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- Investment appraisal of synthetic firm producing algae based fuels in Sweden

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Abstract

Algae based fuels may offer society a plenty of valuable benefits. Those include economical, environmental, and social benefits representing sustainability. Investors may have a wealth maximising option to diversify their portfolio hence reducing risks. Besides tax income and reduced unemployment rate, government gets a facility to reach environmental goals and to obtain energy security. When investor and government are satisfied, the other groups of society in a whole enjoy sustainability amenities.

However, researches that have been done in the area of algae fuels have still controversies whether the technology can be worth of attention. In spite of the debates, there are companies claiming that they run commercial installation. As a fact, these commercialisations are carried out in complete secrecy. Herewith, there are no enough information available helping investors to study economical feasibility of technologies. Since it has a place, the industry of algae fuel production is not very well supported and hence has a barrier for development.

This paper considers an investment appraisal of technology producing algae based fuels. This technology has been technically and economically approved on the pilot project but in the less developed country. However, neither this technology nor analogs are present in Sweden. Therefore, authors evaluate it in the conditions of developed market of Sweden. The economical and financial evaluation of synthetic firms comprises classical Net Present Value approach, Stochastic Capital Budgeting and Real Option valuation. The set of these methods was chosen for testing the project on robustness in the condition with uncertainties and flexibilities. This is for the purpose to assist investment managers in the case when net present value appraisal is not enough for objective decision “to invest now or wait”.

Abbreviations

ABF - algae-based fuel
BAT - best available technology
Bb – Botryococcus braunii
CCS - Carbon capture and storage
CHP - combined heat and power plant
DH - district heat plant
EXW – ex work (international commercial terms 2008)
GHG - green house gas
HTU – Hydro Thermal Upgrading
HVP – high value added product
IRR – internal rate of return
LED – Light Emitting Diode
NPK – Nitrogen, Phosphor, Kalium (potassium)
NPV – net present value
SME – small and medium enterprises
ROA – Real Option Analysis
b/cd – barrels per calendar day
bbl – barrels
b/d – barrels per day
tcf – trillion cubic feet
ppm – parts per million
EBITDA – earnings before interest, tax, depreciation, amortisation
GMB – geometric Brownian motion
NCF – net cash flow (revenue minus cost)
RSD – relative standard deviation
RME – rapeseed methyl ester
B2B – business – to – business
B2C – business – to – customer

Glossary

- Axenic – “describes a culture of an organism that is entirely free of all other "contaminating" organisms (www, Wikipedia, 6, 2010)”;
- Bio-catalytic cracking – “refining process of breaking down the larger, heavier, and more complex hydrocarbon molecules into simpler and lighter molecules. Catalytic cracking is accomplished by the use of a catalytic agent (*Catalyst*) and is an effective process for increasing the yield of gasoline from crude oil (EIA, 2006)”. Prefix “bio-“ means that there is an organic matter taking place in the process (Rozzell, 1999);
- Bio-crude (Green crude, biopetroleum) – biological material derived from living, or recently living organisms used for distillation of carbon-based fuels. (www, Wikipedia, 3, 2010);
- Botryococcus braunii (Bb) – “is a green, pyramid shaped planktonic microalgae. The species is notable for its ability to produce high amounts of hydrocarbons. Up to 86% of the dry weight of Bb can be long chain hydrocarbons i.e. botryocuccus oils: botryococcenes, alkadienes and alkatrienes. Transesterification can NOT be used to make biodiesel from botryococcus oils” (Banerjee, *et al.,* 2002; Metzger and Largeau, 2005; www, Wikipedia, 10, 2010);
- Carbon neutral – “refers to achieving net zero carbon emissions by balancing a measured amount of carbon released with an equivalent amount sequestered or offset” (www, Wikipedia, 14, 2010);
- Catalyst – a substance that increases the rate of a chemical reaction without itself undergoing any permanent chemical change, and may be regenerative (Soanes, C., Stevenson, A., 2006);
- Cetane number – “Generally, diesel engines run well with a CN from 40 to 55. Fuels with higher cetane number which have shorter ignition delays provide more time for the fuel combustion process to be completed. Hence, higher speed diesels operate more effectively with higher cetane number fuels” (www, Wikipedia, 12, 2010);
- Continuous stirred-tank reactor – “also known as vat- or backmix reactor, is a common ideal reactor type in chemical and environmental engineering” (www, Wikipedia, 9, 2010);
- Distillation – “method of separating mixtures based on differences in their volatilities in a boiling liquid mixture. Distillation is a unit operation, or a physical separation process, and not a chemical reaction. It is used to separate crude oil into more fractions for specific uses such as transport, power generation and heating” (www, Wikipedia, 19, 2010);
- Eichhornia (Water hyacinth) – “are a free-floating perennial and fastest growing aquatic plants, can double their population in two weeks. Water hyacinth may rise above the surface of the water as much as 1 meter in height. The leaves are 10–20 cm across, and float above the water surface. It has a high capacity of uptaking heavy metals, such as Cd, Cr, Co, Ni, Pb and Hg etc, plant has abundant nitrogen content, it can be used a substrate for biogas production” (Joel de la Noie, 1998; Reddy and Tucker, 1983; www, Wikipedia, 7, 2010);
- Fatty acid methyl ester (FAME) – “can be created by an alkali catalyzed reaction between fats or fatty acids and methanol. The molecules in biodiesel are primarily FAMEs, usually obtained from vegetable oils by transesterification” (www, Wikipedia, 5, 2010);

- Fischer-Tropsch synthesis – "is a catalyzed chemical reaction in which *synthesis gas*, a mixture of carbon monoxide and hydrogen, is converted into liquid hydrocarbons of various forms. The principal purpose of this process is to produce a synthetic petroleum substitute, typically from coal, natural gas or biomass" (www, Wikipedia, 8, 2010);
- Gasification – "process that converts carbonaceous materials, such as coal, petroleum, biofuel, or biomass, into carbon monoxide and hydrogen by reacting the raw material, such as house waste, or compost at high temperatures with a controlled amount of oxygen and/or steam. The resulting gas mixture is called synthesis gas or syngas and is itself a fuel" (www, Wikipedia, 20, 2010);
- Green fuels – when biocatalytic cracking and traditional fractional distillation used to process properly prepared algal biomass i.e. biocrude, then as a result we receive the following distillates: kerosene (jet fuel), gasoline, diesel, etc.. Algae are low-input, high-yield feedstocks to produce biofuels. It is claimed that algae can produces up to 30 times more energy per acre than land crops such as soybeans, etc. (Rapier, 2008; www, Wikipedia, 4, 2010);
- Hydrocyclone – "a device to classify, separate or sort particles in a liquid suspension based on the densities of the particles. Hydrocyclone may be used to separate solids from liquids or to separate liquids of different density" (www, Wikipedia, 18, 2010);
- Hydroprocessing (uncountable)– Any of several chemical engineering processes including hydrogenation, hydrocracking and hydrotreating, especially as part of oil refining;
- In situ – its natural place or position (Latin) (Soanes, C., Stevenson, A., 2006);
- Inter alia – among other things (Latin) (Soanes, C., Stevenson, A., 2006);
- Medium – the substance in which an organism lives or is cultured (Soanes, C., Stevenson, A., 2006);
- Mental frame – mental construct consisting of elements, and the relations among them, that are associated with a situation that is of interest of a decision maker (Beach and Connolly, 2008);
- Phytoremediation aka bioremediation – "systematic use of plants to treat environmental contamination. It is being investigated as a potential low-cost technology to help meet environmental regulations" (www, House Committee on Agriculture, 1, 2010);
- Polyaromatic hydrocarbon – "i.e. polycyclic aromatic hydrocarbons (PAHs) known for their carcinogenic, mutagenic and teratogenic properties" (www, Wikipedia, 11, 2010);
- Pyrolysis – "chemical decomposition of condensed substances by heating, that occurs spontaneously at high enough temperatures. The word is coined from the Greek-derived elements pyro "fire" and lysys "decomposition"(www, Wikipedia, 16, 2010);
- Rectification column. "Rectification is an application of distillation and its uses include fractionation of crude oil. If the distillate obtained during distillation is distilled again, a new distillate is obtained with an even higher concentration of volatile components. As the procedure is repeated, the concentration of volatile components in the distillate increases on each occasion. In practice, this multi-stage distillation process is carried out in the form of countercurrent distillation (rectification) in a column" (www, GUNT Hamburg, 1, 2010);

- Sulphur – "burning of coal and/or petroleum by industry and power plants generates sulfur dioxide (SO_2), which reacts with atmospheric water and oxygen to produce sulfuric acid (H_2SO_4). This sulfuric acid is a component of acid rain, which lowers the pH of soil and freshwater bodies, sometimes resulting in substantial damage to the environment" (www, Wikipedia, 13, 2010);
- Transesterification – is a chemical process of transforming large, branched, triglyceride molecules of vegetable oils and fats smaller, straight chain molecules, almost similar in size to the molecules of the species present in diesel fuel (Pandey, 2008).
- Peak oil - "The term Peak Oil refers the maximum rate of the production of oil in any area under consideration, recognising that it is a finite natural resource, subject to depletion" invented by Colin Campbellin (2001) cited in Robelius (2007.)
- Third generation fuels – are the fuels are derived from non-edible sources. Read more in chapter 3.
- Bio – feedstock – raw material used in the production and manufacturing of a product. Prefix "bio-" means that there is an organic matter taking place in the process (Rozzell, 1999)
- Energy security – "or security of supply, is the ability to supply energy to meet demand at a price that protects economic growth. Uneven distribution of fossil fuel supplies among countries, and the critical need to widely access energy resources, has led to significant vulnerabilities. Threats to global energy security include political instability of energy producing countries, manipulation of energy supplies, competition over energy sources, attacks on supply infrastructure, as well as accidents and natural disasters" (www, Wikipedia, 2, 2010).

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1 Introduction

The degree and number of ecology related problems discovered, accepted and not solved worldwide indicate that humanity did not overcome them yet. It might mean that human kind badly think of consequences of decisions they take. It might moreover mean that people do not concur on the common problem but solve own money driven problems forgetting about environment. The money driven behaviour leads to competition with each other and hence to protection of information, i.e. findings of knowhow solution to those problems. This competitive protection of information leads to postponing in practical realisation of those findings, therefore a progress overcoming environmental problems is not yet observed. In fact, humanity should anticipate and outstrip those problems before taking decisions.

The outstripping solution may be a technology that is able to solve the range of ecological and economical problems. Water and atmosphere contaminations as well as *energy security* are those problems that can be avoided with the considered in this paper technology (pers. com. Chernov *et. al*., 2010). The technology, which produces direct fossil fuel substitutes like gasoline, diesel and kerosene, uses a *bio-feedstock* cultivated on its production site. *Microalgae* are the feedstock, which is renewable and alternative source for *green fuels*. Herewith according to the statements by Grahn and Hansson (2009), Nygren (2008), Ruth (2008), the technology belongs to the *third generation*.

However, competing behaviour does not allow the solution to be practically realised. This is because of controversies among scholars' opinions about economical feasibility of such technology where pessimistic views are prevailing. On the other hand, we observe that big corporations invest huge money in the algae fuel pilot production whereas it can be also a business for small and medium enterprises. Moreover, investments in such industry are not observed at any level in some countries including Sweden. Thus, it might be a missing opportunity for Sweden as an environmentally conscious country.

In this paper authors consider, by doing an economical feasibly study, the technology that has technical potential to be adopted at any level of business enterprise in Sweden.

The more particular reasons for doing this are outlined in the consequent sub-chapters with reference to the literature research.

1.1 Problem background

Considering why the technology should be adopted in Sweden, one should take into account problems of more wide content. As it was mentioned, there are problems of environmental and economical nature. Let have look on the problem of economical nature first. One of those is energy dependency on imports of liquid fuels and bio-feedstock for biofuels from other countries. If reader look at the below table 1, it may become clear that energy dependency for Sweden is crucial issue for energy security of the country. Absence of own oil and gas productions can negatively influence on overall economy of the country.

Table 1. Petroleum reserves (Hilyard, 2008)

Country	Sweden	Denmark	Norway	Germany
Refining capacity	437,000 b/cd	174,400 b/cd	315,000 b/cd	2,417,083 b/cd
Oil production	0	312,000 b/d	2.25 million b/d	67,500 b/d
Oil reserves	0	1.188 billion bbl	6.865 billion bbl	367 million bbl
Gas reserves	0	2.490 tcf	79.13 tcf	9 tcf

Moreover, this table should be read having in mind the consequences of near future given the fact that depletion of oils is globally reached their peak. According to Robelius's forecasts (2007), the oil industry experiences a "*Peak oil*" tendency. According to the best-case scenario, human kind will observe decline in supplies of fuels at the end of the current decade (ibid).

Having zero oil production and reserves (Hilyard, 2007; Hilyard, 2008), and in spite of recent oil drilling tests (OPAB and Oljeprospektering, 2007) in the Baltic sea, Sweden has various environmental objectives leading to become an oil free society until 2030 (www, Regeringskansliet, 1, 2010; Persson, 2006; Sahlin, 2005).

Therefore, goals of energy independency and environmentalism are major incentives for national policies. Obviously, energy dependency on other countries' supplies lead to the uncertainty in national security. Different actions are practiced in order to reach the goals of energy and environmental safety. Hence, politicians (Naturvårdsverket, 2005) by means of economical and environmental instruments encourage production and use of bio-fuels. These include tax reliefs on bio-fuels, subventions on instalment of newly developed technologies, support of R&D in the area of alternative energy supplies, etc. (Persson, 2006).

As it is clear and an accepted fact by policy developers, the presence of bio-feedstock does not fulfil the total country demand for fuels. Forest residuals, agricultural crops that are in conflict with the food supply, are considered major feedstock for biofuels today. This is also the case with ethanol, which will be largely imported if the goal of full fossil fuel avoidance is to be reached (Hilyard, 2007; Persson, 2006; Sahlin, 2005). Taking into consideration the scarcity of such (Andræ, 2009; Persson, 2006), it creates imports of raw materials, meaning that problem of oil (energy) dependency still exists and hence it is not possible to reach the energy independency goal for the country, whatsoever at the end of the days.

Geo-economic dependency on the energy sources and their possible scarcity initiate engineering of renewable energy. There are commercially successful technological realisations in exploitation the renewable sources, but whether they are socially or environmentally justified; this is another aspect of the issue. However, production of algae-based fuels (ABF) as one of those alternatives seems to be environmentally friendly, whereas commercialisation of the technology needs to be realised (Marsh, 2009; Carlsson, *et al.,* 2007).

The barrier for technology to be widely realised include numerous approaches and conclusions that are withdrawn by commercial and scientific researches in the area. This phenomenon may be enriched with commercial secrecy and vested interests from lobby group of oil industry. The enclosure 1 illustratively represents an enormous amount of methods and approaches incorporated in the area of bio-fuels industry. Moreover, this area should be considered in the content of multiple uncertainties: content of political, market, human, and operational factors.

Production of biodiesel is often associated with the high cost involved in the process of oil extraction from biomass (Andræ, 2009). When one talks about biodiesel, we immediately see a picture of exploitation such agricultural crops as canola, sunflower, etc. Many investigators (Alabi et al., 2009) perceive a new source of biomass as algae somewhat sceptically claiming that fuels from algae will not be competitive with fossil fuel either, because the process of oil extraction is still practiced (Cherubini, *et al*., 2009; Brennan and Owende, 2010). Nevertheless, if there would exist a method, which cuts major costly processes in production, investors will be still reluctant to take an investment decision until more practically approved information arrives.

There are sources claiming that ABF production is not yet economically attractive (Mata, *et al.,* 2010; Walker, 2009). On the other hand, conclusions from the laboratory research and pilot projects demonstrate that ABF may be very competitive with the fossil-fuel if the certain conditions are met (Brown, 2009; pers. com. Chernov, 2010). Scientific and commercial experiments to produce high-value added products (HVP) and ABF products are carried out since the 1960s (Sheehan *et al.,* 1998; Spolaore, *et al*., 2006). Those experiments are done more privately and only a few economic feasibility studies are publicly available, and must rely on the little data (often based on the engineering estimates) available in the public domain (Dmitrov, 2007; Fredin, 2009). However, the facts of economic attractiveness are also supported by the heavy investments with the oil giants ExxonMobil Corp, Chevron, avian corporations, private investors, government programs, and specialised companies (Marsh, 2009; www, Oilgae, 1, 2010).

Herewith, taking into account the above mentioned unfavourable for technology situation in the field, one may conclude that lack of economical feasibility studies may restrain the decision maker from thinking of this technology as a solution for environmental and economical problems. Definitely, the decision maker can represent either or both investor groups, i.e. private as well as political. Therefore, the results of this economical feasibility study should disclose at least to what degree the considered technology could be financially attractive in the uncertain conditions.

1.1.1 Opportunity background

The degree of controversy of above claims makes authors to think of taking the most promising technology into the Swedish setting and study it for economic efficiency. The ongoing debate besides other factors brings the uncertainty to the investors. As a result, environmentally friendly industry faces barriers in its development. The environmentally positive impact of ABFs is *inter alia* explained by the fact of *carbon neutrality* (Packer, 2009). Production of ABF eliminates introduction of new CO_2 that is going to be depleted from the earth with crude oil. The amount of CO_2 exhausted with combustion of the 1st ton of ABF is used back for algae nutrition leading to the 2nd ton of ABF and so forth making close loop. It is technically easy (pers. com. Chernov *et al.,* 2010) to equip the most polluting industries with ABF production which can play role of carbon offsetting, and some of those industries are the following: the district heat (DH) and combined heat and power plants (CHP); iron and steel industry; cement producers.

Due to dynamically developing environmentalism, the mentioned industries experience a burden of legislative restrictions in regards to the technogenic factors they bring. Those requirements lead to the use of best available technology (BAT) with less polluting features. They tend to use the alternative bio-feedstock and\or the green house gas (GHG) preventing technologies at the current premises. Nevertheless, it might be costly to make revamps, retrofit, etc. Hence, it is important to find the proactive solutions to not only reduce emissions as it is facilitated by carbon capture and storage (CCS) methods but produce green fuels.

A recent finding by Kolesnikov, et al. (2009) that resources of mineral oil seem to be in abundance can bring higher uncertainties to the alternative energy investment decisions. Plenty of mineral oil can have a downwards price effect on fossil fuel making biofuels uncompetitive. In fact, Kolesnikov's, *et al*. (2009) finding is theoretical one and it might take decades until it realises to practice. However, such trends make a decision to be uncertain today: whether to invest into ABF production or wait. Today, it is when we already met environmental challenges that must be abolished by means of knowhow and innovation.

The opportunity is a technology invented by BioDieselDnepr Ltd. and other relative stakeholders, which according to the claims of innovators is defended on the pilot project as being competitive with fossil fuels at the current state of affairs of Ukrainian market. Economical evaluation of given technology is introduced in the enclosure 4. The knowhow methods applied in the technology is the result of long lasting scientific work and experiments carried out in the Chemistry-Technological University of Dnepropetrovsk and Polytechnical University of Charkov, Ukraine, and practically realised by Chernov *et al.,* (2010) in BioDieselDnepr Ltd.. Encouraging, was the proclamation from the Cabinet of Ministers of Ukraine endorsed on 22 of December, 2006, by № 1774 "The program of biofuels production development".

1.1.2 Investors' problem as a focal problem

Investors may find it complicated to venture in the newly developed technology mainly having in mind a few alternative options to invest considering the volatility of (market) fuel prices. Due to high degree of uncertainty in returns, high operational and adoption costs, investors and firms are not readily adopting technology of *third generation* biofuels production (Walker, 2009; Alabi et al., 2009).

Many investment decisions involve both large sunk cost of investment and uncertainties regarding future prices, operational costs, tax and regulatory policies. Widely used Net Present Value (NPV) rule doesn't represent the real picture of the investment and thus some implicit assumptions are often overlooked (Dixit and Pindyck, 2004). In reality, such characteristics as irreversibility and a possibility to delay are very important in most of the investment decisions. A rapidly growing literature in a real option theory shows that ability to delay an irreversible investment costs greatly affect investment decision (ibid). Often, decisions are made not only on the concrete numbers but involve more complex and sophisticated process such as involvement of intuition, personal attitudes, preferences and characteristics (Lee et al., 1999).

1.2 Aim

The aim of this research is to analyze the economic and financial feasibility of ABF production in Sweden on the basis of BioDieselDnepr technology using traditional investment appraisal methods, stochastic budgeting and theory of real options.

Therefore the key research (problem) questions are:

1. Will ABF production be profitable without governmental support in the developed economic environment?
2. How do considered methods change managerial decision to invest?
3. What are the opportunities and obstacles for adopting such technology in Sweden?
4. When is it optimal to invest in ABF production?

