TASK II REPORT

A PRELIMINARY FEASIBILITY ASSESSMENT OF THE PREFERRED ALTERNATIVE FOR IMPLEMENTING A COMMERCIAL SCALE BIO-ETHANOL FUELS PROGRAM FOR ARMENIA IN THE NEAR TO MID TERM

ASSISTANCE TO THE BIO-ETHANOL PRODUCTION DEVELOPMENT IN ARMENIA, GEF-CS-16/2007

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October 23, 2008

Executive Summary

This report documents the results of a preliminary feasibility analysis for two proposed bio-ethanol production facilities to be constructed in Armenia in the near to mid term—a 7,000 tonne per annum bio-ethanol plant for processing Jerusalem artichoke and a 7,000 tonne per annum dry mill corn fractionation facility.

As a land-locked country without any significant deposits of crude oil, Armenia is fully 100 percent dependent upon fuel imports to meet a growing demand for petrol in the motor transport sector. Moreover, dramatic increases in world crude oil trading prices over the past year are already being passed onto and reflected at retail petrol outlets. In addition, prices for petrol in Armenia are expected to increase at an even more rapid rate in the future as long-term import contracts lapse and are renegotiated at higher market prices over time. Moreover, natural gas prices from Russia are expected to increase by early next Spring making CNG more expensive and causing sympathetic upward pressure on petrol prices as well. Such trends will make alternative motor transport fuels such as bio-ethanol more competitive in the market. Finally, bio-ethanol for blending as a motor transport fuel has the potential to reduce imports of petrol through displacement, reduce foreign exchange drains, increase energy security of supply in a traditionally unstable region of the world, create value from domestically grown bio-ethanol feedstocks on surplus lands, create jobs in depressed rural areas, and improve local air quality particularly in congested urban areas.

One of the key factors for determining the overall success of a biofuels program is the availability of appropriate feedstocks at attractive prices. Corn and sugarcane serve as the major feedstocks for current bio-ethanol production throughout most of the world today, but virtually any feedstock with high sugar or starch content can be utilized for bio-ethanol production. Armenia's climatic conditions are not suitable for sugarcane production; however, the project team has identified several alternative crops suitable to Armenia's climate for cultivation on available agricultural land that is not intended for the production of food crops. In particular, Jerusalem artichoke was identified as a crop with great potential as a feedstock for bio-ethanol production in Armenia in the near to mid term. It can be cultivated on land that is currently fallow. Moreover, it possesses relatively high carbohydrate content, especially in its root tuber, thereby making it extremely suitable for bio-ethanol production. Similarly, feed corn for livestock and poultry is a suitable crop for the soils and micro climates found in several parts of the country. Utilizing a dry mill corn fractionation process, feed corn can be processed in such a manner as to extract all of the starches contained in the feedstock corn for conversion into bio-ethanol while at the same time producing important animal feed co-products that have a higher percentage of protein, fats, and carbohydrates than that found in unprocessed dry corn which is currently the principal animal feed used by livestock and poultry producers in Armenia today.

During the conduct of this preliminary feasibility study, the project team focused its comparative evaluation efforts on two very different types of bio-ethanol plants: one based on an inulin extraction process for Jerusalem artichoke to be situated in the vicinity of Sisian and Goris in Syunik Marz as the most appropriate feedstock; and, a second plant based on a dry milling process with fractionation utilizing feed corn grown in Tavush Marz as a feedstock. The recommended capacity sizes of these two plants was 7,000 tonnes per annum each based on the assumption that the Government of Armenia would mandate 5 percent blending of bio-ethanol by volume with petrol by the year 2014.

This Task II Report analyzes feedstock availability to meet this goal in two marzes with high rural unemployment rates, evaluates potential bio-ethanol and co-product markets in Armenia today, determines the most appropriate conversion process technology for each bio-ethanol feedstock recommended, selects and evaluates proposed sites for these two plants, performs a site-specific environmental assessment for each of these proposed sites, and conducts a financial analysis of these two proposed bio-ethanol plants including detailed sensitivity analyses.

One final set of observations is warranted prior to summarizing the findings and recommendations of this preliminary feasibility study report. There are a number of advantages and disadvantages that should be recognized from the outset when considering a decision on whether or not to implement a nationwide bio-ethanol program.

With respect to advantages, bio-ethanol can be produced from domestic renewable feedstock sources, helps to stimulate agricultural employment in depressed rural parts of the country, can provide Armenian farmers and bio-ethanol processing plant owners with a dependable revenue stream, is non-toxic and biodegradable, can lower air emissions in major metropolitan areas such as Yerevan and Gumry when combusted as a motor transport fuel, can reduce overall greenhouse gas emissions, and help to reduce foreign exchange drains on the Armenian economy for the benefit of the Armenian people. Cellulosic ethanol production also holds the promise of addressing an assortment of environmental problems in the mid to longer term while producing a high quality fuel. Production of these fuels also helps move the Armenia toward increased energy security. Lastly, since bio-ethanol production facilities are also small refineries, the bio-ethanol that leaves the facility needs no further processing other than blending with petrol.

On the other hand, a nationwide bio-ethanol program could face several hurdles or challenges. Ethanol has a lower energy content value compared to petrol and could face an initial public acceptance hurdle. In addition, higher blended levels of ethanol in petrol (e.g., greater than 10%) are not compatible with existing non-flex fuel vehicles, pipeline infrastructure, distribution systems, or tanks and pumps at retail outlets. In addition, no co-product markets currently exist in Armenia for useful by products from bio-ethanol conversion processes, and must be created first. Finally, while bio-ethanol derived from cellulosic feedstocks is not likely to impact food crop production, its greatest disadvantage is that there is currently no proven and economically viable celluosic conversion production process available at the commercial-scale anywhere in the world today, and in the case of hybrid trees it requires feedstock plantings several years in advance of construction of an actual processing plant.

Land Availability for Feedstock Production

Guiding principles during the conduct of this bio-ethanol program assessment were to:

- Focus on surplus lands only
- Start with lands from the Soviet era that are not presently being utilized for food production and unlikely to ever be brought back into useful production
- Primarily concentrate on marginal lands between 1,000 and 2,400 meters in elevation or else saline soils that cannot be utilized for food production regardless of elevation
- Rule out lands that are not accessible by mechanized farm equipment or include endangered species of plants or animals
- Maintain the goal of sustainability uppermost throughout and do not consider land or crops that could conceivably displace food production for human consumption

An inventory of the nation's total tillable land including sown areas and tillable land not presently under cultivation for each Marz is presented in the table below.

Table ES.1 – Amount and Percentage of Total Tillable Lands Not Being Utilized in Each Marz

Region	Present Utilization of Tillable Lands (Thousands of Hectares)			
	Total	Sown Areas with Crops	Not Under Cultivation	% of Total Not Being Used
Vayots Dzor	16.3	3.7	12.6	77.3%
Kotayk	37.8	17.6	20.2	53.4%
Tavush	25.4	13.9	11.6	45.7%
Aragatsotn	54.6	32.9	21.7	39.7%
Syunik	43.8	27.3	16.5	37.7%
Shirak	79.8	53.4	26.4	33.1%
Lori	42.2	31.4	10.7	25.4%
Yerevan	1.6	1.2	0.4	25.0%
Armavir	43.2	34.0	9.2	21.3%
Ararat	27.4	22.8	4.6	16.8%
Gegharkunik	80.9	71.9	9.0	11.1%
Total	**453.0**	**310.1**	**142.9**	**31.5%**

Source: Armenia Cadastre, 2006

Potential Feedstock Crops Evaluated

Types of feedstocks initially considered by the project team included the following:

- Typical crops used for bio-ethanol production worldwide
- Non-typical crops and biological wastes containing starches
- Cellulosic sources for future bio-ethanol process technologies

In this regard, over 20 potential feedstocks were evaluated for their possible suitability in Armenia including:

- Sugar Beet
- Sugar Cane
- Feed Corn
- Wheat
- Barely, Rye, and Oats
- Potatoes
- Fruits
- Jerusalem Artichoke
- Chicory
- Sweet Potatoes
- Sweet Sorghum
- Cheese Production Waste
- Wine Production Waste
- Fruit and Canning Waste
- Spoiled Fruits
- Sugar Factory Waste
- Trees from Forests
- Grain Straw
- Hybrid Popular
- Willow Trees
- Mulberry Trees

Results of Bio-Ethanol Feedstock Suitability Assessment

The best feedstocks from the standpoint of being able to be grown on surplus and/or marginal lands in Armenia, as well as being processed in plants utilizing commercially available processing technology in the near to mid term, include the following:

- Jerusalem artichoke
- Feed corn for livestock and poultry
- Sweet sorghum
- Chicory

Similarly, the best feedstocks for cellulosic conversion in the mid to longer term include:

- Grain straw
- Fast growing hybrid trees (such as poplar, mulberry, and willow)

Most Suitable Locations for Growing Acceptable Feedstocks with Fermentation Conversion

After extensive additional evaluation by the project team and its agricultural specialists, it was determined that the best locations for growing acceptable feedstocks within Armenia from the perspective of recommended bio-ethanol feedstocks, prevailing climatic conditions, soil suitability, elevation constraints, and possible access to irrigation include the following potential locations throughout Armenia in the near to mid term as presented in the table below:

Table ES.2 – Most Optimal Locations for Growing Suitable Feedstocks for Fermentation Processing Plants in the Near to Mid Term

Potential Location	Possible Bio-Ethanol Crops	Typical Climate Conditions	Soil Conditions	Elevation Range	Condition of Irrigation Network
Sisian and Goris	- Jerusalem Artichokes - Chicory - Feed Corn	- Cool to cold temperatures - Medium to short growing season - Good rainfall	- Brown & black - Good conditions especially near the Vorotan River	- 600 to 2100 meters above sea level	- Very old network
Yeghegnadzor	- Sweet Sorghum - Feed Corn	- Mild to cool temperatures - Medium growing season - Good rainfall	- Brown & black	- 1000 to 1500 meters above sea level	- Only in low lands
Vardenis	- Jerusalem Artichokes - Chicory	- Cold temperatures Short growing season - Good rainfall	- Brown & black - Very good for potatoes	- 1900 to 2300 meters above sea level	- Very old network
Yeghvard	- Sweet Sorghum - Feed Corn	- Cool to cold temperatures - Short to medium growing season	- Many saline soils - Very good for wheat	- 1300 to 1500 meters above sea level	- Many irrigated lands
Artik	- Jerusalem Artichokes	- Cool to cold temperatures - Short to medium growing season - Good rainfall	- Mostly brown soil	- 1600 to 1700 meters above sea level	- Many irrigated lands
Haghartsin (near Ijevan)	- Corn - Sweet Sorghum	- Mild temperatures - Long growing season - Good rainfall	- Post forest land - Very rich soil	- 400 to 1300 meters above sea level	- Very old network

Similarly, potential locations throughout the country where bio-ethanol feedstocks in sufficient quantities suitable for processing in celluosic conversion plants in the mid to long term *but for which plantings must be considered now in the case of hybrid trees* are shown in the table below:

Table ES.3 – Most Optimal Locations for Growing Suitable Feedstocks for Celluosic Conversion Plants in the Mid to Longer Term

Potential Location	Possible Bio-Ethanol Crops	Typical Climate Conditions	Soil Conditions	Elevation Range	Condition of Irrigation Network
Ararat Valley	- Grain Straws	- Mild temperatures - Two growing seasons for grains	- Mostly black soil, some brown soil areas	- 800 to 900 meters above sea level	- Very old network
Armash	- Hybrid Trees	- Mild temperatures	- Mostly brown soil, some saline areas	- 800 to 900 meters above sea level	- Very old network
Hrazdan	- Hybrid Trees	- Cold temperatures - Short growing season	- Mostly brown soil	- 1800 to 1900 meters above sea level	- Very old network

Matching Feedstocks to the Most Appropriate Bio-Ethanol Conversion Technology

The most appropriate conversion technologies for each of the most promising bio-ethanol feedstocks evaluated by the project team are matched up in the table below for both fermentation processes and cellulosic conversion processes:

Table ES.4 – Matching Specific Feedstocks to the Most Appropriate Conversion Technology

Most Appropriate Technology	Applicable Bio-Ethanol Feedstock
Fermentation Processes	
Inulin Extraction	Jerusalem Artichokes, Chicory
Sugar Fermentation	Sweet Sorghum
Dry Mill Starch Extraction	Feed Corn
Dry Mill with Fractionation	Feed Corn
Cellulosic Conversion Processes	
Ligno-Cellulose Sugar Platform	Grain Straws, Hybrid Poplar, Mulberry Trees, Willow Trees
Thermochemical Platform	Grain Straws, Hybrid Poplar, Mulberry Trees, Willow Trees

The feasibility study team has selected inulin extraction for use in processing Jerusalem artichoke and dry mill with fractionation for feed corn.

Assessment of Potential Bio-Ethanol Market Size and Estimated Ceiling Price

A forecast of bio-ethanol production market size required to achieve selected blending levels by volume with petrol in thousands of tonnes per annum is presented in the table below:

Table ES.5 – Forecast of Bio-Ethanol Production Required to Achieve Selected Blending Levels Assuming a 10% Growth in Demand for Petrol (in Thousands of Tonnes per Annum)

Indicator	Year											
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
5% Level of Blending (E5 Fuel)												
Petrol	172	189	208	229	252	277	305	335	369	406	446	491
Bio-Ethanol	8.6	9.5	10.4	11.4	12.6	13.9	15.2	16.8	18.4	20.3	22.3	24.5
10% Level of Blending (E10 Fuel)												
Petrol	172	189	208	229	252	277	305	335	369	406	446	491
Bio-Ethanol	17.2	18.9	20.8	22.9	25.2	27.7	30.5	33.5	36.9	40.6	44.6	49.1

Critical Note**:** If the imported petrol is not of a high quality or contains moisture, there will be performance and maintenance problems with automobiles that are operated with E5 or E10 fuels and the program will be a failure.

These projections formed the basis of the decision to develop 14,000 tonnes per annum of bio-ethanol production capacity by 2014 and roughly 49,000 tonnes per annum by the year 2020.

Similarly, a forecast of the estimated wholesale price of petrol in AMD/liter during the period 2009–2020 is presented in the table below and represents the maximum ceiling price that can be charged for bio-ethanol derived fuels for blending over time based upon for selected rate of growth increases in the wholesale price of petrol:

Table ES.6 –Forecast of the Estimated Wholesale Price of Petrol in AMD/Liter (2009 – 2020)

Rate of Increase in Wholesale Price	Year											
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
5% Growth	298	313	329	345	362	381	400	420	441	463	486	510
10% Growth	312	344	378	416	457	503	553	609	670	737	810	891
20% Growth	341	409	491	589	707	848	1,018	1,221	1,465	1,758	2,110	2,532

Assumption – 2008 wholesale price = AMD 278/liter

Potential Co-Product Markets and Estimated Prices

The sale of co-products from a planned bio-ethanol plant is essential to ensure the economic viability of such a project, especially if no direct financial subsidies will be provided by Government to guarantee the success of a bio-ethanol program over time.

Potential co-products from a Jerusalem artichoke plant include:

- Pulp which can be utilized as a high carbohydrate animal feed
- Feedstock for anaerobic digestion to produce heat and power
- CO_2 for the non-alcoholic beverage industry and dry ice

Potential co-products from a corn fractionation plant include:

- Dried distillers grain and solubles (DDGS) which is used elsewhere as a high protein animal feed
- Germ which contains edible oils for cooking
- Bran for its high content of dietary fiber
- CO_2 for the non-alcoholic beverage industry and dry ice

Table ES.7 – Typical Co-Product Pricing Compared to the an Average Reference Price for Feed Corn

Co-Product	Projected Price in U.S. Dollars per Tonne	Percentage of Local Dry Corn Price
Local Feed Corn	$393	100%
High Protein Distillers Grains	$416	106%
Germ	$452	115%
Fiber	$216	55%

The value assigned to the Jerusalem artichoke co-product is significantly lower at $266 per tonne even though its protein content is comparable to that of high protein distiller's grains. The price was discounted to reflect the current lack of experience and markets for this particular animal feed product not only in Armenia but also elsewhere.

Estimate of Total Financing Requirements for Each Plant

A comparative summary of cost to construct and total financing requirements is presented in the table below for each of the two proposed plants assuming a limited recourse project financing with a 60/40 debt to equity ratio:

Table ES.8 – Comparison of Total Financing Requirements in 2008 U.S. Dollars

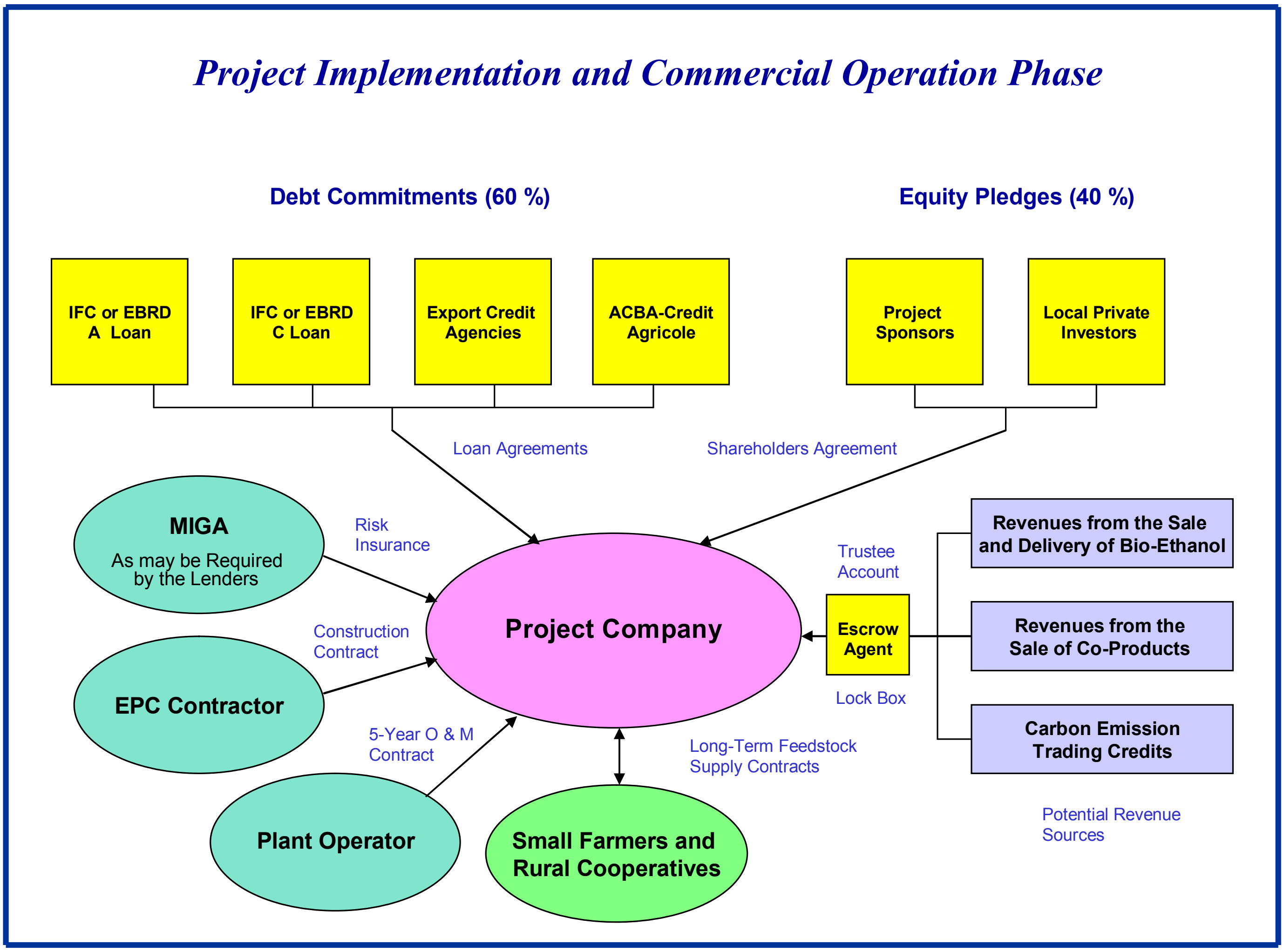
Major Cost Components	7,000 Tonne per Annum Jerusalem Artichoke Plant	7,000 Tonne per Dry Mill Corn Fractionation Plant
EPC Cost to Construct	11,867,000	13,387,000
Owners Costs	2,148,000	2,223,000
Total Installed Bio-Ethanol Project Cost	**14,015,000**	**15,610,000**
Implementation Planning Costs	311,000	379,000
Project Development Fee	560,000	624,000
Commitment and Disbursement Fees	126,000	135,000
Financial Advisory and Arrangement Fees	268,000	288,000
Working Capital	1,0000,000	1,100,000
Interest During Construction	720,000	864,000
Total Soft Costs	**2,985,000**	**3,390,000**
Total Project Financing Requirements	**17,000,000**	**19,000,000**

Source: BBI International and Enertech International, Inc. based on estimates of current international equipment and construction costs prevailing today; these costs could be lower depending upon the amount of local sourcing.

Illustrative Transaction Structure for Project Implementation

A proposed transaction structure showing the interactions among the various participants during the implementation stage of either of these two projects, along with suggested sources of both debt and equity, are presented in the table below for a 7,000 tonne per annum bio-ethanol processing plant:

Figure ES.1 – Illustrative Transaction Structure for a Proposed 7,000 Tonne per Annum Bio-Ethanol Processing Facility



Results from the Project Team's Preliminary Financial Analysis

The major variables for the financial analysis of a biofuels project are bio-ethanol price, feedstock price, co-product price, and energy costs. The assumptions and inputs used by the project team to determine the project's overall financial viability included:

- *Bio-Ethanol Retail Price*. The bio-ethanol retail price used in the financial forecast is $1.34 (410 AMD) per liter of denatured bio-ethanol. The net price includes denatured bio-ethanol product sold at $1.34 per liter less shipping ($0.01/liter) and a 1% sales commission.
- *Bio-Ethanol Yield.* The yield is an important variable for profitable bio-ethanol production. A yield of 92.4 liters of denatured bio-ethanol for each tonne of Jerusalem artichoke (at 80% moisture or less) processed was used in the financial analysis. In addition, a yield of 378.51 liters of denatured bio-ethanol for each tonne of feed corn (at 15% moisture or less) processed was used in the financial analysis. The yield level of different types of Jerusalem artichoke is under review and current studies conducted in Armenia are showing significantly higher yields for some of the hybrid species than

the project team actually included in its financial projections in an effort to be as conservative as possible in its modeling activities.

- *Feedstock Price*. Feedstock prices were set to ensure the plant has a minimum Return on Investment (ROI) of 15%. These prices were derived in the financial model and represent the highest price that the processing plant can pay for feedstocks, and any price below these figures will earn the investor additional profits and higher returns. The delivered feedstock price for Jerusalem artichoke in the analysis is $88.52 per tonne (27 AMD per kg). The delivered feedstock price for feed corn in the analysis is $393 per tonne (119 AMD per kg).
- *Co-Product Price*. The selling price for Jerusalem artichoke co-product is assumed to be $266 per tonne. This co-product of bio-ethanol production from Jerusalem artichoke is not currently available, so there is significant uncertainty regarding its sales potential. The price was estimated based upon the expected protein content of the product. It is uncertain if buyers would value the product similarly. The selling price for the distiller's grains from corn is assumed to be $416.12 per tonne or 106% of the corn price on a dry basis. Similarly, germ is assumed to sell for $451.95 per tonne or 115% of the corn price on a dry basis, and bran is assumed to sell for $216.15 per tonne or 55% of the corn price on a dry basis.
- *Financing*. 100% equity financing was assumed for financial modeling purposes since this is the more conservative approach while at the same time addressing the potential risks of this project (technology, feedstock, and product markets), as well as accounting for the absence of large-scale commercial loans for this type of project in Armenia today. If the project proponents are able to obtain loans with interest costs below the expected rate of return, then returns on investment would improve on a leveraged basis.

A comparative summary of the preliminary financial model outputs for these two proposed plants is presented below where the unleveraged return on investment (ROI) is the average project return for the 11 years of the financial forecast, including the construction year:

Table ES.9 – Summary Comparison of Financial Modeling Results

Armenia Bio-Ethanol Projects	Jerusalem Artichoke	Feed Corn
11-year Average Annual ROI	15%	15%
Required Feedstock Price in $/ tonne (feedstock costs must be less than or equal to this price to be financially viable)	$88.52	$393
Internal Rate of Return	15.2%	15.7%
Earnings Before Interest, Taxes, Depreciation, and Amortization (EBITDA) Year 2	$3,071,036	$3,478,799
Bio-Ethanol Fuel Retail Price ($/liter)	$1.34	$1.34
Total Installed Project Cost	$14,015,000	$15,610,000

Finally, the project team found that these two projects were financially sound and viable as long as average delivered feedstock prices remained at or below $88.52 per tonne (27 AMD per kg) for Jerusalem artichoke and $393 per tonne (119 AMD per kg) for feed corn in 2008 prices.

Comparative Sensitivity Analysis Results

The following tables show the change in the projected average annual ROI for the project for increasing and decreasing ethanol and feedstock prices. All other variables are assumed to remain constant.

Table ES. 10 - Sensitivity and Breakeven Analysis for a Jerusalem Artichoke Processing Plant

Feedstock and Ethanol Price Sensitivity
10-Year Average Annual Return on Investment
Ethanol Project - 7K JA

Jerusalem Artichoke ($/ton)	Ethanol ($/liter)										
	0.84	**0.94**	**1.04**	**1.14**	**1.24**	**1.34**	**1.44**	**1.54**	**1.64**	**1.74**	**1.84**
8.52	33.4%	39.7%	46.0%	52.3%	58.6%	64.9%	71.2%	77.5%	83.9%	90.2%	96.5%
18.52	27.1%	33.4%	39.7%	46.0%	52.4%	58.7%	65.0%	71.3%	77.6%	83.9%	90.2%
28.52	20.9%	27.2%	33.5%	39.8%	46.1%	52.4%	58.7%	65.0%	71.3%	77.6%	83.9%
38.52	14.6%	20.9%	27.2%	33.5%	39.8%	46.1%	52.4%	58.7%	65.0%	71.3%	77.6%
48.52	8.3%	14.6%	20.9%	27.2%	33.5%	39.8%	46.1%	52.4%	58.8%	65.1%	71.4%
58.52	2.0%	8.3%	14.6%	20.9%	27.3%	33.6%	39.9%	46.2%	52.5%	58.8%	65.1%
68.52	-5.5%	2.0%	8.3%	14.7%	21.0%	27.3%	33.6%	39.9%	46.2%	52.5%	58.8%
78.52	-14.3%	-5.5%	2.0%	8.4%	14.7%	21.0%	27.3%	33.6%	39.9%	46.2%	52.5%
88.52	-23.2%	-14.4%	-5.6%	2.0%	8.4%	14.7%	21.0%	27.4%	33.7%	40.0%	46.3%
98.52	-32.1%	-23.3%	-14.4%	-5.6%	2.0%	8.4%	14.7%	21.1%	27.4%	33.7%	40.0%
108.52	-41.0%	-32.2%	-23.3%	-14.5%	-5.7%	2.0%	8.4%	14.8%	21.1%	27.4%	33.7%
118.52	-49.9%	-41.1%	-32.2%	-23.4%	-14.6%	-5.7%	2.0%	8.5%	14.8%	21.1%	27.4%
128.52	-58.8%	-49.9%	-41.1%	-32.3%	-23.4%	-14.6%	-5.8%	2.1%	8.5%	14.8%	21.2%
138.52	-67.7%	-58.8%	-50.0%	-41.2%	-32.3%	-23.5%	-14.7%	-5.8%	2.1%	8.5%	14.9%
148.52	-76.5%	-67.7%	-58.9%	-50.0%	-41.2%	-32.4%	-23.5%	-14.7%	-5.9%	2.1%	8.5%
158.52	-85.4%	-76.6%	-67.8%	-58.9%	-50.1%	-41.3%	-32.4%	-23.6%	-14.8%	-5.9%	2.1%
168.52	-94.3%	-85.5%	-76.6%	-67.8%	-59.0%	-50.1%	-41.3%	-32.5%	-23.6%	-14.8%	-6.0%

Table ES.11 - Sensitivity and Breakeven Analysis for a Dry Mill Corn Fractionation Plant

Feedstock and Ethanol Price Sensitivity
10-Year Average Annual Return on Investment
Ethanol Project - 7K Corn w/ Frac

9.381632 MMLY Plant

Corn ($/tonne)	Ethanol ($/tonne)										
	0.84	**0.94**	**1.04**	**1.14**	**1.24**	**1.34**	**1.44**	**1.54**	**1.64**	**1.74**	**1.84**
313.00	-2.6%	3.3%	9.0%	14.7%	20.4%	26.0%	31.7%	37.3%	43.0%	48.7%	54.3%
323.00	-4.5%	1.9%	7.6%	13.3%	19.0%	24.6%	30.3%	36.0%	41.6%	47.3%	53.0%
333.00	-6.4%	0.5%	6.2%	11.9%	17.6%	23.3%	28.9%	34.6%	40.3%	45.9%	51.6%
343.00	-8.4%	-0.9%	4.9%	10.5%	16.2%	21.9%	27.6%	33.2%	38.9%	44.5%	50.2%
353.00	-10.3%	-2.5%	3.5%	9.2%	14.9%	20.5%	26.2%	31.8%	37.5%	43.2%	48.8%
363.00	-12.3%	-4.3%	2.1%	7.8%	13.5%	19.1%	24.8%	30.5%	36.1%	41.8%	47.5%
373.00	-14.2%	-6.3%	0.7%	6.4%	12.1%	17.8%	23.4%	29.1%	34.8%	40.4%	46.1%
383.00	-16.2%	-8.2%	-0.8%	5.0%	10.7%	16.4%	22.1%	27.7%	33.4%	39.0%	44.7%
393.00	-18.1%	-10.2%	-2.4%	3.6%	9.3%	15.0%	20.7%	26.3%	32.0%	37.7%	43.3%
403.00	-20.1%	-12.1%	-4.2%	2.2%	7.9%	13.6%	19.3%	25.0%	30.6%	36.3%	42.0%
413.00	-22.0%	-14.1%	-6.2%	0.8%	6.6%	12.2%	17.9%	23.6%	29.3%	34.9%	40.6%
423.00	-24.0%	-16.0%	-8.1%	-0.6%	5.2%	10.9%	16.5%	22.2%	27.9%	33.5%	39.2%
433.00	-25.9%	-18.0%	-10.1%	-2.2%	3.8%	9.5%	15.2%	20.8%	26.5%	32.2%	37.8%
443.00	-27.9%	-19.9%	-12.0%	-4.1%	2.4%	8.1%	13.8%	19.5%	25.1%	30.8%	36.5%
453.00	-29.8%	-21.9%	-13.9%	-6.0%	1.0%	6.7%	12.4%	18.1%	23.8%	29.4%	35.1%
463.00	-31.8%	-23.8%	-15.9%	-8.0%	-0.5%	5.3%	11.0%	16.7%	22.4%	28.0%	33.7%
473.00	-33.7%	-25.8%	-17.8%	-9.9%	-2.1%	3.9%	9.6%	15.3%	21.0%	26.7%	32.3%

Key Technical Findings and Recommendations

Highlights of key technical findings and recommendations include the following:

- The preferred scenario for developing a new bio-ethanol industry in Armenia is promoting two processing of 7,000 tonnes per annum capacity each at separate locations in the near to mid term
- The most promising bio-ethanol feedstocks that can be produced in large quantities on surplus lands by 2014 include Jerusalem artichoke, feed corn, sweet sorghum, and possibly chicory
- The most appropriate conversion process for Jerusalem artichoke is inulin extraction and dry mill with fractionation for feed corn
- Recommended feedstocks and land requirements to produce 14,000 tonnes per annum of bio-ethanol by 2014 are:

Table ES.12 – Feedstock and Land Use to Produce 7,000 Tonnes of Ethanol per Annum

Metric	Jerusalem Artichoke	Feed Corn
Feedstock in Tonnes	97,000	21,000
Tonnes per Hectare	20	4
Hectares Needed	4,850	5,250
Unutilized Hectares Available	143,000	

Source: BBI International calculations

Suggested Policy Measures for Consideration by Government

Suggested government energy and transportation policy measures to stimulate bio-ethanol market development in Armenia include the following:

1) Develop an EU fuel standards program by 2009
2) Mandate a minimum fuel blending program at 5 percent by volume by 2014 coupled with an excise tax on imported bio-ethanol
3) Increase mandated blending requirement to 10 percent by volume by 2020
4) Classify denatured bio-ethanol as a motor transport fuel for tax purposes rather than as ethanol for use in alcoholic beverages which is subject to a 600 AMD per liter sin tax
5) Institute vigorous enforcement of fuel quality standards testing at fuel depots and retail outlets
6) Treat bio-ethanol as a renewable energy resource
7) Develop and implement a nation-wide public awareness program to introduce and promote the production and use of bio-ethanol

1.0 Background and Introduction

1.1 Summary of the Findings and Recommendations from Task I

A summary of the preliminary findings, recommendations, and conclusions from the month-long Phase 1 study effort completed on August 8, 2008 is presented below:

1. A government mandate specifying 5 percent blending of bio-ethanol with petrol for use as a motor transport fuel nationwide by 2014 and 10 percent blending by 2020 will be required to provide the overall incentive and necessary push for the establishment of a new bio-ethanol industry in Armenia.

2. Vigorous enforcement of fuel quality standards and frequent testing at fuel depot tanks and retail outlet pumps will be required to ensure program success.

3. The most promising bio-ethanol feedstocks that can be produced in large quantities on marginal lands in Armenia in the near to mid term include Jerusalem artichokes, cattle corn, sweet sorghum, and possibly chicory.

4. The most promising bio-ethanol feedstocks in the mid to longer term include grain straws and possibly fast growing hybrid trees such as poplar, willow, and mulberry.

5. The preferred scenario for developing a new bio-ethanol industry in Armenia today is promoting several (2 – 3) smaller bio-ethanol processing facilities in separate locations throughout the country based on the most appropriate conventional processing technology currently available for a given local feedstock for providing bio-ethanol fuels in the near to mid term, and at least two additional processing facilities to be located elsewhere based upon the most promising cellulosic conversion technology in the mid to longer term.

6. The findings of an extensive institutional, legal, and regulatory review point to a need for classifying and treating bio-ethanol as a renewable energy resource. Legislation may be necessary for a successful biofuels industry.

7. The findings and results of the preliminary sectoral environmental review indicate that the overall environmental impacts of a biofuel production and usage in Armenia would be considered positive including the reduction of greenhouse gas (GHG) emissions over time.

8. The prospect for creating a new and sustainable bio-ethanol fuel industry utilizing marginal lands and/or surplus lands not presently being tilled for the production of food is quite promising in Armenia in the near to mid term, especially in rural areas that are currently experiencing extremely high rates of unemployment and low economic growth rates.

1.2 Selection of a Preferred Bio-Ethanol Development Scenario

In addition, the following scenarios of a sustained bio-ethanol production program development in Armenia were considered and evaluated by project team during Phase I:

Scenario 1

- One large fermentation facility for Jerusalem artichokes, chicory, sweet sorghum, or late harvest feed corn in the near to mid term with a capacity of 14,000 tonnes of bio-ethanol per annum by 2014
- One or more cellulosic conversion plants in the mid to longer term with a total combined capacity of 35,000 tonnes of bio-ethanol per annum by 2020

Scenario 2

- Two to three smaller fermentation facilities for selected localized feedstocks in the near to mid term with a total combined capacity of 14,000 tonnes of bio-ethanol per annum by 2014
- One or more larger cellulosic conversion plants in the mid to longer term with a total combined capacity of 35,000 tonnes of bio-ethanol per annum by 2020

Scenario 3

- Forego fermentation processes, continue government-sponsored bio-ethanol research, and encourage the planting of hybrid tree plots in the near to mid term
- Focus on 2 or more large-scale cellulosic conversion plants in the mid to longer term with a total combined capacity of 49,000 tonnes of bio-ethanol per annum by 2020

Key Recommendations from the Task I Report

- Selection of Scenario 2 as the preferred strategy for moving forward with a nationwide bio-ethanol production program that has the added advantage of more widely distributing the positive economic benefits throughout the country particularly in rural areas with high unemployment rates.
- Enactment of a mandated bio-ethanol blending program for the nation specifying 5 percent blending of bio-ethanol with petrol for use as a motor transport fuel nationwide by 2014 and 10 percent blending by 2020 to provide the overall incentive and necessary push for the establishment of a new bio-ethanol industry in Armenia. Such a mandated program may also want to include either an outright ban on imported bio-ethanol for blending with petrol or else a tariff on imported bio-ethanol intended to meet such targets over time from domestic resources.
- Establishment of a rigorous enforcement program to ensure compliance with strict fuel quality standards along with frequent testing at fuel depot tanks and retail outlet pumps that will be required to guarantee program success and acceptance over time by the retail consumer.

- Continued Government research support and promotion among private farmers of the most promising bio-ethanol feedstocks that can be produced in large quantities on marginal and uncultivated tillable lands in Armenia in the near to mid term especially for such potential bio-ethanol feedstock crops as Jerusalem artichokes, late harvest feed corn, sweet sorghum, and possibly chicory.
- Continued research on celluosic conversion technologies for application in the mid to longer term especially for grain straws and fast growing hybrid trees.

1.3 Targeted Locations for the Initial Bio-Ethanol Production Program

Potential locations throughout the country where promising bio-ethanol feedstocks suitable for processing in fermentation plants can be grown in sufficient quantities are illustrated in Table 1.1 below with preferred locations highlighted in grey:

Table 1.1 – Most Suitable Locations for Growing Accepted Feedstocks for Fermentation Plants

Potential Location	Possible Bio-Ethanol Crops	Typical Climate Conditions	Soil Conditions	Elevation Range	Condition of Irrigation Network
Sisian and Goris	- Jerusalem Artichokes - Chicory - Feed Corn	- Cool to cold temperatures - Medium to short growing season - Good rainfall	- Brown & black - Good conditions especially near the Vorotan River	- 600 to 2100 meters above sea level	- Very old network
Yeghegnadzor	- Sweet Sorghum - Feed Corn	- Mild to cool temperatures - Medium growing season - Good rainfall	- Brown & black	- 1000 to 1500 meters above sea level	- Only in low lands
Vardenis	- Jerusalem Artichokes - Chicory	- Cold temperatures Short growing season - Good rainfall	- Brown & black - Very good for potatoes	- 1900 to 2300 meters above sea level	- Very old network
Yeghvard	- Sweet Sorghum - Feed Corn	- Cool to cold temperatures - Short to medium growing season	- Many saline soils - Very good for wheat	- 1300 to 1500 meters above sea level	- Many irrigated lands
Artik	- Jerusalem Artichokes	- Cool to cold temperatures - Short to medium growing season - Good rainfall	- Mostly brown soil	- 1600 to 1700 meters above sea level	- Many irrigated lands
Haghartsin near Ijevan	- Corn - Sweet Sorghum	- Mild temperatures - Long growing season - Good rainfall	- Post forest land - Very rich soil	- 400 to 1300 meters above sea level	- Very old network

Similarly, potential locations throughout the country where bio-ethanol feedstocks in sufficient quantities suitable for processing in celluosic conversion plants in the mid to long term *but for which plantings must be considered now in the case of hybrid trees* are shown in Table 1.2 below:

Table 1.2 –Most Suitable Locations for Growing Accepted Feedstocks for Celluosic Plants

Potential Location	Possible Bio-Ethanol Crops	Typical Climate Conditions	Soil Conditions	Elevation Range	Condition of Irrigation Network
Ararat Valley	- Grain Straws	- Mild temperatures - Two growing seasons for grains	- Mostly black soil, some brown soil areas	- 800 to 900 meters above sea level	- Very old network
Armash	- Hybrid Trees	- Mild temperatures	- Mostly brown soil, some saline areas	- 800 to 900 meters above sea level	- Very old network
Hrazdan	- Hybrid Trees	- Cold temperatures - Short growing season	- Mostly brown soil	- 1800 to 1900 meters above sea level	- Very old network

1.4 Recommended Bio-Ethanol Conversion Technologies

For accepted feedstock crops the following conversion technologies were evaluated as indicated in Table 1.3 below:

Table 1.3 – Matching Specific Feedstocks to the Most Appropriate Conversion Technology

Most Appropriate Technology	Applicable Bio-Ethanol Feedstock
Fermentation Processes	
Inulin Extraction	Jerusalem Artichokes, Chicory
Sugar Fermentation	Sweet Sorghum
Dry Mill Starch Extraction	Feed Corn
Dry Mill with Fractionation	Feed Corn
Cellulosic Conversion Processes	
Ligno-Cellulose Sugar Platform	Grain Straws, Hybrid Poplar, Mulberry Trees, Willow Trees
Thermochemical Platform	Grain Straws, Hybrid Poplar, Mulberry Trees, Willow Trees

The feasibility study team has selected inulin extraction for use in processing Jerusalem artichoke and dry mill with fractionation for feed corn.

2.0 Appraisal of Armenian Bio-Ethanol Feedstock Availability and Price

This section is intended to provide a detailed analysis of the most suitable bio-ethanol feedstocks that can be grown in Armenia in the near to mid-term to support the recommended bio-ethanol program.

2.1 Discussion of Suitable Bio-Ethanol Feedstocks for Armenia

The project team considered a list of 20 potential feedstock crops from which four crops (Jerusalem artichoke, chicory, sweet sorghum, and feed corn) were chosen for possible bio-ethanol production via an appropriate fermentation technology in the near to mid term and two crops (grain straw and fast growing hybrid trees) were chosen for bio-ethanol production by the most applicable celluosic conversion technology in the mid to longer term. After careful evaluation and analysis, the project team selected both Jerusalem artichoke and feed corn as the most suitable bio-ethanol feedstocks for Armenia in the near to mid-term. In this regard, each tonne of Jerusalem artichoke produces about 92 liters of ethanol. To produce the projected 7,000 tonnes of ethanol, 97,000 tonnes of tubers are needed. Similarly, to make 7,000 tonnes of ethanol from feed corn, 21,000 tonnes of corn are needed. Table 2.1 highlights feedstock, land requirements, and expected yields for both recommended bio-ethanol feedstock crops.

Table 2.1 – Feedstock and Land Use to Produce 7,000 Tonnes of Ethanol per Annum

Metric	Jerusalem Artichoke	Feed Corn
Feedstock in Tonnes	97,000	21,000
Tonnes per Hectare	20	4
Hectares Needed	4,850	5,250
Unutilized Hectares Available	143,000	

Source: BBI International calculations

The project team has reviewed the two feedstocks recommended above in detail. Neither crop is presently grown commercially on a large scale in the country. However, several small farms exist that are already growing feed corn (mostly in Ararat Marz and Tavush Marz), as well as a scattering of farms growing Jerusalem artichoke.

The Ministry of Agriculture is supporting a program of increasing feed corn production in Armenia to reduce the import of corn and to develop a local market for feeding livestock. The program has seen limited success. Where farmers use good techniques, the yields have been very good, but in many cases the yields have been far below what would have been expected. One complaint that the project team has heard during our many site visits was that no wholesale market currently exists for the corn. In this regard, farmers are on their own to find somebody to purchase their corn.

Several attempts have been made to commercially grow domestic species of Jerusalem artichokes, mostly for ethanol production. To date, none of those attempts have been successful. There are indications for production of foreign species of Jerusalem artichoke for inulin production facilities in Vanadzor.

The project team also reviewed the use of chicory in place of Jerusalem artichoke. However, additional studies are required to determine what species of chicory would grow best in the upper elevations of the agricultural lands available for use in a larger bio-ethanol program, and how the specifications of the crop will compare to Jerusalem artichoke.

As discussed above, Armenian production of the recommended feedstocks (Jerusalem artichoke and feed corn) is currently quite limited. Initial growing trials for Jerusalem artichoke have been conducted, and the plant grows wild in many areas of the country. The project team has substantiated that there is enough land currently available to produce the required 97,000 tonnes of tubers. However, it will likely take guaranteed off-take agreements between a dedicated bio-ethanol processing plant and the prospective Jerusalem artichoke growers to ramp up production to commercially sustainable levels. The financial analysis of the proposed project which is presented in detail later in this report indicates that a bio-ethanol plant designed to process Jerusalem artichoke could, under the best of circumstances, pay as much as 27 AMD per kg and still make a profit. Experience from other projects indicates that the introduction of new crops is extremely difficult, due to the prevalence of traditional farming methods. Another area of concern is that Jerusalem artichoke is an invasive species. Once established, the crop is difficult to eliminate, as tubers (and parts of tubers) remaining in the ground will regenerate without re-planting. However, recent documented experience in Armenia suggests that after cattle or hogs have grazed on Jerusalem artichoke shoots in the Spring, that after three prunings or grazings, the Jerusalem artichoke will die off naturally without chemical application.

What small amount of feed corn production that exists in Armenia today is intended primarily as livestock and poultry feed and has no direct value as a food crop such as sweet corn. Armenian users of feed corn such as poultry, cattle, and hog producers have resorted to importing corn for feed uses. Anecdotal evidence from one poultry producer suggests that the import price for corn is significantly above the global price for corn. Most likely, this premium is driven by the limited amount of imports coupled with high transportation costs. It is expected that local farmers will only produce and sell corn at prices similar to the prevailing import price. Otherwise, local supply would have increased to meet some or all of the local demand. The financial analysis which is presented in detail later in this report indicates that the proposed ethanol plant can pay as much as 147 AMD per kg of corn and still make a profit. The import price for corn in 2008 was 119 AMD per kg.

Unfortunately, very limited historical price information for corn is available, and none for Jerusalem artichoke. Due to the absence of significant local production, domestic corn pricing is determined by the global price of corn, plus transportation costs to Armenia. Global corn prices have sharply increased in past few years. Due to demand from various sources such as feed in India and China as well as for biofuels in the United States, it is anticipated that international corn prices will remain above their historic average levels for the foreseeable future.

2.2 Analysis of Sustained Production Potential for Preferred Feedstocks

Present agricultural practices prevalent throughout Armenia today will need to be improved and upgraded to sustain a nationwide bio-ethanol program and to achieve long-term success, even at the modest levels of 14, 000 tonnes of bio-ethanol per annum required to achieve 5 percent blending of bio-ethanol with petrol by 2014.

Improving Yields and Reducing Feedstock Production Costs

Current agricultural practices and methods of crop cultivation in Armenia are driven by many objective as well as subjective factors. These include but are not necessarily limited to the following aspects and factors:

- One of the greatest hurdles to improved productivity in this sector is psychological – farmers do not yet appreciate nor consider that additional expenses can lead to greater additional profits.
- In addition, there is a major lack of trust by farmers in business partnerships where they must be dependent upon another person or corporate entity to make a profit based upon several previous bad experiences by farmers regarding their signed contracts. As but one example, the project team heard numerous complaints regarding the interpretation of the contract between farmers and Grand Tobacco which specified that a farmer would deliver an agreed upon quantity to specific location. Even though farmers delivered the required quantity of tobacco stated in their contracts, the tobacco company refused to pay the full contracted price because of questions over the quality of tobacco delivered thereby precipitating extreme mistrust among many farmers, which remains unresolved to this day.
- The high price and sometimes even lack of fertilizers, chemicals, technical information, better quality seeds and plants, and reliable irrigation water oftentimes leave farmers no choice but to rely upon traditional methods of cultivation or totally go out of business.
- Moreover, the fragmentation of agricultural lands into smaller, non-economical plots does not lend itself to greater mechanization for planting and application of fertilizers.
- Finally, the lack of knowledge and experience are the biggest barriers for agricultural development.

If such hurdles and limiting factors can be systematically addressed over time, it is entirely feasible to improve feed corn yields up to 7 tonnes/hectare, and Jerusalem artichoke yields to 40-45 tonnes/hectare. In particular, the wider spread usage and application of organic and mineral-based fertilizers has the potential to almost single-handedly improve feedstock crop yields to these levels. This is especially true for lands situated in alpine and sub alpine zones where crop fertilization has not been employed since 1991. Moreover, farmers could achieve further improvements in yields simply by rotating crops every few years or so.

Technical Requirements for Improved Jerusalem Artichoke Cultivation

To better understand how Armenian farmers can go about improving yields and reducing overall feedstock costs to more competitive levels for Jerusalem artichoke, the project team has developed the follwing technical requirements and specifications for the cultivation of Jerusalem artichoke as indicated in Table 2.2 below:

Table 2.2 - Technical Requirements and Specifications for the Cultivation of Jerusalem Artichoke

No.	Activity	Application Dates		Recommended Agro-Technical Requirements and Specifications	Estimated Cost (in AMD)	
		From	To		Best Practice	Current Practice
The Year of Field Establishment						
1	Fertilization with manure and mineral fertilizers	10.10	20.10	30-40 t/ha of manure or $P_{90}K_{60}$ (deep tillage)	100,000+ 12,000+ 12,000+ 25,000	-
2	Deep tillage (winter tillage)	20.10	25.10	30 cm depth	45,000	45,000
3	Cultivation and harrowing	25.03	30.04	12-15 cm depth	25,000	25,000
4	Preparation of furrows	15.04	17.04	Width of hillock` 80 cm, Width of furrows` 20 cm, depth` 15-20 cm	30,000	-
5	Planting of tubers	20.04	30.04	Distance between plants` 40 cm, by two sides of hillocks with staggered order	40,000	40,000
6	Irrigation	20.04	30.04	300 m^3 / ha irrigation norm	7,000	7,000
7	Weeding and digging	13.05	15.05	Distance between plants and hillocks	20,000	-
8	Periodical irrigation	if necessary		5-10 times 300m^3/ha irrigation norm	35,000 50,000	
9	Weeding and digging along with deep hilling and feeding	03.06	05.06	15 cm depth by N30 kg normalization deepening of furrows and hilling by 10 cm	35,000	-
10	Harvesting of tops	05.10	15.10	Stems removal	20,000	20,000
Total					**456,000**	**137,000**
Following Years						
1	Refreshing of furrows	15.03	20.03	Cleaning of water furrows	20,000	20,000
2	Weeding – digging and feeding	25.05	15.08	2 times distance between plants and hillocks by total norm of N30P60K40 kg	80,000	-
3	Periodical irrigation	if necessary		8-10 times 300m^3/ha irrigation norm	85,000	85,000
4	Harvesting of tops	20.10	25.10	Mow and remove the top grown during vegetation (50 t/ha of green mass)	25,000 20,000	25,000 20,000
5	Tubers harvesting	Before snow		Harvesting with potato harvesting machines, collecting and transport loading (25-30 t/ha)	70,000	70,000
6	Refreshing of furrows, with replanting of smaller tubers	Just after harvesting or at same time		After sorting the left tubers or its pieces are to put to furrows and to cover with soil	25,000	25,000
Total					**325,000**	**245,000**

1) To obtain estimated costs for Jerusalem artichoke per ha utilizing best practices, the project team divided the estimated costs from the first year by 10 and then added the annual estimated harvest cost (i.e. - (456,000/10) +325,000=370,600 AMD per ha)
2) Therefore, the approximate cost of 1 kg of Jerusalem artichoke utilizing best practices is 370 600/40 000= 9.265 AMD per kg
3) Estimated cost of production with current practices is (137,000/10)+245,000=258,700 AMD per ha
4) Therefore, the approximate cost of 1 kg of Jerusalem artichoke with current practices is 258,700/25,000=10.3 AMD per kg

Technical Requirements for Improved Feed Corn Cultivation

Similarly, to better understand how Armenian farmers can also go about improving yields and reducing overall feedstock costs to more competitive levels for feed corn, the project team has developed the follwing technical requirements and specifications for the cultivation of feed corn as indicated in Table 2.3 below:

Table 2.3 - Technical Requirements and Specifications for the Cultivation of Feed Corn

No.	Activity	Application Dates		Recommended Agro-Technical Requirements and Specifications	Estimated Cost (in AMD)	
		From	To		Best Practice	Current Practice
1	Fertilization with manure and mineral fertilizers	15.10	20.10	30 t/ha of manure or $P_{90}K_{60}$ (deep tillage)	100,000+ 12,000+ 12,000+ 25,000	-
2	Deep tillage (winter tillage)	20.10	25.10	25-30 cm depth	45,000	45,000
3	Cultivation and harrowing	25.03	30.03	12-15 cm depth	25,000	25,000
4	Sowing and harrowing	20.04	30.04	Wide rows with 60-70X25-30 cm sowing scheme The sowing norm is 25kg/ha Depth 8-10cm	15,000+ 25,000	25,000
5	Periodical irrigation	if necessary		3-8 times 550-850 m^3/ha irrigation norm	35,000+ 50,000	35,000
6	Cultivation and feeding of soil between rows			2-3 times 12-14 cm depth 7-8 cm depth 5-6 cm depth Feed with N60 norm	(12,000+ 20,000) x 2-3 times	32,000
7	Chemical weeding	Before plants have 20-25 cm height, when they have 4-8 leaves		Dialen-super (1-1.5 l/ha), 350-400 l/ha of solution	30,000	30,000
8	Artificial pollination	During blossoming		2-3 times with rope	15,000	
9	Harvesting of ears	20.07	20.08	At the period of complete ripenin 140,000 ears/ha	40,000	
10	Extraction of grain and storage	10.10	25.10	At after harvesting period 4-6 t/ha	90,000	90,000
11	Total transportation cost				40,000	40,000
Total					**670,000**	**357,000**

1) The approximate cost of 1 kg of feed corn utilizing best practices is 670,000/7,000=95.71 AMD per kg
2) The approximate cost of 1 kg of feed corn with current practices is 357 000/4 000 =89.25 AMD per kg

2.3 Assessment of Land Suitability and Overall Availability in Targeted Marzes

As discussed in Section 2.1 above, approximately 4,850 hectares of land will be required for Jerusalem artichoke and 5,250 hectares for feed corn to provide sufficient feedstock for the production of 14,000 tonnes of bio-ethanol per annum by 2014.

