Biofuels: Current policies, future goals, feedstocks, costs

A theory-based evaluation

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Contents

Abstract

The objective of this study is to examine the role, policies, costs and future perspectives of biofuels in Austria and the Czech Republic by analysing their impact in each country's energy sector and their impact on economic development. As the European union must meet the 2030 climate goals, biofuels have emerged as a significant alternative to fossil fuels, emphasizing the importance of transitioning to renewable energy sources with those playing a central role. This research aims to compare the policies and market structures that influence the usage of biofuels in both countries and the integration of biofuels into their national energy strategies, highlighting similarities and differences in regulatory frameworks, biomass availability, economic feasibility and technological implementation. The rationale behind the study is to understand how national strategies, resource availability and regulatory environments influence the effectiveness of biofuels as a tool for decarbonization. The methodology is based on a comparative analysis of qualitative and quantitative data from national reports, EU directives, academic literature and statistical databases. It evaluates each country's feedstock potential, policy frameworks, economic conditions and technological adoption, focusing on both first- and second-generation biofuels. Another aim is to evaluate the long-term potential of biofuels in the mentioned countries. The study concludes that, while Austria is positioned as a regional leader in bioenergy, the Czech Republic requires further policy alignment and investment to fully realize its potential. For both countries, increasing the role of biofuels will depend on overcoming economic barriers and aligning national policies with EU climate directives while policy harmonization, investment in second-generation technologies, and efficient use of biomass resources will be essential for both countries moving forward.

1 Introduction

Biofuels are renewable energy sources produced from organic materials such as crops, agricultural waste, forest biomass, etc. They serve as an alternative to fossil fuels in transport, heating, and electricity production. Their purpose is to contribute to the efforts against climate change. Globally, biofuels are considered to be a very important component of renewable energy strategies, because they reduce greenhouse gas emissions. However, problems such as land use restrictions, production costs, and feedstock availability affect the possibility of usage. Many European countries are integrating biofuels into their energy policies to meet decarbonization targets, including Austria and the Czech Republic [1].

As the states of the EU move toward its 2030 climate goals, biofuels have emerged as one of the key players in its renewable energy transition.

Austria has been strongly focused on biofuels, aiming for climate neutrality by 2040. Austria aims to have a well-established bioenergy infrastructure, and it invests in research on biomass processing, which supports the transition from fossil fuels. A recent review of Austria's bioenergy market shows that bioenergy already covers more than a quarter of the country's final energy demand and is projected to keep growing steadily through 2030, driven by favourable policies and mature supply chains [2].

The Czech Republic has also recognized biofuels as an important part of its energy potential, but its approach has been more reserved, due to certain laws and economic restrictions. The country has significant forest biomass resources, which could support biofuel production. Recent studies have shown that the technical biomass potential from forestry in the Czech Republic has been significantly reduced due to a bark beetle calamity, which caused a major increase in damaged wood mass between 2017 and 2019 [3].
However, usage of biofuels on a large scale hasn't yet been achieved. In 2019, biofuels accounted for 6.2 percent of gross final energy consumption in the Czech transport sector, contributing to the country's total renewable energy share of 16.2 percent [4].
The current development of biofuels in the Czech Republic is directed by national sectoral initiatives and by broader EU policies. The National Climate and Energy Plan (NCEP) of the Czech Republic, revised at the end of 2024, outlines the continued role of biofuels in meeting renewable energy targets for transport, with emphasis on sustainable advanced biofuels [5]. However, efforts are still fragmented between ministries and regional programs [6]. The country's feedstock potential has its limitations and opportunities. With constrained availability of arable land and food-security sensitivities, the future of Czech biofuels is expected to depend less on first-generation sources (like rapeseed and corn), and more on second-generation technologies that utilize forest biomass, agricultural residues, and industrial byproducts [7].

This paper outlines the Czech Republic's and Austria's current biofuel policies, overviews strategic goals for 2030, assesses feedstock availability, and analyzes the economic conditions influencing biofuel production and usage. It also situates the Czech and Austrian case within the wider European Union context.

The objective of this study is to examine the role of biofuels in aforementioned countries by analyzing their impact in each country's energy sector and their impact on economic development. The methodology of this paper is a comparative analysis of Austria and the Czech Republic based on official reports, statistics, and academic sources.

2 Types of biofuels and EU trends

Biofuels are renewable energy sources derived from organic materials such as crops, agricultural residues, and forest biomass. They are used as substitutes for fossil fuels in transportation, both district heating and local heating, and electricity generation.
Biofuels are divided into four categories, based on the source material and the technology used in their production [1].
First-generation biofuels are produced from edible crops, such as corn, sugarcane, rapeseed, and wheat. These crops are rich in sugars, starch and other matters that have a relatively high caloric value. These fuels include ethanol and biodiesel. They are the most commercially available biofuels today. However, their reliance on food crops has raised some ecology related concerns, such as food security, land competition, and environmental degradation [8].
Second-generation biofuels are created from non-edible biomass such as residues from agriculture (straw, husks), forestry (wood chips, bark), or industry. Intentionally planted energy crops are also used extensively. These materials aren't involved with food production, which means that they're more environmentally sustainable.
Third-generation biofuels are derived from algae, which can produce large quantities of lipids for biodiesel or carbohydrates for ethanol without requiring land usage. While they're promising in terms of sustainability, these technologies are currently experimental and are not yet commercialized [1].
Fourth-generation biofuels represent the newest technology, combining various high technology methods, such as metabolic engineering and synthetic biology with carbon capture and storage (CCS) techniques. These biofuels are not only designed to be carbon neutral but potentially carbon negative by removing CO2 from the atmosphere during production [1].

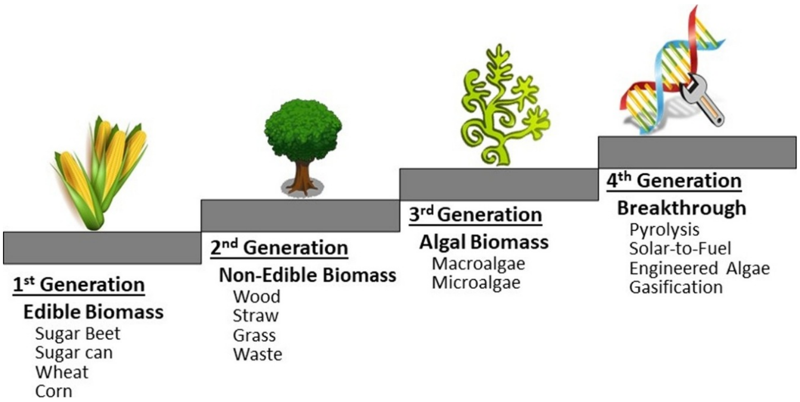

Figure 1: Different generations of biomass [9]].

At the EU level, the treatment of biofuels is described in climate and energy policies such as the Renewable Energy Directives - I, II and III. For an example, RED II mandates a 14 percent share of renewable energy in transport by 2030 and a minimum 3.5 percent share of advanced biofuels [10]. Countries across the EU are responding with different strategies. States like Germany and Sweden are going full-in with implementation of this directive, but others, including the Czech Republic, remain more cautious - they prioritize policy alignment with EU targets over domestic biofuel development [6, 11].

3 Availability and utilization of biomass

3.1 The Czech Republic

Biomass is currently the most prominent renewable energy source in the Czech Republic, accounting for approximately 58% of the country's renewable energy consumption in 2022 [12]. Most of this contribution comes from the heating and cooling sector, where biomass is the dominant renewable source [12]. This occurrence is largely due to the country's large forest resources, an agricultural base with a long history, and well-developed infrastructure for heat and power generation. Unlike weather-dependent sources such as solar or wind, biomass offers predictable supply and is technologically well integrated into combined heat and power (CHP) systems and heating plants [13].