1.3 Purpose of the study

Despite all obstacles preventing the progress of ABF production, we should contribute to the promotion of such industry. There are many fascinating issues surrounding algae. However, we touch upon the ABF production from the economical aspect, since the financial feasibility can be an initial stimulus for the stakeholders who stand behind political and investment will.

The purpose of this study is to see whether there is an economical feasibility behind the considered technology. If the results will be positive then there is a sense to provide it on the Swedish market, which can stay in line with national objectives. We believe that if the technology shows itself viable in the conditions of developed market, it will be even more financially attractive for the rest of the world.

By doing the calculus, we strive to make an input into the research area. Herewith, we expect that new data and questions will arrive that should be solved in the further research. For instance, life circle and cost benefit analysis including energy balance, and environmental assessment will have to be carried out after this paper.

1.4 Delimitations

No engineering and biochemistry issues are of concern in details.

2 Method

This chapter outlines different methods used in gathering the data for empirical study, literature review, deciding on theory, country and technology.

2.1 Approach, choice of method

We have selectively applied a set of methods from marketing research approach suggested by Kotler and Keller (2006, pp. 102-118), and Jobber and Fahy (pp.81-94). As a fact some informational sources are inaccessible therefore we eluded them relying on available materials.

The literature presented and discussed in this paper has been mainly accessed from LIBRIS, the national database of Swedish libraries. During the literature and publications search, there were also used such databases as ScienceDirect, Web of Knowledge, Scopus, Ebrary, Emerald, Jstor. The keywords used are presented in the enclosure 5.

The data for empirical study was obtained from the internal source of the Ukrainian company BioDieselDnepr as a report from the pilot project. Besides that, a field research was conducted in gathering the input data applied in the models where qualitative and quantitative sources of information were used such as e-mail communication with sales persons and managers, phone interviews. Secondary sources of information were of great help in the forms of reports and web pages of relevant institutions.

Data analysis is aimed to measure the economic attractiveness of ABF production and therefore quantitative analysis has been chosen for this study. The main tools for analytical evaluation were the following software: @Risk, Risk Simulator 2010 and Excel 2007.

Throughout the text, there have been used the technological terms. These are indicated in *italic* typeface. For readers' convenience, the definitions for these terms are taken from open public sources and are cited in the chapter "Glossary".

2.2 Choice of country

"Sweden has a chance to be an international model and a successful actor in export markets for alternative solutions," said Mona Sahlin (2005), minister for sustainable development in Sweden.

There are numerous incentives to consider Sweden as the country of choice. Those vary from the personal to social significance. However, the most-valuable are the following:

- Government initiatives and the large demand for green fuel have attracted investments in the sector. The inability of domestic supply to meet demand coupled with the targets set for efficiency in the transportation sector is expected to boost the market. (Cormick and Kaberger, 2005);
- Target to be the first oil free society in the world must be supported (Sahlin, 2005, Hilyard, 2007);
- Limited raw material resources for the 1st and 2nd generation biofuels (Andræ, 2009);
- There is no commercial competition existent in the area of ABF industry in Sweden (Fredin, 2009), however research is started in 2010 by the Sveriges tekniska forskningsinstitut in Borås (Grahn and Hansson, 2009).

2.3 Choice of technology

The main reasons for choosing BioDieselDnepr technology are a multiple ability of algae as a feedstock to solve the problematic areas of anthropogenic life. By disclosing the economical aspect of germinating alternative solution, we would like to contribute to it because of its positive effect in the subsequent issues.

Algae fuels do not conflict with food or feed crops: unlike first generations biofuels, cultivation of algae does not require land and much water. Land-based cultivation systems do not depend on soil fertility and can be conducted on barren land (Alabi et al., 2009; Campbell, 2008; Neltner and Tester, 2008). Farming of algae culture in the closed land based systems is done all around year independently of seasonal weather changes (Mata *et al*., 2009).

Sustainable use of water resources: Both marine and freshwater algae can be cultivated, so either source of water can be used. Some freshwater species can be grown in higher salinity. The technological process allows for sustainable recycling of water in the system and use of wastewaters (pers. com. Chernov *et al.,* 2010). Wastewater treatment can be done by removal of NH_4^+, NO_3^-, PO_4^{3-}, and organic meters, making algae to grow using these water contaminants as nutrients (Mata *et al*., 2009).

Benefits to farmers: farmers can organise fuel supply cooperatives having significant reduction on input cost, generating rural employment, and increasing rural electrification and heat (Alkalay, 2007; Alabi et al., 2009). It is known, cooperatives allow for achieving economies of scale and vertical integration into supply chain gaining market control which is economically feasible (Nilsson, 2004; Royer, 2003).

Energy security: *Green fuels* from algae share the same benefits with 1st and 2nd generation biofuels, such as the potential to increase energy independency by reducing reliance on imported fuels and bio-feedstock (Alabi et al., 2009; Demirbas, 2009).

Mitigation of atmosphere pollutions: Algae are theoretically carbon neutral in that they recycle CO_2 otherwise released to the atmosphere, rather than adding CO_2 to it (as occurs when fossil fuels are burned) (Mata, 2009; Alabi et al., 2009; Demirbas, 2009; Packer, 2009).

In addition, we consider the areas of practical utilisation of above mentioned potential which are introduced in the chapter 3.1.1 “Application area”.

3 Algae based fuel industry (review)

Taxonomy of science in the algal area dates back to the 1800^{th}. William Henry Harvey (1811—1866) was the first to divide the algae into four divisions based on their pigmentation (www, Wikipedia, 15, 2010). However, a Dutch microbiologist, Martinus Willem Beijerinck (1851-1931) has been an initiator to report about a pure (*axenic*) culture of algae stems (Andersen, 2005). Whereas the 20^{th} century was a period when algae was discovered and tested on the subject of the HVPs, energy source, and environmental remediation.

Nowadays, the hypothesis of possibility to produce wide range of synthetic fuels has been proved on the pilot projects worldwide (www, Oilgae, 1, 2010). As a result, algae as the renewable source has been considered throughout two generations of liquid biofuels, and today synthetic fuels derived from algae considered as the third generation *green fuels*. The main feature of green fuels is that they are alike with fossil fuels and even somewhat better in the quality. The distinguishing character of the 3^{rd} generation from the 1^{st} and 2^{nd} generation fuels is its utility to be used as original fuel without a need to be blend with fossil fuels as it is in case with ethanol and biodiesel. Whereas, the 3^{rd} generation fuels fit to the existent petroleum products storage and distribution infrastructure, moreover can be integrated to the petroleum refining facilities.

However, 1^{st} generation biofuels refined from terrestrial crops such as sugar cane, sugar beet, maize and rape seed create a harm on world food markets, help to cause water shortages and precipitate the destruction of the world's forests. The 2^{nd} generation biofuels derived from lingo cellulosic agriculture and forest residues and from non-edible feedstock address some of the above mentioned problems. However, there is concern over competing land use or required land use changes. Therefore, based on current knowledge and technology projections, 3^{rd} generation fuels specifically derived from microalgae are considered a technically viable alternative energy resource that is devoid of the major drawbacks associated with 1^{st} and 2^{nd} generation biofuels.

3.1 Technology outline

To the problem background, we should additionally elucidate how complex the ABF area is. From a diagram presented in the enclosure 1, one can see how vast the distribution of research area should the decision maker take into account. The same reason compels us to restrain describing those technological pros and cons because of colossal multiple-choice variables. Furthermore, it can be argued by the fact that there is no enough primary and historical data available simply due to the commercial confidentiality (Berg-Nilsen, 2006; Andræ, 2009; Fredin, 2009). Most researches are privately financed and hence the primary data is barely accessible. Therefore, this and other social phenomenon is, as result, halting the progress in the area. Moreover, if we put those into different content like political, market, climate factors, it will even complicate the choice for decision maker due to the uncertainty. Hitherto, there is not yet found a common denominator for those technological approaches since we still witness discrepancies among scholars and investigators protecting own money driven researches and oil giants' interests.

As one of the outcomes of above stated phenomenon is that the concept of production process is heavily influenced by the experiences obtained while the 1st generation of biofuels e.g. *Fatty acid methyl ester inter alia* have been developed. Leaving the fact of sustainability and costs involved in biomass cultivation of food competing crops, it is mainly borrowed that production process should obligingly composed of dewatering and drying the biomass for extraction oil before it is to be refined into fuels (Cherubini, et al., 2009; Brennan and Owende, 2010; Andræ, 2009; Fredin, 2009; Rapier, 2008). A diagram of possible technological processes is introduced in the enclosure 1. Those thermo-chemical processes are obviously electricity and chemical ingredients consuming. Whereas the 2nd generation developers, pursuing cost efficiency studied the possibility of processing the biomass somehow avoiding those stages. However, oil extraction has been still considered in combination with *transesterification* and *pyrolysis* of dry biomass where a proper *catalyst* is still ought to be found (Tran, et al., 2010; Demirbas, 2009). As one of the alternative approaches was a *gasification* of biomass and upgrading the outcome, i.e. *bio-syngas* with *Fischer-Tropsch (FT) synthesis* into green fuels (Pandey, 2008; Rapier, 2008). Worthy to say, FT process still has its drawbacks. *Hydroprocessing* is the process also borrowed from the petroleum industry; however, it is still costly because extracted oil has to be used in the process.

ABFs produced with BioDieselDner Ltd technology can be taken to the 3rd generation. The core uniqueness implies an innovative method of treating the algal biomass into the substance similar to terrestrial crude oil. The scholars in the University of Oklahoma (2009) approached this method also. It consists of a refining process where biomass treated with catalyst is converted into suspension for bio-catalytic cracking, and as a result we get *bio-crude*, which easily distilled into the following fractions: kerosene, gasoline, diesel, masout (pers. com. Chernov, *et al*., 2010). Referring to the illustrative enclosure 2 and comparing it with enclosure 1, one can see the differences of the chosen technology from others. Such innovative approach allows for cost effective use of energy resource since the stages of dewatering are innovatively approached, i.e. drying the biomass and extraction of oil are avoided (ibid).

As one of the reasons of choice why we consider BioDieselDnerp technology is its major cost-effective dissimilarity (enclosures 2) with above-mentioned approaches (enclosure 1), which are proved still not be economically feasible at least in the near future (Carlsson, et al., 2007). The following features distinguish considered in paper technology from the world wide introduced. This can evidently justify the claims of developers that their method of producing fuels from algae is economically feasible at any return of scale.

Hence, we consider this bio-refining technology as the most promising, because it fulfils (pers. com. Chernov, *et al.,* 2010) the following conditions for being technically and economically viable biofuels resource (Brennan and Owende, 2010):

- it should be competitive or cost less than petroleum fuels and 1st, 2nd biofuels;
- should require low to no additional land use;
- should enable air quality improvement (e.g.CO_2 mitigation);
- should require minimal to no drinking water use.

According to technical features and capabilities, BioDieselDnerp solution (2010) meets these conditions and makes a substantial input to meeting the primary energy demand simultaneously providing environmental benefits (pers. com. Chernov, 2010).

3.1.1 Application areas

The area of application is numerous which gives a great opportunity to diversify business risks and gain competitive advantage with the diverse HVPs like chemical and\or pharmaceutical products. However, HVPs products are not considered in this research.

With respect to considered in the paper technology, the following are the projects that can be realized as a standalone project or in combination with the other options:

- **Standalone project producing only biofuels.** The technology implies cultivation of micro-algae called *Botryococcus braunii* reach on hydrocarbons in combination with *Eichhornia* (Water hyacinth) for deriving green fuels. For particular description of the given technology, refer to the chapter 3.2.2.

  Such option is itself flexible in production of synthetic fuels. Meaning that technology allows for adjustment the proportion of fractions produced (kerosene, diesel, gasoline etc.) matching the market conjuncture (pers. com. Chernov, 2010). If we qualitatively consider algae diesel, it contains no sulphur and performs better than petroleum diesel (Mata et al., 2009). Moreover, there is no need to modify the compression ignition engines and blend green fuels with fossil ones in order to enable it for use in the unmodified engines. Whereas, lighter distillates such as kerosene and gasoline exceed in quality the ones of petroleum origin as well (ibid).

- **Biorefinery project in synergy with fish farms.** Fish farm waters must be purified after fish life excrement and leftovers, at the same time water used (*medium*) for cultivation the micro-algae has to be also cleaned up before it can be utilised again in bioreactors executing a sustainable closed loop use of water (ibid). The *in situ* bioremediation (*phytoremediation*) is provided by the ability of Eichhornia (Joel de la Noie et al., 1992; Reddy and Tucker, 1983) grown in the fishponds to clean up water after cultivation of micro-algae and before it goes back to the bioreactors.

- **Biorefinery project in synergy with farm manure or grass digesters.** The most sustainable and economy efficient synergy project is relevant for the livestock farms with manure biogas digesters. Evidently, methane deriving process results in up to 50% of CO_2 as outcome (DGS and Ecofys, 2005; Smyth *et al*., 2009). This surplus of CO_2 can be easily utilised for nutrition of microalgae. Moreover, CO_2 obtained from the methane combusted in the electro-generator or CHP installations is also successfully nourished to the microalgae. Electricity derived from the mentioned generator is used for internal electrification the biorefinery project whereas the surplus of heat from CHP is used for heating bioreactors cultivating microalgae and ponds with Eichhornia. Moreover, Eichhornia can remediate waters after biogas digesters and used as a co-substrate in those biogas digesters (Reddy and Tucker, 1983). Finally, farmer gets governmental incentives for CO_2 reduction.

- **Biorefinery integrated in a carbon mitigation project.** Besides biogas digester synergy, some possible variants of synergy projects are illustrated in the enclosure 8. The heaviest donors for CO_2 can be cement producers, DH and CHP facilities.

- **Diversified biorefinery project with high-value added products.** At the minor technical upgrades, a holistic approach for the production of both green fuels and HVP co-products can be integrated into biorefinery. This model is similar to petroleum refineries where fuels are produced simultaneously with chemicals and other high-value materials. Some algae species give more options to consider pharmaceutical, food and feed additives production, etc..

- **Potential substituter for mineral oil in petroleum industry.** As it is known, Swedish state among others is pretending to be the first mineral oil-free society (Hilyard, 2007; Persson, 2006; Sahlin, 2005), meaning that mineral oil refining industries has to reconsider their feedstock or simply sell the equipment as a scrap metal. Therefore, the most sustainable solution to this problem is the technology considered here. BioDieselDnerp Ltd. invented the method of converting algal biomass into *synthetic biocrude*. This process is done with BioDieselDnerp invented catalyst that plays the most crucial role in the whole biorefining process. The algal biomass concerted with the catalyst into biocrude is successfully used in the petroleum cracking and *distillation* facilities. Therefore, biocrude is cracked and distilled into fractions as much the same way as mineral oil is made to kerosene, gasoline, diesel and other heavier fractions. Herewith, we see how that almost written off petroleum infrastructure can be freely utilized substituting mineral crude with biocrude (pers. com. Chernov, *et al.*, 2010).

3.2 BioDieselDnepr knowhow

Additionally to a disclosure of this technology related issues in chapters 2.3 and 3.1.1 and slightly touched upon in 3.1, more description is given in the following chapters.

The paper focuses on the technology that enables cultivation of algae despite on divergence of Swedish climate and daylight conditions. Local availability of nutrient sources has been also taken into account. There is a technical match with environmental objectives of the country, which explains the environmental sustainability. Marketability is fulfilled for the account of ever needed product, as well as introduced concepts and solutions (ch. 2.3 and 3.1.1) for various industries giving flexibility in risk diversification strategies and competitive advantages (Charter and Polonsky, 1999). Energy efficiency is achieved useing cheap energy supplies that are produced on-site.

3.2.1 General supremacy

Given project presumes cultivation of algal biomass and further treatment of it with the *bio-catalytic cracking* method into synthesis biocrude. Such biocrude is distilled on kerosene (jet fuel), gasoline, diesel and masout, whereas by-products are oxygen and fertilizers. The distillation process can be placed on virtually any equipment that is used for refining mineral crude oil. The project does not require fertile soils and has comparatively low variable costs for the account of technology intensive and automatized processes.

Should be noted that synthesis fuels derived on the give technology from the renewable and CO_2 neutral source should be recognised as green fuels of the 3rd generation. The other fact complying with the goals of environmental regulations is that those fuels are of superior quality:

- The fraction of gasoline with octane number 95 and density of 690 kg/m^3 corresponds to the standards method ASTM D 5798-99:EN 228 and EURO-4;
- Comparing the synthetic diesel fraction with petroleum diesel of EN-590 standard, we have the following table 2:

Table 2. Key qualitative comparison of synthetic and petroleum diesels (BioDieselDnepr, 1, 2, 2010)

	synthetic diesel	petroleum diesel
cetane number	75	55
polyaromatic hydrocarbon	0,1%	6
Sulphur	0 ppm	50
Density	767 kg/m^3	835

Sulphur content is lower than 10 mg/kg (equivalent to 10 ppm) than such diesel corresponds to environmental class Miljöklass 1-diesel (MK1) in Sweden (www, SPI, 2, 2010). Moreover, emissions of carbon dioxide are much lower than after petroleum diesel. In addition, for the account that a source for synthetic fuels is algae which uses CO_2 as a nutrition source, we can argue that such fuels are carbon neutral. Earlier was mentioned that 1 ton of algal biomass may consume up to 2 tons of CO_2. Low content of polyaromatic hydrocarbon means less cancerogenic exhaust and flue gases we breathe. Plankton origin gives the ABFs a biodegradable feature, which is important in case of spill out in the nature. Higher cetane number gives us higher engine efficiency. Such fuels are used as usual petrol ones without modernization of engine and fuel supply and injection systems. Petrol and synthetic fuel could be mixed at any ratio. Besides that, higher quality means more kilometres run and less wore engines.

3.2.2 Technological process and the methods incorporated

Here is described a core technology units that comprises a standalone project. The same installation is currently run on the pilot project in Ukraine. Since it is a testing facility, the constant upgrades are made for the purpose of testing until economies of scales will be reached. Nowadays the capacity of producing the biomass up to 12 t per 24 h has been reached successfully and it is not yet limited. Nevertheless, the objective to meet the highest economies of scale is to be met shortly. Modular composition allows for easy scaling up of production capacity giving flexibility for initial investment decision. Herewith, positive projections for 100 t of biomass per 24 h are already given in terms of capital investments and payoffs. Modular system gives also an option of gradual scaling down, if it will be necessary.

Enclosure 2 outlines the major stages incorporated in the production process as well as enclosure 8 gives an illustration about the area of applications. For a visual guidance, it is suggested to watch the promo video at www, Authors' page, 1, 2010. However descriptively, the production process involves below following.

- Cultivation of Botryococcus braunii (enclosure 3) takes place in the closed land based system called *continuous stirred-tank reactor* innovated into *photobioreactor* by BioDieselDnepr (enclosure 9). Whereas enclosure 10 gives a visual insight of other competing cultivating approaches. Definitely, closed system gives a chance for SMEs to enter the market and hence a goal "produce locally – consume locally" has only positive effect on employment rate and in a whole on national economy.

  Photobioreactor plays a role of accommodator where algae is grown in the favourable for growth conditions. Those conditions are 24 h light, nutrients supply (table 3) and ambient temperature. Moreover, this system allows for extracting O^2 out and provides microbial isolation which is important in disease control.

  Optimal spectrum realised with help of internal LED illumination gives the most efficient lux conversation in photosynthesis process of algae, defining the rapid growth rate of mass. Whereas, pulse mode and LED facilitate electricity savings hence defining cost efficiency. System "shelf life" is 10 years without replacement of lighting units. Alabi, et al., (2009) states, that internal illumination is more effective than sun lighting. There are other advantages and disadvantage behind all systems, but it will take another bioengineering paper to outline them.

  Table 3. Medium ration (BioDieselDnepr, 1,2, 2010)

	unit	Per ton of biomass
H_2O	T	2,5
CO_2	T	1,4
KNO_3	Kg	0,56
$Ca_3(PO_4)_2$	Kg	0,333
$MgSO_4$	Kg	0,25
$FeSO_4$	Kg	0,066
$C_6H_8O_7$	Kg	0,5

  Inside the photo bioreactor, microalgae are nourished with the medium that should be prepared according to the following ration in table 3. This is carried out under operators' strict control. It should be mentioned that 70 – 80% of required macro- and microelements is usually present in the river, effluent or industrial waters. Therefore, the qualitative characteristics of local water supply should be studied thoroughly in order to balance it with minimum required according to the table 3.

