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Discussions on capacity mechanisms for selected markets in the recent energy crisis

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Abstract

Capacity mechanisms have been implemented in many countries for different purposes, even though the primary motivations are to ensure the system reliability and security of supply and protect consumers against price fluctuations. The energy crisis, starting in the aftermath of the COVID-19 pandemic and deepening further following the Russian invasion of Ukraine, adversely affected electricity markets. Countries heavily dependent on gas for power generation could not escape the price surges. At this point, the function of capacity mechanisms in ensuring price stability became controversial. This study mainly aims to build a critical review of the capacity mechanisms considering the impacts of the recent energy crisis on the electricity markets. After addressing the success of six selected electricity markets in protecting consumers against price spikes, it discusses redesigning the current mechanisms.

Keywords: *Electricity Market, Security of Supply, Capacity Mechanisms, Energy Crisis, High Prices*

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1. Introduction

In energy-only markets, electricity generators are rewarded only for their energy delivered to the grid. Under the assumption of competitiveness, each power plant offers a market price capturing their short-run marginal costs such as fuel and maintenance. The market-clearing price is determined by the intersection of supply and demand curves under the merit order rule, and the equilibrium price reflects the marginal cost of the last power plant that takes part in the electricity generation.

Today, electricity generation and trade methods have been significantly altered. European electricity sector experiencing market liberalizations in the 1990s started to make efforts to reduce greenhouse gas emissions, which constitutes an example of this transition [1]. Along with incentives such as feed-in tariffs, renewable energy sources' share has rapidly increased in installed capacity and electricity generation. Nonetheless, this increase has been brought by lower wholesale electricity prices since renewables offer low or even zero marginal costs to the market. Thus, the demand not increasing at the same rate as supply, lower prices, and lower utilization rates have adversely affected the profitability of conventional generation plants such as coal and gas. As a result, these baseload power plants have been unable to cover their capital expenditures (CAPEX) and operating expenditures (OPEX) over time [2]. This situation, also called the "missing money problem," compels the generators not to operate in the short run and finally shut down in the long term. Indeed, this problem mainly results from the price caps on electricity prices put by regulators to protect consumers and prevent abuse of the market power in the absence of demand elasticity [3]. Therefore, the plants that have a chance to operate only at peak times cannot fully meet their costs. In that sense, this bottleneck affects the financial sustainability of the power plants and the success of energy-only markets in generating sufficient price signals to incentivize new investments [4]. Furthermore, regarding system reliability, electricity systems must have adequate resources to respond to unexpected power plant failures and or fluctuations in demand [5]. Hence, properly designed and implemented capacity mechanisms can be an alternative to energy-only markets to solve the missing money problem and offer a more flexible generation capacity [2].

In the mechanisms defined as "*administrative measures to ensure the achievement of the desired level of security of supply by remunerating generators for the availability of resources*" in [6], specific incentives are offered to capacity providers in return for retaining available capacity or investing in new capacity. Today, capacity mechanisms are implemented with different motivations in the electricity markets. In France, the primary goal is to meet peak demand in the winter and encourage Demand Response Participation (DRP). Unlike France, in Italy, the mechanism aims to meet peak demand in the summer and support the gas plants facing the threat of closure [7]. Similarly, in the UK and Belgium, mechanisms started to be implemented to encourage new investments in the market and avoid shutdowns [8]. Türkiye introduced a capacity mechanism to promote domestic coal plants as a national energy policy, even though it aimed to keep gas plants in the system, which face the danger of closure. While establishing a mechanism as insurance for restructuring the electricity system experiencing rapid penetration of renewables, Germany aimed to shut down nuclear plants in the short term and phase out coal plants in the mid-term [9]. Despite these different motivations, all capacity mechanisms have a critical mission of ensuring supply security while protecting consumers from power interruptions and price spikes, as in the OFGEM's identification as "*designed to help ensure the security of electricity supply at the least cost to the consumer*."

This paper aims to reveal the impacts of the recent energy crisis in the selected markets implementing different capacity mechanisms. The study is composed of five sections. The capacity mechanisms in electricity markets are introduced in Section 2, and the impacts of the recent energy crisis on the six selected electricity markets are evaluated in Section 3. The function of the mechanisms in the energy crisis is discussed in Section 4. Finally, Section 5 concludes the paper.

