Federal Ministry
Republic of Austria
Climate Action, Environment,
Energy, Mobility,
Innovation and Technology

Integrated Austrian Network Infrastructure Plan

Draft for public consultation

Vienna, 2023

Legal notice

Media owner, publisher, editor:
Federal Ministry Republic of Austria Climate Action, Environment, Energy, Mobility, Innovation and Technology, Radetzkystraße 2, 1030 Vienna, Austria
Vienna, 2023. Last updated: 25 October 2023

Feedback: If you would like to share any feedback about this brochure, please contact sup.oenip@bmk.gv.at.

Table of Contents

1 Introduction

1.1 Background

Austria has defined the goal of becoming climate-neutral by 2040 and thus wants to become a pioneer in Europe in energy transition and climate protection. The goal of climate neutrality is legally anchored in the Renewable Energy Expansion Act [EAG] and the Gas Industry Act [GWG]. To achieve climate neutrality, a transformation of the energy system is required to achieve a complete substitution of fossil energy sources with renewable energy sources. The transformation process also makes important contributions to increasing the resilience and security of the Austrian energy supply, to the affordability of energy for the population and to making it more attractive as a business location. Forward-looking and predictable development enables timely and targeted investment decisions by private individuals and companies and thus also contributes to the avoidance of stranded costs.

There is already a clearly increasing trend towards electrification in the area of energy production and consumption. Since electrical energy can be used in many ways and usually with particularly high efficiencies, the trend towards electrification of energy applications will continue in the course of the transformation towards a climate-neutral energy system. For this reason, the expansion of electricity generation from renewable sources will be particularly important in the course of the phase-out of fossil fuels. In the Renewable Energy Expansion Act [EAG], the goal of increasing the share of domestic renewable energies in Austria's total electricity consumption to 100% by 2030 (national balance) was anchored. The existing electricity infrastructure will have to be adapted to the new conditions.

In the area of gas supply, Austria faces the challenge of phasing out the use of natural gas by 2040 and replacing it with renewable electricity or other renewable energy sources. In addition, the current geopolitical situation, especially the conflict in Ukraine, has led to a crisis situation on the energy market, in which Austria's high dependence on natural gas supplies from Russia has created major challenges. In sum, this and the limited availability of renewable gases such as biomethane and renewable hydrogen mean that they are mainly used in those applications where no alternatives are available.

The expansion and further development of the network infrastructures for electricity, natural gas and renewable gases are of particular importance in the necessary transformation of the energy system. In the past, expansion planning in the area of electricity and gas infrastructure was carried out relatively independently by the responsible network operators. Today, however, a strategic integrated approach to network infrastructure development is required, as timely and ongoing expansion, transformation and modernisation of the energy infrastructure are crucial for the long-term and continuous maintenance of security of supply. Thanks to an integrated approach, the further development of the energy infrastructure is no longer based on individual sector considerations, but is planned on the basis of a common supply objective. This integrated network infrastructure planning enables a cost-efficient and targeted expansion of the electrical network and supports measures for a suitable restructuring of the gas infrastructure. This approach should also enable improved coordination of efficient and demand-oriented network expansion with the expansion of facilities for the generation and storage of electricity and gas from renewable sources.

In order to meet future requirements, section 94 of the Renewable Energy Sources Act stipulates that the Federal Minister for Climate Protection, Environment, Energy, Mobility, Innovation and Technology must prepare an integrated network infrastructure plan (NIP). This is to be aligned as an accompanying measure in accordance with the "Governance Regulation" (EU) 2018/1999 and subjected to a strategic environmental assessment.

- This version of the integrated network infrastructure plan is the first version. Since the energy transition must be accelerated and the energy system is characterised by very dynamic developments, the integrated network infrastructure plan pursuant to the Renewable Energy Sources Act will be further developed and supplemented every five years at the latest.

1.2 Integrated Network Infrastructure Plan (NIP)

The Integrated Network Infrastructure Plan is an overarching strategic instrument that shows the fundamental requirements and objectives of network planning in the electricity and gas sectors for a holistic energy transition. With a view to the overall energy system, the NIP - in accordance with the legal mandate - is to support the concrete network planning of electricity transmission networks, gas networks in the area of long-distance pipelines and network levels 1 and 2, as well as the planning of the development of a hydrogen infrastructure. It is upstream of the network planning activities of the respective companies and complements them on a strategic level. Its synoptic view helps to ensure that the specific interactions are recognised in the planning, construction and operation of infrastructure and that synergies between energy sources, generation and consumption sectors are utilised as early as in the planning phase of energy infrastructures, for example in the network integration of electrolysis projects.

Sector coupling is of particular importance in an integrated energy system. This concerns not only "classic applications" such as gas-fired combined heat and power plants, but increasingly also infrastructure for biomethane and renewable hydrogen, as well as associated generation plants such as electrolysers and also corresponding storage technologies.

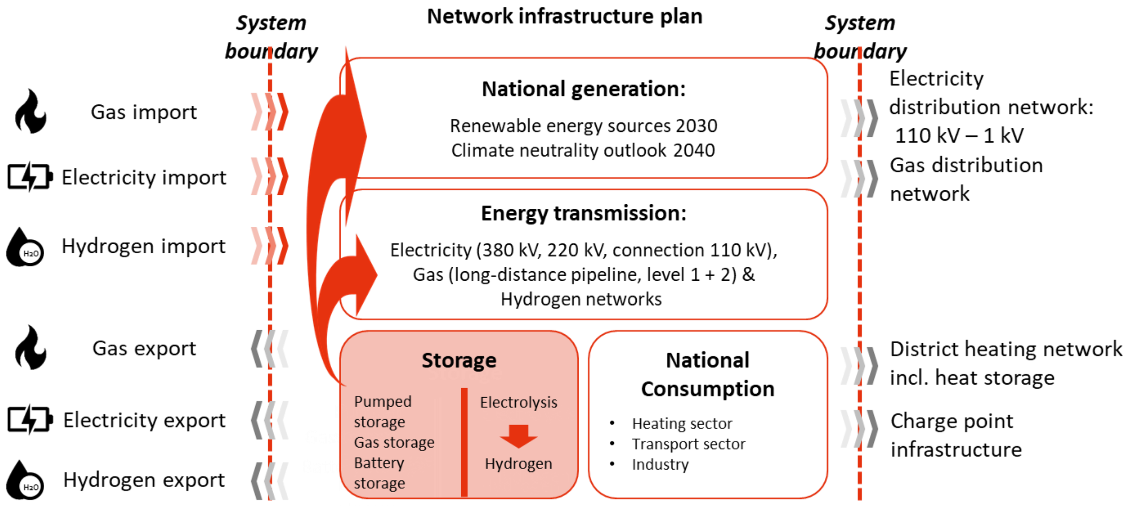


Figure 1: Study area and system boundaries of the integrated network infrastructure plan

The system boundaries shown in Figure 1 indicate which areas are taken into account in the NIP. In accordance with the legal mandate, the focus is on the area of energy transmission. In the electricity sector, these are the 380 kV and 220 kV networks up to the transformer stations, to which the subordinate 110 kV distribution networks are connected. These are no longer part of the area under consideration. In the area of gas supply, the NIP focuses on the transmission network and network levels 1 and 2 on the one hand, and on the future network infrastructure for hydrogen on the other.

The considerations are based on current scenarios for the development of national energy consumption and the national generation of electrical energy from renewable energy sources incl. renewable gases. They are supplemented by questions about the use of storage technologies and flexibility options.

In order to take the dynamic development of the transformation of the energy system into account, this first version of the network infrastructure plan is designed for a planning period up to 2030. However, since the use of infrastructure is designed for decades and the transformation of the energy system will continue until 2040 in any case, the NIP also offers an outlook for the year 2040. It will subsequently be updated, developed and supplemented accordingly – in accordance with the EAG every five years.

1.3 Structure and contents of the integrated network infrastructure plan

Chapter 2 describes the principles and economic benefits of future integrated network infrastructure planning for electrical energy, methane and hydrogen. The main part of the chapter is the derivation of transport requirements and network needs for the years 2030 and 2040 on the basis of determined area potentials for renewable electricity and biomethane production and assumed energy quantity structures. The energy quantity frameworks were collected by the Federal Environment Agency with the "Transition Scenario" and assume the achievement of climate neutrality in 2040. This is done on the basis of comprehensive scientific model-based methods developed for the NIP within the framework of cooperative research. The plans of the Austrian transmission system operators and the market and distribution area manager are incorporated into the network infrastructure from 2030 onwards presented in the NIP.

The results are presented and discussed in chapter 3. The findings and calculation bases of the NIP are compared and discussed with the plans of APG and AGGM.

2 Integrated infrastructure planning

2.1 Principles and economic benefits of integrated planning

The integrated network infrastructure plan (NIP) represents the first strategic planning document of its kind in which the electricity and gas infrastructure required in Austria in the future is considered collectively up to 2040. The primary objective of the NIP is to identify transport needs for electricity and gas between regions, taking into account generation and consumption. The advantage of integrated planning lies in the possibility of an analysis across energy carriers, which considers the need for conventional network expansion by taking cross-sector solutions into account. This clearly distinguishes the integrated approach from the operational planning of a transmission system operator or market area manager. These plans have to take into account, for example, contingencies and market obligations, but without including other energy sources.