The project team conducted a number of site visits to two widely separated areas of the country. These included several regions within Tavush Marz in the north for production of feed corn and the northern portions of Syunik Marz in the south for the production of Jerusalem artichoke. Both areas have ample surplus arable land that is currently not under cultivation. Moreover, unemployment is extremely high in the agricultural sectors of both regions.

The plant sites that were ultimately recommended by the project team were chosen to take advantage of available land in the area. To reduce transportation costs for the feedstock, bio-ethanol plants should typically be located in the center of the production area. In this regard, it is usually cheaper and more cost-effective to transport a liter of bio-ethanol than the feedstock required to produce it. There is sufficient land available in the immediate vicinity of both proposed sites to meet the feedstock demand.

Much of the existing crop production is of low quality at premium prices. Farmers are seeking out viable commercial crops and related markets that can increase their current poverty level standard of living. Current use of irrigation, fertilizer, pesticides, and mechanized farm equipment is very limited throughout both regions.

Estimate of Maximum Potential of Suitable Land for Both Feedstocks

The Agricultural Center of Goris has stated that there was 16,834.1 hectares of land that is immediately available for expanded agricultural production in the vicinity of Sisian and Goris. Given an expected yield of 40 tonnes per hectare, approximately 2,187.5 hectares of land would be required for growing Jerusalem artichoke in sufficient quantity to supply a 7,000 tonnes per annum processing plant. This would still leave 88% of the available land for food crop production in the future.

Similarly, the Agricultural Center of Ijevan stated that there was 10,367.4 hectares of unused agricultural land presently available in Tavush Marz. Given an expected yield of 4 tonnes per hectare 3,333 hectares of land would be needed for growing corn in sufficient quantity to supply a 7,000 tonnes per annum processing plant. This would still leave 68% of the available land for future food crop production.

A more detailed assessment of current land availability is presented in the following sections for both Jerusalem artichoke in Syunik Marz and feed corn in Tavush Marz.

Determining Land Availability for Jerusalem Artichoke in Syunik Marz

The initial identification of land found suitable for the growing of Jerusalem artichoke was based upon the following selection criteria and factors: elevation, microclimate, soil type, land erosion, and slope of the land. The lands ultimately selected for the possible production of Jerusalem artichoke in the vicinity of Sisian and Goris were screened by the project team's local agricultural experts including Dr. Andreas Melikyan (plant growing), Dr. Albert Yezekyan (soil science), Professor Rianos Mkrtchyan (climatology) utilizing all five of these selection criteria.

The project team next evaluated those lands found to be suitable in the vicinity of Sisian and Goris based upon the following assumptions:

- Processing plant capacity was determined to be 7,000 metric tonnes of bio-ethanol per annum
- Only local varieties of Jerusalem artichoke would be planted
- Jerusalem artichoke yields were estimated at 40 tonnes/hectare with proper cultivation
- Harvesting would begin in the 1st week of November and finish by the 2nd week of November
- 26.2 % of the Jerusalem artichoke would come from farms within 10 km of the site
- 37.2 % of the Jerusalem artichoke would come from 10-20 km of the site
- 36.5 % of the Jerusalem artichoke would come from greater than 20 km from the site
- Harvesting costs were assumed to be 15 AMD per kg in 2008

Moreover, it was also assumed that the local farmers and not agri-business concerns would be responsible for growing Jerusalem artichoke, that at least for the present the Jerusalem artichoke crop would be harvested by hand picking in the field, and that the tubers would be placed into 100 kg bags with the green mass stacked and baled separately.

While the planned Jerusalem artichoke processing plant will only be capable of processing approximately 87,500 metric tonnes of Jerusalem artichokes per year based upon the estimated yields assumed above, production and contracting targets should be set 10% higher (at 96,250 metric tonnes) to provide a margin of safety for plant operation. As such, all of the following production calculations are based on producing and collecting 96,250 tonnes per year. However, since only 87,500 metric tonnes of Jerusalem artichoke per year will be actually delivered to the processing plant in any given year, the cost model will be based on 87,500 metric tonnes. A study of available land for Jerusalem artichoke growing prepared by the project team's agricultural and land experts shows there is the capability to produce 281,299 metric tonnes of Jerusalem artichoke within 50 km of the plant.

Characteristics and Availability of Land for Jerusalem Artichoke

The following map depicted in Figure 2.1 below illustrates the major communities in Syunik Marz, while Tables 2.4 and 2.5 show the amount of suitable and available land by community for growing Jerusalem artichoke within the Goris and Sisian regions respectively.

Figure 2.1 - Map of Major Communities in Syunik Marz

Table 2.4 – Characteristics and Availability of Land in the Goris Region of Syunik Marz

No.	Community	Tillable Land (in ha)		Maximal Potential Suitable Land for Growing JA (in ha)	Land Availability by Elevation Above Sea Level (in ha)	
		Total	Irrigated		1,000-1,500m	1,500-2,000m
1	Aravus	229.7		100	-	229.7
2	Bardzravan	292.2		50	-	292.2
3	Brun	205.1		90	-	205.1
4	Goris town	1373		300	1,373	-
5	Khndzoresk	1,795.1		350	1,100	695.1
6	Khoznavar	298.1		150	-	298.1
7	Khot	572.5		180	572.5	-
8	Khnatsakh	976.2		210	-	976.2
9	Kornidzor	1,232.3		150	1,232.3	-
10	Halidzor	530.6		200	-	530.6
11	Harzhis	987.1		210	-	987.1
12	Hartashen	883.6		200	-	883.6
13	Nerkin Kndzoresk	476.0		120	476	-
14	Shinuhayr	1,565.2		310	1,565.2	-
15	Shurnukh	186.2		150	186.2	-
16	Vorotan (Goris)	6.0			6	-
17	Avarants	231.6		120	-	231.6
18	Verishen	198.5		120	198.5	-
19	Vaghatur	413.3		150	-	413.3
20	Tatev	500.3		200	300.3	200
21	Tandzatap	65.5		20	65.5	-
22	Tegh	2,421.5		350	2,421.5	-
23	Tandzaver	112.4		80	112.4	-
24	Karahunj	703.1		180	-	703.1
25	Karashen	497.8		200	297.8	200
26	Kashuni	81.2		40	81.2	
	Total	**16,834.1**		**3,160**		

NOTE: Where colored communities are in the area or not far from the potential plant site

Table 2.5 – Characteristics and Availability of Land in the Sisian Region of Syunik Marz

No.	No. on Map	Community	Tillable Land (in ha)		Maximal Potential Suitable Land for Growing JA (in ha)	Land Availability by Elevation Above Sea Level (in ha))	
			Total	Irrigated		1,000-1,500m	1,500-2,000m
1		Arevis	133.0	10	5		133.00
2	14	Akhlatyan	779.3	39	25		779.30
3	3	Aghitu	757.0	23	250		757.00
4	5	Angeghakot	1,569.4	500	350		1,569.40
5	8	Ashotavan	418.4	18	180		418.40
6	10	Bnunis	467.7	28	200		467.70
7	17	Brnakot	1,973.8	637	150		1,973.8
8	18	Balak	584.0	34	180		584.00
9	15	Gorayk	1,636.7	60	300		1,636.70
10	22	Getatagh	161,1	50	120		161.10
11	21	Dastakertk	6.0			6	
12		Darbas	593.0	212	200		593.00
13	25	Tasik	431.5	103	120		431.50
14	29	Tanahat	83.0	10	30		83.00
15	28	Ishkhanasar	670.0	28	180		670.00
16	30	Ltsen	283.0	15	110		283.00
17	34	Lor	159.0	35	50		159.00
18	35	Tsghuk	884.5	53	180		884.50
19	42	Hatsavan	361.6	123	150		361.60
20	50	Mutsk	893.4	80	200		893.40
21	53	Noravan	1,013.6	75	250		1,013.60
22	60	Shenatagh	166.3	32	50		166.30
23	64	Shaghat	1,023.1	70	250		1,023.10
24	62	Shaqi	1,679.3	130	250		1,679.30
25	63	Vorotan	381.7	39	120	100	281.70
26	71	Sisian town	1,306.0	1,000	250		1,306.00
27	Z	Salvard	600.6	41	180		600.60
28	73	Sarnakunk	1,063.2	60	210		1,063.20
29	74	Spandaryan	797.6	51	200		797.60
30	76	Soflu	446.0	21	180		446.00
31		Vaghatin	870.5	50	200		870.50
32	81	Tolors	542.5	32	180		542.50
33	94	Torunik	224.0	30	120	100	124.00
34	95	Uyts	1,213.7	449	210		1,213.70
Total			**24,173.5**	**5,630**	**3,870**		

Determining Land Availability for Feed Corn in Tavush Marz

The initial identification of land found suitable for the growing of feed corn was based upon the following selection criteria and factors: elevation, microclimate, soil type, land erosion, and slope of the land. The lands ultimately selected for the possible production of feed corn in the vicinity of Haghartsin near Ijevan were screened by the project team's local agricultural experts including Dr. Andreas Melikyan (plant growing), Dr. Albert Yezekyan (soil science), Professor Rianos Mkrtchyan (climatology) utilizing all five of these selection criteria.

The project team next evaluated those lands found to be suitable in the vicinity of Haghartsin based upon the following assumptions:

- Processing plant capacity was determined to be 7,000 tonnes of bio-ethanol per annum
- Various varieties feed corn seed will be utilized as provided by the Ministry of Agriculture
- Feed corn yields were estimated at 7 tonnes/hectare with proper cultivation
- Harvesting would begin in the 1st week of September and finish by the 1st week of October
- 5 % of feed corn would come from farms within 10 kilometers of the site
- 2 % of the feed corn would come from 10-20 kilometers of the site
- 93 % of the feed corn would come from greater than 20 kilometers from the site
- Harvesting costs were assumed to be 15 AMD per kg in 2008

Moreover, it was also assumed that the local farmers and not agri-business concerns would be responsible for planting and growing feed corn, that at least for the present the feed corn crop would be picked in the field and shucked into 100 kg bags in the vicinity of the farmers' fields, and that the feed corn would then be stored in humidity-controlled storage containers or buildings for use throughout the season. In some cases, the farmers can store the feed corn themselves until it is needed at the plant. In this case, the plant owner would be expected to pay for corn and storage services to the farmers.

While the dry mill with corn fractionation plant will process about 23,000 metric tonnes of feed corn per year, production and contracting targets will be 10% higher (or about 25,600 tonnes) to provide a margin of safety for plant operation. As such, all of the following production calculations are based on producing and collecting 25,600 tonnes per year. However, since only 23,300 tonnes per year will be delivered to the processing plant, the financial model forecasts will be based on 23,000 tonnes per annum of delivered feed corn. A study of available land for corn growing prepared by the project teams local agricultural experts shows there is the capability to produce all 23,000 tonnes per year within 50 km of the plant.

Characteristics and Availability of Land for Feed Corn

The following map depicted in Figure 2. 2 below illustrates the major communities in Tavush Marz, while Tables 2.6, 2.7, and 2.8 show the amount of suitable and available land by community for growing feed corn within the Ijevan, Noyemberyan, and Tavush regions respectively.

Figure 2.2 - Map of Major Communities in Tavush Marz

Table 2.6 – Characteristics and Availability of Land in the Ijevan Region of Tavush Marz

No.	No. on Map	Community	Tillable Land (in ha)		Maximal Potential Suitable Land for Growing Feed Corn (in ha)	Land Availability by Elevation Above Sea Level (in ha)	
			Total	Irrigated		800-1,000m	1,000-1,500m
1	1	Azatamut	26.2		10	26.20	-
2	2	Aknaghbyur	231.7		231.7	-	231.7
3	3	Agavnavank	225.3		125	-	225.3
4	4	Acharkut	9.1		0	9.10	-
5	5	Aygehovit	1,084		500	1,084.00	-
6	8	Achudjur	995.3		450	80,00	915.3
7	15	Berkaber	153.7		100	153.70	-
8	16	Gandzakar	826.5		300	-	826.5
9	17	Getahovit	357.3		200	-	357.3
10	18	Gosh	253.4		150	-	253.4
11	G	Dilijan town					
12	21	Ditavan	200.8		150	-	200.8
13	23	Enokavan	246.2		120	-	246.2
14	25	Teghut	156.7		100	156.70	-
15	A	Ijevan town	810		250	-	810
16	28	Lusahovit	114.8		110	-	114.8
17	29	Lusadzor	201.5		150	201.50	-
18	30	Khashtarak	594		300	594.00	-
19	31	Khachardzan	245.1		120	-	245.1
20	32/33	Tsakhkavan	312.1		100	-	312.1
21	34	Kirants	230.3		60	230.30	-
22	37	Hakhardzin	439.9		150	-	439.9
23	39	Hovk	243.3		120	-	243.3
24	52	Sari gyugh	465.7		150		465.7
25	53	Sevkar	1,111.1		200	1,111.10	
26	54	Vazashen	833.4		150		833.4
Total			**1,0367.4**		**4,296.7**		

Table 2.7 – Characteristics and Availability of Land in the Noyemberyan Region of Tavush Marz

No.	No. on Map	Community	Tillable Land (in ha)		Maximal Potential Suitable Land for Growing Feed Corn (in ha)	Land Availability by Elevation Above Sea Level (in ha)	
			Total	Irrigated		800-1,000m	1,000-1,500m
1		Ayrum					
2	10	Archis	431.7		200.00		431.70
3	11	Bagratashen	1266.5		400.00	1,266.50	
4	12	Baghanis	302.8		120.00	302.8	
5	13	Barekamavan	379.3		250.00	379.30	
6	14	Berdavan	1,336		450.00	1,336.00	
7	27	Lchkadzor	186		120.00		186.00
8	19	Debedavan	330.4		150.00	330.40	
9	20	Deghtsavan	198.5		120.00	198.50	
10	22	Dovegh	309.1		180.00		309.10
11	35	Koti	1,858		350.00	1,858.00	
12	36	Koghb	1,298.3		400.00	1,000.00	298.30
13	38	Hakhtanak	744.9		200.00	300.00	444.90
14	39	Noyemberyan Town	1,051		350.00		1,051.00
15	44	Voskepar	473.9		180.00	200.00	273.90
16	45	Voskevan	449.9		210.00	100.00	349.90
17	50	Ptghavan	320		180.00	320.00	
18	51	Jujevan	154.3		154.30	100.00	54.30
19	24	Zorakan	779.3		210.00	779.30	
Total			**11,869.9**		**4,224.30**		

Table 2.8 – Characteristics and Availability of Land in the Tavush Region of Tavush Marz

No.	No. on Map	Community	Tillable Land (in ha)		Maximal Potential Suitable Land for Growing Feed Corn (in ha)	Land Availability by Elevation Above Sea Level (in ha)	
			Total	Irrigated		800-1,000m	1,000-1,500m
1	6	Aygedzor	565.8		250	565.8	
2	7	Aygepar	9.2		9.2	9.2	
3	9	Artsvaberd	1,061		250	200	861
4	B	Berd, town	751		350		751
5	55	Varagavan	290.3		200		290.3
6		Tovuz	722.4		350	300	422.4
7	26	Itsakar	51.7		50		51.7
8	32	Tsaghkavan	410.9		150		410.9
9	40	Movses	774.0		300		774
10	41	Navur	415.4		150		415.4
11	42	Nerkin Karmir	809.6		250	809.6	
12	43	Norashen	609.0		300		609
13	46	Chinari	433.6		210	333.6	100
14	47	Chinchin	463.3		300		463.3
15	48	Choratan	640.8		200	200	440.8
16	49	Paravakar	527.8		250	327.8	200
17	56	Verin Karmir	619.0		240		619
Total			**9,154.8**		**3,809.2**		

2.4 Conclusions on Recommended Feedstock Supplies and Suggested Pricing

General Comments on Land Availability

The two feedstocks examined were Jerusalem artichoke for Syunik Marz and feed corn in the Tavush Marz. Working with the Agricultural Centers in each region, the project team calculated that there is sufficient land for both feedstocks. Even with the production of the feedstock for bio-ethanol in these two regions, there will be plenty of available land for other crops should they become economical in the future.

Jerusalem Artichoke Production

Jerusalem artichoke is not currently used in commercial quantities or applications in Armenia today. There is evidence to suggest the climate and soil conditions are suitable throughout the northern part of Syunik Marz for Jerusalem artichoke. The fact that the plant is growing wildly in many regions of Armenia suggests that it is well adapted to the local conditions. However, there are risks associated with introducing a new crop to an area. Large-scale field trials have not yet been conducted therefore commercial production yields are not assured. Further research is also necessary to identify the best techniques for commercial production, cultivation, and harvesting. Fertilizer, pesticide and water requirements must also be determined through larger-scale pilot plantings. Moreover, due to the persistence of tubers in the ground, the plant is perceived by many as invasive, which may be a deterrent for farmers considering adoption of this new crop. On the other hand, Jerusalem artichoke has great potential for serving as a dedicated energy crop for feedstock supply to a bio-ethanol plant as there are few other uses and markets for this particular crop. Long-term delivery contracts and/or partial pre-payment by the bio-ethanol plant will likely be required to provide enough incentives for growers to take on the risk of growing a new crop with a single market off-taker.

If yields are around 40 to 45 tonnes per hectare, pricing for Jerusalem artichoke is expected to be approximately $50 per tonne (15 ADM per kilogram) as farmers move towards more modern production practices. Due to the lack of existing pricing information for this particular feedstock, the financial model was set to achieve a minimum unleveraged Return on Investment (ROI) of 15% that indicates that the processing plant can pay up to $88 per tonne for Jerusalem artichoke and still achieve a 15% ROI. Any amount below this $88 per tonne ceiling will improve the overall financial performance of the plant.

Feed Corn Production

Any feed corn produced commercially in Armenia for future use in a bio-ethanol facility could find alternative use as directly supplied animal feed for cattle, hogs, and poultry—particularly if there is a reluctance to use co-products from the dry mill fractionation plant as a substitute animal feed. In this regard, it is expected that over time the price for local feed corn could approach the imported price of corn since imports are the only alternative to domestically grown corn for animal feed.

The 2008 price for imported feed corn into Armenia was approximately $400 per tonne (120-140 ADM/kg). The project team's analysis indicates that while higher yield seeds are now being sown by local farmers, that the upward pressure on corn production costs especially from the higher cost of, fertilizers weed suppressants, and diesel fuel for tractors is offsetting enhanced revenues from higher crop yields. However, since imported corn can be obtained at 135 AMD/kg, farmers will have to beat this price if they hope to enter into long-term contracts with a bio-ethanol processing plant. In any event, due to the lack of historical corn pricing in Armenia, the financial model was set up to achieve a minimum ROI of 15% indicating that the plant can pay no more than $393 per tonne for feed corn from local farmers to remain attractive to potential investors.

3.0 Evaluation of Bio-Ethanol Market Trends and Usage Worldwide

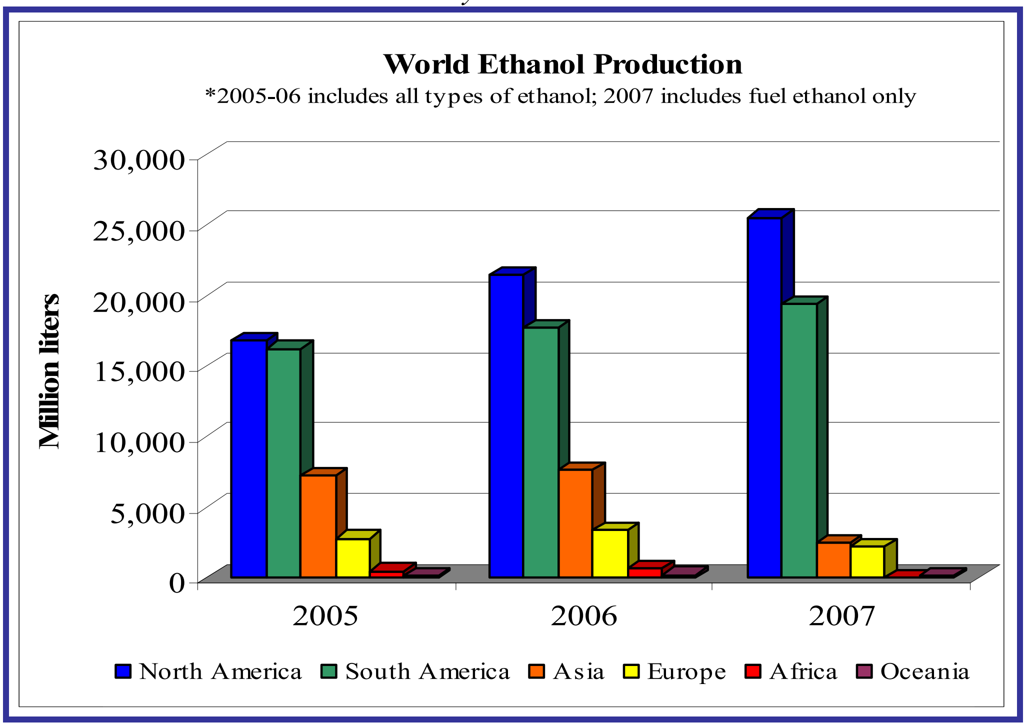
World ethanol markets are comprised of three distinct segments: fuel, industrial, and beverage (in order of production and use). At present, world economics, as well as environmental and oil dependency concerns, are providing enormous opportunities for world fuel ethanol growth while population growth will offer modest growth opportunities for the much smaller industrial and beverage segments. Worldwide fuel ethanol production reached approximately 13.1 billion gallons in 2007.

Of the world's total ethanol production, approximately 75% is now fuel ethanol. Even though the bulk of the world's fuel ethanol production still comes from Brazil and the U.S., there are significant developments in other countries as well. Some of these could result in the establishment of new production centers in addition to the traditional ones in the western hemisphere.

3.1 International Market Leaders

Brazil was traditionally had long been the world's number one fuel alcohol producer, making 11 to 19 billion liters of anhydrous alcohol each year. The United States surpassed Brazilian production in 2006 through a combination of policy changes and low corn prices making bio-ethanol production a profitable venture. A major driver from increased bio-ethanol production in the U.S. was due to the replacement of the commonly used oxygenate MTBE. MTBE was contaminating water supplies and many states banned the use leaving ethanol as the only viable alternative. Figure 3.1 shows fuel ethanol production worldwide by geographic region.

Figure 3.1 – Worldwide Ethanol Production by Continent



Source: Renewable Fuels Association

North and South America are the world's leading bio-ethanol production regions, with no indication of change in the near future. Total production in the Americas in 2007 reached nearly 45 billion liters, or about 90% of the world bio-ethanol output. Total U.S. ethanol production in 2007 was 20 billion liters.

Europe produced over 1.7 billion gallons of bio-ethanol in 2007, up from 1.5 billion liters in 2006. Currently the standard for 5.75% blending of biofuels in the EU is a directive rather than a requirement; however, the EU is considering legislation for a 10% mandated requirement by 2020.

Sizeable new production centers are emerging in Thailand, where production was 352 million liters of bio-ethanol in 2007, as well as China where recently completed projects have raised bio-ethanol production capacity to over 3.7 billion liters. China; however, has put a moratorium on new corn bio-ethanol plants and any new plants will be cassava or cellulosic.

India currently requires 5% bio-ethanol blends in most regions of the country, and the government is considering extending the bio-ethanol blend mandate countrywide. In Latin America, new bio-ethanol production initiatives are in place in many countries, particularly Argentina. Even Brazil – where the original bio-ethanol distilleries use molasses and sugar cane – is seeing production growth.

3.2 Alternative Uses of Bio-Ethanol Worldwide

Clean Octane

Octane is a measurement of petrol's auto-ignition resistance. The octane number gives the percentage by volume of iso-octane in a mixture of iso-octane and n-heptane that has the same anti-knocking characteristics as the fuel under consideration. For example, petrol with a 90 octane rating has the same ignition characteristics as a mixture of 90% iso-octane and 10% heptane.

Table 3.1 shows the octane rating of several compounds in pure form. Frequently referred to as "Dirty Octane," Benzene, Toluene, and Xylene, have toxic human and environmental effects; in many cases, they have been strictly limited in the amount allowed in fuels.

Table 3.1 – Octane Ratings of Various Compounds

Compound	Octane Rating
n-heptane	0
iso-octane	100
Benzene	101
Methanol	113
Toluene	114
Ethanol	116
Xylene	117

This leaves bio-ethanol as the highest-octane compound that does not have negative human or environmental effects. It is a great source for “Clean Octane” and this provides another incentive for its use in transportation fuels.

<u>Petrol Extender</u>

There is some potential for bio-ethanol, or any fuel-blending agent, to extend the supply of transportation fuels.

3.3 Estimated Impact of a Bio-Ethanol Plant on Local Rural Development

A bio-ethanol plant can re-invigorate a rural community. While a 7,000 tonnes per annum dry mill fractionation facility creates only about 13 new direct jobs in the plant, several hundred jobs will be created during the plant construction phase. In addition, there will be a significant secondary and derived employment ripple effect throughout the entire regional economy encompassing such diverse jobs as truck drivers, mechanics, welders, and repairmen to name but a few, some of them being skilled positions requiring special training or education. Moreover, rural communities have been repeatedly revived economically due to the existence of such a new core industrial anchor in a rural community. Finally, a new bio-ethanol plant supports literally hundreds of direct farm workers within a fifty-kilometer radius of the plant.

4.0 Potential Fuel Market for Bio-Ethanol in Armenia

Bio-ethanol will serve two purposes in the fuel market in Armenia: (1) to extend the supply of petrol; and (2) to increase the octane value of the blended fuel. Armenia uses about 172,000 tonnes of petrol per year. Assuming that all of the petrol sold can be converted to E-5 (95% petrol, 5% bio-ethanol), the potential bio-ethanol market is approximately 8,500 tonnes in 2008. Estimated demand for bio-ethanol at 5% blending by the end of 2014 is projected by the project team to be around 14,000 tonnes per annum as derived in the following section below.

4.1 Potential Market Size for Bio-Ethanol Products in Armenia Through 2020

Some recently manufactured automobiles from Western Europe, Japan, and the United States are built to operate with E85 petrol. Any old vehicle normally can operate with E5 petrol and most vehicles are capable of operating at E10. The age of vehicles is decreasing in Armenia as newer cars are purchased allowing for a larger market base for bio-ethanol. At this point, only E5 is reasonable. As the retirement of the 10 plus year old cars occurs, the majority of cars will be able to use E10.

As was pointed out in the Task 1 report, the estimated level of bio-ethanol assuming E5 blending of all petrol in Armenia by 2014 will be 13,900 tonnes per annum. Assuming that by 2020 nearly all the country's cars will be able to use E10 petrol mix, the total estimated level of bio-ethanol will be approximately 49,100 tonnes per annum as indicated in Table 4.1 below:

Table 4.1 – Forecast of Bio-Ethanol Production Required to Achieve Selected Blending Levels Assuming a 10% Growth in Demand for Petrol (in Thousands of Tonnes per Annum)

Indicator	Year											
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
5% Level of Blending (E5 Fuel)												
Petrol	172	189	208	229	252	277	305	335	369	406	446	491
Bio-Ethanol	8.6	9.5	10.4	11.4	12.6	13.9	15.2	16.8	18.4	20.3	22.3	24.5
10% Level of Blending (E10 Fuel)												
Petrol	172	189	208	229	252	277	305	335	369	406	446	491
Bio-Ethanol	17.2	18.9	20.8	22.9	25.2	27.7	30.5	33.5	36.9	40.6	44.6	49.1

Critical Note**:** If the imported petrol is not of a high quality or contains moisture, there will be performance and maintenance problems with automobiles that are operated with E5 or E10 fuels and the program will be a failure.

4.2 Market Characteristics

Bio-Ethanol Pricing

Agricultural production of the proposed feedstocks in Armenia is currently extremely limited, resulting in comparatively high expected production costs. However, the relatively high level of petrol prices in the country help offset the high feedstock prices to a certain degree. The historic retail price of petrol in Armenia over the past five years is illustrated in Table 4.2 below:

Table 4.2 - Retail Price of Petrol (2003 – 2007)

Pricing Indicator	Year				
	2003	2004	2005	2006	2007
Retail Price (ADM/Liter)	282	311	333	361	328

Source: Website, National Statistical Service

As of July 1, 2008, the average price of petrol was well above 400 ADM/liter. An estimated price for petrol of 410 ADM/liter for 2008 was used for this study. An import tax of 112,000 ADM/tonne of petrol or about 120 ADM/liter has been in effect since May of 2008.

The financial analysis assumes a sales price for bio-ethanol of 410 AMDs per liter ($1.34/liter) at plant start up. This amount is higher than the historical average, but it is expected that oil and petrol prices will remain at the higher level of the recent past. While bio-ethanol contains about 30% less energy per liter than petrol, bio-ethanol has a higher octane number that enhances its value as a blend component for higher priced midlevel and premium petrol. The bio-ethanol price used in the analysis assumes that domestically produced bio-ethanol will not be subject to the 120 AMD per liter import tax on imported petrol. The price the plant receives for bio-ethanol is the single most important metric in determining financial viability of the proposed plants. Sensitivity analysis showing the impacts of bio-ethanol pricing is available in the financial section of this report.

Blending Logistics

The most efficient way of introducing bio-ethanol into the fuel supply is to blend the fuels at the fuel depots for petrol. All of the petrol used in Armenia is imported today, and there are several depots located throughout the country that store and distribute the petrol.

Due to its relatively small size, Armenia is considered one market for the purposes of this study. The longest possible distance in Armenia is about 350 km, but the distance between the production facility and the major market for bio-ethanol (Yerevan) is much less.

4.3 Discussion of the Likelihood of Bio-Ethanol Product Exports

Due to its favorable chemical properties, bio-ethanol could be exported to other countries, depending upon its price relative to petrol. However, since petrol prices in Armenia are comparatively high and are expected to remain so for the foreseeable future, it is anticipated that all domestic bio-ethanol produced by these two facilities will be consumed within Armenia.

4.4 Suggested Bio-Ethanol Marketing Strategy

Since the domestic petrol market is relatively concentrated, the bio-ethanol plants should sell their product directly to the wholesalers, as that reduces the commissions and fees associated with middlemen. From a logistics perspective, the most advantageous point to introduce bio-ethanol into the petrol supply is at the fuel depots. Splash-blending equipment can be installed and petrol blended with bio-ethanol before the resulting blend is distributed by truck to the petrol stations for resale.

4.5 Summary of Market Findings and Conclusions

The relatively small size of the bio-ethanol plants and their limited contribution with regards to the overall petrol use, the market risk for bio-ethanol in Armenia is limited. At expected blend levels of E5, the bio-ethanol produced should be readily absorbed into the petrol market. Its high octane value further makes it an attractive blend component. To avoid fuel quality issues from other sources (e.g. blending water) being attributed to the introduction of bio-ethanol, a rigorous testing and quality control protocol is recommended to demonstrate that the addition of bio-ethanol improves overall fuel quality.

Armenia’s dependence on imported petrol and the associated high domestic petrol prices helps to create an opportunity for domestically produced bio-ethanol. The proposed bio-ethanol plants would augment petrol supply by a total of about 5%, which can readily be absorbed by the petrol market. Introduction in the supply chain can be easily achieved through splash-blending at the fuel depots. The bio-ethanol price in the financial model is set at $1.34/liter.

5.0 Review of Potential Co-Products and Their Implicit Values

This section of the preliminary feasibility study reviews the anticipated co-products of these two proposed bio-ethanol projects. The primary co-products of alcohol production from a corn dry mill bio-ethanol plant with fractionation are high protein distiller's grains, corn germ and bran, and carbon dioxide. The corn germ also contains oils that are useful in human food markets and the bran contains fiber. Similarly, the Jerusalem artichoke processing plant will produce bio-ethanol, carbon dioxide, and an animal feed co-product, which is also high in protein.

5.1 Discussion of Likely Bio-Ethanol Co-Products

Potential Co-Products from a Corn Fractionation Plant

Distiller's grains are the residues that remain after high quality cereal grains have been fermented by yeast. In the fermentation process, nearly all of the starch in the grain is converted to bio-ethanol and carbon dioxide, while the remaining nutrients (proteins, fats, minerals, and vitamins) undergo a three-fold concentration in the beer, which after distillation and centrifugation of the still bottoms, yields distillers wet grains (DWG) and "thin stillage." The thin stillage is subsequently concentrated via evaporation and the "heavy syrup" is added back to the DWG. This material is then dried to 10% moisture, producing dried distiller's grain and solubles (DDGS). Front-end fractionation as proposed for this project separates the non-starch components (germ and fiber) of the corn from the starch.

The addition of the soluble fraction increases the protein and vitamin potency of the final product and removes the logistical problems associated with marketing wet feed. It also provides a solid baseline byproduct that can be marketed while allowing development of both the wet feed and special blend feed markets. DDGS is the most common and highest volume form of feed product derived from a dry mill facility. Typical composition of DDGS from feed corn is shown in Table 5.1 below. The DDGS yield from corn is 198.2 kg/ tonne of feed corn.

Table 5.1 – Typical Composition High Protein Distiller's Grains (DDGS) from Corn Fractionation

Component	Percentage Weight
Moisture	10
Protein	36-48
Fat	6-7
Ash	6-7
Starch	3-5

DDGS derived from feed corn contains nutrients that have been demonstrated by numerous experiments to have important growth promoting properties for dairy and beef cattle, poultry and swine. For dairy cattle the high digestibility and net energy content of DDGS and DWG, compared to other feed ingredients (soybean meal, canola meal, brewers spent grains as examples), as well as the high fat content, results in feeds that yield greater milk production. For beef cattle the improved rumen health, energy effect of the fiber, and palatability has been shown in feedlot studies to result in faster and more efficient gains.

For poultry, feeding tests have demonstrated that DDGS favorably affects fertility and hatchability. DDGS is an excellent ingredient for supplying protein to broilers where the diet has been adjusted to limit certain amino acids. For hogs, research has shown that DDGS can effectively furnish portions of the energy, protein and other key nutrients during all phases of production.

In addition to bio-ethanol, CO_2, and the high protein distiller's grains, the dry fractionation process produces germ and bran co-products. The germ fraction is oil rich and the bran has high fiber content. At this time these products will not be refined by the plant, but rather sold to other industries as feedstocks for corn oil production and food uses, for example. Table 5.2 below shows the composition of the germ and fiber fraction of the corn kernel. The germ and bran yields are 71.4 kg and 37.5 kg per tonne of corn respectively.

Table 5.2 – Corn Fraction Compositions (Dry Basis)

Component	Fraction Compositions (by %)	
	Germ	Bran
Starch	11.9	7.3
Protein	18.4	3.7
Oil	29.6	1.0
Ash	10.5	0.8
Sugars	10.8	0.3
Fiber	18.8	86.9

Potential Co-Products from the Jerusalem Artichoke Plant

The principal co-product that can be expected from the Jerusalem artichoke processing plant is an animal feed, which is high in protein. There is very little information available internationally regarding its suitability as feed, so market development for this product would be even more challenging than distiller's grains from corn. The expected feed co-product yield is 64.2 kg per tonne of Jerusalem artichoke.

Table 5.3 – Approximate Feed Co-Product Composition

Component	Wet Cake	Dry Cake
Water	65.0	10.0
Protein	13.7	35.3
Dietary Fiber	17.4	44.7
Fat	3.9	10.0
Non-Fiber Carbohydrate	Trace Only	Trace Only

In addition, the Jerusalem artichoke processing plant is expected to produce dry ice and liquid carbon dioxide (CO_2) as co-products. Carbon dioxide, whether solid, liquid, or in a gaseous form is recognized as safe for use in preserving foods from spoiling. Food industry sectors and associated applications that utilize the greatest amount of CO_2 include:

- Beef, pork, and poultry slaughter operations
- Frozen food storage and transportation
- Supplemental cooling for refrigerated products
- Meat, sausage, and bakery processing
- Carbonation of beverages

Moreover, non-food applications include:

- Various chemical processes
- Oil extraction via CO_2 injection
- Dermatologists
- Blood banks
- Pharmaceutical manufacturing
- pH control

Typically, a CO_2 processing company will construct a facility next to the bio-ethanol plant. The raw CO_2 is piped to the facility for finishing. In order for the processing facility to be economically viable, there must be a close market for the finished CO_2. If justified, the bio-ethanol plant can easily capture raw carbon dioxide. However, further processing is necessary if it is to be used for commercial purposes. At most, the revenue potential from the sale of CO_2 is approximately 3% of total plant revenues.

5.2 National Markets for Co-Products

High protein dry distiller's grain and soluables (DDGS) is a valuable animal feed product that should obtain prices at least equal to feed corn. The removal of the starch in the corn by the dry mill corn fractionation plant concentrates the remaining components, such as protein, edible oils, and minerals. This higher protein content increases the value as animal feed. Currently, some animal producers (e.g. poultry farms) in Armenia import corn as feed, and a portion of that corn (about 15% for poultry for instance) could be substituted with distiller's grains. However, there is very little knowledge in the country regarding the benefits of using distillers grains instead of corn, so the distillers grains market would need to be developed through an education campaign and perhaps the added incentive of prices slightly below corn.

The only two commercial prospects that the project team located within Armenia today that may serve as potential markets for DDGS are highlighted below and include:

Araks Poultry which utilizes about 13,000 tonnes of imported feed corn per year as poultry feed for its Araks and Yerevan poultry plants. The price that Araks Poultry pays for imported feed corn is $420-450 per tonne. Araks also imports 2,000 tonnes of wheat at $400-420 per tonne, 3,000 tonnes of pressed soya at $850-900 per tonne, and 2,000 tonnes of pressed sunflower seeds at $350 per tonne. However, in 2008, they intend to purchase local feed corn from Tavush Marz, as well as plant and harvest roughly 2,000 hectares of feed corn on their own feed corn on leased land in Tavush.

Dvin Concern consumes about 14,000 tonnes of feed corn per year and possesses some limited experience with the utilization of ethanol production waste co-products as animal feed. Moreover, they have plans to cultivate their own feed corn in the future.

The other commercially valuable co-products from a dry mill corn fractionation plant are germ and fiber. The germ has a high content of edible oils, which can be sold for processing into corn oil for human consumption. The fiber can be used for human food as well, for example to increase the amount of fiber in baked goods.

Co-products from processing Jerusalem artichoke into bio-ethanol will require lab analysis and educational information in order to ensure the development of a national market for these feed products.

5.3 Export Markets for Co-Products

All of the co-products are expected to be dried, so they can be stored and/or shipped to nearby feed markets outside of Armenia if an attractive economic opportunity arises.

5.4 Review of Co-Product Pricing Structures

The pricing of various co-products depends on supply and demand, as well as the value of comparable livestock feeds. Due to the absence of significant other producers of the products in the region, supply will be almost exclusively provided by the proposed plants. Demand needs to be developed due to the novelty of the products in the country (for corn products) or globally (for Jerusalem artichoke).

The price for dry distillers grain and soluables (DDGS) is also impacted by the price of corn, since it is used as a substitute for feed corn. Prices used in the financial analysis for the dry mill corn fractionation bio-ethanol plant are shown in Table 5.4 below, which compares the estimated price of feed corn in Armenia today with average prices for DDGS, bran, and fiber elsewhere in the world:

Table 5.4 – Typical Co-Product Pricing Compared to the an Average Reference Price for Feed Corn

Co-Product	Projected Price in U.S. Dollars per Tonne	Percentage of Local Dry Corn Price
Local Feed Corn	$393	100%
High Protein Distillers Grains	$416	106%
Germ	$452	115%
Fiber	$216	55%

The value assigned to the Jerusalem artichoke co-product is significantly lower at $266 per tonne even though its protein content is comparable to that of high protein distiller's grains. The price was discounted to reflect the lack of experience and markets for this particular animal feed product.

Other potential co-product markets exist in Armenia. For instance, CO_2 is widely used in Armenia for sparkling waters and non-alcoholic drinks, as well as dry ice production that is used for cooling of ice cream and meats in the absence of electrified cooling. In this regard, several sources for CO_2 production already exist. One in Hankavan extracts CO_2 from local mineral water. Moreover, dry ice is presetly being produced at the Polivinilazetat chemical plant. The market price today for a 20 kg cylinder of CO_2 is 10,000 ADM (or roughly 500 ADM per kg), but smaller cylinders are more expensive (due to charge losses). Dry ice retail prices are 1000 ADM per kg while the cost of production is about 700 ADM per kg.

Finally, only limited commercial demand exists in Armenia today for protein supplements, primarily for athletes. The current price of such protein supplements is $40 - 300 per kg. However, all protein is imported so a potential small market may also exist for this particular co-product.

5.5 Conclusions and Recommendations for Co-Products

The revenues from the co-products described above are crucial for the profitability of bio-ethanol plants if no direct financial subsidies are being made available by Government. Further discussions with the potential buyers of these products are recommended to gauge their level of interest and potential sales volumes and prices. The high prices of importing feed corn to Armenia provide an opportunity to sell distiller's grains, a substitute for feed corn, at a relatively high price. In the case of the Jerusalem artichoke co-product, animal trials with species relevant to Armenia are required to ascertain its value.

The expected co-product yields per tonne of corn are: 198.2 kg DDGS; 71.4 kg germ; and 64.2 kg bran. The animal feed co-product yield from Jerusalem artichoke is 64.2 kg per tonne.

For the purposes of this study the following values were assigned to co-products for the financial analysis: $416 per tonne for high protein distiller's grains; $452 per tonne for feed corn germ; $216 per tonne for bran; and $266 per tonne Jerusalem artichoke feed.

Finally, both Dvin Concern and Araks Poultry are very interested in working with a potential investor in a bio-ethanol plant in Tavush Marz that can provide corn-based co-products as animal feed, but only at a price competitive with imported corn

6.0 Matching Potential Feed Stocks to Production Processes

6.1 Matching Production Technologies to Available Bio-Ethanol Feed Stocks

The production of bio-ethanol or ethyl alcohol from starch or sugar-based feedstocks has been practiced for thousands of years. While the basic process steps remain the same, the process has been considerably refined in recent years, leading to highly efficient processes that now yield more energy in bio-ethanol and co-products than is required to make the products.

In the dry milling corn fractionation process, corn, wheat or other high-starch grains are first ground into meal and then slurried with water to form a mash. Enzymes are added to the mash to convert the starch to the simple sugar, dextrose. Ammonia is also added for pH control and as a nutrient to the yeast. The mash is processed through a high temperature cook step, which reduces bacteria levels prior to fermentation. The mash is cooled and transferred to the fermenters where yeast is added and the conversion of sugar to bio-ethanol and carbon dioxide (CO_2) begins.

Jerusalem artichoke undergoes a similar process, the main difference being the preparation of the feedstock and different enzymes to convert the inulin.

After fermentation, the resulting "beer" is transferred to distillation where the bio-ethanol is separated from the residual "stillage." The bio-ethanol is concentrated to 190 proof using conventional distillation and then is dehydrated to approximately 200 proof in a molecular sieve system. The resulting anhydrous bio-ethanol is blended with about 5% denaturant (usually petrol) and is then ready for shipment to markets throughout the country.

The stillage is separated into a coarse grain fraction and a "soluble" fraction by centrifugation. The soluble fraction is concentrated to about 30% solids by evaporation. This intermediate is called Condensed Distillers Solubles (CDS) or "syrup." The coarse grain and syrup fractions are then mixed and dried to produce distiller's dried grain and solubles (DDGS), a high protein animal feed product.

The project sponsor should ensure that reputable design and construction firms are engaged throughout the development, design, and construction of the project. The construction firm should guarantee the completion of the project within a fixed budget and time schedule and must warrant all workmanship for a period of not less than a year following startup. The firm should be capable of posting performance, materials, and labor bonds and should be willing and financially able to accept liquidated damages provisions in their contract, if it is required by the sources of debt financing for the project.

The supplier of the bio-ethanol process technology and the designer of the process should be experienced and well regarded, to guarantee the performance of the plant so long as the construction firm builds it to the designer's specifications. This guarantee should include a minimum yield requirement, and specific quality requirements of products. The guarantee should also include quality and quantity requirements of feedstock (usually a bushel of #2 yellow corn). Requirements for energy and utility consumption for the use of chemicals and enzymes, and for the process water, with respect to consumption, should be stated in the process guarantee. The volume and characteristics of wastewater should also be addressed in this guarantee, and all requirements should be presented on a per bushel basis. The guarantee is normally considered satisfied if a successful performances test of several days duration is completed after plant startup.

In some cases, the same firm may be both the designer and the constructor. In such cases, the General Constructor (GC) will provide the performance guarantees and the process designer will act as a subcontractor to the GC. In cases where separate contracts are held for both the designer and the construction contractor, the process and construction guarantees would be in separate documents. The project team recommends that there be a single “turnkey” contract providing the strongest possible financial resources to back the design and construction scope of work.

What follows is a list and short description of firms that the project team knows to be successful and reliable in the bio-ethanol industry that work internationally and have designs for smaller plants.

Delta-T Corporation headquartered in Williamsburg, Virginia is a design-build firm that provides alcohol plants, systems and services to the fuel, beverage, industrial and pharmaceutical markets. Delta-T is known for pioneering many of the innovations currently in use by the newest generation of bio-ethanol plants, including the commercialization of molecular sieve dehydration, zero discharge of process wastewater, and more efficient refining and purification systems to produce high quality alcohols. Delta-T has provided alcohol production, dehydration and purification solutions to more than 60 clients worldwide, including projects in Russia, India, Western and Eastern Europe, Africa, the Caribbean and South America.

Delta-T Corporation is located at 323 Alexander Lee Parkway, Williamsburg, Virginia, 23185
Telephone 1 (757) 220-2955. Web address: http://www.deltatcorp.com/

ICM, Inc. of Colwich, Kansas, serves the agricultural industry by developing and implementing innovative and practical processing solutions. ICM, Inc. employs about 100 people in all aspects of bio-ethanol project development and operation including cash and commodity trading of corn, marketing of bio-ethanol and distillers grain, process consulting, engineering, equipment fabrication, field installation, and plant start-up. The former technology leader of High Plains Corporation formed ICM. High Plains operates plants in Nebraska, Kansas, and New Mexico. ICM does own and operate a facility in Russell, Kansas, which acts as both a training and research facility for their technology. Six of the latest bio-ethanol plants in the United States have utilized ICM technology.

ICM Inc. is located at 310 N. First Street, Colwich, Kansas, 67030
Telephone 1 (316) 796-0900. Web address: http://www.icminc.com/

Katzen International, Inc. of Cincinnati, Ohio is one of the most experienced bio-ethanol plant process designers and technology suppliers in the world, having operated worldwide for over forty years. Katzen International, Inc. was formed in 1955 by Dr. Raphael Katzen. Katzen International provides innovative and advanced design concepts in a wide variety of industries, such as agriculture, chemicals, sugar, cryogenic and pulp and paper. Although based in the United States, Katzen has completed projects in over 25 countries.

Katzen International Inc. is located at 2300 Wall Street, Suite K, Cincinnati, Ohio 45212
Telephone 1 (513) 351-7500. Web address: http://www.katzen.com/

Praj Schneider is a design/engineering/build firm with experience in the bio-ethanol industry in multiple countries.

The firm is headquartered in 5634 South 85th Circle; Omaha, NE 68127. Telephone: 1 (402) 331-7230. Web address: http://www.prajschneider.com

6.2 Promising Technology Paths for Future Bio-Ethanol Feedstocks

Bio-ethanol can be produced using a variety of feedstocks. Technologies exist to convert diverse sources of biomass such as wood and plant material to bio-ethanol. Two promising technology paths that are currently being commercialized are enzymatic hydrolysis and gasification.

Gasification is the decomposition of solid and liquid organic material into a gas by controlling the amount of oxygen available. Gasification recycles complex organic molecules into single carbon molecules of CH_4, CO_2, and CO. This so-called "syngas" can be further processed into bio-ethanol via catalytic conversion.

Enzymatic hydrolysis of cellulosic feedstocks is similar to the process used in corn to bio-ethanol dry mills. The main difference is that the starch in corn is easily hydrolyzed into sugars, while cellulosic biomass contains cellulose as well as hemi-cellulose and lignin, which have evolved to resist decomposition. To hydrolyze these compounds, new enzymes need to be developed and implemented. As of today, there are a small number of demonstration scale plants that are attempting to prove their technology for future commercial operations.

Second generation technology based upon cellulosic conversion processes have actually been used for producing ethanol for decades. The benefit of the cellulosic process is that bio-ethanol can be produced from waste or non-crop material, thereby not impacting crop prices by taking crops out of the supply chain or by taking away lands that could be used for crops for feeding humans and cattle.

However, a scientific breakthrough is needed to reduce the operational cost of transforming wood and crop fibers into ethanol. Several cellulosic pilot projects are now operating and providing some promise that the cost of production will be lower than current fermentation processes. There is even promising research in Armenia (Center for Microbiology and Microbial Depository) that could prove to be the breakthrough that scientists have been seeking for decades.

7.0 Plant Design Characteristics and Associated Costs to Construct

This section provides the conceptual process design basis for both a Jerusalem artichoke processing plant and also a dry mill corn fractionation facility, as well as establishes associated project statistics that are required for the financial analysis. It should be noted from the outset that the nameplate capacity of each of these two proposed bio-ethanol plants is 7,000 tonnes of *un*denatured ethanol per year. Neat (undenatured) ethanol to be used as a transportation fuel is typically blended ("denatured") with petrol or a similar substance at a rate of about 5%. This blending makes the final product (ethanol blended with petrol) unfit for human consumption, avoiding the tax on beverage alcohol. The production capacity of the proposed plants is 7,362 tonnes per year of denatured ethanol, due to the addition of petrol.

