COMPARISON OF THE NECPS OF THE CZECH REPUBLIC AND AUSTRIA CONCERNING ELECTRICITY INFRASTRUCTURE

By Dean Dunovski and Benedikt Zöchling

Co-operating Universities

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1 Abstract

Electricity interconnection is continually on the rise across the European Union. Combine that with the continued rise in promoting renewable energy sources (RES) and an increasing trend in overall consumption, more generation and a more stable electricity network is needed to accommodate stable power flows between member states. This is increasingly becoming obvious in both Austria and the Czech Republic. Austria's target for 2030 in final RES consumption is 46-50%. This represents an increase of 12-16 percentage points from their 2020 target of 34%. In addition, Austria plans to source 100% of its consumption from renewables. With a planned expansion of renewable generation and rise in consumption in Austria and its neighbouring countries, investments in electricity infrastructure will be required in an amount ranging between EUR 26 to 33 billion over the next decade. A similar case presents itself in the Czech Republic. Czechia's 2030 targets in final energy consumption from RES are 22% which represents an increase in 9 percentage points from its 2020 goal of 13%. With expected generation in RES and nuclear to be constructed in the next two decades as well as increased cross-border cooperation, investments in electricity infrastructure are needed in an amount of about EUR 24 billion over the next decade.

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2 Motivation

The core objective of this paper will be to analyze proposed investments in the electricity sector with regards to transmission system infrastructure. In addition, we will figure out if an investment gap exists based on proposed policies in both NCEPs and the actual investments that are being proposed. Such policies that will be extensively evaluated include:

- Interconnection
- Electricity infrastructure
- Market integration
- Smart grids

With further decarbonization developments rising in the next decade such as increase in RES use, electromobility, energy efficiency, etc., a more stable grid will need to be constructed in order to support such developments. Such investments that will need to be made include transmission infrastructure and smart grid technology. Providing efficient investments as well as proper legislation will help ensure that both states can achieve their respective 2030 framework targets. More importantly, it may also help decrease energy poverty and ensure a secure supply of energy across the region.

3 INTRODUCTION

In the European Union (EU), Directive 2018/2001 on the promotion of the use of energy from renewable sources has and continues to set binding national targets for member states of the EU on the share of renewable energy sources in energy consumption (European Commission, 2018). The 2030 binding EU target has established at least a 32% share in gross final energy consumption. An additional binding target based on this directive is for the European Commission to support funding member states towards developing transmission and distribution grid infrastructure with the purpose of achieving a 15% electricity interconnection target by 2030. Regulation No 347/2013 provides guidelines on trans-European energy infrastructure as well as information on Projects of Common Interest (PCI). PCIs are projects that improve energy infrastructure and are necessary in order to implement the EU's interconnection policy (European Commission, 2013). Specific criteria that applies to PCI's include electricity transmission and storage projects as well as electricity smart grid projects. Regulation No 2018/540 displays a Union wide list of PCIs (European Commission, 2017). This will cause member states across the EU think up new solutions in order to maintain electric grid stability to accommodate these new measures. A more in-depth look at how Czechia and Austria are considering these measures will be viewed to see what changes they are doing to their respective electricity systems.

4 Czech Republic

According to the National Energy and Climate Plan of the Czech Republic, a goal of 22% in RES share gross final energy consumption is to be achieved by 2030 (Ministry of Industry and Trade, 2019a). This represents an increase in 9 percentage points from the national goal set for 2020 targets with current shares already reaching just over 15% (Ministry of Industry and Trade, 2019b). In terms of the electricity sector, the final consumption is expected to increase from 13.4% to 16.9% over the next decade representing an increase of 3.5 percentage points. Table 1 shows the expected installed generation capacity from RES.

Table 1: Expected installed capacity (Ministry of Industry and Trade, 2019a)

Installed generation capacity (MWe)	2020	2025	2030
Biomass	376	435	454
Hydropower	1090	1117	1127
Biodegradable component of MSW	55	133	154
Biogas	369	337	287
Geothermal	10	10	10
Wind	282	625	970
PV	2068	2628	3975
Total	**4240**	**5285**	**6977**

Projected investments needed for the next decade in RES development total at approximately CZK 327.5 billion (approx. EUR 12.3 billion)[1]. Of this value, CZK 135.7 billion will be invested towards electricity generation (Czech Technical University in Prague, 2020). Based on this future increase in RES share and capacity, both in Czechia and its neighbouring states, as well as trying to meet the interconnection target, it is important that the transmission and distribution grid infrastructure goes through certain improvements in order to maintain a stable electric system. In terms of target goals related to interconnection,

[1] EUR 1 = CZK 26.5

Czechia's transmission system (TS) has been able to maintain import and export capacity reserve at 30% and 35%. This shows that Czechia is already meeting its national target that goes in line with the EU's 15% interconnection goal by 2030. As a result, Czechia has not made any specific policies in regard to this target (Ministry of Industry and Trade, 2019a).

4.1 Czech Electric System

ČEPS is the transmission system operator (TSO) in Czechia.

