UNIVERZITA J. E. PURKYNĚ V ÚSTÍ NAD LABEM

TU WIEN

Czech-Austrian Spring and Summer School

BIOFUELS: POLICIES, FEEDSTOCKS, COSTS

Natálie Obleserová, Aadit Malla

Co-operating Universities

UNIVERZITA J. E. PURKYNĚ V ÚSTÍ NAD LABEM

TU WIEN

UNIVERSITÄT FÜR BODENKULTUR WIEN BOKU

Financial support by

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Prague and Vienna, 2023

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1. ABSTRACT

The transport sector in Europe is a significant contributor to carbon emissions, necessitating the implementation of sustainable interventions. Among the various potential *solutions*, biofuels have emerged as viable options due to their immediate applicability, the potential for local production, compatibility with existing engines, and renewable origins. In comparison to fossil fuels, biofuels have the advantage of emitting fewer greenhouse gases and can be easily blended with conventional fuels. Ongoing research efforts in this field focus on advancing biofuel production methods, assessing their economic viability, and evaluating their environmental performance.

In recent years, countries like Austria and the Czech Republic have witnessed a surge in biofuel production, primarily in the form of biodiesel and bioethanol. The use of biofuels, however, is not without concerns. There are debates surrounding land use, potential impacts on food prices, and water consumption associated with biofuel production. Despite these concerns, European policies actively promote the utilization of biofuels, emphasizing their significant role in reducing carbon emissions in the transport sector. Various factors influence the economics of biofuel production. Technological advancements, such as the development of more efficient conversion processes and novel feedstocks, can potentially enhance biofuels' economic feasibility. Market demand for biofuels is also a crucial factor, which factors like government mandates, incentives, and consumer preferences can influence. Both technology and market dynamics continue to evolve, shaping the future of biofuel production and adoption in Europe.

2. MOTIVATION

The transport sector is seen as a major contributor to the European energy sector decarbonization. The sector accounted for 31% of the final energy demand in the EU in 2019 with an estimated continued steep growth rate until 2030 [1]. As seen in the Figure 1, of over 350 Mtoe of energy consumption (in 2020) [1], the majority is supplied from fossil-based carbon-emitting sources accounting for 20% of anthropogenic greenhouse emissions in the EU [2]. Hence this mandates the need for immediate sustainable interventions. One such sustainable application is the integration of biofuels which could play an important role in the decoupling of the sector from its large fossil fuel dependence.

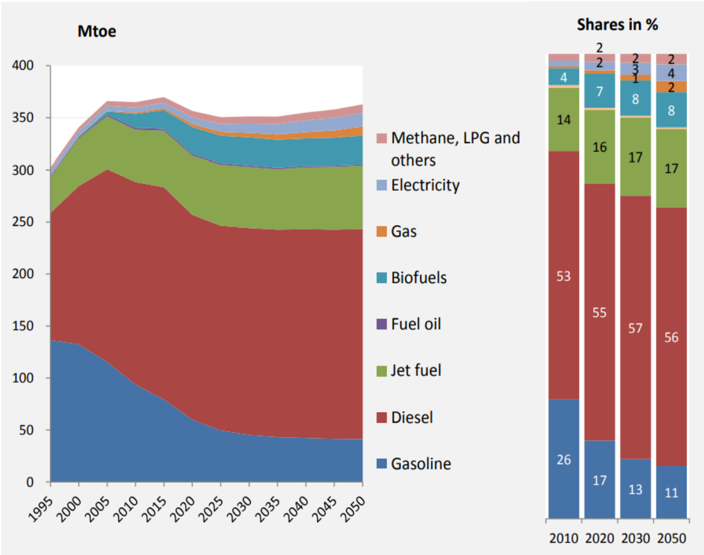


Figure 1: EU Transport Fuel Share[1]

Figure 2 shows the fuel share in road transport which is dominated by fossil-based sources in Austria and Czech Republic. As a result, the average emission per km is higher than the EU average of 120gCO2/km (Figure 3). Hence there is potential for significant improvement in the sector. Thus emphasizing the immense need for intervention. Hence this paper

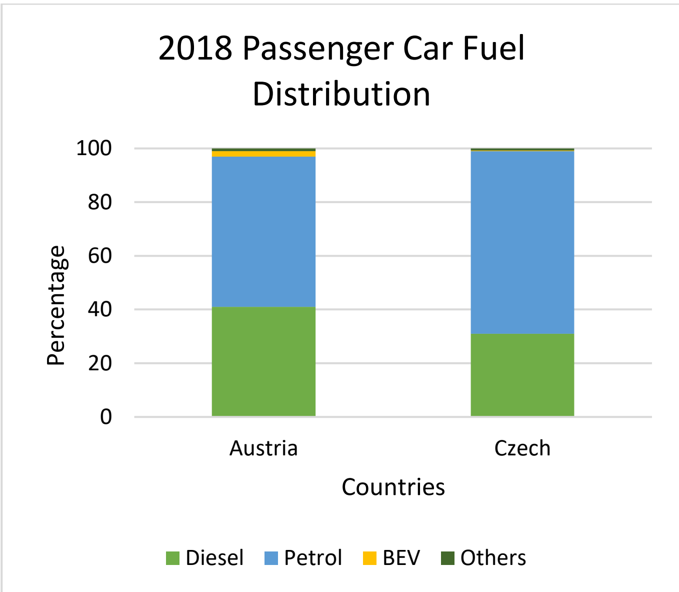


Figure 2:Passenger Car fuel share in the two countries [3]

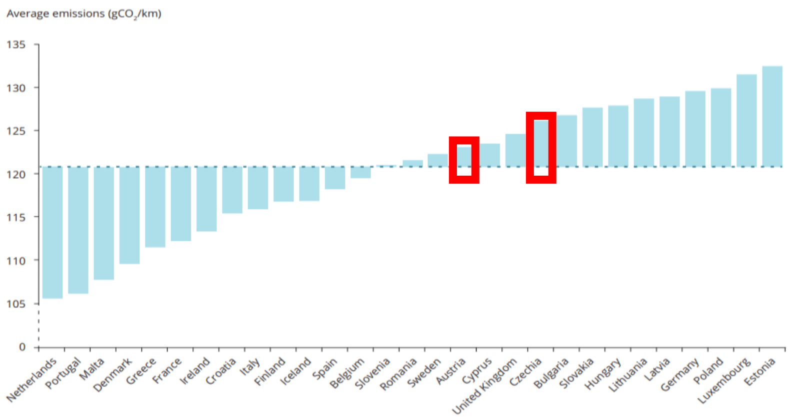


Figure 3:Average CO2 emissions by country (Transport) [3]