7.1 Bio-ethanol Process Design for a Jerusalem Artichoke Facility

Introduction to the Proposed Process Design Basis

For the proposed project, the project team has developed a process design basis for the production of bio-ethanol from Jerusalem artichoke. The proposed production model is based on fermenting the carbohydrate portion of the tuber (root) of the plant. This fermentable portion of the plant is composed primarily of inulin, a polymer of fructose and glucose.

The scale of production for the proposed plant is 7,000 tonnes of bio-ethanol per annum. This is the equivalent of about 8.9 mega liters of anhydrous bio-ethanol. However, there is little published information indicating how much feedstock is required to meet this desired production level. To establish the annual production requirement, the project team estimates two key parameters: inulin yield and conversion of inulin to bio-ethanol. Table 7.1 below shows an abridged composition of Jerusalem artichoke collected from several different sources.

Table 7.1 – Jerusalem Artichoke Composition[1]

Sample	A	B	C	D	Average
Preparation	Raw	Raw	Raw	Raw	--
Water (%)	NR	82.1	80.,1	78.0	80.1
Total Carbohydrates	15.9	14.1	16.7	17.3	16.0
Protein	0.5	2.1	2.1	2.,0	1.7
Dietary Fiber	4.0	2.6	0.6	1.3	2.,1
Fat	0.2	0.6	0.1	1.0	0.5
Inulin*	11.9	11.5	16.1	16.0	13.9

* The Inulin content presented here is a calculated value (Total Carbohydrates - Dietary Fiber)

This study assumes that the average compositions from samples A, B, C, and D are representative of Jerusalem artichoke that will be used in the proposed facility.

The conversion of inulin to bio-ethanol will determine the amount of feedstock required by the proposed plant. Inulin is a $C_{6n}H_{10n+2}O_{5n+1}$ polymer of fructose with a glucose end unit, where n is the number of units in the polymer. In order to convert inulin to bio-ethanol the

[1] Kays, S. J. and S. F. Nottingham. *Biology and Chemistry of Jerusalem Artichoke*. CRC Press, 54-55.

polymer chain has to be broken via hydrolysis (acidic or enzymatic) and then the individual sugar units are fermented by an organism to bio-ethanol. Alternatively, there are organisms that can perform both steps simultaneously.

The theoretical yield of bio-ethanol from sugar is 0.51 g/g. Because it is a polymer of 6-carbon sugars, inulin generates 1.11 grams of 6-carbon sugars per gram of polymer when hydrolyzed due to the addition of a water molecule to each sugar monomer during hydrolysis. Therefore, the theoretical bio-ethanol yield from inulin is 0.5661 g/g. In reality it is unlikely that the proposed project will have a 100% efficient inulin conversion. Table 7.2 below shows inulin conversion efficiencies as reported in various published experimental results.

Table 7.2 – Inulin to Bio-ethanol Yields[2]

Reported Efficiency	g EtOH perg Inulin
100% (theoretical)	0.5661
92%	0.5208
89%	0.5038
84%	0.4755
83%	0.4699

The reported experimental results show bio-ethanol yields ranging from 83% to 92% efficiency. The 89% conversion efficiency was achieved by using a yeast which was capable of performing both the hydrolysis and fermentation, while the 92% conversion efficiency was achieved by separate hydrolysis and fermentation with bacteria.

Based on the average inulin content of 13.9% and the 92% fermentation efficiency the plant must process nearly 97,000 tonnes of Jerusalem artichoke roots (tubers) per annum.

The process description and conceptual design information that follow have been written based on processing 97,000 tonnes of artichoke tubers, using simultaneous hydrolysis and fermentation. The conceptual design developed by the project team for the proposed plant is based on the production parameters established above. As the project progresses additional testing will be required to confirm or modify these assumptions, and the modification of any of the assumptions will have to be incorporated into the eventual detailed design.

It is intended that the Jerusalem artichokes will be grown by local farmers, and that the tubers will be delivered raw to the plant. The preferred storage method is in-field storage over the winter months and harvesting the plants as needed. Once harvested, refrigerated storage is the best method—though it is expensive. Little data is available that provides inulin degradation information in regards to non-food use. However, it has been shown that winter storage results in syrups with much more glucose than fructose,[3] which may be an advantage for the proposed project.

The tubers are stored as received in insulated bins that have seven days of storage capacity. From the storage bins, the tubers are cleaned to remove most of the entrained soil and debris. Then they pass into a knife mill for chopping. At this point the artichokes are ready to enter

[2] Ohta, K., S. Shigeyuki, and T. Nakamura. 1993. Production of High Concentrations of Ethanol from Inulin by Simultaneous Saccharification and Fermentation Using *Aspergillus niger* and *Saccharomyces cerevisiae*. Appl. and Enviro. Microbiol. 59:729-33.

[3] Schorr-Galindo, S. and J. P. Guiraud. 1997. Sugar potential of different Jerusalem artichoke cultivars according to harvest. Biores. Tech. 60:15-20.

the processing steps. As noted earlier, the Jerusalem artichokes already contain a significant amount of water, so they are slurried with additional recycled process water as may be required for processing and sent to the hydrolysis and fermentation area.

There are two different ways to accomplish the hydrolysis: chemically and biologically. Chemical hydrolysis, through the addition of acid, requires neutralization and generates significant quantities of precipitated salts, which lead to yield losses. Biological hydrolysis occurs with enzymes, bacteria, and yeasts and typically does not generate any undesirable by-products, but may have higher operating costs than chemical methods. Until a test program can determine the best method, the preliminary design will utilize a biological method in order to minimize capital equipment costs and limit yield losses. The hydrolysis and fermentation operations are conducted simultaneously within the fermentation tanks. In addition to enzymes, yeast is added to the slurry to ferment the fructose and glucose to bio-ethanol.

The fermentation broth, or beer, is then sent to the distillation area where bio-ethanol is removed and partially purified. The partially-purified bio-ethanol is then dehydrated and denaturant is added resulting in the bio-ethanol product. The still bottoms are sent to the centrifuge operation, where the liquid stillage is separated from the unfermented solids and yeast. The liquid stillage is recycled back to the front end of the process and used as makeup water wherever possible; any surplus is discharged as effluent wastewater or potentially reclaimed via ultra filtration and reverse osmosis.

The centrifuge cake containing the unfermented solids and yeast is sold wet as the distiller's wet cake or DWGs, or dried and sold as distillers dried cake. As an option, the liquid still bottoms can be concentrated by evaporation and added back to the centrifuge cake as syrup to fortify the nutritional attributes of the animal feed co-product. Based on the composition information presented earlier, an approximate composition of the resulting dry and wet cakes is presented in Table 7.3 below based upon the assumption that the wet cake consists of 35% solids and that the dry cake contains fully 90% solids.

Table 7.3 – Approximate Feed Co-Product Composition

Component	Wet Cake (%)	Dry Cake (%)
Water	65.0	10.0
Protein	13.7	35.3
Dietary Fiber	17.4	44.7
Fat	3.9	10.0
Non-Fiber Carbohydrate	Trace Only	Trace Only

Note that this composition is based on the average Jerusalem artichoke composition presented above, and does not include the addition of enzymes or yeast, which increases the protein content of the finished product proportionally to the amount of enzyme and yeast added.

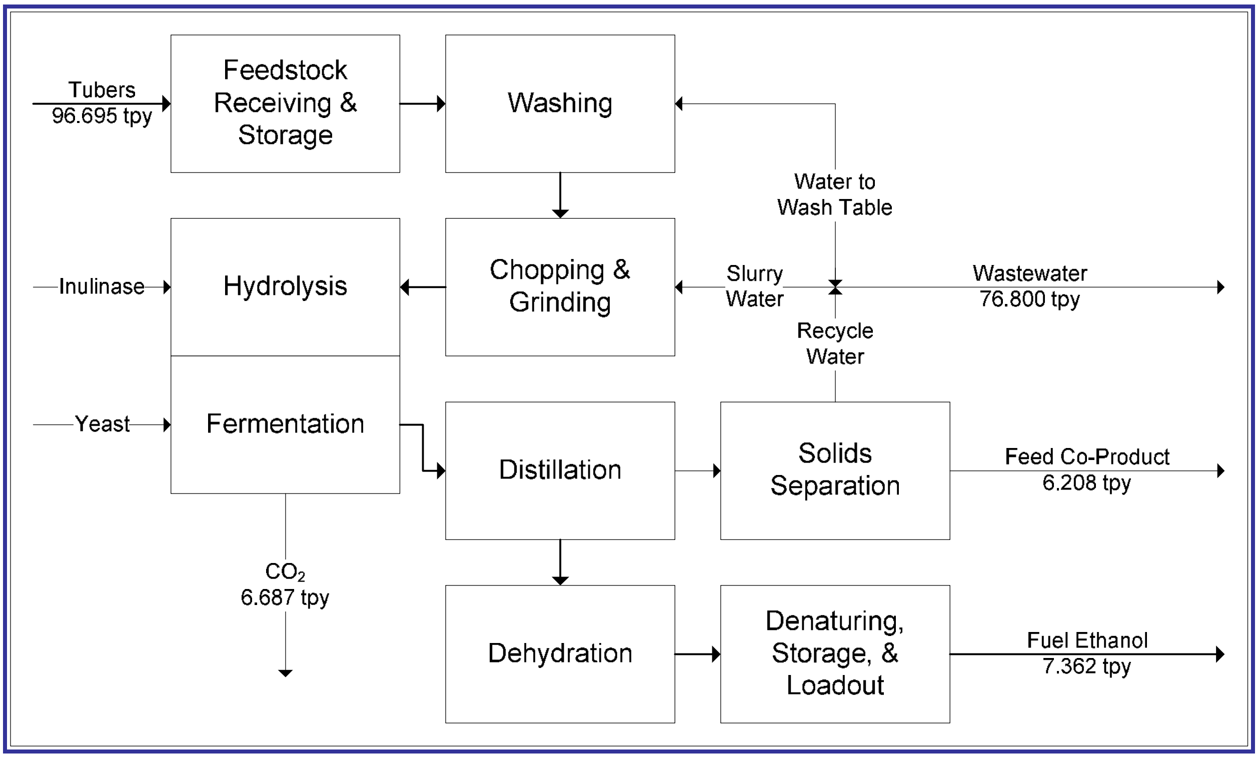
Jerusalem Artichoke Processing Plant Conceptual Design

The conceptual process design for a Jerusalem artichoke processing plant incorporates the following process areas and unit operations. Each is described in the section that follows:

Area 1000 – Feedstock Receiving, Storage and Preparation
Area 2000 – Chemical and Nutrient Preparation
Area 3000 – Yeast Propagation
Area 4000 – Simultaneous Hydrolysis and Fermentation
Area 5000 – Distillation and Dehydration
Area 6000 – Stillage Handling
Area 7000 – Bio-ethanol Denaturing, Storage, and Loadout
Area 8000 – Utilities

The Block Flow Diagram for the proposed process is presented in Figure 7.1 below. The process area descriptions and project statistics are presented on the following pages.

Figure 7.1 – Block Flow Diagram for a Jerusalem Artichoke Process Plant



Jerusalem Artichoke Process Description by Area

This section provides a step by step description of the process areas and unit operations included in the conceptual design.

Area 1000: Feedstock Receiving, Storage, and Preparation

Area 1000 includes the front-end feedstock receiving, storage, and preparation operations.

The Jerusalem artichokes feedstock for the proposed plant will be harvested in the Spring, processed into a powder, and stored locally until needed. To assure continuous operation, the plant will have seven days of on-site storage.

The powdered feedstock is transferred from storage at the plant via a conveyor to Area 4000.

Area 2000: Chemical and Nutrient Preparation

Area 2000 is where chemicals, nutrients, and reagents are prepared. This area also includes the acid and caustic clean-in-place (CIP) reagents, and the reagents required for hydrolysis and fermentation including enzymes, yeast and trace nutrients, all of which require re-suspension or dissolution prior to use in the process.

Area 3000: Yeast Propagation

The yeast re-suspension and propagation equipment is located in Area 3000. In this area, purchased starter yeast is re-suspended in the yeast propagation tanks. The yeast propagation tanks would be equipped with top-mounted agitators, filtered air supply, CIP distribution headers and spray nozzles, recirculating pumps and external coolers.

The yeast grow in the propagation tanks on a slip-stream of the saccharified feedstock slurry under aerated conditions for approximately 16 hours before being pumped into the one of the production fermenters where bio-ethanol production occurs.

Area 4000: Simultaneous Hydrolysis and Fermentation

In Area 4000, the feedstock from Area 1000 is transferred to the first fermentation tank.

Filter-sterilized inulinase enzyme is then added to begin the hydrolysis process. In the production fermenters, the feedstock/enzyme slurry is inoculated with yeast from Area 3000 and allowed to ferment for approximately 48-56 hours. The production fermenters are staged to allow for one tank being cleaned and filled, another tank undergoing fermentation, and a final tank being drained for product recovery on a continuous, sequencing batch-wise basis with one fermenter being harvested every day. Temperature and suspension in the production fermenters is maintained via an external pump-around loop that includes a counter-current heat exchanger. The tanks are agitated to help drive the mass transfer required for the microbial bioconversion to reach completion.

In this process, the fermentation process occurs in parallel with the hydrolysis of the inulin substrates: as the inulinase enzymes convert the inulin into its monomeric sugars, primarily fructose and glucose, the yeast metabolize the sugars into bio-ethanol and carbon dioxide. The simultaneous hydrolysis and fermentation process is very similar to the standard throughout the commercial dry mill bio-ethanol industry in the U.S. because it prevents substrate inhibition due to catabolite repression while preventing yield losses from opportunistic contaminants. Any free simple sugars present at the beginning of the fermentation process will be utilized initially and preferentially by the overwhelming number of yeast cells introduced in the seed inoculum.

After the fermentation process is complete, the fermentation broth containing approximately 5.6% bio-ethanol is transferred to an agitated beer well that serves as the surge tank for the subsequent distillation process in Area 5000.

CO_2 generated by the fermentation process is vented through a CO_2 scrubber, to capture and return bio-ethanol that is present in the CO_2 stream coming off the production fermenters. The scrubber water, containing extracted bio-ethanol, is combined with the clarified beer in the beer well prior to distillation. The CO_2 is then vented, or it can be transferred off-site to a CO_2 recovery and upgrading unit.

Area 5000: Distillation and Dehydration

The bio-ethanol produced in Area 4000 is recovered and purified in Area 5000.

The fermentation beer containing bio-ethanol is transferred from the beer well, through a series of integrated heat recovery heat exchangers, into the distillation column. The beer feed to the distillation columns is pre-heated by passing it through two counter-current heat exchangers. In the first counter-current heat exchanger, the 35º C beer is used to condense the hot, vaporized anhydrous bio-ethanol exiting the molecular sieves that are used to dehydrate the bio-ethanol product. The partially preheated beer is then sent through the second counter-current heat exchanger where it is heated up to the operating temperature of the beer column by the still bottoms (stillage) exiting the reboiler on the bottom of the beer column.

The pre-heated beer is then introduced to the distillation columns to separate the bio-ethanol product from the fermentation beer. Volatilized, saturated bio-ethanol is sent to the molecular sieve dehydration units to break the azeotrope resulting in an anhydrous bio-ethanol product stream. The anhydrous product is condensed by the first counter-current heat exchanger that was used to pre-heat the diluted beer on its way to the distillation column, and sent to the bio-ethanol storage and load-out area.

The two molecular sieve units are operated in a reciprocating mode, with one unit regenerating while the other is in operation. During regeneration, anhydrous bio-ethanol vapor from the unit in operation is used to regenerate the other unit by dissolving the entrained water, which is then sent back to the rectifying section of the distillation column.

The water and residual solids that remain behind after the bio-ethanol is removed via distillation is sent to Area 6000 for solids removal and concentration.

Area 6000: Stillage Handling

In Area 6000 the stillage generated by the distillation process is further processed. The whole stillage contains all the residual solids and water from the upstream production unit operations. The whole stillage consists primarily of yeast, residual inulin, fiber, protein, fats and oils, and dissolved salts and ash.

The whole stillage from the beer column is first sent to a bank of decanting centrifuges where the suspended solids are removed, yielding a clarified centrate or "thin stillage" and a "wet cake." The wet cake contains the bulk of all suspended solids left over from the upstream production operations, including the yeast, fiber, and protein.

Approximately 25% of the clarified thin stillage may be used as recycled process water, known as backset. Backset is recycled back to the upstream operations as makeup water, and is limited to a maximum of 50% of the required makeup water. The balance of the thin stillage, or all of it if none is used as backset, is sent to a series of evaporators, where it is concentrated under vacuum into syrup called thick stillage.

The first evaporator is called the heat recovery evaporator and it doubles as the overhead condenser for the rectifying section of the distillation column. Hot bio-ethanol and water vapors from the rectifying column are used to heat the thin stillage under vacuum, driving off water which is subsequently condensed and recycled or sent to wastewater treatment. The condensed bio-ethanol and water vapors are returned to the rectifying column as reflux.

The partially concentrated stillage is then sent to a second evaporator that is also operated under vacuum. In the finishing evaporator, high pressure steam is used to drive off additional water, which is subsequently condensed and recycled or sent to wastewater treatment. The finishing evaporator concentrates the stillage into thick stillage containing more than 35% total solids. The concentrated syrup, which contains all the soluble components from the production process, is then added back to the wet centrifuge cake to produce a fortified animal feed product.

The fortified wet cake is then sent to a direct, gas-fired drier which dries the wet material from approximately 35% solids (65% moisture) up to 90% solids (10% moisture). This creates a dried product that has great utility and value as an animal feed product. Drying the product to less than 10% moisture stabilizes the material, creating a non-perishable feed product with an extended shelf life.

After exiting the direct-fired drier, the animal feed product is cooled to ambient temperatures and sent to product storage.

Area 7000: Bio-Ethanol Storage and Load-out

Area 7000 includes the bio-ethanol product storage and load-out equipment.

In Area 7000, purified anhydrous bio-ethanol from Area 5000 is combined with denaturants and pumped to the denaturant bio-ethanol storage tank. Bio-ethanol is held in the denaturant product storage tank until ready for load-out, when it is pumped to the bio-ethanol load-out station and loaded into trucks for transport to market. A rail load-out station is not included in the current design due to the small size of the bio-ethanol plant.

Area 8000: Utilities

Area 8000 comprises the Utility systems for the plant. For this project, the utilities will include a gas-fired boiler and steam generation system, electrical supply, an air compressor, a glycol chiller, potable and process water systems, and an ultra-filtration system to reclaim process water for reuse or discharge.

Optional utilities might include a solid fuel biomass boiler or an anaerobic digestion system to help reduce operating costs associated with the use of natural gas.

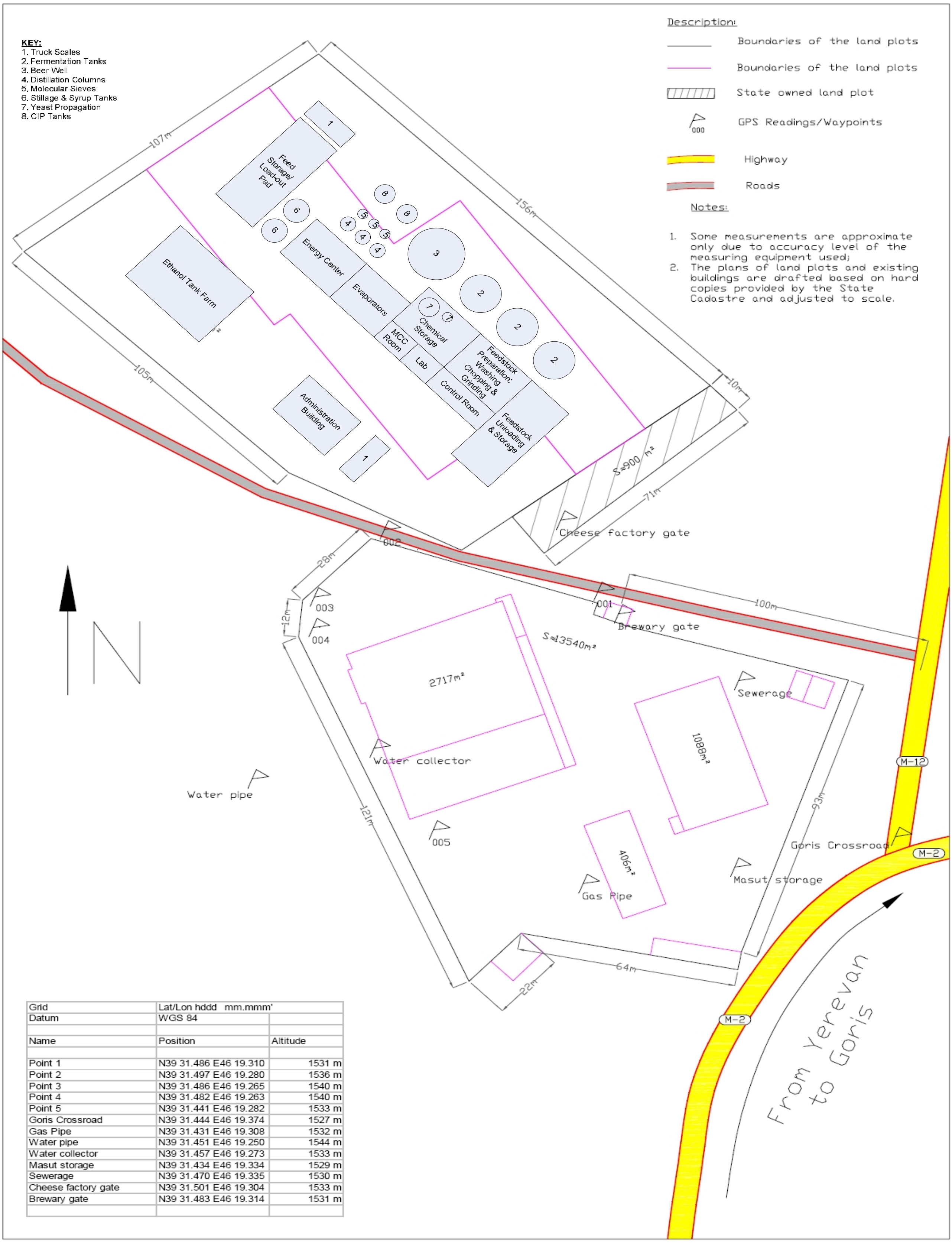
Site Description and Layout Arrangement at Goris

The proposed plant site is located just off Route M2, approximately 2 kilometers from the Community's local government office in Goris. The site is within the city limits of Goris.

The site is approximately 2.5 hectares in size and comprises one roughly rectangular plot of land, and another plot of land that contains new storage facilities. The rectangular plot was used previously for producing ethanol. All necessary utilities are located at the site.

A site layout arrangement for the plant process areas is presented in Figure 7.2 on the following page.

Figure 7.2 – Proposed Site Layout Arrangement for a Jerusalem Artichoke Processing Plant at Goris



Grid	Lat/Lon hddd mm.mmm'	
Datum	WGS 84	
Name	Position	Altitude
Point 1	N39 31.486 E46 19.310	1531 m
Point 2	N39 31.497 E46 19.280	1536 m
Point 3	N39 31.486 E46 19.265	1540 m
Point 4	N39 31.482 E46 19.263	1540 m
Point 5	N39 31.441 E46 19.282	1533 m
Goris Crossroad	N39 31.444 E46 19.374	1527 m
Gas Pipe	N39 31.431 E46 19.308	1532 m
Water pipe	N39 31.451 E46 19.250	1544 m
Water collector	N39 31.457 E46 19.273	1533 m
Masut storage	N39 31.434 E46 19.334	1529 m
Sewerage	N39 31.470 E46 19.335	1530 m
Cheese factory gate	N39 31.501 E46 19.304	1533 m
Brewary gate	N39 31.483 E46 19.314	1531 m

Major Equipment List for a Jerusalem Artichoke Processing Plant

The major equipment components of the plant are listed below in Table 7.4 below. The major equipment components would be sized appropriately for the chosen scale of production.

Table 7.4 – Major Equipment List for the Goris Plant

Area	Equipment Category	Equipment Type
1000	Truck Scales	TRUCK-SCALE
1000	Feedstock Truck Unloading Conveyor	BELT
1000	Feedstock Storage Bins	VERTICAL-VESSEL
1000	Feedstock Transport Conveyor	BELT
1000	Feedstock Wash Table	MISCELLANEOUS
1000	Wash Water Tank	VERTICAL-VESSEL
1000	Wash Table Pump	CENTRIFUGAL
1000	Wash Water Pump	CENTRIFUGAL
1000	Shredder Feed Conveyor	BELT
1000	Shredder	MILL
1000	Shredder Discharge Conveyor	SCREW
2000	Sulfuric Acid Pump	CENTRIFUGAL
2000	Petrol Pump	CENTRIFUGAL
2000	Inulinase Pump	CENTRIFUGAL
2000	Sulfuric Acid Storage Tank	FLAT-BTM-STORAGE
2000	Propane Storage Tank	HORIZONTAL STORAGE
2000	Petrol Storage Tank	FLAT-BTM-STORAGE
2000	Inulinase Storage Tank	FLAT-BTM-STORAGE
2000	Ammonia Addition Pkg	PACKAGE
2000	CIP System	MISCELLANEOUS
3000	Yeast Seed Tank	VERTICAL-VESSEL
3000	Yeast Propagation Tank	VERTICAL-VESSEL
3000	Propagation Tank Agitator	FIXED-PROP
3000	Propagation Tank Pump	CENTRIFUGAL
4000	Fermentation Tank Agitator A/B/C	FIXED-PROP
4000	Fermentation Tank A/B/C	VERTICAL-VESSEL
4000	Fermentation Cooler A/B/C	PLATE-FRAME
4000	Fermentation Recirc/Transfer Pump A/B/C	CENTRIFUGAL
4000	Beer Storage Tank	FLAT-BTM-STORAGE
4000	Beer Transfer Pump	CENTRIFUGAL
4000	Vent Scrubber	ABSORBER

Area	Equipment Category	Equipment Type
5000	Beer Column	DISTILLATION
5000	Beer Column Reboiler	SHELL-TUBE
5000	Beer Column Condenser	SHELL-TUBE
5000	Beer Column Feed Interchanger	PLATE-FRAME
5000	Beer Column Bottoms Pump	CENTRIFUGAL
5000	Beer Column Reflux Pump	CENTRIFUGAL
5000	Beer Column Reflux Drum	HORIZONTAL-VESSEL
5000	Rectification Column	DISTILLATION
5000	Rectification Column Reboiler	SHELL-TUBE
5000	Start-up Rect. Column Condenser	SHELL-TUBE
5000	Rectification Column Bottoms Pump	CENTRIFUGAL
5000	Rectification Column Reflux Pump	CENTRIFUGAL
5000	Scrubber Bottoms Pump	CENTRIFUGAL
5000	Rectification Column Reflux Drum	HORIZONTAL-VESSEL
5000	Stripper Column	DISTILLATION
5000	Stripper Column Reboiler	SHELL-TUBE
5000	Stripper Column Condenser	SHELL-TUBE
5000	Stripper Column Feed Interchanger	PLATE-FRAME
5000	Stripper Column Bottoms Pump	CENTRIFUGAL
5000	Stripper Column Reflux Pump	CENTRIFUGAL
5000	Stripper Column Reflux Drum	HORIZONTAL-VESSEL
5000	Molecular Sieve (9 pieces)	PACKAGE
6000	Whole Stillage Centrifuge	DECANTER
6000	1st Effect Evaporation	SHELL-TUBE
6000	2nd Effect Evaporation	SHELL-TUBE
6000	3rd Effect Evaporation	SHELL-TUBE
6000	Evaporator Condenser	SHELL-TUBE
6000	1st Effect Pump	CENTRIFUGAL
6000	2nd Effect Pump	CENTRIFUGAL
6000	3rd Effect Pump	CENTRIFUGAL
6000	Evaporator Condensate Pump	CENTRIFUGAL
6000	Evaporator Condensate Drum	HORIZONTAL-VESSEL
6000	Syrup Storage Tank	FLAT-BTM-STORAGE
6000	Syrup Tank Agitator	FIXED-PROP
6000	Syrup Tank Pump	CENTRIFUGAL
6000	Cake/Syrup Mixer	MIXER

Area	Equipment Category	Equipment Type
6000	Dryer	DRYER
6000	Cake Storage	CONCRETE-SLAB
7000	Denaturant In-line Mixer	STATIC
7000	Ethanol Product Pump	CENTRIFUGAL
7000	Ethanol Product Storage Tank	FLAT-BTM-STORAGE
8000	Firewater Pump	CENTRIFUGAL
8000	Firewater Storage Tank	FLAT-BTM-STORAGE
8000	Cooling Tower System	INDUCED-DRAFT
8000	Plant Air Compressor	CENTRIFUGAL
8000	Cooling Water Pump	CENTRIFUGAL
8000	Instrument Air Dryer	PACKAGE
8000	Plant Air Receiver	HORIZONTAL-VESSEL
8000	Make-up Water Pump	CENTRIFUGAL
8000	Process Water Circulating Pump	CENTRIFUGAL
8000	Process Water Tank	FLAT-BTM-STORAGE

7.2 Bio-ethanol Process Design Basis for a Feed Corn Fractionation Facility

Introduction to the Proposed Process Design Basis

The project team developed a process design basis based on their knowledge of corn fractionation and bio-ethanol production technologies that are widely deployed and commercially available in the United States, Mexico, and Ecuador. The proposed production model is based on using a dry fractionation front end to split the corn kernel into its germ, bran, and endosperm fractions and then fermenting the starch contained primarily in the endosperm fraction.

The corn typically used in the dry mill bio-ethanol industry is #2 yellow dent corn with an average moisture content of 15%. The composition of a corn kernel as a whole, and the composition of the germ, bran, and endosperm fractions resulting from the dry fractionation process are presented in Table 7.5 below:

Table 7.5 – Corn Whole Kernel and Fraction Compositions (Dry Basis)

Fraction Component	Whole Kernel	Endosperm	Germ	Bran
Starch	75.0	88.4	11.9	7.3
Protein	8.9	8.0	18.4	3.7
Oil	4.0	0.8	29.6	1.0
Ash	1.5	0.3	10.5	0.8
Sugars	1.7	0.6	10.8	0.3
Fiber	8.9	1.9	18.8	86.9

Currently in the United States, bio-ethanol yields from corn fractionation plants are around 379 liters of anhydrous bio-ethanol per tonnes of #2 yellow dent corn. In order for the proposed Haghartsin plant to produce 7,000 tonnes per annum, the plant will have to process about 25,500 tonnes of feed corn per annum.

Corn Fractionation Process Description

Corn will be grown for the project by local farmers and delivered to the plant as whole kernels. Once harvested, silo storage is the best method. Provided the corn has been allowed to dry to less than 15% moisture there are no special storage methods required to prevent spoilage.

The corn is stored as received in silos that have seven days of storage capacity. From the silos, the kernels pass through a scalper to remove entrained soil and debris. Then they pass into the front end fractionation package that mills the kernels and separates them into endosperm, germ, and bran.

At this point the high starch endosperm flour is ready to enter the bio-ethanol plant. The endosperm is slurried with water as necessary for processing and enzymes are added to the mash to convert the starch to the simple sugar, glucose. Ammonia is also added for pH control and as a nutrient to the yeast. The mash is processed through a high temperature cook step, which reduces bacteria levels prior to fermentation. The mash is cooled and transferred to the fermenters where yeast is added and the conversion of sugar to bio-ethanol and CO_2 begins.

The distillation, dehydration, and alcohol denaturing steps are very similar in the corn plant as they are in the Jerusalem artichoke plant; therefore, they will not be discussed again here.

The stillage from the endosperm fermentation still contains unfermentable material, although the amount is much less because the majority of this material was removed by the front end fractionation. It is also processed in a similar method to the Jerusalem artichoke stillage discussed earlier, and will not be repeated here. Naturally, due to the different input feedstock composition, the fortified animal feed product will have a different composition from the dry mill corn fractionation process than from a Jerusalem artichoke processing plant.

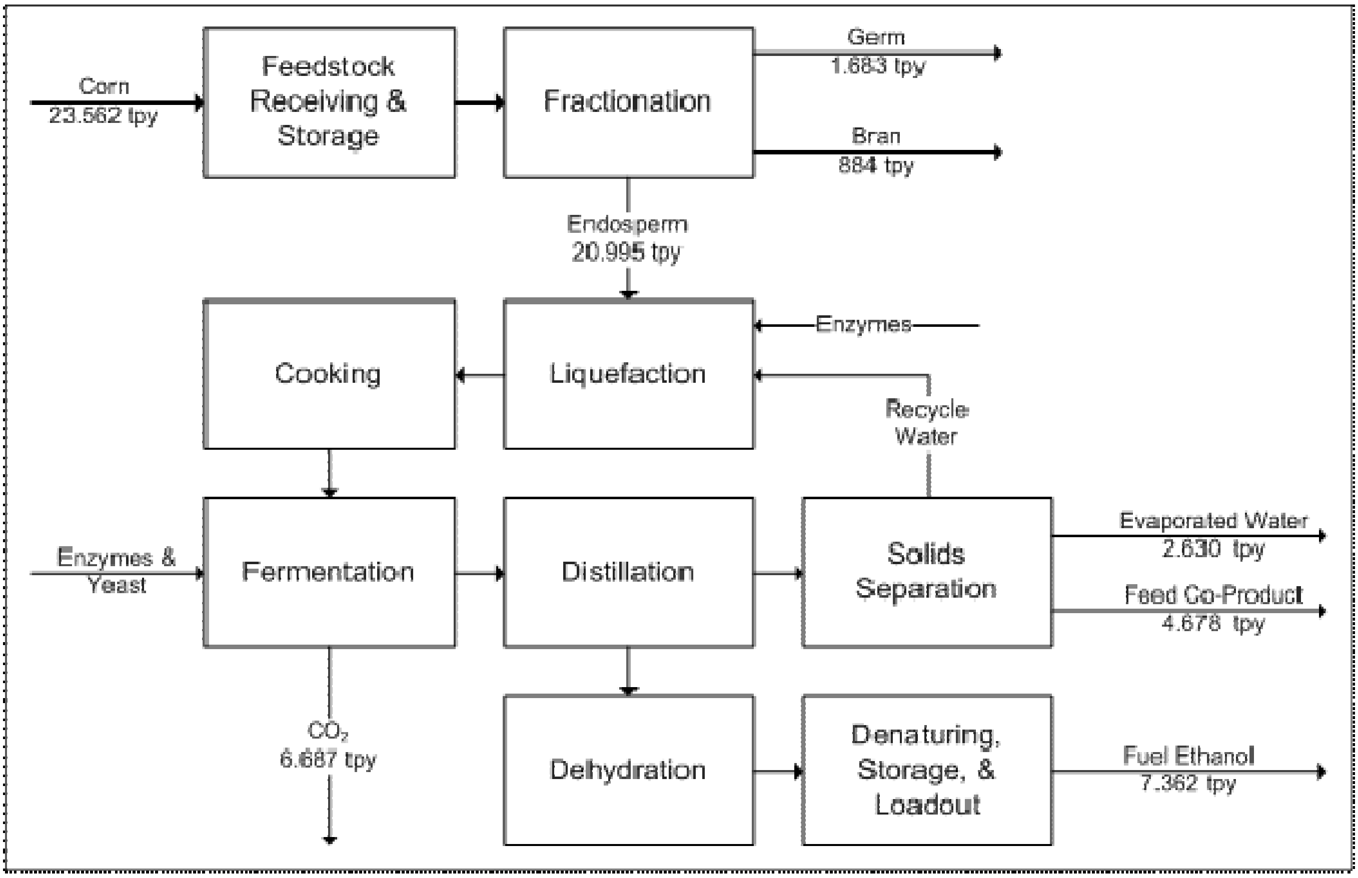
Conceptual Corn Fractionation Process Design

The conceptual process design for the plant incorporates the following process areas and unit operations. Each is described in the section that follows:

Area 1000 – Feedstock Receiving and Storage
Area 2000 – Dry Fractionation
Area 3000 – Chemical and Nutrient Preparation
Area 3500 – Yeast Propagation
Area 4000 – Liquefaction and Cooking
Area 5000 – Simultaneous Hydrolysis and Fermentation
Area 6000 – Distillation and Dehydration
Area 7000 – Stillage Handling
Area 8000 – Bio-ethanol Denaturing, Storage, and Loadout
Area 9000 – Utilities

The Block Flow Diagram for the proposed process is presented in Figure 7.3 below. The process area descriptions and project statistics are presented on the following pages.

Figure 7.3 – Block Flow Diagram of the Corn Fractionation Process



Corn Fractionation Process Description by Area

This section provides a step by step description of the process areas and unit operations included in the corn fractionation conceptual design.

Area 1000: Feedstock Receiving and Storage

Area 1000 includes the front-end feedstock receiving and storage.

Corn will be transported to the plant via trucks and handled with standard grain equipment. It can be stored off site in centralized elevators, or by individual farmers on their property. However, to assure continuous operation, the plant will have 7 days of on-site storage.

From the storage silos the corn is metered via weigh-belt and transferred to Area 2000.

Area 2000: Dry Fractionation

Area 2000 is where the corn is separated into its germ, bran, and endosperm components.

The standard dry fractionation process typically involves milling steps to remove the bran and germ. Then there is a series of polishing, drying, and sifting using both gravity tables and purifiers to concentrate the endosperm, bran, and germ. Although the process is termed dry fractionation, it typically requires a small amount of water. There are at least 11 fractionation technology providers to the dry mill bio-ethanol industry. Commercial dry fractionation technologies can vary from the standard process by using corn cracking, tempering, and special mills to help create the corn fractions, and air aspiration as part of the fraction separation process.

The project team recommends that the project utilize an "off the shelf" fractionation package from an established technology provider.

The proposed bio-ethanol plant will sell the bran and germ fractions as they come out of the fractionation unit. Only the endosperm fraction is retained by the plant for use in the bio-ethanol production process.

From the fractionation unit, the endosperm is conveyed into Area 4000.

Area 3000: Chemical and Nutrient Preparation

Area 3000 is where chemicals, nutrients, and reagents are prepared. This area also includes the acid and caustic clean-in-place (CIP) reagents, and the reagents required for hydrolysis and fermentation including enzymes, yeast and trace nutrients, all of which require resuspension or dissolution prior to
use in the process.

Area 3500: Yeast Propagation

The yeast resuspension and propagation equipment is located in Area 3500. In this area, purchased starter yeast is resuspended in the yeast propagation tanks. The yeast propagation tanks would be equipped with top-mounted agitators, filtered air supply, CIP distribution headers and spray nozzles, recirculating pumps and external coolers.

The yeast grow in the propagation tanks on a slip-stream of the saccharified feedstock slurry under aerated conditions for approximately 16 hours before being pumped into the one of the production fermenters where bio-ethanol production occurs.

Area 4000: Liquefaction and Cooking

In this area, the endosperm flour is slurried with water and enzymes to begin the saccharification and fermentation processes.

Endosperm flour comes into this area where it is slurried with water, and a small amount of α-amylase enzyme is added to begin breaking down the starch polymers into glucose units. The goal is not to generate large amounts of sugar, but rather to reduce the viscosity of the slurry for ease of pumping through the remainder of the process. Then the slurry passes through a mash cooker to reduce bacteria levels. After cooking, it is cooled to the fermentation temperature, about 35° C, and send to Area 5000.

Area 5000: Simultaneous Hydrolysis and Fermentation

In Area 5000, the feedstock from Area 4000 is transferred to the first fermentation tank. Filter-sterilized α-amylase enzyme is then added to begin the hydrolysis process. In the production fermenters, the feedstock/enzyme slurry is inoculated with yeast from Area 3500 and allowed to ferment for approximately 48-56 hours. The production fermenters are staged to allow for one tank being cleaned and filled, one tank undergoing fermentation, and one tank being drained for product recovery, on a continuous, sequencing batch-wise basis, with one fermenter being harvested every day. Temperature and suspension in the production fermenters is maintained via an external pump-around loop that includes a counter-current heat exchanger. The tanks are agitated to help drive the mass transfer required for the microbial bioconversion to reach completion.

In this process, the fermentation process occurs in parallel with the simultaneous hydrolysis of the starch substrates: as the amylase enzymes convert the starch into glucose, the yeast metabolize it into bio-ethanol and carbon dioxide. The simultaneous hydrolysis and fermentation process prevents substrate inhibition due to catabolite repression while preventing yield losses from opportunistic contaminants. Any free simple sugars present at the beginning of the fermentation process will be utilized initially and preferentially by the overwhelming number of yeast cells introduced in the seed inoculum.

After the fermentation process is complete, the fermentation broth containing approximately 10.7% bio-ethanol is transferred to an agitated beer well that serves as the surge tank for the subsequent distillation process in Area 6000.

CO_2 generated by the fermentation process is vented through a CO_2 scrubber, to capture and return bio-ethanol that is present in the CO_2 stream coming off the production fermenters. The scrubber water, containing extracted bio-ethanol, is combined with the clarified beer in the beer well prior to distillation. The CO_2 is then vented, or it can be transferred off-site to a CO_2 recovery and upgrading unit operated by a third party.

Area 6000: Distillation and Dehydration

This area is identical to the Area 5000 described in the Jerusalem artichoke conceptual design.

Area 7000: Stillage Handling

This area is identical to the Area 6000 described in the Jerusalem artichoke conceptual design.

Area 8000: Bio-ethanol Storage and Load-out

This area is identical to the Area 7000 described in the Jerusalem artichoke conceptual design.

Area 9000: Utilities

This area is identical to the Area 8000 described in the Jerusalem artichoke conceptual design.

Site Description and Layout Arrangement at Haghartsin

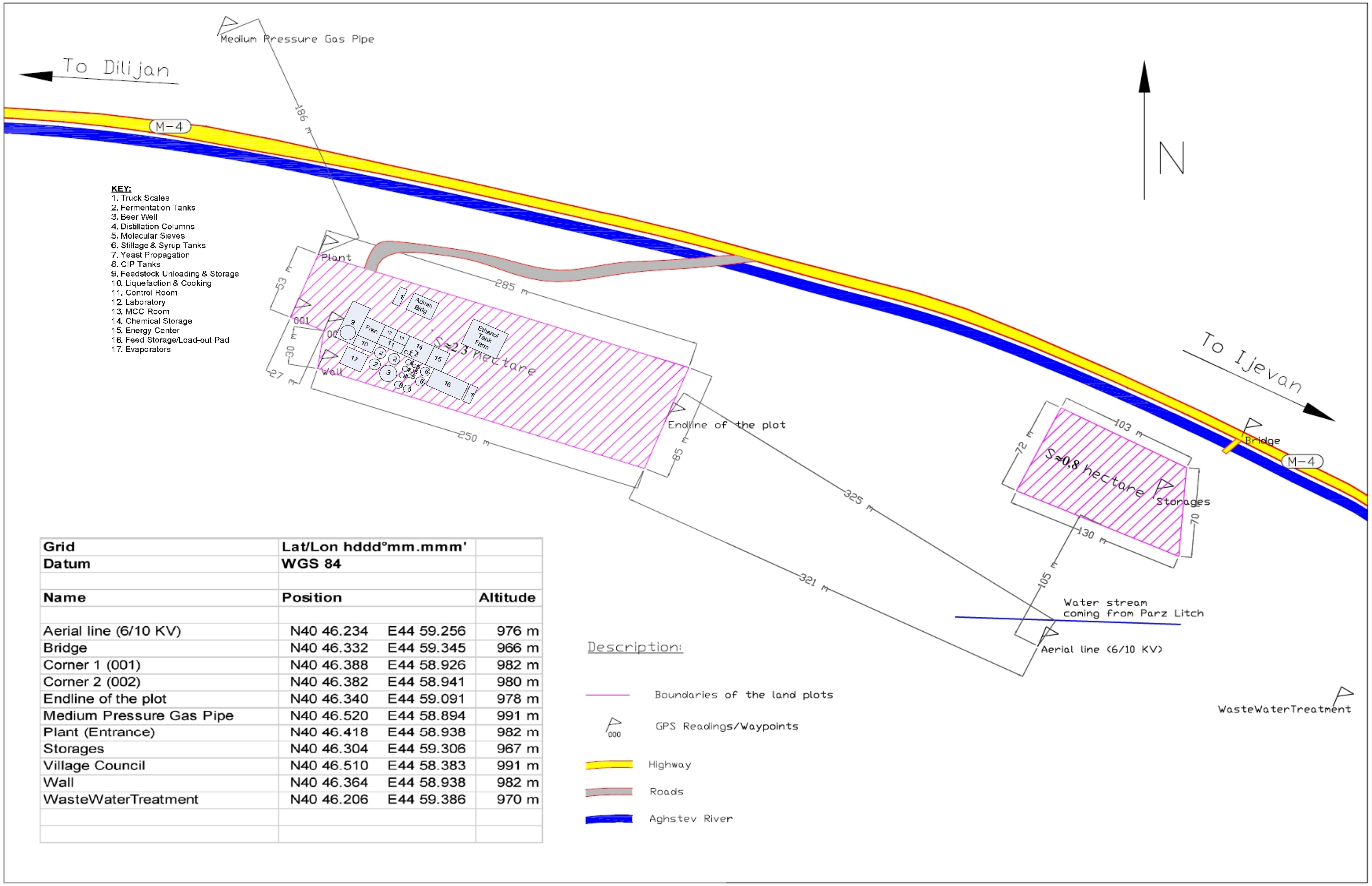
The proposed location for this plant is sited on land off highway M4 just north of Haghartsin village, approximately 1 km from the Community's local government office. Haghartsin is home to industrial and commercial facilities, including concrete factory and commercial storage areas. The city of Dilijan lies approximately 15 km to the west and the Marz center of Ijevan lies approximately 30 km to the east.

The site is approximately 2.5 hectares in size and comprises roughly two rectangular plots of land, currently an abandoned brown site that was previously used as for mobile military weapons installation and a storage area. Surrounding land is largely made up of industrial development.

Most of the necessary utilities are in close proximity to the site. A natural gas pipeline and a 10 kV electrical line are both within 500 meters of the site. No commercial use sewer lines are available in Haghartsin which requires an on-site waster treatment plant.

A site layout arrangement for the plant process areas is presented in Figure 7.4 on the following page.

Figure 7.4 – Conceptual Site Arrangement of the Corn Fractionation Process



Grid	Lat/Lon hddd°mm.mmm'		
Datum	WGS 84		
Name	Position		Altitude
Aerial line (6/10 KV)	N40 46.234	E44 59.256	976 m
Bridge	N40 46.332	E44 59.345	966 m
Corner 1 (001)	N40 46.388	E44 58.926	982 m
Corner 2 (002)	N40 46.382	E44 58.941	980 m
Endline of the plot	N40 46.340	E44 59.091	978 m
Medium Pressure Gas Pipe	N40 46.520	E44 58.894	991 m
Plant (Entrance)	N40 46.418	E44 58.938	982 m
Storages	N40 46.304	E44 59.306	967 m
Village Council	N40 46.510	E44 58.383	991 m
Wall	N40 46.364	E44 58.938	982 m
WasteWaterTreatment	N40 46.206	E44 59.386	970 m

Major Equipment List

The major equipment components of the plant are listed below in Table 7.6. The major equipment components would be sized appropriately for the chosen scale of production.

Table 7.6 – Corn Fractionation Major Equipment List

Area	Equipment Name	Equipment Type
1000	Truck Scales	TRUCK-SCALE
1000	Feedstock Truck Unloading Conveyor	BELT
1000	Feedstock Storage Bins	VERTICAL-VESSEL
1000	Feedstock Transport Conveyor	BELT
1000	Hammer Mill	MILL
1000	Mill Conveyor	BELT
2000	Dry Fractionation Package	PACKAGE
3000	Sulfuric Acid Pump	CENTRIFUGAL
3000	Petrol Pump	CENTRIFUGAL
3000	Amylase Pump	CENTRIFUGAL
3000	Sulfuric Acid Storage Tank	FLAT-BTM-STORAGE
3000	Propane Storage Tank	HORIZONTAL STORAGE
3000	Petrol Storage Tank	FLAT-BTM-STORAGE
3000	Amylase Storage Tank	FLAT-BTM-STORAGE
3000	Ammonia Addition Pkg	PACKAGE
3000	CIP System	MISCELLANEOUS
3500	Yeast Seed Tank	VERTICAL-VESSEL
3500	Yeast Propagation Tank	VERTICAL-VESSEL
3500	Propagation Tank Agitator	FIXED-PROP
3500	Propagation Tank Pump	CENTRIFUGAL
4000	Beer Column Feed Economizer	SHELL-TUBE
4000	Waste Vapor Condenser	SHELL-TUBE
4000	Hydrolysis/Screw Feeder/Reactor	VESSEL W/ PADDLES
4000	Hydrolyzate Unloading Pump	ROTARY-LOBE
4000	Hydrolyzate Slurry Dilution Water Pump	CENTRIFUGAL
4000	Reslurrying Tank	VERTICAL-VESSEL
4000	Reslurrying Tank Agitator	FIXED-PROP
4000	Hydrolyzate Cooler	SHELL-TUBE
4000	Reslurrying Tank Unloading Pump	CENTRIFUGAL
5000	Fermentation Tank Agitator A/B/C	FIXED-PROP
5000	Fermentation Tank A/B/C	VERTICAL-VESSEL
5000	Fermentation Cooler A/B/C	PLATE-FRAME

Area	Equipment Name	Equipment Type
5000	Fermentation Recirc/Transfer Pump A/B/C	CENTRIFUGAL
5000	Beer Storage Tank	FLAT-BTM-STORAGE
5000	Beer Transfer Pump	CENTRIFUGAL
5000	Vent Scrubber	ABSORBER
6000	Beer Column	DISTILLATION
6000	Beer Column Reboiler	SHELL-TUBE
6000	Beer Column Condenser	SHELL-TUBE
6000	Beer Column Feed Interchanger	PLATE-FRAME
6000	Beer Column Bottoms Pump	CENTRIFUGAL
6000	Beer Column Reflux Pump	CENTRIFUGAL
6000	Beer Column Reflux Drum	HORIZONTAL-VESSEL
6000	Rectification Column	DISTILLATION
6000	Rectification Column Reboiler	SHELL-TUBE
6000	Start-up Rect. Column Condenser	SHELL-TUBE
6000	Rectification Column Bottoms Pump	CENTRIFUGAL
6000	Rectification Column Reflux Pump	CENTRIFUGAL
6000	Scrubber Bottoms Pump	CENTRIFUGAL
6000	Rectification Column Reflux Drum	HORIZONTAL-VESSEL
6000	Stripper Column	DISTILLATION
6000	Stripper Column Reboiler	SHELL-TUBE
6000	Stripper Column Condenser	SHELL-TUBE
6000	Stripper Column Feed Interchanger	PLATE-FRAME
6000	Stripper Column Bottoms Pump	CENTRIFUGAL
6000	Stripper Column Reflux Pump	CENTRIFUGAL
6000	Stripper Column Reflux Drum	HORIZONTAL-VESSEL
6000	Molecular Sieve (9 pieces)	PACKAGE
7000	Whole Stillage Centrifuge	DECANTER
7000	1st Effect Evaporation	SHELL-TUBE
7000	2nd Effect Evaporation	SHELL-TUBE
7000	3rd Effect Evaporation	SHELL-TUBE
7000	Evaporator Condenser	SHELL-TUBE
7000	1st Effect Pump	CENTRIFUGAL
7000	2nd Effect Pump	CENTRIFUGAL
7000	3rd Effect Pump	CENTRIFUGAL
7000	Evaporator Condensate Pump	CENTRIFUGAL
7000	Evaporator Condensate Drum	HORIZONTAL-VESSEL
7000	Syrup Storage Tank	FLAT-BTM-STORAGE

Area	Equipment Name	Equipment Type
7000	Syrup Tank Agitator	FIXED-PROP
7000	Syrup Tank Pump	CENTRIFUGAL
7000	Cake/Syrup Mixer	MIXER
7000	Dryer	DRYER
7000	Cake Storage	CONCRETE-SLAB
8000	Denaturant In-line Mixer	STATIC
8000	Ethanol Product Pump	CENTRIFUGAL
8000	Ethanol Product Storage Tank	FLAT-BTM-STORAGE
9000	Firewater Pump	CENTRIFUGAL
9000	Firewater Storage Tank	FLAT-BTM-STORAGE
9000	Cooling Tower System	INDUCED-DRAFT
9000	Plant Air Compressor	CENTRIFUGAL
9000	Cooling Water Pump	CENTRIFUGAL
9000	Instrument Air Dryer	PACKAGE
9000	Plant Air Receiver	HORIZONTAL-VESSEL
9000	Make-up Water Pump	CENTRIFUGAL
9000	Process Water Circulating Pump	CENTRIFUGAL
9000	Process Water Tank	FLAT-BTM-STORAGE

7.3 Comparison of Proposed Bio-Ethanol Plant Operating Characteristics

A side-by-side comparison of plant operating statistics for a proposed 7,000 tonne per annum facility designed to process Jerusalem artichokes and also a feed corn fractionation plant of similar capacity is presented below in Table 7.7 based on a 350-day operating year. The project statistics shown are general guidelines only and may change with the specific plant design and other project variables as a result of modifications during detailed engineering design.

