SWOT

BioFuel SWOT - Analysis

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Content

1. Introduction

In times of shrinking fossil energy resources, biofuels are a visible alternative for satisfying today's transport needs. Among many others, the main advantages of biofuels are their potential to reduce greenhouse gas emissions and their contribution to secure energy supply. On the other hand, the production of biofuels is land and cost intensive.

In order to get an overview of advantages and disadvantages of biofuels, a SWOT analysis was conducted in the framework of the project Biofuel Marketplace. This analysis addresses biofuels in comparison with fossil fuels and in comparison with each other. It will serve as a basic document for creating a favorable policy framework to promote biofuels.

The project Biofuel Marketplace (www.biofuelmarketplace.com) provides a biofuel information portal combined with a supply and demand information system (a web-based biofuel marketplace) in order to provide a forum where Europe's biofuel stakeholders can promote their technologies, exchange ideas, sell and buy biofuel products, disseminate results of national, international and European research activities and raise awareness of the public and the professional community. Recent European advances, projects, products, results and patents are screened at strategic, management and technological levels and the commercially feasible results of European initiatives are fed into the Biofuel Marketplace to be made available for all European stakeholders through the project website.

2. Method

Originally a SWOT Analysis is a strategic planning tool used to evaluate the Strengths, Weaknesses, Opportunities, and Threats involved in a business venture. In this paper the SWOT Analysis is not applied to a specific business venture, but to technologies for the production of biofuels. Factors which are internal to the technology usually are classified as strengths (S) or weaknesses (W), and those external to the technology (in competition with other technologies) are classified as opportunities (O) or threats (T). The SWOT matrix is shown below.

	positive	negative
internal	**Strength**	**Weakness**
external	**Opportunity**	**Threat**

The objective of this SWOT analysis is to demonstrate most suitable biofuels in order to replace fossil fuels. Therefore, a SWOT analysis was conducted in a first step by comparing biofuels with fossil fuels.

In a second step, a distinct SWOT analysis was conducted for different biofuel types including bioethanol, lipid derived fuels, biomethane, BtL-fuels and bio-hydrogen. A separated SWOT analysis for different types of biofuels is necessary since their life cycles vary largely, depending on feedstock type and cultivation, processing, and application. Further, the result of evaluating these fuels is largely influenced by natural (climatic, topographic) conditions of the cultivated region. For example, production of bioethanol from sugarcane in Brazil is much more efficient, than ethanol production from starch in Europe. In order to reduce geographical impacts on the evaluation of biofuels, the SWOT analysis was only conducted for Europe, though even in Europe the conditions vary largely from region to region.

Regarding the results, the reader should keep in mind that the number of positive or negative aspects does not determinate the overall evaluation of the fuel, as all aspects and arguments are qualitative and not quantitative in nature.

3. Results

The demonstration of the results is based upon tables showing the strengths, weaknesses, opportunities, and threats. These tables provide an overview of the advantages and disadvantages of biofuels. A detailed description about the whole life cycle of biofuels is given by RUTZ & JANSSEN (2007).

3.1. SWOT Analysis for Biofuels and Fossil Fuels

In this chapter, a SWOT analysis was conducted by generally comparing biofuels with fossil fuels. Both fuel types are substitutes and in competition, but only biofuels are renewable and therefore a sustainable option as transport fuel. Apart from this broad comparison, a detailed SWOT analysis for different biofuel types is presented in the subsequent chapters.

	Biofuels	**Fossil fuels**
Strengths	The production of biofuels contributes to secure energy supply.	Long term experience exists for the production and use of fossil fuels.
	The use of biofuels can reduce GHG emissions.	A well established infrastructure (filling stations; vehicles) exists for fossil fuels.
	Due to a longer value chain within the national boundaries, biofuel production creates new employment.	The production of fossil fuels is characterized by scale effects because of centralized refineries.
	Feedstock production for energy purposes creates jobs especially in rural areas.	Fossil fuels are characterized by high energy content per volume.
	The production of biofuels creates an additional distribution channel for agricultural products and rise the income for farmers.	--
	Some biofuels can be produced decentralized and thus strengthen rural economies.	--
	Feedstock production for energy purposes can reduce agricultural premiums and subsidies.	--

