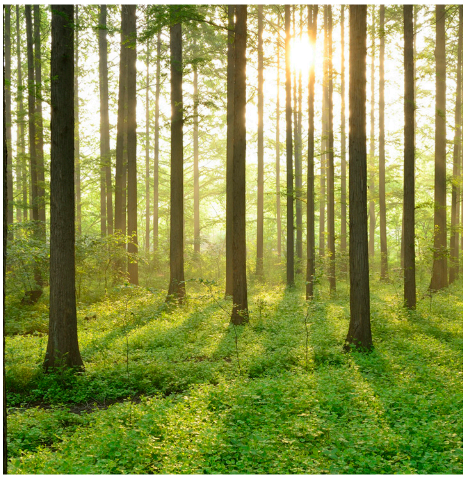
POWER COMING FROM RUSSIA AND BALTIC SEA REGION´S ENERGY SECURITY

REPORT 2023:940



FUTURE ELECTRICITY MARKET DESIGN

Energiforsk

Power coming from Russia

Baltic Sea region´s energy security

EWA LAZARCZYK, CHLOE LE COQ

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Energiforsk AB | Phone: 08-677 25 30 | E-mail: kontakt@energiforsk.se | www.energiforsk.se

Foreword

Russia's war in Ukraine has significantly impacted Russia's energy trade with Europe, particularly in relation to natural gas and oil deliveries but also electricity trade.

This study investigates the extent to which the Baltic Sea region relies on Russia as an electricity supplier.

At the time the project application was submitted, there was no awareness of Russia's plan to invade Ukraine. The primary objective of the project was then to review the electricity trade between Russia and the Baltic Sea region.

The project has been carried out by Chloé Le Coq from the Stockholm Institute of Transition Economics and Ewa Lazarczyk from Reykjavik University. It was funded by Energiforsk's research program Future Electricity Market Design (FemD).

Summary

Russia has supplied fossil fuel and other energy to the Baltic Sea region for decades. Before the 2022 war against Ukraine, Russia was Europe’s main supplier of natural gas and an increasingly significant player in electricity transfer; two-thirds of the total Russian electricity export was directed to Finland and Lithuania. However, the electricity trade with Russia has recently been under scrutiny as Russia decided to stop commercial trade with Finland starting on the 15th of May 2022 and discontinuing its commercial exchange with Latvia and Lithuania (via Kaliningrad) a week later. These actions raised anxiety about the reliability of Russia's electricity and the region's energy security in general.

This report focuses on the Baltic Sea region's dependency on Russia as an electricity power supplier. Energy economic analyses studying Russia usually pay attention to its crucial role as a natural gas supplier. This study's originality lies on the electricity focus, by examining Russia's role in the electricity trade in the EU, particularly in the Baltic Sea region. We focus on the countries most directly affected i.e., Finland, Estonia, Latvia, and Lithuania. We illustrate the asymmetric electricity trade between these countries and assess how the Baltic Sea Region’s (BSR) overall energy security might be affected.

Section 1 defines the concept of energy security and introduces the topic of the report.

Sections 2 and 3 describe Russian commerce with the Nordic and Baltic electricity markets.

Section 2 discusses two important features of the electricity trade between Russia and the BSR. First, electricity prices are sensitive to supply and demand in other energy markets, notably natural gas. We note that the cost of other energy commodities drives electricity prices. Second, despite limited Russian electricity exports, we highlight Russia's dominance in the hydrocarbons sector and nuclear technology transfer.

Section 3 provides a snapshot of electricity flows between Russia and the BSR, and its context. The connection with the Baltic states is unique as the Baltics´ power system is a part of the large “BRELL” system. Western Russia has overcapacity in electricity supply and Russian electricity is relatively cheap. We provide here an overview of the energy profile of the countries directly involved in electricity trade with Russia.

HIGHLIGHT 1: Russia is Finland´s second largest electricity import source, but only accounts for 10% of Finnish consumption. This could be important in terms of energy security, even if the Scandinavian part of Nord Pool is a reliable “backup” in case of electricity shortage. Nord Pool relies heavily on hydropower; half of Scandinavian electricity demand is met by this technology. However in dry years Nordic countries need to rely more on power imports, Russia included.

Section 4 focuses on the BSR's dependency on Russian electricity and presents various energy security measures.

The missing trade assessment is our first measurement of the security of the electricity trade. We consider the available import options to assure BSR's adequate energy supply. We first look at the flows in Nord Pool (i.e., in the Elspot Market), then compare them with the maximum available capacity.

The desynchronization assessment is our second measurement of security of the electricity trade. We focus on how desynchronization from the BRELL power network may be challenging, if it happens before the Baltics are ready for grid separation. The peculiar case of Kaliningrad is also discussed.

The import diversification assessment is our third measurement of the security of the electricity trade. We base our assessment on the consequences of Russia's May 2022 halt of electricity exports to Finland, when cross-border electricity exchange between Finland and its main import and export destinations changed in two ways -- imports from Sweden to Finland increased and so did the volatility of net exchange with Estonia.

HIGHLIGHT 2: The "missing trade" capacity between BSR countries and Russia is significant.

HIGHLIGHT 3: The power grid's topography and connection between Russia and Finland differ significantly from the Russian connection with the Baltic states. In particular, it is difficult to stop the flow of electrical power within the BRELL network as it constitutes one synchronized area. Hence, although commercial flows between BSR and Russia decreased prior to the May 2022 halt, power flows are still present.

HIGHLIGHT 4: Due to the gradual limitation of commercial flows between BSR and Russia and the 2022 cut-off, Finland and Sweden have an increasing role in the Baltics' electricity trade.

Section 5 discusses three future issues associated with the Baltic energy security.

The first relates to the pace of supply and demand in the Nordic region, where demand could grow by more than 60 percent into 2050. This will require that Nordic generation capacities - particularly renewables - expand; this will necessitate substantial investment in new storage technology. Norway's announcement in August 2022 that lower levels in its hydro reservoirs might limit its electricity export capacity has exacerbated energy anxiety, as Norway is seen as the reliable "backup" in case of electricity shortages.

The second issue relates to Russia's uncertain future role as an energy supplier in the region. Russia is a key player regarding nuclear energy investment in the world, covering around 25% of nuclear power plant construction worldwide and, before 2022, two planned nuclear power plants in the region under study here.

The third issue relates to the energy security challenges faced by the Baltic States, i.e., ensuring heating for households and industry, and overall demand for electrical power. A greener economy would require dynamic investment into technologies like renewables or nuclear energy.

HIGHLIGHT 5: Finland and the Baltics seek to strengthen their energy security by investing in renewables. However, they will also need backup capacities in the short run. Given the reliance of the Baltic states on fossil fuels, it may increase the Baltic states' dependency on Russian energy commodities.

Section 6 concludes with a discussion of the "weaponization" of Russian electricity. This strategy's credibility depends on two crucial elements. First, without limits on Nord Pool imports, it will not impact the BSR, although relying only on Nord Pool transactions might be expensive. Second, for "weaponization" to hold, the Baltics cannot be well connected with the European grid.

However, given the EU's economic goals of green transition and electrification, Russian energy might still be a key factor, particularly if there is insufficient investment in alternative power generation in Europe.

HIGHLIGHT 6: Weaponization of the Russian electricity is a credible strategy, particularly if there is a limit to imports from Nord Pool and the Baltic States are not well connected to the European grid.

HIGHLIGHT 7: Unless the Nordics and BSR invest heavily in new generation sources, Russian electricity might be a compelling alternative, although it would again enhance Moscow's geopolitical influence.

Keywords

Energy security, Baltic Sea region, Electricity Weaponization, Energy mix, Price variability, Congestion, Kaliningrad, Nord Pool

Sammanfattning

Ryssland har levererat fossila bränslen och annan energi till Östersjöregionen i decennier. Innan 2022 och kriget mot Ukraina var Ryssland Europas främsta leverantör av naturgas och en allt viktigare aktör inom elöverföring. Elhandeln med Ryssland har dock nyligen varit under granskning då Ryssland beslutade att stoppa dess kommersiella elhandel med Finland från och med den 15 maj 2022 och avbryta sitt kommersiella utbyte med Lettland och Litauen (via Kaliningrad) en vecka senare. Dessa åtgärder väckte oro avseende tillförlitligheten av Rysslands elexport och regionens energisäkerhet i allmänhet.

Denna rapport fokuserar på Östersjöregionens beroende av Ryssland som elkraftsleverantör. Energiekonomiska analyser som studerar Ryssland uppmärksammar vanligtvis dess avgörande roll som naturgasleverantör. Denna studies originalitet ligger i dess fokus på el, genom att undersöka Rysslands roll i elhandeln i EU, särskilt i Östersjöregionen. Vi behandlar främst de mest påverkade länderna, Finland, Estland, Lettland och Litauen. Vi uppmärksammar den asymmetriska elhandeln mellan dessa länder och bedömer hur Östersjöregionens övergripande energisäkerhet kan komma att påverkas.

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1 PURPOSE AND SCOPE OF THE STUDY

1.1 ELECTRICITY TRADE AND SECURITY

All nations confront multiple challenges and must make tough decisions regarding their energy supply, among them finding the right energy mix and how to acquire needed energy. How to best organize energy trade with foreign suppliers is one of the most challenging issues for nearly every country's leaders.

Conventionally, electricity security centres on the assurance that the balance of supply and demand is maintained, given that any electricity system needs to be instantaneously balanced.

This report focuses on a critical additional dimension – the security of transfer and adequacy of energy imports in a region facing major geopolitical and economic challenges, including the war on Ukraine.

The International Energy Agency (IEA) (n.d.) defines energy security as an uninterrupted energy supply, at affordable prices. This concept encompasses a multifaceted phenomenon, as it also refers to notions of energy efficiency, trade, sustainability, diversification of supply, and security of transfer through transit countries (Misik, 2016; Andriosopoulos et al, 2017; Gasser, 2020). We analyze the pattern of commercial transfers between the Baltics, Finland, Russia, and Belarus, focusing on the *external* energy security issue.

1.2 SCOPE

Definition of the Baltic Sea Region (BSR). The term "Baltic Sea Region" covers the countries engaged in the European Union Strategy for the Baltic Sea Region1, launched in 2009 to improve cooperation between states touching the Baltic Sea. The macro region includes Sweden, Denmark, Estonia, Finland, Germany, Latvia, Lithuania, and Poland. This report focuses primarily on the four nations directly affected by electricity trade with Russia, i.e., Estonia, Finland, Latvia, and Lithuania. However, any variation in electricity trade between Russia and these four countries will eventually also affect neighbouring countries with whom they share transmission lines. This is particularly the case for Denmark, Sweden, and Norway as they are members of the Nord Pool power exchange.

The power coming from Russia. Russia is the main natural gas supplier for many EU member states. Therefore, most studies analyze the energy security challenges associated with Russian pipeline gas. This EU-Russia dependency and the threat it poses to energy security has been discussed extensively (see the literature overview in, e.g., Gasser, 2020 or Le Coq and Paltseva, 2022). This report focuses on the electricity supply security between Russia and the Baltic Sea Region (BSR) countries and electricity directly produced in Russia, but also includes energy from Belarus and the Kaliningrad region.

[1] see https://www.balticsea-region-strategy.eu/about/about

Table 1 provides a basic import index, which equates the share of Russian electricity in the residual BSR's electricity demand (i.e., total consumption minus domestic production). It gauges the importance of the electricity trade between Russia and BSR over the last three years.

Table 1. Imports from Russia/(Consumption-Production)

	Finland	*Estonia*	*Latvia*	*Lithuania*
2021	50%	15%	41%	24%
2020	20%	8%	47%	30%
2019	39%	70%	98%	31%

Note: Own calculations based on Nord Pool data.

The ratio varies significantly over time and across countries. To understand the significance of these trends, it is necessary to dive into the data and analyze whether supply security is a concern in the case of BSR electricity trade with Russia.

Electricity trading requires a specific supply security analysis. Providing a reliable assessment of electricity supply security is challenging. As for any other commodity, electricity supply security is a multidimensional concept (including demand, supply, transmission constraints, and political constraints). However, the lack of storage and the multiple generation technologies, with different associated costs, require a specific supply security analysis.

Historically, most energy security literature has focused on fossil fuels, particularly natural gas (e.g., Le Coq and Paltseva, 2009). The originality of this study is to focus on the electricity trade. Electricity has a few crucial features that differentiate it from the natural gas commodity. While both resources require a complex market design to provide a continuous flow at an affordable price, electricity cannot be stored at scale and requires complex network transmission management[2]. This implies that timely imports, even modest, can significantly impact the nation's power system. Timely imports matching high demand provide the necessary power, help avoid black- or brown-outs and restrain prices. Hence, the lack of imports can exacerbate a tense situation in the market, with insufficient local production and soaring prices.

In today's electricity markets, intermittent generation is growing. Well-connected power markets are of crucial importance, as they help to spread the excess or fill up the lack of wind and solar and balance them with more stable resources – hydropower or peaking plants using natural gas. This power landscape is quickly changing, due to soaring gas prices.

