Armenian Renewal Resources and Energy Efficiency Fund

RENEWABLE ENERGY PROJECT

Wind Power Development in Armenia

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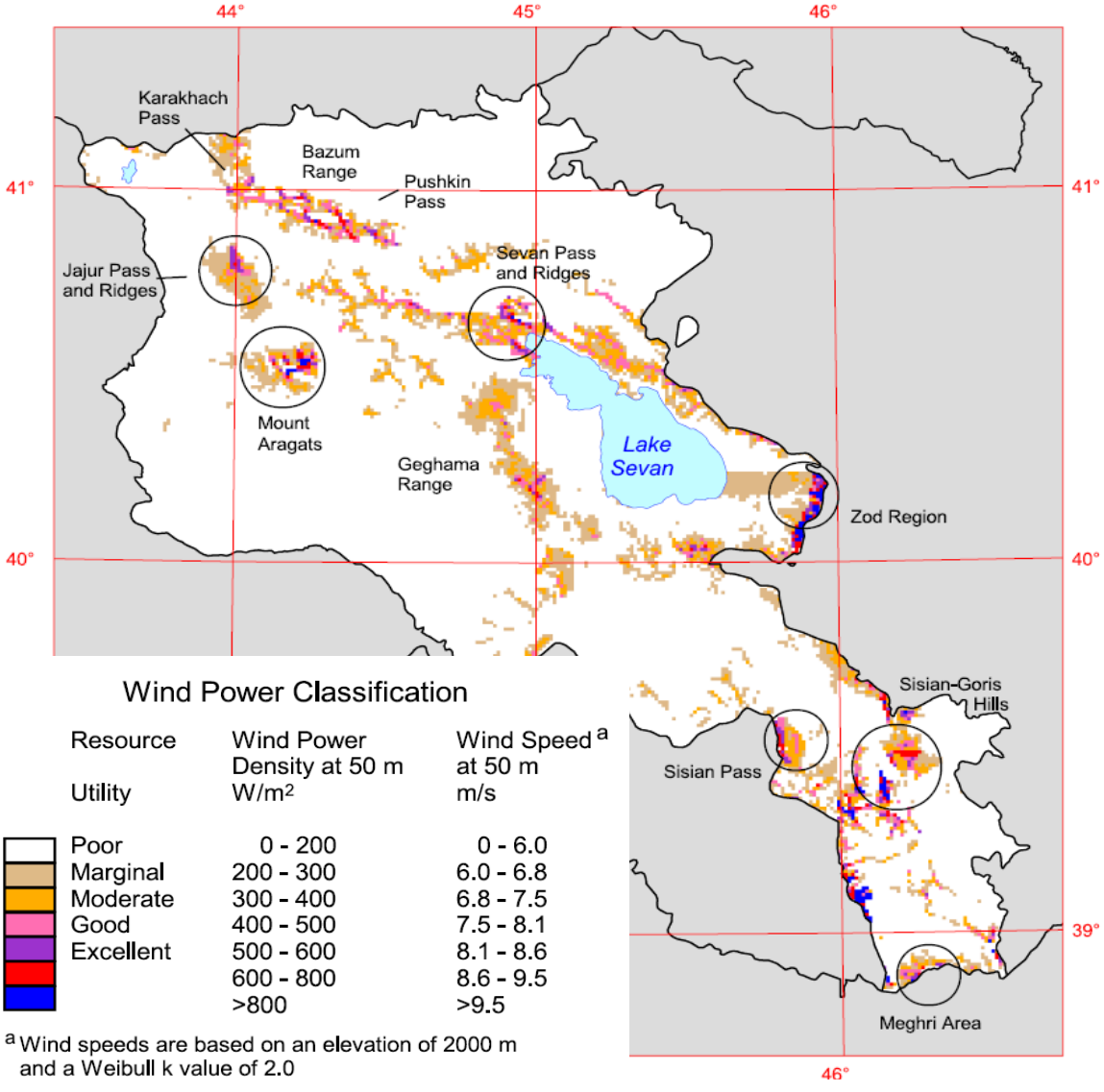
1. SUMMARY

1.1 Wind Power Potential of Armenia

According to the Armenian Wind Atlas developed in 2002-03 by The United States National Renewable Energy Laboratory (NREL) in collaboration with SolarEn Co (Armenia) the most perspective areas for grid connected wind power development in Armenia from purely wind power resource point of view are corresponds to the wind Class from 4 to 7 (Good and Excellent classes). Table and figure bellow summarise the results of Wind Atlas for this territories of Armenia.

Wind Resource Utility Scale	Wind Class	Wind Power at 50 m height	Wind Speed at 50 m height	Total Area	Windy Land	Total Capacity Installed
		W/m^2	m/s	km^2	%	MW
Good	**4**	400-500	7.5-8.1	503	1.8%	2500
Excellent	**5**	500-600	8.1-8.6	208	0.7%	1050
Excellent	**6**	600-700	8.6-9.5	165	0.6%	850
Excellent	**7**	>800	>9.5	103	0.4%	500
TOTAL				**979**	**3.5%**	**4900**

As could be seen from these table and figure, the perspective areas for wind power in



Armenia are limited and located mostly on remote mountainous passes typically with high elevation (2000 m and more) with limited and hard access. This will lead to higher than average on site transportation and installation costs of wind turbines. From considered 4 perspective wind class areas only class 4 (upper level of Good class) and class 5 (lower level of Excellent class) can be considered as realistic for construction of real wind power plants. The "turn-key" cost of installation for up to MW class wind turbines for these two "realistic" class sites in Armenia was assessed in 2006-07 by several local developers (Solaren LLC, Zod Wind LLC, AR Energy LLC, Gierret Co) and international vendors (Gamessa, Vestas) and was in the range of 1.3 - 1.6 mln €/MW.

More detailed assessment of technical wind power potential could be assessed based on actual wind power monitoring (continuous on-site measurements of wind flow). The table bellow summarised the results of such assessments based on previous, on-going and planned monitoring projects in Armenia. The right column presents the results confirmed by already completed wind power monitoring and the left column presents the results based on ongoing and planned monitoring activities.

Confirmed by monitoring	Currently (February 2008) not confirmed by monitoring
Pushkin pass: 19.5 MW total installed capacity, about 48.9 mln. kWh annual average production **Kharaxach pass (Eastern gate):** 125 MW total installed capacity, about 320 mln. kWh annual average production. **Zod pass:** 50 MW total installed capacity, about 120 mln. kWh annual average production	**Kharaxach pass (Western gate):** 125 MW total installed capacity, about 300-320 mln. kWh annual average production. **Sisian pass (Bichanag pass):** 155 MW total installed capacity, about 420-430 mln. kWh annual average production. **Charentsavan region:** 20 MW total installed capacity, about 45 mln. kWh annual average production.
Subtotal: 195 MW with about 490 mln. kWh annual average production	**Subtotal: 300 MW with about 765 mln. kWh annual average production**
495 MW total installed power, about 1.25 billon kWh annual average production	

Absolute majority of considered areas (except Bichanag pass**)** in the table bellow are belong to the wind class 4 and 5.

1.2 National Targets for Wind Power Development in Armenia

Armenian energy strategy documents highlight the Windpower as a high priority area of the countries' energy sector development. For instance, the Diversification Strategy Document, adopted by GoA in June 2005, sets a highest national target for the windpower: to install 500 MW of grid-connected windpower capacity till 2025[1].

In order to achieve this goal the above mentioned technical wind power potential should be considered in the first place. Based on the information about the wind class of considered areas and assessments of turn-key cost of wind turbine installation the utilisation of above mentioned potential will require € 650-800 mln of total investments.

1.3 Current Wind Power Tariff in Armenia

[1] Energy Sector Development Strategies in the Context of Economic Development in Armenia. Adopted by the Government of Armenia. Session Protocol No 24, Resolution No 1. 23 June 2005.

Before 2004 the wind tariffs were not fixed in Armenia and developers negotiate different tariffs with PSRC RA on project basis. In February 2004 the wind tariff was fixed by the decision of PSRC RA as 7.0 USD cents per kWh (without VAT).

According to the decision № 207-N from May 2007of PSRS RA, new tariff for the grid connected wind electricity is set as 35 AMD per one kWh of electricity delivered to the grid (without VAT). The tariff is fixed in Armenian drams and should be recalculate each year by adjusting it to the changes in Armenian Dram/USD exchange rates as well as to the changes in Consumer Price Indexes. Later that year (August 2007) by additional decision of PSRS RA (№ 353-N) the wind tariff was linked to Armenian Dram/€ exchange rate. It should be noted that in contrast with tariffs for SHPP, defined in the above mentioned decisions, the new wind tariff has no constant component.

Absence of the constant component in wind tariff as well as uncertainties in prediction of inflation and currency exchange rates led to the situation when developers of wind power projects are unable to perform feasibility study for typical project life cycle span (20-25 years) in sound manner.

1.4 Break Even Tariffs of Several Wind Power Projects in Armenia

The "Break even tariff" (BET) of grid-connected wind power project (WPP) is determined as the specific cost of wind electricity production under which the Net Present Value (NPV) of the given WPP will be equal to zero. In other words, BET describe the threshold of wind electricity tariff after which the given WPP can become economically feasible. In reality, the valid wind electricity tariff should be higher then the BET of the WPP in order to ensure the feasibility and profitability of the project. Thus, BET can be perceived as a good indicator for the owner/developer of the WPP to make a "go-or-not-go" decision on the project.

Under the framework of EU Tacis 120653/C/SV/Am "Support to the Energy Policy of Armenia" Project, analysis of BET were performed for several WPPs considered during the last decade in Armenia by various developers. The table below summarise the results of this analysis.

Considered Wind Power Projects	Break even tariff for the project Base Case, €/kWh (without VAT)	Wind electricity tariff for the time of the project, €/kWh (without VAT)
14.5 MW Semyonovka WPP (Gegharkunik marz, RA)	**0.1224**	0.077 (or 35 AMD)
19.5 MW Zod WPP (Gegharkunik marz, RA)	**0.1036**	0.052 (or 7.0 USD cents)
19.5 MW Pushkin Pass WPP (Lori marz, RA)	**0.0902**	0.052 (or 7.0 USD cents)
124.1 MW Kharaxach WPP (Shirak marz, RA)	**0.0715**	0.071 (or 9.6 USD cents)

As could be seen from this table, wind electricity tariffs valid and/or discussed at the time of the project preparation are lower than the break-even tariffs for all considered WPPs. Not surprisingly during the last decade and now the developers consider the wind power as not feasible option in Armenia.

1.5 Sensitivity Analysis of Several Wind Power Projects in Armenia

General sensitivity

The results of the performed general sensitivity analysis of considered WPPs in different regions of Armenia shows, that there are three groups of parameters: Most sensitive (or most "important"); important; and less important ones, which are affecting NPV or financial feasibility of the projects. The most important parameter is the initial capital cost of the project, mostly determined by the cost of main equipment (imported wind turbines). "Important" parameters are the delivered energy (energy production); debt interest rate and avoided cost of energy (wind electricity tariff). They have a sensitivity of about the half of the magnitude of the most sensitive parameter - cost of the project. Among the less "important" parameters could be mentioned the impact of Certified Emission Reduction (CER) valid for Armenia under CDM of Kyoto protocol. The obtained results indicate that under current conditions;

- All considered WPPs (base cases) are economically not feasible and have negative NPV;
- Only 124.1 MW Kharaxach WPP can achieve positive NPV in some cases of initial parameters variations.

