WHOLESALE ELECTRICITY MARKETS IN EUROPE:

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ABSTRACT

Energy markets are complex economical structures allowing producers and consumers to exchange energy commodities for money. We divide energy markets based on energy resources and time horizons. In most of the energy markets key restriction is time, because for some, it is mandatory to meet demand and supply at the same time or the whole system might collapse. Good example of this kind of energy commodity would be electrical energy, where when the supply does not meet demand at the same time or via versa, the frequency of the whole grid goes from typical 50Hz and might lead to blackout. To satisfy everchanging demand and balance the grid there are many energy submarkets operating mostly through power exchanges to offer both sides different products. The electricity is often sold in forms of options and then resold multiple times, which easily lead to intransparency surrounding the price building. To tackle this issue, the European Union introduced the *Regulation on the internal market for electricity ((EU) 2019/943)* and *Regulation on wholesale energy market integrity and transparency (1227/2011/EU).* This legislation makes it mandatory for traders to provide the selling data to the Agency for the Cooperation of the Energy Regulators (ACER). Furthermore, the European Commission releases a review of the energy price and cost development biannually starting in 2014.

Different countries and their governments face different obstacles and options based on their landscapes when it comes to the efforts of trying to change the current status quo. Their populations also take various stances depending on the price changes that come from different sources as well as the differing positions on debated sources such as nuclear or coal.

The European Union generally fosters a competitive market in the efforts to provide its citizens with sufficient electricity at possibly reasonable prices. In this paper we will look at the different countries' approaches and their results to assess how effective their work has been so far. To do so, we will work with the data provided by the European Commission as well as published papers related to the studied subject.

MOTIVATION

Even though the countries within the European Union work with the same directives and regulations, their application still differ for every country and even neighboring countries can showcase huge disparities between their rules. Implementing EU legislation is a continuous process and not all countries are implementing them with at the same rate. Some of the countries were also able to put national exceptions in the legislation. Another interesting aspect portray the differences in energy mix, just like in the case of Austria and the Czech Republic which will be studied and discussed further in this paper. In this paper authors will also look through history of energy industry in both countries to make clear picture for reader about the past, present and future situation. The results will also be compared with the data on larger scale within the whole Union. This way we can discover possible trends and hypothesize about the possible reasons.

INTRODUCTION

In the current state of affairs, dealing with the staggering inflation, energy is one of the most discussed topics in economy. People are finding it increasingly difficult to afford everyday necessities and it is not unusual for them to include energy prices within their justified complaints. We will therefore look at the latest situation at the Austrian, Czech and EU market and their development in the past months and years, analyze, among other things, the effects of the Russian-Ukrainian war and previously the Covid-19 pandemic.

The other part of our research is the historical evolution of these countries as the history they both overcame went in different directions. As a result of these historical occurrences, one can still observe variance in the structure of the sources at the moment.

This paper will be diving into the specificities of each of the aforementioned countries and their plans for the future, but also looking for the spots where they overlap. Besides that, we will compare the differences and look for their possible power exchange,

Last but not least, we will take a look at the markets on a broader scope and consider their cross-border capacities.

Since electricity is one of the major components exploiting the energy mix and a very present topic when talking about sustainability, we will then take a closer look at its presence in the markets. We will compare the sources for both countries and discuss the differences.

METHODS

The primary topic for this paper is comparison of the current and past states of legislature of energy markets in Austria, Czech Republic and in broader scope the whole European Union. Energy Market describes a market whose main purpose is the provision and trade of energy sources. It is a very dynamic market with ever changing goals, incentives and rules. (Mousavi F., 2021). Currently, there are multiple smaller markets throughout the European Union that promote competition within the countries. General description with the laws and directives that are in place at this time can be found on the website of European Commission. (Commission, n.d.).

To be able to describe the contemporary picture of the specific energy mixes, statistics from the "Our World in Data" website. **Fehler! Verweisquelle konnte nicht gefunden werden.**, **Fehler! Verweisquelle konnte nicht gefunden werden.** as well as were also retrieved from this source (Ritchie H., 2022). The website provides a deeper look into the whole energy structure, consumption, as well as the citizens' access to it. This makes it a very valuable source when looking for statistics. The data will be used to provide comparison between Austria and Czech Republic with commentary to differences.

HISTORY

The wholesale electricity market in the European Union has seen several transformations over the last few decades. It's important to note that prior to the 1990s, the electricity sector across most of Europe was characterized by national monopolies. State companies were responsible for the generation, transmission, distribution, and retail of electricity in their respective countries. The liberalization and integration began with European Union's First Energy Package in 1996 and continued till today with other legislation aiming to connect the whole EU electricity market. For purpose of this paper, it is crucial to at least mention the first three energy packages.

First Energy Package (1996-1998)

The First Energy Package was adopted between years 1996 and 1998. It started the process of liberalizing the EU's energy market. It included directives for the internal market in gas and electricity, focusing on establishing common rules for the transmission, distribution, supply, and storage of electricity and natural gas. (European Parliament, 1997)

Key points:

- **Unbundling of accounts**: energy companies were required to keep separate accounts for their generation and transmission businesses to ensure transparency.
- **Third party access**: guaranteed access for other companies to transmission and distribution networks
- **Regulated network tariffs**: to prevent discriminatory pricing

Second Energy Package (2003)

The Second Energy Package, enacted in 2003, built on the first package, bringing more extensive liberalization measures. Its focus was to improve the functioning of the internal energy market. (European Parliament, 2003)

Key points:

- **Legal unbundling**: requiring electricity companies to separate the legal entities responsible for generating energy and delivering it
- **Increased consumer choice:** all non-household consumers could freely choose their electricity and gas supplier from July 2004, and all consumers from July 2007
- **Enhanced regulatory powers:** national regulators were given increased powers to enforce the new regulations

Third Energy Package (2009)

The Third Energy Package was adopted in 2009, with further measures to create a fully operational and competitive internal energy market. (European Parliament, 2009)

Key points:

- **Ownership unbundling:** where energy generation and supply interests are fully separated from network operations to avoid conflicts of interest.
- **Establishment of the Agency for the Cooperation of Energy Regulators (ACER):** ACER was given the task of coordinating national regulatory authorities and ensuring market integration.
- **Strengthening consumer rights:** the package included rules on transparency and clarity of bills and contracts.

Czech Republic history and development

The Czech Republic's electricity sector has experienced several pivotal moments over the past century, characterized by technological advancement, socio-political shifts, and overall growing demand for electricity.

In the early 20th century, the motivation for systematic electrification was not industry but agriculture, which required mechanization due to a shortage of labor. Small power plants with local distribution networks were established, and demand for electricity grew, especially after World War I. By the late 1920s, 70% of the population had access to electricity.

From the 1920s to the 1930s, 20 public utility power companies were established, accelerating the electrification process. Despite the high price of electricity at the time, electrification was propelled by shared ownership among the state, local governments, and consumers. However, this electrification drive was disrupted by the onset of World War II,

during which major power plants were built but the electricity distribution network suffered substantial damage.