Table 7.7 – Bio-Ethanol Plant Statistics

Bio-Ethanol Plant Characteristics	Jerusalem Artichoke Process	Corn Fractionation Process
Plant Inputs		
Feedstock (tonnes/year)	96,695	23,567
Water (m^3/yr)	0	26,910
Electricity (kWh/yr)	1,787,000	3,299,000
Thermal Energy (GJ/yr)	79,556	69,612
Plant Outputs		
Denatured Ethanol		
(tonnes/year)	7,362	7,362
(liters/year)	9,381,632	9,381,632
Co-Product (tonnes/year)		
Wet (65% moisture)	15,964	12,199
Dry (10% moisture)	6,208	4,678
CO_2 (tonnes/year)	6,670	6,670
Wastewater (m^3/yr)	76,800	5,629

7.4 Storage Requirements

To ensure that these two bio-ethanol plants can run continuously, it is recommended that at least one weeks' worth of storage space for each of the major inputs (corn and Jerusalem artichokes) and two weeks' worth of storage capacity for outputs. Table 7.8 below presents recommended storage requirements in tonnes for feedstock inputs and a variety of outputs. Depending on the contractual agreements, additional storage may be required or desired.

Table 7.8 – Recommended Storage Requirements for the Proposed Plants

Feedstock Inputs and Product Outputs	Tonnes of Storage
Feed Corn	458
Jerusalem Artichoke	1,860
Distillers Grains	179
Fiber	34
Germ	65
Jerusalem Artichoke Co-Product	239
Ethanol	268

7.5 Indicative Budgetary Cost Estimates

Projected Jerusalem Artichoke Plant Capital Costs

The project team has prepared a cost estimate for the proposed plant by factoring costs for a 95 mega liter corn to bio-ethanol facility to the equivalent 8.9 mega liter (i.e. – 7,000 tonnes per annum) plant, and adjusting the values to accommodate for larger and heavier equipment due to the higher mass throughput. Table 7.9 illustrates anticipated capital costs for such a plant.

Table 7.9 – Estimate of General Contract Capital Costs for a 7,000 Tonne per Annum Bio-Ethanol Plant Utilizing Jerusalem Artichoke as the Feedstock

Major Equipment or Cost Category	Estimated Cost in U.S. Dollars
Total EPC Contract Costs	
Major Equip. & Field Tank	6,645.000
Design/ Build Packages	886,000
Electrical, Instrumentation & Controls	310,000
Protective Covering & Painting	111,000
Mechanical Piping & Valves	332,000
Steel Structures	443,000
Concrete	443,000
Buildings	221,000
Civil/Site	44,000
Equipment Rental/ Consumables	664,000
Sub-Total Construction	10,099,000
Detailed Engineering	1,010,000
EPC Fees	758,000
Sub-Total Project Services	1,768,000
Project Total EPC Cost	**11,867,000**
Owners Project Cost Estimate	
Site Development	775,000
Tuber Receiving and Storage	133,000
Insurance & Performance Bond	0
Administration Building, Office, Lab Equipment	664,000
Fire Protection & Potable Water	199,000
Rolling Stock and Shop Equipment	111,000
Organizational Costs and Permits	133,000
Spare Parts	133,000
Total Owners Costs	**2,148,000**
Total Installed Project Cost Estimate	
Project EPC Cost	11,867,000
Owners Costs	2,148,000
Total Installed Ethanol Project Cost	**14,015,000**

The estimated total combined cost for the pilot plant is $14.0 million. This estimate is based on the preliminary design, and as such, the cost may vary by ± 30%.

Projected Corn Fractionation Plant Capital Costs

The project team has prepared a cost estimate for the proposed plant by factoring costs for a 95 mega-liter corn to bio-ethanol facility to the equivalent 8.9 mega-liter plant, and adding costs for fractionation equipment. The anticipated capital costs are presented in Table 7.10 below:

Table 7.10 – Corn Fractionation Bio-ethanol Plant Projected Capital Costs

Major Equipment or Cost Category	Estimated Cost in U.S. Dollars
Total EPC Contract Costs	
Major Equip. & Field Tank	6,158,000
Fractionation Package	1,679,000
Design/ Build Packages	912,000
Electrical. Instrumentation & Controls	319,000
Protective Covering & Painting	114,000
Mechanical Piping & Valves	342,000
Steel Structures	456,000
Concrete	456,000
Buildings	228,000
Civil/Site	46,000
Equipment Rental/ Consumables	684,000
Sub-Total Construction	11,394,000
Detailed Engineering	1,139,000
EPC Fees	854,000
Sub-Total Project Services	1,993,000
Project Total EPC Cost	**13,387,000**
Owners Project Cost Estimate	
Site Development	775,000
Tuber Receiving and Storage	133,000
Insurance & Performance Bond	0
Administration Building. Office. Lab Equipment	664,000
Fire Protection & Potable Water	199,000
Rolling Stock and Shop Equipment	111,000
Organizational Costs and Permits	133,000
Spare Parts	208,000
Total Owners Costs	**2,223,000**
Total Installed Project Cost Estimate	
Project EPC Cost	13,387,000
Owners Costs	2,223,000
Total Installed Ethanol Project Cost	**15,610,000**

The estimated total combined cost for the pilot plant is $15.6 million. This estimate is based on the preliminary design, and as such the cost may vary by ± 30%.

7.6 Comparative Personnel Requirements

The personnel requirements utilized in developing variable cost inputs to the financial model in this preliminary feasibility study are listed in Table 7.11 below:

Table 7.11 – Personnel Requirements for the Proposed Plants

Labor Category	Jerusalem Artichoke	Corn Fractionation
Administration/Management		
General Manager (includes Commodities and Logistics Mgt)	1	1
Production Supervisor/Engineer	1	1
Accounting/ Clerical	1	1
Production Labor		
Laboratory Manager	1	1
Shift Supervisors	2	2
Shift Operators	3	3
Yard Staff	2	2
Maintenance		
Maintenance Manager	1	1
Maintenance Staff	0	1
Total Number of Direct Hire Plant Employees	**12**	**13**

8.0 Estimate of Total Financing Requirements

8.1 Financing Required for a Jerusalem Artichoke Processing Plant

An estimate of total financing requirements for a 7,000 tonne per annum bio-ethanol plant designed to process Jerusalem artichoke is presented in the Table 8.1 below assuming a limited recourse project financing with a 60/40 debt to equity ratio:

Table 8.1 –Estimate of Total Financing Requirements Assuming a Project Financing for the Jerusalem Artichoke Processing Plant

Major Cost Components	Estimated Cost in U.S. Dollars
EPC Cost to Construct	11,867,000
Owners Costs	2,148,000
Total Installed Bio-Ethanol Project Cost	**14,015,000**
Implementation Planning Costs	311,000
Project Development Fee	560,000
Commitment and Disbursement Fees	126,000
Financial Advisory and Arrangement Fees	268,000
Working Capital	1,0000,000
Interest During Construction	720,000
Total Soft Costs	**2,985,000**
Total Project Financing Requirements	**17,000,000**

8.2 Financing Required for a Dry Mill Corn Fractionation Processing Plant

Similarly, an estimate of total financing requirements for a 7,000 tonne per annum dry mill corn fractionation processing plant designed to process feed corn is presented in Table 8.2 below assuming a limited recourse project financing with a 60/40 debt to equity ratio:

Table 8.2 –Estimate of Total Financing Requirements Assuming a Project Financing for the Jerusalem Artichoke Processing Plant

Major Cost Components	Estimated Cost in U.S. Dollars
EPC Cost to Construct	13,387,000
Owners Costs	2,223,000
Total Installed Bio-Ethanol Project Cost	**15,610,000**
Implementation Planning Costs	379,000
Project Development Fee	624,000
Commitment and Disbursement Fees	135,000
Financial Advisory and Arrangement Fees	288,000
Working Capital	1,100,000
Interest During Construction	864,000
Total Soft Costs	**3,390,000**
Total Project Financing Requirements	**19,000,000**

9.0 Proposed Finance Design

9.1 Alternative Financing Approaches Considered

The project team evaluated two possible approaches to financing these proposed projects. The first was predicated upon a 100 percent equity deal while the second was a limited recourse project financing utilizing an extremely conservative debt to equity ratio of 60/40.

9.2 Need for Participation by an International Financial Institution Partner

In talking to various potential multilateral and bilateral lenders, the project team has singled out either the International Finance Corporation (IFC) of the World Bank Group or else the European Bank for Reconstruction (EBRD) as possibly the best-qualified international financial institutions to review an application of this nature from a technical perspective on a fast-track basis. Either institution can also take an equity position in the project whether direct or quasi-equity, and participate as a partner in the Project Company from the outset as opposed to just being available to provide dollar-denominated debt. In addition, given the inherent country risks associated with developing a project of this nature and magnitude in an emerging market country like Armenia, it is probably advisable to have the involvement of a multilateral development bank in the project as a major project participant to give comfort to other potential lenders and interested local investors. Lastly, participation by such a multilateral institution serves as an added insurance policy against unwarranted interference by any agency of the Government of Armenia with the continued operation of this privately financed and owned energy project once it has been implemented.

9.3 Rationale for a Limited Recourse Project Financing

The major financeable elements of the project security package that justify moving forward on a limited recourse project finance basis will be the various exclusive licenses, permits, supplier contracts with farmers or rural communities, escrow and reserve accounts, and insurance coverage that the Project Company will have already assembled or else will have to be obtained over time as various project documents are completed during the project planning stage.

These exclusive arrangements include but are not necessarily limited to the following:

- Long-term feedstock supply agreements and standard contracts arranged through ACBA-Credit Agricole with local farmers and community organizations
- Sales agreements for bio-ethanol with retail fuel dealers, outlets, and distributers
- Distribution contracts for the sale of co-products
- Final Clean Development Mechanism (CDM) agreement (if qualified which seems unlikely here) including permission to trade carbon credits
- Local siting and construction permits from the municipality involved
- EPC contract with enforceable performance penalties and liquidated damages
- Extended plant and process warranties and possible 5-year O & M
- Appropriate insurance package as may be required by the lenders

9.4 Potential Sources of Debt Considered

The Project Team has identified the following potential sources of debt, along with their indicative commercial terms and conditions, for funding these projects on a limited recourse project finance basis. These include:

International Finance Corporation "A" Loan—Loans for IFC's own account. Exposure limited to 25 percent of overall project cost for "Greenfield" projects up to a maximum of $100 million, with an appropriate tenor in line with the project's cash flow, plus up to two year grace period during construction build-out, and interest rate based on the 6-month LIBOR rate plus approximately 300 – 350 basis points for projects backed by a strong corporate guarantee and LIBOR plus 500 – 600 basis points for projects being developed by start up companies, unless a partial risk guarantee (PRG) can be obtained from World Bank which would save about 100 basis points, as well as stretch out tenors another 1-2 years. However, such a PRG will require a sovereign guarantee from the Government of Armenia.

International Finance Corporation "C" Loan—Subordinated or convertible debt with fixed 5-7 year repayment period or else preferred stock with no repayment schedule or some combination, often with a coupon rate and income participation or option to covert features. Debt will be unsecured with higher overall pricing and higher expected return on investment as compared to an A loan. Interest rates range from 17 to 20 percent depending upon the overall soundness of the project and strength of projected cash flows.

European Bank for Reconstruction and Development "A" Loan—Typical ceiling of 25 percent of overall project cost up to a maximum of $100 million, 10 - 12 year tenor including up to 2-year grace period, and an interest rate based on the 6-month LIBOR rate plus a spread similar to what is being offered by IFC in today's tight credit markets. Not interested in equity participation for Greenfield projects in Armenia.

European Bank for Reconstruction and Development "B" Loan—Commercial bank syndication underwritten by EBRD, 5-7 year tenor, and an interest rate at the 6-month LIBOR rate plus approximately 500 - 600 basis points for Armenia

Export-Import Bank of the United States—U.S. Ex-Im Bank's export credit lending programs are LIBOR-based, and can be made available at either fixed or variable interest rates. All programs and product lines available to U.S. equipment exporters through U.S. Ex-Im Bank Loan are presently open for Armenia. Maximum coverage is an amount equal to 85 percent import cover plus 15 percent local costs as well as capitalization of exposure fees and interest during construction for projects with minimal environmental impacts, maximum of 10-year repayment term plus up to 3-year grace period, interest rate of LIBOR plus approximately 350-400 basis points, and a one time risk exposure fee of approximately 16-24 percent of the total amount of the export credit being offered depending on risk category assigned to the project. Ex-Im Bank cover/support for short- and medium-term private sector transactions is typically limited to transactions with a commercial bank as obligor or guarantor. Coverage for all private sector transactions requires that the transaction be supported by an irrevocable Letter of Credit.

Private Export Funding Corporation—An alternative to the Export-Import Bank of the United States for long-term dollar-denominated export credit debt is through the Private Export Funding Corporation, more commonly referred to as PEFCO. Loans from this particular source essentially have interest rates, tenors, and exposure fees similar to export credits from the Export-Import Bank of the United States.

U.S. Overseas Private Investment Corporation Direct Loan—The borrower of a project finance loan from U.S. OPIC is typically an overseas entity that is at least 25 percent owned by an OPIC-eligible U.S. business. Such loans can be used to fund overseas investments, permanent working capital accounts, fixed assets, and expansions of existing facilities or systems. This product is expressly intended to provide funding support to creditworthy operations overseas that have the projected cash flow to repay the loan. As to the maximum size of a loan under this program, U.S. OPIC can make guarantees available up to a limit of $250 million per project, but typically limits participation to 50 percent for new starts and 75 percent for expansion projects. U.S. OPIC direct financing has fixed interest rates that are U.S. Treasury-based, plus a spread of 400 - 600 basis points, and payable quarterly or semi-annually.

ACBA-Credit Agricole—Local debt financing for the agriculture sector in Armenia. Typical tenors for rural farmers and related social infrastructure projects in Armenia today are up to a maximum of 18 months repayment for loans intended to cover working capital, seeds, and fertilizer for instance, and greater than three years for repayment of capital equipment items such as tractors and combines at interest rates of roughly 16 percent for members in good standing in the local farmers association and 20 percent for all others. Priority lending is for local farmers.

Cascade Credit—Low interest rate lending support and leasing products for rural farmers and small hydro producers with tenors for rural farmers ranging between 6 months and 8 years and loan sizes ranging from $5,000 – $15,000. Typical small hydro loans have average tenors of 4 years plus up to a 2-year grace period with an average loan size of $2.6 million. With respect to interest rates, rural farm loans are between 12 – 15% and roughly 16 – 18% for energy projects. Interest rates for Cascade Credit leasing programs average around 16%. Finally, group lending is possible with local farmers' associations.

Vendor Financing—Several vendors have tentatively expressed a willingness to provide vendor financing and/or stretched out payment terms for projects of this nature if backed by a strong corporate guarantee.

9.5 Average Annual Unleveraged Return on Investment Requirement

The unleveraged return on investment expectations among most potential local investors was 15 percent. The IFC was a little more aggressive stating that for Armenia it would typically expect an unleveraged return of between 15 and 20 percent. For the purposes of the financial analysis of these two project opportunities, the project team utilized an average 15 percent return, which seemed sufficient to interest serious local investors.

9.6 Applicability of the CDM Process to Support a Project Financing

The Clean Development Mechanism (CDM) is one of the instruments set up by the 1997 Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) which allows industrialized nations and countries with economies in transition, collectively known as Annex I countries, to gain credit for greenhouse gas (GHG) emission reductions achieved through projects undertaken in developing and emerging market countries. As defined by Article 12 of the Protocol, the CDM has two purposes: to assist Annex I countries in complying with their Kyoto commitments, and to help non-Annex I countries achieve sustainable development. Thus, under the CDM, an Annex I country or private company may engage in projects in non-Annex I countries that reduce emissions of GHGs and help non-Annex I countries achieve sustainable development. The certified emissions reductions (CERs) generated through CDM projects may be used by Annex I countries to help them meet their Kyoto commitments.

As mentioned above, one purpose of the CDM process is to assist developing countries to achieve sustainable development. Sustainable development is a broad concept that includes environmental sustainability, economic development, and social equity. While a planned program of bio-ethanol production satisfies all those definitions in sustainable development, determining a baseline and proving additionality may be difficult when blending of bio-ethanol is mandatory. However, in principle, biofuel projects are eligible under the CDM. To be included in CDM projects though, biofuel projects have several barriers to overcome first including: (a) the establishment of approved baseline and monitoring methodologies which is a necessary requirement for validation; (b) certified emission reduction (CER) revenues will in most cases only cover part of the additional cost of biofuels compared to conventional fuels; and (c) CO_2 abatement costs of biofuels are in general higher than current CER prices. Nevertheless, biofuel programs may provide an opportunity to develop projects with strong sustainable development components, and therefore contribute strongly to the twin objectives of the CDM process: sustainable development in developing countries and achievement of part of the Kyoto target in developed countries

Using Jerusalem artichoke or corn-derived bio-ethanol for blending with petrol is a strategy that is extremely timely and relevant to Armenia today. Not only can such a strategy help reduce GHG (Greenhouse gas) emissions and improve overall air quality in major urban centers such as Yerevan and Gyumri, but it can also serve as an instrument to stimulate rural economic development. In addition, such a strategy could contribute towards improved energy security by reducing the country's exposure to economic shocks from extreme volatility in world oil market prices as well as regional instability that could cause a disruption in fuel supply. These later two concerns are becoming increasingly important since Armenia presently imports fully 100 percent of its motor transport fuel requirements in addition to facing growing demand for motor fuels as the economy expands and living standards improve. The Armenian Ministry of Energy may choose to implement a bio-ethanol blending policy for Armenia with a target of five percent blending by volume with petrol by 2014. Once this policy has been launched, it will make it possible to create an entire new energy industry without relying upon significant subsidies and financial subsidies as has occurred elsewhere most notably in Brazil and the United States. With a policy framework in place and with the noteworthy absence of direct financial subsidies, a bio-ethanol project sponsor *may under certain specific circumstances under the CDM rules* be able to prove additionality giving the developer access to CER emission trading credits under the Kyoto Protocol CDM process.

The CDM process poses some special coordination issues by virtue of its unique structure. For example, the CDM is a project-based form of credit trading, and trading under this mechanism establishes a contract between a party with a firm national emission cap (Annex 1 country) and one with out such a cap (non-Annex I party). Article 12 of the Kyoto Protocol subjects the projects under the CDM to have a number of eligibility criteria, foremost being that the projects have to meet the overall objective of contributing additional financing for sustainable development (for non-Annex I countries).

Three other issues are important to take into consideration when requesting CERs under the CDM process. These include that:

1) Bio-ethanol projects covered under government subsidy programs are not eligible for the CDM process nor are they eligible if a mandatory fuel blending program exists *unless that program is not rigorously enforced*.

2) The project sponsor must be able to prove additionality to be eligible (i.e. – that the project would not be financially feasible or viable without the use of CERs)

3) The tools used for determining baseline and reduced emission levels with bio-ethanol blending must ensure avoidance of double counting of emission reductions from the production of biofuels. In this regard, to be eligible under CDM, biofuels projects must be able to substantiate that:

    - The producers of biofuels Substitute liquid biofuels for fossil fuels
    - The producers of biofuels hold CER claims from the production of biofuels only
    - Biofuels are sold to wholesale customers, final consumers, or fueling stations,
    - Biofuels are consumed only in the transport, residential, commercial, or industrial sectors
    - Project sponsors are active project participants and not just passive investors

In the event that a host country exports biofuels, a different framework is required to account for leakage resulting from exports of biofuels to Annex I countries. In this regard, export-oriented projects are eligible for CDM credits even if the country has a mandatory blending program.

If a bio-ethanol project adheres to the policy procedures and guidelines outlined above, it can take advantage of the trading of CERs under the CDM process. Payments under CDM are quite flexible. In this regard, CERs can either be sold at a price per tonne over time during the operation of the plant and thus continue to drive revenues to the bottom line from now until 2013 or else accept a combination of an upfront payment with a reduced price per ton during the intervening years of commercial operation through 2013.

In summary, the CDM process can be a potential source of funding for a bio-ethanol plant, but only under certain highly restrictive circumstances. Moreover, it will require that specific methodologies and approved monitoring activities for determining emission reductions be worked out first. Finally, the financial analysis of the proposed projects conducted by the project team does not include any revenue from CERs sales. If, in fact the projects do qualify under CDM rules, these revenues would improve the viability of the projects accordingly.

10.0 Preliminary Finance Plans and Illustrative Transaction Structure

This section contains suggested finance plans for these two bio-ethanol processing plants based on a limited recourse project financing as opposed to an unleveraged 100 percent equity deal utilized in the project team's financial modeling for this study. However, the reason the project team used a straight 100 percent equity deal for modeling purposes in this preliminary feasibility study is that it gives more conservative results, and can be achieved with greater timeliness and certainty rather than submitting the project to a lengthy due diligence process with an uncertain outcome. However, a limited recourse project finance will, if structured correctly, yield considerably higher returns to the investors since it is a leveraged deal utilizing long-term debt carrying significantly lower effective interest rates than the equity return expectations from investors.

10.1 Suggested Limited Recourse Project Finance Plan for the Goris Plant

Level of Gearing

A debt to equity ratio of 60/40 is proposed for this first of a kind biofuels project in Armenia, which is an extremely conservative level of gearing if there is a guaranteed market based on mandatory blending of 5 percent of bio-ethanol by volume by the year 2014. This is especially true for a plant that will be first to market.

Likely Sources of Debt

Several lending institutions have expressed interest in this project opportunity including IFC, EBRD, and ACBA-Credit Agricole. In this regard, the most likely sources of debt for this planned $17.0 million project are presented in the table below:

Table 10.1 – Sources of Debt for the Goris Jerusalem Artichoke Processing Plant Project

Sources of Debt	Amount in Millions of U.S. Dollars	Percent of Total Debt	Percent of Total Costs
International Finance Corporation or EBRD A Loan	2.6	25.5	15.3
International Finance Corporation or EBRD C Loan (Mezzanine Financing)	1.7	16.7	10.0
Export Credits	3.9	38.2	22.9
ACBA-Credit Agricole (Local Currency Debt)	2.0	19.6	11.8
Total Debt	**10.2**	**100.0**	**60.0**

Anticipated Sources of Equity

Similarly, anticipated sources of equity for this planned $17.0 million project are listed in the table below:

Table 10.2 – Sources of Equity for the Goris Jerusalem Artichoke Processing Plant Project

Sources of Equity	Amount in Millions of U.S. Dollars	Percent of Total Equity	Percent of Total Costs
Project Sponsor	4.0	58.8	23.5
Other Local Investors	2.8	41.2	16.5
Total Equity	**6.8**	**100.0**	**40.0**

Guarantee Mechanisms Currently Under Consideration

It is assumed that many of the following backstop guarantees will be required to secure long-term loans for this project:

- Mortgages on all company fixed plant facilities, land, and other related assets
- Collateral assignment of all retail supply contracts and off-take agreements until such time as senior debt has been retired
- Lock Box managed by a reputable international commercial bank as the project company's Trustee
- Possible establishment of a prepaid reserve account sufficient to cover at least six months of debt service
- Assignment of the prepaid reserve account and any other revenue accounts until such time as senior debt has been retired
- Step-in rights in the event of an uncured default whereby lenders would have the right to assume operation of the project company, as well as exercise authority to appoint replacement board members
- Inter-creditor arrangement assuring against disruptive enforcement of different security rights of the various lenders

Proposed Exit Strategy for Potential Investors

Several possible exit strategies exist for the initial equity partners, including an initial public offering on either the AIM Exchange in London, the RTS Exchange in Moscow, or possibly even the Yerevan Stock Exchange within three to four years of the successful completion and commercial operation of the facility. However, probably the most credible near-term exit strategy is either a partial stock sale to another strategic investor interested in rapidly penetrating the renewable energy market in Armenia, or else a friendly takeover offer from another petroleum importer or retail petroleum product distribution company.

10.2 Suggested Limited Recourse Finance Plan for the Haghartsin Plant

The suggested plan for the Haghartsin dry mill corn fractionation processing plant is almost identical to the proposed finance plan highlighted in Section 10.1 above. The only difference is in the actual amounts of debt and equity required to finance this facility on a limited recourse project finance basis. Likely sources of debt and equity for this plant are presented in Tables 10.3 and 10.4 below:

Likely Sources of Debt

Several lending institutions have expressed interest in this project opportunity including IFC, EBRD, and ACBA-Credit Agricole. In this regard, the most likely sources of debt for this planned $19.0 million project are presented in the table below:

Table 10.3 – Sources of Debt for the Haghartsin Dry Mill Corn Fractionation Processing Plant Project

Sources of Debt	Amount in Millions of U.S. Dollars	Percent of Total Debt	Percent of Total Costs
International Finance Corporation or EBRD A Loan	3.0	26.3	15.8
International Finance Corporation or EBRD C Loan (Mezzanine Financing)	1.7	14.9	9.2
Export Credits	4.7	41.3	24.5
ACBA-Credit Agricole (Local Currency Debt)	2.0	17.5	10.5
Total Debt	**11.4**	**100.0**	**60.0**

Anticipated Sources of Equity

Similarly, anticipated sources of equity for this planned $19.0 million project are listed in the table below:

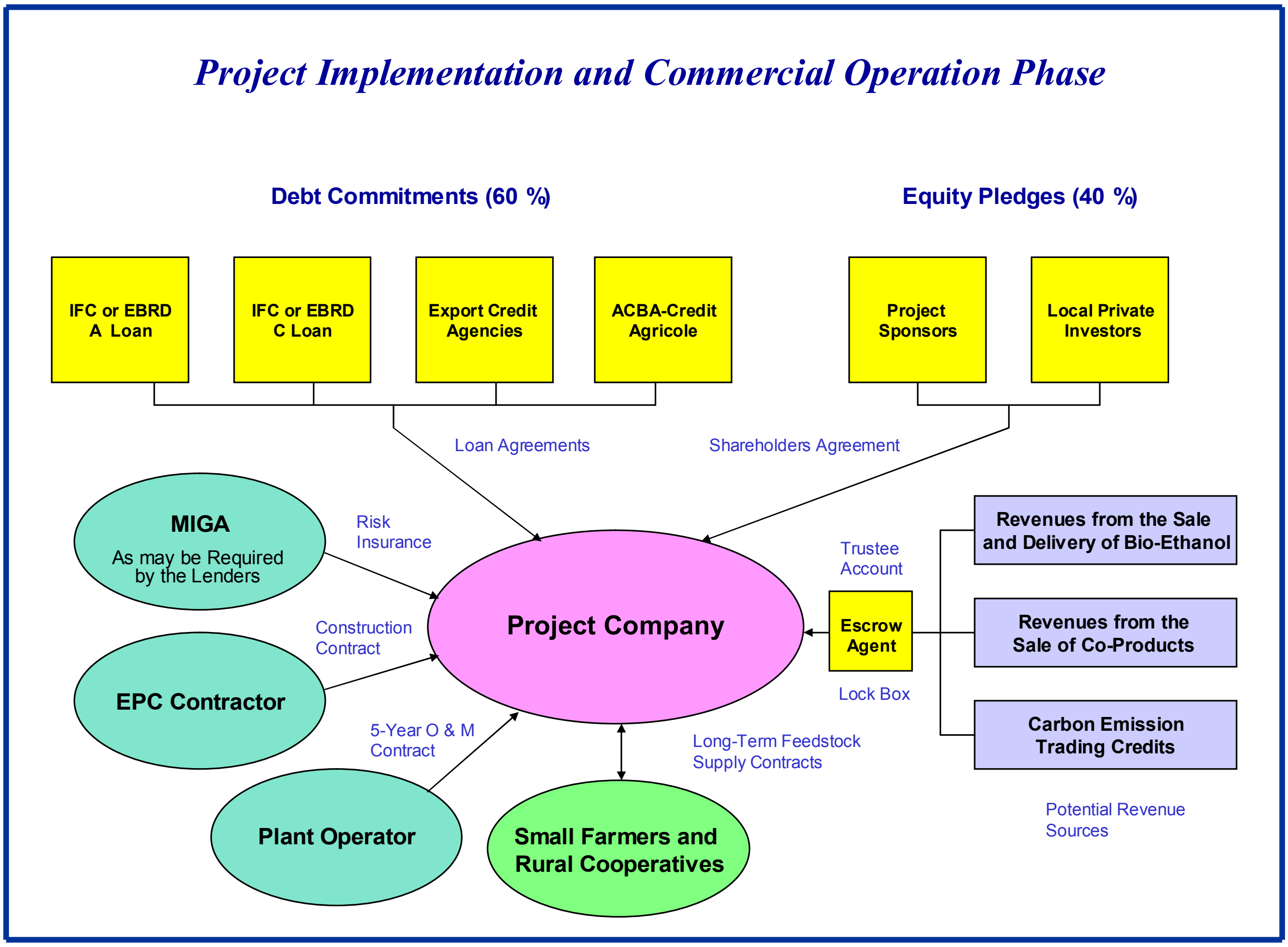
Table 10.4 – Sources of Equity for the Haghartsin Dry Mill Corn Fractionation Processing Plant Project

Sources of Equity	Amount in Millions of U.S. Dollars	Percent of Total Equity	Percent of Total Costs
Project Sponsor	4.0	52.6	21.1
Other Local Investors	3.6	47.4	18.9
Total Equity	**7.6**	**100.0**	**40.0**

10.3 Illustrative Transaction Structure for Project Implementation

A proposed transaction structure showing the interactions among the various participants during the implementation stage of either of these two projects, along with suggested sources of both debt and equity, are presented in Figure 10.1 below for a 7,000 tonne per annum bio-ethanol processing plant:

Figure 10.1 – Illustrative Transaction Structure for a 7,000 Tonne per Annum Processing Plant Project



11.0 Economic and Financial Analysis of the Proposed Facilities

Due to the lack of reliable price information for the proposed feedstocks (Jerusalem artichoke and feed corn), the financial analysis was necessarily conducted by setting an acceptable unleveraged return on investment (i.e. – 15%) and solving for the cost of the feedstock that would guarantee this return over time, which in any event is considered to be the most conservative approach. A variety of scenarios was analyzed to assess the sensitivity of the projected results to the different assumptions.

Using a bio-ethanol price of 410 AMD per liter ($1.34 per liter), Jerusalem artichoke can be purchased for a maximum of 27 AMD per kg ($88.52 per tonne) to receive an average return on investment of 15% over the first 10 years. Similarly, to achieve an average return on investment of 15%, feed corn must be purchased for less than or equal to $393 per tonne (Armenia import costs for corn in 2008 have been around $400 per tonne).

11.1 Assumptions and Key Inputs to the Financial Model

Principal Assumptions Used in the Financial Forecast

The major variables for the financial analysis of a biofuels project are bio-ethanol price, feedstock price, co-product price, and energy costs. The assumptions and inputs used by the project team to determine the project's overall financial viability included:

- *Bio-Ethanol Retail Price*. The bio-ethanol retail price used in the financial forecast is $1.34 (410 AMD) per liter of denatured bio-ethanol. The net price includes denatured bio-ethanol product sold at $1.34 per liter less shipping ($0.01/liter) and a 1% sales commission.

- *Bio-Ethanol Yield.* The yield is an important variable for profitable bio-ethanol production. A yield of 92.4 liters of denatured bio-ethanol for each tonne of Jerusalem artichoke (at 80% moisture or less) processed was used in the financial analysis. In addition, a yield of 378.51 liters of denatured bio-ethanol for each tonne of feed corn (at 15% moisture or less) processed was used in the financial analysis. The yield level of different types of Jerusalem artichoke is under review and current studies conducted in Armenia are showing significantly higher yields for some of the hybrid species than the project team actually included in its financial projections in an effort to be as conservative as possible in its modeling activities.

- *Feedstock Price*. Feedstock prices were set to ensure the plant has a minimum Return on Investment (ROI) of 15%. These prices were used in the financial model and represent the highest price that the processing plant can pay for feedstocks, and any price below these figures will earn the investor additional profits and higher returns. The delivered feedstock price for Jerusalem artichoke in the analysis is $88.52 per tonne (27 AMD per kg). The delivered feedstock price for feed corn in the analysis is $393 per tonne (119 AMD per kg).

- *Co-Product Price*. The selling price for Jerusalem artichoke co-product is assumed to be $266 per tonne. This co-product of bio-ethanol production from Jerusalem artichoke is not currently available, so there is significant uncertainty regarding its sales potential. The price was estimated based upon the expected protein content of the product. It is uncertain if buyers would value the product similarly. The selling price for the distiller's grains from corn is assumed to be $416.12 per tonne or 106% of the corn price on a dry basis. Similarly, germ is assumed to sell for \$451.95 per tonne or 115% of the corn price on a dry basis, and bran is assumed to sell for \$216.15 per tonne or 55% of the corn price on a dry basis.

- *Co-Product Yield.* A state-of-the-art bio-ethanol plant should yield about 64 kg of co-product at 10% moisture per tonne of Jerusalem artichoke processed. The distiller's grains from corn will yield 198 kg per tonne (at 15% moisture), germ is assumed to yield 71 kg, and bran 38 kg per tonne.

- *Incentive Payments.* The financial forecast does not include any tax credits or bio-ethanol incentive payments. Instead, the feedstock prices were set to result in a before tax return on investment of about 15%. In the event that there is a difference between the prices assumed in the model and possible higher prices that are offered to the market in the future when these two processing facilities will come on line, this shortfall would necessarily have to be covered by subsidies or incentives to either growers or plant owners to ensure long-term viability of the recommended program.

- *Financing*. 100% equity financing was assumed for financial modeling purposes since this is the more conservative approach while at the same time addressing the potential risks of this project (technology, feedstock, and product markets), as well as accounting for the absence of large-scale commercial loans for this type of project in Armenia today. If the project proponents are able to obtain loans with interest costs below the expected rate of return, then returns on investment would improve on a leveraged basis.

- *Electricity Price.* The electric rate is assumed to be 4.7¢ per kWh.

- *Water Usage.* Due to the high water content of the Jerusalem artichoke, little or no process water needs to be added. On the other hand, the corn fractionation plant will require 1,140 liters of water per tonne of corn processed.

- *Natural Gas Price*. The price for natural gas is assumed to be \$7.52 per GJ.

- *Carbon Dioxide Sales.* 100% of the CO_2 is assumed to be sold at \$3 per tonne. This raw CO_2 would need to be further processed to be useful. The assumption that all of the CO_2 can be sold is the best case scenario. The price estimate is based on pricing in the United States.

Table 11.1 shows the key project assumptions discussed above plus additional assumptions used in the financial projections.

Table 11.1 – Assumptions Used In the Financial Forecast for Both Jerusalem Artichoke and Corn

Armenia Bio-Ethanol Project	Jerusalem Artichoke	Feed Corn
Nameplate Ethanol Production (tonnes/year)	**7,362**	**7,362**
Anhydrous Ethanol Production (tonnes/year)	7,000	7,000
Product Values		
Conversion Rate (liters/ tonnes feedstock)	92.4	378.51
Ceiling Price for Feedstock ($/tonne) (represents highest price that can be paid for feedstock and still achieve a 15% ROI)	88.52	393.00
Ethanol ($/liter)	1.34	1.34
Ethanol Shipping Cost ($/liter)	0.01	0.01
Feed Product (DDGS or JA Feed) ($/ tonne)	266.00	416.12
Germ ($/ tonne)	n/a	451.95
Bran ($/ tonne)	n/a	216.15
CO_2 ($/ tonne)	3.00	3.00
Denaturant ($/liter)	1.34	1.34
Natural Gas ($/GJ)	7.52	7.52
Electricity ($/kWh)	0.047	0.047
Makeup Water ($/1,000 liters)	n/a	0.02

11.2 Cash Flow Projections and Summary of Key Financial Metrics

Summary Comparison of Alternative Processing Facilities

A fixed pre-tax average annual Return on Investment (ROI) of 15% was used to determine the required feedstock price to achieve a financially viable investment opportunity. A summary of the preliminary financial model outputs are presented in Table 11.2 below. The ROI is the average project return for the 11 years of the financial forecast, including the construction year. In addition, the 11-year economic forecasts for each plant are presented in the appendices.

Table 11.2 – Summary Comparison of Financial Modeling Results

Armenia Bio-Ethanol Projects	Jerusalem Artichoke	Feed Corn
11-year Average Annual ROI	15%	15%
Required Feedstock Price in $/ tonne (feedstock costs must be less than or equal to this price to be financially viable)	$88.52	$393
Internal Rate of Return	15. 2%	15. 7%
Earnings Before Interest, Taxes, Depreciation, and Amortization (EBITDA) Year 2	$3,071,036	$3,478,799
Bio-Ethanol Fuel Retail Price ($/liter)	$1.34	$1.34
Total Installed Project Cost	$14,015,000	$15,610,000

Based on these results and competitive guidelines, either plant can provide sufficient economic returns with the assumptions used in this report. The price of bio-ethanol and the price of the feedstock have the greatest impact on financial performance of the proposed plants. The risk is perceived to be greater with Jerusalem artichoke due to the lack of commercial production experience, costs for cultivation and harvest, and historical pricing data. However, in the final analysis, such risks are common to any new dedicated energy crop.

Anecdotal data for corn prices indicates that the corn price of $393 per tonne (used to achieve 15% ROI) is similar to the price of imported corn in 2008 ($400 per tonne). This price is significantly above the world market price of corn, likely at least in part due to high transportation costs to Armenia and small trading volumes. It would be expected that local corn producers could grow corn profitably at these prices, but corn production in the country has only started to increase rather recently through the incentives provided by the Ministry of Agriculture.

Further research is needed to verify the actual production costs of both Jerusalem artichoke and feed corn in Armenia. In addition, the markets for DDGS and the Jerusalem artichoke co-product need to be evaluated further to verify the assumptions used in this report.

11.3 Sensitivity Analysis Results

The variables that have the greatest impact on the project's profitability are the delivered price for feed corn and Jerusalem artichoke and also the bio-ethanol selling price. This is the case for all bio-ethanol plants, not just the proposed bio-ethanol projects in Armenia. A series of sensitivity analyses were run to examine the effect of critical parameters on the projected 11-year Average Annual After-Tax ROI. Please see Figures 11.1 through 11.11 which present the results of these sensitivity analyses. Each of the sensitivity figures assumes that only one variable is changing and that all others are constant as listed in the financial assumptions listed towards the beginning of this chapter. As expected, the projected profitability as measured by the ROI is very sensitive to the corn, Jerusalem artichoke, and bio-ethanol prices; somewhat sensitive thermal energy price; and relatively insensitive to the electricity price.

The sensitivity to feedstock price shows that, with a bio-ethanol price of $1.34/liter, the ROI breaks even at Jerusalem artichoke prices around $110 per tonne. Similarly, the plant breaks even with a corn price of $498 per tonne.

As can be seen in the Annex, energy costs typically represent about 15 percent of a plant's operating expenses. The corn plant breaks even with thermal energy below $42 per GJ. The Jerusalem artichoke plant breaks even with thermal energy prices below $34 per GJ.

The cost of electricity has a small affect on the average annual after-tax ROI; doubling the cost of electricity is projected to reduce ROI by about one percentage point. Bran and carbon dioxide prices have a similar small impact on the profitability of the plant.

The price of DDGS, Jerusalem artichoke co-products, and germ has a moderate effect on the profitability of the facility. As mentioned previously, the price obtained for DDGS and germ are generally correlated to the cost of corn, the feed it would nominally replace. The sensitivity profile thus helps to illustrate the impact of a price premium or drop due to saturation; a price change of $100 per tonne changes the ROI by about five percentage points.

Figure 11.1 – Effect of Jerusalem Artichoke Price on 11-year Average Annual ROI

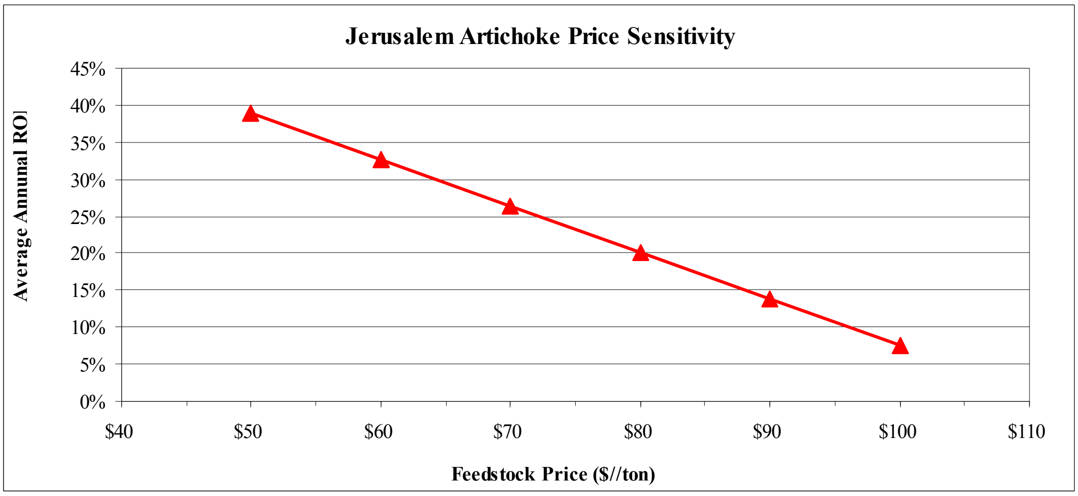


Figure 11.2 – Effect of Corn Price on 11-year Average Annual ROI

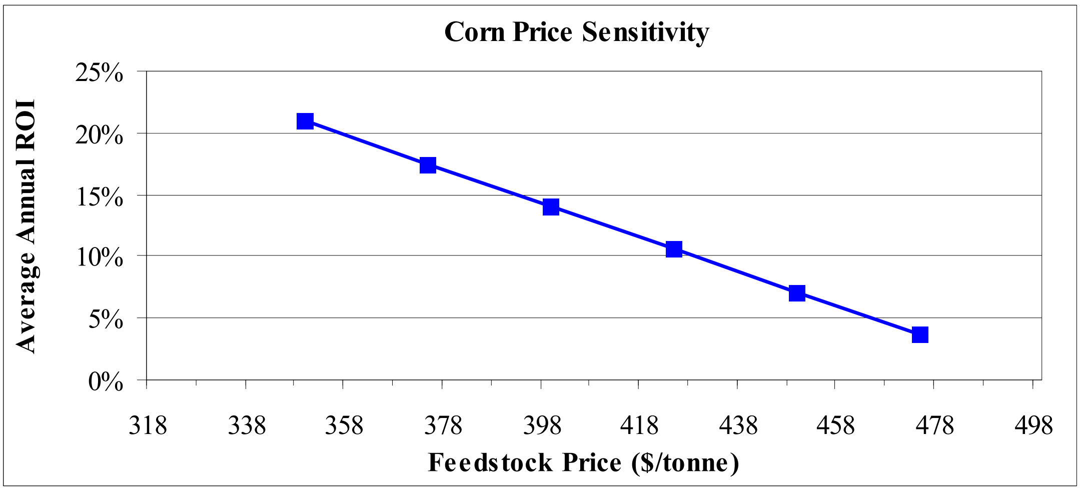


Figure 11.3 – Effect of Ethanol Price on 11-year Average Annual ROI

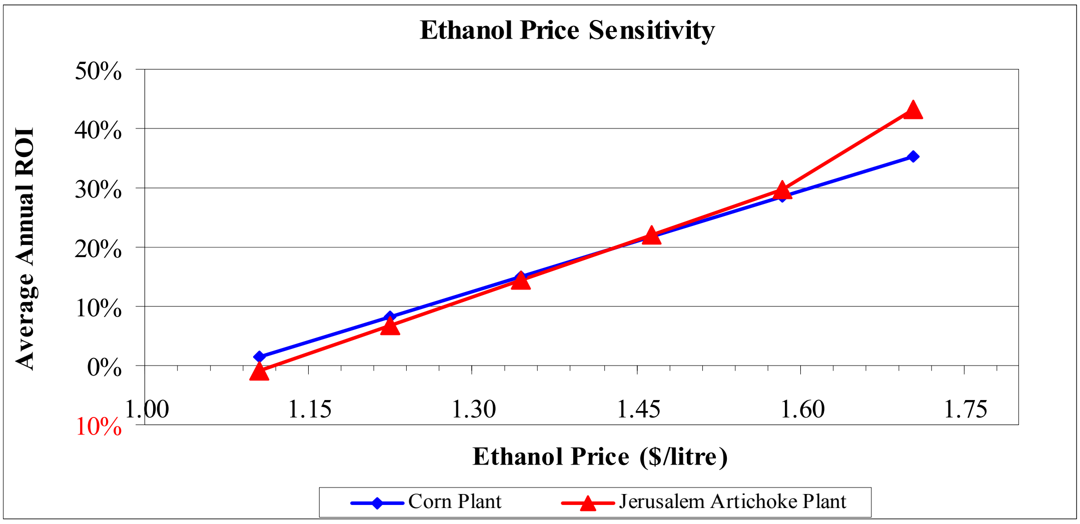


Figure 11.4 – Effect of Thermal Energy Price on 11-year Average Annual ROI

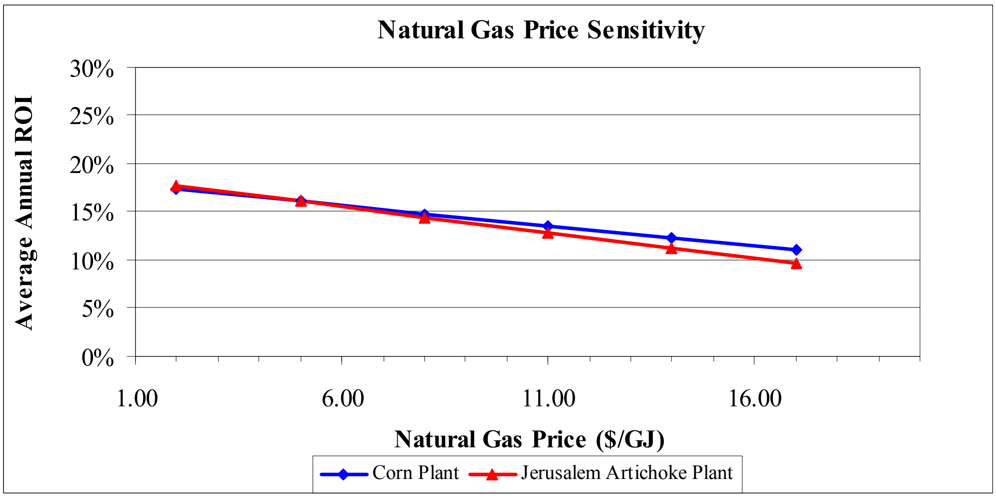


Figure 11.5 – Effect of Electricity Price on 11-year Average Annual ROI

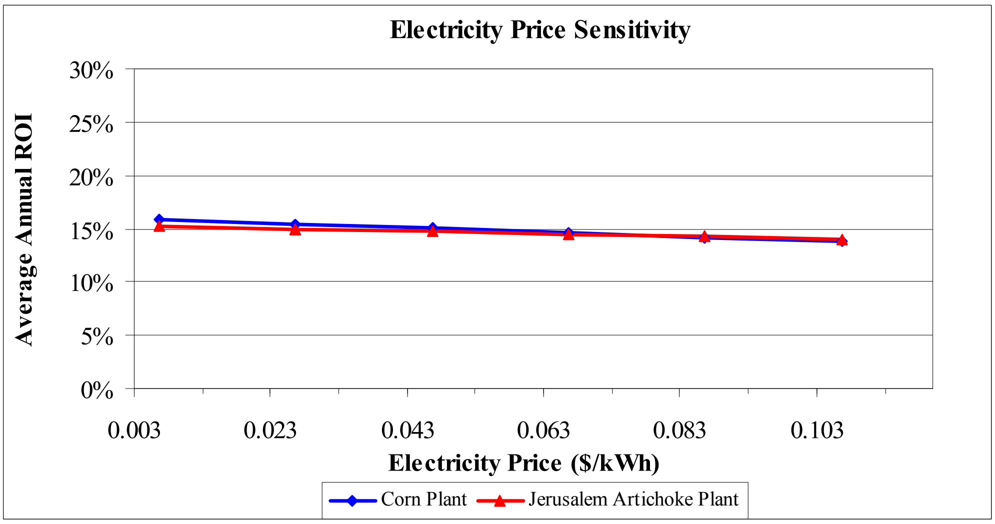


Figure 11.6 – Effect of DDGS Price on 11-year Average Annual ROI

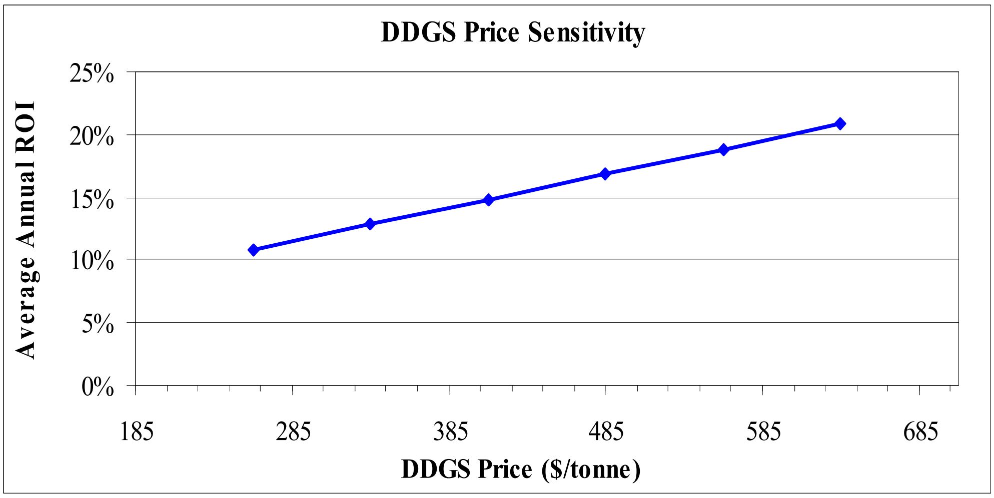


Figure 11.7 – Effect of Germ Price on 11-year Average Annual ROI

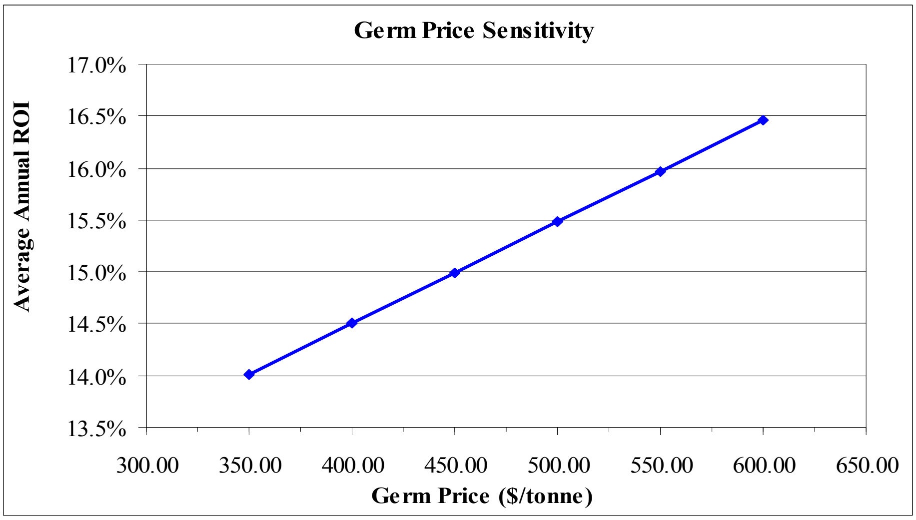


Figure 11.8 – Effect of Bran Price on 11-year Average Annual ROI

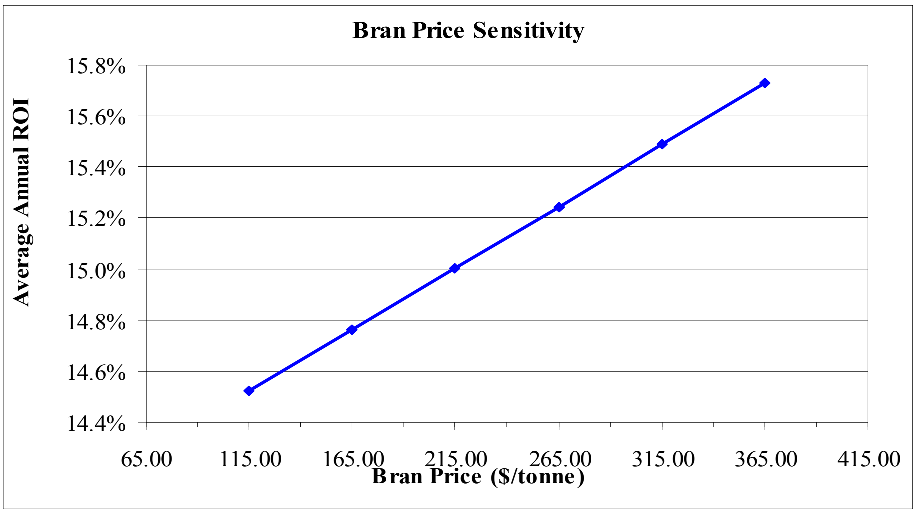


Figure 11.9 – Effect of Jerusalem Artichoke Feed Price on 11-year Average Annual ROI