Electricity markets and rising trade benefits are increasingly interconnected. Therefore, mutual dependency with neighbouring regions, together with the spread of intermittent resources, may facilitate the weaponization of electricity

[2] Kirchhoff's circuit laws pertain here. They were first described in 1845 by German physicist Gustav Kirchhoff

exports by a geopolitically-powerful country like Russia (Scholten et al., 2020 or Lazarczyk and Le Coq, 2022).

1.3 THE PRINCIPAL ISSUES

This report aims to understand whether energy security is a compelling factor in the electricity trade between Russia and the BSR. In particular, our analysis focuses on the BSR's dependency on the current electricity trade between Russia and the Nordic electric system.3 We seek to capture this relationship by addressing the following key questions:

What is the current electricity trade between the Baltic Sea Region and Russia? We consider the four countries directly involved in electricity trade with Russia (out of eight countries in the EU's Baltic Sea Region Strategy4). We analyze the change in electricity trade between the producers (Russia, Belarus, Kaliningrad) and the consumers (Finland and the Baltic States).

How vital is the Russian electricity supply for the Baltic Sea Region? We measure the dependency of the BSR, using different inputs. We complement the traditional import dependency ratio by considering the issue of desynchronization, and the missing trade between the countries.

How important is the Russian electricity supply for the European market? To measure this effect, we look at how a full delivery blockage between Finland and Russia affected the Nord Pool market. We measure the increased prices' volatility in Nord Pool, the pivotal role of Finland and Sweden, and the resulting change in the electricity trade pattern for the Baltics.

How likely is the weaponization of Russian electricity? Russia and BSR could diversify their exports and imports, respectively. The answer to this question depends on the balance of power between Russia and the Baltic region.

[3] This report addresses electricity per se. It does not discuss the links between electricity and natural gas markets, i.e., how gas market conditions (interrupted supply and high gas prices) impact electricity generation.

[4] Sweden, Denmark, Estonia, Finland, Germany, Latvia, Lithuania and Poland.

2 BACKGROUND

This analysis embraces two key points of departure. One is that energy markets are increasingly physically and politically interconnected. A dramatic illustration of this development is the effect of Russia's war on Ukraine on the world's energy markets. Our second starting point is that Russia has stated, in its current energy plan, its determination to remain a key player in the fossil fuels market while increasing its presence in electricity generation by investing heavily in nuclear energy and continuing to be a major supplier of reactors and nuclear fuel.

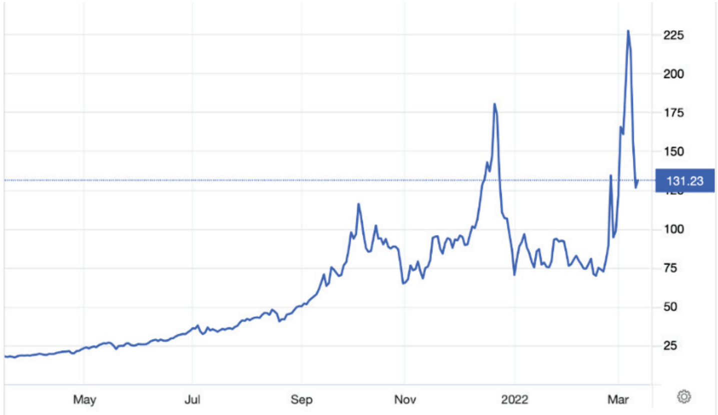
2.1 ELECTRICITY PRICES DRIVEN BY THE COST OF OTHER ENERGY COMMODITIES

Recent events make it even more apparent that the choice of generation technology affects market equilibrium. The cost of fuel used for power generation dictates which technology is dispatched first (baseload) and which is last (peak load); it also links markets trading various energy commodities. While electricity prices depend on market fundamentals, they are also sensitive to supply and demand conditions in the other energy markets, notably natural gas. As markets and electrical grids are interconnected, political tensions affecting one energy market will likely affect other markets.

The European gas market began experiencing significant price increases in fall 2021 (Figure 1). Starting in May 2021, prices in the Dutch TTF Gas market – the leading European gas benchmark – increased from 25 EUR/MWh to the first peak on October 5th, when prices reached 115 EUR/MWh, then temporarily dropped and reached another peak of 178 EUR/MWh just before Christmas 2021. Prior to this unprecedented increase in gas prices, since 2010, prices had oscillated between 3.37 EUR/MWh to around 28 EUR/MWh. The reasons for these increases were threefold: cold weather, low levels of gas reserves, and transformed future contract pricing mechanisms.

In 2020, 87% of Gazprom's long-term contracts were linked to the current spot prices and only 13% to oil prices – the standard only a few years back (Le Coq and Paltseva, 2022). These high spot prices drove future contract prices to a higher level. Therefore, it was not in Gazprom's economic interest to deliver additional gas capacity to the European market, as the increased supply (above contractual agreements) would decrease gas prices on the spot market and reduce Gazprom's revenues.

Figure 1. Natural gas prices – Dutch TTF Gas



Source: https ://tradingeconomics.com/commodity/eu-natural-gas
Note: Dutch TTF Gas is a leading European benchmark price. Units: EUR/MWh

After the spike of December 2021, gas prices stabilized at the beginning of 2022, albeit still exhibiting a four-fold increase when compared with the first quarter of 2021. The war that broke out on 24 February 2022 sent prices soaring, reaching new records – above 225 EUR/MWh. These high gas prices translated into steep electricity prices at the wholesale and retail markets (von der Fehr et al., 2022).

2.2 RUSSIA'S ENERGY PLAN STRATEGY

In 2014, the Russian government published a draft of its energy strategy until 2035. The document was subsequently amended and approved in 2020 (Cannolly et al., 2020). The further development of its hydrocarbon exports is the main pillar of the country's stated strategy. Indeed, Russia was on the right track here until its war against Ukraine. It was a dominant exporter of energy in 2021: 1st net exporter of gas (23% of the global exports); 2nd highest net exporter of crude oil (13% of global exports); and the 3rd net exporter of coal (15% of global exports) (IEA, 2021).

The document stresses the increasing importance of Asian markets, especially China. Even if 40% of the imported gas in the EU came from Russia then, Russia already acknowledged that it might not last, given the EU's decarbonization policies and its move towards renewables (Cannolly et al., 2020).

Apart from Russia's dominance in the hydrocarbons sector, the country is also one of the nuclear tech leaders (together with China and the USA), actively exporting their nuclear technology to countries like India, China, Egypt, and Turkey (WNA, 2021; Oxenstierna, 2014; Buongiorno et al., 2019). So even if Russian electricity exports are limited (and contributing only 3 percent of Russian income in 2019), Russia's electricity generation's dominance might be more severe (Combs, 2022).

3 RUSSIA AND THE BALTIC SEA REGION ELECTRICITY TRADE

As a background for the ensuing discussion, it is helpful to summarize some data about current electricity supply and demand conditions in the BSR countries. We first present the existing connection between Nord Pool and Russia/Belarus, the two main BSR electricity trade areas. We then describe the energy profile of the studied countries, outlying their generation technology, consumption level, and connection to the European grid. Finally, we discuss the importance of the BSR electricity trade for Russia.

3.1 CONNECTIONS BETWEEN NORD POOL AND THE RUSSIAN MARKET

Russia and Nord Pool have different market mechanisms -- Nord Pool is an energy-only market with zonal pricing and Finland constitutes a single price zone, while Russia operates a capacity-based market, with nodal pricing.

The reform of the Russian electricity market started in 2006 and was completed in 2011. As a result, the country has been divided into around 8000 nodes for location marginal pricing, reflecting the congestion in the grid. The land has been separated into different price zones, the first covering the European part of Russia and the Urals, and the second in Siberia; several 'non-price' areas have also been created (see Gore et al. 2012 and Viljainen et al., 2014).

In 2011, the electricity price that end-users faced increased by 30-40% due to the newly introduced capacity compensation mechanisms (Gore et al., 2012). These compensation mechanisms also affected the profitability of the cross-border trade with Finland. Before 2011, Finland imported from Russia steady flows of electricity equal to the full capacity of the transmission line. In 2013, the utilization of the connection declined to 30 percent (Ochoa and Gore, 2015), dropping from around 11 TWh of imported electricity in 2011 to only 4 TWh in 2013 (CEEP, 2014). This resulted from the introduced capacity remuneration mechanism, a capacity charge that the trader – Inter RAO Nord, the only importer of Russian electric power to the Nordics – had to pay to purchase electricity on the Russian side. The payment was based on the maximum export in any of the peak hours of the month, making it unprofitable for the trader to export electricity in peak hours and thus limiting the trade in the hours with highest demand (Ochoa and Gore, 2015).

There are several connection points between the two markets. Russia is connected to Norway and Finland. The connection in the Baltic Sea Area is through an AC cable Estonia – Russia and Latvia – Russia. Lithuania is connected to the Kaliningrad area and the Belarussian grid. Additionally, Estonia is connected to Finland through two interconnectors: Est-link 1 and Est-link 2. A third interconnector is under construction and should be operational in 2035. Another connection is the Swedish-Lithuanian link, which connects the southern Swedish SE4 area with Lithuania.

In addition, the Baltics´ power system is a part of a large Russian operating synchronous electricity system -- BRELL -- connecting, as the name indicates, the electricity systems of Belarus, Russia, Estonia, Latvia, and Lithuania (Figure 2).

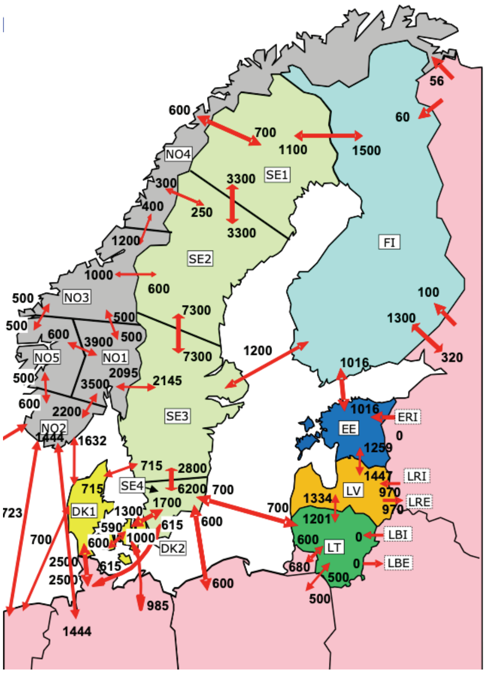
The desynchronization of the Baltic states from the BRELL grid is planned for 2025 (The Baltic Times, 2022); these efforts increased after the start of the war against Ukraine. Recently, Lithuanian President announced that the country will disconnect from BRELL in 2024 (Euractiv, June 2022). Once desynchronized from the BRELL grid, the Baltics will join the Western European synchronization area through the connection with Poland. However, until then, the three countries are dependent on the Russian-operated BRELL grid for the stability of their power network.

Figure 2. The BRELL power ring

Source: Brinkis et al., 2011

In 2010, Estonia was the first Baltic country to join the Scandinavian electricity exchange – Nord Pool. The other two neighbouring, Lithuania and Latvia, joined in 2012 and 2013, respectively (Nord Pool, n.d). The following Figure shows the maximum net transfer capacitates (NTC) values, valid from 12 January 2022.

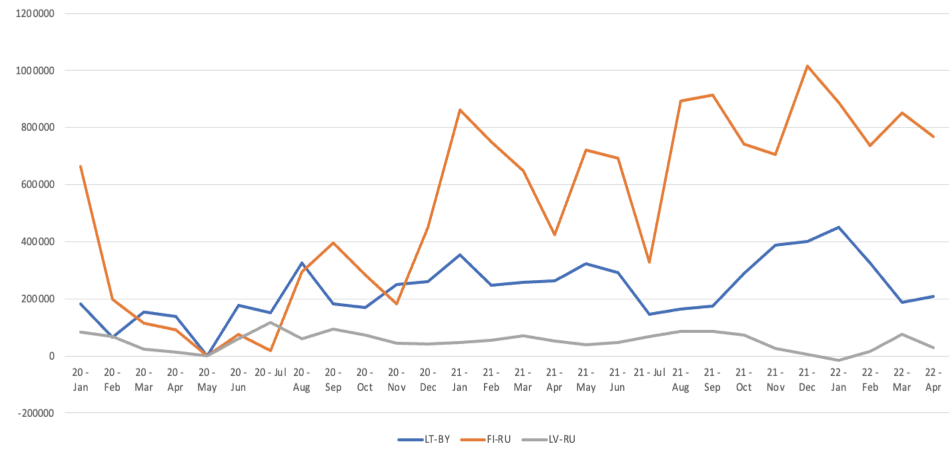
Figure 3. NTC values between Russia and BSR countries (MW)



Source: ICIS, 2019

Between 2016 and 2019 there was no trade between Russia and Latvia on the Nord Pool day-ahead market. Only in 2020 did the maximal assigned Elspot capacities reach 950 MW from Russia to Latvia and 800 MW in the opposite direction. Estonia has no capacity registered for Russian trade in Elspot. However, although commercial trading in the Nord Pool day-ahead market does not exist, as in case of Estonia, or is limited, as in case of the other two Baltic states, the power flows between the region and Russia and Belarus exist as these power systems operate on the same electrical grid. The following graph provides a general overview of the recent electricity exchange between Russia and Belarus and the Baltic Sea Region (Figure 4).

