Compressed Natural Gas (CNG) as an alternative fuel in a liberalized energy market. Business analysis in the case of Greece.

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I hereby declare that the work submitted is mine and that where I have made use of another’s work, I have attributed the source(s) according to the Regulations set in the Student’s Handbook.

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Abstract

This dissertation was written as part of the MSc in Energy Law, Business, Regulation and Policy at the International Hellenic University.

The subject which is analyzed in this dissertation is the prospects of Compressed Natural Gas (CNG) in order to be developed as an alternative fuel in the Greek energy market which became very recently fully liberalized.

In the first chapter the elements that compose CNG's price are defined. Regulated and unregulated charges are being studied and a calculation of the product's final cost is approached, in order to examine its competitiveness against other traditional fuels.

A business analysis takes place in the second chapter. There is a brief description of the activity and taking a few assumptions into consideration, a detailed business plan is conducted, examining the basic scenarios and some subscenarios.

Conclusions and three appendixes in total are following. It also worth mentioning that this dissertation is accompanied by some "excel" files which were used for the documentation of the business plan.

Keywords: CNG, natural gas, business, energy, fuel

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Preface

By the present note, I would like to express my deepest gratitude to my supervisor, Prof. Kostas Andriosopoulos for his continuous support during this year. His experience and expertise in the energy sector worldwide were very helpful during my research.

Also, I would like to express my gratefulness for Prof. Dr. em. Athanassios Kaissis whose valuable assistance, contribution and suggestions enabled me to attend this postgraduate programme.

Contents

INTRODUCTION

Natural gas is an energy source that enters more and more in the EU energy and environmental policy, since in most EU countries it is used for:

- Electricity generation (natural gas fired power plants).
- Transportations (dual fuel cars, ships).
- Industrial use.
- Households (heating / cooling).

Natural gas in general is considered to be a cheap energy source in all type of uses, since in most cases it replaces Liquefied Petrol Gas (LPG) or oil which seems to be far more expensive and less efficient. Countries that have a wide access to natural gas have a competitive advantage in their economy against those who do not have such an access. Especially with the vast evolution of shale gas it is estimated that the gas prices will be further decreased. In terms of sustainability natural gas is said to be one of the most environmental friendly energy sources, far more “clean” than oil with very low carbon emissions.

The only major problem with natural gas, at least as far as Greece is concerned, is that with the current situation only a few large urban centers (such as Athens, Thessaloniki, Larisa, etc) have access to it since these cities are interconnected with the high pressure pipeline that crosses the Greek territory. That means till nowadays industries and households sited in most of Greek cities do not have access to that cheap and environmental friendly energy source.

The solution to this problem seems to be a new alternative technology that has been recently integrated into the Greek legal energy framework. This new alternative technology is Compressed Natural Gas (CNG) which allows the transportation of natural gas not through the pipelines but through special formatted trucks (Picture 1), providing that way full access to remote consumers, either industries or households.

Picture 1: CNG trucks.

(Source: http://www.kathimerini.gr/912125/article/oikonomia/epixeirhseis/h-energeiakh-epanastash-toy-cng)

However what really matters at the end of the day is whether the final price of the product (CNG) including all relevant costs and fees (compression, transportation, decompression, etc) remains competitive as well. So from the business point of view there are actually two questions that need to be answered:

1) Which is the final cost that an industrial customer is going to pay for this alternative fuel? Is this cost competitive related to other traditional and well established in the Greek energy market fuels?
2) Taking into account that from January 1, 2018 the Greek natural gas market is fully liberalized, is it worth for an energy company to enter into this new business?

1. COST ESTIMATION

The scope of this part of the dissertation is to record the individual cost elements that compose the supply chain of Compressed Natural Gas (CNG). In addition, an estimation of the total cost of CNG supply is attempted here to the final industrial customer for both high and medium pressure compression. More specifically, this framework attempts to analyze and evaluate the key financial parameters that shape the final cost of supplying natural gas in a compressed form to an industrial customer which is far away from the natural gas supply grid, through special formatted trucks (Picture 1).
From this point of view, this part of the dissertation is formed by four (4) distinct signposts, including:

1) The recording of key cost elements.
2) The analysis, calculation and then the synthesis of all the factors that shape the final cost of the CNG supply to the final industrial consumer.
3) Preliminary study for CNG supply to a remote industrial customer.
4) Primary conclusions and penetration capabilities of CNG to the market.

1.1 Cost points

1.1.1 Introduction

The cost of the supply chain of CNG is formed from the following individual cost elements:

1) *Cost of capital*, that means the total cost to purchase and install the necessary equipment for compression, transportation and decompression.
2) *Fixed cost of operation and maintenance* which includes fixed expenses for the operation of the compressor station and the scheduled maintenance of the whole equipment.
3) *The variable operating and maintenance costs*, which include: (a) Compressor station operating costs, (b) Decompression system operation costs, (c) Road transportation costs of CNG.

The initial purpose here is to analyze and estimate only the cost data related to the operation and maintenance of the CNG supply chain.

It is worth mentioning that the charges of natural gas are divided into: (a) *Regulated* and (b) *Unregulated*. More specifically, regulated charges relate to the following charges: (i) Fee for the use of the National System of Natural Gas (NSNG), (ii) Fee for the Distribution Network (Medium and Low Pressure), (iii) Special Consumption Tax, (iv) Fee for Security of Supply, (v) Rewarding fee for the Regulatory Authority for Energy (RAE). Sections below (Regulated charges and Unregulated) show the detailed aspects of these charges.

1.1.2 Regulated Charges

Fee for the use of the National System of Natural Gas (NSNG)

The transportation charge of natural gas represents the monthly fee for the use of the National System of Natural Gas (NSNG) from seller to meet buyer's needs and is expressed in €/MWh. It includes the filling capacity and the filling of the quantity of the transported natural gas and is calculated in accordance with the Tariff Regulation of Basic Activities of the National System of Natural Gas (NSNG) (Government Gazette 2093/05.07.2012).

It is mentioned that this charge depends on the duration of the contract, the exit zone and the final consumption profile in relation to the declared capacity to the Operator (HGTSO) and therefore has no fixed price. In any case, the fee for the use of the National System of Natural Gas (NSNG) is a charge which, regardless of the supplier, remains fixed by the Operator and can be optimized by appropriate operational handling. In conclusion, for the purposes of this section, the charge in question varies from 2.0 €/MWh to 2.5 €/MWh.

Fee for the Distribution Network (Medium and Low Pressure)

The distribution network fee is related to the distribution network's charge for the use of the distribution network by the distribution administrator (distribution administrators are DEDA, EDA Attikis, EDA Thess depending on the geographic area of each customer). It is worth mentioning that until August 2015 there was a regulation of the distribution charge calculation which varied much lower than the current level (≈1€/MWh). Nowadays, the distribution charge is settled for each user, regardless of the supplier, the distribution administrator or the geographical region to 4 €/MWh on the total quantity to be measured and recorded in the measuring station by the distribution administrator (Government Gazette 994/14.08.2015).

Special Consumption Tax

The natural gas from September 1, 2011 is charged with Special Consumption Tax (SCT) settled to 0.0054€/kWh (Government Gazette 425/17.03.2011 - Law 3986/2011).

Fee for Security of Supply

The algorithm for the annual adjustment of the fee is defined according to the decision of RAE 344/2014 (Government Gazette 2536/23.09.2014). More specifically, the Fee for Security of Supply which burdens the natural gas from November 1, 2014 amounts to C x 0.18 €/MWh for industrial consumers. It is stressed that the above fee is C x 0.16 €/MWh for the consumption of natural gas which is consumed exclusively for the production of electricity and C x 0.48 €/MWh for the consumption of natural gas by “Protected Consumers”. It is highlighted that the C- factor is directly dependent on the current amount of the account for the security of supply (in million Euros). For the current year and on the basis of the "HGTSO Report on transactions and balance of the security of supply account" factor C is set to C = 0.1767. The unitary Fee for Security of Supply to be paid by consumers for each category of natural gas consumption is readjusted as follows: (i) 0.1767 x 0.16 = 0, 028 €/MWh for the consumption of natural gas exclusively for electricity generation, (ii) 0.1767 x 0.48 = 0.085 €/MWh for the consumption of natural gas by “Protected Consumers” and 0.1767 x 0.18 = 0.032 €/MWh for all other natural gas consumptions.

Rewarding fee for the Regulatory Authority for Energy (RAE)

The Rewarding fee for the Regulatory Authority for Energy (RAE) is set to 0.021505 €/MWh (Government Gazette 425/17.03.2011).

Concentrating Table of Regulated Charges

Table 1 below summarizes the regulated charges with the corresponding values adopted here.

Table 1: Regulated charges.

Description	Price	Unit	Reference
Fee for the use of the National System of Natural Gas (NSNG)	2.50	€ / MWh	Government Gazette 2093/05.07.2012
Fee for the Distribution Network (Medium and Low Pressure)	**4**	€ / MWh	Government Gazette 994/14.08.2015
Special Consumption Tax	5.4	€ / MWh	Government Gazette 425/17.03.2011 (Law 3986/2011)
Fee for Security of Supply	0.032	€ / MWh	Government Gazette 2536/23.09.2014 (RAE Decision 344/2014)
Rewarding fee for the Regulatory Authority for Energy (RAE)	0.021505	€ / MWh	Government Gazette 425/17.03.2011 (RAE Decision 506/2010)

1.1.3 Unregulated Charges

Procurement price

The procurement price of natural gas is the most important factor for the final price of CNG supply to the customer, given that it is the purchasing price of the fuel itself. It is worth mentioning that the volatility of the natural gas price is typical of energy markets and depends on a variety of different factors, the change of which on a case by case basis can bring about significant changes in its price.

The liberalization of the Greek natural gas market, gives the opportunity to holders of natural gas supply licenses, to obtain natural gas either through Liquefied Natural Gas (LNG) imports (from the LNG terminal in Revythousa island) or through auctions conducted by the Public Natural Gas Company (DEPA). For the calculations carried out in this dissertation DEPA is considered as the main source of gas supply and consequently costing and the related auctions it holds for quarterly or yearly basis. It is worth mentioning that to participate in these auctions, it is essential that participants have previous natural gas supply license.

An important element for determining the final procurement price of the natural gas is the starting price of the respective auction, which is determined on the basis of a methodology approved by the Regulatory Authority for Energy (Decision 592/2014).

On the basis of the mentioned decision, the above starting price incorporates the following cost components:

Unit weighted average cost of gas supply

The weighted average unitary cost of supply, is calculated in $/MWh and for the purpose of determining it, is taken into account the allocation of the contracted quantities of long-term procurement contracts of DEPA per source as well as the respective costs per source. The purchasing costs of long-term contracts are calculated based on international oil prices as established for the period in depth six months and calculated quarterly.

Unitary cost of using National Natural Gas System (NNGS) infrastructure

The costs resulting from the use of the National Natural Gas System (hereinafter referred to as NNGS) infrastructure are calculated in €/MWh and take into account the costs arising from the use of the NNGS entry points and the cost of installing LNG. The costs resulting from the use of NNGS entry points are calculated according to the basic pricing regulation for NNGS activities (Government Gazette 2093/05.07.2012) and represents a cost for the delivery of quantity to the Virtual Reporting System (VRS). The cost of using the LNG terminal, which mainly concerns the gasification cost, corresponds to the cost of delivering a weighted quantity of LNG to the VRS.

Management costs

For the calculation of unitary management cost which is calculated in €/MWh, the direct management cost of DEPA and indirect costs associated with conducting the auction, are taken into account. For the last year, the unitary cost amounted to 0.02 €/MWh for annual auctions and 0.03 €/MWh for the quarterly ones.

At the date of the auction and if the final price of the unitary cost of supply and the unitary cost of use of NNGS infrastructure are taken into account in determining the unitary auction starting price is not known, estimates are made based on international oil prices and the formulas mentioned in the NNGS Basic Activities Pricing Regulation.

The unitary starting bid price is announced in $/MWh and the individual parts calculated in €/MWh are converted to $/MWh. Indicatively, the auction starting price is listed in the table below for the first quarter of 2018 as formulated and announced in DEPA’s official website in the relevant section.

Table 2: Auction Starting Prices for the First Quarter 2018.

(Source: http://www.depa.gr/content/article/002006004001/1931.html)

Reference Month	January 2018	February 2018	March 2018
Auction Starting Price ($/MWh)	22.765		
Currency Rate €/$	1.24005	-	-
Auction Starting Price (€/MWh)	18.35813	-	-

The Starting Price Auction ($/MWh) of 22.765 $/MWh (Table 2) as set out in the first quarter of this year's auction, will also be used as a reference for the cost of supplying the fuel at the compression point. Considering therefore the currency rate (euro/dollar) as it is shaped on January 2018, the price in euro that will be taken into account for the purposes of this dissertation will be *18.358 €/MWh.*

In addition, this price is also the basis for determining the supplier's profit margin, which will be shaped in such a way as to reflect the variable costs of the parties involved, depreciation and the desired profit margin from the activity while making the fuel competitive for 100% substitution of competitive fuels. In the long run, it is estimated that the supply of fuel is expected to take place on receipt of contracted quantities of liquefied natural gas from diversified sources and may lead to significant reductions in the cost of fuel supply.