Forest biomass is currently the most important source in bioenergy production in the Czech Republic. The total available volume of dendromass (woody biomass) for energy purposes through 2036 is around 13.47 million tons annually, with 7.645 million tons (56.7 percent) derived from primary forest production [4]. This includes fuelwood and approximately 0.77 million tons of wood chips from logging residues.

However, this supply has its problems: recent bark beetle outbreaks created a short-term surplus of waste. That means there was more wood and forest debris than needed, caused by the rapid removal of trees damaged by the insects. As these infestations stabilize and harvesting intensity declines, a significant reduction in long-term forest biomass availability is expected, lasting potentially 30 years [4].

In 2019 alone, approximately 14.9 million cubic meters of wood mass were damaged, a year-on-year increase of more than 75% compared to 2018 (8.6 million cubic meters), and much higher than in 2017 (4.1 million cubic meters). The damage was almost entirely caused by long-term bark beetle overpopulation, particularly in spruce and pine forests. The worst-affected regions were Vysočina, followed by South Moravia, South Bohemia, and Central Bohemia. In contrast, calamitous logging was decreasing in Moravian-Silesian, Olomouc, and Zlín Regions, while the situation worsened westward into Pilsen and Karlovy Vary, and northward into Ústí nad Labem and Liberec [14].

According to recent estimates, the technical potential of forest dendromass for energy use is expected to decrease by 22% by 2030 compared to the reference period 2016–2020. By 2050, a total decrease of approximately 36% is projected (an additional 14% from the previous period), mainly due to the long-term impacts of the bark beetle calamity, past overharvesting, and climate changes affecting forest health. A similar trend has been or can be expected in neighbouring EU countries similarly impacted by climate change, but at a scale depending on their conditions (height distribution and forest composition) [14].

This projected decline in forest biomass potential is illustrated in Figures **??** and **??**.

Although the potential of biomass in the Czech Republic appears sufficient for substantial energy use, the viable portion is much lower, approximately 50% of the theoretical maximum. Spatial and ecological factors limit real-world amount of usable material, particularly in regions with steep slopes, protected forests, or fragmented land ownership [15].

Agricultural residues, biogas, and energy crops provide a large share of bioenergy potential. Agricultural residues, especially cereal straw, contribute around 30 percent of total biomass use. Specialized energy crops like maize silage, miscanthus, and short-rotation coppice (SRC) trees make up another 8 to 10 percent [7]. However, these crops are often grown on arable land (land suitable for growing food), which causes problems between energy and food security goals [6]. Recent studies show that energy crops can deliver valuable ecosystem services. They improve soil quality and enhance biodiversity. They also heavily contribute to carbon sequestration- capturing carbon dioxide from the atmosphere and storing it, in order to reduce greenhouse gases [3]. These benefits strengthen the role of these crops not only in renewable energy supply, but also in helping to manage land in a more sustainable way.

Biogas production has become one of the mainstream biofuels in the past decade. As of 2020,

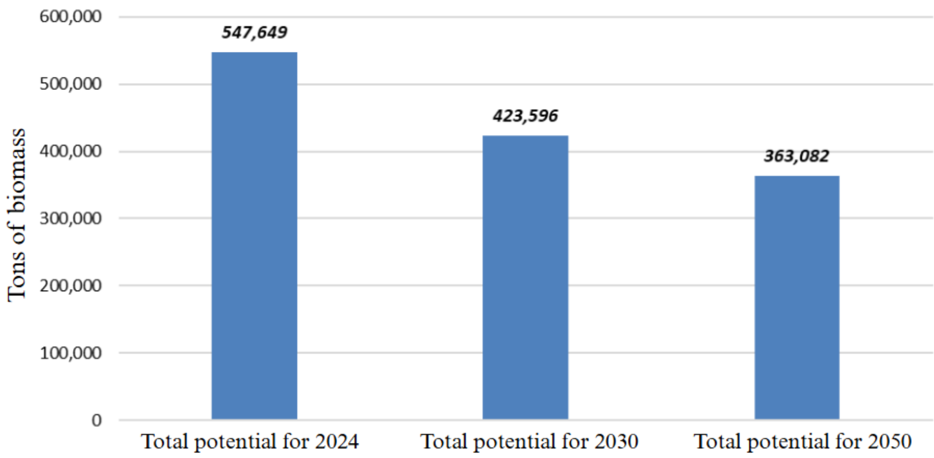

Figure 2: The predicted decline in the total volume of available wood residue biomass potential in the Czech Republic between 2024, 2030 and 2050 [14].

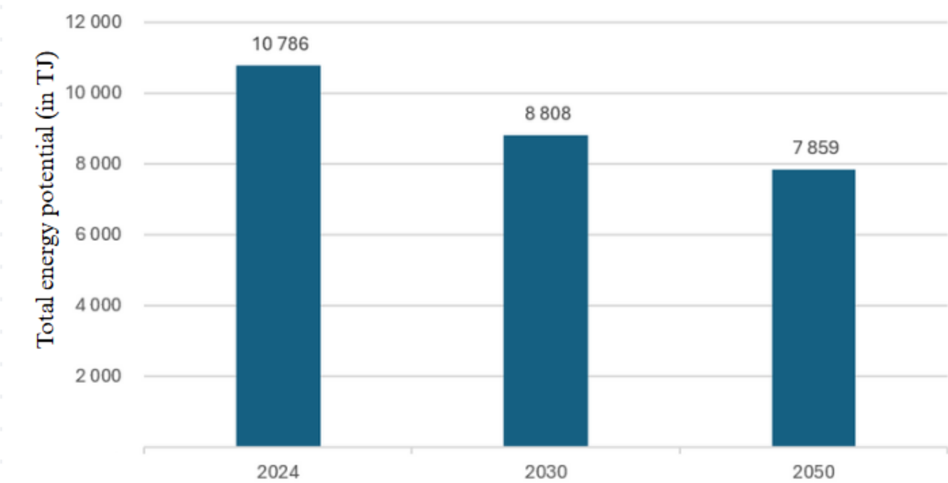

Figure 3: Prediction of total energy potential of dendromass in the Czech Republic in 2024, 2030, and 2050 in TJ (terajoules) [14].

over 500 biogas plants were operating in the Czech Republic, with an average input of 13,900 tons of biomass per facility per year [7]. Most facilities use maize silage and manure, with a growing share of biodegradable municipal waste (food leftovers).

Czechia currently has seven biomethane production plants, although not all of them are fully operational because of low financial support of biomethane production [16]. One of the key facilities is located in Litomyšl, which converts agricultural waste (mainly manure and silage) into biomethane. This biomethane is then injected directly into the national gas grid [17].

Biomass processing is done using various methods. Pelletization is applied to wood residues, like sawdust and bark, which makes them easier to store and transport, especially for heating systems in rural households. Combustion in combined heat and power (CHP) and municipal heating plants is used often, as is anaerobic digestion of agricultural waste for biogas [15].

Biomass is used primarily in different energy sectors. It plays a major role in heat production, particularly through district heating plants using wood chips and straw. It is also used in electricity generation, mainly in CHP systems, and increasingly in biogas production, especially on farms and in rural areas [7]. These uses are expected to expand as new technologies and policy incentives, especially those targeting biomethane, are implemented [19].

