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Alternative Fuels & Policies

Richard Mark Smit
345832
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Erasmus School of Economics
Department of Regional, Port & Transport Economics
Supervisor: Giuliano Mingardo

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Contents

1.1 Abstract

During the recent years, fuel has become a large topic of discussion. The word 'oil' has a loaded meaning, it is seen, besides an important product that drives large parts of the global economy, as a harmful good, to the economy and even claimed reasons for wars. Historically, oil has become so important it is seen as a weapon of mass destruction, as several countries are so powerful in providing oil, that when they instruct an embargo, many countries go into soaring recessions, as was seen in the first oil crisis in 1973 (Frum, 2000). Another problem that oil has is it's non-renewable property. Research shows that oil is expected to last another 35 to 40 years (Shafiee & Topal, 2009). The risks of not having a complete transition to an alternative fuel before then are unthinkable. The final problem that arose in the recent decades is the environmental damage caused by the burning of oil (Oil Change International, 2014). The climate changes that have occurred since have to be contained, since it causes heavy storms, changing of the seasons, which in turn causes disruptions in the production of food, and many other risks, where many are still unknown. The current largest new alternative types of fuels are electricity, hydrogen and biofuels. These fuels all have their pros and cons as well as the pros and cons of the relevant infrastructure, making it hard to predict which one will be 'the new oil'.

The Dutch government has introduced many fiscal advantages for those willing to buy and drive clean cars, increasing the sales of these 'green' cars (Rijksoverheid, 2014). However, due to government budget cuts some of these incentives have been diminished, causing the growth of the sales of clean cars to decrease immediately. Since new technologies in the clean fuel industry are expected to arise in the next few years, one can call the timing of the diminishing incentives unfortunate.

The infrastructure of the new types of fuels is mostly regulated locally. This causes a divergence in the type of fuel that is promoted within the Netherlands, but also within the European Union. The Netherlands is one of the leading countries in electric driving, however, a small economy such as the Netherlands cannot have an impact on the new type of alternative fuel, and thus the investments made will be useless when the new alternative fuel turns out to be a different one than anticipated.

1.2 Introduction

This thesis is about alternative fuels and the Dutch policy regarding these fuels. The current discussion about this topic motivated me to write about this topic. Mobility has become more important, and everyone deals with it on a daily basis. Fuels play a very important role, as the increase in mobility causes an inevitable increase in the demand of fuel. In this thesis, the focus will rely on fuels used in the automobile industry. The comparison will be done between the historical development of fuels, the recent development of alternative fuels and the Dutch governmental policies to stimulate these fuels. We can then draw a conclusion if the policies imposed by the Dutch government are in line with the developments in fuels. This leads to the following research question:

"To what extent is the Dutch policy for stimulating clean vehicles coherent with the developments of alternative fuels?"

The sub-research questions are conducted as follows:

- *"What are the historical developments of fuels?"*
- *"What are the recent developments of alternative fuels and their relevant pros and cons?"*
- *"What is the Dutch policy for stimulating clean vehicles?"*

The methodology that will be used in this thesis is literature research. Besides scientific articles, also news articles and data from several national statistical databases will be used.

This thesis will start with the historical development of fuel and automobiles to get a good view of the transition to an increased mobility in history. Then, three types of alternative fuels will be analyzed with their corresponding pros and cons. At the end of this section, all the pros and cons of the different alternative fuels will be analyzed in an overview. After this section, the Dutch policy for stimulating clean vehicles will be analyzed, started with the European Union's guidelines, followed by the Dutch national incentives and ending with the Dutch local infrastructure investments. Finally, a conclusion can be drawn with all the previous data and the main research question can be answered.

2. The History of Automobiles & Fuel

According to the Cambridge dictionary, fuel is defined as “a substance that is used to provide heat or power” (Cambridge Dictionary, 2014). Since this thesis is one focusing on transport economics, the focus will rely solely on the power use of fuel. Furthermore, the focus will rely on the fuel used in automobiles.

2.1 Early Years of the Automobile

The first automobile can be traced back to 1672, a steam-powered vehicle that was too small to carry a human being, however, this was the basis of the further development of the automobile as a mode of transport (Hergé, 2014). The development of steam-powered road vehicles at the time, were not large and powerful enough to carry transport or people, therefore the development slowed down until the early 19th century. At that time, in 1801, Richard Trevithick had a full-sized vehicle running on roads in Great Britain (Buchanan, 1958). The development of steam powered vehicles came to a near stop when the British government posed the Locomotive Act in 1865, restricting speed limits to four mph in the country and two mph in the city. It also imposed a law that obligated a man to walk 60 yards in front of each self-propelled machine, with a red flag or lantern. The vehicles must travel at walking pace and the man was there to warn approaching traffic. This caused a shift to the development of trains instead of automobiles.

In 1860, the first patent was granted for the principle of the four-stroke internal combustion engine for Chistian Reithmann (The Motor Museum in Miniature, 2014). The patent was later granted for the French engineer Alphonse Beau de Rochas in 1861. The motors produced by these inventors where not practical, and thus not economically viable. In 1877, Nikolaus Otto was the first to successfully produce and sell these new type of engines. He believed his new type of engine would permanently replace the steam engine, even though his engine was inefficient and produced only three horsepower (Wise, 1974). This was mostly due to a lack of suitable fuel sources. The early experimenters with the combustion engines used gases as hydrogen, oxygen, or coal gasses. A few years later, in 1893, Rudolf Diesel obtained a patent for the first diesel compression ignition engine (Rudolf Diesel, 1895).

Ironically, the first practical-to-use car was fueled by electricity. Thomas Parker was an engineer who had a passion for electricity. In 1884 he invented the first electric car (The Telegraph, 2009). This was made possible partly because of the availability of rechargeable batteries.

The first practical automobile running on petrol or gasoline is regarded to be the Benz Patent Motor Car. This car was patented on January 29th, 1886. The car produced 0.6 horsepower and was successfully tested by the wife of the inventor, Bertha Benz. She took her kids and drove 194km in 1888 (Mercedes Forum, 2011). The fuel that was used in that car was Ligroin, derived by distilling petroleum. Ligroin was used as a laboratory solvent that was purchased in inter alia pharmacies, which Berthe Benz did during her travel (Mercedes Forum, 2011).

2.2 Fordism

In the beginning of the 20th century, electric cars were much more popular than cars powered by gasoline or petrol. They were more reliable considering the distance they needed to cover. In the time, journeys traveled by cars were at most a few kilometers, further distances were traveled by train. Electric cars were more reliable and needed less maintenance. In the beginning of the first World War in 1914, gasoline powered cars became more popular, petroleum was significantly cheaper and due to the efforts of Henry Ford's mass production of cars, gasoline powered cars themselves became cheaper as well (Owning Electric Car, 2014). Another problem electric cars encountered was the inefficient and often very heavy and large batteries. The range of the cars was very limited compared to gasoline powered cars and the purchasing cost much higher. When the demand for mobility increased, the ranges of vehicles had to increase as well, something that gasoline powered vehicles did very well. The production car of the Ford company, the T model, was relatively cheap, $21,650 in today's currency (Bak, 2003). The engine of the T model was designed to run on kerosene, gasoline or ethanol. Due to the prohibition era, where alcohol was banned, and the decreasing costs of gasoline, gasoline was the fuel of choice for most of the owners (English, 2008). In the graph depicted below, the historical price of oil can be seen. The real prices of oil are slowly decreasing from the 1870 onwards, giving the gasoline powered car a massive competitive advantage.