Figure 1 shows the current transmission system in Czechia. Table 2 shows general characteristics of the transmission system. Over the next decade, development of the transmission system will continue as Czechia further tries to fulfill its energy targets (Ministry of Industry and Trade, 2019a). Such measures to improve the system include the following:

- System maintenance
- New transmission/distribution lines
- Gradual phase-out of the 220 kV network
- Developing or improving TS/DS transformation links

Figure 1: Czech Transmission System (ČEPS, a.s., 2020)

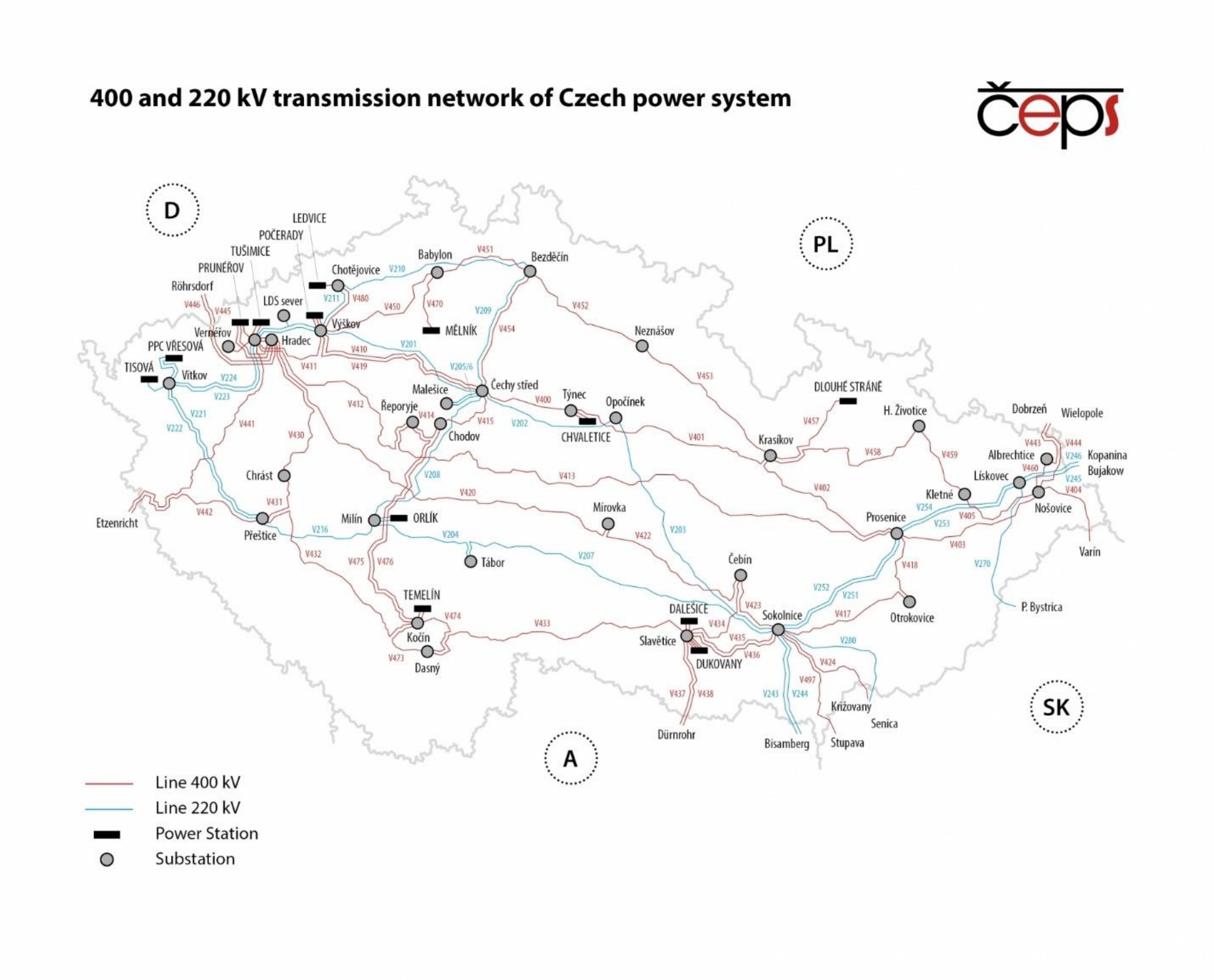


Table 2: Czech TS characteristics (ČEPS, a.s., 2020)

Facility Description	Total
Transmission Lines	
400 kV	3780 km
of which double and multiple lines	1417 km
220 kV	1737 km
Of which double and multiple lines	866 km
110 kV	84 km
Of which double and multiple lines	78 km
Substations	
400 kV	28
220 kV	14
110 kV	1
Transformers	

400/220 kV	4
400/110 kV	49
220/110 kV	20
400 kV phase-shift transformers	4

Table 3 shows upcoming planned generation facilities that are expected over the next two decades which also includes RES in the form of the wind park at Chomutov (ČEPS, a.s., 2018). In order to accommodate this additional capacity, additions to the grid will be needed to ensure proper power evacuation of this new generation. Therefore, over the next decade, new transmission lines will need to be constructed and substations will need to be upgraded. The 220 kV network is to be gradually phased-out by 2040 and reinforced with 400 kV double lines. Table 4 displays the construction of new lines up until 2050. With the gradual phase-out of the 220 kV network, transformers and substations will also need to be upgraded in order to accommodate the increase in the 400 kV network. Additionally, the effects of Czechia's further economic growth are leading to an increase in national consumption. By 2025, the construction of new 400/110 kV substations are expected to be constructed in Vítkov, Dětmarovice, Prague North and Milín in order to accommodate the increase in demand in these areas (Ministry of Industry and Trade, 2019a). The network reinforcement will also cause an increase in reactive power in the distribution system as a result which will need to be compensated with added facilities in order to maintain appropriate voltage limits.