2. Capacity Mechanisms in Electricity Markets

In electricity markets, there are different types of capacity mechanisms, and countries shift from one mechanism to another over time, depending on the market needs or the failure of the available mechanism. Generally, mechanisms can be classified into volume-based and price-based, as suggested by the Agency for the Cooperation of Energy Regulators[10][1]. As clarified in [6],

[1] Note that in some studies more or fewer categories are used. Some of them distinguish between strategic reserves, capacity payments and various forms of capacity markets, see [11].

policymakers let the market set capacity price in the volume-based mechanisms after deciding on the required capacity. On the other hand, in the price-based mechanisms, they determine the price and then decide how much it will be invested for a given price to the market. Capacity auctions, capacity obligations, strategic reserves, and reliability options are the main types of volume-based mechanisms. On the other side, capacity payments as a price-based mechanism constitute the first step of the capacity mechanisms in many electricity markets today. It is noteworthy that there is a tendency for the markets to give up priced-based mechanisms and shift to volume-based ones, particularly to capacity auctions. Furthermore, there is another distinction between mechanisms such as centralized and decentralized ones. In centralized mechanisms, capacity is purchased by the system operator or government, while in non-centralized ones, it is procured by electricity suppliers or consumers [5]. In addition, centralized mechanisms have a long-term approach since the capacity procured has to be available within a few years following the procurement procedure [12]. Conversely, decentralized ones with bilateral negotiations show a short-term approach since the contract duration may vary from one day to one year.

As a non-European example, in the Pennsylvania-New Jersey-Maryland (PJM), “Capacity Auctions” has been implemented since the first delivery year of 2007/2008 based on the Reliability Pricing Model (RPM). Incremental auctions are held to achieve the resource adequacy target for the delivery year. Due to transmission restrictions and different supply and demand conditions, PJM is divided into sub-regions called “Locational Deliverability Areas.” The RPM determines the demand curve by considering specific parameters such as installed reserve margin, cost of new entry, net energy, and ancillary services revenue offset for each region. Market-clearing price and target reserve level are determined at the intersection of demand and supply curves. Similarly, the UK adopted capacity auctions in 2014, abandoning the energy-only market.

In France, “Capacity Obligations” was launched in 2016 for the first delivery year of 2017. In the mechanism, electricity suppliers are obliged to hold a capacity certificate corresponding to the future peak demand of their customers four years before the target delivery year. Certificates can be obtained from suppliers' generation units (power plants or DRPs) or other capacity operators [13]. Certification contracts are signed among the capacity providers and the system operator.

In Belgium, “Strategic Reserves” was introduced in 2014. In this mechanism, the system operator or regulatory authority determines the required capacity level, while payments for capacity holders are set through a tender [5]. This reserve is applied only as a last resort in a supply shortage. The system operator punishes the capacity providers who cannot supply the amounts of energy agreed in the contract. Like Belgium, Germany also introduced strategic reserves into its electricity system in 2018.

In Italy, “Reliability Options” was put into practice in 2019. In this mechanism, system operator and capacity providers sign long-term option contracts. In this way, a certain amount of capacity is available in case of a supply shortage or a crisis in the national electricity system. Furthermore, positive differences between the spot price in the market and the strike price in the option contracts are paid back to the system operator. Thus, the regulatory authority redistributes these price differences to consumers through discounts on electricity bills [14].

“Capacity Payments” regarded as a primitive form of the mechanisms, has been implemented in many countries, such as the UK, Italy, Spain, Ireland, Greece, and Portugal. As a recent example, Türkiye adopted capacity payments in 2018. In this mechanism, central authority determines power plants' payments according to their installed or available capacity levels.

There is no consensus on which mechanism to choose under which conditions. Mechanisms have their advantages and disadvantages. To illustrate, capacity auctions can be effective, provided that the target capacity level is determined correctly. Otherwise, it can result in excess capacity, so the costs reflected on consumers can increase, as observed in the UK in 2014, or it can end up with insufficient capacity and fail to ensure resource adequacy. In capacity obligations, in case of suppliers lack accurate long-term consumption forecasts, fluctuating prices for consumers and lacking long-term price signals for investors are inevitable [15]. In strategic reserves, the plants included in the mechanism cannot offer electricity to the energy market and are entirely financed through capacity payments. This reduces the mechanism's efficiency in the long term and makes retention of reserve costlier [15]. Capacity payments can become open to pressures and political interventions by market participants ambitious to receive more payments [16]. The payments could also discourage the retirement of old generation capacity and disincentive new investments [17].

For reliability options, it is critical to determine the strike price properly, ensure price stability, and encourage DRP against sudden price increases simultaneously [2].

3. The impacts of the recent energy crisis on the selected electricity markets

The COVID-19 pandemic breaking out at the end of 2019 and spreading rapidly worldwide in 2020 seriously impacted global energy markets. Uncertainty brought by the severe epidemic caused new energy investments to be delayed or affected the sustainability of the existing ones adversely. As a result of the strong rebound effect and recovery after the loosened COVID-19 restrictions in mid-2021, the demand for gas increased remarkably [18]. Also, following a cold winter in Europe, energy prices rose further in the same year. On the other hand, the energy crisis deepened following the Russian invasion of Ukraine on 24 February 2022**.** The gas prices reached record highs in August 2022, as seen in Figure 1. Considering the EU imported 155 billion cubic meters of natural gas from Russia in 2021, corresponding to approximately 45% of EU gas imports and close to 40% of its total gas consumption [19] also as given in Table 1, the sanctions on Russia increased electricity prices in many European countries, mainly relying on gas for power generation.