Compression cost

Compressed Natural Gas (CNG) means compressing natural gas in such a way that per unit volume increases the energy content when it is stored. It should be mentioned that the international bibliography, the relevant technical reports and the existing technologies suggest the compression of the fuel up to 250 bar in order to maximize energy density in relation to storage capacity.

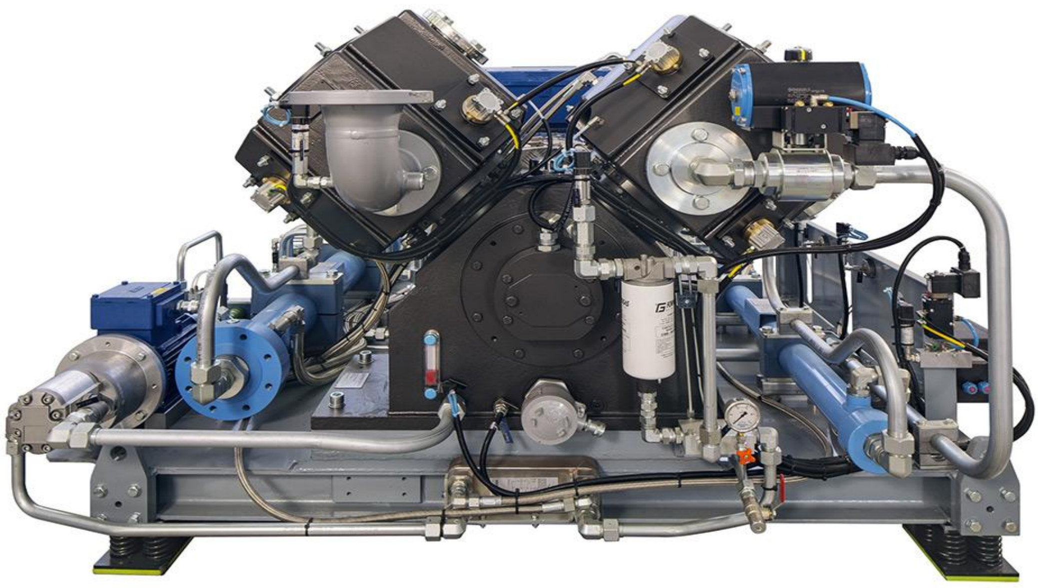
It is obvious therefore, that natural gas taken at the exit point from the grid at pressures much lower than the operating pressure of the storage systems is required with suitable compressors, shall compressed to a pressure of 250 bar. For this necessary increase of pressure, a significant amount of energy is required which creates an additional cost at the unitary price of fuel.

In the context of this dissertation, additional cost is considered, which is added to the cost of the power supply consumed by the compression unit. In order to have a more detailed view, two scenarios (Scenario I and Scenario II) are examined based on the pressure level of the interconnection point (the point where the Mother Station is interconnected with the grid). More specifically, Scenario I examines the compression from medium pressure (Scenario I: Compression from 19 bar to 250 bar) and Scenario II examines the compression from high pressure (Scenario II: Compression from 70 bar to 250 bar). This separation is made from the beginning because there is considerable variation between the high pressure grid and the medium pressure grid in relation to its operating pressure. The table below shows the pressures in relation to the grid.

Table 3: Examined compression scenarios.

Scenarios	**Type of Grid**	**Grid pressure (bar)**	**Compression pressure CNG (bar)**
Scenario I	Medium Pressure	19	250
Scenario II	High pressure	70	250

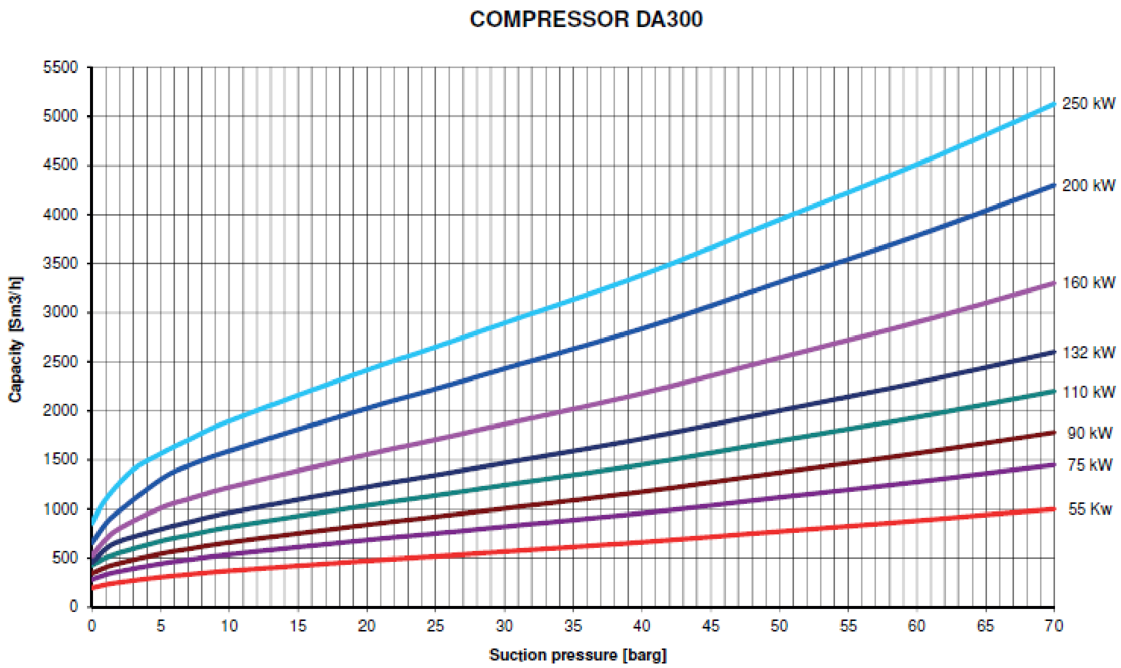
Table 3 shows that the high pressure natural gas grid has about 268% higher pressure. The above difference undeniably results in significant savings in the amount of energy that is required to compress the fuel at a pressure of 250 bar. It is worth mentioning that both the general design of the compressor and the consumable compression work depend significantly on the design parameters which will be directly correlated with the supply chain optimization requirements. The most important size of these parameters is the trailer filling rate, which from international experience in such installations is set to 1500Nm^3/hr. For the purposes of this dissertation and the determination of energy consumption, the FORNOVOGAS compressor (www.fornovogas.it), DA300 type (Picture2) was selected.



Picture 2: DA300 Compressor (Fornovogas).

(Source: http://www.fornovogas.it/en/products/da300/)

The operating profile of the selected compressor is shown in Picture 3. It worth mentioning, based on the manufacturer's available relevant capacity curves by power, that the operating consumption depends on both the filling rate (Capacity in Sm^3/h) and from the input pressure (Suction Pressure in barg).



Picture 3: DA300 Compressor operating profile (Fornovogas).

(Source: http://www.fornovogas.it/wp-content/uploads/DA300_ENG.pdf)

The diagram of Picture 3 shows an increase in the requirement in power at a constant rate of filling as the input pressure decreases. Based on the power of the compressor and the time required to fill a trailer with a capacity of 4,500 Nm^3 CNG, the consumed power by the compressor is calculated.

In order to specify the cost of electricity consumed in the compression stage is taken into account the price of MWh according to: (i) the unitary cost of supply and (ii) the cost of the regulated charges that are imposed on electricity tariffs. The cost of electricity supply is determined taking into account the market prices from independent power utilities for invoices in Medium Voltage with low utilization rate. From this point of view the cost of electricity supply is defined in 65 €/MWh. Considering the profile of similar facilities connected at Medium Voltage grid, the electricity procurement costs and additional charges in the unregulated part of the electricity bill, the final price for energy costs excluding VAT, is set to 120 €/MWh. In the sections which follow, two scenarios will be presented for connection to the natural gas grid of medium pressure and high pressure, for filling capacity vector with 4,500Nm^3 at a constant filling rate of 1,500 Sm^3/hr.

Compression cost (from Medium Pressure grid)

The medium pressure natural gas grid has a nominal operating pressure of 19 bar. From the diagram of Picture 3 it is clear that in order to achieve a stable filling rate of 1,500 Sm^3/hr, it is required to adopt a 160KW power compressor solution. Given that the special formatted trailer has a capacity of 4,500Nm^3, the required filling time is calculated at three hours. With this data, the power consumed by the compressor for this filling time is calculated at 480KWh.

Having already calculated that the final unitary energy price is 120 €/MWh, for filling a special formatted trailer the total cost reaches 57.6 €. By reduction compared to the energy content of a vector which has been determined at 49.27 MWh of natural gas, the final cost for the compression of 1MWh of fuel to the pressure of 250barg, is estimated at 1.17 €/MWh (Table 4).

Table 4: Calculation of compression cost for CNG from Medium Pressure grid.

Rated Power (KW)	160
Filling (m³)	1,500
Filling time (hr)	3
Consumed energy (kWh)	480
Electricity costs (€/kWh)	0.12
Load Filling Cost (€)	57.6
Cost / MWh	1.17

Compression cost (from High Pressure grid)

The high pressure natural gas grid has a nominal operating pressure of 70 bar. From the diagram of Picture 3 it is clear that in order to achieve a stable filling rate of 1,500 Sm^3/hr, it is required to adopt a 90KW power compressor solution. Given that the special formatted trailer has a capacity of 4,500Nm^3, the required filling time is calculated at three hours. With this data, the power consumed by the compressor for this filling time is calculated at 270KWh.

Having already calculated that the final unitary energy price is 120 €/MWh, for filling a special formatted trailer the total cost reaches 32.4 €. By reduction compared to the energy content of a vector which has been determined at 49.27 MWh of natural gas, the final cost for the compression of 1MWh of fuel to the pressure of 250barg, is estimated at 0.66 €/MWh (Table 5).

Table 5: Calculation of compression cost for CNG from High Pressure grid.

Rated Power (KW)	90
Filling (m³)	1,500
Filling time (hr)	3
Consumed energy (kWh)	270
Electricity costs (€/kWh)	0.12
Load Filling Cost (€)	32.4
Cost / MWh	0.66

From the above data it is more than clear that there is a significant difference in the filling cost of a trailer, depending on the pressure level of the interconnection point. This difference is calculated in percentage *44%* lower cost for compression from High Pressure grid.

Transportation costs

The transportation of CNG, is carried out with specially shaped towed carriers (trailers) bearing steel storage tanks with a nominal filling pressure 250 bar and capacity about 4,500 m³. In Picture 4, there is shown a specially designed compressed gas transfer vector.

Picture 4: CNG trailer.

(Source: http://news.fibatech.com/equipment/superjumbo-cng-tube-trailer/)

The above mentioned trailers are transfered to the final consumer (industry) with special tractors, composing the logistics supply chain from the compression station (Mother Station) to the delivery point (Daughter Station), which is in this case an industrial consumer. It is worth mentioning that the transfer of CNG is a very crucial part of the supply chain that makes up the commission, given that it is possible to shape the overall costs and therefore to determine both the competitiveness compared to other fuels that substitutes and the overall viability of the proposed business as well. That is why the transfer of CNG deserves detailed study, research and optimizing the supply chain in order to ensure continuous supply of the customer with fuel.

For the above reasons, it is important to determine the unitary price of the transport costs of CNG per kilometer in a manner which will include all individual costs associated with its operation. Standard costs that shape the final price of the transport of a CNG load with capacity 4,500m³ at nominal pressure 250bar, are analyzed into: (i) Fuels of tractors, (ii) Maintenance of tractors (spare parts, labor), (iii) Insurance costs both for tractors and drivers, (iv) Drivers Compensation (salary, insurance contributions, overtime) and (v) Fees, charges and relevant certifications.

From related communications with companies engaged in the business of fuel transportation that are dealing several years in the field, but also from related public bids filed for similar activities, unitary costs generated per kilometer for the transport of CNG from the compression station (Mother Station) to the point of delivery (Daughter Station), is calculated about 2.96 €/km.

Decompression Cost

For the use of CNG in the delivery point (Daughter Station) specific procedures are required for the interconnection to the consumer's supply system, since the operating pressure needs to be decreased at a level about 2-4 bar. It is well known that during decompression of natural gas at pressures much lower than the storage pressure, natural gas absorbs heat (phenomenon known as Joule Thompson) creating that way moisture condensation due to very low temperatures which is possible to destroy parts of the equipment and the trailer.

From this point of view during the decompression process natural gas requires to be heated so as to avoid the above mentioned phenomenon, to maintain a constant gas composition and finally to protect the equipment. For warming the fuel before decompressing, there are numerous commercially available systems which according to the decompression rate at the discharge station and the output pressure, it is possible to warm the gas to temperatures of about 70°C to 80°C. For the heating of CNG, these systems use electricity.

On the basis of the technical characteristics of a decompression system for calculations of this dissertation, the following values were adopted: Filling rate = 800 Nm³/h and Power = 30 kW. It is mentioned that for the decompression of a carrier with storage capacity of 4,500 m³, with the use of a decompression device with the above technical specifications, about 5.5 hours are required. With estimated total electricity costs reaching 120 €/MWh, the decompression cost of CNG amounts to 0.41 €/MWh (Table 6 below).