Table 3: Planned generation plants to be connected to the TS (ČEPS, a.s., 2018)

Generation Plant	Installed Capacity (MW)	Date of Connection
Chomutov wind park	140	November 2020
Temelín nuclear plant – Unit 3	≤1700	December 2035
Dukovany nuclear plant – Unit 5	≤1200	December 2035
Temelín nuclear plant – Unit 4	≤1700	December 2036
Dukovany nuclear plant – Unit 6	≤1200	December 2036

Table 4: Length of new transmission lines (in km) (Ministry of Industry and Trade, 2019a)

Construction of TS lines	Length of new 400 kV lines in 2017-2025	Length of new 400 kV lines in 2026-2050
Construction within a new route	189	70
Construction of double line in original route	572	629
Total length	**761**	**699**

With an additional wind park that will be added to the TS at the end of this year as well as future RES in the Karlovy Vary area with a capacity of 100 MW (ČEPS, a.s., 2018), the following measures are being proposed to the system in order to accommodate this new source:

- Adding a new double 400 kV line between Vítkov and Vernéřov.
- Adding a new double 400 kV line between Vítkov and Přeštice.
- Constructing a new 420 kV substation at Vítkov.
- Extending the Přeštice 420 kV substation.

Taking into account the additional nuclear units at Temelín and Dukovany power plants, the following measures are being proposed to the TS which include:

- Adding a double 400 kV line between Kočín and Mírovka.
- Adding a 110 kV line between Kočín and the Temelín NPP.
- Adding a double 400 kV line between Mírovka and Čebín.
- Renovating and modernizing the existing Kočín TR.
- Adding a loop from the 400 kV line V413/416 to the Mírovka substation.
- Adding a double 400 kV line between Kočín and Přeštice.
- Extending the Přeštice, Kočín, Mírovka, and Čebín 420 kV substations for the connection of necessary lines.
- Adding a new double 400 kV line between Slavětice and Sokolnice.
- Building another new double line from the Sokolnice 420 kV substation.
- Reconstructing and extending the Slavětice 420 kV substation.
- Reconstructing and extending the Sokolnice 420 kV substation.

In terms of interconnection with neighbouring EU member states and its geographical location, Czechia has had complications with trying to keep a balanced power flow (ČEPS, a.s., 2018). Combined with Germany's continued phase-out of nuclear, high renewable generation and inadequate capacity for its transmission, while also considering the high consumption in Austria and Italy, Czechia has faced issues with scheduled market flows and actual physical flows in the system. As a result, the Commission has added projects to its list of PCIs (European Commission, 2017) to aid in improving Czechia's interconnection that include the following measures to its TS:

- Doubling of an existing 400 kV line between Přeštice and Kočín.
- New double 400 kV line between Kočín and Mírovka.
- Reconstruction and extension of the Kočín 420 kV substation.
- Construction of a new 420 kV substation at Vítkov.
- Conversion of an existing double 220 kV line between Hradec and Vítkov to a double 400 kV line between Vernéřov and Vítkov.
- Conversion of an existing double 220 kV line between Vítkov and Přeštice to a double 400 kV line.
- Reconstruction and extension of the Mírovka 420 kV substation.
- Loop from the existing 400 kV line between Řeporyje and Prosenice to the existing 420 kV substation Mírovka.
- Construction of a new cross-border line between Otrokovice (CZ) and Ladce (SK).

4.2 Infrastructure Investment

Figure 2 displays the projected development of the Czech TS in 2028. An investment breakdown from ČEPS, a.s. was made in their ten-year transmission system development plan of the Czech Republic from 2019-2028. This takes into account the measures that have been mentioned previously in this paper as well additional project to help improve the TS. The total investment in this period is to be about CZK 66 billion (EUR 2.47 billion) (ČEPS, a.s., 2018). However, due to lengthy planning periods and continued delays with permitting procedures, a more probable distribution of funding over this period can be seen in

Table 5.

Figure 2: State of Czech TS in 2028 (ČEPS, a.s., 2018)

