Promoting Renewable electricity: Targets, strategies, by technology

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1. Abstract

In this seminar paper, a comparative analysis of renewable energy strategies and targets in Austria and the Czech Republic within the context of the European Union's renewable energy directives for 2030 was made. Specifically, we investigated how each country aligns its national policies with broader EU policies such as RePowerEU, Fit for 55, and the European Green Deal, focusing on their implementation through both national and corporate actions. An objective comparison of the differences in renewable energy targets between Austria and the Czech Republic, is the core of this paper. A detailed examination of EU and national directives related to renewable energy sources and an analysis of corporate strategies within the two countries were made. This paper reveals how Austria, and the Czech Republic are adapting their energy policies to not only meet EU requirements but also to phase out coal power plants, secure energy independence, and exploit their geographical potential for renewable energy development, such as solar, wind, and hydroelectric power. Furthermore, the potential of small modular reactors (SMRs) in the Czech Republic is discussed as part of its potential future energy mix. This paper concludes with a critical comparison of the national renewable energy targets and strategies, providing insights into their implementation towards EU energy objectives.

2. Introduction - Energy mix

In order to leave an environment worth living in for future generations, measures to reduce greenhouse gas emissions must be implemented quickly. To achieve the climate targets defined in the Paris Climate Agreement of 2015, which all UN member states have committed to meeting, phasing out fossil fuels is an essential step. The promotion of renewable electricity plays a central role in global efforts to meet these challenges. This paper examines the various targets and strategies being used around the world to drive the development and implementation of renewable energy technologies. It discusses what policies are being implemented by the Czech Republic and Austria to move towards the goal of a greener energy infrastructure. [1]

Energy mix Austria

In 2022, the structure of the Austrian energy mix showed a significant dependence on fossil fuels and renewable energies. With 35% of gross domestic consumption, the combustion of oil dominated the energy market, followed by natural gas with 21.3%, which was mainly used in thermal power plants and for heating. Coal, despite declining trends in the global energy context, still contributed 7.5% to energy production. However, the proportion of renewable energy sources, which accounted for 29.5% of gross domestic consumption, is positive. These consisted of biogenic fuels, hydropower, wind power and photovoltaics.

The use of hydropower was particularly formative for Austria's energy profile, as 40% of the country's total electricity consumption came from this source. This reflects Austria's topographical advantages, which enable the extensive use of hydroelectric potential. In addition to hydropower, 19.4% of electricity was generated from thermal power plants, with natural gas accounting for the majority of fuel use at 11.2%. Wind energy and photovoltaics contributed 7.4% and 3.5% respectively, underlining the increasing expansion and integration of these technologies into the national grid.

[1] https://www.consilium.europa.eu/de/policies/climate-change/paris-agreement/

Despite progress in domestic generation, Austria remained dependent on energy imports, which accounted for 29.4% of electricity demand. [2]

Energy mix Czech Republic

In 2022, traditional energy sources continued to dominate the Czech Republic's energy mix. The largest share of primary energy came from coal at 35.24%, underlining its continued importance in the national energy portfolio. Oil followed with 24.73%, while nuclear energy made a significant contribution of 16.72%. Natural gas accounted for 15.89% of energy requirements, while renewable energies were comparatively underrepresented at 6.57%.

The largest share of electric production, 43.47%, came from coal-fired power plants, and 36.5% was generated by nuclear power, which demonstrates the central role of nuclear energy in the Czech energy supply. Natural gas contributed 7.67% and renewable energies contributed 12.33% to electricity generation. The Czech Republic's role as a net exporter of electricity is noteworthy, with exports to Austria amounting to 12.54 TWh. This corresponded to 14.8% of the Czech Republic's total electricity production and covered around 13% of Austria's electricity demand in 2022. [2] [3] [4]

EU energy mix

In 2021, the European Union's primary energy consumption was made up of a diversified energy source structure. The dominant source was oil, which accounted for the largest share of total consumption at 34.2%. Natural gas followed with 23.3%, underlining its essential role in the EU's energy supply. Nuclear energy, contributed 12.8%, while renewable energy sources such as wind, solar and biomass together accounted for 15.6% of energy consumption. This data shows the continued dependence on fossil fuels, while at the same time the integration of renewable energy sources is progressing.

A specific focus on the generation of electrical energy in 2022 shows a more advanced picture of diversification in the EU. Wind power was one of the leading renewable energy sources with a 15.9% share of total electricity production, closely followed by nuclear power, which provided a significant share of the electricity supply with 21.9%. Hydropower, one of the oldest sources of renewable energy, contributed 11.3%, while solar energy contributed 7.6% to the electricity mix. Natural gas, which is often seen as a bridging technology on the way to a climate-neutral future, supplied 19.6% of electricity. Coal, although declining, was still responsible for 15.6% of electricity generation, highlighting the challenges and the EU’s ongoing transition to climate neutrality. [5]

3. Energy Development

Energy development in the European Union is given by european plans, which aim at reducing the carbon emissions. Thus, the means undertaken will include phasing out coal and gas power plants, as well as increasing energy efficiency. However, the plans are limited by the technical

[2] https://oesterreichsenergie.at/stromstatistik-1
[3] https://ourworldindata.org/energy/country/czechia#electricity-mix
[4] https://energy-charts.info/charts/import_export/chart.htm?l=de&c=DE&interval=year&year=2022&flow=physical_flows_all
[5] https://www.consilium.europa.eu/de/infographics/how-is-eu-electricity-produced-and-sold/

capacities of the grid, energy security, and the potential of renewable sources. The strategic goal is to end all energy sources imports from Russia by 2027.

