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J.E.PURKYNĚ
V ÚSTÍ NAD LABEM

Seminar thesis

State of biofuels: difference in types, quantities, feedstocks and costs (2000 – 2015)

in the framework of the

Interdisciplinary Bilateral Winter and Summer School on Economic Environmental policy and Technical aspects of Energy Systems

Supervisor:
Dr. Amela Ajanovic

Authors:
Sebastian Ehrmann
Jan Purchard

Summary

Abstract

In order to meet the EUs 2020 goals of a reduction of greenhouse gas emissions by 20% and to increase the share of renewables of final energy consumption by 20 % various technologies, such as biomass, wind and hydro power plants can be considered. About 14% of global greenhouse gas emissions are emitted in the transport sector. According to the EU directive 2009/28/EC on "renewables", it is obligatory to substitute 10% of the energy content of fossil fuels by energy sources based on renewable energy production, such as biodiesel and bioethanol. Austria fulfills the actual mandatory substitution of 5,75% and 443.389 tons of biodiesel and Hydrotreated-Vegetable Oil (HVO), and 88.843 tons of bioethanol were sold in 2013. Biodiesel prices are correlated with fossil diesel prices. In Austria the main feedstock used for bioethanol production is maize and cereal and rape seed oil for biodiesel production. In Czech Republic mainly rape seed, wheat and sugar beet are used for biofuel production. Supports by the state have a strong influence on price development. On a European level biofuel production increased significantly over the last decade, whereby Germany, Spain and France were the most important biofuel producers. On a global scale, Brazil and the USA are the leading biofuel countries.

Introduction

There are serious concerns among scientists related to anthropogenic global climate change. The IPCC (2013, 15) reports that greenhouse gases contributed to a global surface warming in the range of 0,5°C to 1,3°C over the period 1951 and 2010. The cooling effects of aerosols were considered.

Although the costs of the mitigation of greenhouse gases are of around 1% of GDP in a global perspective, they are small relative to the costs and risks of climate change. It is estimated that the net benefits of mitigation policies are of the order of $2,5 trillion (Stern, 2006, 16f).

In 2010, 14% of global greenhouse gases were emitted by the transport sector (Figure 1) (IPCC, 2014, 44). In Austria the transport sector accounts around 33% of final energy use in 2013 (Figure 2) (BMWFW, 2015). Therefore, it is crucial to promote greenhouse gas mitigation strategies.

Various strategies for the mitigation of greenhouse gases in the transport sector can be considered. Apart from the use of electrical vehicles and hydrogen fuels, the use of biofuels is an attractive option to reach this goal.

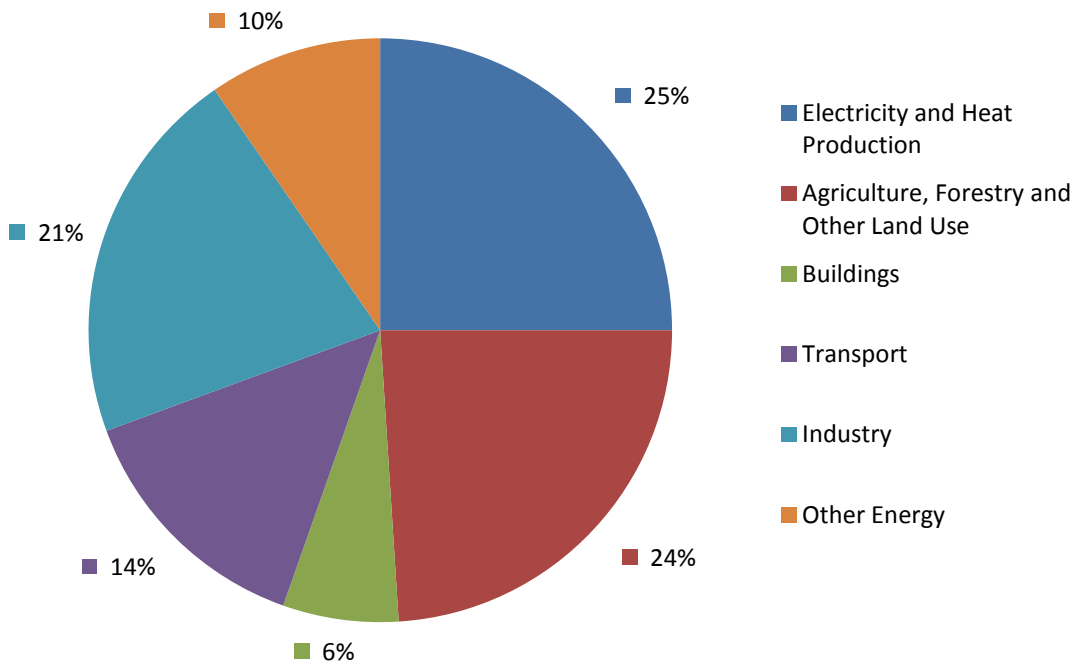


Figure 1: Greenhouse gas emissions by economic sector in 2010 (IPCC, 2014, 44), Author's illustration

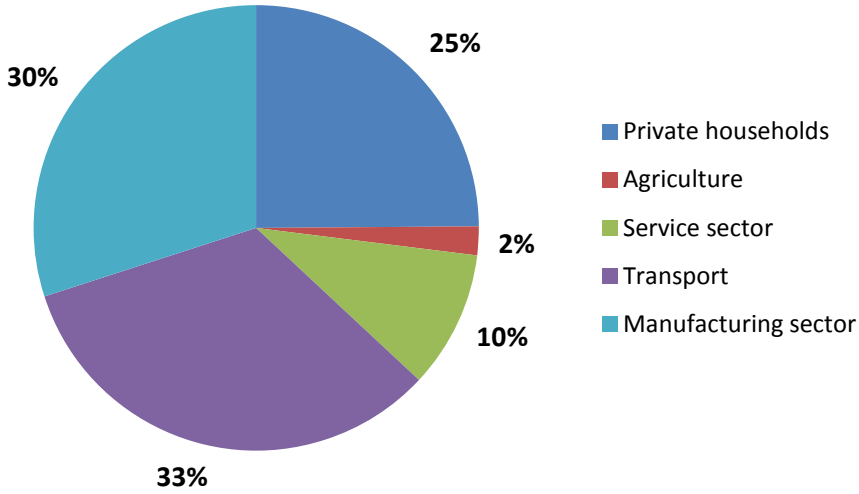


Figure 2: Final energy use by sectors in Austria 2013 (BMWFW, 2015), Author's illustration

Core objective

The core objective of the seminar thesis is to give an overview of the biofuel sectors of Czech Republic and Austria and to compare them. Apart from the national sectors, the European point of view is of interest. Due to the fact that the main global players in the biofuel sector are non-European countries, the sector mentioned is also discussed on a worldwide scale. Especially, data on historical development of quantities, feedstock, prices and types of biofuels are of interest.

Methodology

The seminar thesis is mainly based on literature data for biofuels. Literature from official entities (e.g. Agricultural Ministry, European Commission) as well as scientific publications were used. Due to a lack of data on biofuel prices in Czech Republic, the data were provided after request from the Czech research institute VUZT.

Statistic data, mainly provided by EUROSTAT, were analyzed and visualized using Microsoft Excel 2007. Based on these graphs, a comparison between Czech Republic and Austria was done.

Furthermore, cartography methods were used in order to create a map with the world's most important biofuel producers. The map was created with GIS (Geographical information systems), with ArcGIS 2013 (software from ESRI Company), to be precise.

Definition of biofuels

Biofuels are categorized in three generations. First generation biofuels simply use a specific part of the plant biomass, e.g. oil, starch and sugar, for fuel production and are, therefore, less efficient. Second generation biofuels make use of the whole plant or waste biomass for fuel production. Whereas first generation biofuels are produced by applying extraction or fermentation processes, production of second generation biofuels is based on more complex thermo-chemical processes. In contrast to first and second generation biofuels, third generation biofuels use algae biomass as raw material. Due to high biomass production, higher yields can be achieved. However, production costs are too high for competing with first and second generation biofuels (Präsoll, 2012, 23ff).

The European Commission defines biofuels as “liquid fuels from a non-fossil biological origin and a renewable energy source, to be distinguished from fossil fuels.”(EUROSTAT, 2016a). According to EUROSTAT (2016a) they and can be split into two categories, namely biogasoline (bioethanol, biomethanol, bioETBE and bioMTBE) and biodiesel (biodiesel (methyl-ester), biodimethylester, Fischer Tropsch, cold-pressed bio oil and all other liquid biofuels), which means that the categories refer to first generation biofuels (see above).

Further explanations for renewable energy sources are given in Table 1.

Table 1: Renewable energy sources for biofuels (BMLFUW, 2014,6) Author’s illustration

Bioethanol	Bioethanol is ethanol produced out of biomass with an alcohol content of at least 99 v.-%
Biodiesel	FAME (Fatty acid methyl ester) is a methyl ester based on plant and animal oils and fats.
Biomethan	Biomethan production is based on pyrolysis and fermentation processes of biomass.
Bio- ETBE	Ethyl-tert-butylether production is based on bioethanol and can be charged with 37 % of its energy content as renewable energy resource.
Bio-MTBE	Methyl-tert-butylether production is based on biomethanol and can be charged with 22 % of its energy content as renewable energy resource.
Superethanol E85	Fuel admixtures with a share of bioethanol depending on the season between 65 and 75 v.-%.
HVO	Hydrotreated Vegetable Oil refers to hydrocarbons based on plant and animal oil or fats produced by hydro-treatments.

Results

Legal Framework for Biofuels in the European Union

In order to foster increases in biofuel production, it is crucial for policy makers to set incentives. The White Paper of the European Commission “European transport policy for 2010: time to decide” was an important step towards the use of biofuels in the transport sector (BMLFUW, 2014, 5). It was expected that CO2 emissions would increase by around 50% from 1990 to 2010. Road transport accounts for 84% of CO2 emissions in the transport sector. Furthermore, it was considered desirable to reduce the dependency on fossil oil from the level of 98% (EC, 2001, 10).

In the framework of the EU 2020 targets (EC, 2015), the following sub-targets concerning climate change and energy sustainability were announced: (i) greenhouse gas emissions 20% lower than in 1990, (ii) 20% of energy from renewables and (iii) 20% increase in energy efficiency.

The target for the share of renewables in the gross final consumption of energy differs among EU-member states due to heterogeneity in renewable energy potentials and energy mixes. Therefore, the EU’s 20% target is translated into individual targets for each member state. The target for the share of energy from renewable sources in gross final consumption of energy in 2020 is 13 % in Czech Republic and 34 % in Austria (Directive 2009/28/EC).

Apart from this target, it is obligatory for all member states to achieve a share of biofuels in transport of a minimum of 10% of petrol and diesel consumption by 2020. This 10% target for biofuels does not

vary between member states; it is argued that fuels for the purpose of transport are traded easily (Directive 2009/28/EC).

