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Problems and Challenges of the European Electricity Exchange in the Course of the Energy Transition

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Contents

Abstract

This work concerns itself with the main problems and challenges of the European energy transition, with a specific focus on Austria and Czech Republic, as well as with feasible solution and the question, how plausible it is to meet all requirements of the goals and targets, that have been set by the EU due to decarbonization. In order to answer the question, the work tries to build up an intersectional and comprehensive picture of the current situation of the European electricity transmission. It starts with setting up a foundation, by explaining the current electricity market in Europe to understand subsequent mechanisms of trading and infrastructure. This is followed by the already named goals and targets of the EU. The main part of the work consists of three major problems and challenges of energy transition. The first part discus the problems of financing and integration of RES. We will either have a look at the financing and integration strategies of the government, as well as perform a comparison regarding the competitiveness of RES and thermal ES. Further the work will focus on already existing problems, due to the integration of RES in the grid. The last part evaluates a new concept of a fully digitized power grid, called smart grid and meters. It will be analyzed regarding to its problem-solving potential as well as the benefits it brings with it. Additionally, the positive effects on social welfare of the energy transition are mentioned shortly. The conclusion distinctively shows, that though, sufficient solutions for the discussed problems already exist, but neither the political framework conditions, nor the required financial support is provided by the government yet.

1 Introduction

The modern world, as we know it today, develops steadily. That such a growth is even feasible, the main pillar of the society have to develop as well, to satisfy the requirements of this futuristic world. One of these main pillars is the energy sector, which assignment it is, to provide electricity sufficiently and responsible. However, to comply this task today proves to be increasingly difficult, particularly in the course of digitisation and the technological bloom. The demand rises exponentially, whereas the thermal energy systems (ES) won't remain an ecological solution, due to climate change. Compensating this discrepancy seems to be the main objective of decarbonization and also the biggest challenge for the European electricity market and its member states.
So far, the existing literature analysing this problem, is split up into various sectional-specific approaches to find individual solutions. Some concentrate on the analysis of specific problems and modelling various trajectories of potential developments the energy sector,(Szabó et al. 2019),(Defeuilley 2019). Others are are having a deeper look at the problems of either, implementation of RES or the therefore resulting impact,(Breyer et al. 2018),(Zakeri et al. 2016), or the financing of the energy transition, (Cormack et al. 2020). To sum it up, the literature comprising inter-sectional approaches to analyse the problems and challenges of the energy transition are very limited, and that, even if a comprehensive overview over a topic often provides solutions, that were

not able to be seen, when only a small sector is scoped. That's why we aim to make an inter-sectional approach to analyse the current (01.06.2022) progress of the energy transition in European. The main focus of this work will refer to the major problems and challenges, that occur in the course of energy transition, as well as on possible solutions with a specific focus on Austrian and Czech Republic market in the context of European electricity transmission.

The first part, the status quo, is meant to build the foundation of the work and should provide a framework of the current market situation as well as of the climate goals and targets Europe, Czech Republic and Austria set themselves by plans and contracts. The main part of the paper is split into three parts. The first part concerns itself with the financing and integration of the energy transition. It will discuss strategies of the respective countries in order to meet the European requirements of a sustainable market in the EU. Further, an economical comparison between RES and thermal ES is made to clarify the competitive status quo. The next part discusses the problems of loop - and transit flows and possible interventions. The final part consists of an analysis of a new concept for a power grid called "smart grid and meter", that claims to be the solution for all problems of the current energy market. In the end, this work aims to make a statement about the plausibility overcoming all discussed problems in the course of energy transition and meeting the named goals and targets concluded of the EU regarding to the climate change. Furthermore, there will be a short outlook on how the decarbonization influences the social welfare. This work tries to underline the importance of the energy sectors' development in order to ensure a secure, competitive and sustainable market.