	Feedstock production for biofuels is a useful measure for using set-aside land.	--
	Feedstock production has the ability to green wastelands and to prevent further land degradation.	--
	The production of co-products provides additional income.	--
	Biofuels are not or only little toxic.	--
	The supply chain of biofuels can be characterized by relatively short transport distances (locally produced and locally used).	--
Weaknesses	Feedstock production for biofuels is land consuming.	The use of fossil fuels causes dependence of imports.
	The use of biofuels leads to a diversification of transport fuels which arises the need of different technologies (e.g. engines).	The use of fossil fuels contributes to global warming through greenhouse gas emissions.
	Fuel prices largely depend on the sale of co-products.	The demand of fossil resources causes conflicts and wars.
	Feedstock production largely depends on many vagaries of nature, including extreme weather conditions and pest attacks.	The use of fossil fuels is controlled by few international Mega-companies.
	Biofuels are characterized by lower energy content per volume than fossil fuels.	Fossil fuel prices are continuously rising.
	--	The supply chain for fossil fuels is characterized by long transport distances.
	--	Crude oil and fossil fuels are highly toxic.
	--	Oil spills from ocean tank ships pollute the environment.

Opportunities	Biofuels have the opportunity to replace a large percentage of fossil fuels.	The market of transport fuels is dominated by fossil fuels and will likely be so in the foreseeable future.
	Biofuels have the opportunity to decrease dependency on crude oil.	For fossil fuels a powerful and well structured political lobby exists.
	Biofuels have the opportunity to decrease imports of crude oil.	Fossil fuels have the chance to persist on the market as long as the price is considerably higher than the price for biofuels.
	Biofuels have the opportunity to reduce air pollution and GHG emissions.	With rising prices of crude oil other fossil resources (such as e.g. oil sands and oil schists) become competitive.
	An early introduction of biofuels facilitates a peaceful change from the era of fossil fuels to the era of future fuels.	--
	Since biofuels are of rising interest, there exist many research initiatives.	--
	New more efficient energy crops will be found for biofuels production.	--
	New and more efficient conversion technologies will be found and existing technologies will be improved.	--
	The EU directive and several national fuel strategies are promoting biofuels.	--
	The EC has set targets to increase the market share of biofuels (2 % 2005; 5.75 % 2010)[1].	--
	Due to Directive 2003/96/EC[2], tax reductions for biofuels were introduced in many European countries.	--

[1] Directive 2003/30/EC of the European Parliament and of the Council of 8 May 2003 on the promotion of the use of biofuels or other renewable fuels for transport

[2] Directive 2003/96/EC 27 October 2003 restructing the framework for the taxation of energy products and electricity

	Directive 2003/17/EC[3] allows blending fossil fuels with biofuels.	
	In some European countries blending of fossil fuels with biofuels is mandatory.	--
	Biofuels are characterized by constant or decreasing fuel prices through economies of scale.	--
Threats	The biofuel market is a relatively new market.	Fossil fuel production is limited due to the limited availability of crude oil.
	Of all transport fuels, biofuels have a market share of barely 1 % (2005) in the EU[4].	The market share of fossil fuels will decrease.
	The political lobby for biofuels is weak when compared to the lobby of fossil fuels.	The mid depletion point (peak oil) for crude oil is expected for the next 5-15 years.
	Biofuel production is limited due to land availability for feedstock production.	Discoveries of new oil fields rapidly decreased in the last few years.
	Feedstock production of biofuels is in competition with food production.	--

[3] Directive 2003/17/EC of the European Parliament and of the Council of 3 March 2003 amending Directive 98/70/EC relating to the quality of petrol and diesel fuels

[4] EC (2006, p. 10)

3.2. SWOT Analysis for Bioethanol

Bioethanol can be produced from different feedstock sources including sugar, starch, and cellulose. These feedstock types determine the whole life cycle of bioethanol production. Therefore three separated SWOT analyses were conducted for ethanol from sugar, starch, and cellulose and demonstrated in a single table. Nevertheless, since the common end-product is ‘ethanol’ some items of the three SWOT analyses are the same.

fuel	**Bioethanol**		
feedstock	**sugar**	**starch**	**cellulose**
Strengths	Sugar can be easily processed to ethanol.	Existing cultivation techniques can be used for cultivating starchy crops.	Feedstock costs are relatively low.
	Large experiences in the production of bioethanol from sugar are available (especially in Brazil).	--	A very broad range of feedstock can be used for ethanol production, since many plants contain large amounts of cellulose[5].
	Existing cultivation techniques can be used for cultivating sugar crops.	--	Feedstock must not be part of the food chain, since also non-food crops can be used for ethanol production.
	--	--	For feedstock production only low inputs of fertilizer and pesticide are required.
	--	--	New cultivation techniques, such as mixed cropping, are advantageous to biodiversity.
	--	--	Perennial plants (instead of annual plants for sugar and starch) prevent soil erosion and are advantageous to ground water protection.