Table 6: CNG decompression cost calculation model.

Rated Power (KW)	30
Filling (m³)	800
Filling time (hr)	5.625
Consumed energy (KWh)	168.75
Electricity costs (€/KWh)	0.12
Load filling Cost (€)	20.25
Cost / MWh	0.41

However with regards to the cost of decompression it is very important the right strategic business decision to be taken in relation to the part which will bear it. It is understood that the decompression rate is directly dependent on the rate of consumption of CNG by the final consumer, therefore constitutes a dynamically changing size and directly associated with the optimization of reverse logistics and management of the final consumer stocks.

Summary Table of Unregulated charges

Table 7 reflects all the individual unregulated charges to corresponding values adopted in estimating the cost of supply in this dissertation.

Table 7: Individual costs of unregulated charges.

Description	Price	Unit
Natural Gas Procurement Price	18.358	€/MWh
Compression Costs *(High Pressure)*	0.66	€/MWh
Compression Costs *(Medium Pressure)*	1.17	
Transportation Costs	2.96	€/MWh
Decompression Costs	0.41	€/MWh

1.2 Cost Calculation

In the framework of the current study for the cost of CNG supply, a case study for road transportation of CNG to an industrial consumer at a distance of 80 km from the

Mother Station is developed. Table 8 reflects all the assumptions adopted in the calculations. Two different solutions / techniques of transportation are proposed in the section below.

Table 8: Assumptions

Natural Gas Energy Content	**m³**	**KWh**	**MWh**	**Remarks**
	1	11,405.67	0.01140567	
Trailer Capacity	**Parameter**	**Technical Solution 1**	**Technical Solution 2**	**Remarks**
	Nm³	4,500	11,600	***TS1**: Steel storage arrays* ***TS2:** Composite storage arrays*
	Filling Factor	96.00%	96.00%	*Usable Capacity*
	Capacity	4,320	11,136	
	Trailer's Energy Content MWh / trailer	49.272	127.014	
	Load Value € / trailer	779.49	2,009.35	
Transportation Cost	**Unitary transportation costs (€/km)**	**Distance (Km)**	**transportation costs 1 MWh (€)**	
	2.96	80	4.55	

Specifically, Technical Solution 1 refers to the transportation of CNG by trailer that utilizes steel storage arrays of CNG with total capacity amounting to 4,500 m³, while Technical Solution 2 refers to the transportation of CNG by trailer that utilizes composite storage arrays of CNG, made from synthetic materials, with total capacity amounting to 5,800 m³. Each tractor will carry two arrays per itinerary. Therefore the total capacity per itinerary amounts to 11,600 m³. Actually the "useful" capacity is 4% less for both the proposed technical solutions, given that in any case it is required to remain in the arrays pressure of approximately 10 Atm.

Table 9 presents the individual cost elements that compose the supply chain of CNG to industrial consumers on the basis of assumptions that were analyzed with thoroughness in the previous sections. Remarkably, given the possibility of changing the individual cost components the final cost of supplying CNG can be modified. However, in any case, given that the logistics supply chain of CNG has been mapped in details, a re-assessment of costs would be quite easy.

Table 9: Evaluation of individual costs for CNG supply.

	Individual Costs	Price	Unit	Remarks
Regulated charges	Fee for the use of the National System of Natural Gas (NSNG)	2.50	€/MWh	*Government Gazette 2093/05.07.2012*
	Fee for the Distribution Network (Medium and Low Pressure)	4.00	€/MWh	*Government Gazette 994/08.14.2015*
	Special Consumption Tax	5.4	€/MWh	*Government Gazette 425/17.03.2011 (Law 3986/2011)*
	Fee for Security of Supply	0.032	€/MWh	*Government Gazette 2536/23.09.2014 (RAE Decision 344/2014)*
	Rewarding fee for the Regulatory Authority for Energy (RAE)	0.021505	€/MWh	*Government Gazette 425/17.03.2011 (RAE decision 506/2010)*
Unregulated Charges	Natural Gas Procurement Price	18.358	€/MWh	
	Compression Costs (Medium Pressure)	1.17	€/MWh	
	Compression Costs (High Pressure)	0.66	€/MWh	
	Transportation Costs	2.96	€/Km	
	Transportation Costs	4.81	€/MWh	
	Distance (km)	80	Km	
	Decompression Costs	0.41	€/MWh	

In the above basis for Scenario I which refers to the compression of natural gas from Medium Pressure grid, the total cost of CNG is formed as depicted in Table 10.

Table 10: Total Cost of CNG from Medium Pressure grid.

Natural Gas Procurement Price	18.358
Fee for the use of the National System of Natural Gas (NSNG)	2.50
Fee for the Distribution Network (Medium and Low Pressure)	4.00
Special Consumption Tax	5.40
Fee for Security of Supply	0.032
Compression Costs	1.17
Transportation Costs	4.81
Decompression Costs	0.41
Rewarding fee for the Regulatory Authority for Energy (RAE)	0.021505
Total Procurement Cost - € / MWh	*36.70*

Respectively, in the above basis for Scenario II which refers to the compression of natural gas from High Pressure grid, the total cost of CNG is formed as depicted in Table 11.

Table 11: Total Cost of CNG from High Pressure grid.

Natural Gas Procurement Price	18.358
Fee for the use of the National System of Natural Gas (NSNG)	2.50
Special Consumption Tax	5.40
Fee for Security of Supply	0.032
Compression Costs	0.66
Transportation Costs	4.81
Decompression Costs	0.41
Rewarding fee for the Regulatory Authority for Energy (RAE)	0.021505
Total Procurement Cost - € / MWh	*32.19*

1.3 Initial Conclusions

Undeniably, the current market conditions in natural gas as established both internationally and at European and national level, favoring the development of investment projects that the given period of time can potentially reshape energy policy and market by offering strategic advantages to investors by realigning the fuel demand and consequently the enlargement of their customer's base.

It is worth mentioning that natural gas, due to quality characteristics and low cost, seems to have a high acceptance in both residential and industry sector. At this point of time the penetration of natural gas is satisfactory, although the purchase prices are at very low levels due to international circumstances and domestic demand due to the financial crisis is greatly reduced. From this point of view it is necessary to emphasize that there is no high possibility of increasing demand through the expansion of transmission and distribution networks. Therefore, an alternative approach to further develop the natural gas market is considered the development of "virtual pipelines" that means by adopting the CNG technology through the system of Mother / Daughter stations, as described earlier.

In the context of this part of the dissertation the unitary price of the cost of supply of natural gas by the relevant auction of DEPA, was evaluated. The procurement cost of gas, imports the greater uncertainty, as currently it is at lower levels in recent years and also important is the fact that in calculating the final price it should be taken into account on a monthly basis and the modification in the exchange rate between the euro and US dollar (€/$) which introduces additional uncertainty.

The most important component which should constitute a major criterion for the location of the filling station (Mother Station) is the compression cost of natural gas at a pressure such as to allow the transportation of loads with a higher energy density. On the basis of the above mentioned analysis, it was realized that the pressure that gas is taken up at the input of the compressor, is the most important element for the design of a compressor which is designed to serve specific filling rates. More specifically, it was found that the supply of the compressor with natural gas from the high pressure grid (compression from 70 bar to 250 bar) for a constant compression rate (1,500Nm^3) brings about a 44% lower compression costs (0.61 € instead of 1.17 € for compressing from medium pressure). Consequently from the compression cost point of view, the supply of the compressor station from the high pressure grid is retained as the most advantageous solution. Respectively the decompression cost is a cost element that is also important to be decided the impact that will have to determine the fuel price given per MWh, taking into account that the basis of the customer's consumption profile even for similar equipment may vary significantly.

In addition and with respect to the grid’s pressure as a criterion for selecting the station's location, it should be noted that the use of medium pressure grid, burdened with an additional significant cost which refers to the fee for the use of Distribution Network and amounts to 4.00 €/MWh. Considering that cost which currently is about 25.28% of the fuel’s total price, it seems that the selection of the station supply from the high pressure grid is considered as the optimal solution.

With regard to regulated charges, as described earlier, there is not any flexibility because there is not any option for negotiating them. However, and given the frequent variation of these factors in the context of the overall fiscal adjustment is essential to be monitored and recorded. A significant increase in such charges is very likely to affect the competitiveness of natural gas in general compared to other fuels, thus the competitiveness of CNG also.

Transportation cost of CNG is also an important issue for CNG’s logistics supply chain. Without any doubt, the transportation cost is extremely crucial because apart from very high demand for constant monitoring and optimization it also introduces very high costs on the unitary price per MWh. It is understood that the transportation cost is an important factor of the CNG's final purchasing price given that it is directly correlated with the location of the filling station and the distance of the final industrial consumer. In this section the transportation cost was estimated at 2.96 €/km. It worth mentioning that transportation costs are directly related to fuel costs, the proximity of final industrial consumers and the transported load, therefore it is possible to significantly diversify its price.

In conclusion, it should be very clear that thorough analysis and investigation is required on issues related to: (i) The selection of compressor station's location (whether it would be near the High or Medium Pressure grid), (ii) The selection of means of transportation (Technical Solution I or II), (iii) Devices and equipment in general for compression and decompression, (iv) The Cost benefit analysis based on the aforementioned variations.

2. BUSINESS PLAN

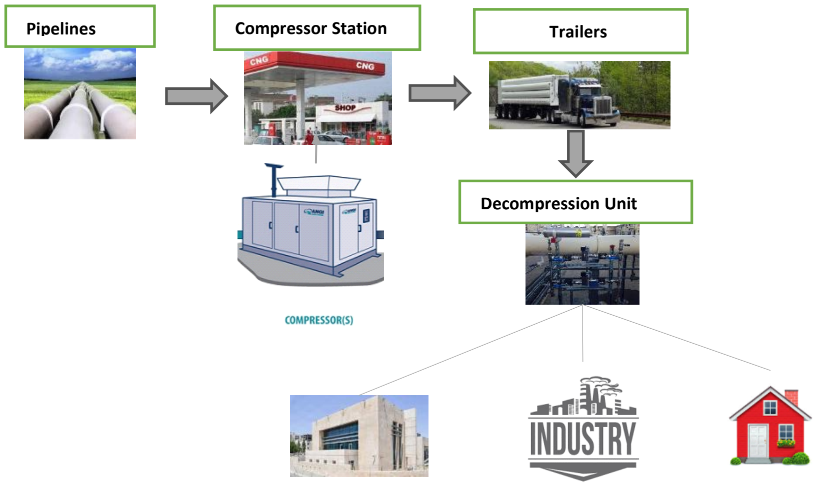
From *January 1, 2018* the Greek natural gas market has been fully liberalized according to the provisions of the *Law 4336/2015* (Government Gazette 94/14.08.2015). That means every single natural gas consumer either industrial or household, wherever in Greece, is an eligible customer for all energy companies dealing in the Greek natural gas market.

The scope of this chapter of the dissertation is to research whether this new alternative fuel (CNG) can be proved to be a new business opportunity for energy companies in this energy framework of fully liberalized market.

So this chapter is actually a business plan for the activation of an energy company in the compressed natural gas (CNG) business in order to supply customers outside the national transmission and distribution system (High and Medium Pressure pipelines).

2.1 Business Activity Description

The commercial start up of a CNG supply company is being considered in the region of Northern Greece and specifically in Central Macedonia. Activation in the CNG sector involves customers who have thermal energy needs and are out of the transmission and distribution network, thus not being able to consume natural gas. These customers are mainly active in the Industry and Tourism sectors. Customers are also considered to be public buildings with high energy needs as well as clusters that are connected to a micro-distribution network. Customer’s fuels that compete with natural gas are mainly LPG (Liquefied Petroleum Gas), crude oil and heating oil.



Picture 5: CNG Supply Chain

The logistics chain is shown in Picture 5. The energy company creates a supply station (Mother Station) located within the existing transmission (High Pressure) and distribution network (Medium Pressure). As described in details in the previous chapter, at this station natural gas is compressed (250 bar) into specially shaped CNG bottles, which are located in trailers. Trailers are transfered with tractors to the customer's facilities where they are deposited and connected via a decompression unit (2-4 bar) to the existing pipeline that ends up in the burner in order to produce the required for the operation of the customer thermal energy.

The energy company will offer natural gas at a competitive price against the fuel currently supplied (LPG / crude oil) so that there is sufficient enough incentive for customers in order to convert their burners in a way that could use an alternative fuel. This price has been assumed to be at least 15% less than the cost of the existing fuel.

The energy company will undertake the entire supply chain function by supplying the customer with a) The main product that is the natural gas, b) The transportation, c) The decompression and d) The conversion (retrofit) of the existing burner.

In other words, the energy company will almost completely bear the burden of investing with the customer simply having a small cost of constructing a short pipeline network from the point of trailer till the existing burner. This solution is proposed in order to make the sale easier by delivering to the customer a complete package of services and deducting the costs that could be a barrier for its final decision.

