

SECURITY OF SUPPLY REPORT 2020 EXTRACT

Tallinn 2021

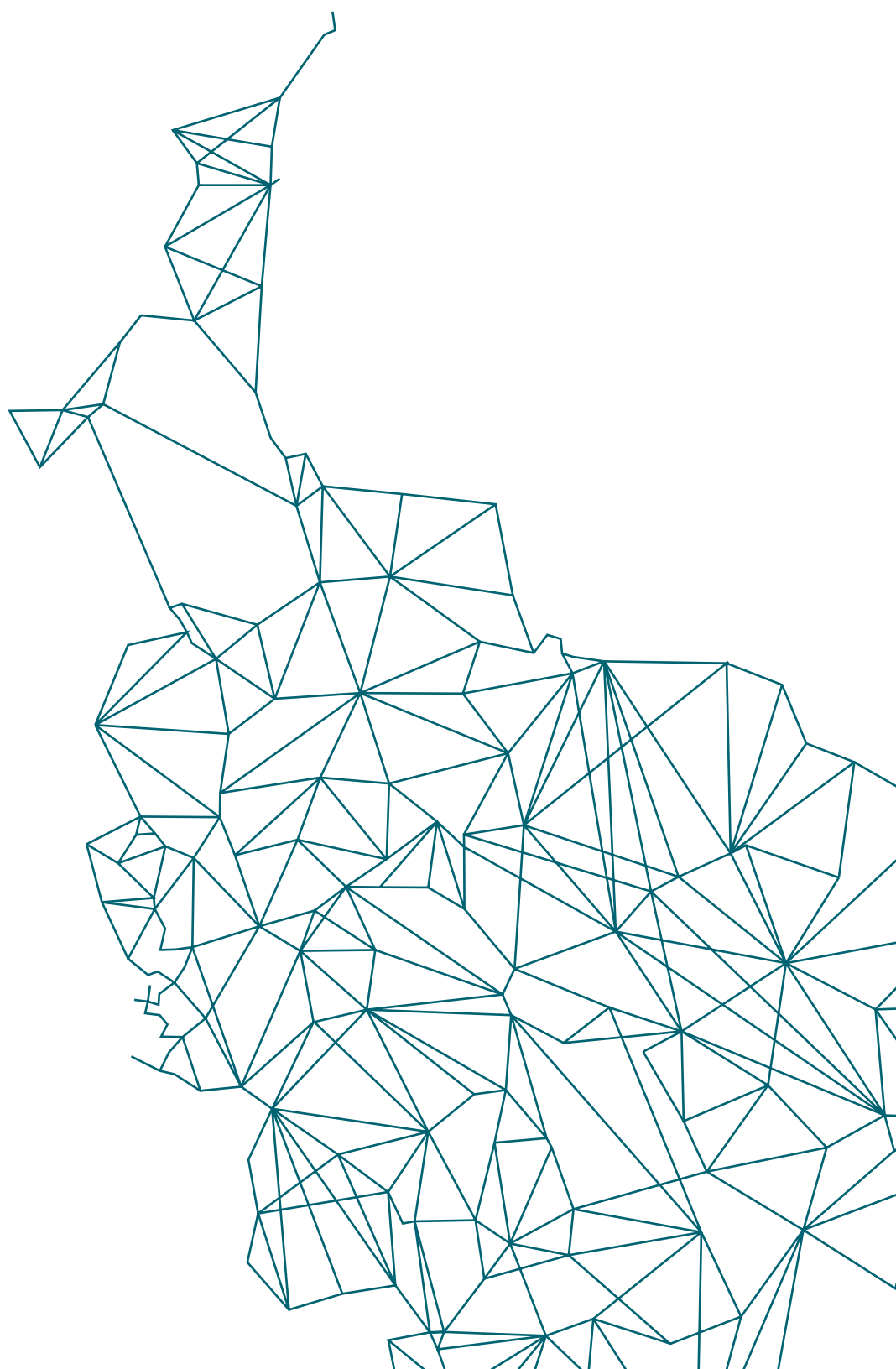


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1 Summary

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1 SUMMARY

The Security of Supply Report for 2020 assesses the security of supply in the entire electricity value chain view: system reliability, network adequacy, resource adequacy and cyber security. The security of supply of the electricity system depends on all of these components and more precise assessments are given in the respective chapters of this document.

Resource adequacy	System reliability	Network adequacy	Cyber security
Adequate electricity generation ensures that generation and demand are in balance in the electricity system at any moment of time. The resource adequacy assessment is based on various scenarios that are used to analyse possible situations and the state of resource adequacy in those situations.	The capability to keep the electricity system as a whole together and operational and to cope with various disruptions and outages.	Adequate transmission capacities and connections with neighbouring systems ensure the functioning of the market and, in the case of major outages or domestic deficit, import capability. The transmission network ensures that electricity reaches demand centres. The distribution network makes sure that electricity reaches the end user.	System management is becoming more and more complex and dependent on information technology systems. This makes cyber security an important pillar for ensuring secure operation of the system.
Demand			
<i>Being able to direct customers' consumption habits (e.g. via the market platform for flexibility services) makes it possible to increase the involvement of consumers on the electricity market. Flexibility services allow customers to offer part of their flexible consumption on the market as equivalent service to the generation of electricity.</i>			

Scenarios	Demand	Generation	Network connections ¹	Estimated probability ²
European energy market scenario (4.4.1)	Covering entire peak demand	Generation used by Europe as a whole	European transmission capacities used	>90% (expected)
Baltic synchronous area scenario (4.5.1)	Covering entire peak demand	Generation used by the Baltic States as a whole	AC connections between Baltics in operation; DC connections with Scandinavia and Poland in reduced volume	<10% (possible)
Baltic emergency continuity scenario (4.5.2)	Reduced coverage of peak demand	Generation used by the Baltic States as a whole	AC connections between Baltics in operation; DC connections with Scandinavia and Poland lacking	<1% (low likelihood)
Estonian vital service continuity scenario (4.5.3)	Covering the demand of vital service and general-interest service	Generation used by Estonia as a whole	No AC connections available; no DC connections available	<0.1% (not likely)

¹ Network connections with third countries are not considered.
² Expert opinion

1.1 KEY CONCLUSIONS OF 2020

Based on the analysis in this Security of Supply Report, the security of supply of the electricity system of Estonia and the Baltics is ensured. Due to the fast-changing environment, constant development of the electricity system and energy markets must continue to ensure the security of supply in the future.

Elering's major projects and politico-economic environment support security of supply in the long term. The following table summarises the impacts that increase and decrease security of supply for the three most significant activities and factors.

Activity/impact	Impact that increases security of supply	Impact that decreases security of supply
Synchronisation	Eliminates systemic risk that a third party will jeopardise security of supply.	The number of synchronous connections will decrease and the technical risk of becoming an energy island will increase. With additional measures, the risks will be mitigated.
Climate policy	Adds new capacities (offshore wind farms) and makes storage competitive on the market.	Will eliminate from the market carbon-intensive generation capacities that have a pre-plannable production cycle and can be adjusted flexibly.
Supporting the competitiveness of the economy	A more efficient, leaner grid along with flexible management of demand and flexible possibilities of joining the grid will, in the long run, ensure lower network fees and a competitive edge for joining the network. Bringing additional market possibilities (reserves) to the market will also have an effect on connecting new generating facilities.	Guaranteeing intra-Estonian generating capacities will increase the price of electricity for Estonian consumers and may reduce the natural, market-driven addition of generating facilities in the long term.

1.1.1 Resource adequacy

Resource adequacy is regarded by Elering as a situation where the expected electricity demand is covered by local generating capacity, import possibilities and demand management.

Ensuring resource adequacy consists of three key stages:

1. Applying the reliability standard (see chapter 4.3) based on the socioeconomic balance and assessing security of supply on the basis of this criterion;
2. Long-term assessment of resource adequacy (for more on this, see chapter 4.4. and chapter 4.4.1);
3. If the long-term resource adequacy assessment indicates resource adequacy indicators are at values that are superior to the levels envisioned by the reliability standard, this means resource adequacy is ensured. If the assessment shows that the situation in future will be inferior to what is allowed by the standard, the next move under European Commission guidance would be to remove the market disruptions and, as a last resort, apply a capacity mechanism (for more details on this, see chapter 4.3).

A European Parliament regulation obliges all member states seeking the possibility to apply the capacity mechanism in the future to adopt a reliability standard developed on the basis of a common standard. In Estonia, reliability standard studies have been conducted and the findings are being implemented into Estonian legal acts. An explanation of the standard's indicators and analysis prepared for determining the standard can be found in chapter 4.3.

All of Europe's TSOs engage in cooperation with ENTSO-E in preparing the annual pan-European Mid-term Adequacy Forecast (the MAF). In the course of this process, all countries are polled as to their best knowledge on which power plants are currently commissioned, operational; or on reserve, whether additional capacities can be expected, how demand may change in the years in question, what the capacities of the transmission lines are, when scheduled stoppages will take place at power plants and statistics on power outages. On the basis of such an all-encompassing database, probabilistic analyses are conducted, giving the best possible overview of the situation as regards long-term adequacy of the entire European electricity system. For this report, Elering carries out simulations that test the region's security of supply, in order to perform quality control on the results. Based on these analyses, it appears that Estonia's resource adequacy will be in good shape until at least 2030. For more detailed results, see chapter 4.4.