Under the merit-order rule, in which the cost of the most expensive energy source determines the overall price, rising gas prices were the determinant of electricity prices in many markets. On the other hand, these price increases can vary between the countries depending on their market design, interconnection capacity, generation mix, market concentration, or some regulatory measurements [20].

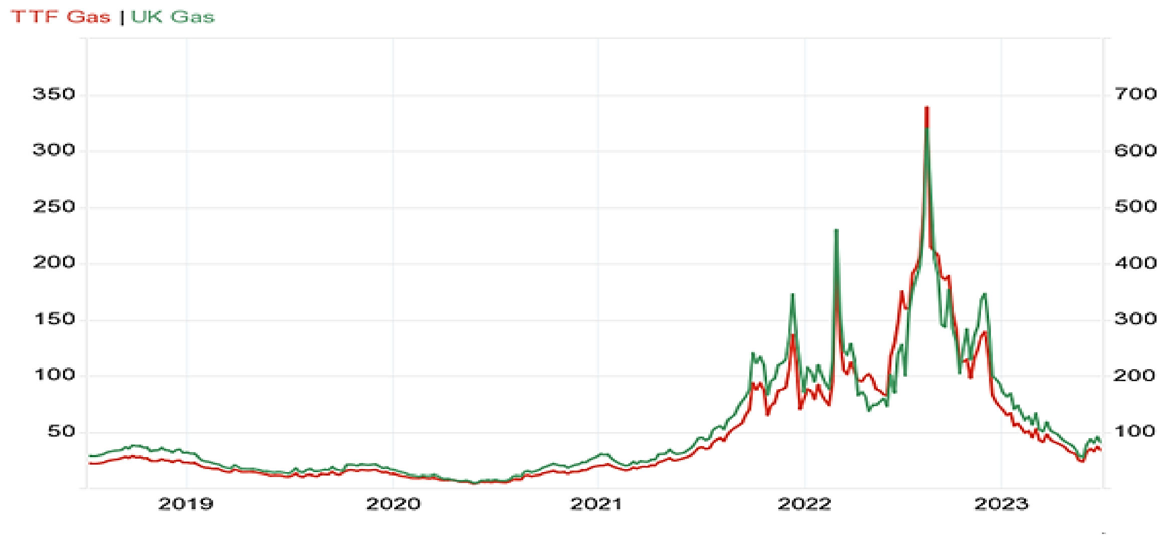


Fig. 1: Natural gas prices, 2019-2023 (USD/MMBtu)

Source: https://tradingeconomics.com/commodity/natural-gas

Before analyzing the impacts of increasing gas prices in selected countries' electricity markets and revealing how vulnerable they are to price shocks, it is helpful to review their reliance on imports of fossil fuels from Russia and generation mix.

Table 1: Countries' dependence on Russia in fossil fuel imports in 2021[2]

Country	Coal	Oil	Gas
Belgium	31%	44%	8%
France	20%	5%	27%
Germany	24%	31%	60%
Italy	56%	17%	38%
Türkiye	21%	14%	44%
United Kingdom	23%	7%	4%

Source: IEA**,** see [21].

[2] In 2019, Russian coal and gas imports had different shares in electricity generation of countries such as (2%, 1%) for Belgium, (1%, 0%) for France, (6%,7%) for Germany, (3%, 21%) for Italy, (8%, 6%) for Türkiye and (1%, 1%) for the UK, see [22].