[5] A detailed description of so called „Next-Generation-Feedstock“, is given by WWI (2006 p. 37ff)

	Europe has a favorable policy and institutional environment for promoting bioethanol.		
	Ethanol has a high octane number which is good for combustion properties (the anti knocking number is enhanced).		
	Ethanol contains 35% oxygen which reduces particulate and NO_x emissions from combustion when compared to the combustion of petrol.		
	Combustion of ethanol results in low CO emissions.		
	Bioethanol can be blended with gasoline at any ratio.		
	Ethanol contains no sulfur, causing no emissions of sulfur oxides.		
	Small amounts of bioethanol are neither toxic to humans nor to the environment.		
Weaknesses	In Europe the production of ethanol mainly depends on a single feedstock source: sugar beets.	The feedstock costs for starchy crops are high.	Ethanol processing from cellulose is relatively cost intensive.
	The feedstock costs for sugar crops are high.	--	Ethanol processing from cellulose is relatively energy intensive.
	For feedstock cultivation fertilizers and pesticides are required.		There are no experiences for large-scale production of ethanol from cellulose.
	Ethanol is characterized by high vapor pressures.		
	Blending gasoline with ethanol increases emissions of volatile organic compounds.		
Opportunities	Energy input for ethanol processing from sugar is lower than ethanol processing from starch and cellulose.	Energy input for ethanol processing from starch is lower than ethanol processing from cellulose.	Research is carried out to optimize ethanol processing from cellulose.
	--	Research is carried out to optimize ethanol processing from starch.	Due to the use of the whole plant, high yields per hectare are expected.

	Tax exemptions and mandatory blending obligations could largely increase use of ethanol.		
	The European fuel standard for ethanol prEN15376 is under development[6].		
	Agricultural productivity continuously rose since many years which decreases costs for feedstock production[7].		
Threats	Limited land is available for cultivating sugar beets.	Energy input for ethanol processing from starch is higher than ethanol processing from sugar.	Energy input for ethanol processing from cellulose is higher than ethanol processing from sugar or starch.
	Sugar beets are food crops (competition of ethanol with food products).	Most starchy crops are food crops (competition of ethanol with food products).	Production costs for ethanol from cellulose are relatively high.
	In most European countries the use of bioethanol is not yet established and thus limited infrastructure for ethanol distribution exists.		

[6] An overview about biofuel standards in Europe is given by RUTZ & JANSSEN (2006)

[7] ARNOLD et al. (2005 p.46)

3.3. SWOT Analysis for Lipid Derived Biofuels

Lipid derived biofuels are pure plant oils and biodiesel. In Europe, both fuel types are currently mainly produced from rape seed, although other feedstock types can be used as well. Large experiences for the use of pure oil and biodiesel were gained especially in Germany. The main difference between pure oil and biodiesel is an additional process step, the so called transesterification of the oil for the production of biodiesel. Biodiesel has very similar properties to fossil diesel, whereas more modifications of vehicle technology are required for the use of pure oil. Apart from these differences, the production of the feedstock and the pressing of the oil seeds is the same for pure oil and biodiesel.

fuel	**pure plant oil**	**biodiesel**
Strengths	Pure plant oil is successfully utilized as fuel in the transport sector as well as for electricity generation.	The properties of biodiesel (viscosity, ignition properties) and fossil diesel are similar.
	Pure oil can be easily processed in decentralized small oil mills.	The co-product glycerine of the transesterification process can be sold.
	The flashpoint of pure oil is very high and therefore easy to handle and store.	Cetane number and lubricating effect (important to avoid wear in the engine) of biodiesel is significantly higher than fossil diesel.
	In Germany good experiences with the use of pure oil in agricultural vehicles have been made.	The toxicity of biodiesel is lower compared to fossil diesel.
	Pure oil is biodegradable in a short time in soil and water.	For biodiesel a European standard EN14214 exists.
	Pure rape oil is not toxic.	--
	A fuel standard for pure oil exists in Germany DIN V 51605.	--
	Existing cultivation techniques can be used for cultivating oil crops, such as rape seed.	
	Pure oil and biodiesel contain practically no sulfur, causing no emissions of sulfur oxides.	
	The press cake can be used as fodder or fertilizer.	