It is important to note that Elering does not base its evaluation of resource adequacy only on the MAF and on the assumption that the power market will function in the ordinary manner. Extraordinary scenarios are a way of assessing the risks posed to resource adequacy by unlikely but high-impact events. Elering has the capability and readiness to perform probabilistic and deterministic analyses to describe unlikely but high-impact situations so that their risk level can be evaluated and contingency plans prepared for lowering the risks. For instance, this report includes an analysis of a scenario where the Baltics' power systems would operate in island mode due to extraordinary events. Extraordinary scenarios are the factor that bring out the need to have firm capacities in Estonia. Elering defines "firm capacity" as capacities, both in regard to generation and demand-side management, which can be relied on during periods of high demand.

1.1.2 System reliability

Due to the developments in the Unified Power System of Russia (hereinafter referred to as IPS/UPS), a systemic risk has emerged, the most severe form of which is separation into a separate synchronous area of the Baltic States. To reduce the risks and ensure the stability and reliability of the electricity system, we will carry out the project for synchronising the Baltic States with the continental European frequency area. Within the framework of the project:

1. **We will develop the capability of the Baltic synchronous area** - the capability to cope with an unexpected islanding in the Baltics already exists today, but, to maintain the stability of the system, short-term large-scale automatic restriction of consumers will have to be imposed on island mode operation in the case of major outages. Through additional developments and measures, we will achieve capability for long-term synchronous operation in an N-1 (switch-off of any one element) situation without imposing any automatic restrictions on consumers. The most important measures are:
 - **Ensuring adequate inertia** – this ensures the maintenance of the stability of the system in the case of outages and better frequency stability in an ordinary situation. To synchronise the electricity system of the Baltic States with the continental European electricity system, it is necessary to ensure that there is an adequate quantity (17,100 MWs) of inertia in the system of the Baltic States at any moment in time. Baltic TSOs will install a total of nine synchronous compensators across the Baltics. The installation of synchronous compensators will ensure that the system operates reliably in the event of deviations from frequency following an outage.
 - **Development and implementation of a system services framework** – The Baltics will adopt and develop respective capabilities pursuant to the principles of continental European frequency reserves, and create local voltage control capability.
 - **The existing management systems will be updated and additional ones introduced**, to meet the requirements of continental European frequency areas.
 - **Fast emergency reserves** through the existing HVDC submarine cables between the Baltic and Nordic countries as well as through those to be established between Lithuania and Poland.
2. The synchronisation solution currently being implemented, connecting to the continental European synchronous area along with the planned investments, will not limit the transmission capacities within the Baltic countries or in the direction from the Baltics to the Nordics and continental European electricity systems. Thus, the trading opportunities enjoyed by market participants inside the European Union will not worsen.
3. Thanks to European co-financing, synchronisation with continental Europe will not increase the transmission rate compared to the situation where the Baltic electricity system would remain connected to the IPS/UPS system.

Both today's experience and various adequacy analyses show that Estonia's resource adequacy is and will be at a high level both today and in 2030. Considering the currently known generating capacities, demand forecasts and potential for managing demand, high reliability standards are ensured. It is important to note that the high security of supply level will be achieved on the consideration that Estonia has approximately 1000 MW of firm capacity for system operation purposes. Elering's view is that it is important to ensure that Estonia has that 1000 MW capacity. If electricity market information and forecasts show that the amount of firm capacity in Estonia will be lower than 1000 MW or if the results of probabilistic analyses show poorer results than allowed by the standard, the use of a capacity mechanism should be explored.

1.1.3 Network adequacy

Today's situation with regard to transmission networks can be deemed good:

- Pursuant to systemic maintenance and the programme for removing trees from power line clearances, the number of trees that have fallen on power lines or had to be felled is down significantly. For years, this had been one of the biggest causes of Energy Not Served.
- In 2019, energy not served due to the transmission network failures accounted only for 216.14 MWh (the annual electricity demand of an average household is approximately 10 MWh). In spite of the amount of energy not served last year, which was one of the highest ever, the transmission reliability of the transmission network is excellent. Transmission reliability = actual energy served/projected energy served * 100%.
- High uptime of HVDC submarine cables: EstLink 1 – 98.42% and EstLink 2 – 97.51% (2019).
- The need for restrictions in respect of management of the domestic transmission network loads has been minimal, close to zero.

To ensure long-term reliability and minimise the energy not served due to the non-functioning transmission network, we will carry out the following developments and activities:

- To ensure adequate capacities in the Latvian direction, the third Estonia-Latvia connection will be completed in 2020. Over half of the Harku-Lihula-Sindi line segments are already finished and energised.
- Within the framework of the synchronisation project, we will renovate the 1st and 2nd existing 330 kV overhead transmission lines running to Latvia (Narva-Valmiera).
- As part of the synchronisation project, sufficient resources for ensuring minimum reaction capability and inertia will also be added to the network, ensuring preservation of system stability and network capacity to operate in different types of generation and synchronous connection modes.
- We will further develop the condition and risk-based system for the maintenance and replacement of equipment in order to become even more efficient at minimising energy not served due to failures of equipment or network parts. Manufacturer requirements will be observed first and foremost when it comes to maintenance of substation equipment. Older and less reliable equipment will undergo maintenance more frequently and the length of the maintenance interval will be reduced depending on the needs of the equipment. We will also make a case-by-case decision whether it would be more efficient to pre-emptively replace a specific piece of equipment before an old substation is renovated in full or whether it should undergo maintenance until the substation is renovated, depending on how great a risk is posed by an equipment failure. At the same time, substation equipment due to be renovated three years before substation renovation will not undergo maintenance if the condition of the equipment so allows. In the case of lines, condition-based maintenance will be employed. Line maintenance is based on data gathered at annual inspections, on the basis of which a maintenance plan is prepared.
- In autumn 2020, a long-term network development plan will be completed in collaboration with distribution grid companies. The objectives of the development plan are: (for more on this, consult the chapter entitled „Optimaalne võrgu arenguplaan")
 - finding optimal investment alternatives considering the lowest cost to society,
 - ensuring an increase in the security of supply as well as the management of electricity supply risks in high-demand regions; and
 - reducing variable expenses.
- The network allows new subscribers to connect to the grid on flexible conditions and thereby optimise the costs of having a network connection and also make more effective use of existing network resources.

1.1.4 Cyber security

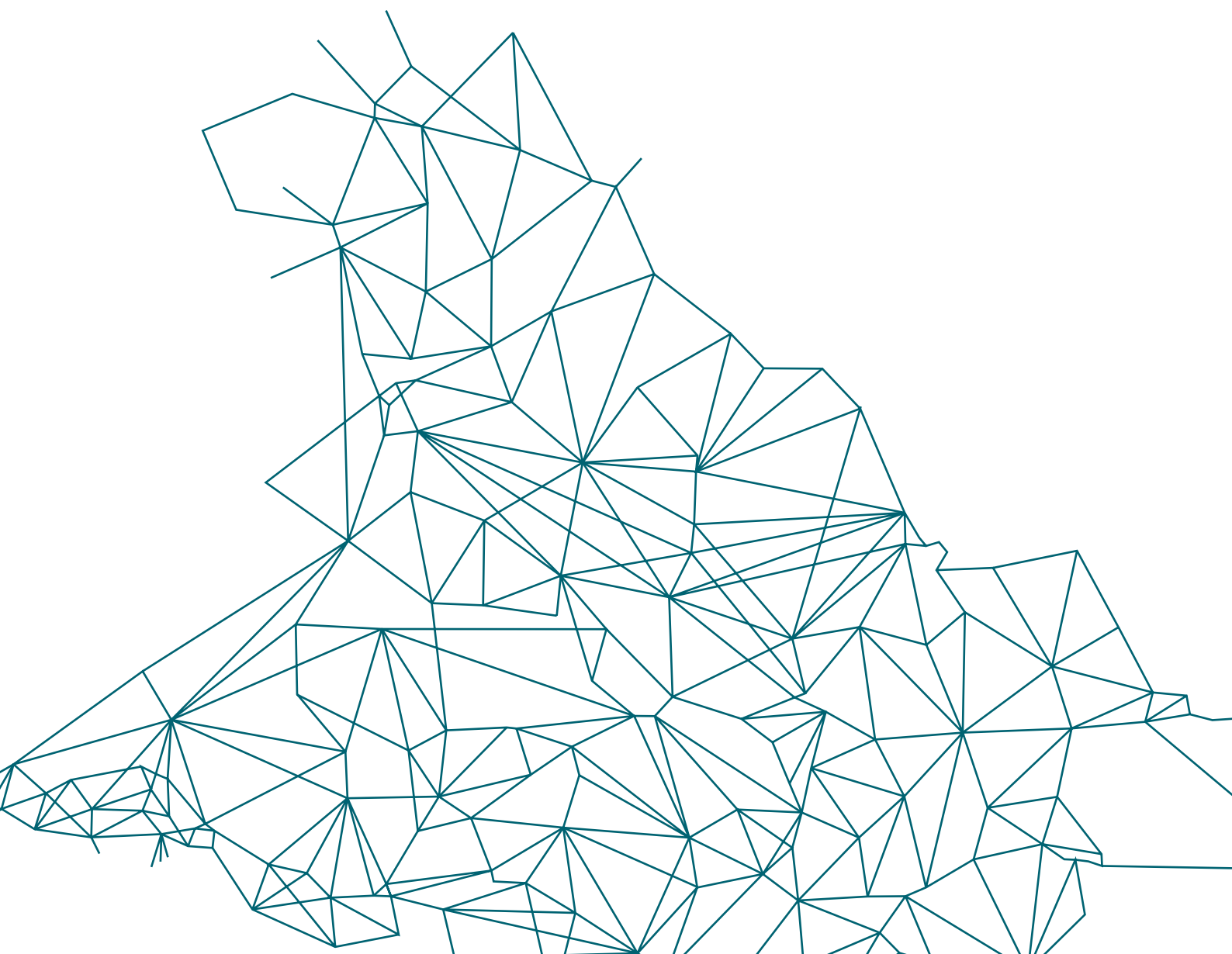
2019 did not see any cyber security incidents in transmission networks resulting in interrupted service to consumers.