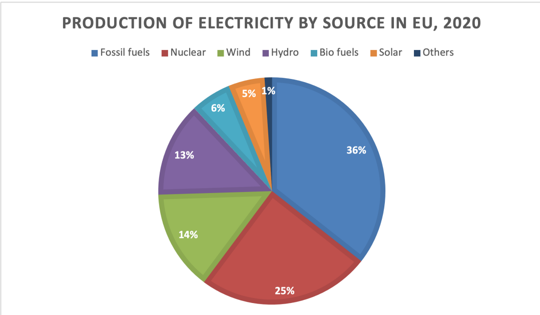
2 Status quo

2.1 Electricity Market in the EU

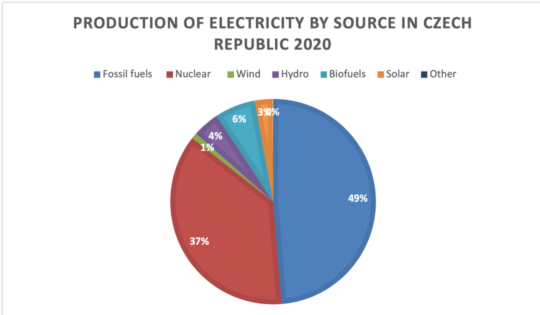
To understand the challenges the electricity market is facing, we must understand the characteristics of the commodity, structure of the market, its interconnectedness, mutual ties and main targets set by European Union. The process of delivery of generated electricity from powerplants includes actors in the area of transmission systems, market regulations and market coupling. Power producers are mainly plants or renewable facility operators. They can choose to either sell the electricity they generate 'over the counter' (or OTC trading for short), this means to sell it directly to large customers such as industrial enterprises or energy suppliers via electricity exchanges. Transmission system operators (TSOs) are responsible for controlling and operating the transmission grid. They are entities operating independently from the other electricity market players and are responsible for the bulk transmission of electric power on the main high voltage electric networks. The main activity is the contracting of ancillary service providers by determining the required control reserve capacity, administrating the auction process for the reserve tendering, and calling the reserves when needed. The Electricity Supplier serves the final customer with bought on the electricity market at a certain price or via bilateral contracts. The intermediate is an aggregator that contracts both generation capacity and final customers in cooperation with the electricity suppliers to deliver ancillary services to the TSO. Key association that manages the cooperation of European TSOs is the Entso-E that has currently around 35 members from 39 countries including Austrian Power Grid AG, Vorarlberger Übertragungsnetz GmbH and Czech ČEPS a.s. Nominated Electricity Market Operators (NEMOs) are market operators in regional or national markets and, together with the TSOs and the regulatory authorities are supervising bids from market participants, matching and allocating of orders according to the results of the single day-ahead market coupling and the single intraday market coupling and publish prices. Austria's NEMOs are EPEX Spot SE, EXAA AG and Nord Pool AS while Czech market has only one NEMO and that's OTE a.s. Market coupling is European key to higher electricity market interconnection, liquidity and harmonization of different systems of electricity exchanges and price differences reduction. Originally, transnational electricity trading and the necessary allocation of transport capacities were two separate markets. Through so-called implicit auctions, market coupling combines the previously separate trading transactions into an integrated electricity market. Market coupling systems (PCR, FBMC and XBID) exist both in day- ahead trading and in intraday markets. Price Coupling of Regions (PCR) merges seven European electricity exchanges (APX-ENDEX, Belpex, EPEX SPOT, GME, Nord Pool Spot, OMIE and OTE). The common goal of the power exchanges is the best possible calculation of electricity prices and the efficient utilization of cross-border allocations. The PCR is based on three premises; A uniform algorithm for calculating electricity prices ensures growing transparency and order within the day-ahead market. Decentralised collection of data from PCR members ad own responsibility of individual power exchanges for their market areas. All TSOs send their cross-border transport capacities to a Market Coupling Operator (MCO) - such as Transmission System Operator Security Cooperation (TSC). This is the interface between the TSOs and the power exchanges. The MCO models permanently the capacity values and then transmits the capacity values to the electricity exchange. Once this is done, the electricity traders can submit their offers. The actual coupling is then carried out by the relevant electricity exchanges: they settle supply and demand using an algorithm accepted by all partners. Flow-Based Market Coupling (FBMC) has a goal to increase cross-border capacities, promote supplier competition, increase grid security and minimize prices across in the

market zones. Currently applied in enlarged European Core region that consist of the bidding zone borders between the following EU Member States' bidding zones: Austria, Belgium, Croatia, the Czech Republic, France, Germany, Hungary, Luxemburg, the Netherlands, Poland, Romania, Slovakia and Slovenia. XBID supports cross-border intraday trading efficiency between Belgium, Denmark, Germany, Estonia, Finland, France, Latvia and Lithuania, Norway, the Netherlands, Austria, Portugal, Sweden and Spain. The system called XBID enables bids from market participants from all participating countries to be merged into a single cross-exchange trading possibility allowing for cross-border intraday trading in case there is sufficient transmission capacity available.

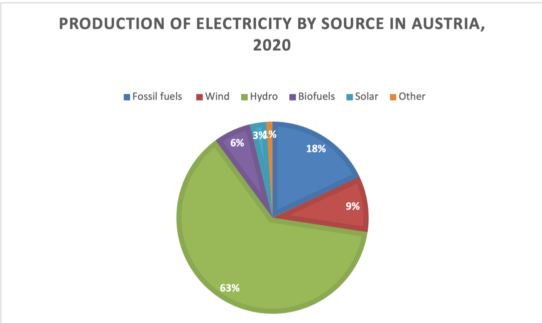
The sources of electricity production vary among the Member States. In 2020, in Denmark over half of electricity production (57 %) came from wind energy, while more than 60% of electricity production in Austria came from hydro power plants. Around 90% of electricity production came from fossil fuels in Malta and Cyprus, while over two thirds (67%) of electricity production came from nuclear power plants in France, followed by 53% in Slovakia. That creates broad energetic portfolio showed on the graph 1.



(a) Current European primary energy sources



(b) Current Czech primary energy sources



(c) Current Austrian primary energy sources

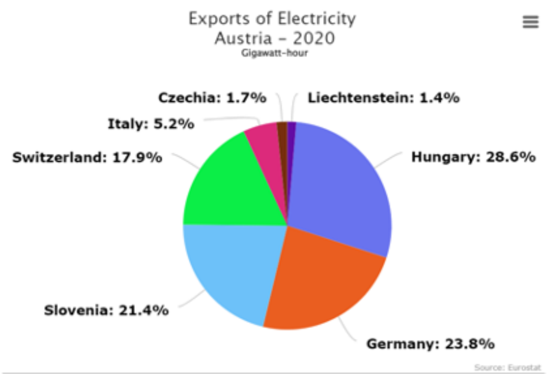
Figure 1: Data from Eurostat

The Czech energy sector has been largely built around two large nuclear plants and a number of smaller conventional coal power plants. Nuclear and coal power plants provide primarily baseload power at a high level of utilization, while gas-fired units, reservoir hydro and pumped storage provide flexible generation (1).

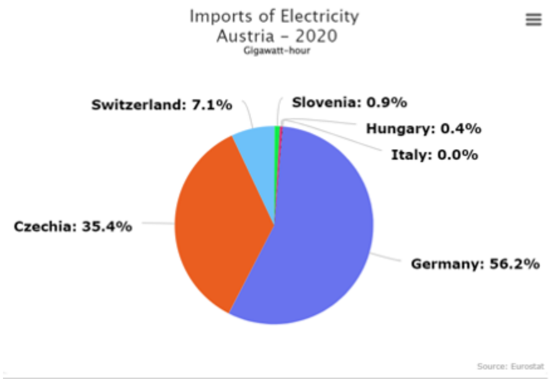
The Czech energy mix was made up of 52.5 percent fossil fuels (40 percent lignite, 9.6 percent natural gas, 2.6 percent bituminous coal, etc.), 40.75 percent nuclear power, and 6.75 percent renewables (3.4 percent biomass, 2.27 percent solar, 0.65 percent water, 0.43 percent wind energy, etc.) (1).