2.1 Biofuels in Transport

Electric vehicles are seen as the imminent future of the transport sector. They are envisioned to provide clean, renewable, efficient and cost-effective sustainable means. However, it can be argued that these scenarios are rational only in the long-run (post 2030). In the short run, pre-2030/35, the electrification of the entire car stock does not seem realistic. Thus, other options require consideration. Amongst many, biofuels is an alternative option that could provide means for immediate intervention and support the uptake of electrification. Also, it provides diversification of the technology, thus restricting the transition risks.

Biofuels are particularly effective in the short-run due to the following reasons:

- Possibility of local Production
- Application in existing gasoline and diesel engines
- Generation from a variety of renewable sources, including agriculture waste.
- Lower greenhouse gas emission compared to fossil fuels (Also considering the post-life disposal and handling of a lithium-ion battery)
- Possibility of combining it with fossil fuels for generating different fuel blends

3. Problem Statement

This research is aimed at understanding the existing status of biofuel production and application in the transport sector in the European context with a focus on Austria and the Czech Republic. In doing so, the research tries to answer the following research questions:

- How has biofuel production and application in Transport developed over the 10-20 years?
- How does the application of bio-fuels compare in terms of economic viability?
- How are the environmental performance of biofuel applications in the transport sector?

The availability of literature focusing on these two countries are very limited. This paper thus aims to assess better the current situation and aid in the improved planning and development of production of such fuel sources.

4. State of the Art

Biofuels are alternative renewable fuel sources made from organic matter such as crops, waste, and algae. These fuels are generated through a naturally occurring biological process and hence are carbon neutral. The commonly used raw materials used for production include [4]

- Corn
- Soyabean
- Sugarcane
- Algae
- Waste
- Wood and forestry residue

Benefits of biofuels

- Clean, renewable source of energy
- Energy Soverginitiy
- Ensure sustainable
- Market diversity
- Improve local economy and employment opportunities

The growth of biofuel production over the last two decades has seen a rapid surge in global production dominated mainly by Brazil, the United States, and the European Union. Favorable policy measures are seen as the primary cause of the rise in production [5]. In the European context, the production rise can be associated with the Renewable Energy directive that mandates 10% transport energy from renewable energy sources by 2020, rising to 14% in 2030.

But the increase in production also brings concerns about its impact on food prices, land use and greenhouse gas emissions. The EU directive includes the principles of waste hierarchy in Directive 2008/98/EC to ensure no additional demand for land while promoting the use of wastes and residues.

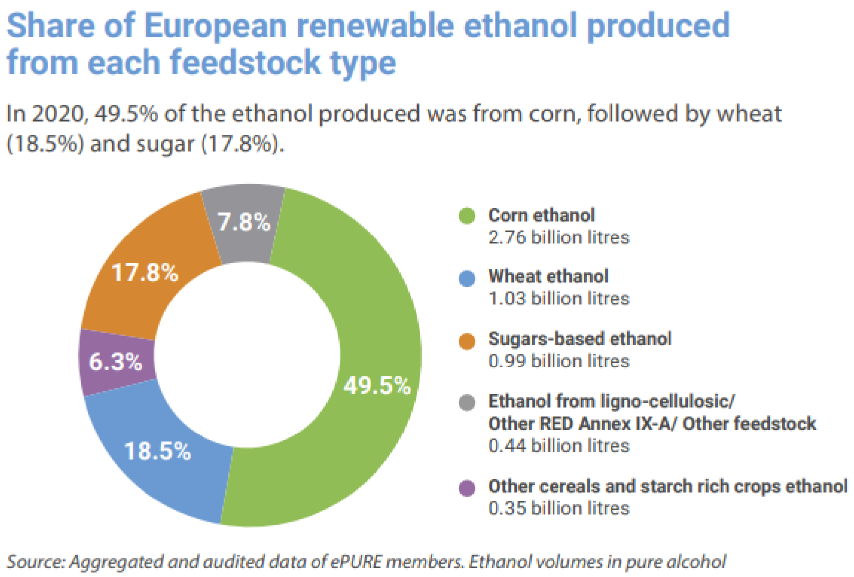


Figure 4: EU current ethanol production [6]

Austria has total renewable ethanol installed capacity of 275 Million liters and 255 million liters for CZ, which total to 5% of the total European capacity.

[7] estimated the biofuel potential from agricultural and forestry residues, as well as biogenic waste, the analysis assumes the conversion of these feedstocks into biochemical ethanol or thermochemical drop-in diesel. The yield estimates used are 0.25 tonnes of ethanol per tonne of feedstock and 0.20 tonnes of drop-in diesel per tonne of feedstock

The successful large-scale application of biofuels requires technological interventions toward boosting local production, which favorable policy measures must support. The technical aspects include research and development in large-scale production technologies and locally sustainable raw materials identification. This would further need government support, including allocation of subsidies, investment, and enforcement of bio-fuel use.