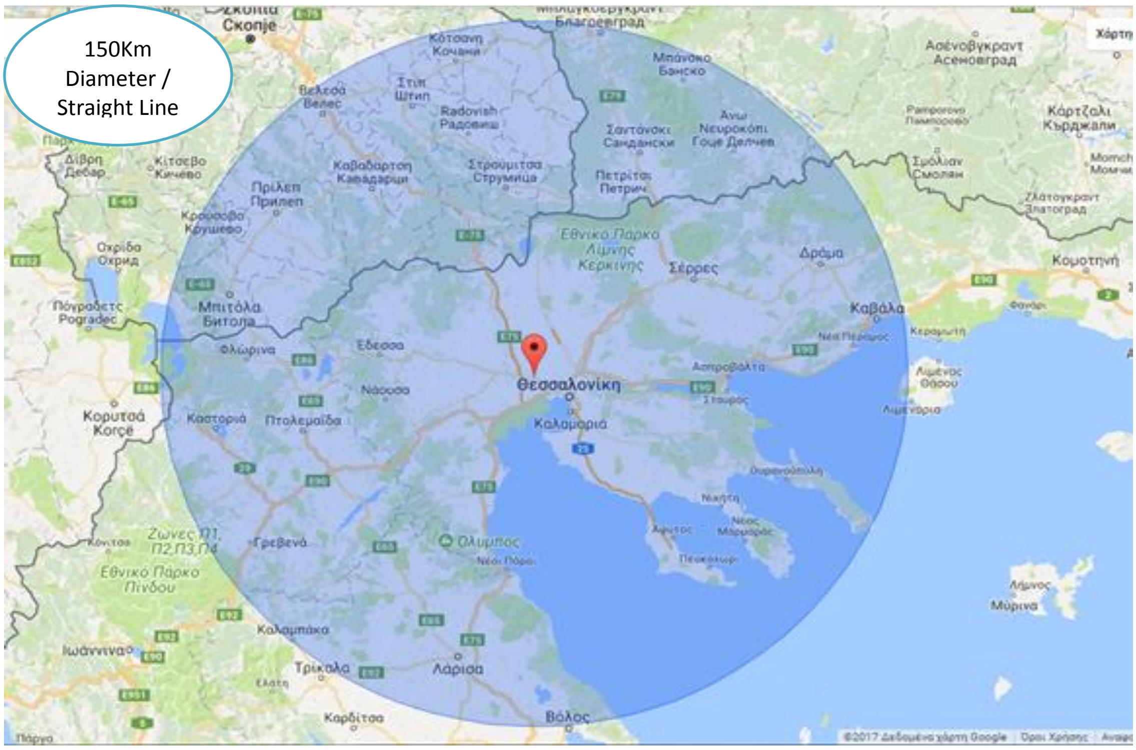
The operations of trailer transportation, maintenance and repair of the equipment will be outsourced (due to lack of expertise and necessary equipment) and in cooperation with reliable and experienced external partners, active in the market and specialized in these services.

In Table 12 below are summarized the basics of the CNG's commercial activity, as well as the geographical area that can be covered by the supply station. It should also be noted that this business plan is accompanied by excel files containing all the data and calculations described below.

Table 12: *Basic Business Model Elements*

Basic Business Model Elements			
Contracts	*Burners Conversion*	*Outsourcing*	*Product - Price*
The contracts that will be signed with customers will contain, among other things, clauses that refer to: A. Minimum period of time for the customer to obtain natural gas from the company (given that the company will have installed the required equipment at its own expenses). B. Overdue payments.	The conversion of the existing burners (retrofit) will be done by the energy company (outsourcing) in cooperation with a specialized manufacturing company. Conversion costs will be charged exclusively to the energy company. Through this policy and through the supply of all the equipment required for the procurement of natural gas the energy company actually "binds" the customer.	The activities to be outsourced are: A. The transportation of CNG trailers from the supply station to the final consumer and vise versa. B. Installation and maintenance of all necessary equipment, both energy company's and its customers. (Compressors, Decompressors, Trailers)	The price to be purchased by the customer will follow the rule of 15% discount on the cost of burning the consumer's current fuel. Therefore, the final price offered will result in savings in the energy costs of the final consumer of at least 15%.

As far as the geographical region is concerned, the business plan has been implemented setting the city of Thessaloniki as the city where the compression station (Mother Station) will be installed. The coverage range is about 150 km and depends on the size of customer's consumption, as it is shown in Picture 6 below.



Picture 6: Geographical region.

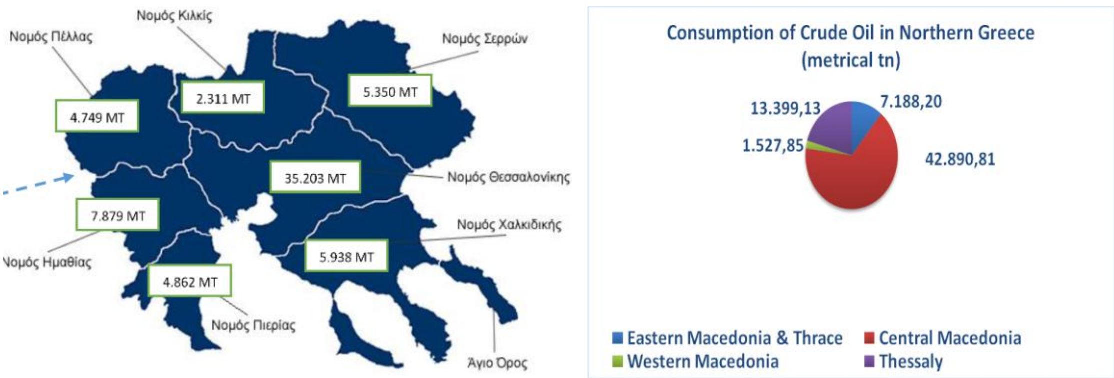
With precisely the same technical and economical magnitudes used in this business plan, it can be applied to start a commercial activity in any part of Greece not covered by a pipeline and which can be considered to have a corresponding large potential market.

Areas of expansion in the future are considered as:

1) Western Macedonia.
2) Eastern Macedonia.
3) Western Greece.
4) Peloponnese.
5) Areas of Central Greece near Attica.

2.2 Competitiveness of Natural Gas - Market

The target market for the energy company is shown in Picture 7, which presents the size of the competitive fuel market. The main objective is the market of LPG and crude oil. Especially LPG is the "closest" fuel compared to natural gas since burners need only a few modifications in order to convert them and industries that already using LPG have a developed culture in the use of gas fuels.



Picture 7: Target market.

From data available by a large LPG trading company, the LPG market of northern Greece corresponds to a natural gas market of 114.86 mcm (million cubic meters) while that of Central Macedonia corresponds to a natural gas market of 81.178 mcm. Respectively with data received from the Hellenic Statistical Authority (http://www.statistics.gr/en/home/) the crude oil market of Central Macedonia corresponds to a natural gas market of 62.15 mcm. Overall, the Central Macedonia market corresponds to about 140 - 150 mcm of natural gas.

Regarding the competitiveness of CNG in relation to LPG, Picture 8 shows comparatively the difference between LPG prices and the selling price based on which the financial results and potential cash flows of the business plan are presented.

Picture 8: Price comparison between LPG and CNG.

This graph shows that the price of CNG is competitive even with deduction of 15% on the final sale price of LPG (based on the assumption that in order to be competitive the natural gas should be 15% cheaper than the existing fuel). Accordingly, the crude oil price after deduction of 15% reaches 39.53 €/MWh, which is still higher than the CNG's selling price. The quoted prices are final actual purchasing prices to existing customers, crossed with prices as quoted daily in the fuel price bulletins (http://oil.gge.gov.gr/).

2.3 Model Assumptions

In order to develop this business model the following assumptions have been made, as they are shown in Table 13:

Table 13: Model Assumptions

Customers	Nm3/Day	
Medium Customer	3.502	
Medium Customer - Seasonality	3.502	
Large Customer	12.706	
Large Customer - Seasonality	12.706	
Seasonality	**High**	**Low**
Medium Customer	80%	20%
Large Customer	70%	30%
Advance Payment Leasing	20%	
Leasing Interest Rate	6.5%	
Financing		
Equity	30.00%	
Bank Loan	70.00%	
Cost of Capital & Lending		
WACC	14.00%	
Lending Cost	4.50%	
Natural Gas Prices		
Initial Selling Price (€/MWh)	38	
Initial Purchase Price (€/MWh)	26.00	

- Based on actual customer consumptions (in LPG and crude oil), the assumptions have been made for their consumptions at natural gas. The breakdown into four categories was based on consumption and on the basis of customer seasonality. Large customer's real consumption data have been obtained from a ceramics industry, while medium size customer's real consumption data have been obtained from a dairy industry.
- Seasonality 80% high - 20% low indicates that the customer consumes 80% of the energy required in one semester and the remaining 20% in the second one.
- Lease-related information relates only with the development of a specific scenario to be described below. The lease concerns the way of acquiring part of

the equipment (20% down payment of equipment and 6.5% interest rate on residual value).

- Funding has been considered to be made with 70% of the required funds coming from bank loan.
- The cost of capital is 14% while that of borrowing at 4.5%.
- The selling price of the natural gas has resulted from the need to give the final consumer a price of less than 85% of the energy price he pays using an existing fuel.

2.4 Scenarios

The scenarios that have been developed are shown in Table 14 and Table 15. There are two different stages of scenario creation. The first stage is based on how the equipment is acquired, whether the equipment is purchased by the energy company or whether part of it is acquired through the leasing method. The second stage involves the development of sub-scenarios which will be discussed below.

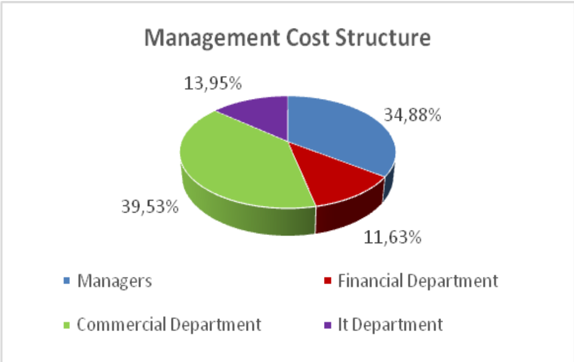
2.4.1 Basic Scenarios

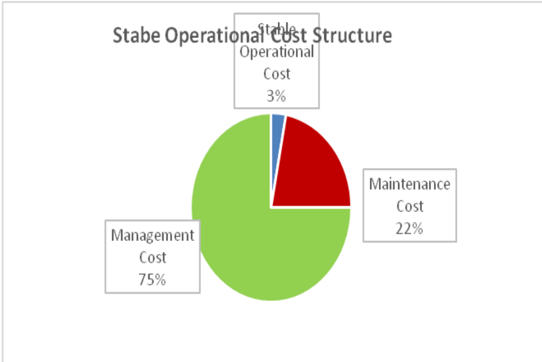
1) *High Capex Scenario:* All equipment purchased by the energy company.
2) *High Opex Scenario:* Part of the equipment is purchased through leasing.
3) *All inclusive - High Capex scenario:* Like High Capex, with the difference that the energy company also undertakes the cost of converting customers' burners.
4) *All Inclusive - High Opex scenario:* Like the High Opex, with the difference that the energy company also undertakes the cost of converting customers' burners.

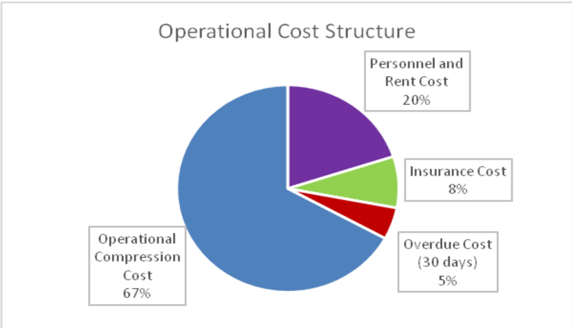
Table 14: Scenarios based on how the equipment is acquired.