Post-World War II, Czechoslovakia's energy sector underwent significant changes in ownership, and the Czechoslovak Power Plants were established to manage electricity production and distribution. Despite post-war challenges, such as a growing electricity shortage and outdated infrastructure, power plant performance was improved, resulting in a twofold to threefold increase in output during the 1950s.

During the 1960s and 1970s, the construction of large coal-fired power plants and high-voltage transmission lines were prioritized, and the country became part of an international power grid. A planned economy led to the policy of "cheap electricity", resulting in significant price imbalances between production costs and selling prices, leading to inefficiency and wasteful consumption.

The 1980s marked a turning point with the construction of the Dukovany Nuclear Power Plant and the beginning of the construction of the Temelin Nuclear Power Plant. Despite the continuation of the policy of "cheap electricity", attempts were made to better align prices with costs, albeit with limited success.

After the Velvet Revolution in 1990, the Czech energy sector underwent fundamental transformations. The state-owned Czech Power Plants were divided into several independent entities, and modern technology was introduced to existing projects. The Temelin Nuclear Power Plant project was revised, and its completion marked a milestone in the history of Czech energy. The 2000s saw the commissioning of the Temelin Nuclear Power Plant and significant investment in infrastructure upgrades, contributing to a robust and efficient energy sector in the Czech Republic. (ČEZ, n.d.)

Austria History

Prior to the decision to liberalize the energy markets in Europe in late 1990s with the Directive 96/92/EC, many of the countries fostered a monopolized market. Based on the comparison between Astria and Germany when dealing with the liberalization, it is possible to observe the approach these two countries chose. (Madlener & Jochem, 2001) At first, Austria decided to take a gradual approach to transform the market, however, this method appeared to give an advantage to bigger countries which chose to open their market quicker. That led to a more abrupt opening in Austria with the second round of the EIWOG legislature. The market thus became liberalized in 2001 before the deadline set by the directive and sooner than many other member states. Since the opening and unbundling of energy markets of the member states, there are several hundred companies participating daily in thousands of transactions. Before the energy arrives at the hands of the final consumer, it is resold several times. The trades happen between different countries and companies to promote competition to offer the most cutthroat prices for the end consumers (Commission, n.d.).

While the market in Europe was opening, there were changes happening on the eastern borders. The major gas dispute between Russia and Ukraine in 2006 and 2009 had influence on the gas supply and prices within Europe. This development cannot be omitted

when overviewing the history of European Energy market (Stern, 2006). Relatively shortly after resolving the dispute in 2006, another one arose in 2009, that is also analyzed by the Oxford Institute for Energy Studies (Pirani S., 2009).

During spring 2005, a dispute between Russia's Gazprom and Ukraine's Naftogaz Ukrainy started and reached its climax in January 2006, when Russia stopped sending gas through Ukraine. The cutoff lasted only a couple of days and the two countries were able to agree on January 4th the same month. During the months of the dispute, a number of countries reduced the gas supplied by Russia by significant amounts, in Austria this constituted around one third of its gas imports (Stern, 2006).

In October 2007 this fragile agreement began cracking again. As a follow up of unsuccessful negotiations of February 2008, Russia reduced the gas supply from the beginning of March 2008 just like it did a few years prior. The relations remained tense till the end of the year. At the beginning of 2009, Ukraine's Naftogaz agreed to only buy gas from Gazprom, however the tensions stayed unresolved. To be safe from other possible disputes, Austria cut the imports of natural gas from Russia by 60% and increased imports from Germany and Norway (Pirani S., 2009).

After the gas crises of 2006 and 2009, the ambitious idea of the Energy Union (Mišík, 2016) in the scope of European Union was introduced. Austrians consider them handled generally well enough, which became relevant with the idea of Energy Union. Mišík hypothesizes that Austria's rather negative attitude stems from their government being able to overcome the aforementioned gas crisis and generally considers it competent in times of challenges. Thus, they are unwilling to give up their power. He comes to this conclusion based on comparative studies where Austria's, Czech Republic's and Slovakia's opinions were evalueated.

The environmental consciousness in the population was growing throughout this time and the technical advancements could not be ignored. One of the theories to make energy more sustainable calls for sector coupling[1] . Since the focus is on a new idea, Ornetzeder (2020) took upon to analyze the case study of the residential complex Rosa Zukunft in Salzburg. By including this small-scope study, the aim was to identify specific challenges that could arise in an attempt to introduce new technologies into an already established market. Ornetzeder was able to conclude that the execution of this idea is possible and could bring some positive outcomes, however, currently, the model is not economically feasible without subsidies from the government or other initiatives.

The early 2020s were then an extraordinarily turbulent period, starting with the Covid-19 pandemic, followed by Russia's attack on Ukraine. Both events had a big influence on the energy market. After the beginning of the pandemic, the energy sector took a hit globally. The initially lowered demand for fossil fuels for mobility, however, the latest trends suggest that this notion did not translate into a transition toward a more carbon-neutral society. Energy providers did not take this opportunity to stick to this trend and seemingly preferred to return to carbon-based sources in many instances (B. Zakeri, 2022).

The other big hit for the energy sector, especially within the European market came in late February 2022. Russia's invasion made a huge imprint in the energy world as it is a dominant natural gas provider for Europe, which has taken a strong stance for Ukraine's sake. This made the energy prices skyrocket and caused a lot of uncertainty for winter 2022.

[1] involves the increased integration of energy end-use and supply sectors with one another. This can improve the efficiency and flexibility of the energy system as well as its reliability and adequacy. Additionally, sector coupling can reduce the costs of decarbonization (L. Van Nuffel, 2018)

(Figure 4.1a) Looking at the data presented by Gutmann et al. (2023) the invasion and the following price increase did not lead to more people being opposed to globalization; however, a vast majority of Austrian people was not in favor of it. Taking study by Gutmann et al. (2023) into account one may conclude that the energy market in Austria might become more closed and self-sufficient, at least based on the current wishes of the surveyed population. This hypothesis was not confirmed with this research and would need to be reviewed more in the future as well as compared with the observable unfolding in reality.

Both of these significant historical milestones are summarized in the recent paper (B. Zakeri, 2022) reviewing their effects. Possible consequences of these events are evaluated in a paper that questions Austria's position towards (Anti-)Globalization in the energy sector. (J. Gutmann, 2023) According to a survey whose results are visible in Table 1 conducted by the same study just before and two months after the invasion one can see that the general tendency of the Austrian population to take care of their own market stays strong. The drop in people convinced against Austrian economic globalization was at a low 0.6% while the number of people believing that Austria should be focusing more on being self-sufficient rose by 5.5% and those being convinced that not being self-reliant is a priority issue for the country rose by 12.3%.

Combining the findings of these studies should bring out the positives and negatives the liberalization process had on the Austrian energy market as well as point out certain possible challenges that might arise in the future.

	Before (February) (%)	After (April) (%)
(1) "Economic globalization is bad for Austria."	51.5	50.9
(2) "Austria should become less dependent on foreign imports."	80.2	85.7
(3) "Priority issue: Independence from energy imports."	45.8	58.1

(1) and (2): figures denote the share of respondents who completely agree or agree with the statement.
(3): figures denote the share of respondents who consider this issue a policy priority

Table 1: Globalisation attitudes in Austria before and after the Russian invasion

By reading these papers in chronological order it is not difficult to follow the changes of relevant topics. One can see that the energy sector is ever-evolving, especially within the European Union when the forces from the individual member state influence the discussions. It is quite clear that the EU and its member states will continue adjusting the energy policies in the future, what will have to be studied stays the direction they will decide on.