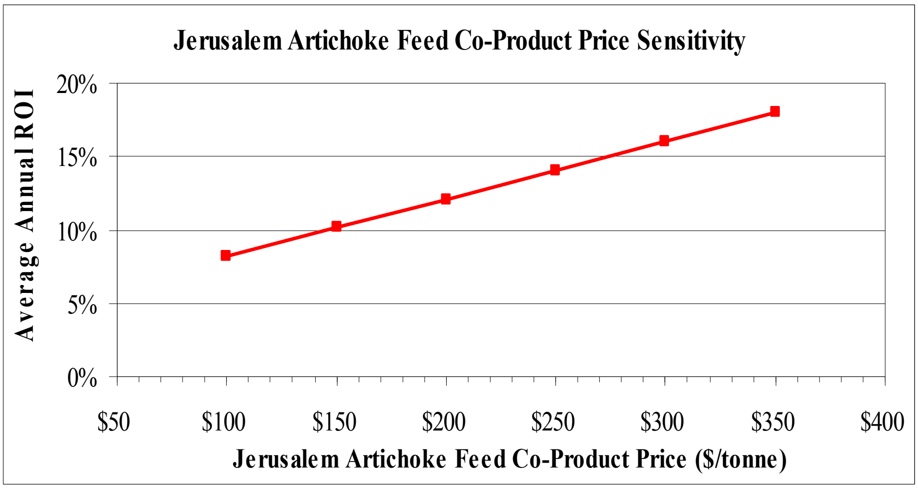


Figure 11.10 – Effect of Carbon Dioxide Price on 11-year Average Annual ROI

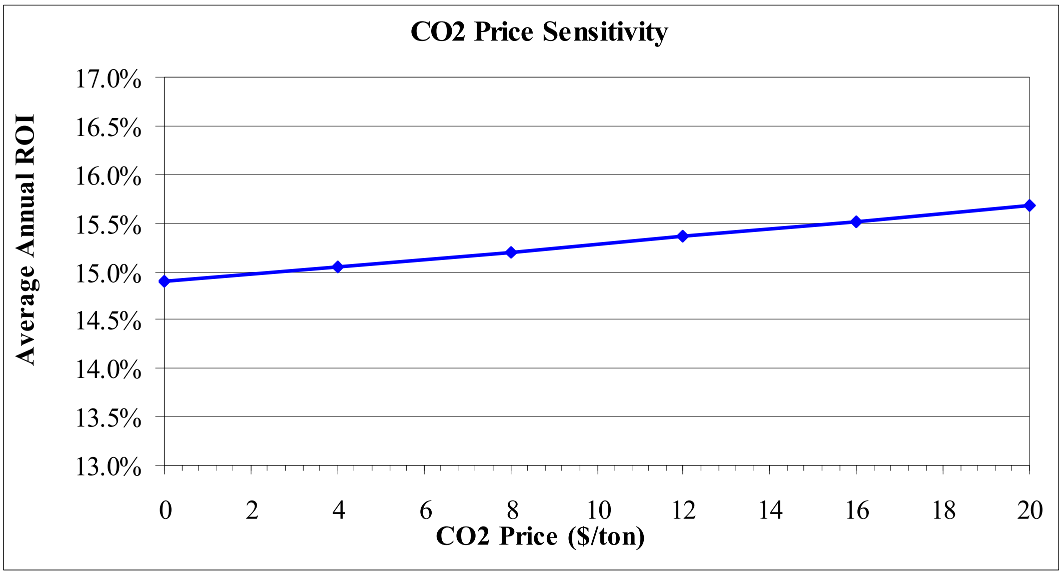
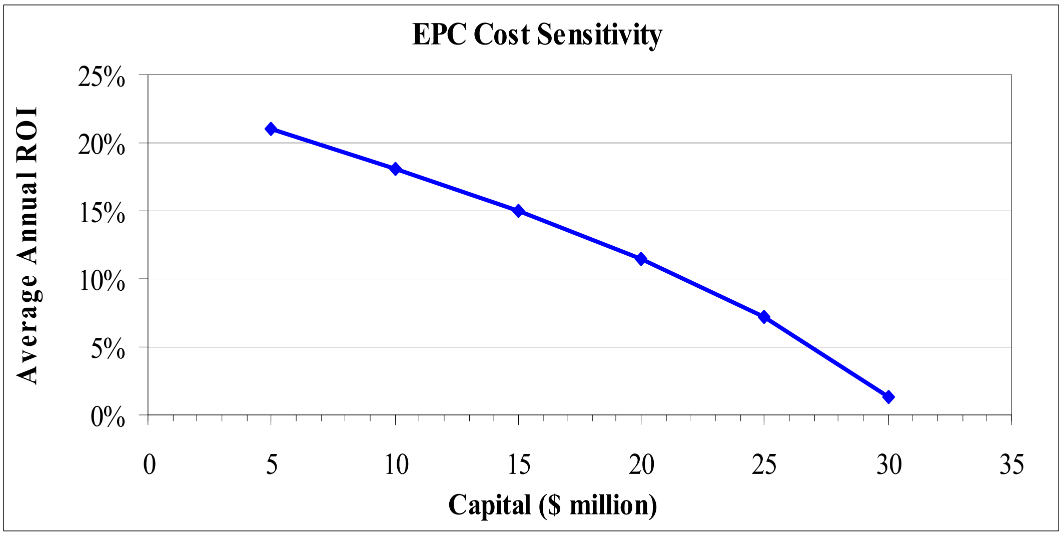


Figure 11.11 – Effect of EPC Price on 11-year Average Annual ROI



The following tables show the change in the projected average annual ROI for the project for increasing and decreasing ethanol and feedstock prices. All other variables are assumed to remain constant. Finally, Appendixes A and B present financial projections (10-year pro-forma) for a 7,000 tonne per annum Jerusalem artichoke plant and 7,000 tonne per annum corn processing facility, respectively.

Table 11.3 - Sensitivity and Breakeven Analysis for Jerusalem Artichoke Plant

Feedstock and Ethanol Price Sensitivity
10-Year Average Annual Return on Investment
Ethanol Project - 7K JA

Jerusalem Artichoke ($/ton)	Ethanol ($/liter)										
	0.84	**0.94**	**1.04**	**1.14**	**1.24**	**1.34**	**1.44**	**1.54**	**1.64**	**1.74**	**1.84**
8.52	33.4%	39.7%	46.0%	52.3%	58.6%	64.9%	71.2%	77.5%	83.9%	90.2%	96.5%
18.52	27.1%	33.4%	39.7%	46.0%	52.4%	58.7%	65.0%	71.3%	77.6%	83.9%	90.2%
28.52	20.9%	27.2%	33.5%	39.8%	46.1%	52.4%	58.7%	65.0%	71.3%	77.6%	83.9%
38.52	14.6%	20.9%	27.2%	33.5%	39.8%	46.1%	52.4%	58.7%	65.0%	71.3%	77.6%
48.52	8.3%	14.6%	20.9%	27.2%	33.5%	39.8%	46.1%	52.4%	58.8%	65.1%	71.4%
58.52	2.0%	8.3%	14.6%	20.9%	27.3%	33.6%	39.9%	46.2%	52.5%	58.8%	65.1%
68.52	-5.5%	2.0%	8.3%	14.7%	21.0%	27.3%	33.6%	39.9%	46.2%	52.5%	58.8%
78.52	-14.3%	-5.5%	2.0%	8.4%	14.7%	21.0%	27.3%	33.6%	39.9%	46.2%	52.5%
88.52	-23.2%	-14.4%	-5.6%	2.0%	8.4%	14.7%	21.0%	27.4%	33.7%	40.0%	46.3%
98.52	-32.1%	-23.3%	-14.4%	-5.6%	2.0%	8.4%	14.7%	21.1%	27.4%	33.7%	40.0%
108.52	-41.0%	-32.2%	-23.3%	-14.5%	-5.7%	2.0%	8.4%	14.8%	21.1%	27.4%	33.7%
118.52	-49.9%	-41.1%	-32.2%	-23.4%	-14.6%	-5.7%	2.0%	8.5%	14.8%	21.1%	27.4%
128.52	-58.8%	-49.9%	-41.1%	-32.3%	-23.4%	-14.6%	-5.8%	2.1%	8.5%	14.8%	21.2%
138.52	-67.7%	-58.8%	-50.0%	-41.2%	-32.3%	-23.5%	-14.7%	-5.8%	2.1%	8.5%	14.9%
148.52	-76.5%	-67.7%	-58.9%	-50.0%	-41.2%	-32.4%	-23.5%	-14.7%	-5.9%	2.1%	8.5%
158.52	-85.4%	-76.6%	-67.8%	-58.9%	-50.1%	-41.3%	-32.4%	-23.6%	-14.8%	-5.9%	2.1%
168.52	-94.3%	-85.5%	-76.6%	-67.8%	-59.0%	-50.1%	-41.3%	-32.5%	-23.6%	-14.8%	-6.0%

Table 11.4 - Sensitivity and Breakeven Analysis for Corn Plant

Feedstock and Ethanol Price Sensitivity
10-Year Average Annual Return on Investment
Ethanol Project - 7K Corn w/ Frac

9.381632 MMLY Plant

Corn ($/tonne)	Ethanol ($/tonne)										
	0.84	**0.94**	**1.04**	**1.14**	**1.24**	**1.34**	**1.44**	**1.54**	**1.64**	**1.74**	**1.84**
313.00	-2.6%	3.3%	9.0%	14.7%	20.4%	26.0%	31.7%	37.3%	43.0%	48.7%	54.3%
323.00	-4.5%	1.9%	7.6%	13.3%	19.0%	24.6%	30.3%	36.0%	41.6%	47.3%	53.0%
333.00	-6.4%	0.5%	6.2%	11.9%	17.6%	23.3%	28.9%	34.6%	40.3%	45.9%	51.6%
343.00	-8.4%	-0.9%	4.9%	10.5%	16.2%	21.9%	27.6%	33.2%	38.9%	44.5%	50.2%
353.00	-10.3%	-2.5%	3.5%	9.2%	14.9%	20.5%	26.2%	31.8%	37.5%	43.2%	48.8%
363.00	-12.3%	-4.3%	2.1%	7.8%	13.5%	19.1%	24.8%	30.5%	36.1%	41.8%	47.5%
373.00	-14.2%	-6.3%	0.7%	6.4%	12.1%	17.8%	23.4%	29.1%	34.8%	40.4%	46.1%
383.00	-16.2%	-8.2%	-0.8%	5.0%	10.7%	16.4%	22.1%	27.7%	33.4%	39.0%	44.7%
393.00	-18.1%	-10.2%	-2.4%	3.6%	9.3%	15.0%	20.7%	26.3%	32.0%	37.7%	43.3%
403.00	-20.1%	-12.1%	-4.2%	2.2%	7.9%	13.6%	19.3%	25.0%	30.6%	36.3%	42.0%
413.00	-22.0%	-14.1%	-6.2%	0.8%	6.6%	12.2%	17.9%	23.6%	29.3%	34.9%	40.6%
423.00	-24.0%	-16.0%	-8.1%	-0.6%	5.2%	10.9%	16.5%	22.2%	27.9%	33.5%	39.2%
433.00	-25.9%	-18.0%	-10.1%	-2.2%	3.8%	9.5%	15.2%	20.8%	26.5%	32.2%	37.8%
443.00	-27.9%	-19.9%	-12.0%	-4.1%	2.4%	8.1%	13.8%	19.5%	25.1%	30.8%	36.5%
453.00	-29.8%	-21.9%	-13.9%	-6.0%	1.0%	6.7%	12.4%	18.1%	23.8%	29.4%	35.1%
463.00	-31.8%	-23.8%	-15.9%	-8.0%	-0.5%	5.3%	11.0%	16.7%	22.4%	28.0%	33.7%
473.00	-33.7%	-25.8%	-17.8%	-9.9%	-2.1%	3.9%	9.6%	15.3%	21.0%	26.7%	32.3%

12.0 Project-Specific Environmental Impact Assessment for Each Plant

Bio-ethanol can help to reduce the negative impact of the transportation sector on the environment. However, there are also negative environmental impacts related to the bio-ethanol industry. The purpose of this section is to evaluate both the positive and negative environmental impacts and to propose mitigation measures to minimize and/or eliminate negative environmental impacts. In this regard, the ethanol production and distribution process can be divided into several stages and each stage needs to be evaluated separately.

The project team has conducted research and analysis regarding various feedstock sources and production processes.

The following three scenarios were considered by project team for the bio-ethanol development program in Armenia for the near to mid-term:

- One large fermentation facility for Jerusalem artichokes, chicory, sweet sorghum, or late harvest feed corn in the near to midterm time horizon with a capacity of 14,000 tonnes per year of bio-ethanol to be operational by 2014
- Two to three smaller fermentation facilities for selected localized feedstocks in the near to midterm with a total combined capacity of 14,000 tonnes of bio-ethanol per year to be operational by 2014
- Forego fermentation processes, continue government-sponsored bio-ethanol research, and encourage the planting of hybrid tree in the near to mid term which would be used as the source for the cellulosic process

The project team has concluded that constructing two small plants will achieve the greatest benefits to Armenia and is therefore the preferred option. The following site-specific plants were chosen by the project team for a proposed bio-ethanol development program in Armenia with a total combined capacity of 14,000 tonnes of bio-ethanol per year to be operational by 2014:

- A 7,000 tonnes per annum bio-ethanol plant based on an fermentation process designed to extract inulin from Jerusalem artichoke tubers as its feedstock and situated at Goris in Syunik Marz
- A 7,000 tonnes per annum bio-ethanol plant based on a dry mill process with fractionation designed to process feed corn as its feedstock and situated at Haghartsin in Tavush Marz

The advantages of two plants over one larger facility are basically associated with risk mitigation and reduction of the possibility of a catastrophic failure of one feedstock due to localized pathogens, pest infestation, or adverse weather, and also built in redundancy of plant processing capabilities in the event that one plant suffers an unexpected and lengthy outage.

12.1. Nationwide Baseline for Air Emissions

The transportation sector is considered one of the main sources of air pollution in Armenia today. In major cities transportation consist of more than 50% of the emissions into the atmosphere and in some cases up to 90%. These emissions include hydrocarbons, nitrogen oxide, sulfur dioxide, smoke particulate pollutants, and some traces of heavy metals.

Depending on type of fuel used, surface transportation can be divided into three main categories: petrol, diesel fuel, and natural gas. Bio-ethanol will be used as a substitute for petrol. Petrol engines emit up to 400 types of hydrocarbons, as well as carbon oxide and nitrogen oxide into the atmosphere.

Taking into account existing geographical and climatic conditions in Armenia, the emission reduction from transportation sources is considered an important issue. Emission reductions from the transportation sector are especially critical for Yerevan. Due to the one million habitants and unfavorable climatic and atmospheric circulation conditions, Yerevan is very vulnerable from transportation-related air pollution impacts. Moreover, in recent years the air pollution levels have increased significantly as a result of the influx of new cars and intensive construction activities in the downtown area in particular. Air pollution is also of concern in other cities and towns throughout the country.

The quantity of emissions from different types of transportation sources in 2007 is presented in the table below that are from data RoA Ministry of Nature Protection, which were estimated based on annual volume of different type of imported fuel. These figures will serve as the air quality environmental baseline for the purposes of conducting this environmental assessment.

Table 12.1 – Transportation-Related Air Emissions in Armenia, 2007

Fuel Type	Air Emissions in Tonnes								
	NOx	CH_4	VOC	CO	N_2O	CO_2	C	SO_2	Pb
Petrol	5578	337	22004	81527	14	537532	0	31	0.829
Diesel Fuel	5125	71	2373	10558	15	380213	521	64	-
Compressed Natural Gas	3126	14505	2066	16687	0	565549	0	-	-
Total	**13,829**	**14,912**	**26,442**	**108,772**	**28**	**1,483,293**	**521**	**95**	**1**

Source - RoA Ministry of Nature Protection

As can be seen from the table, emissions from petrol engines have a much more significant impact on the environment than other fuel sources. If the project is not realized, then fuel imports would increase because they are closely related to the number of vehicles which are anticipated to increase in the future. The anticipated increase in imports and use of the additional fuel will increase air pollutants into the atmosphere. Accordingly, fuel substitution or else blending bio-ethanol into petrol can significantly reduce future transportation-related air emissions in Armenia.

12.2 Current Water Contamination Levels Near Preferred Plant Sites

Similarly, the project team had to establish an initial baseline for water pollution in both Syunik Marz and Tavush Marz in the general vicinity of where the feedstock crops would be grown and also where the processing plant would be situated. In this regard, data was obtained from the Armenian Ministry of Nature Protection for the most recent month available and compared to maximum allowable levels under current law. A comparison of surface water pollution levels in the vicinity of both preferred sites and maximum permissible concentration of contaminants is presented in Table 12.2 below.

Table 12.2 – Comparison of Surface Water Pollution Levels in the Vicinity of Preferred Sites and Maximum Permissible Concentration of Contaminants

River Basin and Marz	Location of Water Monitoring Station	Maximum Permissible Concentration of Contaminants																	
		Dissolved Oxygen *Limit >6,0 mg/dm^3*	Biological Oxygen Demand $_5$ *Limit 3,0 mg/dm^3*	Chemical Oxygen Demand *Limit 30,0 mg/dm^3*	Nitrite ion *Limit 0,024 mgN/dm^3*	Ammonium ion *Limit 0,39 mgN/dm*	Sulphate ion *Limit 100,0 mg/dm^3*	Nitrite *Limit 120,0 mg/dm^3*	Magnesia *Limit 40,0 mg/dm^3*	Aluminium *Limit 0,04 ml/m^3*	Vanadium *Limit 0,001 mg/dm^3*	Chrome *Limit 0,001 mg/dm^3*	Iron *Limit 0,5 mg/dm^3*	Manganate *Limit 0,01 mg/dm^3*	Copper *Limit 0,001 mg/dm^3*	Zinc *Limit 0,01 mg/dm^3*	Bromine *Limit 0,2 mg/dm^3*	Selenium *Limit 0,001 mg/dm^3*	Cadmium *Limit 0,005 mg/dm^3*
		Actual Level of Surface Water Contamination, April 2008																	
Vorotan River in Syunik Marz	0.5 km above from Goris Village									0.557	0.004				0.003			0.002	
	1 km above from Sisian									0.058	0.041	0.004						0.003	
Agstev River in Tavush Marz	1.2 km above from Dilijan City									0.612	0.002	0.008		0.020	0,003			0.002	
	0.5 km below from City									0.866	0.003	0.011		0.032	0.005				
	1 km above from Ijevan Town									1.191	0.004	0.009		0.040	0.004			0.002	
	Near the Border		3.40							2.256	0.004	0.013	1.17	0.096	0.006				

Source: RoA Ministry of Nature Protection Site: www.mnp.am.

12.3 Environmental Impact Analysis of Feedstock Production

Based on the research conducted by the project team, Jerusalem artichoke and feed corn were chosen as the most appropriate feedstock types for this proposed 14,000 tonnes per annum bio-ethanol program in the near to mid-term. Growing these feedstocks will likely have impacts on the environment which are closely linked to irrigation, mechanization and fertilization, harvesting, and delivery to a collection point, as well as potential deterioration or depletion of the soil resource over time. A review of the likely environmental impacts of growing Jerusalem artichoke and feed corn for the proposed bio-ethanol program on land adjacent or else within close proximity of the selected sites in both Goris in Syunik Marz and also Haghartsin in Tavush Marz are discussed below.

Jerusalem Artichoke Production in Syunik Marz

Jerusalem artichoke grows wild throughout many parts of the country. There were a few earlier attempts at large scale cultivation of this potential feedstock especially for inulin in the pharmaceutical industry, but they were abandoned. It is anticipated that Jerusalem artichoke can be successfully cultivated in the Sisian - Goris region of Syunik Marz.

Climate Conditions within the Sisian – Goris Region

Highlights of climatic data from the Syunik Marz meteorological station are presented below:

- The average annual air temperature is 11.5^{o} C
- The average annual air temperature of the hottest month is 23.0^{o} C
- The average annual air temperature of the coldest month is 0.0 ^{o} C
- The absolute maximum temperature of air is 40.0^{o} C
- The average air temperature of the coldest five days is -9.0^{o} C
- The average air temperature of the coldest day is -12^{o} C
- The duration of the crop growing period is 143 days
- The duration of winter time is 93 days
- The percentage of time at different wind directions and percentage of time that winds are calm:
  - North 15%
  - Northeast 7%
  - East 15%
  - Southeast 7%
  - West 17%
  - Northwest 14%
  - South 10%
  - Calm 56%

Biodiversity

Elevations in Syunik Marz range from 500 meters to 3,900 meters (Kapuytdjur). The land varies from semi desert, dry mountainous and steppe, sub alpine meadows, to alpine landscape zones. The Marz has a rich and unique biodiversity with interesting geological and landscape features. In addition, the Marz is blessed with a number of important natural preserves and historical monuments. In this regard, with the aim of preserving the biodiversity of the region and providing sustainable usage, the Government has established several reserves within the territory of Marz since 1958. The most important of these land preserves are described below.

Shikahogh State Reserve was created in 1958, and is situated in basins of Tsav and Shikahogh Rivers of Syunik Marz. It occupies 12,137 hectares of territory as of 2006. Mtnadzor Gorge is the only naturally well preserved primary forest in Armenia. The main objects for preservation are oak, hornbeam and mixed oak, hornbeam forests, and unique plant complexes. The reserve provides a number of fauna species like wild goat, moufflon, wild boar, among others.

Sosoo Grove State Reserve was established in 1958, and occupies 64.2 hectares and is located in Kapan region between Tsav and Shikahogh Rivers, at 700-800 meters elevation. It protects the territory flora and fauna. The main objects for protection are the only natural grove of plants in the Caucasus Region where numerous relict types grow such as hazel.

Boghakar State Reserve was founded in 1989, to the north of Agarak and Megri towns on the northern slopes of Zangezour mountain range at 1,400-2,100 meters elevation on approximately 2,728 hectares territory. The forest flora and fauna are protected here. Given the success of the Boghakar State Reserve, the RoA also plans to create the **Arevik State Reserve** with the aim of protecting biodiversity of Zangezour, Megri, and Bargushan mountain ranges as well.

Sev Lich Reserve was created in 1987 as a reserve and in 2001 its status was changed and today it has the state reserve status. It occupies 240 hectares territory and is situated at the foothills of Mets Ishkhanasar mountain range. It protects a volcanic lake as well as the near-alpine biological features of the surrounding area.

Goris State Reserve was founded in 1972 and it occupies 1,850 hectares territory, at 1,400 – 1,800 meters elevation. It is located in the basin of the Vorotan and Vararakin Rivers. The purpose for creation of this reserve was the protection of animal species (roe deer, brown bear and wild boar) and also several rare plants species (Phasianus colchicus, Punica granatum, Ficus carica, Iris paradoxa, I. grossgaimi, Centaurea lenzeoides, and Allium spp.).

According to the Armenian natural monument list that was assembled in 2008, Syunik Marz has 20 geological, 16 water-geological, nine hydrographic, four environmental, and three biological nature monuments.

Soil Reserves

With respect to the soil resources base, Syunik Marz mainly has dark semi-dessert, mountainous brown, mountainous black earth, mountain forest, meadow–steppe and mountain meadow soils.

Regional Water Resource Baseline

The main water resource of region is the Vorotan River Basin. The following are monitoring results from the Environmental Monitoring Center of the State Noncommercial Organization of Ministry of Nature Protection of Armenia:

- High levels of vanadium and aluminum were detected in the samples taken from Vorotan, Sisian, and Gorisget Rivers where the maximum permissible limits were exceeded by 11.0–41.0 and 11.4–13.9 times, respectively
- In the samples taken from the Vorotan Basin the limits of nitrate ion were exceeded by 1.4–2.2 times (in the location of Goris Town 9.2 times)
- BOD_5 by 1.4–2.1 times
- Ammonium ion by 5.7 times
- Aluminum by 1.4–3.2 times
- Vanadium by 4.0 times
- Chrome by 3.0–5.0
- Manganese by 2.4–2.8
- Copper 2.0–5.0 times
- Selenium by 2.0–3.0 times
- Other substances were also checked, but found to be within the permissible limits

Potential Jerusalem Artichoke Production Impacts

Various types of agricultural machinery are used during different stages of production including tilling, planting, fertilization, and harvesting. This mechanized equipment is predominantly powered by diesel motors which generate harmful emissions during their operation. The quantity of emissions depends on volume of fuel used and the condition of the machinery.

In addition, common types of fertilizers similar to those used for corn production may also be utilized for increasing crop yields for Jerusalem artichokes including manure, phosphate, potassium, and nitrate fertilizers. However, repeated use can increase unwanted substances and pollutants in storm water run off going into rivers and watersheds, as well as infiltrate and possibly contaminate underground water resources.

Moreover, Jerusalem artichoke possesses the capacity to spread rapidly. Therefore, strong measures are needed to prevent its spreading into other productive agricultural fields where food crops may be growing. In this regard, past experience has shown that there may be difficulties in planting new crops in a field that has been used for growing Jerusalem artichoke. Typically, two to three years may be needed to clean out all vestiges of the Jerusalem artichoke and to restore the land to productive use for other crops.

Feed Corn Production in Tavush Marz

Corn is grown in almost all regions of Armenia in small land plots. Feed corn growing requirements in Armenia are well studied and described in various sources. According to the development projects of the Ministry of Agriculture, corn growing is planned in large scale in Tavush Marz.

Climate Conditions within the Vicinity of Haghartsin

The average climatic conditions prevalent in Tavush Marz in the vicinity of Haghartsin are summarized below:

- The average annual temperature is 10.5^{o} C
- The highest average temperature of the hottest month is 22.2^{o} C
- The lowest average temperature of the coldest month is -0.5^{o} C
- The lowest average temperature of the coldest month is -17^{o} C
- Absolute maximum temperature is 37^{o} C
- Absolute minimum temperature is -24^{o} C
- The average annual temperature is at 13^{00} hours is 25 ^{o} C
- The lowest average temperature of the coldest five day period is -8^{o} C
- The lowest average temperature of the coldest day is -13^{o} C
- The lowest average temperature of the coldest period is -3^{o} C
- The average temperature of the heating period is -2.4^{o} C
- The duration of heating period is 156 days
- The duration of the winter days with lower than 0^{o} C is 92
- The percentage of time at different wind directions and percentage of time that winds are calm:
    - North 3%
    - Northeast 24%
    - East 11%
    - Southeast 1%
    - Southwest 1%
    - West 50%
    - Northwest 4%
    - South 6%
    - Calm 15%

Biodiversity

The Virahayots, Gugarats, and Miapori mountain ranges are situated within Tavush Marz ranging in elevation from 380 meters to 2,993 meters above the sea level. With respect to flora, forests make up approximately 51% of total surface landmass of the Marz. Sagebrush and feather-grass grow in the low flatlands of the region, and luxuriant alpine plants grow in the higher mountainous regions. The forests are generally at elevations from 600 meters to 2,000 meters. Up to the elevation of 900 meters there are sparse woods of wild almond, juniper, snowball, Jerusalem thorn, fig, pomegranate, cherry, jasmine, and other drought resistant trees and bush. Oak trees are common on the elevations of 1,000 meters to 1,600 meters. In addition, the region is rich in mulberry, laurel, apple, and pistachio trees. The main types of trees in forests are Quercus macranthera, Quercus iberica, Fagus orientalis, Carpinus betulus, and Carpinus Orientalis. These forests are also rich in wild apple, pear tree, cherry, hazel trees, Cornlian cherry tree, plum, hawthorn, blackthorn, baumhasel, currants, gooseberry, blackberry, medlar, sea-buckthorn, nettle tree, and other types of trees and bushes. Finally, the region is also rich in edible (esparcette, clover, luzerne, oats, brome – grass cock's foot fescue etc.), medical (everlasting, Saint John's wurt, mint, thyme, bryony, liquorice), nectariferous (maple, esparcette, luzerne, oats, lime, birch, barberry, wild apple, pear tree, hawthorn etc.), and useful herbs.

With respect to fauna, Tavush Marz contains the following species:

Mammals: There are abundant Caucuses bear, wolf, fox, coypu, marten, and greater horseshoe bat, wild goat, Armenian mouflon, and brown bear throughout the forested regions of the Marz. In addition, porcupine can be found in most pastures and farms.

Birds: Twelve types of avian species exist in the region particularly passerines and falcons.

Reptiles: The region is abundant with turtles, a wide variety of grasshoppers, and also snakes. Eden types are the Armenian grasshopper, Lacerta dahli, and Lacerta rostombekovi.

Amphibians and Fish: Salmo trutta m. Fario, Varicorhinus capoeta, Barbus tauricus, Hyla arborea shelkovnikovi, and Rana macrocnemis are the most prevalent species.

With the aim of preserving biodiversity and sustainable usage in this region, Government established several Specially Protected Nature Areas (SPNA) in Tavush Marz starting in 1958. The most important of these nature preserves are described below:

"Dilijan" National Park is located on the slopes of Pambak, Areguni, and Miapor mountain chains in the Agstev and Getik River Basin at an elevation ranging between 1,000 meters and 2,200 meters above sea level. The main reason for creation of this park was the preservation of the Aghstev and Getik Rivers Basin ecosystems, as well as protection of the landscape, biological diversity, natural scenic vistas, and historical monuments throughout the region. Mezofil forests of Caucasus type, symbiosis of beech-tree and oak, yew-tree unique park, rare forest fauna, and also historical, architectural, and rare natural monuments are protected here. Within the park there exist 19 types of reptiles, 69 types of Molluscas, 1,431 types of Arthropodas, and 49 types of mammals including wild cat, wild boar, and roe deer among others. The park area is divided into four reserves, two preservation areas, seven recreational areas and an economic territorial zone. The economic territorial zone is the largest zone.

"Akhnabat Yew Grove" was founded in 1958 on 25 hectares of land. It is located in northeast Armenia on the southwest slope of the Miapor range in the Getik River Basin at an elevation ranging between 1,400 meters and 1,800 meters. The purpose of preserve is protection of an ancient and unique yew (*Taxus baccata*) grove. Rare yew plants have high value due to rot-resistant wood and deep green soft leaves rich in essential oil.

Hazel-Nut Reservation was established in 1958 on 4,000 hectares of land. It is located on the northern slope of the Ijevan Mountain chain at an elevation ranging between 1,500 meters and 1,800 meters. The objectives of this preservation are protection of hazel-nuts, unique yew, and other ancient groves.

Ijevan State Reservation was established in 1971 on 7,800 hectares of land. It is located in northern Armenia in the River Aghstev Basin surrounded by the Ijevan range with an elevation ranging between 900 meters and 2,100 meters. A variety of wild animals and plants are protected in this reservation.

Gandzakar State Reservation was established in 1971 with a total land area of 6,800 hectares. It is located in northern Armenia at the junction of the Paitadjour and Aghstev Rivers. A variety of wild animals are protected in this reservation.

Regional Water Resource Baseline

The main water resource of region is the Aghstev River. The following are monitoring results from the Environmental Monitoring Center of the State Noncommercial Organization of Ministry of Nature Protection of Armenia for this particular river:

- High levels of aluminum and chrome were detected in the samples taken from both the Aghstev and Getik Rivers where the maximum permissible limits were exceeded by 15.3–56.4 and 11.0–13.0 times, respectively
- In the samples taken from Aghstev River, the maximum permissible limit of vanadium was exceeded by 2.0–4.0 times
- The iron limit was exceeded by 1.4–2.3 times
- Manganese limit was exceeded by 2.0–4.0 times (at the border monitoring point of Aghstev it was exceeded by 9.6 times)
- Copper limit was exceeded by 3.0–6.0 times
- Selenium limit was exceeded by 2.0 times
- Chrome limit was exceeded by 8.0–9.0 times
- At the border monitoring point of Aghstev River, the biological oxygen demand ("BOD") permissible limit was exceeded by 1.1 times
- Other substances were also checked, but found to be within the permissible limits

Potential Feed Corn Production Impacts

Various types of farm equipment and agricultural machinery are used during different stages of corn production cycle from tilling, planting, fertilizing, harvesting, and transport to grain silos for storage and sale over time. Most of this equipment is powered by diesel engines which produce harmful emissions are generated during their operation. The quantity of emissions depends on volume of used fuel and technical conditions of the machinery.

Common types of fertilizers used in the growing of feed corn include animal manure, phosphate, potassium, and nitrate fertilizers. These fertilizers can have a harmful impact on waterways and also underground potable water supplies.

Comparison of Feedstock Production Input Requirements and Environmental Impacts

Each recommended feedstock necessarily has different requirements for both fertilizer and irrigation water. These varying needs also have environmental impacts and consequences. Table 12.3 below presents a comparison of these predicted impacts on the environment during the growing process for both Jerusalem artichoke and also feed corn.

Table 12.3 – Comparison of Projected Fertilizer and Irrigation Requirements for the Commercial Production of Jerusalem Artichoke and Feed Corn including Likely Environmental Impacts

Feedstock Type	Fertilizer Demand	Irrigation Demand	Predicted Impact on the Environment	
			Positive	Negative
Jerusalem Artichoke	1) Manure for general tillable lands -30t/ha P90 K70 kg/ ha active substance 2) Feeding N60 kg/ha active substance	1) Single irrigation at vegetation 4 – 9 2) Single irrigation norm –350 -450m^3 3) Irrigation norm 350 – 450x4 – 9		1) It is perennial plant. As a result of the long term cultivation at the same territory and effect of single direction feeding, the land becomes impoverished. 2) It pollutes land by its tubers and stem wastes. Before growing other crops in the future, chemical weeding with proper chemicals will be required.
Feed Corn	1) Manure for general tillable lands – 30t/ha Taking into account P60 K60 kg/ ha active substance 2) Feeding N60 kg/ha active substance	1) Single irrigation at vegetation period 3–8 2) Single irrigation limit 550 – 850 m^3 3) Irrigation limit 550 – 850x3 – 8	1) As a result of mid row and mid plant care, the land is cleaned from weeds	1) Impoverishes the land, as a result it's not advisable to cultivate corn each year on the same land 2) It is necessary to chemically fight against weeds by means of “dialen-super” chemical with the limit of 1–1.5 liter/ha, demand for solution is 350 – 400 liter/ha. Some residues remain in the land.

12.4 Environmental Impact of a Feed Corn Fractionation Processing Plant

Since a dry mill corn fractionation processing plant is much more complex than that of a straight forward fermentation plant for processing Jerusalem artichokes, it will be evaluated first.

Taking into consideration the large-scale corn planting initiative being promoted by the Armenian Ministry of Agriculture throughout the Tavush region, it is proposed to locate a bio-ethanol plant utilizing feed corn as a feedstock in the community of Haghartsin near Ijevan in Tavush Marz. This community is situated on the banks of the Agstev River and is central to many of the sub regions throughout the Marz where feed corn is being promoted as a cash crop for unemployed farmers. The proposed land for the processing facility is located just north of town along the river and on the main highway north to the regional capital.

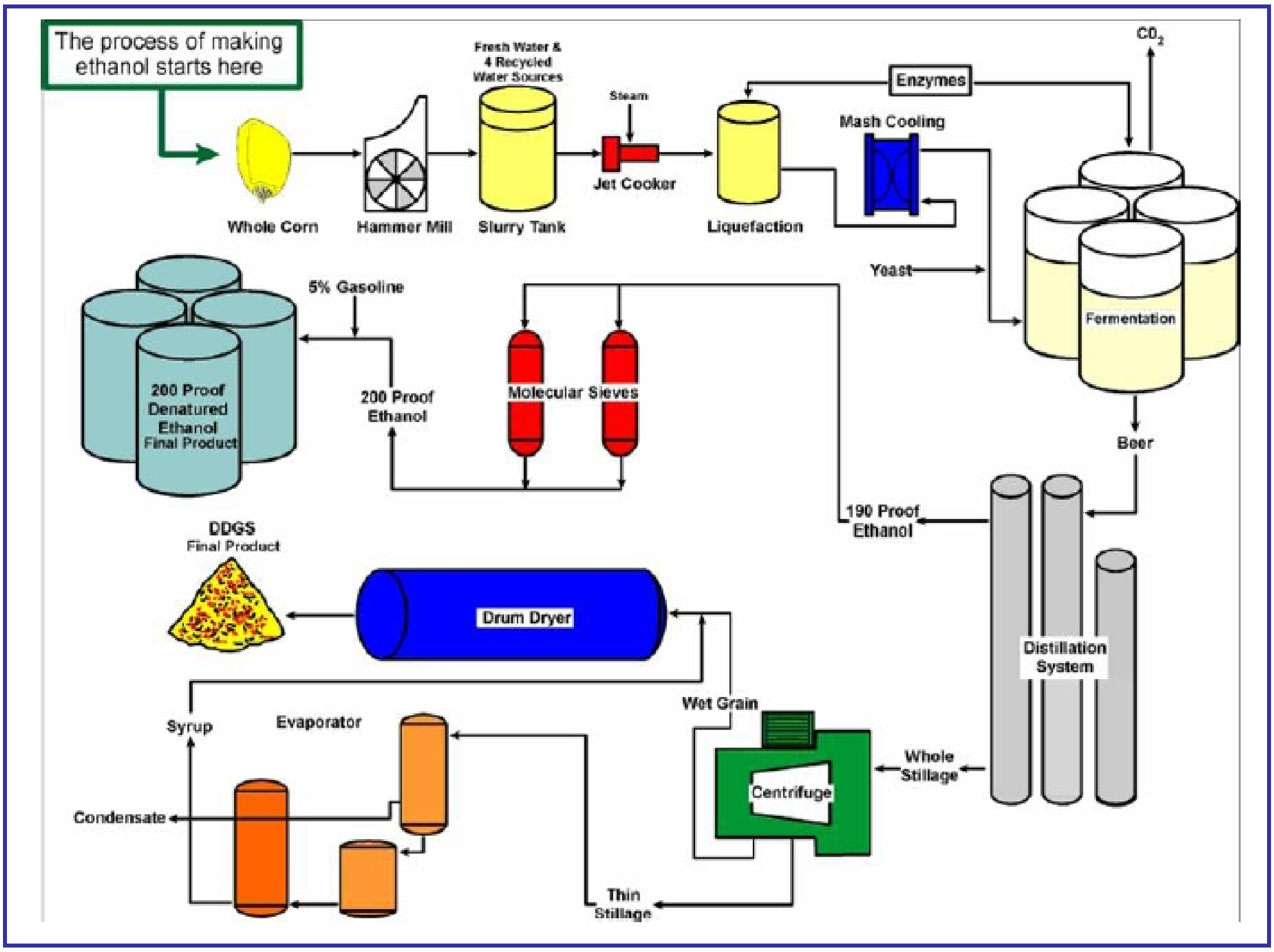
The plant's main systems encompass feedstock preparation, fermentation, and distillation of the feed corn. In this regard, the major plant components would include:

Main Components and Process Flow Diagram

- Administration building
- Corn delivery, storage, and milling equipment
- Mashing, liquefaction, fermentation, and distillation equipment
- By-product centrifugation and drying equipment
- Ethanol and DDGS storage and loading equipment
- Utilities, including electrical substation; natural gas connection; emission control equipment; railroad spur and switch, fire protection system; septic system; access roads and parking; and general stores

The administration building would house plant management; input and output scales, oversight and quality control functions; employee facilities; security; and environment, safety and health operations. The proposed conversion process scheme is presented in Figure 12.1 below:

Figure 12.1 – Process Flow Diagram for Converting Feed Corn into Bio-Ethanol Fuel and Associated Co-Products



Haghartsin Village Biodiversity

The northwest area of Haghartsin community with total length of 6.0 kilometers is connected to economic zone of Dilijan national park territory. The community is surrounded by forests. The forest is located at 1,200-2,000 meters height. From the upper border of the woods begins the mountainous pasture that is covered with mountain-glade flora. The vicinity bordering the community is part of the "Dilijan National Park" distinguished by its flora and fauna diversity, which as described earlier in this chapter.

Small parcels of grazing pastures and fields for growing hay belong to the Haghartsin community and are located throughout the "Dilijan National Park" region. Each year approximately 700 head of hogs and 120 head of cattle utilize these small pastures within the boundaries of the park.

The specific land being proposed for the corn fractionation processing plant was previously zoned industrial and is devoid of any vegetative cover whatsoever.

Potential Environmental Impacts Associated with the Processing Plant

The potential environmental impact associated with the corn fractionation processing plant differs for each stages of the project life cycle from construction, to operation, and finally to plant decommissioning. In this regard, the major concerns are air emissions and waste water.

Impacts during the Construction Stage

During the selection of possible locations for bio-ethanol plants, the existence of the following factors were considered: infrastructure, energy sources, water resources, and available plant operating staff nearby. The property is located just outside of Haghartsin Village on the bank of the Aghstev River on the former site of the Dilijan "Impuls" plant. Some buildings are still left standing on the property and have the potential for being converted into storage facilities for feed corn thereby avoiding additional large-scale construction work. However, the main industrial processing facility and administrative building would still need to be constructed.

During construction, non-organic dust emissions originate due to ground work, material transfer, usage, base and walls construction.

Within the limit of construction stage, emissions will occur from construction machinery (especially diesel). These emissions will likely include nitrogen oxide, carbon oxide, volatile organic compound (VOC), particulate matter, and carbon dioxide. In addition, welding will also create aerosol and manganese emissions. Water is also used during construction mixing concrete for foundations and other purposes. Moreover, the operation of construction equipment will also create noise.

During the 12-month plant construction period, it is anticipated that site preparation and other ground work will entail the removal of roughly 7,000 m^3 of earth and also require approximately 6,300 m^3 of back fill. On-site construction equipment will include diesel operated tractors, dump trucks, excavators, bulldozers, crane, elevator, and several four wheel drive vehicles among others.

Due to the limited size of the proposed plant, the volume of emissions from construction is unlikely to have a significant impact on the environment. The projected quantities of hazardous substances presented in Table 12.4 below are indicative of similar projects elsewhere.

Table 12.4 – Projected Quantities of Hazardous Substances from Facility Construction

Estimated Hazardous Substance Quantities (for a 1-year construction period)							
Dust	CO	VOC	NO_x	SO_2	SP	Welding Aerosol	Manganese Emissions
7.3	4.8	0.482	1.36	0.166	0.237	0.2	0.027

Water Usage and Drainage: Water usage is estimated at 2,500 m^3 for the entire construction period while drainage id expected to total approximately 690 m^3 during the twelve-month construction period.

Noise: The construction equipment and diesel-operated machinery used at the construction site will generate noise that must be abated if it exceeds local community standards.

Waste Disposal: The excess earth from site preparation activities and construction excavation is planned to be used for smoothing and landscaping improvements on site. Construction waste and ruble will be moved to a special location provided by the municipality for which an appropriate contract will be signed.

Impacts during Plant Operation

Expected operational impacts of this corn fractionation processing plant have been estimated based on the preliminary design capacity of 7,000 tonnes per year. These impacts have been derived from data provided by BBI, as well as actual operational experience and measured from local ethanol plants including the Yerevan "Ararat" plant, the "Ayntap" wine-brandy-vodka facility, and the Sevan sugar factory.

Air Emissions: The following plant-related operations typically generate the most harmful substance emissions from a bio-ethanol plant based on a corn fractionation process:

Feedstock Unloading and Preparation

Harvested feed corn is received by truck, unloaded into storage or silage, and undergoes mechanical conversion/processing (grinding). These operations all emit dust.

Feedstock Fermentation Process

The feedstock fermentation and distillation process creates VOC emissions that contain ethanol, acetaldehyde, formaldehyde, acetic acid, and methanol among other emissions.

Process Heat Production

Gas boilers will provide the energy for distillation and other processes, emitting carbon dioxide and nitrogen oxide.

Additional Subsystem Processes

Various types of emissions will also emanate from subsystem processes and subcomponents particularly from processing and storage of co-products.

A summary of typical air emissions and pollution point sources from such a facility is presented in Figure 12.2 below. In addition, an estimate of total anticipated air emission quantities by type of emission is presented in Table 12.5 below

Figure 12.2 – Typical Point Emitters and Emission Types from a Corn Fractionation Plant

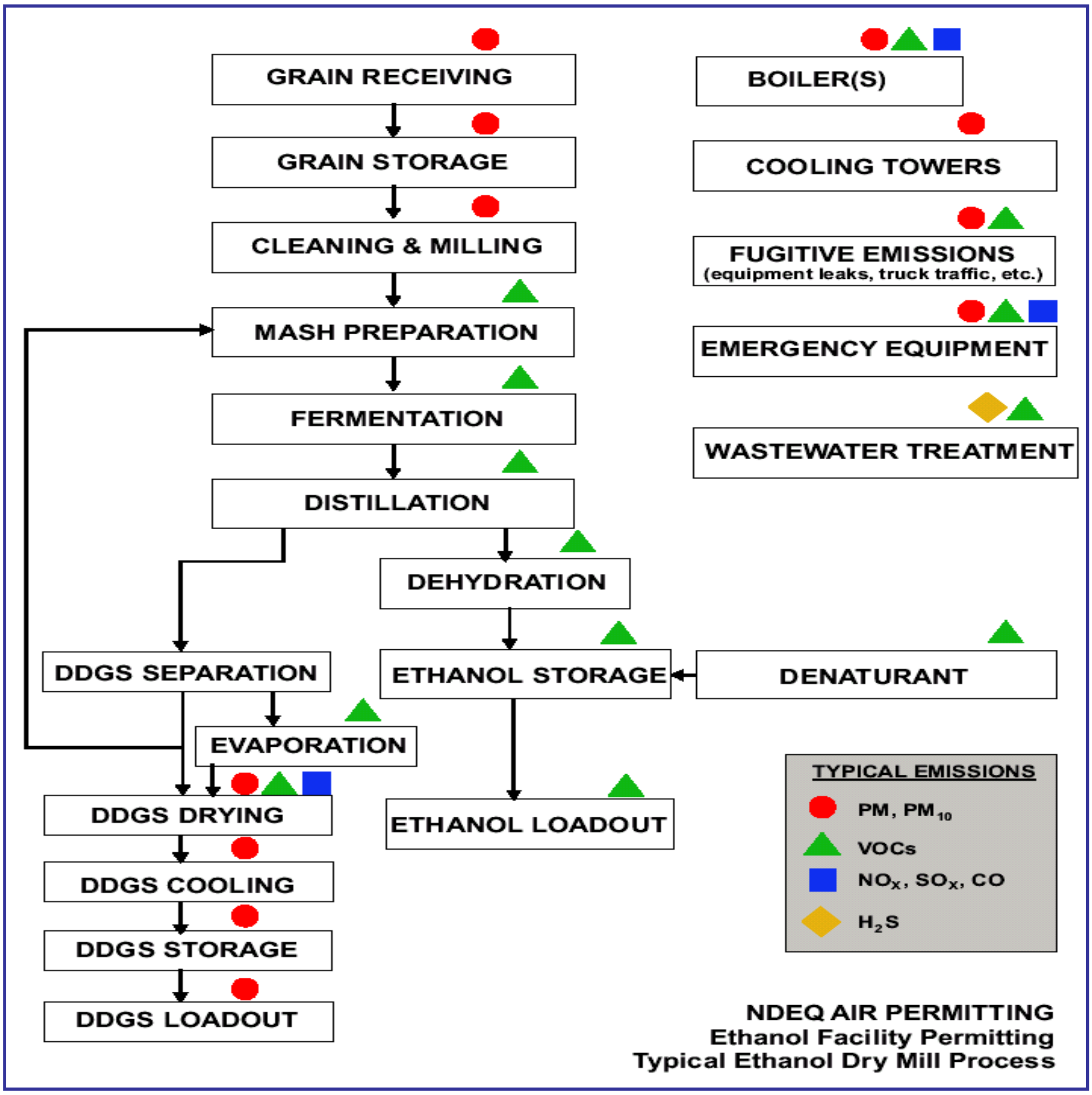


Table 12.5 – Estimated Air Emission Quantities from the Proposed Corn Fractionation Facility

№	Emission Material Description	Quantity in Tonnes/Year		Maximum Concentration Limits, mg/m^3
		Data from U.S. Plants	Local Experience	
1.	Solid Particles (PM)	2.5	3.5	0.5
2.	Small Diameter Solid Particles (PM_{10})	2.2		
3.	Carbon Oxide (CO)	2.7	6.25	5.0
4.	Nitrogen Oxide (NOx)	2.9	3.37	0.085
5.	VOCs	2.3	4.55	1.0
6.	SO_2	1.9	-	0.5
7.	Individual HAP (Acetaldehyde)	0.3	-	-

Source: Minnesota State Depart of Energy, from nine operational or planned plants: The local experience is based on similar plant generalized data.

The RoA Law on Pollution from Harmful Substances specifies the maximum allowed air emissions concentration limits at ground level from a given plant location. For estimating the emissions at the anticipated site at the ground level, it is necessary to have a detailed emission levels produced, stack heights, and site specific wind conditions. However, considering emissions from similar production plants, it can be concluded that the specified norms for air emissions under the law would not be exceeded.