Sensitivity of BET

Under the framework of EU Tacis 120653 Project the sensitivity analysis of break-even tariff (BET) for several WPPs were carried out. BET sensitivity was determined from the variations of such an important initial parameters as "turn-key' cost of the wind turbines, on-site annual average wind speed, etc. The obtained results indicate that:

- Change in the on-site annual average wind speed by 1 m/s will change the production price (or BET) of wind energy with approximately 22% per kWh.;
- The current feed-in tariff in Armenia implies that an annual on-site wind speed higher than 8.5 m/s is necessary to make wind project feasible (positive NPV).

Thus, the current wind power tariff and related methodology of its adjustment did not support the commercial utilisation of wind power projects in Armenia even for areas with up to Excellent wind class (8.0-8.5 m/s annual average wind speed) and could not insure the achievement of national target on Wind Power development in the Republic.

2. Wind Power Potential

2.1. ***General Information***

Wind power potential of Armenia was assessed during the implementation of several projects started as late as the end of 80s - beginning of 90s. During the first phase of the works mainly synoptic data obtained from hydro-meteorological stations of the Republic during the previous decades was used. Synoptic data was recorded once per 3 hours, with the help of rather old and inaccurate wind speed and direction sensors, located on the meteotowers, typically on 10-11m height above ground. Besides, location of absolute majority of the hydro-meteorological stations of the Republic was not representative for adequate wind power resource assessments. These factors were taken into account in the preparation of wind atlases thus providing reasonable good and adequate general results about theoretical wind power potential of Armenia.

But, more important results of this works was the determination of perspective areas for construction of grid-connected wind power plants (wind farms) mostly in mountainous passes, with higher than average wind speeds. During the next phase of works, on determined perspective areas direct continuous measurements (wind power monitoring) were carried out mainly in the frame of two Armenian-Dutch and several Armenian-American international projects. On this stage of work 40-50 m tall towers were used, measurements of wind speed and direction were carried out on 2 or 3 different heights (typically on 10 m, 30 m and 50 m) with scanning rate of 2 seconds and averaging time of 10 min. All sensors were regularly checked and calibrated. Beside, hourly measurements of ambient temperature, air pressure and humidity were carried out in order to correct the value of airflow density.

Currently there are several ongoing wind power monitoring projects. Obtained monitoring data was used to determine the technically accessible and economically feasible grid-connected wind power potential of the several regions of Armenia.

2.2. ***Wind Power Atlases of Armenia***

The first wind power atlas of Armenia was developed by ECOTECH Scientific Association in 1989-90. Synoptic data from 37 hydro-meteorological stations of the Republic was analyzed, and corrections of air density and on openness of all considered meteo-stations were carried out. According to obtained results theoretical wind power potential of the Republic was assessed as 2426 - 4418 MW for two zones of the republic.

In 2002-03, The United States Department of Energy (DOE) sponsored a project to help accelerate the widespread use of wind energy technologies in Armenia through the development of a wind energy resource atlas of Armenia. DOE's National Renewable Energy Laboratory (NREL) led the project in collaboration with SolarEn International Corporation, and its Armenian subsidiary SolarEn LLC. The primary goals of the project were to

- develop detailed wind resource maps for all regions of Armenia and produce a comprehensive wind resource atlas documenting the results and
- establish a wind monitoring program to identify prospective sites for wind energy projects and help validate some of the wind resource estimates.

According to obtained results, theoretical wind power potential of the Republic was assessed as 4900 MW in 4 zones with total area of 979 km^2 - in remarkable agreement

with results obtained previously.

More detailed information for these 4 zones are presented in the table below.

Wind Resource Utility Scale	Wind Class	Wind Power at 50 m height	Wind Speed at 50 m height	Total Area	Windy Land	Total Capacity Installed
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Excellent	**7**	>800	>9.5	103	0.4%	500
TOTAL				**979**	**3.5%**	**4900**

2.3. Wind Power Monitoring Projects in Armenia

Previous Projects

In 1999-2002 in the framework of PSO Projects of the government of The Netherlands two Armenian-Dutch windpower monitoring projects were carried out. During implementation of the ArmNedWind project (1999-2000) five 50m tall monitoring units were installed at Pushkin Pass (Bazum mountains), Eastern gate of Kharaxach Pass (situated between Bazum mountains and Javakhet ridge), Selim Pass (Gegharkunik mountains), Ardanish (northern shore of L. Sevan) and Arpi (Western shore of L. Arpi). Measurements were carried out in accordance with the requirements set up by European Wind Energy Association with unprecedented level of accuracy and completeness for Armenia. As a result of these projects the Pushkin and Kharaxach passes were indicated as the most promising sites for the construction of the first grid-connected wind farms in Armenia. During the second Armenian-Dutch ArmWind Project the site evaluation for Pushkin pass was carried out and pre-feasibility study for 20 MW wind farm on this site was prepared.

In 2005, with the support from a private Italian company, SolarEn LLC erected five monitoring units on Kharaxach Pass. These units are located on both sides along the axis line of the Kharaxach pass and at the east gate of the pass. Regular monitoring data collection and processing are currently in progress.

In the framework of EUROPAID Tacis 120653/C/SV/Am project "Support to the Energy Policy of Armenia" a 40m tall windpower monitoring unit was successfully installed in August 2006 at Semyonovka Pass area close to the existing TV tower (northern shore of Lake Sevan). Measurements of the wind speed and direction (2 different heights), ambient temperature, air pressure and humidity started in September 2006. The measurements were completed in the end of August 2007 and provide 12 month continuous measurements data set.

Planned Projects

Several developers from Germany, Greece, Iran and Russia express their interest to perform complete wind power monitoring of the southern and central parts of Armenia.

2.4. Technical grid-connected wind power Potential

Based on the results of previous and on-going monitoring projects the technical grid-connected wind power potential of the several studied regions of Armenia could be assessed. The right column in the table below presents results confirmed by wind power

monitoring. In the left column the results based on ongoing monitoring and preliminary assessments are presented. Total wind power potential of considered regions of Armenia could be assessed as: 495 MW of total installed grid-connected wind power with about 1.3 billon kWh of annual average production.

Confirmed by monitoring	Currently (February 2008) not confirmed by monitoring
Pushkin pass: 19.5 MW total installed capacity, about 48.9 mln. kWh annual average production **Karakhach pass (Eastern gate):** 125 MW total installed capacity, about 320 mln. kWh annual average production. **Zod pass:** 50 MW total installed capacity, about 120 mln. kWh annual average production	**Karakhach pass (Western gate):** 125 MW total installed capacity, about 300-320 mln. kWh annual average production. **Sissian pass (Bichanag pass):** 155 MW total installed capacity, about 420-430 mln. kWh annual average production. **Charentsavan region:** 20 MW total installed capacity, about 45 mln. kWh annual average production.
Subtotal: 195 MW with about 490 mln. kWh	**Subtotal: 300 MW with about 765 mln. kWh**
495 MW total installed power, about 1.26 billon kWh annual average production	

2.5. Wind Farm Projects in Armenia

In December 2005 first in South Caucasus "Lori 1" wind farm was put in operation at Pushkin Pass in Armenia. Total installed capacity of the farm is 2.64 MW, comprise from the four 660 kW wind turbines. Wind farm was build by support of 3.1 mln US$ grant from the government of Islamic Republic of Iran.

The intention to construct a 20-25 MW wind farm in Zod (Sotk) pass area was announced in 2001 by Gayfeschyan Family Foundations (Miami, USA) and Solaren Co. Ltd. (USA/Armenia). Land allocation for this project was carried out in 2004. The project was discussed with EBRD in conjugation with CDM process.

A private company from Italy is ready to start site evaluation and preliminary works on Kharaxach pass for construction of 90 MW wind farm. Expected total investments for this project will amount about 130-140 mln US$.

Currently negotiations on extension of "Lori 1" wind farm at Pushkin pass are in progress.

More details on this chapter could be found in www.renewableenergyarmenia web site

3. Current Wind Electricity Tariff

According to the May 4, 2007 PSRC decision № 207-N and additional decision 353-N of 31 August 2007, the following tariffs are set for the RE power plants that acquired their licenses for electric energy generation prior to December 1, 2007.

Small Hydro Power Plants

− 18.274 AMD/kWh, without VAT, for electric energy generated by hydropower plants using the natural flow of a river,

− 12.182 AMD/kWh, without VAT, for electric energy generated by hydropower plants built on an irrigation system,

− 8.122 AMD/kWh, without VAT, for electric energy generated by hydropower plants built on the drinking water system.

Wind and Biomass Power plants

− 35.0 AMD/kWh, without VAT, for electric energy generated by these power plants.

The tariffs are due for review annually, prior to 1st of December. The reviewed tariffs are put into force starting from January 1 of next year. For the power plants that have been in operation with current tariff for less than 6 months, the new tariff should be put into force after the expiration of the first 6 months period of operation with the preceding tariff. According to the PSRC, starting from 2008 the tariff for electricity generated from RE power plants need to be reviewed according to the following equation:

$$T = T_1\left[K_1\frac{PI}{100} + K_2\frac{ER_1}{ER_2} + (1 - K_1 - K_2)\right], \quad (1)$$

where:

- **T -** adjusted tariff, AMD;
- **T_1 -** fixed tariff of previous year, AMD;
- **K_1 -** portion of the tariff linked to the inflation. For SHPPs and Biomass it should be equal to 0.25, for Wind it should be equal to **0.1**;
- **PI -** The ratio of consumer price index in September of current year to the one in the same month of previous year;
- **K_2 -** portion of the tariff linked to the currency exchange rate. For SHPPs and Biomass it should be equal to 0.35, for Wind it should be equal to **0.9**;
- **ER_1 -** The arithmetic average of AMD/USD exchange rate for SHPPs and Biomass (AMD/€ exchange rate for Wind) during the period of January-September of current year;
- **ER_2 -** The arithmetic average of AMD/USD exchange rate for SHPPs and Biomass (AMD/€ exchange rate for Wind) during the period of January-September of previous year.