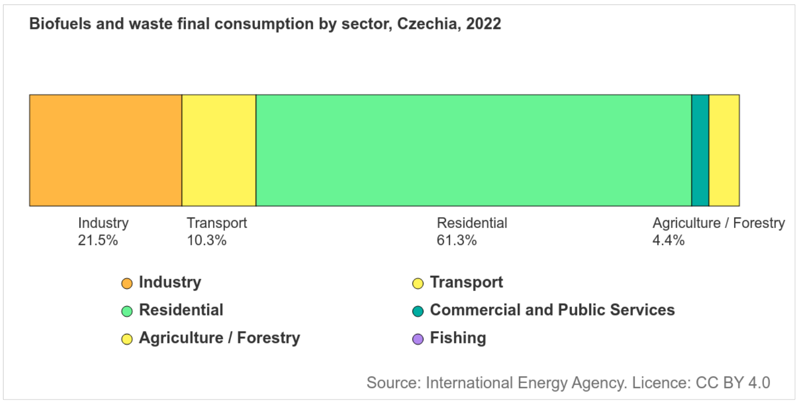

Figure 4: Biofuels and waste final consumption by sector in Czechia, 2022. (IEA 2024) [18].

3.2 Austria

Over the past decades, the bioenergy sector has become a mainstay of Austria's energy accommodation. Biomass provides a substantial contribution to Austria's transition towards a sustainable and climate-friendly energy system, creating a domestic added value as well as employment and spending power. [20]

Biomass is by far the most important domestic energy source (in 2021, 47% of the total domestic energy volume were provided by biomass), followed by hydropower (27%). [20] Shares of wind energy and solar energy are still much smaller but this last is growing. [21]

Around half of Austria's land area is forest land while 32% is agricultural land, as it will be seen, these both are the main source of biomass production. [21] Forests are the main source of raw material, providing the 83% of Austria's biomass volume, while the rest comes from the agricultural and waste sectors. [20] Here is included the production of fuel wood, wood chips, wood pellets, bark and sawmill by-products. [21]

Agricultural biomass and residues are primarily used to produce liquid bioenergy (transport biofuels) and is based on oil crops, sugar crops, starch crops, used cooking oil and animal fats. New technologies for producing advanced biofuels aim at utilizing dedicated bioenergy crops (such as short rotation forestry and miscanthus) or agricultural residues. [22] Organic waste as municipal (solid) and industrial organic waste streams are used in biogas or combustion plants, contributing to increase the biomass potential in Austria. [22]

Austria has over 300 biogas plants, mainly using agricultural residues and manure, and this gas is used for heat, electricity or upgraded biomethane for injection into the gas grid. [21]

Biomass in Austria is used for heat production, around $\frac{3}{4}$ of biomass heat are used in single combustion systems, while the remaining part is used for district heating which showed the highest increase, having almost quadrupled its production since 2005. [20]

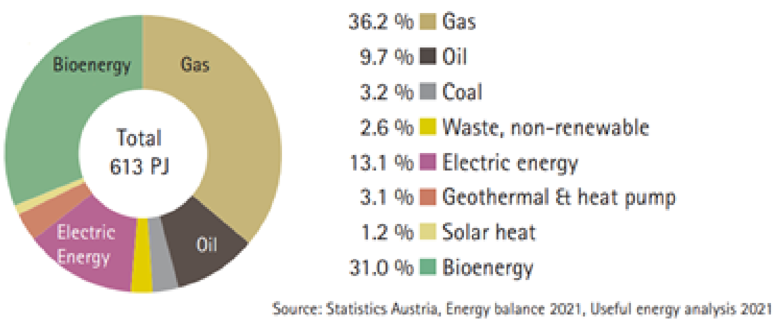

Figure 5: Heating energy consumption in 2021. [20]

Biomass is the third most important producer of green electricity. Biomass combined heat and power (CHP) plants can generate electricity and make an important contribution to electricity base load accommodation. Wood gas cogeneration technology allows for high efficiency regarding small-scale power generation. [20]

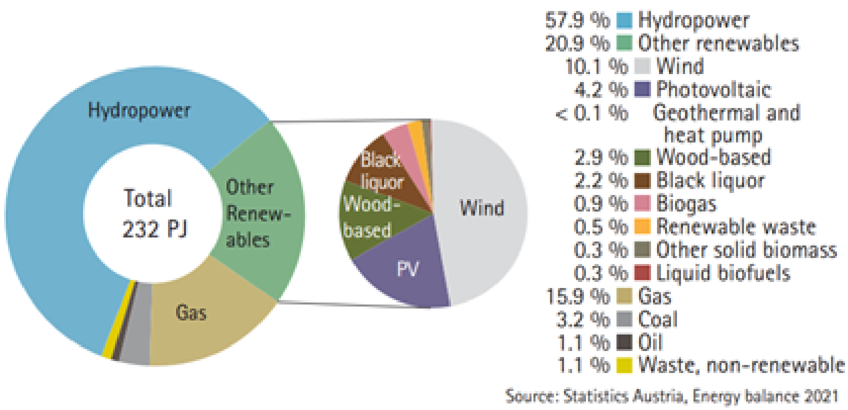

Figure 6: Electricity energy consumption in 2021.[20]

Wood chips and sawmill by-products are used for energy production, cogeneration and district heating plants; pellets are mainly used in domestic heating systems while waste lye, sludge and bark are used to produce electricity and process heat in the pulp and paper industry. [21]

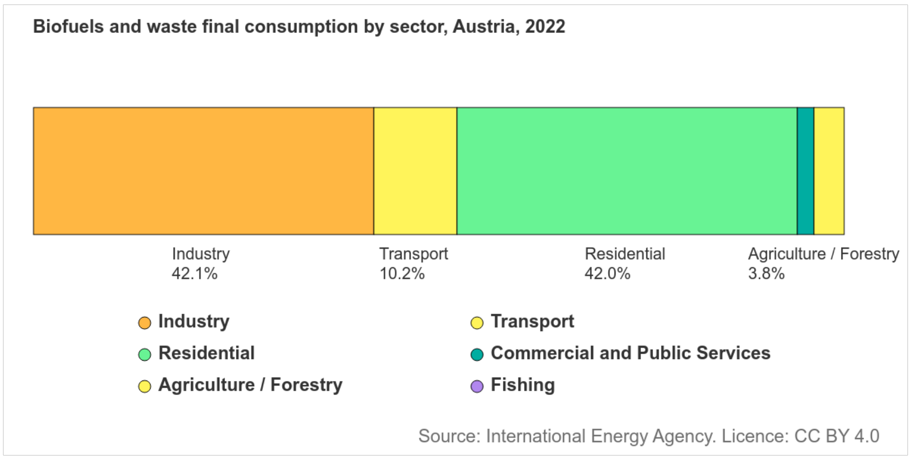

Figure 7: Biofuels and waste final consumption by sector in Austria, 2022. (IEA 2024) [23].

Austria was among the first EU members to establish national standards for solid biofuels, publishing a comprehensive quality guideline for wood and agricultural pellets as early as 1999 [24].

4 Relevant policies, directives, and regulations on biofuels

4.1 The Czech Republic

The development of biofuels in the Czech Republic is shaped by a combination of European Union legislation and national policy instruments.
Czechia follows key EU directives that set binding targets and sustainability standards for renewable energy use in transport and heating. National ministries implement specific regulatory frameworks.
The most important laws, directives, and strategies for buiofuels in the Czech Republic include:

1. Renewable Energy Directive (RED II) - Directive (EU) 2018/2001 on the promotion of the use of energy from renewable sources [10]
2. Renewable Energy Directive (RED III) - Directive (EU) 2023/2413, which amends RED II and raises renewable energy targets [25]
3. National Renewable Energy Action Plan (NREAP) of the Czech Republic [10]
4. National Energy and Climate Plan (NECP) submitted to the European Commission as part of long-term climate commitments [6]
5. Government Decree No. 189/2018 Sb. on the conditions for renewable energy support in the Czech Republic [15]
6. Vyhláška č. 110/2022 Sb., setting sustainability criteria for biofuels and biomass at the national level [15]

The original Renewable Energy Directive (RED II) required each EU Member State to ensure that renewable energy made up at least 14 % of final energy consumption in transport by 2030. Within that share, at least 3.5 % had to come from biofuels (fuels produced from non-food biomass) [10]. These rules had set the foundation for national-level support mechanisms, like tax reductions, grants etc.