In order to ensure systematic organisation of cyber security, Elering is engaged in three major activity areas:

- management and administration of cyber security,
- ensuring operational cyber security,
- raising awareness and readiness.

During the last year, cyber security in the electricity sector has become an important topic at the European Union level. The European Commission is preparing a regulatory framework for establishing a uniform baseline level for cyber security in the electricity sector.

Increasing attention is being devoted to achieving objectives arising from the European Union's climate policy and growth in decentralised generation, which will start to have an increasing impact on the stability of the electricity system. This will likely lead to the establishment of various flexibility services that allow network operators to increase or decrease the load on dispersed generation or demand if necessary. As a consequence of such a development, the number of information systems and data to be transmitted for ensuring security of supply will increase, as will the potential attack points in the electricity system.



2 Resource adequacy

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- **Based on the best information currently available, the adequacy of Estonia's electricity system for the next decade is ensured.**
- **Elering assesses the adequacy of the electricity system with respect to the reliability standard established in Estonia and using the probabilistic method, as specified in the European regulation on the internal market for electricity. The deterministic method is also in use to support the probabilistic approach.**

2.1 SUMMARY OF THE CHAPTER ON RESOURCE ADEQUACY

Ensuring resource adequacy consists of three key stages:

1. Establishing the reliability standard (see chapter 4.3) based on the socioeconomic balance
2. Long-term resource adequacy assessment of (a more detailed description of the methodology can be found in chapter 4.4 and the detailed results for Estonia and other Baltic Sea region countries is found in chapter 4.4.1)
3. If the long-term assessment of the electricity system indicates resource adequacy indicators are at values that are superior to the levels envisioned by the reliability standard, this means resource adequacy is ensured. If the assessment shows that the situation in future will be inferior to what is allowed by the standard, the next move under European Commission guidance would be to remove the market disruptions and, as the last resort, apply a capacity mechanism (for more details on this, see chapter 4.3).

An Estonian Parliament regulation obliges all member states seeking the possibility to apply the capacity mechanism in the future to adopt a reliability standard developed on the basis of a common methodology. In Estonia, reliability standard studies have been conducted and the findings have been sent to the cabinet for approval. There definitive benchmarks will be agreed for gauging resource adequacy. An explanation of the standard's indicators and analysis prepared for determining the standard can be found in chapter 4.3.

All of Europe's TSOs engage in cooperation with ENTSO-E in preparing the annual pan-European Mid-term Adequacy Forecast (the MAF). In the course of this process, all countries are polled as to their best knowledge on which power plants are currently commissioned, operational, or on reserve, whether additional capacities can be expected, how consumption may change in the years in question, what the capacities of the transmission lines are, when scheduled stoppages will take place at power plants and statistics on power outages. On the basis of such an all-encompassing database, probabilistic analyses are conducted, giving the best possible overview of the situation as regards long-term adequacy of the entire European electricity system. It allows TSOs to determine what they consider the most critical points, be they inadequate connections, ambitious climate goals, lack of load-following power plants or some other area. For this report, Elering carries out simulations that test the region's security of supply, in order to carry out quality control on the results. Based on these analyses, it can be stated that Estonia's resource adequacy will be in good shape until at least 2030. For more detailed results, see chapter 4.4.

Elering has the capability and readiness to perform probabilistic and deterministic analyses to describe unlikely but high-impact situations so that their risk level can be evaluated and contingency plans prepared for lowering the risks. For instance, this report includes an analysis of a scenario where the Baltics' power systems would operate in island mode due to extraordinary events. It also analyses the potential impact on resource adequacy should some power plant with managed capacity close prematurely or if there is a significant addition of renewable energy capacities.

Analyses show that Estonia will need to maintain approximately 1000 MW of firm capacity for system operation purposes, most of which should be managed capacity. This is also corroborated by probabilistic analyses – if Estonia has 1000 MW, the adequacy of the electricity system is ensured. If electricity market information and forecasts show that the amount of firm capacity in Estonia will be lower than 1000 MW or if the results of probabilistic analyses show poorer results than the standard, the implementation of a strategic reserve capacity mechanism should be explored.

2.2 DEFINITION OF RESOURCE ADEQUACY AND ITS ROLE IN SECURITY OF SUPPLY

Generation and demand must be in balance in the electricity system at any moment in time. Resource adequacy is a measure of the system's ability to ensure, in different conditions, that domestic power generation plus import capacity are sufficient for covering demand. In giving an assessment, the resource adequacy indicators for the future are analysed in different scenarios that may become realised in Europe, the region and Estonia. As demand changes from one year to the next (mainly increasing) and the volume of generating capacities is time-variable, it is important for the resource adequacy analysis to be updated each year. Making investments into generating capacities and demand management usually takes years and it is important to anticipate resource adequacy years in advance.

Figure 4.1
Demand, resource adequacy
and energy not served

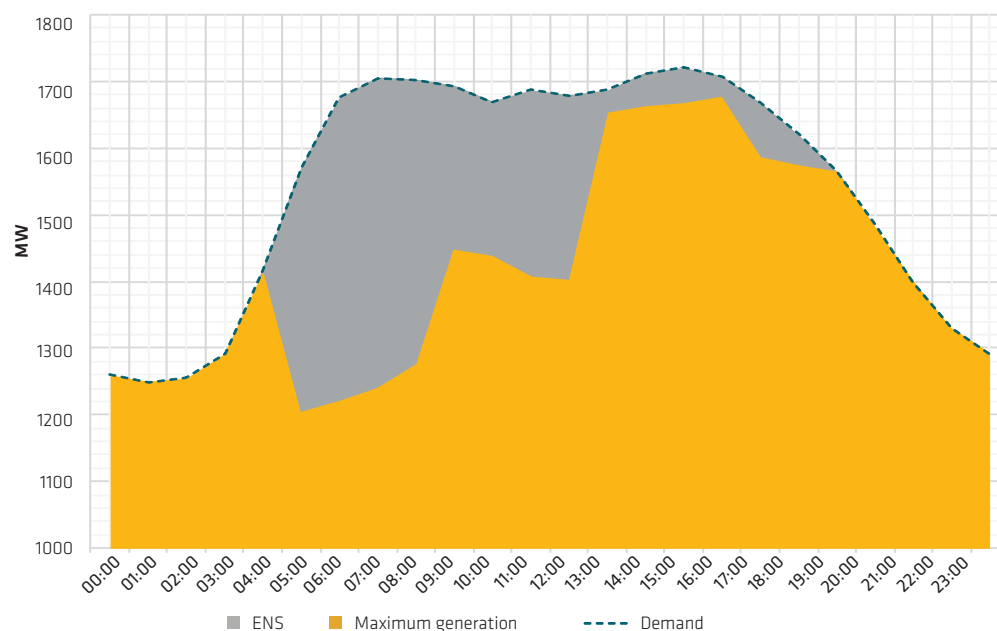


Figure 4.1 shows an illustrative situation where expected demand could not be met, and between maximum capacity and demand is a zone called Expected Energy Not Served or EENS (or Energy Not Served or ENS). The figure also reveals another important parameter, Loss of Load Expectation or LOLE. In this situation, there are 16 LOLE hours (ranging from 04.00 to 19.00), which means that power demand could not be covered completely by generation in 16 hours. The LOLE time arises in situations where generation is just a few MW short as well as where the deficit is several hundred MW. The existence of LOLE indicates that the power plants participating in a market cannot generate as much as customers demand or there is a bottleneck in regard to transmission capacities and it is not possible to transport the electricity to the consumer. Here it is important to note that such a situation does not mean a blackout risk or necessarily restricting flow of power to consumers, as LOLE is an assessment of the day-ahead market balance; TSOs can still ease the situation by drawing on reserves.

It is hard to assess the seriousness of a problem solely on the basis of LOLE hours, and thus the EENS and LOLE parameters must be viewed in conjunction. A marker is also needed to guide the decision on whether the forecasted indicators of resource adequacy are “adequate” or “deficient”, and this is why Estonia has established a *reliability standard*.

2.3 ESTONIAN RELIABILITY STANDARD

European Parliament regulation 2019/943, which governs internal markets for electricity, stipulates that each member state must have its own standard of security of supply, based on a methodology that is common to all member states. Each member state uses its standard to specify the level of resource adequacy that is acceptable. In cooperation with the Ministry of Economic Affairs and Communications and the Competition Authority, Elering has carried out the determination of the levels of Estonia's reliability standard. The determination was made based on an analysis performed by an external consultant³.

Pursuant to the regulation, the reliability standard is expressed through two parameters – Loss of Load Expectation (LOLE) and Expected Energy Not Served (EENS). The parameters to be used for determining the reliability standard are the Value of Lost Load (VOLL), unit [EUR/MWh], and Cost of New Entry (CONE), unit [EUR/MW]. To calculate CONE, the standard technology must be determined – one that would be the most probable investment decision for establishing additional capacity on condition that the plant is built to meet the markets' competitive conditions.

Some of the more significant requirements for CONE standard technology:

- May not be subsidised or subsidised by the state in any way.
- Must be a standard solution, meaning that different project developments should not have major technical or economic differences in relation to the development site. The generation method is reliable and the fixed and variable costs are known. The technology's efficiency and profitability should not depend on the unit's capacity, it must be easily scalable.
- The addition of generation technology does not bring the project into conflict with decisions made to meet climate goals.