Figure 4. NordPool – Russia and Belarus monthly exchange volumes



Note: Data from Nord Pool. Positive values are imports. LT – Lithuania; BY – Belarus; FI – Finland: RU – Russia; LV – Latvia. Monthly data; units- MWh.

In 2020, because of the Covid-19 pandemic, electricity demand decreased in the region, thus reducing the need for imports. The beginning of 2021 brought a slow recovery of the economy, and the demand for electrical power increased, which was accompanied by an increase in Russian exports to Finland. The newly built Ostrovietz nuclear power plant started to operate at the end of 2020, resulting in a reduction of commercial transfers between the Baltics, Russia, and Belarus. However, the topography of the grid connecting these countries – BRELL – does not allow for a complete separation of the Baltics from Russia or Belarus. Therefore, the exchange transfers between those countries still exist, even if the commercial flows to the Nord Pool day-ahead market Elspot have been discontinued.

3.2 DIFFERENT ENERGY PROFILES ACROSS THE BSR'S COUNTRIES

In 2021, Finland and the Baltics generated approximately 117 TWh of electricity, which covered 74 percent of the region's electricity needs. The rest was imported from the neighbouring countries, i.e., Sweden, Norway, Russia, Belarus, and Poland.

In this section, the energy profiles of Finland and the Baltics are described.

3.2.1 Finland

Finland is part of the well-connected Nord Pool electricity market. In 2022, 18 percent of the generation capacity came from hydropower, 16 percent from nuclear, and 33 percent from fossil fuels; wind and biomass capacity were correspondingly 18 and 11 percent of the total capacity (Table 2).

Table 2. Installed Capacity per Production Type, Finland

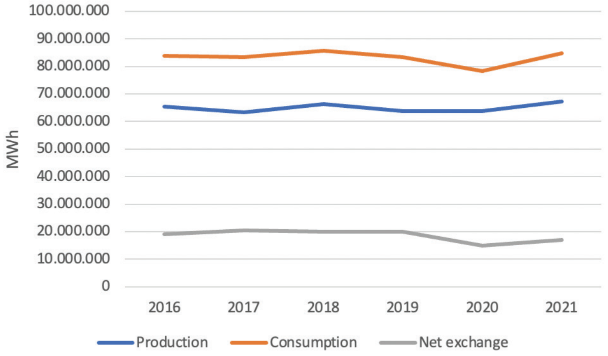
Production type (MW)	2021	2022
Fossil Peat	1135	1116
Nuclear	2794	2794
Fossil Hard Coal	1682	1682
Wind Onshore	2422	3184
Hydro Run-of-river and poundage	3153	3167
Other renewable	273	322
Solar	7	7
Waste	163	114
Fossil Gas	1849	1935
Fossil Oil	1089	1051
Other	436	462
Biomass	1860	1895
Total Grand Capacity	16863	17729

Source: ENTSO-E Transparency Platform.

With a 1,300-km border between Finland and Russia, the two countries are involved in significant commercial exchanges. They are connected through three 400kV transmission lines (to Vyborg, Russia) and by 110 kV lines from Ivalo and Imatra in Finland. Since 2016, electricity imports from Russia have corresponded on average to 28 percent of total Finnish imports.

Finland is a net importer of electricity. Between 2016 and 2021, national generation covered up to 81 percent of Finnish demand, with the highest share being covered locally during Covid in 2020 (Figure 5). Most Finnish electricity imports come from Sweden (bidding zones SE1 and SE3). Between 2016 and 2021, the second largest electricity exporter to Finland was Russia.

Figure 5. Production vs. Consumption, Finland.



Source: Based on data from Nordpoolgroup.com.

3.2.2 The Baltics

The Baltic states have historically relied on Russia (previously the USRR) for meeting most of their energy needs[5] (Salay et al. 1993). They are still connected to the Russia-controlled BRELL electricity grid but, as mentioned above, are planning to disconnect in 2025. They rely heavily on the fossil fuel electricity produced by natural gas (Latvia and Lithuania) and shale oil (Estonia) (Table 3). Almost absent from the Estonian energy landscape, hydro power is important in Latvia (56 percent of the energy mix) and Lithuania (27 percent of the energy mix). All three Baltic states have been investing in renewable electricity production. Onshore wind meets 14 percent of the energy mix in Estonia and Lithuania. Solar has been developing rapidly in Estonia and Lithuania, reaching 7 percent and 4 percent penetration, respectively. Biomass met 7 percent of the energy mix in Estonia, the highest share of that type of production across the Baltics.

Table 3. Installed Capacity per Production Type in 2021, Baltic States.

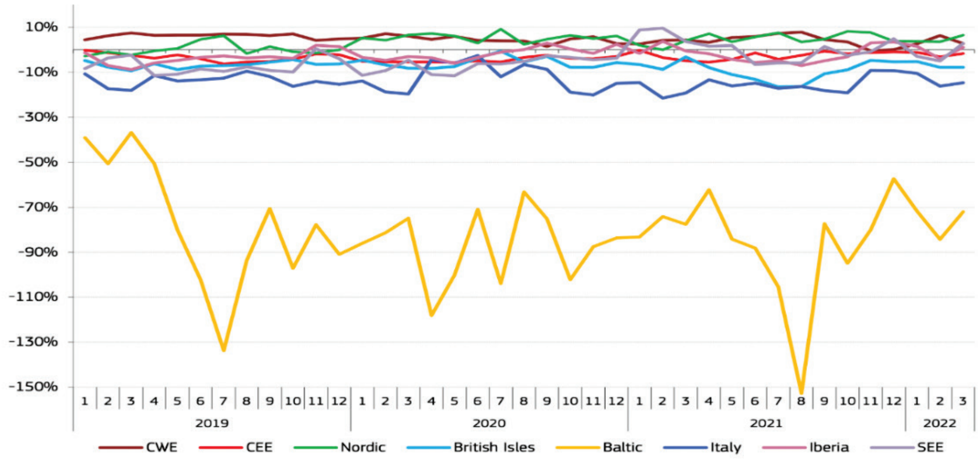
Country	*Estonia*	*Latvia*	*Lithuania*
Biomass	175	149	99
Fossil Coal-derived gas	74	n/e	n/e
Fossil Gas	98	1021	1887
Fossil Oil shale	1462	n/e	n/e
Hydro Pumped Storage	0	n/e	900
Hydro Run-of-river and poundage	8	1578	128
Other	0	n/e	37
Other renewable	10	n/e	0
Solar	164	11	169
Waste	17	n/e	48
Wind Onshore	329	84	540
Total Grand capacity	2337	2843	3808

Note: Based on data from ENTSO-E Transparency platform. MW

The Baltic states are heavily dependent on their neighbours regarding electricity consumption. They are all net electricity importers (Estonia since 2019). The following figure illustrates the dependency size. The values of net exchange for the Baltics over the period 2016 – 2021 are presented in Table A3 in the Appendix A.

[5] Lithuania used to export electricity to the region while its nuclear power plant was operating.

Figure 6. Net electricity export relative to the domestic generation in European regions.

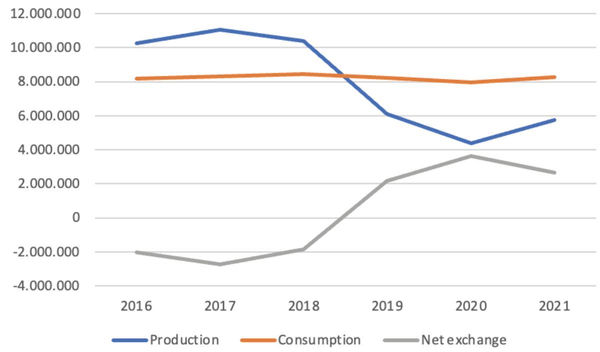


Source: EC (2022a).

Estonia, the northernmost Baltic state, is connected with Russia via three 330 kV overhead alternating current (AC) connections (500-650 MW), with Latvia via two AC overhead lines (500-900 MW) and Finland through EstLink1 and EstLink 2 – two direct current (DC) lines (Konkurentsiamet, 2021). The third line is planned to start operation in 2035 (Fingrid, 2022).

Since 2016, Estonia's electricity demand has remained stable, with around 8 TWh consumed annually (Figure 7). The country is now a net importer of electricity but was a net exporter until 2018. This is explained by a 40% reduction in the total local production of 6 TWh in 2019. This drop came from the decreased production of oil shale units (Eesti Energia, 2020). At the same time, Estonia is a transit country, with 63 percent of its exports going to Latvia. Between 2020 and 2021, 93 percent of its imported electricity came from Finland. Russian electricity used to constitute a large chunk of Estonian imports, with a peak of 28 percent in 2019. Due to the Baltics' efforts to disconnect from the Russian power grid, Russian imports were limited in 2021. They constituted only 5 percent of all Estonian imports amounting to 0.4 TWh of power imported that year. Simultaneously, imports from Finland increased from 3.5 TWh in 2019 to 6.6 in 2020; the amount remained at that level in 2021.

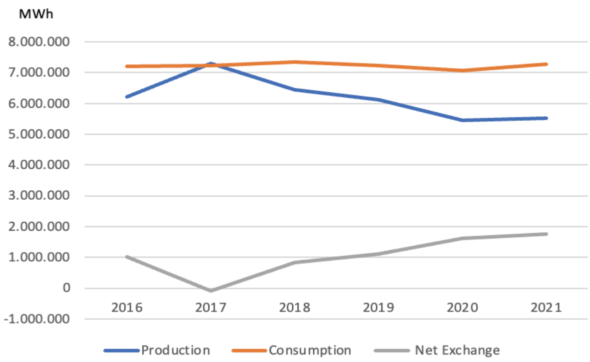
Figure 7. Production vs. Consumption, Estonia



Source: Figure based on hourly data from NordPoolgroup.com.
Note: Data in MWh. Positive values are imports, negative are exports

Latvia, bordering Estonia, Lithuania, and Russia on its three terrestrial sides, has power lines connecting it to all three countries. Three 330 kV lines connect with Estonia, four 330 kV lines with Lithuania, and one line of the same capacity with Russia. Latvia also shares a border with Belarus but has no transmission network connections. Latvia is a net importer of electricity (Figure 8). Its yearly consumption is stable - around 7.2TWh. In 2021, 76 percent of electricity consumption was covered by local production. Most imports come from Estonia, an average of 2.7 TWh yearly in 2016-2021.

Figure 8. Production vs. Consumption, Latvia

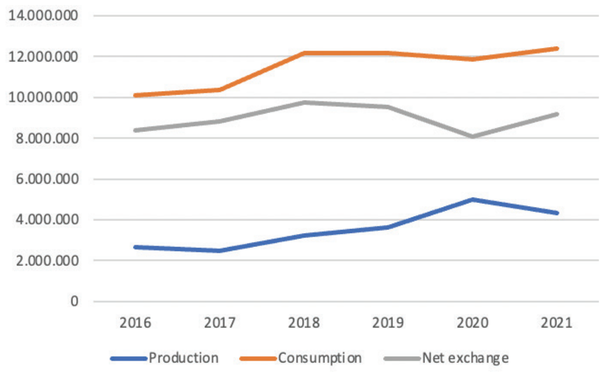


Source: Figure based on hourly data from NordPoolgroup.com. Data in MWh.
Note: Positive values are imports, negative are exports.

Lithuania – the most southern of the Baltics – has power network connections with its neighbours. 400 kV LitPol link connecting the country with Poland, with capacity reaching 500 MW both ways; four 330 kV and three 110 kV lines with Latvia; connection with Belarus (four 330 kV and seven 110 kV lines) and three 330 kV and three 110 kV connecting with the Kaliningrad region. It also has the DC NordBalt line with Sweden, SE 4 area, with a 700 MW capacity to and from Lithuania. Lithuanian electricity consumption is growing, except for 2020, when due to Covid-19, it dropped slightly (3%) compared with 2019 (Figure 9).

Between 2016 and 2021, local production satisfied between 23 to 42 percent of electric power consumption needs. Lithuania is the only Baltic state that had two nuclear reactors. The Ignalina power plant shut down in 2009, turning the country from a net exporter into a net importer of electrical power. In 2021 Lithuania´s net imports covered around 70 percent of its electricity needs. The majority of imports come from Sweden – on average 3.5 TWh yearly were imported from 2016 to 2021, with 2.8 TWh from Latvia, 2.4 TWh from Russia, and 2.1 TWh from Belarus.

Figure 9. Production vs. Consumption, Lithuania



Source: Figure based on hourly data from NordPoolgroup.com.
Note: Data in MWh. Positive values are imports.

In 2021, electricity imports from Russia and Belarus accounted for 45 percent of Lithuania´s total electricity imports (Table 4) and 42 percent of the country´s total electricity consumption, according to Nord Pool data. The single largest power import source was Sweden, providing 31 percent of Lithuania´s total imports. These were followed by imports from Latvia (18 percent). Imports from Poland were relatively low, accounting for only six percent of the country´s total imports.