- Cultivation of Eichhornia (Water hyacinth). However, if the water needs to be purified before Bb cultivation, i.e. there are some chemical elements or pathogens harmful for Bb, it can be adjusted by having the waters in the ponds with Eichhornia. Eichornia has huge capability to neutralise heavy chemical elements and some pathogens, it has the fastest growth rate hence is considered as renewable energy source (Reddy and Tucker, 1983; Joel de la Noie et al., 1992; Lufti and Desougi, 1984). Here, it used for primary bioremediation of dirty waters and in the other processes mentioned. Secondary bioremediation is carried out after waters have been utilised in the bioreactors cultivating Bb. Herewith, technically clean water can be discharged to the nature without being considered as harmful for the environment. This way we use river and effluent water rather than drinking. However, if access to effluent waters is limited, farm liquid residuals as manure or slurry are used as nutrient enrichment for drinking water. However, farm residuals can be used in combination with river and effluent water as well. It should be noticed that those farm residuals and municipal waters are "free of charge" source of nutrients that are required for medium ration. This fact can be used for cost minimisation strategy.

As it was mentioned, water is recycled between bioreactors and Eichhornia ponds. Therefore, according to the plant capacity, total volume of water is renewed every 4-6 months with equivalent portion from above mentioned supply sources.

One may ask: "where do we get rid of Eichhornia mass?". Well, according to Chernov (2010), it is fully utilised in the production process for energy deriving which is to be used for internal needs. In particular, biomass of Eichhornia takes a part in biocrude preparation as well as in gasification of the other processes, i.e. in cogeneration of electricity and heat, and in bio catalytic cracking block (enclosure 8). Water hyacinth biomass being grown on-site as a "part and parcel" of the technology is digested into biogas for cogeneration and CO_2 for nutrition the algae. Biogas cogenerated to heat, electricity and CO_2 also for nutrition. Herewith, according to Chernov *et al.*, (2010), economical efficiency is argued by the fact of energy self-supply process (table 4).

Table 4. Energy supply (BioDieselDnerp, 1, 2, 2010)

Supplies	source	%
Steam	self-supplied	100
Compressed air	self-supplied	100
Heat	self-supplied	100
Electricity	self-supplied	100

- Biomass harvesting. When concentration of algae biomass has reached its maximum, it is being subjected to a certain shock starts multiply in accelerated manner thus accumulating the maximum of hydrocarbons. It is time of harvesting, which is done by means of partial water separation in the *hydrocyclone*. The requited amount of eichhornia is harvested too for further step.

- Biocrude preparation. Hereafter algae-eichhornia sludge mixed with the catalyst and unloaded to the cavitator for homogenization obtaining oily- hydrocarbon mass. The derived mass is a biocrude oil having similar structure with petroleum crude oil.

  The cavitator is engineered by BioDieselDnepr Ltd. based on the latest high technology solutions. Whereas, given catalyst is a key knowhow in the entire technology, and it is developed by the same company.

- Biocatalytic cracking and refining – suspension (biocrude) received to the cracking unit converts into syntheses crude, which is distilled in the *rectification column* on synthetic gasoline, kerosene, diesel and masout. These fractions may be called as green fuels since they are derived from plants and hence are carbon dioxide neutral.

It should be also added that part of biogas from Eichhornia is supplied to the biocatalytic cracking unit. Whereas CO_2 is also use for nutrition of algae and sub products of this process are recycled until full utilisation, hence making technology sustainable.

From the above description, it seen how the algae is supplied with CO_2 as the main nutrient. Herewith, due to algae's ability to consume up to 2 tons of CO_2 per ton of biomass, it explains where carbon originates from, being a base for lipid-hydrocarbonaceous substances (Banerjee, *et al.,* 2002; Metzger and Largeau, 2005). Whereas, it is known that fossil fuels are composed of hydrocarbons, hence one can see similarity with green fuels.

Rounding this subchapter off, should be noticed that hydrocarbons are the chemical carrier of energy that releases to heat energy in the engine of internal combustion. The engine turns heat energy into kinetic energy – energy of motion which the human kinds enjoy driving a car.

3.2.3 Uncertainties of technological process

Operational factors besides others play significant role for decision maker when a few investment options are the subject for concern. The below outlined are the most discussed technical uncertainties, factors that are important to take into account for disclosing economical feasibility.

- Cultivation process uncertainty. Qualitative and quantitative deviation in the features of biomass might take place due to outage and\or negligence of the staff. However, if a firm control is carried out according to the technology requirements prescribed by the provider, deviation might take place in the range of foreseen values. Those controllable factors are chemical, microbial water content and ambient temperature (pers. com. Chernov, 2010).

- Biocatalytic cracking and refining. The major cause for deviation in output is the qualitative and quantitative characteristics of biomass used for preparation of biocrude. However, for credibility purposes, the deviations of output are also considered in calculations. Herewith, percentile projection of such is introduced in the next chapter (*ibid*).

3.2.4 Product slate

Aforementioned technological process gives flexibility in output for the account of catalyst and Eichhornia biomass. These two determinants play crucial role in forming the quality of biocrude. Herewith, producer can adjust the output proportion concentrating on the certain fuel, meaning that certain market demand can be met without additional capital investments.

However, since the process involves an organic growing matter, the insignificant fluctuations in output exist but should be considered as uncertainty. The following figure 1 introduces the production outputs with their capacity ranges. It should be mentioned, that gas phase and masout are recycled in the production process, therefore, these are not counted as outcome nor cost. Whereas, coke and wastage can potentially be used as fertilisers.

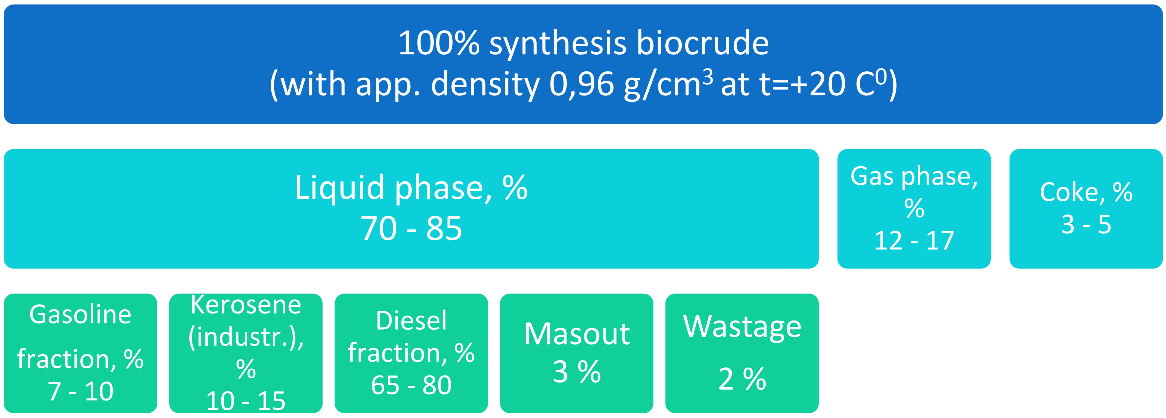

Figure 1. Product slate (adapted from BioDieselDnerp Ltd, 1, 2, 2010)

According to the data from pilot project, a plant with production capacity of 10-12 t of biomass per 24 h gives in average 7,7 t of liquid phase. It results in the following fuels (table 5):

Table 5. Quantitative fractions of fuels (BioDieselDnerp Ltd, 1, 2, 2010)

Fuel	Tons per day	Density, kg/l	Amount, l/day
Diesel	5,39	0,85	6341,2
Gasoline	0,87	0,74	1175,6
Kerosene	0,89	0,77	1155,8
Masout	0,33	0,91	362,6

Fuel fractions are given in tons. Appropriate densities rates to transform tons to a litre equivalent have been used. This is done for the purpose of further convenience in calculations, since historical prices on fuels are given per 1 litre.

4 Theoretical framework

The choice of subjects to be reviewed mainly applies two issues, in particular economical evaluation of technology by means of real option analysis (ROA) and traditional methods used in investment appraisal. Hence, theoretical backgrounds for economic study are briefly introduced in the following chapters.

4.1 Traditional methods used in investment appraisal

Capital budgeting (or investment appraisal) is "the planning process used to determine whether a firm's long term investments such as new machinery, replacement machinery, new plants, new products, and research development projects are worth pursuing. It is budget for major capital, or investment, expenditures". (Sullivan and Sheffrin, 2003, p.375). The main criteria used by managers for evaluation of project's profit are NPV, IRR and Payback period.

4.1.1 NPV

Net Present Value (NPV) is a central tool in discounted cash flow (DCF) analysis, and is a standard method for using the time value of money to appraise long-term projects. According to Pretorius et al. (2008) evaluation of projects should be done on different basis depending on whether it is a project company or a general company. A project company "is generally a one-asset company, highly specific and capital intensive ... with high debt in its capital structure"(ibid, p.95). Differently saying it is a company which exist in the form of a business plan. A term "general company" is applied to existent business with existent cash flows. Therefore, Pretorius et al. (2008) suggests that for a project company (as a basis for NPV calculation) should be taken not after tax cash flows but a business cash flows which is defined as earnings before interest, tax, depreciation and amortization (EBITDA).

The net present value (NPV) is the aggregated value today of a series of cash flows occurring in the future. It is calculated in today's monetary value in order to make future incomes comparable with incomes from other potential projects. The annual net cash flows over the investment's life need to be estimated. It needs however to be considered that one unit today accounts for 1 plus the interest rate next year (1+i). In the discounting process future incomes therefore needs to be taken back to the starting point by dividing the next year amounts with (1+r). The main investment rule is to invest when NPV is zero. The NPV formula is:

$$NPV = \sum_{t=1}^{n} \frac{A_t}{(1+r)^t} - I,$$

where A_t – net cash flows, *I* – initial investment.

This signifies that the higher the interest/discount rate used the lower is the value of future payments. NPV calculation is very sensitive to a discount rate: a small change in discount rate causes a large change in NPV (Campbell and Brown, 2003).

4.1.1.1 Disadvantages of NPV

Notwithstanding underlying advantages, NPV approach has clear limitations. The method assumes that management is able to predict accurate cash flows of the future project. In reality, the more distant future the more it is difficult to make correct predictions. As a result, overestimation or underestimation leads to acceptance of the project that has to be rejected and rejecting of the project that has to be accepted. Additionally, NPV approach assumes that discounting rate will not change over time. In reality, discounting rate changes from one year to another just as interest rate does (Groppelli and Nikbakht, 2006).

It is commonly agreed (Schwartz and Trigeorgis, 2004; Dixit and Pindyck, 1994; Copeland and Antikarov, 2001) that NPV approach presumes that investors will follow a passive commitment once project is undertaken. However, they are not passive but have the flexibility to sell the asset, invest further, wait and see or abandon the project entirely. The orthodox theory of investment has not recognized the importance of interaction between irreversibility of investment, uncertainty over future reward and the choice of investment timing. As researches have proved, real world investment seems to be much less sensitive to interest rate changes than it does to volatility and uncertainty over economic environment. The theory of real options argues that the common investment rule "invest when NPV is zero" is not enough (Dixit and Pindyck, 1994).

4.1.2 IRR

"A discount rate at which NPV becomes zero is called Internal rate of return (IRR)" (Campbell and Brown, 2003**,** p.44)**.** One should think of IRR as a rate of growth that a project is expected to generate. If the internal rate is higher than the cost of capital (r) then the investment should be undertaken (ibid).

4.1.3 Payback period

Payback period is the number of years needed to recover initial investments and in a way represent the riskiness of losing invested money. However, this method doesn't account for a time value of money. Nonetheless, a discounted payback period can be used instead, which presents a more reliable figure. (Groppelli and Nikbakht, 2006).

4.1.4 Sensitivity analysis

In business evaluation, it is important to recognize key value drivers that determine the performance of the business. In such a case, it is very useful to perform sensitivity analysis, i.e. "testing the impact on the outcome from changes in one or more key assumptions" (Helfert, 2001, p.191). Sensitivity analysis is a method to predict the outcome of a decision if a situation turns out to be different compared to the key prediction(s).

4.2 Forecasting methods used for time series data.

Financial planning process in capital budgeting involves making predictions of future cash inflows and outflows. To make good prediction of cash inflows requires both great experience and good knowledge of market and/or use of forecasting tools.

The most general class of models for forecasting in time series is ARIMA (autoregressive integrated moving average) - an advanced econometric modelling technique. ARIMA looks at historical data and performs back-fitting optimization routines to account for historical autocorrelation, the stability of the data to correct for the non-stationary characteristics of the data, and this predictive model learns over time by correcting its forecasting errors. A minimum of 50 observations is required for proper use of this method.

Another method of forecasting is Time Series Analysis, which is used to forecast time series variables by decomposing the historical data into baseline, trend and seasonality elements into the future forecasts. This analysis assumes that the trend and seasonality will exist. For example, when the data variable has trend but no seasonality, then double moving average or double exponential smoothing would be an appropriate forecast model.

Moving averages rank is among the most popular techniques for the pre-processing of time series. They are used to filter random "white noise" from the data, to make the time series smoother or even to emphasize certain informational components contained in the time series. Exponential smoothing is a very popular scheme to produce a smoothed time series. Whereas in moving averages the past observations are weighted equally, exponential smoothing assigns exponentially decreasing weights as the observation get older. In other words, recent observations are given relatively more weight in forecasting than the older observations. Double exponential smoothing is very good in capturing the trend (Mun, 2006).

4.3 Real Option Analysis (ROA)

Real option analysis revolutionized the way practitioners and academics think about investment projects by explicitly incorporating management flexibility into the analysis. Real option approach was adapted from the financial options, which are tradable on the stock markets. Thus, in 1977 Stewart C. Myers has argued that the concept of pricing financial options can also be used in real investments (Gustavsson and Töre 2006). Supporting Myers, Trigeorgis (1996) states: “an option approach to capital budgeting has the potential to conceptualize and quantify the value of options from active management and strategic interactions” (p. 4).

Comparing to traditional NPV approach, which employs “risk-adjusted” discount rate, real options analysis is made on the basis of risk-neutral environment applying risk-free interest rate. The critical advantage of working in risk-neutral environment is its appropriate and convenient setting for option pricing. This allows the multiple operating options available in a typical investment project to be naturally incorporated in the analysis. These options include the optimal investment timing, the option to abandon the project, to temporarily stop and later restart the operation, growing options etc. The other advantage of the risk-neutral framework is that it allows using analytical tools developed in contingent claims analysis to determine both the value of the investment project and its optimal operating policy (Schwartz and Trigeorgis, 2004).

Leslie and Michaels (1997) (cited in Gustavsson and Töre, 2006) compared a traditional NPV methodology with real options and identified corresponding value levers and how each lever affects the valuation (figure 2). They argue that NPV can mislead whenever there is flexibility, especially flexibility to respond to uncertainty over the rate of cash flow growth because it captures only two levers on value creation. Real options "thinking" may lead to increased opportunities to take advantage of upside market potential and mitigate downside risks.

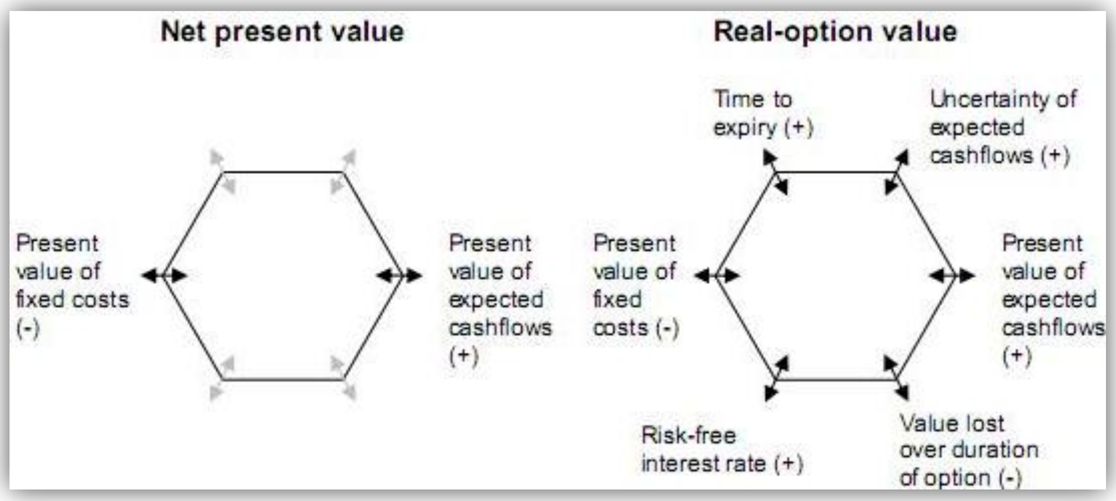

Figure 2. Comparison of valuation methods (Leslie and Michaels, 1997, cited in Gustavsson and Töre, 2006)

However, it is important to note that the two methods, NPV and ROA, do not necessarily oppose but rather complement each other. Dixit and Pindyck (1994) states that “the simple NPV rule must be modified to include the opportunity cost ... that opportunity cost is exactly the value of the option” (p.153). This view is also supported by Copeland and Antikarov (2001), who says that real options approach doesn’t necessarily have to be considered the be-all and end-all in terms of valuation techniques; rather, it should be considered a part of an expanded NPV analysis. The expanded “strategic” NPV is equal to the static “passive” NPV plus the value of real options: $NPVstrategic = NPVstatic + RO$.

Real options theory emphasizes the importance of waiting or staging flexibility, suggesting that managers should either "wait and see" until substantial uncertainty is resolved and the project is more clearly successful, requiring a premium over the zero-NPV or they should stage the decision so that they can revise the situation at critical milestones (Trigeorgis, 2005; Dixit and Pindyck, 2004). The higher value of the option to "wait and see" requires a higher critical investment threshold. The critical project value at which it is optimal to invest must be at a significant premium above the required investment cost, before it is justifiable to invest and give up the option to wait. The meaning of this is that higher uncertainty would most probably lead to investing less or later (Trigeorgis, 2005). Should be noted that the option to "wait and see" increases when uncertainty increases, as does the critical value of optimal investment. However, critical value of optimal investment increases more sharply than it does the option value (Dixit and Pindyck, 2004). Nevertheless, in the presence of competition the option value to wait must be traded off against the strategic dedication value of early investing. (Trigeorgis, 2005).

4.3.1 Stochastic capital budgeting

Standard capital budgeting model doesn’t account for the risks involved in the model. Recently, several authors have used stochastic capital budgeting model to account for risk when investing in a methane digester for instance (Strokes, et al., 2008; Lauer, et al., 2007). Furthermore, Artikis (1999) has outlined the reasons for using simulation rather than other methods in developing capital budgeting model showing that such approach gives better indication of risk involved in the project. Among existent computer simulations, Monte Carlo simulation is the most useful for modelling with significant uncertainty in inputs. Stochastic approach is also helpful in estimation of volatility in net cash flows, which can be used in real options analysis (Strokes, et al., 2008).

4.3.2 Monte Carlo Simulation Method

Monte Carlo methods are often used in finance and mathematical finance to value complex instruments, portfolios and investments. The definition of *simulation* described as "any analytical method that is meant to imitate a real life system, especially when other analyses are too mathematically complex or too difficult to reproduce" (Mun, 2006, p. 112). Monte Carlo simulation randomly generates values for uncertain variables over and over to simulate a real life situation. It calculates numerous scenarios of a model by repeatedly picking values from the probability distribution for uncertain variables and uses those variables for the event.

Simulations are used for many different purposes: to define such events as totals, net profits, gross expenses or it can also be used as a forecasting tool. Specifically, with Monte Carlo simulation can be forecasted future cash flows, costs, revenues, prices which are stochastically evolved (ibid).The method of Monte Carlo simulation is widely used in such software as @Risk, RiskOptimizer, Risk Simulator, etc.

Mun (2006) describes how Monte Carlo simulation can be used to estimate the volatility in the project. First, a model of the project and a decomposition of the future expected cash flows into price, quantity, etc should be constructed. By assigning mean values, probability distribution and standard deviations to the variables and running the simulation with the appropriate software, one can acquire a simulated distribution of the percent changes in the value of the project. The computer program can then easily calculate the simulated volatility. The process as such is quite easy; however setting the parameters for the variable in the model is the hardest part. To estimate parameters for variables, literature suggests using either historical data or subjective estimate form the management (ibid).

4.3.3 Critiques on ROA

Real options theory as well as other theories has its critiques. The main and most common critique is that ROA approach is too complex to be worthwhile (Bowman and Moskowitz, 2001; cited in Gustavsson and Töre, 2006). The main problem comes with evaluation of estimates: if inputs are improperly evaluated then ROA is worthless. Miller and Park (2002) also support critique side saying that real option only works for tradable assets, i.e. when the asset price can be observed in the financial market. They stress on the point that key parameter in ROA is volatility and to estimate volatility one needs appropriate data such as historical data or actuarial information.