Economic Damage: Economic damage is the cost, expressed in AMD, of necessary measures conducted to eliminate the damage caused to the environment. The economic damage evaluation is made on the basis of AMD equivalent and does not generate any financial obligations. As such, economic damage under the law accounts for the following

- Expenses related to the worsening of the general health of the population
- Damage caused to agriculture, forestry, and fish economies,
- Damage caused to production in other sectors of the general economy

Utilizing RoA accounting methods, the project team estimated that economic damage would in all probability amounts to 1,653,680 AMD per year.

Greenhouse Gases: CO_2 emissions from the Ethanol Production and Dryer/TO Stack are estimated to be approximately 8,400 tonnes per year for a 7,000 tonnes per year corn fractionation processing plant. Approximately one-third of the mass of a tonne of feed corn that is fermented to produce ethanol is converted to CO_2. This CO_2 is often considered a low value by-product and as such is vented directly into the atmosphere. It is neither a criteria air pollutant nor a hazardous air pollutant under Armenian law. It does not directly impair human health. However, it is a greenhouse gas emission (GHG) that contributes to global warming. As an alternative to atmospheric venting, CO_2 from the proposed plant could be sold to a third party for liquefaction and resale for use in the food and beverage industry. Such a solution simultaneously avoids emission of a greenhouse gas and also increases the revenue generated by the fuel ethanol plant.

Process Water: Process water is required for feedstock preparation, equipment cooling, energy production and cleaning, as well for daily routine purposes. Water recycling is possible in the most of production processes. A circulating water system is proposed by the project team to facilitate recycling. In addition, a community water supply network is anticipated for drinking water. Two sources of production water supply were considered by the project team as indicated below:

- To use the community drinking water supply net
- To use nearby flowing river water after cleaning it

An estimate of total water usage requirements at the site by volume for the proposed corn fractionation plant is presented in Table 12.6 below:

Table 12.6 – Water Usage Volumes

Water Usage Aim	Data from U.S.	Armenian Data
Production Needs	26,761m^3/year	12,100 m^3/year
Communal Needs	0.7 m^3/day	0.5 m^3/day

Sources: Data from the United States; local Armenian data is taken from similar production documents

Waste Water: All production or process water for a corn-based plant will be recycled at the site and there will be very little if any industrial wastewater other than possible spills. However, due to the high level of water in the tubers of Jerusalem artichoke, there will be need to discharge some process water at a Jerusalem artichoke based plant. On the other hand, communal wastewater for both types of plants is estimated at 0.5 m^3/day, which can be discharged into the community sewage system or else stored in a septic tank and periodically transferred to the nearby sewage system.

Jerusalem artichoke plant would discharge approximately 76,800 m^3/year. An on-site anaerobic treatment system will be used to treat process wastewater by removing substances that create a biochemical oxygen demand (BOD). The treatment system facilitates conversion of dissolved organic carbon, in the form of chemical oxygen-demanding substances or biochemical oxygen-demanding substances, to methane and CO_2. The treated process wastewater will be reused within the process. The methane generated in the anaerobic treatment system will be combusted in the Distillers' Dried Grains with Solubles (DDGS) dryers to offset a portion of the natural gas demands of the plant. The plant will also include a methanator flare to combust the methane gas when the dryers are not in use.

The non-processed discharge water from both types of plants would be approximately 5,600 m^3/year, which will be comprised partially of non-contact cooling water (i.e. cooling tower blowdown). The chemical make-up of the cooling tower blowdown will be largely defined by the water quality of the plant supply water. Naturally occurring components of the plant supply water will be concentrated due to evaporative losses. A small amount of water treatment chemical additives will be added to the cooling tower to prevent scaling, corrosion, and biological growth. Non-contact cooling water will be discharged from the cooling tower at an elevated temperature, as compared to the incoming temperature of the plant supply water. This water will be combined in the discharge pipeline with the other proposed discharge streams (i.e. RO reject water, multimedia filter backwash, and water softener regeneration), which are not at an elevated temperature.

A comparison of actual wastewater pollution from the Sevan sugar processing plant is and statutory limitations for utilizing municipal sewage systems or else dumping untreated waste water straight into water courses is presented in Table 12.7 below

Table 12.7 – Wastewater Pollution Indicators and Statutory Limitations

№	Wastewater Pollutant	Actual Concentration of Pollutants from the Plant in g/m³	Municipal Sewage System Limitation in g/m³	Pollution Limitation for Water Courses in g/m³
1.	BOD	40.0	240.0	6.0
2.	Suspended Particles	75.0	215.0	0.25
3.	Chlorides	110.0	350.0	300
4.	Sulfate	500.0	500.0	500
5.	Nitrate	30.0	40.0	10
6.	Nitrogen general	10 - 75	-	10
7.	Phosphorus (P_2O_5)	2 – 9.5	-	3.5
8.	pH	7.8	6.5- 8.5	6.5- 8.5

Source: Sevan Sugar Plant data

Finally, an analysis of non-utility wastewater discharge from a typical corn fractionation processing plant in the United States is presented in Table 12.8 below; however, these levels could be different for local water in Armenia:

Table 12.8 - Non-Process Utility Wastewater Discharge Composition

Discharge Parameter	Discharge Estimates
Bicarbonate (milliequivalents/Liter)	10.5
Chlorides (mg/L as Cl)	13
Sulfates (mg/L as SO4)	425
Calcium (mg/L as Ca)	159
Magnesium (mg/L as Mg)	58
Total Hardness (mg/L as CaCO3)	636
Iron, Total (mg/L as Fe)	0.02
Sodium (mg/L as Na)	22
Salinity (mg/L)	566
Potassium (mg/L as K)	2.1
Phosphorus (mg/L)	0.63
Manganese (mg/L as Mn)	0.06
pH	8
Total Dissolved Solids (mg/L)	707
Conductivity (micromhos/cm)	1.141
Boron (mg/L)	0.03

Source: Minnesota State Department of Energy estimation for an assumed plant

Hazardous Pollutant Storage and Usage: The corn fractionation process generates various types of hazardous substances including ammonia, non-organic acids, alkaline and salts. These substances are utilized in the fermentation process particularly the wastewater filtering station and laboratory. Admission, storage, and utilization of hazardous substances will be organized in accordance with the requirements specified in the required Technical Safety Certificate for a hazardous production facility.

Co-Products: During plant operation, liquid and solid wastes are generated which have the potential for being converted to important and valuable co-products. This potential stream includes:

- Corn processing wastes amounting to 10,200 tonnes/year
- Liquid waste and syrups amounting to 4,670 tonnes/year

The above specified wastes have high edible value and can be used as a feed for animals. Besides, with further processing, it is possible to derive other edible products.

Waste: In this regard, essentially all of the corn received at the plant could be converted into ethanol and ethanol production by-products that would be sold as plant output. Other than cleaning waste, no continuous process waste from ethanol production operations would be generated. Annual cleaning would generate primarily calcium carbonate scale. The hazardous waste generated at the plant will be from solvents used for washing parts, lubricating oils, and laboratory wastes. These wastes will only be stored temporarily on site in appropriate containers.

If spilled or leaked, fuel ethanol is not likely to result in long-term environmental damage because it is readily biodegradable over a reasonably short period of time. However, there are health and safety hazards associated with the product and its manufacture. Finally, anhydrous ammonia, which is used in the process, is a vapor at ambient temperature and pressure, and a release of this material would not present a material threat to ground-water resources; therefore, no mitigation is needed.

Noise: Plant operation generates noise from trucks and other machinery. The noise level must not exceed RoA statutory limits. At the plant work areas, the level of permissible noises depending on work category ranges between 50 dBA and 80 dBA and 40 dBA to 70 dBA for the surrounding community.

Odors: Odors may be emitted from various processes within an ethanol facility depending on weather conditions such as temperature, wind direction, wind speed, and humidity. Unscheduled plant outages can also result in unexpected odors. VOCs from the fermentation, distillation, and the DDGS dryers are generally considered to be the main contributors to odors that are emitted from ethanol facilities.

Appearance: The exhaust from the boilers and dryers will be sent to a 50 meter stack, which will be the highest stack at the proposed plant. The plume is not anticipated to be visible under conditions greater than 15° C. The tall stack height promotes dispersion of air emissions, reducing potential health and odor impacts. The proposed plant's stacks would be visible from nearby residences and roads. In addition, water vapor plumes may also be visible from the cooling tower cells, which each can be 10 meters in height. The plant will operate 24 hours per day, seven days per week. As such, there will be exterior lighting for night time operations to help ensure worker safety and plant security. Downward-pointing lights will be used to illuminate plant roads and pathways, wallmounted building lights will be used at building entrances and there will be implementation of glare reduction filters on all outdoor lighting fixtures.

Other Potential Impacts: Other impacts could conceivably include vibrations, as well as localized impacts to flora and fauna, nearby preserved areas, and cultural monuments. However, these potential impacts are deemed minimal at best and are not considered to be of any significant consequence whatsoever. The proposed plant site is situated 180-200 meters from Haghartsin Village residential areas. Immediately at the site border is an industrial facility under construction since this property has already been zoned for industrial use by the municipality. Finally, according to RoA Law on Sanitary Standards for industrial facilities (CH 245-71 of production facilities plan), ethanol production is classified as Category III which specifies a minimum distance from residential areas of at least 100 meters is the lowest sanitary-hygienic zone and is clearly being met at this site.

12.5 Environmental Impact of a Jerusalem Artichoke Processing Plant

The proposed site for a 7,000 tonne per annum Jerusalem artichoke processing plant is to be located in the administrative borders of Goris City. The Syunik Marz region of Armenia is considered to be favorable for growing Jerusalem artichoke. Taking into consideration this circumstance and the ready availability of required infrastructure in Goris Town, the project team felt strongly that this location represented the best available site in southern Armenia.

The proposed site is located in the industrial sector of the town, in the territory of a former beer factory, which has all the necessary conditions such as gas line, water supply, sewage system, electrical power, and necessary buildings for the storage of a sufficient quantity of Jerusalem artichokes to provide a steady supply throughout the year.

Goris City Biodiversity

Goris Town is located on the banks of Goris River. The city is surrounded by gently sloping mountains. The slopes on the way to the town are partially covered with forests and velvet grass. Moreover, Goris is a garden city. The "border" between the old and new towns is the Vararak River. Most lands in the surrounding vicinity are covered with mountain forests. The lower parts of these sloping mountains are steppes which are used as tillable land, meadows, and pasture land for livestock grazing.

Flora

On the banks of river, there are forests that consist of poplars, red juniper, dewberry, and rosehip among others. The forest belt appears in the form of mixed forests. Rare and disappearing types grow here including Punica granatum, Amygdalus nairica, Zyzyphus jujuba, Lycium Anatolicum.

Fauna

The animals and birdlife in the surrounding area include the following: some species of bats, field mouse, hare, wild boar,goat, wolf, wild cat, wild birds, and magpie among others. Moreover, the following mamals are listed in the Red Data Book of Armenia: Rhinolophus mehelyi, Barbastella leucomelas, Ursus arctos syriacus, Vormela peregusna, Lutra lutra meridionalis, Panthera parbus tullianus, Capra aegagrus, and Ovis ammon gmelin. Similarly, birds include: Accipiter brevipes, Circaetus gallicus Aguila chrysaetos fulva, Tetraogallus caspius, Monticola saxatilis, Monticola solitarius, Luscinia svecica occidentalis, Remiz pendulinus menzbieri, Sitta tephronata obscura, Tichodroma muraria, Emberiza buchanani:

Potentil Impact Associated with the Processing Plant

Impact during the Construction Phase

The proposed 7,000 tonne per annum Jerusalem artichoke plant at Goris will require a smaller plant footprint and is a less complex facility compared to a dry mill corn fractionation facility. Accordingly, the construction process would have a much smaller overall environmental impact than a similarly sized corn fractionation processing plant.

Impact during Plant Operation

The likely environmental impacts from operation of the Haghartsin corn fractionation processing plant have already been evaluated in detail in Section 12.4 above. The estimated environmental impacts of the Goris Jerusalem artichoke processing plant will be similar in nature to those of the Haghartsin plant, but in all probability actually less so in emission volumes given the lack of complexity of the process design and smaller footprint on the actual site. Thus, the environmental indicators would be similar and need not be repeated in detail in this section.

Moreover, compared with feed corn, Jerusalem artichoke contains more water thereby requiring considerably less water make up during ethanol production.

The proposed plant is to be located in the industrial part of Goris north of the village. The plant is surrounded by a non-functioning factory, filling station, and storage and waste land. The residential part of town is located at several hundred meters distance. No other public or educational organizations exist near the site.

12.6 Summary of Recommended Environmental Mitigation Measures

Mitigation Measures during the Construction Phase

During the construction phase it will be necessary to implement the following environmental mitigation measures:

- Roads to and at the construction site must be covered with asphalt or gravel
- Construction site must be enclosed/fenced in and construction material storage should be covered with non transparent covers
- Wheels of vehicles leaving the construction site must be washed
- Transportation of building materials and waste must be done by truck with covers over the load
- Daily working area must be periodically sprayed with water to reduce dust
- Noise impact should be reduced by regulating working hours and scheduling the heavy construction machinery during daytime hours
- Storm water accumulation and filtration must be addressed

Mitigation Measures under Emergency Situations and Normal Plant Operations

During operation of the bio-ethanol plant, emergency situations, force majeures, and unfavorable meteorological conditions can arise. To prevent or reduce the possibility of environmental contamination and negative impact on environment during such unplanned events, it is necessary to develop emergence plans which include the following measures:

- Develop and install automated fire protection system
- During events of force majeure (earthquake/temblor, slide, flood etc), the plant work is terminated and staff is evacuated to a safe place.
- During a fire, electricity must be disconnected to all equipment items, fire protection must be activated, and staff must be evacuated to a safe place.
- During unfavorable meteorological conditions, air pollution may increase at the ground level.

After receiving confirmation of unfavorable meteorological conditions such as high winds, extended calm stretches, and fog to cite but a few examples, emergency measures may have to be undertaken for each level of danger as indicated below:

- Danger Level I – notification of production supervisors and restriction of selected activities as may be warranted
- Danger Level II – termination of feedstock mechanical processing during to curtail dust emissions and discharges
- Danger Level III – termination of all electricity and natural gas energy supplies

In any event, the following general measures should be taken into account during normal plant operations:

- The use of best available control technology should minimize the potential for adverse air quality impacts, including offensive odors and adverse health and visibility impacts.
- VOCs generated by the plant should be vented through a gas-fired regenerative thermal oxidizer unit rated at 95 percent efficiency.
- Baghouses with 99.9 percent efficiency for PM_{10} should control emissions of particulate matter.
- Solid waste generated in the plant will be disposed of at an appropriate landfill.
- The denaturing tank will be sited within a lined secondary containment structure sized to contain 110 percent of the largest tank within the tank farm. In the unlikely event of a release, the contents of this tank would be contained within this containment structure. Additional controls will be implemented to minimize the risk of ground water contamination. These include tank alarms, secondary containment in tank transfer areas, and management practices to supervise the transfer of this material.
- Odors directly from the plant's fermentation process will be controlled by its wet scrubber. Odors from the distillation and distillers dried grains with solubles dryers will be controlled by the Thermal Oxidizer/Heat Recovery Steam Generator (TO/HRSG). The TO/HRSG will destroy at least 95 percent of the VOCs.

- Personnel entering milling rooms and boiler rooms would be required to wear hearing protection due to the high noise levels.
- The storm water will be contained, controlled and, if necessary, treated, prior to discharge.
- Prevention of spillage or loss of fluids, oil, grease, etc. from vehicle maintenance, equipment cleaning, or warehouse activities will be a high priority to prevent contamination of storm water run off containing these substances.
- Provision of collection facilities and arrangement for proper disposal of waste products such as petroleum waste products and solvents will be required at the site.
- Adherence to good housekeeping practices on the site will be required to keep trash from entry into water streams.
- All paint, solvents, and petroleum products will be properly and safely stowed so that they cannot be exposed to storm water run off.
- Bag houses must be used at all times when the following equipment is in operation: grain receiving, handling, and conveyor; grain elevator, hammer mill, DDGS handling and conveying; and also the DDGS lead-out truck spout.
- Emissions from the distillation process will be vented into scrubbers.

Mitigation Measures during Facility Decommissioning

It is necessary to have established plans available from the outset for the decommissioning of the plant to prevent or reduce possible negative environmental impacts. With respect to possible hazardous substance cleanup, it is not anticipated that such substances will exist when the plant is decommissioned. However, if such substances are discovered during plant disassembly, cleanup or storage of such hazardous substances will be undertaken in accordance with the plans that were developed for such an eventuality at the time of start up and commissioning. In addition, a decommissioning plan will be developed from the outset which will include using all the feedstock on hand before decommissioning along with decontamination of all equipment that may have come into contact with such harmful substances during the life of the plant. In any case, the most important task will be to remove and destroy all substances that are listed in the hazardous category.

After all equipment has been disassembled and decontaminated, it can be sold to other companies to the extent that they still possess residual economic value. Unsuitable or unusable equipment items and its parts can be sold as scrap metal. The further usage of the site and equipment buildings can be discussed with local government authorities. Finally, attention should be given to finding continuing staff employment and helping displaces staff to address social issues before rendering a final plant liquidation decision.

12.7 Environmental Impact Analysis of the Bio-Ethanol Distribution System

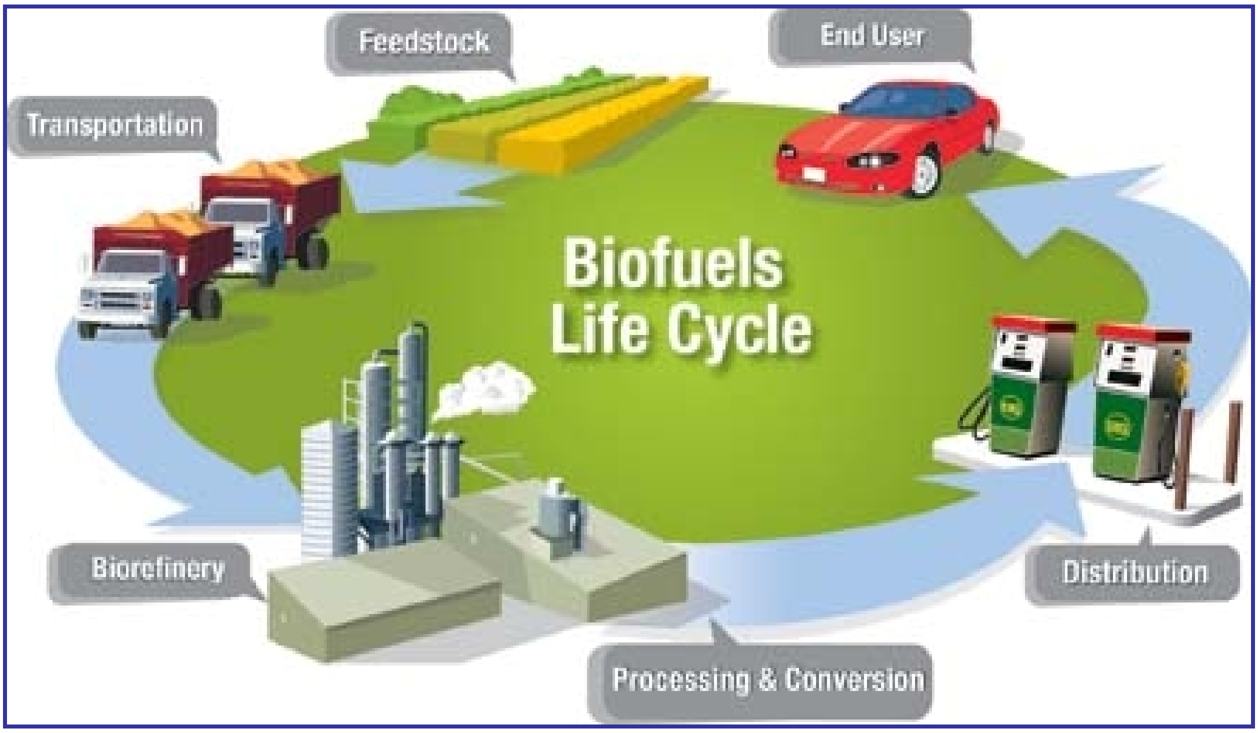
One of the main purposes of the project is the reduction of harmful fossil fuel impacts and green house gas emission reductions. Partial replacement of petrol by bio-ethanol makes it possible to reduce the emission of harmful substances to the atmosphere from internal combustion engines. Blending of bio-ethanol also allows avoiding usage of oxidation additives. Moreover, the oxygen content in ethanol allows for the more complete oxidation of fuel thereby reducing particulate matter and carbon oxide emissions to the environment. In this regard, according to all available technical data, 10% bio-ethanol blending reduces harmful emissions to the atmosphere of particulate pollutants by approximately 50% and carbon oxides by up to 30%.

Because the crops used for bio-ethanol production utilize carbon dioxide as they grow to maturity, ethanol emits less total greenhouse gases than petrol. Considering the amount of carbon gases consumed by crops used for bio-ethanol production, it can be concluded that from the point of view of a total Greenhouse gas emissions balance, that bio-ethanol programs in the motor transport sector actually reduce such harmful emissions over time.

12.8 Discussion of Potential Biofuels Life Cycle Emission Reductions

As discussed above, biofuel such as ethanol derived from Jerusalem artichoke and feed corn offer potential greenhouse gas (GHG) reductions compared to petroleum-based liquid fuels. In this regard, while the combustion of biomass is considered carbon neutral, the production of biofuel can result in considerable GHG emissions. These emissions are highly variable and determined by a range of factors such as agronomic practices (for energy crops), conversion technology, and fuel choices. Life-cycle assessments (LCAs) show that ethanol production uses very little petroleum, regardless of the production pathway (Farrell, Plevin et al. 2006; Wang 2006). Substituting ethanol for gasoline is thus a viable strategy for reducing petroleum demand. In addition to reducing petroleum use, ethanol offers potential reductions in transport sector greenhouse gas (GHG) emissions. Figure 12.3 shows a typical biofuel life-cycle.

Figure 12.3 – Typical Life-Cycle for a Biofuels Program

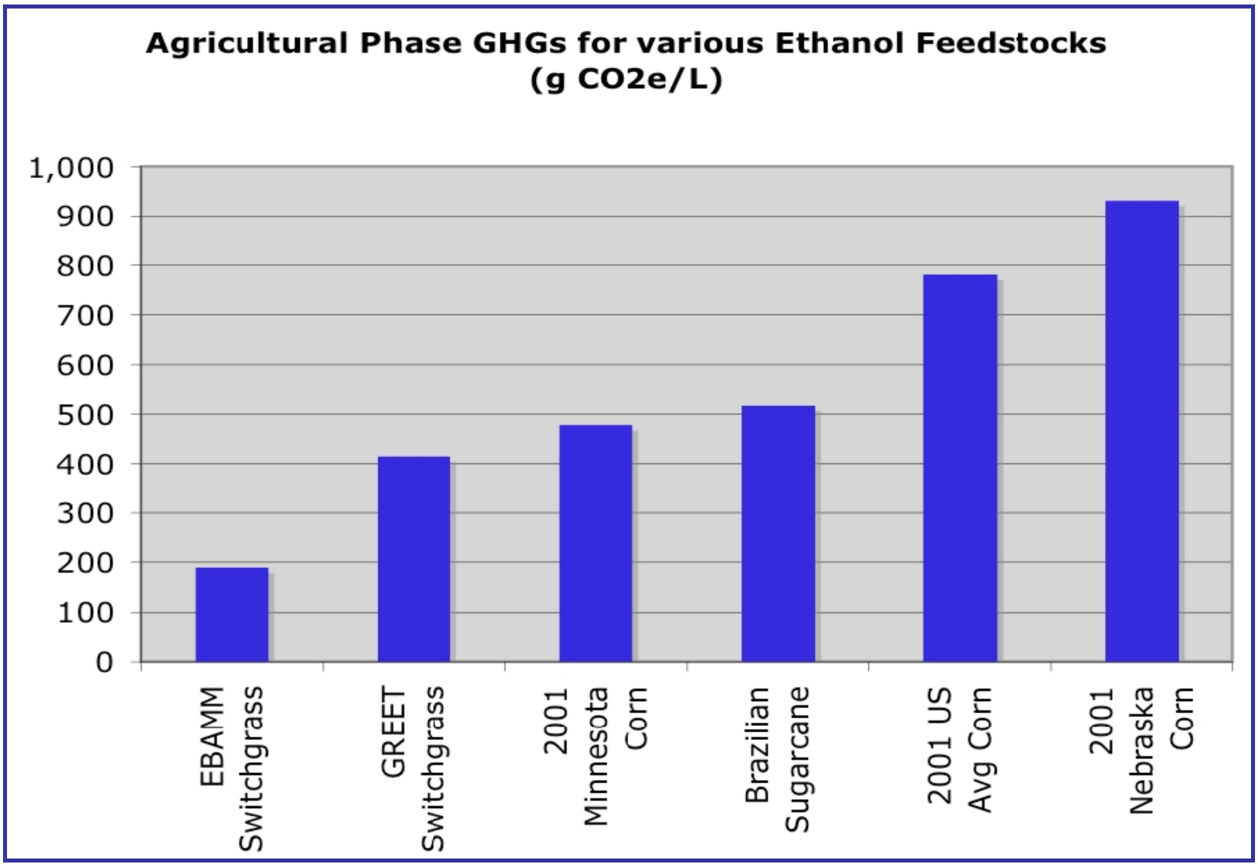


Agricultural Phase GHG Emissions

Agricultural GHG emissions are highly site-specific, as they are dependent on agricultural practices, soil condition, and climatic conditions. Figure 12.4 below illustrates the range of GHG emissions from a variety of ethanol feedstock production pathways. A liter of ethanol produced from energy-efficient corn grown in rain-fed conditions (e.g. Minnesota) releases

478 g CO_2 equivalent emissions in the agricultural phase, whereas ethanol from most energy intensive corn (Nebraska) releases 931 g/L.

Figure 12.4 – Comparison of Agricultural Phase GHG Emissions from Various Potential Feedstocks

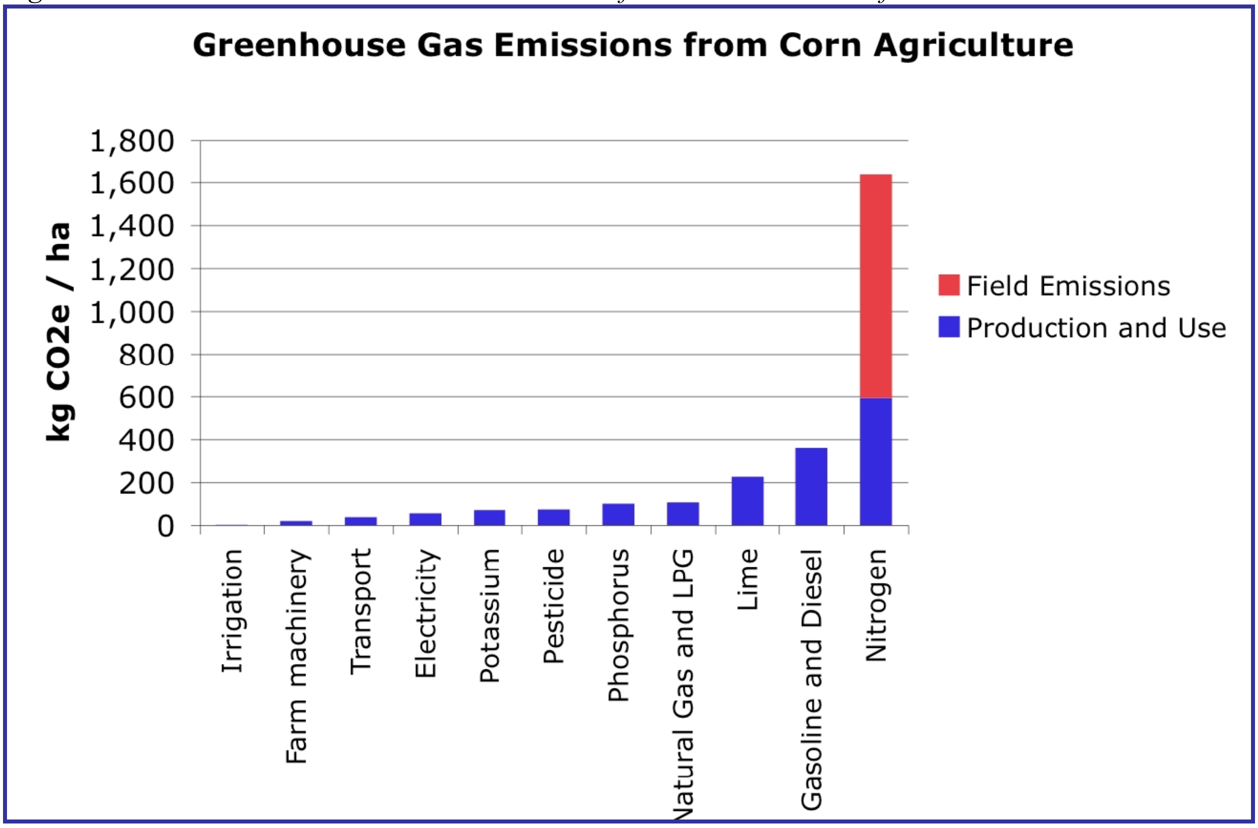


Source: University of Berkeley (2006)

There are significant uncertainties surrounding the N_2O emissions from agriculture, including both direct emissions from the field and indirect emissions from nutrient runoff. An accounting system would need to select a value from this wide uncertainty range as representative. For example, the guidelines issued by the Intergovernmental Panel on Climate Change (IPCC) suggest that 1.25% of the synthetic nitrogen applied to agricultural soils will be emitted as N_2O, although this is considered a default value, with a range 0.25% to 2.25%, and it accounts only for direct field emissions. A sensitivity analysis of the range of GHG emissions from nitrogen fertilizer and lime application for corn ethanol indicates that the choice of N_2O emissions' factor alone controls the magnitude of GHG emissions and whether these are greater than or less than those from petrol. The best estimate for the GHG emissions shows an 18% reduction versus petrol, yet when including uncertain emissions from lime and N fertilizer emissions, the range is a 29% reduction to a 36% increase in GHG emissions versus petrol. Finally, most scientists agree that ethanol leads to a reduction in GHG emissions compared to petrol.

Figure 12.5 below illustrates the influence of various agricultural inputs on the GHG emissions from corn production.. As can be seen, agricultural phase greenhouse gas emissions for bio-ethanol feedstock production are completely dominated by the use of nitrogen fertilizers in the feedstock-growing phase. The value shown for nitrogen includes both upstream (fertilizer production) and field emissions.

Figure 12.5 – Predicted Greenhouse Gas Emissions from the Production of Feed Corn

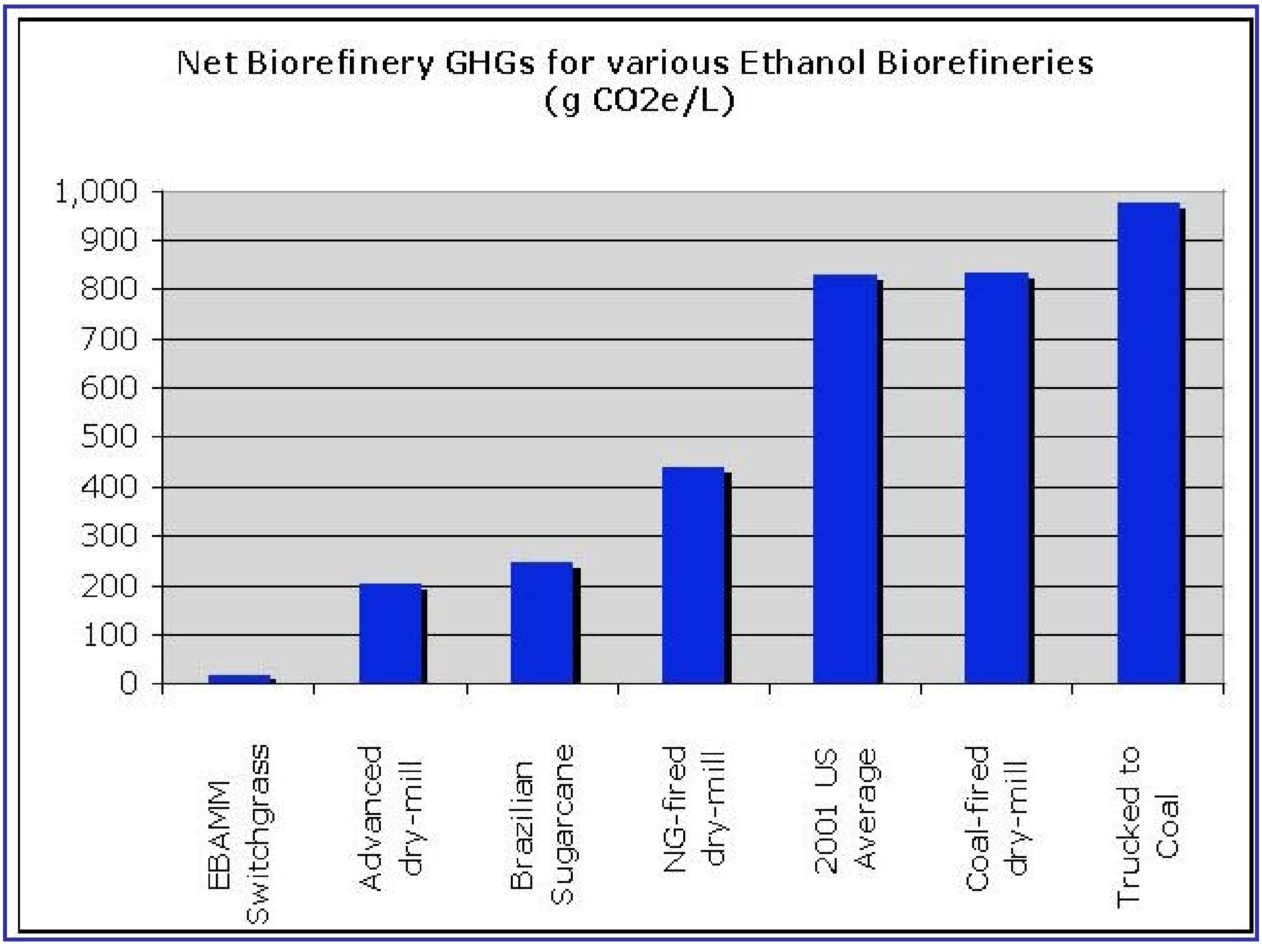


Source: University of Berkeley (2006)

Bio-Refinery Phase GHG Emissions

As a sequential industrial process, ethanol production is far less complex and uncertain than agricultural feedstock production. Figure 12.6 below shows the range of GHG emissions for the bio-refinery phase of various production pathways, net of any co-product credits.

Figure 12.6 – Net Bio-Refinery Greenhouse Gas Emissions for Various Refinery Types



Source: University of Berkeley (2006)

Ethanol GHG Reductions

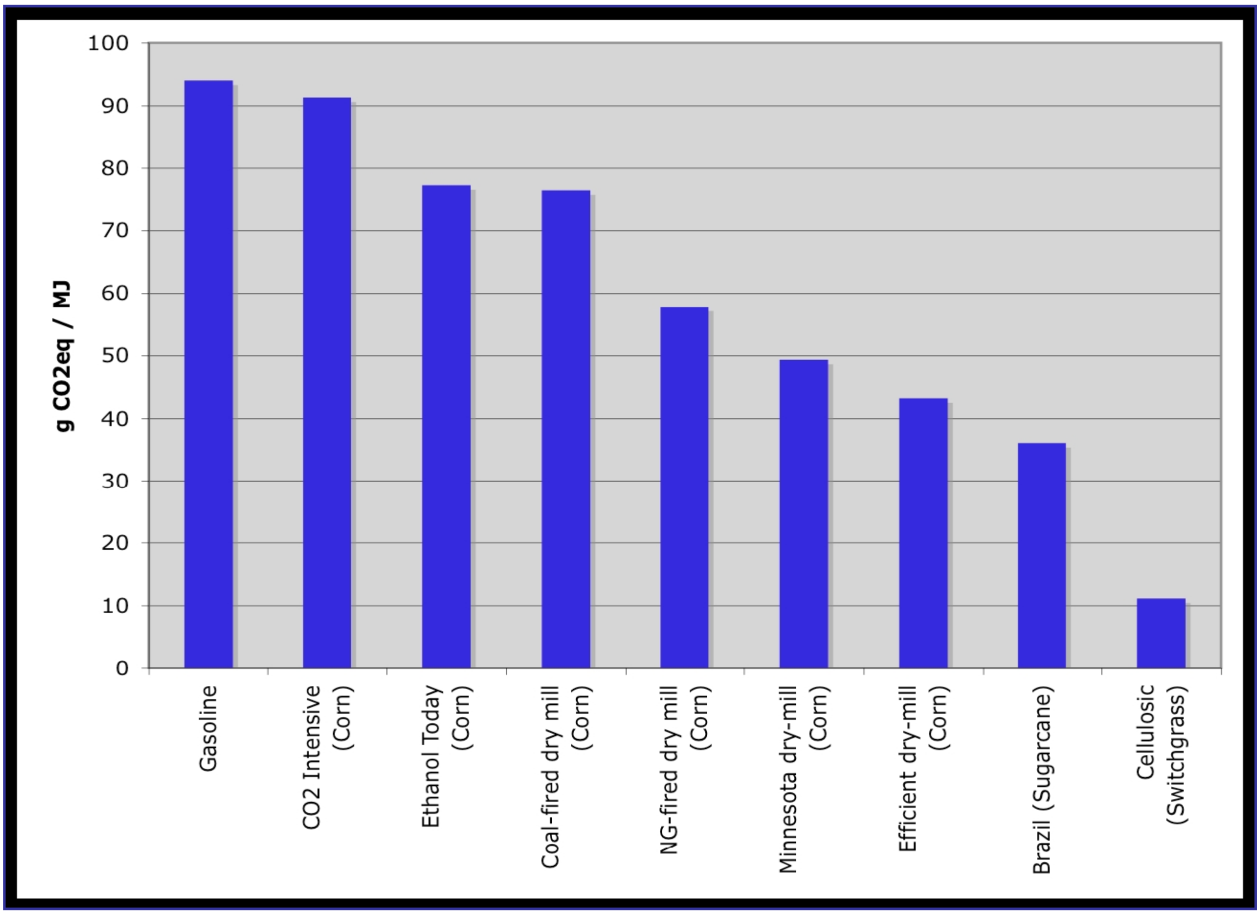
The carbon released as CO_2 by the combustion of biofuels is absorbed from atmospheric CO_2 during feedstock growth. The net CO_2 emissions from the combustion of biofuels are thus considered to be zero. The life-cycle global warming contribution of any biofuel is therefore determined by the GHGs emitted during the production or collection of the feedstock and its conversion to a liquid fuel. Biofuels have the potential to have low global warming intensity (GWI). To analyze the GHG reduction potential from ethanol, each pathway must be compared to some baseline. Typical analysis compares the grams of life-cycle CO_2-equivalent emissions from ethanol production to those of conventional petrol production.

A study conducted in 2006 by University of California, Berkeley, showed that the average corn-based ethanol in the US has a life-cycle GHG savings of 18% versus petrol; however, there is significant uncertainty, which ranges from a 36% reduction to a 29% increase versus petrol (Farrell, Plevin et al. 2006). This estimate; however, is an average based on an industry survey from 2001. More than half of the current U.S. ethanol production capacity has come on-line since that survey, so the older, less efficient stock of bio-refineries are over-represented in that analysis. The percentage of more efficient dry-mill facilities is increasing rapidly, resulting generally in a reduction in the industry average energy use and GHG emissions.

Most noteworthy is the statistic that bio-ethanol from average feed corn processed in a natural-gas-fired dry mill plant results in life-cycle emissions of 59 g CO_2 eq per MJ of ethanol, a 37% reduction in GHG emissions compared to conventional petrol.

Figure 12.7 below shows life-cycle GWI of Ethanol Pathways and Petrol. Ethanol Today describes a statistical average corn ethanol production pathway as of 2001 in U.S., including both wet- and dry-mill facilities. Combustion-phase emissions are included only for petrol; combustion phase carbon from biofuels is considered climate neutral.

Figure 12.7 - Life-Cycle GWI of Ethanol Pathways and Petrol



Source: Berkeley (2006)

Petrol GWI is approximately 94 g CO_2 eq/MJ but statistical average corn ethanol production pathway as of 2001 in US, including both wet- and dry-mill facilities, is approximately 87 g CO_2 eq/MJ. However, survey of twelve efficient gas fired dry mill plants in Minnesota, U.S., indicated GWI of as low as 45 g CO_2 eq/MJ. These calculations are done for corn but values for Jerusalem artichoke would be almost identical to the corn because there is not a significant difference in the energy needed to plant and to process between the two feedstocks.

12.9. Overview of Positive and Negative Impacts by Project Stage

Bio-ethanol production can have positive or negative impact on environment. All stage balance permits to conclude that on the whole the project has positive impact that is connected with blending of ethanol with fuel. Project plan of 5% ethanol blending will permit to reduce up to 15% carbon oxide emissions that will constitute 3,300 tonnes by 2007 estimation.

Considering vehicle quantity growth this number has tendency for growth. Other hazardous substance emission changes in various sources have different explanation and are demonstrated here. Impact comparative indicators are shown in Table 12.9 below.

Table 12.9 – Summary of Positive and Negative Environmental Impacts by Project Stage

Project stages	Emissions	Water usage	Wastes	Other impacts
Negative imact				
Growing stage • Corn • JA	Σ 0.32 tonnes/year[1] Σ 0.32 tonnes/year	3,850 m^3/year 3,000 m^3/year	-	Land impoverishment
Production stage (total 14 thousand tones of ethanol)	Σ 15.2 tonnes/year	2,6761 m^3/year	29,740 t/year[2]	Noise and odor` medium
Distribution system stage	Σ 6.1 t/year[3]		-	Noise medium
Positive impact/impact reduction				
Distribution system stage	3,300	-	-	-
Equal petrol 14,000 tonnes/year transportation	Σ 6.1 t/year[4]			

References

Berkeley (2006). California Policy Should Distinguish Biofuels by Differential Global Warming Effects, by Richard J. Plevin, University of California, Berkeley, September 26,

Farrell, A. E., R. J. Plevin, et al. (2006). "Ethanol Can Contribute to Energy and Environmental Goals." Science 311: 506-508.

Wang, M. Q. (2006). GREET 1.7 (beta) Spreadsheet Model, Center for Transportation Research, Energy Systems Division, Argonne National Laboratory.

[1] The Σ symbol shows the sum of emissions; however, it does not represent emissions levels by the individual substances.
[2] Wastes are used entirely in the field of agriculture and animal farming.
[3] This represents the sum of emissions produced from transporting 14,000 tonnes of bio-ethanol. An average distance of 300 kilometers has been assumed for these calculations. However, train transportation impacts have not been considered.
[4] The transportation distance has been reduced by 50% considering that the proposed plants will be located mid way between Yerevan and Armenia's international borders in both the north and the south.

13.0 Likely Project Risks and Suggested Mitigation Measures

13.1 Highlights of Potential Project Risks

The Project Team recognizes that there are manifold risks involved in the development of all such first-of-a-kind projects in Armenia today. For instance, the project *may* be subject to some or all of the following risk factors that are typical to projects of this nature in emerging markets:

Market Risks—Potential market risks include the possible lack of willingness of farmers to plant bio-ethanol feedstock crops because there is not presently a proven market for such crops on a sustained basis—particularly for Jerusalem artichokes which presently do not have another economic use or known value in the marketplace. Similarly, well established markets for co-products such as DDGS and animal feed from dried Jerusalem artichoke stillage do not presently exist in Armenia. With respect to feed corn, there is always the possibility that corn can be imported in large quantities more cheaply that it can be grown in Armenia further creating a potential market failure for farmers.

Technology Risks—Potential technology risks include lower equipment reliability than historically proven, higher forced outages for more complex processes systems such as dry mill corn fractionation when deployed in emerging markets due to lack of proper maintenance or training, insufficient commercial experience with dedicated Jerusalem artichoke processing plants, system compatibility problems, and too sophisticated of a technology for commercial deployment in an emerging market setting where preventative maintenance is not always widely practiced.

Construction and Operating Risks—Potential risks associated with cost overruns during construction and failure to operate and maintain the project once that it has reached commercial operation.

Financial and Macroeconomic Risks—Potential risks in this area include greater than expected general inflation, deterioration of official exchange rates which could affect debt repayment as well as the cost of spare parts and replacement components over time, a weakening of current investment incentives especially with respect to foreign investors, a tightening of the tax regime and dividend repatriation rules, and a rising cost of local currency debt.

Political Risks—Potential risk of civil unrest and violence exists everywhere in the Caucasus Region, which could result in damage to bio-ethanol facilities and disruption of supply chains and product deliveries.

Expropriation Risks—Potential risk that a Government will either declare the entire sector of strong national security interest and confiscate the assets under one pretext or another, or else abrogate all environmental permits and licenses held by the private sector developer in an effort to take over this recently formed industry.

Currency Inconvertibility Risks—Potential risk that the Central Bank will have insufficient foreign exchange reserves and will thus no longer be able to convert local currency to foreign exchange for debt repayments, importation of spare parts, and dividend repatriation by foreign investors.

Business Interruption Risks—Potential risks due to capricious changes in Government rules and regulations pertaining to the fuel transport sector or any other such action that negatively impacts normal cash flows and revenue collections such as elimination of the mandate for 5 percent blending of bio-ethanol with petrol by 2014.

13.2 Managing Specific Project Risks during Construction and Operation

Many of these risks can be readily addressed and mitigated either through insurance products available from MIGA or else through extended warranties and long-term O & M contracts with the selected process provider or equipment vendor.

With respect to more project-specific project risks and consistent with the recognized principles of project risk allocation and sharing among the various sectors and parties involved in any given privately financed transaction on a limited recourse project finance basis, the following risk management matrix is proposed for consideration by potential lenders and investors. This risk assessment matrix presented in Table 13.1 below suggests remedies and likely impacts on lenders and investors to a variety of possible risk events.

Table 13.1 – Illustrative Risk Management Matrix for Phase a 7,000 Tonne/Year Bio-Fuel Plant

Risk Event	Reason or Cause	Proposed Remedy	Consequences for Lenders	Consequences for Investors
Construction Period				
Cost overruns	Insured event	Proceeds from insurance policy	Draw on standby finance if insurance policy exhausted: debt cover factors reduced if standby debt used	Returns eroded by servicing of standby finance
	Uninsured force majeure	Draw on standby finance	Debt cover factors reduced if standby debt used	Returns eroded by servicing of standby finance
	Owner variation orders	Draw on standby finance and limit scope of variations by owner	Debt cover factors reduced if standby debt used	Returns eroded by servicing of standby finance
	Changes of law, delays in obtaining site approvals, or increased taxes	Standby finance drawn and future CPE subsidies reduced dramatically	Debt cover factors reduced if standby debt used	Returns might be reduced because of timing events
Delays in completion	Insured force majeure	Proceeds from insurance policy	Standby finance drawn if insurance policy exhausted; debt cover factors reduced	To extent ability to pay dividends is postponed, returns eroded
Failure of facilities to meet performance specifications at completion tests as a result of flawed installation	Facility cannot achieve full operational design capacity output	Redesign and replacement by vendor under warranty clauses	Debt cover factors reduced if remedy fails to correct the defect or deficiency; credit risk on vendor	Returns reduced if remedy fails to correct the defect or deficiency
Operating cost overruns	Costs exceed original estimates, not insurance or force majeure event	Seek performance penalties from the vendor and/or EPC contractor	Debt covers factors reduced if standby debt used	To extent ability to pay dividends is postponed, returns eroded
Insurance cost increases	Insurance costs exceed original estimates from insurers	Working capital is drawn down earlier than expected	Debt cover factors slightly reduced depending on timing effect	To extent ability to pay dividends is postponed, returns eroded
Increased financing costs	Interest rate increase	Standby finance drawn upon to cover increased debt burden	Debt cover factors are slightly reduced depending on timing effect	To extent ability to pay dividends is postponed, returns eroded
	Adverse exchange rate change	Standby finance may be drawn upon to cover foreign exchange	Debt cover factors are slightly reduced depending on timing effect	To extent ability to pay dividends is postponed, returns

Risk Event	Reason or Cause	Proposed Remedy	Consequences for Lenders	Consequences for Investors
		payments		eroded
	Adverse change in terms and conditions of finance	Standby finance may be drawn upon	Debt cover factors are slightly reduced depending on timing effect	To extent ability to pay dividends is postponed, returns eroded
Government Interferences	Minor changes in tax, law, customs, environmental, and legal requirements	Standby finance may be drawn upon	Debt cover factors would be slightly reduced if standby finance is utilized	Returns might be reduced because of timing events
	Nationalization, expropriation, or all licenses/ consents are withdrawn	Proceeds from expropriation insurance from either MIGA or other insurers	Loans are repaid or assumed as compensation	Investors get compensated to the extent of their insurance coverage limit
	Capricious changes in governmental regulations for the sector	Proceeds from business interruption insurance from either MIGA or other insurers	Loans continue to be repaid until issue resolved with Government through negotiation	No effect since investors continue to receive dividends
Operation Period				
Operating cost overrun	As a result of failures by the operating staff	Working capital or else standby finance drawn upon	No effect unless standby finance is drawn which lowers debt cover factors	Returns eroded by servicing of standby finance
Insurance cost increases	Cost of annual insurance premiums raised due to increased risks	Working capital or else standby finance drawn upon	No effect unless standby finance is drawn which lowers debt cover factors	Returns eroded by servicing of standby finance
Inflation or else adverse changes in cost of finance, exchange rate fluctuations, and interest rates	Changes in exogenous economic variables beyond the control of the owners	Pass on cost increases to consumers through increases in monthly tariffs to the extent permitted under existing laws	No effect	Possibility of erosion of returns if rate increases do not keep abreast of inflation
Foreign exchange non-convertibility	Changes brought about by the Government's fiscal and monetary policies which are beyond the control of the owner	Proceeds from currency inconvertibility insurance with either MIGA or other insurers	No effect since loans continue to be repaid	No effect
Failure to make available sufficient foreign exchange for dividend repatriation	Changes brought about by the Government's fiscal and monetary policies which are beyond the control of the owner	Standby finance may have to be drawn upon	Debt covers factors reduced if standby debt used	No effect for local investors unless standby finance is drawn which will erode returns
Forced outage of facilities due to temporary capacity reduction	Owner's fault	Increased overtime costs to repair and addition component or system replacement costs	No effect unless standby finance must be drawn upon to correct the problem	Returns might be reduced because of the timing of such events
Non-performance of government undertakings and obligations	Failure of Regulatory Authorities to perform obligations and honor licenses	Proceeds from political and/or business interruption insurance from insurers	Loans continue to be repaid until issue resolved with Government through negotiation	No effect since investors continue to receive dividends
Government Interferences	Minor changes in tax, law, customs, environmental, and	Standby finance may be drawn upon	Debt cover factors would be slightly reduced if standby finance is utilized	Returns might be reduced because of timing events

Risk Event	Reason or Cause	Proposed Remedy	Consequences for Lenders	Consequences for Investors
	legal requirements			
	Nationalization, expropriation, or all licenses and consents are withdrawn	Proceeds from expropriation insurance from either MIGA or other insurers	Loans are repaid or assumed as compensation	Investors get compensated to the extent of their insurance coverage limit
	Capricious changes in governmental regulations for the energy sector	Proceeds from business interruption insurance from either MIGA or other insurers	Loans continue to be repaid until issue resolved with Government through negotiation	No effect since investors continue to receive dividends

14.0 Potential Benefits and Importance to the Country

14.1 Likely Program Advantages

With respect to advantages, bio-ethanol can be produced from domestic renewable feedstock sources, can provide Armenian farmers and bio-ethanol processing plant owners with a dependable revenue stream, are non-toxic and biodegradable, have lower air emissions in a major metropolitan area such as Yerevan than petrol when combusted as a motor transport fuel, can reduce overall greenhouse gas emissions, and reduce foreign exchange drains on the Armenian economy for the benefit of the Armenian people. Cellulosic ethanol production also holds the promise of addressing an assortment of environmental problems in the mid to longer term while producing a high quality fuel. Production of these fuels also helps move Armenia toward increased energy security. Lastly, since bio-ethanol production facilities are also small refineries, the ethanol that leaves the facility needs no further processing other than the appropriate blending with petroleum fuels.