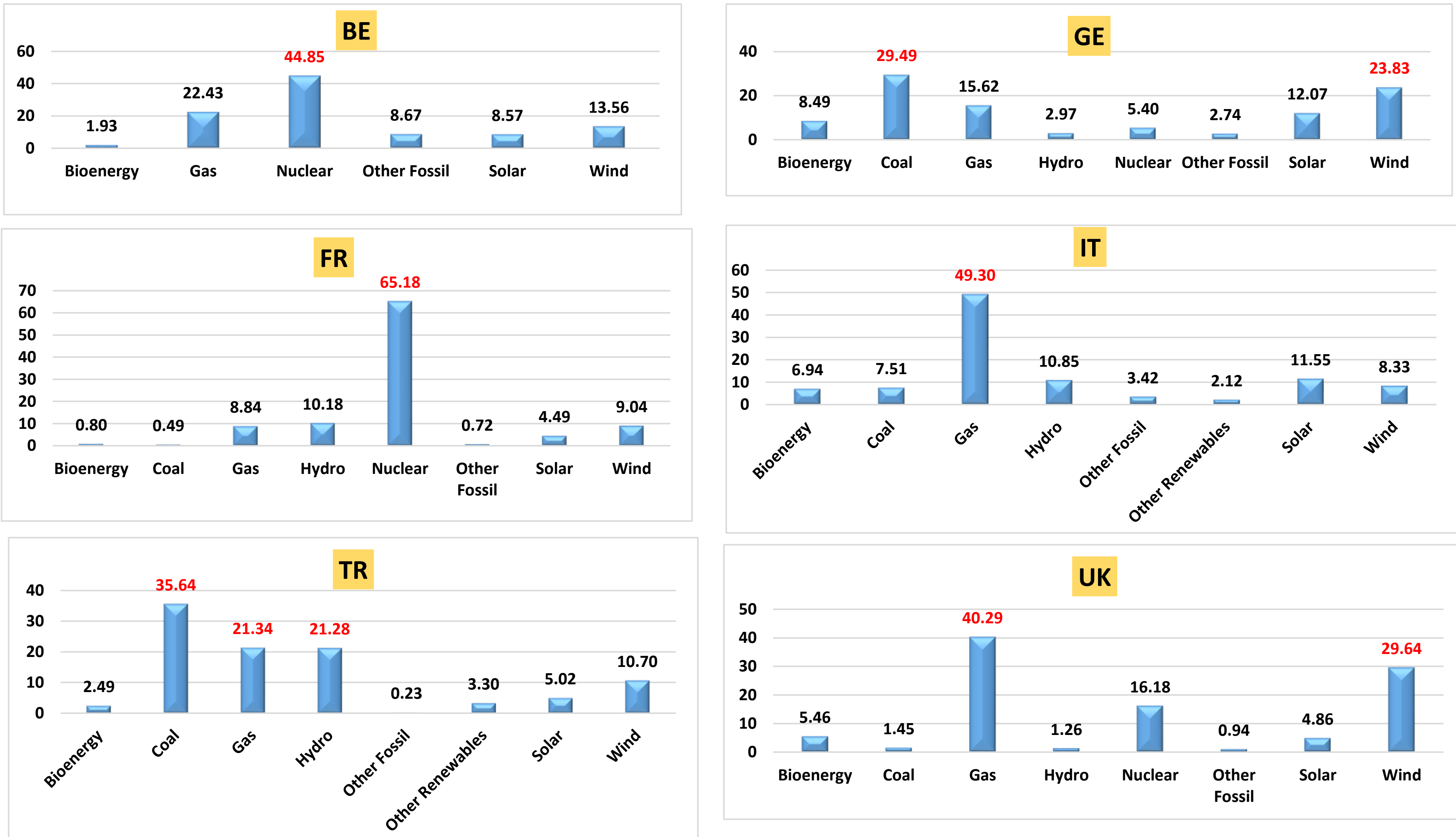


Fig. 2: Power generation of countries by sources (%) in 2022

Source: https://ember-climate.org/

As illustrated in Figure 2, Belgium, Italy, Türkiye, and the UK depend on gas for power generation. In the UK and Italy, aiming to increase the share of renewable energy in the generation, this dependency was over 40% in 2022, which makes the increases in global gas prices more alarming for them. It is evident that the rise in gas prices severely affected the electricity markets in these countries. Interpreting Figure 3 and Table 2 together, the impacts of the energy crisis continued to be observed intensively after August in the countries such as Italy, whose dependence on gas still existed in the following months, and wholesale electricity prices remained higher.