4.4 Previous research and studies

Looking at the renewable energy technology, real option theory has been widely used in energy and agricultural sectors. As can be expected, real option theory has been applied in a wide range of methods in order to evaluate and analyse investment decisions. In the table 6 presented examples of resent studies of ROA application used to evaluate agricultural investments.

Table 6. ROA application in valuing agricultural investments

Study	Issue
Schmit *et al.*, (2009)	Optimal investment and operating decisions (entry-exit, mothballing) of dry-grinding corn ethanol facilities
Stokes *et al.*, (2008)	Analysis of economic and financial feasibility of installing a methane digester
Isik *et a*l., (2003)	Investment in an emerging market of remote sensing technology: model of entry-exit decision and capacity choice
Hyde, Stokes and Engel (2003)	Optimal replacement decision of an operational milking system with an automatic milking system
Tauer (2006)	Entry and exit decision from dairy farming
Purvis *et al.*,(1995)	Optimal investment in free-stall dairy housing

4.5 Modelling of the problem

An investment in ABF technology involves significant uncertainties about benefits and costs associated with the project. To account for risk involved in the project we will simulate uncertainty in the capital budgeting model and generate distributions of possible NPVs. Thus, a probabilistic assessment of NPV can be made to help determine the feasibility of a project. We also will use stochastic budgeting for volatility estimation of net cash flows (NCFs) as Stockes et al., (2008) did in their study of investment in a methane digester. This volatility is a critical input for determining the option value. Moreover, simulated NCFs can be used to estimate the investment value and the payout rate.

4.5.1 Parameter estimation

- *Volatility.* Since we do not have historical data regarding similar project from related industry, neither data from the financial market we will apply the approach used by Stockes et al., (2008) and Vintila (2007): rolling a great number of Monte Carlo simulations (minimum 3000 iterations), the standard deviation of discounted NCFs is obtained and then relative standard deviation (RSD) is used as a proxy of underlying asset. $RSD = \frac{(Std.Dev.of\ array\ X)*100}{(average\ of\ array\ X)}$ (Dodge, 2003).
- *Payout rate* is a percentage of discounted NCFs in relation to investment cost.
- *Risk free rate* is represented by the expected rate of return for a riskless security (treasury bill or government bond) with the same maturity as project life (Vintila, 2007*).*

4.5.2 ROA modelling

Let V(t) denote a time t- value of a ABF technology with V(0) which represents its present value at the beginning of time horizon. V(t) is a discounted sum of all NCFs associated with the investment. According to Postali and Picchetti (2006, cited in Schmit et al., 2009, p.15), Geometric Brownian Motion (GBM) is a good approximation for crude oil prices. As fuel prices are stochastic, the value of the project, V, is believed to be also stochastic. Therefore it is assumed that V follows GMB with drift μ and variance σ so that

$dV(t) = \mu V(t)dt + \sigma V(t)dz_t$. Observe that $\mu V(t)dt$ is the immediate expected capital gain on V.

The investment in ABF technology pays intermediate cash flows in almost the same way as stock pays dividends. Therefore, a capital gain can be written as the difference between the total expected return, α, and payout rate or so called "dividend", δ. Hence, the diffusion equation for the value of the ABF technology investment can be written as

$$\frac{dV(t)}{V(t)} = (\alpha - \delta)dt + \sigma\, dz_t, \qquad (1)$$

where $dz_t = e_t\sqrt{dt}$ is the increment of Wiener process with zero mean and unit standard deviation having an instantaneous variance equal to *dt,* representing natural measure of risk.

Let *I* denote the initial cost of investment in ABF technology. We assume that the investment opportunity can be delayed. Thus, the delay can be thought of as an option to supervene *–I* SEK at time *t* in exchange for *V(t).* In the region *V(t) > I,* the NPV is positive. However, under the presence of the option to delay this condition is insufficient for investment decision.

Let $F = F(V)$ be the investment strategic value consisting of the sum of NPV and the option to delay investment. Since investment opportunity, *F(V)*, yields no cash flows until the time, *T* the investment is undertaken, the only return from it is its capital appreciation. By imposing a non arbitrage condition, Bellman equation is then applied:

$$\rho F dt = E(dF) \qquad (2)$$

The above equation says that over time interval *dt*, the total expected return on the investment opportunity, $\rho F(P)dt$, is equal to its expected rate of capital appreciation. The dynamics of *F* is found using Ito's Lemma (Dixit and Pindyck, 1994) gives:

$$dF = \frac{dF}{dV}dV + \frac{1}{2}\frac{\partial^2 F}{\partial V^2}dV^2 \qquad (3)$$

Substituting equation (1) for *dV* into (3) gives the dynamic of F

$$dF = \left[(\alpha - \delta)\frac{dF}{dV}V + \left(\frac{\sigma^2 V^2}{2}\right)\frac{\partial^2 F}{\partial V^2}\right]dt + \sigma V\, dz \qquad (4)$$

Hence, Bellman equation becomes:

$$\left(\frac{\sigma^2 V^2}{2}\right)\frac{\partial^2 F}{\partial V^2} + (\alpha - \delta)\frac{dF}{dV}V - \rho F = 0 \qquad (5)$$

According to Dixit and Pindyck (1994) the solution to (5) being as a second order differential equation, gives the value of the investment opportunity, *F(V).* However, *F(V)* must satisfy the following conditions: $F(0) = 0, F(V) = V^{*} - I$ and $F'(V^{*}) = 1$, where V* is the minimum project value at which it is optimal to invest. Equation (5) and corresponding boundary condition suggests that the option value consist of NPV and a perpetual call option on investment, meaning that the option to invest never expires.

To maximize the market value of the project we will use the contingent claims method. Thus, the project's dynamics given by (1) can be risk adjusted by changing the natural probability measure of risk to risk-neutral measure. Hence, we construct a portfolio that is long in the option to delay investment and short *n* units of the project under consideration so that (5) can be free and discharge from α and ρ. In particular, we assume that the economy is sufficiently "complete" and stochastic changes in V are spanned by existing assets in the economy given the infinite number of combinations of assets that can be formed in a diversified economy (ibid, Stockes et al., 2008). This ensures that risk can be diversified by the investment in the assets (portfolio), whose value is perfectly correlated with V.

The short position of replicating portfolio will require a payment of $\delta V \frac{dF}{dV}$ SEK per time period. Holding a long position in the project will demand a risk-adjusted return μV, which equals to a capital gain αV plus the dividend stream δV. Using dynamics of F given by (3) we obtain the total return on portfolio over a short time interval *dt*:

$$\left(\frac{\sigma^2 V^2}{2}\right)\frac{\partial^2 F}{\partial V^2}dt - \delta V\frac{dF}{dV}dt \qquad (6)$$

Note that this return (6) is risk-free. Hence, to avoid arbitrage possibilities it must equal $rFdt = E(dF)$ and the appropriate Bellman equation is then:

$$\left(\frac{\sigma^2 V^2}{2}\right)\frac{\partial^2 F}{\partial V^2} + (r - \delta)\frac{dF}{dV}V - rF = 0 \qquad (7)$$

Observe that equation (7) is identical to (5) except that risk-free interest rate *r* replaces the discount rate *ρ,* which is the firm specific. The same boundary conditions apply to (7) as did to (5). According to Dixit and Pindyck (1994), the solution for *F(V)* has the form:

$$F(V) = \begin{cases} AV^{\beta_1} & \forall \quad V \leq V^{*} \\ V - I & \forall \quad V > V^{*} \end{cases}, \qquad (8)$$

where $V^{*} = \left(\frac{\beta_1}{\beta_1 - 1}\right) I$ (9)

$$A = \frac{V^{*} - I}{(V^{*})^{\beta_1}} = \frac{(\beta_1 - 1)^{\beta_1 - 1}}{\beta_1{}^{\beta_1} I^{\beta_1 - 1}} \qquad (10)$$

$$\beta = \frac{1}{2} - \frac{r-\delta}{\sigma^2}\frac{r-\delta}{\sigma^2} + \sqrt{\left(\frac{r-\delta}{\sigma^2} - \frac{1}{2}\right)^2 + \frac{2r}{\sigma^2}} \qquad (11)$$

Equations (8-11) give the value of investment opportunity and trigger value V^*at which it is optimal to make an investment. If the value of the investment is less than trigger value, the opportunity to invest is AV^{β_1} consists of NPV and call option value. If the value of the investment is more than trigger value, the value of the investment is simply the NPV, i.e. $V - I$. Hereof, as the value of the investment increases the value of the option to delay investment decreases.

5 Background for empirical study

This chapter provides an insight to the Swedish biofuel market and related policies with the aim to present a holistic picture about macroeconomic issues. However, the focus is put on a biofuel market.

5.1 Biofuels in Sweden – Energy Policy Overview

Sweden is the one to have most ambitious policy for renewable energy. Presently it obtained to have about 28% of energy supplied from renewable sources with the aim to increase it to 50% by 2020 and have a vehicle fleet that is independent of fossil fuels by 2030 (USDA Foreign Agricultural Service, 2006 – 2009). However, 3 years earlier Swedish oil independency was set to be reached by 2020 (Persson, 2006). The biofuel industry in Sweden is set to expand mainly due to the new legislation on energy and climate strategy passed by the Swedish parliament. The general economic policy instruments that put a price on greenhouse gas emissions together with beneficial conditions for cars running on alternative fuels will encourage a different choice of fuel. By the middle of 2010 Swedish government aims to implement new EU biofuel directive that enables a blending of 10% ethanol and 7% biodiesel. Development of plug-in hybrid vehicles and electric cars is supported alongside.

The promotion of the use of ethanol and biodiesel is implemented mainly through tax reliefs - there are no taxes on ethanol and biodiesel. In addition to tax reliefs, Sweden provides different policy instruments to stimulate use of biofuels. Mentioning a few, those instruments are: “gasoline and diesel cars emitting less than an average of 120 grams of carbon dioxide per kilometre are exempt from vehicle tax”, “energy tax on conventional diesel will be raised by a total of SEK 0.40 per litre by 2013” comparing to the total tax for diesel of SEK 5.42 in 2009, etc (Dahlbacka, 2009, p. 4-5).

Swedish bio-diesel rapeseed methyl ester (RME) is produced from rapeseed. About 50% of the rapeseed produced in Sweden is used for biodiesel. In addition to domestic raw material, imported rapeseed oil, mainly from the Netherlands and Lithuania was used in 2008. Yet, Sweden largely promotes ethanol (E85) as alternative biofuel believing that cheaper biofuel benefits both the climate and consumers (ibid). On the other hand, several EU countries want to treat ethanol as an agricultural commodity levying high tariffs.

From the table 7 it is seen that consumption of biodiesel in 2010 is 140 metric tons (Mt) of which 60 Mt (43%) is imported, which indicates a great potential for biodiesel market as well as high demand.

Table 7. Biodiesel Production / Consumption / Trade (thousand tons), (Dahlbacka, 2009)

Biodiesel	2006	2007	2008	2009	2010
Production	20	70	80	100	100
Imports	40	50	40	40	60
Total Supply	60	120	120	140	160
Exports	0	0	10	20	20
Consumption	60	120	110	120	140

5.2 Governmental support

Businesses are heavily supported for innovations in the environmental sector. This support is carried out in the forms of cheap investment capitals, funds, subsidies, CO_2 allowances, tax reliefs, political will, informative and consultancy supports, etc. Numerous agencies on a national as well as on a local levels, run periodically programs stimulating business to reduce pollutions and improve services, etc. (www, Swedish Energy Agency , 1, 2, 2010; www, Tillväxtverket, 1,2, 2010; www, CMF, 1, 2010; www, Naturvårdsverkets, 1, 2010; www, Industrifonden, 1, 2010; pers. com. Innovationsbrons, 2010).

5.2.1 Tax reliefs on biofuels

According to the current situation, biofuels are exempt from so called "punktskatter". The punktskatter – an excise duties introduced by "energiskatt" – energy tax and "koldioxidskatt" - carbon dioxide tax. These taxes are an obligation of producer to put them on the top of its producer price. This means that the end consumer pays those taxes whereas the producer collects them and transfers to the inland budget (Monti, 2003; Neelie, 2005; USDA Foreign Agricultural Service, 2006 - 2009; www, SPI, 2, 2010; pers.com. SPI, 2010). In particular, biofuels from pilot projects are exempt from both duties.

However, the more "free of tax" biofuels introduced on the market the less government gets income. Being aware of this fact, government is currently working on decision to balance those tax reliefs. A revision of the energy tax directive is currently discussed within EU and a proposal for a revised directive might be published this year, 2010. It is discussed that the directive would include both a split of excise duties into energy tax and carbon dioxide tax for biofuels as well as separate minimum tax rates for biofuels (pers. com. SPI, 2010).

6 Empirical findings

Pursuing to fulfil the aim of paper, the research of data has been done in Sweden. The following chapters reveal those findings as well as estimates of the calculations.

It should be mentioned that underlying principle for projecting the budget is: “Pay maximum - get minimum”. However, when the plan comes to practical establishing, the opposite principle has to be applied: “Pay minimum – get maximum”. Herewith, the first principle should be taken into account by the retriever while replicating this paper for his \ her own purposes.

6.1 Conditions for capital budgeting model

As it was mentioned, we consider a synthetic project established on Swedish market. Projecting the entity, one must hold conditions clear. Therefore, making the accounts transparent, we put the project in the following conditions:

- Project life period is taken as 10 years because it represents the economic and physical life of the equipment.
- It has no reinvestment and\or recapitalisation strategies during its life period, herewith no expansions are considered. This way we believe to avoid distortion of true value of the project which is moreover important when one judges it against the value of the project that induces immediate investment according to the real option analysis;
- Even though it produces mainly four products, the only three of them are considered because they create app. 95% of turnover due to their higher prices and higher volumes produced;
- Technically, the production cost part represents one asset i.e. biocrude from which those multiple products are finally refined. Therefore, the project is evaluated as one asset project;
- Accrual accounting principle is applied, meaning that income and expenses are allocated to periods to which they apply, regardless of when they actually received or paid;
- Value added tax is not considered in either expense nor income part of budgeting;
- No governmental and other institutions grants or alike financial support are considered as a means of direct infusion of money;
- The underlying principle for projecting the budget is: “Pay maximum - get minimum”;

6.2 Initial investment outlay

According to the set above delimitations, the budget is developed for a stand along project producing only green fuels. The capacity of ABF production plant is to be 10- 12 tons of biomass produced per day. The same size of ABF production pilot project is currently running in Ukraine. Therefore, the technology related information about production capacity of input and output will be used from the pilot project for our estimation. However, the prices are adopted from the Swedish market setting, though.

The total land area needed to allocate the project is 3000m^2 (0,3 ha) of which 2000m^2 needed for building to place biomass cultivating facilities , laboratory and office. Note, production of green fuels from algae does not require a specific type of land nor climate; therefore it can be installed in any region of Sweden. Herewith, initial investment outlay is outlined in the enclosure 11 in details. The costs for tangible assets consist of the following:

- The price for equipment includes producer's price (BioDieselDnepr, 1, 2010), transportation cost from Ukraine to Sweden (pers. com. Alpha Projects & Logistics ApS, 2010) and custom clearance (www,Tullverket, 2010). Producer's price includes installing of equipment, start up operation and staff education. Besides that, a onetime royalty fee is included in the total price of equipment, giving a right to use the technology method (pers. com. Chernov, 2010).
- Real estate with needed plot of land was estimated based on the market price of existent industrial facility that is most suitable for the type of production and does not require much rebuilding (pers. com. Svensk Fastighetsförmedling, 2010). However, some uncertainty was given to rebuilding expense in the stochastic budgeting.
- The capacitive tank park is calculated to fulfil the required storage capacity of fuels for 10 days. Prices were taken from the fuel tank producer and include transportation costs from Denmark to Sweden with custom clearance (www, CGH Nordic, 2010).
- Investment in security system (Intrusion alarm, CCTV Surveillance system, Fire Alarm System) is based on consultation with G4S (pers.com. G4S, 2010).
- Price of laboratory equipment is adapted from numbers applied on pilot project in Ukraine since the equipment is imported (BioDieselDnepr, 1, 2010).
- IT and office facilities are estimated based on required felicities for the staff employed.

Establishing and start up operational costs, presented in enclosure 11, among others include costs of CO_2 and electricity as they are needed only for start up operation. The price of CO_2 is provided by AGA (pers.com., AGA, 2010). Electricity price was chosen with energy taxes but without VAT (www, EON, 1, 2010).

Marketing, legal expertises, IT and expenses for extra technical expert are based on qualified guesswork. However, extraordinary costs have been also included in order to cover unexpected activities, despite on governmental informative support.

As the project and technology is very new for Sweden, one might also consider costs associated with the start up of operation. Given the fact that the key production processes is automated and controllable the authors do not expect the variations in outcome greater than predicted. Moreover, together with the purchase of technology a seller provides the staff for 3 months with the purpose to educate local workers while setting up the operation.

Much attention has been put on **administrative regulatory costs** (enclosure 13). The major complication that we met estimating them was the fact that there is no similar technology established in Sweden. Meaning, there is no existent completely similar business entity to copy historical data from.

The feature of 100% environmentally friendly technology was brought up while making inquiries to the relevant authorities (www, Verksamt, 1, 2010) and biofuel producers (www, Retriever Sverige, 1, 2010). Inquiries were underling that synthetic fuels are produced from CO_2 neutral organic matter of own produce. These fuels surpass the quality of fuels of petroleum origin exciding the normative of Miljöklass 1 standard. Technology does not produce toxic wastes and by-products; water is bio-remediated and recycled, colossal amount of carbon dioxide is neutralised. From the other side, these technicalities have to be also considered:

- Project produces flammable and explosive good;
- Some chemicals are used in the production process;
- Production process involves tree types of activities i.e. cultivation of organic matter, chemical mechanical conversion of organic matter to biocrude with consequent thermal refining to fuels, and cogeneration of biogas to electricity and heat for internal use;
- Product derived with the method incorporated in technology should be inspected thoroughly for final approval and hence classify them as green biofuels;
- Technology and its methods is also a subject for thorough studying and certification;
- Environmental issues as to how the water used is purified and how much of CO_2 is neutralised should be approved.

Herewith, this presumes the following procedures which in monetary value have the most burden at establishing as well as in the consequent operational years (www, Verksamt, 1, 2010):

- ✓ getting approved and consequently inspected as chemical operator;
- ✓ registering the product in the chemical register;
- ✓ getting approved and consequently inspected for flammable and explosive goods operation "general permit";
- ✓ getting approved and consequently inspected on the issue of environmentally hazardous activities "environmental permit"

However, this list does not end on it. The report about total municipal cost mentioned in the enclosure 13 outlines them thoroughly (Näringslivets Regelnämnd, 2008). Complication of issue justifies the reason of why Tillvaxtverket (Swedish Agency for Economic and Regional Growth), Kemikalieinspektionen (Swedish chemical agency), Naturvårdsverkets (The Swedish Environmental Protection Agency), Swedish Petroleum Institute gave a partial respond on the question, while the rest 26 respondents found it impossible to quote on those expenditures. The overall meaning was that in order to adequately estimate those costs, the relevant technology projecting documentation should be provided and project installed under inspection. Therefore, it depends from case to case. However, they gave a good navigation in the field. If we pay attention on the table in the enclosure 13 we can see that average firm bears 4,4 M SEK per year of administrative costs or 266833 SEK in average per employee a year. The rates for approval and inspection mainly depend on the number of employees, volume produced, total revenue, and profit after tax.

Näringslivets Regelnämnd provides great help in this regards. The enclosure 11 contains the estimate of annual total administrative regulatory costs for establishing year, whereas projection of the item for consequent years is shown in the enclosure 14 part 2 (P&L account, see under fixed cost). However, according to the mission of this organisation and its report "Regelindikator 2009" these costs have a tendency to decrease with 2,5 % yearly (Näringslivets Regelnämnd, 2010).

In addition to the decreasing tendency, we could include the assumption that the project is financially supported with the government fund, since it complies with environmental goals. However, for sake of transparency we do not consider governmental grants or financial support like subsidies, and allowances in this paper.

6.3 Sources of inflows and outflows

The primary sources of **cash inflow** are the sold products (chapter 3.2.4): diesel, gasoline and kerosene. Coke and wastage can potentially be used as fertilisers, however; we disregard them as it can be used as a source of nutrients for medium ration.

As it was mentioned in chapter 3.2.1, ABFs are by the quality the same and even better as of fossil fuel origin. Moreover, according to Swedish legislation, green fuels produced on the pilot projects are exempt from energy and carbon taxes (Monti, 2003; Neelie, 2005; USDA Foreign Agricultural Service, 2006 - 2009; pers.com SPI, 2010). Therefore, since our synthetic project belongs to the category of pilot, as there is no similar once on the market, its products are currently not taxed. However, it is most likely for the close future that energy tax will be introduced for biofuels on the same level with fossil fuels, but will be still exempted from carbon dioxide tax. This is considered as uncertainty in price for the output (chapter 6.5.1). However, this vagueness is moreover enriched with the increasing tendency on fossil prices, caused by ever growing demand and declining prognoses of oil reserves (Robelius, 2007). Therefore, objectively approaching in defining the price for output, we made statistical forecast based on historical data on fossil fuel prices.