The NIP focuses on the planning of the higher-level network-based energy infrastructures for electricity and gas. Since generation from wind power and photovoltaics is volatile, high negative residual loads are to be expected in the power system [1] (Energy Brainpool, 2019). In order to meet these challenges, hybrid solutions that integrate the energy sources electricity, gas and heat are being investigated. By linking electricity, gas and heat networks, seasonal storage facilities can be integrated into the planning, for example (Fraunhofer-Institut für System- und Innovationsforschung, 2019) (Kienberger, Greiml, & Braunstein, 2021). In addition, integrated access through hybrid coupling can enable energy conversion cascades with increased primary energy efficiency and can minimise transport requirements for individual energy carriers.

The integrated planning approach of the NIP is intended to support the path to Austrian climate neutrality by 2040 and directly brings clear economic benefits for Austria. With an integrated view of the energy carriers electricity and gas, synergies between the energy carriers can be used and thus the entire Austrian energy system can be optimised. This

---

[1] Residual load is the term used to describe the electricity consumption that "remains" after deducting fluctuating renewable electricity generation. In simplified terms, this refers to electricity consumption that cannot be covered by electricity generation from wind turbines or PV systems. A negative residual load thus means that electricity generation from wind turbines or PV systems exceeds consumption.

approach ensures that future infrastructure developments are coordinated with each other and thus domestic resources are used in the best possible way. Coordinated planning avoids the creation or further expansion of infrastructure that is not needed. Long planning horizons for infrastructure require such a planning approach at the earliest possible stage. By coordinating the expansion of the infrastructure, the costs for the end customers, which are incurred through the network tariffs, are also minimised.

The massive price increases for natural gas and subsequently also for electricity triggered by the Russian war of aggression on Ukraine underline the need for adequate infrastructure planning with regard to both cost considerations and security of supply. The diversification of gas supply and the reduction of import dependency on Russian natural gas are of central importance for future security of supply. Therefore, the energy infrastructure must also be geared towards this goal.

In addition to energy savings, key points for reducing national import dependencies are the promotion of domestic energy production from renewable energies. In addition to increasing efficiency, the priority is to tap the economically and ecologically viable domestic renewable potential. The increasing electrification of the energy system also plays an important factor here. On the one hand, the replacement of fossil energy sources with electrical energy leads to clear efficiency gains - e.g. in the use of heat pumps or electromobility - but overall, this changeover results in a steady increase in electricity consumption. To meet this increasing electricity consumption, not only a rapid expansion of national renewable electricity generation is necessary, but also of the associated network infrastructure to be able to guarantee transport between generation plants and centres of consumption. In addition to the aspect of security of supply, a high share of renewable generation also has a price-dampening effect on wholesale electricity prices.

In sum, it can be assumed that the societal benefits of an integrated energy infrastructure expansion in the sense of the NIP will clearly exceed the costs. As already mentioned in this chapter, an integrated renewable energy system brings fundamental advantages for Austria, both from a technical and an economic perspective.

2.2 Integrated plan

For the NIP, future infrastructure requirements arise for the electricity transmission network, the natural gas transmission network and for network levels 1 and 2 for gas.

Figure 2 shows the identified electricity transport demand corridors and necessary repurposing or expansions in the gas sector, which primarily serve the future transport of hydrogen. The electricity transport demand corridors are those corridors which, in the analysis of the overall system , prove to be necessary both for the elimination of the bottlenecks listed in chapter 2.3 and for an expansion of electricity transport capacities. The repurposing or expansions in the gas infrastructure shown result from the modelled hydrogen demand and planned electrolysis projects. Figure 2 shows the sector-coupling elements and battery storage systems that were also taken into account when identifying the infrastructure requirements. Although these flexibilities bring valuable relief at certain points, considerable additional transmission capacities are still required in the electricity network.

The identified transport demand corridors result from the possibility of using high generation potentials of renewable energies in the east, Austria's central embedding in the European interconnected system and the storage capacities available in western Austria in the form of pumped storage power plants. The east-west balancing necessary for a resilient and future-proof "renewable interconnected Austria-wide system" can best be achieved by a meshed extra-high voltage network, as shown in Figure 2. In the areas highlighted in dark green – Hessenberg substation to Weissenbach substation, Obersielach substation to Lienz substation and Pongau substation to Weissenbach substation – APG has already initiated line reinforcement measures (e.g. general renewal or voltage conversion) as of June 2023, which have not yet been taken into account in the NIP modelling to determine the transport requirements.

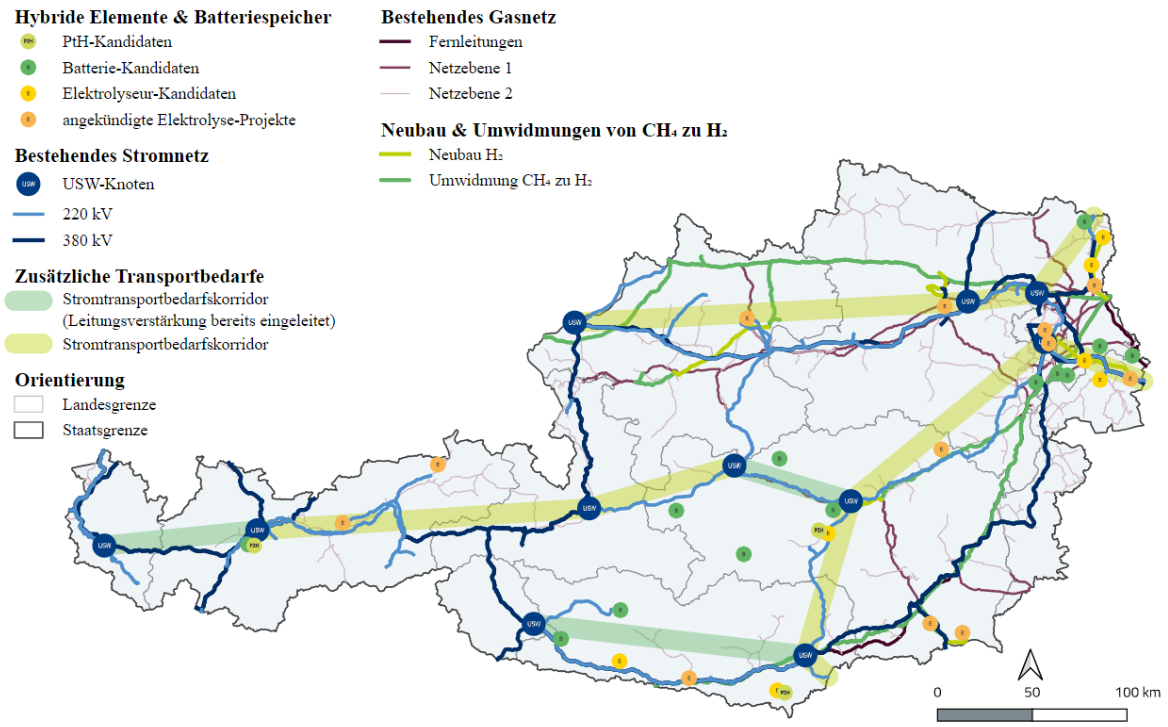
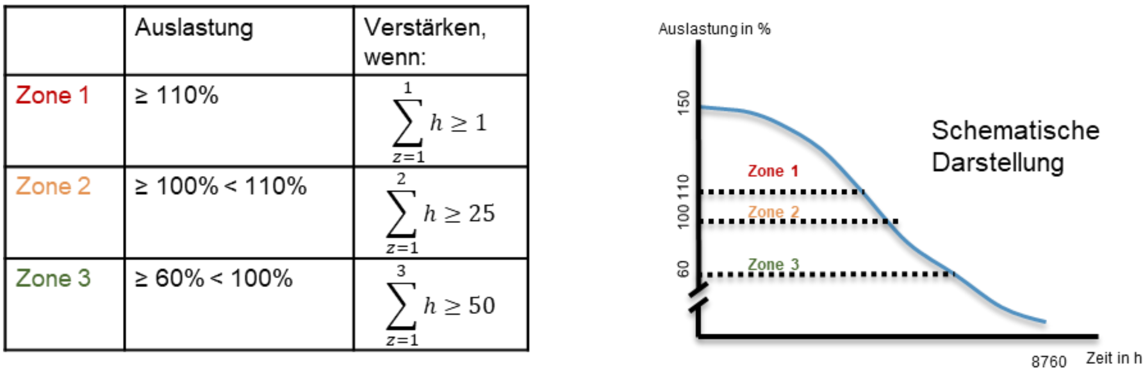


Figure 2: Integrated plan in the electricity and gas network under consideration including flexibility measures (PtX, battery storage), Source: (Lehrstuhl für Energieverbundtechnik an der MU Leoben; Institut für Elektrizitätswirtschaft und Energieinnovation an der TU Graz, 2023)

The detailed assumptions and modelling on which the analysis results presented are based are described in subchapters 2.3 and 2.4.

2.3 Electrical power network

The utilisation of the existing line infrastructure in the electrical power network was determined using a methodology developed in the InfraTrans2040 project (Lehrstuhl für Energieverbundtechnik an der MU Leoben; Institut für Elektrizitätswirtschaft und Energieinnovation an der TU Graz; Österr. Wirtschaftsforschungsinstitut, 2023). As shown in Figure 3 , in order to identify bottlenecks, the power transmission lines are first divided into different zones based on the degree and duration of utilisation. Zone 1 includes lines with very high utilisation, which exceeds 110 percent in at least one hour per year. Zone 2 includes lines with high utilisation rates exceeding 100 percent for 25 hours or more per year, unless they have already been assigned to Zone 1. Lines are allocated to Zone 3 if they are utilised at 60 percent or more for 50 hours or more per year and have not already been allocated to Zones 1 or 2. With the representation of zone 3, a simplified assumption is made for the consideration of the (n-1) criterion[2].