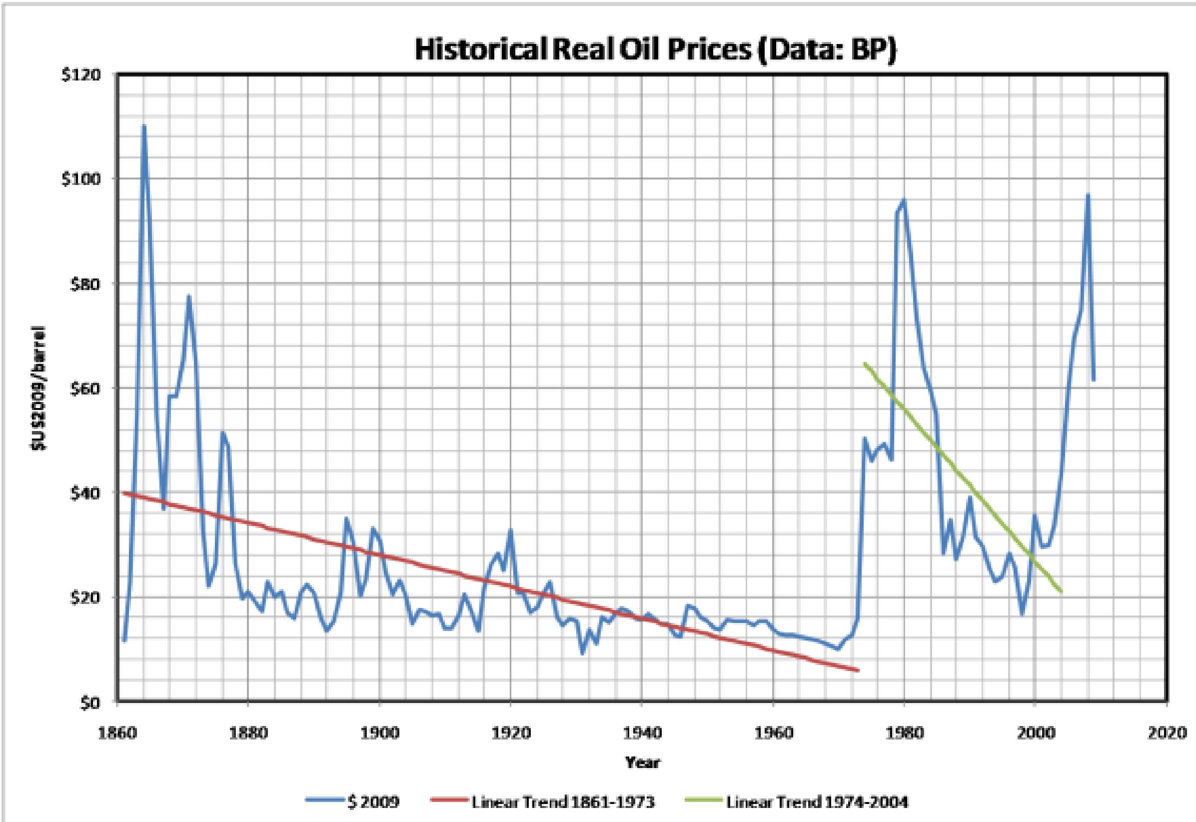

Figure 1: Historical Real Oil Prices (Tegg, 2010)

The mass production of Henry Ford initiated a modern economic system of mass production. The Ford Motor Company introduced three simple principles that allowed the factory to produce the T-model at an, at the time, extremely low cost; standardize the product, the usage of specialized labor introduced the assembly line and paying the workers high enough wages so that they are able to buy the products they produce (Tolliday & Zeitlin, 1987). All these three principles ensured higher productivity per worker, meaning their wages increased along with their loyalty to the Ford Motor Company, despite the national recession that was emerging (Oi, 1983). The flow of materials required to produce the cars was reorganized, increasing the efficiency of the assembly line in the factory. The tools required to assemble the car were simplified in such a fact that a single tool was used for a single task, something very innovative at the time. This required massive investments, and in four years, in the period of 1909 to 1913 the book value of tools and machines increased more than 700% (Raff, 1991). These investments caused the assembly time of a Model T to drop from 12 hours to two hours 40 minutes. Henry Ford also introduced a profit-sharing system for employees if they were to produce more than 300,000 Model Ts, these incentives also increased the productivity of the workers. By 1920, production was soaring above 1 million annually. Ford hired external companies to identify the best workers, even if they seemed unemployable by other companies. The further increase of productivity allowed him to drop the prices for the Ford Model T even further, pushing the electrical cars further behind (Clymer, 1950). These innovations of economies of scale created a notion in economics in the pre-World War I era, named after Henry Ford, Fordism.

The economies of scale introduced by the Ford Motor Company created massive entry and exit barriers for new automobile manufacturers. Less efficient producers went bankrupt, and the number of automobile producing firms decreased from 2000 in 1900 to 100 in 1920, right after the first World War (Brancheau, Wharton, & Kamalov, 2014). The World War caused an increase in the price of oil and global decline of economic activity (The National Bureau of Economic Research, 2010), temporarily slowing down the automobile industry.

2.3 Increasing Growth of the Automobile Industry

The growth of the automobile industry and the innovation of their engines required more and higher quality petrol. In 1913, thermal cracking was introduced, a chemical process transforming a higher fraction of crude oil into petrol. A decade later, catalytic cracking was introduced, allowing an even higher fraction of oil to be transformed into petrol, with an even higher quality (Shell, 2014).

During the Great Depression in the years preceding the second World War, the amount of automobile manufacturers decreased even further, since the market matured and entry barriers became higher and higher. According to the research of B. Curtis Eaton and Richard G. Lipsey (1980, p. 721-729), specific capital, as used in the automobile industry, increases commitment to the market and thus creates artificial entry barriers. The automobile manufacturers, in case of entry of another party, have to stay in the market long enough after the entry, so that the net present value of the entrant is negative. Since the large investment costs that had to be made by automobile manufacturers created a large enough commitment, the amount of manufacturers decreased over time.

Using similar mass production, another big player in the automobile market was General Motors. In the 1920s, General Motors (GM) introduced several car models using common parts, where Ford only focused on one model. Furthermore, GM introduced a consumer financing model, allowing more people to be able to afford a car. Despite the post WWI recession of the 1920s, GM sold more automobiles than

Ford at the end of the 1920s. The economic growth after the great depression boosted the sales of GM to a staggering 4.5 million (GM Lifestyle, 2014).

During WWII, automobile manufacturers became even larger due to contracts with governments for producing vehicles that would be used in the war. General Motors was the largest wartime contracting company, allegedly producing vehicles for both the Allied force and the Axis force, although the production for the latter is ambiguous, as GM stated that their factories in Germany were nationalized and they had no control in the production on that end. Conspiracy theorists claim that GM was profiting from the war by selling deliberately on both sides (Peck & Scherer, 1962).

During the era after the second World War, automobile manufacturers, along with oil producing companies became larger and more powerful. The net income of GM was almost $900 million in 1961, increasing to $1.5 billion in 1963 (GM Heritage Center, 1963). At the other side of the Pacific Ocean, in Japan, automobile manufacturers began to arise, led by Toyota. In Germany, the (re)start of Volkswagen was slowed down due to the aftermath of the war, however, in 1960 the German government forfeited their stake in the company, and the company started to excel, with the Volkswagen Beetle as their flagship (Knorr, 2000).

2.4 The Oil Crisis

The heavy reliability on oil supplying countries became obvious during the oil crisis in 1973. In response of the US aid of weapons to Isreal, escalating the already tense atmosphere in the Middle-East, 17 Arab countries, today responsible for almost 46% of the total oil production (Central Intelligence Agency, 2012), issued an embargo on the US and other countries aiding Isreal. Main effect of the embargo was the explosion of the price of oil, almost quadrupling. The countries exploiting oil gathered a mass amount of wealth, and they realized they had a weapon in their hands in the shape of oil. The economic effects were massive, energy resources were threatened and fuel reserves for vehicles were almost exhausted. President Nixon of the USA asked gasoline stations to not sell any fuel in the weekends, except Saturday during the day. Many gasoline station managers complied, resulting in large congestions around gasoline stations on Saturday. The Netherlands was one of the countries that received a full embargo, and with desperate attempts to ration fuel resources, gave out prison sentences to those who exceeded their portion of electricity (Frum, 2000).

One of the countries that profited from the oil embargo was Japan. Their cars were far more fuel efficient compared to the American cars. Research shows that in the short-run, the price elasticity of oil is very low, while a car size adjustment is made in the long run, it is here that automobile manufacturers in Japan profited (Mogridge, 1978).

2.5 Post-Oil Crisis Era

The oil crisis made it clear to the world that the dependence on the Middle-East was far too high, which triggered incentives to invest in alternative fuel resources. Brazil started a program in 1975 called Proálcool, financed by the government, to eliminate fossil fuel powered cars in favor of cars running on ethanol, extracted from sugar cane. Below, a graph is depicted showing the oil dependence, measuring oil imports, of both USA and Brazil. After 1975, when Proálcool was introduced, a sharp decrease can be seen in the dependence of oil, where ethanol powered cars became more wanted. Below, the percentages of sales of different types of cars in Brazil can be seen. Flex cars are cars powered by inter alia ethanol and as can be seen, the sale of these type of cars exceed the sale of gasoline powered cars by 2005 (Bastos, 2007).