Herewith, fuel prices (enclosure 14, part 1) for projected revenues (*ibid*, part 2) were derived based on forecasted with Risk Simulator software (2010). The business administration expertise allows us to appropriately use the derived data. In particular, we used time series analysis as a forecasting method applying Double Exponential Smoothing model. We also considered ARIMA model but due to low number of observations had to choose another approach. Holt-Winter's multiplicative has also been tested and compared with Double Exponential Smoothing (DES) results. However, we stay with the last one (DES) because Holt-Winter's multiplicative is more applicable for the data where seasonality is observed, which is not in our case. Herewith, historical and forecasted prices of fossil fuels are attached in the enclosure 6.

Nevertheless, from the figure 3 we observe that Double Exponential Smoothing model in overall quite nicely capture the trend, though the error in forecasted data exists. Also, should be noted that forecast for kerosene is somewhat biased due to low number of observations

(15) whereas observations for gasoline and diesel is 40 each. However, such errors will be taken into account in stochastic capital budgeting.

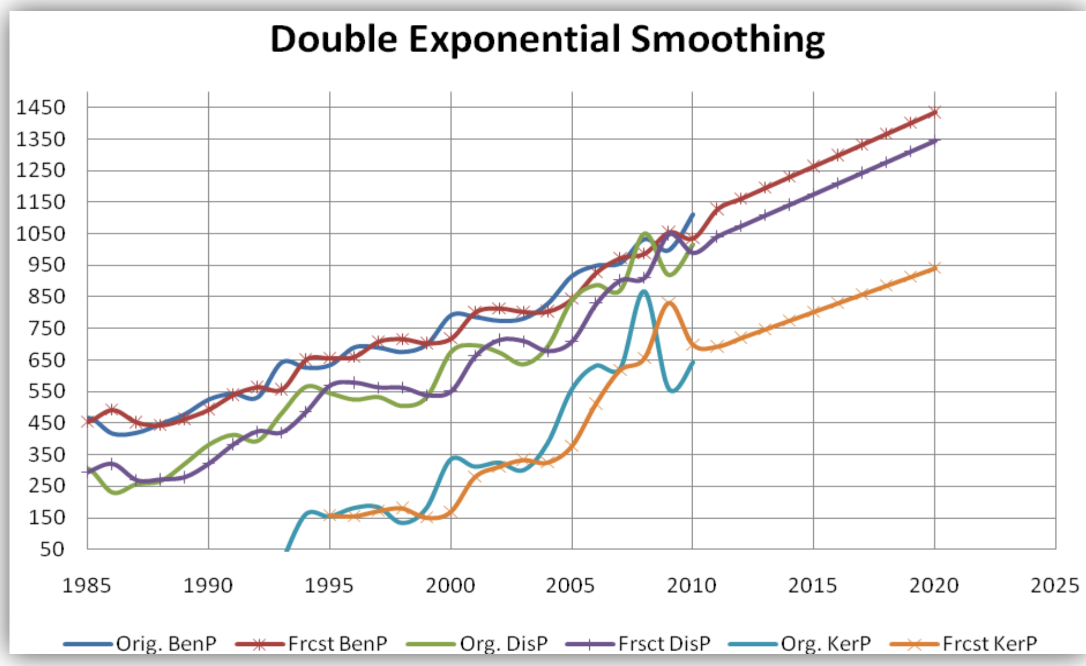

Figure 3. Fuels price forecast (authors' calculations; enclosure 6)

Herewith, ceiling prices are the result of forecast for the period of 2011 – 2020 yy. However, we presume 20% discount from the ceiling prices defying it as list price, whereas minimum prices is derived as percentage from price structure on fossil gasoline in 2009 given in enclosure 15. Accordingly, the minimum producer price is a sum of product total cost (productkostnad) and gross margin (bruttomarginal), i.e. (3,55+0,85) = 4,4 SEK/L for fossil gasoline, which is 36% out of retail price 12,06 SEK / L in 2009. Herewith, we assume that the minimum price will represent on average 36% of the forecasted price. The same principle applies to the prices on diesel and kerosene. However, sale price assumed to be a mean of Max and Min prices with skewness to the Min price following our underling principle "get minimum". These set of prices is introduced in the enclosure 14, part 1. Should be noticed that today's (07.05.2010) top price on synthetic diesel is 15,09 SEK which is available online on www, Framtidsbranslen, 1, (2010). Nevertheless, the products are sold at aforementioned prices under following conditions:

- Direct access to the B2B customer. As it was mentioned, the qualitative characteristics of given product allows for direct substitution of the fossil fuels.
- Existent demand – ever needed product, at least for 10 years ahead according to the qualified guesswork.

On the **expense side**, fixed and variable costs (enclosure 12), capital depreciation, principal, interest and taxes all contribute to total cash outflow. Notice that the first establishing year (2011) has only half year of production period. Hence, labour cost and other relative one are introduced only for half year. Estimates related to the fixed and variable costs are the following:

- Labour expenses are taken from Swedish statistics on salaries (www, lonestatistik, 1, 2010) and expected to grow with 2% annually in real terms according to Swedish statistic (www, ekonomifakta, 1, 2010).
- Maintains of equipment is 1,5% annually of initial investment (pers.com., Chernov, 2010). Maintains of building is assumed to be 1% annually of initial investment.
- The prices of laboratory costs are adapted to the Swedish setting from the pilot project run in Ukraine (BioDieselDnepr Ltd, 1, 2010).
- Insurance is calculated as 3% of the beginning year value of the equipment and 2% as the beginning year value of building.
- Prices for fertilisers for algae nutrition are taken from "Lantmännen Lantbruk Park&Mark" (pers.com., 2010). These prices are expected to grow with 1,5% annually (ibid).
- Transportation cost adopted from Den Nya Välfärden (2002) according to the annual inflation indexes (www, ekonomifakta, 1, 2010).
- Annually projected administrative regulatory costs are shown in enclosure 14, part 2.
- For asset depreciation, we chose to apply 2% of depreciation on building and 78% on equipment to depreciate it through its 10 years physical life time.
- Other extraordinary costs are put based on qualified guesswork or else compensated for the account of uncertainties inserted in the stochastic budgeting.

6.4 Results of traditional evaluation method

Examining financial feasibility of ABF project, a capital budgeting model was developed to determine the net cash flows (enclosure 14). To study economical feasibility of the project, several evaluation models were applied. However, this chapter discloses NPV, IRR and payback period calculations.

In defining net present value, business cash flows (EBITDA) were taken as a basis for discounted cash flow analysis. Due to innovative nature of the project, it is perceived to be quite risky business. Therefore, its capital structure consists of 75% of venture capital provided by a business angel at 25% interest rate and 25% assumed as a bank debt at 5% interest rate. However, since EBITDA was used as a basis for NPV, the interest rate on venture capital has been taken as for discounting rate (table 8). Such high discount rate is explained by the fact that business angels usually require high interest rate. Whereas, the bank loan interest rate has been considered in budgeting P&L account for the only purpose to show its influence on profit after tax. Avoiding double discounting of cash flows with the rate of opportunity cost, it has not been included into discounting rate, but they are included in ROA (chapter 6.6).

Table 8. Discount rate and structure of capital (authors' assumption)

Equity (venture capital)	**75%**
Debt (bank loan)	25%
Proportion of capital (debt to equity ratio)	33%
Cost of equity (interest rate)	25%
Cost of debt (interest rate)	5%
Discount rate	**25%**

Herewith, the results of discounted cash flows analysis showed positive NPV which is equal to 11,4 M SEK. The other criteria used for evaluation of project profit also showed positive results where IRR is 47% and greater than discount rate (25%); payback period is 3,1 years, which is perceived to be relatively short meaning that the investment sum can be recovered reasonably quickly. However, the authors leave this indicator for investors' decision. According to the rules of traditional evaluation methods, these calculations lead to conclusion that investor has to accept this project. However, these results represent a certainty equivalent project where inputs are assumed to be known for sure.

6.5 Stochastic budgeting

Indeed, we never know for sure what happens in the future especially when the talk is about political will or state of nature. By incorporating uncertainties associated with the future cash flows into capital budgeting model, we are able to observe the range of possible outcomes of project's profitability.

6.5.1 Uncertainties imbedded in the stochastic budgeting

Presented in table 9 sources of uncertainty and their distributions were incorporated into stochastic budgeting. The types of distribution to the following items are taken as recommendations from external sources (Stockes et al., 2008; Mun, 2006). Whereas, the distributional spread is set on assumptions based on data outlined in the paper. In general, distributions were chosen to capture minimum and maximum predictable levels with corresponding probabilities The actual numbers taken into account are projected in the enclosure 14, part 1, whereas the distribution graphs laid down in the enclosure 7.

Table 9. Uncertainty assumption for capital budgeting model

Uncertainty	Description	Distribution	
Project outlay (investment cost)	Total cost of equipment, start up operational cost, variable and fixed costs for the 1st operational month	Lognormal (enclosure 7)	Mean = 14,8M SEK, Std.Dev.= 1,2M SEK
Production capacity	The amount of fuel production by fractions: gasoline (G), diesel (D), kerosene (K)	Uniform (enclosure 7)	(G): Min = 801 L, Max = 1297 L, Likeliest = 1049 L (D): Min = 5882 L Max = 7247 L, Likeliest = 6564 L (K): Min = 1103 L, Max = 1272 L, Likeliest = 1188 L
Price for output	Producer price for products sold: gasoline (G), diesel (D), kerosene (K)	Lognormal (enclosure 7)	(G): Mean = 6,66 SEK, Std.Dev.= 2 SEK (D): Mean = 6,8 SEK, Std.Dev.= 1,97 SEK (K): Mean = 4,48 SEK, Std.Dev.= 1,13SEK

6.5.2 Results of stochastic budgeting

In figure 4 presented results of stochastic simulation (running 3000 iterations) of NPV with help of @Risk software (2010). It is clear that 20% of all possible outcomes will be less than zero. With 90% confidence, we can say that this project can end up with NPV in the range from -9,2 M SEK to +41,2 M SEK with the mean of 12 M SEK.

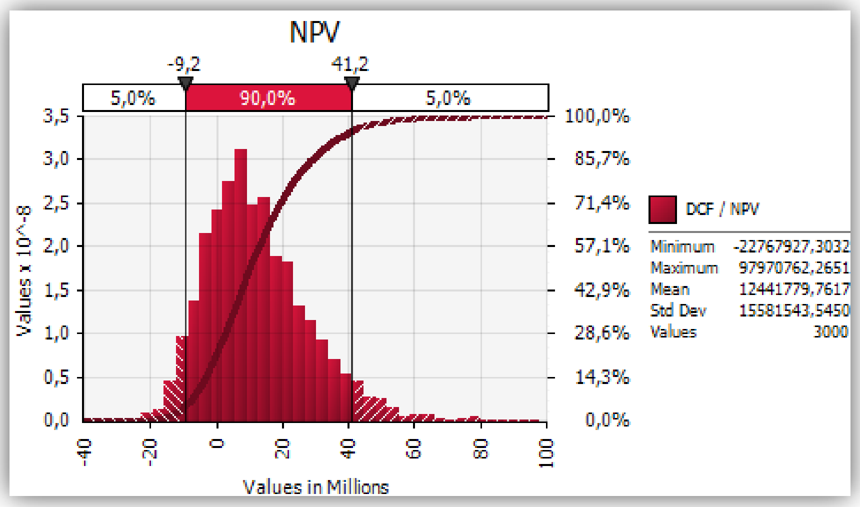

Figure 4. Probability distribution of possible NPVs (authors' calculations, 2010; @Risk, 2010)

In uncertain environment evaluation it is important to know which input has the most influence on the outcome and how a change in particular variables affects the predicted outcome. For this reason, we derived sensitivity analysis based on uncertainties incorporated into stochastic budgeting (figure 5).

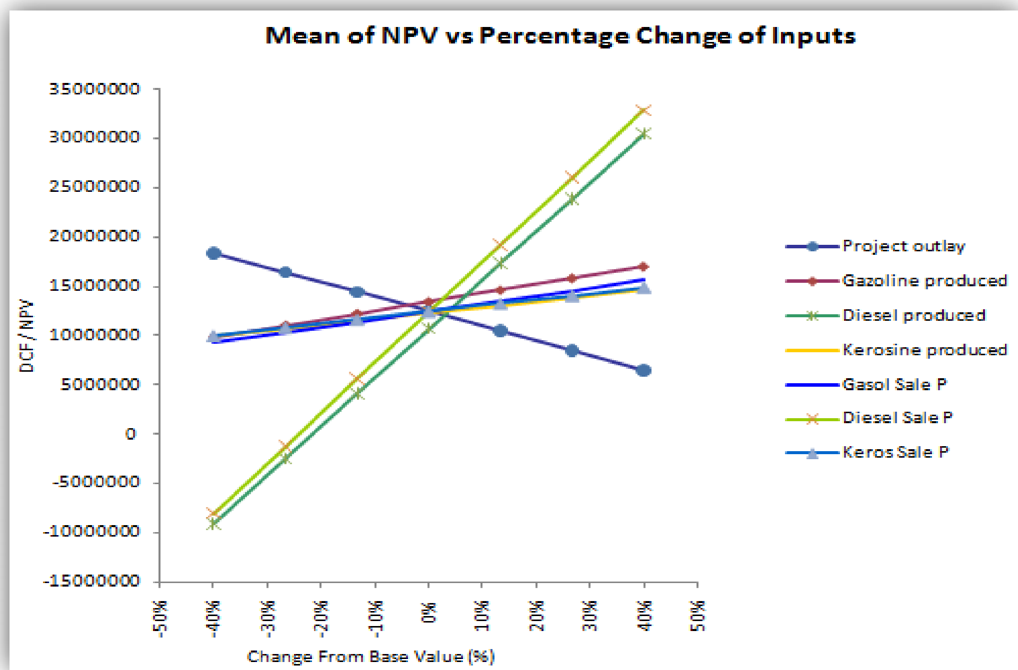

Figure 5. Sensitivity analysis of inputs (authors' calculations, 2010; @Risk, 2010)

From the graph above it is easy to notice that the diesel sales price and its amount produced are very sensitive to changes. Thus, a decrease in diesel sales price by 10% decreases NPV by app. 60%, the same 10% decrease in diesel production decreases NPV by almost 70%. Should be noticed, it is only these variables that can cause NPV to be negative if we expect change from the base value up till 50%. Relatively high sensitivity is observed behind investment cost: a decrease by 10% in investment cost increases NPV by 20%. All other variables are almost indifferent to the change unless large variation from the base vale is expected.

6.6 Results of real option analysis

In traditional valuation methods, only a finite time horizon is considered. However, in reality, once the project is undertaken it is assumed that it will run forever and therefore assumption of GBM with infinite time horizon was applied in evaluation with ROA approach. Moreover, the same approach can be found in a study conducted by Stokes et al. (2008), who valued investment in a methane digester, and a study by Schmit et al. (2009), who did analysis of ethanol plant investment.

To evaluate ABF production plant by method of real option analysis the estimates of volatility, σ^2 and payout rate, δ has been obtained via stochastic simulation. These parameter values are then used to estimate trigger value of the project and its strategic investment opportunity.

Volatility of the underlying asset is estimated from the distribution of probability of discounted NCFs from Monte Carlo simulation using @Risk software (2010). As standard deviation is obtained in the same values as NPV (i.e. millions SEK), relative standard deviation has been used to convert it to percentage equivalent. Thus, a standard deviation of 57% is obtained, corresponding to a variance $\sigma^2 = 0{,}32$. This estimated volatility is within the range of conventional option valuation where the diffusion parameter often approaches 50% (Stokes et al., 2008). The average payout rate, δ is estimated to be 18%. The risk free interest rate is assimilated to inflation-linked government bonds with 10 years maturity date and corresponds to a rate of 4% (www, riskgalden, 1, 2010,).

Based on the above estimates, other unknown parameters, β and A using formulas (11) and (10) correspondingly, were calculated for the purpose of option pricing. Thus, $\beta = 1{,}98$ meaning that the value of the project should be almost twice as large as investment sum before the project should be undertaken. Parameter $A = 0{,}000000025$ is just used for option value (i.e. opportunity cost) calculation.

The clear advantage of using stochastic simulation is that values of some unknown parameters are empirically estimated. Although, the clear disadvantage is that very little is known about precise nature of the uncertainty of the underlying inputs.

Applying the above mentioned estimates into ROA modelling, presented in chapter 4.5.2, it was found that the optimal value of the project, V* at which it is optimal to invest is 30M SEK. Whereas, the calculated present value, V, of the ABF production plant under posed conditions is 26,2M SEK and the option value to “wait and see” is 0,2M SEK (difference between strategic value and NPV line). These results are graphically presented in figure 6. Thus, ROA suggests not investing now (despite of positive NPV) but to wait until more information will arrive. As uncertainty of ABF production plant is high, ROA requires a substantial premium over investment sum in order to shield the risk.

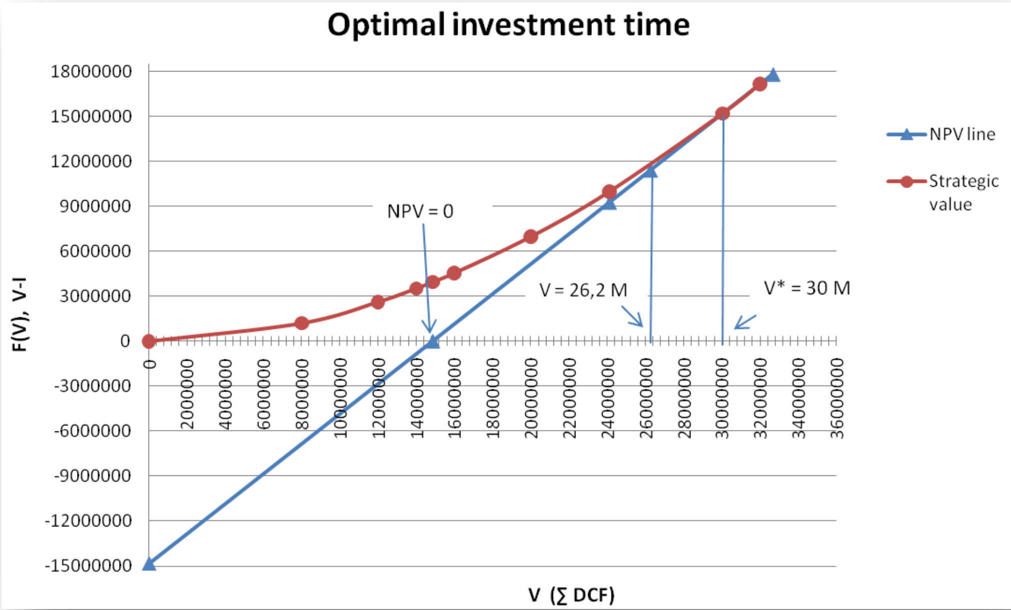

Figure 6 Value of the investment opportunity, F(V), as a function of project value (V), for δ = 0,18, r = 0,04, σ = 0,57 (authors' calculations, 2010)

6.7 Deviation of results

It is know that micro- and macro environments are nowadays dynamically evolving. Therefore replicating this case, one should consider the historical development and current state of affairs in the environment where technology supposed to be placed.

Due to numerous factors, the results may deviate if we put a research object into different content. In our case, the technology invented in Ukraine is studied in Swedish market conditions.

This study was based on the assumption that the equipment was enquired based on EXW Dnepropetrovsk, Ukraine and therefore all transportation, logistics expenditures and custom duties, levies, and VAT has been included to the price of equipment imported to Sweden. Nevertheless, researcher can consider taking into the account the locally purchased equipment as the technology consists of such units that should be available in every country besides those units that are invented at BioDieselDnerp Ltd..

The external factors should be remembered, since the price trends on input and output may fluctuate and, moreover, tend to increase. The political wills are not stable either, and the technology as itself may be more developed and even the method will be upgraded or changed according to the future market challenges.

7 Analysis and discussion

In this chapter authors attempt to analyse results derived in previous chapters, discuss how each method used for investment appraisal impact the investment decision and to answer research questions, which were put at the beginning of this paper.

7.1 Economic and financial feasibility of the ABF production plant

Economic and financial feasibility of the project to a great extend depends on the assumptions applied to the capital budgeting and valuation models. Nevertheless, constructed capital budgeting (enclosure 14, part 2) illustrate that under strict market and financial conditions the project gives positive after tax net cash flows, which profess good financial viability.