National impacts of European targets

The Czech Republic aims to achieve emission reductions in line with its commitments under the Fit for 55 package and to contribute to achieve EU climate neutrality by 2050. The Czech Republic's strategic objective is to reduce the share of fossil fuels in primary energy consumption to 50% by 2030 and 0% by 2050, and to completely phase out the use of coal for electricity and heat generation by 2033[6]. Modelled scenario shows the feasibility of meeting these targets, but with ambitious policies and measures. Total emissions fall by 63% by 2030 compared to 1990, by 68% in ETS, and beyond sectors (ESR) by 32% compared to 2005[7]. The model is aiming for an emission value of 6.3 Mt in 2050, but further reductions are assumed from the LULUCF and waste sectors, which are not modelled in sufficient detail. The scenario also confirms the assumption of a complete phase-out of coal for heat and power by 2033, with a significant decrease already between 2025 and 2030.[8] The targets are composed of strategic targets, such as diversification, clean energy, security measures, and dependence reduction.

Diversification of Energy sources

The EU aims to diversify its energy sources to reduce reliance on fossil fuels, particularly natural gas from Russia. This includes increasing the use of renewable energy sources and promoting energy efficiency. The EU is actively working to reduce its dependence on fossil fuels[9]. This is crucial for enhancing energy security and reducing vulnerability to external supply disruptions. A significant part of the energy diversification strategy involves increasing the share of renewable energy sources in the overall energy mix[10]. This includes wind, solar, hydroelectric, and biomass energy sources, which are considered cleaner and more sustainable alternatives to fossil fuels.

Alongside promoting renewable energy sources, the EU is focusing on improving energy efficiency across various sectors. By enhancing energy efficiency, the EU aims to reduce overall energy consumption and decrease the reliance on imported energy sources. The EU's energy development forecast emphasizes a transition towards cleaner energy sources to combat climate change and achieve climate neutrality goals. This transition involves phasing out coal and other high-emission energy sources in favor of low-carbon alternatives. The EU has introduced policy initiatives such as the European Green Deal and the REPowerEU plan to accelerate the shift towards renewable energy sources and energy efficiency. These initiatives aim to drive investments in clean energy technologies and infrastructure. Overall, the EU's focus on diversifying energy sources towards renewables, improving energy efficiency, and transitioning to clean energy reflects a comprehensive strategy to enhance energy security, mitigate climate change, and reduce reliance on fossil fuels, particularly natural gas imports from Russia.

[6] https://www.mpo.cz/assets/cz/energetika/strategicke-a-koncepcni-dokumenty/2023/10/Aktualizace_NKEP_10_2023_final.pdf
[7] Ibid
[8] https://www.mpo.cz/assets/cz/energetika/strategicke-a-koncepcni-dokumenty/2023/10/Aktualizace_NKEP_10_2023_final.pdf
[9] https://www.iea.org/commentaries/accelerating-energy-diversification-in-central-and-eastern-europe
[10] https://www.mdpi.com/2227-7099/11/3/83

Transition to Clean Energy

The EU has set ambitious targets to reduce greenhouse gas emissions and achieve climate neutrality by 2050. This necessitates a significant shift towards clean energy sources to reduce greenhouse gas emissions and combat climate change. A crucial part of the transition to clean energy involves expanding the use of renewable energy sources such as wind, solar, hydroelectric, and biomass. These sources are considered environmentally friendly and sustainable alternatives to fossil fuels. Decarbonization is a central theme in the EU's clean energy transition. The transition to clean energy requires a transformation of the energy sector, including investments in renewable energy infrastructure, grid modernization, and energy storage technologies.[11] This transformation is essential for integrating intermittent renewable energy sources into the grid effectively, which also requires implementation of sophisticated grid control system.

The EU has implemented supportive policies and initiatives to facilitate the transition to clean energy, such as the European Green Deal and the Fit for 55 package. These policies aim to drive investments in clean energy technologies, promote energy efficiency, and accelerate the shift towards a sustainable energy system. The transition to clean energy not only helps in achieving climate goals but also brings economic benefits such as job creation in the renewable energy sector and reduced environmental impact from fossil fuel use. It also enhances energy security by reducing dependence on imported fossil fuels. In summary, the EU's transition to clean energy involves a comprehensive shift towards renewable energy sources, decarbonization of the energy sector, policy support for clean energy initiatives, and the realization of economic and environmental benefits. This transition is crucial for achieving climate neutrality, enhancing energy security, and promoting sustainable development in the EU.

Energy Security measures

The EU is implementing measures to enhance energy security, such as improving energy efficiency, diversifying energy imports, accelerating the transition to clean energy, and making intelligent investments in energy infrastructure. Improving energy efficiency is a key component of energy security measures in the EU[12]. By reducing energy consumption through efficiency measures in buildings, transportation, and industry, the EU aims to enhance energy security, lower energy costs, and decrease reliance on imported energy sources. Diversifying energy sources is essential for reducing dependence on a single energy supplier or fuel type. The EU is working to diversify its energy mix by increasing the share of renewable energy sources[13], promoting energy storage technologies, and exploring alternative sources such as hydrogen. Investing in energy infrastructure is crucial for ensuring a reliable and resilient energy supply. The EU is focusing on modernizing and expanding energy infrastructure, including electricity grids, gas pipelines, and storage facilities, to support the transition to clean energy and enhance energy security. Energy storage technologies play a vital role in ensuring a stable energy supply, especially with the integration of intermittent renewable energy sources[14]. The EU is investing in energy storage solutions such as batteries, pumped hydro storage, and hydrogen storage to balance supply and demand and enhance energy security.