The aforementioned tariff equation (1) from the decisions of PSRC RA can be simplified to the following two forms:

For SHPPs and Biomass: $$T = 0.4T_1 + 0.25T_1\frac{PI}{100} + 0.35T_1\frac{ER_1}{ER_2}\ , \qquad (2.1)$$

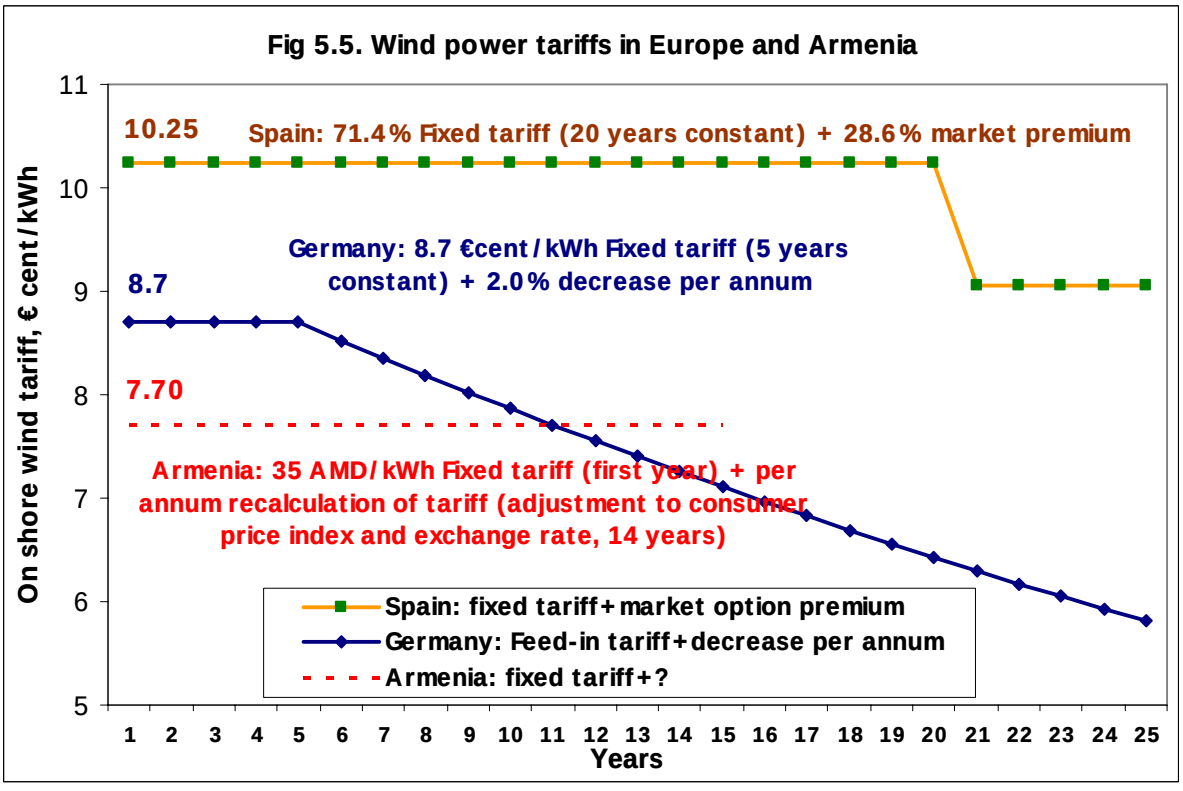
For Wind: $$T = 0.1T_1\frac{PI}{100} + 0.9T_1\frac{ER_1}{ER_2}\ , \qquad (2.2)$$

Absence of the constant component in wind tariff as well as uncertainties in prediction of inflation and currency exchange rates led to the situation when developers of wind power projects are unable to perform feasibility study for typical project life cycle span (20-25 years) in sound manner.

It is expedient to present brief description of wind tariffs in some European countries.

Wind energy is playing an important role in several European countries and it is relevant to compare the Armenian tariff structure with some European countries. One of the most popular policy options for supporting new renewable electricity are variations of the feed-in tariff[2] and the Renewables Portfolio Standard [3] (RPS). Feed-in tariffs offer a long-term, fixed price payment to renewable energy generators, whereas the RPS seeks to create price competition between renewable energy generators to meet defined targets at least cost, and typically define a maximum cost through a price cap instrument.

The European Union (EU) has substantial experience with both approaches although; the majority of European countries have adopted feed-in tariffs. While RPS policies typically seek to create electricity price competition, feed-in tariffs require utilities to purchase



power from renewable energy generators at a fixed price. These fixed prices are structured either in the form of long-term payments based on generation cost[4] (as in Germany) or in

[2] Also referred to as advanced renewable tariffs (ARTs), renewable energy feed-in tariffs (REFITs), FITs, fixed price tariffs, and standard offer contracts

[3] Referred to in Europe as quota obligations, renewable energy obligations, or tradable green certificate (TGC) systems

[4] Plus a reasonable profit.

the form of a fixed premium on top of the spot market price for electricity (as in Spain). In Fig. 5.5, retrieved from Final Report "Renewable Energy Economic Potential of Gegharkunik marz, Republic of Armenia" Volume I (October 2007) prepared under the framework of EU Tacis 120653 Project, the price current wind tariffs in Armenia, Germany and Spain are compared.

In Armenia the "Energy law" of the Republic mandates the grid operator (single buyer) to purchase all electricity generated by renewable energy source upon receipt of the Operation License from PSRC RA in a period of 15 years. The current tariff for wind energy generation is set at 35 AMD/kWh (or about 0.077 €/kWh). According to the last Decision of the PSRC RA[5], this tariff should be recalculated each year in order to adjust for changes in inflation (official consumer price index) and the development in the exchange rates of AMD towards Euro (see above). Taking into consideration that it is difficult to predict those adjustments at the feasibility analysis stage of the WPP in Armenia and the fact that current methodology did not fix a constant component of the wind tariff the line for Armenia on the Figure 5.5 are presented as "dashed" line.

The tariffs in Germany for wind power onshore projects are covering time span of 20 years. The first 5 years the tariff is fixed - 0.087 €/kWh, and in the following 15 years the tariff will be reduced by 2.0% per annum. It should be noted, that the feed-in tariff in Germany is independent of retail rates.

The Spanish government has in this year (2007) revised a tariff scheme for renewable energy consisting of two components: a fixed tariff and a market option tariff premium for a period of 20 years[6]. The fixed tariff option is 0.0732 €/kWh (2007 base price), reducing to 0.0612 €/kWh (2007 base price) after 20 years of operation. The market tariff option is the sum of the market pool price plus a market option premium and other components. The market option premium is today 0.0293€/MWh (2007 base price).

[5] Resolution No 353-N of the Public Service Regulatory Commission RA of 31 August 2007
[6] http://www.greenjobs.com/Public/IndustryNews/inews02997.htm

4. Feasibility and Sensitivity studies of Wind Power Projects

4.1. General Information

Under the framework of EU Tacis 120653/C/SV/Am "Support to the Energy Policy of Armenia" Project, feasibility analysis (including general sensitivity and sensitivity of BET) were performed for several WPPs considered during the last decade in Armenia by various developers:

- 14.5 MW Semyonovka (Sevan) grid-connected Wind Power Project, (Gegharkunik marz, RA);
- 19.5 MW Zod grid-connected Wind Power Project, (Gegharkunik marz, RA);
- 19.5 MW Pushkin Pass grid-connected Wind Power Project, (Lori marz, RA);
- 124.1 MW Kharaxach Wind grid-connected Wind Power Project, (Shirak marz, RA).

In the ANNEX more detailed locations of these WPPs are presented.

For feasibility and sensitivity analysis specialised free-source "RET Screen" Software, developed by Natural Resources Agency (Canada), was used. This software is dedicated to overcome the barriers for renewable energy technology implementation at the feasibility stage. It provides a proven methodology for comparing conventional and renewable energy technologies. The software permits an easy screening of various RE projects and can be easily customised to determine the "break-even tariff" of the considered project. Additionally, the financial component of the software allows performing sensitivity and risking analysis with a great degree freedom.

The main objective of feasibility and sensitivity analysis is to calculate and analyse how given variations of certain project input parameters affect financial parameters of WPPs (Net Present Value, After Tax IRR and ROI, Year-to-positive cash flow) as well as the value of break-even tariff (see the definition below) and provide this information to project developers.

"Break even tariff" (BET is the minimum price of kWh of generated energy to be paid to the power plant by utility in order to secure the zero economic profit of the project. Thus, BET is determined as necessary feed in tariff to the central grid (for isolated grid and off

grid applications it is simply the sale price of energy) under which the Net Present Value (NPV) of the project equals to 0. It can be assumed that in order for the owner of the project to get an economic profit or make a positive decision on the project it is necessary that the tariff established for the project be greater than BET.

The RetScreen model allows only performing sensitivity analysis of maximum three pre-defined main financial feasibility outputs (parameters), namely: After Tax IRR and ROI, Year-to-positive cash flow and Net Present Value. In addition to that, the software was customised in order to perform sensitivity analysis of BET from various initial parameters.

On the following pages, the BET sensitivity analysis tables shows the tariff impact (i.e. energy production cost) when two key parameters (e.g. capital cost and discount rate) are varied by the indicated percentages. The BET calculation which results in cost higher than the current tariff established by PSCR in Armenia and thereby NOT feasible (negative NPV) are presented on grey background cells. The base case values are indicated in **Bold**

For the break even tariff sensitivity study, the following input variables with their ranges of variation from project design values were selected:

First pair: Total Capital Costs with variation of ±10% and ±20%,
Annual Electricity Production with variation of ±2.5% and ±5% (7.5% and 15%);

Second pair: Total Capital Costs with variation of ±10% and ±20%,
Discount Rate with variation of ±15% and ±30%;

Third pair: Annual Electricity Production with variation of ±2.5% and ±5% (7.5% and 15%);
Discount Rate with variation of ±15% and ±30%

The mentioned sensitivity variation ranges of input parameters for projects have been selected according to the following local conditions in Armenia:

- The current Armenian tax legislation requires a reimbursable payment of 20% value added tax (VAT) on energy equipment on the border of import. Such payment is considered as a capital cost (although it is partly recuperated in following years of operation) as it can not be waved. Removing this initial cost barrier for renewable energy project can influence the attractiveness of these projects;
- The experience in the area of Armenian renewable energy projects suggests that a 15% maximum annual electricity generation variation is a normal range and reasonable for sensitivity calculations;
- And finally, a maximum of 30% variation in the discount rate is a justified range for analysis in Armenia.

The Figures and Tables presented bellow are retrieved from of EU Tacis 120653 Final Report "Renewable Energy Economic Potential of Gegharkunik marz, Republic of Armenia" Volume I (October 2007). The numbering of tables and figures are correspond to that source:

4.2. Feasibility study of Semyonovka Pass wind power project

4.2.1. Semyonovka Pass wind power project.

The project is developed based on wind power monitoring results obtained during one

year of measurements in 2006-07. The site is located at Semyonovka pass area at elevation of 2435 m above sea level. The site is at distance of 5 km from the Tsovagyugh village. The site has well developed infrastructure with access roads, proximity to railway and grid (35 and 110 kV high voltage transmission lines).

The main parameters of the project are:

⇒ annual average wind speed at hub height of wind turbines 6.4 m/s,
⇒ total installed capacity 14.45 MW (17 turbines with 850 kW of rated power each),
⇒ gross annual average energy production 29.1 mln kWh/year,
⇒ annual average energy delivered to the grid 25.25 mln kWh/year,
⇒ total initial cost 22.1 mln €,
⇒ current wind electricity tariff 35 AMD/kWh, or € 0.077/kWh (without VAT)[7].

The main technical and economical results of the feasibility analysis are given in the table below.

Summary of RET Screen runs	Units	Semyonovka WPP
Installed capacity	MW	14.5
Renewable energy delivered	MWh	**25 251**
Total Costs, of which:	€	22 100 000
Energy Equipment	€	15 500 000
Pre-tax IRR and ROI	%	-1.5%
After-tax IRR and ROI	%	-1.3%
Payback period	yr	13.1
Year-to-positive cash flow	yr	more than 20
Net Present Value - NPV	€	-8 045 128
Annual Life Cycle Savings	€	-944 978
Benefit-Cost (B-C) ratio	-	(0.21)
Energy production cost	€/kWh	0.122
Project equity	€	6 631 862
Project debt	€	15 474 345
Debt payments	€/yr	2 518 378
Debt service coverage	-	0.64

The table below summarise the results of BET calculations for Semyonovka WPP.