[8] estimated the availability of feedstock for biofuel production in Europe based on an auto-regressive model summarized in Table 1:

Table 1: Estimated Feedstock Availability[8]

Category	Without Covid-19 correction		With Covid-19 correction	
	Max Availability (Mt)	Min Availability (Mt)	Max Availability (Mt)	Min Availability (Mt)
Agriculture Residues	74	51	65	49
Forestry residues	46	41	41	36
Wastes	35	24	31	21

Biofuels in various forms have immense potential for application in the transportation sector. Some common applications seen are [9]:

Table 2: Types of Biofuels-An Overview

Fuel Type	Source	End-use
Ethanol	Corn, Sugarcane, wheat	In conventional gasoline Engines
Biodiesel	Vegetable oils, animal fats, or recycled cooking oil	Heavy-Duty Vehicles
Algal Biodiesel (Green Diesel)	Microalgae	Similar application but higher production efficiency
Cellulosic Biofuels	Nonagricultural plants	Heavy duty vehicles

Green diesel ("renewable diesel"), is a hydrocarbon fuel with a chemical structure similar to fossil petroleum diesel. However, unlike biodiesel, which is produced through transesterification, green diesel is produced by the hydrotreatment of fats or oils. It closely meets the specifications of conventional diesel, allowing it to be used directly in compression ignition engines without requiring modifications [10]. Green diesel has a higher heating value, better stability, and cetane value than biodiesel and petroleum diesel while emitting lower sulfur. However, producing green diesel from algal oil is currently expensive, and further research is needed to make it economically viable on a large scale. Continued studies on crude algal oil purification and advanced hydrotreatment with effective catalysts are expected to advance the development of green diesel.

Algal biomass also holds potential as a major feedstock for bio-jet fuel production, with algal oil capable of being converted into eco-friendly jet fuel through various technologies. The aviation industry's goal of achieving carbon neutrality and reducing CO2 emissions has driven the approval and adoption of jet fuel from algal oil, which has been found to reduce GHG emissions by 76% compared to conventional jet fuel. While the bio-jet fuel market is currently limited, it is expected to grow in response to climate change concerns, and algal bio-jet fuel is seen as a critical component in replacing conventional jet fuel to meet global sustainability targets. Despite its futuristic potential, commercialization of third-generation algal biofuels on a large scale still faces challenges that require further research and development.

4.1 Biofuels in Austria

In Austria, the production of biofuels is a significant part of the country's energy sector and the transport sector's most important emission-reducing and fossil fuel substitute. The application of biodiesel was initiated in 2005. As of 2021, around 4.7% of biodiesel and bioethanol were added to fuels, with a maximum of 7% biodiesel allowed. This allowed the total sales of 405,937.20 tons of biodiesel and 10,524.13 tons of hydrogenated vegetable oils (HVO) through admixture. Additionally, 25,011.73 tons of biodiesel and 1,158.86 tons of HVO were sold in pure form or as fuel with higher biogenic additives. The biofuel register confirmed the sustainability of 430,948.93 tons of biodiesel and 11,657.47 tons of HVO [11].

10% of biodiesel production in Austria comes from domestically grown rapeseed. However, a large portion of the feedstock for ethanol production is sourced within the country. To meet the demand for biofuels, approximately 55,000 hectares of rapeseed and around 80,000 hectares of wheat, corn, and sugar beets are allocated for biofuel production [12]. [8] also suggest a large potential for forest residue considering the availability of dense forests covering 46% of the country's total land area with AustroCel Hallein an in operation biorefinery already producing biofuels from this resource. The plant is able to produce 30 million liters of bioethanol per year.

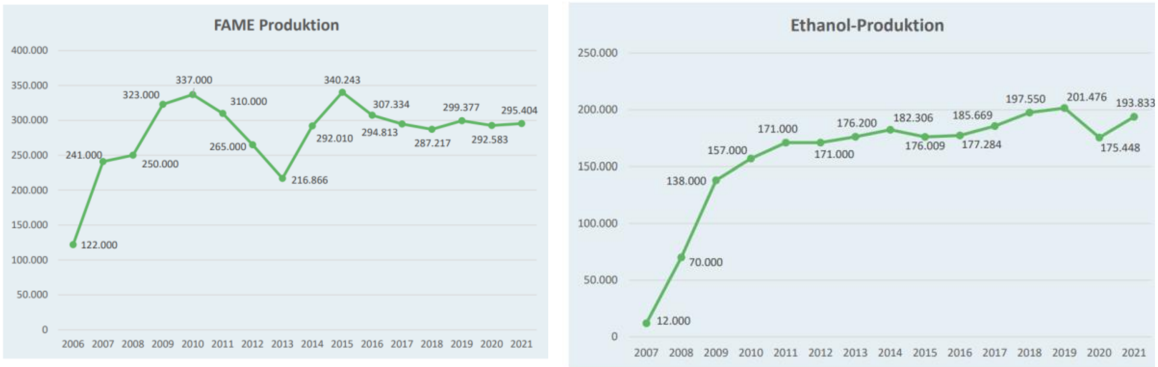


Figure 5: Development of Biodiesel (left) and Ethanol (right) Production in Austria (tons)[11]

As per literature based on 2012 political regulations have immense support for the development of 2G biofuels in Austria. Directive 2009/28/EC allows 2G biofuels to be double-counted towards the minimum target of 10% renewable energy use in the transport sector. This framework incentivizes the production and adoption of 2G biofuels, driving their development and implementation [12].

An autoregressive model developed by [8] estimates availability of sustainable crops for use as feedstock for biofuel production in 2025 to be 0.5 -2 million tonnes per year. This study estimates higher availability of forest residues at about 7-10 million tonnes per year.

Of the overall emission reduction achieved in Austria in 2021 , 3.08% (below the target of minus 6%), biofuels contributed to about 3.04% of this reduction, while renewable electricity accounted for about 0.04%. This shows the influence and potential of biofuels towards contributing to the overall decarbonization of the energy sector. The direct CO2 emission savings from biofuel use in the transport sector in 2021 amounted to 1.37 million tons. However, the target achievement calculations do not consider indirect land use change (ILUC) emissions. The average greenhouse gas intensity of all biofuels produced in Austria ranged from 14.7 to 36 g CO2/MJ. All biofuels used in Austria in 2021 were 23.1 to 85.7 g CO2/MJ. The eligibility of biofuels with a high risk of indirect land use change was restricted based on the revised guideline for the promotion of renewable energy use. This restriction took effect at the end of 2020, with palm oil-based biofuels no longer counted towards national targets since July 1, 2021 [11].