Finding VOLL requires a determination of the prices that different sectors (industry, service sector and private sector) consider their VOLLs. VOLL can be construed as the losses incurred per MWh of electricity not served or the maximum price that consumers would be prepared to pay for an MWh to forestall an outage.

CONE and VOLL values can be used to determine the socioeconomically optimum number of LOLE hours based on the schematic below:

$$LOLE_{norm}(h) = \frac{CONE \text{ (EUR/MW)}}{VOLL \text{ (EUR/(MWh))}}$$

All further resource adequacy analyses and parameters are assessed against the determined normal LOLE and EENS value derived therefrom. Based on the study conducted, the optimum average number of LOLE hours in Estonia would be 9. At the time of preparation of this report, the cabinet had not yet signed off on the number of LOLE hours, but the socioeconomic benefit is greatest at precisely this point.

Should it emerge that the actual situation is worse than 9 hours, potential market disruptions must be removed to keep them from impeding the addition of market-based capacities. If even this does not help, a capacity mechanism must be announced, essentially amounting to state aid to power producers so that they can offer capacity in the amount needed. As a result of mapping the different mechanisms and suitability, the most promising solution appeared to be a strategic reserve; the study in question can be read on Elering's website.⁵ The reserve must consist of capacity that does not participate in the electricity market but is ready to cover peak demand.

³ https://elering.ee/sites/default/files/2020-07/Study%20to%20Establish%20an%20Estonian%20Reliability_0.pdf
⁴ <https://elering.ee/uuringud>

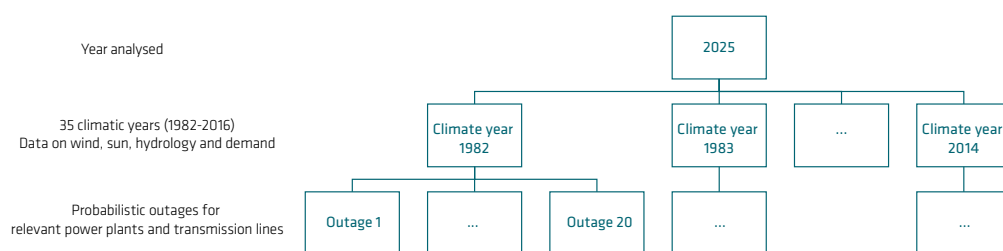
2.4 RESOURCE ADEQUACY OF THE EUROPEAN AND BALTIC SEA REGION ELECTRICITY SYSTEM

2.4.1 Resource adequacy on the basis of the ENTSO-E MAF

Every year ENTSO-E prepares a pan-European resource adequacy report (Mid-term Adequacy Forecast – MAF). The report is based on the data provided by European system operators about the generation capacities, demand and transmission capacities of every country and the Pan-European Market Modelling Database (PEMMDB) comprising the collected data. Elering values such a database highly and verifies the quality and accuracy of the data based on the best of its knowledge regarding Estonia and neighbouring countries. The report covers the period of up to 2030 and the results include the resource adequacy indicators for all European countries. The analyses of the next years will be based on the data set out in the national energy and climate plans to be submitted by all EU countries.

The resource adequacy is assessed using the probabilistic method. The methodology is based on the Monte Carlo method, which involves a simulation of 35 different climate years, each one run 20 times, taking into account changes in demand, wind generation, solar generation, hydrological situation and outages in system elements (see Figure 4.2 for a schematic of Monte Carlo scenarios). This analysis consists of 3500 simulated years. This sample is obtained by drawing up 20 random outage profiles for 35 climatic years and optimising the use of all European power plants and connections pursuant to the lowest socioeconomic cost. Such optimisations are made using five different software models to reduce systematic error that could occur from the peculiarities of the logic of a single model. When a very large number of simulations are performed, it is extremely probable that extreme and unlikely situations will also arise, not only ordinary situations. An example of an extreme situation is where several large power plants suffer an outage simultaneously at peak demand at a time when the renewable energy generation happens to be low.

Figure 4.2
Diagram of
Monte Carlo
scenarios

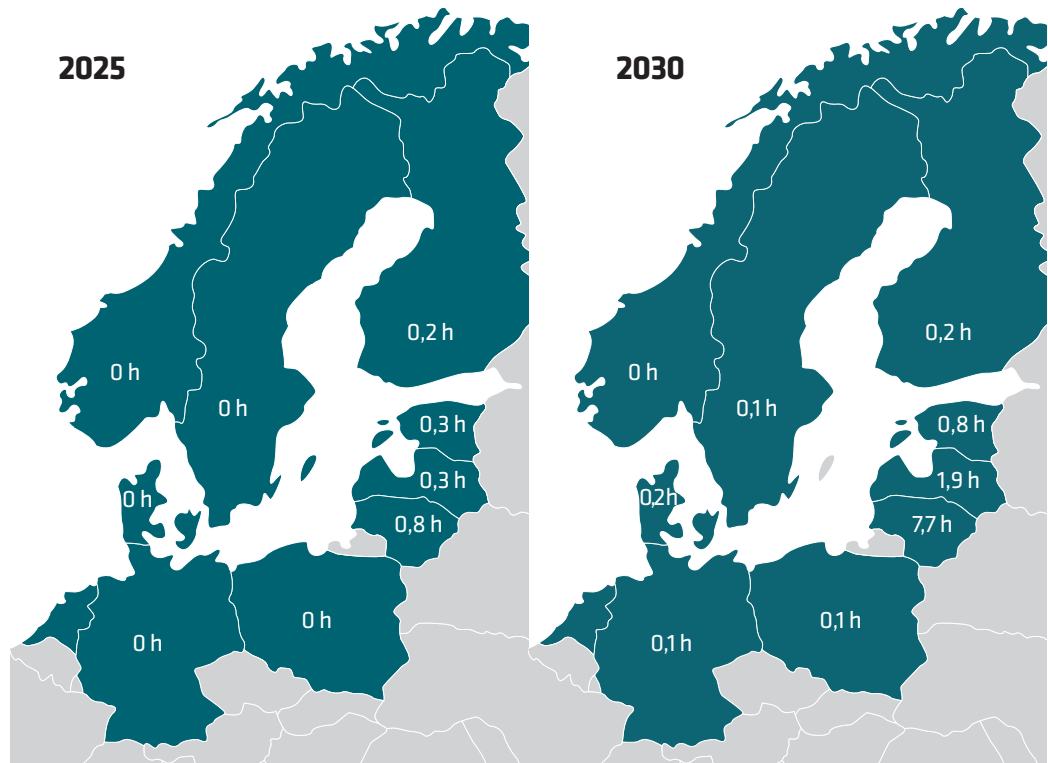


Such an analysis makes it possible to assess the probability of deficits in resource adequacy. As a result of the simulations, the annual average Expected Energy Not Served (EENS) is calculated along with the average Loss of Load Expectation (LOLE). To read in more detail about the methodology developed by ENTSO-E, see the latest MAF⁵. The analysis has developed the EENS and LOLE indicators in European countries for 2025 and 2030 in the Baseline Scenario, which includes the development of generation capacities in European countries to the best of current knowledge.

Findings

The findings of ENTSO-E MAF 2020 can be read in the report.⁶ It also includes the TSOs' comments regarding the results, which should give a better overview of why such values are to be expected. However, this report mainly looks at the adequacy of the Baltic Sea region electricity system. Figure 4.3 illustrates the results obtained. Here we see that in both of the years under observation, the Baltic states could develop a situation where demand exceeds the capacity supplied by the market in certain hours, but the likelihood of this happening is very low and it is much lower than the reliability standard established permits. Pursuant to the Estonian reliability standard, it would not be reasonable to invest into new capacities to cover these few hours.

Figure 4.3
Based on the study conducted, the optimum average number of LOLE hours in Estonia in 2025 and 2030.



Comparing 2025 to 2030, it is important to take note of the trend that the resource adequacy parameters are becoming worse in nearly all countries, yet they still fall within the envelope of the reliability standard established by the respective countries. The main changes occurring during these five years arise from the expense of growth of demand arising from electrification of various sectors. The growth of demand can be ensured, to some extent, by significant growth in the share of electricity generated from renewable sources and increased demand management potential.

As can be seen in Figure 4.1, EENS can vary greatly during LOLE hours and thus they should be viewed together. Table 4.1 shows the EENS and EENS% for all countries in the region, and this also characterises the percentage of EENS in total annual demand.

Table 4.1
EENS in the Baltic region
in 2025 and 2030

	EENS, [GWh]		EENS%, [%]	
	2025	2030	2025	2030
DE	0.12	0.33	0.0000	0.0000
DK	0.04	0.08	0.0000	0.0000
EE	0.04	0.14	0.0000	0.0000
FI	0.10	0.12	0.0000	0.0000
LT	0.12	2.71	0.0000	0.0002
LV	0.03	0.36	0.0000	0.0000
NO	0.00	0.00	0.0000	0.0000
PL	0.01	0.07	0.0000	0.0000
SE	0.04	0.07	0.0000	0.0000

The greatest ENS value was in Lithuania, 2.71 GWh. That will make up just 0.0002% of Lithuania's total demand in 2030. EENS values in other countries were very low.

Using the same methodology, Elering has carried out simulations with the PLEXOS electricity market model and the findings were the same as the ones from the ENTSO-E analysis. This gives Elering additional certainty regarding the quality of its resource adequacy assessment.

This analysis covers the years 2025 and 2030. In subsequent years, it is planned to add other years to the ENTSO-E analysis. Analysing generation and demand trends and the data reported by countries, there is no reason to expect that in either 2025 or the period from 2025 to 2030 there will be years where the resource adequacy level will be worse than in the years analysed.