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[11] https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficiency-targets-directive-and-rules/energy-efficiency-directive_en

[12] https://www.mdpi.com/2227-7099/11/3/83

[13] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2023%3A650%3AFIN&qid=1698237100377

[14] https://energy.ec.europa.eu/news/commission-prolongs-energy-emergency-measures-12-months-2023-11-28_en

Establishing emergency response mechanisms is essential for managing energy supply disruptions or crises. The EU has mechanisms in place to coordinate emergency responses, share energy resources among member states, and ensure continuity of energy supply during emergencies. Energy security in the EU is closely linked to international cooperation and partnerships. The EU collaborates with neighboring countries, international organizations, and energy suppliers to enhance energy security, promote energy diversification, and address common energy challenges. Overall, energy security measures in the EU encompass a range of strategies, including improving energy efficiency, diversifying energy sources, investing in infrastructure, deploying energy storage solutions, establishing emergency response mechanisms, and fostering international cooperation. These measures are essential for ensuring a reliable, sustainable, and resilient energy supply in the EU.

Reduction of Reliance on Russian gas

Efforts are being made to reduce the EU's dependence on Russian natural gas, with plans to decrease import reliance to 0% by 2027.[15] One of the primary approaches to reducing reliance on Russian gas is to diversify gas supplies by sourcing from alternative sources and routes. This includes increasing imports of liquefied natural gas from global markets, developing new gas pipelines from non-Russian suppliers, and exploring domestic gas production. In addition to diversifying gas supplies, the EU is promoting the use of alternative energy sources such as renewable energy, hydrogen, and energy storage technologies. By shifting towards cleaner and more sustainable energy sources, the EU aims to decrease its dependence on fossil fuels, including Russian natural gas, while reducing carbon emissions[16]. Energy efficiency initiatives in buildings, transportation, and industry can help lower gas consumption and enhance energy security. Investing in energy infrastructure, including gas pipelines, interconnectors, and storage facilities, is crucial for enabling the diversification of gas supplies and increasing the collective energy security[17]. Implementing supportive policies and regulatory frameworks can facilitate the transition away from Russian gas. This includes promoting competition in the gas market, ensuring transparency in gas contracts, and fostering a favorable investment climate for alternative gas suppliers. Collaborating with international partners and gas suppliers outside of Russia is key to diversifying gas supplies and enhancing energy security.

By implementing these strategies and initiatives, the EU aims to reduce its reliance on Russian natural gas, enhance energy security, promote sustainability, and mitigate geopolitical risks associated with major energy dependence on a single supplier. This concerted effort towards diversification and decarbonization of the gas sector aligns with the EU's broader energy transition goals and contributes to a more resilient and sustainable energy system.

Global Energy Trends

The energy mix in the EU is expected to continue evolving, with a potential return to traditional energy sources in the short term due to changing geopolitical dynamics. One of the prominent global energy trends is the rapid growth of renewable energy sources such as solar, wind, hydroelectric, and biomass[18]. Countries worldwide are increasingly investing in renewable energy

[15] https://www.dw.com/en/war-in-ukraine-why-is-the-eu-still-buying-russian-gas/a-68925869
[16] https://www.iea.org/reports/how-to-avoid-gas-shortages-in-the-european-union-in-2023/executive-summary
[17] https://energy.ec.europa.eu/energy-explained/energy-infrastructure-eu_en
[18] https://www.eea.europa.eu/en/topics/in-depth/energy#:~:text=The%20total%20amount%20of%20energy,4%25%20from%202021%20to%202022.

technologies to reduce carbon emissions, enhance energy security, and promote sustainable development. The global energy sector is undergoing a significant transition towards cleaner and more sustainable energy sources. This transition involves phasing out fossil fuels, increasing the share of renewables in the energy mix, and adopting energy efficiency measures to address climate change, enhance energy security, and meet growing energy demand[19]. Many countries and regions are intensifying their efforts to decarbonize the energy sector and reduce greenhouse gas emissions. This includes setting ambitious climate targets, implementing carbon pricing mechanisms, and promoting the electrification of transportation and heating to achieve a low-carbon energy system[20]. Technological advancements play a crucial role in shaping global energy trends. Innovations in energy storage, smart grids, electric vehicles, and renewable energy technologies are driving the transition towards a more sustainable and resilient energy system. These innovations are essential for integrating variable renewable energy sources and optimizing energy use. Energy security remains a significant concern globally, with countries seeking to enhance resilience in the face of supply disruptions, geopolitical tensions, and natural disasters.

Diversifying energy sources, investing in energy infrastructure, and promoting energy efficiency are key strategies to improve energy security and reduce dependence on volatile energy markets. Collaboration among countries and regions is essential for addressing global energy challenges, promoting energy access, and achieving sustainable energy transitions. International initiatives, partnerships, and agreements play a crucial role in advancing clean energy technologies, sharing best practices, and fostering energy security on a global scale. By monitoring and adapting to these global energy trends, countries can navigate the evolving energy landscape, seize opportunities for innovation and collaboration, and work towards a more sustainable, secure, and resilient energy future. Embracing clean energy solutions, enhancing energy efficiency, and fostering international cooperation are key pillars in addressing the complex energy challenges facing the world today.

4. EU Energy targets

The European Union has set clearly defined targets through various ambitious packages of measures. The striking "Fit for 55" package aims to reduce greenhouse gas emissions by 55% by 2030 compared to 1990 levels, a significant step towards climate neutrality. This package was supplemented by the REPowerEU package, which was introduced as a direct response to the Russian attack on Ukraine and the resulting energy supply problems. This package aims to reduce dependency on energy imports, particularly Russian gas, and is intended to strengthen the EU's energy supply security. All of these measures are overarched by the European Green Deal, which comprises a wide range of political initiatives and aims to make the EU climate-neutral by 2050.