In Austria the greatest share of electricity is generated from hydroelectricity sources with 63 percent. A smaller percent of the electricity in Austria is produced from fossil

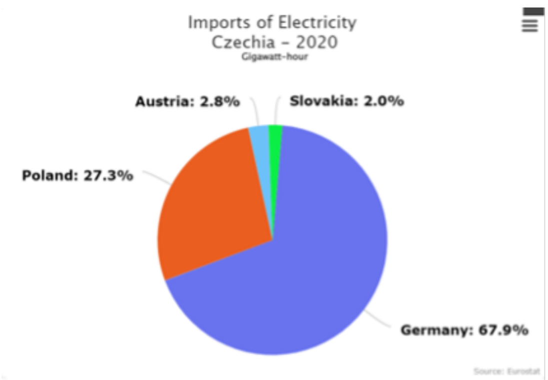
fuels compared to the rest of the world (1).
Latest data shows that the EU imported 53% of its energy at a cost of around EUR 400 billion, which makes it the largest energy importer in the world. Six Member States depend on a single external supplier for their entire gas imports and therefore remain too vulnerable to supply shocks. It has also been estimated that every additional 1% increase in energy savings cuts gas imports by 2.6%. Important topic is also that 75% of our housing stock is energy inefficient (2).



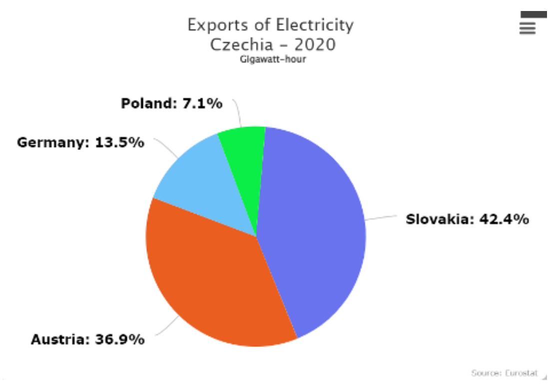
(a) : Electricity export from Austria, 2020 according to data from Eurostat. Total value of exported electricity from Austria in 2020 is 22 326,7 GWH sources



(b) Electricity import to Austria, 2020 according to data from Eurostar. Total value of imports is 24 522,5 GWH



(c) Electricity import to Czechia, 2020 according to data from Eurostat. Total value of imported electricy in 2020 is 13 368 GWH



(d) Electricity import from Czechia, 2020 according to data from Eurostat. Total value of Exported electricy from Czech republic in 2020 23 521 GWH

Figure 2: Data from Eurostat

2.2 Goals and Targets

In matters of future development of energy market have the most significant impact goals and targets ratified by European countries in Paris Agreement adopted at the

Paris climate conference in December 2015. The three basic pillars on which the goals are based are security of supply, competitiveness and sustainability of European energy trade. Countries agreed to pursue efforts to limit global warming below 2°C by aiming to produce zero emissions and as a contribution to the objectives of the agreement, countries have submitted comprehensive national climate action plans. Each Member State must have set out a roadmap with measures and domestically established measurable progress indicators, with a view to the long-term 2050 goal of reducing greenhouse gas emissions in the Union by 80-95% compared to 1990. The roadmap must include indicative milestones for 2030, 2040 and 2050, and specify how they contribute to achieving the Union's energy efficiency targets in accordance with Directive 2012/27/EU. In December 2020, the EU submitted its updated and enhanced Nationally Determined Contributions (NDC) containing the target to reduce emissions by at least 55% by 2030 while focus is on energy production as the production and use of energy account for more than 75% of the EU's greenhouse gas emissions. The path towards clean energy consists of three steps; ensuring a secure and affordable EU energy supply, developing a fully integrated, interconnected and digitalised EU energy market and prioritising energy efficiency, improving the energy performance of our buildings and developing a power sector based largely on renewable sources. An EU-wide target by 2030 is 32% as a share of renewable sources in gross final energy consumption. This EU level target will drive continued investment in renewable energy. The EU target would not be translated into national targets via EU legislation, thus leaving greater flexibility for Member States to meet their greenhouse gas reduction targets in the most cost-effective manner in accordance with their specific circumstances, energy mixes and capacities to produce renewable energy. In different words this decision provides Member States the opportunity to reach their gas reduction targets by energy savings, more efficient electricity infrastructure and cross-border trading. It is also within the general goals that the infrastructure must allow for new developments on the energy market, such as decentralised production, new storage technologies (f.e. use of buildings as storage facilities) and digitalisation.

The Federal Government of Austria focus on infrastructure development, security of energy supply, the development of new market models, innovation, research and development following the general EU target of turning the energy system into a modern, low-input, carbon-free system by 2050. According to data published in Integrated National Energy and Climate Plan for Austria in 2019, there are ambitious goals set regarding the share of RES in gross final energy consumption. Target for year 2030 is in this case 46-50%. The development of renewable energy in the electricity sector will also be instrumental in achieving the objective of eliminating dependency on imports by 2030. Specific for Austria's energy policy is the Nuclear-free decarbonisation. Austria will consistently defend this position at all levels and will lobby for no more funding for nuclear energy. Austria will therefore continue to fight against the use of nuclear energy at European and international level and to push for continual improvements to nuclear safety. Austria will therefore also continue to drive forward the socially and environmentally compatible development of the network infrastructure with focus on development of following corridors; North-south electricity interconnections in western

Europe, North-south electricity interconnections in central eastern and southern Europe with the aim to build more extensive connection especially with Italy and Germany. National objectives are also related to other aspects of the internal energy market such as increasing system flexibility, in particular related to the promotion of competitively determined electricity prices in line with relevant sectoral law, market integration and coupling, aimed at increasing the tradeable capacity of existing interconnectors, smart grids, aggregation, demand response, storage, distributed generation, mechanisms for dispatching, re-dispatching and curtailment, and real-time price signals. National objectives to prevent energy poverty are also not negligible as around 20% of households are at risk of energy poverty.
The main target of the Czech Republic is to reduce the total greenhouse gas emissions by 30%by 2030 compared to 2005. The target of share of RES in gross final consumption is 22%. Main difference between CZE and AT is in Czechs positive attitude towards nuclear energy. The target for year 2040 in share of individual fuels in gross electricity generation is 46–58%of nuclear energy. Czech Republic further plans to develop electricity network infrastructure in the context of the nations of Central Europe, strengthening international cooperation and integration of the electricity and gas markets in the region including support for the creation of an effective and operational joint EU energy policy. One of main priorities is also balanced energy mix: A balanced mix of primary energy sources and electricity generation sources based on a broad portfolio, efficient use of all available domestic energy sources and coverage of the consumption needs of the Czech Republic by guaranteed electricity generation to the ES with adequate reserves. Maintaining available strategic reserves of domestic forms of energy. In other areas the Czech Republic has not set any specific quantifiable targets in public research, development and innovation specifically related to the Energy Union.
To summarize partial targets of the ongoing market development; members of European Union are aiming on being world leaders in developing the next generation of renewable energy technologies, including environment-friendly production and use of biomass and biofuels, together with energy storage. Furthermore, facilitating the participation of consumers in the energy transition through smart grids, smart home appliances, smart cities, and home automation systems and also to create efficient energy systems, and harnessing technology to make the building stock energy neutral following more sustainable transport systems that develop and deploy at large scale innovative technologies and services to increase energy efficiency and reduce greenhouse gas emissions.