Comparison

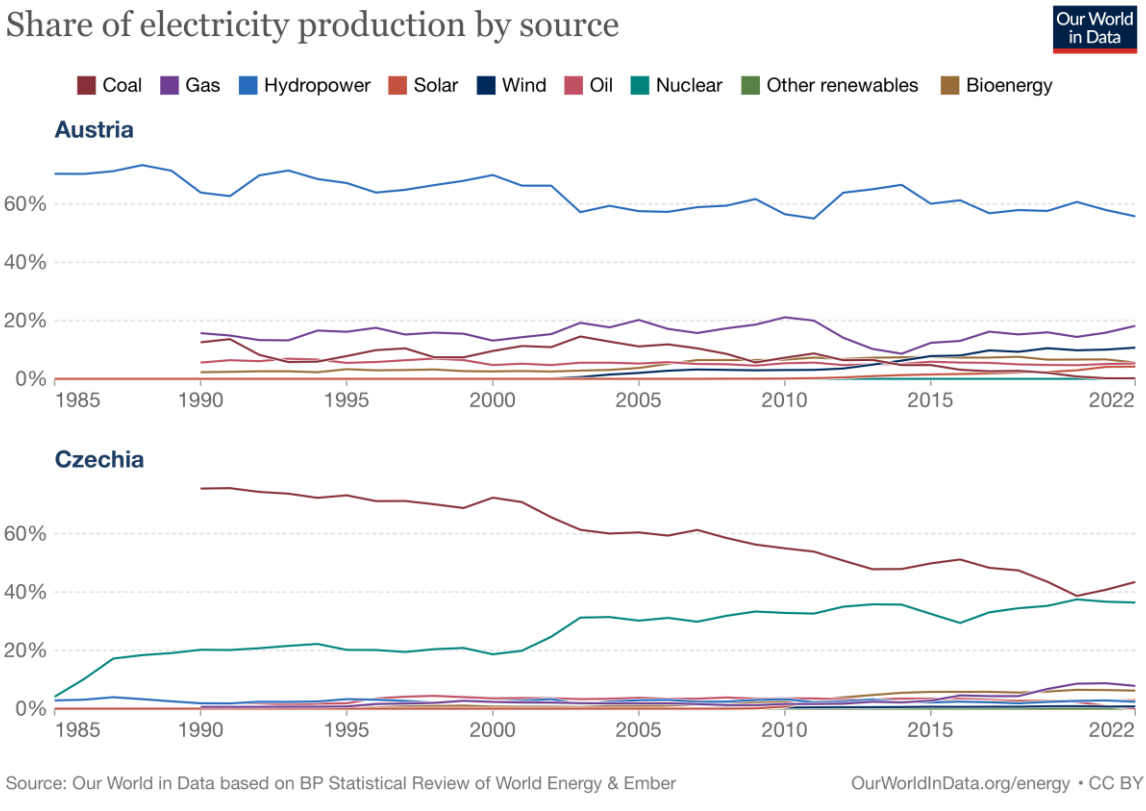
The historical development of the wholesale electricity markets in the Czech Republic and Austria has been influenced by geographical, political, and industrial factors. Both nations have shaped their energy policies according to the resources they had access to, the Czech Republic primarily focused on coal and nuclear energy, while Austria focused on leveraging its hydroelectric potential.

The liberalization of their respective electricity markets was a significant turning point for both countries. The Czech Republic started operating in a fully liberalized wholesale electricity market in 2002, with the participation of its largest energy company, ČEZ, and other subjects. Similarly, Austria liberalized its electricity market in 2001, following the EU directives, and witnessed the entry of numerous independent power producers alongside its state-owned Verbund.

A stark contrast between the two is in their stand on nuclear power. The Czech Republic, with nuclear power plants such as Dukovany and Temelín, has favoured heavily on nuclear power, whereas Austria has a legal ban on nuclear power since 1978. This contrast has significantly shaped their wholesale electricity market structures.

Recently, as a response to EU directives and global sustainability goals, both nations are looking towards more sustainable options, each facing unique challenges that have surfaced from their historical reliance on specific types of energy sources. The Czech Republic is grappling with the challenge of replacing its aging coal and nuclear power plants. At the same time, Austria is striving to balance the intermittent output of its increasing wind power sector with the steady, albeit limited, output from its hydroelectric power stations.

The intertwined histories of these two countries' wholesale electricity markets underscore the complex interactions of geography, policy, industry, and international directives in shaping energy landscapes. However, both countries are still struggling with gas dependency that has a huge impact on both markets.



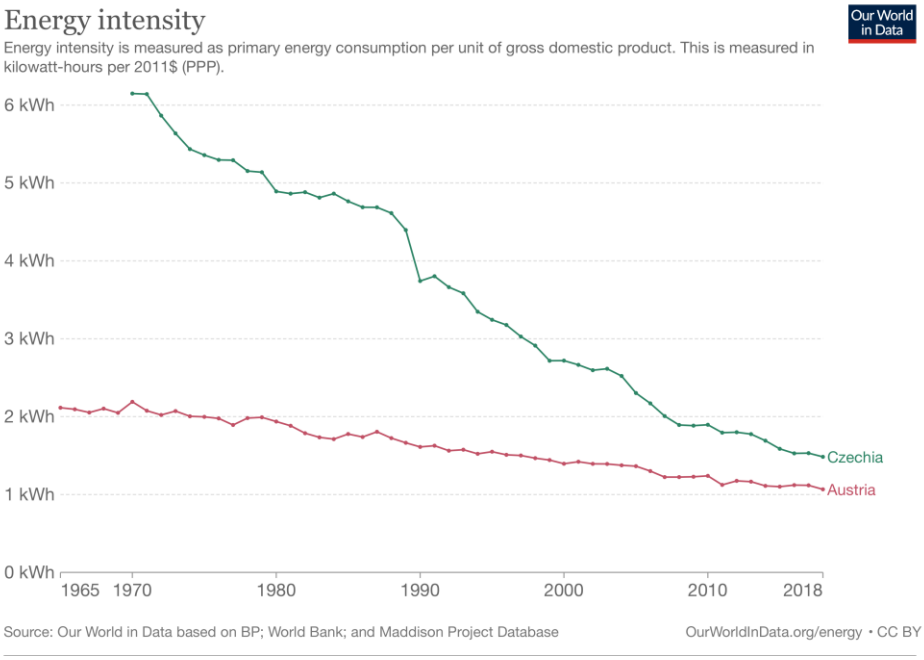
The graphic representation of electricity production by source provides an insightful view into the progression of energy generation in both the Czech Republic and Austria. In the Czech Republic there is a gradual downward trend in the reliance on coal as a primary electricity source. This is counterbalanced by an upswing in power production from nuclear, gas, and solar power plants.