Table 4. Russian imports as percentage of all Lithuanian imports

	From Russia	*From Belarus*	*From Sweden*	*From Poland*	*From Latvia*
2021	16%	29%	31%	6%	18%
2020	19%	21%	44%	3%	13%
2019	22%	24%	30%	3%	21%
2018	25%	14%	25%	6%	30%
2017	25%	12%	29%	4%	30%
2016	23%	16%	26%	4%	31%

Source: Authors’ own calculations based on Nord Pool data.

3.3 BSR’S ELECTRICITY TRADE AND RUSSIA’S ENERGY PLANS

In 2020, 59 percent of Russian electricity came from fossil fuels, with gas and oil constituting 44 percent of the generation mix; nuclear capacity represented 20 percent of the generation mix, and the rest came from renewables[6]. Russian electricity export to Europe focused on Finland and Lithuania, where in 2018-2019 two thirds of total Russian electricity export was directed. In 2021, Russian exports to Finland amounted to almost 8.7 TWh.

According to 2016 data, production capacity, of 12.6 GW, in Western Russia was much higher than the annual demand peak of 7.5 GW (Jaaskelainen et al., 2018), creating the opportunity to trade the excess with neighbouring countries, i.e.,

[6] https://ember-climate.org/app/uploads/2022/02/Global-Electricity-Review-2021-Russia.pdf

Finland and the Baltic States. Additionally, Russia does not adhere to EU environmental regulations, which decreases the price of its electricity and makes local fossil fuel production less competitive (Juozaitis, 2021). Finland and Lithuania are the main importers of Russian electricity, as is summarized in Table 5.

Table 5. Russian electricity exports 2014 – 2019.

Indicator	2019	+/-	2018	2017	2016	2015	2014
Export, billion kWh	**19.338**	**+15.7%**	**16.711**	**+15.7%**	**17.002**	**17.492**	**14.044**
Finland	7.023	+1.7%	6.903	+1.7%	5.2816	3.383	2.995
China	3.099	-0.3%	3.109	-0.3%	3.320	3.299	3.376
Lithuania	6.286	+42.4%	4.415	+42.4%	3.019	2.995	3.216
Belarus	0.031	-3.7%	0.049	-3.7%	3.181	2.815	1.425
Kazakhstan	1.437	+6.7%	1.347	+6.7%	1.164	1.542	1.644
Georgia	0.525	+154%	0.206	+154%	0.369	0.511	0.607
Mongolia	0.372	-10.5%	0.416	-10.5%	0.3	0.284	0.39
Azerbaijan	0.091	+19.3%	0.076	+19.3%	0.0596	0.055	0.053
Other	0.474	149%	0.19	149%	0.2716	2.608	0.318

Source: Inter RAO after Juozaitis (2021).

Energy income flows The income dependence of energy trading for Russia is unmistakeable. Between one-third to one-half of Russian revenues comes from oil and gas extraction and export, used for publicly financed activities like the social welfare system or military spending (Becker T. 2020). The energy sector also subsidizes other industries by providing inputs below market prices (Cannolly et al., 2020).

Russian electricity exports are relatively limited compared to the country´s primary energy exports: oil, gas, and even coal. In 2019, Inter RAO´s, Russia´s only electricity export and import operator, reported total revenue from electricity trading of 77 billion roubles, or 770 million Euro/$862 million (Juoazaitis, 2021), while the same year, income from oil amounted to $123 billion, gas $26.3 billion and coal $17.6 billion[7].

Russia's involvement in the nuclear energy domain. In its 2014 Energy Strategy statement, Russia set ambitious plans to double its nuclear energy production by 2030 (Jaaskelainen et al., 2018). Russian nuclear power plants (operating, planned and under construction) are shown in Figure 21. Note that this is in addition to Russia being a major export supplier of nuclear reactors and nuclear fuel (see discussion in sections 2.2 and 5.3).

In addition, Russia was instrumental in constructing Belarus' first nuclear power plant (NPP), Ostroviets, in operation since November 2020. This plant, located only 20 kilometres from the Lithuanian border, provoked multiple protests in Vilnius. According to the geopolitical experts (Juozaitis and Česnakas, 2017), its construction, which started in 2013, was an answer to the Polish-Lithuanian efforts

[7] https://www.weforum.org/agenda/2022/03/russia-gas-oil-exports-sanctions/

to construct another nuclear power plant in the region, Visaginas, which was to replace Ignalina NPP. The project was eventually abandoned.

The decision to pursue the construction of a NPP near the EU border was both commercially and politically motivated. Already in 2018, Belarussian energy production surpassed electricity consumption needs, indicating that the main purpose of a new NPP was future regional trade. Moreover, the plant's site is far from the Belarussian industrial area; it was considered the worst location for NPP construction by the Belarusian Academy of Science in 1993 (Juozaitis and Česnakas, 2017). In addition, the cost of the Ostrovets´ electricity has been estimated at 7.7-euro cents/kWh, to break even. Details of the loan agreement between Belarus and Russia have been renegotiated; payment on the loan will only start in April 2023, meaning that until then electricity could be offered to Nord Pool at a much lower price than the current high prices. However, due to fears of inadequate security standards of the plant, and over-reliance on Belarusian electricity, Lithuania stopped all commercial trade with Belarus in 2021.

4 DIFFERENT DIMENSIONS OF ELECTRICITY TRADE SECURITY

In this section, we first explore energy security for the electricity trade, stressing the issue of external energy supply. We then base our assessment on events that have affected the electricity trade between Russia and BSR. This allows us to characterize dependency on Russian electricity of Nord Pool, the main electricity market of the BSR countries. In the following subsections, we explore different datasets and present various energy security measures.

4.1 "MISSING TRADE" AND ENERGY SECURITY

One way to assess the external security of supply is to look at the available import options to assure adequate energy supply. We first look at the flows in Elspot, then compare them with the maximum available capacity. This missing trade assessment is our first measurement of the security of the electricity trade. This section analyses whether the potential for trade between Russia and the BSR has been fully realized.

4.1.1 Elspot's flows vs. available capacities

Between 2016 and 2021, electricity flows between Russia/Belarus and BSR were relatively important. However, the construction of the Ostroviets nuclear power plant and the Ukraine war have triggered more permanent changes in the Elspot flows between Russia/Belarus and BSR countries, as illustrated in Table 6.

First, due to concerns over inadequate security standards of the Ostroviets power plant, in November 2020 Lithuania stopped all commercial trade with Belarus. In 2020, the year when the Ostroviets NPP started to operate, the average hourly Elspot flows from Belarus to Lithuania dropped to 198 MWh, from 594 in 2019 (the highest number between 2016 and 2022). Average hourly Elspot flows from Kaliningrad to Lithuania also decreased from 336 MWh in 2018 to 207 in 2021 and 101 MWh in 2022[8]. Second, Latvian electricity trade with Russia through Elspot started only in 2020, reaching 327 MWh in 2021 and dropping to 68 MWh in 2022. As for Estonia, no commercial Elspot flows from Russia to Estonia were recorded at Nord Pool in the analysed period.

[8] For 2022 fdata cover the period until middle of August.

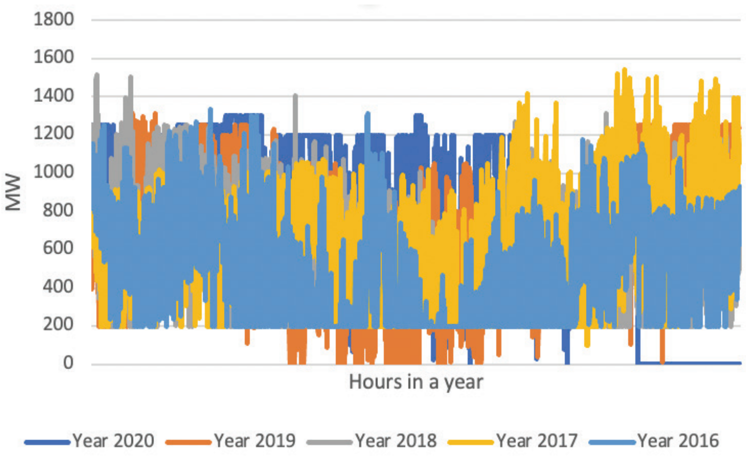
Table 6. Elspot flows from Russia and Belarus to the Baltics

		Belarus to Lithuania	*Kaliningrad to Lithuania*	*Russia to Latvia*	*Russia to Estonia*
2022	**avr**	0,00	100,92	67,52	0
	min	0,00	0,00	0	0
	max	0,00	434,00	488	0
2021	**avr**	0,00	206,57	326,68	0
	min	0,00	0,00	0	0
	max	0,00	600,00	950	0
2020	**avr**	197,79	217,51	34,34	0
	min	0,00	0,00	0	0
	max	1250,00	550,00	950	0
2019	**avr**	593,68	299,38	0	0
	min	0,00	0,00	0	0
	max	1369,00	550,00	0	0
2018	**avr**	292,03	336,09	0	0
	min	0,00	0,00	0	0
	max	1237,00	600,00	0	0
2017	**avr**	88,63	287,27	0	0
	min	0,00	0,00	0	0
	max	991,80	600,00	0	0
2016	**avr**	130,55	231,61	0	0
	min	0,00	0,00	0	0
	max	967,40	576,00	0	0

Source: Based on Nord Pool data.
Note: Flows are understood as planned flows between the bidding areas resulting from the day-ahead price calculations.

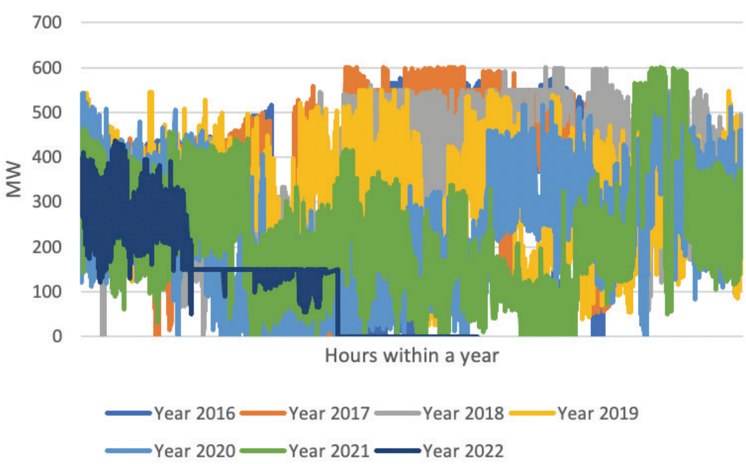
When Lithuania stopped all commercial flows with Belarus, no Belarusian electricity was traded on Elspot. This is illustrated in Figure 10, showing the evolution of maximal Elspot capacities available for trade between Lithuania and Belarus. The commercial flows with the Kaliningrad region have also fallen (Figure 11). The average, minimum and maximum capacities assigned for Elspot trade between Russia, Belarus and Lithuania can be found in Table A1 in the Appendix A. The summary statistics for Elspot capacities for Latvia and Russia are presented in Table A2 in the Appendix A.

Figure 10. Elspot Capacity for Lithuania-Belarus connection



Source: Based on Nord Pool data.
Note: The day-ahead trading capacities give the upper limit for power flow between the bidding areas. The capacities are published before 10:00 on the day before delivery.

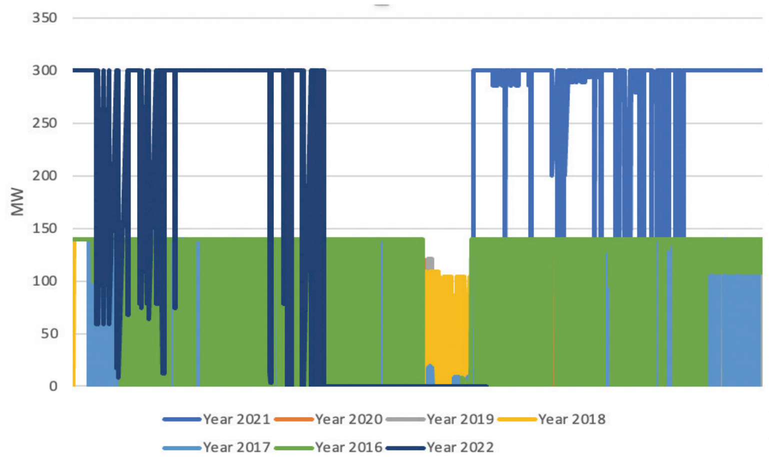
Figure 11. Elspot Capacity for Lithuania-Kaliningrad connection



Note: Based on Nord Pool data. The day-ahead trading capacities give the upper limit for power flow between the bidding areas. The capacities are published before 10:00 on the day before delivery.

Figure 12 provides the same variable for the electricity trade between Finland and Russia. Contrary to the decreasing Elspot flows between Russia and the Baltics and chaotic Elspot capacities, trade with Finland has been much more stable.

Figure 12. Elspot Capacity for Finland-Russia connection



Note: Based on Nord Pool data. The day-ahead trading capacities give the upper limit for power flow between the bidding areas. The capacities are published before 10:00 on the day before delivery.

4.1.2 The "missing trade" measurement

In electricity trade and provision, the instantaneous balancing of supply and demand is critical. Whether the available trading capacity is fully used depends on locally available supplies or other connections. Between 2016 and 2022, Lithuania reached maximum capacity of trade with Russia every year, except for 2021. Latvia reached the maximum capacity of 950 MW in 2020 and 2021, and Lithuania used the maximum power of the trade connection with Belarus in 2019, with flows of 1369MW for a few hours[9].