Austria

Legal framework

The above-mentioned EU directive 2009/28/EC forces EU member states to increase the share of renewables in the transport sector to 10 % until 2020. Apart from biofuels, production of electrical power for transport activities based on renewables is a valid method to reach this purpose. Biofuel production based on waste and residual material is counted twice (UBA, 2016).

The EU directive 2009/28/EC was incorporated into national law in Austria by an amendment of the fuel regulation (Kraftstoffverordnung). 5.75 % of the energy content of fuels have to be substituted by biofuels (Präsoll, 2012, 59). Austria over-accomplishes the mandatory substitution rates presented in Table 2.

Table 2: Mandatory and achieved substitution admixtures of biofuels in Austria (Präsoll, 2012, 60) Author's illustration

Year	Mandatory Substitution	Achieved Substitution
2008	4,66 %	5,5 %
2009	5,75 %	7,0 %
2010	5,75 %	6,58 %
2011	5,75 %	6,75 %

The above-mentioned substitution goal can be achieved with admixtures of 7 % biodiesels and 5 % Bioethanol. From 2020 onwards, the substitution goal is increased to 20 % of energy content (BMLFUW, 2014).

Furthermore, the EU directive 2009/30/EC obliges providers of fuel to reduce the live cycle greenhouse gas emissions per energy equivalent by at least 6 % by the end of 2020 (UBA, 2016).

In Austria, the reduction of the live cycle greenhouse gas emissions is regulated by the fuel regulation (Kraftstoffverordnung). Only fuels based on renewable energy sources may be counted for greenhouse gas mitigation and as substitution of fossil fuels when fulfilling a set of sustainability criteria for ecological standards (BMLFUW, 2014). Arable land of high biological diversity or high carbon content is not suitable for energy crop production. Furthermore, the sustainability criteria mentioned make it obligatory to increase the reduction of greenhouse gas emissions in comparison to fossil fuels. In order to guarantee both requirements, the whole supply chain has to be documented. Sustainability certificates ("Nachhaltigkeitsnachweise") guarantee the sustainability criteria of biofuels produced or sold in Austria (UBA, 2016).

Apart from the obligatory substitution goal, there are also tax incentives meant to foster biofuel production. In Austria, no fuel taxes have to be paid for biofuels (BMLFUW, 2014, 8).

Quantities

In 2013, about 5.700.000 tons of fossil diesel were sold in Austria and counted for the substitution goal according to the fuel regulation (Kraftstoffverordnung). 443.389 tons of biodiesel and HVO were sold as admixtures, of which 1.447 tons fulfilled the parameter "Double Counting". Furthermore,

about 63.000 tons were sold with higher biogenic contents, in diesel fuels or in pure form. However, these amounts didn't fulfill the sustainability criteria (Table 3, Figure 3) (BMLFUW, 2014, 19).

Apart from diesel sells, 1.576.719 tons of fossil gasoline with admixtures of 88.843 tons of bioethanol (40.924 tons as biogenic content of ETBE) were sold in 2013. Furthermore, 792 tons of plant oils were used in the agricultural sector. Apart from the agricultural sector, plant oils are used in Austria mostly for road freight transport, which accounts for about 17.000 tons. Furthermore, 711 tons of biomethane were used for traffic purpose (BMLFUW, 2014, 19).

In Austria, energy consumption increased most significantly in the transport sector over the last decades, mainly because of the economic situation and the opening to the eastern European countries. The energy consumption in the transport sector is mainly based on fossil oil products and, therefore, highly dependent on its prices and imports from geopolitically delicate regions. However, the increasing trend of greenhouse gas emissions in the transport sector could be reduced by applying appropriate measures (e.g. the substitution of 5,75 % of fossil fuels with biofuels and mobility management) (BMLFUW, 2010).

Table 3: Fuel sales in Austria by types in 2013; Source: BMLFUW (2014, 19), Author's illustration

	Tons	GWh
Fossil gasoline	1.530.347	18.279
Fossil ETBE in gasoline (53%)	46.372	464
Fossil diesel	5.682.768	67.878
Biodiesel and HVO blendings (incl. amounts charged twice)	444.835	4.595
Pure Biodiesel B100	62.694	644
Bioethanol in blendings and E85	47.919	359
Biogene ETBE in blendings (47%)	40.924	409
Plant oils (agriculture)	792	8
Plant oils in feets	17.050	175
Biogas	711	10

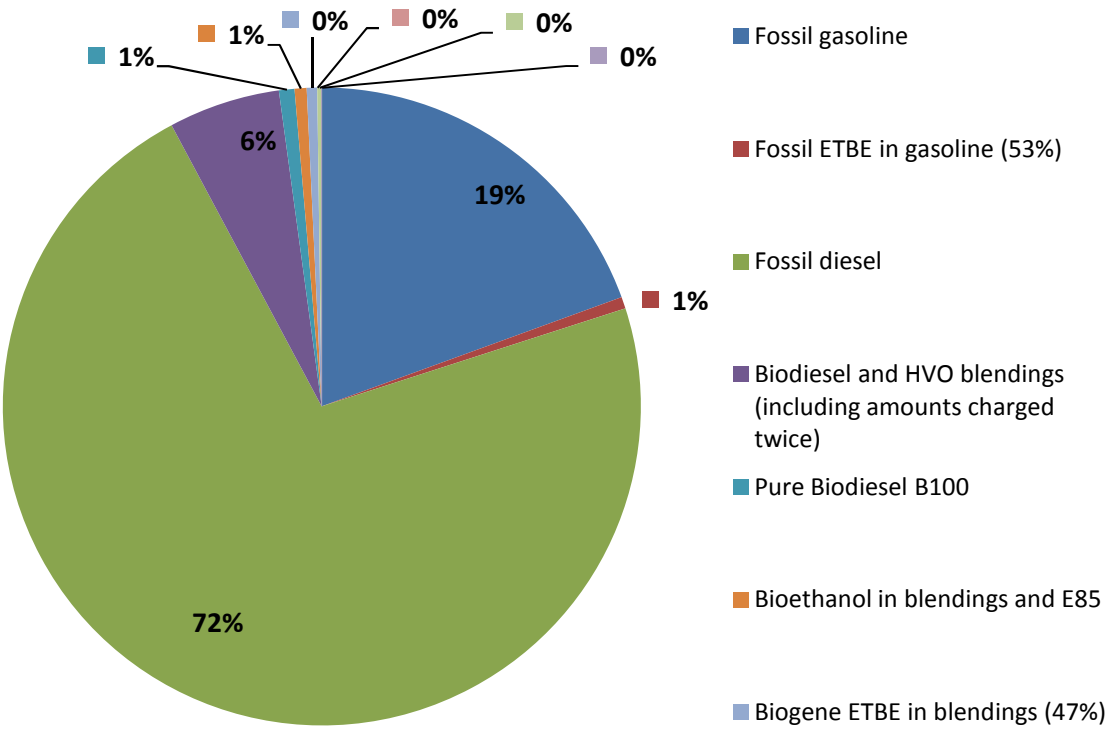


Figure 3: Fuel sales in Austria by types in 2013; Source: BMLFUW (2014, 19), Author's illustration

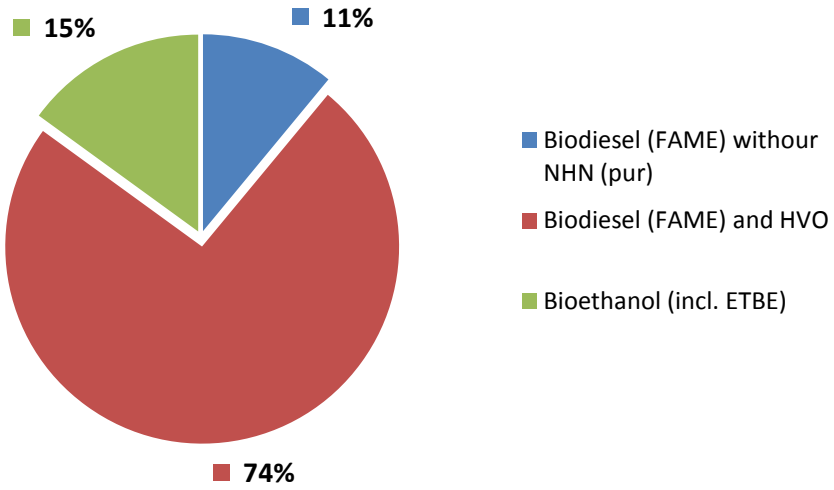


Figure 4: Share of biogene fuels in 2013; Source: BMLFUW (2014, 17), Author's illustration

Diesel can be blended with biodiesel by 7 vol.-%, whereas only 5 vol.-% of bioethanol can be added to gasoline. The share of diesel and gasoline in Austria and the higher energy density of biodiesel led biodiesel to be the most important biofuel in Austria (Figure 4). Premium diesel types were blended with HVO (BMLFUW, 2014, 17).

Bioethanol

In 2007, an industrial plant for biodiesel production in Lower Austria was finished. Its production capacity was about 160.000 tons bioethanol per year and expanded to about 190.000 tons per year

in 2009. Apart from bioethanol, 190.000 tons of DDGS (Ditiller's Dried Grain with Solubles) – a protein rich feedstuff – were produced. Since 2013, side products of the starch production are also used for bioethanol production, and CO2 from fermentation processes can be used for beverage industries (BMLFUW, 2014, 13).

In 2014, about 176.000 tons of bioethanol were produced, which was about twice the amount of domestic sales. Maize and cereal were the most significant raw materials for bioethanol production with a share of 55% and 45% of total production. Apart from maize and cereal, small amounts of molasses were used for bioethanol production (Figure 5) (BMLFUW, 2014, 13).

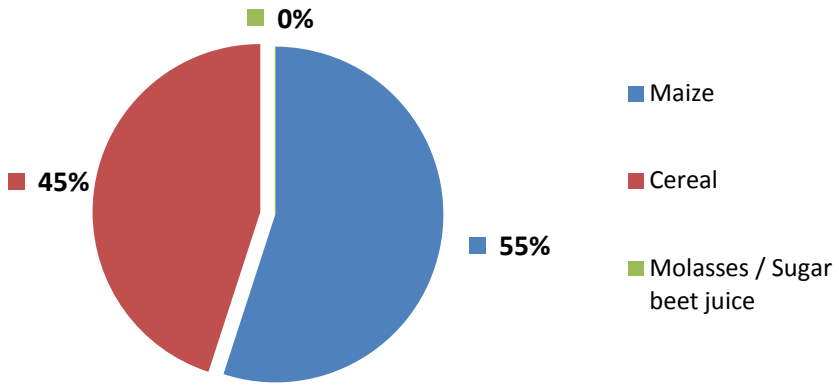


Figure 5: Bioethanol; Source: BMLFUW (2014, 14), Author's illustration

Biodiesel

In 2013, the production of biodiesel in Austria was about 127.000 tons and considered to be sustainable, and met about 44% of the domestic use of sustainable biodiesel. Most of the producers used a mix of raw materials (Figure 6). Biodiesel based on rape seed with about 70% of domestic biodiesel production was the most significant part. The remaining part of biodiesel was based on animal fats, used cooking oils and small amounts of soy. No palm oil was used in Austria for biodiesel production (BMLFUW, 2014, 12).