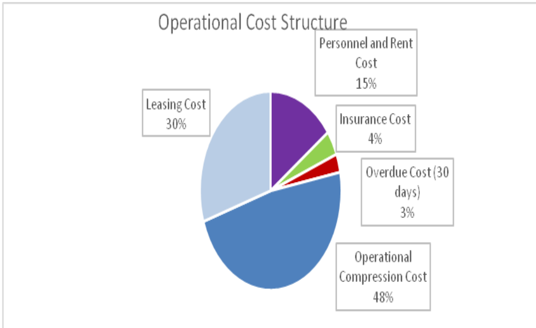
	#1. High Capex	**#2. High Opex**	**#3. All inclusive – High Capex**	**#4. All Inclusive – High Opex**
Supply station	Purchase	Purchase	Purchase	Purchase
Compressors	Purchase	Purchase	Purchase	Purchase
Trailers	Purchase	Leasing	Purchase	Leasing
Trailers (transport)	Outsourcing	Outsourcing	Outsourcing	Outsourcing
Decompressors	Purchase	Leasing	Purchase	Leasing
Retrofit	Customer	Customer	Company	Company

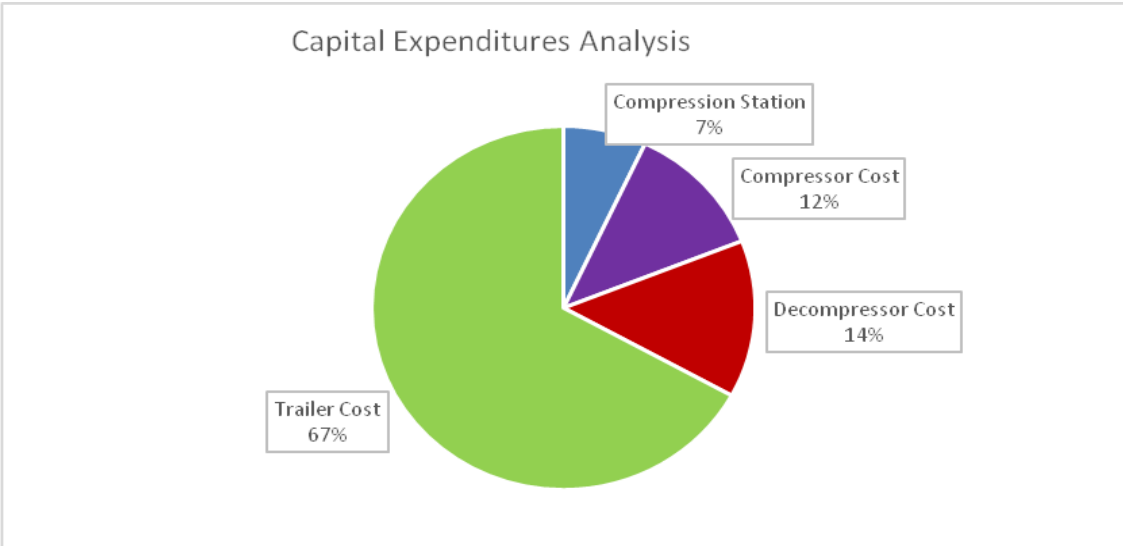
Cost of Capex Scenarios 1 & 3 *vs* Cost of Opex Scenarios 2 & 4

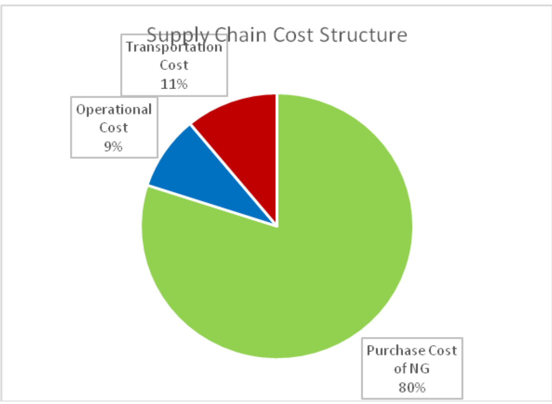


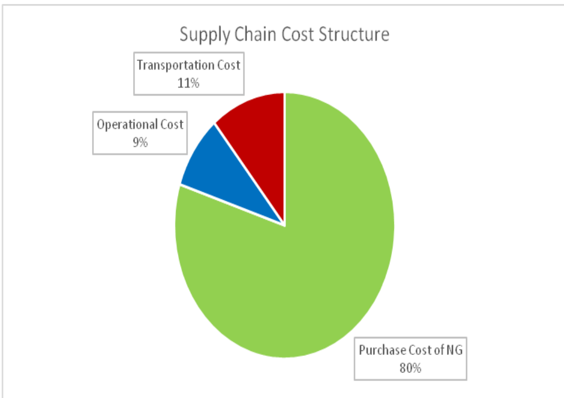












2.4.2 Subscenarios

Using the above separation, three more scenarios (Base, Best, Worst) were created (shown in Table 15) which were applied for each of the above cases. These three scenarios were created taking into account four important factors which are: a) The mix of customers b) The initial purchase price of natural gas c) Sales growth for the first 5 years and d) Initial number of customers in the first year. All assumptions (such as consumption per customer) taken into account in this business plan are described below.

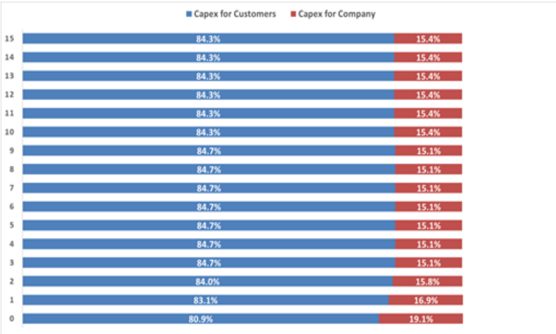
Table 15: Subscenarios.

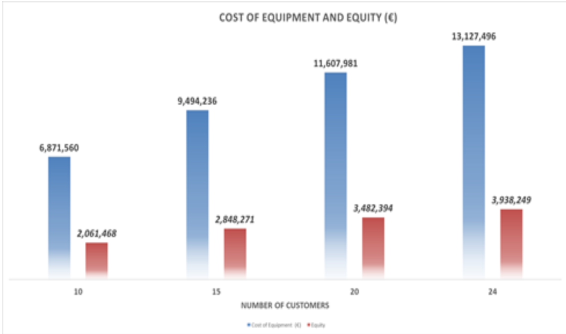
	BASE	BEST	WORST
MEDIUM CUSTOMERS	30%	10%	50%
MEDIUM CUSTOMERS IN SEASONALITY	20%	10%	50%
BIG CUSTOMERS	30%	50%	0%
LARGE CUSTOMERS IN SEASONALITY	20%	30%	0%
NATURAL GAS PRICE	26	26	27
GROWTH 1^{st} YEAR	50%	50%	20%
GROWTH 2^{nd} YEAR	30%	20%	20%
GROWTH 3^{rd} YEAR	20%	20%	10%
GROWTH 4^{th} YEAR	0%	20%	0%
GROWTH 5^{th} YEAR	0%	10%	0%
# OF CUSTOMERS 1^{st} YEAR	10	10	4

2.4.3 Scenario High Capex

Basic points are as follows:

- Financing: 30% Equity, 70% Bank Loan (4.5%).
- Investment cost (1^{st} year) = 6.8 million € / Equity (1^{st} year) = 2.06 million €.
- Ratio Customer Capex / Capex Company is 84% (Trailers & Compressors) - 16% (Compressors).
- IRR (15 years) = 114.2%, NPV (15 years) = 13.84 million €, IRR (7 years) = 77.7%, NPV (7 years) = 5.22 million €.
- Payback period 15 years, Own funds for start-up activity = 400 thousand € (30% of the cost of supply station and compressor).



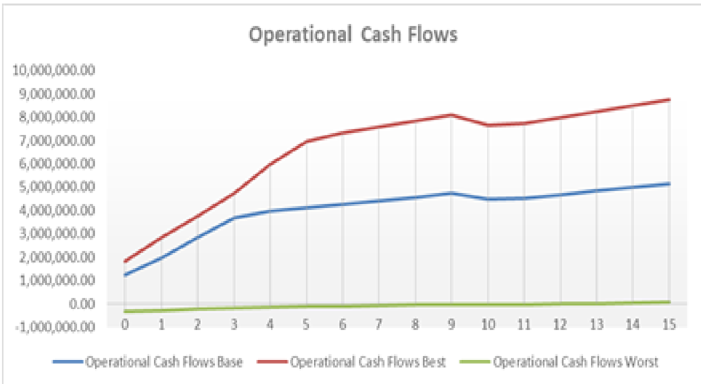


Consumption based on the specific mix of customers is as follows:

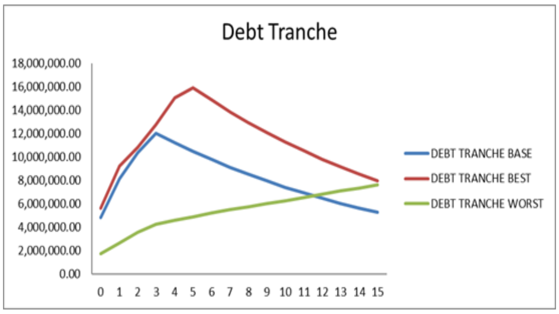
- *10 Customers* - 29.5 mcm / 4 Compressors / 10 Compressors / 20 Trailers
- *15 Customers* – 44.3 mcm / 5 Compressors / 15 Compressors / 30 Trailers
- *20 Customers* – 59.0 mcm / 7 Compressors / 20 Compressors / 40 Trailers
- *24 Customers* – 70.8 mcm / 8 Compressors / 24 Compressors / 48 Trailers

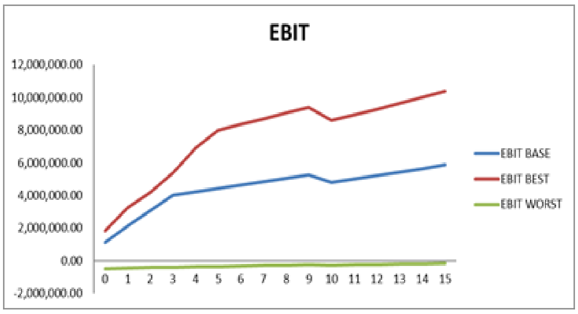
Operational cash flows are shown in the diagram below. The internal rate of return (IRR) on final cash flows (after the payment of capital and interest on the loan) is equal to 114%. Especially for the first 7 years the final (not the operational) cash flows are as follows:

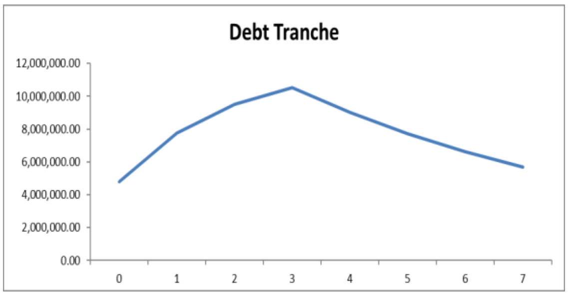
- 1st Year: -806,860.52 €
- 2nd Year: 273,681.97 €
- 3rd Year: 1,110,931.05 €
- 4th Year: 1,820,036.59 €
- 5th Year: 2,628,028.57 €
- 6th Year: 2,862,901.37 €
- 7th Year: 3,094,699.25 €

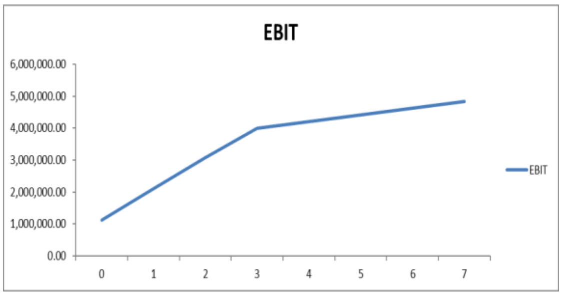


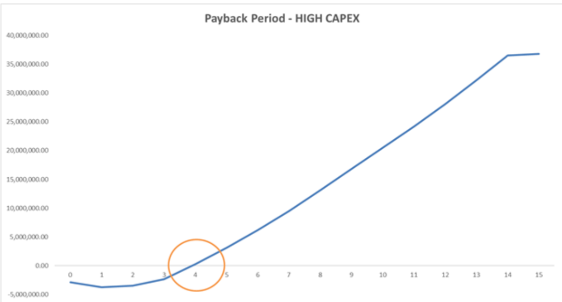
The following diagrams show debt tranche and EBIT for the three sub-scenarios.

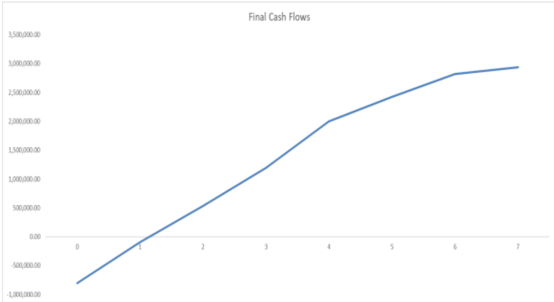








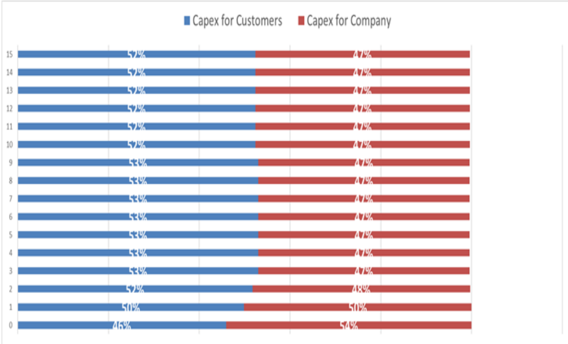


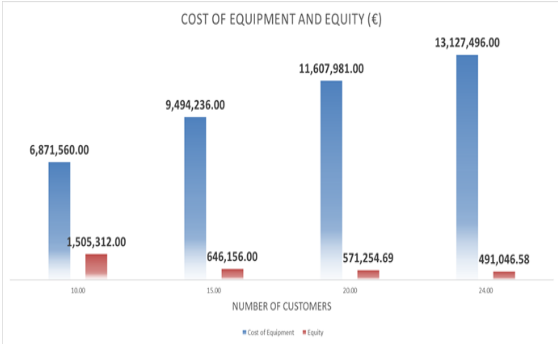


2.4.4 Scenario High Opex

Basic points are as follows:

- Leasing 20% down payment, 6.5% interest rate (100% tax deductible). Payback period 7 years for trailers and 10 years for decompressors.
- Non-Leasing Equipment (Supply Station & Compressors) with 30% Equity and 70% Bank Loan (4.5%).
- Ratio Capex Company / Capex Customer 50% (Trailers & Compressors) 50% (Compressors).
- IRR (15 years) = 94%, NPV (15 years) = 10 million €, IRR (7years) = 71.9%, NPV (7 years) = 2.3 million €, Investment cost (1st year) = 6.8 million €, Equity (1st year) = 1.5 million €.
- Own funds for start-up activity = 400 thousand € (same as High Capex scenario since it concerns Supply Station and Compressor costs).