In 2023, the European Union adopted an amended version of the directive (RED III) which is more strict than RED II. Under RED III, members of the EU must now achieve either a 29 % share of renewable energy in transport by 2030 or show a minimum 14.5 % reduction in greenhouse gas emissions in the transport sector compared to fossil fuel use [25]. A new sub-target requires that at least 5.5 % of energy for transport comes from biofuels and renewable fuels of non-biological origin (RFNBOs, e.g. hydrogen fuels). These new fuels are supported by using multipliers. For example, advanced biofuels and RFNBOs count double toward the target, and renewable electricity used in road vehicles counts four times [15].

RED III also specifies important restrictions. So-called “caps” limit how much certain fuel types can count toward renewable targets. Conventional biofuels (those made from food and feed crops) are capped at 7 % of final energy consumption in transport. This means that even if more of these fuels are used, they will only be credited up to this ceiling in national reporting. Similarly, fuels made from used cooking oil or animal fat are capped at 1.7 %. But, they benefit from a multiplier of 2, which gives them more credit toward targets [25].

The Czech Republic is required to incorporate RED III into national law by mid-2025 (18 months after its release in 2023). This means that national action plans and legislation must be updated to incorporte the new targets and rules [25]. Implementation is done by the Ministry of Industry and Trade (MPO), which handles energy policy, and the Ministry of Environment (MŽP), which oversees climate impact and sustainability enforcement. The Ministry of Agriculture also plays a key role, particularly regarding the use of arable land for energy crops [6, 15]. The country obvo+iously lacks a unified national strategy, resulting in fragmented efforts between ministries [6].

Sustainability and emissions savings criteria introduced in RED II have been tightened further under RED III. To count toward the national targets or to qualify for financial support, all biofuels must meet defined minimum emissions savings - from 65% to 80% [25].

So far, the Czech Republic has primarily supported first-generation biofuels, especially biodiesel from rapeseed, through tax exemptions and blending mandates such as E5 (5% ethanol) in gasoline

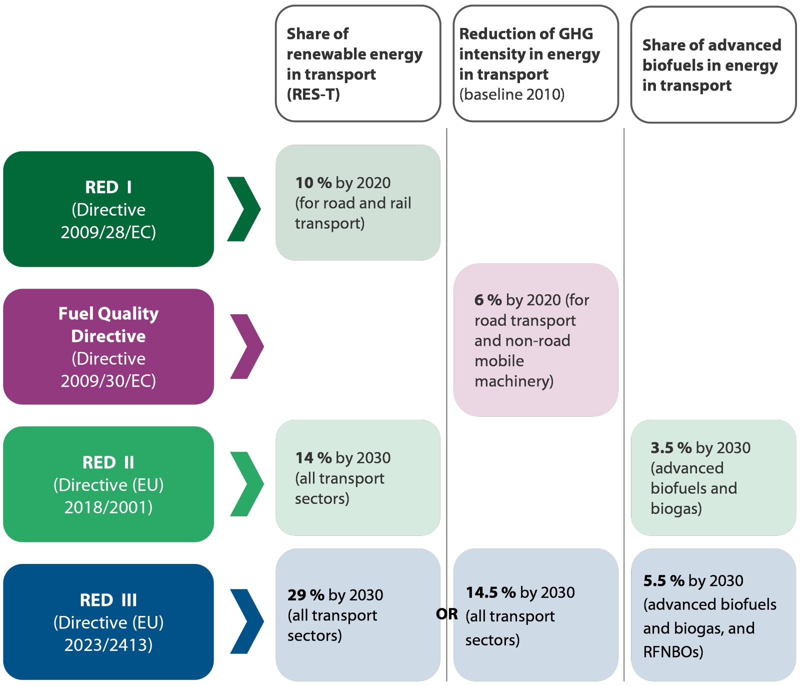

Figure 8: Evolution of EU transport-related renewable energy directives and targets: RED I, RED II and RED III. [26]

and B7 (7% biodiesel) in diesel fuel. Even though these instruments helped increase the market share of biofuels, they have raised concerns about food security and environmental impact [7]. Support for second-generation and advanced biofuels is still limited, because of high production costs and underdeveloped infrastructure.

The Czech Republic now faces new difficulties under RED III. The updated directive raises the bar for almost all categories, including biofuels. Meeting these requirements will demand more than just policy updates. It will require coordination across ministries, more focus on advanced biofuel production, and investments for infrastructure.

4.2 Austria

Austria intends to move towards a transformation to a highly efficient and climate-neutral energy, mobility and economic system. The energy policy is simultaneously conducted at two levels, the federal level and level of Austria's nine federal provinces. [27, 21]

The final version of the Austrian national energy and climate plan (NECP) for the period from 2021 to 2030 was submitted to the European Commission and includes the following objectives by 2030: [21]

1. Reduction of GHG emissions in sectors outside the EU ETS by 48% (without ETS flexibility); using ETS flexibility, the target is around minus 46% by 2030 compared to 2005.
2. Increase the share of renewable energy in gross final energy consumption to 57%.
3. Coverage of 100% of domestic electricity consumption from renewable sources.
4. Improvement of primary energy intensity, defined as primary energy use per GDP unit, by 25-30% compared with 2015.

The "Strategy for Adaptation to Climate Change" is a combination of a strategic approach to climate change adaptation with a comprehensive action plan for the implementation of concrete recommendations for action. [27]

For the heating and cooling sectors a 'heating strategy' in collaboration with the provinces must be developed. [27]

As in the Czech Republic case, Austria must attend the EU legal framework including the Renewable Energy Directive (RED) that has to be implemented into the national laws. [22]

The Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology is the main government institution responsible for energy matters at the federal level but is also responsible for transport, energy R&D and environmental protection, including climate action and emissions from combustion.The Federal Ministry of Finance is responsible for setting energy taxes.At the regional level, the governments of the nine federal provinces have responsibility for policy making, setting subsidy levels and implementing regulatory control of energy companies. [27]

These institutions create relevant policy instruments in renewable electricity, biomass-based heat, transport evolutions and gas consumption.[21]

The main legislations that have impacted the biofuels production and use in Austria include: [28]

- EU Renewable Energy Directive (RED) 2009/28/EC
- EU Renewable Energy directive (RED II) 2018/2001/EU
- EU Fuel Quality Directive (FQD) 2009/30/EC
- EU ILUC Directive (EU) 2015/1513
- Fuel Ordinance BGBl. II Nr. 398/2012 idF BGBl. II Nr. 86/2018
- Sustainability Ordinance BGBl. II Nr. 157/2014
- Ordinance on Agricultural Feedstocks for Biofuels BGBl. II 250/2010
- Mineral Oil Tax Law BGBl. I Nr. 630/1994 idF BGBl. I Nr. 104/2018
- Bioethanol Blending Order BGBl. II Nr. 378/2005 idF BGBl. II Nr. 63/2016

Austria is committed to becoming climate neutral by no later than end of 2040, without using nuclear power. This means that the unavoidable greenhouse gas emissions will be compensated by carbon storage in natural or technical sinks, being this the guiding principle of the long-term climate strategy 2040. [21, 29]

5 Biomass limits and the role of biofuels in 2030 targets

5.1 The Czech Republic

The potential of biofuels to contribute to the Czech Republic's 2030 renewable energy and transport targets is limited not only by technology or policies, but also by the realistic potential of domestic biomass. While theoretical figures suggest a good enough supply, recent national analysis (including the methodology developed under the TAČR THÉTA programme) describes different constraints that reduce the usable share of biomass significantly [30].