4.2 Biofuels in the Czech Republic

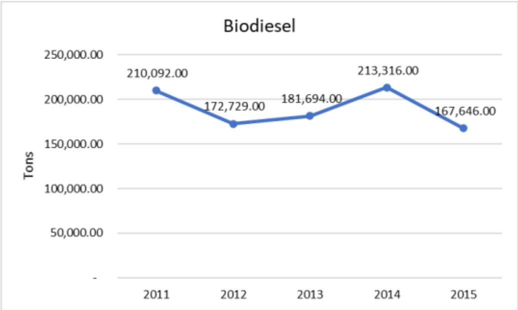
The use of organic materials, green energy as a contribution to the improvement of the environment, elimination of waste, and preventing global warming through low greenhouse gas emissions are the factors that make biofuels popular. But it is also important to look at this phenomenon from the beginning of its production.

To be able to refuel buses, trucks, or other vehicles with biofuel instead of diesel or petrol, it has to go through a long, logistically complicated agricultural process. In the Czech Republic, a very popular source of biofuel is rapeseed. This crop is primarily used because of the business point of view. The former prime minister and unsuccessful candidate for president of the Czech Republic Andrej Babiš owns the conglomerate holding company

Agrofert a.s. and their extensive activity is to buy the land in the Czech Republic and produce rapeseed on it. The graph shows the Czech Republic's first place in the share of fields sown with rapeseed on all arable land. While the average in the 28 countries is 6.3 percent, in the Czech Republic, this technical crop is now blooming on almost sixteen percent of the fields. According to current rules, diesel sold in the Czech Republic must contain at least 6% bio-components. This mainly consists of rapeseed oil methyl ester (FAME). In addition to regular biodiesel, "pure" biodiesel B100 and mixed diesel B30 are sold.

In recent years, a third to a half of rapeseed oil grown in domestic fields was used for their production. Last year, according to the calculation of the Research Institute of Agricultural Technology, 32.9 percent of the area of agricultural land sown with rapeseed was used for the production of biodiesel, in the record year 2011 it was 46.7 percent of cultivated rapeseed.

Another important biofuel, bioethanol, which is mixed with gasoline, is produced from other crops, mainly sugarcane, wheat and corn [13].



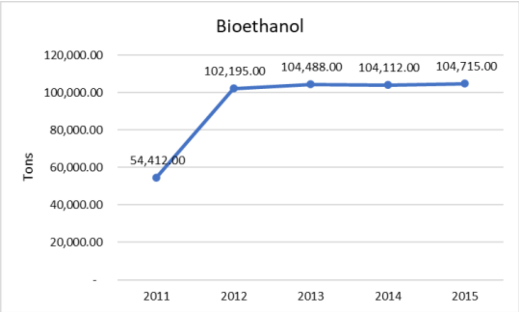


Figure 6: Development of Biodiesel (left) and Ethanol (right) Production in Czech Republic (tons)[14]

Figure 6 shows bioethanol and biodiesel production in the Czech Republic. Bioethanol production is seen to have stagnated from 2012 to 2015. Biodiesel production saw a decline in 2015 due to the tax increase. However, with recent developments in the energy market and fuel scarcity, the production quantities have drastically changed, with combined production of 200,000 tons. However, the latest data on disaggregated production could not be acquired over the course of the study.

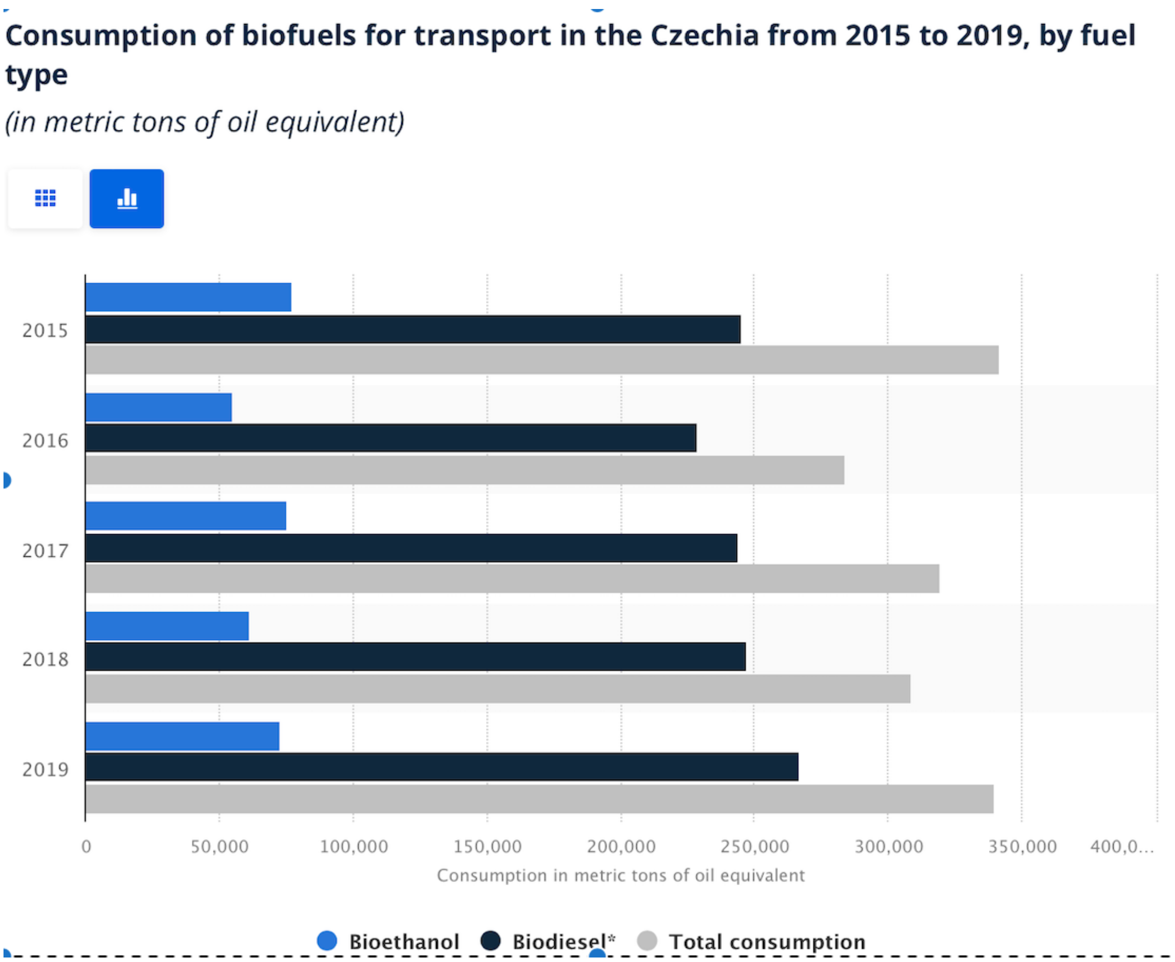


Figure 7: Consumption of biofules for transport in Czechia

The graph shows how many tons of bioethanol and biodiesel have been consumed in the Czech Republic over the past four years and shows that biodiesel is the most used biofuel in the Czech Republic by almost 200,000 tons in 2019.