3 Methodology

3.1 The Problem of Financing and Integration

3.1.1 Financing and Integration Strategies

Current common policy of European Member States is not only support of producers of green electricity but also support of its importers. The renewable energy financing mechanism is based on the idea that the collective nature of the 2030 EU target for

renewable energy should reflect the EU countries' collective efforts.
To integrate renewable production progressively and efficiently into a market that promotes competitive renewables and drives innovation, energy markets and grids have to be fit for renewables. Existing legislation and new market rules need to be fully implemented, enabling the roll-out of new technologies smart grids and demand response for an efficient energy transition. In line with the Environmental and Energy Aid Guidelines, renewable production needs to be supported through market-based schemes that address market failures, ensure cost-effectiveness and avoid overcompensation or distortion. Low-cost financing for capital intensive renewables depends on having a stable investment framework that reduces regulatory risk. This is necessary to ensure investor confidence and to attract investments from international funds, large scale project promoters and cooperatives and households in a market-based framework that keeps capital costs down. The Commission will facilitate cooperation and convergence of national support schemes leading to more cross border opening through in-depth discussions with Member States on the respective Commission Guidance and the Environmental and Energy Aid Guidelines. The amount funds set aside for the development of new sources of primary energy in the territory of Europe and to achieve goals jointly set by the members of European Union are to be found in their National Energy and Climate plans that were created following the Paris agreement.
Primary tools used for support of green energy are purchase price guarantee and mandatory quota (mandatory share of green electricity in the total consumption of final customers) that can be combined with other tools like tendering (concluding contracts for the purchase of green electricity in the amount set by the quota on the basis of state tenders). EU implements financing mechanisms with the aim to better support renewable energy projects, and thereby encourage a greater uptake of renewable energy sources across the EU. As mentioned, the private sector plays an important role in the successful rollout of renewable energy sources across the EU. Private investors have an equal opportunity to contribute to the mechanism. The main objective is to enable EU countries to work more closely together in the take-up and promotion of renewables. In so doing, the countries can more easily achieve both individual and collective renewable energy targets. The mechanism links countries that voluntarily pay into the mechanism (contributing countries) with countries that agree to have new projects built on their soil (hosting countries). The financial contributions that enter the financing mechanism scheme will, through competitive tenders for grants, support new renewable energy projects in all EU countries that are willing to host such projects.
The grants cover either the installation of a renewable-production facility with certain capacity (investment support), or the actual production of renewable energy (operating support). The size of the grant is determined by the outcome of the tender procedure, where only the most competitive projects will be selected and receive support, corresponding to their bid in the tender.

3.1.2 Financial Barrier of the Realisation

In order to answer the objective of the work, we have to further look at the problems and weaknesses of the strategies, that occur during the realisation process. To convince an investor to put money in a new technology, he needs to be sure if it's economical sustainable and can compete with the existing technology, even if gets financial support of the state. To find an answer to this question, we gathered all financial information about renewable energy systems. This information consists of the money RES consume, but also of how RES produce profit and in which way it differs from the thermal ES. We started the research by using google scholar. We found a scientific article, that compares the levelized costs of electricity of the common ES used in Europe, (Wissel et al. 2008). Based on the results of this study, we deduct pricing and investment dynamics. Further, we conceptually analyse the cost distribution of RES and thermal ES, and what impact it has regarding the profit of the ES (Haas 2021), hence also the competitiveness.

3.2 Loop - and transit flows

One of the major effects of the energy transition is the shift from a long term (forward market) to a short term (spot market) electricity trade. That means with further implementation of RES in the transmission grid the time between buying and consuming the energy gets shorter. As electricity is yet not sufficiently storable, this shift can be referred to the absolute dependence of RES on meteorological conditions, such as wind or solar radiation. Additionally, the interconnection capacities needs to be extended to ensure adequate electricity exchange in the event of failed RES due to i.e. unfavorable weather conditions. Unfortunately, the "old" transmission grid of European is yet not suitable to adapt on this dynamic shift. Based on that evidence, we started our research for already existing problems, caused by the integration of RES in the "old" grid. We found two articles in google scholar describing predominantly physical grid problems, (Skånlund 2013),(Mišík2149 n.d.). The resulting issues are so called "loop - and transit flows", which we are already able to see in south-east Europe as a direct consequence of the high integration rate of RES in the German power grid. Reducing those unscheduled flows, can be considered as a challenge in the course of the energy transition. Even if they still can have positive effects in the host area, it's the negative effects we are focusing on, as they are the predominant majority. We qualitatively analyze this problem by defining it, showing all major causes and effects that occur in neighboring countries and conceptually dicuss feasible solutions.(Skånlund 2013)

3.3 Future Grid Concept

The grid in Europe as it is today, is nearly perfectly adjusted to the requirements and conditions of the last centuries. However, that does not mean it is for now. As our world develops, either the demand for energy, as well as the consciousness for greenhouse gas based global warming is rising. An adequate response to this trend is a more efficient and green way to generate and consume energy. In order to adapt on this potential

development, the power grid must be modernised and adjusted to the new conditions. The claim on this new grid would refer on solving multiple following problems of the existing grid sufficiently. The rising need of energy, hence also transmission capacities, must be handled until the green slowly arising infrastructure can be put into operation. This would need a highly efficient management of the accessible resources. Furthermore, it must be flexible and adjustable at various upcoming situation as well as provide a secure supply. Of course, it still has to be economical and ecological sustainable.
In order too find potential concepts or ideas how to solve the current (01.06.2022) grid problems, we found several scientific paper about the smart grid and meters in google scholar regarding different aspects of impact (Zheng et al. 2013),Dong et al. (2012). Further the official website of the European commission provides specific information about her plans and current projects with smart grids and meters. Smart grid and meters are cooperating technologies to adapt on the current challenges of power management. The smart grid per definition is a cyber-physical energy network system which includes a bidirectional communication system with the power flow structure to gain intelligence and automated control by monitoring. The smart meter is a sensor device, that measures and records actual power usage and provides it for the smart grid. By linking those two technologies, it is possible to provide a huge amount of data, which could help persist the current challenges of the grid.
We will analyse the smart grid and meters conceptually according to its potential upgrade it can bring into the sector of energy exchange in comparison to the "old" grid. We will discuss further benefits and the question if this technology is capable of handling the impact of the energy transition on the existing power grid.