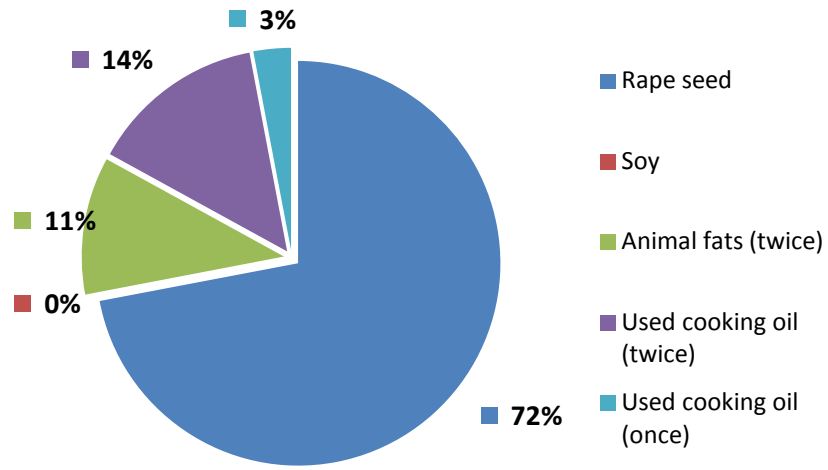


Figure 6: Biodiesel; Source: BMLFUW (2014, 13), Author's illustration

Plant oil fuels

Apart from bioethanol and biodiesel, also comparably small amounts of plant oil were used in 2013. About 790 tons of plant oil were used as biofuels in the agricultural sector. In comparison with the previous year it was a small increase. However, this increase was due to higher sales of two mills, whereby a decreasing trend of other producers in the agricultural sector was notable (BMLFUW, 2014, 14).

Biofuel Potential

In Austria, the potential for liquid biofuel production is mainly limited by arable land for rape seed production. Alternatively, the arable land could be used for the production of wood chips from short-rotation trees. Both of the energy sources mentioned compete with crops for material use for the land (Figure 7) (Haas et al., 2001, 67).

As shown in Figure 6, rape seed oil is the most important raw material for biodiesel production in Austria. Präsoll (2012, 142f) shows that a hypothetical self-sufficiency of biodiesel production based on rape seed oil would lead to a space requirement about 7 times the space used for rape seed production in Austria in 2011. An average rape seed yield of 3,36 t/ha with an average oil content of 40 % would lead to a space requirement for the whole biodiesel production of 377.000 ha of arable land. However, in 2011 only 53.000 ha of arable land were used for rape seed production. Furthermore, not 100 % of the rape seed production were used for oil and biodiesel production. In 2011, a self-sufficiency of biodiesel production would require an extension of the rape seed production area of about seven times or an increase of 155 % of the oil seed production area if only rape seed is produced or about 28 % of the total arable land in Austria for rape seed production (Präsoll, 2012, 142f).

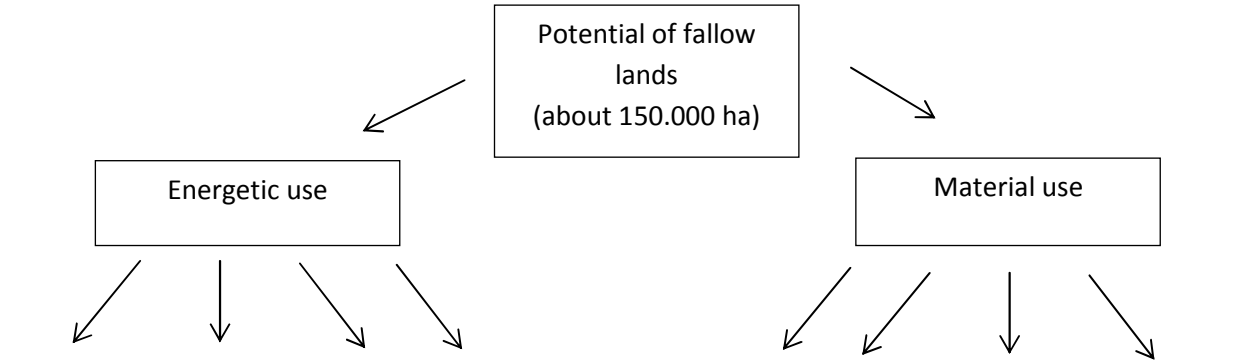
Haas et al. (2001, 72) give an overview of studies which estimate the biodiesel potential in Austria. The estimates for the technical potential are in the range of 140.000 t/a and 350.000 t/a.

Konrad (2008) estimates the potential of substituting fossil fuels by biofuels in Austria. The study takes into account various production systems and uncertainties in fuel demand by applying various scenarios. The author concludes that the potential for substitution of fossil fuels is in the range of 24 % to 111 %. More than half of the scenarios predict a substitution of fossil fuels of more than 50 %. Pure fuels based on biodiesel are not recommendable due to low per hectare yields and ecological impacts. Therefore, production of linseed and rape seed should not exceed 14 % vs. 33 % for biofuel production. Maize production could be extended to 40 % of arable land. The CO2-saving potential is in the range of 17 % and 86 %. In about three quarters of the scenarios the estimated CO2 savings exceeded 30 % (Konrad, 2008, 183f).

In 2000, an average EU-15 citizen required about 4.400 m² land for nutrition, material use and agricultural raw materials. A self-sufficient nutrition requires between 1.500 and 2.000 m² of land. A space requirement per capita of 2.000 m² and demographic estimations would lead to a apace requirement of 1.900.000 ha in 2050. Therefore, the concurrence between food and energy production would increase. The Austrian Ministry of Agriculture estimated a realistic biomass scenario for 2020 with 400.000 ha land. Half of the land should be available for biodiesel and bioethanol production (Christian et al., 2010, 72ff).

The technical potential for biofuel production in Austria is, therefore, not sufficient for achieving the goals mentioned above. Therefore, biodiesel supply in Austria is dependent on imports. Plans of the

EU to increase the share of biofuels to 10 % by 2020 without increases in import are only achievable with a constant or decreasing fuel demand and a successful extension of the biomass potentials (Präsoll, 2012, 145).



Short rotation wood	**Miscanthus Whole plant cereal**	**Rape seed**	**Sugar beet, cereal**		**Short rotation wood**	**Rape seed, sun flower**	**Hemp, flax**	**Other regenerative raw materials for material use**
		RME Rape seed oil	Ethanol					

Figure 7: Competing land use (Haas et al., 2001, 69) Author's illustration

Greenhouse gas emissions saving

The greenhouse gas emission savings in the transport sector related to biofuels are presented in Table 4.

Table 4: Direct CO2 Savings in the transport sector due to usage biofuels in Austria from 2005 to 2013; Source: BMLFUW (2014, 21), Author's illustration

Year	CO2 Savings in tons	Biodiesel und HVO	Ethanol	ETBE	Plant oils	Biogas	Energy in GWh
2005	252.160	92.000					943
2006	931.984	330.500			10.000		3.485
2007	1.102.312	370.046	20.401		17.981		4.120
2008	1.375.041	406.291	29.673	55.238	19.276		5.129
2009	1.723.458	521.611	35.583	63.841	17.784		6.427
2010	1.668.065	501.667	60.727	45.473	17.393		6.220
2011	1.677.309	506.770	53.366	49.783	16.731		6.255
2012	1.657.232	498.761	63.477	42.238	16.823	540	6.180
2013	1.727.693	506.083	47.919	40.924	17.842	711	6.473

Price development

Data for fuel prices in Austria are provided by the BMWFW (2016). As shown in Figure 8, fuel prices increased between 2002 and 2008. In 2008, the economic crisis led to a decline in fuel prices. However, prices recuperated and reached a maximum in 2012. After the peak in 2012, fuel prices constantly decreased. It is notable that there were only short periods where gasoline prices exceeded diesel prices.

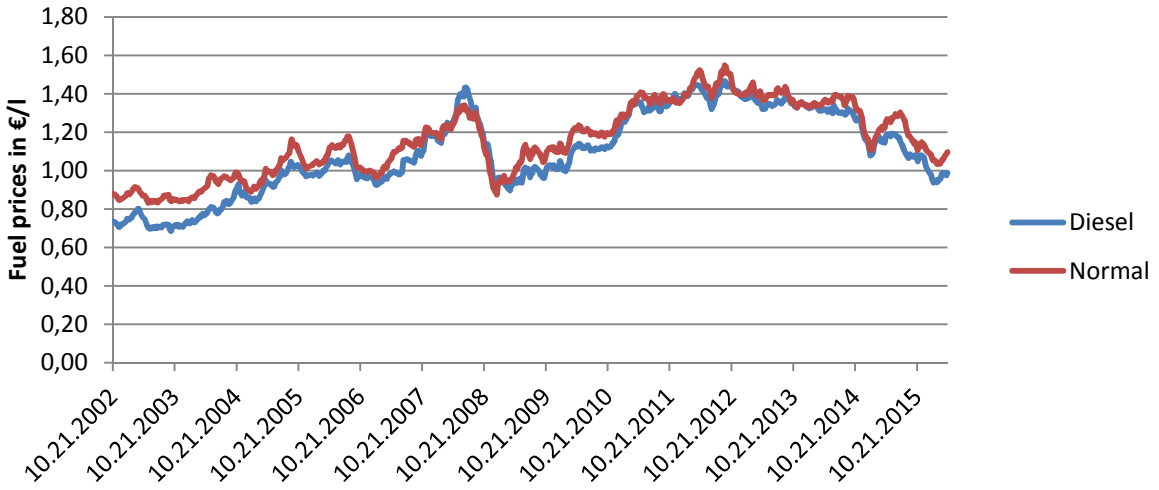


Figure 8: Diesel and gasoline prices in Austria Source (BMWFW, 2016)

The German supply has a significant influence on the Austrian biodiesel market. The wholesale prices for biodiesel are highly dependent on its raw material rape seed oil. Prices moderately increased in the years 2005 to 2006/07 (Figure 9). Coincidently, with a price boom in food, rape seed prices increased by 30 % in the period around the end of 2007. When raw material markets calmed, biodiesel prices lagged behind rape seed oil prices. When rape seed oil prices increased from 2009, biodiesel prices increased as well. The distance between the two curves in Figure 9 indicates the small margin in biodiesel production (Präsoll, 2012, 171).