Evaluation of economic feasibility is somewhat more complicated. One should bear in mind that discounting rate has significant influence on the result, which is seeing from the sensitivity analysis and proofed by the theory. It should be also repeated that discounting rate is not constant and varies over time, thus changing predicted outcome. Nevertheless, the use of high discounting rate still gives positive NPV, all other being constant, confirming viability of the project.

The use of more ample valuation approach then NPV gives slightly different result. It's rather hard to make an investment decision for risk-averse person under results from sensitivity analysis which showed 20% probability of negative NPV. Hence, it may be a sign of not accepting the project because of its inability. Wide spread of results (high standard deviation) points out to high risk involved. It should be noted that this riskiness is determined by the input data put to the stochastic budgeting. For example, the reason for wide spread between min and max product price is that max price involves taxes that are imposed on fossil fuel. Since biofuels are currently exempted from those taxes, we are not sure how much, and when they will be imposed, we are allowed to take a gap between products cost price and fossil fuel retail price. Under most probable prices, which take only a small part of above mentioned gap, the NPV is positive. However, if biofuels will become a subject to a full taxation the NPV will be negative.

Will ABF production be profitable without governmental support?

From empirical findings and the above analysis become clear: without governmental support ABF production is unlikely to be profitable. At least some of tax reliefs should exist, e.g. no CO2 tax. It is seen from the case study that tax reliefs on biofuels is a good tool for supporting producers of biofuels.

However, investors look not only to the fact of profitability but also rather to its level in comparison with other available options. The approach of ROA is very useful in valuing the opportunity cost. According to the results presented in chapter 6 "empirical findings", despite of positive NPV the estimated project has an option value "to wait" which equals to 0,2M SEK. Under highly uncertain environment, even positive NPV is not sufficient condition to trigger immediate investment. Most investors would prefer to wait until some uncertainties will disperse. Therefore, if the government would like to reach its goal of fossil fuel free society and stimulate production of biofuels, it should consider benefits for biofuel producers that would also cover the opportunity cost.

When is it optimal to invest in ABF production?

As theory of real option suggests, a positive NPV does not necessarily implies the right time for investment. In such rapidly expanding technology as algae fuel production there might be a value to wait and observe future technological and fuel price development. By doing so, the investor might experience a better, more cost efficient method of extracting fuels from algae, a better method of cultivating them, or sufficiently high prices on fossil fuels. On the other hand, by investing today the investor can gain good market share as a "first mover". Eventually, even though Sweden put accent to promote such alternatives as gas and electric cars, it might take a decade or more to change the existent infrastructure. As we observe, methane-deriving technologies are developed long ago but the use of gas in vehicles are still not prevailing fuel. This is because of high investments needed to change the entire infrastructure. Contrary, the ABFs having alike feature with fossil fuels are well fitted to existent infrastructure, therewith being a direct substitute to fossil fuels ABFs should not face any problem in this regard.

An early investment, in its turn, can open up new options, which are not existent before project is actually realised. These options are expansion / scaling up, deferring and later restarting the operation if things go unfavourably and the exit option. By answering the question "when to invest" we should take into account the resulting benefits of the investment and whether they are damaging or benefiting the competitor. Given the degree of secrecy of ABF production, it is expected that the emerging competitors will have contrarian behaviour and thus an aggressive price competition is not expected. Moreover, the option value to "wait and see" is relatively low and the optimal investment point is quite close to an evaluated situation (refer to figure 6). Herewith, the above-mentioned facts and current market situation leads to conclusion that the investor should commit to an early investment.

7.2 Impact of evaluation methods on investment decision

Intuitively, more advanced evaluation methods should provide clearer picture about the posed problem at the same time simplifying managerial decision. But, let us see: ***"how different valuation methods change managerial decision to invest?".***

Under traditional NPV rule, the manager would <u>decide to invest</u>. However, after sensitivity analysis the risk-averse person would be <u>in doubt</u> whether to invest or reject proposal. He/she might want to consult other specialists or spend additional time gathering extra information. Nevertheless, even after that there is no guarantee that he/she will be satisfied with the findings in order to make the correct decision. Theory suggests that when NPV has a marginal value (near 0 or near hurdle rate) it is valuable to use ROA approach. Thereby, real option analysis, despite on positive NPV, tells us to <u>wait</u> until uncertainties disperse and the situation became clearer or until prices for the produced commodities will be high enough to shield the underlying risk.

Supporting the theory, we agree that traditional valuation methods in investment appraisal do not always provide the correct answer. NPV approach is useful under conditions when future predictions are certain. Using NPV method under uncertain environment may frankly lead to a wrong decision. The stochastic budgeting and sensitivity analysis are, of course, supportive in capturing uncertainties and providing wider frame to be considered at the same time introducing carefulness into manager's behaviour. As for today, the most advanced method in valuing irreversible investments (in reality almost all investments are irreversible) is the real options analysis. Real options approach is not just about getting a number, it provides a useful framework in strategic decision making that can help to prevent making mistakes. In the other words, ROA brings flexibility into managerial behaviour. The above analysis is graphically presented in figure 7.

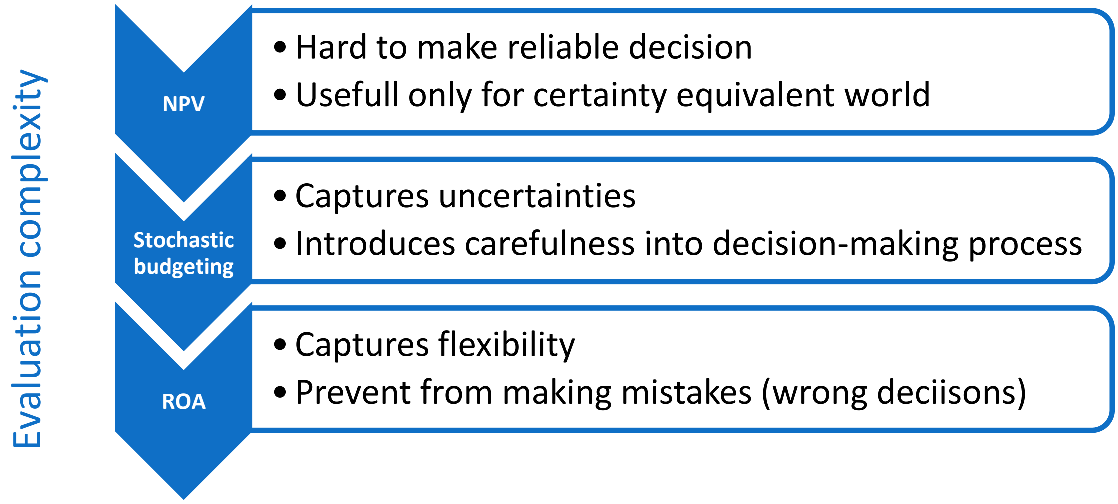

Figure 7. Evaluation methods and their influence on decision-making (developed by author's)

Consequently, advanced valuation methods do not explicitly simplify the process of decision-making but lead to a structural thinking and facilitate in concentrating on critical variables that significantly influence outcome.

Nevertheless, should be pointed that ROA values the opportunity but not the cost of waiting. On this issue scholar has still to work further to find even better way to value irreversible investments, where both opportunities and costs are valued and weighted.

7.3 Opportunities and obstacles for adopting ABF production in Sweden

Prevailing seems to be the opportunities rather than obstacles. A political will directed towards environmentalism makes everything possible to reach its goals for improving the state of affair in the nature. Looking at the Swedish energy policy becomes clear that main accent in support within biofuels is put to RME, ethanol and biogas. It is clearly stated in the Biofuels report (2009) that second-generation biofuels such as RME will continue to be supported even though import of raw materials will be required. Moreover, it encourages with tax exemptions installing the pilot projects within renewable energy sector, which fits to the technology we considered. These are both energy security and environmentally driven factors. Contributory to the opportunity is the fact that Sweden makes the business environment to be more economically attractive. This is confirmed by the observation mentioned in the chapter 6.2

about administrative regulatory costs decreasing tendency. Objectively evaluating this issue one should look at the "The Doing Business project 2009" report (World Bank Group, 2009). It is seen that Sweden is ranked as the 17^{th} on easy of doing business among 181 countries, whereas Ukraine is the 145^{th} one. Therefore, comparing only these two facts it can be easily concluded that opportunity for the technology to be potentially realised is much higher in Sweden since it is more attractive for the investor to run/have business in the more favourable environment. The favourable environment makes the uncertainties less hazardous for the business. Thus, business becomes less risky because uncertainties clarify with the time went by.

However, the competition field has to be always considered as the source of risks involved in adopting such technology. Should be mentioned that technologies producing indirect substituting products as ethanol, RME, biogas do not cause significant threats for the considered project. Simply mentioning a few weak points, those technologies are:

- single product technologies, hence there is no flexibility in the product portfolio;
- dependent on the external raw material supplies, often imported hence are limited;
- infrastructure should be adopted countrywide, hence is too costly;
- machinery should be adopted, which is not supported by the vehicle manufactures. Therefore, heavy construction and transportation machinery as well as aviation fleet have not yet been proposed a final solution in regards of environmentally friendly fuels;
- ethanol and biogas contain less energy, hence are consumed hugely;
- are less friendly in respect of environmental, social and energy safety.

Indeed, there are nowadays newly commercial installations producing synthetic fuels surpassing in the quality and production methods of the above mentioned products. However, whether they are the most successful in gaining the economies of scale on the long run is the only time will prove that.

The fossil fuel industry will be still a direct competitor; moreover, it will take place when the energy tax is imposed on the products of considered project. However, on the contrary the fossil full producers may be more discouraged by carbon tax producing CO_2 depleting fuels. Therefore, they will adopt and they are already trying to incorporate green technologies in their refining facilities. One of such approaches is adoption of algae based source as CO_2 neutral source of hydrocarbon and lipids. Therefore, according to Chernov (2010), newly invented method of cultivation and treating the algae biomass into alga-crude highly suggests for petroleum refinery consider it as means of diversification in raw materials supplies and reduction of impact on the environment. However, as our finding shown the stand alone project is also attractive at the certain conditions, therefore the products produced should be considered as a direct substitute for fossil fuels, hence are the threats for petroleum industry on the municipal level. Moreover, this threat is supported by the fact of "locally produced - locally consumed" concept of the business. This implies the following environmental, social and economical benefits:

- locally created jobs, enforcing rural development and lessen social unemployment benefits assignments;
- significantly reduced delivery cost, since the main raw material "biocrude" is produced on site;
- reduced delivery, handling and storage costs also achieved for the account of direct access to the B2B customer and optionally to B2C, avoiding deliveries to wholesale fossil fuel depots. This is because the ABFs are fully compatible with existent engines and infrastructure;
- lesser transportation reduces CO_2 and other contaminants impact on the nature, hence less health problems in the community resulting in stronger generations.

Finally, the multiple areas of application and issues mentioned in the chapters 3.1.1 and 2.3 set the technology in front of the others that are currently introduced on Swedish market. Herewith, this competitive advantage justifies the claims of being it as the 3rd generation and sustainable technology.

8 Conclusions

The problem raised up in this paper declares about controversy among scientist regarding economic feasibility of ABF production. Findings presented above prove that production of third generation biofuels (in particular fuels from algae) is feasible under certain conditions (e.g. tax reliefs). However, should be mentioned that economic attractiveness of ABF production to a great extend depends on the methods and technology applied.

Taking into account considered technology can be drawn an optimistic conclusion about its economical and financial feasibility. However, the fact that this paper is about a synthetic firm should be kept in mind. The principle "Pay maximum - get minimum" could have led calculations to the worst case scenario, nevertheless the results are still promising. Therefore, as suggestion, the technology should be approved practically on the pilot project running all possible tests on it, which is pointed out in the chapter "Suggestions".

It is clear from the discussion that analytical tools applied here are of great support for investment decision; however, other decision-making methods such as market observation and analysis should not be neglected. The use of more complicated evaluation models does not give the straight answer to the problem but provides hints and guidelines to the structural and strategic thinking. We adhere to the fact that traditional evaluation methods do not give an adequate picture to the problem-solving in a multifaceted reality. We found to be supportive and useful such evaluation methods as stochastic budgeting and real option analysis, which help not only apprise but conceptualize projects facilitating in risk mitigation. Of course, ROA is not perfect valuation method but it is the best what we have for today.

Hence, the contribution of this study is that it reveals economic attractiveness of the shadowed industry and secondly, uncovers the effect of the evaluation method on the investment decision.

8.1 Suggestions

The first need that authors met on the initial stages of research is lack of techno-economic data (due to secrecy of data). This data is the bioengineering estimates that determine the effect of input on output. The data could be used in production function formulation relevant to the technology considered. It is known that each production process has its own specific production function, which is used in profit-cost optimisation problems taking into account constraints. However, testing facilities are needed for this, because "forecasted" engineering production function has to be adjusted to the real production data. The adjusted production function is convenient when one solves the problems of scaling up the capacity of plant, etc..

The hypothesis applied for ROA modelling that value of the project follows GBM would be valuable to verify in further studies. It was assumed that change in project value follows the stochastic trends of fossil fuel prices. It is valuable to prove it because this approach could be easily used for mathematical modelling in other similar problem.

The other issue is that paper studied the project with predefined time life (10 years) under condition that reinvestments have not been taking into account, and the equipments is 100%

depreciated. However, if one considers to replicate this study for its own use for instance business plan, it is suggested to consider an expansion strategy if the accumulated cash flows will allow for that. In such a case, the planner will reach economies of scale, which should positively reflect on the end NPV figure and other financial indexes.

Moreover, intelligence research on the subject of technogenic competitive advantage could be done for the purpose of disclosing the situation whether the considered technology has a direct competitors in the field for the future.

Since authors dealt with relatively new technology, not tested on the long run, proper economical and financial analysis ought to be done based on the historical economic and bioengineering data. Obviously, the historical data is needed for such kind of works; therefore, an empirical observation should be run in the relevant conditions to get such data. Thereafter given the results of empirical observations it will become logical to carry out the decisive studies, such as: life cycle analyses disclosing energy balance, cost benefit analysis, environmental assessment, etc..

Having in mind the environmental goals of country and the equivalent features of technology, could be generally suggested that human kinds should extensively practice R&D of various systems within the multiple area (chapters 3.1.1) of ABF production. Herewith, taking into account the optimistic results of this research, instalment of relevant facilities based on considered technology can be justified in economical terms. Therefore, research institutions will not have financial burden, meanwhile investor has positive cash flows reducing risks through diversification of his\her investment portfolio.

Novelty of technology brings many undiscovered areas to be studied. Therefore, establishing pilot project in Sweden for the purpose of collaboration and exchange of knowledge would be valuable contribution to highly needed infant industry. These united affords have to utilise the highest potential of technology reaching the common goals of environmental and energy safety.

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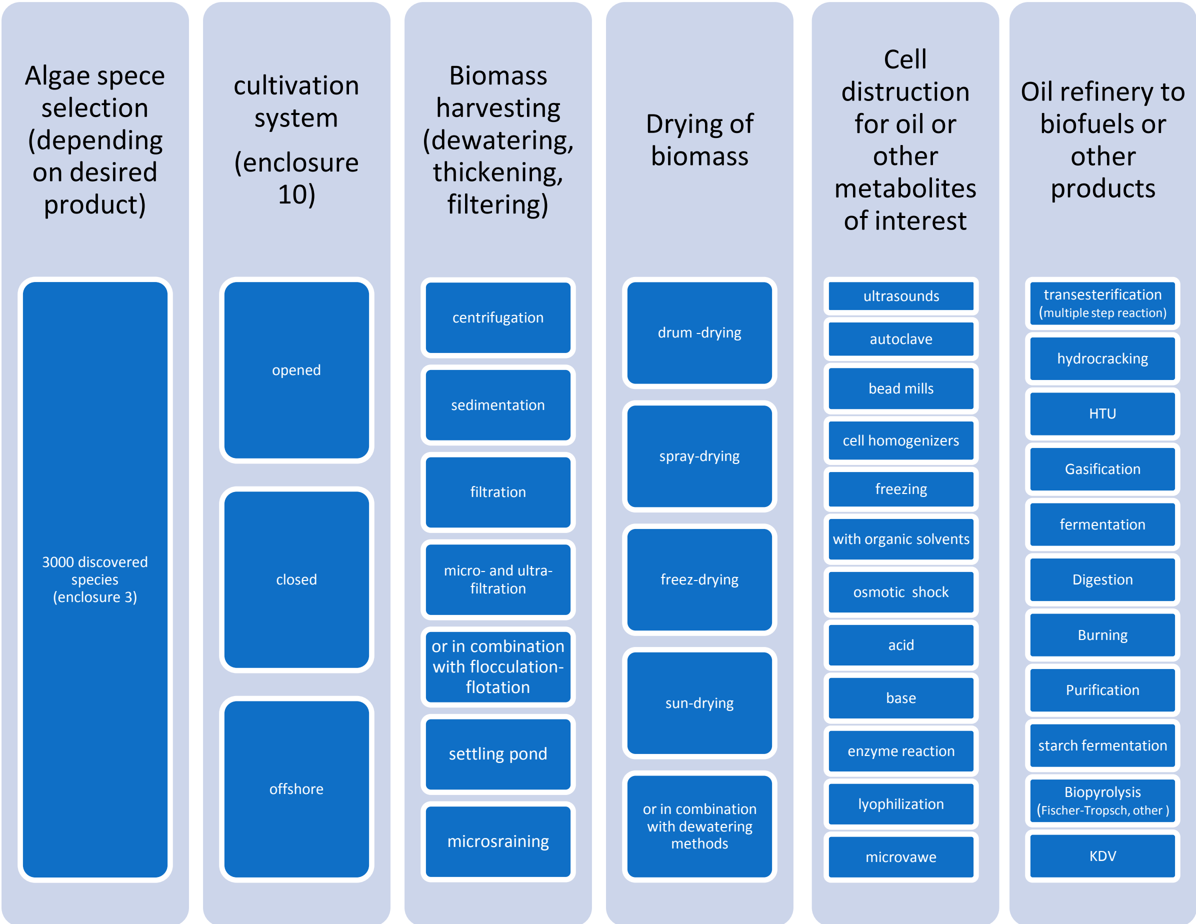
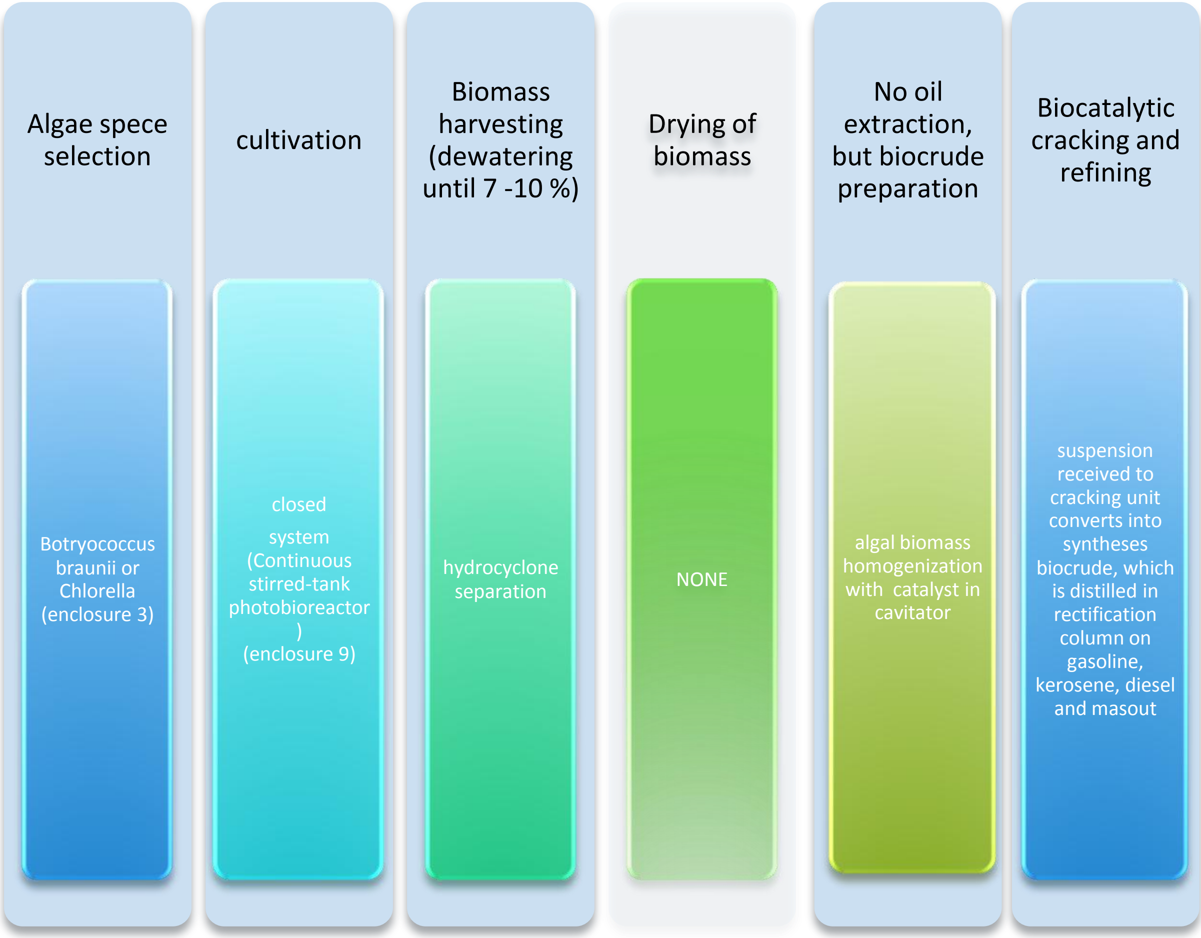
Enclosures

Enclosure 1. Diagram: Biofuels technology outline.