In 2019, the commercial day-ahead flows from Kaliningrad to Lithuania equalled the maximum capacity assigned to Elspot trade, for 96 percent of hours. In 2021, this percentage decreased to just 70 percent, meaning that 30 percent of the time the capacity assigned for commercial trade was not used. This amounted to 39 GWh in 2021. In November 2020, commercial trade from Belarus to Lithuania was halted, a situation that continues. However, in 2019, when electricity from Belarus was still commercially traded in Lithuania, electricity transfers on the day-ahead market met the maximum assigned capacity 65 percent of the time. The total amount of "missing trade" – available capacity for trade that has not been used amounted to 1.4 TWh. Neither have available import capacities from Sweden or Poland been maximized. In 2019, trading capacity from Sweden was maximized some 50 percent of the time, dropping to 44 percent in 2021. The "missing trade" gap was around 2 TWh in both years. The total capacity of the Polish connection was used at 12 percent in 2019 and increased to 22 percent in 2022; the "missing trade" gap was 3 TWh in both years. See Table A4 in the Appendix A.

This "missing trade" value is a rough measurement, as we do not control for several variables (e.g., temperature and economic activity) that affect electricity consumption. We need to consider the time of the day, i.e., peak, and off-peak hours. In electricity trading, the time of delivery is of crucial importance, as the balance between the demand and supply must be met instantaneously. Otherwise,

[9] Elspot capacites are summerized in Tables A1 and A2 in the Appendix A.

the risk of blackouts emerges. Off-peak hours are characterized by low electricity consumption and lower prices, as generation units supplying electricity have lower marginal costs. During peak hours, the demand is high and additional capacity needs to come online to meet consumption needs. The most expensive units generating power in the peak hours set the price for electricity delivered in that time slot. Although electricity is traded both in peak and off-peak hours, the possibility of trade becomes crucial to satisfy regional needs when local production cannot cover the demand. Therefore, analyzing how many "missing trade" opportunities are in the peak vs. off-peak hours is essential. Nord Pool defines peak hours as 9:00 to 20:00 and distinguishes two off-peak periods: off-peak 1 from 1:00 to 8:00 and off-peak 2 two from 21:00 to 24:00 (Table 7).

Table 7. Percent of time when maximal Elspot flows to Lithuania have been reached during peak hours.

	Kaliningrad	*Belarus*	*Sweden*	*Poland*
2021	69%	0%	51%	25%
2019	96%	57%	67%	14%

Note: Own calculations based on Nord Pool data. Peak hours: 9 a.m. – 8 p.m.

The data in Table 7 indicate that the availability of transfer capacity during peak hours does not seem to be a problem; there is adequate capacity, so interconnection per se seems to be sufficient.

4.2 DESYNCHRONIZATION AND ENERGY SECURITY

Desynchronization from the BRELL grid. In 2007, the prime ministers of the Baltic states announced a regional strategic priority to desynchronize from the Russian Integrated Power System/Unified Power System (IPS/UPS) and become part of the Continental European Synchronous Area (Litgrid, n.d). After long negotiations in 2018, the decision to join the European Network through Poland was reached; in 2019 and 2020, the EU allocated substantial funds for the Baltic desynchronization project.

Lithuania has recently announced that the full desynchronization is scheduled for 2024, a year earlier than planned. Until then, Russian, and Belarusian electricity flows through the Baltics to maintain the grid's stability and prevent blackouts. Although since the end of 2020 the Baltics have reduced or stopped commercial electricity flows from Belarus and Russia, the import ratios indicate that 16 percent of all electricity imports to Lithuania originated in Russia (Table 8) (Kaliningrad region), and the share of imports from Belarus even increased, as compared with previous years (see Table 9). As a result, in 2021, 45 percent of electricity imports to Lithuania came from Russia and Belarus. Still, these flows to ensure the grid's stability are not considered commercial trading.

Table 8. Imports from Russia as the share of the overall country´s imports.

	Finland	*Estonia*	*Latvia*	*Lithuania*
2021	0,36	0,05	0,18	0,16
2020	0,13	0,04	0,24	0,19
2019	0,32	0,28	0,28	0,22
2018	0,35	0,20	0,27	0,25
2017	0,26	0,10	0,28	0,25
2016	0,26	0,05	0,26	0,23

Note: Own calculations based on Nord Pool data.

Table 9. Lithuanian imports from Belarus as the share of the overall country´s imports

	Lithuanian imports from Belarus
2021	0,29
2020	0,21
2019	0,24
2018	0,14
2017	0,12
2016	0,16

Note: Authors' calculations based on Nord Pool data.

Disconnecting from the BRELL power network and closing the transmission lines with Russia and Belarus requires massive investment and strengthening of the power grid in the Baltics, the Kaliningrad area, and north-western Russia.[10] The Baltics signed the agreement on desynchronization from IPS/UPS in 2018. Although publicly opposing the desynchronization project, Russia has already made substantial improvements to its power grid and invested in the Kaliningrad area. Two 330 kV transmission lines were constructed in mainland Russia along the Baltic states and Belarus borders.

The Kaliningrad area – This Russian enclave situated on the Baltic Sea, between Poland and Lithuania, used to be a net importer of electricity. Things changed in 2005 with the new 450 MW combined heat and power plant, Kaliningradskaya. In 2010, a second 450 MW unit became operational, turning the region into a net exporter of electricity.

Desynchronization has left Russia with essentially three options regarding the situation of Kaliningrad: synchronization, negotiation, or autonomy. However, synchronization, i.e. linking the European Network with the Baltics, is difficult for political reasons; Russia barely considered this path. Negotiation implies cooperation between Lithuania and Russia to construct an additional power line through Lithuanian territory, joining Kaliningrad with Belarus. The third and most expensive option – autonomy – requires Kaliningrad to function as an isolated system (Masera et al, 2016).

[10] The BRELL agreement was signed in 2001 (Juozaitis, 2021).

Russia chose the latter 'island' mode and decided on a massive investment of an additional 967 MW capacity, almost doubling capacity. Three natural gas-fired power plants Talakhovskaya (161 MW), Mayakovskaya (157 MW) and Pregolskaya TPP (454 MW), and one coal-fired plant Primorskaya TPP (195 MW) were built. Together with the Kalinigradskaya CHPP of 900 MW, CHPP-10 of 24 MW, Gusevskya TPP of 8.5 MW, and 5.1 wind farm, the total generating capacity of the region in 2018 was 1904.6 MW (Juozaitis, 2021).

1705 MW of Kaliningrad's capacity runs on natural gas; therefore, the security of the gas supply was also a priority for the detached region. "In December 2017, Russia built two underground natural gas reservoirs that expanded Kaliningrad's natural gas storage capacity to 174 million cubic meters" (Juozaitis, 2021), and there were plans to develop it further. Additionally, Kaliningrad has at its disposal a LNG tanker - FSRU Marshal Vasilevskiy - capable of storing 174,000 cubic meters of LNG, which corresponds to 100 million cubic meters of natural gas. Furthermore, a new plant able to supply Kaliningrad with LNG has been opened last year close to the Russian-Finnish border. The Portovaya plant, situated in the Leningrad region, had its first shipment in September 2022, and its yearly capacity is 1.5 million tons (Reuters, 16th of September 2022).

Kaliningrad has already conducted three tests of readiness to operate in an 'island' mode: in 2019 for 72 hours, in 2020 and 2021 for 8 hours. In 2022, a test was scheduled for June but was cancelled. Another one was planned for the 24th of September and to last 14 hours (Litgrid, n.d. 2) but was also cancelled.

4.3 IMPORT DIVERSIFICATION AND ENERGY SECURITY

The capacity of a country or region to ensure energy security depends on its import diversification opportunities. Import diversification would imply for the BSR that, in case of a sudden break in Russian power, the region would be able to replace it by either increasing imports from the other suppliers or extending domestic production.

To investigate the BSR import diversification option, we use the abrupt 2022 energy trade suspension between Finland and Russia. On May 14, Russia announced that it would stop the export of electricity to Finland; a day later, the flow stopped (Figure 13).

Figure 13. Finnish imports from Russia.

Source: NordPool[11]

This dramatic unilateral action allows us to better gauge the credibility of import diversification for the BSR. In the following subsections, we assess the effects of the trade suspension, showing that it led to import substitution and price volatility changes.

4.3.1 Import substitution from Nord Pool

According to Reima Päivinen, Senior Vice President of Power System Operations at Fingrid, "The lack of electricity import from Russia will be compensated by importing more electricity from Sweden and by generating more electricity in Finland[12]." We analyze this claim by first looking at the trade situation between 24 February 2022 (the beginning of the war in Ukraine) and 14 May 2022 (see Table 10). During this period, around 10% of Finland's total electricity consumption was supplied by Russia (see Tables 10 and 11). The total export to Estonia amounted to approximately 1707 GWh. Since 15 May, the average hourly imports from Sweden have increased from 1119 MWh (in the period 24th of February 14th of May) to 1942 MWh.

Table 10. Finnish electricity exchange since 24 February 2022

		Finland – import from Russia	*Finland – import from Estonia*	*Finland-Sweden net exchange*	*Finland – import from Sweden*	*Finland – export to Estonia*
24.02-14.05	sum	1.955.761	1.837	2.136.405	2.148.671	-1.707.920
	average	1.018	0,96	1.112	1.119	-889
15.05-4.10	sum	0,00	17.885	6.664.966	6.668.032	-2.507.839
	average	0,00	5,21	1.942	1.942	-730

Note. Author´s calculations based on Nord Pool data. Values in MWh; hourly averages.

[11] https://www.nordpoolgroup.com/en/Market-data1/Power-system-data/Exchange1/FI/Hourly1/

[12] https://www.fingrid.fi/en/news/news/2022/electricity-trading-with-russia-will-suspend--no-threat-to-the-sufficiency-of-electricity-in-finland/

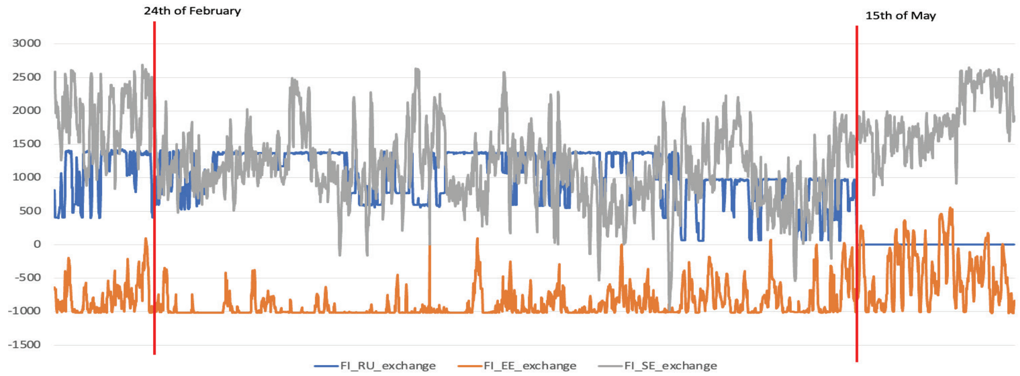
Table 11. Finnish and Swedish electricity production and consumption since 24 February 2022

	Finland	*Sweden*	*Finland*	*Sweden*
24.02-14.05	Production	Production	Consumption	Consumption
sum	15.523.831	38.042.532	17.994.448	30.874.218
average	8.085	19.813	9.372	16.080
15.05-4.10				
sum	22.644.917	57.883.856	26.998.633	43.027.825
average	6.598	16.865	7.866	12.537

Note. Author´s calculations based on Nord Pool data. Values in MWh; hourly averages.

Figure 14 illustrates the evolution of the cross-border electricity exchange between Finland and its main import and export destinations, increasing imports from Sweden and increased volatility of net exchange with Estonia. Having enough capacity to replace the "missing" Russian electricity and maintain or even increase the exports to Estonia depends on whether energy in Finland and Sweden will be sufficient.

Figure 14. Finnish electricity cross border exchange January – August 2022



Note: FI – Finland, RU – Russia, EE – Estonia; SE – Sweden.

To analyze the effect of an abrupt interruption of electricity trade on the Nord Pool, we next look at the change in price volatility after Russian electricity stopped flowing into the Scandinavian power system.