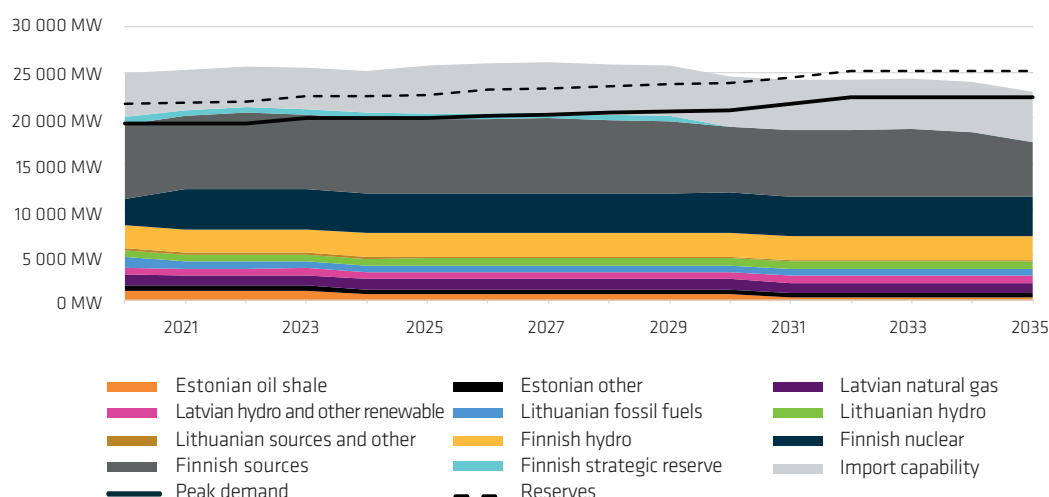
2.4.2 Regional resource adequacy on the basis of the deterministic approach

In cooperation with system operators from neighbouring countries – Fingrid, AST and Litgrid – Elering has also used a deterministic approach to assess the security of supply. The deterministic method visually collates the presumed generation capacities to be used with the quantity of the electricity demand and necessary reserves forecast in the studied countries. The advantage of the method is its simplicity, annual resolution and visual effectiveness.

The analysis presumes that the electricity market functions as a whole. From the end of 2025, it is presumed that the Baltics will be synchronised with the central European electricity system. The assumptions as to generation capacities are based on data filed by power producers and the TSO's assessment, taking into account climate policy goals and developments in renewable energy. For Estonia and Latvia, the wind or solar generating capacities used during peak load periods has not been factored in, as there are still hours in the entire period when the total output from these sources in the Baltics is zero. With the addition of more wind and solar capacity, these situations will not persist, but when and to what extent they should be taken into account in deterministic analysis is currently difficult to anticipate. It is important to note that the peak demand forecast does not reflect the demand management and demand response potential in the Baltics, which may be considerable in the short term and may reduce peak load.⁶ Assessment of the volume of necessary reserves for the functioning of the electricity system are based on system operators' forecasts and desynchronisation of the Baltics from the IPS/UPS system and synchronisation with the central European electricity system.⁷

Figure 4.4 depicts, to the best of the knowledge of Baltic and Finnish system operators, the generation and transmission capacities to be used during the period of 2020-2035 in the Baseline Scenario in Estonia, Latvia, Lithuania and Finland. The same figure also depicts peak demand and reserve need forecasts for the period, assuming that synchronisation with Central Europe will take place in 2025. The analysis shows that the countries dealt with depend on external import to cover peak load, but it is not anticipated that there will be a need to limit reserves before 2031. Import capacities add up to 4800 MW for the countries; by 2026, the figure is projected to be 5500 MW.⁸

Figure 4.4
Generation and
transmission capacities
in the Baltics and Finland
in the period 2020-2035



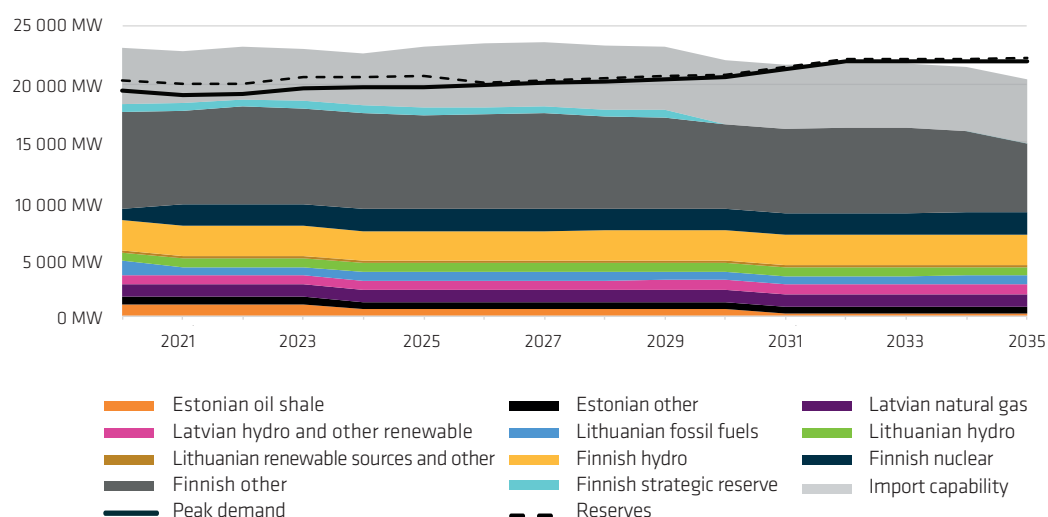
6 The price-sensitivity of consumption and the resulting consumption management are to a great extent linked to the price of electricity. With today's relatively low electricity prices, the reduction or shifting of consumption is not widespread as the economic benefit stemming from it is low. In the case of greater volatility of electricity prices, which a reduction in resource adequacy can cause, the economic benefit from the management of consumption increases as well, as does the motivation to manage consumption.

7 In general, three types of reserves are maintained for the functioning of the electricity system. Primary reserves and secondary reserves restore the operation of the electricity system after an outage. Tertiary reserves are thereafter used to replenish the primary and secondary reserves for the event of the next outages.

8 From the standpoint of the security of supply, the possibility of importing electricity from Russia has not been taken into account as a result of the different market system, which will curtail free movement of electricity.

Figure 4.5 shows Baltic and Finnish generation and transmission capacities in a severe N-2 disruption situation. In the deterministic analysis, the N-2 disruption situation is used as the minimum level for ensuring the adequacy of the electricity system. This means that system must be ready for the two biggest elements being non-operational during peak demand. After the occurrence of an N-2 situation, it is no longer presumed that additional reserves will be maintained for subsequent outages (N-3 or N-4). In the region analysed, the most severe N-2 situation is if the two Finnish nuclear plant units go off line at the same time. The figure shows the Baltics' additional reserves maintained up to 2025, stemming from the current agreement between the Baltics and Russia and Belarus. After the synchronisation with central Europe, the Baltics maintain only primary reserves in an N-2 situation. As a result of this analysis, no deficits in generation capacities are foreseen up to 2032.

Figure 4.5
Generation and
transmission capacities
for use in an N-2
scenario in the Baltics
and Finland in the
period 2020-2035



Looking at the results of the deterministic analysis, it should be borne in mind that when forecasting for such a long periods, it is difficult to foresee developments in the economy, the power plants' variable costs and the price of electricity, which impact the profitability of existing plants and approval of investment decisions. The Narva power plant closure date depends on the price of carbon allowances and how fast the price increases, while the closure of Latvian gas plants will also depend on the price of gas, which has been very low this year, but may in future grow to a level where plants have so little access to the market that keeping all gas plants in operation would not be economically rational. Furthermore, a major growth in renewable energy can be anticipated in the next 10 years, and this has not been factored into this analysis for the Baltics. As for Finland, there are open questions concerning the speed of closure of the coal-fired plants and new nuclear energy capacities, namely when the launch of the third reactor at Olkiluoto might take place, if at all, or when the Hahnikiivi nuclear plant might go online.

2.5 EXTRAORDINARY SCENARIOS

According to the MAF compiled by ENTSO-E, Estonia meets the reliability standard common in Europe, but MAF presumes a functioning European electricity market and does not take into account very low-probability events. Besides that, a number of market disruptions also hinder the European energy-based electricity market; due to which it is in doubt in a number of European countries whether investments needed for resource adequacy can be found on the open market. For these reasons, Elering also analysed additional continuity scenarios. We used the deterministic method to analyse the scenarios. Figure 4.6 visualises the low probability of continuity scenarios different to the market scenario, and expresses the probability of scenarios as seen by Elering.

Figure 4.6
Estimated probability
of occurrence of
scenarios



2.5.1 Baltic synchronous area scenario

Assumptions

- The Baltics must be prepared for a Baltic synchronous area scenario at every point in time without the realisation of this scenario resulting in planned restrictions of demand.
- Until the end of 2025 – The Baltic states' synchronous operation with the IPS/UPS energy system has come to a rapid, no-deal end. The Baltic States have been stranded in island mode and comprise a separate Baltic synchronous area. Rapid re-synchronisation with the IPS/UPS system is not possible; it is necessary to have the capability to operate up to 12 months independently until extraordinary synchronisation with continental Europe.
- After 2025 – the Lithuania-Poland AC connection has been interrupted and the Baltic countries will have to be able to cope on their own until the AC connection has been restored.
- DC connections with the Nordic countries and Poland are usable, but in the reduced volume, taking into account the restriction of 400 MW imposed on the largest element. The largest generation capacities are likewise capped at 400 MW.
- An N-1 situation means that another DC cable has been switched off.
- In such a situation the Baltic States will depend on DC connections with neighbouring systems for their rapid frequency reserves.
- The Baltics must have sufficiently firm generation capacities.

