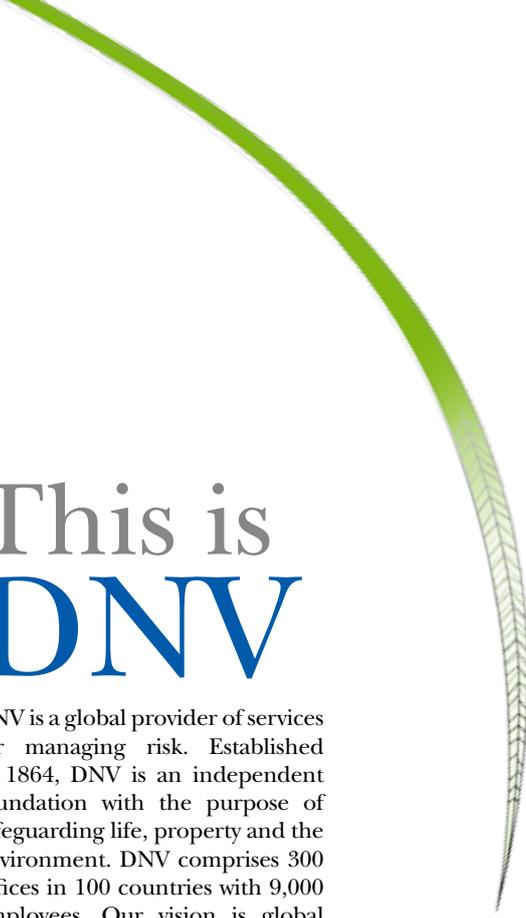


Biofuels 2020

A policy driven logistics and business challenge

Research and Innovation, Position Paper 02 - 2010



This is DNV

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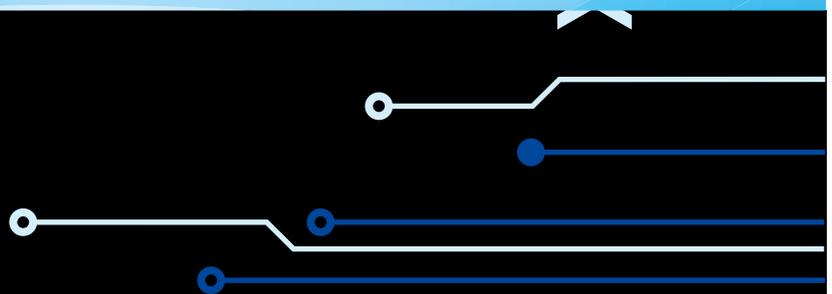
Summary

This study presents the findings from hypothesis development and interviews with several actors, shareholders and authorities in the biofuel value chain. DNV initially developed a hypothesis for how we expect the biofuel industry to look like in 2020. The initial hypothesis was based on literature search and scenario development, and covered:

- Resource and distribution
- Actors and drivers
- Technology
- Policy

The hypothesis was tested on a number of actors in the biofuel industry, and the findings are presented in this position paper.

In summary one can say that several major breakthroughs are required for successful commercialisation of second generation of biofuels. Key stakeholders do not believe this will happen before 2015. The existing bio-refineries are small and scale up will be limited by feedstock logistics not technology or market challenges. All the stakeholders agreed that the biofuels industry will be heavily influenced by government and policy, to the extent that the industry will be policy driven. Finally, the speed of penetration of biofuel will depend on the renewal of the car fleet, since most of today's vehicles only can handle a low addition of biofuels. All stakeholders agreed that not more than 10 % of the transportation fuel will be biofuel on a global level, and that it will be sold blended with hydrocarbons.



Introduction

Biofuels are important for two key reasons. They are expected to reduce the carbon footprint from the transportation sector, and they will reduce the dependence on foreign fuel sources in key economies.

Given this significance, what will the biofuel market look like in 2020?

DNV Research & Innovation has created a hypothesis for the biofuel market in an effort to try to answer this question.