	Auslastung	Verstärken, wenn:
Zone 1	≥ 110%	$\sum_{z=1}^{1} h \geq 1$
Zone 2	≥ 100% < 110%	$\sum_{z=1}^{2} h \geq 25$
Zone 3	≥ 60% < 100%	$\sum_{z=1}^{3} h \geq 50$

Figure 3: Schematic representation of the determination of line utilisation in the electrical power network, Image: (Lehrstuhl für Energieverbundtechnik an der MU Leoben; Institut für Elektrizitätswirtschaft und Energieinnovation an der TU Graz; Österr. Wirtschaftsforschungsinstitut, 2023)

Figure 4 shows the modelled basic networks for the consideration of the electrical power network. In addition to the existing lines, the network shown contains the new construction (light green) and conversion projects (dark green) published by the Austrian transmission system operator APG in the network development plan for 2030 and 2040, in which existing 220 kV systems will be converted to 380 kV systems. At network level 1, the network development plans (NEP) of the transmission system operators up to and including NEP 2021 are taken into account (APG , 2021c).

---

[2] The (n-1) criterion states that the system must be designed such that the failure of a single component (such as a power line) does not lead to an interruption of the power supply. This principle must be observed by network operators when planning transmission networks.

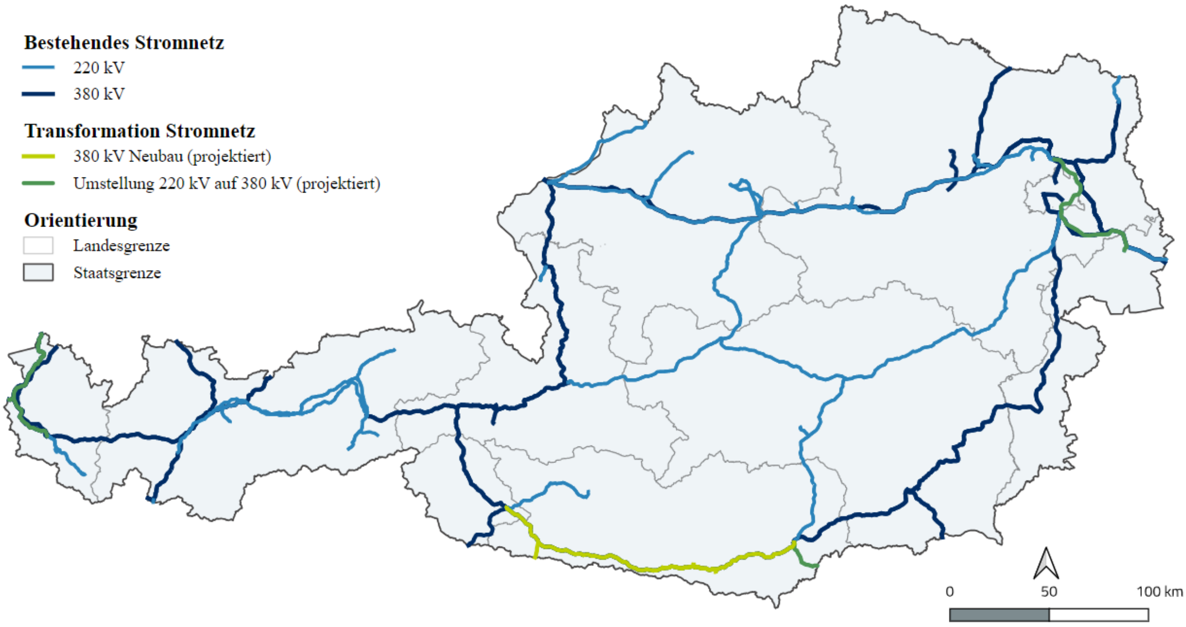
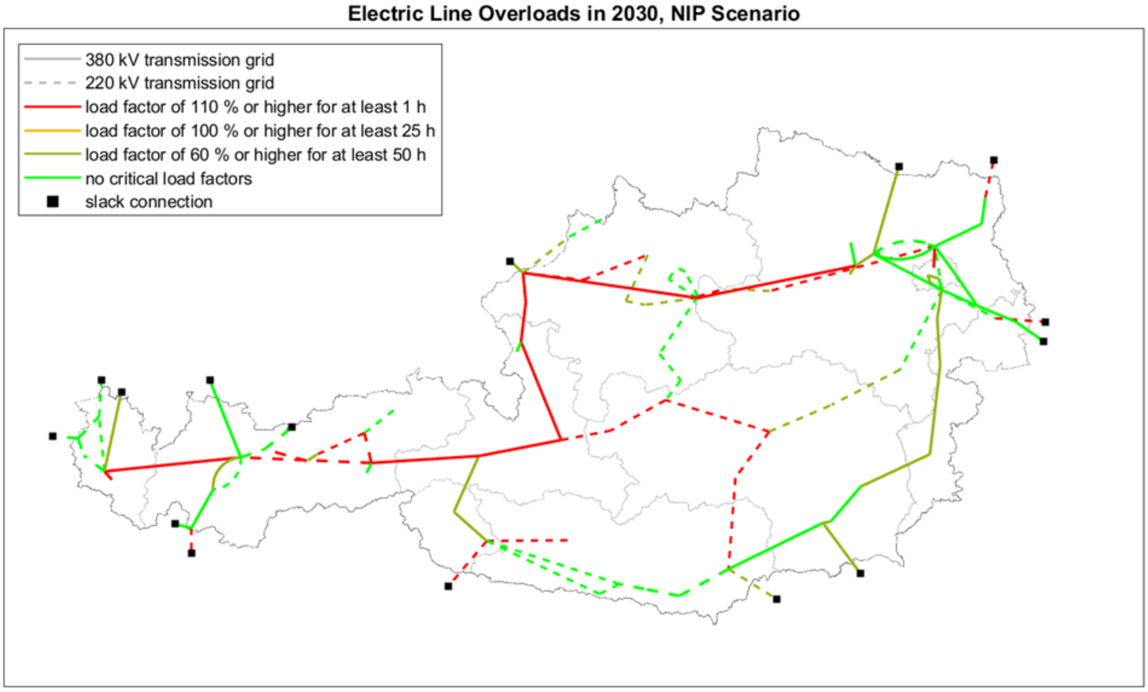


Figure 4: Considered electricity network including known expansion projects up to 2040, Image: (Lehrstuhl für Energieverbundtechnik an der MU Leoben; Institut für Elektrizitätswirtschaft und Energieinnovation an der TU Graz, 2023)

The assumed generation and consumption quantities result in the line utilisation shown in Figure 5 of the basic network shown in Figure 4 in the normal switching state (without any further assumed expansion measures). The network bottlenecks identified coincide with the results of the university research project InfraTrans2040 despite energy quantity frameworks that deviate significantly in some instances.

In particular, those lines that enable the transport of electricity from east to west would be heavily overloaded without the assumption of further line expansion measures in the electricity network. These network bottlenecks cannot be completely eliminated by using the flexibility elements discussed above, but they can be reduced. The integration of the determined network-serving flexibilities (power-to-gas, power-to-heat, battery storage) shows selective relief in the network bottlenecks that arise from the integration of photovoltaics, wind and hydropower. This is particularly evident in the east and south of Austria - for example on the 380 kV Styria line and in Carinthia (cf. Figure 5). With regard to the transport requirements described above, note that expansion measures do not necessarily have to be carried out directly at the point of the network bottleneck, but that relief in the meshed network can also be brought about in particular by ring connections or on parallel branches.