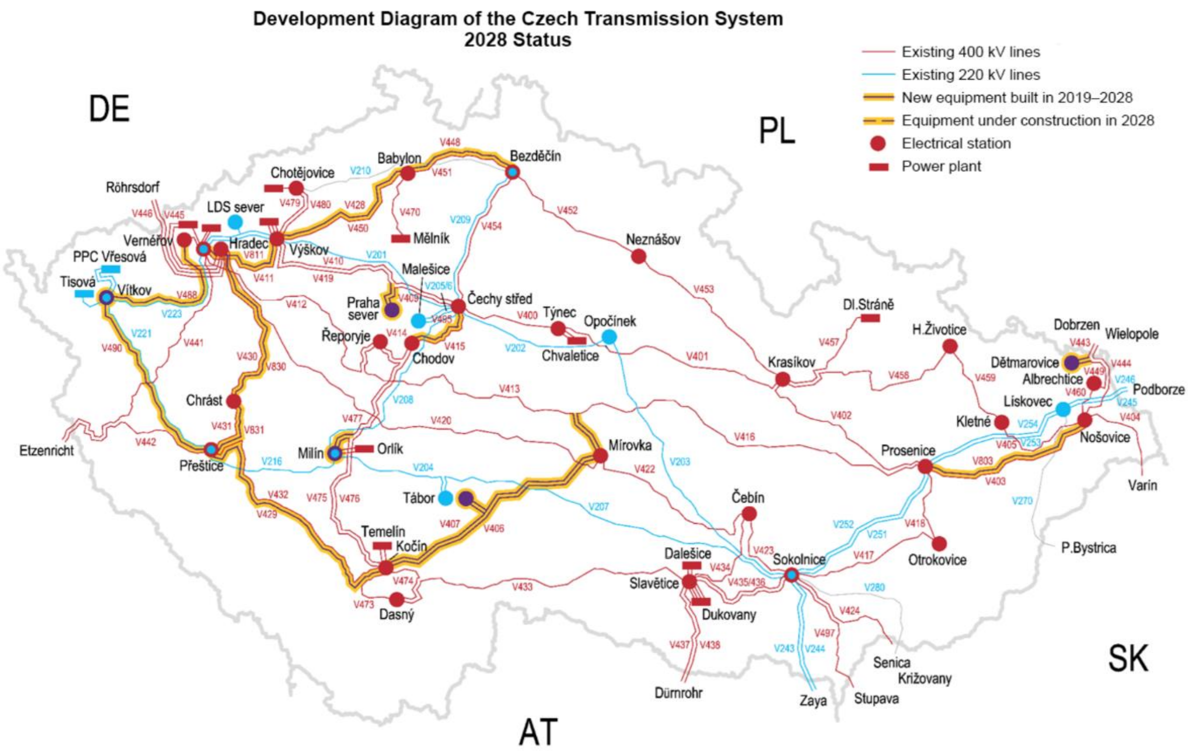


Table 5: Probable Investments in the TS 2019-2028 (ČEPS, a.s., 2018)

Investment Breakdown (CZK billions)	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	SUM
Development—Customers	1,764	1,803	0,986	1,885	2,485	0,802	0,894	0,384	0,403	0,305	**11,712**
Development—ČEPS	1,521	1,181	0,634	0,818	1,482	1,319	0,472	1,068	2,470	2,382	**13,347**
Renovation—Substations	0,325	0,531	0,350	0,525	0,607	0,369	0,409	0,083	0,123	0,406	**3,728**
Renovation—Lines	0,889	1,472	0,648	0,257	0,254	0,880	0,668	0,610	0,928	1,362	**7,967**
SR+RP	0,381	0,157	0,330	0,450	0,550	0,550	0,650	0,650	0,650	0,650	**5,019**
Other	0,412	0,306	0,299	0,371	0,370	0,370	0,520	0,520	0,520	0,520	**4,207**
Total	**5,292**	**5,450**	**3,247**	**4,307**	**5,747**	**4,291**	**3,612**	**3,315**	**5,095**	**5,624**	**45,981**

Note: SR+RP = Small-scale renovation and real property

Table 5 shows a total investment of about CZK 46 billion (EUR 1.72 billion) showing a gap of CZK 20 billion (EUR 0.75 billion). Taking the above investments combined with the further investments in the generation and distribution system, the Czech NECP shows a total cumulative investment of CZK 651 billon (EUR 24.32 billion) in the whole electrical system from 2021-2030 (Ministry of Industry and Trade, 2019a).

Table 6 shows a breakdown of these investments.

Table 6: Investment in the Czech electrical system 2021-2030 (Ministry of Industry and Trade, 2019a)

System	Investment (EUR billion)[2]

[2] EUR 1 = CZK 26.5

Generation	15.62
Transmission	1.94
Distribution	6.76
Total	**24.32**

In terms of the distribution system, Czechia is turning towards the use of smart grid technology in order to make a more efficient network that regulates energy based on actual consumption and also will improve use of RES. Additionally, promoting smart grid development will better prepare the grid for connecting electric vehicles and batteries to it while also improving cross-border network cooperation. A major project that is in the process of being implemented is the ACON Smart Grids which is a joint project between Czech and Slovak distribution system operators, E.ON Distribuce (CZ) and Západoslovenská distribučná (SK). This project is also a PCI in the EU and is the first PCI project of distribution companies in the Central and Eastern Europe region (Ministry of Industry and Trade, 2019a). The project is to be realized in 2024 and its estimated value is EUR 221 million (ACON, 2020). EU financial support from the Connecting Europe Facility (CEF) programme has funded the project in the amount of EUR 91.2 million (Ministry of Industry and Trade, 2019a).

4.3 Moving forward

Policies that can help improve electricity infrastructure moving forward include the following:

- Use of financial support at both national and EU level
- Removal of administrative burdens such as issues with permitting
- Setting proper business regulatory rules to attract infrastructure investments

In Czechia, the Energy Regulatory Office (ERU) sets a new price regulation every 5 years for the electricity and gas sectors. For the new regulatory period from 2021-2025, the ERU ensures a pro-investment approach using a regulatory asset base model (RAB) in which the weighted average cost of capital will be constant throughout the regulatory period (Energetický regulační úřad, 2020). This guarantees a fixed rate of return and reducing risk on the investment despite the uncertain nature of RES and decentralized resources and the high capital intensiveness of these projects. The RAB model also ensures that the ERU will protect private investors by revising these rates to account for any unexpected increases in capital expenditures, thus providing added security to these investments.