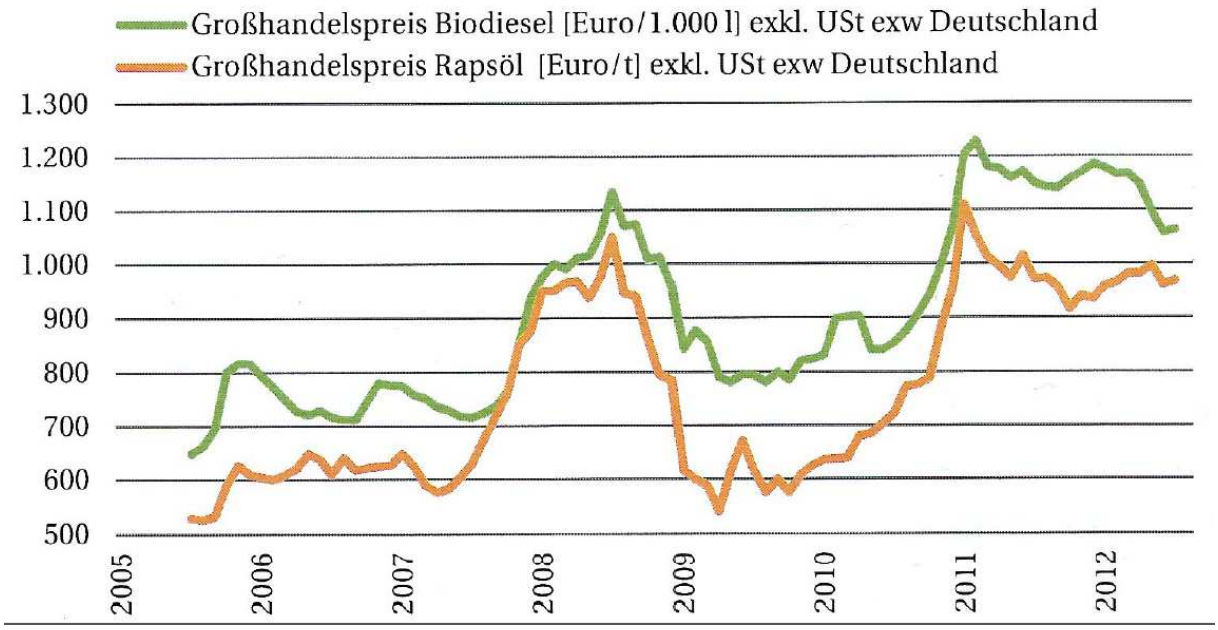


Figure 9: Price development for biodiesel and rape seed oil in Germany (Präsoll, 2012, 171)

Due to direct biodiesel admixtures to fossil fuels, prices of diesel and biodiesel developed similarly (Präsoll, 2012, 174). Figure 10 indicates that biodiesel is cheaper than diesel. However, when considering lower energy densities and higher fuel consumption of biodiesel, the economic benefit is not so clear (Präsoll, 2012, 175).

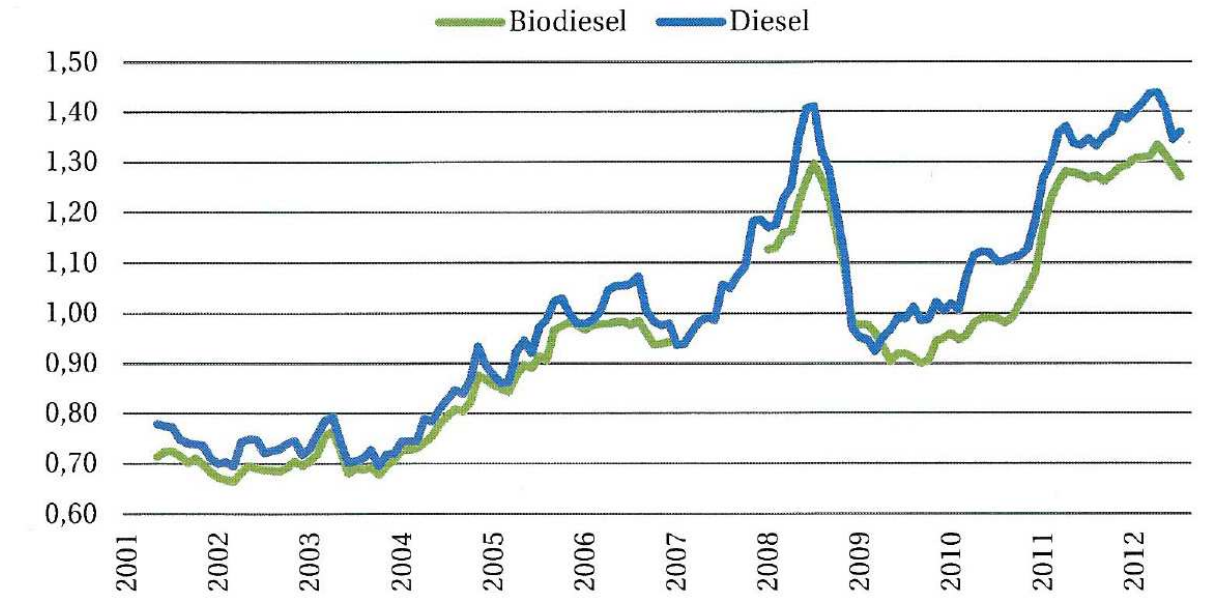


Figure 10: Nominal price development of biodiesel and diesel in €/l (Präsoll, 2012, 174)

Czech Republic

Next to hydropower, biomass is the second most significant and in the long run maybe the most perspective renewable resource for creating heat and energy in Czech Republic. We can already find the use of biomass for heat in some households. In several cities, biomass serves central heating (Třebíč, Měňany na Berounsku, Jindřichovice pod Smrkem na Liberecku) and it is used more and more as infusion for heat power stations. Biofuel should, according to today's energy policy, contain up to 85% from all renewable resources in 2030. However, today's share is only 19 % (Matějček, 2008).

Feedstock used for biofuels

A great part of the biomass in Czech Republic includes biofuels. The common biofuel in Czech Republic is FAME, which is used as compensation for fossil diesel, and bioethanol substitutes fossil gasoline. As presented in Figure 12, the production of biodiesel exceeds the production of biogasoline. Biofuels are not generally in pure form, but they are blended in various concentrations. They can serve well in almost all motor engines without any problems if the concentrations of biofuels are maximum 5%. Pure biofuels also exist in highly concentrated blends, e.g. E85 with a share of bioethanol of 85 %, E95 with a share of 95% bioethanol, blended engine diesel (SMN30) containing 30% of FAME, pure rape seed oil, biogas, etc. The use of SMN30 has a great tradition in Czech Republic, because this fuel was used in the 90s of the last century. In future second generation biofuels should be used, which will be produced only from lignocellulosic biomass or woody crops, agricultural residues or waste. In Czech Republic, rape seed, wheat and sugar beet are considered the most important crops for biofuel production. As shown in the Figure 11, production increased over time, mainly due to measures taken by policy makers (Eagri, 2015).

FAME in Czech Republic is created by the fining process called estrification, in which methanol is blended with sodium hydroxide and then with rape seed oil. A side product is glycerol stage, which is used for bioglycerol production (Eagri, 2015).

Czech bioethanol is created from resources which contain pentose or substances convertible to pentose like amyl or pulp. There are 3 biomass groups used for bioethanol:

1. Biomass with amyl

2. Lignocellulosic biomass

3. Biomass with pentose

An important benefit of the biofuel sector in Czech Republic is a decrease of dependency on non-renewable resources of energy like fossil oil or gas. In addition, biofuels can create multiple job opportunities and fortify the economy of the state (Hromádko, 2010).

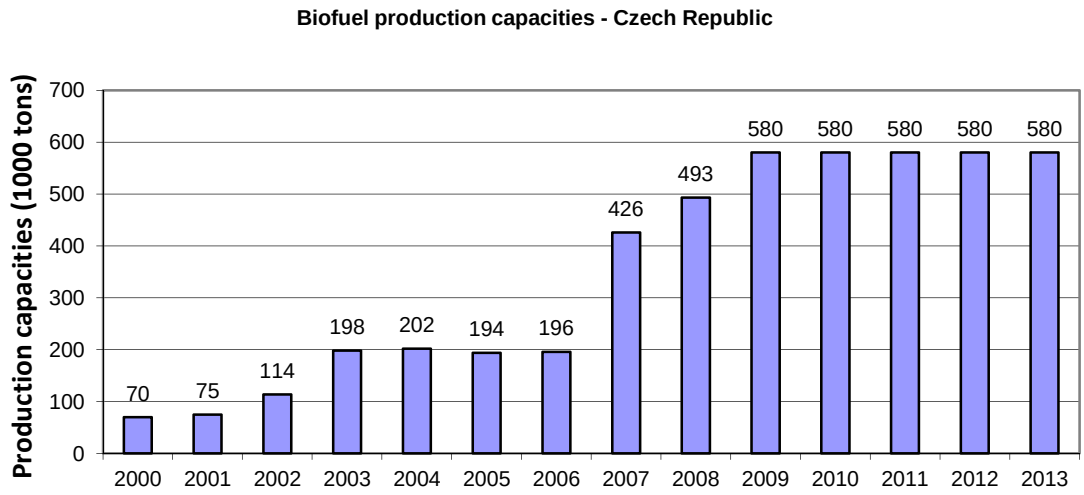


Figure 11: Biofuel production capacities- Czech Republic, data based on EUROSTAT (2016b)

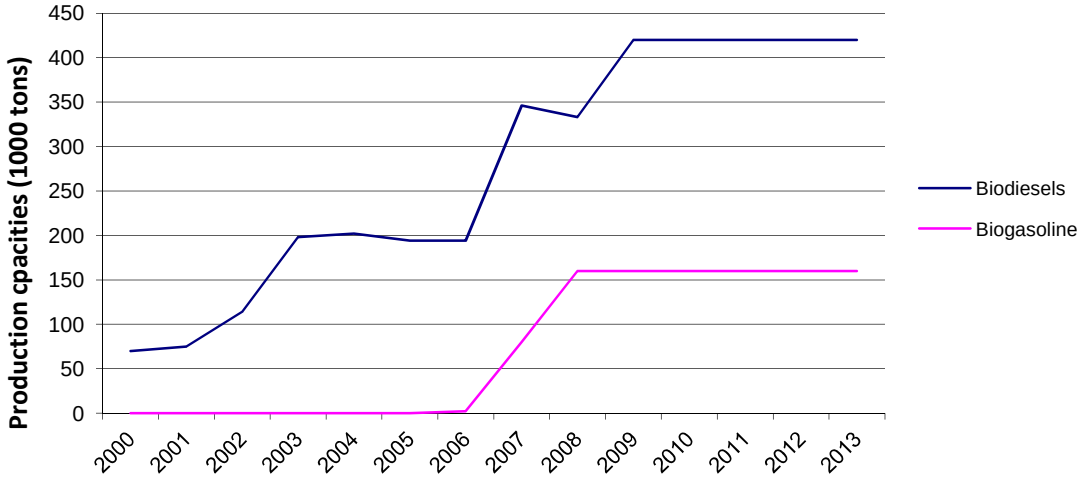


Figure 12: Biodiesels and Biogasoline production in the Czech Republic, data based on EUROSTAT (2016b)

Legal framework

1.1.2016 resorts to decrease of pure and highly concentrated biofuels support in traffic. The Parliament of Czech Republic accepted law no. 382/2015, which changed law no. 353/2003 about consumer taxes and other contextual laws. On the basis of the law from 1.1.2016 taxes from blended engine diesel increased, FAME B100 (pure biodiesel) taxes were created and tax refunds for alcohol in E85 were decreased. This change is divided into two periods of time, firstly into the period leading up to 30.6.2017 and secondly the period from 1.7.2017 onwards. In the first period, financial benefits are reduced, which is supposed to compensate for the money provided in the second half of 2015 (Eagri, 2015).