Table 5.1.1. Break Even Tariff	Semyonovka WPP
Approved feed-in tariff, €/kWh	**0.0770**
Break even tariff, €/kWh	**0.1224**
Installed capacity, MW	14.5
Renewable energy delivered, MWh	25 251
Total Costs, €	22 106 207

[7] under 454.55 AMD = 1 €o exchange rate (May 2007).

4.2.2. Results of Sensitivity Analysis for Semyonovka WPP

The general sensitivity analysis of the project is performed based on the built-in feature of the RetScreen model. The list of parameters under variation and the ranges of variations are presented in the text box. The model allows to perform sensitivity analysis only for 3 fixed financial parameters of the project: NPV, After-tax IRR and Year-to-positive cash flow. The Fig. 5.1 presents the results of sensitivity analysis of main input parameters of the project on NPV. The box in upper right part of this figure indicates the range of variations of input parameters. In addition to that, several runs of the model is performed in order to determine the sensitivity of the BET under the given variations of the initial parameters (see the text box).

Table 5.3.2 below illustrates the result of BET value calculation for Semyonovka Pass project (base case) as well as the results of sensitivity of the BET under the variation of different parameters.

Table 5.3.2	Sensitivity analysis of BET: 14.5 MW Semyonovka pass WPP					
Discount rate:	30%		1 € =	454.55	AMD	
Capital Costs:	20%		**Current wind electricity tariff: 35 AMD/kWh (€ 0.077 kWh)**			
Electricity Output:	15%					
Sensitivity ranges		**Total Capital Costs (mln. €)**				
Annual Electricity Production (MWh)		**17.68**	**19.90**	**22.11**	**24.32**	**26.53**
		-20%	-10%	**0%**	10%	20%
21463	-15%	0.1199	0.1322	**0.1445**	0.1567	0.1690
23357	-8%	0.1099	0.1212	**0.1325**	0.1438	0.1551
25251	**0%**	**0.1015**	**0.1119**	**0.1224**	**0.1328**	**0.1433**
27144	8%	0.0942	0.1039	**0.1137**	0.1234	0.1331
29038	15%	0.0879	0.0970	**0.1061**	0.1152	0.1243
		Total Capital Costs (mln. €)				
Discount Rate (%)		**17.68**	**19.90**	**22.11**	**24.32**	**26.53**
		-20%	-10%	**0%**	10%	20%
7.0%	-30%	0.0920	0.1011	**0.1102**	0.1194	0.1285
8.5%	-15%	0.0968	0.1065	**0.1163**	0.1261	0.1359
10.0%	**0%**	**0.1015**	**0.1119**	**0.1224**	**0.1328**	**0.1433**
11.5%	15%	0.1062	0.1173	**0.1284**	0.1395	0.1506
13.0%	30%	0.1108	0.1226	**0.1343**	0.1460	0.1578
		Discount Rate (%)				
Annual Electricity Production (MWh)		**7.0%**	**8.5%**	**10.0%**	**11.5%**	**13.0%**
		-30%	-15%	**0%**	15%	30%
21463	-15%	0.1302	0.1373	**0.1445**	0.1515	0.1585
23357	-8%	0.1194	0.1260	**0.1325**	0.1390	0.1454
25251	**0%**	**0.1102**	**0.1163**	**0.1224**	**0.1284**	**0.1343**
27144	8%	0.1024	0.1080	**0.1137**	0.1192	0.1247
29038	15%	0.0955	0.1008	**0.1061**	0.1113	0.1165

Break-even tariff cases higher than feed-in tariff.

Break-even tariff cases equal or lower than feed-in tariff.

The obtained results indicates that, for all considered variations the determined base case BET value (€ **0.1224**/kWh) as well as all the range of obtained BET values (from €

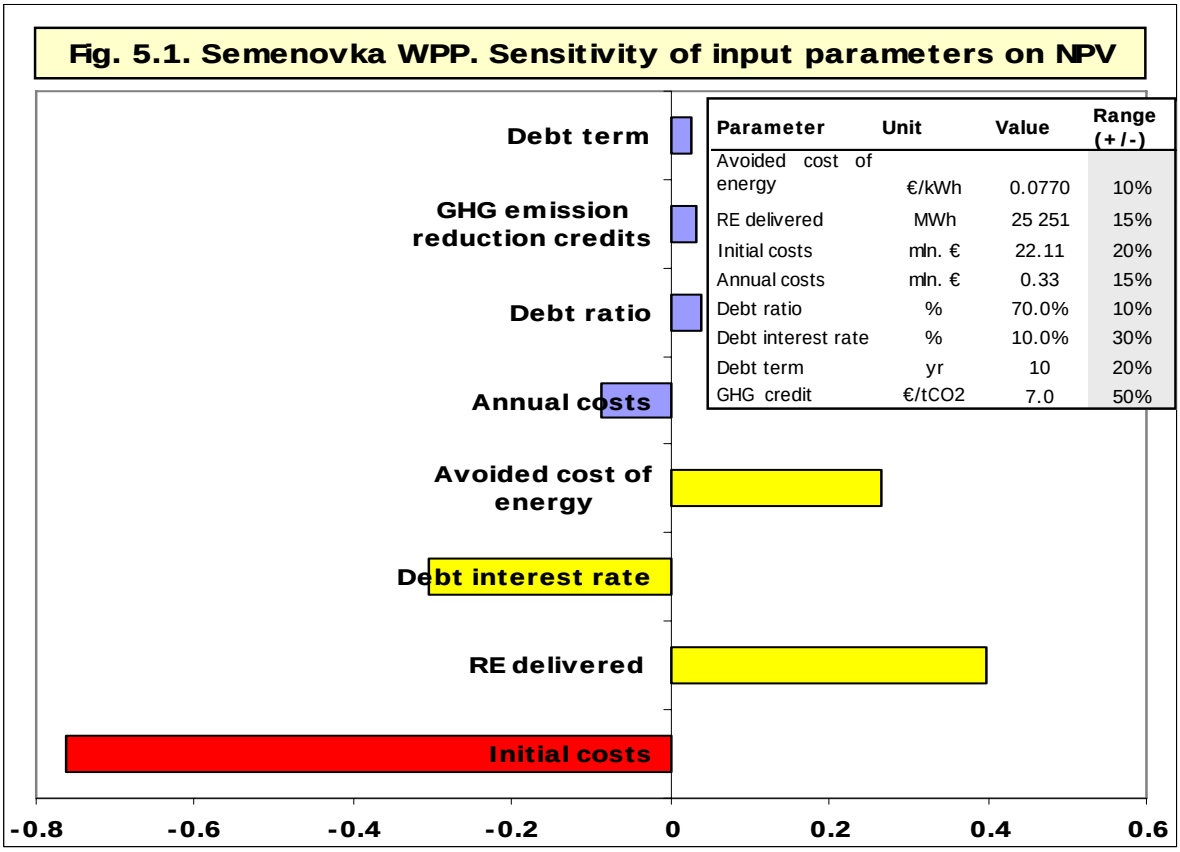
0.0879/kWh to € 0.1690/kWh) remained less than the current[8] feed in tariff of 35 AMD/kWh, or € 0.077/kWh and the project becomes under these conditions economically NOT feasible.

Table 5.3.2-a. General Sensitivity analysis: 14.5 MW Semyonovka pass WPP	
Most "important" and sensitive parameters	
Initial costs	-0.761
"Important" and sensitive parameters	
RE delivered	0.399
Debt interest rate	-0.305
Avoided cost of energy	0.266
Less "important" and sensitive parameters	
Annual costs	-0.087
Debt ratio	0.038
GHG emission reduction credits	0.033
Debt term	0.025

The sensitivity analysis of Semyonovka Pass wind project demonstrates that it will remain economically **not feasible** (negative NPV) under the **current € 0.077/kWh feed-in tariff** despite the considered variations in the input parameters (discount rate, capital costs, and annual electricity generation). The Base case value of BET indicates that the project will become economically feasible only if the feed-in tariff will be higher than € 0,1224/kWh.

A general sensitivity analysis of the 14.5 MW Semyonovka Wind Power Project, i.e. influence of variation of initial parameters on NPV (or financial feasibility) of the project is summarised in Table 5.3.2-a and shown in Fig. 5.1. The results of the general sensitivity analysis are presented in the Table 5.3.2-a are grouped in three categories: Most sensitive (or most "important") parameters, important and less important parameters.

Fig. 5.1. Semenovka WPP. Sensitivity of input parameters on NPV



Parameter	Unit	Value	Range (+/-)
Avoided cost of energy	€/kWh	0.0770	10%
RE delivered	MWh	25 251	15%
Initial costs	mln. €	22.11	20%
Annual costs	mln. €	0.33	15%
Debt ratio	%	70.0%	10%
Debt interest rate	%	10.0%	30%
Debt term	yr	10	20%
GHG credit	€/tCO2	7.0	50%

[8] According to the Decision No 208-N of the PSRC RA of 4 May 2007

4.2.3. Cost of the projects

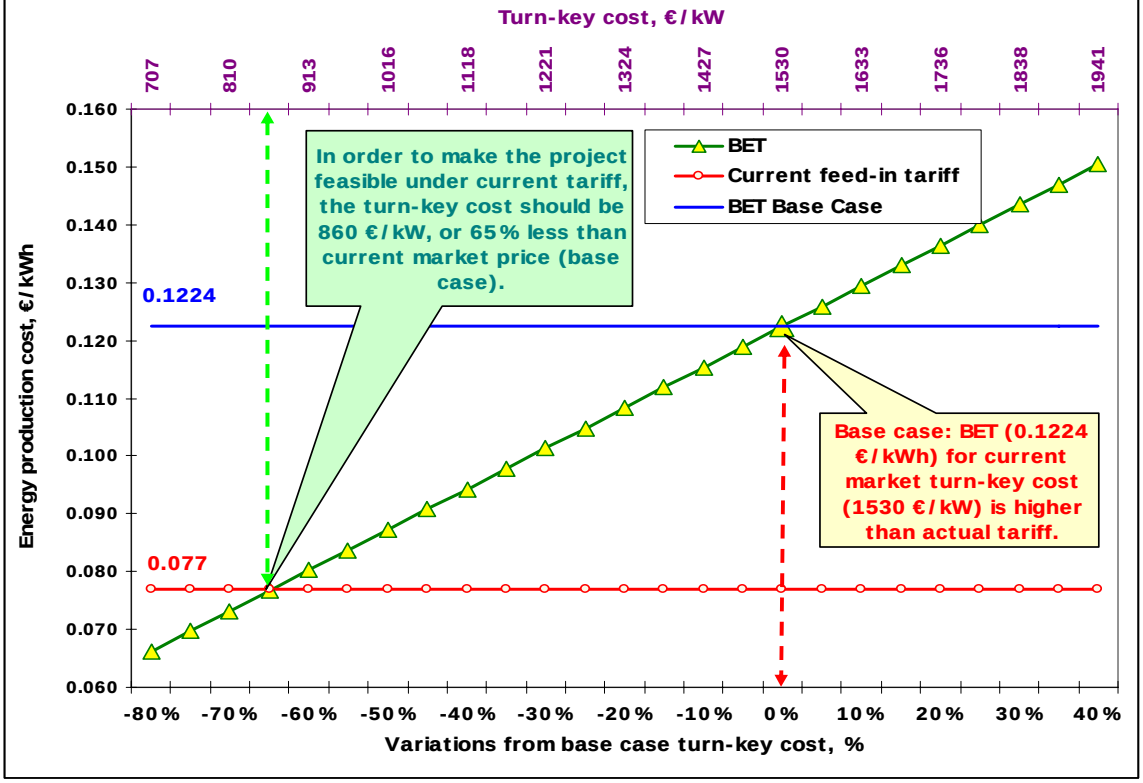
The calculations indicate that the initial capital cost of the project is the most important parameter for the feasibility of the project – its sensitivity magnitude is about 0.8 (the minus sign indicates that the decrease of initial costs will increase the value of NPV, see also Fig. 5.1).