Sources: Alabi et al. (2009); Sjors van Iersel et al. (2009); Mata et al. (2010); Cherubini, et al., (2009); Brennan, L., Owende, P., (2010).

Enclosure 2. BioDieselDnepr generic technology outline.



Source: (BioDieselDnepr, 1, 2, 2010)

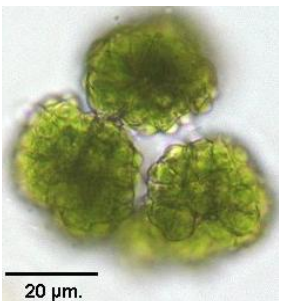
Enclosure 3. Lipid content and productivities of different microalgae species, and comparison with other biodiesel feedstock.

Marine and freshwater microalgae species	Lipid content (% dry weight biomass)	Lipid productivity (mg/L/day)	Volumetric productivity of biomass (g/L/day)	Areal productivity of biomass (g/m^2/day)
Ankistrodesmus sp.	24.0–31.0	–	–	11.5–17.4
Botryococcus braunii	25.0–75.0	–	0.02	3.0
Chaetoceros muelleri	33.6	21.8	0.07	–
Chaetoceros calcitrans	14.6–16.4/39.8	17.6	0.04	–
Chlorella emersonii	25.0–63.0	10.3–50.0	0.036–0.041	0.91–0.97
Chlorella protothecoides	14.6–57.8	1214	2.00–7.70	–
Chlorella sorokiniana	19.0–22.0	44.7	0.23–1.47	–
Chlorella vulgaris	5.0–58.0	11.2–40.0	0.02–0.20	0.57–0.95
Chlorella sp.	10.0–48.0	42.1	0.02–2.5	1.61–16.47/25
Chlorella pyrenoidosa	2.0	–	2.90–3.64	72.5/130
Chlorella	18.0–57.0	18.7	–	3.50–13.90
Chlorococcum sp.	19.3	53.7	0.28	–
Crypthecodinium cohnii	20.0–51.1	–	10	–
Dunaliella salina	6.0–25.0	116.0	0.22–0.34	1.6–3.5/20–38
Dunaliella primolecta	23.1	–	0.09	14
Dunaliella tertiolecta	16.7–71.0	–	0.12	–
Dunaliella sp.	17.5–67.0	33.5	–	–
Ellipsoidion sp.	27.4	47.3	0.17	–
Euglena gracilis	14.0–20.0	–	7.70	–
Haematococcus pluvialis	25.0	–	0.05–0.06	10.2–36.4
Isochrysis galbana	7.0–40.0	–	0.32–1.60	–
Isochrysis sp.	7.1–33	37.8	0.08–0.17	–
Monodus subterraneus	16.0	30.4	0.19	–
Monallanthus salina	20.0–22.0	–	0.08	12
Nannochloris sp.	20.0–56.0	60.9–76.5	0.17–0.51	–
Nannochloropsis oculata.	22.7–29.7	84.0–142.0	0.37–0.48	–
Nannochloropsis sp.	12.0–53.0	37.6–90.0	0.17–1.43	1.9–5.3
Neochloris oleoabundans	29.0–65.0	90.0–134.0	–	–
Nitzschia sp.	16.0–47.0			8.8–21.6
Oocystis pusilla	10.5	–	–	40.6–45.8
Pavlova salina	30.9	49.4	0.16	–
Pavlova lutheri	35.5	40.2	0.14	–
Phaeodactylum tricornutum	18.0–57.0	44.8	0.003–1.9	2.4–21
Porphyridium cruentum	9.0–18.8/60.7	34.8	0.36–1.50	25
Scenedesmus obliquus	11.0–55.0	–	0.004–0.74	–
Scenedesmus quadricauda	1.9–18.4	35.1	0.19	–
Scenedesmus sp.	19.6–21.1	40.8–53.9	0.03–0.26	2.43–13.52
Skeletonema sp.	13.3–31.8	27.3	0.09	–
Skeletonema costatum	13.5–51.3	17.4	0.08	–
Spirulina platensis	4.0–16.6	–	0.06–4.3	1.5–14.5/24–51
Spirulina maxima	4.0–9.0	–	0.21–0.25	25
Thalassiosira pseudonana	20.6	17.4	0.08	–
Tetraselmis suecica	8.5–23.0	27.0–36.4	0.12–0.32	19
Tetraselmis sp.	12.6–14.7	43.4	0.30	–

Source: Mata et al., 2010

Plant source	Seed oil content (% oil by wt in biomass)	Oil yield (L oil/ha year)	Land use (m^2 year/kg biodiesel)	Biodiesel productivity (kg biodiesel/ha year)
Corn/Maize (*Zea mays* L.)	44	172	66	152
Hemp (*Cannabis sativa* L.)	33	363	31	321
Soybean (*Glycine max* L.)	18	636	18	562
Jatropha (*Jatropha curcas* L.)	28	741	15	656
Camelina (*Camelina sativa* L.)	42	915	12	809
Canola/Rapeseed (*Brassica napus* L.)	41	974	12	862
Sunflower (*Helianthus annuus* L.)	40	1070	11	946
Castor (*Ricinus communis*)	48	1307	9	1156
Palm oil (*Elaeis guineensis*)	36	5366	2	4747
Microalgae (low oil content)	30	58,700	0.2	51,927
Microalgae (medium oil content)	50	97,800	0.1	86,515
Microalgae (high oil content)	70	136,900	0.1	121,104

Source: Mata et al., 2010



Botryococcus braunii. Source: www, Rudekinc, 1, 2010; www, Lifesciences, 1, 2010;

Enclosure 4. Accounts from demo plant in Ukraine. Production capacity per 24h is 10 – 12 tons of biocrude.

Staff employed: Chemist – 1, biologist – 1, operators – 4, facility manager – 1, secretary – 1.

Capital investments:

Production equipment (БиоМ – 1™, БКК™, other facilities):	4.872.000 UAH
Other establishing costs (tank park, interior construction works and installment electrical equipment, laboratory equipment, CO_2*:	500.000 UAH
Electricity*:	250kW/h*24*10*0,78 = 46.800 UAH
TOTAL:	**5.418.800 UAH**

*CO_2 is purchased for start up, electricity purchased during first 10 days for 0,78 UAH per kW/h.

Monthly production capacity in terms of biomass: 11 tons x 30 = 330 tons

Monthly product outcome is 70% of 11 t biomass (less 2% waste): 748 kg x 11t x 30 = 246,84 tons of synthetic fuels from algae and eichhornia

Revenue:

Product slate (70%) derived from 1,1 t of biocrude (biomass with density 0,96g/cm^3 at 20 C^o) consists of the following distillates (in average reached):			**Revenue, UAH**	
			Sales price	earnings
Diesel	70%	539 kg	5	2695
Gasoline	10%	87 kg	6	522
Kerosene	15%	89 kg	3	267
Masout	3%	33 kg	1,5	49,5
Wastage and fertilisers	2%	- 24 kg		
TOTAL:		748 kg		**3533,5 UAH**

Production costs:

	unit	Per ton of biomass	Price UAH per 1kg	Cost
H_2O	t	2,5	8,44 / m^3	21,1
CO_2	t	1,4	1,24	
KNO_3 (potassium-nitrate)	kg	0,56	9,48	4,74
$Ca_3(PO_4)_2$ (calciumphosphat)	kg	0,333	3,6	1,2
$MgSO_4$ (magnesium sulfate)	kg	0,25	3,6	0,9
$FeSO_4$ (ferrous sulphate)	kg	0,066	0,76	0,05
$C_6H_8O_7$ (citric acid)	kg	0,5	9,80	4,9
TOTAL:				**32,9 UAH**

Salaries	18 000 /330 = 54,55 UAH
Transportation cost	5 000/330 = 15,15 UAH
Depreciation of investments	5.418. 800x40/100/12/330 = 547,35 UAH
Overhead expenses	4.000/330 = 12,12 UAH
Marketing	2000/330 = 6,06 UAH
Other costs	10.000/330 = 30,30 UAH
Taxes	3533,5x30x0,9% = 954,04 UAH
TOTAL:	**1620 UAH**

Production profitability calculation:

Income from product slate sold (748kg)	3533,5 – (1620 x 1,1) = 1751,5 UAH
Income from 1 ton of fuels sold	1751,5 / 748 x 1000 = 2341,6 UAH
Monthly income	2341,6 x 246,84 = 577995 UAH
Payback period	5.418. 800/577995 = 9,3 months
Profitability	2341,6 /(1620 x 1,1) *100 = 131,4 %

Source: translated from BioDieselDnerp Ltd., 1, 2010.

Enclosure 5. List of keywords used for literature search

Algae fuel*	economic efficiency*
Algae biofuel*	economic feasibility*
synthetic fuel	economic viability*
algae biodiesel*	economic assessment*
algae diesel*	investment option*
Microalgae*	profit maximization*
	real option analysis*
	financial appraisal*
	efficiency*
	product slate
In Swedish	
Alger bränsle*	ekonomisk effektivitet*
Alger biobränsle*	ekonomisk genomförbarhet*
syntetiskt bränsle*	ekonomisk vialability*
Alger biodiesel*	ekonomisk bedömning*
alger diesel*	investeringsalternativ*
Mikroalger*	vinstmaximering*
drivmedel*	lönar analys*
GROSSHANDELSPRIS	finansiella bedömningar*
RME*	Kostnaden för optimal*
Flygfotogen	effektivitet*
Flygbränsle	
flyfotogen	skattesatser drivmedel
drivmedel skater	Alternativa drivmedel
Beskattningen av drivmedel från förnybara energikällor	koldioxidneutrala drivmedel
algbränsle	
In Danish	
Alger brændsel *	økonomisk effektivitet *
Alger biobrændstof *	økonomiske gennemførlighed *
syntetisk brændstof	økonomiske vialability *
alger biodiesel *	økonomisk vurdering *
alger brændsel *	investering option *
alger diesel *	gevinstmaksimeringspolitik *
Mikroalgen *	reelt valg analyse *
Biobrændstoffer*	finansiel vurdering *
	cost optimazation *
	effektivitet *
or investeringer under usikkerhed* or reel mulighed analysis*	
or investering under osäkerhet * or verkliga analysis alternativ*	

Enclosure 6. Historical and forecasted prices of fossil fuels

Historical data of Benzine and Diesel prices, excl. VAT, last updated on 2010-03-16 (www, SPI, 1, 2010)

Historical data of Kerosine, excl. VAT (Dagens Industri, 2010; pers.com. Svenska Statoil AB, 2010)

Forecasted prices, Öre per liter, derived on 10.04.2010

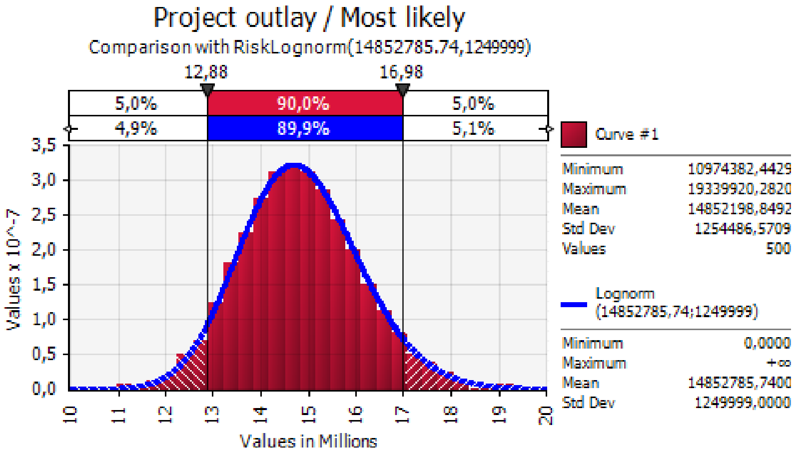
(blue) **Holt-Winter's Multiplicatiive**

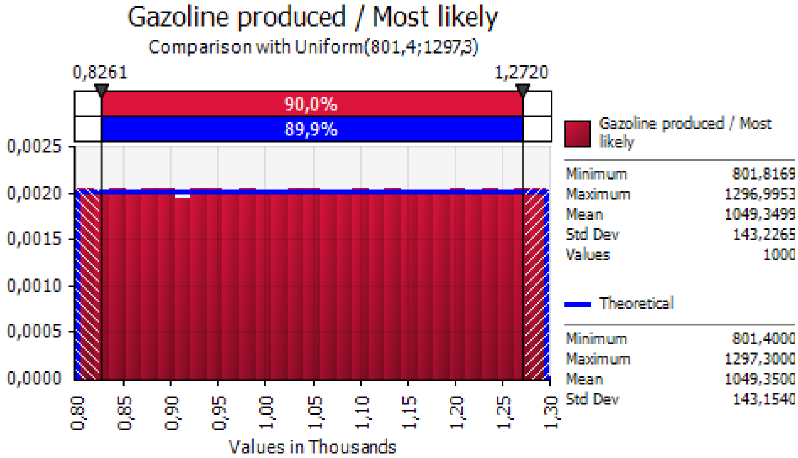
(green) **Double Exponential Smoothing**

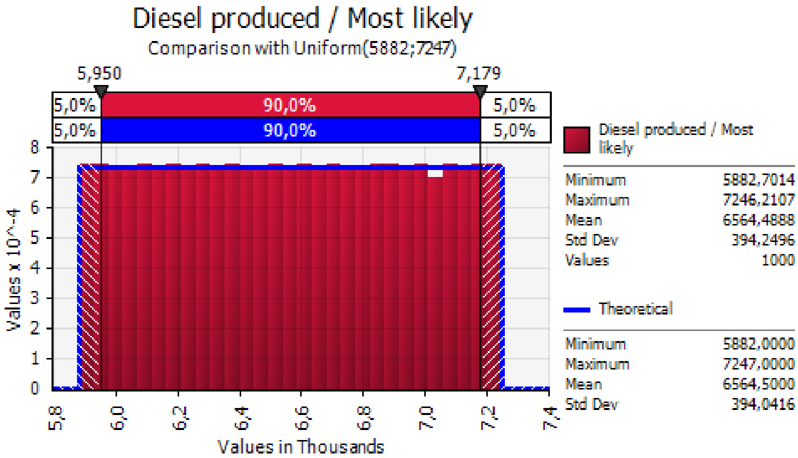
Year	Orig. BenP	**Frcst BenP**	**Frcst BenP**	Org. DisP	**Frsct DisP**	**Frsct DisP**	Org. KerP	**Frcst KerP**	**Frcst KerP**
1970	92			67					
1971	102	92		77	67				
1972	102	101	101	74	74	75			
1973	107	103	103	82	75	75			
1974	137	107	108	55	81	81			
1975	141	135	135	50	62	62			
1976	159	145	145	59	53	52			
1977	163	162	162	60	57	56			
1978	185	169	169	66	59	58			
1979	218	190	190	98	64	64			
1980	294	223	223	148	90	90			
1981	352	298	297	184	137	137			
1982	394	367	364	233	179	179			
1983	417	417	414	252	231	230			
1984	424	446	444	285	261	259			
1985	467	455	453	305	296	293			
1986	417	493	491	230	321	318			
1987	420	453	452	257	269	266			
1988	448	444	443	267	272	270			
1989	479	464	463	322	279	278			
1990	526	494	494	382	323	322			
1991	543	541	540	413	383	381			
1992	532	565	564	394	424	422			
1993	642	558	557	482	421	419	Org. KerP		
1994	626	652	651	565	486	484	159		
1995	634	656	655	544	570	568	154	159	
1996	690	661	661	524	578	576	181	156	156
1997	689	709	708	532	563	561	184	172	172
1998	675	717	716	504	562	560	134	181	181
1999	699	704	703	533	539	536	180	152	152
2000	791	719	719	675	551	549	334	169	169
2001	786	802	801	696	663	662	312	280	280
2002	774	814	813	673	714	712	325	312	312
2003	781	803	803	636	710	708	301	334	334
2004	828	804	804	693	678	676	386	326	326
2005	915	844	843	838	710	708	557	378	378
2006	948	928	927	886	829	829	632	512	512
2007	956	974	973	870	902	902	622	619	619
2008	1032	988	988	1050	911	910	867	656	656
2009	997	1055	1055	918	1049	1048	559	831	831
2010	1110	1036	1036	1015	989	987	642	699	699
2011		1128	1128		1041	1040		693	693
2012		1162	1162		1075	1072		720	720
2013		1196	1196		1109	1105		748	748
2014		1231	1230		1142	1138		776	776
2015		1265	1264		1176	1171		803	803
2016		1299	1299		1210	1203		831	831
2017		1333	1333		1243	1236		858	858
2018		1367	1367		1277	1269		886	886
2019		1402	1401		1311	1302		914	914
2020		1436	1435		1345	1334		941	941

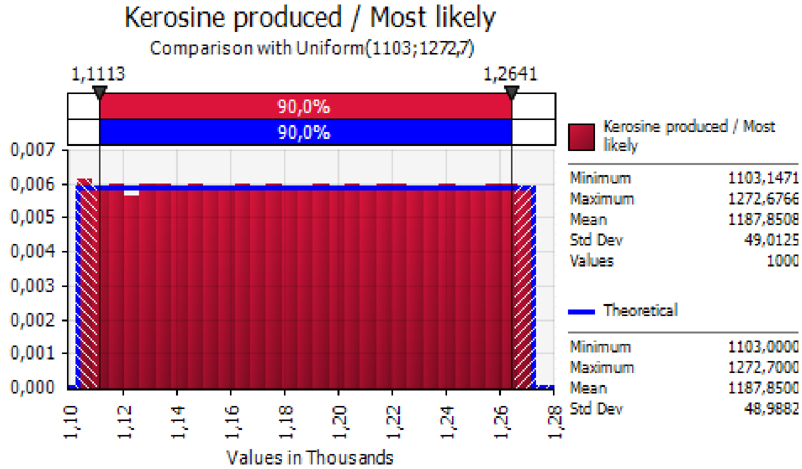
Source: authors' calculation on Risk Optimiser software (2010)