4 Results

4.1 The Problem of Financing and Integration

4.1.1 Financing and Integration Strategies

This package presents an opportunity to speed both the clean energy transition and growth and job creation. By mobilising up to an additional 177 billion euro of public and private investment per year from 2021, this package can generate up to 1% increase in GDP over the next decade and create 900.000 new jobs. It will also mean that on the average the carbon intensity of the EU's economy will be 43% lower in 2030 than now with renewable electricity representing about half of the EU's electricity generation mix. The EU's 2021-2027 long-term budget, together with the NextGenerationEU recovery instrument, amounts to more than €2.018 trillion. This unprecedented response will help repair the economic and social damage caused by the coronavirus pandemic and aid the transition towards a modern and more sustainable Europe. Another important instrument of EU is REPowerEU Plan. This plan is a response to the hardships and global energy market disruption caused by Russia's invasion of Ukraine, urging the transformation of Europe's energy system and ending the EU's dependence on Russian fossil fuels, which are used as an economic and political weapon and cost European taxpayers nearly €100 billion per year and tackling the climate crisis. EU is planning to spend 30% of the EU budget to fight climate change and therefore mainly invest in carbon-free energy. For Czech republic the development of RES and other supported energy for the period 2021–2030 corresponds to a total of CZK 511.2 billion, of which CZK 411.4 billion is represented by the existing operating aid for current sources, CZK 53.5 billion is represented by the related operating aid for current sources to keep them in operation and CZK 46.4 billion is represented by support for new sources (of which CZK 35.1 billion is for RES and the rest for other supported energy sources – high-efficiency cogeneration and secondary sources). To ensure the fulfilment of its long-term vision the State Energy Policy defines the Czech Republic's strategic energy objectives and sets out strategic priorities. Investment in the construction of new sources is provided by energy companies and decisions are based entirely on the expected return on investment. The state may use its instruments to influence the behavior of investors to a limited extent and a manner that is compatible with competition law (using for example tools mentioned in the Methodology).

According to Integrated National Energy and Climate Plan for Austria the budget reserved for investment into Energy system development is EUR 31,547-38,547 million for the period 2021-2030, while the budget is divided mainly in aids for operating current sources. Close cooperation between the government and business is a key factor for success in Austria and intense collaboration between the state and private investors opens up major opportunities. Austria's approach is therefore to use public funds to trigger the broadest industrial research investment possible.

4.1.2 Financial Barrier of the Realisation

We will first focus on the conceptual analysis of the cost distribution of RES and non-RES, and hence the impact on the pricing dynamics. Afterwards we compare the LCOE of the different ES (Wissel et al. 2008). In the end we will analyse the impact of the cost's distribution on the profit. The way, the levelized costs of electricity are calculated can be seen in the formulas 1,3 beneath.(Haas 2021)

LCOE:

$$C_{ele}[\frac{€}{MWh}] = \underbrace{\frac{C_C + C_{OF} + C_{misc}}{T}}_{\text{fix costs}} + \underbrace{c_{fuel} + c_{CO_2} + c_{OC}}_{\text{variable costs}} \tag{1}$$

(2)

Profit:

$$\pi[\frac{€}{MWh}] = \underbrace{R(x)}_{\text{clearing price at the market}} - \underbrace{c(x)}_{\text{varibale costs}} \tag{3}$$

$$\tag{4}$$

In formula 1 the costs are split into fix - and variable costs. Fix costs consist of the investment C_C, performance C_{OF} and operational C_{misc} costs as well as the hours of performance per year (T$[\frac{h}{a}]$). Clearly visible is that the fix costs are reciprocal proportional to T. Variable costs are fuel, CO_2-taxes and work-related operational costs. Those can also be called marginal costs, as they build the price of the bid. The clearing or equilibrium price (EP) is then the price for what the electricity gets sold.
Throughout the comparison of the power plant's LCOE and profit the investment costs are specific regarded to the output of electricity generation. The analysis showed that RES and non-RES distinguish in the distribution of their costs. Non-RES, compared to the RES, have very low investment costs but high variable costs. The variable costs of the RES in contrast are extremely low. This comes down to the fact that non-RES have to pay high fuel and CO_2 prices, whereas the RES just use a natural/priceless source of powering their generator. Nevertheless, the high investment costs of RES are definitely considered as a serious problem, which could only put an end to if the remaining conditions will be improved. The relative distribution of the different costs can be seen in figure 3[1].

When it comes to the analysis of the profit, the results distinguish from the expectation the graph 3 may lead to. Unlike the fix costs, variable costs are not dependent of T, which means, throughout the life cycle of a power plant they stay constant, whereas the fix costs decrease by the time the power plant generates electricity. Referring to the result of the comparison of the LCOE's, the RES so will constantly pay very low variable costs, whilst their fix costs decrease with their duration of operation. This can be explained by the formula 1 from above. As we know, the clearing price of the market is always set by the marginal costs of the power plant with the highest costs of electricity generation (Merit-Order). The RES, with its very low marginal costs, are obtaining a very high deviation between the EP and their marginal costs according to formula 3. This π is then used to cover the high fix costs. Non-RES obtain lower profits because of their higher variable costs.(Wissel et al. 2008)

[1]Translation of graph 3
x-axis: browncoal-steam ; stonecoal-steam ; petroleum gas- gas & steam ; PWR ; biomass ; ROR
legend: Kapitalkosten:capital costs ; Betriebskosten:operational costs ; Brennstoffkosten:fuel costs; Min.backup Kosten:min.backup costs ; Mehrkosten,max.backup Kosten:max.backup costs ; Zertifikatskosten:certificate costs ;