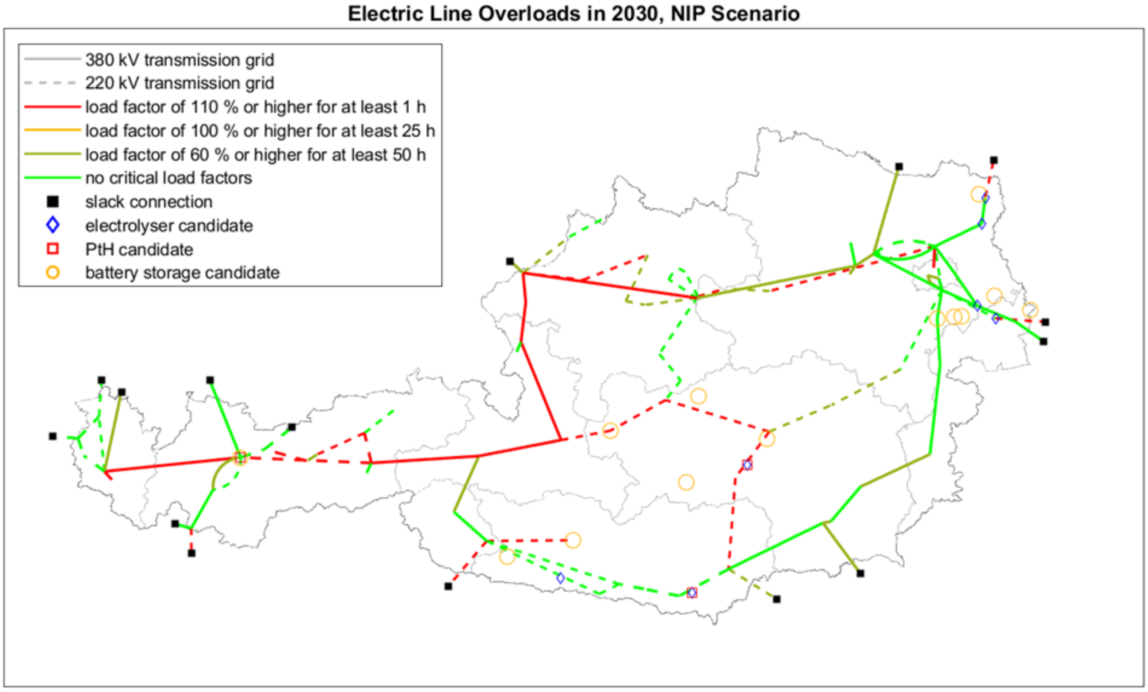
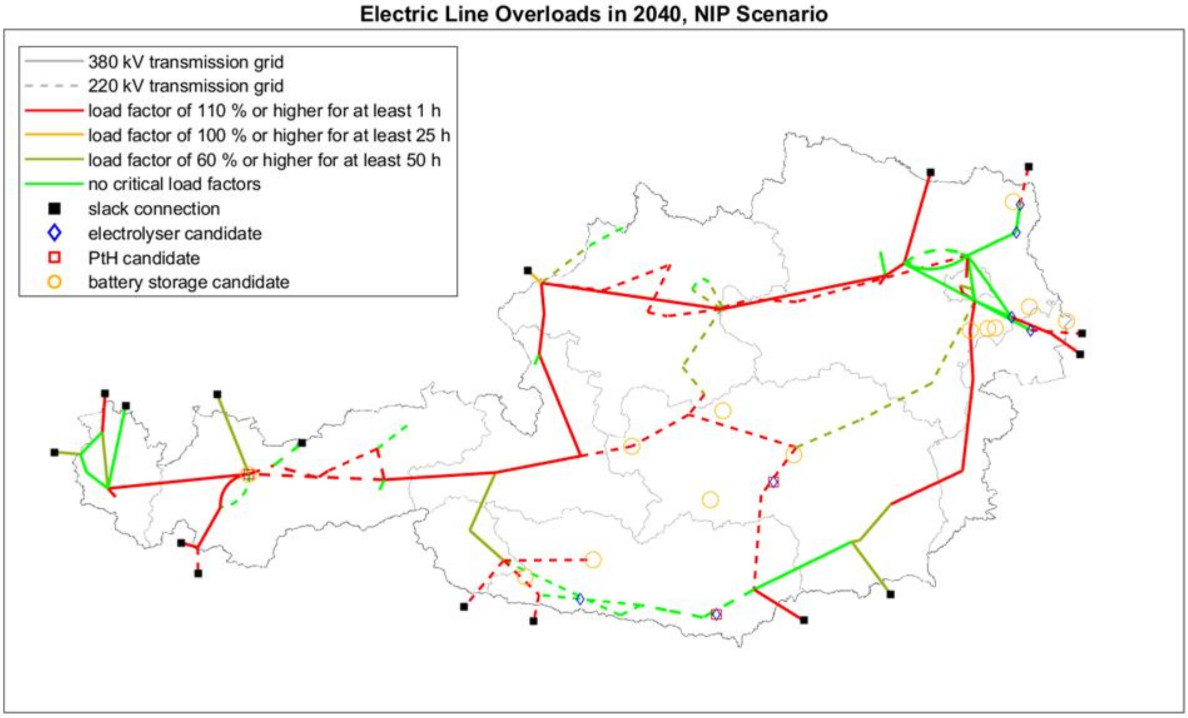


Figure 5: Modelled electricity network utilisation in network expansion 2030 with (bottom) or without (top) additional flexibility options in the year under consideration 2030, Image: (Lehrstuhl für Energieverbundtechnik an der MU Leoben; Institut für Elektrizitätswirtschaft und Energieinnovation an der TU Graz, 2023)

Figure 6 shows the loads in network level 1 (extra-high voltage) in 2040 using the flexibility options assumed after 2030. Refer to Figure 4 for the assumed basic network. This shows that the increasing generation from renewable energy sources up to 2040, especially from photovoltaics and wind power, leads to higher load flows in the bottlenecks already identified for 2030. The increased transport needs in the electrical network in the east-west and north-south connections will therefore increase even further by 2040. Taking into account the mentioned flexibility options in the area of power-to-gas, power-to-heat and battery storage, there are selective reliefs, but these do not lead to a fundamental change in the identified bottlenecks (Figure 6 (below)). The selective use of sector-coupling flexible elements (power-to-gas, power-to-heat) has even led to higher load flows in some cases for lines that previously had a lower load. This is due to the fact that in 2040 the capacity needed for overall network relief is no longer available due to the required balancing power generation at another point in a heavily loaded electrical power network. In the analysis, only the expansion measures shown in Figure 4) were taken into account, but no additional reinforcement.


Electric Line Overloads in 2040, NIP Scenario
380 kV transmission grid
220 kV transmission grid
load factor of 110 % or higher for at least 1 h
load factor of 100 % or higher for at least 25 h
load factor of 60 % or higher for at least 50 h
no critical load factors
slack connection
electrolyser candidate
PtH candidate
battery storage candidate

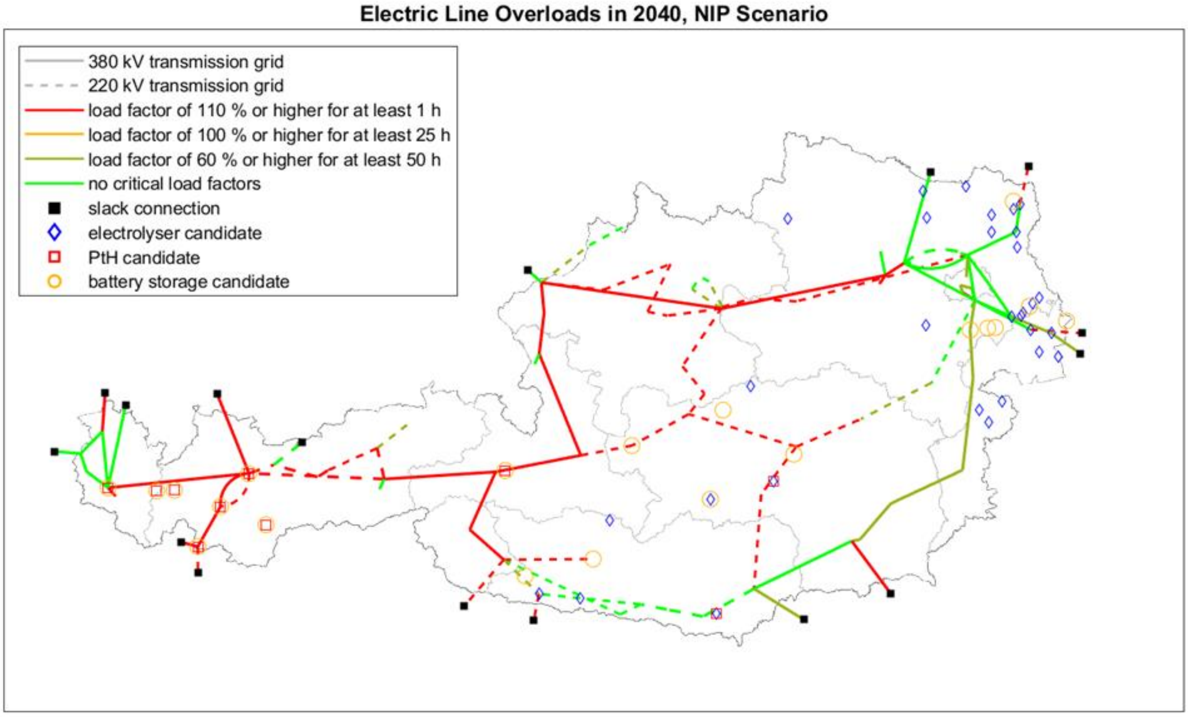

Electric Line Overloads in 2040, NIP Scenario
380 kV transmission grid
220 kV transmission grid
load factor of 110 % or higher for at least 1 h
load factor of 100 % or higher for at least 25 h
load factor of 60 % or higher for at least 50 h
no critical load factors
slack connection
electrolyser candidate
PtH candidate
battery storage candidate

Figure 6: Modelled electricity network utilisation in network expansion 2040 with (bottom) or without (top) additional flexibility options in the year under consideration 2040, Image: (Lehrstuhl für Energieverbundtechnik an der MU Leoben; Institut für Elektrizitätswirtschaft und Energieinnovation an der TU Graz, 2023)

Taking into account the possibilities described in i for network relief through sector coupling and additional selective flexibilities, the transport demand corridors shown in Figure 7 emerge. These result from the need to achieve additional resilience in the system through a network meshed at the high and extra-high voltage level. These are in line with the results of APG's network analyses, despite the strongly diverging quantity structures. In the areas highlighted in dark green in Figure 7, i.e. Hessenberg substation to Weissenbach substation, Obersielach substation to Lienz substation and Pongau substation to Weissenbach substation, measures for line reinforcement (e.g. general renewal or voltage conversion) have already been initiated by APG as of June 2023. The sections mentioned appear in the currently valid network development plans, but are not scheduled for completion until after 2030. Therefore, these planned line conversions are not included in the modelled baseline network. From the NIP modelling, which is based on different generation and consumption assumptions than those of APG, transport requirements were also identified for these line sections.