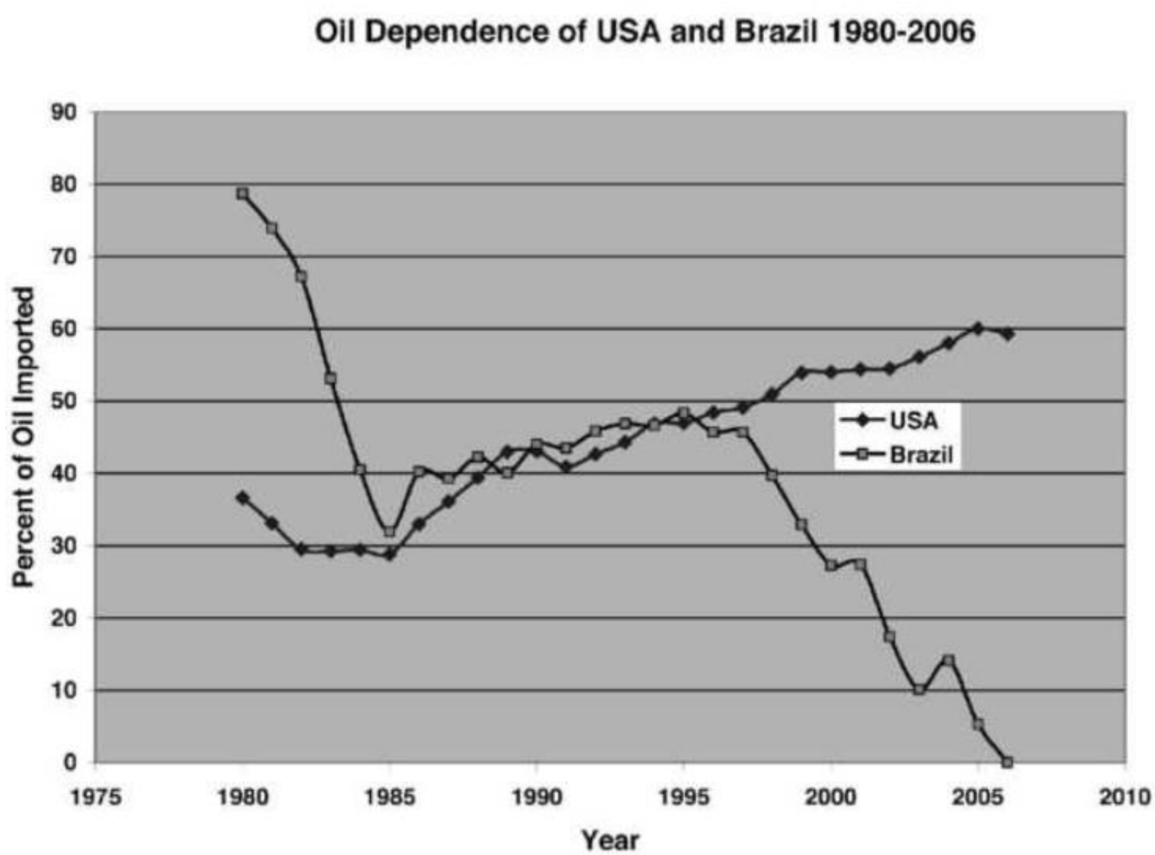

Figure 2: Oil Dependence of USA and Brazil 1980-2006 (The Institute for Energy Resourcefulness, 2014)

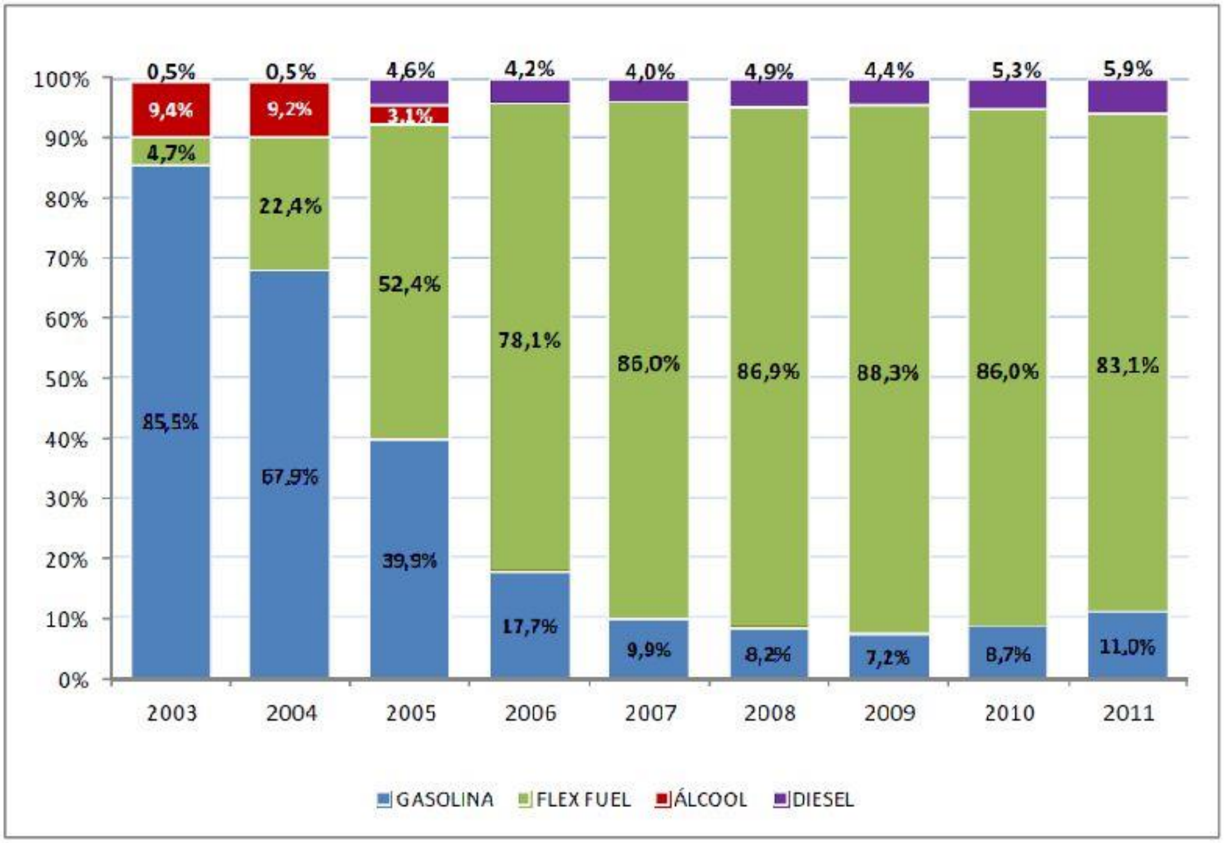

Figure 3: Percentage of different types of cars in Brazil (New sales) (Pinguelli, Villela, & Campos, 2013)

2.6 Environmental Issues

Another discussion that arose in the late 20th century is the one of environmental issues. Below, a graph is depicted that shows the global carbon dioxide emissions from fossil fuels. The risks of these emissions include; climate change, increasing or decreasing rainfall, influenced agricultural yields, health related issues, disrupted ecosystems and an effect on the supply and/or quality of (drinking) water. In politics, the urgency of protecting the environment was realized, and in 1972 the first United Nations Conference on the Human Environment was held. In this conference, also known as the Stockholm Conference, common principles were set to preserve the environment. One of these principle reads: "The natural resources of the earth, including the air, water, land, flora and fauna and especially representative samples of natural ecosystems, must be safeguarded for the benefit of present and future generations through careful planning or management, as appropriate (United Nations Environment Programme, 1972)." After this conference, nations agreed on the collaboration on environmental policies. This increased the incentives for private companies for investing in alternative fuels and engines.

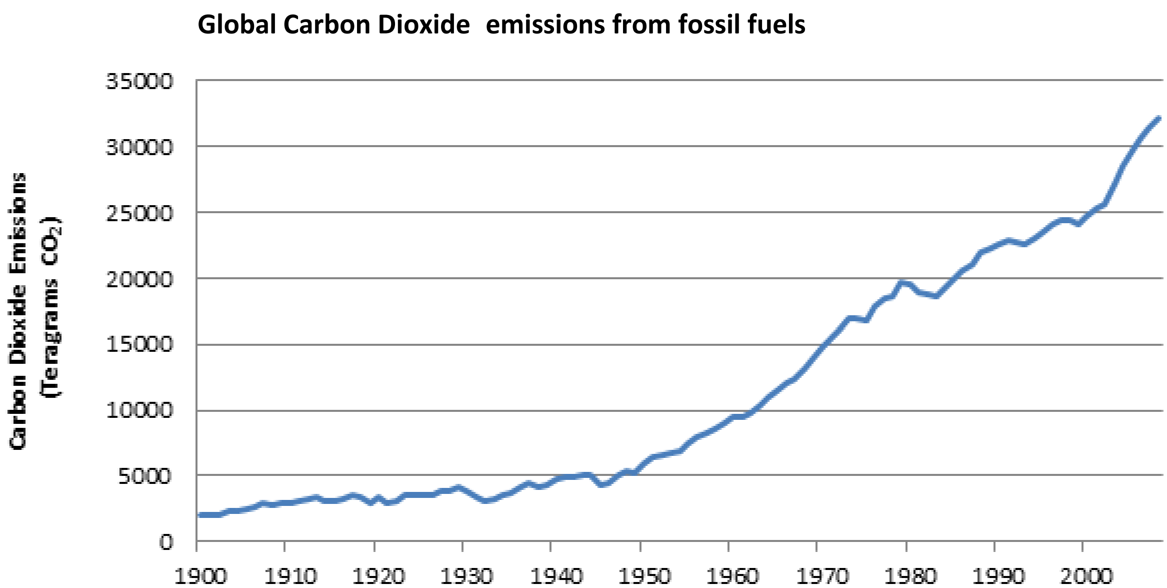

Figure 4: Global carbon dioxide emissions from fossil fuels (Boden, Marland, & Andres, 2010)

2.7 Oil Spikes

The historical oil price shows another spike in the early 2000's. This spike was caused by several factors. The falling value of the dollar was one of them, since oil is purchased in dollars. Tension in the Middle-East, such as the war in Afghanistan and Iraq and the decline of oil reserves were other factors that contributed to this spike. The highest price was achieved in July 2008, right before the economic crisis that caused the oil price to plumit. Multiple studies have showed that recessions that occur after an oil spike is not a statistical coincidence (Hamilton, 2005). Oil spikes tend to reduce supply in oil-intensive industries, while other industries would reduce demand during such a scenario (Lee, Kiseok, & Ni, 2002). Oil spikes also show that the economic dependence on oil is far too high.