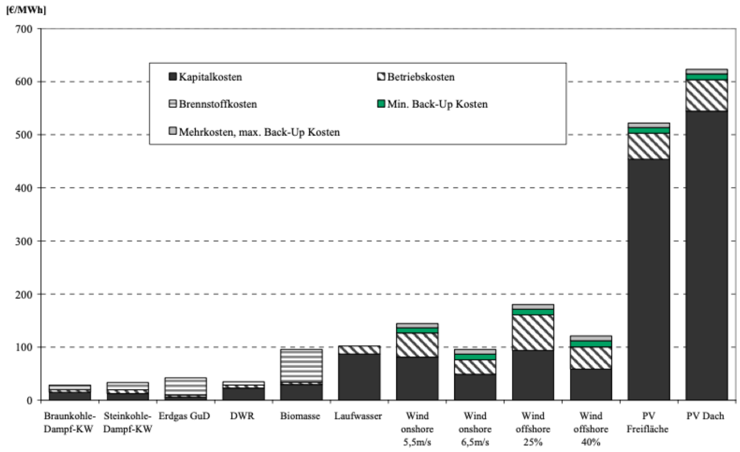


Figure 3: LCOE of the compared ES(Wissel et al. 2008)

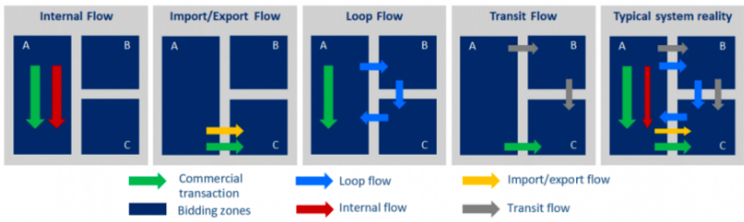


Figure 4: Representation of loop- and transit flows

4.2 Loop - and transit flows

Preliminary, we must define loop- transit flows. At our current market solutions, a uni-, bi or multilateral trade takes place inside or across the border of a bidding zone. The therefore resulting scheduled flows between the transaction participants should determine the actual physical flow by using their available transfer capacity (ATC). However, according to Kirchhoff's second law, electricity will always take the path of least resistance, from source to sink. Therefore, it can happen, that the electricity gets distributed, due to the fact that the current market solution is not fully able to represent the physical realities of the power grid. Those unscheduled deviations between the flows are called loop - and transit flows. As they occur in external control areas, they are negative external effects related to a commercial transaction. Precisely, loop flows are unscheduled flow within a neighbouring bidding zone/control area, whereas transit flows are unscheduled flows between two or more bidding zones/control areas.(Skånlund 2013). In the graphic 5 the definitions of loop - and transit flows are visualised.

As previously mentioned, the present grid is not able to represent the actual physical realities, due to insufficient price signals. This comes down to the fact, that it was developed as an integrated national system with a long term projectable thermal based generation, a limited exchange and a steady growth in consumption and national load. Though, in the course of energy transition, consistent thermal ES are being replaced by the highly variable RES, what brings energy imbalance, while additionally the market itself grows by connecting further bidding zones. Logically, the current grid is not able to adapt as fast as the expansion of the European electricity exchange takes place, wherefore several issues occur.

For instance, we look at south-east Europe, who inadvertently inhabit loop and transit flows induced by Germany. The major cause for this was the shutdown of Germany's oldest nuclear powerplant in the south. As a result northern Germany built many new RES, like solar or wind, in the course of the new energy transition. Now It produces a big surplus, that has to be transferred to the south. However, due to the fact, that the grid of Germany is way less developed than the grid of its neighbor countries like Czech Republic, Slovakia and Poland, the electricity takes the way of least resistance trough their territory instead of taking the shortest way inside of Germany (loop flows). Moreover, Germany produces a big surplus of energy, that is traded across its borders, also often to Austria. By transmitting this energy, the electricity again predominantly takes the way through the neighbouring countries and cause two severe issues (transit flows). (Mišík2149 n.d.)

The first one is congestion inside of the host area. This often leads to an unintentional reduction of the own scheduled flows, which prohibits the maximum usage of trading and transmission capacities and leads therefore to financial losses. The second one is related to the security of supply and system services, whereby loop and transit flows threaten the emergency capacity that need to be available all the time, in the case an outage or an blackout appear. Originally, both problems were causing high costs only for the host area, until, in 2012 and 2013, the European commission engages the responsible countries to pay compensation payments to the affected regions,(Skånlund 2013).

4.3 Future Grid Concept

The goal of the analysis was to find out whether smart grid and meters are capable of the current problems and challenges in the course of the energy transition. To get a short overview of the "old" and the smart grid, tabular 5 shows some major differences between those two. In the beginning we analysed roughly all important functions and later the therefore resulting effects and benefits.

Smart meters are measuring devices inside of the grid, that transmit and receive information of the power flows across the entire distribution grid. The smart grid process and monitor this information sent, by the meters, and is so able to manage itself, adjusted on every type of situation. This kind of diagnose, based on the bidirectional communication, leads to a very efficient way of planning and handling various tasks of different parties like supply utilities or the consumer itself. It even provides benefits for the government and the environment. (Barai et al. 2015)

With the information, the smart grid gathers, the utilities such as TSO or SO can plan better in terms of disruption, capacity or peak and transformer load management. For example, through constant data processing an automated control can identify where

Existing Grid	Smart Grid
Electromechanical	Digital
One-way communication	Two-way communication
Centralized generation	Distributed generation
Few sensors	Sensors throughout
Manual monitoring	Self-monitoring
Manual restoration	Self-healing
Failures and blackouts	Adaptive and islanding
Limited control	Pervasive control
Few customer choices	Many customer choices

Figure 5: Comparison of the existing and the smart grid

disruptions occur and can therefore response really fast. In the case of an outage/blackout this can safe much money and restores security. By taking even cross border power flows into account, the system is able to enhance resiliency and forecasting against external threats like loop - and transit flows. Based on that way of capacity management, resulting blackouts can be prevented. In addition, it is enabled to disconnect and reconnect certain loads remotely in order to optimise the power flows. Furthermore, it provides information about the trading costs of electricity in real time. As a result, consumers are able to decide by their own when to activate devices with high energy consumption or just when they consume electricity. This dynamic pricing does not only lower their bills but is also meant to compensate the gap between the demand and the peak load. As a consequence the probability of congestion lowers significantly, so the security of supply rises.(Zheng et al. 2013) According to the environment, flatten the peak shows some different benefits. By contributing to the proper distribution of the existing power usage, the smart grid prevents the activation of thermal based ES and therefore the emission of greenhouse gases and pollution.