The solution to the identified network bottlenecks presented on the basis of the transport demand corridors is based on the expansion of existing transmission corridors in the area of South-east substation via Hessenberg substation to Tauern substation as well as Hessenberg substation to Obersielach substation and the reinforcement of 220 kV capacities in Carinthia. In the area of the Central Alps, increased transport capacities enable the efficient integration of pumped storage capacities in the European electricity network interconnection, which have an important role in a completely renewable electricity system. The evaluation of the implementation of solutions within these transport demand corridors is not part of the present analyses, but is the task of the transmission system operator's planning and network operation management.

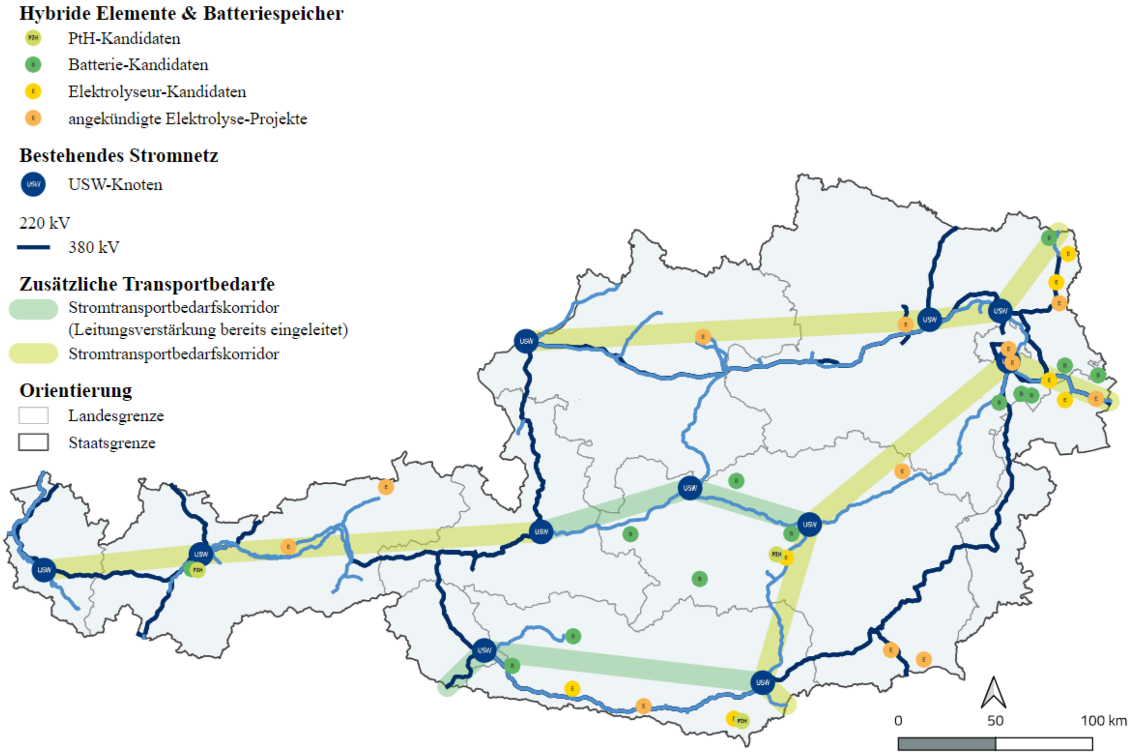
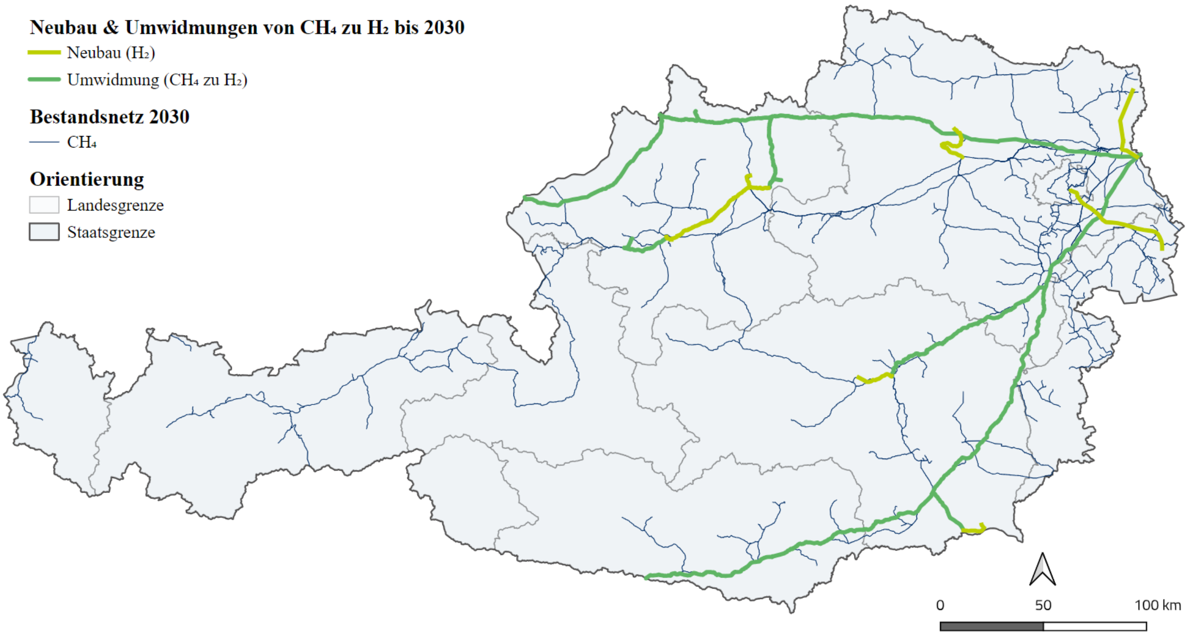


Figure 7: Identified transport demand corridors in the electricity network, Image: (Lehrstuhl für Energieverbundtechnik an der MU Leoben; Institut für Elektrizitätswirtschaft und Energieinnovation an der TU Graz, 2023)

2.4 Gas network (methane and hydrogen)

For the assessment of the gas network, the energy carriers methane and hydrogen are discussed together, since in the scenario assumptions, the demand for methane is largely replaced by hydrogen and the developments of the respective necessary pipeline infrastructures depend on each other. For lengths and diameters of international transmission lines, reference is made to representations published by the market area manager Austrian Gas Grid Management AG (AGGM). The pipeline routing, the lengths of the national transmission networks and network levels 1 and 2 were taken from the natural gas stock statistics of (E-Control, 2022). Further technical parameters were determined with the help of statistical data from (E-Control , 2022a) or taken from previous projects (Greiml, et al., 2020).

For the basic network in the gas sector in 2030 assumed in the modelling (cf. **Fehler! Verweisquelle konnte nicht gefunden werden.**), the information on already existing pipelines (AGGM, 2021) (E-Control, 2022) is supplemented by planned projects from the coordinated network development plan [KNEP] (AGGM, GCA u. TAG, 2023) and the long-term and integrated planning (LFiP) up to and including 2022 (AGGM, 2023). Furthermore, hydrogen projects along the international transmission pipelines Trans Austria Gas Pipeline, West-Austria Gas Pipeline and Penta-West, the storage connection in Puchkirchen / Upper Austria as well as the East H2 Collector[3] are included in the LFiP 2022 (AGGM, 2023). Other LFiP 2022 projects presented by AGGM as part of the H2 Roadmap for Austria are not required in the same way. They were further examined for their usefulness in the analysis due to the scenario quantity structure, which differs greatly from the assumptions of the AGGM. For this evaluation, electrolysis projects that have been announced are taken into account in addition to the localised hydrogen demand. This results in the future hydrogen network in Figure 8.



---

[3] The East H_2 Collector is a planned new construction of a pipeline to transport hydrogen between Zurndorf in Burgenland and Vienna Simmering. The project is included for the first time in the long-term and integrated planning 2022 (LFiP 2022).

Figure 8 Hydrogen network 2030, Image: (Lehrstuhl für Energieverbundtechnik an der MU Leoben; Institut für Elektrizitätswirtschaft und Energieinnovation an der TU Graz, 2023)

For the year 2040, it is assumed that 10.7 TWh of biomethane from Austrian generation plants will be fed into the gas network. The majority of the remaining gas demand in 2040 will be covered by hydrogen per the Transition Scenario. In order to limit excessive investments in new pipeline construction as much as possible, exclusive methane transport is assumed in regions without existing parallel pipeline structures. In other regions, existing parallel structures that exist in the current natural gas network can be used to supply these regions with both hydrogen and methane. In this way, on the one hand, domestic biomethane potential can be realised and, on the other hand, nationwide coverage of the demand for hydrogen can be ensured as quickly as possible. A large part of the existing structure of the methane network - especially in western Austria - will be needed in the future to be able to tap the national biomethane potentials. The necessary repurposing and new buildings for the hydrogen infrastructure in 2040 are shown in Figure 9.