In Table 5, rates of the consumer taxes (and the amounts of returned taxes) are presented for the types of highly concentrated and pure biofuels according to the law concerning consumer taxes in the period between 1. 1. 2016 and 30. 6. 2017.

Table 5: Legal framework, data based on Eagri (2016)

	Mineral oil taxes (Period 1.1. 2016 to 30.6 2017 (Kč/1000 l)
SMN B30 (with FAME)	9 265
FAME B100	4 590
Vegetable oil	4 590
Alcohol in fuel Etanol E85	12 840 (alcohol rate 10 230)
Ethanol E95	0
„B30“ with HVO	10 950 (HVO* rate 3 285)
Pure HVO	0

The amount of support was monitored and evaluated every year. According to the outcome of the evaluations, taxes increased or decreased.

Bioethanol/Biogasoline

As mentioned above, bioethanol is a possible form of biogasoline. EUROSTAT only provides data for biogasoline but not for bioethanol. Therefore, only data and graphs for biogasoline are presented in this paper.

The biogasoline production capacities are shown in Figure 13. The most popular brand of biogasoline in Czech Republic is E85.

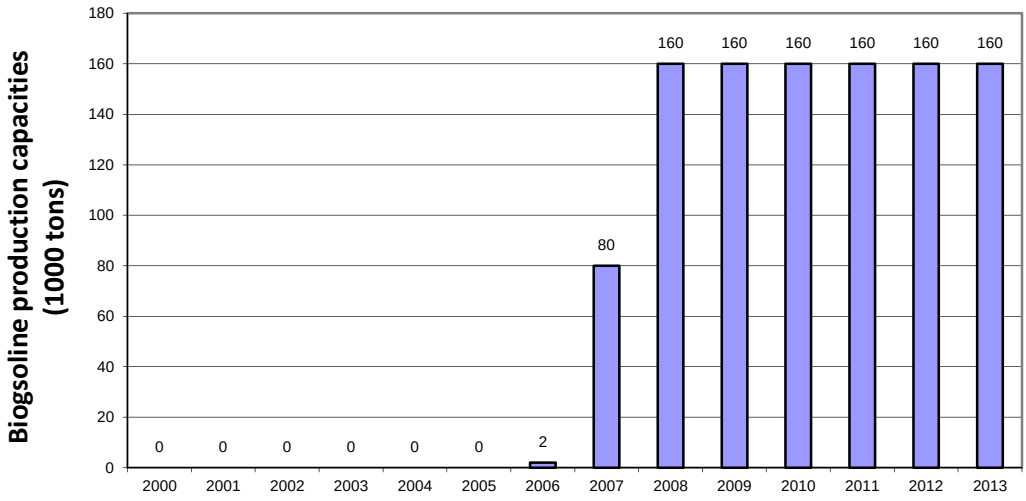


Figure 13: Biogasoline - production, data based on EUROSTAT (2016b)

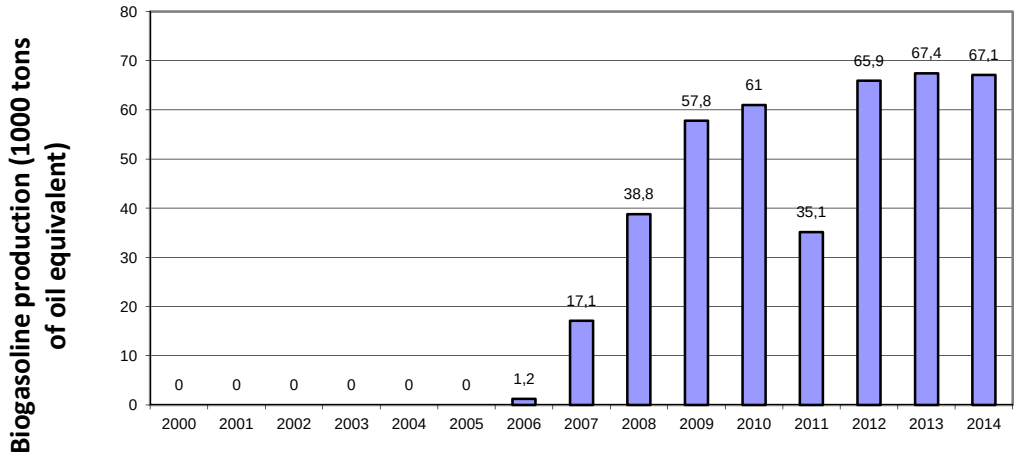


Figure 14: Biogasoline – renewable energy production, data based on EUROSTAT (2016b)

First attempts to create bioethanol are date back to 1996. However, production increased from 2007 to 2009 and has been more or less stable since then (except 2011) (Figure 14). These figures are small in comparison with biodiesels production.

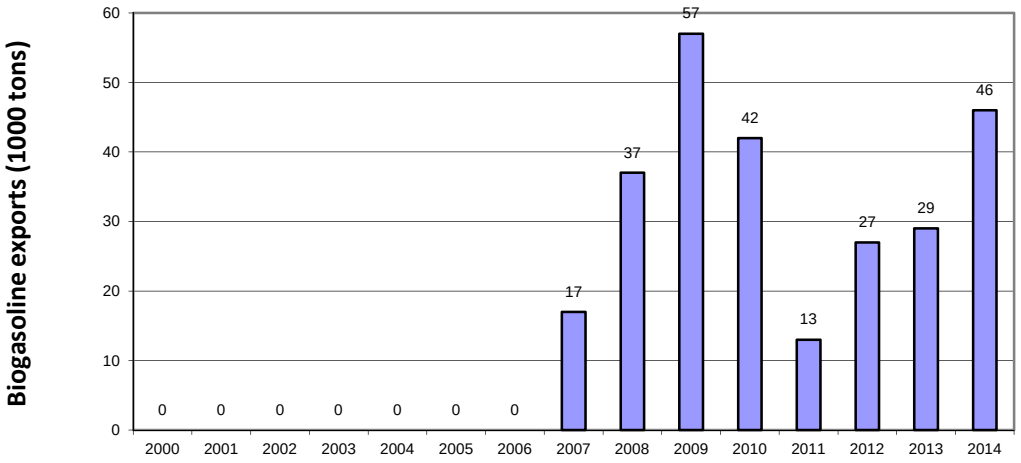


Figure 15: Biogasoline – export, data based on EUROSTAT (2016b)

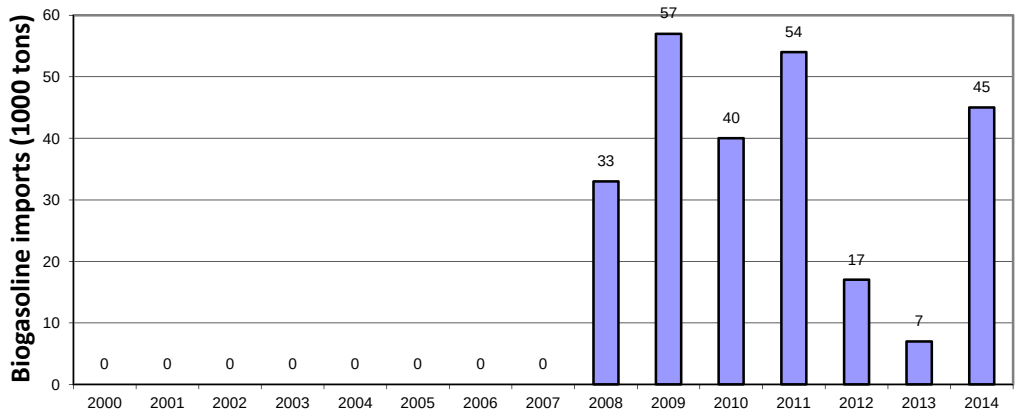


Figure 16: Biogasoline – import, data based on EUROSTAT (2016b)

Exports and imports of biogasoline oscillated heavily over the last years (Figures 15, 16). These ups and downs were caused by changes in state support and laws. The standard production over the last years is about 160.000 tons of biodiesel (Figure 13).

Biodiesel

For the statistic research, for the following figures mostly biodiesels like SMN30 and B100 were considered.

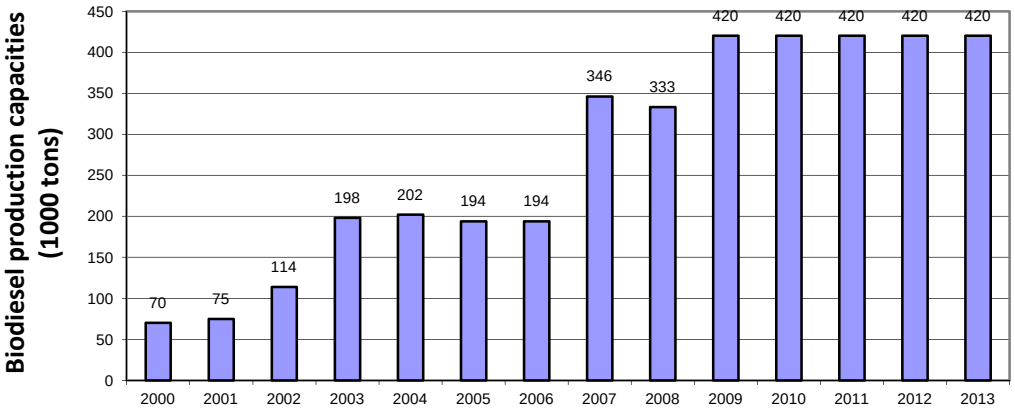


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Figure 17: Biodiesels production capacities, data based on EUROSTAT (2016b)

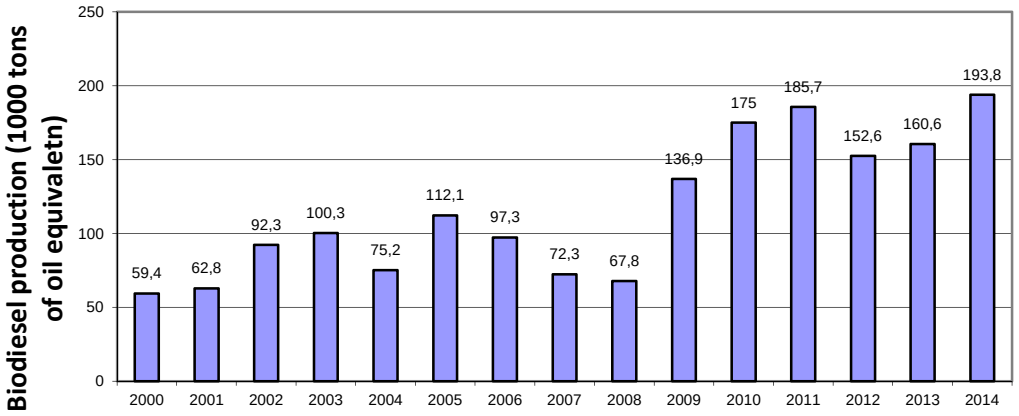

Figure 18: Biodiesels – renewable energy production, data based on EUROSTAT (2016b)

Biodiesel production exceeds biogasoline production in Czech Republic (Figures 14, 18) due to higher supports for producers, long tradition and scaling effects.