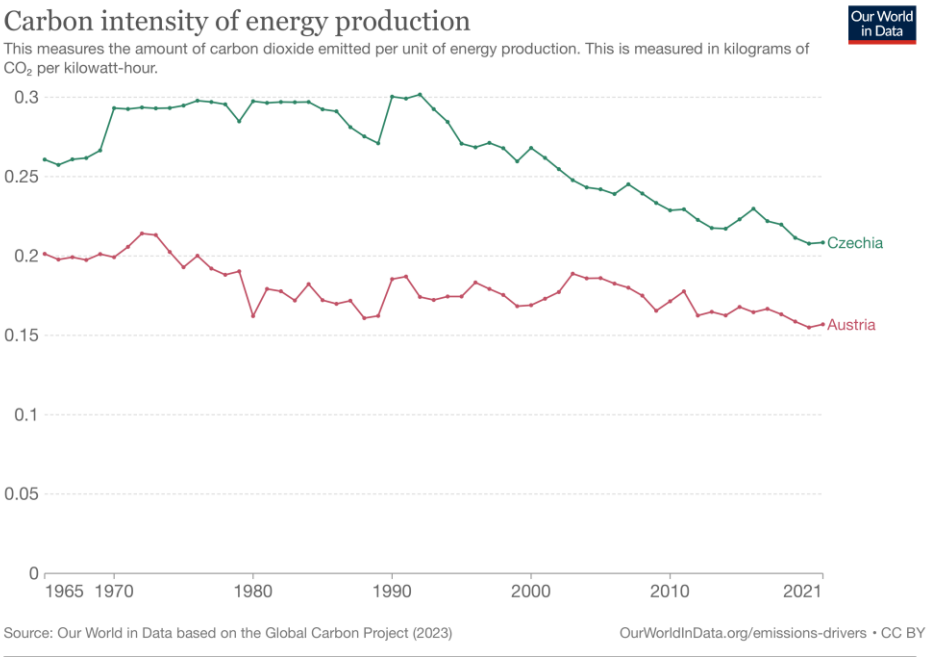
By the year 2020, coal-based power production in Austria was reduced to less than 1 percent. The past two decades have seen a marked surge in energy production from wind and solar sources, highlighting the country's push toward renewable energy. Nevertheless, gas continues to play a significant role in Austria's energy mix, accounting more than 15 percent of total electricity production.

When examining the renewable energy potential of both Austria and the Czech Republic, it is important to note that the potential for hydroelectric energy appears to have been largely exhausted in both countries. The observation of the graph shows stagnant production of hydroelectric power over last decades, suggesting an exhaustion in hydroelectric generation potential.

Conversely, the development and expansion of other renewable energy sources, specifically solar and wind energy, have been more prominent. The technological advancements increased efficiency; reduced price have allowed wider application. FVE has shown an impressive growth curve, reflecting the robust expansion of photovoltaic installations. Simultaneously, wind energy has also experienced an uptick, with an increasing number of wind turbines being installed.

This shift towards solar and wind energy marks a critical step in the evolution of Austria's and the Czech Republic's energy landscapes. The growing prominence of these renewable sources indicates the countries' commitment to diversifying their energy mix and bolstering their green energy, which is key to achieving their sustainability and decarbonization goals.





Observing the charts for carbon intensity and energy intensity for both the Czech Republic and Austria shows some remarkable progress. There is a noticeable reduction in the carbon intensity of energy production in both nations, a trend that reflects a shift toward more sustainable and environmentally friendly energy generation methods.

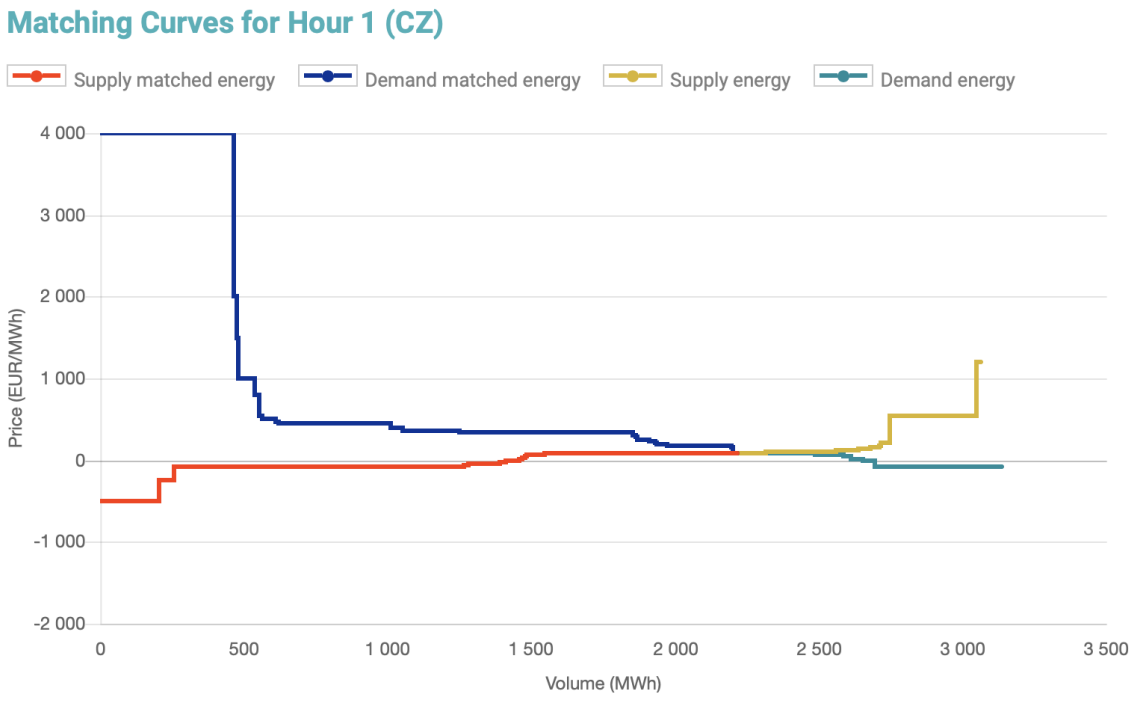
Simultaneously, there has been a significant decrease in energy intensity, the measurement of energy efficiency, in both countries. Over the past forty years, Austria has commendably managed to cut its energy intensity by half, improving its energy efficiency. The Czech Republic, on the other hand, has made even more substantial strides, reducing its energy intensity to about a third of its value four decades ago, but still behind Austria.

What's particularly noteworthy is the effect of these combined reductions on the Czech Republic's CO_2 emissions. By using energy more efficiently and focusing on less carbon-intensive sources, the Czech Republic has made significant progress in reducing its carbon footprint. This highlights the tremendous strides the country has made in adopting cleaner and more efficient energy production strategies, while also presenting the transformative impact such strategies can have on environmental sustainability.

EUROPEAN ELECTRICITY MARKET

The European Union electricity markets are a complex network of interlinked exchanges, bringing together energy providers, consumers, and grid operators across EU. Over the years, the EU has strived to harmonize these markets through several legislative packages, defining energy products to encourage the free flow of electricity across national borders, leading to competitive prices, and overall integration. (Commission, n.d.) (Commission, n.d.)