In order to do so, a set of three scenarios for biofuels for 2020 were developed through a workshop with wide representation from DNV. The three scenarios represented a national, regional or global market for biofuels. The scenarios contain information on the most promising technology, political decisions that must be in place, and what the number one trigger is for each scenario. Based on the scenarios and a plenary discussion a hypothesis was developed for how the biofuel market will look in 2020.

The hypothesis is divided into four areas:

- Resource and distribution
- Actors and drivers
- Technology
- Policy

To test out the hypothesis, a number of stakeholders within the biofuel value chain have been interviewed. The stakeholders consisted of a technology provider, a regional utility company, three international oil and gas companies, representatives from EU governmental agencies, representatives from leading universities, and a representative from the biomass industry.

This paper is structured as follows. First there is a summary of key findings. This is followed by facts and figures of the present biofuel situation. Thereafter a more in-depth run-through of the hypothesis and the remarks given by the consulted stakeholders is presented.

Key findings

The stakeholders all generally agreed on the technical and logistic challenges throughout the biofuel value chain. There was general agreement concerning the outlook of the biofuels use and production challenges towards 2020. Several major breakthroughs are required for successful commercialisation of second generation of biofuels. Key stakeholders do not believe this will happen before 2015.

It is clear that there are challenges that are specific to particular feedstock and biofuel type and process, but many areas are similar to agriculture, logistics, refinery and fuel quality issues in established industries.

The existing biorefineries are not as big as oil refineries and scale up will be limited by feedstock logistics. The number of biorefineries will thereby be very large in order to penetrate the market. For Europe alone, 200 – 400 biofuel plants are needed to meet the EU requirement of 10% biofuel in 2020.

All the stakeholders agreed that the biofuels industry will be heavily influenced by government and policy, to the extent that the industry will be policy driven. The policy issues range from international to national to regional to local issues. Trade barriers will remain to benefit local production and strengthening security of supply.

The biofuel industry will be influenced by several factors. These include: taxes and tariffs, technology funding, renewable energy regulations, energy security vs energy price, food vs fuel issues, sustainability, traceability and certification requirements, and local decisions on how available biomass will be utilised. The speed of penetration of biofuel will depend on the renewal of the car fleet, since most of today's vehicles only can handle a low addition of biofuels. These factors need to be looked at in totality as no factor alone will drive the biofuel market.

Scale up limited to feedstock logistics

Policy driven industry

Renewal of car and truck fleet determines the speed of penetration of biofuels

Facts and figures

– The present situation

An overview of what biofuels are, how much is produced where and the regulations in the EU and the USA that are shaping the future of the market.

BIOFUEL PRODUCTS

Figure 1 shows the major pathways through which biofuels are produced. The focus in this presentation is on bioethanol and biodiesel.

Bioethanol is an alcohol produced by the biological fermentation of carbohydrates derived from plant material. It can be used directly in cars designed to run on pure ethanol or blended with gasoline, thus functioning as a substitute product for gasoline.

Biodiesel is a synthetic diesel-like fuel produced from vegetable oils, animal fats or recycled cooking grease. It can be used directly as fuel, which requires some engine modification, or blended with petroleum diesel and used in diesel engines with few or no modifications.

First generation biofuels rely on crops that have readily accessible sugars, starches and/or oils as their feedstock, such as corn, soy, palm, rapeseed and sugarcane. Production of biofuels involves either fermenting the sugars or transesterification of fatty oils. Net energy losses, minimal greenhouse gas savings and conflicts with food production are some of the issues here. Biofuel distribution companies are working almost exclusively with food crop-based biofuels, as those represent the bulk quantities of what is currently available.

Second generation biofuels use lignocellulosic biomass as feedstock, and can use forest and agricultural production wastes, such as corn stalks, as well as dedicated biofuel crops like switchgrass. The fuel is made by breaking down

the cellulose using enzymes/ microorganisms into sugar, or by using a thermochemical route. Second generation biofuel technologies convert a greater proportion of the feedstock biomass into biofuels.

Third-generation biofuels have often been defined as algae biofuels and “fourth-generation” biofuels have been considered to be production using modified organisms or advanced biochemical methods of production.