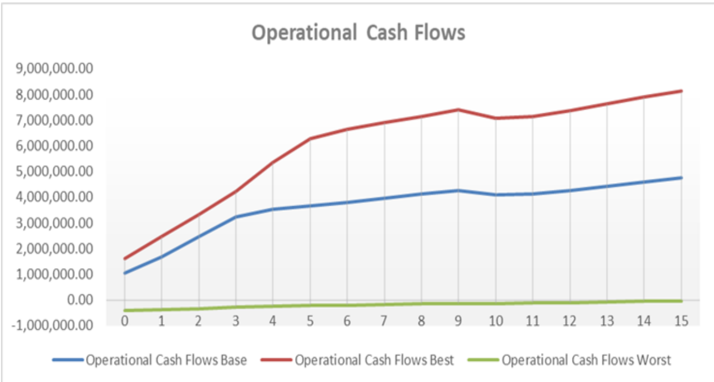


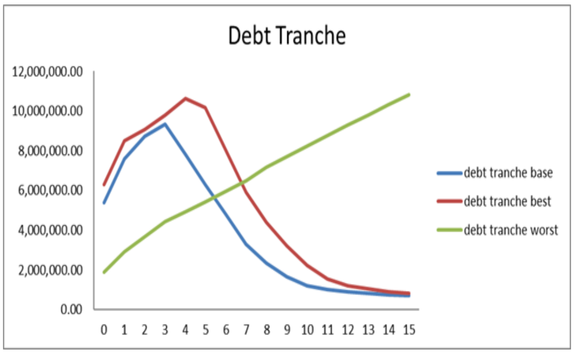
Consumption based on the specific mix of customers is as follows:

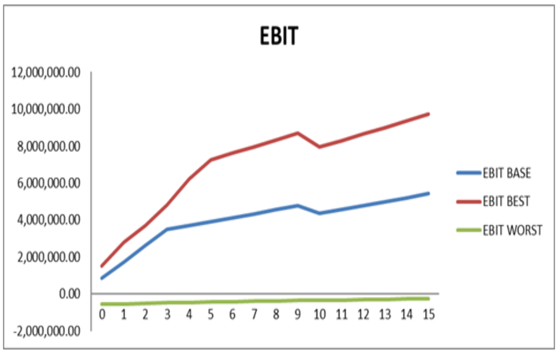
- *10 Customers* - 29.5 mcm / 4 Compressors / 10 Compressors / 20 Trailers
- *15 Customers* – 44.3 mcm / 5 Compressors / 15 Compressors / 30 Trailers
- *20 Customers* – 59.0 mcm / 7 Compressors / 20 Compressors / 40 Trailers
- *24 Customers* – 70.8 mcm / 8 Compressors / 24 Compressors / 48 Trailers

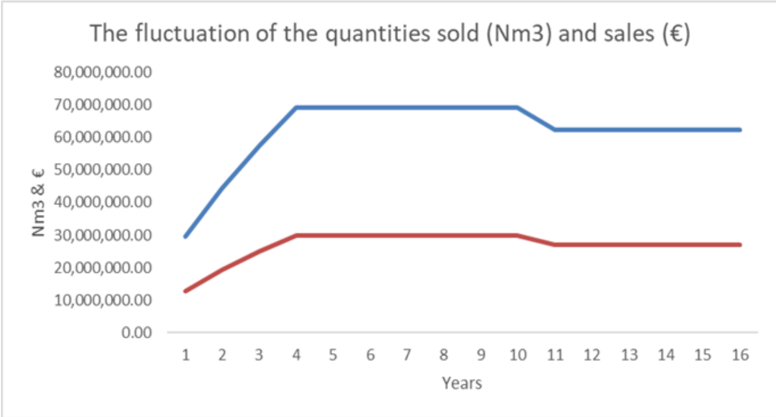
Operational cash flows are shown in the diagram below. The internal rate of return (IRR) on final cash flows (after the payment of the capital and interest on the loan) is equal to 105%. Especially for the first 7 years the final (not the operational) cash flows are as follows:

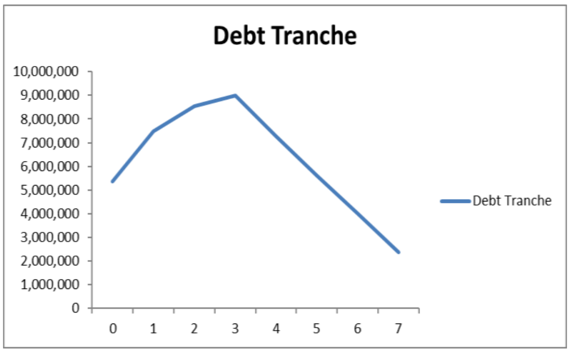
- 1^{st} Year: -446,560 €
- 2^{nd} Year: 32,170 €
- 3^{rd} Year: 382,280 €
- 4^{th} Year: 813,519 €
- 5^{th} Year: 1,251,150 €
- 6^{th} Year: 1,408,291 €
- 7^{th} Year: 1,567,538 €

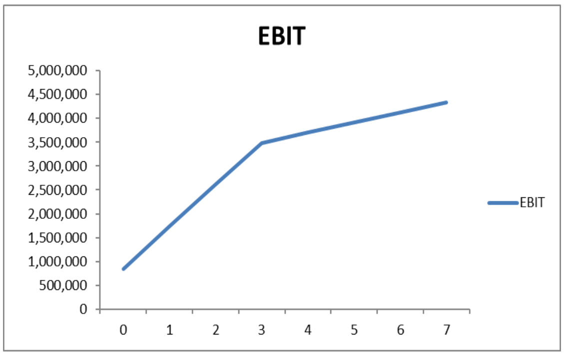


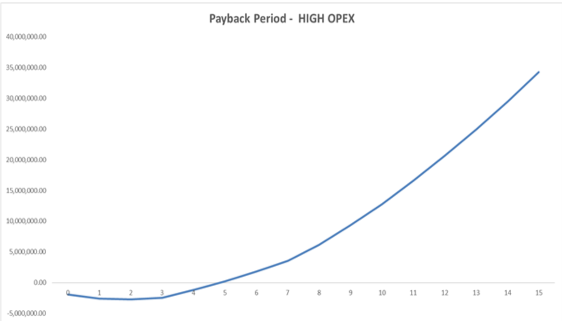


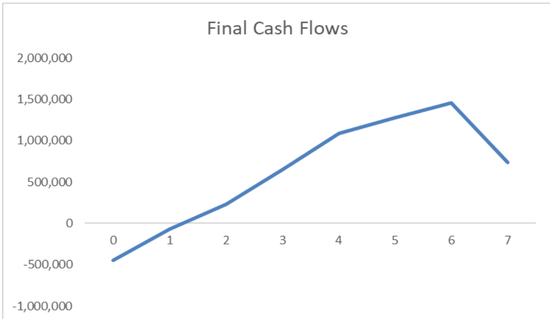












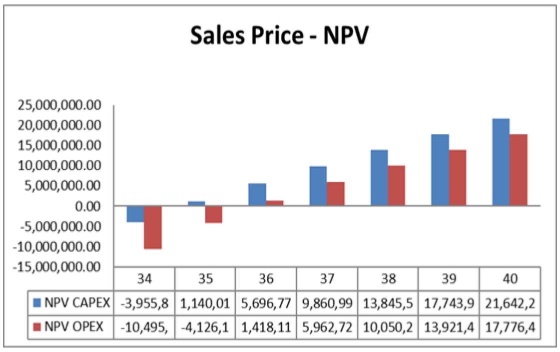
2.4.5 Scenarios Comparison: High Capex vs High Opex

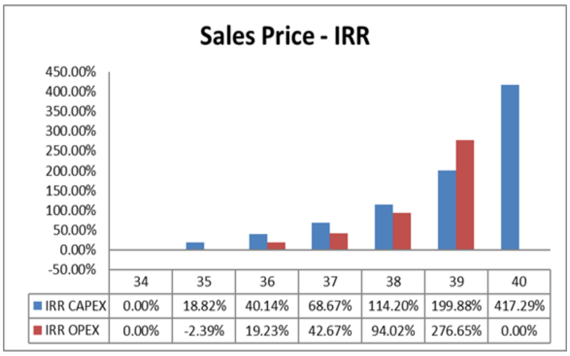
The High Capex scenario has a higher internal rate of return (IRR). The reason is that the energy company has less annual lending since:

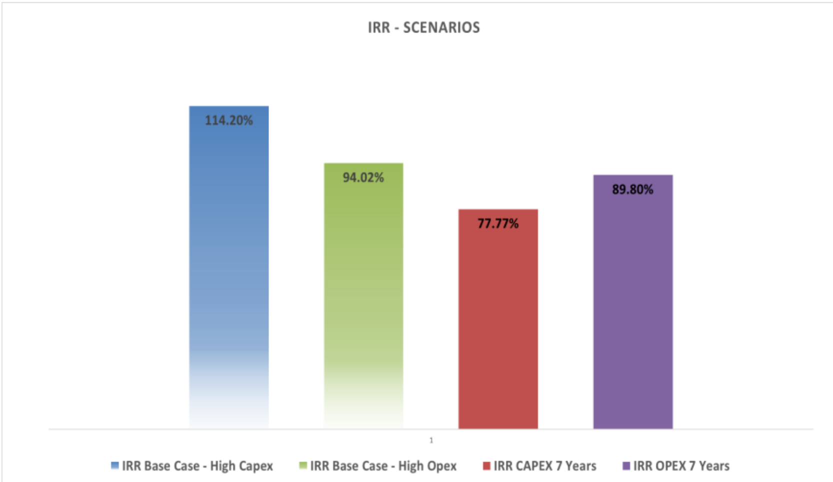
A. It has a longer payback period (15 years compared to 7 and 10 years for the High Opex scenario).

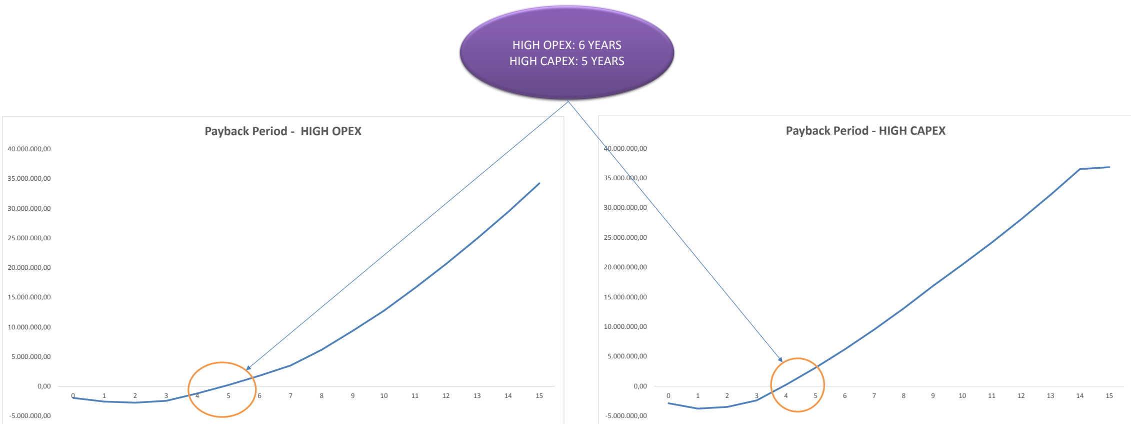
B. It yields 4.5% of the 70% of the equipment while at High Opex it accounts for 6.5% of 80% of the equipment and the rest like the High Capex scenario.

C. The difference in the IRR (7 years) is due to the fact that payback in the CAPEX scenario is reduced from 15 to 7 years, with the result that capital payback due to borrowing increases.



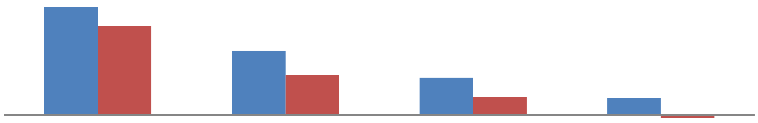






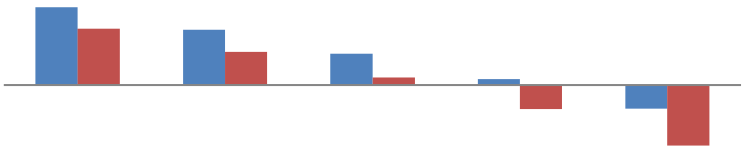
In the diagrams below, a sensitivity analysis has been made in the case that Brent prices raise leading to a relevant rise in the purchase price of Natural Gas. LPG prices are not correlated with those of Brent so its price cannot be predicted. For this reason, sensitivity analysis has been made for natural gas market prices ranging from 21.9 €/MWh to 25.9 €/MWh (that means after distribution costs and all taxes and fees these prices become 26 €/MWh - 30 €/MWh).