Fit for 55

The EU’s "Fit for 55" package represents a holistic approach that aims to reduce the EU’s greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels, with the ultimate goal of achieving climate neutrality by 2050. It includes a comprehensive overhaul of the EU Emissions Trading Scheme, sets increased targets for renewable energy and energy efficiency and introduces new regulations to reduce emissions from cars and trucks. It also includes important measures for social

[19] https://www.mpo.cz/assets/cz/energetika/strategicke-a-koncepcni-dokumenty/2023/10/Aktualizace_NKEP_10_2023_final.pdf
[20] https://taxation-customs.ec.europa.eu/carbon-border-adjustment-mechanism_en#:~:text=Why%20CBAM%3F-,CBAM,production%20in%20non%2DEU%20countries.

mitigation through the Social Climate Fund and to promote a sustainable circular economy, all of which together help to strengthen and broaden the EU's ambitious green new regulations to reduce emissions from cars and trucks. It also includes important policy objectives. [21]

REPowerEU

REPowerEU is a comprehensive plan developed by the European Union to increase energy independence from Russian fossil fuels and secure Europe's energy supply. The plan aims to reduce energy consumption, diversify energy sources and accelerate the development of renewable energy. It includes investments in energy infrastructure and measures to promote energy efficiency. REPowerEU is a central part of the European Green Deal and plays a crucial role in helping the EU achieve climate neutrality by 2050 by promoting renewable energy and improving energy efficiency. [22]

New Green Deal

The European Green Deal is an ambitious EU program that aims to make Europe climate-neutral by 2050. This plan includes comprehensive measures to promote biodiversity, the circular economy and a sustainable industrial policy. The Green Deal aims to accelerate the transition to sustainable food production, decarbonize industrial processes and improve energy efficiency. These measures are designed to achieve the goals of climate neutrality while ensuring a just transition that includes and supports all levels of society. [23]

Expansion targets

Specifically, the Fit for 55 package sets the target of 42.5% of the energy consumed in the EU coming from renewable sources by 2030. This corresponds to an almost doubling of the share of renewables by 2022. Each member state must make its contribution to achieving this ambitious target, regardless of how much it emits. Sector-specific targets have been formulated for 2030, for example that the building sector must obtain 49% of its energy consumption from renewable sources. The industrial sector must increase its use of renewable energy sources by 1.6% per year. For the use of hydrogen in industry, it was stipulated that 42% of the hydrogen used should come from renewable sources and 60% by 2035. In heating and cooling, the use of renewable energy should increase by 1.1% per year until 2030. The member states were given two options for action in the transport sector. They can reduce emissions from the transport sector by 14.5% by 2030 or increase the share of renewable energies in transport by at least 29%. [24]

Solar energy

The REPowerEU Plan, introduced in response to the energy supply crises intensified by the Russian attack on Ukraine, aims to significantly expand solar energy capacity. Solar generation capacity is to

[21] https://www.consilium.europa.eu/de/policies/green-deal/fit-for-55/
[22] https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/repowereu-affordable-secure-and-sustainable-energy-europe_de
[23] https://www.consilium.europa.eu/de/policies/green-deal/#=texts=Multi-What%20is%20the%20European%C3%A4Gr%C3%BCne%20Deal%3F%20to%20become%20climate%20neutral%20by%202050
[24] https://www.consilium.europa.eu/de/infographics/fit-for-55-how-the-eu-plans-to-boost-renewable-energy/

be doubled to 320 GW by 2025 and increased to 600 GW by 2030 to support the European electricity grid. The plan includes the gradual introduction of an obligation to install photovoltaic systems on new public and commercial buildings and ultimately also on residential buildings. In parallel, a strategy is being pursued to double the use of heat pumps, which should also contribute to the increased use of renewable energies. Member states are also required to designate special "go-to" areas for renewable energy generation plants, in which shortened and simplified approval procedures are to be applied. [25]

Biomass, biofuels and hydrogen

The EU Renewable Energy Directive sets ambitious targets for the use of advanced biofuels, which are to increase from a share of 1% by 2025 to 5.5% by 2030. There are also plans to install hydrogen electrolysers with a total capacity of 40 GW by 2030, which will produce ten million tons of renewable green hydrogen from renewably generated electrical energy. [25]

Offshore wind energy

The European Union has set significant targets for offshore wind energy that underline the enormous potential of ocean winds to achieve energy and climate goals. By 2022, 12 GW of offshore wind turbines have already been installed in European waters. The target is ambitious: These capacities are to grow to 110 GW by 2030. This growth is to be driven further, with a long-term target of 317 GW by 2050. [25]

Onshore wind energy

Regarding onshore wind energy, the European Union is also pursuing ambitious targets to increase its share of electricity generation from renewable sources. In 2022, 204 GW of onshore wind turbines were already in operation. The EU plans to more than double this capacity to over 500 GW by 2030. This expansion is expected to make a significant contribution to Europe's electricity supply and is a key part of the Green Deal, which aims to achieve climate neutrality by 2050. [26]

5. National implementation

AT Strategy

Austria has set itself the goal of achieving climate neutrality by 2040. A key step towards achieving this goal is the complete conversion of the electricity supply to renewable energy sources by 2030. This national target, which aims to achieve 100% electricity from renewable sources over the entire year, is supported by various comprehensive packages of measures. The focus here is not only on increasing renewable energy generation capacity, but also on creating a robust infrastructure to ensure the efficient use and distribution of renewable energy. These plans include the increased integration of modern energy technologies and the optimization of existing infrastructure to ensure maximum energy impact and maximize energy efficiency.