BIOFUEL PRODUCTION

Global fuel ethanol production has grown by 15% a year on average, largely led by ethanol production in the USA. The production in 2009 was 66 635 million L/a . The US (corn) and Brazil (sugarcane) account for about 89 % of global ethanol production. Output in China and Europe and the rest of the world is growing rapidly.

Biodiesel production is perceived by many governments as a relatively easy and direct step to reducing reliance on fossil fuels for transportation. The production in 2009 was 11 016 million L/a ¹. The EU currently represents 90% of global biodiesel production and consumption but the USA is now accelerating its biodiesel production capabilities at a faster rate than Europe.

BIOFUEL REGULATION

Regulations are a powerful driver for biofuel development. The EU directive on renewable energy (2009/28/EC) stipulates that each member state has to ensure that 10% of the fuel for the transport sector is biofuel or renewable electricity in 2020. In order to be able to count the biofuel as a renewable source of fuel the minimum GHG reduction must currently be 35 % compared to fossil fuels.

¹ *Business Insight – Next generation biofuels*

From 2017 the requirement will be a 50 % reduction, and 60 % reduction for new installations built after 2017. Some of the first generation biofuels will struggle to meet this target.

In the USA the EPA Renewable Fuel Standard version 2 (EPA-RFS2) and the California Low Carbon Fuel Standard (CA-LCFS) are driving the US market. The EPA-RFS2 requires that 36 billion gallons (136 billion l) of renewable fuel are available in the US market by 2022. The GHG reductions required by 2022 are 20% for renewable fuel,

50% for advanced biofuel and biomass based diesel, and 60% for cellulosic biofuel compared to the conventional fuel 2005 baseline.

California is the single largest transportation fuel market and the CA-LCFS requires the fuel suppliers to report and reduce the GHG emissions of gasoline and diesel. By 2020 the aggregate GHG emissions of all fuels must be 10% below the 2010 levels. Eleven other states in the US are working on similar regulations.