14.2 Anticipated Developmental Impacts

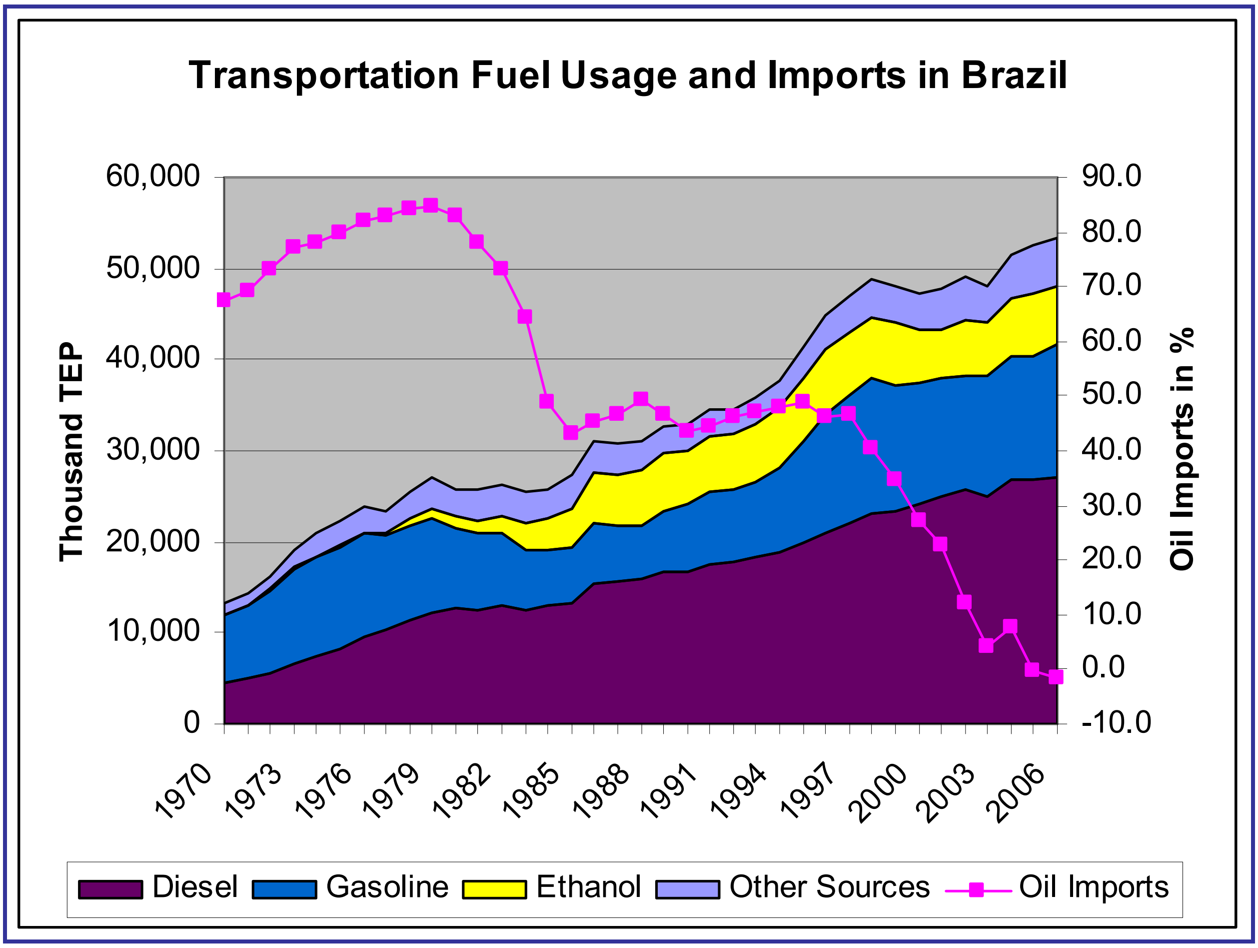
The proposed projects are also expected to have significant and positive developmental impacts and benefits to Armenia. The most important impacts and benefits are summarized below:

1. *Stimulation of Employment in Depressed Rural Areas.* A bio-ethanol feedstock production program of this magnitude will have an instant and measurable positive economic and job creation impact upon the two most depressed parts of Armenia. As such, it will give hope to countless rural farmers and give them an incentive to join Armenia's market economy.
2. *Human Capacity Building*. Most of the civil construction and electrical work would be provided by local Armenian contractors; overseen by an experienced EPC contractor with extensive international experience in bio-ethanol plant construction. Also, new jobs would be created both directly and indirectly. These jobs will require new skills and training to operate and maintain the two plants throughout their commercial lifecycles.
3. *Technology Transfer*. There has been little experience with bio-ethanol processing plants for Jerusalem artichoke on a major commercial scale and no experience whatsoever with dry mill corn fractionation and co-product processing. Only small demonstration facilities using Jerusalem artichoke have been implemented to date. In a sense, this project will create a whole new industry in Armenia since these two plants will be the first commercial-scale biofuel facilities in the country.
4. *Economic Development Benefits*. Substantial tax revenues would be generated, as well as money spent in local rural economies. Armenia would be producing motor transport fuels from domestic renewable energy resources for use in displacing more expensive imported fuel source thereby helping to improve Armenia's balance of payments.
5. *Other Benefits*. The project will demonstrate the commercial viability of bio-ethanol production from a renewable and sustainable resource.

15.0 Review of Potential Bio-Ethanol Policies and Incentives

Subsidies, incentives, and governmental policies intended to promote bio-ethanol use have played a significant role in the adoption of ethanol blending in the countries that currently use biofuels in their motor transport sectors. Until the recent upswing in global oil prices, ethanol was usually more expensive to produce than petrol. To facilitate widespread adoption of ethanol, various governments have established ethanol programs designed to promote its use. Support is usually driven by internal national factors. One of the most important drivers is energy security. While the U.S. is still largely dependent on imported oil (over 60% of consumption), Brazil has reduced its dependency on imports from 80% in 1975 to becoming a net exporter in 2006. During this same period of time, ethanol use in Brazil increased from 0% to 12% of all transportation fuels (see Figure 15.1 below). "Other sources" consist of kerosene and natural gas.

Figure 15.1 - Transportation Fuels and Oil Imports in Brazil



Source: BBI International analysis of Ministerio de Minas e Energia Data from Brazil

Policy makers also promote ethanol production for the associated environmental benefits. While ethanol production requires some fossil fuels (e.g. natural gas is used to make fertilizer for growing corn, as well as for providing process heat in the ethanol plant), the energy balance reflects that ethanol also contains renewable energy from photosynthesis in the corn plant. While the exact number is subject to different assumptions, in general, for every seven units of fossil energy used, ethanol from corn delivers 10 units of energy in return.

Rural development is another driver for worldwide support of biofuels. Since feedstocks are grown on agricultural land, increasing demand results in increased economic development in rural areas; however, biofuels policies have faced increased scrutiny in recent months. The two most controversial topics are the food versus fuel issue, and the actual level of environmental benefits accruing from bio-ethanol programs. While producers benefit from feedstock price increases, consumers can suffer from increased costs for food supplies. This is particularly true for less economically developed populations where the share of income used for food is high. However, the demand from biofuels is by far not the biggest driver for increasing food prices. The recent increase in the price of energy, especially crude oil, has a much larger impact on food prices. In addition, increased demand from growing populations in countries such as India and China, increasing incomes and the associated increase in demand for meat (which is very grain-intensive to produce) contribute to higher food demand ultimately resulting in higher food prices. Speculative demand for all commodities, in combination with a weakening dollar, has also contributed to higherfood prices.

Environmental concerns are mostly related to land use changes triggered by higher agricultural product prices. By historical averages, current prices for commodities such as corn and soybeans are high. The higher prices provide an incentive to increase production, which in many cases means expanding the amount of land used for agriculture. If the expansion land is currently forested, turning it into arable land will require deforestation resulting in environmental harm which will likely outweigh the benefits of biofuels for many years. However, as indicated above, biofuels are only one contributing factor out of many to higher prices for agricultural products, and expansion of arable land will continue even in the absence of demand from biofuels. Also, not all expansion land will require deforestation. Brazil, for example, has vast amounts of potential farm land available that are covered with grasses, which would have minimal environmental impact if converted to biofuels production.

Typically, most biofuels policies and incentives address the price and/or the volume of biofuels. For example, a national government can mandate that a certain amount of biofuels must be used, as is the case in the EU and the U.S. Such mandates set a minimum volume (e.g. 5% of all fuels, or 300 million tonnes), and usually impose penalties if the target is not met. An alternative policy approach is to reduce the price of the finished product, and let the market determine the amount to be used. As an example, Brazil uses some of the revenues from petrol sales to subsidize the cost of ethanol for the end user. In many countries, biofuels enjoy a partial exemption from the taxes levied on regular fuels, making it less costly for the consumer to purchase biofuels. However, the reduction in taxes results in decreased revenues for the national government.

15.1 Highlights of Policies and Incentives Used Worldwide

Bio-Ethanol Policy of the United States

The current main policy supporting ethanol in the U.S. is the Renewable Fuels Standard (RFS), which mandates minimum amounts of ethanol to be used in future years. The RFS is accompanied by the Volumetric Ethanol Excise Tax Credit which is a credit for the fuel blenders. The blender's credit provides an incentive to blend regular petrol with ethanol. Both instruments are described in more detail below.

The Renewable Fuels Standard

The 2007 U.S. Energy Bill was signed into law on December 19, 2007. The legislation included a revised Renewable Fuels Standard. The bill established a 36 billion gallon renewable fuels standard (RFS), headlining several important provisions for biofuels. H.R. 6 will take effect on January 1, 2009 – with the exception of the 9.0 billion gallon requirement for the current RFS program that will take effect in 2008.

The 36 billion gallon RFS has several different provisions for assorted types of biofuels. These include conventional biofuels, advanced biofuels, cellulosic biofuels, and biomass-based diesel. The legislation (H.R. 6) defines these categories as follows:

Conventional biofuel is ethanol derived from corn starch. Conventional ethanol facilities that commence construction after the date of enactment of the legislation must achieve a 20 percent greenhouse gas (GHG) emissions reduction compared to baseline lifecycle GHG emissions. The 20 percent GHG emissions reduction requirement may be adjusted to a lower percentage (but not less than 10 percent) by the U.S. Environmental Protection Agency (EPA) Administrator if it is determined the requirement is not feasible for conventional biofuels.

Advanced biofuel is renewable fuel, other than ethanol derived from corn starch, which is derived from renewable biomass, and achieves a 50 percent GHG emissions reduction requirement. The definition – and the schedule – of advanced biofuels include cellulosic biofuels and biomass-based diesel. The 50 percent GHG emissions reduction requirement may be adjusted to a lower percentage (but not less than 40 percent) by the Administrator if it is determined the requirement is not feasible for advanced biofuels. Cellulosic biofuels that do not meet the 60 percent threshold, but do meet the 50 percent threshold, may qualify as an advanced biofuel.

Cellulosic biofuels is renewable fuel derived from any cellulose, hemicellulose, or lignin that is derived from renewable biomass, and achieves a 60 percent GHG emission reduction requirement. The 60 percent GHG emissions reduction requirement may be adjusted to a lower percentage (but not less than 50 percent) by the Administrator from the EPA if it is determined the requirement is not feasible for cellulosic biofuels.

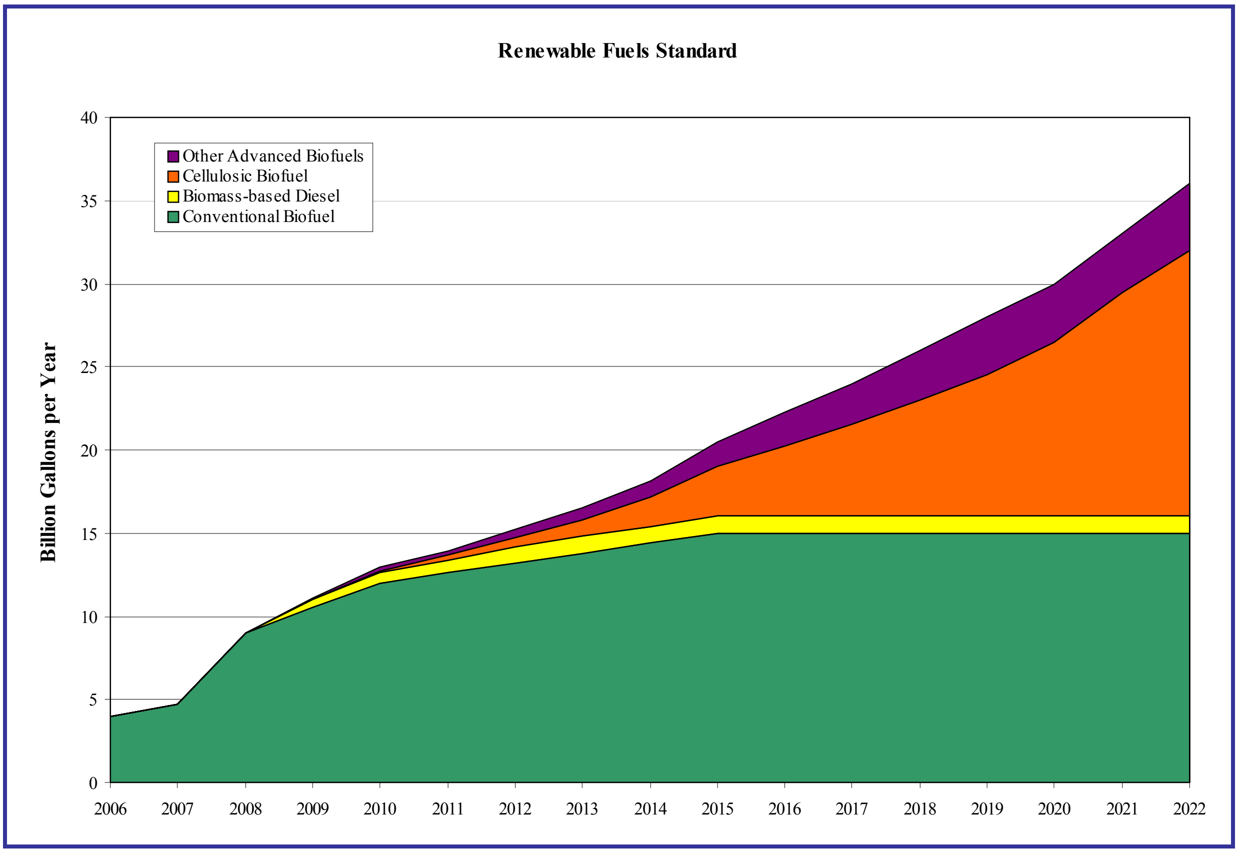
Biomass-based diesel is renewable fuel that is bio-diesel as defined in section 312(f) of the Energy Policy Act of 1992 (42 U.S.C. 13220(f)) and achieves a 50 percent GHG emission reduction requirement. Notwithstanding the preceding sentence, renewable fuel derived from co-processing biomass with a petroleum feedstock is considered an advanced biofuel if it meets advanced biofuels requirements, but is not biomass-based diesel.

H.R. 6 sets the following targets for each of these biofuels types. The following table and figure below show RFS volumes from 2008 to 2022.

Table 15.1 – Renewable Fuels Standard Volumes in Billion Gallons

Year	Conventional Biofuels	Advanced Biofuels			Total RFS
		Cellulosic Biofuels	Biomass-Based Diesel	Undifferentiated	
2008	9.0	---	---	---	9.00
2009	10.5	---	0.50	0.10	11.10
2010	12.0	0.10	0.65	0.20	12.95
2011	12.6	0.25	0.80	0.30	13.95
2012	13.2	0.50	1.00	0.50	15.20
2013	13.8	1.00	1.00	0.75	16.55
2014	14.4	1.75	1.00	1.00	18.15
2015	15.0	3.00	1.00	1.50	20.50
2016	15.0	4.25	1.00	2.00	22.25
2017	15.0	5.50	1.00	2.50	24.00
2018	15.0	7.00	1.00	3.00	26.00
2019	15.0	8.50	1.00	3.50	28.00
2020	15.0	10.50	1.00	3.50	30.00
2021	15.0	13.50	1.00	3.50	33.00
2022	15.0	16.00	1.00	4.00	36.00

Figure 15.2 – H.R. 6 RFS Volumes by Year



In addition to the 36 billion gallon RFS, the bill authorizes $500 million annually for fiscal year 2008 to 2015 for the production of advanced biofuels that have at least an 80 percent reduction in lifecycle greenhouse gas (GHG) emissions relative to current fuels. It also authorizes $25 million annually for fiscal year 2008 to 2010 for research and development and commercial application of biofuels production in states with low rates of ethanol and cellulosic ethanol production; and a $200 million grant program for fiscal year 2008 to 2014 for the installation of refueling infrastructure for E-85 (85% ethanol blends). It is important to keep in mind that these funds are authorized, but not appropriated yet. Unless these funds are appropriated by the relevant departments, no money will be available.

The bill also includes appropriations for waivers to be granted based on various environmental, economical, and/or production scenarios. It authorizes the EPA Administrator, one or more States, or a refiner/blender to petition for a waiver of the renewable fuels mandate. The Administrator is authorized to waive the renewable fuels mandate if implementing the requirement would severely harm the economy or the environment, or that there is inadequate domestic supply to meet the requirement. There is a separate waiver provision for cellulosic biofuels if the minimum volume requirement is not met. The Administrator is authorized to reduce the applicable volume of required cellulosic biofuels, and make available for sale a cellulosic biofuels credit at the higher of $0.25 per gallon or the amount by which $3.00 per gallon exceeds the average wholesale price of a gallon of petrol (in the United States). Finally, beginning in 2017, if the EPA Administrator waives at least 20 percent of the mandate for two consecutive years, or waives 50 percent of the mandate for a single year, the Administrator is authorized to modify the volume requirement for the remaining years of the renewable fuels mandate.

Ethanol production above the minimum RFS is not viable unless sold at prices that are attractive to petrol blenders i.e., rack unleaded price plus a portion of the 51¢ per gallon Volumetric Ethanol Excise Tax Credit. Otherwise, voluntary blending above the level required by the RFS will decline until ethanol prices fall to the point where voluntary blending becomes profitable.

V.E.E.T.C. or "Blenders Credit"

The Volumetric Ethanol Excise Tax Credit, or V.E.E.T.C., was originally put into place on January 1, 2005. The credit was intended to give tax relief credit to vendors that blend ethanol with petrol for resale.

The credit originally was set to give 51 U.S. cents for every gallon of ethanol greater than 190 proof that was blended. This credit is measured out by volume so the blend concentration is not important, allowing E10, E85, and any other approved blend values to be included. This blender's credit was to apply from January 1, 2005 through December 31, 2010, but was changed by the 2008 Farm Bill amendments to apply through December 31, 2008. It was amended such that for the next two years, January 1, 2009 to December 31, 2010, the tax relief amount was reduced to 45 U.S. cents per gallon.

Ethanol Program Incentives in Brazil

Brazil's PROALCOOL program started in 1975 with two main objectives: to improve national energy security and to provide alternative demand for sugar production. The oil crisis in 1979 underscored the importance of having a domestic supply of transportation fuel. Volatile world sugar markets provided an incentive to promote another outlet for sugar in times of low world sugar prices.

Initially, the Brazilian Government provided a variety of incentives to establish ethanol as a viable alternative to petroleum fuel, aiming for nationwide use of E-20. These included:

- Low interest rate loans
- Guaranteed purchases of ethanol through the state-owned oil company (Petrobras)
- Regulated production quotas and prices for ethanol to be competitive with petrol
- Production quotas for sugar and export controls

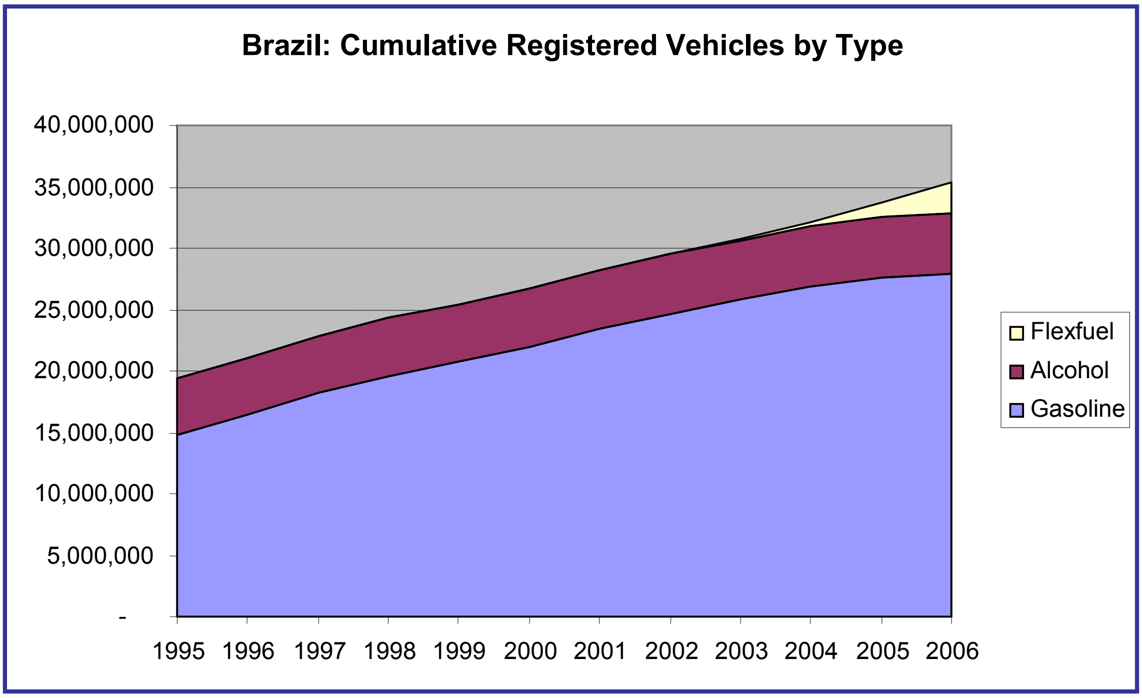
For example, when low oil prices resulted in petrol that was cheaper than ethanol, petrol was taxed to subsidize ethanol. Production of sugarcane was increased through subsidized loans for new investments with extended grace periods. Similar incentives were offered for investments in processing capacity. The Brazilian Government ended up paying 80-90% of the investments through subsidized interest rates combined with high inflation.

In addition, imports of foreign alcohol were restricted to guarantee a market for the domestically produced ethanol. To increase demand for ethanol, alcohol pumps were installed at all gas stations, and the cost of ethanol was kept significantly below (40%) the cost of petrol. Regulations were passed that required car manufacturers to build vehicles that can utilize ethanol and ethanol blends, and distribution companies were required to include ethanol in their fuel mix. Tax incentives were offered to make ethanol-fueled cars competitive with regular cars. In 1984, 95.8% of all new car sales were neat ethanol-fueled cars.

The Brazilian Government also provided incentives for research activities in related fields, such as improved sugarcane strains, mechanized harvesting of sugarcane, conversion processes and engine technology.

The adoption of ethanol in Brazil hit a snag in 1989. The cars that operated on alcohol were designed to run only on alcohol, unlike today's flex fuel vehicles (FFVs). FFVs can be operated on ethanol blends containing between 0% and 100% of ethanol (up to 85% in the US). When demand for ethanol in 1989 exceeded supply, consumers with alcohol-only vehicles were not able to use alternative fuels such as petrol. Not being able to fuel their vehicles had a significant negative impact on the public's perception of the utility of ethanol as a fuel. Fortunately, the arrival of FFVs eliminated the risk of not being able to find appropriate fuel for one's vehicle. In addition, the flexibility of these vehicles allows the user to select the most advantageous fuel depending on the relative prices at the pump at the time of fueling. Ethanol prices in Brazil are significantly below regular petrol prices, more than making up for the loss in mileage associated with the lesser energy content of ethanol compared to petrol. In September of 2007, FFVs accounted for over 85% of all new vehicle sales in Brazil. 40% of the petrol sold in Brazil is now replaced by ethanol. As indicated in Figure 15.3 below, almost all car registrations are for petrol vehicles.

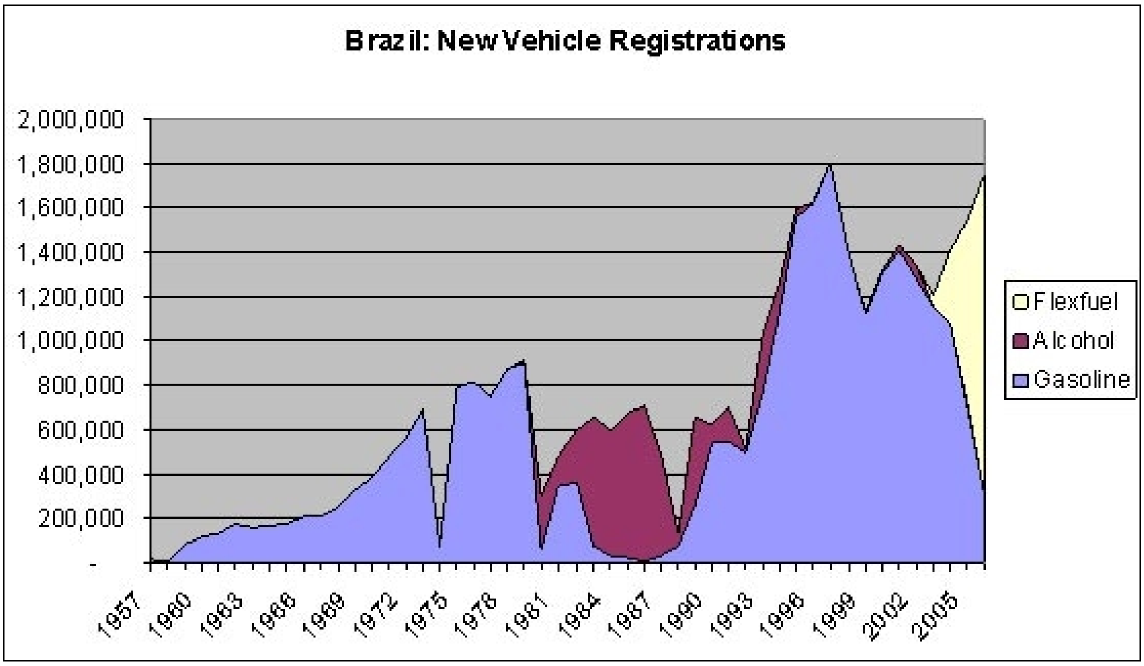
Figure 15.3 – Cumulative Registered Vehicles by Type



Source: ANFAVEA. Anuario Estatistico (1999) 1957/1998

Figure 15.4 below indicates the dramatic increase in new registrations for flex fuel vehicles since 2003.

Figure 15.4 – Annual New Vehicle Registrations



Source: ANFAVEA. Anuario Estatistico (1999) 1957/1998

Today, Brazil has a volume requirement for ethanol between 20% and 25%, depending on ethanol supplies and prices. There are also price incentives in the form of reduced taxes. Regular petrol is taxed R$ 0.28 per liter, while ethanol does not incur this tax. In addition, there is R$ 0.2616 Social Tax on petrol, while ethanol's Social Tax is 11.85% which was about R$ 0.14 in July 2007 in Sao Paolo.

Policies in Other South American Countries

Argentina: The Biofuels Act, passed in April 2006, mandates a 5% blend of bio-diesel and ethanol by 2010. The aim of this legislation is to benefit both the farming market and small businesses. The government also plans 15 years of fiscal incentives which may include refund of sales tax, exemption from fuel tax, tariff exemption for imported machinery. Differential export taxes strongly favor bio-diesel—the export tax for virgin soybean oil is 20%; the export tax for bio-diesel is just 5%. The government fixes the price of diesel at $.48/liter; it is unclear if this price will apply to bio-diesel also.

Chile: In 2006, the Chilean government convened an advisory committee to investigate biofuels production opportunities. In January 2007, the committee released a report siting tax exemptions and mandatory use as necessary steps for domestic biofuels production. The committee also wrote that production costs in Chile may deem it wiser to import biofuels from nations with lower production costs. The government estimates that 170,000 hectares are available to cultivate biofuels feedstocks. After reviewing the report, President Bachelet will decide what steps to take.

Columbia: In 2001, Columbia passed legislation requiring a 10% ethanol blend by 2009 set to increase gradually to 25% over 15-20 years. Currently, Cities with populations exceeding a half million are mandated to use 10% ethanol blends. Upon re-election in 2006, President Uribe declared that biofuels production will be a top priority of the administration.

Paraguay: Promotion of Biofuels Law N 2748 was signed in October of 2005. This law will set a mandate for biofuels blending based on domestic production per the Ministry of Trade and Industry. This law allows for the following tax incentives: reduced corporate tax, tax exemptions on leases, royalties, licensing of intellectual property and technology. In order to obtain these benefits, domestic feedstocks must be used. This law aims to mitigate volatile petroleum prices, create jobs and increase domestic sugarcane production. Paraguay's Minister of Industry and Commerce, Jos Mara Ibez, stated that Paraguay plans to produce 300 million liters of bio-diesel annually by 2011.

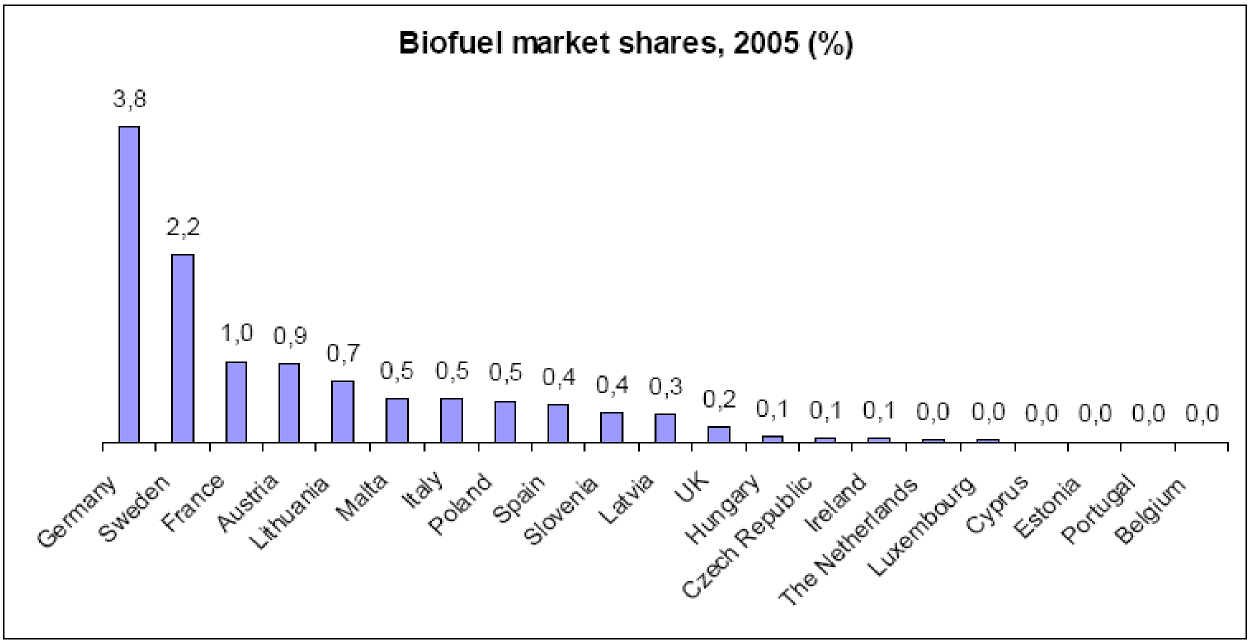
Peru: The Andean Trade Promotion and Drug Eradication Act enables Ethanol produced in Peru to be imported into the United States duty free.

Venezuela: According to World Watch Institute, the Venezuelan Government is phasing in an E10 mandate. No other information is available.

Promotion of Biofuels in the European Union

In 2003 the EU Commission established the Biofuels Directive for the promotion of biofuels use in the transportation sector. The targets that were established, also termed reference values, were 2% by 2005 and 5.75% by 2010. However, the 2005 target was not reached as biofuels use was only 1.0% by the end of 2005 (see Figure 15.5). Several member states—Italy, Slovenia and the United Kingdom have not updated their biofuels targets to reflect the EU directive of 5.75% by 2010; each nation currently has a goal lower than the directive. In February, 2007 the EU energy ministers met and agreed to increase the biofuels use to 10% by 2020. An important change in EU agricultural policy now enables new member states to qualify for receipt of the €45 per hectare subsidy for growing dedicated energy crops. Nations now qualifying include original member states and new states including: Bulgaria, Czech Republic, Estonia, Cyprus, Latvia, Lithuania, Hungary, Poland, Romania and Slovakia.

Figure 15.5 – Percentage of Bio-Ethanol Blending Attained by Each EU Country, 2003 - 2005



EU25: 1.0% (estimate)

Source: biofuels progress report (COM (2006) 845)

Note: data were not available for Denmark, Finland, Greece and Slovakia

More recently, in January 2008 the EU Commission presented a review of the 2003 biofuels directive. It re-confirmed the 10% target for 2020, but biofuels technologies must deliver life-cycle CO_2 savings of at least 35% compared to fossil fuels. However, feedstocks planted after January 1, 2008 in protected areas, "highly biodiverse" grasslands, forests and wetlands will not be considered as counting towards the 10% target. The so-called "Green NGOs" in Europe have a strong lobby and many politicians listen to their arguments so that the politicians are not considered anti-green. Therefore, as biofuels issues such as the fuels vs. food issues arise, new arguments are taken seriously and re-evaluation of biofuels legislation occurs.

Highlights of the current policies and incentives in each EU country, as well as the overall status of their respective biofuels programs, are presented below:

Austria: Austrian law allows for tax credits for bio-diesel blended in amounts of 4.4% or greater; the tax credit ranges from 0.5 to 29.7 cents per liter dependent on blend. Pure bio-diesel (B100) is exempted from this tax entirely. In October 2005, a 2.5% volumetric biofuels blend obligation was enacted. Impressively, the biofuels share was 3.2% in 4th quarter of 2005. The biofuels share was only 0.2% for the previous three quarters prior to the mandate going into effect.

Belgium: In 2005, Belgium lifted tax of ethanol blended in volumes of at least 7%; taxes were lifted for bio-diesel blended in levels of at least 2%.

Czech Republic: The Cabinet approved full use of biofuels in the Czech Republic starting in June 2007. The Biofuels Program, approved in September 2006, does not suggest incentives. There is a bill under consideration that would reduce or remove excise tax; however, the cabinet is split on this issue. RFA reports that rapeseed based bio-diesel blended in volumes greater than 30% are exempted from excise tax.

Denmark: All biofuels production is exported because there are no tax exemptions for biofuels in Denmark.

Estonia: Estonia exempts biofuels used in transport or heating applications from excise tax.

France: France began offering financial incentives for biofuels production in 1993. An annual quota of production qualifying for reduced tax is established each year. The quota for 2008 is for 3.5 billion liters of biofuels production. It has been the case that the quota qualifying for tax reduction exceeds actual production each year. In 2005, the fuel taxes were as follows (€/liter): 0.42 diesel; 0.09 bio-diesel; 0.59 petroleum gas; 0.22 ethanol. The tax relief was not as generous in 2006 due to the cost of biofuels programs. In theory, the tax relief is adjusted annually to make biofuels cost competitive with petroleum fuels. In January 2005, France established a mandate of 2% blend but most fuel suppliers chose an extra payment, allowable by law, rather than supply biofuels.

Germany: Bio-diesel had previously enjoyed tax free status, but the German government started taxing bio-diesel in June, 2006. This was due to increased bio-diesel sales due to petroleum diesel being more expensive. Now that petroleum diesel prices have dropped and bio-diesel is taxed, bio-diesel demand has slowed.

Greece: The Government of Greece has announced plans to produce 160 and 400 million liters of bio-diesel and ethanol respectively by 2010. Greece provides tax exemptions for biofuels production. The 2007 quota is 114 million liters of bio-diesel production.

Hungary: In July 2006, the government passed legislation exempting ethanol blends of 70% or more from excise tax. Excise tax accounts for 30% of the cost at the pump and the exemption will expire at the end of 2012. The Agricultural Ministry has earmarked €359 million of EU funding for promotion of biofuels production between 2007 and 2013. The Agricultural Ministry also announced plans to ramp up ethanol production from 70,000 tonnes in 2006 to 800,000 tonnes by 2010.

Italy: Ethanol is exempt from excise tax up to €0.34 per liter but there is quota for the amount of biofuels that qualify for the tax exemption.

Lithuania: Biofuels are exempt from excise tax based on the proportion of biofuels blended on a tonnes basis.

Netherlands: Starting in January 2007 a 2% bio-diesel blend is required. In 2006, Shell began blending and selling a 2% ethanol blend. The government provided tax relief for blends containing at least 2% biofuels; the relief is €10.10 per 1,000 liters for ethanol blended petrol and €6.10 per 1,000 liters for bio-diesel.

Poland: Poland provides tax excise exemption for ethanol in the amount of €0.31 for every liter blended with petrol at a rate of 2-5%; when blended at 5-10% the excise exemption is extended to €0.38 per liter; above 10% the exemption is €0.46 per liter for each liter blended. The Bio-Fuel law encourages use of domestic feedstock by requiring 75% of biofuels production to enter into five-year contracts with fixed feedstock prices.

Portugal: A quota for biofuels exempt from excise tax is set annually.

Spain: Biofuels are exempt from all taxes. If biofuels are blended the tax exemption only applies to the portion blended. This exemption is valued at €0.24.

Sweden: Sweden provides a tax relief in a slightly different manner than excise tax relief. Ethanol is only subject to VAT tax and not petrol taxes and has been consistently cheaper than petrol. Roughly 700 large volume retail fueling stations are required to sell biofuels. Carbon dioxide vehicle taxes are lower on biofuels vehicles. As of 2007, 85% of government vehicle purchases must be either hybrids or flex-fuel.

Incentives in Other European Nations

Switzerland: In March 2007, The Swiss Regional and National Parliaments lifted fossil fuel taxes on compressed natural gas (CNG) comprised of biogas and natural gas. This represents a tax reduction of €0.28 per liter which will allow the CNG to sell at a 30% discount to petroleum petrol or diesel.

Ukraine: The Government of Ukraine passed legislation creating a Biofuel Production Program in December 2006. The primary outcome of this legislation is government support for rapeseed production with a goal of 10% of cultivated land dedicated to rapeseed. It is intended that 75% of rapeseed production will be dedicated as bio-diesel feedstock to supply some 20 crushing plants. It is not clear if the government intends to focus solely on rapeseed oil or bio-diesel. The government anticipates crushing capacity reaching over 600,000 tonnes whereas 2006 oil production was 49,000 tonnes. Ukraine already offers a subsidy of €13.96 per hectare of winter rapeseed and €9.07 per hectare for spring rapeseed.

15.2 Institutional Framework for Bio-Ethanol Production in Armenia Today

Existing Legislation, Resolutions, and Codes

Several laws and regulations with the potential for impacting a potential bio-ethanol in Armenia were reviewed and highlighted in the companion Task 1 Report entitled *The Potential for Expanding the Production of Promising Bio-Ethanol Feedstocks in Armenia Today* published in August 2008. These laws and regulations encompassed various aspects of the energy, water, and agriculture sectors and included the following:

- Energy Law
- Law on Energy Savings and Renewable Energy
- Law on Public Service Regulatory Body
- Public Service Regulatory Commision Resolutions
- National Safety Strategy
- Law on the Protection of Plant Life
- Law of Protection of Selection Achievements
- Law on Seeds
- Law of Biodiversity
- Law on Environmental Impact Analysis
- Land Code
- Water Code

Republic of Armenia Technical Standards

The most recent standards for internal combustion engine fuel were adopted by the Government of Armenia (GoA) in 2004.[1] The document was based on the Republic of Armenia (RoA) Law on Standardization. It regulates quality for all fuel types except aviation petrol and jet engine fuel. The Rules establish standards for the following finished petroleum products:

Non-Ethanol Automobile Fuel

- Normal (regular) quality
- Premium quality
- Super quality

Diesel Oil

The Rules also provide safety indicators, protection, and security measures to be taken during the transportation, sale, consumption and storage of fuel, as well as certification requirements. Along with that, by individual tables indicators of quality, such as spark-safety, lead content, consistence, sulfur quantity, benzol, hydrocarbon and oxide content for each type of fuel are provided.

Moreover, the Rules provide that each fuel transportation and storage container should have the name and type of the fuel, information about producer and importer of the fuel, net and gross weight of the container, production date, identification mark and a "keep open flames away" note. Requirements for different (transportation and sale) containers for fuels are described in a separate chapter of the Rules.

As the Rules state under environmental requirements, fuel is on the fourth level of gravity and allowable level of hydrocarbons in the air should not exceed 5 mg/m^3 (100 mg/m^3 in construction zones and working areas).

As an attachment, the Decree contains a list of 26 fuel standards including:

- Standards on liquid fuels (HMT-EN 237)
- Safety standards of operation; Dangerous substances, classification and general requirements (GOST[2] 12. 007)
- Transparent and non-transparent oil (GOST 33)
- Fuel for engines (GOST 511)
- Mineral oil (GOST 1756)
- Oil and petroleum (GOSTs 3900, 2177, 2477, 6356)
- Petroleum (GOST 29040, GOST 28828, GOST-R 51941, GOST-R 51930)

In order for blended bio-ethanol/petrol fuel to burn properly, the levels of quality listed in the standards above must be followed. International practice has shown that in cases when the

[1] GoA Decree No. 1592 (11.11.04) on Approval of Technical Rules for Internal Combustion Engine Fuel
[2] State standard

standards are not followed and petrol of low quality is blended with bio-ethanol, the results can be plugged petrol filters, phase separation of fuel and water, and impurities entering the combustion chambers of the engines.

The introduction of bio-ethanol will cause minor reductions in the performance of the vehicles in any case due to the difference in energy content, but adding bio-ethanol to low quality petrol can easily result in complete consumer dissatisfaction and disapproval of the bio-ethanol program. Countries that have started bio-ethanol blending have introduced stringent rules and enforcement of rules to ensure consumer satisfaction and success of the bio-ethanol fuel blending program.

In this regard, it is critical that the petrol to be blended with ethanol does not contain water. As mentioned above, if ethanol is blended with petrol which contains water, phase separation of water and petrol will occur as ethanol has an affinity for water and engine performance will be significantly diminished. It is imperative that *all* containers which contain petrol be completely dried of all water content prior to being used.

Certification of Motor Transport Fuels

Sale of fuel without certification is prohibited. The certification of fuel should be carried out in accordance with the GoA Decree No. 1170 (12.08.04) on Mandatory Schemes for Certification of Goods and Services and Identification Marks. The entire process comprises the following stages:

1) Submission of application for certification;
2) Review of application;
3) Sampling and identification by the certification body;
4) Testing (with participation of the applicant representative(s));
5) Finalizing of the testing results and issuance of a certificate;
6) Monitoring.

Certification is done by an independent licensed entity called OCTAN-Test. The certificates are issued for 12, 24, and 36 months depending on the particular case. For petrol, the certificate should be given for no more than one year, but no less than a three-month period. Along with OCTAN-Test monitoring fuel quality SNCO, a branch of the Ministry of Trade and Economic Development, also carries out monitoring of the fuel stations and imported fuel no less than once a year. In case a violation is discovered, the certificate can be suspended or revoked.

Most countries in Central and Eastern Europe that have started bio-ethanol projects have instituted EU standards for petrol and EU certification process to allow for consistency in the market for petrol and for blending of bio-ethanol into the petrol. Following these standards and certification process will assurance that the bio-ethanol can be blended in any country without causing any car performance problems.

The use of EU standards is important because samples from the tests performed in Armenia can be sent to EU laboratories for calibration and periodic verification of tests performed by local laboratories. This is a key part of the enforcement of the standards in other countries that has been important in maintaining reliable certification and monitoring processes.

Taxation of Motor Transport Fuels

The Armenian legal framework outlines a specific tax regulation for petrol and diesel products[1]. The fuel importers pay a fixed VAT and excise tax payment in the amount of 112,000 ADM per one tonne of petroleum, while the immediate sellers pay fixed profit taxes in the amount of 1% of sold fuel, but no less than AMD 2,500. The sale of imported petroleum is exempted from the VAT.

The production of ethanol in Armenia is covered by the tax legislation as well. In this regard, the sale of ethanol from local beverage producers carries an excise tax of 600 AMDs/liter to which a VAT is then added. Countries producing bio-ethanol have typically categorized different types of ethanol (beverage ethanol, medical ethanol, and bio-ethanol for motor transport vehicles) and exclude bio-ethanol from such excise taxation. In addition, it is not clear under the current tax code whether bio-ethanol would be excluded from either such excise taxes or the VAT. Clarification is required regarding either exemption or potential future taxes on an industry and product that does not currently exist in Armenia.

Bio-Ethanol as a Renewable Energy Resource

As seen above, some countries have included bio-ethanol in the list of renewable resources. In these cases, there are various types of grants, subsidies or tax relief to the bio-ethanol projects that provides a period of time for the bio-ethanol market to mature in the country. There is presently no such distinction under Armenia's current institutional, legal, and regulatory framework. Moreover, in Armenia's case, the agricultural sector presently lacks suitable markets for corn and Jerusalem artichokes, and some type of support or incentive may be needed to encourage investment from the initial producers.

Again, as mentioned above for other countries, one commonly used support mechanism is the mandated use of bio-ethanol. Blenders are required to purchase the specified blending amount of bio-ethanol from the market. If the market is competitive, then the price of the blended fuel will include the cost of imported petrol plus the market price of bio-ethanol. If a competitive market for bio-ethanol does not exist, then a regulated price in a bio-ethanol purchase contract would need to be dictated by a regulated body to ensure no abuse of market power.

15.3 Recommended Changes to Armenia's Existing Institutional Framework

- Bio-ethanol is not mentioned in any of the main legal documents regulating promotion and development of the renewable energy in Armenia, namely the RoA Law on Energy Saving and Renewable Energy (09.11.04), the Energy Sector Development Strategy of Armenia[2], which provides a detailed description and programs for development of available domestic energy resources, or the MoE Action Plan[3]. To fill that gap, an amendment should be made to the Law on Energy Saving and Renewable Energy. Bio-ethanol should at least be referred to in the definition of the renewable energy resources given as "a group of energy carriers emerged from wind, solar, hydro, geothermal, and biomass, which can be used for consumption".
- Bio-ethanol does not receive special treatment, as do other renewable resources including biogas. Thus, bio-ethanol should be included in the national strategies and

[1] RoA Law on Fixed payments for benzene and diesel fuel, adopted on December 25, 2003
[2] GoA Resolution No 1 of 24[th] Protocol, adopted on June 23, 2005
[3] GoA Decree No. 1296, adopted on November 1, 2007

programs for development of domestic renewable resources. These programs along with research of available resources should also provide indicative targets for use of bio-ethanol and monitoring procedures. It appears that a mandatory level of bio-ethanol usage will be needed at least for the initial years of production.

- The Government of Armenia should provide financial support for feedstock improvement and cellulosic research programs. The research should demonstrate commercial readiness of bio-ethanol production and biomass conversion technologies derived from forestry and agriculture sources to the energy production. It should identify the highest value use and market potential for agricultural and forest products as a potential source of energy and demonstrate new crop systems and biomass handling, storage and distribution options, both in terms of technology and price.
- As with other countries, a long-term program should be developed for promotion of biofuels in the transportation sector. Through adoption of relevant legal acts, the Government of Armenia should ensure minimum proportion of bio-ethanol is placed on the market. In parallel, necessary excise taxes should be imposed on imported ethanol intended to meet mandatory blending requirements.
- Promotion of the use of biofuels in the transportation sector is a step towards integration of international guidelines into national legislation such as the EU Directive 2003/30/EC on the promotion of the use of biofuels or other renewable fuels for motor transport (08.05.03) in particular.
- The standardization bodies should develop and adopt new technical standards concerning quality of fuel and level of emissions. However, these standards should be aimed at assurance of optimum engine performance.
- Vigorous enforcement of fuel quality standards and frequent testing at fuel depot tanks and retail outlet pumps will be required to ensure overall program success.
- It will be imperative that *any* ethanol implementation program be carried out by an entity that has its interest in the success of such a program. The implementation should not be left to entities that see this more as an obligation or that feels that the introduction of ethanol will take away part of its market share.
- Finally, a nation-wide public awareness program should be developed and implemented to introduce and promote production and use of bio-ethanol. Along with positive impacts such as reduction of air emissions, provision of new employment opportunities for rural areas and diversity of energy sources for the country, use of bio-ethanol, even not quite justified commercially but acceptable as a policy development, would lead to significant changes in the market. Thus, at the national level, high quality petrol should be certified and assured by the government. If not, consumers will have to deal with performance sacrifice and replacement of filters of the vehicles, which is also a cost item.

16.0 Proposed Implementation Schedule

The implementation of the proposed projects can be divided into two phases: the goal for Phase 1 is to prepare for construction of the plant, and Phase 2 is the actual construction of the plant. At the end of Phase 2, the plant should be operational.

Phase 1

The duration of Phase 1 will depend mostly on the amount of time necessary to raise the required financing. The project sponsors will need to assess the risks and rewards associated with this project, and it may take substantial time to raise both the debt and the equity required if the project is to be financed on a limited recourse project finance basis. In particular, potential lenders will subject these projects to an intensive due diligence process before committing to lending to the project, In the case of the IFC, this review process typically takes up to six months and sometimes longer before a Board decision is rendered. Then the loan agreement must be negotiated between the parties that could take another month or so before final agreement is reached on loan covenants and conditionalities. In the case of potential investors, they will want to review a detailed business plan and market assessment before committing funds. Accordingly, the project proponents will need to assemble a significant amount of project information, as well as provide evidence of both sufficient feedstock supply contracts and off-take sales agreements to convince other investors that the project merits consideration. Following are some of the steps that are required to implement each of these projects and their approximate planning and construction timelines.

1) Set up legal entity to implement projects, raise seed funding (6 weeks)
2) Identify a Process Design provider, negotiate and sign contract (3 months)
3) Identify an Engineering, Procurement and Construction (EPC) contractor, negotiate and sign contract (2 months)
4) Establish permitting requirements and sequence: (several months)
5) Establish feedstock supply contracts for corn and Jerusalem artichoke (in parallel with other activities)
6) Identify and contract with ethanol buyers (in parallel with other activities)
7) Identify and contract with co-product buyers (in parallel with other activities)
8) Validate availability of electricity, natural gas and water at sites (in parallel with other activities) and obtain utility contracts.
9) Secure sites (in parallel with other activities)
10) Develop business plan and raise remainder of financing (6 - 8 months)

Phase 1 will take at least six to eight months to arrange project financing which is the longest and most critical path time element highlight above. Depending on the level of interest from both lenders and investors and length of time for Government to put in place the provisions for a mandated bio-ethanol blending program, total project planning activities could take anywhere 12 to 18 months before construction can start.