Results of the deterministic analysis

Figure 4.7
Baseline scenario for
Baltic synchronous
area

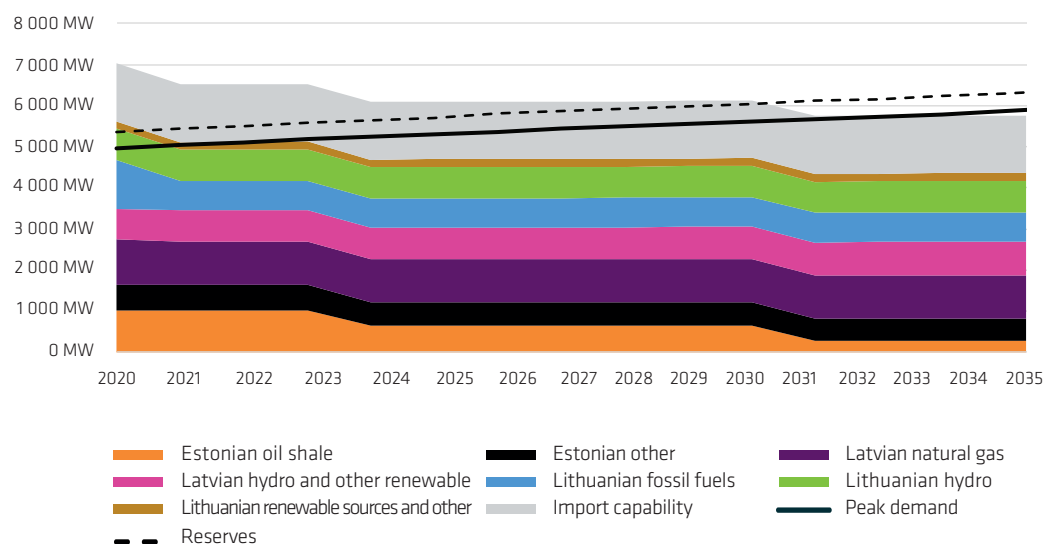
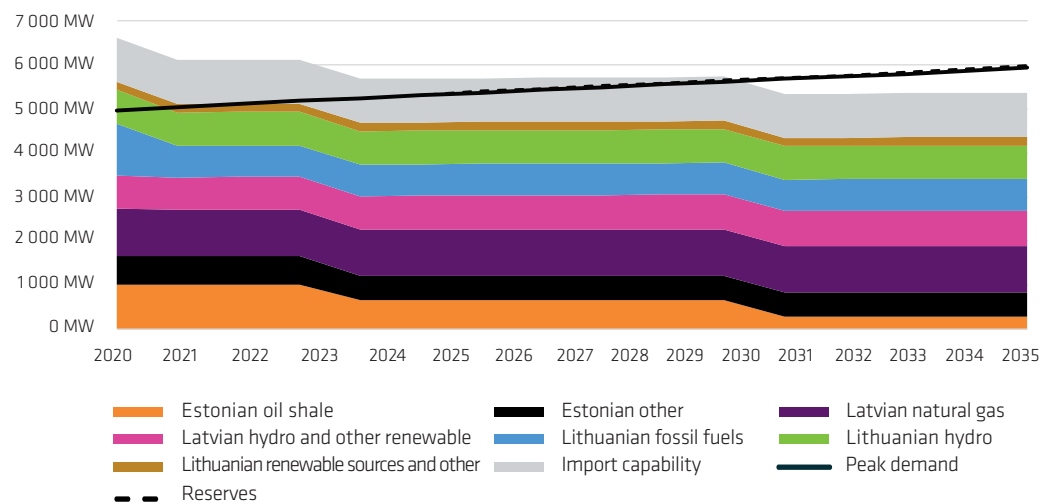


Figure 4.8
Baltic synchronous area
N-1 scenario



The Baltic synchronous area scenario analysis shown in figure 4.7 and 4.8 shows that the Baltic states' resource adequacy would be covered until 2030 using known load-following generation capacities and transmission capacities. From 2030, however, there may be situations where it is not possible to keep a sufficient quantity of reserves, and in an N-1 situation there may be shortages of generating capacities. Along with other Baltic TSOs, Elering is creating readiness for operating in island mode, and readiness will be established by way of investments made in the course of the synchronisation project. The investments will reduce, over time, the impact that the risk of the Baltic countries' being stranded in island mode operation will pose to the stability of the Estonian electricity system.

Based on the current assessment, should the Baltic synchronous area scenario become realised, the Estonian electricity system must have about 1000 MW of load-following generating capacities. In combination with the other generation capacities in the region and DC connections available in reduced volume, it would in such a case be possible to meet Estonian electricity demand during peak load times.

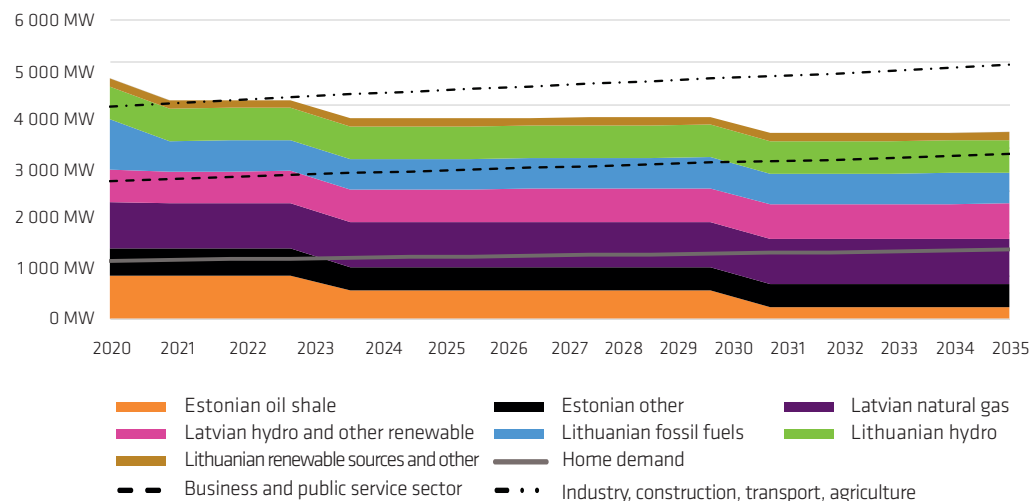
2.5.2 Baltic emergency continuity scenario

Assumptions

- Until the end of 2025 – the Baltic States have been stranded in island mode operation with respect to the IPS/UPS energy system and form a separate Baltic synchronous area.
- After the end of 2025 – the Baltic States are stranded in island mode operation with respect to the European energy system and form a separate Baltic synchronous area.
- There are no DC connections with other regions.
- The estimated duration of the scenario is two months, during which it would potentially be possible to restore at least one DC connection.
- The demand data for the sectors are from the databases of statistical offices of the Baltic countries, through which the share of the sector in the total final demand has been found and it has been presumed that the share of the sector will also remain the same during peak demand.

Figur 4.9
Baltic emergency
continuity scenario

Results of the deterministic analysis



In the scenario shown in figure 4.9, where none of the DC connections in the Baltics is usable, the load-following generation capacities are out of operation and the forecasted demand load grows, it is not possible to cover demand at every point in time with the generation capacities. The analysis indicates that in the absence of DC connections it would certainly be possible, from the standpoint of resource adequacy, to ensure electricity supply of households as well as the business and public service sector in the Baltic States while the electricity supply of other sectors should be limited, if necessary. Due to the increasing electricity demand, the electricity supply to the industrial sector should be increasingly limited if this scenario becomes realised. Moreover, it should also be taken into account in the case of such a scenario that the electricity supply quality will be significantly affected. Without transmission capacities, it is not possible today for the Baltic States to ensure adequate fast frequency reserves, due to which additional outages may result in additional automatic phase-out of demand. Frequency reserves are obtained within the framework of the synchronisation project.

It should be emphasised that this scenario is an unlikely extreme case where very many improbable events coincide: an interruption of synchronous operation either from the IPS/UPS or central European frequency area, simultaneous interruption of four DC connections and sufficient high demand in the winter period. The likelihood that all of the above events will happen simultaneously is less than once per 100 years.

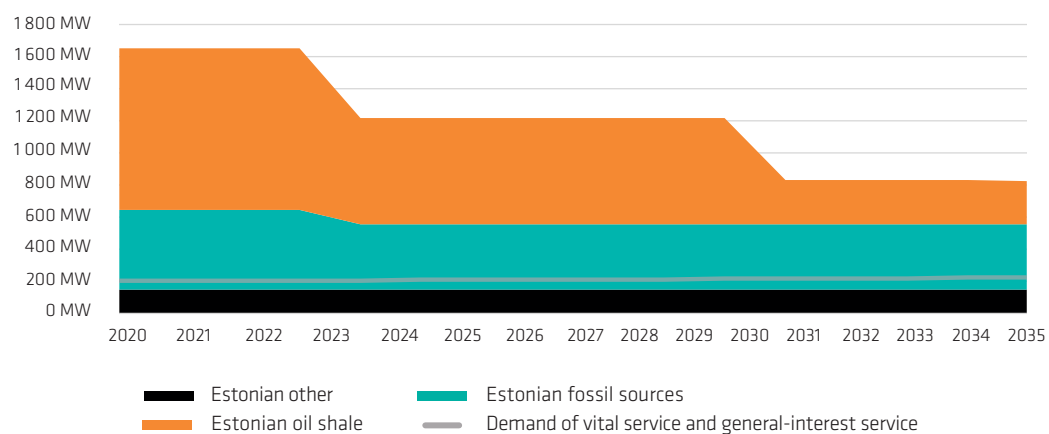
2.5.3 Estonian vital service scenario

Assumptions

- Estonia has been stranded in extraordinary island mode operation.
- There are no power connections to other countries.
- The electrical system should be ready to operate for an unlimited period of time.
- The electricity system must be able to constantly cover the demand of vital service and the demand of general-interest service.
- The estimated maximum demand of vital service and general-interest service is 200 MW. It is important to note that this is an estimate and Elering along with related parties will carry out activities to make this estimate more precise. However, Elering considers that this assessment to be higher than the actual situation and that this presumption is a conservative one from the standpoint of the security of supply.