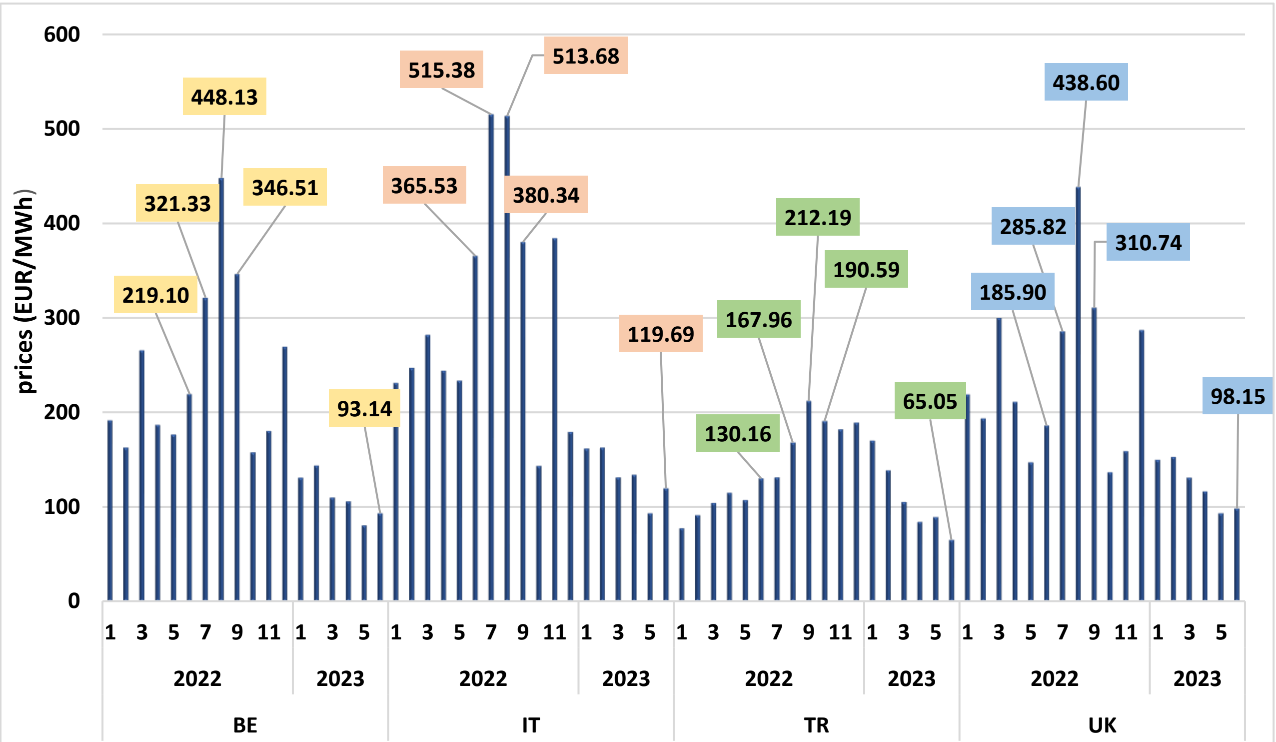


Fig 3: Monthly day-ahead electricity prices in the countries relying on gas for power generation in 2022

Source: NORDPOOL, EXIST

At this point, a simple question arises: What was the situation in the countries relatively less dependent (ones less than 16% in 2022 for this study) on gas but on mostly clean energy, such as Germany and France? Figure 4 shows that wholesale electricity prices also surged remarkably in these markets following August 2022.

Table 2: Share of gas in power generation (%)

Country	July 2022	August 2022	September 2022
Belgium	27.21	28.87	25.24
France	9.87	9.97	10.78
Germany	13.92	15.23	13.03
Italy	50.06	50.6	50.02
Türkiye	19.85	30.45	27.19
United Kingdom	46.03	50.42	44.92

Source: https://ember-climate.org/

For Germany, already planning to shut down the last three nuclear power plants in 2023, the cut down on Russian gas led the country to prioritize the other alternatives, namely coal, as a cheaper source of electricity. Nonetheless, along with higher demand for coal-fired power, supply problems under the sanctions on Russia, Europe's largest coal producer in 2021 [23], caused coal prices to rise, as seen in Figure 5. Furthermore, due to CO_2 taxes under the European Emission Trading Scheme, electricity generation from coal became more expensive for Germany. Weaker winds also worsened power generation and affected market prices.

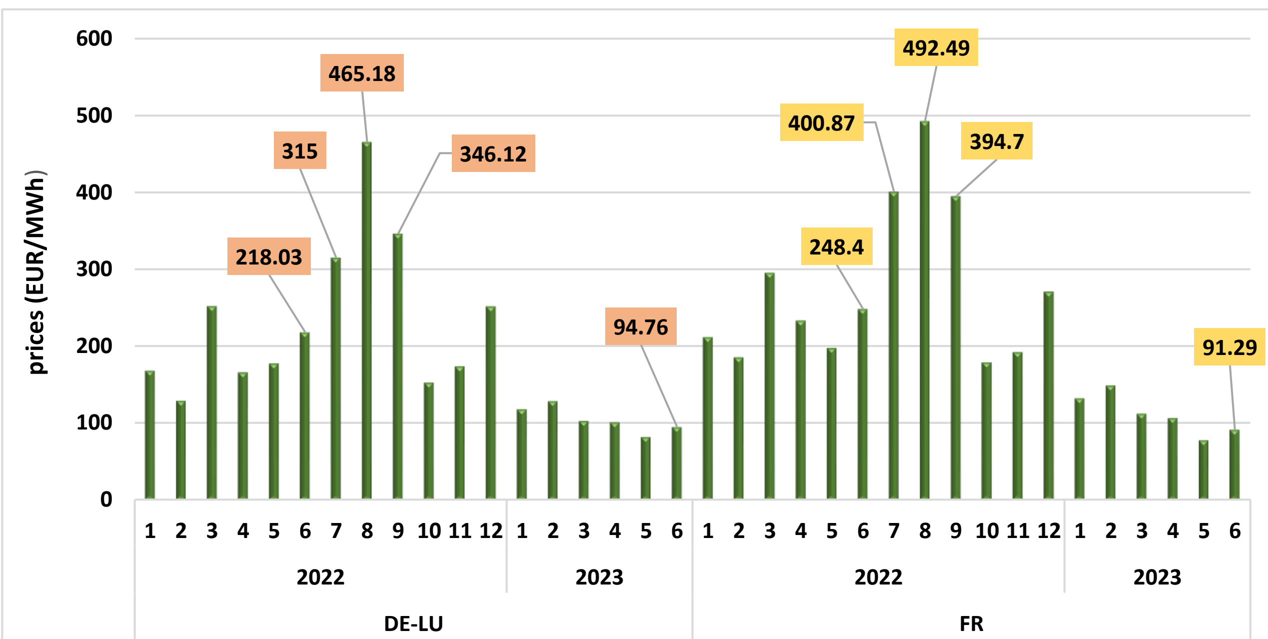


Fig. 4: Monthly day-ahead electricity prices in the countries relatively less relying on gas for power generation in 2022

Source: NORDPOOL

Even though France generates its electricity primarily from nuclear sources (more than % 65 in 2022), it also suffered from high electricity prices. Along with large parts of the nuclear fleet becoming unavailable for maintenance operations and the decrease in hydro production due to the summer drought, France became a net importer in 2022, an electricity exporter for more than four decades [24].