4.3.2 Import substitution on prices

The GARCH model approach is a popular method for estimation of volatility. Developed by Bollerslev (1986) for analysis of price developments of financial assets, the method has also been used in evaluations of volatility of electricity prices (Hadsell et al., 2004 and 2006). The model allows for analysis of persistence and mean reversion that have been shown to characterize electricity prices (Engle and Patton, 2001). Persistence of volatility is observed when periods of high and low volatility are clustered, or when we can observe that "today´s return has a large effect on the forecasted variance many periods in the future" (Hadsell et al., 2004). Secondly, after periods of increased volatility, it tends to return to normal levels. In the analysis, we define the following model:

$$R_t = \mu + \varepsilon_t \qquad (1)$$

$$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2 \qquad (2)$$

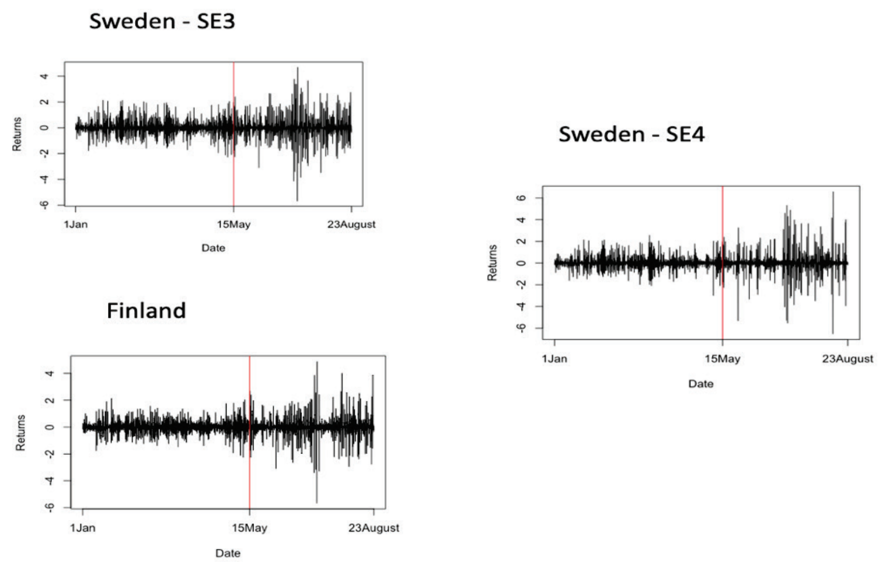
Equation (1) expresses day-ahead returns[13] R_t as a random walk process. Equation (2) describes conditional variance σ_t^2 as a result of the mean (omega), the ARCH term captured by alpha describing the news about volatility from the previous period and the GARCH term captured by beta which describes previous period forecasted variance.

Alpha "quantifies the size of the effect – how much volatility increases irrespective of the direction of the shock" and "beta captures the degree of volatility persistence" (Hickey et al., 2012).

Sweden and Finland

The sudden Russian halt of electricity exports to Finland on 15 May 2022 is associated with increased price volatility in southern Sweden, in Finland and, to a lesser extent, in the Baltics. The volatility is measured as the standard deviation of the logarithmic returns[14] using a GARCH model approach. Figure 15 shows the evolution of the logarithmic returns of Elspot price in Sweden - zones SE3, SE4 - and in Finland. In the first period (January – 14 May 2022), volatility in SE3 is equal to 0.38 and it increases to 0.59 in the second period (15 May – August 2022).

Figure 15. Volatility in southern Sweden and Finland, 2022.



[13] Which are defined as logarithmic returns, as defined in next footnote.

[14] Defined as $\ln\left(\frac{p_t}{p_{(t-1)}}\right)$ where ln is a naural logarithm, p_t is the zonal price on the day t

In case of zone SE 3, the comparison of two GARCH models estimated for the respective periods (before and after 15 May) also indicates the volatility in the second period has slightly increased and is characterized by higher degree of volatility persistence expressed as beta (Table 12).

We find similar results for the most southern Swedish bidding zone – SE4 – where the volatility measured as the standard deviation of the logarithmic returns is equal to 0.36 in the first period, and 0.65 in the second period. The corresponding values for Finland are 0.34 and 0.54.

Table. 12 Results from GARCH estimation for southern Sweden and Finland

	1st January – 14th May	*15th May – 23rd August*
	Estimate	**Estimate**
Sweden – SE3		
Alpha	0.06	0.03
Beta	0.93	0.96
Sweden – SE4		
Alpha	0.13	0.08
Beta	0.85	0.91
Finland		
Alpha	0.16	0.05
Beta	0.80	0.95

The comparison of the models in Table 12 for the respective periods (before and after 15 May) for all three bidding zones indicates that the volatility in the second period has slightly increased and is characterized by higher degree of volatility persistence, expressed as the beta coefficient[15].

The Baltics

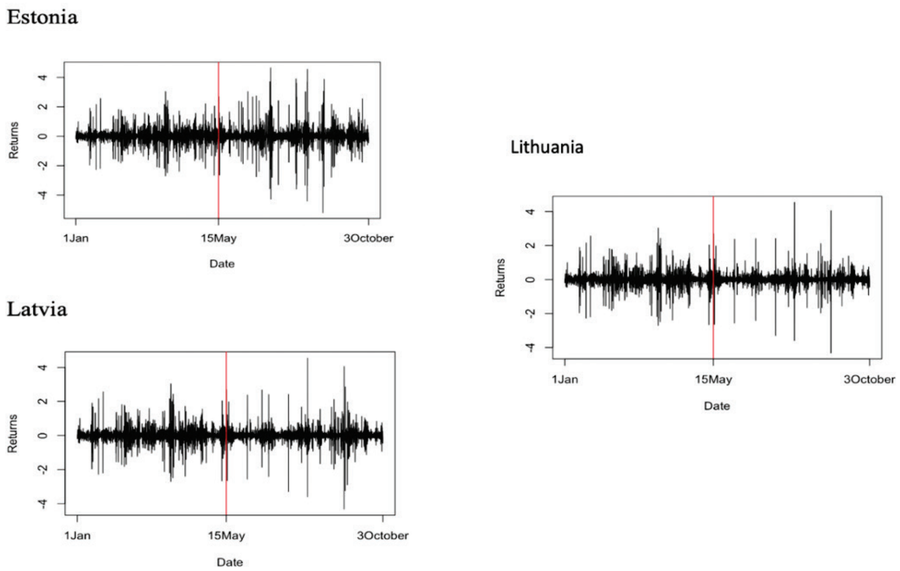
The price difference between Estonia and Latvia has grown since 15 May 2022, a sign that there was more congestion between the two areas. From the beginning of 2022 to 22 August of that year, 77 percent of hourly prices between Estonia and Latvia were identical. Between Latvia and Lithuania, the same prices prevailed for 95 percent of hours. In the first period, these countries had the same prices 90 percent of the time, but this number dropped to 52 percent in the second period (after 15 May), meaning that the congestion between the areas i.e., price differences, have increased. For comparison, in 2021 the similarity of prices among the three countries occurred in 94 percent of hours, meaning that the registered congestion between the Baltics was only observed 6 percent of the time.

Volatility measured as standard deviation of the returns series have indeed increased in case of Estonia and was equal to 0.41 and 0.5 in the two periods, but it has dropped slightly in case of Latvia and Lithuania with the numbers in the first period: 0.38 and 0.37; and 0.35 and 0.32 in the second period (Figure 16). However,

[15] Tables B1- B5 in Appendix B present the coefficients from GARCH estimations for both periods and all three zones.

the spread between the minimal and the maximal price has reached 3997€/MWh, while in 2021 the spread was around 1001 €/MWh.

Figure 16. Volatility in the Baltics.



5 KEY FINDINGS AND FUTURE ISSUES

This section outlines our conclusions regarding the energy security linked to Russian electricity trade for the BSR. First, we stress Nord Pool's "new" pivotal role in the BSR region's electricity trade. Further, we discuss the future energy security issues related to electricity trade, given our findings and the environmental goals set by the BSR countries.

5.1 THE "NEW" ROLE OF NORD POOL IN THE BSR'S ELECTRICITY TRADE

Over the years, and mostly because of the events described in Section 4, Finland and Sweden have become pivotal electricity providers in the region, replacing Russia and Belarus as main power providers for the Baltic States. Between 2016 and 2021, these two countries have jointly exported 45 TWh of electric power to the region, of which Finland provided 54 percent.

Table 13 illustrates the increasing role of Finland and Sweden in the Baltics' electricity trade. It provides the *diversification ratio* (measured as the share of imports from one supplier to all imports in a year) over the period 2016-2021. Estonia was a net exporter of electricity until 2019, and imports from Finland corresponded to roughly 15 – 29 percent of Estonian electricity generation. Since 2019, Estonian power production has substantially decreased, turning the country into a net importer of electricity. Finland has remained the primary source of their imports. In addition, Estonia was a net exporter to Russia, except in 2019, when 1.2 TWh of Russian power flowed into the Estonian power system. Latvia's imports from Russia have also been decreasing over the last years while main imports have been from Estonia.

Interestingly, Estonia was the main exporter to Latvia in 2019 and onwards, when its local production decreased. Estonia turned into a net importer; as such it was a transit country. Belarus and Russia are Lithuania´s main sources of imports, although Elspot trading with Belarus stopped by the end of 2020 and the day-ahead commercial flows with Russia have been limited. The second important source of imports is Sweden. The comparison of the size of net imports from Russia to the BSR and Finland to the size of the local production is presented in Table A5 in the Appendix A.

Table 6. Diversification ratio - Baltic States

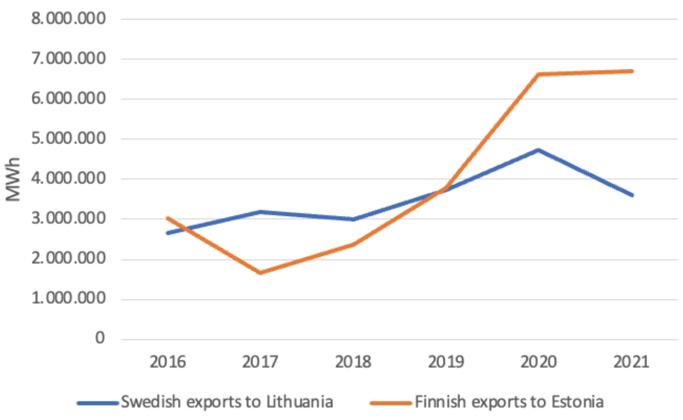
	Latvia		***Estonia***		***Lithuania***		
Import from	**Russia**	**Estonia**	**Russia**	**Finland**	**Russia**	**Belarus**	**Sweden**
2021	0,18	0,72	0,05	0,93	0,16	0,29	0,31
2020	0,24	0,61	0,04	0,94	0,19	0,21	0,44
2019	0,28	0,68	0,28	0,70	0,22	0,24	0,30
2018	0,27	0,71	0,20	0,79	0,25	0,14	0,25

Note: *Diversification ratio*: net imports from a specific location/ all imports[16]

[16] Table 13 is an extension and adaptation of Tables 8 and 9.

Figure 17 illustrates imports from Finland to Estonia and from Sweden to Lithuania, over time. The increasing trend over the analyzed period is visible in both cases.

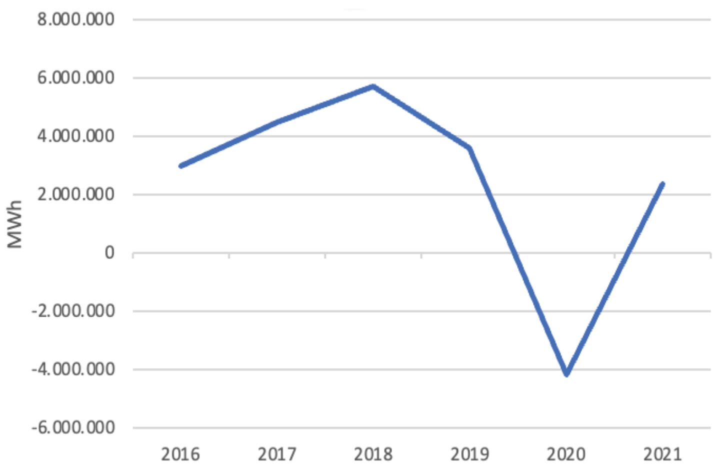
Figure 17. Finnish and Swedish exports to the Baltics



Source: Based on data from Nord Pool.

Figure 18 illustrates Finnish *adjusted production gap* (measured as the difference between the domestic production and imports from Sweden and Norway, less national consumption). Given the nature of electricity, any production gap needs to be filled with generation from external suppliers. A positive adjusted production gap implies additional imports from Russia are required. The more positive the adjusted gap variable is, the more likely Russia will increase its electricity export towards Finland. In 2016, this adjusted gap was approximately 2.9 TWh, reaching around 5.7 TWh in 2018. In 2020, Finnish production, together with imports from Sweden and Norway, exceeded local consumption needs, resulting in an "excess" of 4 TWh of electricity. The following year, the adjusted gap was around 2 TWh.

Figure 18. The adjusted production gap -Finland



Source: Own calculations based on Nord Pool data.

The *adjusted production gap* is a rough measure of the dependency on Russia. It allows us to gauge the amount of electricity needed to meet demand through own production and imports from Nord Pool members Sweden and Norway, measured on a yearly basis. But it does not consider the timing of electrical flows. As such, this gives a yearly estimate of the flows that will need to be replaced when electricity from Russia stops flowing.

Finland imported approximately 38 TWh of electricity from Russia over this period. We argue that power coming from Russia was partially used to cover Finnish demand but was also exported to Estonia. The Finnish adjusted gap was falling until 2020 (see Figure 18), implying a decreasing share of Russian imports. At the same time, the share of Russian electricity imported by Finland and available for exports to Estonia was growing (Table 14). In 2021, approximately 6.7 TWh of electricity, corresponding to approximately 77 percent of imports from Russia, was exported to Estonia. The evolution of Finnish exports to Estonia as a share of Finnish imports from Russia is presented in Table 14. Between 2016 and 2019, and in 2021, the amount of electricity Finland exported to Estonia exceeded imports from Russia to Finland. In 2020, the “Covid year”, the situation changed and exports to Estonia surpassed the imports from Russia by 131 percent; it was also the year when the volume of imported Russian electricity was the lowest – only 2.8 TWh, as opposed to 7.5 TWh in 2019 and 8.6 TWh in 2021.