When it comes to continued use of national funding such as the Operational Programme Enterprise and Innovations for Competitiveness (OP EIC) to help modernize the electric system. This grant has specific priorities within its framework dedicated to supporting the construction of smart electricity networks. Greater interest in this grant should be able to cover the expected increase in decentralized sources in the system and consumption management technology (Ministry of Industry and Trade, 2019a). Additionally, continued use of EU funds such as the European Regional Development Fund and the CEF programme should be exploited for aid in modernising energy infrastructure.

Additionally, removing administrative burdens for project developers related to project planning and permitting is also important moving forward. Permitting procedures remain complex especially when the procedures in PCI and non-PCI projects in energy infrastructure are different in most member states. Ways to mitigate these burdens can be a cooperation between member states and the EU in making common rules and a one-stop-shop method in streamlining the permitting process (Rademaekars, 2018).

5 Austria

This section provides an overview and a short analysis of the proposals of the Austrian Federal Ministry for Sustainability and Tourism (Österreichisches Bundesministrerium für Nachhaltigkeit und Tourismus, from now on referred to as BMNT) in the NECP concerning Energy, Electricity and similar topics.

5.1 Short overview

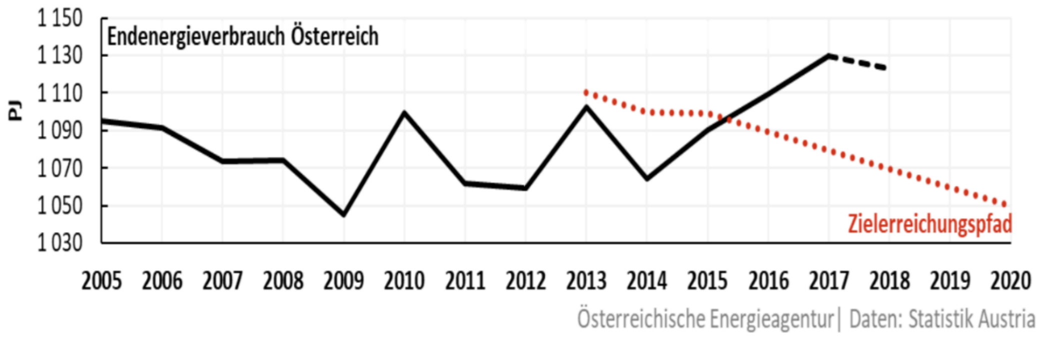
Generally, the Austrian government wants to promote the switch to renewable energy sources and energy efficiency measures for heating and cooling on the whole energy and industry sector by new regulatory policies, financial incentives and by phasing out of counterproductive incentives and subsidies (BMNT, 2019, p. 11). The share of renewable energy in the gross final energy consumption shall be 46-50% and all the electricity shall be produced from renewable sources. The government wants to achieve this by a rooftops solar panel and small-scale storage program, by creating the possibility of feeding biogas and renewable hydrogen into the natural gas infrastructure and developing a hydrogen strategy. Furthermore, there shall be tax advantages for hydrogen ad biogas, tax exemptions for sustainable biogas and hydrogen and bio-liquefied natural gas (bio-LNG), a tax advantage for LNG and the tax for self-produced and self-consumed electricity generated via Photovoltaic systems shall be abolished (BMNT, 2019, p. 13). Concerning the energy supply security Austria plans to invest in the gas, electricity and district heating infrastructure as well as in storage including heat accumulators and to grant remunerations to storage for system capacity. Efficient existing installations shall be maintained, and the demand response accelerated (BMNT, 2019, p.16). Concerning the internal energy marked the Austrian government has the goal to accelerate and simplify licensing procedures, relax power line regulations, develop an Austrian grid infrastructure plan, accelerate market integration and energy system flexibility and to adapt the grid tariff structure (BMNT, 2019, p. 16). The 100,000 rooftops solar panel and small-scale storage program and the preferential tax treatment for renewable hydrogen and biomethane are also amongst the 12 flagship projects defined for Austria's #mission2030 (BMNT, 2019, p. 21).

5.2 Current Policies and current situation

5.2.1 Energy consumption and efficiency

A key role in reaching Austria's 2020 targets is a reduction in energy consumption through higher energy efficiency. Measurements taken in order to reach this goal include compulsory external energy audits for large companies, the requirement for energy suppliers to implement energy efficiency measures and various strategic measures to support energy efficiency (BMNT, 2019, p. 37).

Comparing the target trajectory with the actual energy consumption one has to conclude that these measures were not sufficient.



Source: Austrian Energy Agency, Statistics Austria, 2019

Endenergieverbrauch Österreich	Final energy consumption in Austria
Zielerreichungspfad	Target trajectory
Österreichische Energieagentur	Austrian Energy Agency
Daten: Statistik Austria	Data: Statistics Austria

Figure 3 Energy consumption in Austria compared to the 2020 goals (BMNT, 2019, p. 37).

In 2018 we saw a decline in Energy consumption but in 2019 the figures were again higher than in 2017 according to the Federal Statistic Agency of Austria (Statistik Austria, 2020).

According to the Federal Ministry of Sustainability and Tourism the reason for the higher Energy consumption is an increase in transport and industrial production (BMNT, 2019, p. 38). Apparently, this increase had not been expected. Looking at the success of the measures separately the ministry concludes that the most successful tools were energy taxation and obligatory measures concerning heating and hot water systems. Looking at the absolute numbers, energy efficiency obligation schemes for energy suppliers are responsible for the biggest share of the energy savings (BMNT, 2019, p. 39).