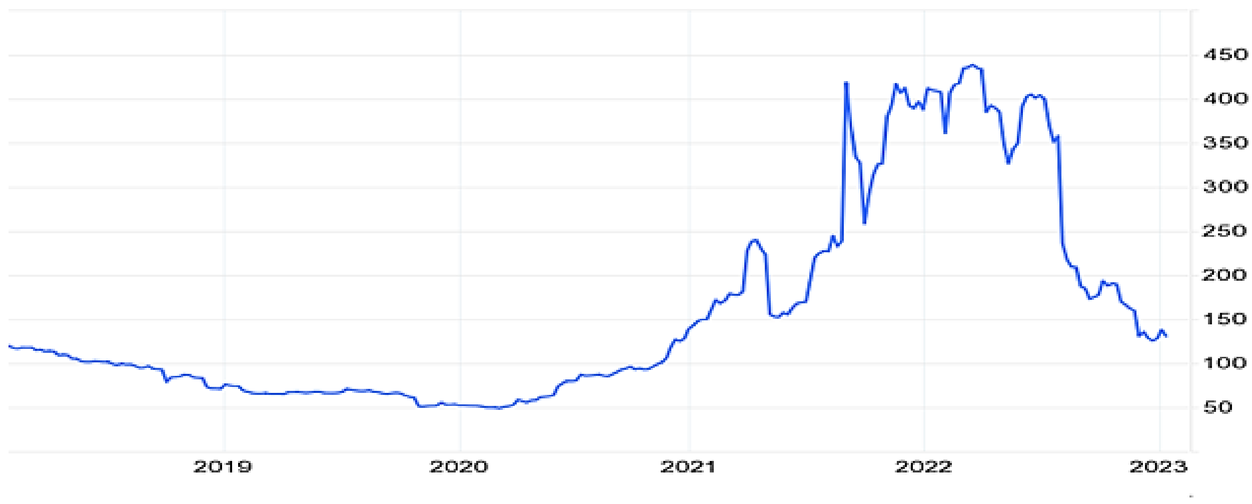


Fig. 5: Global coal prices, 2019-2023 (USD/T)

Source: https://tradingeconomics.com/commodity/coal

4. The discussions on capacity mechanisms in the recent energy crisis

One of the main objectives of the capacity mechanisms is to ensure the security of supply while protecting consumers from power interruptions and price spikes in extreme cases. Though the energy crisis starting with the COVID-19 pandemic and deepening with the Russian invasion of Ukraine is an example of this case, the success of the markets in achieving this objective is questionable.

In the wake of Russia's invasion of Ukraine, the cut of energy supply to the EU, and the low availability of nuclear and hydropower generation, European electricity prices reached record levels. The countries mainly dependent on gas for electricity generation have been more vulnerable to market price increases due to the Russian curtailment of energy supply to Europe. As analyzed in this study, the wholesale electricity prices in Belgium, Italy, Türkiye, and the UK rocketed. A common source of motivation in these countries for applying a capacity mechanism was to support the gas plants facing the threat of closure and avoid shutdowns with the concerns of security of supply. Indeed, the recent energy crisis showed that countries' dependence on imported sources for their energy mix posed a threat to energy security and price stability. The price spikes also in the countries prioritizing clean energy in their energy mix revealed the vulnerability of the markets to unexpected cut-offs, such as the low availability of nuclear as in France and weaker winds as in Germany. Due to rising wholesale electricity prices, as illustrated in Figure 6, household electricity prices have also increased remarkably in some selected countries, such as Italy, Germany, Belgium, and the UK.