The Figure 5.2. summarise the results of sensitivity analysis of BET of the project from the "turn-key" cost. As its follows from this figure, the Semyonovka WPP project base case cost (22.1 mln €) and corresponding "turn-key" cost of **1530 €/kW** implies to the BET value of 0.1224 €/kWh which is significantly higher than the current tariff for wind electricity. From another side, in order to make Semyonovka WPP feasible under the current tariff the turn-key cost should be somehow reduced to **65%** (about **860 €/kW**) of base case estimation, which is well below current market price.

In this context it should be noted, that due to the absence of local manufacturing capacities of modern wind turbines in Armenia all main component for wind power plants should be imported to Armenia. The main cost of equipment for WPP (wind turbines) comprise about 60-80% of the total initial cost of the wind project.

According to current VAT (value added tax) in Armenia imported wind turbines will be subject to 20% value added tax payments (VAT). In order to reflect this, the 20% VAT is added to initial cost estimations for all RetScreen runs of WPP and other RE projects. Such a situation indicates that in order to facilitate the wind power development in Armenia, some measures could be recommended in order to reduce the initial costs of WPP by reducing the burden of VAT on imported equipment for RE projects.

Fig. 5.2. Semenovka WPP: Dependence of BET from turn-key cost

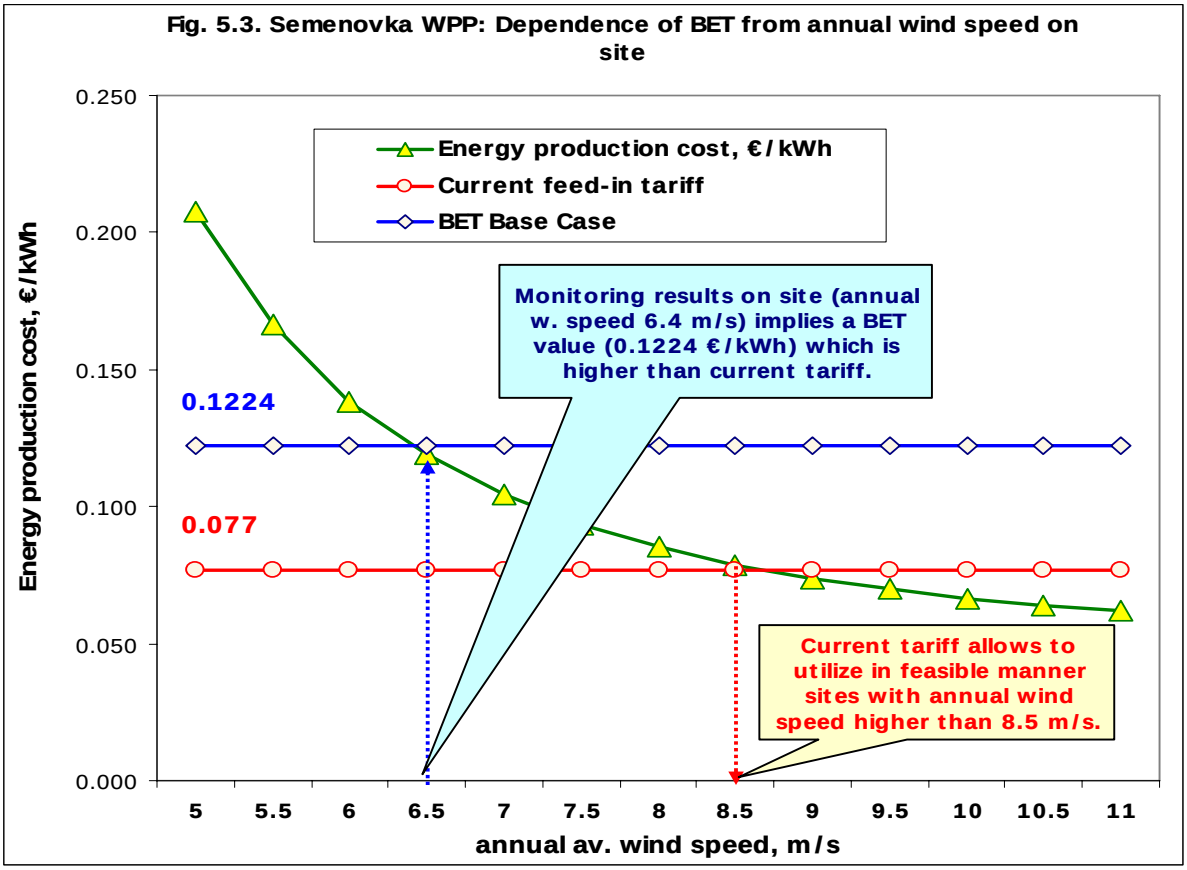


4.2.4. Delivered Energy

The results of the sensitivity analysis shown that the delivered energy (energy production), debt interest rate and avoided cost of energy (wind electricity tariff) have a sensitivity of about the half of the magnitude of the most sensitive parameter - cost of the project, and could be considered as important parameters. Thus they should be considered as important parameters of Semyonovka WPP.

The major interest has the delivered energy of the project, because it is directly determined by natural limitations of wind power flow energy on considered site in Gegharkunik marz. A change in the annual average wind speed of 1 m/s will change the production price of wind energy with approximately 22% per kWh. The Current feed in tariff in Armenia indicates that a annual wind speed higher than 8.5 m/s is necessary to make wind project feasible (see Figure 5.3).

Fig. 5.3. Semenovka WPP: Dependence of BET from annual wind speed on site



4.2.5. Feed-in Tariff Escalation Scenarios

The Semyonovka Wind Power Project study has been conducted with the assumption that the tariff of electricity purchase to the grid remains unchanged during the all the project lifetime (20 years) and equal to the currently tariff set by PSRC RA in May 2007[9]. This assumption do not reflect a RE tariff escalation rate as a financial incentive mechanism for wind power development fully in line with the current fixed RE tariff policy of PSRC RA.

At the same time it should be stressed, that in the project calculations the general inflation are included. For instance, in the Base Case scenario of Semyonovka WPP the general

[9] 35 AMD/kWh without VAT, or 0.077 €/kWh at the May 07 exchange rate of 454.54 AMD/€

inflation annual rate is equal to 4.0%. It is a general rule of thumb for these type of calculations that if inflation is taken into consideration in the benefit/cost analysis and also the escalation rate of cost of energy should also be considered.

In order to perspective the obtained results and to reflect the possible impact of a wind tariff escalation rate on the project on NPV and after-tax IRR, several runs of Semyonovka WPP via RetScreen model were performed. The general inflation rates were considered for a inflation range started from 0 % up to 10%. For each of these cases, different escalation scenarios was considered as well: started with 0.0% escalation rate and up to 8.0% . The results of these calculations are presented in the table below.

Table 5.3.3. Influence of tariff escalation on main parameters of Semyonovka WPP

Escalation rate,%	BET, €/kWh	NPV, mln. €	After-tax IRR, %
Inflation 0.0%			
0	0.1199	-7.38	0.2%
0.4%	0.1164	-6.98	0.9%
4.0%	0.0874	-2.45	7.4%
5.0%	0.0803	-0.84	9.2%
6.0%	0.0736	0.94	10.9%
7.0%	0.0674	2.94	12.6%
8.0%	0.0616	5.18	14.2%
Inflation 4.0%			
0	0.1261	-8.45	-2.2%
(Base case) 0.4%	**0.1224**	**-8.05**	**-1.3%**
4.0%	0.0919	-3.51	6.1%
5.0%	0.0844	-1.91	8.0%
6.0%	0.0774	-0.12	9.9%
7.0%	0.0709	1.87	11.7%
8.0%	0.0647	4.11	13.4%
Inflation 6.0%			
0.0%	0.1224	-8.05	-1.3%
0.4%	0.1266	-8.78	-3.3%
4.0%	0.0950	-4.25	5.1%
5.0%	0.0873	-2.65	7.2%
6.0%	0.0801	-0.86	9.1%
7.0%	0.0733	1.13	11.0%
8.0%	0.0669	3.37	12.9%
Inflation 10.0%			
0.0%	0.1426	-11.28	negative
0.4%	0.1384	-10.87	-14.8%
4.0%	0.1039	-6.34	1.6%
5.0%	0.0955	-4.74	4.3%
6.0%	0.0875	-2.95	6.8%
7.0%	0.0801	-0.96	9.0%
8.0%	0.0732	1.28	11.2%

During these calculations, other parameters of the project (Initial cost, Energy delivered, Discount rate, etc.) were equal to the Base Case values.

The table illustrates that by a 0% general inflation rate the positive values of NPV for Semyonovka WPP could be achieved if 6.0% escalation rate scenario for wind electricity tariff would be applied. In that case the after-tax IRR of the project will be 10.9%. In case

of 10.0% general inflation, the positive NPV could be achieved by a 8.0% tariff escalation rate. Under the 4.0% of general inflation (Base case) the positive NPV for Semyonovka WPP can be achieved if a 7.0% tariff escalation rate would be applied[10].

The effect of tariff escalation on the general feasibility of the project is significant – after all, it improve the "avoided cost of energy", i.e. the 4-th sensitive and "important" parameter of the project (see in section 5.3.1 above).

The effect on the general feasibility of the project by a tariff escalation is significant and could be perceived as one of the efficient incentive mechanisms for a support and incentive for wind power development in the country in general, and increase the economical wind power potential of the Gegharkunik marz of Armenia.

4.2.6. Different prices of CER

Table 5.3.5. Break even tariff under various CER Prices	
CER price, € per ton of CO_2 equiv	**Break Even Tariff, €/kWh**
0	0.1250
5	0.1231
(Base Case) 7	**(Base Case) 0.1224**
9	0.1216
15	0.1194

Finally, the sensitivity of annual costs, the debt ratio, greenhouse gases (GHG) emission reduction credits and debt term is about 5-10 times less than the sensitivity of the parameters categorised as important parameters, so they could be perceived as less important.

The cash inflow to the project due to certified emission reductions is calculated for various prices of Certified Emission Reductions (CERs) valid for Armenian RE projects under Clean Development Mechanism of the Kyoto Protocol. Effect of inclusion of various CER prices on the break even tariff of Semyonovka project is presented in the table 5.3.5 below. From this table it appears that CER revenues under various CER price scenarios do not strongly affect the BET for the Semyonovka project, although a CER price of € 7 per ton will reduce the BET with 2½%.