The market makers of the EU's electricity market are the power exchanges and specialized national subjects. There are 3 main types of the markets: day-ahead, intraday, and forward markets, where electricity is bought and sold. Examples for exchanges are EPEX SPOT in Western Europe, Nord Pool in Northern Europe, GME in Italy and PXE in Czech Republic. These exchanges play a crucial role in setting electricity prices, ensuring supply and demand balance, and facilitating cross-border trading. The price is typically set based on pay as cleared approach. Pay as cleared approach of auction sets price and volume traded based on the point where demand curve meets supply curve. The curves must be at first put in order. The demand curve is set in order based on price from highest to lowest. The supply curve is set in opposite price order from lowest to highest price. The important thing is that the price for the whole market is set by last accepted bid. So, the most expensive powerplant that is still accepted sets the price. (ofgem, n.d.) (OTE, 2019)



(OTE, 2023)

Based on the Demand-Supply graph of the electricity market, these can be observed. Some participants place bids at extremely high prices, demonstrating a critical need for electricity. These participants may not believe that the actual clearing price will reach their bid levels, but they need to ensure they will be able to secure the power.

At the opposite side, there are instances where bids are placed at significantly negative prices. This may seem counterintuitive, but it arises from the operational constraints of certain power plants. For these plants, once they are up and running, it can be more expensive and disruptive to shut them down in response to low demand, compared to the cost of continuing operation.

These dynamics illustrate the complexities of balancing supply and demand in electricity markets. As renewable energy capacity grows, the volatility in electricity pricing is increasing, thereby making effective market mechanisms even more crucial in the transition towards sustainable energy systems.

The trading of electricity across the borders, remains subject to the limitations imposed by cross-border capacities. These constraints arise due to the finite physical capacity of the interconnectors that transmit electricity between different market zones. In situations where demand exceeds this cross-border transmission capacity, known as congestion, it leads to price disparities between these zones. In essence, electricity becomes more expensive in the zones with high demand and limited supply access, while it may be cheaper in zones with surplus electricity.

Congestion income is the revenues generated from the allocation of scarce transmission capacity and is provided to Transmission System Operators (TSOs). This income is typically reinvested to bolster the grid infrastructure to increase transmission capacity. This reinvestment aims to mitigate congestion issues, thereby facilitating more seamless cross-border trading, improving market efficiency, and fostering competitive pricing in the European Union electricity market. (Fingrid, 2017)

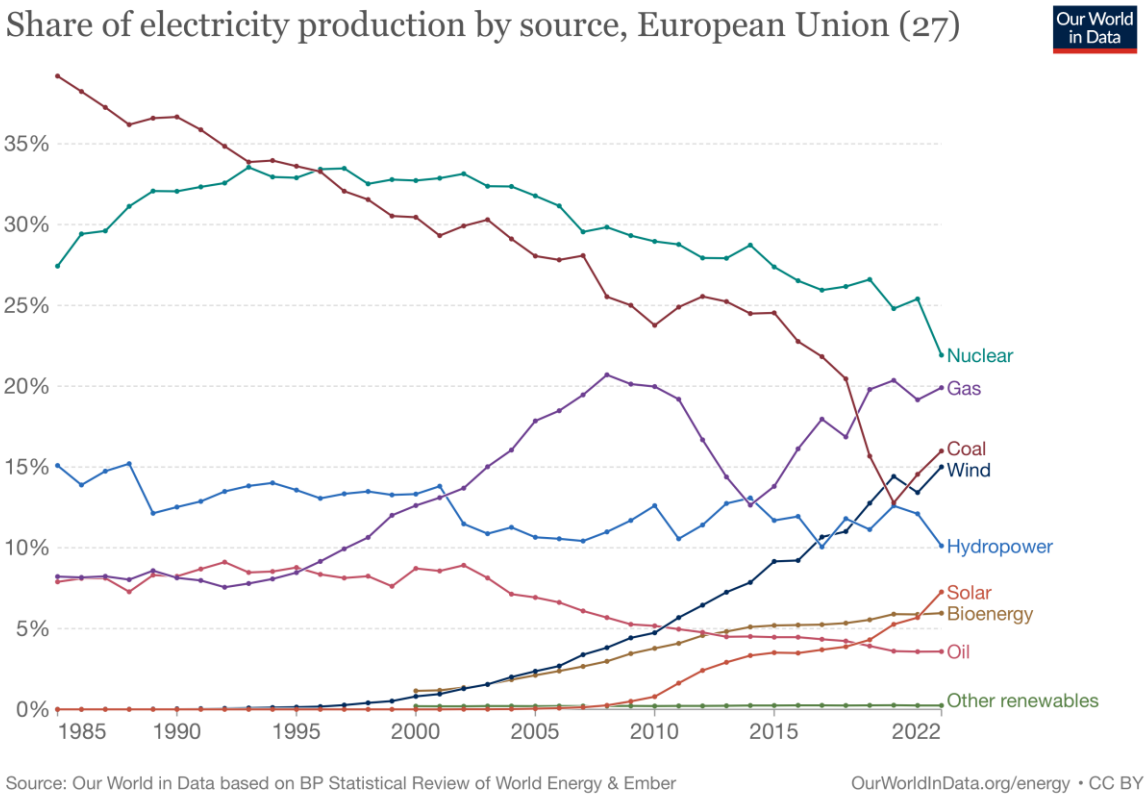


Figure 1: Development of the shares of the energy mix in Austria

EU's electricity market is moving over the years to increasing volatility in electricity production. This heightened unpredictability is attributed to the rise in the integration of Renewable Energy Sources (RES) into the power grid. Different types of RES such as solar, wind, and hydro have inherently variable and somewhat unpredictable production patterns, due to environmental factors like sunlight, wind speed, and rainfall, which can differ greatly based on geographical location and time.

For instance, solar panels generate electricity during daylight hours and are influenced by the intensity of sunlight, which can vary dramatically with weather conditions and time of year. Wind turbines, on the other hand, produce energy when wind speeds are within certain thresholds, also it is important to note differences between onshore and offshore powerplants. This contrasts with traditional power plants such as coal or nuclear, which have consistent and controllable output.

This shift in energy production is evident in the graph above, which illustrates the EU's electricity production over time. You can observe periods of steep increase or decrease in energy production, corresponding to the fluctuating output from RES. This variability poses both challenges and opportunities for the electricity market, necessitating innovative grid management strategies and market mechanisms to ensure a reliable and balanced power supply. To mitigate some of the RES risks, there have been steady increase in gas powerplants in last couple of years. Gas powerplants are often the ones setting the market price.

Market types

Day-Ahead Market (DAM):

The Day-Ahead Market is the electricity market, where electricity is traded one day ahead of actual delivery. Market participants might submit their bids for each hour of the day, indicating the amount of electricity they are willing to either buy or sell and for which price. These bids are matched and cleared by the market operator to determine the market clearing price for each hour of the following day. The Day-Ahead Market helps participants to manage their anticipated positions of the following day.