3. The current fuel situation

3.1 Introduction

Through the course of history, mobility, and consecutively fuel, has become a large part of society. As an example of the increased mobility, the amount of kilometers traveled by Dutch people by car increased from 15.9 billion km in 1960 to 151.2 billion km in 1998, an increase of 850% (Centraal Bureau voor de Statistiek, 2003). Below, the Dutch trade of oil can be seen. The obvious increase in trade is a confirmation of the increasing value of oil in industry, transport and society.

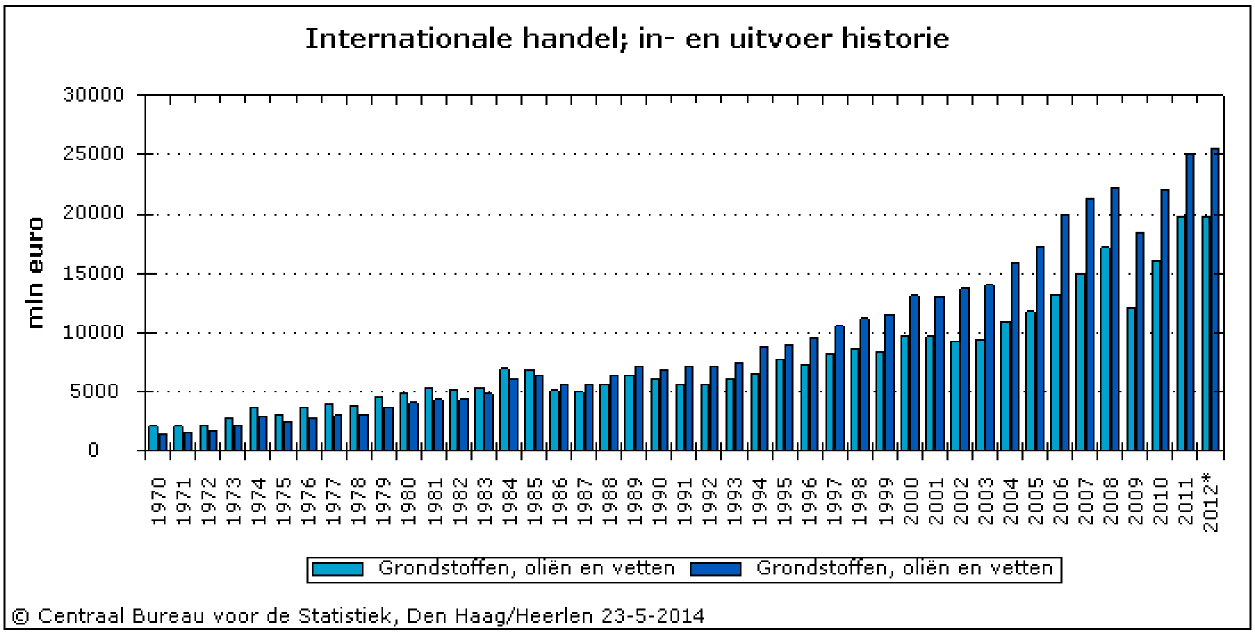

Figure 5: Dutch Import & Export of oils (Centraal Bureau voor de Statistiek, 2013)[1]

Companies exploiting oil fields and producing fuels are becoming more and more powerful. According to the Fortune 500, the list of the 500 largest companies in the world ranked by revenue, oil companies can be found on places 1, 3, 4, 5, 6 and 10. Also, automobile manufacturers can be found on places 8 and 9. The list is topped by Royal Dutch Shell, with a revenue of 481.7 billion USD (Fortune, 2013). The list confirms the suspicion that, despite large investments in alternative fuels and environmental issues, oil is still the most common fuel. According to the yearly reports of Shell in 2013, 2 million barrels were processed each day for automobile fuel, including gasoline, diesel and gas (Shell, 2013). Despite the

[1] Translations: Grondstoffen, olien en vetten = raw materials, oils and fats

power of these companies, research has shown that oil reserves are estimated to last just another 35 to 40 years (Shafiee & Topal, 2009).

In the course of time, automobile manufacturers have made numerous efforts in making cars more efficient, or running on a completely different type of fuel. The first widely available hybrid car was the Toyota Prius, which is still the world's bestselling hybrid car. A hybrid car uses the conventional combustion engine, combined with a battery and electric power. At low speeds, the battery powers the car, not using any fuel. When the battery is exhausted, or the speed is too high, the fuel engine is turned on automatically. When the car runs on the combustion engine, the battery is then automatically recharged . The first generation of the Prius was launched in 1997, with many technological advancements since, the newest being able to drive fully electric for 18km with a maximum speed of 62km/h (Green Car Congress, 2012). Toyota is currently investing in plug-in hybrid vehicles, these vehicles can be recharged through household electricity and once their battery has been exhausted, the automobile functions as a conventional hybrid car. Most of Toyota's investment are now looking into storing, generating and conserving energy by the car itself, through for example solar energy (Toyota Motor Corporation, 2013). Below*,* 4 different types of Toyota vehicles are depicted. HV (Hybrid Vehicle) is the first generation Prius, where the battery is only used at short distances and low speeds. The next generation is the PHV (Plug-in Hybrid Vehicle), where the battery has a higher capacity and thus longer distances and higher speeds can be obtained when powered by the battery, which can be recharged using household electricity. For smaller cars used mostly in cities, the EV (Electric Vehicle) is powered solely by a battery, which can also be recharged through household electricity. The possible future with hydrogen is depicted by the FCV (Fuel Cell Vehicles), which also has a battery for short distances, and powered by hydrogen fuel cells on longer distances.

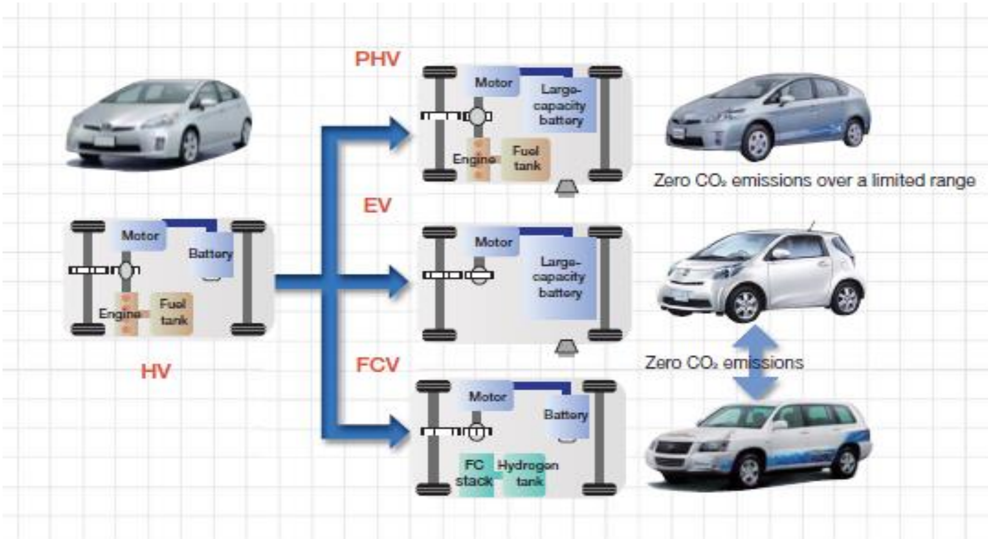

Figure 6: Toyota's new type of alternative vehicles (Toyota Motor Corporation, 2013)

For the next part of this analysis, three types of alternative fuels will be analyzed by their pros and cons. This way, an overview can be created with their strengths and weaknesses.