5 Dicussion

5.1 The Problem of Financing and Integration

5.1.1 Financing and Integration Strategies

Taking in comparison financial expenditure reserved by the Member States of the European Union for the development of their energy market and financial resources provided by EU we can state that the financial cornerstone of both the sources and infrastructure development is the budget defined by EFSI (European Fund for Strategic investments). Leading strategy is the combination of both private investments and European funds. Beside the main financial pool defined by European Union there are also many additional support schemes and funding programs developed as a reaction to recent events that have significant impact on global economy f.e.: covid pandemic and Russian aggression in Ukraine. The impact of war at Ukraine will probably lead to a bigger financial focus on investment into flexible sources replacing the place of natural gas in European Energy resources portfolio and therefore complying with the requirements of balanced energetic mix.

5.1.2 Financial Barrier of the Realisation

Throughout the analysis of the LOCE, it appears that thermal and renewable ES have a different distribution of their costs. Therefore, the comparison, regarding the competitiveness between them, was not easy to execute. Thermal ES have lower fix costs as well as a stable rate of production, what makes them ideal for secure Investments. Nevertheless, thermal ES must be abolished in order to meet the climate target goals for reducing greenhouse gas emissions. Hence RES must be further developed and integrated in the grid. However, they have neither low fix costs, nor a stable rate of production because of their dependency on meteorological effects. Nevertheless, it's the variable costs what makes them attractive for the future. By producing energy with low variable costs, the deviation between clearing price/EP and the marginal costs are very high, and therefore also the profit. Furthermore, the urgency of the energy transition forces the government to subsidise the integration of RES in the grid. Moreover the likelihood of an profitable investment rises significantly, if it is known, that the government pushes the development of the grid infrastructure (5.1.1) to better fit in RES and compensate the instability/variability of their production. Regardless, the grid is yet not built, and until then it's a critical phase of the transition, where profit and supply are threatened by the underdeveloped infrastructure and the therefore resulting problems that appear in Europe. But still, a green transition is not debatable and must be executed in any way. Even the jobs that may be lost by shutting down thermal ES, can be retrieved by RES. To sum it up, it's the governments responsibility to provide the political and physical frame conditions, where the weaknesses of RES are getting compensated through subsidies or other policies, so the investment in RES an their integration don't stagnates.
A potential weakness of the analysis may be the variable components of the LCOE. The price is dependent on the fuel costs or on the height of CO2 taxes. It can further be influenced by the inflation, that increase the costs of long term credits like the ones of RES. Even external effects like the current war (01.06.2022) between Russia and Ukraine has an significant impact on the comparison, by i.e. increasing the price of petroleum gas, that is commonly in operation for security supply.
As already mentioned, a similar research has been made by the University of Stuttgart(Wissel et al. 2008). For the future, it would be interesting, if the time of operation for wind or solar ES can be expanded somehow. Regarding to formula 1, this could lower the high investment cost and hence, may increase the attractiveness of an investment in RES.

5.2 Loop - and transit flows

Europe live through a critical phase of transition, where grid issues like loop - and transit flows occur frequently. If a country inhabits unscheduled flows, it often causes congestion, what leads to major issues like a loss of security and profit. In the case of Germany and south-east Europe, such a situation comes down to the underdeveloped grid of Germany. Even if they already pay compensation payments, this mustn't become a normal condition. Though, the further implementation of RES in the grid cannot be stopped neither.

The solution to loop - and transit flows must be a reconfiguration of the whole market and the power grid, which is also the conclusion all concerned countries in south-east Europe and Germany agreed on. With the introduction of flow based market coupling and a adequate delimitation of the bidding zones in all regions (i.e AT-GE, 2017), transit flows would become loop flows, which are internalised in the algorithm of the market. Both measures are intended to make the scheduled flows more equal to the physical flows, since this market solution better represents the physical realities. Furthermore, it would be highly efficient if the TSO's, as they are currently responsible for their own bidding zone, are starting a cooperation to exchange information of ATC, supply, and surplus in order to ensure a secure and well-coordinated grid development. Last but not least it must be said that it's indispensable to invest in cross border trade and physical infrastructure to enlarge short term trading capacities, so future power grids, that abstain from reliable thermal ES, are always ready to import energy if their own RES aren't able to generate the needed demand. Nevertheless, the development should happen simultaneously and in homogeneous steps, in order to avoid further problems related to a significant difference in technological or economical progress among the membership countries.(Skånlund 2013).
Partial solution like the mentioned delimitation of bidding zones, or the integration of modernised market systems like FBMC or X-Bid, are no sufficient solutions, but support the European grid during the critical phase of transition. Nevertheless, the appearance of loop - and transit flows hinder the progress of the energy transition, and are therefore a severe problem, which should be eradicated immediately. A integration stop of RES would have severe consequences regarding to full fill the requirements of the targets and goals. Just as in chapter 5.1.2, the government needs to put effort in the modernisation of the grid in order to minimise the weaknesses of RES.
Due to steady growing grid and the rising numbers of member states in the European market coupling, loop- and transit flows can always occur somewhere else, wherever the path of least resistance is at the moment. Therefore, it's hard to forecast and prepare the grid for such an incident. The paper "THREE COUNTRIES, THREE VIEWS? LOOP AND TRANSIT FLOWS IN ELECTRICITY GRIDS FROM AUSTRIAN, CZECH AND SLOVAK POINT OF VIEW" (Mišík2149 n.d.), shows how difficult it is to handle unscheduled flows and how the European commission investigate the situation to solve it.
A future research project could be a measuring device inside of the grid, that shows the current resistance in the transmission line to be able to predict upcoming unscheduled flows.