Intraday Market (IDM):

The Intraday Market allows market participants to adjust their positions closer to time of delivery, often up to just a few hours before actual delivery. It offers the flexibility to respond to unanticipated changes in prediction of demand or supply. Trades in the Intraday Market are typically done continuously, meaning that transactions can occur at any time during the trading period as soon as a matching offer is found.

Forward and Futures Market:

In Forward and Futures Markets, contracts are traded for the delivery of electricity in the future, often months or years ahead. These markets allow participants to lock in prices for future delivery, providing a hedge against future uncertainty. The difference between forwards and futures lies in their settlement: forward contracts are typically settled at the end of the contract period, while futures are settled daily, based on the market price movement. Most common types of products are yearly, quarter yearly, monthly products. The other common sub types are baseload and peak load products. Baseload products are for 24h every day in the period. Peak load products from 8:00 to 20:00 in working days. (Schindler, 2013)

Balancing Market:

The Balancing Market operates closest to real-time. Its purpose is to ensure that supply and demand are balanced in real time. This is where the Transmission System Operator (TSO) steps in to call on pre-contracted reserve power or demand response to balance the system, and charges or pays market participants based on the cost of these services.

Capacity Market:

Capacity Markets are tools used by some countries to ensure that sufficient capacity is available to meet peak demand in the future. In these markets, electricity producers are paid not only for the energy they generate but also for committing to have capacity available when needed.

Czech electricity market

The Czech Republic's wholesale electricity market, like many others in Europe, has evolved over the past few decades. Changes in legislation, technological advancement, environmental policy, and the market liberalization have shaped its current form.

The transition to a competitive market started with the Energy Act of 2000. The act opened the electricity and gas markets for future competition. The act also established the Energy Regulatory Office (ERO) in Czech **Energetický regulační úřad**, responsible for overseeing the liberalization process and protecting consumers.

In 2002, the Czech Republic joined the Organization for Economic Co-operation and Development (OECD), that lead to increase to competition in energy markets. A key year for the Czech Republic is 2004 when it joined the European Union. Forcing the compliance with the EU's energy market regulations, including the 1st, 2nd, and 3rd energy packages. This led to complete unbundling of generation, transmission, and distribution services.

In line with EU legislation, the Power Exchange Central Europe (PXE) was established in 2007. PXE operates the Czech electricity market and has a significant influence on the price of electricity traded in the Czech Republic. Since the mid-2010s, the Czech Republic's electricity market has been fully integrated with those of neighboring countries through the Multi-Regional Coupling (MRC) till 2020. (Interim, 2019)

Czech Republic's wholesale electricity market of today operates under a liberalized, competitive framework. Producers, traders, and large consumers participate in the spot and derivatives market on the PXE. The day-ahead market is the most liquid segment, setting the reference price for most of the electricity traded in the country.

The Czech market is tightly interconnected with its neighboring countries, especially Slovakia, Hungary, and Poland. Cross-border electricity flows are common, with the Czech Republic often being a net exporter of electricity. The Czech Republic is also member of SIDC and SDAC projects, which further enhances cross-border trading. (Anon., 2023) (OTE, 2021)

Comparison

Austria and the Czech Republic, both integral players in the European electricity markets, have shown over the years the development of their respective wholesale electricity markets, particularly in relation to market liberalization, power exchanges and market integration.

In Austria, the power exchange activities are centered around the Austrian Power Grid (APG) and the EXAA Energy Exchange Austria, which is a central European power and gas trading platform. The Austrian electricity market operates within the larger EU Internal Energy Market and is interconnected with Germany, thus aligning their electricity prices, barring congestion. Furthermore, with the implementation of the Market Coupling project,

the Austrian and German day-ahead markets are fully integrated, improving the efficiency of cross-border electricity trade.

Contrastingly, the Czech Republic's wholesale electricity market is administered by the Power Exchange Central Europe (PXE), which operates under the Prague Stock Exchange. PXE offers trading in electricity and gas futures for the Czech Republic. The Czech electricity market has achieved significant price coupling with Slovakia, Hungary, and Romania via the 4M Market Coupling project, and with Germany, Austria, and Poland via the Multi-Regional Coupling (MRC).

Despite the progress in market coupling, both countries experience constraints due to limited cross-border capacities, which can lead to price differentiations between zones during periods of congestion. Such congestion incomes are redirected towards enhancing the grid infrastructure and increasing transmission capacities by local TSOs. Due to close proximity both markets have close relation and often the price for the Austria and Czech Republic is same or difference is minor one.

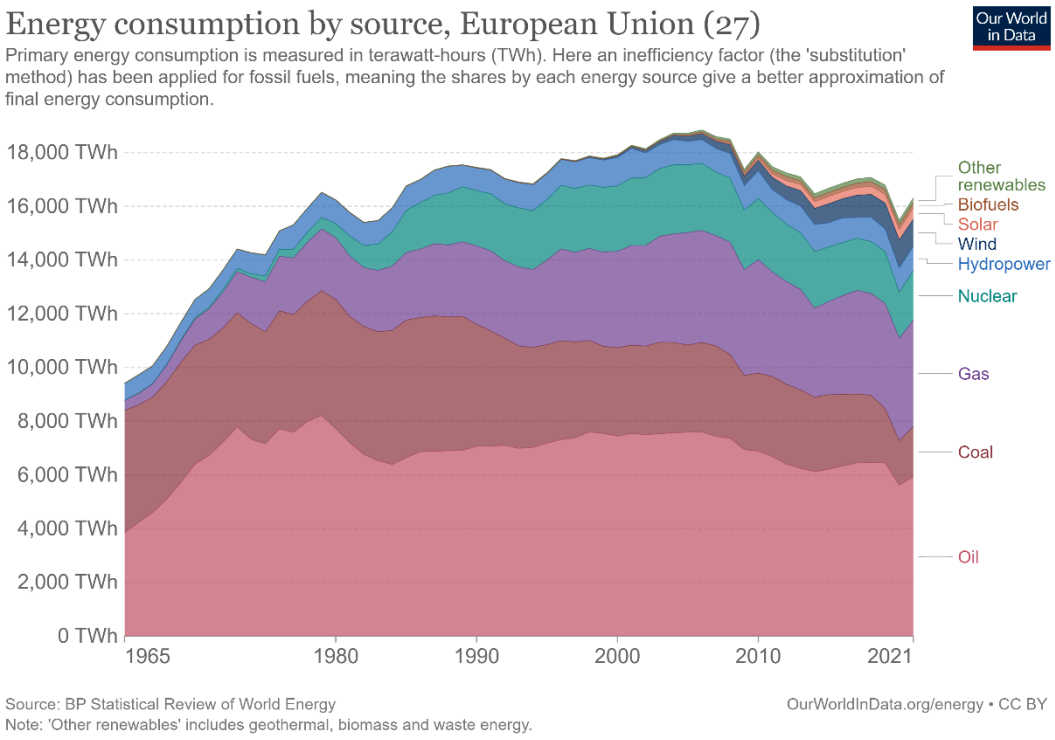


Figure 2: Energy consumption in the European Union

European energy market

The competitive nature of the wholesale market has been set for over 20 years now and had to deal with multiple obstacles to show that the structure is robust. The liberalized market allows a number of companies to partake in thousands of transactions daily.