3.2 Hydrogen as a fuel

Besides the hybrid vehicles, Toyota is also researching the possibility of cars powered by hydrogen. The reaction of oxygen and hydrogen generates electricity which powers the car, creating a driving range that is similar to gasoline powered vehicles of similar size. Hydrogen can also be produced from various primary energy sources, such as steam reforming, coal, because of its greater availability, or electrolysis, where chemical elements are separated by electricity. Toyota however, recognizes the problem that the infrastructure needed for the refueling of hydrogen is far from sufficient and has yet to be created. Toyota's aim is to introduce a fuel cell vehicle powered by hydrogen in major cities in 2015, where infrastructure for hydrogen can be relatively easily built (Toyota Motor Corporation, 2013). At current oil prices, hydrogen is considered much more expensive. However, if the efficiency in the conversion of fuel cells in the vehicle itself is considered, hydrogen is very cost competitive if the extra costs for a hydrogen vehicle compared to a gasoline vehicle is a maximum of €1000,-. (Wietschel, Hasenauer, & de Groot, 2006).

Other automobile manufacturers, such as Daimler, Honda, Hyundai and Nissan are also planning to produce vehicles powered completely on hydrogen by 2015 (Collision Repair Magazine, 2012).

3.3 Problems with Hydrogen as a fuel

Since there are multiple ways to produce hydrogen as a fuel cell, the future of hydrogen as a fuel is ambiguous. For example, natural gas is considered to be the most efficient material to produce hydrogen, however, gas is also a fossil fuel and since the production of electricity also requires large amounts of gas a lock-in effect might be created, where gas exploiting companies are not willing to produce for hydrogen production. Constructing infrastructure for hydrogen is estimated to cost between USD 1 trillion and USD 4 trillion in the European Union, equaling between 0.07% and 0.3% of the annual GDP of the European Union (Wietschel, Hasenauer, & de Groot, 2006) (Eurostat, 2013). In the USA, the conversion of infrastructure would amount to USD 500 billion (Romm, 2004). Currently, the largest barrier of obtaining a widespread introduction of the hydrogen vehicle is the cost of the infrastructure, as studies have shown that there are no technological barriers for the construction of the hydrogen infrastructure, but merely economic barriers (Dunn, 2002).

3.4 Electricity as fuel

Another alternative fuel is electricity. Multiple automobile manufacturers are investing in fully electric vehicles, and almost all the large automobile manufacturers have at least one fully electric model. However, the range of these vehicles are not large enough yet for long distances, and these vehicles are thus mostly created for commuting. The range of electric cars are typically between 160km and 400km (ANWB, 2014). Charging electric vehicles can be done by the household electricity grid, for example during the night. The Dutch government is investing much in the future of electric driving, consequently, many charging stations for cars have been placed. With a subscription and a card, people can charge their car in just over two hours at a marked spot. In the Netherlands, over 4000 of these stations can be found. The Netherlands is leading in this market, as in the whole of France, a little under 100 of these stations can be found. In Spain there are only 33 (Oplaadpalen, 2014).

3.5 Problems with Electricity as a fuel

The largest barrier for the widespread introduction of electric vehicles is the significantly higher price of the vehicle compared to conventional combustion engines. According to a survey of the Financial Times in 2010, 75% of British and American car buyers have or would consider buying an electric vehicle, however, also 75% of the respondents claimed not to be willing to pay a higher price for an electric car compared to a gasoline powered car (Reed, 2010). The largest reason for the high price on electric cars is the battery, ones that are efficient enough for an economically viable range of the vehicle drive the cost of the car up to significantly higher levels than gasoline powered vehicles. The company that has the newest innovation in this sector is Tesla Motors (Autoblog Green, 2010). The company uses the same technology as batteries used in laptops, making the battery in the vehicles around 3 times cheaper than conventional batteries (Krolicki & Kim, 2011). This technology has been sold to multiple automobile manufacturers, consequently, the expectation is a sharp decrease in the price of electric vehicles when several manufacturers of cars will introduce their new electric model using the battery technology of Tesla in 2015.

As explained in the previous section, another problem with electricity is the lack of international widespread loading stations. The Netherlands has enough stations for the vehicle to be used in the country itself, however, the lack of these stations in other countries limit the intra-country travel with electric vehicles. The largest problem is that electric vehicles don't possess a range comparable to other gasoline powered vehicles. For example, the most efficient vehicle on the market is the Toyota Plugin Hybrid, reaching a range of 870km (Voelcker, 2012), compared to the most efficient electric vehicle, the Tesla Model S, reaching only 334km (Shahan, 2014).

The question whether electricity as a fuel is actually cleaner than conventional gasoline also depends on the fuel mix. The manner in which electricity is created can also create large emissions, possibly offsetting the emissions saved when driving electric. In the Netherlands in 2013, 1.95% of all used electricity is created with renewable sources such as wind or solar energy (Centraal Bureau voor de Statistiek, 2014), which has an obvious emission rate of 0%. Coal is widely mentioned as the 'dirtiest' way to produce electricity. Coals are burned and emission is very large. According to research, coal is responsible for a small fraction of energy for a country, but responsible for the largest part of emissions. In the Netherlands, coal is also one of the most used method for producing electricity, as can be seen in the figure depicted below, where the different types of methods for producing electricity is shown and the corresponding input. As can be seen, coal and gas are much more used compared to renewable energy sources. When driving an electric car, the indirect emissions, those from the (coal)production to create electricity, might offset the advantages of driving electric.

The Netherlands is, despite its current 'dirty' fuel mix, aiming for a durable fuel mix. In a new vision, the aim is to reduce the CO2 emission with 60% compared to 1990 in the long-run. Also, all vehicles must be CO2 free from 2035. The expectation is that the vision will be translated to an action plan and presented to the Dutch government at the end of 2014 (Verkeersnet, 2014).

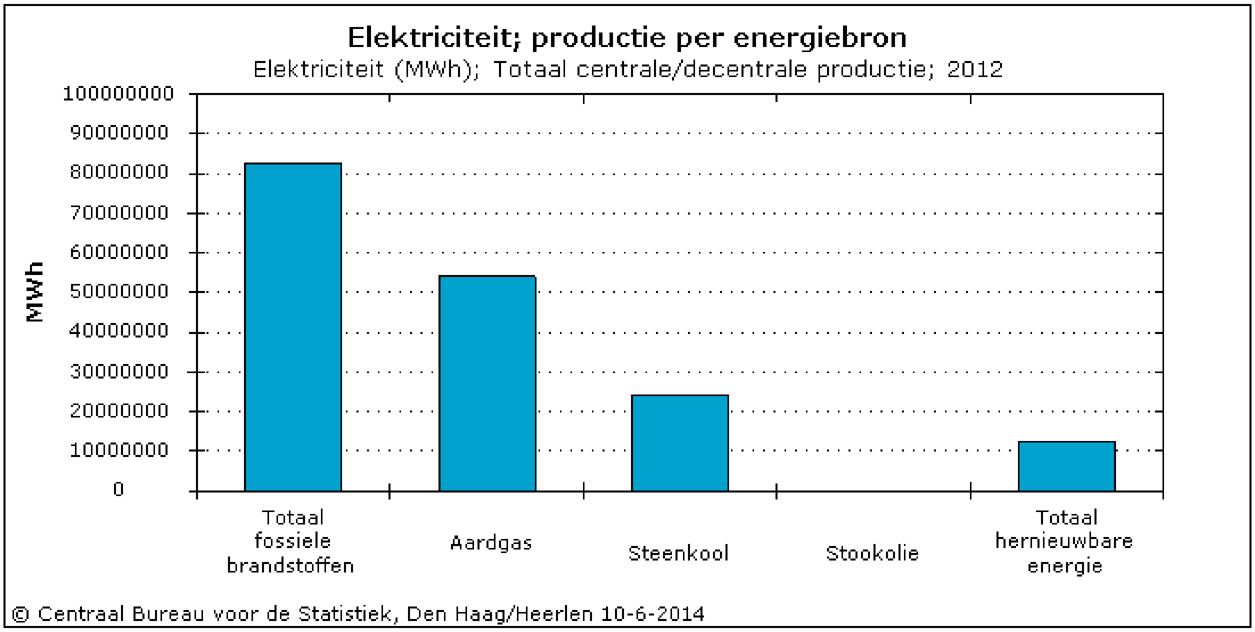

Figure 7: Electricity: production per energy source in MWh in 2012. (Centraal Bureau voor de Statistiek, 2014)[2]

As discussed before, the Netherlands is one of the leading countries in the infrastructure of electric driving. One would expect it also to be one of the leading countries in the share of renewable energy. The contrary is true, the graph below shows the share of energy from a renewable source per country in the EU, and the Netherlands can be seen at place 25th. Ironically, since the country on first place, Sweden, has almost no (public) infrastructure for electric driving whatsoever (Oplaadpalen, 2014).