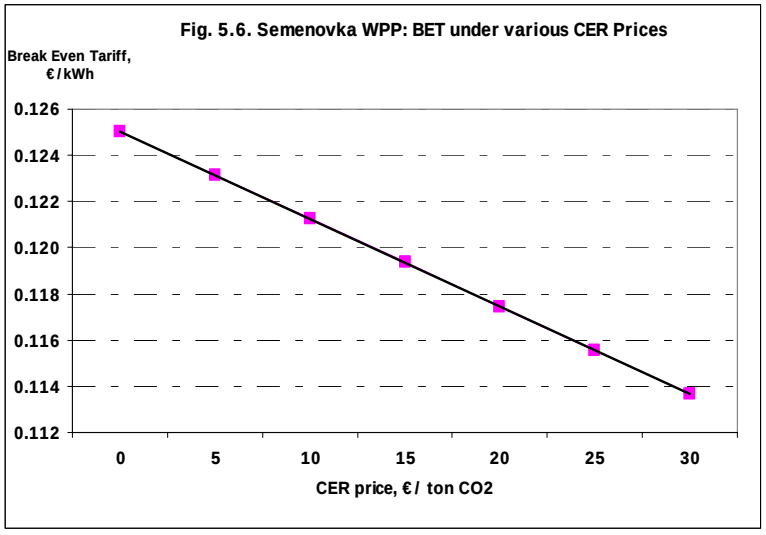


Fig. 5.6. Semenovka WPP: BET under various CER Prices

In order to illustrate this result a series of calculations was performed for the Semyonovka project under various CER prices. The results are summarised in Fig. 5.6. The impact of increasing CER price has a linear impact on decreasing the project BET, i.e. each time the CER price increased by € 5 per ton of CO_2, the BET value decreased by 2.0%. The figure present also the equation of the trend line for obtained results.

Generally it could be concluded that incorporation of the CDM into the wind power projects in Gegharkunik marz of Armenia under current conditions will not lead to the significant reduction of the BET of the wind projects and thus will not affect significantly

[10] The non-zero escalation rate of Base case (0.4%) is due to some technical reasons of simulation runs on RetScreen model.

on the project feasibility.

4.3. Zod Pass Wind Power Project

4.3.1. Brief Description of the Project

19.5 MW Zod wind power plant (Sotk Town) project is the first commercial grid connected renewable project in Armenia. Zod Wind CJSC has made extensive wind resource monitoring in the area with favourable results. A project pre-feasibility study has been conducted in 2001 and updated in the framework of the Project.

The main parameters of the project are:

- ⇒ annual average wind at hub height of wind turbines 8.1 m/s,
- ⇒ total installed capacity 19.55 MW (23 turbines with 850 kW of rated power each),
- ⇒ gross annual average energy production 53.59 mln kWh/year,
- ⇒ annual average energy delivered to the grid 46.57 mln kWh/year,
- ⇒ total initial cost 30.83 mln € (41.62 mln USD)
- ⇒ wind electricity tariff at the time of project (the year 2001) was 0.0519 €/kWh, without VAT [11].

4.3.2. Results of BET Sensitivity Analysis for Zod WPP

The BET calculations for Zod Pass project (base case) as well as the results of sensitivity of the BET under the variation of different parameters are presented in the table 5.4.2 below. The obtained results shows for all the sensitivity variations the determined base case BET value (€ **0.1036**/kWh) remain lower than the feed in tariff (€ 0.0519/kWh) valid at the time of project approval (the range of obtained BET values is from € 0.0818/kWh to € 0.1271/kWh).

Table 5.4.2 Sensitivity analysis of BET, 19.5 MW Zod WPP

Discount rate: 30%
Capital: 20%
Electricity Output: 5%
Wind electricity tariff at the time of the project: € 0.0519/kWh

Sensitivity ranges		Total Capital Costs (mln. €)				
Annual Electricity Production (MWh)		24.66	27.75	**30.83**	33.91	36.99
		-20%	-10%	**0%**	10%	20%
44240	-5%	0.0904	0.1000	**0.1090**	0.1181	0.1271
45404	-3%	0.0881	0.0975	**0.1062**	0.1150	0.1238
46568	**0%**	**0.0864**	**0.0950**	**0.1036**	**0.1122**	**0.1207**
47732	3%	0.0838	0.0927	**0.1011**	0.1094	0.1178
48896	5%	0.0818	0.0905	**0.0987**	0.1068	0.1150
		Total Capital Costs (mln. €)				
Discount Rate (%)		24.66	27.75	**30.83**	33.91	36.99
		-20%	-10%	**0%**	10%	20%
7.0%	-30%	0.0790	0.0871	**0.0946**	0.1021	0.1096
8.5%	-15%	0.0824	0.0910	**0.0991**	0.1071	0.1152
10.0%	**0%**	**0.0859**	**0.0950**	**0.1036**	**0.1122**	**0.1207**
11.5%	15%	0.0893	0.0990	**0.1081**	0.1172	0.1263

[11] or 0.07 USD cents/kWh according to PSRC RA. This tariff was valid until 4 May 2007.

13.0%	30%	0.0927	0.1030	**0.1126**	0.1222	0.1318
		Discount Rate (%)				
Annual Electricity Production (MWh)		7.0%	8.5%	**10.0%**	11.5%	13.0%
		-30%	-15%	**0%**	15%	30%
44240	-5%	0.0995	0.1043	**0.1090**	0.1138	0.1185
45404	-3%	0.0970	0.1016	**0.1062**	0.1109	0.1155
46568	**0%**	**0.0946**	**0.0991**	**0.1036**	**0.1081**	**0.1126**
47732	3%	0.0923	0.0967	**0.1011**	0.1055	0.1098
48896	5%	0.0901	0.0944	**0.0987**	0.1029	0.1072

Break-even tariff cases higher than feed-in tariff.

Break-even tariff cases equal or lower than feed-in tariff.

The BET sensitivity analysis of Zod Pass wind project demonstrates that it will remain economically not feasible (negative NPV) under the € 0.0519/kWh (without VAT) feed-in tariff.

4.4. Pushkin Pass Wind Power Project

4.4.1. Brief Description of the Project

The 19.5 MW Pushkin Pass grid-connected Wind Power Project, located at Bazum mountainous ridge (Lori marz, RA) was considered in 2002 in the framework of Armenian-Dutch ArmWind project supported by the grant from the PSO agency of the Ministry of Economy of The Netherlands.

Currently on this site is located the first 2.6 MW "Lori 1" wind farm in Armenia (commissioned in December 2005). This small windfarm was constructed by grant support and is not regarded as a commercial installation.

The feasibility analysis of Pushkin Pass wind power project was based on 24 months of wind power monitoring data (1999-2000) carried out under ArmNedWind Project on 2 monitoring units (50 m height, measurements on 30 and 50 m above ground level) located on the top of the Pushkin pass [12].

The main parameters of the project are:

- ⇒ annual average wind at hub height of wind turbines 8.3 m/s,
- ⇒ total installed capacity 19.55 MW (23 turbines with 850 kW of rated power each),
- ⇒ gross annual average energy production 54.7 mln kWh/year,
- ⇒ annual average energy delivered to the grid 48.9 mln kWh/year,
- ⇒ total initial cost 27.67 mln €,
- ⇒ wind electricity tariff at the time of project (in year 2002) 0.0519 €/kWh, without VAT (0.07 USD cents/kWh [13]).

4.4.2. Results of BET Sensitivity Analysis for Pushkin Pass WPP

The BET calculations for Pushkin Pass project (base case) as well as the results of sensitivity of the BET under the variation of different parameters are presented in the table 5.5.2 below. The obtained results shows for all the sensitivity variations the determined base case BET value (€ **0.0902**/kWh) remain lower than the feed in tariff (€

[12] ArmNedWind Project "Wind Resource Assessment Study". Final Report PSO 98/AM/2/1. Oct 2000.

[13] This tariff was active till 4 May 2007. The appropriate decision of the PSRC RA was issued to the public in August 2007.

0.0519/kWh) valid at the time of project approval.

Table 5.5.2	Sensitivity analysis of BET, 19.5 MW Pushkin pass WPP					
Discount rate:	30%					
Capital:	20%	Wind electricity tariff at the time of project: € 0.0519/kWh				
Electricity Output:	5%					
Sensitivity range		Total Capital Costs (mln. €)				
Annual Electricity Production (MWh)		**22.14**	**24.91**	**27.67**	**30.44**	**33.21**
		-20%	-10%	**0%**	10%	20%
46478	-5%	0.0796	0.0873	**0.0950**	0.1027	0.1104
47701	-3%	0.0775	0.0850	**0.0926**	0.1001	0.1076
48924	**0%**	**0.0756**	**0.0829**	**0.0902**	**0.0976**	**0.1049**
50147	3%	0.0737	0.0809	**0.0880**	0.0952	0.1023
51370	5%	0.0720	0.0790	**0.0859**	0.0929	0.0999
		Total Capital Costs (mln. €)				
Discount Rate (%)		**22.14**	**24.91**	**27.67**	**30.44**	**33.21**
		-20%	-10%	**0%**	10%	20%
7.0%	-30%	0.0698	0.0762	**0.0827**	0.0891	0.0956
8.5%	-15%	0.0727	0.0796	**0.0865**	0.0934	0.1002
10.0%	**0%**	**0.0756**	**0.0829**	**0.0902**	**0.0976**	**0.1049**
11.5%	15%	0.0785	0.0862	**0.0940**	0.1018	0.1096
13.0%	30%	0.0814	0.0896	**0.0978**	0.1060	0.1142
		Discount Rate (%)				
Annual Electricity Production (MWh)		**7.0%**	**8.5%**	**10.0%**	**11.5%**	**13.0%**
		-30%	-15%	**0%**	15%	30%
46478	-5%	0.0870	0.0910	**0.0950**	0.0990	0.1030
47701	-3%	0.0848	0.0887	**0.0926**	0.0964	0.1003
48924	**0%**	**0.0827**	**0.0865**	**0.0902**	**0.0940**	**0.0978**
50147	3%	0.0807	0.0844	**0.0880**	0.0917	0.0954
51370	5%	0.0788	0.0823	**0.0859**	0.0896	0.0932

Break-even tariff cases higher than feed-in tariff.

Break-even tariff cases equal or lower than feed-in tariff.

The BET sensitivity analysis of Pushkin Pass wind project demonstrates that it will remain economically not feasible (negative NPV) under the € 0.0519/kWh (without VAT) feed-in tariff.

4.5. Kharaxach Pass Wind Power Project

4.5.1. Brief Description of the Project

The 124.1 MW Kharaxach Pass grid-connected Wind Power Project, located between Bazum and Javaghet mountainous ridges (Shirak marz, RA) was considered in February-March 2002 in the framework of Armenian-Dutch ArmNedWind and ArmWind projects, supported by the grant from the PSO agency of the Ministry of Economy of The Netherlands. The works were stopped in August 2002.

In the beginning of the 2007 it was announced about the intention of private company from Italy to start 90 MW wind project on this site.

The feasibility analysis of Kharaxach Pass WPP presented bellow is based on 24 months

of wind power monitoring data (1999-2000) carried out under ArmNedWind Project on one monitoring unit (50 m height, measurements on 30 and 50 m above ground level) located at the western gate of the pass near Musaelyan village.
The main parameters of the project are:

- ⇒ annual average wind at hub height of wind turbines 8.2 m/s,
- ⇒ total installed capacity 124.1 MW (146 wind turbines with 850 kW of rated power each),
- ⇒ gross annual average energy production 347.3 mln kWh/year,
- ⇒ annual average energy delivered to the grid 301 mln kWh/year,
- ⇒ total initial cost 174 mln €
- ⇒ wind electricity tariff at the time of negotiations of the project with PSRC RA was € 0.071/kWh, without VAT [14].

4.5.2. Results of BET Sensitivity Analysis for Kharaxach Pass WPP

The BET calculations for the Kharaxach Pass project (base case) as well as the results of sensitivity of the BET under the variation of different parameters are presented in the table 5.6.2 below.