Table 7. Finnish exports to Estonia as the share of Finnish electricity imports from Russia

2021	77%
2020	232%
2019	50%
2018	30%
2017	29%
2016	52%

As illustrated in Table 15, the percentage of sent Russian electricity has been increasing – from 26 to 36 percent. Finland´s main import channel is via Sweden, but the share of these imports among all Finnish imports has been fluctuating – from 61 percent in 2018 to 85 percent in 2020.

Table 8. Net imports from a specific location/ all imports (Finland)

	Finland	***Finland***
	from Russia	**from Sweden**
2021	36%	62%
2020	13%	85%
2019	32%	66%
2018	35%	61%
2017	26%	69%
2016	26%	70%

5.2 SHORT-TERM ISSUES

In the short term, the security of Baltic power sector and the wider economy depends on whether and when the threat of detachment from Russian and Belarussian current power network will happen. The other main issues, inter alia, are high fossil fuel prices and the Baltics' traditional reliance on Russian energy imports. Both concerns are discussed in the following sections.

5.2.1 Is full desynchronization from Russia credible?

Desynchronization of the Baltics from the BRELL network means that there will be no connection with Russia and Belarus and no possibility of this energy trade between the two countries and the region. This will be a big disadvantage for Ostroviets, however, it will stop further dependence of the region on Russian electricity. Although Russia has opposed the Baltics' decision to synchronize with continental Europe, it has moved quickly to improve its infrastructure and might be ready to "cut the cables" earlier than the Baltics. A threat is if Russia would decide to prematurely cut the Baltics from the BRELL network, either within the framework of the BRELL agreement - with six months' notice - or more abruptly. If the Baltics are not ready to disconnect, this could result in blackouts and socio-economic mayhem.

An abrupt disconnection from BRELL could be harmful for Kaliningrad if it comes too early. As we noted earlier, Kaliningrad has conducted three successful exercises of operating in an 'island' mode, with the longest one of 72 hours, but it is not evident if the enclave is ready for a complete 'island' operation. Moreover, two tests scheduled for 2022 have been cancelled. If the region is not ready for total disconnection, it will need to rely on power flows from Poland or Lithuania, a situation that might be politically difficult for Russia.

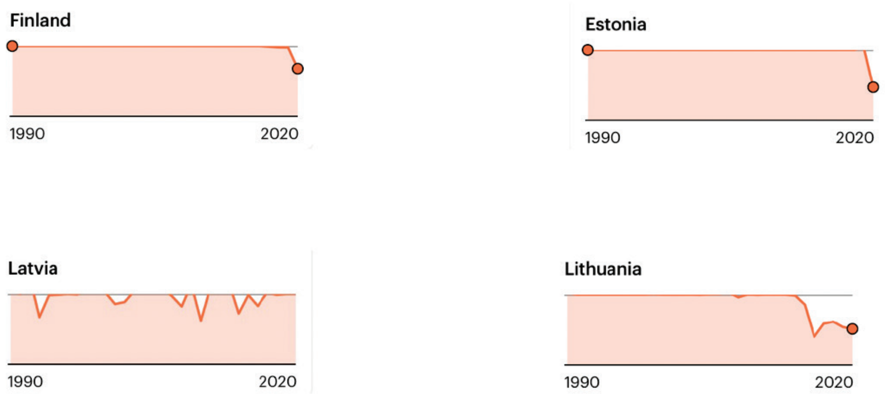
The interconnections between the neighbouring areas - Poland and the Nordics - are critical. The Baltics are already currently net importers of electricity; this might deteriorate soon, according to some studies (Petrichenko et al, 2021a). This signals that the interconnection dependency within the area could become even more significant (Petrichenko et al, 2021b).

5.2.2 Baltic energy dependence

The Baltics' electricity capacity relies heavily on fossil fuel. Here are a few examples: gas – 36 percent in Latvia, 50 percent in Lithuania, (only 4 percent in Estonia) and fossil oil shale in Estonia – 63 percent. At the same time, Latvia depends entirely on Russian gas, Lithuania 50 percent and Estonia 46.3 percent (see Figure 19).

Estonia depends 100% on Russian oil. With such a high share of power generation utilizing fossil fuels and with high fossil fuel prices, the cost of power generation in the Baltics is expected to increase. This, in turn, will impact the affordability of electricity – which is one of the cornerstones of the energy security definition. Publicly, Finland and the Baltics claim that they want to strengthen their energy security by investing in renewables. However, these stances need balancing capacity.

Figure 19. Dependency on Russian gas



Source: (IEA, 2022)

5.3 FUTURE ISSUES

The question of long-term Baltic energy security depends on the pace of supply and demand development in the region, dynamic investment into technologies like renewables or nuclear energy and climate conditions enabling the water-rich North to power its economies with green electricity.

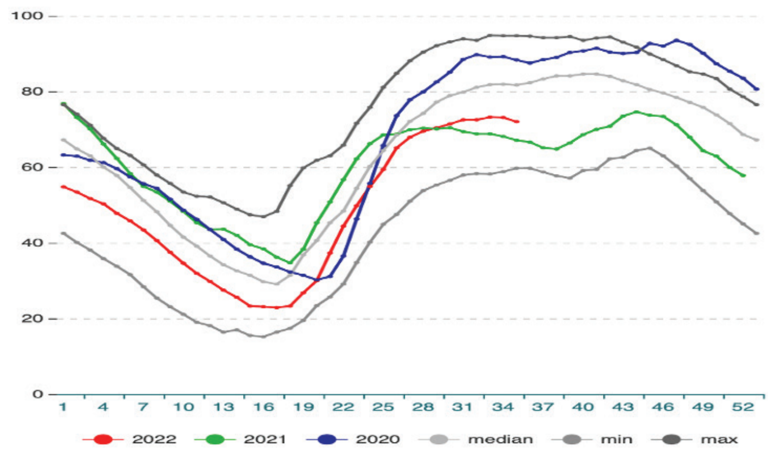
5.3.1 Growing demand in the Nordics

In 2020, the combined demand for electricity in the Nordics amounted to 406 TWh; this is expected to grow by more than 60 percent into 2050 (Nordenergi, 2021). The main electrification growth component will come from the industrial and transportation sectors, which will be targeted by calls to decarbonize the economy.

Such a massive increase in demand will require that the generation capacities of the Nordics expand too. In 2021, energy generation in the Nordics amounted to 419 TWh; this will need to increase substantially to keep up with increased demand. Scenarios of future energy sector development assume that most of the generation expansion in the Nordics will come from renewables, wind and solar (Nordenergi, 2021). The intermittent nature of these power sources requires development of storage technology such as large batteries or "power to X" - a term used to describe technologies that convert electricity into other energy carriers e.g., hydrogen, for the use in sectors hard to electrify (Lazarczyk et al., 2022).

Nord Pool is reliant on hydro as the main technology in their energy mix. Hydro energy, contrary to more traditional types of electricity generation, depends on climate and goes through cycles with wet and dry years. In wet years, water reservoirs are filled up, offering the possibility to use cheap hydro power, but in dry years water availability and therefore price goes up; the capacity of especially Norwegian hydro production decreases. 2022 saw one of the drier years, as is illustrated in Figure 20.

Figure 20. Reservoir content for the Nord Pool area.



Source: Nord Pool.

5.3.2 Russia's involvement in the current and future nuclear energy

Although commercial trade of Russian electricity is not a substantial part of BSR power networks, Russian presence in the sector is reflected in its technology involvement.

Russia is the key player regarding nuclear energy investment in the world. Since 2006, the Russian nuclear industry has been undergoing a massive expansion, as the government introduced a new program to replace gas power generation with nuclear energy. The sector has been one of the key industries subject to the modernization policy started in 2009. Rosatom – the Russian State Atomic Energy Corporation – has announced that the Russian nuclear capacity will double by 2030 and secured contracts for the construction of around twenty reactors worldwide in the same period (Oxenstierna, 2014). This aim has not been fully achieved – in 2009 Russian nuclear capacity was at 21.743 Mwe[17] and rising to 27.727 MWe in 2021, an increase of 27 percent (WNA, 2021). Still, Russia, together with China and Korea, has been pursuing a steady rate of construction, as opposed to Europe and USA, where the cost of nuclear power plants deployment turned out to enormously exceed the forecast (Buongiorno et al., 2019).

Russia has 37 operable reactors and 3 reactors under construction (Figure 21) (WNA, 2021).[18] The exports of nuclear goods and services are important aspects of the Russian economic objectives and its policy. According to Rosatom forecast from 2021 the company was expecting to be involved in the construction of 5-6 nuclear reactors a year, covering around 25% of the nuclear power plant construction market. Some of these investments are paid directly (India, China),

[17] Megawatt electric - One million watts of electric capacity.

[18] For an overview of nuclear power in Russia, see also https://world-nuclear.org/information-library/country-profiles/countries-o-s/russia-nuclear-power.aspx

some rely heavily on Russian financing, e.g., Belarus, Bangladesh and Hungary use Russian loans.[19]

Figure 21. Nuclear power plants in Russia

Source: WNA (2021)

Second, looking specifically at the BSR, Russia has been involved in the construction of two nuclear power plants in the region. The Finnish power plant was a joint investment, where Russia (i.e., Rosatom's subsidiary RAOS Voima) held 34% equity. This project, involving a construction of a power plant in Hanhikivi was recently terminated due to “significant and growing delays during the last years” (FT, May 2, 2022).

In 2020, the construction of the first of the two blocks of Ostroviec nuclear power plant was accomplished, and the 1110 MWe reactor started feeding the electricity into the grid. The proximity of the investment, located in West Belarus, 23 km from the border with Lithuania, and 55 km from the Lithuanian capital, has caused much debate, especially on the Lithuanian side. With the construction financed with Russian credit, the company - Belarusian NPP - (WNA, 2021) was able to offer electricity at favourable rates[20]. However, the Baltic states reacted strongly against the investment, and discussed the possibility of limiting the size of transfer between Lithuania and Belarus[21]; Moscow at one point accused the Lithuanian grid operator of purposefully limiting the transfer.[22]

[19] In April 2021, Hungary received a five-year delay on payment for its extension of the Paks nuclear power plant currently responsible for 46% of its electricity generation.

[20] The results showed that nuclear would be competitive, with overnight costs $1960/kW and levelized electricity price 5.81 cent/kWh (compared with coal $1175/kW and 6.52 cent/kWh, and gas $805/kW and 6.76 cent/kWh) from: WNA (2021)

[21] https://www.enerdata.net/publications/daily-energy-news/lithuania-will-restrict-power-transmission-capacity-will-belarus.html

[22] https://web.archive.org/web/20201127133703/https:/www.lrt.lt/en/news-in-english/19/1263485/moscow-accuses-lithuania-of-discrimination-calls-not-to-limit-electricity-trade

5.3.3 Future energy security of the Baltics?

In 2021, electricity demand in the Baltic States amounted to 27 TWh, with Lithuania consuming 44 , Estonia 30, and Latvia 26 percent. Due to the electrification of the economy, rising needs in heat supply, households, and industry, the demand for electrical power in the Baltics is expected to rise by 60–65 percent by 2050 (Nordic Energy Research, 2022). At the same time, the Baltics are planning to close some of their fossil fuels generators by 2030, due to their high emissions (Petrichenko et al, 2021a). The needed generation will be supplied through renewable energy; according to a 2019 study, by 2050 Baltics offshore wind capacity could amount to 26 GW (EC, 2019). However, this requires extensive investment as currently the region does not have any offshore generation and the onshore capacity amounted to only 1 GW in 2022[23]. Another potential source of renewable generation is solar power, especially in Latvia and Lithuania where the current capacity is respectively 14 and 259 MW.

The Baltics do not currently have any nuclear generation, although Lithuania had two reactors, that were shut as the part of the country´s accession to the EU (EU, 2003). However, Estonia is investigating the potential for small modular reactor technology (SMR), an investment with Swedish Vattenfall (Vattenfall, 2021).

[23] Data for 2022 from ENTSO-E Transparency platform.

6 Conclusions

This report aims to characterize the dependency of the Baltic Sea Region countries on electricity imports from Russia. Our main conclusion is that the supply of Russian electrical power (or the lack of it) is not currently a major concern for Finland, Estonia, Latvia, and Lithuania. However, in the short term, the BSR's energy security depends on the uncertainties of the weaponization of Russian electricity and in the long term on the pace of the BSR and Nordic demand and supply growth.

6.1 TOWARDS THE WEAPONIZATION OF THE RUSSIAN ELECTRICITY?

Two ways to weaponize electricity. Given the past trends in electricity trade between Russia and the BSR, Russian weaponization in this sensitive area can take at least two forms: directly stopping electricity trade with the neighbouring countries or - what could have more severe immediate consequences - abruptly detaching the Baltic countries from the BRELL power grid.