Figure 4.10
Estonian vital
service scenario

Findings



As Figure 4.10 shows, Estonian vital service and general-interest service power demand can be covered using existing generation capacity, but stability of the electricity system and keeping demand and supply in balance are critical for this scenario.

2.6 FORECAST OF ELECTRICITY DEMAND UP TO 2035

The following section gives an overview of the forecasted demand in the Estonian electricity system as well as factors and preconditions that could potentially influence demand. Elering's demand forecast has remained unchanged in recent years. The forecast will be fine-tuned based on updated statistics and the results of the completed studies.

In previous Security of Supply Reports, a growth rate of 1% per year was used to estimate the growth of demand. For a more detailed forecast, Elering AS commissioned a load forecast study from the Tallinn University of Technology in 2017. To forecast the loads, a model was devised for finding the estimated load on various levels: the substation level, regional level, and the entirety of the Estonian electricity network. Three different scenarios were developed using this model: medium (baseline), rapid and slow development. The table below describes demand using two indicators: annual demand and peak load. In the demand forecast view, the basis is the medium scenario in the abovementioned load forecast study.

Table 4.2
Summary of
statistics and
forecast for total
demand and peak
load up to 2035

Demand statistics			Demand forecast		
Year	Annual demand, TWh	Peak load, MW	Year	Annual demand, TWh	Peak load, MW
2005	7.2	1331	2020	8.7	1564
2006	7.8	1555	2021	8.9	1594
2007	8.2	1526	2022	9	1609
2008	8.3	1525	2023	9.1	1623
2009	7.8	1513	2024	9.2	1636
2010	8.2	1587	2025	9.2	1649
2011	7.9	1572	2026	9.3	1661
2012	8.1	1433	2027	9.4	1674
2013	7.9	1510	2028	9.4	1680
2014	7.8	1423	2029	9.4	1685
2015	7.9	1553	2030	9.5	1690
2016	8.2	1472	2031	9.5	1695
2017	8.3	1474	2032	9.5	1701
2018	8.4	1544	2033	9.5	1706
2019	8.2	1541	2034	9.6	1711
			2035	9.6	1717

To this point, overall electricity demand is showing a growth trend, but the peak loads on the electricity system have remained essentially unchanged in the 10 years – between 1423 and 1587 MW. The peak load, 1587 MW, was recorded 10 years ago in 2010, which coincided with an exceptionally cold winter period. It should nevertheless be considered that there will be some peak load growth due to rising demand in the next 10 years and subsequent decrease in the annual demand growth rate. Elering's forecast of peak loads up to 2035 is laid out in the figure below.

Figure 4.11
Statistics and
forecast for peak
loads up to 2035

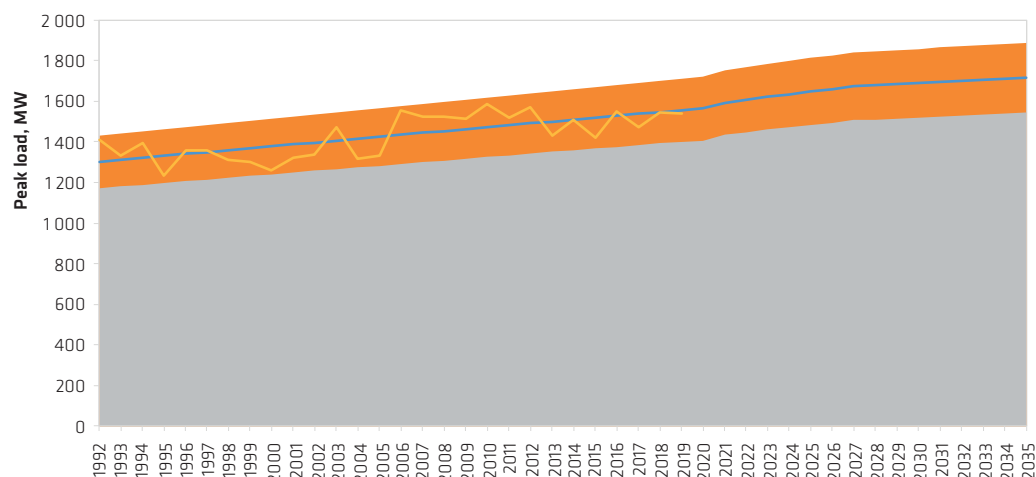


Figure 4.11 shows that the actual peak load fluctuates between the standardised peak load and in a $\pm 10\%$ interval. According to this forecast, peak load will also be 1600 MW or less in 2021, although it will already have grown to the level of 1700 MW by 2032.

According to the load forecast made by the Tallinn University of Technology, the growth in average peak load will be on the order of 1.14% in the period of 2020-2022, but after that it will start to decrease and from 2028 it will grow by 0.31% per year.

The changes in peak load over the years will be significantly affected by weather patterns. Changeable weather means that actual peak loads may also temporarily go beyond the forecast range. A recurrence of the warm winters of recent years may also affect the growth rate of peak loads in the future.

New projects and consumer connections have not directly been taken into account in the general forecast, as it would be an extraordinary occurrence to connect capacities that would have a material effect on demand (e.g., the metal industry, cellulose plant and, in recent years, server farms). If such major consumers should accrue in Estonia, they would be treated separately and their impact would start to be considered in preparing forecasts.

No major consumers were added in 2020, and as of this writing, no new connection projects for major consumers have accrued. In the more distant future, electricity demand may be increased to some extent by loads related to the Rail Baltic project, but the peak load growth will have a more modest impact and currently fits into the forecast margin.

2019 had a warmer winter than average and this shows up clearly in the demand statistics, where the annual demand was about 2% lower than the previous 2018. At the same time, peak load for the calendar year has stayed at the same level – the 2019 peak hour of 1541 MW was measured on the morning of 22 January.

The dramatic growth in electric cars may lead to greater-than-usual growth in demand. Replacing the entire internal combustion engine fleet with electric cars could, according to a rough estimate, impact the growth of power demand by 10-20% compared to today's level. To forecast the share of electric cars and its impact on electricity demand, a separate more precise impact analysis should be conducted.

2.6.1 Distribution grids

In accordance with subsection 66 (2) of the Electricity Market Act, each year distribution network operators must submit to the Competition Authority a written assessment of the expected total demand capacity demand within their service areas for each of the seven years following the submission of the assessment.

Subsection 66 (3) of the Electricity Market Act provides that by 15 June each year the transmission network operator submits to the Competition Authority a written assessment, as precise as possible, of the expected total demand in the transmission network for each of the seven years following the submission of the assessment. The transmission network operator also notes the presumptions on which its assessment is based.

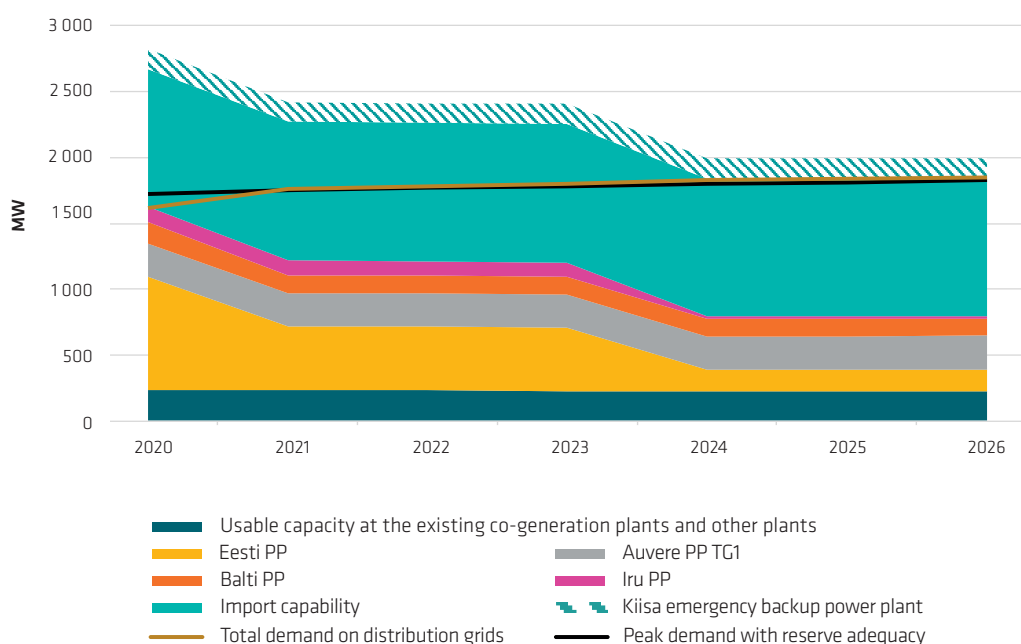
The table below sets out the data submitted by distribution network operators in 2020. Pursuant to their demand capacities, the total demand should remain in the range of 1615 to 1850 MW in the period 2020-2026. The total demand reported by distribution grids has also been compared in the table below to Elering's peak load forecast and it can be concluded that the total power demand of distribution grids is more reflective of the extreme forecast, comparable to Elering's forecast that takes into account exceptionally cold winter and faster load growth margin and aligns quite precisely with it.