Table 5.6.2		Sensitivity analysis of BET, 124.1 MW Kharaxach pass WPP				
Discount rate:	30%					
Capital:	20%	**Wind electricity tariff at the time of project: € 0.071/kWh**				
Electricity Output:	5%					
Sensitivity ranges		**Total Capital Costs (mln. €)**				
Annual Electricity Production (MWh)		**139.22**	**156.62**	**174.02**	**191.42**	**208.83**
		-20%	**-10%**	**0%**	**10%**	**20%**
285912	-5%	0.0610	0.0681	**0.0753**	0.0824	0.0896
293436	-3%	0.0594	0.0664	**0.0733**	0.0803	0.0873
300960	**0%**	**0.0579**	**0.0647**	**0.0715**	**0.0783**	**0.0851**
308484	3%	0.0565	0.0631	**0.0698**	0.0764	0.0830
316008	5%	0.0552	0.0616	**0.0681**	0.0746	0.0810
		Total Capital Costs (mln. €)				
Discount Rate (%)		**139.22**	**156.62**	**174.02**	**191.42**	**208.83**
		-20%	**-10%**	**0%**	**10%**	**20%**
7.0%	-30%	0.0519	0.0579	**0.0639**	0.0699	0.0759
8.5%	-15%	0.0549	0.0613	**0.0677**	0.0741	0.0805
10.0%	**0%**	**0.0579**	**0.0647**	**0.0715**	**0.0783**	**0.0851**
11.5%	15%	0.0609	0.0681	**0.0753**	0.0824	0.0896
13.0%	30%	0.0638	0.0714	**0.0789**	0.0865	0.0941
		Discount Rate (%)				
Annual Electricity Production (MWh)		7.0%	8.5%	**10.0%**	11.5%	13.0%
		-30%	-15%	**0%**	15%	30%
285912	-5%	0.0673	0.0713	**0.0753**	0.0792	0.0831
293436	-3%	0.0655	0.0695	**0.0733**	0.0772	0.0810
300960	**0%**	**0.0639**	**0.0677**	**0.0715**	**0.0753**	**0.0789**
308484	3%	0.0623	0.0661	**0.0698**	0.0734	0.0770

[14] or 0.096 USD cents/kWh. This tariff was negotiated between representatives of PSO agency (The Netherlands) and PSRC RA and fixed for the ArmNedWind Kharaxach project by PSRC RA.

316008	5%	0.0609	0.0645	**0.0681**	0.0717	0.0752

Break-even tariff cases higher than feed-in tariff.

Break-even tariff cases equal or lower than feed-in tariff.

The BET sensitivity analysis of Kharaxach Pass project demonstrates that for all considered variations the determined base case BET value (€ **0.0715**/kWh without VAT) is slightly higher than the feed-in tariff (€ 0.071/kWh) negotiated during the discussion of the project with PSRC RA. Thus, it becomes economically not feasible (negative NPV) under the negotiated feed-in tariff.

In addition, the sensitivity analysis demonstrates that the NPV of the project will become positive if the annual production will increase by 3% under the base case assumption.

At the same time the calculation illustrates that by a decrease of the total capital cost by 10% the project will have positive NPV under all the considered range of variations of annual production. A 30% decrease of the discount rate will also compensate 10% increasing of the project total capital cost.

The Table 5.6.2-a summarises the results of calculations of main financial feasibility parameters via RetScreen model for considered several sensitivity cases.

Table 5.6.2-a	**Base Case: € 174.02 mln, 10.0 % Discount rate**	**€ 191.42 mln, 7.0 % Discount rate**	**€ 139.22 mln, 7.0 % Discount rate**	**€ 139.22 mln, 13.0 % Discount rate**
BET of the project by case, €/kWh	**0.0715**	**0.0519**	**0.0699**	**0.0638**
After-tax IRR and ROI (%)	9.8	7.4	16.8	16.8
Simple Payback, years	8.4	9.2	6.7	6.7
Year-to-positive cash flow, year	12.3	13.5	8.7	8.7
Net Present Value, €	-1 049 404	3 857 551	61 286 659	15 401 702
Annual Life Cycle Savings, €	-123 263	364 125	5 785 027	2 192 491
Benefit-Cost ratio	0.98	1.07	2.47	1.37

5. Conclusions

For a project like the Semyonovka pass wind project to turn feasible a number of measures can be introduced in Armenia. The results of the performed general sensitivity analysis shows, that there are three groups of parameters: Most sensitive (or most "important"); important; and less important ones, which are affecting NPV or financial feasibility of the projects.

The calculations stress that the initial capital cost of the project is the most important parameter, mostly determined by the cost of main equipment (imported wind turbines). So it is important to cut down the initial capital cost (the most sensitive parameter influenced NPV and feasibility) by looking for a cheaper equipment provider and overall reduction in construction costs. In this context it should also be noted, that due to the absence of local manufacturing capacities of modern wind turbines in Armenia all main

component for wind power plants should be imported to Armenia.

According to current VAT (value added tax) in Armenia imported wind turbines will be subject to 20% value added tax payments (VAT). In order to support the wind power development in Armenia, some measures could be recommended in order to reduce the initial costs of WPP by reducing the burden of VAT on imported equipment for RE projects.

The second group – "Important" parameters are the delivered energy (energy production), debt interest rate and avoided cost of energy (wind electricity tariff). They have a sensitivity of about the half of the magnitude of the most sensitive parameter - cost of the project,

The major interest has the delivered energy of the project, because it is directly determined by natural limitations of wind power flow energy on considered site in Gegharkunik marz. A change in the annual average wind speed of 1.0 m/s will change the production price of wind energy with approximately 22% per kWh. The Current feed in tariff in Armenia indicates that a annual wind speed higher than 8.5 m/s is necessary to make wind project feasible.

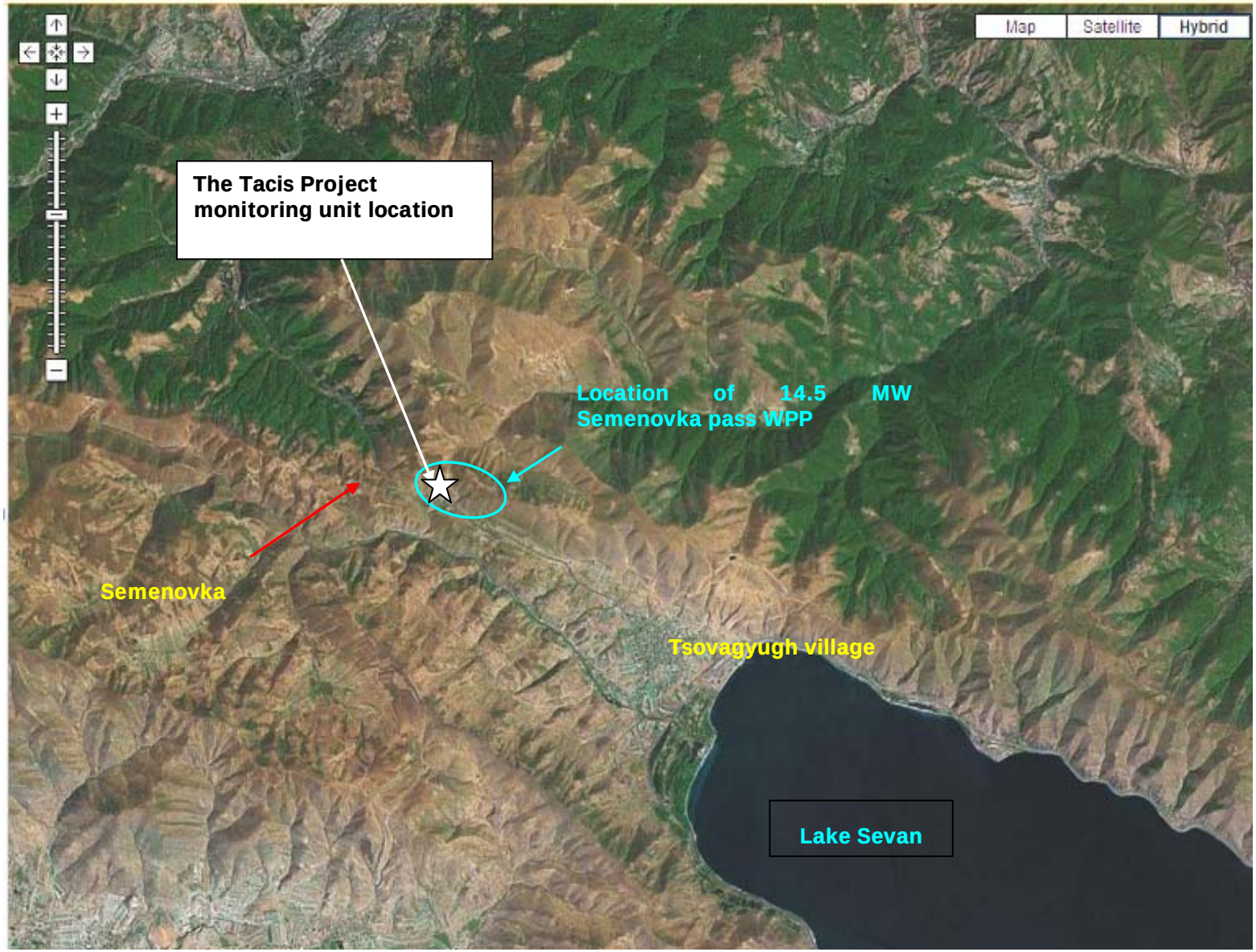
A strong incentive is a change in the feed in tariff for wind energy. The tariff methodology does not provide the investor with ability to evaluate the long-run feasibility calculations for the tariff as the new (and current) methodology in Armenia for the tariff includes consumer price index and foreign exchange rate fluctuation from year to year. Development of wind energy in Armenia will benefit from a consideration of a review of both the initial tariff rate and the tariff methodology.