Coal and oil started off as the main sources of energy within the European Union. While the use of coal has went back over time, its role was overtaken mostly by higher share of natural gas and nuclear power. **Fehler! Verweisquelle konnte nicht gefunden werden.** however

ends with the data ending in 2021 so especially the position of natural gas will have to be examined later when sufficient data is available.

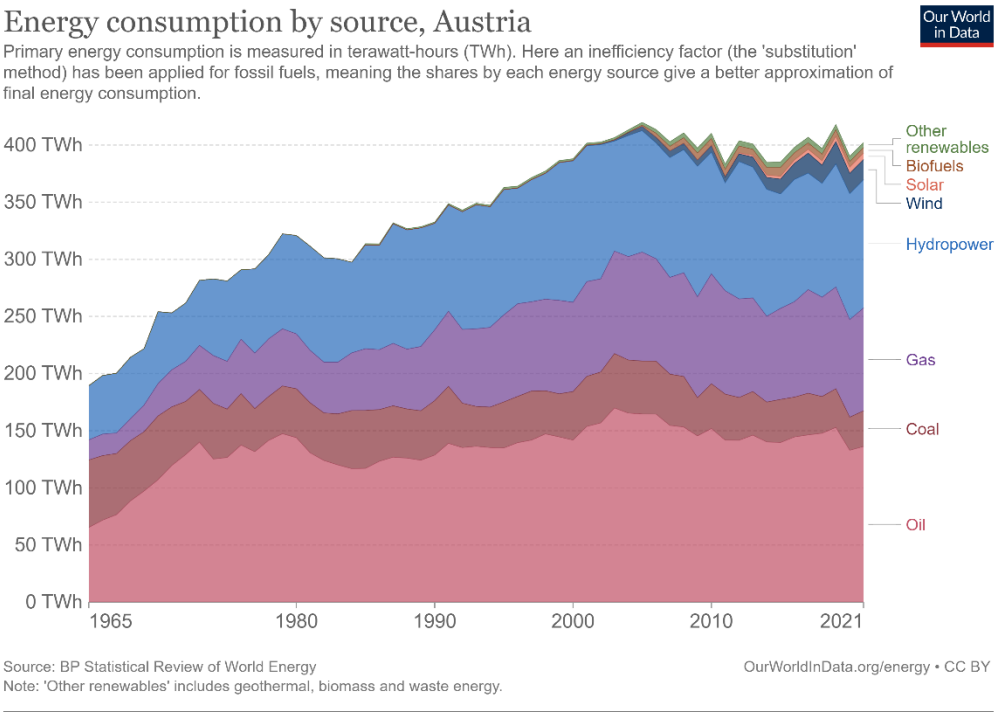


Figure 3: Energy consumption in Austria

Austrian Energy market

The energy mix for Austria differs from the European average. Although the first place is still taken by oil, thanks to the Alps and Alpine glaciers, Austria has always had a bountiful number of robust rivers that have been historically exploited to produce energy. As a result, roughly one third of Austria's energy always originated from hydropower, which makes it the second largest share and therefore a very significant player in the mix.

In , we can see the Austrian energy mix and how it evolved over time. The state in 2021 shows that 33.06% came from oil, 27.22% from hydropower and 21.89% from gas. Less than 10% originted from renewable sources, out of those, wind took the biggest share with 4.29%. Noticable is also the continuous lack of use of nuclear power in Austria, which has not changed since the referendum of 1978 that showcased that the majority was against its utilization (Anon., 2018). This mindset has not been overcome since.

The use of natural gas has been steadily rising till the 90s, since then the amount produced by it has not changed by much. This more or less constant value is also visible in 1 where the share has been roughly 20-25% for the past 25 years.

We can also follow a slow rise in wind power since the year 2000 as well as slow but still rising increase in solar power since 2010. Other renewables make up a small share and do not seem to follow the rising trend and stay around 3.5% of the sources of produced energy, although their introduction to the market started soon.

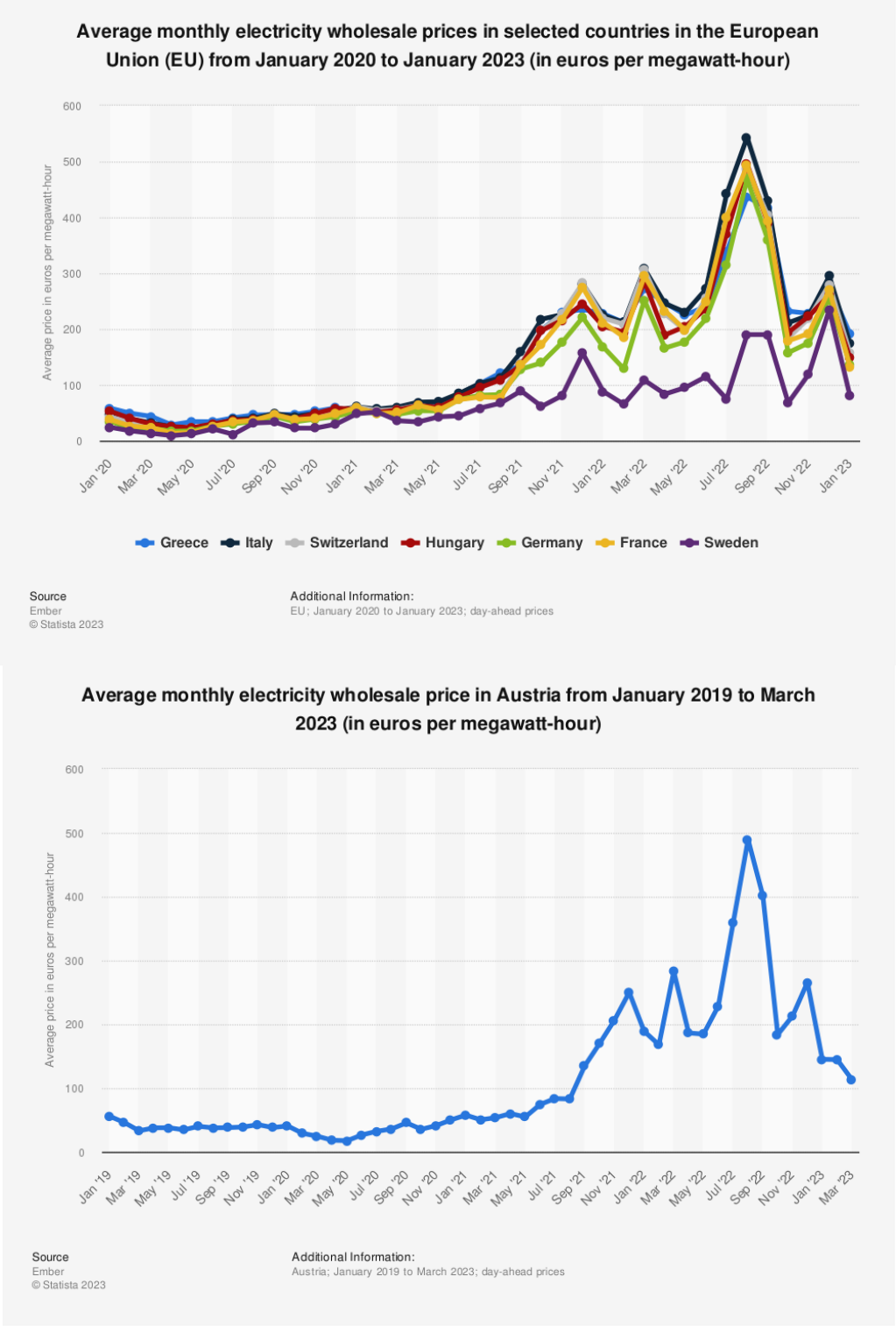


Figure 4:Energy prices in European countries 4.1a (above) and in Austria 4.1b (below) in reaction to the Covid-19 pandemic and the Russian attack on Ukraine.