Renewable Energy Act

The Renewable Energy Expansion Act is a key legislative tool that Austria is using to create the necessary legal and organizational framework for the energy targets. The Act aims to increase electricity generation from renewable sources by 27 terawatthours by 2030. Specifically broken

[25] https://www.europarl.europa.eu/factsheets/da/sheet/70/energie-aus-erneuerbaren-quellen#textblocks%20april%202021%20decreased%20sp1.2har%20spf%2045%25%20to%20achieve%20
[26] https://www.parliament-gv.at/dokument/X/XVII/EU/166586/imfname_11322511.pdf

down, the target provides for 11 TWh to come from photovoltaics, 10 TWh from wind power, 5 TWh from hydropower and 1 TWh from biomass. In addition, the law strengthens investment security for existing and new biogas plants, which should enable the production of 5 TWh of renewable gas by 2030. Extensive funding programs are planned to promote the expansion or new construction of photovoltaic, wind power and electricity storage facilities. This legislative initiative reflects Austria's comprehensive strategy of shaping a more environmentally friendly and energy-autonomous future through sustainable investments and clear legal requirements. [27]

Subsidy Programs

To accelerate the deployment of renewable energies, the Austrian Federal Government has implemented various subsidy programs. These will be briefly outlined below.

Market Bonus

The market bonus is available for wind power plants, hydroelectric power plants, photovoltaic systems, and biomass-based generation plants. The market bonus subsidizes the difference between the actual production costs and the respective reference market price. The market bonus is awarded through an auction based on the Merit Order principle. This means all applicants offer their production costs and the lowest bids are accepted until the funding pot is exhausted. The market bonus can be granted for the construction, expansion, or revitalization of plants for a duration of 20 years. If the reference market price in a given month exceeds the offered production costs, the market bonus is either suspended or the difference exceeding the offered production costs to the market price is reimbursed. This funding is financed with a renewable energy surcharge and a renewable energy contribution fee, which all end consumers pay through network charges. [28] [29]

Investment Grant

The second type of subsidy according to the "Erneuerbaren Ausbaugesetz" are investment cost grants for renewable generation plants. Investment grants are available for photovoltaic systems and energy storage units. Photovoltaic systems are supported with a fixed amount per kWp and must have a total performance of less than 1 MWp. Depending on the location and type of installation, there are both surcharges and deductions. Surcharges apply to systems that are integrated into buildings, are floating or installed on already sealed surfaces. For photovoltaic systems installed on agricultural land without dual use, the full investment cost grant is not paid out. For areas such as closed landfills, military sites, or mining areas, no investment cost grant is paid. In the 2023 funding call, energy storage systems connected with a photovoltaic system were also supported. A fixed amount per installed kWh is paid out. The supported storage systems must have a total capacity of less than 50 kWh. In total, €600 million was available for investment grants in 2023. [30]

Hydrogen Strategy

As a significant portion of Austria's energy supply depends on natural gas, a substitute needs to be found. Not only is natural gas used as an energy carrier, but it is also crucial as a process gas in industry. Hydrogen could serve as an alternative for both purposes. Green hydrogen is produced by electrolysis. The electrical energy required for electrolysis should come from renewable sources. Electrolysers can also act in a grid-supporting manner since they can be activated during periods when there is an abundance of electricity from renewable sources. In 2022, the Austrian Federal Government introduced a hydrogen strategy. This strategy aims to ensure that by 2030, the energy-

[27] https://www.bmk.gv.at/service/presse/gewessler/2021/20210317_eag.html
[28] https://www.next-kraftwerke.at/wissen/marktpraemie
[29] https://oesterreichsenergie.at/publikationen/ueberblick/detailseite/eag-analyse
[30] https://www.bmk.gv.at/themen/klima_umwelt/energiewende/erneuerbare/foerderungen/pv/eag.html

intensive industry largely replaces natural gas or other fossil fuels with hydrogen. Furthermore, a total electrolyser capacity of 1GW is to be installed in Austria by 2030. A legal framework will be established, and hydrogen will be promoted as an integral part of our energy system. To increase the relevance of hydrogen in our energy system, the corresponding infrastructure must also be developed. By 2030, the gas infrastructure is to be gradually converted to a hydrogen infrastructure. [31]

Transport Strategy

In 2021, the Federal Ministry for Climate Protection published the "Mobility Master Plan 2030." This plan outlines the strategy for traffic planning up to 2030 and beyond. According to the master plan, by 2040, only 42% of passenger travel is expected to rely on motorized individual transport, compared to 61% in 2018. The shares of trips made by walking, cycling, or using public transport are expected to significantly increase. By 2040, the electrification of passenger cars should be largely complete. The same applies to buses and commercial vehicles. [32]

CZ Strategy

The Czech strategy is supporting the use of locally available heat sources to reduce dependence on fossil fuel imports and strengthen the local economy. Transformation of district heating systems to utilize low-carbon energy sources and transport energy to consumers, especially in urban agglomerations. Consequently, the aim is to ensure high-quality and efficient transport connections for all regions of the Czech Republic within the trans-European transport networks to all neighboring states. There are significant attempts to ameliorate recycling and return organic matter to the soil. The waste management system has Introduced separate collection of bio-waste as common practice in Czech cities and municipalities for composting, biogas production, and digestate. On national level, we see support of renewable mobility and electromobility, including infrastructure development for charging electric vehicles. These measures and goals in the energy sector are part of a broader strategic framework aimed at sustainable and efficient energy use and environmental protection in line with the principles of sustainable development and the global Sustainable Development Goals of the United Nations.[33] The Czech Republic has a major overarching document, the Action plan, and then individual plans in each section. These plans are detailly examined below.