About a third of the energy used in Austria is produced within the country. A big share of it stems from renewable energy sources with hydroelectricity and biogenic fuels as the biggest contributors. The other two thirds are being important. The by far biggest share of the imported energy comes in the form of oil and natural gas. The security of supply has increased with a fall of the net import tangent from 72.2% in 2005 to 64.5% ten years later (BMNT, 2019, p. 40).

The risk assessments for the electricity supply are currently on a voluntary basis. The infrastructure for energy supply is protected by the Austrian Program for Critical Infrastructure Protection (APCIP) which is carried out by the Federal Chancellery and the Ministry for Interior together with all relevant players (BMNT, 2019, p. 43).

5.2.2 Infrastructure and Grid Interconnectivity

Concerning grid connectivity with neighbouring states the Federal Ministry of Sustainability and Tourism states that the EU-goal of an electricity interconnection level of 10% in 2020 has already been overachieved in 2017 with a level of 15.2%.It does state however that there are bottlenecks in the transmission network for Hungary, Czechia, Slovenia, Italy and Switzerland. Due to regulatory requirements another bottleneck exists for Germany as of October 1, 2018. A direct grid connection between Austria and Slovakia does not exist. Due to its geographical position Austria plays a role in a lot of initiatives working towards an integrated electricity grid and market in the European Union. It is part of the Central Eastern European region (CEE), the Central Southern European region (CSE) and the Central Western European region (CWE) (Austrian Power Grid AG, 2014). Austria is also part of the Central and South-Eastern Europe Connectivity (CESEC) regional initiative formed by EU and non-EU countries in order to speed up the integration of gas and electricity markets. Austria has two transmission system operators, the Austrian Power Grid AG (APG) and Vorarlberger Übertragungsnetz GmbH (VÜN). While VÜN is present in the very west of Austria, APG is responsible for most of the Austrian transmission system and the two operators collaborate closely. The two transmission system operators have to submit Network Development Plans to the regulator E-Control (BMNT, 2019, pp. 44-46).

In the EU Projects of Common Interest (PCIs) for electricity transmission are detected by a cooperation of the Member States, the Commission and the Agency for the Cooperation of Energy Regulators. The goal is to build nine transmission corridors within the EU. Austria is especially affected by north-south-flows within the European network and plays a role in balancing the volatility in renewable energy generation. Therefore, the PCIs where Austria contributes with current projects concern the north-south electricity interconnection in western respectively in southern and eastern Europe. The projects include:

- A capacity increase of the hydro-pumped electricity storage in Kaunertal in the west of Tyrol
- A 380 kV interconnection between St. Peter in Upper Austria and Isar in Germany
- A 380 kV internal line between St. Peter in the west of Upper Austria and Tauern in the west of Salzburg
- A 380 kV internal line between Westtirol and Zell am Ziller in the East of Tyrol
- A 220 kV interconnection between Würmlach in Carinthia and Somplago in Italy (BMNT, 2019, p. 47).