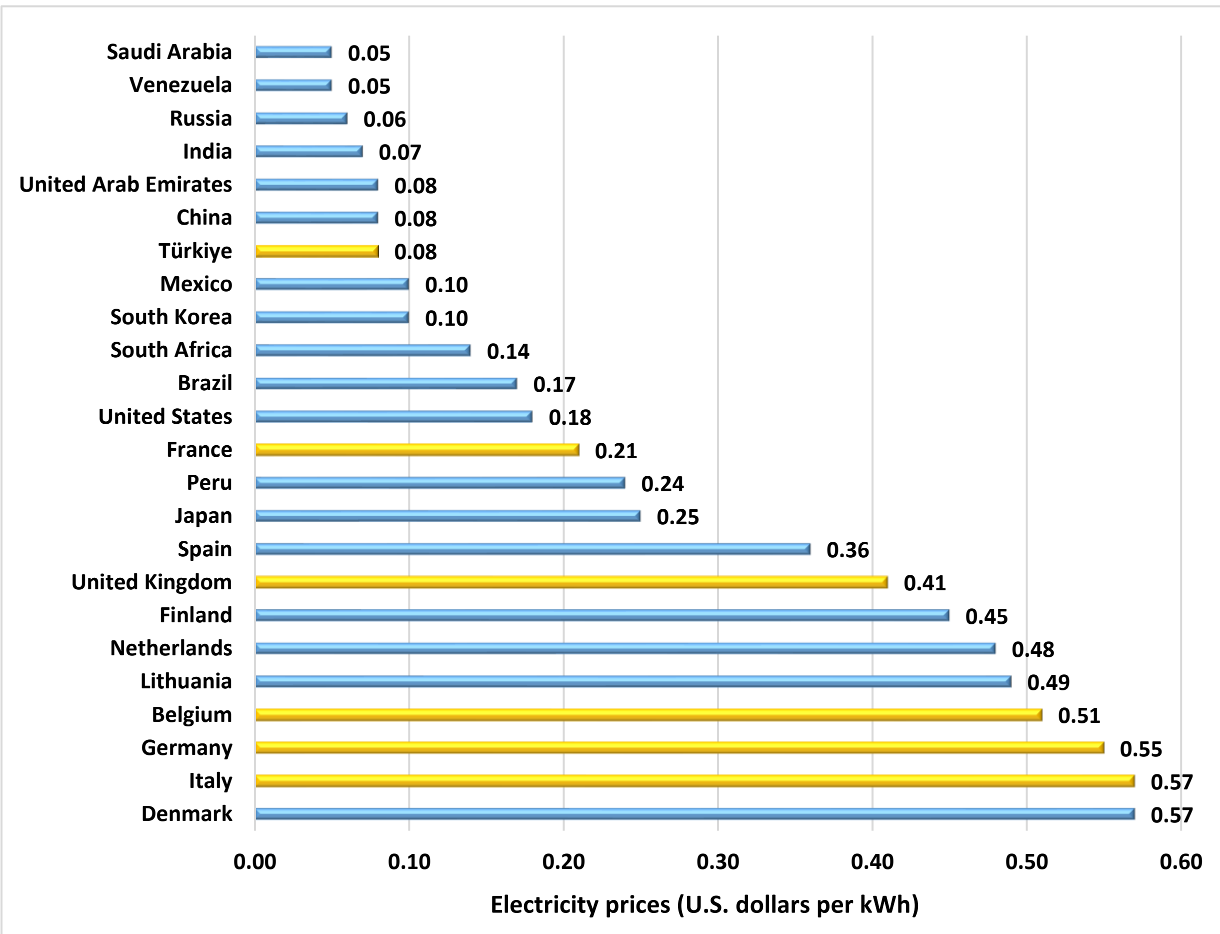
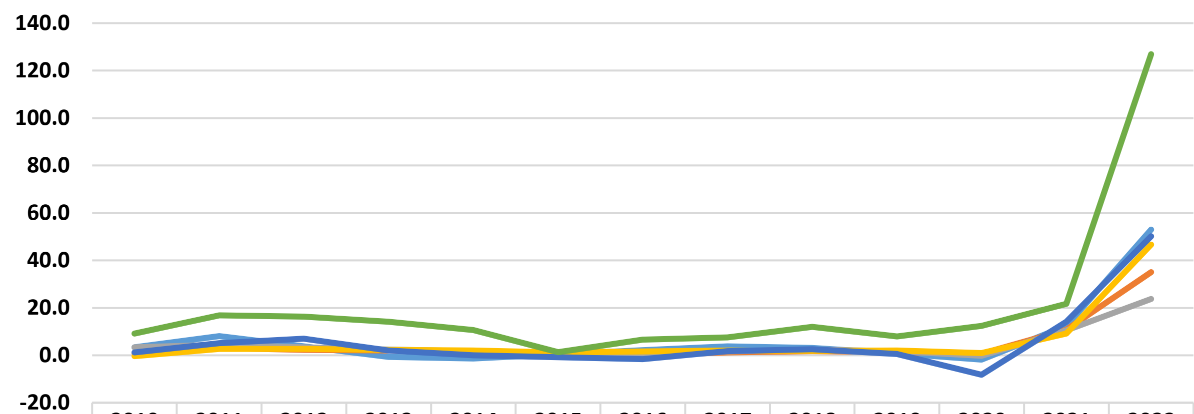


Fig. 6: Household electricity prices worldwide in September 2022

Source: https://www.statista.com/statistics/263492/electricity-prices-in-selected-countries/

Surging electricity prices drastically increased the living costs of low-income families in these countries. As seen in Figure 7, the share of energy expenditures on households' budgets rose drastically in 2022. Although household electricity prices were lower in Türkiye compared to the other selected countries, the rise in energy prices in 2022 put higher pressure on Turkish people's livelihoods and purchasing powers. Unlike the other countries more cautious about market interventions, France individually[3] introduced price caps on wholesale electricity prices [20], even though price caps are generally regarded as ruling out market efficiency and incentive for new investments. As another measure, in France, EDF, as a state-owned enterprise, started to sell cheaper electricity to retailers to keep prices lower. In this way, France could offer electricity to consumers at relatively more affordable prices. On the other hand, for example, the German government made do with cutting gas use by reducing heating in public buildings and turning off the lights at night starting in September 2022 to avoid gas shortages in winter [25].