Action Plan 2024 - 2025

The Action Plan 2024-2025 for Czech Republic aims to support the industry's recovery from the impacts of COVID-19 and other ongoing challenges. It outlines measures across six areas, including inter-ministerial collaboration, organizational development, data utilization, human resources support, infrastructure enhancement, and marketing initiatives. Specific activities include destination marketing, system organization revisions, data research planning, workforce skill development, and infrastructure modernization. The plan was approved by the Czech government in November 2023[34]

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[31] https://www.bmk.gv.at/dam/jcr:102ada24-2f3e-4fdf-86de-3c41b5fafa9b/BMK_Wasserstoffstrategie_ExecutiveSummary_DE_UA_final.pdf

[32] https://www.bmk.gv.at/themen/mobilitaet/mobilitaetsmasterplan/mmp2030/faq.html

[33] https://vlada.gov.cz/assets/ppov/udrzitelny-rozvoj/Strategicky_ramec_Ceska_republika_2030-compressed-_1_.pdf

[34] https://mmr.gov.cz/cs/ministerstvo/cestovni-ruch/pro-profesionaly/koncepce-strategie/akcni-plan-2024-2025

and has an indicative purpose in terms of achieving carbon emission reductions across all economic segments.

Strategic plan in transportation

The Czech government has recently approved a comprehensive transportation policy that spans from 2021 to 2027, with a primary focus on sustainability and modernization. This strategic plan aims to foster the development of a reliable and environmentally sustainable transport system, catering to the needs of both passengers and freight while reducing energy consumption and emissions. The key objectives of this policy include enhancing energy efficiency and promoting environmentally friendly practices across various modes of transportation, such as road, rail, water, and air. The strategy also emphasizes the importance of integrated and multimodal transport solutions to improve connectivity and accessibility throughout the country. In addition to environmental considerations, the policy seeks to address challenges related to infrastructure development, digitalization, and innovation within the transport sector. It aims to leverage emerging technologies to optimize transport services, enhance safety, and improve overall efficiency.

The approved transportation policy reflects a commitment to shaping a modern and sustainable transport network that supports economic growth, social cohesion, and environmental protection. It underscores the importance of long-term planning and investment in transport infrastructure and services to meet the evolving needs of Czech citizens and businesses.[35] The most evident implementation is through municipal transportation providers' strategies, which lead to the reduction of carbon emissions in cities through the employment of ecological vehicles, and better interconnectedness. Moreover, there is an ongoing initiative on the implementation of high-velocity rail network, which aims at reducing emissions arising from intermunicipal transportation. All of the initiatives within the strategic plan aim at promoting low-emission economy.

National Research, Development, and Innovation Policy of the Czech Republic 2021+.

Energy plays a key role in the national research, development, and innovation policy in the Czech Republic for the period from 2021 onwards. This document focuses on strategic goals and measures in the field of energy with the aim of achieving sustainable and efficient energy use in the country. One of the main objectives is to support innovations in renewable energy sources, which have the potential to reduce dependence on fossil fuels and contribute to environmental protection. Planned measures include supporting research and development of new technologies for clean energy, such as solar and wind power plants, biofuels, or geothermal energy. Emphasis is also placed on increasing energy efficiency, which can lead to energy savings and cost reductions for industrial enterprises and households. Reducing greenhouse gas emissions is another key element within the energy strategy, contributing to the fight against climate change.

Within the planned measures, the development of energy infrastructure is also taken into account, which is essential for the efficient distribution and utilization of energy from various sources. Supporting innovative energy solutions for industry and households is another important element that can contribute to the modernization of the energy sector and increase the competitiveness of the Czech economy. The implementation of planned measures in the field of energy is in line with European guidelines and standards, emphasizing sustainable development and environmental protection. The Czech Republic is widely utilizing available EU funds to support energy innovation for

[35] https://www.mdcr.cz/Media/Media-a-tiskove-zpravy/Vlada-schvalila-dopravni-politiku-do-roku-2027-Pr

the successful implementation of the strategy and achieving the set goals in the field of energy in the Czech Republic, such as peak load smoothening.[36]

National initiative on Industry 4.0

In the context of Industry 4.0, energy efficiency plays a critical role in optimizing industrial operations and reducing environmental impact. One key aspect highlighted is the integration of advanced technologies, such as Internet of Things (IoT) devices and data analytics, to monitor and optimize energy consumption in real-time. This allows manufacturers to identify inefficiencies, adjust operations accordingly, and minimize energy waste throughout the production cycle, e.g. in manufacturing. This data is then analyzed to identify opportunities for energy savings and process optimization. For example, predictive maintenance powered by IoT can help prevent energy-intensive breakdowns, reducing downtime and energy losses. Moreover, manufacturers are encouraged to leverage solar, wind, or other renewable energy sources to power their operations, reducing reliance on fossil fuels and lowering carbon emissions. Another aspect emphasized is the concept of energy flexibility, where manufacturing processes can dynamically adjust energy consumption based on demand, energy prices, and grid conditions. This flexibility allows companies to participate in demand response programs and optimize energy usage during peak hours, contributing to grid stability and cost savings.

Overall, Industry 4.0 offers significant opportunities for improving energy efficiency and sustainability in manufacturing. By leveraging advanced technologies and adopting renewable energy solutions, manufacturers can reduce their environmental footprint while enhancing operational efficiency and competitiveness in the global market, while fostering low-carbon electricity production.[37]

State Environmental Policy of the Czech Republic 2030 with a Perspective to 2050

The State Environmental Policy of the Czech Republic 2030 with a perspective to 2050 is a strategic document approved by the Czech government in 2021. This document builds upon the long-term efforts of the Ministry of the Environment in environmental protection and encompasses a wide range of topics related to environmental conservation. SEAP 2030 focuses on defining strategic directions and goals up to 2030, with a vision to achieve an ideal state by 2050. The document includes visions for both overall environmental policy and specific areas, considering relationships with other strategic documents at the national, European, and international levels. It takes into account legislative documents, sustainable development principles, and predictions of external influences such as socio-demographic and economic developments, as well as global pressures. The main three areas of SEAP 2030 are: Environment and health, Low-carbon and circular economy, and nature and landscape