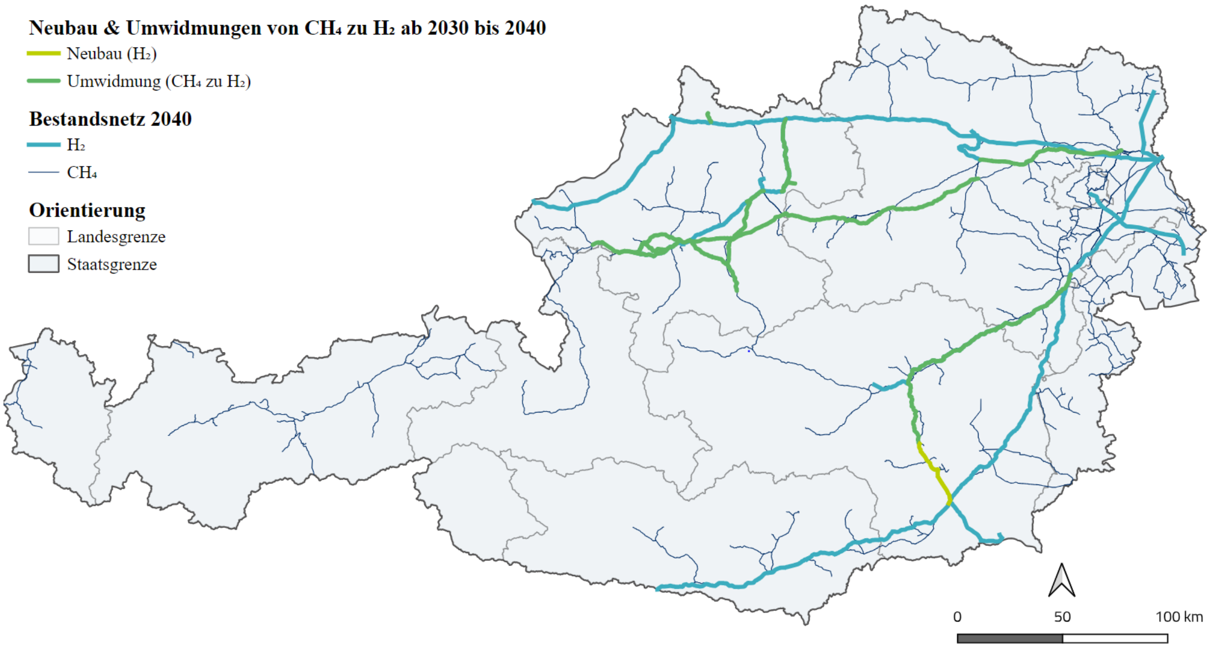


Figure 9 Hydrogen network 2040, Image: (Lehrstuhl für Energieverbundtechnik an der MU Leoben; Institut für Elektrizitätswirtschaft und Energieinnovation an der TU Graz, 2023)

3 Presentation and discussion of results

3.1 Comparison of results

The Austrian federal government has set itself the goal of climate neutrality by 2040. The NIP examines the necessary infrastructure of the electricity transmission network as well as the gas transmission network and network levels 1 and 2 in an integrated manner for the first time. This interlaced planning approach is intended to support and drive the achievement of climate neutrality.

The results of the NIP show high additional transport needs in the Austrian electricity transmission network infrastructure as well as the necessity to reconstruct the gas transmission network and network levels 1 and 2. The main basis for deriving these future requirements for the network infrastructure are the assumed energy quantity structures for electricity and gas from the Transition Scenario. In order to better classify the results from chapter 2, the energy quantity frameworks and network plans of the transmission system operators and the market area manager as well as the results from two research projects ("InfraTrans2040 - Scenarios and expansion plans for a sustainable economic system in Austria"; study on the "Role of gas infrastructure in a climate-neutral Austria 2040") were compared with those of the NIP. In the projects mentioned above, the future requirements for the electricity and gas networks up to 2030 and 2040 were scientifically analysed, while APG and AGGM carry out the analyses from a network operation perspective.

3.2 Summary

The Austrian energy infrastructure must be comprehensively adapted by 2030 or 2040 in order to be able to respond to technological changes, digitalisation, market coupling and the requirements arising from the goal of climate neutrality. In the process, the electricity and gas networks are confronted with different challenges. While the gas network needs to be adapted to a decreasing demand for methane and the requirements of a growing hydrogen economy as well as to leverage the biomethane potentials available in Austria, the focus in the electricity network is on the integration of a significantly growing renewable electricity generation and the increasing electrification of energy consumption.

The methodology used in the NIP takes equal account of developments in the electricity and gas sectors in a joint and integrated planning approach. This makes it possible to identify and exploit synergies in infrastructure development between these sectors and thus optimise the use of energy sources. As described in chapter 2, this planning approach is not to be equated with the approach of operational network planning as carried out by the transmission system operator for electricity or by the market area manager for gas. From the integrated consideration of the NIP simulations, essential findings can be derived for the transmission network and for network levels 1 and 2:

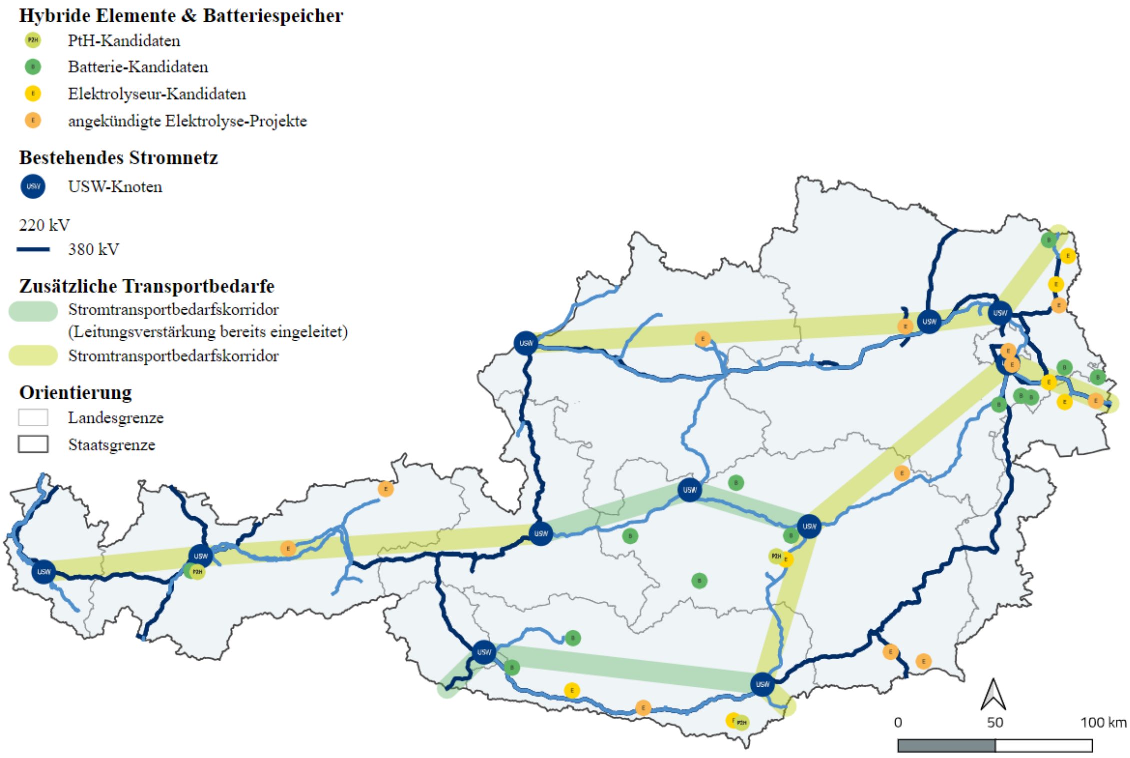


Figure 10: Electricity demand corridors of the transmission network 2030, Image: (Lehrstuhl für Energieverbundtechnik an der MU Leoben; Institut für Elektrizitätswirtschaft und Energieinnovation an der TU Graz, 2023)

For the electricity transmission network, electricity transport demand corridors appear in 2030, especially between eastern and western Austria. To ensure the efficient interaction of renewable power generation and pumped storage in the European interconnected network, network reinforcement is also necessary in the Central Alps. The assumed flexibility measures (electrolysis, power-to-heat and battery storage) can reduce the calculated loads, but not eliminate them. In order to alleviate these burdens, the electricity transport demand corridors shown in Figure 10 are determined. For certain line sections, APG has already initiated measures for line reinforcement. The demand corridors of the NIP largely coincide with the identified planning areas of the APG and the ongoing research project InfraTrans2040 (Lehrstuhl für Energieverbundtechnik an der MU Leoben; Institut für Elektrizitätswirtschaft und Energieinnovation an der TU Graz; Österr. Wirtschaftsforschungsinstitut, 2023).

The electricity demand corridors are therefore "no regret" demand corridors that can be derived from each analysis independently of the different quantity structures in them. By 2040, NIP modelling shows that the load on certain line sections will continue to increase. An important driver here is the significant increase in renewable electricity generation from wind turbines and PV in eastern Austria. Although a further expansion of flexibility options has been assumed until 2040, they can only provide selective relief in the transmission network even in the time horizon up to 2040, which is why further transport requirements are to be expected between 2030 and 2040. These developments are to be taken into account in an update of the NIP and also by the transmission system operator in future planning.

From the NIP modelling and validation of the results with planning of other actors and projects, it follows that beyond the currently existing project plans of the transmission system operator (NEP 2021), further measures will be necessary in the transmission system up to 2030 or 2040. The electricity transport demand corridors shown are understood as "no-regret"" Infrastructure requirements towards achieving climate neutrality in 2040. Significant network adaptations will also be necessary in the distribution networks in the future. Although the analysis of the distribution networks is outside the scope of the NIP, it should be noted that in order to integrate renewables and achieve climate neutrality, appropriate network expansion and reinforcement measures must also be implemented at distribution network level.