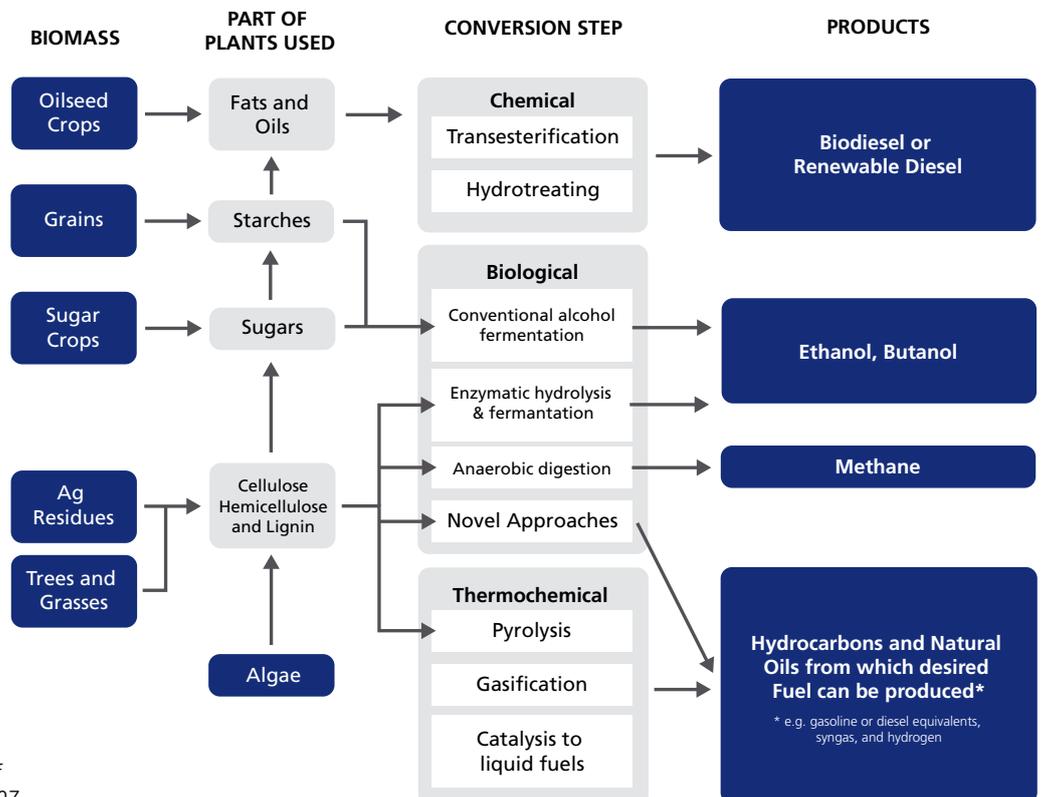


Figure 1. A schematic view of the major sources, production routes, and types of biofuels. Source: Peña and Sheehan, 2007

Resource and distribution

Sugarcane or cellulosic sources or food? Blended or not? Trade barriers removed?

DNV Hypothesis:

In 2020 a maximum of 10 % of the transportation fuel will be biofuel. The biofuels will mainly be sold to the customers as blends with regular hydrocarbons.

The international market will be dominated by ethanol from sugarcane, but ethanol from cellulosic sources has also taken off in 2020. Although ethanol will dominate on a global level, biodiesel will be preferred in certain regions. Bioethanol and biodiesel will be traded globally in the same way as gasoline is traded today. Blending and distribution will use the same infrastructure as is used for hydrocarbons today.

The biorefineries will be located close to the biomass feedstock and then transported to the blending facilities as bioethanol or biodiesel. In addition to the liquid biofuels biogas will grow, but this will happen on a more local level with sewage and manure/waste as the main feedstock.

Remarks by consulted stakeholders:

All stakeholders agreed that not more than 10 % of the transportation fuel will be biofuel on a global level and that they will be sold blended with hydrocarbons. However, two of the oil companies highlighted that there will be large variations around the globe and locally we will see a larger penetration. The representatives from EU governmental

agencies also pointed out that the development of electric cars will influence the amount of biofuels utilized.

All stakeholders agreed that there would be little cellulosic ethanol available in 2020. Typical foodcrops would still be used for biofuel production in 2020, although the focus will be to reduce the use. The supply base for ethanol is ten times bigger than for vegetable oils which leads to an increase for bioethanol compared to biodiesel. For biodiesel, one of the oil companies pointed out that blending is easier which makes it more attractive. The representatives from EU governmental agencies also mentioned that the car manufacturers are key actors.

Two of the oil companies did not see any indications that the trade barriers would be removed. The representatives from EU governmental agencies pointed out that the trade regulations depend on the source of the biofuel. When it comes to the location of the biorefinery both the technology provider and the representatives from EU governmental agencies indicated that the feedstock can be transported longer distances, equivalent to timber.

The oil companies do not think biogas will play an important role while the representatives from EU governmental agencies, the representative from the biomass industry and the utility company thought it will be an important part of the mix.

Actors and drivers

Small players or oil majors? Will consumers pay a price premium for biofuels?

DNV Hypothesis:

The major actors in the biofuel market in 2020 will be the national and international oil companies and they will operate both refining and distribution of biofuels. This means that the start-ups will be acquired by the oil majors. However, the oil companies will not own farmland; instead they will have long-term sourcing contracts. The biogas market on the other hand will be dominated by local actors such as municipalities.

The biofuel market will continue to be driven by policy and security of supply will be a more important driver compared to climate change. Innovation in the transportation sector will offset the increased demand due to global population growth. The oil price will in 2020 thereby stay between 50 and 100 USD\$. The consumers will not be willing to pay a price premium for biofuels, so policy instruments have to make biofuels cost competitive.

Remarks by consulted stakeholders:

Stable supply of cost-effective feedstock is a key issue, and the stakeholders stated that oil companies already have started to buy up farmland in some areas as contracts were not sufficient to ensure supply.