[2] Translations: Aardgas = Gas, Steenkool = Coal, Totaal hernieuwbare energie = Total renewable energy

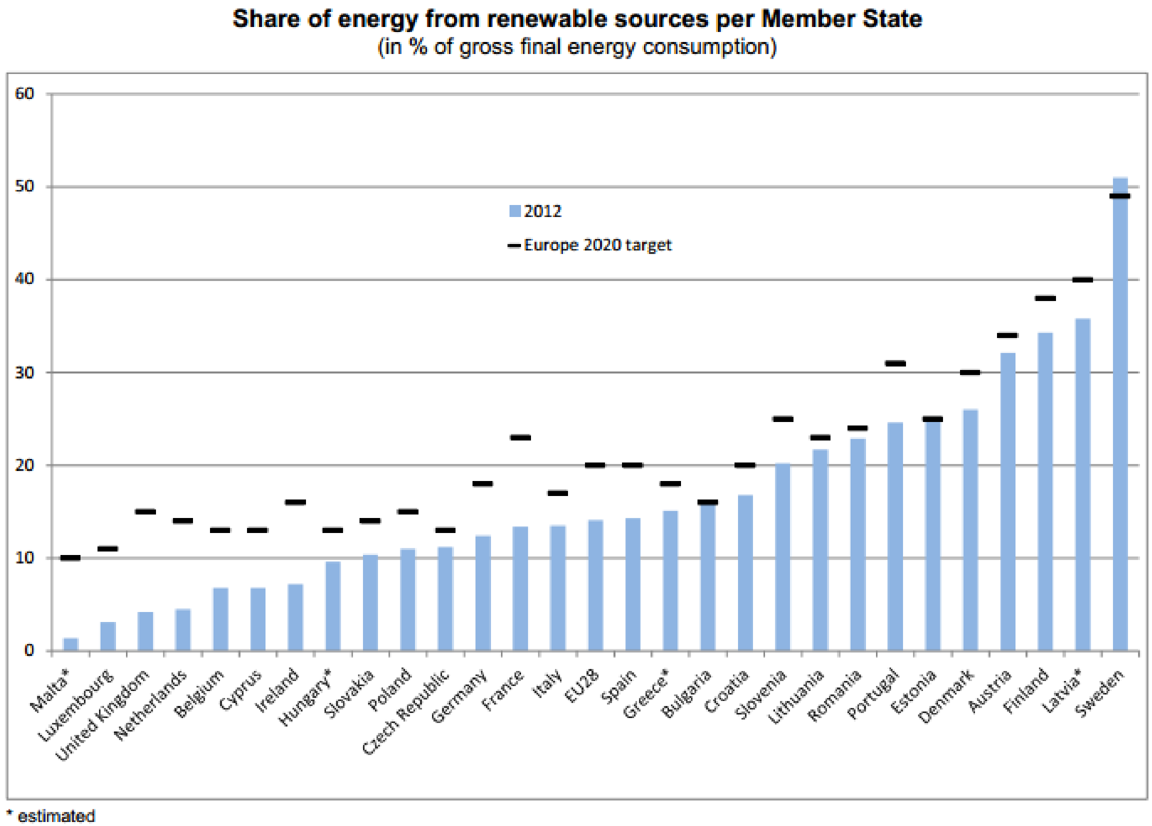

Figure 8: Share of energy from renewable sources per Member State (Eurostat, 2014).

3.6 Biofuel

Another alternative source of fuel is Biofuel. Biofuel refers to the conversion of recently living organisms to substances containing energy, such as oil or diesel. Biofuels can be traced back to the early 20th century, where Henry Ford planned to run his famous T model completely on ethanol, while other cars where designed to run on peanut oil. Due to the cheap oil in that time, the innovations in biofuels were held back, until 1975, when Brazil introduced their Proálcool, as discussed in part 2.6. Poor countries see massive opportunities in biofuel, as farmers can sell their production to gasoline producing companies as well. Also, the dependence on the oil exploiting countries decrease with the use of biofuel, as there are many ways of producing biofuel, using products such as grain, vegetable oil, sugar, hemp, corn and many other biomasses. In this analysis, the focus will rely on the largest types of biofuels, as there are many, ethanol and biosdiesel.

3.6.1 Ethanolfuel

Ethanol used as fuel is a type of alcohol found in beverages. Ethanol can be produced from several sources, such as sugar, corn and potato. A large advantage of ethanol as a fuel is the fact that it can be used as a quasi-renewable fuel, an additive for conventional gasoline or solely on ethanol. The widespread use of ethanol started in Brazil, where flex-fuel vehicles can run on a mixture of ethanol and water (Science Daily, 2014). In Brazil, all vehicles are obligated to have some sort of mixture of ethanol in the gasoline since 1975. In 2007 the Brazilian law stated that the mixture of ethanol must be at least 25% In the US, almost all cars can run on a mixture of gasoline and ethanol, where a maximum of 10% ethanol is allowed (Worldwatch Institute Center for American Progress, 2006).

The reduction in emissions of ethanol compared to conventional gasoline is estimated to be around 13%. Another production type of ethanol, cellulosic ethanol, where wood, grasses or inedible parts of plants are used, decreases emission by 88% (Energy Future Coalition, 2014). The advantage of this alternative type of production of ethanol is the fact that no crops are used that are normally used as food, a problem that will be discussed later. Both types of ethanol decrease the dependence on oil-exploiting countries, as most of the raw materials used to produce ethanol or cellulosic ethanol are found in nearly every country. Cellulosic ethanol can also be produced from materials such as paper or cardboard, something that is thrown away in many countries in large amounts. If these materials are recycled and transformed into bioethanol, the future of the relatively new fuel can be great.

3.6.2 Biodiesel

Biodiesel can be created from multiple products, such as: sojaoil, cornoil, palmoil, animal fat or cooking oil. Which product is used to produce biodiesel depends on a country's climate. Tests have been made with used cooking oil to reduce the relatively high price of biodiesel fuel, however, used cooking oil has a lower quality than fresh oil, resulting in engine problems and a lower efficiency (Murayama, 1994). The largest advantage of biodiesel is the renewable property of the raw materials used to produce biodiesel. Another advantage is the non-toxic property of the raw materials, however the required chemicals for the production process are toxic. The CO_2 emmission of biodiesel is also much lower compared to conventional diesel (U.S. Department Of Energy, 2003). Many countries support the use of biodiesel with tax incentives, the USA for example, has several regions where schoolbusses are run completely on biodiesel (National Biodiesel Board, 2014). In the graph depicted below, the national production of biodiesel of the USA is shown.

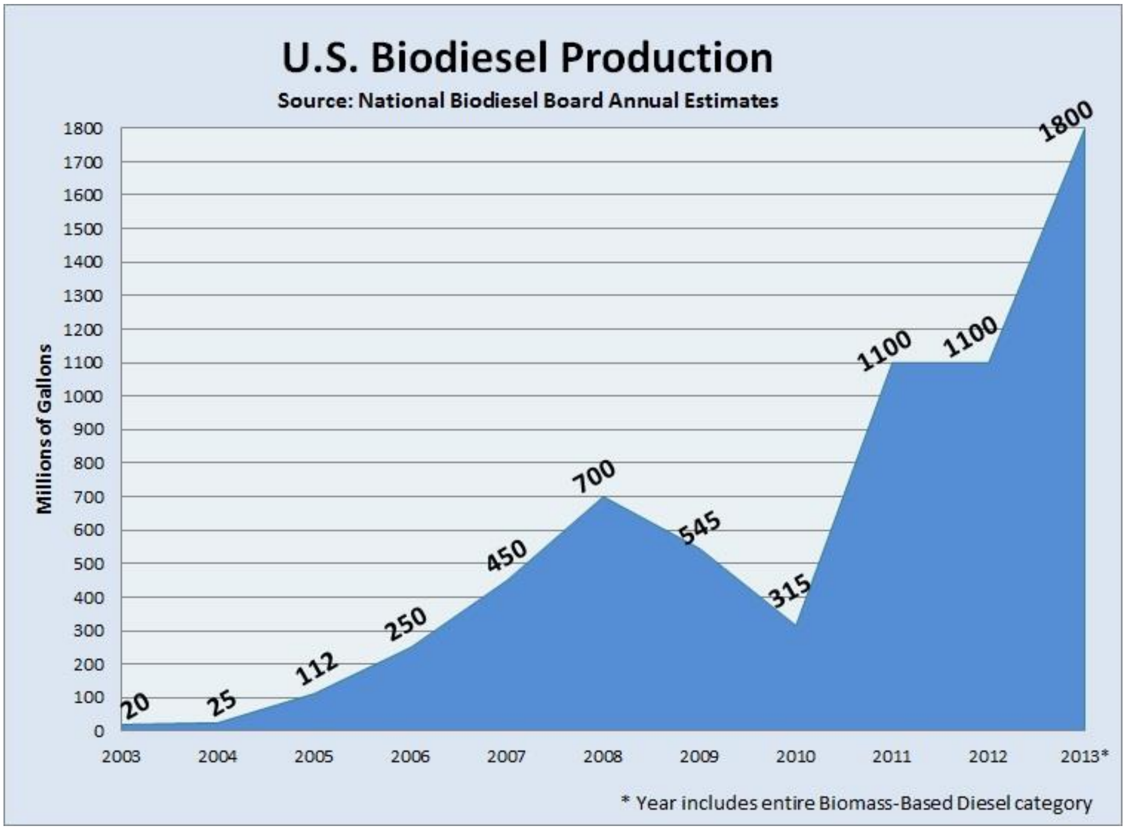

Figure 9: U.S. Biodiesel Production (National Biodiesel Board, 2014).