The Czech Republic consumed approximately 5.4 million tons of biomass for energy use in 2021 (excluding household firewood). In order to meet 2030 climate targets, including stopping the usage of coal in district heating systems, this number would need to increase by 900,000 to 1.3 million tonnes annually, primarily for use in combined heat and power systems (CHP) [30]. The methodology states that such increase isn't likely to be achieved, due to sustainability constraints, costs, and regional supply-demand differences.

The most important factor is not how much biomass exists, but how much can actually be used. In many areas, forests can't be harvested more without harming the ecosystem. On farms, removing too much straw can damage the soil. Some land is needed for food or protected by law. Even when biomass is available, it's often too far away or hard to transport. These limits mean only part of the biomass can be used for energy in a way that follows EU rules. On top of this, only biomass that meets the sustainability and emissions savings criteria of RED II and RED III can be counted toward national renewable targets or benefit from public support [10].

One of the most important observations from the methodology is the territorial misalignment between biomass availability and energy demand. Figure ?? represents this issue by showing the allocation of biomass potential from agricultural and forest land across the Czech Republic in 2030, factoring in bark beetle damage and other key ecological factors. Darker areas represent higher sustainable potential and lighter areas indicate scarcity or environmental limitations. [30]

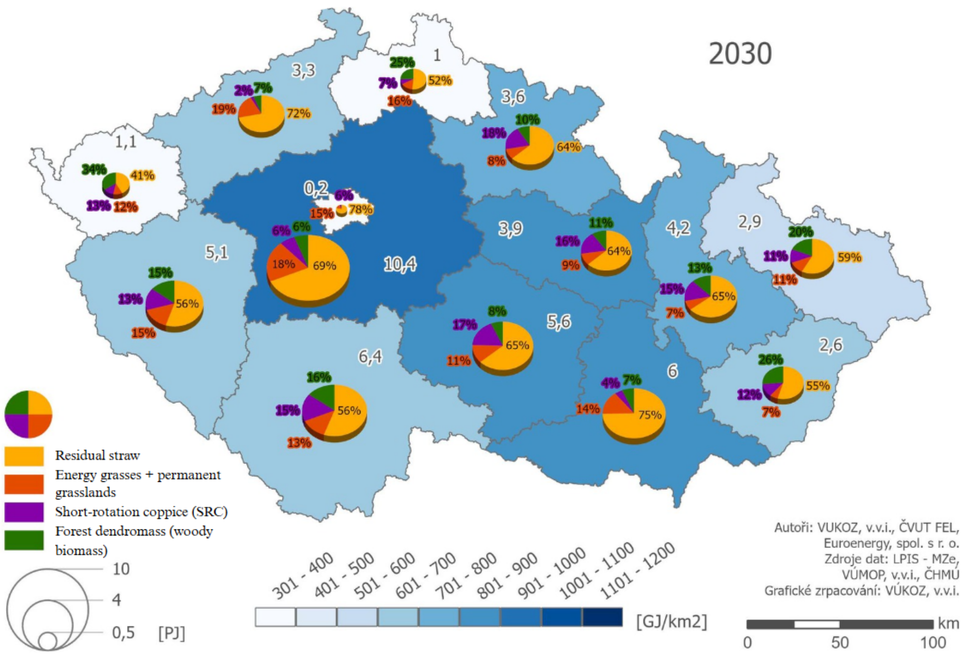

Figure 9: Map of predicted biomass potential allocation from agricultural and forest land, considering the bark beetle calamity and other key aspects, in the Czech Republic, for 2030 [30].

This spatial imbalance is especially problematic in industrial regions such as Ústecký and Moravskoslezský, where district heating demand is high but local biomass resources are low. Areas such as Vysočina and South Bohemia have relatively good amount of available biomass, but lower energy demand. These mismatches mean that biomass will often need to be transported over long distances. Costs will be raised because of that and emissions savings will be reduced.

Region	Biomass potential	Heating demand
Vysočina	High	Low
South Bohemia	High	Medium
Pardubice	Medium	Medium
Ústecký	Low	High
Moravskoslezský	Low	Very High
Zlín	Medium	Medium

Table 1: Regional biomass availability vs. heating demand (selected regions)

5.2 Austria

Austria is an active participant in the IEA Bioenergy Technology Collaboration Programme, whose goal is to promote the use of environmentally sustainable and competitive bioenergy based on the sustainable use of biomass to provide a substantial contribution to a sustainable energy supply. [22]

The Austrian Climate Change Act sets a maximum threshold for greenhouse gas emissions on a yearly as well as sectoral basis. It applies to six sectors—agriculture, buildings, energy and industry, fluorinated greenhouse gases, transport, and waste—and defines rules for the development and implementation of effective climate mitigation measures outside the EU emissions trading scheme. [27]

Austria's use of biomass could increase by 38% by the year 2030, with about half of this potential associated with the agricultural sector and half with the forestry sector. As in nearly all energy transition scenarios, biomass is developing into the most important energy source nationwide and is expected to overtake oil and natural gas in the medium term. [20]

To meet its sectoral targets, the Federal Government is required to devise measures that focus on: [27]

- Increase the energy efficiency,
- Increase the share of renewables in final energy consumption,
- Increase energy efficiency in the building sector,
- Consider climate protection aspects in spatial planning,
- Improve mobility management,
- Enhance waste prevention,
- Protect and expand carbon sinks,
- Provide economic incentives to boost climate protection efforts.

The existing measures, which will be continued until 2030, are expected to be further developed. In the case of biofuels, Austria blends approximately 7% biodiesel with diesel fuel and around 10% bioethanol with petrol. [20]

In addition, a certain proportion of 100% biodiesel is still used for captive fleets. Almost all rail in Austria is electrified, further contributing to the share of renewable energy in the transport sector. [20]

By 2050, biomass is expected to be increasingly used as a substitute for natural gas, for electricity generation, high-temperature industrial processes, and the transport sector. [20]

6 Biofuels in transport: Current use and future potential

6.1 The Czech Republic

The use of biofuels in the Czech Republic's transport sector is modest compared to the levels seen in other EU countries. According to Eurostat, biofuels made up approximately 7.1 % of the energy consumed in Czech transport in 2021, which aligns with the maximum contribution allowed from first-generation biofuels under RED II [31]. Majority of this share comes from biodiesel (FAME) blended in fossil diesel (B7), and bioethanol blended in petrol (mostly E5). Biofuels and biogas currently make up only a small fraction of transport fuel, well below the RED III target of 5.5 % for renwablefuels [25, 31].

Despite this, the Czech Republic does have some capacity for expanding the role of biofuels in transport. One promising area is second-generation bioethanol, which can be produced from agricultural residues such as wheat straw. A recent study on a pilot plant in Litvínov suggests that Czech lignocellulosic ethanol could replace a meaningful portion of imported fossil fuels while not crossing the borders of varuous restrictions [32]. However, production costs and limited infrastructure stay as the biggest obstacles.

Another underdeveloped resource is biomethane. As of 2023, seven biomethane plants exist in the Czech Republic, although not all of them are currently operational due to low financial and infrastructural support [16]. The "Litomyšl" facility converts agricultural waste into biomethane, which is injected into the national gas grid [17]. Future expansion is planned through government programs that want to increase biogas injection into the gas grid and promote its use as a vehicle fuel, particularly for public transport [16].

If the Czech Republic aims to meet the RED III target of a 29 % renewable share in transport or a 14.5 % GHG reduction by 2030, biofuels will have to play a larger role. This will require more than simply increasing blending ratios. It will involve investment in biofuel production and building infrastructure such as bio-LNG stations [25, 30].

International experience shows that this is possible. In Sweden, for example, biofuels accounted for over 30 % of energy used in transport by 2022 [33]. Germany has also expanded use of advanced biofuels throughvarious types of support.