Phase 2

Construction of the plant depends on the performance of the process design provider and the EPC contractor. Construction will take at least one year to reach start up and commercial operations under the best of conditions.

Total Duration of Project Planning and Implementation

Thus, the total project planning and implementation schedule for each proposed bio-ethanol processing plant is expected to take anywhere from 24 to 36 months from project inception to full commercial operation.

17.0 Alternative Strategic Development Concepts

The project team was also asked with developing at least three alternative strategic development concepts and evaluating their likelihood of either qualifying for various sources of specialized funding or else being rejected altogether for violating the terms and conditions for loan or funding pre-qualification. In this regard, the team developed the following alternative strategic development concepts for possible consideration to implement this proposed bio-ethanol program:

1) Mandatory Fuel Blending Program or Renewable Fuels Standard mandating 5% bio-ethanol blending by volume with imported petrol by 2014 and 10% by 2020 coupled with an excise tax on imported ethanol for fuel blending
2) Direct Subsidy Volumetric Tax Credit to Blenders to ensure that the retail cost of bio-ethanol remains cheaper than petrol
3) Indirect Light Subsidy Program including such measures as classification of bio-ethanol as a renewable energy resource, accelerated depreciation for plant and equipment items, establishment of bio-ethanol as a motor transport fuel as opposed to ethanol for the alcoholic beverage industry which is presently subject to a 600 AMD "sin tax", and free seeds and fertilizer to rural farmers for the first few years especially for feed corn
4) No Subsidies of Any Kind Whatsoever

A comparison of these strategic implementation strategies or concepts for development is presented in Table 17.1 below from the standpoint of access to various types of alternative funding sources:

Table 17.1 – Assessment of Access to Various Sources of Funding for Project Implementation

Strategic Development Concept	IFC and/or EBRD Long-Term Loans	Carbon Emmission Trading Credits	Export Credit Agencies and Mixed Credits	Local Commercial Bank Loans
Mandatory Fuel Blending Program with Excise Tax on Imports	Medium to High	Low to Medium	High	High
Direct Subsidy Volumetric Tax Credit	Low (Disqualified)	Low (Disqualified)	Medium to High	High
Indirect Light Subsidy Program	High	Medium	High	High
No Fiscal Subsidies of Any Kind	High	High (if Proven Additionality)	High	High

NOTE: Access to lower interest rate long-term loans from IFC or EBRD will contribute more to overall project financial viability than the value of CERs under the Clean Development Mechanism

18.0 Areas Requiring Further Study and Evaluation

It is suggested that the Renewable Resources and Energy Efficiency (R2E2) Fund of Armenia evaluate the following unresolved topics or areas further in support of such a proposed bio-ethanol program for Armenia:

1) The institutional framework and organizational structure that best ties together rural farmers, the bio-ethanol processing plant, and a local agricultural development bank such as Cascade Credit or ACBBA-Credit Agricole including the development of standardized model supply contracts between the small scale rural farmers and the bio-ethanol feedstock processing plant;
2) Evaluation of potential co-product markets in Armenia including validation of price and willingness to pay, and whether the processing plant should include the processing, packaging, and distribution of such co-products to the market as part of its business plan or else should a wholesale distributor be created to take over responsibility for marketing such co-products;
3) The ramifications of the various proposed implementation strategies, incentive programs, and possible subsidy concepts should be validated with such organizations as the World Trade Organization, the CDM process managed by the United Nations in Bonn, and such multilateral financing institutions as IFC and EBRD since current guidance from these organizations is less than clear regarding eligibility and access to various potential funding sources if such strategies are pursued or implemented; and
4) Finally, further research and analysis is warranted regarding the timing of proceeding with the planting of potential bio-ethanol feedstocks such as fast growing hybrid trees for processing in future celluosic conversion plants.

APPENDIX A

FINANCIAL PROJECTIONS (10-YEAR PRO-FORMA) FOR A 7,000 TONNE PER ANNUM JERUSALEM ARTICHOKE PROCESSING FACILITY

Ethanol Project - 7K JA
Production Assumptions

Annual Feedstock Contribution (% of ethanol production and yield)

Nameplate Denatured Fuel Ethanol (litre/year)	9,381,632	Corn:	0.00%	378.51 anhydrous litre/tonne
Anhydrous Ethanol Production (litre/year)	8,934,888	Jerusalem Artichoke	100.00%	92.40 anhydrous litre/tonne
Operating Days Per Year	350			

Product Yields & Energy Consumption	1st Year Operations	2nd Year Operations	3rd Year Operations	4th Year Operations	5th Year Operations	6th Year Operations	7th Year Operations	8th Year Operations	9th Year Operations	10th Year Operations
Ethanol Production Increase Over Previous Year	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Denatured Ethanol Sold (litre/year)	4,867,280	9,381,632	9,381,632	9,381,632	9,381,632	9,381,632	9,381,632	9,381,632	9,381,632	9,381,632
Ethanol Price ($/litre)	$1.3443	$1.3711	$1.3986	$1.4265	$1.4551	$1.4842	$1.5139	$1.5441	$1.5750	$1.6065
Ethanol Sales Commission (% of Ethanol Price)	1.000%	1.000%	1.000%	1.000%	1.000%	1.000%	1.000%	1.000%	1.000%	1.000%
Ethanol Transportation ($/litre)	$0.0100	$0.0102	$0.0104	$0.0106	$0.0108	$0.0110	$0.0113	$0.0115	$0.0117	$0.0120
Delivered JA Price ($/tonne)	88.52	89.41	90.30	91.21	92.12	93.04	93.97	94.91	95.86	96.82
Annual JA Usage (tonne/year)	52,376	96,695	96,695	96,695	96,695	96,695	96,695	96,695	96,695	96,695
JA Co-Product Produced (kg/year)	3,362,667	6,208,000	6,208,000	6,208,000	6,208,000	6,208,000	6,208,000	6,208,000	6,208,000	6,208,000
JA Co-Product Yield (kg/tonne)	64.20	64.20	64.20	64.20	64.20	64.20	64.20	64.20	64.20	64.20
JA Co-Product Price ($/tonne)	266.000	268.660	271.347	274.060	276.801	279.569	282.364	285.188	288.040	290.920
Co-Product Sales Commission (%)	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
CO_2 Yield (kg/litre)	0.748	0.748	0.748	0.748	0.748	0.748	0.748	0.748	0.748	0.748
Percent of CO_2 Produced that is Sold	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
CO_2 Sold (tonne/year)	3,461	6,670	6,670	6,670	6,670	6,670	6,670	6,670	6,670	6,670
CO2 Price ($/tonne)	$3.000	$3.030	$3.060	$3.091	$3.122	$3.153	$3.185	$3.216	$3.249	$3.281
Electricity Use (kWh/tonne)	18.481	18.481	18.481	18.481	18.481	18.481	18.481	18.481	18.481	18.481
Annual Electricity Use (million kWh/year)	0.968	1.787	1.787	1.787	1.787	1.787	1.787	1.787	1.787	1.787
Electricity Price ($/kWh)	$0.0467	$0.0476	$0.0486	$0.0495	$0.0505	$0.0515	$0.0526	$0.0536	$0.0547	$0.0558
Natural Gas Use (kJ/litre)	8,480	8,480	8,480	8,480	8,480	8,480	8,480	8,480	8,480	8,480
Annual Natural Gas Use (GJ/year)	41,041	79,556	79,556	79,556	79,556	79,556	79,556	79,556	79,556	79,556
Natural Gas Price ($/GJ)	$7.5211	$7.6715	$7.8249	$7.9814	$8.1410	$8.3039	$8.4699	$8.6393	$8.8121	$8.9884

Ethanol Project - 7K JA
Production Assumptions, continued

	1st Year Operations	2nd Year Operations	3rd Year Operations	4th Year Operations	5th Year Operations	6th Year Operations	7th Year Operations	8th Year Operations	9th Year Operations	10th Year Operations
Effluent Water Disposal (1000 litre/tonne)	0.794	0.794	0.794	0.794	0.794	0.794	0.794	0.794	0.794	0.794
Annual Effluent Water Disposal (1000 litre/year)	41,600	76,800	76,800	76,800	76,800	76,800	76,800	76,800	76,800	76,800
Effluent Water Disposal Price ($/1000 litre)	$0.0633	$0.0640	$0.0646	$0.0653	$0.0659	$0.0666	$0.0672	$0.0679	$0.0686	$0.0693
Denaturant Use (% of ethanol sold)	5.000%	5.000%	5.000%	5.000%	5.000%	5.000%	5.000%	5.000%	5.000%	5.000%
Annual Denaturant Use (litre/year)	241,987	446,744	446,744	446,744	446,744	446,744	446,744	446,744	446,744	446,744
Denaturant Price ($/litre)	$1.3443	$1.3711	$1.3986	$1.4265	$1.4551	$1.4842	$1.5139	$1.5441	$1.5750	$1.6065
Chemicals & Enzymes Cost ($/litre ethanol)	$0.0210	$0.0212	$0.0214	$0.0216	$0.0219	$0.0221	$0.0223	$0.0225	$0.0227	$0.0230
Number of Employees	12	12	12	12	12	12	12	12	12	12
Average Salary Including Benefits	$6,400	$6,560	$6,724	$6,892	$7,064	$7,241	$7,422	$7,608	$7,798	$7,993
Maintenance Materials & Services (% of Capital Equipment Cost)	2.500%	2.538%	2.576%	2.614%	2.653%	2.693%	2.734%	2.775%	2.816%	2.858%
Property Tax & Insurance (% of Depreciated Property, Plant & Equipment)	2.000%	2.060%	2.122%	2.185%	2.251%	2.319%	2.388%	2.460%	2.534%	2.610%
Inflation for all other Administrative Expense Categories										

Financial Assumptions

USE OF FUNDS:	
Project Engineering & Construction Costs	
EPC Contract	$11,867,000
Site Development	$775,000
Rail	$0
Storage	$133,000
Other Project Costs	$0
Contingency	$0
Total Engineering and Construction Cost	$12,775,000
Development and Start-up Costs	
Inventory - Feedstock	$0
Inventory - Chemicals/Yeast/Denaturant	$0
Inventory - Spare Parts	$133,000
Startup Costs	$0
Fire Protection & Potable Water Systems	$199,000
Administration Building & Office Equipment	$664,000
Insurance & Performance Bond	$0
Rolling Stock and Shop Equipment	$111,000
Organizational Costs and Permits	$133,000
Capitalized Interest & Financing Costs	$0
Working Capital/Risk Management	$0
Total Development Costs	$1,240,000
TOTAL USES	**$14,015,000**

SOURCE OF FUNDS:		
Senior Debt		
Principal	$0	0.00%
Interest Rate	9.00%	fixed
Lender and Misc. Fees	$0	1.000%
Placement Fees	$0	0.000%
Amortization Period	10	years
Cash Sweep	0.000%	
Subordinate Debt		
Principal	$0	0.00%
Interest Rate	8.50%	interest only
Lender Fees	$0	0.000%
Placement Fees	$0	1.500%
Amortization Period	10	years
Equity Investment		
Total Equity Amount	$14,015,000	100.00%
Placement Fees	$0	0.000%
Common Equity	$14,015,000	100.000%
Preferred Equity	$0	0.000%
Grants		
Amount	$0	0.00%
TOTAL SOURCES	**$14,015,000**	

Investment Activities	
Income Tax Rate	0.00%
Investment Interest	3.00%
Operating Line Interest	8.00%
State Producer Payment	
Producer payment, $/gal	$0.000
Estimated annual payment	$0
Incentive duration, years	0
Other Incentive Payments	
Small Producer Tax Credit	0
% of CCC Payment	0%

Plant Operating Rate

Month	% of Nameplate
13	0.0%
14	0.0%
15	0.0%
16	0.0%
17	0.0%
18	50.0%
19	100.0%
20	100.0%
21	100.0%
22	100.0%
23	100.0%
24	100.0%

Accounts Payable, Receivable & Inventories	Receivable (# Days)	Payable (# Days)	Inventories (# Days)
Fuel Ethanol	14		8
Distillers Grain	14		8
Denaturants		10	15
Chemicals & Enzymes		15	20
Feedstock		10	10
Utilities		15	

Ethanol Project - 7K JA
Proforma Balance Sheet

	Construction (Year 0)	1st Year Operations	2nd Year Operations	3rd Year Operations	4th Year Operations	5th Year Operations	6th Year Operations	7th Year Operations	8th Year Operations	9th Year Operations	10th Year Operations
ASSETS											
Current Assets:											
Cash & Cash Equivalents	0	0	2,026,091	4,724,255	7,567,296	10,559,944	13,707,171	17,014,629	20,487,266	24,130,765	27,951,040
Accounts Receivable - Trade	0	545,604	571,759	582,532	593,514	604,709	616,122	627,755	639,615	651,704	664,029
Inventories											
Feedstock	0	132,474	247,014	249,484	251,979	254,499	257,044	259,614	262,210	264,832	267,481
Chemicals, Enzymes & Yeast	0	111,000	10,829	10,937	11,047	11,157	11,269	11,381	11,495	11,610	11,726
Denaturant	0	25,737	26,252	26,777	27,313	27,859	28,416	28,985	29,564	30,156	30,759
Finished Product Inventory	0	124,023	232,091	234,713	237,367	240,054	242,774	245,528	248,316	251,138	253,995
Spare Parts	0	0	0	0	0	0	0	0	0	0	0
Total Inventories	0	393,235	516,186	521,912	527,706	533,569	539,503	545,508	551,585	557,736	563,961
Prepaid Expenses	0	0	0	0	0	0	0	0	0	0	0
Other Current Assets	0	0	0	0	0	0	0	0	0	0	0
Total Current Assets	0	938,839	3,114,036	5,828,699	8,688,516	11,698,222	14,862,795	18,187,892	21,678,466	25,340,205	29,179,029
Property, Plant & Equipment											
Property, Plant & Equipment, Land	12,154,500	13,882,000	14,382,000	14,882,000	15,382,000	15,882,000	16,382,000	16,882,000	17,382,000	17,882,000	18,382,000
Less Accumulated Depreciation & Amortization	0	893,668	1,814,242	2,764,543	3,749,473	4,772,190	5,853,534	6,955,379	8,100,413	9,289,090	10,521,833
Net Property, Plant & Equipment	12,154,500	12,988,332	12,567,758	12,117,457	11,632,527	11,109,810	10,528,466	9,926,621	9,281,587	8,592,910	7,860,167
Capitalized Fees & Interest	(344,013)	(327,699)	(294,929)	(262,159)	(229,389)	(196,619)	(163,850)	(131,080)	(98,310)	(65,540)	(32,770)
Total Assets	11,810,487	13,599,471	15,386,865	17,683,997	20,091,653	22,611,413	25,227,412	27,983,433	30,861,743	33,867,576	37,006,427
LIABILITIES & EQUITIES											
Current Liabilities:											
Accounts Payable	0	265,952	276,493	279,470	282,480	285,525	288,604	291,719	294,870	298,057	301,280
Notes Payable	0	376,278	0	0	0	0	0	0	0	0	0
Current Maturities of Senior Debt (incl. sweeps)	0	0	0	0	0	0	0	0	0	0	0
Current Maturities of Working Capital	0	0	0	0	0	0	0	0	0	0	0
Total Current Liabilities	0	642,230	276,493	279,470	282,480	285,525	288,604	291,719	294,870	298,057	301,280
Senior Debt (excluding current maturities)	(1,065,695)	0	0	0	0	0	0	0	0	0	0
Working Capital (excluding current maturities)	0	0	0	0	0	0	0	0	0	0	0
Deferred Income Taxes	0	0	0	0	0	0	0	0	0	0	0
Total Liabilities	(1,065,695)	642,230	276,493	279,470	282,480	285,525	288,604	291,719	294,870	298,057	301,280
Capital Units & Equities											
Common Equity	14,015,000	14,015,000	14,015,000	14,015,000	14,015,000	14,015,000	14,015,000	14,015,000	14,015,000	14,015,000	14,015,000
Preferred Equity	0	0	0	0	0	0	0	0	0	0	0
Grants (capital improvements)	0	0	0	0	0	0	0	0	0	0	0
Distribution to Shareholders	0	0	0	0	0	0	0	0	0	0	0
Retained Earnings	(1,138,818)	(1,057,758)	1,095,372	3,389,527	5,794,173	8,310,888	10,923,808	13,676,714	16,551,873	19,554,519	22,690,146
Total Capital Shares & Equities	12,876,182	12,957,242	15,110,372	17,404,527	19,809,173	22,325,888	24,938,808	27,691,714	30,566,873	33,569,519	36,705,146
Total Liabilities & Equities	11,810,487	13,599,471	15,386,865	17,683,997	20,091,653	22,611,413	25,227,412	27,983,433	30,861,743	33,867,576	37,006,427

Ethanol Project - 7K JA
Proforma Income Statement

	Construction (Year 0)	1st Year Operations	2nd Year Operations	3rd Year Operations	4th Year Operations	5th Year Operations	6th Year Operations	7th Year Operations	8th Year Operations	9th Year Operations	10th Year Operations
Revenue											
Ethanol	0	6,428,799	12,639,273	12,892,058	13,149,900	13,412,898	13,681,156	13,954,779	14,233,874	14,518,552	14,808,923
Co-Product	0	853,461	1,634,484	1,650,829	1,667,338	1,684,011	1,700,851	1,717,860	1,735,038	1,752,389	1,769,912
DWG	0	0	0	0	0	0	0	0	0	0	0
Carbon Dioxide	0	10,866	20,211	20,413	20,617	20,823	21,032	21,242	21,454	21,669	21,886
State Producer Payment	0	0	0	0	0	0	0	0	0	0	0
Total Revenue	0	7,293,127	14,293,968	14,563,301	14,837,854	15,117,732	15,403,038	15,693,880	15,990,367	16,292,609	16,600,721
Production & Operating Expenses											
Feedstocks	0	4,636,605	8,645,484	8,731,939	8,819,258	8,907,451	8,996,525	9,086,491	9,177,356	9,269,129	9,361,820
Chemicals, Enzymes & Yeast	0	101,634	189,509	191,404	193,318	195,251	197,204	199,176	201,168	203,179	205,211
Waste Heat	0	0	0	0	0	0	0	0	0	0	0
Natural Gas	0	308,671	610,314	622,521	634,971	647,670	660,624	673,836	687,313	701,059	715,080
Electricity	0	45,171	85,060	86,761	88,497	90,266	92,072	93,913	95,792	97,707	99,661
Denaturants	0	325,293	612,552	624,804	637,300	650,046	663,046	676,307	689,834	703,630	717,703
Makeup Water	0	0	0	0	0	0	0	0	0	0	0
Wastewater Disposal	0	2,635	4,913	4,962	5,011	5,061	5,112	5,163	5,215	5,267	5,320
Direct Labor & Benefits	1,000	6,000	6,150	6,304	6,461	6,623	6,788	6,958	7,132	7,310	7,493
Total Production Costs	1,000	5,426,009	10,153,983	10,268,694	10,384,816	10,502,369	10,621,372	10,741,845	10,863,808	10,987,283	11,112,289
Gross Profit	(1,000)	1,867,118	4,139,986	4,294,607	4,453,038	4,615,363	4,781,666	4,952,035	5,126,558	5,305,326	5,488,432
Administrative & Operating Expenses											
Maintenance Materials & Services	0	162,500	304,500	309,068	313,704	318,409	323,185	328,033	332,953	337,948	343,017
Repairs & Maintenance - Wages & Benefits	0	0	0	0	0	0	0	0	0	0	0
Consulting, Management and Bank Fees	0	150,000	153,000	156,060	159,181	162,365	165,612	168,924	172,303	175,749	179,264
Property Taxes & Insurance	48,618	243,090	267,560	266,663	264,821	261,850	257,586	251,431	244,170	235,153	224,236
Admin. Salaries, Wages & Benefits	30,200	70,800	72,570	74,384	76,244	78,150	80,104	82,106	84,159	86,263	88,419
Legal & Accounting/Community Affairs	775,000	96,000	97,920	99,878	101,876	103,913	105,992	108,112	110,274	112,479	114,729
Office/Lab Supplies & Expenses	84,000	120,000	122,400	124,848	127,345	129,892	132,490	135,139	137,842	140,599	143,411
Travel, Training & Miscellaneous	200,000	50,000	51,000	52,020	53,060	54,122	55,204	56,308	57,434	58,583	59,755
Total Administrative & Operating Expenses	1,137,818	892,390	1,068,950	1,082,921	1,096,231	1,108,701	1,120,173	1,130,054	1,139,135	1,146,774	1,152,831
EBITDA	(1,138,818)	974,728	3,071,036	3,211,686	3,356,807	3,506,662	3,661,494	3,821,982	3,987,423	4,158,553	4,335,601
Less:											
Interest - Operating Line of Credit	0	0	30,102	0	0	0	0	0	0	0	0
Interest - Senior Debt	0	0	0	0	0	0	0	0	0	0	0
Interest - Working Capital	0	0	0	0	0	0	0	0	0	0	0
Depreciation & Amortization	0	893,668	887,804	917,531	952,161	989,947	1,048,573	1,069,076	1,112,264	1,155,907	1,199,973
Pre-Tax Income	(1,138,818)	81,060	2,153,130	2,294,155	2,404,646	2,516,715	2,612,920	2,752,906	2,875,159	3,002,646	3,135,627
Current Income Taxes	0	0	0	0	0	0	0	0	0	0	0
Net Earnings (Loss) for the Year	(1,138,818)	81,060	2,153,130	2,294,155	2,404,646	2,516,715	2,612,920	2,752,906	2,875,159	3,002,646	3,135,627
Pre-Tax Return on Investment	-8.1%	0.6%	15.4%	16.4%	17.2%	18.0%	18.6%	19.6%	20.5%	21.4%	22.4%
11-Year Average Annual Pre-Tax ROI	14.7%										

Ethanol Project - 7K JA
Proforma Statements of Cash Flows

	Construction (Year 0)	1st Year Operations	2nd Year Operations	3rd Year Operations	4th Year Operations	5th Year Operations	6th Year Operations	7th Year Operations	8th Year Operations	9th Year Operations	10th Year Operations
Cash provided by (used in)											
Operating Activities											
Net Earnings (loss)	(1,138,818)	81,060	2,153,130	2,294,155	2,404,646	2,516,715	2,612,920	2,752,906	2,875,159	3,002,646	3,135,627
Non cash charges to operations											
Depreciation & Amortization	0	893,668	887,804	917,531	952,161	989,947	1,048,573	1,069,076	1,112,264	1,155,907	1,199,973
	(1,138,818)	974,728	3,040,934	3,211,686	3,356,807	3,506,662	3,661,494	3,821,982	3,987,423	4,158,553	4,335,601
Changes in non-cash working capital balances											
Accounts Receivable	0	545,604	26,155	10,773	10,982	11,195	11,412	11,634	11,859	12,090	12,324
Inventories	0	393,235	122,951	5,725	5,794	5,863	5,934	6,005	6,077	6,151	6,225
Prepaid Expenses	0	0	0	0	0	0	0	0	0	0	0
Accounts Payable	0	(265,952)	(10,541)	(2,976)	(3,010)	(3,045)	(3,080)	(3,115)	(3,151)	(3,187)	(3,223)
	0	672,887	138,565	13,522	13,766	14,014	14,266	14,524	14,786	15,053	15,326
Investing Activities											
Fixed Asset Purchases	12,154,500	1,727,500	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000
Capitalized Fees & Interest	(344,013)	16,314	0	0	0	0	0	0	0	0	0
	11,810,487	1,743,814	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000
Financing Activities											
Senior Debt Advances	(1,065,695)	1,065,695	0	0	0	0	0	0	0	0	0
Repayment of Senior Debt	0	0	0	0	0	0	0	0	0	0	0
Working Capital Advances	0	0	0	0	0	0	0	0	0	0	0
Repayment of Subordinate Debt	0	0	0	0	0	0	0	0	0	0	0
Equity Investment	14,015,000	0	0	0	0	0	0	0	0	0	0
Grants	0	0	0	0	0	0	0	0	0	0	0
Cash Sweep for Debt Service	0	0	0	0	0	0	0	0	0	0	0
Distributions to Shareholders	0	0	0	0	0	0	0	0	0	0	0
Net Increase (Decrease) in Cash	0	(376,278)	2,402,369	2,698,164	2,843,041	2,992,648	3,147,227	3,307,458	3,472,637	3,643,499	3,820,275
Cash (Indebtedness), Beginning of Year	0	0	(376,278)	2,026,091	4,724,255	7,567,296	10,559,944	13,707,171	17,014,629	20,487,266	24,130,765
Cash (Bank Indebtedness), End of Year	0	(376,278)	2,026,091	4,724,255	7,567,296	10,559,944	13,707,171	17,014,629	20,487,266	24,130,765	27,951,040
IRR	15.2%										

Appendix B

Financial Projections (10-Year Pro-Forma) for a 7,000 tonne per Annum Feed Corn Fractionation Processing Facility

Ethanol Project - 7K Corn w/ Frac
Production Assumptions

		Annual Feedstock Contribution (% of ethanol production and yield)		
Nameplate Denatured Fuel Ethanol (litre/year)	9,381,632	Corn:	100.00%	378.51 anhydrous litre/tonne
Anhydrous Ethanol Production (litre/year)	8,934,888	Jerusalem Artichoke	0.00%	92.40 anhydrous litre/tonne
Operating Days Per Year	350			

Product Yields & Energy Consumption	1st Year Operations	2nd Year Operations	3rd Year Operations	4th Year Operations	5th Year Operations	6th Year Operations	7th Year Operations	8th Year Operations	9th Year Operations	10th Year Operations	Annual Escalation
Ethanol Production Increase Over Previous Year	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Denatured Ethanol Sold (litre/year)	4,867,280	9,381,632	9,381,632	9,381,632	9,381,632	9,381,632	9,381,632	9,381,632	9,381,632	9,381,632	
Ethanol Price ($/litre)	$1.3443	$1.3711	$1.3986	$1.4265	$1.4551	$1.4842	$1.5139	$1.5441	$1.5750	$1.6065	2.00%
Ethanol Sales Commission (% of Ethanol Price)	1.000%	1.000%	1.000%	1.000%	1.000%	1.000%	1.000%	1.000%	1.000%	1.000%	0.00%
Ethanol Transportation ($/litre)	$0.0100	$0.0102	$0.0104	$0.0106	$0.0108	$0.0110	$0.0113	$0.0115	$0.0117	$0.0120	2.00%
Delivered Corn Price ($/tonne)	393.00	396.93	400.90	404.91	408.96	413.05	417.18	421.35	425.56	429.82	1.00%
Annual Corn Usage (tonne/year)	12,859	23,606	23,606	23,606	23,606	23,606	23,606	23,606	23,606	23,606	
Corn DDGS Produced (kg/year)	2,534,271	4,678,655	4,678,655	4,678,655	4,678,655	4,678,655	4,678,655	4,678,655	4,678,655	4,678,655	
Corn DDGS Yield (kg/tonne)	198.20	198.20	198.20	198.20	198.20	198.20	198.20	198.20	198.20	198.20	
Corn DDGS Price ($/tonne)	416.118	420.279	424.482	428.726	433.014	437.344	441.717	446.134	450.596	455.102	1.00%
Additional Corn Fractionation Co-Products											
Germ											
Germ Yield (kg/tonne)	71.4	71.4	71.4	71.4	71.4	71.4	71.4	71.4	71.4	71.4	
Germ Production (tonne/yr)	918	1,686	1,686	1,686	1,686	1,686	1,686	1,686	1,686	1,686	
Germ Sale Price ($/tonne)	451.95	456.470	461.034	465.645	470.301	475.004	479.754	484.552	489.397	494.291	1.00%
Germ Transportation ($/tonne)	5.00	$5.050	$5.101	$5.152	$5.203	$5.255	$5.308	$5.361	$5.414	$5.468	1.00%
Sales Commission (%)	1.00%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	0.00%
Bran											
Bran Yield (kg/tonne)	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	
Bran Production (tonne/yr)	482	885	885	885	885	885	885	885	885	885	
Bran Sale Price ($/tonne)	216.15	218.312	220.495	222.700	224.927	227.176	229.448	231.742	234.059	236.400	1.00%
Bran Transportation ($/tonne)	5.00	$5.050	$5.101	$5.152	$5.203	$5.255	$5.308	$5.361	$5.414	$5.468	1.00%
Sales Commission (%)	1.00%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	0.00%
CO_2 Yield (kg/litre)	0.748	0.748	0.748	0.748	0.748	0.748	0.748	0.748	0.748	0.748	
Percent of CO_2 Produced that is Sold	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	
CO_2 Sold (tonne/year)	3,461	6,670	6,670	6,670	6,670	6,670	6,670	6,670	6,670	6,670	
CO2 Price ($/tonne)	$3.000	$3.030	$3.060	$3.091	$3.122	$3.153	$3.185	$3.216	$3.249	$3.281	1.00%
Electricity Use (kWh/tonne)	140.047	140.047	140.047	140.047	140.047	140.047	140.047	140.047	140.047	140.047	
Annual Electricity Use (million kWh/year)	1.801	3.306	3.306	3.306	3.306	3.306	3.306	3.306	3.306	3.306	
Electricity Price ($/kWh)	$0.0467	$0.0476	$0.0486	$0.0495	$0.0505	$0.0515	$0.0526	$0.0536	$0.0547	$0.0558	2.00%
Natural Gas Use (kJ/litre)	7,420	7,420	7,420	7,420	7,420	7,420	7,420	7,420	7,420	7,420	
Annual Natural Gas Use (GJ/year)	35,911	69,612	69,612	69,612	69,612	69,612	69,612	69,612	69,612	69,612	
Natural Gas Price ($/GJ)	$7.5211	$7.6715	$7.8249	$7.9814	$8.1410	$8.3039	$8.4699	$8.6393	$8.8121	$8.9884	2.00%
Fresh Water Use (1000 litre/tonne)	1.140	1.140	1.140	1.140	1.140	1.140	1.140	1.140	1.140	1.140	
Annual Fresh Water Use (1000 litre/year)	14,659	26,910	26,910	26,910	26,910	26,910	26,910	26,910	26,910	26,910	
Fresh Water Price ($/1000 litre)	$0.0200	$0.0202	$0.0204	$0.0206	$0.0208	$0.0210	$0.0212	$0.0214	$0.0217	$0.0219	1.00%

Production Assumptions, continued

	1st Year Operations	2nd Year Operations	3rd Year Operations	4th Year Operations	5th Year Operations	6th Year Operations	7th Year Operations	8th Year Operations	9th Year Operations	10th Year Operations	Annual Escalation
Effluent Water Disposal (1000 litre/tonne)	0.239	0.239	0.239	0.239	0.239	0.239	0.239	0.239	0.239	0.239	
Annual Effluent Water Disposal (1000 litre/year)	3,071	5,638	5,638	5,638	5,638	5,638	5,638	5,638	5,638	5,638	
Effluent Water Disposal Price ($/1000 litre)	$0.0633	$0.0640	$0.0646	$0.0653	$0.0659	$0.0666	$0.0672	$0.0679	$0.0686	$0.0693	1.00%
Denaturant Use (% of ethanol sold)	5.000%	5.000%	5.000%	5.000%	5.000%	5.000%	5.000%	5.000%	5.000%	5.000%	
Annual Denaturant Use (litre/year)	243,364	446,744	446,744	446,744	446,744	446,744	446,744	446,744	446,744	446,744	
Denaturant Price ($/litre)	$1.3443	$1.3711	$1.3986	$1.4265	$1.4551	$1.4842	$1.5139	$1.5441	$1.5750	$1.6065	2.00%
Chemicals & Enzymes Cost ($/litre ethanol)	$0.0210	$0.0212	$0.0214	$0.0216	$0.0219	$0.0221	$0.0223	$0.0225	$0.0227	$0.0230	1.00%
Number of Employees	13	13	13	13	13	13	13	13	13	13	
Average Salary Including Benefits	$8,291	$8,498	$8,710	$8,928	$9,151	$9,380	$9,615	$9,855	$10,101	$10,354	2.50%
Maintenance Materials & Services (% of Capital Equipment C	2.500%	2.538%	2.576%	2.614%	2.653%	2.693%	2.734%	2.775%	2.816%	2.858%	1.50%
Property Tax & Insurance (% of Depreciated Property, Plant	2.000%	2.060%	2.122%	2.185%	2.251%	2.319%	2.388%	2.460%	2.534%	2.610%	3.00%
Inflation for all other Administrative Expense Categories											2.00%

Financial Assumptions

USE OF FUNDS:	
Project Engineering & Construction Costs	
EPC Contract	$13,387,000
Site Development	$775,000
Rail	$0
Storage	$133,000
Other Project Costs	$0
Contingency	$0
Total Engineering and Construction Cost	$14,295,000
Development and Start-up Costs	
Inventory - Feedstock	$0
Inventory - Chemicals/Yeast/Denaturant	$0
Inventory - Spare Parts	$208,000
Startup Costs	$0
Fire Protection & Potable Water Systems	$199,000
Administration Building & Office Equipment	$664,000
Insurance & Performance Bond	$0
Rolling Stock and Shop Equipment	$111,000
Organizational Costs and Permits	$133,000
Capitalized Interest & Financing Costs	$0
Working Capital/Risk Management	$0
Total Development Costs	$1,315,000
TOTAL USES	**$15,610,000**

SOURCE OF FUNDS:		
Senior Debt		
Principal	$0	0.00%
Interest Rate	9.00%	fixed
Lender and Misc. Fees	$0	1.000%
Placement Fees	$0	0.000%
Amortization Period	10	years
Cash Sweep	0.000%	
Subordinate Debt		
Principal	$0	0.00%
Interest Rate	8.50%	interest only
Lender Fees	$0	0.000%
Placement Fees	$0	1.500%
Amortization Period	10	years
Equity Investment		
Total Equity Amount	$15,610,000	100.00%
Placement Fees	$0	0.000%
Common Equity	$15,610,000	100.000%
Preferred Equity	$0	0.000%
Grants		
Amount	$0	0.00%
TOTAL SOURCES	**$15,610,000**	

Investment Activities	
Income Tax Rate	0.00%
Investment Interest	3.00%
Operating Line Interest	8.00%
State Producer Payment	
Producer payment, $/gal	$0.000
Estimated annual payment	$0
Incentive duration, years	0
Other Incentive Payments	
Small Producer Tax Credit	0
% of CCC Payment	0%

Plant Operating Rate

Month	% of Nameplate
13	0.0%
14	0.0%
15	0.0%
16	0.0%
17	0.0%
18	50.0%
19	100.0%
20	100.0%
21	100.0%
22	100.0%
23	100.0%
24	100.0%

Accounts Payable, Receivable & Inventories	Receivable (# Days)	Payable (# Days)	Inventories (# Days)
Fuel Ethanol	14		8
Distillers Grain	14		8
Denaturants		10	15
Chemicals & Enzymes		15	20
Feedstock		10	10
Utilities		15	

Ethanol Project - 7K Corn w/ Frac
Proforma Balance Sheet

	Construction (Year 0)	1st Year Operations	2nd Year Operations	3rd Year Operations	4th Year Operations	5th Year Operations	6th Year Operations	7th Year Operations	8th Year Operations	9th Year Operations	10th Year Operations
ASSETS											
Current Assets:											
Cash & Cash Equivalents	0	0	2,609,137	5,719,808	8,980,425	12,395,822	15,971,081	19,711,969	23,623,551	27,711,637	31,982,267
Accounts Receivable - Trade	0	556,867	583,460	594,350	605,451	616,765	628,298	640,053	652,036	664,250	676,699
Inventories											
Feedstock	0	143,573	267,708	270,386	273,089	275,820	278,579	281,364	284,178	287,020	289,890
Chemicals, Enzymes & Yeast	0	111,000	10,829	10,937	11,047	11,157	11,269	11,381	11,495	11,610	11,726
Denaturant	0	25,737	26,252	26,777	27,313	27,859	28,416	28,985	29,564	30,156	30,759
Finished Product Inventory	0	133,049	248,670	251,460	254,284	257,142	260,035	262,964	265,929	268,930	271,968
Spare Parts	0	0	0	0	0	0	0	0	0	0	0
Total Inventories	0	413,360	553,460	559,560	565,733	571,979	578,299	584,695	591,166	597,715	604,343
Prepaid Expenses	0	0	0	0	0	0	0	0	0	0	0
Other Current Assets	0	0	0	0	0	0	0	0	0	0	0
Total Current Assets	0	970,227	3,746,056	6,873,718	10,151,608	13,584,566	17,177,678	20,936,717	24,866,753	28,973,601	33,263,309
Property, Plant & Equipment											
Property, Plant & Equipment, and Land	13,522,500	15,477,000	15,977,000	16,477,000	16,977,000	17,477,000	17,977,000	18,477,000	18,977,000	19,477,000	19,977,000
Less Accumulated Depreciation & Amortization	0	990,796	2,012,147	3,062,152	4,145,787	5,266,274	6,444,517	7,642,448	8,882,808	10,166,103	11,492,803
Net Property, Plant & Equipment	13,522,500	14,486,204	13,964,853	13,414,848	12,831,213	12,210,726	11,532,483	10,834,552	10,094,192	9,310,897	8,484,197
Capitalized Fees & Interest	(390,729)	(375,669)	(338,102)	(300,535)	(262,968)	(225,401)	(187,835)	(150,268)	(112,701)	(75,134)	(37,567)
Total Assets	13,131,771	15,080,762	17,372,807	19,988,031	22,719,853	25,569,890	28,522,327	31,621,001	34,848,244	38,209,365	41,709,939
LIABILITIES & EQUITIES											
Current Liabilities:											
Accounts Payable	0	288,660	300,115	303,358	306,639	309,958	313,315	316,710	320,145	323,619	327,134
Notes Payable	0	198,541	0	0	0	0	0	0	0	0	0
Current Maturities of Senior Debt (incl. sweeps)	0	0	0	0	0	0	0	0	0	0	0
Current Maturities of Working Capital	0	0	0	0	0	0	0	0	0	0	0
Total Current Liabilities	0	487,201	300,115	303,358	306,639	309,958	313,315	316,710	320,145	323,619	327,134
Senior Debt (excluding current maturities)	(1,316,155)	0	0	0	0	0	0	0	0	0	0
Working Capital (excluding current maturities)	0	0	0	0	0	0	0	0	0	0	0
Deferred Income Taxes	0	0	0	0	0	0	0	0	0	0	0
Total Liabilities	(1,316,155)	487,201	300,115	303,358	306,639	309,958	313,315	316,710	320,145	323,619	327,134
Capital Units & Equities											
Common Equity	15,610,000	15,610,000	15,610,000	15,610,000	15,610,000	15,610,000	15,610,000	15,610,000	15,610,000	15,610,000	15,610,000
Preferred Equity	0	0	0	0	0	0	0	0	0	0	0
Grants (capital improvements)	0	0	0	0	0	0	0	0	0	0	0
Distribution to Shareholders	0	0	0	0	0	0	0	0	0	0	0
Retained Earnings	(1,162,073)	(1,016,439)	1,462,693	4,074,673	6,803,214	9,649,932	12,599,013	15,694,291	18,918,099	22,275,745	25,772,805
Total Capital Shares & Equities	14,447,927	14,593,561	17,072,693	19,684,673	22,413,214	25,259,932	28,209,013	31,304,291	34,528,099	37,885,745	41,382,805
Total Liabilities & Equities	13,131,771	15,080,762	17,372,807	19,988,031	22,719,853	25,569,890	28,522,327	31,621,001	34,848,244	38,209,365	41,709,939

Ethanol Project - 7K Corn w/ Frac
Proforma Income Statement

	Construction (Year 0)	1st Year Operations	2nd Year Operations	3rd Year Operations	4th Year Operations	5th Year Operations	6th Year Operations	7th Year Operations	8th Year Operations	9th Year Operations	10th Year Operations
Revenue											
Ethanol	0	6,428,799	12,639,273	12,892,058	13,149,900	13,412,898	13,681,156	13,954,779	14,233,874	14,518,552	14,808,923
Co-Product	0	1,006,208	1,927,013	1,946,283	1,965,746	1,985,403	2,005,257	2,025,310	2,045,563	2,066,018	2,086,679
Germ	0	310,763	745,832	753,291	760,823	768,432	776,116	783,877	791,716	799,633	807,629
Bran	0	163,229	186,899	188,768	190,656	192,563	194,488	196,433	198,398	200,381	202,385
DWG	0	0	0	0	0	0	0	0	0	0	0
Carbon Dioxide	0	10,866	20,211	20,413	20,617	20,823	21,032	21,242	21,454	21,669	21,886
State Producer Payment	0	0	0	0	0	0	0	0	0	0	0
Total Revenue	0	7,919,866	15,519,228	15,800,813	16,087,742	16,380,118	16,678,049	16,981,641	17,291,005	17,606,254	17,927,502
Production & Operating Expenses											
Feedstocks	0	5,025,056	9,369,797	9,463,495	9,558,130	9,653,712	9,750,249	9,847,751	9,946,229	10,045,691	10,146,148
Chemicals, Enzymes & Yeast	0	101,634	189,509	191,404	193,318	195,251	197,204	199,176	201,168	203,179	205,211
Waste Heat	0	0	0	0	0	0	0	0	0	0	0
Natural Gas	0	270,087	534,025	544,706	555,600	566,712	578,046	589,607	601,399	613,427	625,695
Electricity	0	83,566	157,361	160,508	163,719	166,993	170,333	173,740	177,214	180,759	184,374
Denaturants	0	325,293	612,552	624,804	637,300	650,046	663,046	676,307	689,834	703,630	717,703
Makeup Water	0	292	544	549	555	560	566	571	577	583	589
Wastewater Disposal	0	193	361	364	368	372	375	379	383	387	391
Direct Labor & Benefits	2,465	14,790	15,160	15,539	15,927	16,325	16,734	17,152	17,581	18,020	18,471
Total Production Costs	2,465	5,820,912	10,879,309	11,001,369	11,124,916	11,249,970	11,376,552	11,504,683	11,634,384	11,765,676	11,898,581
Gross Profit	(2,465)	2,098,954	4,639,919	4,799,444	4,962,826	5,130,148	5,301,496	5,476,958	5,656,621	5,840,578	6,028,921
Administrative & Operating Expenses											
Maintenance Materials & Services	0	183,083	343,070	348,216	353,439	358,741	364,122	369,584	375,128	380,754	386,466
Repairs & Maintenance - Wages & Benefits	0	0	0	0	0	0	0	0	0	0	0
Consulting, Management and Bank Fees	0	150,000	153,000	156,060	159,181	162,365	165,612	168,924	172,303	175,749	179,264
Property Taxes & Insurance	54,090	270,450	298,416	296,306	293,175	288,833	283,112	275,408	266,503	255,740	242,972
Admin. Salaries, Wages & Benefits	46,518	92,990	95,315	97,698	100,140	102,644	105,210	107,840	110,536	113,299	116,132
Legal & Accounting/Community Affairs	775,000	96,000	97,920	99,878	101,876	103,913	105,992	108,112	110,274	112,479	114,729
Office/Lab Supplies & Expenses	84,000	120,000	122,400	124,848	127,345	129,892	132,490	135,139	137,842	140,599	143,411
Travel, Training & Miscellaneous	200,000	50,000	51,000	52,020	53,060	54,122	55,204	56,308	57,434	58,583	59,755
Total Administrative & Operating Expenses	1,159,608	962,523	1,161,121	1,175,026	1,188,217	1,200,509	1,211,741	1,221,315	1,230,019	1,237,204	1,242,728
EBITDA	(1,162,073)	1,136,430	3,478,799	3,624,418	3,774,609	3,929,639	4,089,756	4,255,643	4,426,602	4,603,374	4,786,193
Less:											
Interest - Operating Line of Credit	0	0	15,883	0	0	0	0	0	0	0	0
Interest - Senior Debt	0	0	0	0	0	0	0	0	0	0	0
Interest - Working Capital	0	0	0	0	0	0	0	0	0	0	0
Depreciation & Amortization	0	990,796	983,783	1,012,438	1,046,068	1,082,920	1,140,676	1,160,364	1,202,794	1,245,728	1,289,133
Pre-Tax Income	(1,162,073)	145,634	2,479,132	2,611,980	2,728,541	2,846,719	2,949,080	3,095,279	3,223,808	3,357,646	3,497,060
Current Income Taxes	0	0	0	0	0	0	0	0	0	0	0
Net Earnings (Loss) for the Year	(1,162,073)	145,634	2,479,132	2,611,980	2,728,541	2,846,719	2,949,080	3,095,279	3,223,808	3,357,646	3,497,060
Pre-Tax Return on Investment	-7.4%	0.9%	15.9%	16.7%	17.5%	18.2%	18.9%	19.8%	20.7%	21.5%	22.4%
11-Year Average Annual Pre-Tax ROI	15.0%										

Ethanol Project - 7K Corn w/ Frac
Proforma Statements of Cash Flows

	Construction (Year 0)	1st Year Operations	2nd Year Operations	3rd Year Operations	4th Year Operations	5th Year Operations	6th Year Operations	7th Year Operations	8th Year Operations	9th Year Operations	10th Year Operations
Cash provided by (used in)											
Operating Activities											
Net Earnings (loss)	(1,162,073)	145,634	2,479,132	2,611,980	2,728,541	2,846,719	2,949,080	3,095,279	3,223,808	3,357,646	3,497,060
Non cash charges to operations											
Depreciation & Amortization	0	990,796	983,783	1,012,438	1,046,068	1,082,920	1,140,676	1,160,364	1,202,794	1,245,728	1,289,133
	(1,162,073)	1,136,430	3,462,916	3,624,418	3,774,609	3,929,639	4,089,756	4,255,643	4,426,602	4,603,374	4,786,193
Changes in non-cash working capital balances											
Accounts Receivable	0	556,867	26,593	10,890	11,100	11,314	11,533	11,755	11,982	12,214	12,450
Inventories	0	413,360	140,100	6,100	6,173	6,246	6,320	6,396	6,472	6,549	6,627
Prepaid Expenses	0	0	0	0	0	0	0	0	0	0	0
Accounts Payable	0	(288,660)	(11,454)	(3,244)	(3,281)	(3,319)	(3,357)	(3,396)	(3,435)	(3,474)	(3,515)
	0	681,567	155,238	13,747	13,992	14,242	14,496	14,755	15,019	15,288	15,562
Investing Activities											
Land Purchase	0	0	0	0	0	0	0	0	0	0	0
Fixed Asset Purchases	13,522,500	1,954,500	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000
Capitalized Fees & Interest	(390,729)	15,059	0	0	0	0	0	0	0	0	0
	13,131,771	1,969,559	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000
Financing Activities											
Senior Debt Advances	(1,316,155)	1,316,155	0	0	0	0	0	0	0	0	0
Repayment of Senior Debt	0	0	0	0	0	0	0	0	0	0	0
Working Capital Advances	0	0	0	0	0	0	0	0	0	0	0
Repayment of Subordinate Debt	0	0	0	0	0	0	0	0	0	0	0
Equity Investment	15,610,000	0	0	0	0	0	0	0	0	0	0
Grants	0	0	0	0	0	0	0	0	0	0	0
Cash Sweep for Debt Service	0	0	0	0	0	0	0	0	0	0	0
Distributions to Shareholders	0	0	0	0	0	0	0	0	0	0	0
Net Increase (Decrease) in Cash	0	(198,541)	2,807,677	3,110,671	3,260,617	3,415,397	3,575,259	3,740,887	3,911,583	4,088,085	4,270,630
Cash (Indebtedness), Beginning of Year	0	0	(198,541)	2,609,137	5,719,808	8,980,425	12,395,822	15,971,081	19,711,969	23,623,551	27,711,637
Cash (Bank Indebtedness), End of Year	0	(198,541)	2,609,137	5,719,808	8,980,425	12,395,822	15,971,081	19,711,969	23,623,551	27,711,637	31,982,267
IRR	15.7%										

APPENDIX C

LIST OF CONTACTS

List of Selected Contacts during the Conduct of the Task I and Task II Study Effort

No.	Name	Place	Entity	Position
1	Armen Ghularyan	Ijevan/Tavush	Tavush Marzpetaran	Marzpet
2	Sargis Poghosyan	Haghartsin/Tavush	Hagartsin Municipality	Mayor
3	Anastas Hakobyan	Gandzaqar/ Tavush	Gandzaqar Municipality	Mayor
4	Samvel Petrosyan	Gyumri/Shirak	Shirak Marzpetaran	Deputy Marzpet
5	Hmayak Abrahamyan	Artik/ Shirak	Artik Municipality	Mayor
6	Lavrent Sarkisyan	Sisian/Syunik	Sisian Municipality	Mayor
7	Nelson Voskanyan	Goris/Syunik	Goris Municipality	Mayor
8	Dr. Areg Galstyan	Yerevan	Ministry of Energy and Natural Resources	Deputy Minister
9	Daniel Stepanyan	Yerevan	Ministry of Energy and Natural Resources	Head of the Renewabale Energy Division
10	Levon Vardanyan	Yerevan	Ministry of Energy and Natural Resources	Head of the Department of Development
11	Samvel Galstyan	Artik	Ministry of Agriculture	Deputy Minister
12	Garnik Petrosyan	Yerevan	Ministry of Agriculture	Head of Plant Growing, Forestry and Plant Protection Division
13	Ashot Voskanyan	Yerevan	Ministry of Agriculture	Director of Center of Agricultural Support
14	Arshaluis Hairapetyan	Yerevan	Ministry of Agriculture	Head of Innovation and Education Department
15	Dr. Aram Gabrielyan	Yerevan	Ministry of Nature Protection	Head of Environmental Protection Division
16	Martiros Tsarukyan	Yerevan	Ministry of Nature Protection	Senior Expert, Department of Soil and Atmosphere
17	M. Tumasyan	Yerevan	Ministry of Economy	Deputy Minister
18	Hayk Mirzoyan	Yerevan	Ministry of Economy	Head of Branch and Regional Economic Development Department
19	Levon Karapetyan	Yerevan	Ministry of Transport and Connection	Head of Transport Department
20	Pavel Siradeghyan	Yerevan	Ministry of Transport and Connection	Senior Expert
21	Hayk Petrosyan	Yerevan	AWSC, Saur Sevan Services	Advisor to the General Director
22	Dr. Evrik Afrikyan	Yerevan	Centre of Microbiology and Microbal Depository, NAS, RA	Director
23	Dr. Levon Antonyan	Yerevan	Centre of Microbiology and Microbal Depository, NAS, RA	Scientific Secretary

24	Artavazd Zaqaryan	Yerevan	ARIAC	Director
25	Hakob Karagulyan	Yerevan	Biotechnology Institute	Director
26	Ani Balabanyan	Yerevan	The World Bank	Financial Analyst, Infrastructure and Energy Services Unit
27	Arthur Kochnakyan	Yerevan	The World Bank	Consultant, Sustainable Development Group
28	E. Stratos Tavoulareas	Yerevan	The World Bank	Consultant
29	Diana Harutyuyan	Yerevan	"Armenia – Improving the Energy Efficiency of Municipal Heating and Hot Water Supply" UNDP/GEF project	Annual Workplan Manager
30	Anahit Simonyan	Yerevan	UNIDO Armenia	Head of UNIDO Operations in Armenia
31	Rafal Golebiowski	Washington, D.C.	International Finance Corporation	Senior Investment Officer, Agribusiness Department
32	Angela Sax	Yerevan	European Bank for Reconstruction and Development	Associate Banker
33	Hakob Andreasyan	Yerevan	ACBA – Credit Agricole	Deputy Chief Executive Officer
34	Robert Dira	Yerevan	Cascade Credit	Chief Executive Officer
35	Ashot Salazaryan	Yerevan	City Petrol Service (CPS)	President
36	Zorik Oganisyan	Yerevan/Eghvard	Oil Refinery and Spirit Plants	Owner
37	Seyran Khachatryan	Goris	Ethanol Spirit Plant in Goris	Technical Director