In the graph, the economic crisis can be clearly seen, as we can see a decrease of more than 50% after 2008. However, these numbers are still insignificant compared to the oil production in the USA, as in 2013, 312,606 million gallons of oil were produced, compared to 1,800 million gallons of biodiesel (US Energy Information Administration, 2014).

3.7 Problems with Ethanol and Biodiesel as a fuel

The introduction of biodiesel and ethanol as a fuel has encountered multiple problems, the largest of these being the food vs. fuel dilemma. This dilemma is defined as the fact that farmers can sell their crops not only to food producers, but also to chemical companies that produce biodiesel. The valuation of petroleum and agricultural products converge, leading to a significant raise in the world food price (Cassman & Liska, 2007). Richer countries will be able to make investments in order to increase the efficiency of their agricultural sector, however, developing countries will rely more on the imports of food and thus the insecurity of the supply of food will increase, which might eventually create more and more hunger in the developing countries, with lethal risks, especially in poor countries.

Another problem with biodiesel as a fuel is the large surface that has to be used when producing the raw materials to produce biodiesel (Roberts, 2006). To meet the demand of large acres of ground, tropical rainforests are being cut to create new space for agricultural activity that can be used for the production of biodiesel. Besides the obvious environmental damage to flora and fauna, the transport of raw materials from the tropical rainforests to the chemical plants require much fuel, causing more emission.

For cellulosic ethanol, larger surfaces have to be utilized to produce an equal amount of fuel compared to the surface conventional fuel requires, because, mostly plants and wood are used for this type of ethanol, which is overabundant in the tropical rainforest, resulting in more deforesting and the resulting inevitable deterioration of inter alia flora, fauna and ecosystems, causing global warming and all the risks that come forth. Paper and cardboard can also be used for cellulosic ethanol, however, in the Netherlands, five million kg of paper is thrown away each year (PRN, 2014), while the Netherlands is named 4th in the list of highest worldwide recycling rates (Aneki, 2014).

Finally, the organic consistency of biofuels create another difficulty, it causes the fuel to have a limited shelf life. Biofuel is estimated to last around 6 months. Accordingly, a tank that is filled with biofuel has to be completely emptied and cleaned before a new batch can be added. This causes the logistical part of the supply chain to be completely altered compared to conventional fuel (Centrum Industriele Veiligheid, 2008).

3.8 Alternative fuels: an overview

To provide an overview of the types of alternative fuels discussed in this chapter, a table is created with the fuel's pros and cons.

Alternative fuels overview:

Type of fuel	**Pros**	**Cons**
Hydrogen	- *Zero CO2 emission* - *Decrease of oil dependence* - *Similar efficiency to gasoline powered vehicles* - *Large availability of raw materials* - *Renewable source*	- *Very high cost of infrastructure* - *Most efficient raw material is natural gas, also a fossil fuel*
Electricity	- *Zero CO2 emission* - *Decrease of oil dependence* - *Possibility to charge vehicle at household electricity grid* - *Renewable source*	- *High price compared to gasoline powered vehicles* - *Infrastructure not (internationally) widespread* - *Lower range compared to gasoline powered vehicles* - *Electricity created from CO2 intensive sources offset the environmental advantages*
Biofuel	- *Lower CO2 emission compared to oil based fuel products* - *Decrease of oil dependence* - *(Quasi)Renewable source* - *Raw materials can be produced (almost) anywhere*	- *Food vs. fuel dilemma* - *Large surface required for raw material production* - *Deforesting and the resulting environmental damage* - *Limited storage life*

4. Dutch policy for stimulating clean vehicles

4.1 Introduction: EU rules and goals for clean vehicles

In 2009, the EU recognized that, in order to stimulate widespread introduction of environmental friendly vehicles, financial incentives and other measures are needed. Therefore, the Directive on the Promotion of Clean and Energy Efficient Road Transport Vehicles was created (European Parliament, 2009). Their goal is to improve the environmental performance of transport by introducing environmental friendly vehicles. The directive tries to monetize environmental damage occurred during the lifetime of a vehicle, an extra cost that consumers should take into account in their purchasing decision. One can compare the emissions of a vehicle as a negative externality, where the social damage created by the vehicle is not implemented in the costs, a case widely studied by economist Pigou (Pigou, 1920).

One of the ways the directive tries to incentivize the sale of clean cars, are tax reliefs or subsidies. The Directive has a guideline for member states that want to impose a tax relief or subsidy (European Commission, 2013), where they impose rules on the fiscal incentives member states want to impose. The rules are as follows:

- Incentives must be non-discriminative
- Incentives must be compatible with mandatory technical requirements
- Incentives must be compatible with state aid rules, this includes that the size of the incentive avoids over-compensation
- Incentives must be in accordance with Directive 98/34/EC, a set of rules that apply inter alia on the technical requirements and the measurement requirements of the emissions (European Parliament, 1998).

Furthermore, the Directive states several recommended principles, aimed to maximize the effectiveness of the incentives in the member states of the EU, in order to converge in the continent-wide incentives. These recommended principles are as follows:

- Incentives should be technological neutral, i.e. the incentives should focus on the environmental friendliness, instead of type of technology used
- Incentives should be performance-based
- Incentives should be proportional to the environmental performance

- The size of the incentive should not exceed additional cost of technology to prevent the incentives from being used as a subsidy
- Incentives should be linked to the CO2 emission limits from the country, when a country has a very low CO2 limit, only the most environmental friendly vehicles should be incentivized

These set of principles set by the European Commission can be translated accordingly by each member state. The next part of the analysis will focus on the incentives imposed by the Dutch government for clean vehicles.

4.2 Incentives imposed by the Dutch national government

In the Netherlands, several taxes have to be paid when purchasing a car. One of them is the BPM, which is calculated over the CO2 emission of the car. For example, a car that has an emission of less than 88 grams CO2 per km, is exempted from this tax. This means that every electric vehicle is free from this tax, a semi-electric vehicle such as the Toyota Prius explained before, has an emission of 25,8 grams per km, also exempting it from the BPM tax (Toyota, 2014). The most sold vehicle in the Netherlands in 2013, the Volkswagen Up (Autoblog, 2014), has an emission of 95 grams per km, obliging it to pay €735,- annually (Belastingdienst, 2014).

Another type of tax that has to be paid for a vehicle is the possession tax. This tax is calculated over the weight of the vehicle. However, for the stimulation of clean vehicles, until January 1st 2016, only vehicles with an emission lower than 50 grams per km, are exempted from this tax. This means that even the cleanest hybrid vehicles are exempted from this tax. For an electric vehicle this tax is also nil (Belastingdienst, 2014). This is done to keep stimulating the population to buy and drive cars with no or very little emission.

For a numerical example, two cars with similar weight and price will be compared. One of these cars will be electric, the other powered by gasoline. This way, we can compare the extra taxes that have to be paid over gasoline powered vehicles compared to electric vehicles.

The Tesla Model S costs €66,640,- incl. VAT, compared to the Audi A5 Sportback 3.0TFSI, that costs €66,250,- incl. VAT. The extra taxes that have to be paid over the Tesla Model S are nil, thus the price of the vehicle remains €66,640,- incl. VAT. However, the Audi A5 has an emission rate of 178 g/km. This means the BPM will be €10,584,-, calculated by the table of the Belastingdienst (Belastingdienst, 2014).

The possession taxes amount up to €1,704,- annually. This means, the total price of the Audi in the first year will amount; €78,538,-. The taxes based on weight are also annual, meaning the price difference between these two cars increase with €1,704,- annually, disregarding the difference in efficiency and price of the fuel.

The exemption of the possession tax for clean vehicles has disappeared since January 2014. This caused a large decrease in the growth of electric vehicles in the Netherlands. The last few months in 2013 showed a massive growth in electric car purchases, since people that bought an electric vehicle in 2013 are exempted from possession taxes until 2018 (Tankpro, 2014).

Currently, one in three vehicles fall under the exempting of the above mentioned taxes, since regular gasoline are become more efficient and cleaner. This means that the incentive of purchasing very clean cars will disappear and the costs for this measure for the Dutch government will become too high. The expectation is thus that the allowed CO2 emission for clean cars will decrease even further (Rijiksoverheid, 2014).

The exemptions of taxes introduced by the Dutch government are all focused on environmental issues. Vehicles that use biofuels are not incentivized, since they still have an emission, despite their renewable characteristic and lesser dependence on oil.