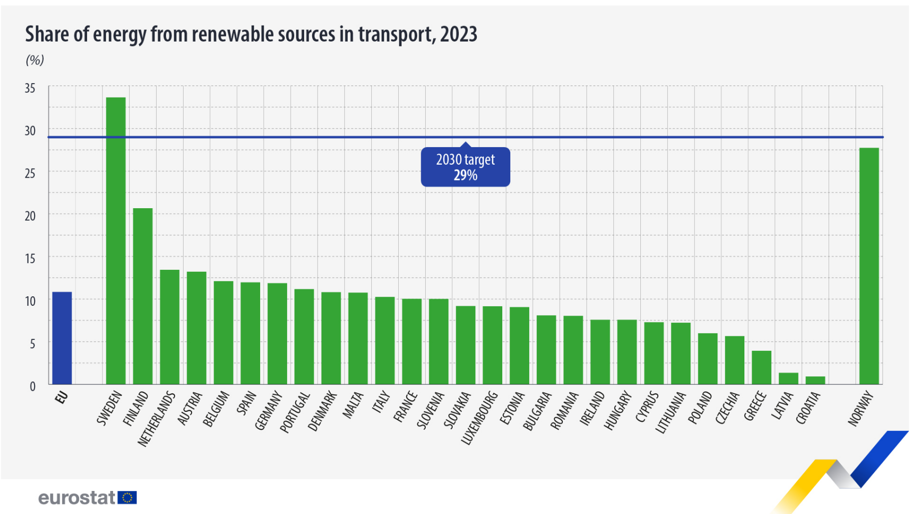

Figure 10: Share of energy from renewable sources in transport across EU countries in 2023 [11]

6.2 Austria

The Fuel Ordinance Amendment lays down the Biofuels Directive, the Renewable Energy Directive, and the Fuel Quality Directive in Austrian law. [34]

Austria has also developed a number of national strategies in the area of transport, such as the Mobility Master Plan and the corresponding R&I Mobility Strategy. Complementary strategic plans for freight transport (the Master Plan for Freight Transport) and for hydrogen (the Hydrogen Strategy for Austria) have also been published recently. [29]

The Austrian Decree on Transportation Fuels led to an amendment of the Austrian tax law, stipulating that there would be no tax on biodiesel and ethanol up to a certain limit. It allows blending of up to 7% of biodiesel with fossil diesel. [22]

Advanced biofuel pathways pursued through Austrian companies and research institutes include cellulosic ethanol, biomethane via gasification, FT-liquids and mixed alcohols from syngas, coprocessing in oil refineries, hydrothermal liquefaction, and electrofuels. [22]

Biomass is the most noteworthy renewable energy source in the transport sector, and due to the further development of renewable energy sources, new mobility concepts-fostering the public transport sector as well as car sharing-are vital to contain carbon emission levels from the combustion of fossil fuels. [20]

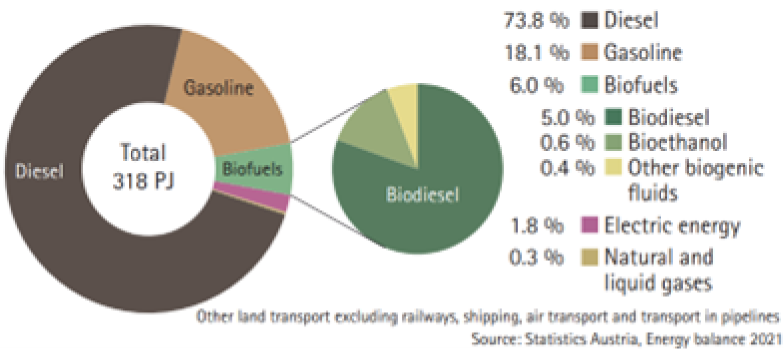

Figure 11: : Road transport energy consumption in 2021 [20].

In Austria, one large bioethanol production facility and seven smaller FAME (biodiesel) production facilities were operating in 2020, and in 2021 another production facility producing ethanol from brown liquor started operation. Other fuels, which are produced in smaller production facilities with no relevant values available, are pure plant oils and biomethane. [28]

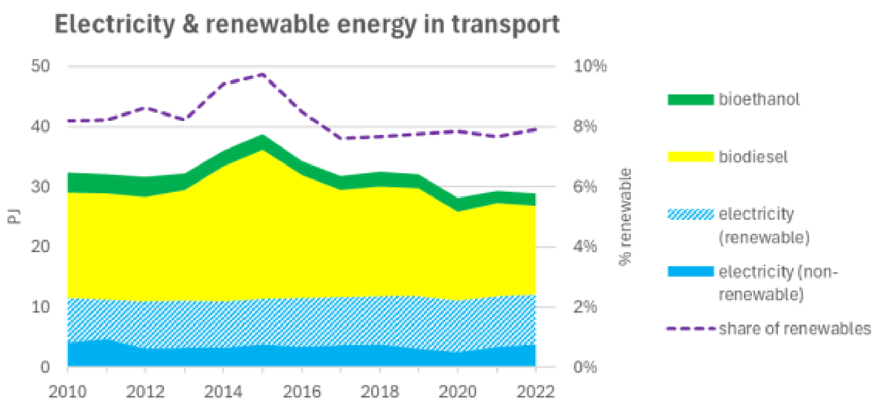

Figure 12: Evolution of transport fuels in Austria. [35]

7 Costs of biofuels

7.1 The Czech Republic

In recent years, biofuels have consistently been more expensive compared to fossil fuels in Europe, including the Czech Republic. In 2022, the cost of biodiesel, depending on the feedstock, was between 70 % and 130 % higher than that of fossil diesel [36]. This price difference affects fuel suppliers and, especially, consumers. It also raises concerns about the long-term sustainability of this system.

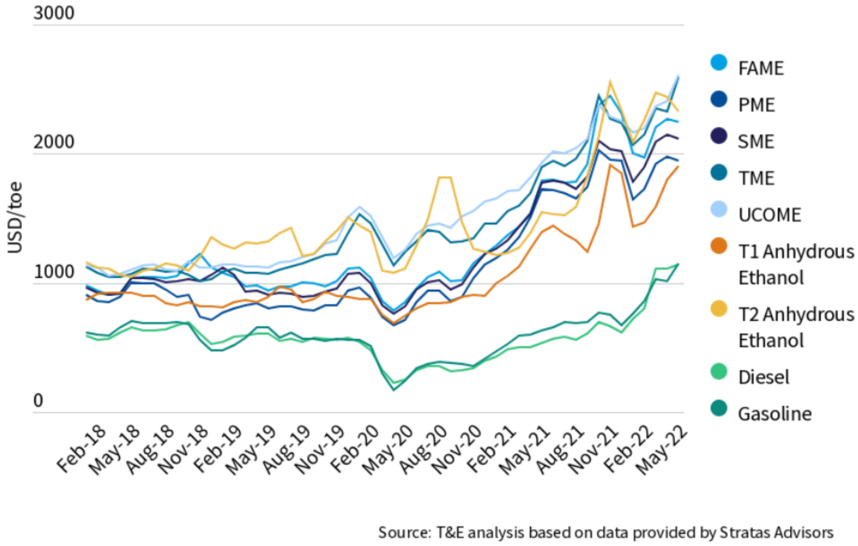

Figure 13: Recent wholesale price developments (USD/toe) across the main fossil fuels and biofuels [36].

In 2022, the Czech government temporarily suspended its mandatory biofuel blending obligation as part of an effort to control fuel prices. However, suppliers were still required to meet greenhouse gas reduction targets for fuels, which encouraged (reduced) use of biofuels to comply with emissions standards [37].