Rapeseed is a plant that can grow with less sunlight and in more moderate temperatures and therefore, it is not too demanding to grow. However, even initial procedures with rapeseed lead to complications. Rapeseed needs to be sown, processed, and all these processes process enormous amounts of water, energy (from fossil fuels), and oil. According to Water Footprint research, approx. 1,500 liters of water are consumed per 1 liter of biofuel. [15]The rapeseed for biofuel production is susceptible to disease and pests, so it is sprayed with pesticides. Studies show that more than 50% of groundwater is contaminated with pesticides [16]. Another disadvantage of growing rapeseed in such an enormous amount, as applied in the Czech Republic, is rapeseed pollen. Rapeseed pollen is problematic because it is much heavier, so it spreads a shorter distance than other pollens, and then it happens that during the season, everything is covered with yellow pollen.

The last but enormous problem of rapeseed cultivation concerns biodiversity. In the Czech Republic, unlike Austria, it is common to have huge fields on which only one crop is grown. Mostly rape or corn, less poppy. In Austria, there are many diverse fields, or small forest. When the economy operates in such a way that most of the fields are planted with rapeseed, biodiversity is reduced. In addition, pesticides are toxic to bees and forest animals because they are metabolized in their livers [17]. [8] estimates the availability of sustainable forestry residue in the Czech Republic as feedstock for biofuel production at about 2.5-3 million tonnes per year by 2025.

This graph (Figure 7) shows us what position the Czech Republic is in with the consumption of biodiesel and bioethanol per kiloton.

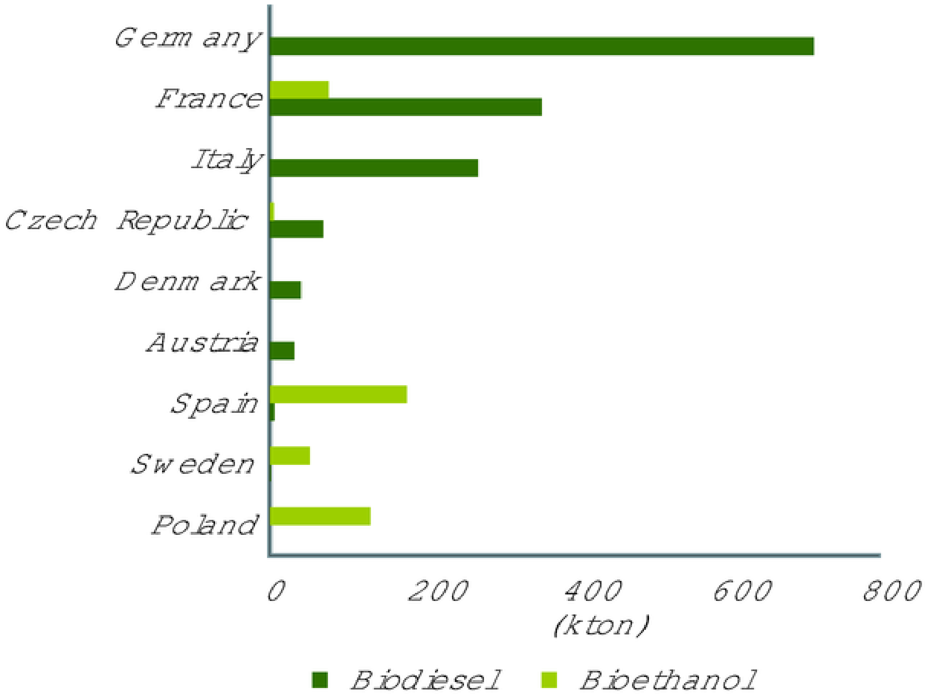


Figure 8: Consumption of biofuels in the Czech Republic in comparison with other European countries

No specific costs for the production of biofuels in the Czech Republic could not be found, nevertheless considering the geographical proximity, the tentative production costs are expected to be similar to those in Austria, as detailed in page 13.

4.3 EU biofuel policy

In 1997 signatories of the Kyoto Protocol pledged to reduce their greenhouse gas emissions by an average of 5% compared to 1990 levels. Transport emissions are responsible for approximately one-third of the EU's CO2 emissions, which is why attention has also increased on fuel. One of the solutions was to dilute biofuels [18].

The first directive was introduced by the European Union in 2003. Later, the rules were amended by another four directives (in the years 2009-2018). The directive from the year 2003 claims that fuel producers must add a minimum proportion of biofuels or other renewable fuels to gasoline and diesel. [12] Each member country had to set the exact share for itself. It was introduced in the Czech Republic by an amendment to the Act on Air Protection in 2007 [19].

But six years later, the opinion on blending biofuels has changed. The cultivation of first-generation biofuels is primarily carbon-intensive, so it often does not meet the original goal of reducing emissions. It reduces species diversity and leads to higher food imports, which can lead to higher prices. In addition, some fuel distributors mixed palm oil into their fuels due to the directive.

The directive in 2009 changed the way to reduce emissions. From now on, individual member states have more freedom to achieve a ten percent share of renewable sources in Transport by 2020. Biofuels were now supposed to be one of the ways to achieve a reduction in emissions, although according to the Union, it was still the most important one [20].