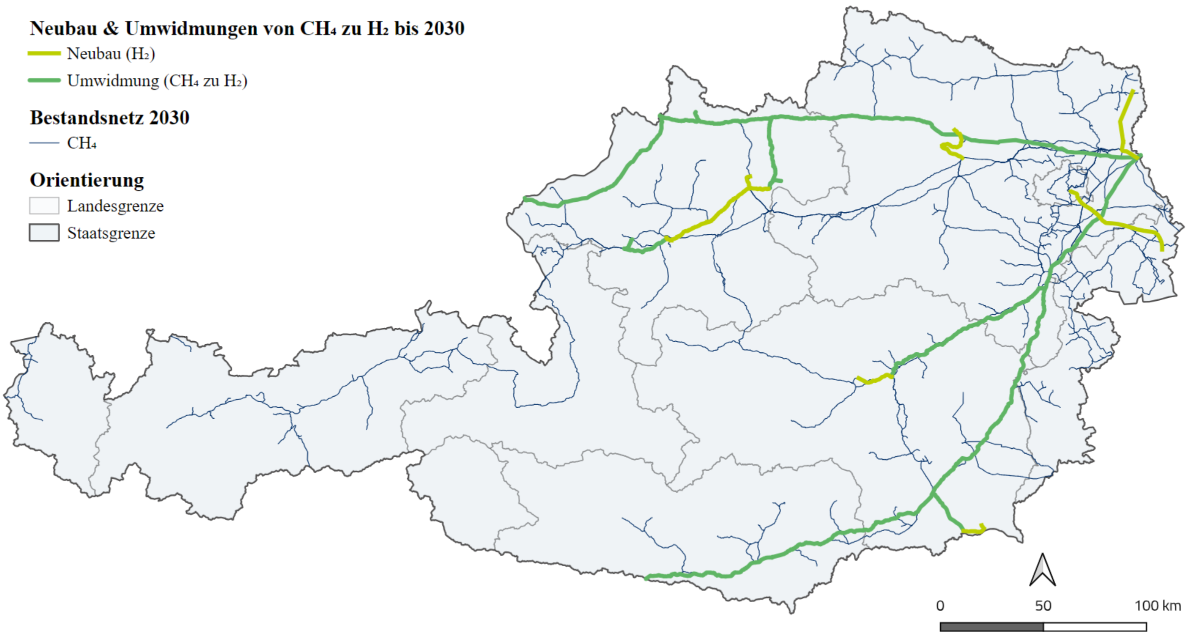


Figure 11: Gas transmission network 2030, Image: (Lehrstuhl für Energieverbundtechnik an der MU Leoben; Institut für Elektrizitätswirtschaft und Energieinnovation an der TU Graz, 2023)

In the gas transmission network and in network levels 1 and 2, a similar methane network structure as that of today is to be expected by 2030 (Figure 11). This distinguishes the higher-ranking gas network levels from the distribution networks, which are not examined in greater detail in the NIP and where a trend towards declining network connections is already discernible (E-Control, 2022). In addition to the projects for new construction and repurposing of long-distance pipelines to hydrogen pipelines already in the planning stage, only a very small amount of new hydrogen pipeline construction appears to be necessary up to 2030. This view is supported by analyses of both the ongoing research projects InfraTrans2040 and GASI 2040 (Lehrstuhl für Energieverbundtechnik an der MU Leoben; Institut für Elektrizitätswirtschaft und Energieinnovation an der TU Graz; Österr. Wirtschaftsforschungsinstitut, 2023) and GASI 2040 (Frontier Economics, TU Wien, 2023) as well as in the context of AGGM's operational planning: no significant changes in the higher-ranking methane pipelines are to be expected by 2030 in comparison with the existing network. In the known analyses and plans, a strong spatial concentration of hydrogen demand is assumed up to 2030. The decisive factor for network planning is the regional location of the industrial hydrogen demand and the planned electrolysis projects. When climate neutrality is achieved in 2040, it can be assumed that the structure of the gas network will change significantly in comparison with the existing network. The increase in hydrogen demand that accompanies the reduction in methane demand due to partial substitution leads to the need for a constant expansion of the hydrogen network. This expansion can largely be achieved by converting existing methane pipelines to hydrogen pipelines, whereby the age, pressure level and structure of the existing customers must be taken into account when converting the pipelines. In order to fully develop the national biomethane potential, the methane transport network and large parts of the existing methane network on network levels 1 and 2 would have to be predominantly maintained until 2040. The results of the NIP in this respect are largely comparable with the results of the InfraTrans2040 project. There are differences to the results of the GASI 2040 study with regard to the necessary hydrogen network. In particular, the differently assumed hydrogen quantity and distribution in the consumption sectors leads to the need for a more extensive hydrogen network infrastructure in the GASI 2040 study. The long-term development of the national methane and hydrogen network beyond 2030 is still subject to uncertainties. The distribution and quantity of nationally produced renewable gases as well as European developments in the gas sector have a significant impact on the long-term development of the national gas network infrastructure. This results in different development paths for the gas network infrastructure, which will be further investigated in the next update of the NIP.

Literature/References

50hertz. (2020). Erfahrungsbericht zum Einsatz von Erdkabeln im Höchstspannungs-Drehstrombereich.

AGGM. (2021). Netzinformationen: Infrastruktur. Von https://www.aggm.at/netzinformationen/infrastruktur abgerufen

AGGM. (2023). Langfristige und integrierte Planung 2022. Wien: Austrian Gas Grid Management AG.

AGGM, GCA u. TAG. (2023). Koordinierter Netzentwicklungsplan 2022. Wien: AGGM, GCA u. TAG.

Amt der Burgenländischen Landesregierung. (2019). Burgenländische Klima- & Energiestrategie. Eisenstadt.

APG . (2021c). Netzentwicklungsplan 2021. Wien: Austrian Power Grid AG.

APG . (25. 04 2023a). Netzkarte Österreich. Von https://pb1-medien.apg.at/im/dl/pboxx-pixelboxx-18712/APG_Netzgrafik_Legende_d_11-2022.pdf abgerufen

APG . (2023b). Markttransparenz - Erzeugung nach Typ. Von https://markttransparenz.apg.at/de/markt/Markttransparenz/erzeugung/Erzeugung%20pro%20Typ abgerufen

APG. (2022). EXAA Spotmarkt-Preise: Day Ahead Preise 2020. Von https://www.apg.at/en/markt/Markttransparenz/crossborder-%0Aexchange/EXAA-Spotmarkt abgerufen

APG. (2023a). Energiesystemplanung – Wege zum klimaneutralen Energiesystem (OVE-Energietechnik Webinar).

APG und VÜN. (2021). Netzentwicklungsplan 2021. Wien: Austrian Power Grid AG, u. Vorarlberger Übertragungsnetz GmbH.

BDEW Bundesverband der Energie- und Wasserwirtschaft. (2018). BDEW/VKU/GEODE Leitfaden - Abwicklung von Standardlastprofilen Gas. Berlin.

BGBl. I Nr. 150/2021. (2021). 150. Bundesgesetz: Erneuerbaren-Ausbau-Gesetzespaket - EAG-Paket. Bundeskanzleramt Österreich.

BGL. (2023). Klimastrategie Burgenland 2030. Land Burgenland.

BGL, L. B. (2022). Burgenland erhöht die Schlagzahl auf dem Weg zu Klimaneutralität und Energieautarkie. Abgerufen am 05. 04 2023 von https://www.burgenland.at/news-detail/burgenland-erhoeht-die-schlagzahl-auf-dem-weg-zu-klimaneutralitaet-und-energieautarkie/

Binderbauer, P.J.; Kienberger, T; Staubmann, T. (2022). Synthetic load profile generation for production chains in energy intensive industrial subsectors via a bottom-up approach. Journal of Cleaner Production.

BMK. (2022). Energie in Österreich - Zahlen, Daten, Fakten. Wien: Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie.

BMK und BMDW. (2022). Wasserstoffstrategie für Österreich. Wien: Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie, und Bundesministerium für Digitalisierung und Wirtschaftsstandort.

Bundesamt für Strahlenschutz. (2022). Feldbelastung durch Hochspannungsleitungen: Freileitungen & Erdkabel. Von https://www.bfs.de/DE/themen/emf/netzausbau/basiswissen/feldbelastungen/feldbelastungen_node.html abgerufen

Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie. (2022). Wasserstoffstrategie für Österreich. Von https://www.bmk.gv.at/themen/energie/energieversorgung/wasserstoff/strategie.html abgerufen

Danish Energy Agency. (2022). Technology Data. Von https://ens.dk/en/our-services/projections-and-models/technology-data abgerufen

Deutsche Energieagentur GmbH. (2014). Das deutsche Höchstspannungsnetz: Technologien und Rahmenbedingungen. Berlin.