Weaknesses	Economic viability depends on seed yields and income from by-products (press cake).	Economic viability strongly depends on seed yields and income from by-products (glycerin)[8].
	Due to its different properties, pure oil is difficult to blend with fossil diesel.	Biodiesel has some properties similar to solvents. Vehicle engines have to be adapted.
	The viscosity of pure oil is very high, especially at low temperatures requiring engine adaptations.	--
	In Europe no common standard for pure oil exists.	--
	Long term storage of pure oil and biodiesel may cause degradations in certain fuel properties, requiring additives.	
Opportunities	The production of pure oil is faced by lower costs than biodiesel by avoiding the costs for transesterification costs.	Biodiesel is the dominant biofuel in the EU at the moment.
	--	Only small modifications have to be done to refit vehicles.
	Tax exemptions and mandatory blending obligations could largely increase use of pure plant oil and biodiesel.	
	Waste oil can be used as cheap feedstock for pure oil and biodiesel.	
	Agricultural productivity continuously rose since many years, decreasing costs for feedstock production	
	Other oil plants than rape seed can be cultivated in Europe (e.g. sun flower, soy).	
Threats	Larger vehicle modifications have to be done for making engines suitable for pure plant oil.	Transesterification requires certain scale of production for being economically viable.
	--	An increasing market for biodiesel will saturate the demand for glycerin and the price for this co-product will decrease.
	In Europe mainly rape seed is used as feedstock source. Rape seed can be cultivated only every few years on the same field.	
	Generally the characteristics of lipid derived biofuels are much more variable than e.g. ethanol characteristics.	

[8] OECD/IEA (2004 p. 80ff)

3.4. SWOT Analysis for Biomethane

For transport purposes only purified biogas, the so called biomethane, can be used. Biogas is produced by digestion of wet biomass, which usually consists of waste materials, such as animal manure or sewage sludge. In order to increase efficiency of this process, vegetable material can be added and co-fermented. Another option of biogas production is the digestion of dry feedstock sources. The present SWOT analysis concentrates on biomethane from waste, since this is the most promising option for the future.

fuel	**biomethane**
Strengths	If waste materials are used for biogas production no additional feedstock has to be cultivated.
	Biogas production is a visible technology to reduce agricultural and municipal organic waste.
	Biomethane is very similar to purified natural gas which is already used as transport fuel in several European countries.
	In many European countries (e.g. in Germany) there exist large experiences for the production of biogas in order to use it in combined heat and power utilities. This experience of biogas production can be used for transport applications.
	The combustion of biomethane has very low exhaust emissions (NOx, CO, Particulate Matter, HC) compared to fossil petrol or diesel.
	Biomethane is not toxic.
	Biomethane can be produced in decentralized facilities.
Weaknesses	For transport applications many modifications of the infrastructure have to be done (filling stations).
	Vehicle technology is not yet broadly established.
	Biogas is far more difficult to store and transport than liquid fuels and requires more storage space due to its substantially lower energy density.
	For transport purposes biogas has to be stored in specially installed pressure tanks at a pressure of 200 bars.
	For transport purposes biogas has to be cleaned (> 95% methane content). Therefore energy input is needed and gas cleaning is only economical in larger facilities.
	Methane itself is a severe greenhouse gas (only if it escapes unburned to the atmosphere).

Opportunities	Biogas is already introduced as transport fuel in several European countries (e.g. Sweden, Switzerland).
	The infrastructure of natural gas can be used for biogas applications without modifications.
	In Sweden a quality standard for biogas exists: SS155438.
Threats	Today the market share of biomethane for transport is very low.
	Consumers are not used to this type of fuel.
	No common European quality standard exists for biogas.