A significant part of Czech liquid biofuel consumption, particularly ethanol and biodiesel, is met through imports. In 2021, the average import price for ethanol was 1,287 USD per ton, which was higher than the EU average of 1,076 USD per ton. These higher import costs contribute to the economic burden of liquid biofuel use in the country [38].

To help manage these costs, the government offers some support, including tax exemptions for certain blends and aid for production facilities. Despite these efforts, economic challenges keep persisting.

Feedstock prices often change due to weather, global markets, and competition with food production, which makes long-term planning and pricing difficult for producers. At the same time, building the facilities needed for biofuels requires big initial investments in equipment, technology, and labor. These costs are a massive barrier for companies, especially without long-term policy support or stable demand from fuel suppliers [39].

7.2 Austria

The institutions, apart from acting in the policy development, play also an important role in the economical aspect, particularly in regulating applicable taxes. To achieve carbon neutrality by 2040, a number of measures have been adopted, including a newly designed taxation system that imposes a price penalty on ecologically destructive activities. This system, enacted in 2021, introduces a CO2 pricing system with a continuously increasing price penalty, from EUR 30 (USD 32.4) per ton CO2 in 2022 up to EUR 55 (USD 59.4) per ton CO2 in 2025. [29]

Regarding to the prices of biofuels in Austria:

- **Biodiesel:** The average export price in Europe was approximately 1321$ per ton, so this European average is a general indication of market trends all around the continent because the Austrian information is limited. [40]
- **Bioethanol:** The wholesale price of bioethanol in Austria is between 4.44$ and 6.08$ per kilogram. [41]

Other measures already in place include an increased Normverbrauchsabgabe (NoVA) tax and the “Right to Plug,” which alleviates previous approval hurdles for the installation of charging stations in multi-apartment buildings. [29]

Techno-economic modelling indicates that integrating biomass-based SNG and Fischer-Tropsch diesel could lower Austria’s energy-system emissions by up to 6 Mt of CO2-equivalent per year while remaining cost-competitive with fossil fuels beyond 2030 [42].

Austria is a net importer of feedstocks for biofuel production. It is not self-sufficient in terms of vegetable oils in general (not only for biodiesel production) and used cooking oil (UCO) for biodiesel production. Feedstock for ethanol production is partly imported, as Austria is a small country and the production facility is located near the Czech border and close to a Danube port. [28]

Biofuel produced from feedstocks with low carbon intensity finds better markets in countries such as Germany and Sweden, where a GHG reduction quota is obligatory. Therefore, there is a lively export of biodiesel produced in Austria from waste materials. [28]

8 Comparison between The Czech Republic and Austria

Austria and the Czech Republic can be compared in four key areas: biofuel development, biomass potential, policy frameworks, and the economics of biomass and biofuels. While both countries are subject to EU directives and climate goals, their strategies and progress in the bioenergy transition are quite different.

8.1 Development and use of biofuels

Austria has developed an extensive and diversified bioenergy system. It operates more than 300 biogas plants, mostly powered by agricultural residues and manure. Biodiesel is blended with diesel up to 7%, and bioethanol is blended with petrol up to 10% [20]. In addition to first-generation fuels, Austria is investing in advanced technologies such as cellulosic ethanol, FT-liquids, biomethane via gasification, and electrofuels [22]. These efforts are supported by a dense network of research institutes, clear long-term policy frameworks, and strong regional coordination.

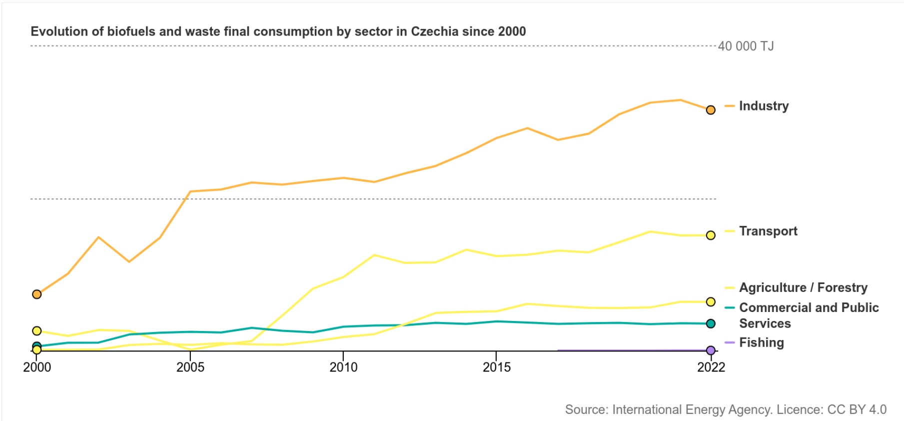

Figure 14: Evolution of biofuels and waste final consumption by sector in Czechia since 2000 (IEA 2024) [18].

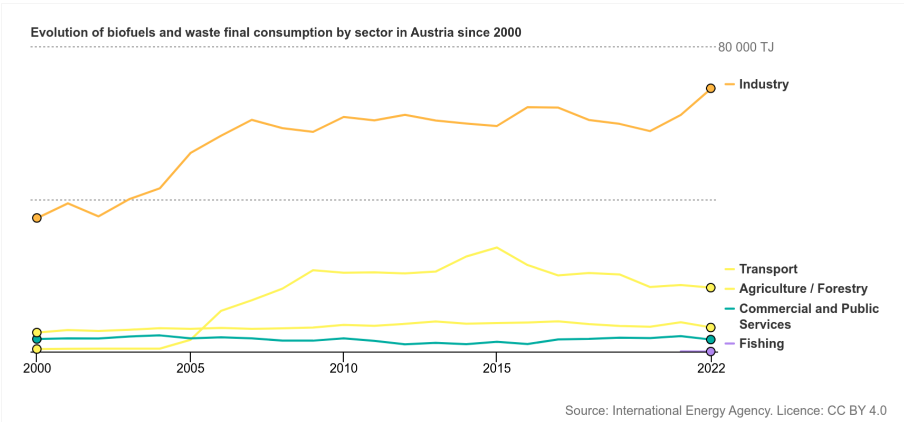

Figure 15: Evolution of biofuels and waste final consumption by sector in Austria since 2000 (IEA 2024) [23].

In contrast, the Czech Republic has a more limited development of biofuels. In 2021, biofuels accounted for 6.2% of the gross final energy consumption in transport, primarily through first-generation blends like B7 and E5 [4, 31]. Although the Litomyšl biomethane plant represents progress in grid injection [17], larger deployment of second and third generation biofuels is still lacking. Some projects, like the lignocellulosic ethanol plant in Litvínov, show promise when it comes to technology [32], but commercialization is still slow, largely due to low financial support, laacking infrastructure, and fragmented policy incentives [6, 19].

Figures 14 and 15 show the difference in the development of biofuel and waste energy use in both countries.

In Czechia, the growth has been relatively slow and remains limited mostly to the transport and industry sector [18]. In 2022, final energy consumption from biofuels and waste in Czechia reached around 15 PJ (petajoules), and most of this was used in transport and industry. Although there was a slight increase after 2010, the overall final consumption remains relatively low.

In Austria, the growth has been stronger. In 2022, Austria's final consumption from biofuels and waste was about 50 PJ [23], which is significantly higher than that of Czechia. The trend for transport is different to Czechia, showing a decline from 2015 to 2022. This may be due to higher use of electric vehicles.

Austria's move toward advanced biofuels makes it better prepared to meet future EU RED III targets. In contrast, the Czech Republic still relies mostly on first-generation fuels, and without major investment in new technologies and biogas, its progress may slow down.

8.2 Biomass potential

Austria benefits from abundant domestic biomass resources, with approximately 50% forest cover and 32% agricultural land [20]. About 83% of the country's biomass is derived from forests, complemented by agricultural residues, wood waste, pellets, and energy crops such as miscanthus [20]. The integration of biomass into district heating, electricity production, and biogas plants is highly developed and regionally balanced.