4.4 Legal Framework for Biofuel Application in Transport

The legal aspects of biofuels in Transport may vary between countries. Selected aspects include, for example, certification and verification [21]. Countries require biofuels to be subject to certifications that demonstrate compliance with sustainability criteria. These certifications provide a framework for evaluating biofuel production's environmental and social impacts. These actions include audits, documentation and reporting to verify compliance with requirements. Tax subsidies and incentives can be found as legal aspects [21]. Governments can offer subsidies, reductions in consumption taxes, and grants to encourage the production, distribution and sale and use of biofuels. They aim to increase the competitiveness of biofuels compared to conventional fossil fuels. Sustainability is also an important legal aspect to ensure that biofuels are produced ecologically and socially sustainably [22]. These criteria include issues such as limiting greenhouse gas emissions, protecting land and water resources, respecting human rights and protecting biodiversity. The last but most key aspect is regulatory policy. Countries have set targets for the future use of biofuels in Transport. These policies determine the percentage of biofuels mixed with fossil fuels, set goals for its consumption, and standardize biofuel qualities, emission limits and other regulations related to biofuel production, distribution, and use.

4.5 Economics of Biodiesel Production

The following factors largely influence the economics of biodiesel production:

- Feedstock Prices
- Processing costs
- Government incentives and Policies
- Market Demand
- Scale of production

The cost of the feedstock influences the overall cost of biofuel production. The feedstock is a direct substitute for food crops, the market volatility in the food market in turn influences the food industry.

Some key aspects related to the economics of Biofuel production in the EU:

- Feedstock Costs: The availability and cost of feedstock play a significant role in the economics of biofuel production. Europe utilizes various feedstocks for biofuel production, including crops like rapeseed, wheat, sugar beet, and other cellulosic biomass sources. The cost and availability of these feedstocks can fluctuate due to weather conditions, agricultural practices, and competing uses (e.g., food production).

- Policy Support: The European Union has implemented policies and regulations to promote the use of biofuels, such as the Renewable Energy Directive (RED). These policies set blending targets, provide incentives and establish sustainability criteria for biofuels. Government support and incentives can impact the economics of biofuel production by reducing production costs or providing market stability.
- Technological Advancements: Advances in biofuel production technologies can improve efficiency, reduce costs, and enhance the viability of biofuel production. Europe has been investing in research and development efforts to improve biofuel production processes, including second-generation biofuels derived from non-food feedstocks and advanced conversion technologies.
- Market Demand and Pricing: The demand for biofuels in Europe is influenced by factors such as energy policies, environmental concerns, and consumer preferences. The market demand and pricing of biofuels can affect the profitability of biofuel production. Fluctuations in fossil fuel prices can also impact the competitiveness of biofuels.
- Certification and Sustainability Requirements: Europe has stringent sustainability requirements for biofuel production, including greenhouse gas emission reductions and land-use criteria. Compliance with these sustainability standards may add additional costs to biofuel production processes.
- Scale of Production: The scale of biofuel production can impact the economics. Large-scale production facilities can benefit from economies of scale, potentially reducing production costs. However, small-scale or decentralized production systems may offer advantages in terms of feedstock availability and regional development.

Production costs

As mentioned above, the costs of biofuels depend on various factors, including feedstock costs, processing technology, economies of scale, and government incentives. Generally, biofuels have historically been more expensive to produce than fossil fuels. However, with advancements in technology, economies of scale, and supportive policies, biofuel production costs have been decreasing, making them more competitive.

As with any other energy generation technology, the production costs of biodiesel consist of initial investment costs (the fixed capital costs) and variable costs. A number of studies assessed during the research showed a wide variation in the costs. However, since the literature are from different years, the changes in the development of costs can also be observed.

For small-scale farm production, investment would be required for an oil seed expeller press. This would provide the possibility of producing biodiesel and feedstock for live stock, thus adding a secondary source of revenue [23]. Estimations range from $0.2-0.4 per liter (in 2008). However, mass scale is needed to meet the immense transport demand and exploit the economies of scale. [24] suggest that large-scale biodiesel application in transportation would reduce ethanol production costs from lignocellulosic sources at a cost of less than USD12 per GJ.[25] estimated biodiesel production costs from castor oil in the range of 0.92-1.56 US$ per liter.

[26] estimate biofuel production costs ranging from 43.5 €/MWh to 116 €/MWh with production ranging from synthetic natural gas to biomethane. The output of biomethane and ethanol are in the ranges of 50-80 €/MWh (in 2010 when the wholesale price of the fossil fuels was 42 €/MWh). Comparison of the cost structures shows a higher share of feedstock costs for biodiesel and ethanol production than second-generation biofuels. Hence the production costs of the second generation fuels are less sensitive to feedstock prices.

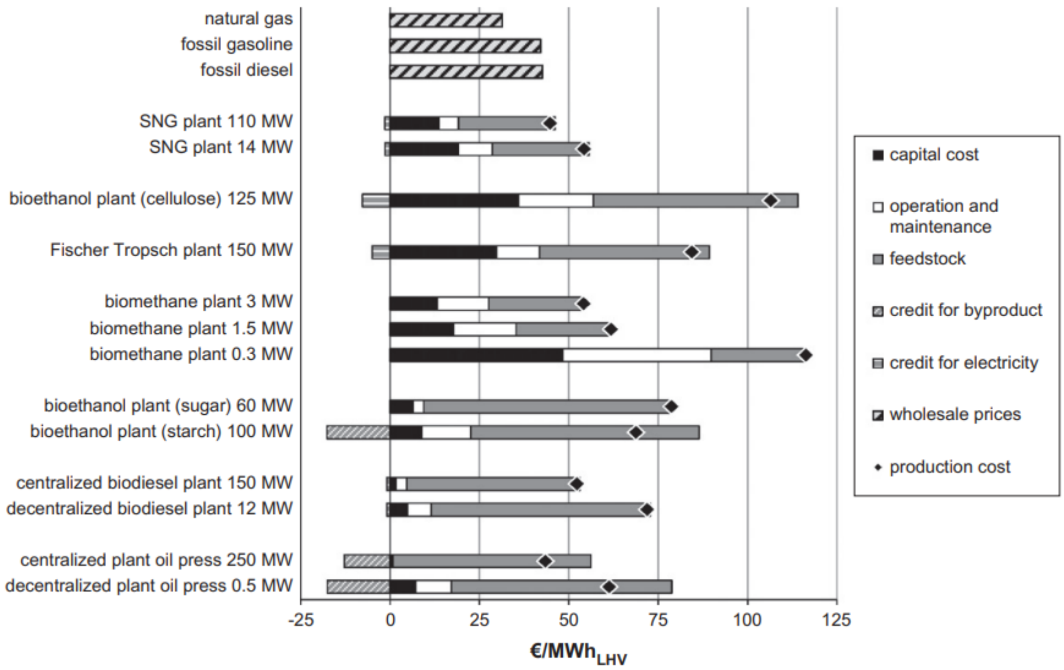


Figure 9: Cost Components of Biofuel Production **[26]**

*Figure **9*** extracted from [26] shows an approximation of the different cost components for the production of different cost components for biodiesel production. Though no systematic patterns can be observed in the costs, feedstock costs are seen to play an important role in all 1st generation production options.