NG Supply Price - IRR



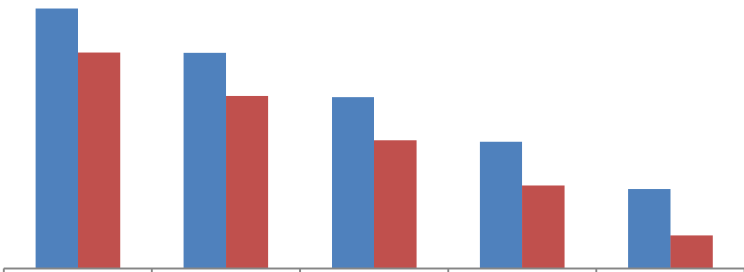
	26	27	28	29
IRR CAPEX	114,20%	68,23%	39,56%	18,17%
IRR OPEX	94,02%	42,30%	18,83%	-3,19%

NG Supply Price - NPV



	26	27	28	29	30
NPV CAPEX	13.845.561	9.821.253,	5.607.533,	991.215,31	-4.185.862
NPV OPEX	10.050.234	5.920.391,	1.317.640,	-4.295.177	-10.753.63

NG Supply Price (sales price 40,36) - NPV

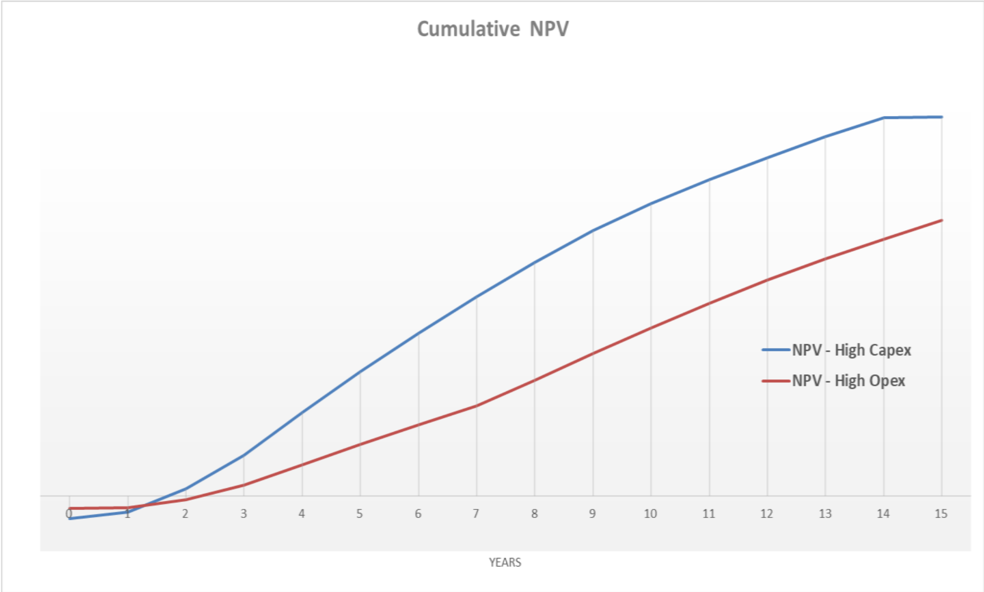


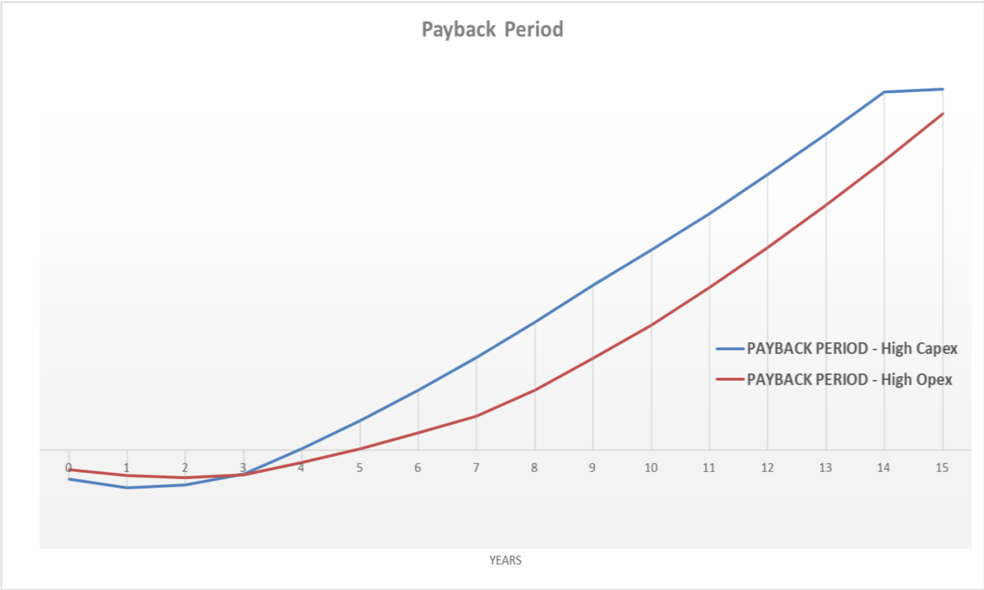
	26	27	28	29	30
NPV CAPEX	23.045.709,74	19.111.819,19	15.177.928,65	11.229.447,99	7.057.280,95
NPV OPEX	19.127.136,15	15.279.681,78	11.373.175,28	7.361.283,74	2.944.265,38

2.4.6 Scenarios Comparison: (All Inclusive) High Capex vs High Opex

Due to the very low cost of burner's conversion (retrofit), the financial indexes of the business plan do not actually change. All Inclusive scenarios differ in that the energy company also undertakes the cost of converting engines to burn natural gas. This cost is estimated at about 1,500€ for a medium size customer and about 5,500€ for a large size customer. So, the total cost is calculated as follows:

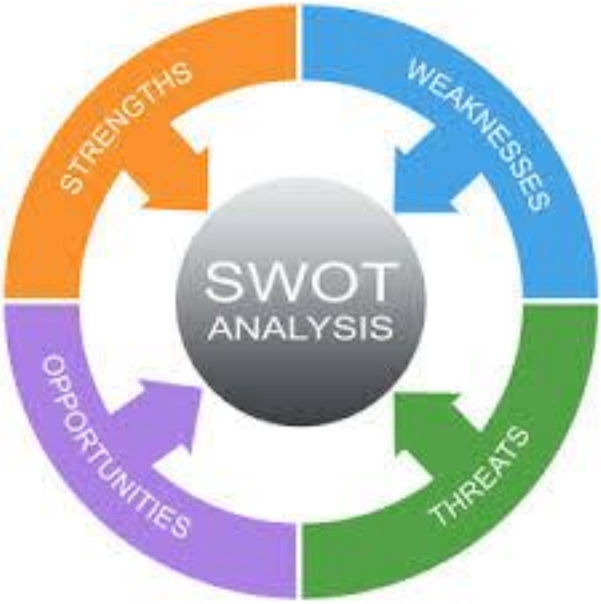
Total cost for burners conversion.				
Number of customers	10	15	20	24
Total conversion cost	33,050	49,575	66,100	79,320





Comparative diagrams of NPV and Payback Period (High Capex vs High Opex) are shown above.

2.5 SWOT Analysis



Picture 9: SWOT analysis.

Table 16: SWOT Analysis.

STRENGTHS	WEAKNESSES
➢ Purchase of natural gas from a pipeline (access to raw material) ➢ Cheaper price compared to competitive products (LPG) ➢ Minimum burner conversion cost ➢ Flexibility to purchase equipment based on number of customers ➢ Not depending from logistics (outsourcing) ➢ Difficult competition from other companies	➢ High cost of equipment acquisition ➢ Way to solve problems / damages ➢ Legislative Framework under development ➢ Lack of experience ➢ Lack of proof of supply reliability in industries ➢ Difficult search for reliable partners for outsourcing services (Transportation, Installation, Maintenance)
OPPORTUNITIES	THREATS
➢ No remarkable CNG project in Greece ➢ Increasing price trend of competitive products (LPG) - Large market size ➢ Funding ability ➢ Business expansion plan (PPC, Mount Athos) ➢ No access through pipeline in northern Greece (only a few industries and cities have currently access to the pipelines)	➢ Entry of competitors in the business (other energy companies) ➢ Possibility of extending the existing grid (pipelines) and connecting to more areas ➢ Lack of reliability in a new product

Conclusions

The activation in the CNG sector seems to be profitable. The choice of financing through bank lending is more profitable than the leasing option. This is because while the required capital is smaller, the service of the capital payback of the equipment per year especially in the first 7 years is actually larger. The reason is that the payback of the value of the equipment is made from the 15 years taken into account for the first financing method, to 7 and 10 years respectively for the trailers and the compressors, which make up 84% of the total capital required. Also, the increased interest rate (6.5%) against that of bank lending (4.5%) reduces the profit margin and the annual cash flows.

In summary, the comparative picture between key scenarios is shown in Table 17 below:

Table 17: The comparative picture between key scenarios.

	High Capex	High Opex	All Inclusive High Capex	All Inclusive High Opex
NPV (m€)	13.84	10.05	13.79	10.02
IRR_{15} (%)	114.20	94	112.72	92.70
PAYBACK PERIOD (years)	5	6	5	6
IRR_7 (%)	77.77	71.90	84.56	67.70

Questionings

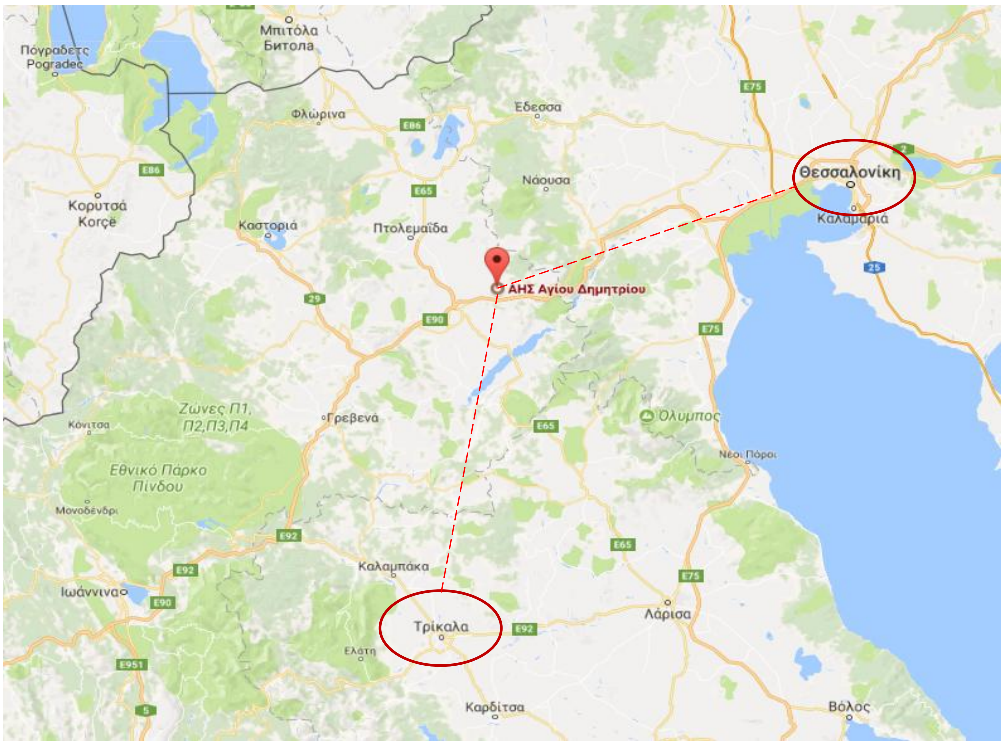
- An important parameter to be taken into account is the reliability of supply of the industries, as CNG is actually a new fuel with only one supplier (this energy company). It will be quite difficult for the first period to get 3 to 4 large industrial customers and to imply on the consumer's consciousness that there will be security of supply.
- The sale process will be time consuming as industries will need either to convert their burners or to replace them. This means that the decision process on their part, taking into account the caution mentioned above for security of supply, will be complicated. On the one hand, a production engineer will not easily approve

this change unless he is fully convinced and a CEO will take into account the fact that there is no bargaining power due to the existence of only one supplier.

- The choice of partners for the outsourcing activities is very crucial for the removal of these concerns on the part of consumers. Such suppliers are available in the market both in CNG equipment (certified dealers) and in transportation. Consistency and reliability will be the dividing line between success and failure.

Appendix 1

Implementation of CNG technology in the lignite power plant of Agios Dimitrios (sited near the city of Kozani, Picture 10) which belongs to PPC (Public Power Corporation).