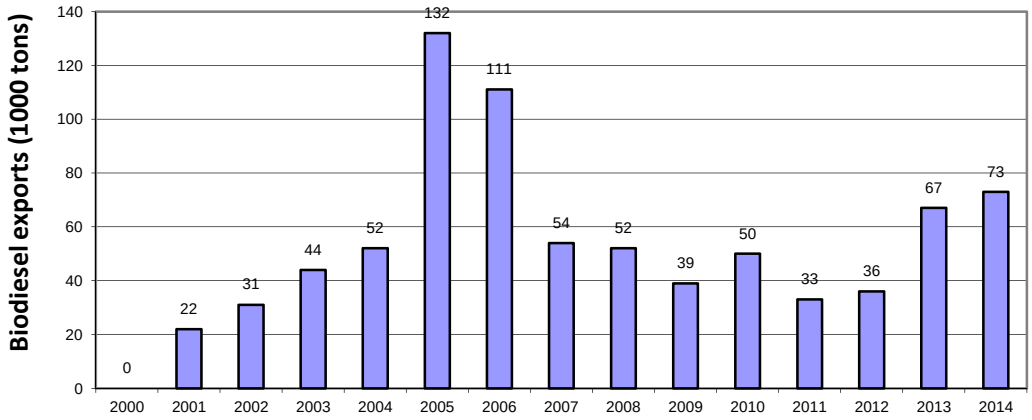

Figure 19: Biodiesels – export, data based on EUROSTAT (2016b)

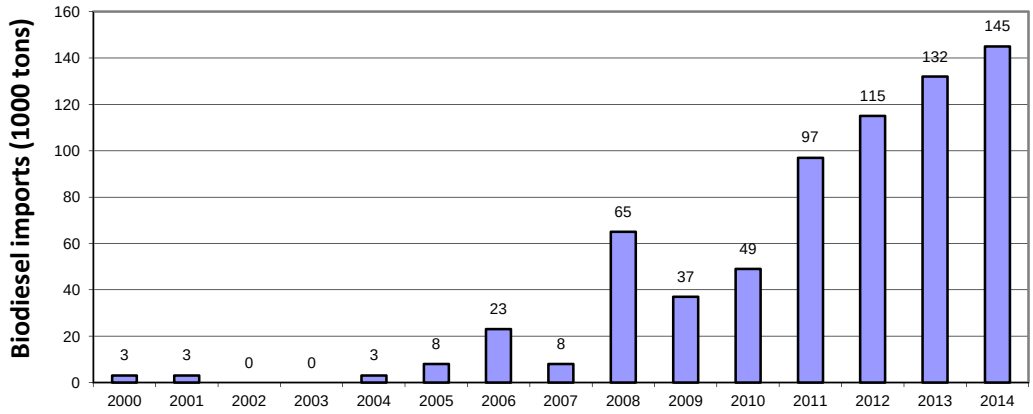

Figure 20: Biodiesels – import, data based on EUROSTAT (2016b)

Exports and imports differ between biogasoline and biodiesels (Figures 15, 16, 19, 20). Biodiesel production in Czech Republic was profitable in the mid-2000s, which led to high export values as shown in Figure 19. Due to changes in the support situation, exports were heavily reduced in 2007.

Price development

Due to state supports, biofuels are cheaper than fossil fuels such as gasoline and diesel in Czech Republic. The price development over the last 5 years is shown in Figure 21. Older data are almost inaccessible for common research purpose. E85 is the most stable biofuel in terms of price development, mainly because of the little amounts of bioethanol used in comparison to biodiesel. Furthermore, the above-mentioned state supports had a significant influence on the biofuel sector, which is also reflected in Figure 21.

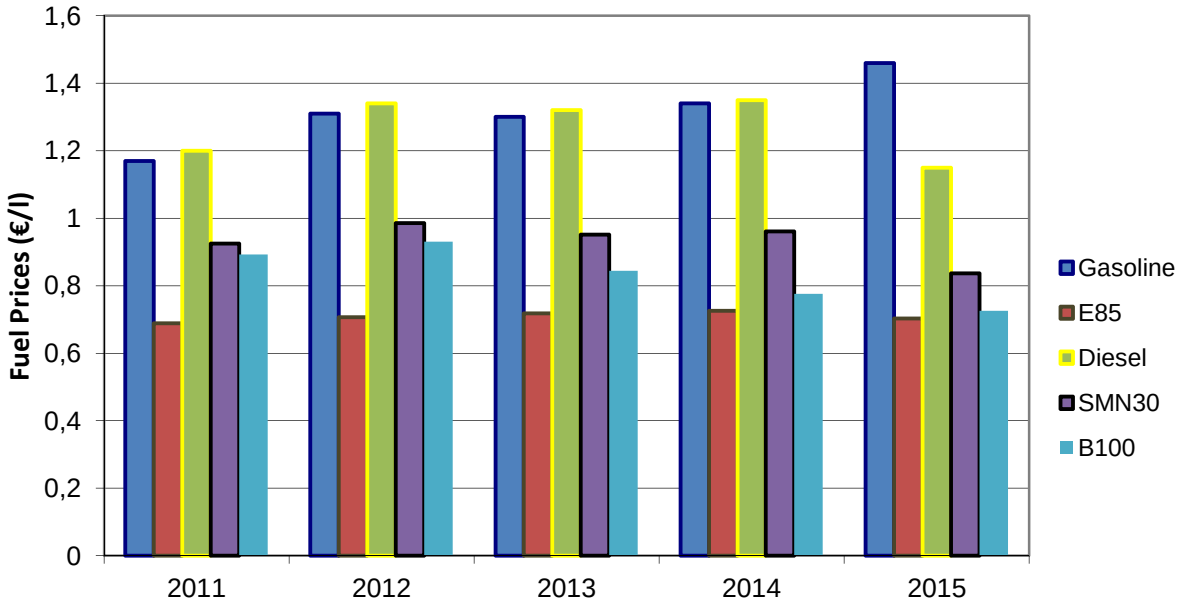

Figure 21: Price of fuels in the Czech Republic, data based on VUZT (2016)

Development of Production Capacities in the European Union

Data on biofuel production capacities are provided by EUROSTAT (2016b). The development of production capacities of biogasoline and biodiesel are presented in Figures 22 – 25.

At the beginning of the 2000s, biogasoline production capacities were at a low level in the EU and the presented member states. From 2005 to 2008, biogasoline production capacities increased most notably in the shown period and reached 5.800.000 tons of oil equivalent in 2013. The most important production capacities can be found in France (460.000 tons), Germany (740.000 tons) and the United Kingdom (720.000 tons). Production capacities for biogasoline in Austria and Czech Republic are in a similar range with 190.000 tons vs. 160.000 tons.

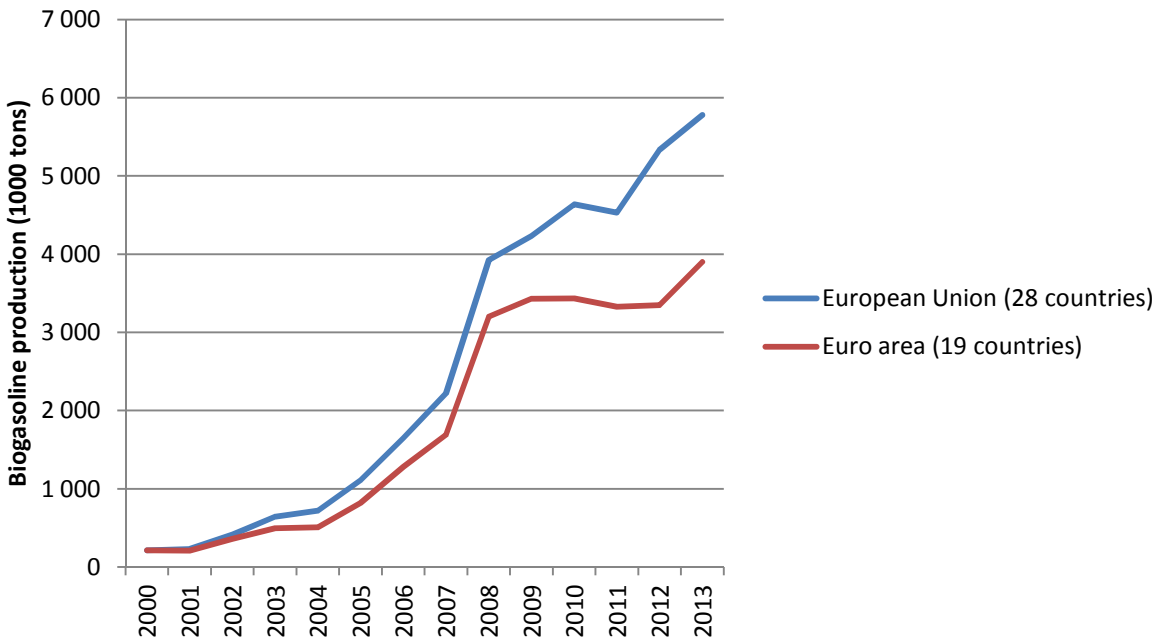

Figure 22: Biogasoline production capacities in Europe, Source: EUROSTAT (2016b)