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
BE	3.4	8.1	3.7	-0.6	-1.4	0.4	2.1	3.7	3.0	0.9	-1.8	12.3	53.0
DE	1.0	3.1	2.2	2.0	0.8	-0.4	0.0	1.2	1.8	1.3	0.7	10.7	35.0
FR	3.3	4.4	3.4	2.4	1.8	0.4	-0.1	1.6	2.4	1.7	-0.2	10.5	23.7
UK	-0.4	2.7	2.7	2.4	2.0	1.2	1.7	2.0	1.9	2.1	0.9	9.1	46.7
IT	1.2	5.2	7.0	2.1	0.0	-0.8	-1.6	1.8	2.6	0.5	-8.2	14.1	50.2
TR	9.2	16.9	16.3	14.2	10.7	1.3	6.6	7.6	12.0	7.9	12.4	21.7	126.9

BE DE FR UK IT TR

Fig. 7: Annual energy consumer price inflation (%)

Source: https://www.worldbank.org/en/research/brief/inflation-database

[3] As a collective measure, EU countries reached a political agreement in July 2022 on a voluntary reduction of natural gas demand by 15% in winter.

The market designs with capacity mechanisms have not protected consumers from price spikes while ensuring the security of supply in the recent energy crisis. Thus, the European Commission and governments were compelled to take other measures against fossil fuel supply shocks. At the same time, these market interventions can bring about a certain level of uncertainty for investors.

The energy crisis addressed the necessity of redesigning markets with the capacity mechanisms that subsidize old coal and gas plants to delay their ultimate shutdowns. The mechanisms, including all existing generators and supporting the plants that cannot be activated even in a supply shortage, are strongly criticized as an obstacle to entering new, fast-start, dispatchable technologies into the markets [26]. In case authorities insist on this scheme, giving special attention to availability seems critical. An incentive scheme based on performance payment can be an effective tool such that generators available when demand is highest can entitle more payments than those that do not [27]. Similarly, there are some other discussions that even though capacity mechanisms can be technologically neutral, specific generator units should ultimately be more privileged due to their significant contribution to the power system's reliability and supply security [28].

Indeed, a new scheme that will accelerate investments in renewable energy, most notably in energy storage capacity, is regarded as a prerequisite for well-functioning electricity markets [29]. Considering that the estimated share of renewables will be 69% by 2030 and 80% by 2050 [30], energy storage systems will be critical to providing system flexibility following the gradual phase-out of fossil-fuel generation technologies, so decarbonizing the European electricity sector. Hence, the countries should focus on redesigning their mechanisms so that the participation of energy storage in the market can be facilitated and incentivized. Lower carbon caps or requirements or the prioritization of lower-carbon technologies can be some elements of this new design as proposed by [30]. Furthermore, integrating demand response participation to the markets, energy efficiency, and conversation measures can be more effective tools for dealing with price fluctuations than the market interventions that will eventually discourage new investments and disregard market efficiency [20].

5. Conclusion and Policy Implications

Ensuring system reliability and security of supply constitutes one of the main objectives in electricity markets. Nevertheless, the rapid increase in the share of renewable energy resources brought some specific problems. As electricity demand increased at a different rate than the generation, it became inevitable for conventional power plants to decrease their profitability due to falling market prices. Over time, this situation threatened system reliability in the short-term, security of supply, and system adequacy in the medium and long term. In this regard, authorities came up with alternative solutions. Implementing a capacity mechanism has been a frequently applied method in markets to ensure the security of supply and mitigate price volatility.

This study aims to evaluate the success of the selected markets with different capacity mechanisms in protecting consumers from high electricity prices in the recent energy crisis. The analyses indicated that the supply crisis resulting from Russian energy curtailment to Europe caused wholesale electricity prices to reach record levels, and consumers suffered from high electricity bills. Even though market interventions, as in France, could brake price spikes in the short term, they can rule out the market efficiency and distort the market signals to new investments in the long run.

The energy crisis revealed that being heavily dependent on imported fuels poses a significant threat to countries to ensure not only security of supply but also price stability. The mechanisms supporting old fuel plants to delay their ultimate shutdowns do not seem effective in dealing with energy crises today, and they will not be sustainable in the future. Thus, electricity systems with capacity mechanisms need to be redesigned so that integration of renewables and energy storage systems will facilitate, and along with demand side management and energy efficiency measures, well-functioning markets, even in a crisis period, will be achieved.

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