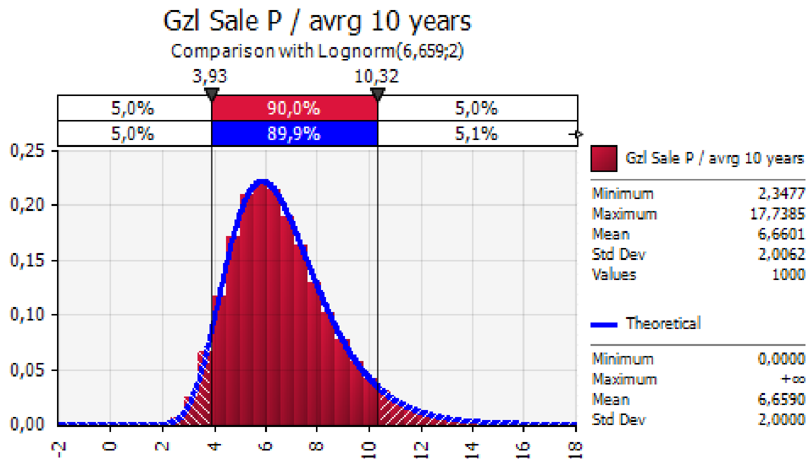
Enclosure 7. Uncertainty distributions

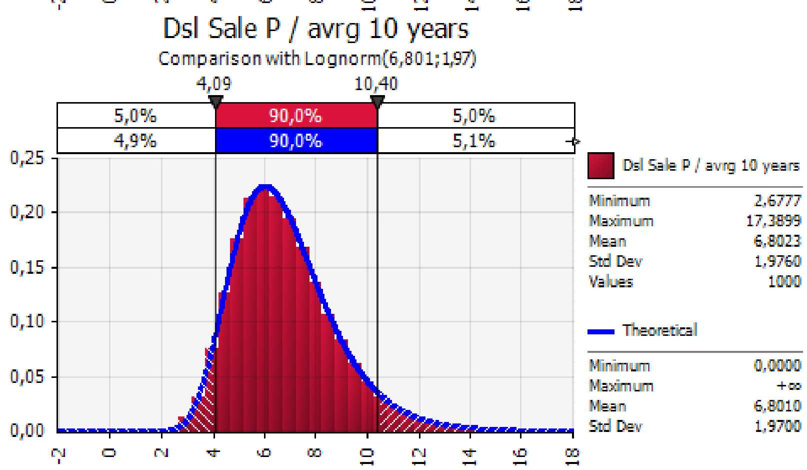


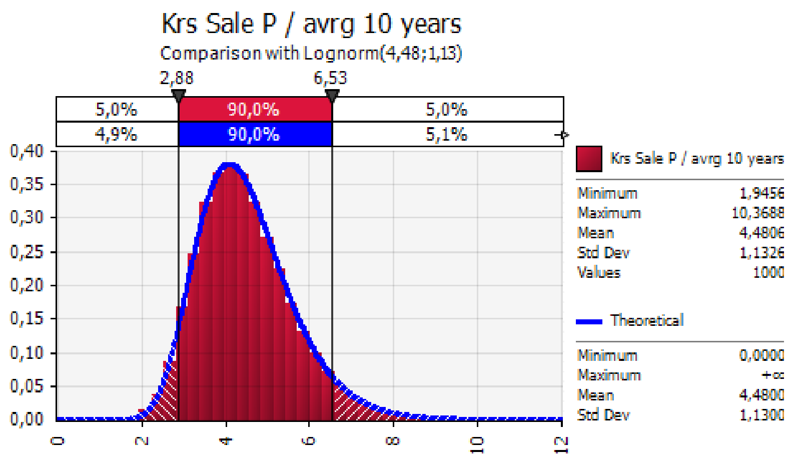






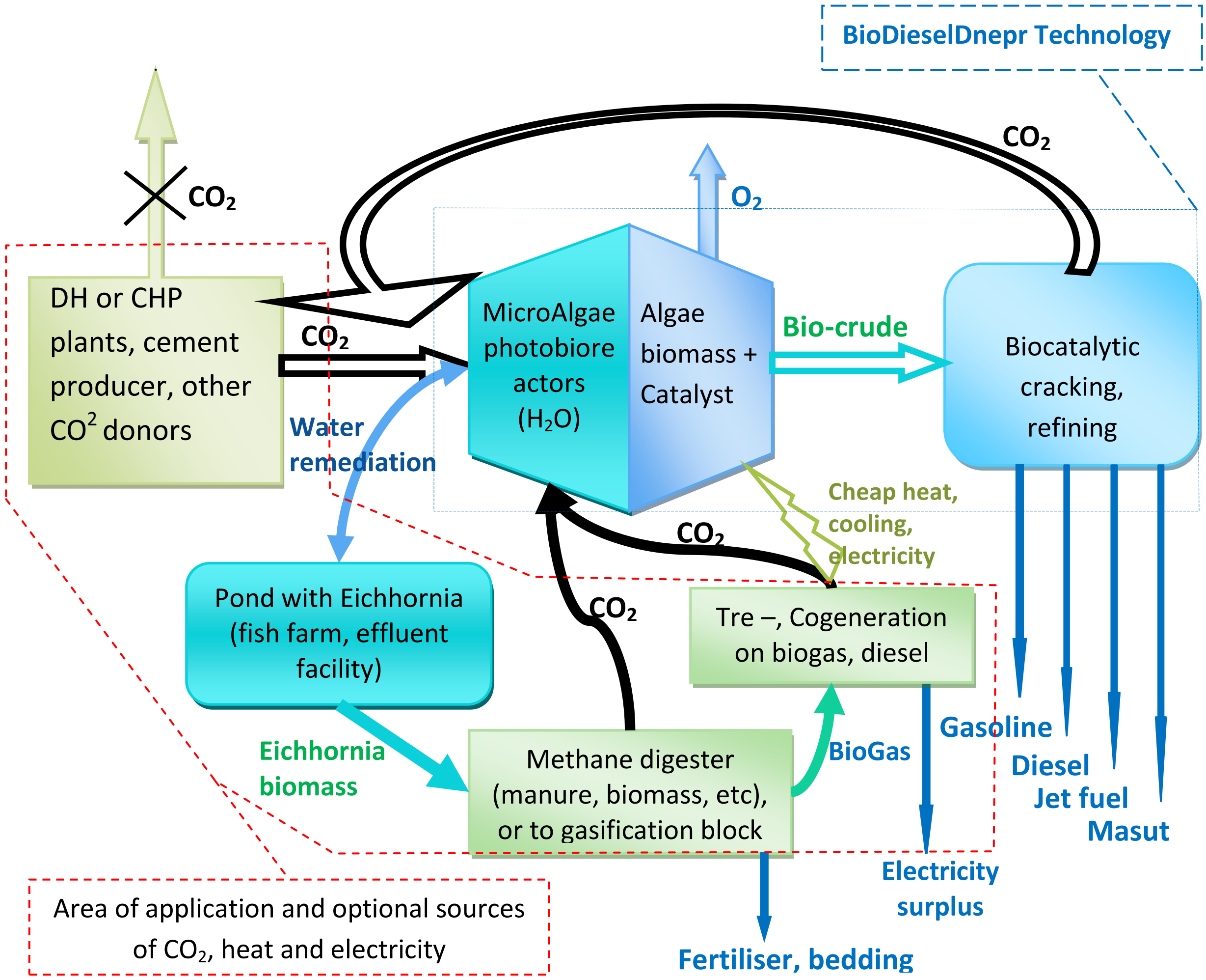






Source: authors' calculations on @Risk software (2010)

Enclosure 8. ABF production and application area for BioDieselDnepr technology



Source: BioDieselDnepr Ltd, 1, 2 (2010); pers. com. Chernov (2010)

Enclosure 9. BioDieselDnerp photobioreactors

Source: BioDieselDnepr Ltd, 1, 2 (2010); Chernov (2010)

Enclosure 10. Other cultivating systems

Traditional bag system (Neltner, 2008)

Tubular photobioreactor inside greenhouse (Berg-Nilsen, 2006)

Tubular photobioreactor outside system (Fredin, 2009)

Open race ponds and lakes (Moheimani, 2005)

Enclosure 11. Investment and establishing costs

Investment costs for production of 10-12 t of biomass per day			
Equipment			5,539,147
Real estate, building 2000m^2 + land 1000m^2			4,500,000
Intrusion alarm			250,000
CCTV Surveillance system			180,000
Fire Alarm System			325,000
Laboratory equipment			280,000
IT and office facilities			255,000
Capacitive tank park:	**Q**	**P per unit**	
Benzin, 10 m3	1	60,000	60,000
Diesel, 50 m3	1	150,000	150,000
Jet fuel, 10 m3	1	60,000	60,000
		TOTAL, SEK:	**11,599,147**

Establishing and start up operational costs 1st year			
Research and Market analysis:			
Marketing			120000
Extraordinary costs (meetings)			17000
Counselling, municipal approvals and inspection:			
Legal expertises			85000
IT experts			53000
Administrative regulatory costs (www, Regelkostnader, 1, 2010)			2190311
Extraordinary costs (tech. advising)			23000
Start up operational costs:	**Q**	**P per unit**	
CO2 for start up, tonn	15.4	1,524	23,470
Electricity for start up, kWt	60000	0.86	51,600
		TOTAL, SEK:	**2,563,381**

Source: Assembled by authors based on research observations from Swedish market, 2010.

Enclosure 12. Fixed and variable costs

Variable Costs (VC) for production of 11 ton biomass per 24h

Assumption: total chemicals annual increase by 1,5%

	Rate per 1 ton biomass, kg	Price (SEK/kg)	Value, SEK	1 year	2 year	3 year	4 year	5 year	6 year	7 year	8 year	9 year	10 year
Production cost of 1 ton biomass:													
Nitrogen fertilizer	0.5	11.85	5.925	11,732	23,463	23,463	23,463	23,463	23,463	23,463	23,463	23,463	23,463
Phosphoric fertilizer	0.333	9.4	3.1302	6,198	12,396	12,396	12,396	12,396	12,396	12,396	12,396	12,396	12,396
MgSO4	0.25	4.95	1.2375	2,450	4,901	4,901	4,901	4,901	4,901	4,901	4,901	4,901	4,901
FeSO4	0.066	10	0.6600	1,307	2,614	2,614	2,614	2,614	2,614	2,614	2,614	2,614	2,614
Citric acid	0.5	9.8	4.9	9,702	19,404	19,404	19,404	19,404	19,404	19,404	19,404	19,404	19,404
Total chemicals:				31,388	62,777	63,718	64,674	65,644	66,629	67,628	68,643	69,672	70,717
	t	m3											
Water,t	2.5	6.9	17.25	380	759	759	759	759	759	759	759	759	759
Extraordinary costs				75,000	40,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000
	Fuels, litters	kr/l											
Transportation costs	8672.51	0.74		1,155,178	2,310,357	2,310,357	2,310,357	2,310,357	2,310,357	2,310,357	2,310,357	2,310,357	2,310,357
			TOTAL VC, SEK	**1,261,946**	**2,413,892**	**2,404,834**	**2,405,790**	**2,406,760**	**2,407,745**	**2,408,744**	**2,409,758**	**2,410,788**	**2,411,833**

Source: Authors' calculations, 2010

Fixed Cost

Annual salary increase, real: 2%

	1 year	2 year	3 year	4 year	5 year	6 year	7 year	8 year	9 year	10 year
Facility manager	180000	384000	391680	399513.6	407504	415654	423967	432446	441095	449917
Secretary	132000	216000	220320	224726	229221	233805	238481	243251	248116	253078
Operator (3 employees)	324000	828000	844560	861451	878680	896254	914179	932462	951112	970134
Biologist	147000	342000	348840	355817	362933	370192	377596	385148	392850	400708
Chemist	171000	348000	354960	362059	369300	376686	384220	391905	399743	407737
Laboratory costs (reagents,other)	10578	20764	20764	20764	20764	20764	20764	20764	20764	20764
Internet and phone communication	23400	28800	28800	28800	28800	28800	28800	28800	28800	28800
Marekting	0	55000	55000	55000	55000	55000	55000	55000	55000	55000
web page hosting and maintance, domain	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
Maintance of equipment	47861	95721	95721	95721	95721	95721	95721	95721	95721	95721
Maintance of building	22500	45000	45000	45000	45000	45000	45000	45000	45000	45000
Insurance of facilties and estates	253172	124098	94334	86445	83395	81437	79744	78135	76570	75037
Security monitoring	11100	22200	22200	22200	22200	22200	22200	22200	22200	22200
Accounters/Auditors	12000	20000	20000	20000	20000	20000	20000	20000	20000	20000
Overheads	80000	100000	80000	80000	80000	80000	80000	80000	80000	80000
TOTAL, SEK	**1,417,611**	**2,632,583**	**2,625,179**	**2,660,497**	**2,701,519**	**2,744,513**	**2,788,672**	**2,833,832**	**2,879,971**	**2,927,097**

Source: Authors' calculations, 2010

Enclosure 13. Administrative regulatory costs

Definitioner

NNR har i fallstudierna valt att dela in företagens regelkostnader i tre olika typer. De tre typern benämner vi och definierar vi på följande sätt:

- **Administrativa kostnader** till följd av krav på att upprätta, sammanställa, lagra eller skicka in information till myndigheter eller tredje part.
- **Materiella kostnader** till följd av krav som medför att de måste göra investeringar i anläggningar eller personal, anpassa produkter eller kostnader för att genomföra åtgärder som exempelvis rehabilitering eller åtgärder kopplade till arbetsmiljö.
- **Finansiella kostnader** till följd av krav på att betala skatter och avgifter.

Vilken lagstiftning ingår?

Utgångspunkten har varit att identifiera företagens kostnader för de stora centrala lagarna, förordningarna och myndighetsföreskrifterna och som berör företagen på ett betydande sätt. Vi har lyft fram och frågat om de mest kostsamma reglerna på följande områden:

- Arbetsmarknadslagstiftningen
  – inklusive arbetsmiljö
- Miljölagstiftningen
- Skattelagstiftningen
  – inklusive årsredovisnings- och bokföringslagstiftning
- Branschlagstiftning som är relevant för det enskilda företaget

Source: Näringslivets Regelnämnd, 2008

Table. Example of administrative regulatory costs in diffrent businesses of Sweden (Näringslivets Regelnämnd, 2008)

	Gnosjö automat-svarvning	Anna Norberg Buss	Stjernsunds Gård	Welcome-Gruppen	Kemibolaget i Bromma	Tranås Energi
Anställda	26	15	7	32	20	14
Omsättning (mkr)	50	13,1	16	37,5	46,8	57,9
Regelkostnader totalt (mkr)	4,8	3,1	2,6	4,3	6,0	5,8
Regelkostnader per anställd (kr)	186 000	204 000	365 000	134 000	298 000	414 000

Enclosure 14. Investment appraisal and P&L.

Investment appraisal of 10 years projet with production capacity - 7,7 t/24h or 8534 l/24h

Investment required		Structure of capital and Discount rate	
Equipment and technology related	11.598.770	Equity (venture cptl)	75%
Establishing, Start up, Admin. Regl. Cst	2.563.381	Debt (bank loan)	25%
Variable Cost, first month operational	223.116	Proportion of capital	33%
Fixed Cost, first month	467.519	Cost of equity (interest r)	25%
Total to invest	**14.852.786**	Cost of debt (interest r)	5%
		Discount rate	**25%**

Uncertainty assumptions

	Most likely	Min	Max	Distribution
Project outlay	14.852.786	14.000.000	17.000.000	Lognormal
Discount Interest rate	25%	Mean = 20%,	Stdv = 2%	Lognormal
Production capacity per 24 h, l:				
Gazoline produced	1.176	801	1.297	Uniform
Diesel produced	6.341	5.882	7.247	Uniform
Kerosine produced	1.156	1.103	1.273	Uniform

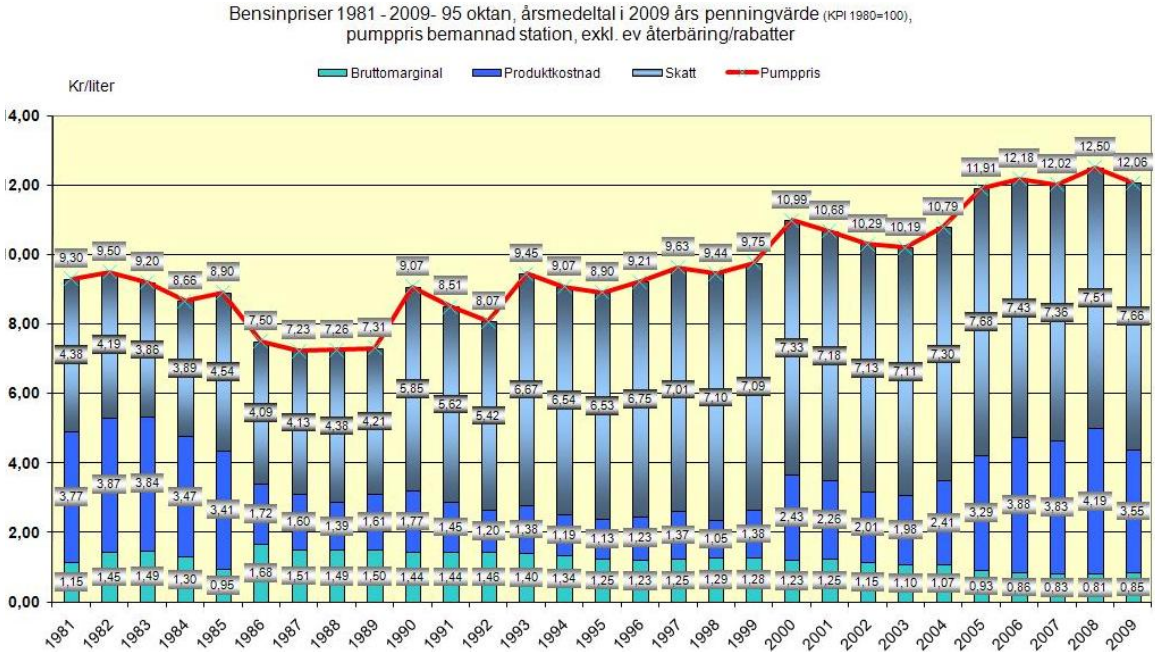
Price for output , SEK (excl. VAT):	**avrg 10 years**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Gazoline list price with 20% discount, Max	10,25	9,0	9,3	9,6	9,8	10,1	10,4	10,7	10,9	11,2	11,5
Gzl Sale Price	6,66	5,86	6,04	6,22	6,39	6,57	6,75	6,93	7,10	7,28	7,46
Min P	4,87	4,28	4,41	4,54	4,67	4,80	4,93	5,06	5,19	5,32	5,45
Diesel with 20% discount, Max	9,49	8,3	8,6	8,8	9,1	9,4	9,6	9,9	10,1	10,4	10,7
Dsl Sale Price	6,80	5,96	6,15	6,33	6,52	6,71	6,89	7,08	7,27	7,46	7,64
Min P	5,46	4,78	4,93	5,08	5,23	5,38	5,53	5,68	5,83	5,98	6,13
Kerosine with 20% discount, Max	6,53	5,54	5,76	5,98	6,20	6,42	6,64	6,86	7,09	7,30	7,528
Krs Sale Price	4,48	4,0	4,1	4,3	4,4	4,6	4,8	4,9	5,1	5,2	5,4
Min P	3,75	3,18	3,31	3,44	3,56	3,69	3,82	3,94	4,07	4,20	4,32

Source: Authors' calculation, 2010 (part 1)

Profit & Loss account converted for analysis purpose(SEK)		half 2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Net turnover from products sold		10103776	20207553	20207553	20207553	20207553	20207553	20207553	20207553	20207553	20207553
Less Variable Costs		1261946	2413892	2404834	2405790	2406760	2407745	2408744	2409758	2410788	2411833
Gross margin		8841830	17793660	17802719	17801763	17800793	17799808	17798809	17797794	17796765	17795720
Less Fixed Cost		1417611	2632583	2625179	2660497	2701519	2744513	2788672	2833832	2879971	2927097
Less Establish. and Adm. Regul. costs (www, regelkostnader, 1, 2010)		2563381	6438608	6816349	7075051	7309634	7533581	7760999	7987352	8207895	8434276
Operating margin (EBITDA)		4860839	8722470	8361191	8066215	7789640	7521714	7249137	6976610	6708899	6434347
Less depreciations		4332475	1021544	291772	129881	92951	83539	80207	78237	76592	75042
Profit before interest		528364	7700926	8069420	7936333	7696689	7438174	7168930	6898373	6632307	6359305
Less interest on Venture fund	0,25	-2812746	-2812746								
Less Interest on bank loan	0,05	-187516	-187516								
Cash credit interest costs +/- income	+0,00125 / -0,02	11425	15573	16211	37771	59373	81291	103774	125599	147497	169468
Profit after interest		-2460474	4716236	8085630	7974104	7756062	7519465	7272705	7023971	6779804	6528772
Less tax	0,28	0	1320546	2263976	2232749	2171697	2105450	2036357	1966712	1898345	1828056
Profit after tax		-2.460.474	3.395.690	5.821.654	5.741.355	5.584.365	5.414.015	5.236.347	5.057.259	4.881.459	4.700.716
NPV, IRR, PBP, AAP, Payout rate, etc..											
Rational Economic life	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Initial Investment against EBITDA	-14.852.786	4860839	8722470	8361191	8066215	7789640	7521714	7249137	6976610	6708899	6434347
Scrab Value (building)											3.676.828
Discounting rate, factor	**25%**	0,800	0,640	0,512	0,410	0,328	0,262	0,210	0,168	0,134	0,107
DCF	-14852786	**3.888.671**	**5.582.381**	**4.280.930**	**3.303.921**	**2.552.509**	**1.971.772**	**1.520.254**	**1.170.481**	**900.453**	**1.085.679**
NPV	**11.404.266**	3888671	5582381	4280930	3303921	2552509	1971772	1520254	1170481	900453	1085679
IRR	**47%**		-5%	20%	32%	39%	42%	44%	45%	46%	47%
Accumulating Discounted Cash flow	-14852786	-10964115	-5381734	-1100804	2203118	4755627	6727399	8247653	9418134	10318587	11.404.266
Pay back period, years	**3,1**										

Source: Authors' calculation, 2010 (part 2)

Enclosure 15. Fossil gasoline price structure



Source: www, SPI, 3, 2010