[10] Analyzed the economic feasibility of third generation biofuels and techno-economic viability assessment of algal biofuels, considering various aspects such as capital and operation costs, cultivation processes, and risk assessments were conducted. The cultivation costs were found to account for 87% of the total cost of biofuel production, with the estimated cost of producing 1 ton of dry algal biomass being around $1225 in 2015. Open pond systems had lower cultivation costs than photobioreactor (PBR) systems, with PBR systems being roughly twice as expensive as open ponds. Additionally, operational costs like labor, power consumption, water, and nutrient costs were higher in PBR systems, impacting the final cost of biofuel production. The selling prices of biodiesel from open ponds and PBRs were estimated at $2.97/L and $4.93/L, respectively.

4.6 Environmental Performance of Biofuels

The use of biofuels, particularly biodiesel, has gained attention due to its potential environmental benefits. However, the sustainability of biodiesel is now being more carefully assessed compared to when biofuels first emerged [27]. Various studies have examined the sustainability of biodiesel, leading to diverse conclusions and fueling the ongoing debate [28] [29]. Though the results of these studies vary primarily due to the underlying assumptions, all primary concerns are common and associated with feedstock sources and allocation methods, land use impacts, system boundaries and functional units. One major concern with biofuel is its potential contribution to indirect land use changes, such as deforestation, which can negatively impact sustainability and greenhouse gas (GHG) emissions. The GHG emission for first-generation biodiesels produced from common feedstocks displayed a large variation ranging from 4 to 505 grams of CO2 equivalent-per-Mega Joule (gCO2e/MJ) across different LCA studies agains an diesel avergae of 84 gCO2e/MJ. Though the average GHG emissions of biodiesel from different feedstocks were lower than those of fossil diesel without considering land use, only palm oil biodiesel without land use change met the EU RED requirement for 50% less GHG emissions compared to conventional diesel [28]. [31] showed the impact direct and indirect impact of the biofuel prodcution against the renewable energy thresholds. As see in Figure 10 (up), a very small margin exists to detrermine the sistainability of first generation biodiesel production.

Second-generation biodiesels produced from nonedible feedstocks have a much environmental performance and show considerably lower GHG emissions compared to petro-diesel. Biodiesel from tallow and used cooking oil exhibited 60-90% lower carbon intensity than petro-diesel [27]. The average GHG emissions per unit of energy for second-generation biodiesels from nonedible feedstocks are considerably lower than petro-diesel, with the values ranging from −88 to 80 gCO2e/MJ [27]. However, the future biodiesel production, third-generation microalgae biodiesel currently emits 3.5 times more GH emissions than conventional diesel and is not seen as a viable option due to bad environmental performance and expensive and energy-intensive production processes.

Apart from GHG emissions, biodiesel has the potential to reduce particulate matter significantly compared to petro-diesel. However, the impact on nitrogen oxide (NOx) emissions remains varied, with some studies suggesting biodiesel may emit higher levels of nitrogen oxides. [29] suggest 70% less hydrocarbons, 50% less particulates and carbon monoxide, and 10% more NOx emissions with the use of 100% biodiesel on a heavy-duty vehicle. Biodiesel has negligible sulfur oxide emissions, lower ozone-forming potential, and can contribute to reduced hydrocarbons and particulate emissions when used in heavy-duty highway engines.

Considering only emissions from direct combustion in an engine, gaseous pollutants such as CO, SO2, NOx, HCs, etc., resulting from incomplete combustion using conventional fossil fuels can be minimized using bio-fuels [30]. [30] also, the emissions in the production to the combustion of biodiesel results in overall pollutant reduction, considering that the CO2 released during engine combustion can be reabsorbed into biomass cultivation processes.

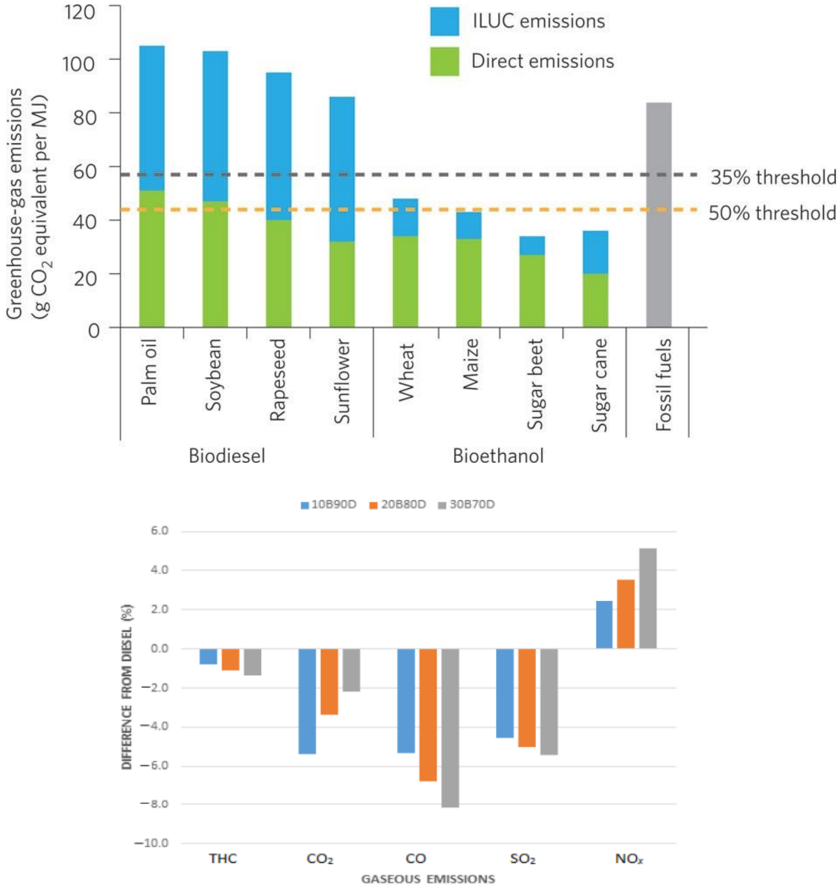


Figure 10: Direct and Indirect Emissions of Biodiesel production(up) **[31]** *.*