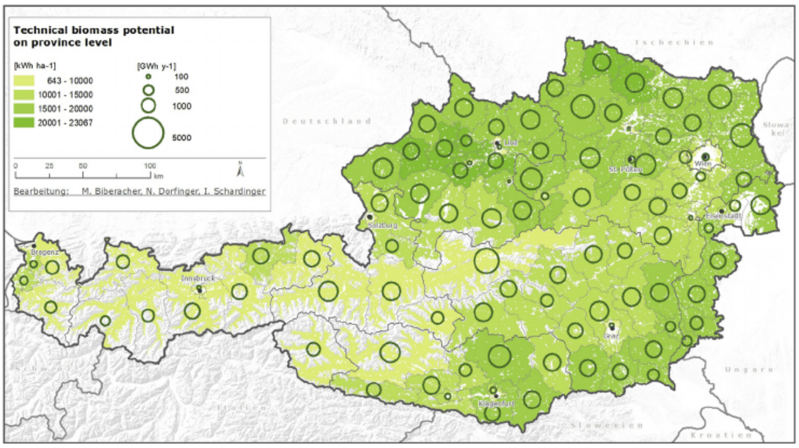

Figure 16: Austria's biomass potential [43].

The Czech Republic has significant theoretical biomass potential, particularly in forest biomass, with an estimated 13.5 million tons of woody biomass available annually [4]. However, environmental and logistical constraints, such as erosion risk, biodiversity protection, and terrain limitations, reduce usable biomass to about 50% of theoretical potential [15, 30].

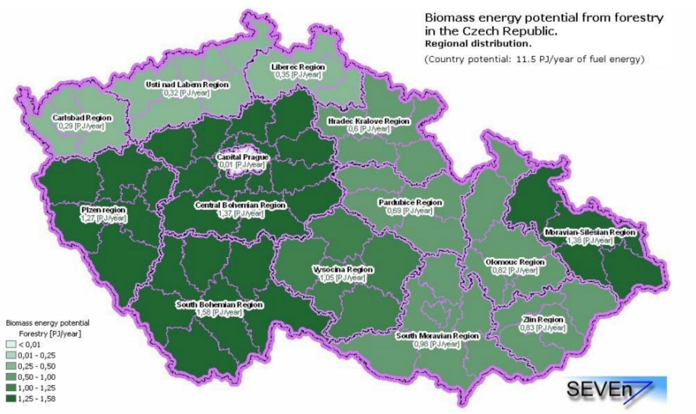

Figure 17: Czechia's biomass (forestry) potential [44].

Recent bark beetle outbreaks have heavily impacted forest biomass availability in Czechia, resulting in a predicted 36% decline in usable forest biomass potential by 2050 [14].

Unlike Austria, the Czech Republic faces stronger regional disparities: biomass is plentiful in rural regions like Vysočina and South Bohemia, but energy demand is concentrated in industrial areas like Ústecký and Moravskoslezský, meaning that expensive transport would be necessary [30].

Figures 16 and 17 show the biomass resource availability in Austria and the Czech Republic. The biomass potential in Austria is relatively evenly distributed across the country, with a slightly lower concentration in the west part of the country, in the area with higher elevation [43].
Czechia shows regional disparities - high forest biomass availability is concentrated in rural areas like Vysočina and South Bohemia, while industrial regions such as Ústí nad Labem and Moravskoslezský have low local resources [44].
This difference shows how Austria can achieve easier regional integration of biomass into energy systems, while the Czech Republic faces challenges related to the need for long-distance transport of biomass.

8.3 Policies

Austria has a unified, multi-level policy structure, where federal and provincial levels work together under frameworks like the National Energy and Climate Plan (NECP), the Climate Change Act, and the Mobility Master Plan [22, 34]. This results in a harmonized and consistent application of climate and renewable energy strategies, including the promotion of both first- and advanced-generation biofuels.

The Czech Republic's approach remains relatively fragmented. While it has incorporated EU directives like RED II and RED III into national law [10], sectoral responsibilities are spread across multiple ministries [6]. The National Renewable Energy Action Plan (NREAP) provides a basic framework, but there is no fully comprehensive bioeconomy strategy, and most support mechanisms still target first-generation fuels [8, 25].

Astria benefits from coordinated policies that foster both traditional and advanced biofuel technologies, whereas the Czech Republic struggles with fragmented support and delayed uptake of newer, sustainable technologies.

8.4 Economic costs of biomass and biofuels

Austria has implemented an effective CO_2 pricing system for non-ETS sectors, starting at EUR 30 per ton in 2022 and set to rise to EUR 55 per ton by 2025, stimulating the competitiveness of renewable fuels including biofuels [29]. The country also supports advanced biofuel development through fiscal incentives and exports biofuels like waste-based biodiesel to high-demand markets such as Germany and Sweden [28].

Biofuels in the Czech Republic remain significantly more expensive than fossil fuels. In 2022, the cost of biodiesel was 70-130% higher than conventional diesel [19]. Ethanol prices were similarly high, reaching USD 1,287 per ton, above the EU average [38]. Although blending mandates and tax exemptions exist [37], the combination of high costs, unstable feedstock prices, and fragmented policy support continues to hinder private investment [19, 39].

Austria's stable regulations make it easier for companies to invest in biomass and biofuel projects. The Czech Republic faces a more uncertain environment, where rules often change and investors are less confident. Czechia also relies more on importing liquid biofuels from other countries instead of producing enough domestically, which makes costs higher and supply less reliable. Another problem is that producing biofuels inside the country is expensive compared to fossil fuels, which discourages local investment. These differences show that Austria and the Czech Republic are moving along quite different paths.

Overall, Austria shows a more advanced and coordinated approach to bioenergy. The Czech Republic is still developing its potential but faces several important challenges. One of the main problems is the lack of unified policies, which makes it harder to plan long-term projects. Another issue is the high cost of producing biofuels compared to cheaper fossil fuels. Czechia also struggles because its biomass potential is highest in rural areas where energy demand is low, while industrial regions with high energy demand have less available biomass. This mismatch means that transporting biomass to where it is needed becomes expensive and complicated.

9 Conclusion

This paper examined the role of biofuels in the renewable energy strategies of Austria and the Czech Republic. Both countries are aiming to achieve EU decarbonization targets, but their approaches and progress are different.

Austria has established itself as one of the leaders in bioenergy.It has mature infrastructure [20], high biomass utilization [22], and a well-defined national strategy supported by policy instruments [29]. Advanced technologies like biomethane, Fischer-Tropsch fuels, and cellulosic ethanol are being actively pursued [42, 22], and Austria blends 7% biodiesel and 10% bioethanol into transport fuels [20].
The Czech Republic's development is more conservative and on the caucious side. Czechia has considerable biomass potential, but much of it is constrained by ecological and logistical factors [30]. Biofuels are used mainly in first-generation blends like B7 and E5, and more widespread use of second-generation biofuels ia limited because of high costs and fragmented policy structures [6, 19].

Both countries face similar challenges - feedstock price volatility, infrastructure limitations, and the obligation to align with EU directives (RED III) [10, 25].

The successful use of biofuels in a national energy system depends not only on technology, but also on whether a country creates the right conditions for that technology to take root.
Austria has done this by treating bioenergy as a long-term priority. It has supported domestic production [21], encouraged its use in transport [20], and integrated biofuels into national climate planning [22].
The Czech Republic is in a different position. Although it has the technical knowledge and natural resources to develop a strong biofuel sector [30], progress has been slower. Still, the Czech Republic has the potential to move forward, if future decisions are more coordinated and consistent with its climate goals.

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