For the biogas market, multinational utility companies will be important actors, according to the utility company, the technology provider and the representatives from EU governmental agencies.

All the stakeholders agreed that the biofuel market will continue to be policy driven. For one of the oil companies, sustainability is the main driver for biofuels. The representative from the biomass industry thinks that climate change will be the most important driver until 2020, but after that security of supply will dominate.

For the oil price, all stakeholders apart from the representatives from EU governmental agencies think the price will stay below 100 USD. The representatives from EU governmental agencies think it will be closer to 150 USD. No stakeholder thinks that the costumers are willing to pay a premium for biofuels.

Technology

A breakthrough for cellulolysis and gasification? What about algae?

DNV Hypothesis:

Sugarcane based ethanol processes will be further improved until 2020 and will dominate the market. However, there will be technological breakthroughs in processes to produce cellulose based biofuels before 2015. There will be breakthroughs both for cellulolysis and gasification processes.

Biogas based on anaerobic digestion will use straightforward technology and there will not be any major technology challenges.

Algae based biofuel will not be a major part of the biofuel mix. The products from algae will primarily be used as chemicals.

Biofuels will in 2020 not use food crops except for agricultural waste products, the feedstock will be dominated by dedicated biofuel crops.

Remarks by consulted stakeholders:

None of the stakeholders believed that there will be significant amount of commercially competitive second generation biofuel by 2015, there are too many issues to be solved. Two of the oil companies said that production using the enzymatic route is the most interesting. Gasification suffers from very high capital costs. This means the

refineries must be very large, but this is limited by logistics, and only feasible for very cheap or no cost feedstock.

Two of the oil companies and the representatives from EU governmental agencies think that biofuels based on algae will be successful, but it will take time.

Looking at the size of biorefineries, the technology provider stressed that it is the logistics that limits the size not the technology. The representatives from EU governmental agencies warned about extrapolating the current situation into the future. If there is a need for very large units, it can happen.

Policy

Shift in subsidies? Global trade agreements or country to country? International standards?

DNV Hypothesis

In 2020 there will be a shift in agricultural subsidies from food production to biofuel production. This will secure the income for the farmers. Policies for better utilization of waste will be in place.

There will also be policies for better air quality; this will drive the use of gas and biogas in the cities.

Issues regarding sustainability will be policy and company brand driven, not consumer driven.

Biofuels will part of global trade agreements. This will be facilitated by international standards for quality, transportation and sustainability of biofuels.

Remarks by consulted stakeholders:

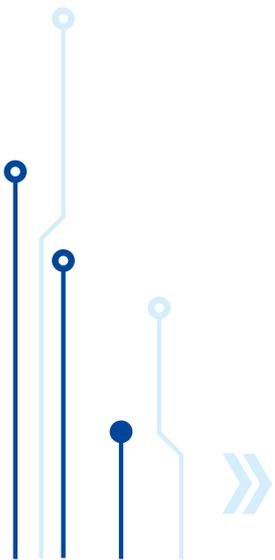
When it comes to the use of food crops, the views of the stakeholders differed somewhat. One oil company said it does not want to add the “famine” factor into their brand. Many of the other stakeholders mentioned that if there is a surplus of food crops it will be used for biofuel production. The representatives from EU governmental agencies said that there is no need to change the farming subsidies. It is up to the farmer to decide what will be produced.

Both the representatives from EU governmental agencies and two of the oil companies stated that policy for air quality is not a driver for biogas. The oil companies said

that the fuels of today are good enough in the developed countries and the representatives from EU governmental agencies pointed out that other policies will be the drivers.

When it comes to sustainability, the representatives from EU governmental agencies pointed out that the collective willingness to pay is larger than that of the individual. However, increased consumer awareness could lead to a situation where labels could make a difference.

Trade is another critical issue. Many of the stakeholders thought there will continue to be trade barriers. The representatives from EU governmental agencies stressed that the trade agreements will not be global, but rather between countries or regions. There are no strong drivers for international standards. There will be national or regional standards one of the oil companies and the representatives from EU governmental agencies pointed out.



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