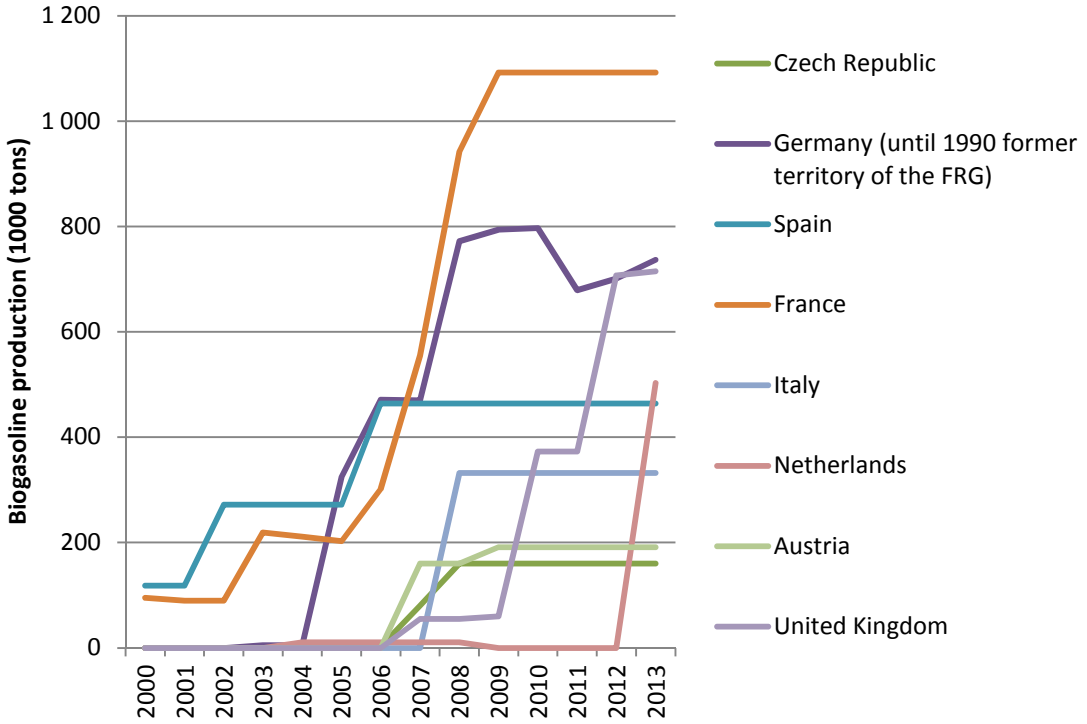

Figure 23: Biogasoline production capacities in various countries in the Europe, Source: EUROSTAT (2016b)

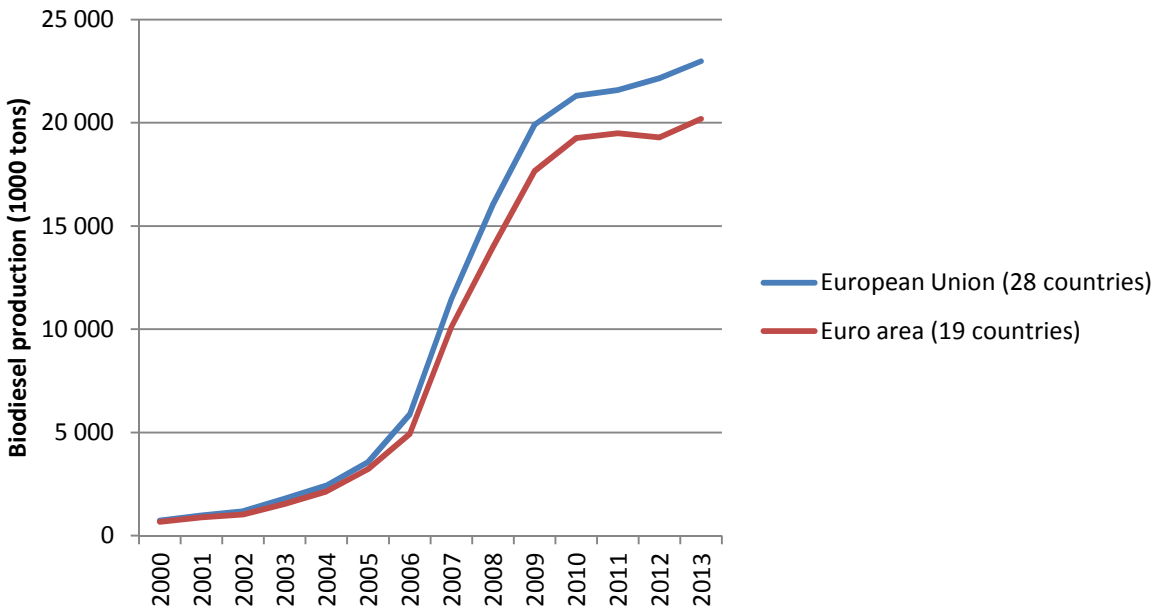

Figure 24: Biodiesel production capacities in Europe, Source: EUROSTAT (2016b)

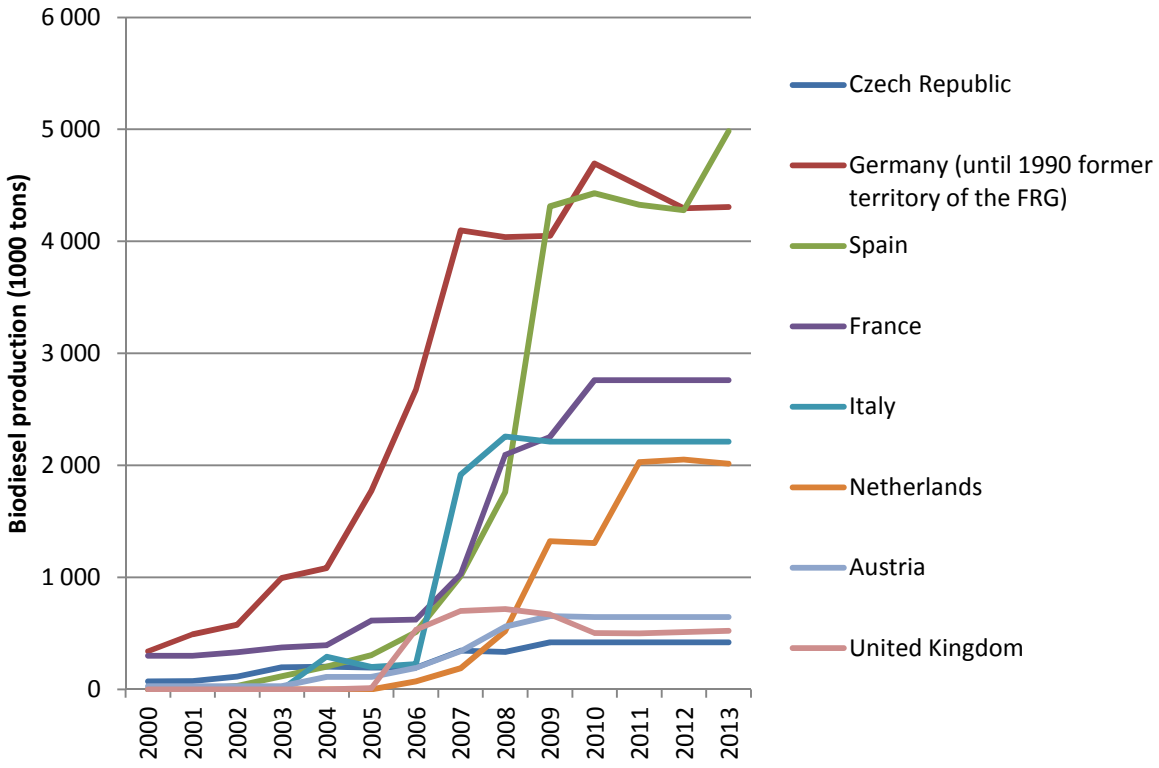

Figure 25: Biodiesel production capacities in various countries in Europe, Source: EUROSTAT (2016b)

Biodiesel production capacities developed in a similar way as biogasoline production capacities. Until 2005 biodiesel production was at a low level in the EU 28. In 2005, Germany's biodiesel production capacities accounted about 50 % of the total production capacity in the EU28. Although Germany more than doubled its production capacities to 4.300.000 tons from 2005 to 2013, the total share of biodiesel production capacities in the EU decreased to about 19 % in 2013. In this year the production capacities of the EU28 almost reached 23.000.000 tons. Spain exceeded the German production capacities for biodiesel for the first time in 2009, and reached almost 5.000.000 tons in 2013. France, Italy and the Netherlands were also important biodiesel producers in the range of

2.000.000 to 3.000.000 tons in 2013. Biodiesel production capacities in Austria exceeded the production capacities in the Czech Republic in 2013 (650.000 tons vs. 420.000 tons).

Worldwide leading biofuel countries

In the present day, biofuels are used almost all over the globe. An overview of global biofuels is provided by a number of reports (e.g. The State of the Biofuels Market: Regulatory, Trade and Development Perspectives). Another example is an interactive map, created by the Global Renewable Fuel Alliance (GRFA), showing the current mandate and planned targets for biofuel production in countries across the globe. The interactive map can be found at the website of GRFA. (GRFA, 2016)

Information provided in Figures 26 and 27 indicate that there are some biofuel blind spots, e.g. Russia, northwest Africa and the Middle East. In Russia, there are some incentives to foster the biofuel sector. However, they are still being debated (Biofuels, 2016). There are some exports to northwest African countries, but the production is close to zero. The Middle East is known in the world for its prim in oil. However, a great part of the land is desert and, therefore, not appropriate for crop production.

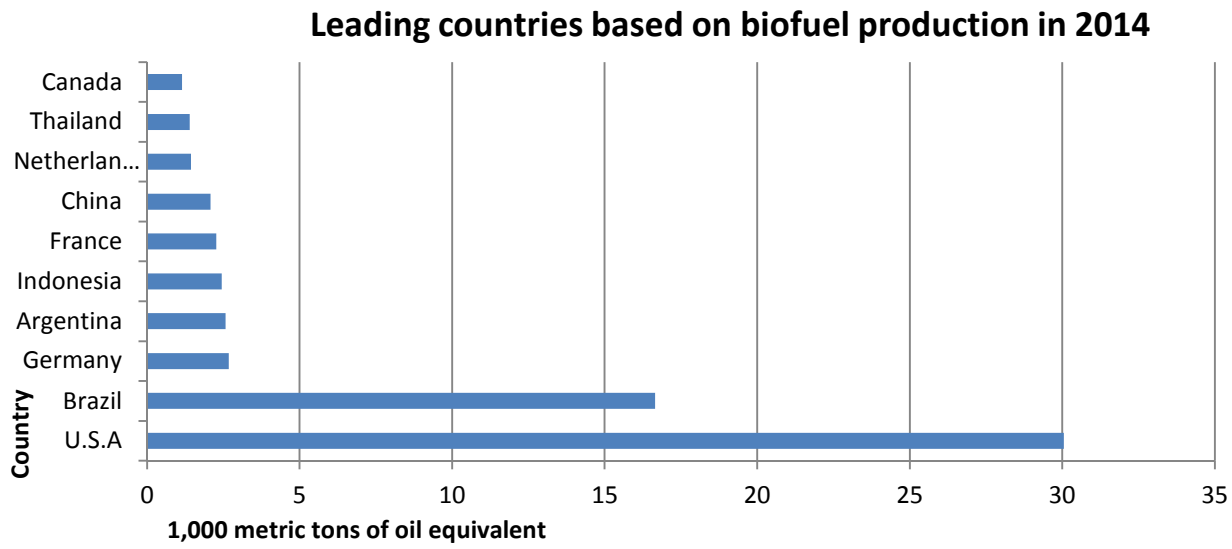

Figure 26: Leading countries based on biofuel production 2014, data based on Statista (2016)

As shown in Figure 26, the biofuel production of European countries is small in comparison with the leading countries in biofuel production worldwide – the USA and Brazil. Accounting just for the bioethanol production of 2007, the USA and Brazil were responsible for 88% of the global production of 13.1 billion US gallons (1 US gallon = 3,8 liters).