Development of the Austrian Electricity Market

The electricity market followed the steps of the rest of the energy market. This means that the opening happened rather quickly after a slower beginning. The process was actually so quick, that Austria completed it before the deadline of the EU regulation. (E-CONTROL, 2011)One obstacle that had to be overcome was the vertically integrated grid system controlled by a monopolistic company. As a solution Austria came up with a balance group system that oversees the transactions. (E-CONTROL, 2013)

Figure 5 shows that the electricity in Austria comes mainly from hydropower, even though the share fluctuates over time. We can observe that the months of May and June last year hydropower made up to two thirds of the whole electricity consumed. The other two important sources are, as shown, thermal and wind. In Figure 6 we can see that the vast majority of the electricity comes from public sector that is subjected to the competitive market. This way we are also able to track the sources rather accurately.

In Figure 4.1 b we can see that the price for 1 MWh was mostly constant throughout 2019 and started rising in September 2021. Its peak was reached late summer/early fall 2022 as a follow up to the risen energy prices due to the war and the uncertainty regarding the sufficient gas supply from Russia. Since then, the prices has almost reached the lower values of 2021. Nonetheless, the price development is still an aspect worth observing in the future.

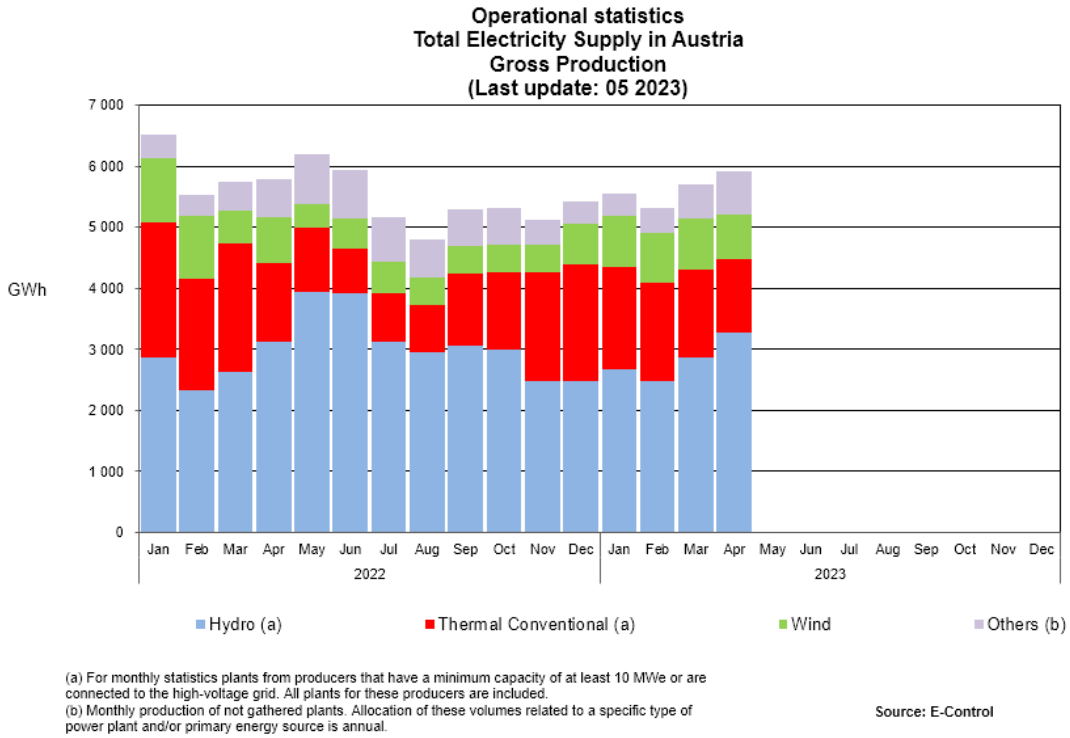


Figure 5: Electricity sources in Austria in 2022 and 2023 (E-CONTROL, 2023)

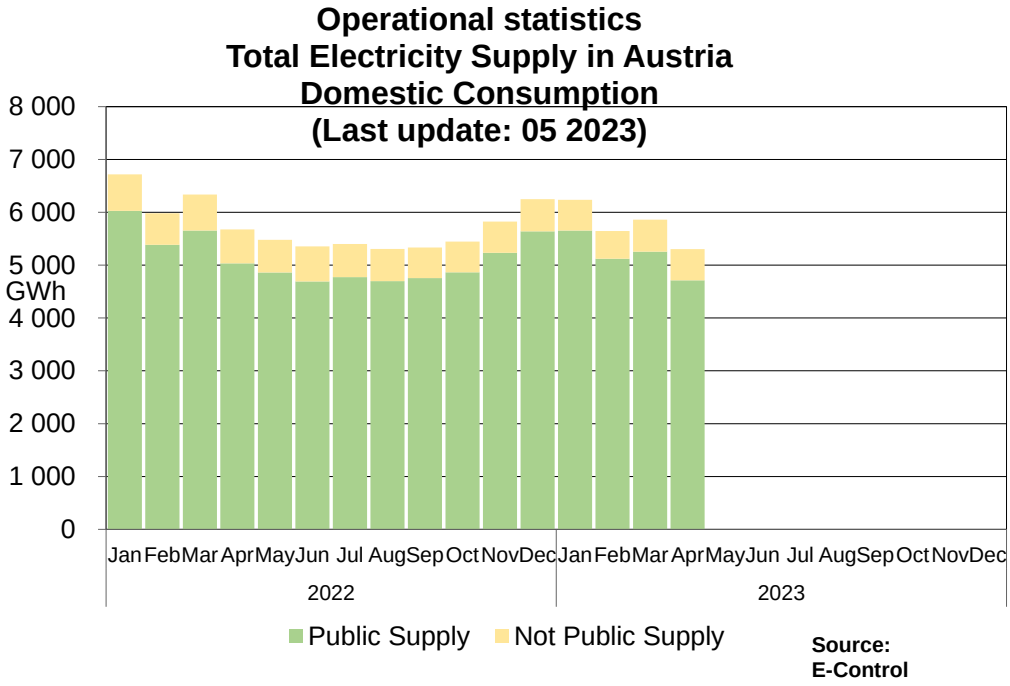


Figure 6: Public versus Non-Public Supply (E-CONTROL, 2023)

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