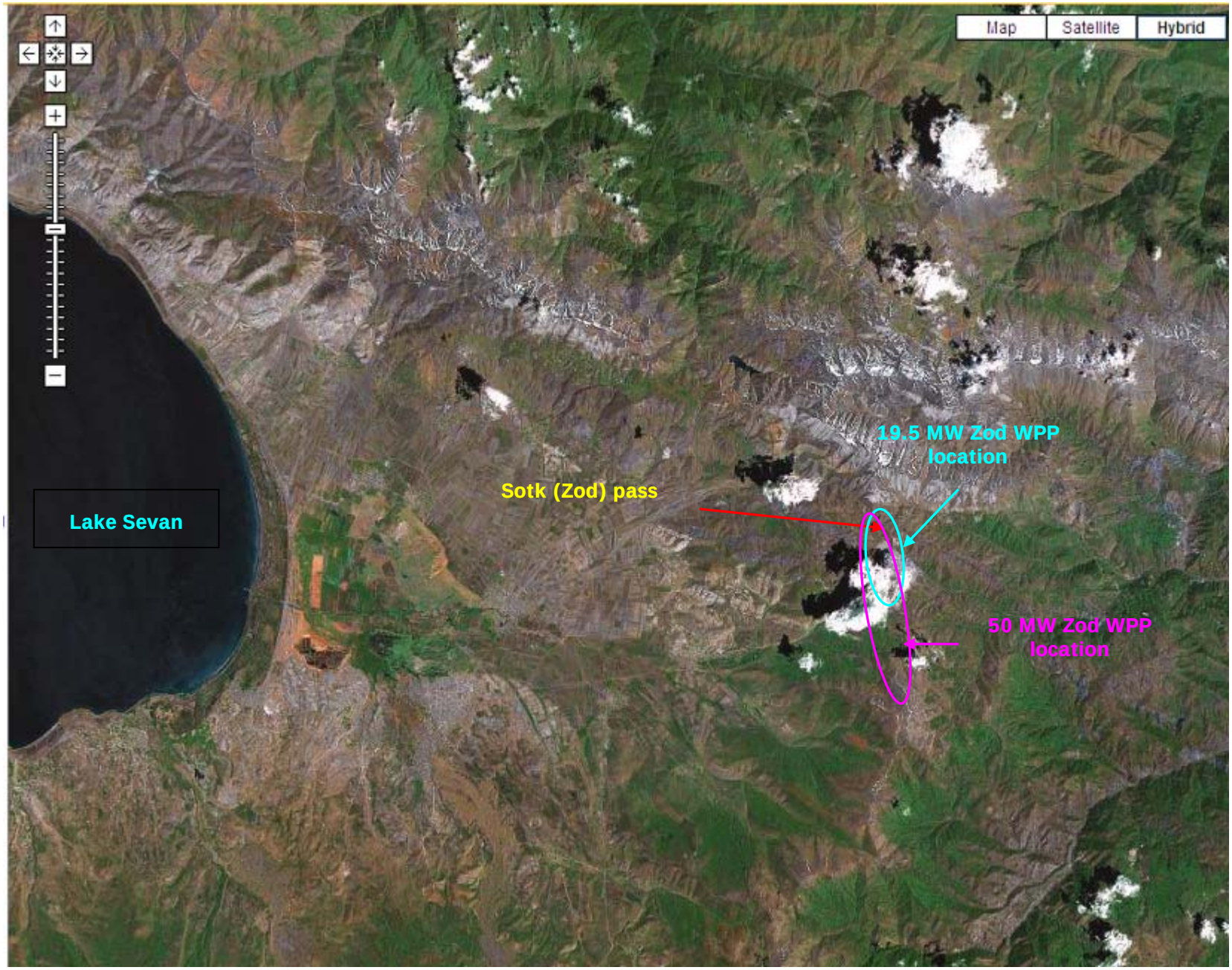
Among the less "important" parameters could be mentioned the impact of CER certified emissions reductions valid for Armenia under CDM. Generally it could be concluded that incorporation of the CDM into the wind power projects in Gegharkunik marz of Armenia under current conditions will not lead to the significant reduction of the BET of the wind projects and thus will not affect significantly on the project feasibility. Each time the CER price increased by € 5.0 per ton of CO_2, the BET value decreased by 2.0%.

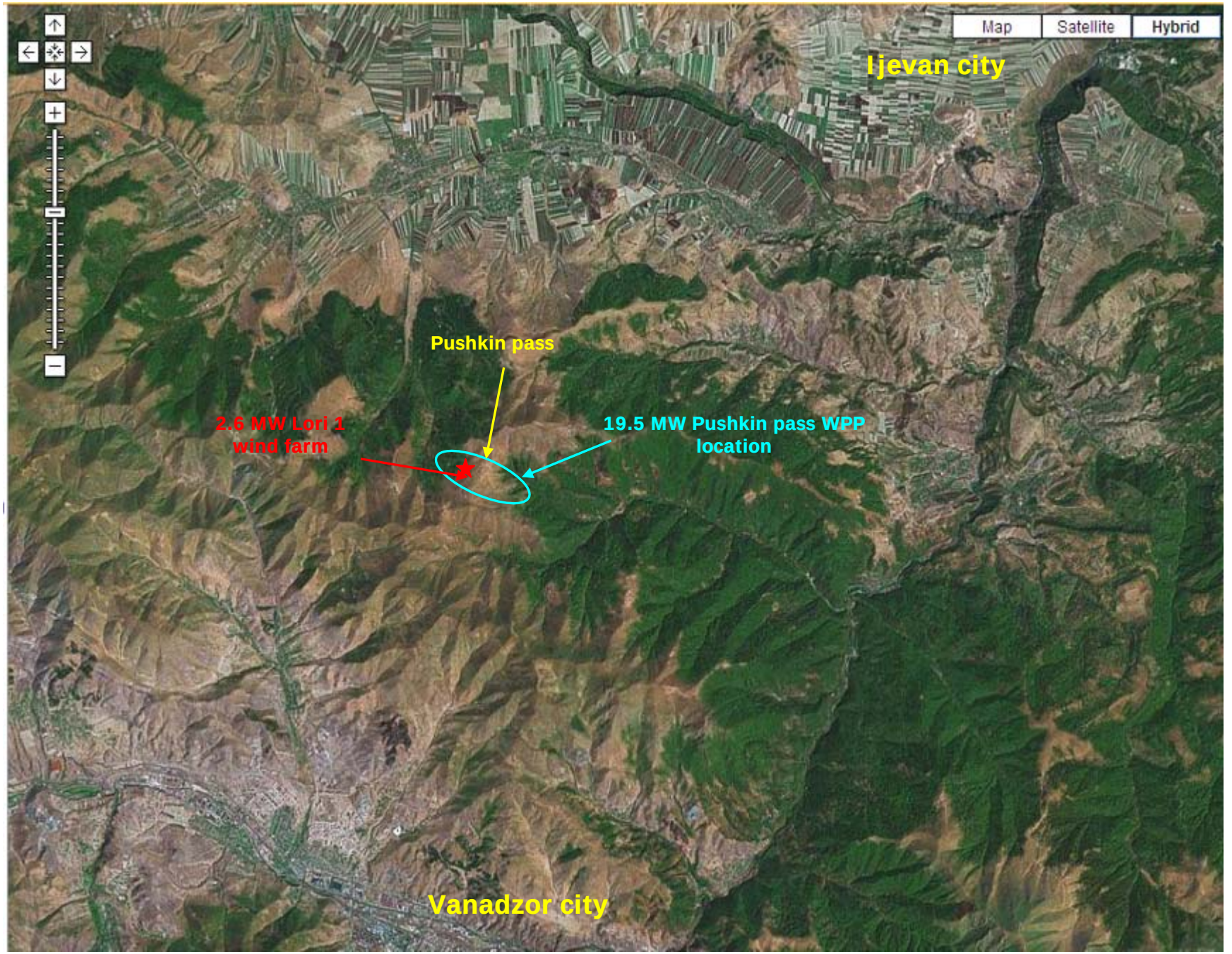
Policy intervention to promote grants and incentives for promoting wind and solar projects should also be considered – this could include VAT exemptions for imported technological equipment, changes in taxation, etc.)

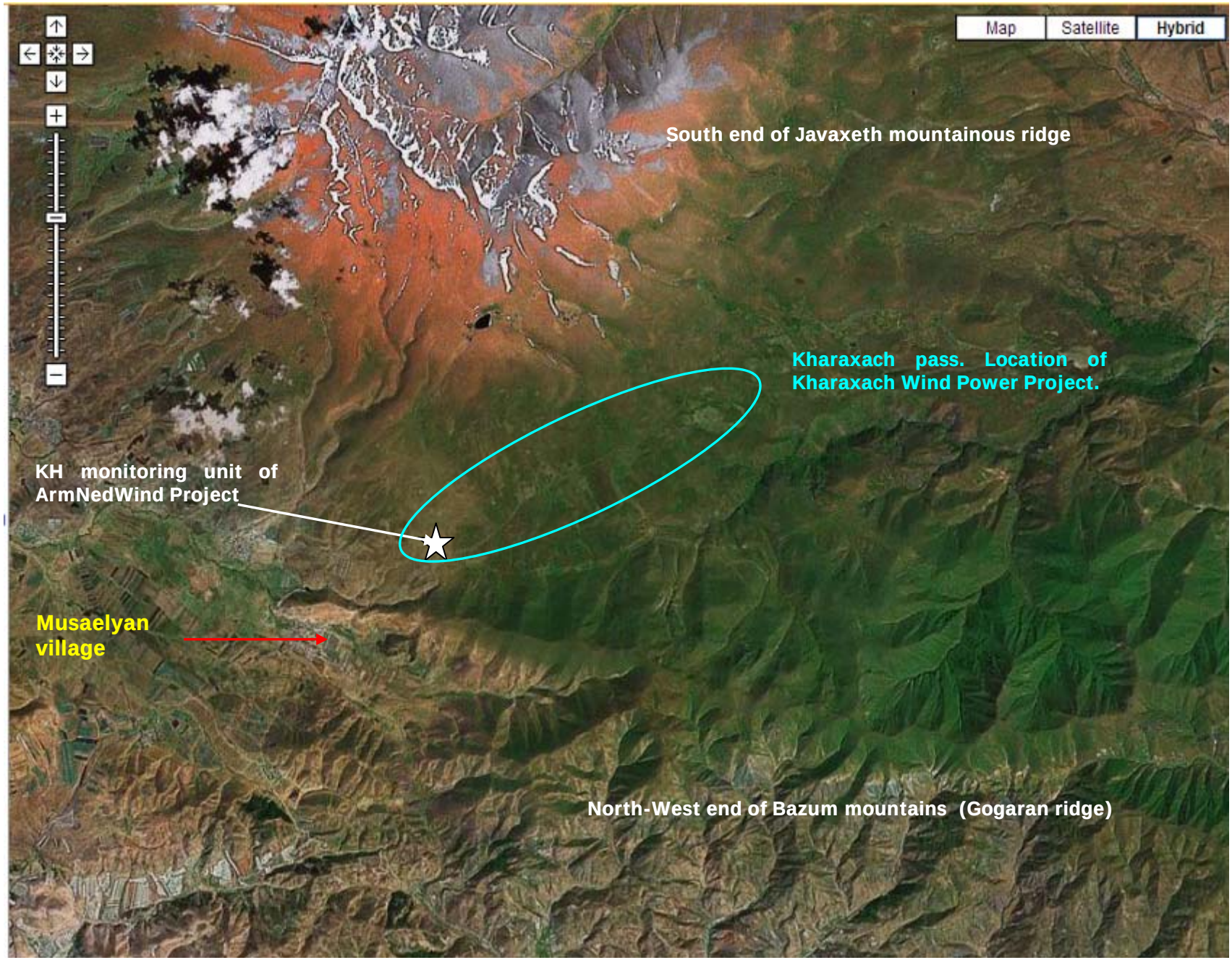
State promotion in terms of soft loans and subsidies as well as tax privileges would help the development of specific and targeted renewable technologies which can offer significant energy saving. The potential for solar thermal energy is very high in Armenia, and can by a targeted approach be utilised much better.

ANNEX


Map
Satellite
Hybrid
The Tacis Project monitoring unit location
Location of 14.5 MW Semenovka pass WPP
Semenovka
Tsovagyugh village
Lake Sevan


Map
Satellite
Hybrid
Lake Sevan
Sotk (Zod) pass
19.5 MW Zod WPP location
50 MW Zod WPP location


Map
Satellite
Hybrid
Ijevan city
Pushkin pass
2.6 MW Lori 1
wind farm
19.5 MW Pushkin pass WPP
location
Vanadzor city


Map
Satellite
Hybrid
South end of Javaxeth mountainous ridge
Kharaxach pass. Location of Kharaxach Wind Power Project.
KH monitoring unit of ArmNedWind Project
Musaelyan village
North-West end of Bazum mountains (Gogaran ridge)