Each of these areas contains specific topics and goals, such as water, air, hazardous substances, noise and light pollution, extreme events, settlements, transition to climate neutrality, circular economy, ecologically functional landscape, and biodiversity conservation. To achieve the goals of SEAP 2030, typological measures will be defined, which will be part of valid component and sectoral strategic documents. Implementation and monitoring of SEAP 2030 will be carried out through additional thematic strategies within the Ministery of Environment and others. Emphasis will be placed on regular monitoring through the use of indicators via the Environmental Report of the Czech Republic. The platform for monitoring the implementation of SEAP 2030 will involve representatives from various sectors, including parliamentary representatives, local authorities, academic communities,

[36] https://www.dataplan.info/img_upload/7bdb1584e3b8a53d337518d988763f8d/narodni-politika-vavai-2021.pdf
[37] https://www.spcr.cz/aktivity/z-hospodarske-politiky/12973-jak-rozumet-konceptu-prumysl-4-0

and non-governmental organizations, with the aim of improving coordination and implementing activities to achieve the goals in carbon emissions reduction.[38]

Climate preservation Strategy

The Climate Protection Policy in the Czech Republic replaces the National Program for Climate Change Mitigation in the Czech Republic from 2004. It defines the main objectives and measures in the area of climate protection at the national level to ensure the fulfillment of greenhouse gas emission reduction targets in line with international obligations. This climate protection strategy focuses on the period from 2017 to 2030, with a perspective to 2050, aiming to contribute to the long-term transition to a sustainable, low-emission economy in the Czech Republic. The evaluation indicates that the target for 2020, corresponding to a 20% reduction in emissions compared to 2005 levels, was likely achieved. However, achieving the Climate Protection Policy targets for 2030 (a 30% reduction compared to 2005) will require additional measures beyond current policies and actions, as current scenarios suggest a shortfall of about 2.5% to meet this goal. Similarly, reaching the indicative target for 2040 is contingent on additional measures. The trajectory of emission reductions is not in line with achieving the indicative target of an 80% reduction in emissions by 2050 compared to 1990 levels, and scenarios for achieving climate neutrality are not yet available.

The Climate Protection Policy comprises a total of 41 measures covering cross-cutting themes, sector-specific actions, research and development, monitoring, and international climate protection and development cooperation. According to the evaluation, 73% of measures have been fully implemented, 22% partially implemented, and 5% not implemented at all[39]

Energy Segment Strategies

Hydrogen Strategy

The Hydrogen Strategy of the Czech Republic focuses on two main strategic goals: reducing greenhouse gas emissions and supporting economic growth. The strategy is built upon four fundamental pillars. Firstly, low-carbon hydrogen production emphasizes the production of hydrogen from renewable sources and explores alternative methods such as natural gas utilization with carbon capture, pyrolysis gasification of organic waste, and hydrogen production using electricity and heat from nuclear power plants. Secondly, utilization of low-carbon hydrogen aims to prioritize hydrogen deployment in sectors where it is most cost-effective, starting with transportation and subsequently expanding to energy production, industrial heat applications, and chemical feedstocks as hydrogen costs decrease. Thirdly, hydrogen transport and storage address the development of infrastructure for hydrogen transport, potentially transforming the Czech Republic into a significant player in hydrogen transportation across Europe. Fourthly, hydrogen technologies emphasize the development of cutting-edge hydrogen technologies to drive innovation and transformation in Czech industry, enhancing research capabilities and industrial competitiveness.

The strategy highlights the importance of collaboration with industry representatives, research institutions, and government bodies in its development. It recognizes the potential for future hydrogen imports due to favorable conditions for renewable hydrogen production in sunnier and windier regions, with the potential suppliers being Morrocco, Chile or Australia[40]. This import

[38] https://www.mzp.cz/cz/statni_politika_zivotniho_prostredi
[39] https://www.mzp.cz/cz/politika_ochrany_klimatu_2017
[40] https://oenergetice.cz/vodik/evropa-na-ceste-k-uhlikove-neutralite-odkud-muze-unie-dovazet-zeleny-vodik?fbclid=IwZXh0bgNhZW0CMTAAAR14TTDhWP9unHaZ4NzOxifiKV1fiZD_3OR3Gi-YX_5xbDyMrEGUS1WdufA_aem_AYJltD7GYqbFR8fSRWqFjIMtY43z7Y1pacAdVummPu-mHuHN-d23RkWaK9H5ShjUEKo38cH8Km3iIWokQlV9i09f

strategy could replace current imports of natural gas and oil, positioning the Czech Republic as a key player in hydrogen transport within Europe.[41]

SMR Strategy

The Czech government has approved a material from the Ministry of Industry and Trade titled "Plan for Small and Medium Reactors in the Czech Republic – Utilization and Economic Benefits." This document outlines the integration of innovative nuclear technology into the State Energy Concept and considerations within the Czech Republic's Regional Development Policy. The plan presents potential investment models and suitable locations. The minister of Industry and Trade, Jozef Síkela views small and medium reactors as complementary to large-scale nuclear facilities, particularly for electricity and heat production. The aim is to leverage the Czech nuclear industry's unique expertise and provide certainty to investors for location preparation and subsequent investment decisions. SMRs represent an innovative nuclear technology poised to enter the market within the next five to ten years, offering significant economic opportunities. Several international projects are underway, with interest expressed by companies like RollsRoyce SMR and GE Hitachi, leading in SMR development.