4.3 Infrastructure in the Netherlands

As seen in the previous section, the fiscal advantages of buying and driving a clean car are regulated at a national level. The infrastructure, however, is regulated at a decentralized level by local provinces or municipalities. This section will focus on the infrastructure in several local areas.

In Rotterdam, people are allowed to request a station for electric cars. This request is free, and the municipality will place the electric station in a parking area close to the requestor's house, a subsidy is even awarded when the requestor wants to place the loading station on their private terrain. Also, subsidies are given to companies that want to place an electric station on their terrain, for employees or visitors. For both cases, the costs of the electricity is paid completely by the municipality if it uses 'green' electricity, created by renewable and clean sources such as wind or solar power (Gemeente Rotterdam, 2014). Other municipalities, such as The Hague (Gemeente Den Haag, 2014) and Amsterdam (Gemeente

Amsterdam, 2014) also provide subsidies to those who want to place electric loading stations in their near proximity.

It is clear that the placing of infrastructure for electric driving is decentralized, the municipalities each are responsible for the placing of the loading stations. Also, we can derive that the amount of loading stations in the city are correlated with the amount of electric vehicles in the city, since owners of electric cars can request a loading station. Since the CO2 emission of electric vehicles is nil, we can conclude that cities focus on environmental emissions, instead of the renewability of the fuel and the corresponding oil dependence. As explained before, the Netherlands is one of the leading countries if it comes to electric driving infrastructure. Despite the 'dirty' characteristic of the Dutch electricity, the fiscal and infrastructural focus remains solely on electric driving in the future.

Currently, there are 2 tanking stations that deliver hydrogen (Fuelswitch, 2014), a third is being built in Rotterdam by Air Liquide (Air Liquide B.V., 2013). These gas stations all have facilities to produce hydrogen at their location. This means that the supply chain is easy, since the large transports are out of the equation. Since hydrogen is still a very new fuel that is not often used, the price is not determined by supply and demand, but artificially. Currently, the price is around €10,- for 100km (Autowereld, 2012). A gasoline powered vehicle uses on average 1 liter per 14km, with the gasoline price on June 10th, 2014, €1.819 (Brandstofzoeker, 2014), that would amount to €12,- per 100km. However, since the very limited infrastructure, an owner of the hydrogen vehicle would have to live very close to one of the two tanking stations to actually profit from owning a hydrogen powered vehicle.

In the Netherlands, there are around 25 tanking stations that provide bio-ethanol as a fuel, compared to around 10 that provide biodiesel (Biotanken, 2014). The price of ethanol is slightly higher compared to conventional fuel, and the burning value is lower than gasoline. This means that more ethanol is required to travel the same distance. The adaption that has to be made to a vehicle is also quite expensive, reaching up to €1500,-. For bio-diesel, the costs are much lower, the burning value is only very slightly higher compared to normal diesel, and the costs of biodiesel is also slightly higher. The adaptation that has to be made to the vehicle is also lower, around €500,-. Ironically, since there is less infrastructure for biodiesel than for ethanol. Several municipalities in the Netherlands are also promoting the use of biofuels by the use of subsidies, however, all the municipalities that promote biofuels are located outside the Randstad, the busiest area of the Netherlands, these areas are; Arnhem, Nijmegen and the province of Gelderland (Fuelswitch, 2014). This shows that also the incentives for using biodiesel is decentralized.

All incentives that the government of the Netherland imposes are mostly focused on companies, for example, subsidies can be requested for clean company cars and clean cars can be depreciated quicker, allowing the companies to pay a lower amount of income taxes (Belastingdienst, 2014). All the private incentives are decentralized, imposed by municipalities or provinces. As explained, there is no unity in the type of fuel that is promoted by all the municipalities, as in the busy area of the Netherlands, the Randstad, electric driving is incentivized, where in the more rural areas biodiesel is promoted.

5. Conclusion

In this research, different types of fuel were analyzed, including the general history of vehicle fuel. All the pros and cons of the different types of alternative fuels were analyzed. Finally, the incentives imposed by the Dutch government were analyzed. A conclusion can now be drawn by answering the research question: "To what extent is the Dutch policy for stimulating clean vehicles coherent with the developments of alternative fuels?"*.* In this context, coherent is defined as follows: logical and a consistent relation of parts.

The analysis showed a few reasons why it is so important to switch to alternative fuels. First, the dependence of oil exploiting countries is increasing and becoming dangerous. An embargo by those countries, as happened in 1973 explodes the price of oil, sending countries into a recession. We can conclude that oil is a dangerous weapon for the economies of other countries that rely on those oil exploiting countries. Secondly, the non-renewable property of oil is a problem. The transition to alternative fuel takes time, and the transition has to be complete before the oil reserves are exhausted, something that can happen in just 35 to 40 years. Finally, the environmental damage that has been done by using oil as a fuel and all the (unknown) risks that come forth.

The Dutch government introduced large fiscal advantages to vehicles that have zero CO2 emissions. This means the fiscal advantages are focused solely on environmental issues. One could argue that biofuels, despite the fact that this type of fuel does have CO2 emission, is still a very good alternative to deal with the first two problems with oil, the oil dependence and the non-renewable property. The government does not take these two problems into account when designing the fiscal incentives, something that a country like Brazil did do, imposing laws that require cars to function on at least a certain percentage of biofuel. In the history of the fuel we can see that the dependence of oil caused many problems in the past, many recessions and even arguably, reason for war.

In the Randstad, many electric loading stations for electric vehicles can be found. With the new technologies in batteries, the price of the electric vehicles will decrease and the barrier for people to switch to electric driving will diminish in the future. However, since 2014, the vehicle tax has to be paid for electric vehicles, causing a sharp decrease in the growth of the sales of electric vehicles. Since the new technologies in the batteries are not yet implemented in the prices of electric vehicles, the price gap has increased, since the extra tax causes an increase in price of electric vehicles. If the Dutch government had waited with the disappearance of this tax until the new battery technology was implemented in the prices of electric vehicles, the increase of the price, and thus the decrease of the sales of electric cars would have been much smaller. This shows that their fiscal policy is not coherent with technological progresses that are made in the alternative fuel powered vehicles.

We also see a divergence in the policies of municipalities of different fuels. In the Randstad, many municipalities invest in electric loading stations, because of the zero CO2 emissions in large cities. In the rural areas, the CO2 emissions is a smaller problem, and mostly biofuels are promoted there. Since the Netherlands is a small country, this is not a very large problem. However, if a larger country such as Germany would have the same divergence in the preferred type of alternative fuel, one could, e.g., not use an electric vehicle to drive through the country, yet only use it in areas where there are sufficient electrical loading stations for the vehicle.

The Netherlands is also one of the only countries with an extended infrastructure for electric vehicles. Other European countries, such as France and Spain have very limited electrical loading stations. If these countries focus on different types of alternative fuels than the Netherlands, the only way to travel abroad with a car is by conventional gasoline, the fuel that all countries have infrastructure for. It is thus recommended that the European Union take a common point of view when regarding which type of alternative fuel to focus on.

The Netherlands is paradoxically one of the leaders in electric driving in the European Union, however one of the lowest on the ranking when it comes to clean energy. The argument of the Dutch government, to focus on the environment, is, despite the focus on electric driving, offset by the lack of clean electricity. The Netherlands is, however, aiming for an efficient fuel mix. This shows that the government is aware of their ‘dirty’ fuel mix and is thriving to improve it. This is a good sign, as the relatively developed electric driving culture is a big step in the right direction. When the fuel mix for producing electricity greatly improves, the Netherlands could be one of the precursors in clean, and especially electric, driving. However, these goals are not yet translated to an action plan, so the implementation of these new ideas will take time, until then the fuel mix is not nearly ‘clean’ enough.

We can see that historically, the whole world started to focus on oil as a fuel, despite the presence of other technologies. We can see that in the Netherlands that infrastructure for alternative fuels are decentralized. This causes divergence between provinces. Also, in other countries in Europe, the infrastructure for electric cars are small-scale. This does not only slow down the transition, if these other countries focus on another type of fuel, the transition in the Netherlands will come to a complete stop. This shows that the local infrastructure is not in line with the historical transition to oil as a fuel, as all countries should be on the same page.

There are also some parts of the Dutch policy that are in coherence with the developments of alternative fuels. The alternative fuel that the Dutch government is incentivizing most, electricity, is technologically speaking the most advanced and the infrastructure the cheapest. One could say that this alternative fuel is a good one, only it is ambiguous to predict for how long. When the new batteries come out, the expected price of electric cars are to decrease and the expected sales to increase. Despite these good signs, the Netherlands is one of the only countries that has an extended infrastructure in electric driving.

As a recommendation, not only the Dutch government should take a unified stance in what alternative fuel to incentivize, also the European Union should unify the member states. This way, the transition to the new alternative fuel will speed up, allowing the European Union to be the leader in alternative fuels in the automobile industry. There are enough historical, climatological and political reasons for this transition to initiate.

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