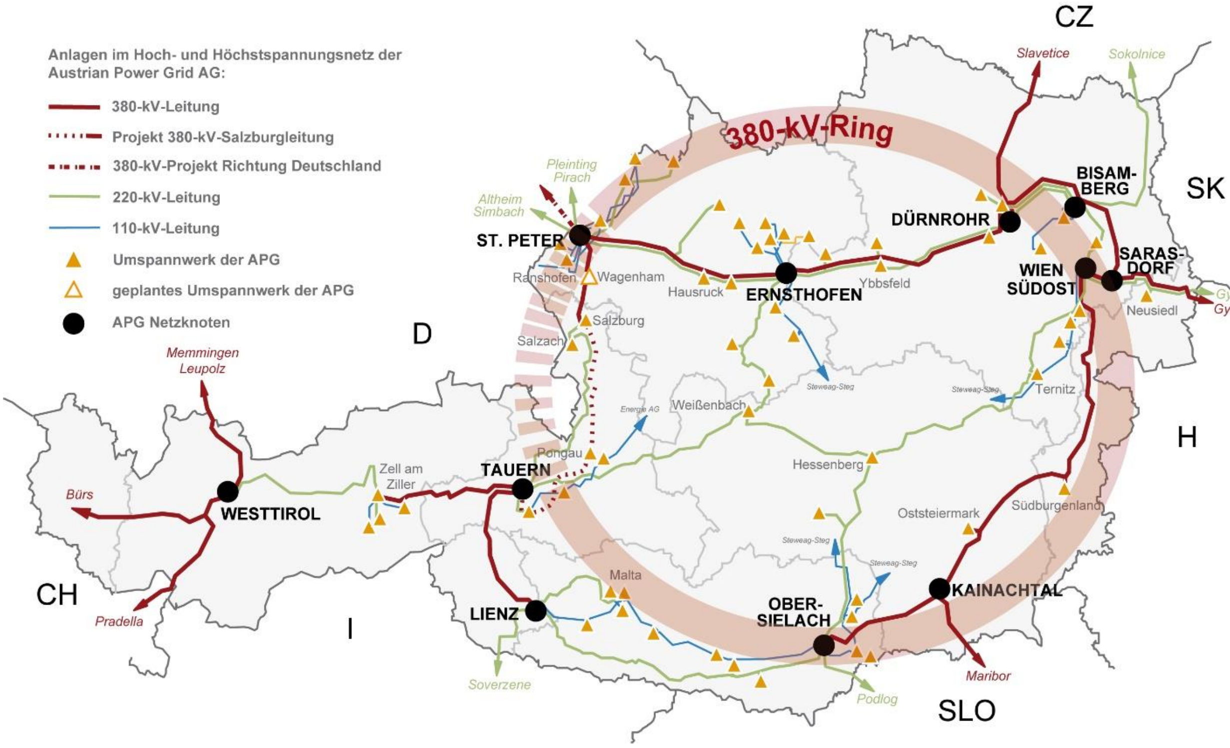


Figure 4 The planned 380kV-ring with the gap closure in Salzburg (Austrian Power Grid AG, 2011)

The above figure shows the current Austrian high-voltage electricity network with the planed gap closure in Salzburg. The other two pending gap closures of the 380 kV-network between Lienz and Obersielach and between Westtirol and Zell am Ziller can be well identified.

The Pentalateral (sic!) Energy Forum is a regional cooperation of the six countries of Belgium, France, Luxembourg, Germany, the Netherlands and Austria. Switzerland is a permanent observer. The cooperation's main aim is forming a regional electricity market as an intermediate step towards an integrated European Union electricity market. Besides the economic and trade aspects, a well interconnected grid is also crucial for achieving this goal (BMNT, 2019, p. 61).

5.3 National targets and objectives

5.3.1 Infrastructure and Grid Interconnectivity

In the NECP Austria has set no target for the interconnectivity of the electricity grid in 2030 as the EU 2030 target of 15% is already achieved since 2017. It is stated though, that in order to achieve the target of 100% electricity production from renewable sources by 2030 Austria's electricity generation capacity needs to increase and therefore new grid infrastructure needs to be built as well. The infrastructure shall be adopted for decentralized generation, digitalisation and new storage technologies. This shall happen in an environmentally- and eco-friendly way without soil sealing and an impact on natural habitats. The BMNT identifies the following cornerstones for reaching this aim:

- Synchronizing the grid development with the development of renewable energy
- Safe-guarding reserve capacity in a cost-effective manner
- Facilitating local storage facility operations and networks by deregulation
- Using waste heat from production processes
- Using buildings as energy storages (BMNT, 2019, pp. 91-92).

Besides the projects for new major transition lines already mentioned in the previous section various other infrastructure projects are also mentioned in the NECP. The projects are located in Upper Austria, Lower Austria and Carinthia (BMNT, 2019, pp. 93-94):

- The new APG Weinviertel line in Lower Austria shall replace outdated infrastructure in the eastern Weinviertel and provide infrastructure fitting for the decentralized power generation in a region with good conditions for wind power stations. The new line shall consist of a 380kV line from Seyring near Vienna to the transformer station Zaya in the northeast, where it shall be connected to the 110 kV-network of Lower Austria (Austrian Power Grid AG, 2016).
- In the central region of Upper Austria a new 220 kV supply ring shall replace and support the current 110 kV-network. The region has seen massive development in both population and production over the last decades which lead to an increase in electricity consumption of 65% between the years 1990 and 2016. Another factor in the rising demand is that the voestalpine AG, Austria's biggest steel producer located in Linz, wants to replace much of its coal consumptions with electricity to reduce its carbon dioxide pollution (Austrian Power Grid AG, 2020).

- Similar to the project in Salzburg, the 380 kV ring connection around Austria shall be completed by building a connection between Lienz in East Tyrol and Obersielach in Carinthia. The exact route planning is not yet finished (BMNT, 2019, p. 94).

5.3.2 Market integration

Austria aims to transform the energy system in order to have an increased system flexibility and minimized market distortions. The key elements in redesigning the energy system are:

- Ensuring grid stability
- Dividing the infrastructure costs fairly, especially with more and more private generators entering the market
- Sending correct price signals to market operators in order to trigger investment and increase flexibility

One main measure to reach this is installing smart meters in 80% of Austria's meter points by the end of 2020 and 95% of the households by 2022 (BMNT, 2019, p. 95).

5.4 Policies and measurements

Measures for a more environmentally friendly electricity infrastructure in Austria include aspects of energy spatial planning. The land use of power plants and transmission infrastructure shall be minimized. This can be achieved by opting for locally available renewable energy sources, good cooperation on an inter-regional level, especially concerning large infrastructure projects, using waste heat and integrated mobility systems. Energy spatial planning shall be integrated in all aspects of special planning. One example would be building compact settlements with district heating systems that have the smallest possible distances to the consumers. The BMNT states that Austria is far from fully exploiting its potential in distance heating especially in the case of using waste heat from production. This shall be changed by effective spatial planning (BMNT, 2019, p. 140).