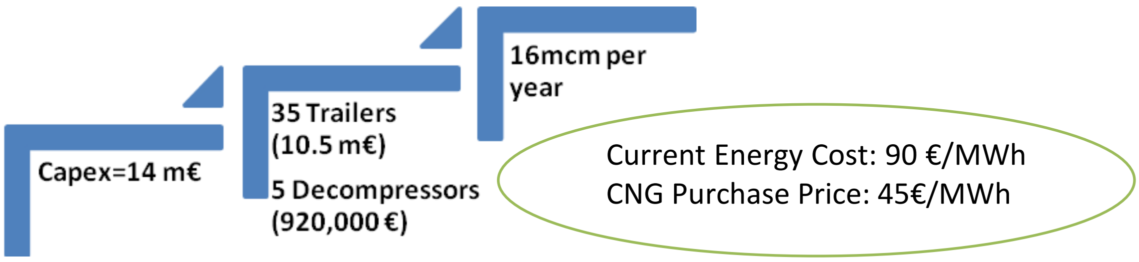


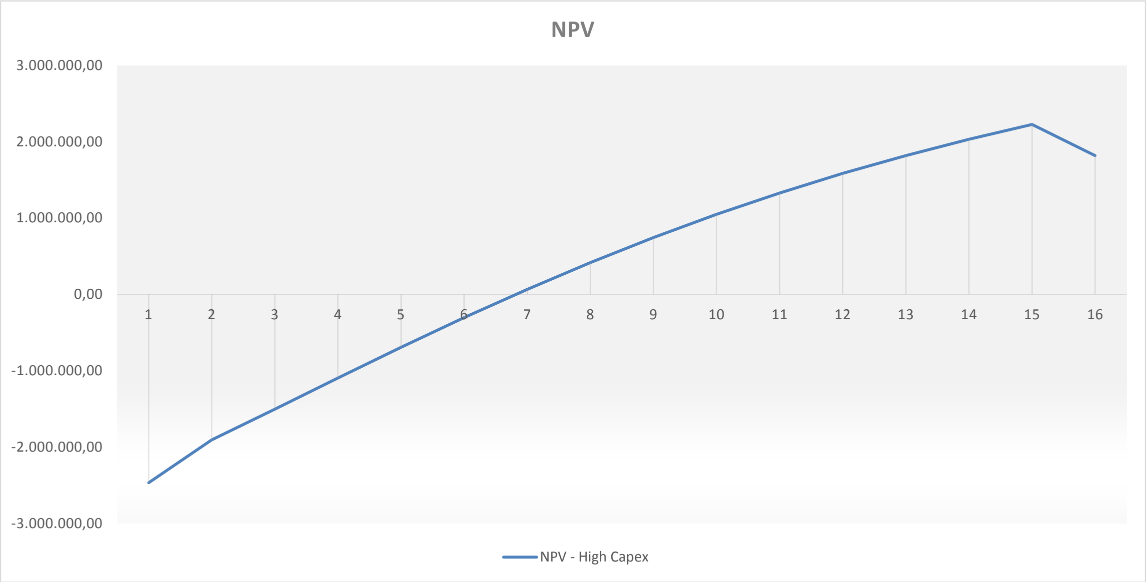
Picture 10: Map showing the site of lignite power plant.

Oil in lignite power plants is used:

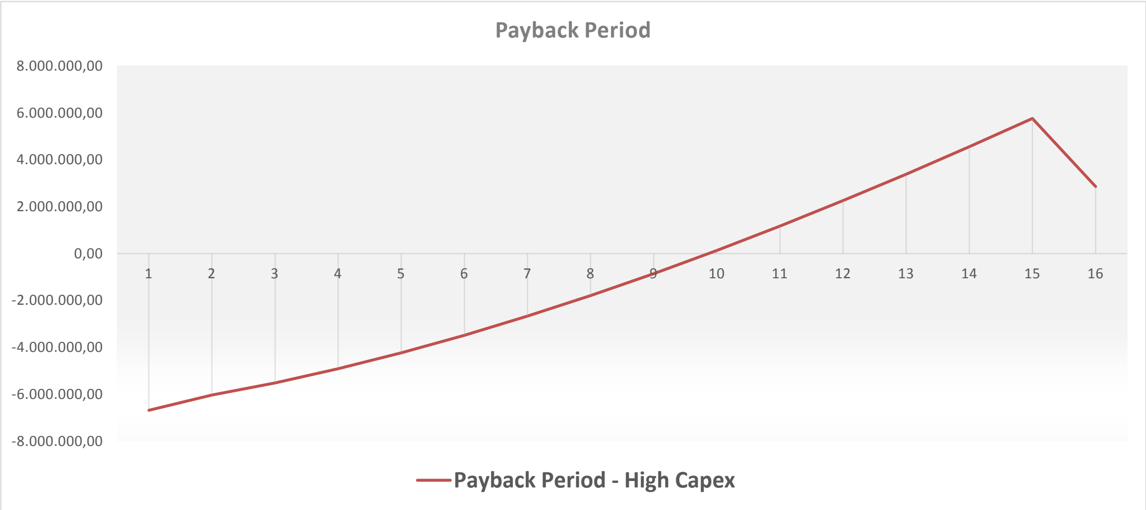
- ➢ For holding and starting the generators.
- ➢ For combustion / load support in case of low quality lignite.
- ➢ For unit operation in case of inability to operate ash removal system.
- ➢ For environmental reasons (particle emission reduction, etc.) - it is not expected in the future after the completion of the planned environmental projects at the plant.
- ➢ For unit operation at minimum load (lower than the current minimum unit load) - "flexible" operation.

The cooperation with PPC for the supply of its plants with natural gas replacing crude oil is a challenge. The reason is that it has a particular consumption profile, which requires very large quantities of natural gas on specific days of the year. This means that in order to meet the demand of PPC, additional equipment should be acquired which will be actually inactive for the longest time, resulting in a large Capex, which would be difficult to depreciate.





Net Present Value (NPV) – High Capex



Payback period – High Capex

Appendix 2

Cash flow tables for the first 7 years (All Inclusive High Capex – High Opex).

Table 18: All Inclusive High Capex Scenario – Cash Flows for the first 7 years.

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Quantities sold (MWh)	337.207	505.811	657.555	789.065	789.065	789.065	789.065	789.065
x Price	38	39	40	40	41	42	43	44
= Sales	12.813.883	19.605.241	25.996.549	31.819.776	32.456.171	33.105.295	33.767.401	34.442.749
stable operational costs	577.231	638.847	705.187	754.007	754.007	754.007	754.007	754.007
management bonus	0	0	0	0	0	0	0	0
cost of sales	10.656.811	16.190.833	21.373.937	26.057.401	26.492.830	26.936.967	27.389.987	27.852.067
= EBITDA	**1.579.841**	**2.775.561**	**3.917.425**	**5.008.368**	**5.209.335**	**5.414.322**	**5.623.408**	**5.836.675**
- Depreciation	460.307	666.794	852.936	1.011.673	1.011.673	1.011.673	1.011.673	1.011.673
= EBIT	**1.119.533**	**2.108.766**	**3.064.489**	**3.996.696**	**4.197.663**	**4.402.649**	**4.611.735**	**4.825.003**
- Taxes	324.665	611.542	888.702	1.159.042	1.217.322	1.276.768	1.337.403	1.399.251
= NOPAT	794.869	1.497.224	2.175.787	2.837.654	2.980.340	3.125.881	3.274.332	3.425.752
+ Depreciation	460.307	666.794	852.936	1.011.673	1.011.673	1.011.673	1.011.673	1.011.673
Working Capital	351.065	537.130	712.234	871.775	889.210	906.994	925.134	943.637
- Change in WC		186.065	175.104	159.540	17.435	17.784	18.140	18.503
= Operating CF	1.255.176	1.977.954	2.853.619	3.689.786	3.974.578	4.119.769	4.267.865	4.418.922
- Investment expenditures	2.071.383	1.174.054	837.638	714.314	0	0	0	0
= CF Available for Debt Service	**-816.207**	**803.900**	**2.015.981**	**2.975.472**	**3.974.578**	**4.119.769**	**4.267.865**	**4.418.922**
Debt Tranche	4.833.227	8.179.662	10.426.476	12.112.426	11.304.931	10.551.269	9.847.851	9.191.328
Principal Payment		322.215	545.311	695.098	807.495	753.662	703.418	656.523
Interest Payment		217.495	368.085	469.191	545.059	508.722	474.807	443.153
Total Debt		8.179.662	10.426.476	12.112.426	11.304.931	10.551.269	9.847.851	9.191.328
Final Cash Flows	**-816.207**	**264.190**	**1.102.586**	**1.811.182**	**2.622.023**	**2.857.385**	**3.089.640**	**3.319.245**
NPV - High Capex	-816.207	231.746	848.404	1.222.496	1.552.448	1.484.036	1.407.598	1.326.494

Table 19: All Inclusive High Opex Scenario – Cash Flows for the first 7 years.

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Quantities sold (MWh)	337.207	505.811	657.555	789.065	789.065	789.065	789.065	789.065
x Price	38	39	40	40	41	42	43	44
= Sales	12.813.883	19.605.241	25.996.549	31.819.776	32.456.171	33.105.295	33.767.401	34.442.749
stable operational costs	577.231	638.847	705.187	754.007	754.007	754.007	754.007	754.007
management bonus	0	0	0	0	0	0	0	0
cost of sales	10.932.664	16.604.613	21.896.680	26.675.738	27.093.154	27.537.291	27.990.311	28.452.391
= EBITDA	**1.303.987**	**2.361.781**	**3.394.682**	**4.390.031**	**4.609.011**	**4.813.997**	**5.023.083**	**5.236.351**
- Depreciation	460.307	628.616	777.807	906.209	906.209	906.209	906.209	906.209
= EBIT	**843.680**	**1.733.165**	**2.616.874**	**3.483.822**	**3.702.802**	**3.907.788**	**4.116.874**	**4.330.142**
- Taxes	244.667	502.618	758.894	1.010.308	1.073.813	1.133.259	1.193.894	1.255.741
= NOPAT	599.013	1.230.547	1.857.981	2.473.514	2.628.989	2.774.530	2.922.981	3.074.401
+ Depreciation	460.307	628.616	777.807	906.209	906.209	906.209	906.209	906.209
Working Capital	351.065	537.130	712.234	871.775	889.210	906.994	925.134	943.637
- Change in WC		186.065	175.104	159.540	17.435	17.784	18.140	18.503
= Operating CF	1.059.320	1.673.098	2.460.684	3.220.182	3.517.763	3.662.954	3.811.050	3.962.107
- Investment expenditures	1.515.227	646.156	571.255	491.047	0	0	0	0
= CF Available for Debt Service	**-455.907**	**1.026.942**	**1.889.429**	**2.729.136**	**3.517.763**	**3.662.954**	**3.811.050**	**3.962.107**
Debt Tranche	5.389.383	7.614.599	8.774.911	9.361.511	7.842.535	6.330.812	4.825.859	3.327.224
Principal Payment		665.315	1.006.850	1.282.178	1.518.976	1.511.723	1.504.953	1.498.635
Interest Payment		331.507	503.253	636.189	750.171	745.275	740.706	736.441
Total Debt		7.614.599	8.774.911	9.361.511	7.842.535	6.330.812	4.825.859	3.327.224
Final Cash Flows	**-455.907**	**30.120**	**379.326**	**810.769**	**1.248.615**	**1.405.956**	**1.565.391**	**1.727.032**
NPV - High Opex	-455.907	26.421	291.879	547.246	739.280	730.209	713.171	690.186

Appendix 3

Cost analysis comparison for All Inclusive Scenarios.

Table 20: Cost analysis comparison (All Inclusive Scenarios).

	High Capex	High Opex
CUMULATIVE YEARLY CONSUMPTION (MWh/Year)	337.207,44	337.207,44
COMPRESSION STATION COST (€))	543.050,00	543.050,00
COMPRESSORS COST (€)	800.000,00	800.000,00
TRAILERS COST (€)	4.600.000,00	920.000,00
DECOMPRESSORS COST (€)	961.560,00	192.312,00
CUMULATIVE CAPEX (€)	6.904.610,00	2.455.362,00
CUMULATIVE COST OF DEBT (€/year)	539.710,35	191.927,46
STABLE OPERATIONAL COST (€/year)	577.231,20	577.231,20
OPERATIONAL COMPRESSION COST (€/year)	473.273,60	473.273,60
OVERDUE COST (€/year)	32.877,73	32.877,73
INSURANCE COST	53.016,01	39.668,27
LEASING TRAILER COST	0,00	289.201,12
PERSONELL and RENT COST (€/year)	144.000,00	144.000,00
OPERATIONAL COST (€/year)	703.167,34	979.020,71
OPERATIONAL COST (€/MWh)	2,09	2,90
TRANSPORT COST (€/year)	1.186.250,00	1.186.250,00
TRANSPORT COST (€/MWh)	3,52	3,52
TOTAL SUPPLY CHAIN COST (€/MWh)	5,60	6,42
NATURAL GAS PRICE	26,00	26,00
FINAL	31,60	32,42
SALES MARGIN	6,40	5,58
TOTAL FINAL	38,00	38,00