The first event was witnessed on 14 May, 2022, when Russia announced that it would discontinue electricity exports to Finland. We note that Russia constituted only a small share of Finnish yearly consumption, at most 10 percent. However, the sudden cut-off of commercial flows impacted Nord Pool day-ahead zonal prices; southern Sweden and Finish Elspot prices became more volatile after May 15. Moreover, the Baltics experienced extreme prices when on 17 August, 2022, zonal prices in the region hit the market´s cap of 4000€/MW.

Another more aggressive way Russia could weaponize electricity is if it prematurely disconnects the Baltics from the BRELL synchronous power system. Since 2019, the Baltics, with EU help, have invested massively into the strategic project of desynchronization from the Moscow-operated power grid and synchronizing with the European electrical network through a connection with Poland. The synchronization with the European grid is set for 2025, with no trade between the Baltics and Russia (or Belarus). However, if Russia disconnects the Baltics from BRELL before this date, severe blackouts may follow.

The credibility of Russian electricity weaponization. The potential impact of the weaponization of Russian electricity on BSR's energy security (therefore the credibility of such an act) depends on several elements. Two seem crucial:

First, whether imports from Nord Pool are feasible. Having enough capacity to replace the "missing" Russian electricity depends on whether hydropower in Norway and nuclear energy in Sweden and Finland will be sufficient. Cooperation regarding transmission networks at the EU level and between Nordic countries will also be essential.

Second, the desynchronization strategy is feasible only if the Baltic states are not well connected with the European grid. The Baltics share their power grid with Russia and Belarus. They should be disconnected from the Moscow-controlled electrical grid BRELL by 2025, or, in the case of Lithuania, in 2024 (Euractiv, June

2022). To accommodate this desynchronization effort, the alternative Polish, Swedish and Finnish connections to the Baltics will be growing in importance. A new Finnish line Est-link 3 is foreseen to start operations in 2035, and a new Polish line – 'Harmony link' – will begin in 2025 24.

On the other hand, a sudden detachment from BRELL could harm the Russian entity of Kaliningrad, if it comes too early; we have noted Kaliningrad's successful past exercises of operating in island mode, but it is unclear whether it is ready to use its power grid in complete isolation. If the region is not prepared for total disconnection, it will need to rely on power flows from Poland or Lithuania, a situation that would be politically difficult for Russia to accept.

6.2 OUTLOOK

The longer-term possibility of the weaponization impact will also depend on the BSR's green transition path and electrification of the economy. More renewable energy produced domestically increases energy security and limits exposure to the price variability of energy commodities. However, intermittent production may also be challenging to the electricity grid's management. Suppose Russian electricity stays at a competitive price. In that case, it could be considered as a cheap and green "backup energy."[25] This, in turn, may increase the BSR's reliance on Russian electricity. With the EU's goal of green transition and electrification of the economy, Russian energy might be key to achieving those goals, particularly if there is insufficient investment in alternative power generation in Europe.

As we illustrated earlier in this report, Sweden, and Finland play an important role as exporters of electricity to the Baltics. Future rapid growth of internal Swedish and Finnish demand might result in less electricity available for export if the expansion of the production capacity does not match the pace of consumption growth in the Nordics.

The possibility of restarting energy trade with Russia depends on the future political situation in the region, and elsewhere. In May 2022 this trade with Finland has been suspended. However, the situation might change; if cooperation between the EU and Russia is re-established at some future point, Russian electricity might flow again, through Finland, through EU transmission networks. This solution could appear attractive as hydro, which is the baseload technology generating electricity in the Nordics, goes through cycles with wet and dry years. In the future, low water levels in these hydro-dominated systems might increase the attractiveness of trade with Russia.

In circumstances when the shortage of local generation cannot be met with imports from the Nordics and Poland, the possibility of nuclear energy trade with Russia or Belarus might be a compelling solution. However, currently the desynchronization project does not leave any transmission lines between the countries that could be used for this trade. Nevertheless, the potential for trade might be revisited if there

[24] https://harmonylink.eu/pl/dom/

[25] According to the EU taxonomy, Russian electricity, mainly producedby nuclear and natural gas power plants, is green.

is a significant power gap in the Baltics. This would exacerbate the region's reliance on their eastern neighbours' power supply.

We conclude by highlighting the economic and geo-political leverage involved in the electricity flowing from Russia to the Baltic State Region. In the context of the escalation of tensions between Russia and the EU, our report anticipates that the electricity trade (as other energy commodities trade) might be weaponized and impact regional security, and beyond, with serious consequences.

Appendix A: Additional data

Table A1. Lithuania - Elspot capacities – trade with Russia and Belarus

2022	Lithuania to Belarus	Belarus to Lithuania	Kaliningrad to Lithuania	Lithuania to Kaliningrad
average	0	0	126,69	127,38
min	0	0	0	0
max	0	0	436	470
2021				
average	0	0	211,02	450,50
min	0	0	0	0
max	0	0	600	470
2020				
average	790,65	757,18	226,93	535,34
min	0	0	0	0
max	1350	1300	550	680
2019				
average	1161,00	748,72	301,87	570,81
min	440	0	0	0
max	1350	1369	552	680
2018				
average	1135,95	485,48	340,84	518,21
min	500	200	0	140
max	1350	1515	600	680
2017				
average	850,05	632,72	340,59	603,49
min	350	100	0	140
max	1350	1541	600	680
2016				
average	885,77	499,93	280,93	566,33
min	350	200	0	135
max	1350	1335	576	680

Notes: Units – MW.

Table A2. Latvia – Elspot capacities – trade with Russia

Latvia	2022	2022	2021	2021	2020	2020	2019	2019	2018	2018
	Latvia to Russia	Russia to Latvia	Latvia to Russia	Russia to Latvia	Latvia to Russia	Russia to Latvia	Latvia to Russia	Russia to Latvia	Latvia to Russia	Russia to Latvia
average	559,68	115,83	364,62	408,09	84,08	95,79	0,00	0,00	0,00	0,00
min	0	0	0	0	0	0	0	0	0	0
max	860	529	860	950	800	950	0	0	0	0

Notes: Units – MW.

Table A3. Baltics net exchange (in MWh)

	Lithuania	**Latvia**	**Estonia**
2021	9.167.054	1.765.989	2.631.754
2020	8.083.719	1.620.064	3.639.511
2019	9.520.486	1.118.145	2.185.345
2018	9.739.611	831.830	-1.843.632
2017	8.821.280	-89.287	-2.718.406
2016	8.391.730	1.007.950	-2.030.844

Source: Nordpoolgroup.com Values are in MWh. Positive numbers indicate imports, negative exports.

Table A4. Comparison between Elspot flows and capacity

2021							
Kaliningrad - Lithuania	Kaliningrad - Lithuania	Belarus - Lithuania	Belarus - Lithuania	SE4 - Lithuania	SE4 - Lithuania	Poland - Lithuania	Poland - Lithuania
%	MWh	%	MWh	%	MWh	%	MWh
70%	39.010	0%	0	44%	2.162.800	22%	3.023.906
2019							
Kaliningrad - Lithuania	Kaliningrad - Lithuania	Belarus - Lithuania	Belarus - Lithuania	SE4 - Lithuania	SE4 - Lithuania	Poland - Lithuania	Poland - Lithuania
%	MWh	%	MWh	%	MWh	%	MWh
96%	21.787	65%	1.358.216	50%	2.107.410	12%	3.098.136

Notes: Table shows imports to the BSR. Percentages indicate for how many hours the Elspot capacity assigned for a particular hour was equal to the actual Elspot flow. MWh values indicate the sum of MWh over the year of the difference between the assigned hourly capacity and the actual flow. Authors calculations based on Nord Pool data.

Table A5. Net Import from a specific connection/local production

	Finland from Russia	Finland from Sweden	Estonia From Russia	Estonia from Finland
2021	0,13	0,22	0,06	1,17
2020	0,04	0,29	0,06	1,50
2019	0,12	0,25	0,25	0,62
2018	0,12	0,21	0,06	0,23
2017	0,09	0,24	0,02	0,15
2016	0,09	0,24	0,02	0,29

	Latvia from Russia	Latvia from Estonia	Lithuania from Russia	Lithuania from Belarus
2021	0,13	0,51	0,44	0,78
2020	0,14	0,36	0,41	0,45
2019	0,18	0,44	0,73	0,81
2018	0,18	0,49	0,91	0,52
2017	0,13	0,32	1,09	0,52
2016	0,18	0,48	0,87	0,60

Appendix B: The GARCH model

Table B1. Results from GARCH estimation for Sweden SE3 for the period 1st of January – 14th of May, 2022.

	Estimate	Std. Error	t value	Pr(>|t|)
mu	0.002532	0.002092	1.2103	0.226182
ar1	1.413618	0.021033	67.2109	0.000000
ar2	-0.512045	0.033784	-15.1563	0.000000
ar3	-0.056432	0.019962	-2.8270	0.004698
ma1	-1.131262	0.000083	-13671.0118	0.000000
ma2	0.191779	0.000101	1899.9621	0.000000
omega	0.002240	0.000607	3.6927	0.000222
alpha1	0.056265	0.009330	6.0304	0.000000
beta1	0.930092	0.012338	75.3834	0.000000

Table B2. Results from GARCH estimation for Sweden SE3 for the period 15th of May – 22nd of August, 2022.

	Estimate	Std. Error	t value	Pr(>|t|)
mu	0.000628	0.004427	1.4193e-01	0.88713
ar1	1.597318	0.016072	9.9385e+01	0.00000
ar2	-0.720573	0.015942	-4.5199e+01	0.00000
ma1	-1.326932	0.000069	-1.9278e+04	0.00000
ma2	0.383195	0.000377	1.0168e+03	0.00000
omega	0.003521	0.000459	7.6652e+00	0.00000
alpha1	0.026967	0.002542	1.0607e+01	0.00000
beta1	0.960964	0.002440	3.9387e+02	0.00000

Table B3. Results from GARCH estimation for Sweden SE4 for the period 1st of January – 14th of May, 2022.

	Estimate	Std. Error	t value	Pr(>|t|)
mu	0.007559	0.002111	3.5802	0.000343
ar1	1.517259	0.017664	85.8964	0.000000
ar2	-0.674105	0.017449	-38.6336	0.000000
ma1	-1.248886	0.000049	-25299.6689	0.000000
ma2	0.312837	0.000091	3449.1071	0.000000
omega	0.005699	0.000760	7.4996	0.000000
alpha1	0.126333	0.015158	8.3342	0.000000
beta1	0.846293	0.014598	57.9739	0.000000

Table B4. Results from GARCH estimation for Sweden SE4 for the period 15th of May – 22nd of August, 2022

	Estimate	Std. Error	t value	Pr(>|t|)
mu	0.002551	0.004672	5.4603e-01	0.58505
ar1	1.596742	0.019914	8.0183e+01	0.00000
ar2	-0.747546	0.019400	-3.8534e+01	0.00000
ma1	-1.350980	0.000127	-1.0604e+04	0.00000
ma2	0.427640	0.000010	4.1762e+04	0.00000
omega	0.006359	0.000719	8.8504e+00	0.00000
alpha1	0.084983	0.008250	1.0301e+01	0.00000
beta1	0.914017	0.005610	1.6293e+02	0.00000

Table B5. Results from GARCH estimation for Finland for the period 1st of January – 14th of May, 2022.

	Estimate	Std. Error	t value	Pr(>|t|)
mu	0.003423	0.007393	0.46302	0.643351
ar1	-0.371308	0.111841	-3.31997	0.000900
ar2	0.229420	0.050175	4.57235	0.000005
ma1	0.743488	0.107727	6.90156	0.000000
omega	0.008942	0.002388	3.74455	0.000181
alpha1	0.155066	0.030767	5.03999	0.000000
beta1	0.779884	0.044143	17.66741	0.000000

Table B6. Results from GARCH estimation for Finland for the period 15th of May – 22nd of August, 2022

	Estimate	Std. Error	t value	Pr(>|t|)
mu	0.001374	0.008051	0.17065	0.8645
ar1	1.732256	0.001093	1584.62455	0.0000
ar2	-1.000231	0.000772	-1295.80688	0.0000
ma1	-1.705573	0.008029	-212.41493	0.0000
ma2	0.971333	0.003973	244.49167	0.0000
omega	0.002502	0.000045	55.63806	0.0000
alpha1	0.046985	0.003650	12.87122	0.0000
beta1	0.947721	0.005124	184.97534	0.0000

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POWER COMING FROM RUSSIA AND BALTIC SEA REGION´S ENERGY SECURITY

This study's originality stems from its electricity-focused approach, analyzing Russia's involvement in the power trade within the EU, specifically in the Baltic Sea region.

Our analysis demonstrates that the unequal electricity trade among these nations has consequences for the energy security of the Baltic Sea Region (BSR). In fact, weaponization of the Russian electricity is a credible strategy, especially when there are constraints on imports from Nord Pool and the Baltic States are insufficient connections between the Baltic States and the wider European grid.

If the Nordics and BSR do not make significant investments in new energy generation technologies, Russian electricity could become an attractive substitute, even though it would reinforce Moscow's geopolitical leverage.

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