Dt. Umweltbundesamt. (2020). Netzausbau. Von https://www.umweltbundesamt.de/themen/klima-energie/energieversorgung/netzausbau#Netzausbau abgerufen

E-Control . (2022a). Erdgas- Bestandsstatistik. Von https://www.e-control.at/statistik/g-statistik/archiv/bestandsstatistik abgerufen

E-Control. (2022). Das Gasnetz. Von https://www.e-control.at/industrie/gas/gasnetz abgerufen

E-Control. (2022). Verbrauchserstruktur. Von https://www.e-control.at/statistik/g-statistik/archiv/marktstatistik/verbraucherstruktur abgerufen

E-Control. (2022a). Strom Bestandsstatistik - Trassen- und Systemlängen zum 31. Dezember 2021. Von https://www.e-control.at/documents/1785851/1811756/BeStOeN-2021_Netz.xlsx abgerufen

E-Control. (2022b). Strom Bestandsstatistik - Jahreszeitreihen Brutto-Engpassleistungen Kraftwerke. Von https://www.e-control.at/documents/1785851/1811756/BeStGes-JR_KWEPL.xlsx abgerufen

E-Control. (2023). Elektrizitätsstatistik. Von https://www.e-control.at/statistik/e-statistik abgerufen

E-Control. (2023). Erdgasstatistik. Von https://www.e-control.at/statistik/g-statistik abgerufen

ElWOG. (4. 26 2010). Elektrizitätswirtschafts- und -organisationsgesetz 2010. Wien.

Energy Brainpool. (2019). Österreichs Weg Richtung 100% Erneuerbare: Eine Analyse von 2030 mit Ausblick 2050.

ENTSO-E. (2023). Regional Investment Plan - Continental Central South. Von https://eepublicdownloads.blob.core.windows.net/public-cdn-container/tyndp-documents/TYNDP2022/public/RegIP-2022-CCS.pdf abgerufen

ENTSO-G. (2021). Ten Year Network Development Plan. Von ENTSOG TEN-YEAR NETWORK DEVELOPMENT PLAN 2020: https://www.entsog.eu/sites/default/files/2021-07/ENTSOG_TYNDP_2020_Annex_C2_Capacities_per_country.xlsx abgerufen

ENTSOG. (2023). TYNDP 2022 The Hydrogen and Natural Gas TYNDP - Annex C2 - H2 Capacities per Country. ENTSOG.

ENTSOG. (2023). TYNDP 2022 The Hydrogen and Natural Gas TYNDP Annex C1 - CH4 Capacities per Country. ENTSOG.

Europäische Kommission. (2020). Union Registry ETS. Von https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets/union-registry_en#tab-0-1 abgerufen

Europäische Kommisssion . (5 2022). REPowerEU. Von https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/repowereu-affordable-secure-and-sustainable-energy-europe_de abgerufen

Fraunhofer-Institut für System- und Innovationsforschung. (2019). Integration erneuerbarer Energien durch Sektorkopplung: Analyse zu technischen Sektorkopplungsoptionen Deutschland. Karlsruhe. Von https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2019-03-12_cc_03-2019_sektrokopplung.pdf abgerufen

Frontier Economics, TU Wien. (2023). Rolle der Gasinfrastruktur in einem klimaneutralen Österreich . Wien (in Druck).

Greiml, M., Traupmann, A., Sejkora, C., Kriechbaum, L., Böckl, B., Pichler, P., & Kienberger, T. (2020). Modelling and model assessment of grid Multi-Energy Systems. International Journal of Sustainable Energy Planning and Management.

Kienberger, T., Greiml, M., & Braunstein, R. (2021). Is Power to Hydrogen an appropriate approach to mitigate PV-induced strain on 110 kV high-voltage grids? CIRED.

KTN. (2014). Energiemasterplan Kärnten. Klagenfurt: Amt der Kärntner Landesregierung.

KTN. (2022). Klimastudie Kärnten - Kärnten Klimaneutral 2040. Klagenfurt am Wörthersee: Amt der Kärntner Landesregierung.

Lehrstuhl für Energieverbundtechnik an der MU Leoben; Institut für Elektrizitätswirtschaft und Energieinnovation an der TU Graz. (2023). Berechnungen für das NIP Szenario .

Lehrstuhl für Energieverbundtechnik an der MU Leoben; Institut für Elektrizitätswirtschaft und Energieinnovation an der TU Graz; Österr. Wirtschaftsforschungsinstitut. (2023). InfraTrans2040: Methodikdokument. Von infratrans2040.at abgerufen

Moser, S.; et al. (2018). Renewables4Industry | Abstimmung des Energiebedarfs von industriellen Anlagen und der Energieversorgung aus fluktuierenden Erneuerbaren - Diskussionspapier zum Projekt Renwables4Industry.

NÖ. (2019). NÖ Klima- und Energiefahrplan. St. Pölten: Amt der NÖ Landesregierung, Gruppe Raumordnung, Umwelt und Verkehr.

NÖ, E. &. (2023). Die Energiewende – 100 % erneuerbare Energie für Niederösterreich. Abgerufen am 05. 04 2023 von https://www.energie-noe.at/die-energiewende

Oesterreichs Energie. (2020). Elektrische und magnetische Felder - Fragen und Antworten. Wien.

Oesterreichs Energie. (2022). Doppelter Stromverbrauch bis 2040. Von https://oesterreichsenergie.at/aktuelles/presseinformationen/detailseite/doppelter-stromverbrauch-bis-2040 abgerufen

OÖ. (2022). Oberösterreichische Klima- und Energiestrategie. Amt der Oberösterreichischen Landesregierung.

Österreichische Energieagentur. (2022). Strategische Handlungsoptionen für eine österreichische Gasversorgung ohne Importe aus Russland. Von https://www.bmk.gv.at/service/presse/gewessler/2022/20220426_ausstieg-russisches-gas.html abgerufen

Österreichische Raumordnungskonferenz. (2018). ÖROK-Bevölkerungsprognose 2018. Von https://www.oerok.gv.at/raum/daten-und-grundlagen/oerok-prognosen/oerok-bevoelkerungsprognose-2018 abgerufen

Oswald, B. R. (2007). 380-kV-Salzburgleitung - Auswirkungen der möglichen (Teil)Verkabelung des Abschnitts Tauern-Salzach neu. Hannover.

Palic M. (2022). Freileitungen und Kabel in Hoch- und Höchstspannungsnetzen. Tübingen: expert Verlag.

PÖYRY. (2018). Wasserkraftpotenzialstudie Österreich. Aktualisierung 2018. .

SBG. (2021). Masterplan Klima+Energie 2030. Land Salzburg.

Sejkora, C.; et al. (2022). Exergy as criteria for efficient energy systems – Maximising energy efficiency from resource to energy service, an Austrian case study. Energy.

Statistik Austria. (2020). Nutzenergieanalyse. Von https://www.statistik.at/statistiken/energie-und-umwelt/energie/nutzenergieanalyse abgerufen

Statistik Austria. (2022a). Energiebilanzen der Bundesländer. Wien: Statistik Austria.

Statistik Austria. (2022b). Nutzenergieanalyse der Bundesländer. Wien: Statistik Austria.

STMK. (2017). Klima- und Energiestrategie Steiermark 2030. Graz: Amt der Steiermärkischen Landesregierung, Abteilung 15 - Energie, Wohnbau, Technik; Fachabteilung Energie und Wohnbau; Referat Energietechnik und Klimaschutz.

STMK, A. 1.-u. (02. 02 2023). Sachprogramm Erneuerbare - Solarenergie. Von Vorträge Energy Lunch 02.02.2023: https://www.ich-tus.steiermark.at/cms/dokumente/12902310_146113849/f6670418/07_EL59_Wieser_Sachprogramm_Photovoltaik.pdf abgerufen

Sweco GmbH. (2016). Neubau der 380-kV-Höchstspannungsfreileitungsverbindung Gütersloh - Wehrendorf gemäß EnLAG. Bremen.

Tennet. (2023). Erdkabel im Kontext der Energiewende. Von https://infomarkt.tennet.eu/erdkabelinfozentrum-prinzhoefte/erdkabelabschnitte# abgerufen

TIR. (2022). Leben mit Zukunft - Tiroler Nachhaltigkeits- und Klimastrategie - Maßnahmenprogramm 2022-2024. Innsbruck: Amt der Tiroler Landesregierung.

TIR. (2022). Tiroler Nachhaltigkeits- und Klimastrategie. Innsbruck: Amt der Tiroler Landesregierung.

TYNDP. (2022a). Scenario Report. Entsog and Entsoe.

TYNDP. (2022b). Regional Investment Plan Continental Central East (Version after public consultation). ENTSOE.

TYNDP. (2023). System Needs Study - Opportunities for a more efficient European power sytstem in 2030 and 2040. ENTSOE.

Umweltbundesamt. (2023). Szenarien für die realisierbare erneuerbare Stromerzeugung im Jahr 2030 und 2040 . Wien (in Druck).

VBG. (2021). Strategie Energieautonomie+ 2030. 6901 Bregenz: Amt der Vorarlberger Landesregierung.

Vopava, J.; B., Thormann; Kienberger, T. (2017). Development of a Model for Power Grids Based on the Cellular Approach for an Optimum Integration of Electric Charging Infrastructure. 1st E-Mobility Power Systen Integration Symposium.

Vopava, J.; U., Bergmann; Kienberger, T. (2020). Synergies between e-Mobility and Photovoltaic Potentials—A Case Study on an Urban Medium Voltage Grid. Energies.

WIE. (2022). Wiener Klimafahrplan. Wien: Magistrat der Stadt Wien.

ZAMG Zentralanstalt für Meteorologie und Geodynamik. (2020). Einstrahlungsmessdaten und Temperaturmesswerte.

Federal Ministry Republic of Austria Climate Action, Environment, Energy, Mobility, Innovation and Technology
Radetzkystraße 2, 1030 Vienna, Austria
+43 (0) 800 21 53 59
servicebuero@bmk.gv.at
bmk.gv.at