The material summarizes insights into SMR technology and recommendations from a working group convened by MPO between 2022 and 2023. It delineates potential applications of SMR technology in the Czech Republic, outlining economic opportunities, including Czech projects and offers from foreign manufacturers. It also identifies prospective locations, describes investment models, and legislative changes needed. The Czech nuclear industry can play a pivotal role in Europe and globally, not only in low-emission electricity generation but also in district heating and hydrogen production. Potential SMR deployment locations include existing nuclear sites and former coal power plant locations like Dětmarovice and Tisová. This plan aims to foster new economic opportunities, preserve nuclear expertise, and establish long-term partnerships with original equipment manufacturer countries. Lower capital expenditures associated with SMRs compared to large nuclear plants make them more accessible to investors, with the first projects providing insights into economic viability and construction timelines.

The plan's implementation aims to prepare the Czech Republic for SMR technology utilization and support the export potential of Czech businesses. State support will be essential for SMR investments, with the government advocating for equitable conditions at the European level, particularly in EU policies, financing, and market frameworks, including those for SMRs.[42]

6. Comparison of national targets

The comparison of the national strategies of Czechia and Austria reveals some similarities and differences in their approaches to key areas such as energy, climate protection, transportation, and environmental policy. The strategies can be divided into several areas, such as energy transition, Renewable energy incentives, hydrogen strategy, and transportation strategy.

Firstly, in Energy transition, Austria has set ambitious goals for achieving climate neutrality by 2040, with a key step being the complete conversion of its electricity supply to renewable energy sources by 2030. This includes specific targets for increasing electricity generation from photovoltaics, wind power, hydropower, and biomass, supported by legislative measures like the Renewable Energy Expansion Act. While Czechia also emphasizes sustainable energy use and the reduction of

[41] https://www.mpo.gov.cz/cz/prumysl/strategicke-projekty/vodikova-strategie-cr-schvalena-vladou--262590/
[42] https://www.mpo.gov.cz/cz/rozcestnik/pro-media/tiskove-zpravy/vlada-schvalila-cestovni-mapu-pro-rozvoj-malych-a-strednich-reaktoru-v-cesku--277820/

dependence on fossil fuels. It has a strategic focus on utilizing locally available heat sources and transitioning district heating systems to low-carbon energy sources. Czechia is also exploring the integration of small and medium nuclear reactors (SMRs) into its energy mix, alongside renewable energy sources.

Secondly, in Renewable Energy Incentives, Austria implements subsidy programs such as the market bonus and investment grants to accelerate the deployment of renewable energies. The market bonus subsidizes production costs for wind, hydro, photovoltaic, and biomass plants, while investment grants support photovoltaic systems and energy storage units. In contrast, Czechia is leveraging EU funds to support innovation in renewable energy technologies, aiming to reduce dependence on fossil fuels and increase energy efficiency. The country is particularly interested in harnessing solar and wind power, biofuels, and geothermal energy.

Thirdly, in the introduction of Hydrogen, Austria has introduced a comprehensive hydrogen strategy to replace natural gas in various sectors with green hydrogen produced from renewable sources. This includes establishing a legal framework, promoting hydrogen technologies, and developing hydrogen infrastructure. Similarly, Czechia is also focusing on hydrogen as an alternative energy carrier, aiming to reduce greenhouse gas emissions and support economic growth. The country is exploring low-carbon hydrogen production methods and aims to develop hydrogen infrastructure by converting the gas infrastructure to support hydrogen.

Fourthly, in implementing green Transporation, Austria's mobility master plan emphasizes reducing reliance on motorized individual transport and promoting walking, cycling, and public transport. It targets full electrification of passenger cars, buses, and commercial vehicles by 2040. In contrast, Czechia's transportation strategy aims for a sustainable and modern transport system, emphasizing energy efficiency, environmental sustainability, and digitalization. The country is also implementing initiatives to reduce carbon emissions in cities through eco-friendly vehicles and improve intermunicipal transport with high-speed rail networks.

Fifthly, Austria's environmental policies are aligned with its climate neutrality goals, focusing on low-carbon and circular economy practices. The country has specific targets for reducing greenhouse gas emissions and transitioning to a sustainable economy. In comparison, Czechia's environmental policies, outlined in the State Environmental Policy 2030, emphasize environmental conservation, health, and a transition to a low-carbon economy. The country is committed to achieving carbon emission reductions and implementing measures to protect biodiversity and natural resources.

In summary, both Czechia and Austria have ambitious national strategies aimed at transitioning to sustainable energy systems, reducing carbon emissions, and promoting environmental conservation. While Austria places significant emphasis on renewable energy expansion and hydrogen technologies, Czechia is exploring a combination of renewable energy sources and nuclear energy solutions like small and medium reactors to achieve its energy and climate goals. Both countries prioritize innovation, energy efficiency, and transitioning to low-carbon transportation systems as part of their broader sustainability agendas.

7. Conclusion

In conclusion, the national strategies of Austria and the Czech Republic demonstrate ambitious and approaches to address energy transition, climate protection, sustainable transportation, and environmental conservation. These aims lead to reducing energy consumption, and thus reduces the load increase on the grid. Austria's emphasis on achieving climate neutrality by 2040 through complete conversion to renewable energy sources and the implementation of comprehensive

measures such as the Renewable Energy Expansion Act and hydrogen strategy highlight a strong commitment to a green future. Similarly, the Czech Republic's focus on utilizing local heat sources, exploring small and medium nuclear reactors, and leveraging EU funds for renewable energy innovation underscores a strategic and diversified path towards sustainability.

Despite differences in specific approaches, both countries prioritize renewable energy incentives, hydrogen development, and the promotion of low-carbon transportation as integral components of their national strategies. These efforts align with broader EU and international objectives for climate action and sustainable development. Overall, Austria and the Czech Republic demonstrate proactive leadership in advancing clean energy solutions and environmental stewardship, setting examples for other nations to follow in the transition towards a greener, more resilient energy future.