3.5. SWOT Analysis for BtL Fuels

BtL fuels (biomass-to-liquid) are referred to as second generation biofuels, since they are not yet produced on large scale. BTL-fuels, which are also called Synfuel or Sunfuel®, are produced by gasifying biomass and subsequently liquefying (synthesizing) the resulting syngas to BtL fuel. The main advantage of this fuel is that a large variety of organic feedstock can be used for its production. The main barriers against a large-scale production of BtL fuels are the high costs for plant investment and fuel production.

fuel	**BtL Fuels**
Strengths	BtL fuels can be produced from nearly all types of feedstock.
	Feedstock costs are very low.
	Feedstock must not be part of the food chain, since also non-food crops can be used for BtL production.
	For feedstock production no (or only low) inputs of fertilizer and pesticide are required.
	New cultivation techniques, such as mixed cropping, are advantageous to biodiversity.
	The cultivation of perennial plants prevents soil erosion and is advantageous to ground water protection.
	The chemical properties of the hydrocarbons in BtL fuels permit efficient and complete combustion with low exhaust gas emission.
	BtL properties can be influenced by changes in specific parameters such as the pressure, temperature and catalysts during synthesis and the subsequent treatment and can thus be “fine-tuned”. Synthetic fuels are therefore also known as tailored fuels or as designer fuels.
	BtL fuel can be used without technical modifications in the engine.
Weaknesses	BtL fuels can only be produced at industrial large scale facilities.
	Currently, costs for investment of BtL plants and fuel production are too high to be competitive with other fuels.
Opportunities	First pilot plants for producing BtL fuels have been already set up.
	Synthetic fuels can be ideally adapted to current engine concepts.
	BtL fuels are often referred to second generation biofuels and large scale production is expected within the next 20 years.
Threats	BtL production did not yet leave the pilot stage.
	BtL fuels are not yet broadly available on the market.

3.6. SWOT Analysis for Bio-Hydrogen

In nature, pure hydrogen is mainly chemically bound in water, biomass, or fossil fuels. Thus, hydrogen it must be extracted from one of these substances, a process which requires energy to make it available as transport fuel. Accordingly, the cleanliness and renewability of this production energy is of critical importance. While a hydrogen fuel cell operates without emissions, the production of hydrogen can cause significant greenhouse gases and other harmful byproducts. Nevertheless, once obtained, hydrogen is a nearly ideal energy carrier. The present SWOT analysis for bio-hydrogen shows, that the main barrier against its introduction is the high production costs, especially if hydrogen is produced directly from biomass. Nevertheless, some experts expect hydrogen to be the fuel for the long term future.

fuel	**bio-hydrogen**
Strengths	The combustion of bio-hydrogen is very clean, only water is emitted.
	Hydrogen is a good, clean and non toxic energy carrier.
Weaknesses	The production of hydrogen is very expensive.
	For hydrogen production large investments in plants are necessary.
	The use of hydrogen requires a new engine technology (fuel cells).
	Although the combustion of bio-hydrogen does not emit greenhouse gases, these are emitted during the production process.
	Depending on how hydrogen is processed it only can be labeled “renewable” if it is generated from biomass or by other renewable energy sources.
Opportunities	Experiences with hydrogen as transport fuel have been already made in some countries (Iceland, USA).
	In the long term future, improved conversion technologies could make hydrogen a viable transport fuel.
Threats	Requirements on the infrastructure for transport purposes are very high since it completely differs from today’s infrastructure.
	Vehicle technology for using hydrogen is not yet cost competitive.

4. Conclusion

This SWOT analysis presented the main advantages and disadvantages, the drivers and barriers of various technologies in the biofuel sector.

In Europe most experiences exist for biodiesel and bioethanol since these two fuels have the highest market share. In contrast, far less experience exist for biofuels which are in their initial phase of market introduction, such as pure oil, biomethane and BtL fuels. For example, the use of pure oil still is a niche application for the agricultural transport sector, supported by the decentralized pressing process of rape seeds. Also the use of biomethane is a good option for transport application, but favorable policies have to be introduced. A legislation which allows to feed biomethane into the natural gas grid could boost its market share for transport purposes. Finally, the use of hydrogen is another option for transport fuel, but only for the far future.

Since a SWOT analysis is always qualitative, it has the great opportunity to objectively demonstrate advantages and disadvantages of fuels. In contrast, qualitative studies are much more susceptible to manipulations, although this is often not the intention. For instance, an often cited argument against biofuels in favor of fossil fuels is the higher costs of biofuels. But, in these calculations external costs for environmental hazards are not accounted. An example of external costs is costs for negative effects of global warming caused by the combustion of fossil fuels.

In conclusion, the present SWOT analysis shows pros and cons of biofuels without judging them. It represents an objective base for discussing the best options for future transport fuels. Such discussions shall be complemented by using results of additional quantitative studies, for example on costs, greenhouse gas emissions and energy balances.

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