*Difference in Emission compared against 100% Diesel (down)***[30]**

In summary, the large-scale sustainability of biodiesel is still the subject of ongoing research and discussion. Various factors influence its sustainability, including feedstock sources, land use impacts etc. While some biodiesel options demonstrate lower GHG emissions and other pollutant reductions compared to petro-diesel, careful consideration of feedstock choices and production methods is necessary to ensure the overall sustainability of biodiesel as an alternative fuel.

4.7 Biofuels in Transport- Recent Development and Impact of Covid-19

Covid had a strong impact on biofuels in Transport. The most striking feature was that the pandemic caused a drop in demand for fuel (due to movement restrictions, border closures, air travel restrictions) [32]. These factors led to a reduction in the consumption of gasoline, diesel, jet fuel and biofuels. Limited demand for biofuels had an impact on their production and distribution. The demand for ethanol and biodiesel also decreased. These changes affected biofuel plants, which were forced to reduce or stop production. It is also important to mention that the pandemic has also affected the availability of raw materials to produce biofuels. Restaurant closures, consumer stagnation, and biofuel producer margins have come under pressure, and food industry restrictions have led to a decrease in the availability of waste oil, which is subsequently used for biodiesel production [33].

The consequences of these factors led to overall stagnation and a reduction in production. But this applies to all branches of the automotive industry. Even after the covid pandemic, some industries did not return to their original state, or at least partially to their original state. Fortunately, biofuels remain an important part of efforts to reduce greenhouse gas emissions and lead a more sustainable and eco-friendlier lifestyle.

Some countries have taken measures to support this industry and minimize the negative impacts of covid.

Some measures included financial incentives. Some countries have financially supported the biofuel sector to sustain it during economic downturns. These financial supports are mainly low-interest loans, tax credits, and subsidies.

In addition to the USA, Brazil and Canada, the European Union has also taken measures for financial support. To prevent the devastating economic effects of covid-19, the European Commission presented the Green Deal initiative, which includes support for the sustainable biofuel sector.

Some countries have also taken measures related to reducing regulatory requirements, simplifying procedures for trading biofuels and raw materials for its production, and extending the validity of certificates to minimize the administrative burden during the pandemic. Another measure was strong support for research and development. Countries increased their investment in biofuels science and research to increase production efficiency and reduce biofuel costs.

After the covid pandemic, biofuels are expected to continue to play an important role in the journey towards sustainability in Transport and in efforts to reduce greenhouse gas emissions. Among the factors that could influence biofuels in Transport after the pandemic are, for example, support for sustainable growth recovery [34]. Biofuels could be one of the key elements in these sustainability efforts and , could therefore receive support and investment. Many regions are aware of the planet's exhaustion and are focusing their economic recovery on sustainable style and low-carbon growth [35].

With the gradual opening of international markets and economies, the resumption of travel and transport activities, and increased demand for Transport and fuels are expected. Biofuels can play a role in meeting environmental goals.

Countries are also likely to continue to introduce stricter emissions standards for Transport. Biofuels with low greenhouse gas emissions have the potential to meet sustainability criteria. Another goal appears to be the goal of reducing dependence on specific raw materials. Support from politicians or private companies could advocate for science and research on biofuel issues. This could include the use of new types of biomasses, waste, algae, synthetic fuels. After the pandemic, further innovations could be expected, such as the use of advanced second-generation biofuels that use, for example, lignocellulosic materials or algae [36].

5. CONCLUSION

The transport sector is a major contributor to energy demand and carbon emissions in the EU. Biofuels are seen as a sustainable alternative to fossil fuels in the short run, as they can be locally produced, used in existing engines, and have lower greenhouse gas emissions. However, there are concerns about the impact of biofuel production on food prices, land use, and greenhouse gas emissions.

The research aims to understand the development of biofuel production and application in the transport sector in Austria and the Czech Republic over the past 20 years. It also investigates the economic viability and environmental performance of biofuel applications in these countries.

Biofuels can be produced from various sources such as corn, soybean, sugarcane, algae, waste, and forestry residue. They offer benefits like being a clean and renewable source of energy, ensuring energy sovereignty, diversifying the market, and improving the local economy. Biofuels also have lower greenhouse gas emissions compared to fossil fuels. Although the overall life cycle analysis of biofuels should consider factors such as feedstock production, processing, and transportation, their use can contribute to reducing carbon dioxide emissions and help mitigate climate change.

Austria has seen an increase in biofuel production, particularly biodiesel from rapeseed oil and bioethanol from wheat and corn. The country aims to meet the 10% target of the renewable energy directive by 2020 and surpass it to reach 16% by 2030. The Czech Republic also produces biofuels, primarily from rapeseed for biodiesel and other crops like sugarcane, wheat, and corn for bioethanol.

The EU has implemented directives to promote the use of biofuels, but there have been concerns about their carbon intensity, impact on biodiversity, and food prices. Certification, subsidies, and sustainability criteria are part of the legal framework for biofuel application in Transport. Governments set targets, regulate fuel blending percentages, and standardize biofuel qualities.

The economics of biodiesel production depend on factors such as feedstock prices, processing costs, government incentives and policies, market demand, and scale of production. Feedstock prices, in particular, can greatly influence the overall cost of biofuel production.

In conclusion, biofuels have the potential to play a significant role in decarbonizing the transport sector in the short run. Both Austria and the Czech Republic share this potential and integration of high levels of biofuels in their transport energy could help both countries meet their respective decarbonization targets in addition to benifitting their respective economies.

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