	Sarvanget SHPP-4	1164	3.73	3204.5	36.6	1046.2	898.8	0.280	70.1	1.88	16.1	13.4	567.0	352.8	199.6	567.0	304.5	107.9
72	Mayraru SHPP-2	507	1.62	3199.2	36.5	501.7	989.6	0.309	36.95	2.28	12.2	10.7	131.9	56.7	4.1	131.8	28.8	-48.4
73	Dzoraget SHPP-1(1.2)	2061	6.58	3192.6	36.4	1977.4	959.5	0.300	106.3	1.6	15.3	12.8	967.4	579.9	303.3	964.6	486	127.5
74	Sarvanget SHPP-1	272	0.86	3161.8	36.1	302.1	1110.5	0.350	29.4	3.4	5.0	6.5	-40.9	-56	-65.8	-40.9	-83.4	-115.2
75	Tashtun SHPP	508	1.56	3070.9	35.1	520.0	1023.6	0.320	43.6	2.7	10.9	9.8	91.4	23.2	-24.0	91.4	-8.1	-82.6
76	Vanadzor SHPP	1191	3.63	3047.9	34.8	1299.2	1090.9	0.360	74.6	2.06	11.2	10.0	257.2	82.1	-39.4	257.2	3.92	-185.8
77	Martuni SHPP-3	758	2.29	3021.1	34.5	810.8	1069.7	0.354	50.6	2.2	10.7	9.7	133.8	28.9	-43.7	133.8	-19.9	-135.0
78	Vanq SHPP (Kaler)	767	2.26	2946.5	33.6	1573.2	929.2	0.317	92.7	1.87	13.4	11.5	556.6	290.3	102.1	556.6	210.1	-49.5
79	Lichq SHPP -1	1061	3.12	2940.6	33.6	1045.8	985.7	0.330	64.3	2.06	12.0	10.6	263.7	108.9	0.59	263.7	50.7	-108.9
80	Arevis SHPP -1(inflow)	476	1.38	2899.2	33.1	480.30	1009.00	0.348	36.20	2.62	9.30	8.80	35.70	-15.30	-50.10	35.70	-48.30	-111.20
81	Arevis SHPP -2(inflow)	999	2.89	2892.9	33.0	964.30	965.30	0.330	61.10	2.10	11.80	10.50	233.10	92.00	-6.70	233.10	38.30	-107.60

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
82	Sevdjur SHPP	941	2.68	2848.0	32.5	745.3	792.0	0.278	51.9	1.94	16.3	13.4	410.9	257.2	147.2	410.9	222.8	81.9
83	Meghradzor SHPP	994	2.78	2796.8	31.9	1032.3	1038.5	0.370	63.7	2.30	9.9	9.2	115.3	-4.9	-87.3	115.3	-71.4	-211.3
84	Shtoganadjur SHPP	310.0	0.85	2725.8	31.1	348.0	1122.5	0.411	30.7	3.60		5.1				-88.9	-131.1	-162.6
85	Lichq SHPP-2	2066	5.52	2671.8	30.5	1828.7	885.1	0.330	101.1	1.83	13.3	11.5	637.3	329.4	111.8	637.3	236.2	-64.4
86	Dalar SHPP	348	0.87	2500.0	28.5	350.0	1005.7	0.470	31.3	3.58	2.5	2.3	-81.75	-87.7	-91.5	-81.75	-91.5	-103.2

SECTION 18. ATTACHEMNETS