5.3 Future Grid Concept

The widespread modernisation/further development of the electricity grid and infrastructure for transmission is distinctively necessary if the energy transition in Europe should succeed. The EU does already have a plan for the integration of the smart grid and meters. Moreover, it's clear, that it is indeed a big enrichment for the whole European electricity market. Nevertheless, the implementation is expensive. First of all, the EU

has to cover all costs of the material used to produce a sufficient amount of devices for the whole EU. Furthermore, the demand of circuit boards, that are constructed in China and need to be imported. The next negative factor is the time the European countries need install them. As mentioned before, this critical time of transition causes many issues. Finally, when it comes to the data processing, a new huge amount of information needs to be managed accordingly, in order to even get the benefit out of the system. So far, it's the task of the nominated electricity market operator to take care of the algorithms. Most certainly, they will need time to adapt on this new grid. Despite of all, the urgency of our situation in the course of climate change and the huge advantages the smart grid brings with it, when its fully functioning, leads to the logical deduction of pro-arguing for the implementation of smart grid and meters. The three guiding principles of the EU's power market are competitiveness, security, and sustainability. With the introduction of smart grid and meters the instability of the RES's supply gets negligible wherefore RES can compete with thermal ES. Further the grid becomes more secure than ever before, because of the monitoring and forecasting functions of the smart meter, that makes it possible to react on outages/blackouts even faster than before. Finally, by increasing the efficiency, simultaneously decreasing the consumption and distributing the demand of electricity over the day, smart grid and meters decrease the emission of greens house gases and the pollution of thermal ES, and is therefore also sustainable. It's not difficult to conclude, that this invention would significantly advance the energy transition, as it solves nearly all problems mentioned in 5.1.2 and 5.2.
Examples where the smart meter is already implemented show very positive results. In the future, the EU plans to expand smart grid and meters across all borders to create a highly efficient cooperating grid. Interesting to know would be, if a common grid across the whole world would be able to improve the standards of the European electricity exchange, or not.

6 Conclusion

This paper was dedicated to estimate the plausibility of overcoming all discussed problems and challenges in the course of energy transition and meeting the named goals and targets concluded of the EU regarding to the climate change. Deposing such a statement needs a comprehensive understanding of the whole topic. To achieve the needed oversight of this complex situation, we observed the problems from different sights and sectors. The energy sector is an interdisciplinary construct, that is driven by economical, ecological, informational, physical, logistical, political and social aspects.
We first focused on the electricity market as the foundations of an economical approach to understand all relevant circumstances of electricity trading. As we could see, this sector is well developed. The EU integrated a liberalised, decentralised, and interconnected market based on a free competition. It further function with highly advanced trading system like XBID or FBMC, which are already able to diminish current problems like loop - and transit flows. Therefore, we consider this sector as enabled to incorporate the incoming energy transition. As we looked at the underlying policies in the terms

of decarbonization, we split our research in two parts. As an outline, we gathered information about the goals and targets set by the EU, AT or CZ in order to slow down climate change. Furthermore, we analysed the financing and integration strategies to accomplish the named contract regulated goals and targets. Regarding the individual targets, that has been set for the Member States, Europe seems to be quite successful on meeting the goals on the path towards security of supply, competitiveness and sustainability of European energy market. Also, the financing of the energy sector by the public sector, seems to be sufficient. Due to the current situation in east Europe, it might be even accelerated by additional budgets (program REPowerEU) to become independent on import of Russian gas. Nevertheless, the financing by the private sector seems to be endangered by high investment costs of RES. Even if the supporting infrastructure is already planned, it seems to be a down slowing factor. As a result, it must be said that the policies are not decisive enough to determine distinct and uniform actions. The political trend is right, it just let to many things unsettled, hence it will still rely on the assertiveness of the respective sectors. This leads to a big detriment of the ecological/sustainable sector. As this branch is still arising, it is deeply dependent on the state, which should provide a supportive outline of regulations. To compensate this, the EU needs to further mobilise funds and decrease the financial support of contra productive technologies. The informational, physical, and logistical sector are very closely linked. The research yield to a lack of transmission capacities, modernised grid infrastructure and far-reaching cooperation in terms of grid development and security of supply. We have looked at loop - and transit flows, analysed their causes and searched for possible improvements of the situation. We concluded, that the only way to eradicate those problems lies in a uniform development, modernisation and extension of the grid. The implementation of smart grid and meters as well as increased transmission capacities provide a sufficient foundation for a secure, sustainable and competitive electricity market. Not only does it reduce problems like outages, congestion or loop - and transit flows, but it also prepares the outline, that amplifies the economical, ecological and social advantages, which RES originally bring with them. Additionally, such an infrastructure would lift the competitiveness of RES significantly. Despite everything, a modernisation like this, propose several challenges. The implementation of the devices as well as cross border constructions need a high amount of logistical work. The new amount of data provided by the smart grid needs to be implemented in the algorithms and linked with the Member states. To sum it up, the problems and the respective solutions are clear, but the realisation hardly depends on EU's valuation of this project, and therefore the financial support.

Overarching, the social aspect of the energy transition should not be overseen. Through providing green energy the taxes for CO2 as well as the prices for electricity at all are getting reduced. Furthermore, the functions of the smart grid can lower the peak load, but also prevent high costs caused by congestion or outages and its consequences. Combined with the consumer specific benefits of the smart meters, the interventions of the decarbonization provide a big potential for the rise of the social welfare(Haas 2021). The targets of the Parisian climate conference are clear. The amount of greenhouse gases must be reduced by 80-95% compared to 1990 in order to stay below 2 degree Celsius of human made global warming. How urgently necessary this concern is, are proving other contracts or scientific research like the Kyoto protocol or the IPCC report, that been recently released. Throughout the analysis, we found many options to reduce the greenhouse gas emissions. However, it needs to be clear, investing in long living and renewable infrastructure is the key to a build up a sustainable and secure future. Even by taking the whole paper into account, the answer, whether the EU and its member states are able to accomplish their goals, can not be answered trivially. It mostly depends on the determination of the state to enact the laws through subvention and increase the taxation of CO2 producing institutions. Additionally top-down policies or sanctions for countries or specific industries may be needed. It further depends on unpredictable events, that can have an impact on the distribution of financial funds, i.e., the current war between Russia and Ukraine (01.06.2022). Overall, the political trend points in the right direction, but in order to meet the requirements and accomplish all the set goals and targets, an ambitious reinforcement of the engagement, and a mobilisation of all affordable funds to invest it in sustainable infrastructure, is indispensable.

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List of Figures