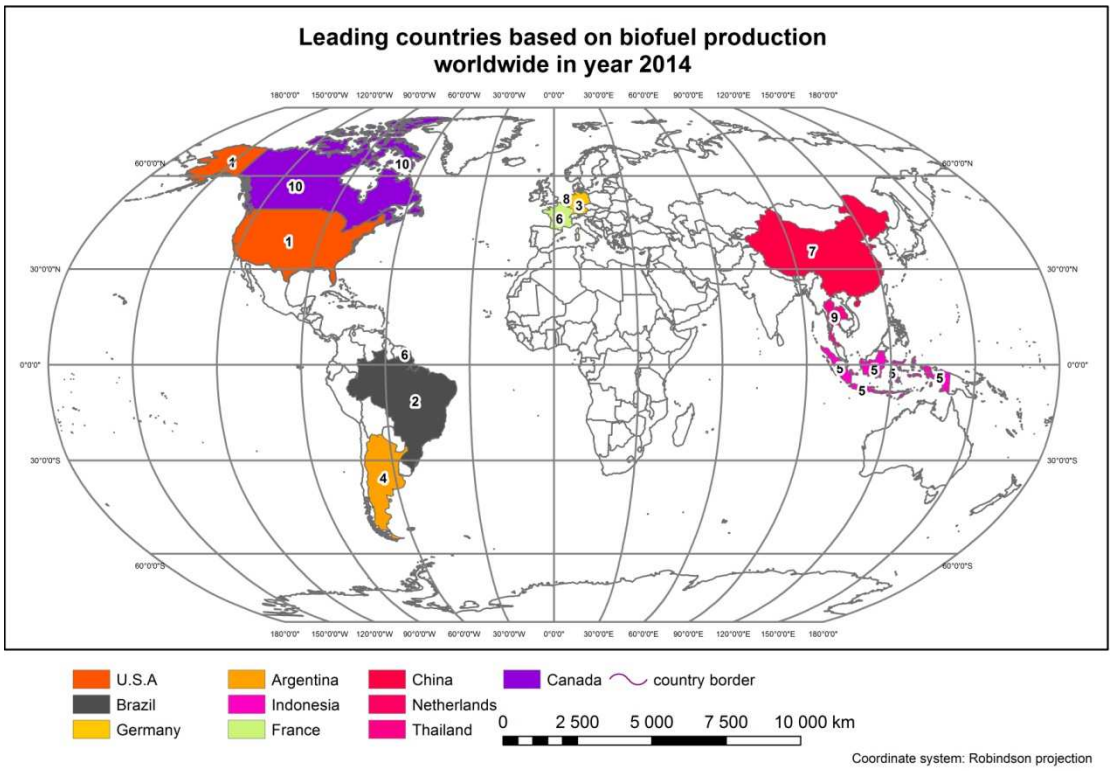

Figure 27: Leading countries based on biofuel production worldwide in year 2014, data based on Biofuel.org (2015), Statista (2O16) and ARCČR500 (2015)

The USA

The USA are the greatest biofuel producers in the world. Production is mainly based on bioethanol from corn. Biofuels are used in all states, but the largest biodiesel consumer is the US Army. Most vehicles on the road today in the USA can run on blends of up to 10% ethanol, and motor vehicle manufacturers already produce vehicles designed to run on much higher ethanol blends. The demand for bioethanol fuel in the USA was stimulated by the discovery in the late 90s that MTBE was contaminating groundwater. One of the first examples for the use of ethanol for vehicles is the Ford T (Beran, 2011).

Feedstock used and places for biofuels

These days, according to RFA (Renewable Fuels Associoation), there are over 200 bioethanol refineries in the USA. Most of them are in the "Corn Belt", which is a part of the American Midwest. The primary resource is corn, but some refineries also use Sorghum (Beran, 2011).

Factories of the second generation are now under construction or already open. Examples are: Emmetsville (Oiwa, copandy POET) Hugoton (Kansas, company Abengoa), Nevada (Iowa, company Dupont) and Galva (Iowa, company QCCP) (Beran, 2011).

Price development

The fuel price development in the USA is presented in Figure 28. Fuel prices have been decreasing since 2013. This is one of the reasons why customers and managers in the USA buy more alternative fuels like gasoline and diesel, alternative fuel can change its value and price because of the time of the year, the location, or even the current political status (Yosemite, 2016).

As shown in Figure 28, price development is quite non-linear in all categories. The price decline in 2008 and 2009 was caused by the global financial crisis. Prices of biodiesel exceeded prices of bioethanol over the last years (Figure 28). Therefore, most "bio-engines" in the USA run on bioethanol (Yosemite, 2016).

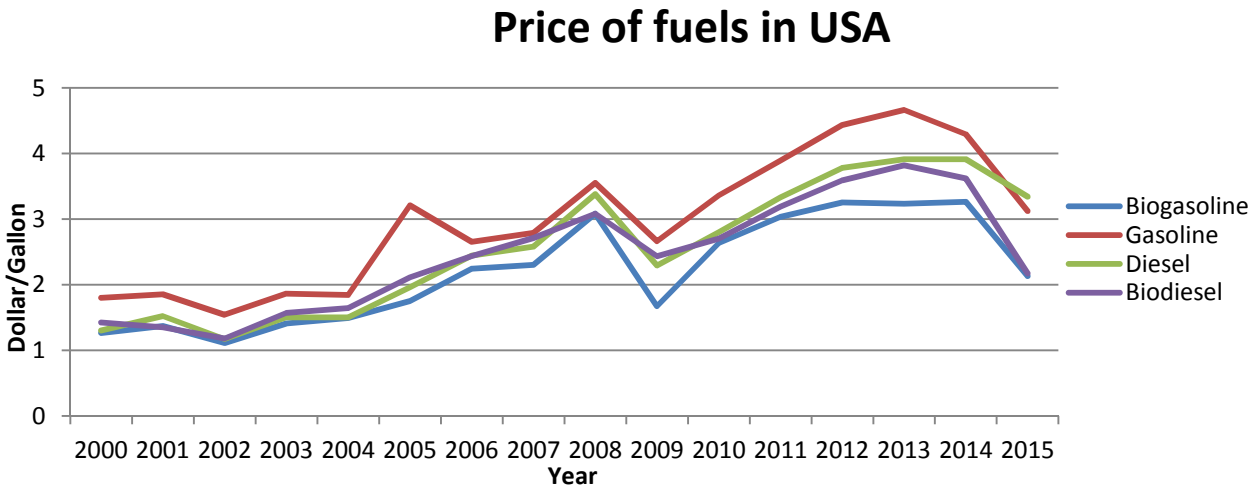

Figure 28: Price of fuels in USA, based on AFDC energy (2015)

Table 6: National average price between January 1 and January 15, 2016, created by AFDC.energy (2016) Author' illustration

Fuel	Price
Biodiesel (B20)	$2.41/gallon
Biodiesel (B99-B100)	$3.21/gallon
Electricity	$0.13/kWh
Ethanol (E85)	$1.86/gallon
Natural Gas (CNG)	$2.09/GGE
Propane	$2.85/gallon
Gasoline	$1.98/gallon

Conclusion

Due to concerns about global climate change, the European Union focuses on some mitigation strategies for greenhouse gas emissions (cf. EU 2020 goals). The EU directives 2009/28/EC and 2009/30/EC take also the transport sector into account, and a substitution goal for fossil fuels of 10% is declared. In Austria, the EU directive was incorporated into national law by the fuel regulation (Kraftstoffverordnung). 5.75 % of the energy content of fuels have to be substituted by biofuels. Austria over-fulfills this requirement.

Although, Austria fulfills this requirement the total production of biofuels is very little in comparison with other European countries leading in the biofuel sector such as Germany, France and Spain. However, Austria dominates Czech Republic in biofuel production. Production fluctuation is seen in Figure 29. In the Czech Republic further development is expected in the next years. An increase in production and new generations of biofuel are supported by the state.

Although the production of biofuels in the European Union has increased significantly, in the last decade it is crucial to note that the biofuel production in the EU is only small in comparison to the leading biofuel countries USA and Brazil.

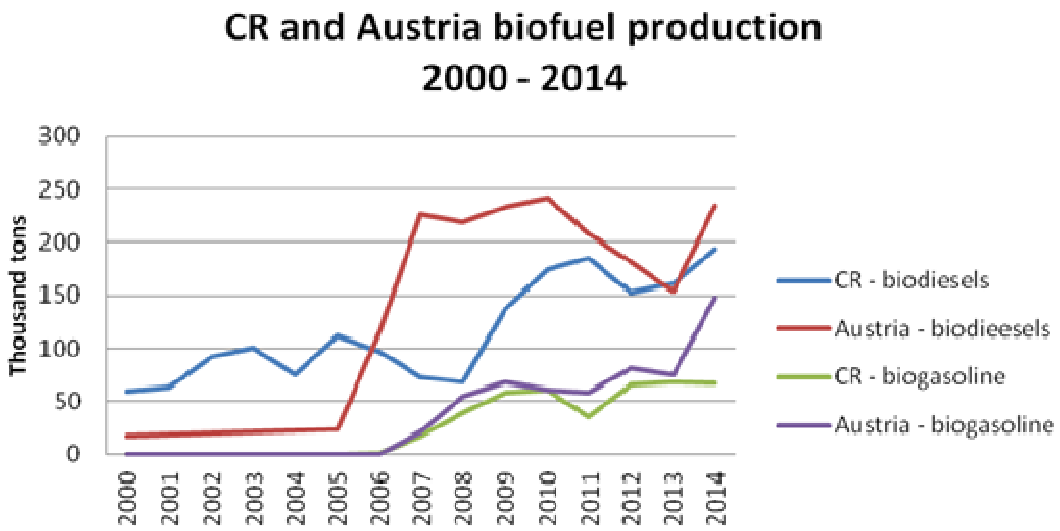

Figure 29: CR and Austira biofuel production 2000 - 2014, based on EUROSTAT (2016b)

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