Another measurement for reaching Austria's targets are renewable energy communities. These communities come in a big variety of legal forms, business models and fields of interest. Members of energy communities can jointly generate, distribute of supply energy. They can carry out projects towards energy efficiency and electromobility, or generate, share and consume energy within a closed network. The formation of energy communities is promoted and supported by the European Union in various ways and in all member states. The aim is to involve citizens in the energy transition and develop new innovative players in the energy market. Their most common legal form within the EU are energy cooperatives (Caramizaro and Uihlein, 2020, pp. 12-14). The benefits of renewable energy communities shall go beyond just saving carbon dioxide emissions and include economic development, new jobs, community integration, cheaper energy, energy security and self-sufficiency (Interreg Europe, 2018).. Due to different circumstances the focus and implementations of energy communities varie between the member states of the European Union. Austria has decided that renewable energy communities must be organized as associations, cooperatives or other partnerships with legal personality. The main focus of renewable energy communities in Austria shall be the common use of the energy produced. The connections within the system shall be in a low voltage network. An analysis of the obstacles for and the potential of renewable energy communities will be prepared by the responsible ministry be 2022 (BMNT, 2019, p. 146).

Another policy important in the European context is that renewable electricity installations placed in neighbouring countries shall receive the same feed-in tariffs like the ones placed in Austria if they feed in directly to the Austrian grid (BMNT, 2019, p. 153).

The Federal Ministry for Sustainability and Tourism states that the measures for reducing the dependency on import and increasing the flexibility of the national energy system will demand investments into storage infrastructure. In the case of heating this means a need for district heating systems especially ones using waste heat. Concerning the electricity grid electrochemical storage facilities shall be promoted. Storage operation shall be made profitable by exempting it from fees applicable to end consumers and by support schemes. Storage facilities in deep geothermal systems are mentioned separately to be support worthy. They allow higher temperatures than shallow geothermal storages and therefore better energy efficiency. Exhausted oil and gas wells are seen as potential storages. It is stated that the legal framework needs to be changed for that, but it can be understood that the ministry is trying to do that. Applied research projects with pilot plants shall receive funding in order to promote storage technologies and make them market ready (BMNT, 2019, pp. 175-176).

The investments for all these infrastructure project, the Federal Ministry states, shall come equally from public players like the provinces, the Federal State or the European Union and from the private sector (BMNT, 2019, p. 177).

In order to accommodate for the needed investments to take place bureaucracy shall be accelerated and reduced and licensing procedures shortened. One example for this is that power lines up to 45 kV will be exempted from approval under the electricity law. The current threshold is 1 kV. This shall enable investments in charging stations for e-mobility. Another important point in making the energy transmission structure investments more efficient is integrating the grid infrastructure plans for electricity and gas in order to use similarities (BMNT 2019, pp. 179-180).

5.5 Investment costs

The measures to reach the goals stated in the NECP will of course not be possible without major investments. The costs for the expansion of electricity generated from renewable sources are estimated to be in the range of 20 to 27 billion Euro. The expansion of electricity networks is expected to cost six billion Euro. All the measures combined require investments of 166.5 to 173.5 billion Euro by public and private players (BMNT, 2019, pp. 259-262). In 2013 Austria's transmission system operator APG planned investments of 2.6 billion Euro for the following 10 years (APG, 2018).

6 Comparison and Conclusion

The general direction in electricity infrastructure development is planned to go in a similar direction. Due to a higher share of renewables and a higher demand significant investment in the grid is required. A special emphasis is on higher flexibility in order to deal with the higher volatility of renewable electricity generation. The path to decarbonizing the electricity generation seems a bit different in the two countries. While the Czech Republic plans to increase its capacity of nuclear power and to build a big new wind park additionally to developing new smaller scale electricity generation from renewable sources, Austria fully focuses on smaller decentralised projects like the 100,000-rooftop-initiative for private photovoltaic systems. This has direct impact on the planned projects for grid infrastructure. While the Czech Republic phases out of the 220 kV system by replacing it with 400 kV lines, Austria plans new 220 kV lines instead of 110 kV infrastructure. Austria's 380 kV ring, that shall be completed with gap closures in Salzburg and Carinthia, also operates at a lower voltage than the 400 kV-system in the Czech Republic. Another indicator for the varying strategies is the fact that in Austria private operators of photovoltaic system can sell electricity back to the grid while in the Czech Republic this is not possible for systems built after 2014. Concerning grid interconnectivity with neighbouring countries the Czech Republic as well as Austria have set no new targets as they have already achieved the existing ones. Despite that European Projects of Common Interest are implemented by both countries.

A clear analysis of the investment gaps for all the projects showed to be a too big task for this paper. Especially for Austria exact sums were hard to get. As the gap closure of the Austrian 380 kV ring in Salzburg shows legal processes can be lengthy and increase the costs significantly which makes exact calculations even more difficult. Obviously both countries work towards their goals and the goals proposed by the European Union concerning electricity markets and grid infrastructure. As smaller countries in the heart of

Europe both countries already have a high interconnectivity in electrical grids with their neighbours and invest in selective projects where they make sense. The investments in the grid infrastructure are big in both countries and the transitions of electricity generation towards renewables will remain a big challenge for the infrastructure providers in both countries. The Czech Republic seems to aim for even bigger new projects than Austria. There are various reasons for this including different starting points in grid infrastructure and the development of electricity generation from renewable sources. Both countries are pat of various initiatives towards an integrated European electricity market. Implementing this aim is a long-term process but many small steps are made towards it. Smart grids as another measure towards an electricity system based on renewable sources are a goal for both countries. Measures are taken to work towards building them but both countries started later than other European countries and the full implementation will need some more time. So, we can say that both the Czech Republic and Austria plan many sensible measures in order to base their electricity system mainly of fully on renewable energy sources. The future will show whether and how they will be implemented and if they are sufficient to reach this goal.

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