Table 4.3
Comparison of
distribution grids'
assessment of total
demand for demand
capacity in the
2019-2025 period and
Elering's system peak
load forecast along
with 10% margin.

Year	Total demand for distribution network, MW	Elering's forecast for system peak demand along with 10% margin in the case of exceptionally cold winters, MW	difference between Elering and Distribution Grids' forecast, MW
2020	1615	1720	105
2021	1758	1753	-5
2022	1779	1770	-9
2023	1805	1785	-20
2024	1831	1800	-31
2025	1840	1814	-26
2026	1850	1827	-23

The difference in the forecasts is around 10% and stems from the decrease caused by the fact that the peak loads occur at different times. At the same time, It is comparable with the more conservative forecast that factors in a margin for colder winters and faster growth in loads. It can be concluded from the analysis that the system's total demand capacity will be guaranteed over the next seven years and will also be compared with respect to the total demand assessment submitted by the Distribution Grids. This is illustrated by the figure below, which shows the domestic capacity used, Distribution Grids' total demand and the system peak load forecast, taking into account a 10% load margin for exceptionally cold winters and faster-than-expected growth in loads.

Figure 4.12 Comparison
of distribution grids'
assessment of total
demand for demand
capacity and Elering's
system peak load
forecast along with
10% margin and how
it will be covered
through domestic
generation capacities
and international
connections.



In the case of the data submitted by distribution networks to Elering, it should also be borne in mind that the demand forecasted in some distribution networks will be covered in this network locally and the capacity to be taken from the transmission network will only be used for repairs and emergencies.

Elering believes that the forecasted demand for the next seven years can be covered using all existing and planned domestic generation facilities and international connections, and domestic connections and investments into the power grid planned in the years ahead are sufficient for this. In the case of unexpected new major consumers connected to the grid, there may be a need to re-configure the grid, but each new connection will be treated separately and this will not be taken into account in this assessment.

2.7 GENERATION UNITS CONNECTED TO THE ESTONIAN ELECTRICITY SYSTEM IN 2020

Based on data obtained from producers and information from distribution grids about generating equipment as of 1 January 2020, the total installed net generating capacity is 3041 MW, of which the capacity used during peak periods accounts for 1779 MW. An overview of the large generation equipment connected to the Estonian electricity system and smaller plants in aggregate as of 1 January 2020 is provided in the following table (see Table 4.4).

Table 4.4
Generation
equipment
connected to the
Estonian electricity
system in 2020

Power plant	Installed net capacity, MW	Possible generating capacity, MW
Eesti Power Plant	1355	867
Balti Power Plant	322	165
Auvere Power Plant	272	250
Iru Power Plant	111	111
Kiisa Emergency Reserve Power Plant	250	150
Põhja Thermal Power Plant	78	78
Sillamäe Thermal Power Plant	16	8
Tallinn Power Plant	39	39
Tartu Power Plant	22	22
Pärnu Power Plant	20.5	20.5
Enefit	10	4
Other industries and cogeneration plants	80	60
Hydro power plants	8.4	4
Wind farms	329	0
Solar power plants	128	0
Total	3041	1779

Micro and small producers with less than 15 MW capacity are included in the above table along with other power plants under the respective type of power plant.

2.8 CHANGES IN GENERATION UNITS 2019-2029 AS INDICATED BY ELECTRICITY PRODUCERS

In accordance with the amendment (16 February 2016) to Section 132 of the Grid Code, "Generation reserve necessary for satisfying consumption demand", all electricity producers must submit to the system operator Elering AS by 1 February of each year the data set out in Annex 3 to the Grid Code for the next 10 years in order to assess the adequacy of the electricity system's reserves. This year, all of the major electricity producers and most of the smaller electricity producers submitted the data. In the case of some of the smaller power plants, the data filed in previous years concerning the planned closure of electricity generation and/or generation equipment were taken into account.

All of this electricity generating equipment, the construction intention of which has been reported to the system operator, cannot be taken into consideration as definite decisions to construct power generation equipment. Some projects are already in the construction phase, and some are also in the planning phase, without a final investment decision having been made. At the same time, it can be assumed that not all of the generation equipment in the planning phase will reach an investment decision and that, in addition, it is not certain which years these projects will actually be completed in.

2.8.1 Changes with respect to 2019

Compared to the previous Security of Supply Report published in 2019, electricity producers have indicated the following biggest changes:

Enefit Energiatootmine AS:

- on the 5th November 2019, Eesti Energia's sole shareholder (the state) signed a written set of guidelines under which the company must until the end of 2023 guarantee that it has 1000 MW of load-following generation capacity in its portfolio.
- the forced closure of Balti PP's 11th block due to environmental restrictions until 2030 is not anticipated. However, significant technical and economic restrictions are related to this unit, as a number of key components of the turbine in this block will reach the end of their service life in the mid-2020s. The company is still in the process of assessing the economic purposefulness of investments into replacing these components.
- The decommissioning dates of Eesti PP pulverized oilshale blocks equipped with flue gas cleaning technology (block 3, 4, 5 and 6) from 2020-2024 are estimates and take into account the guidance provided by Eesti Energia's sole shareholder on 5 November 2019 and the economic restrictions known at the current time in relation to operation of these units.
- As for generating equipment operated on the basis of the limited life time derogation arising from the IED (Article 33), their closure times are estimates and depend mainly on the actual use of the allowed hours.

Solar power plants:

- The total capacity of solar power added to the electricity system has grown significantly.
- As of 1 January 2020, 128 MW of solar power plants have been connected to the system, of which 74 MW was connected in 2019. The data were refined based on the data reported by distribution grids regarding the power plants connected to the grid;

Data for individual power producers are no longer reported in the annexes to the 2020 security of supply report.

2.8.2 Generation equipment to be closed and reduction in capacity of existing generation equipment

Elering currently has been notified of the following decommissioning of generation capacities, capacity reductions and mothballing of generation units:

- 2021 Closure of the Eesti Power Plant blocks, 815 MW;
- 2021 Closure of the Baltic Power Plant block, 130 MW;
- 2024 Closure of additional blocks at Eesti PP, 346 MW;
- 2031 Closure of additional blocks at Eesti and Balti PP, total of 386 MW.

Total generating capacity to be closed for 2019-2024: 1291 MW.

* the capacity to be closed includes capacity to be used with restrictions.

2.9 ASSESSMENT REGARDING THE GENERATION RESERVE NECESSARY FOR SATISFYING CONSUMPTION DEMAND UP TO 2029

The assessment in this report as to the generation reserve needed to satisfy the power demand was put together in light of what Elering sees as the most likely development trends governing generation capacities as not all of the source data submitted to the system operator can be taken into account as projects certain to be realised in the future.

2.9.1 Assessment of adequacy of generation capacity in winter

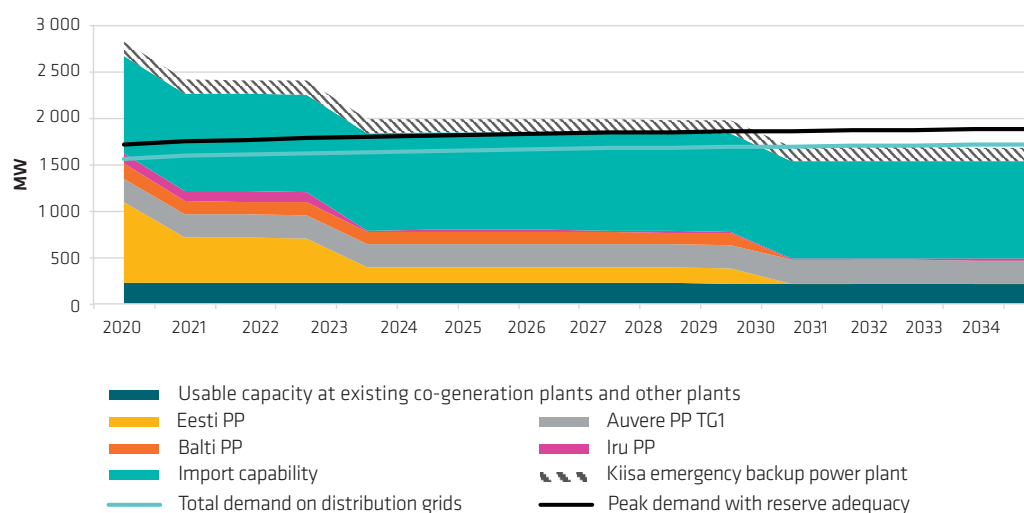
The projected scenario takes into account new power plants that are currently being built or where a firm investment decision or closing date has been communicated to the system operator.

Starting 1 January 2016, the Eesti Power Plant's 1st, 2nd and 7th block and the Balti Power Plant's 12th block will be operated based on Article 33(1) of the Industrial Emissions Directive (limited life time derogation), according to which an operator is allowed to operate these blocks during the period from 1 January 2016 to 31 December 2023 not more than 17,500 operating hours. According to Eesti Energia, three blocks will be closed at Eesti Power Plant in late 2020 and the Balti Power Plant's 12th block will also be closed in late 2020. As the actual use of the operating hours set out in the limited life time derogation depends on the price levels that will take shape on the electricity wholesale market, it is not possible to announce the exact time for the planned closure of the energy generating units. This will be done as soon as possible after the management board of the company has made the relevant decision and the information has been sent to the power exchange for publication.

At the moment, the environmental requirements established on Eesti PP, Auvere PP and Balti PP generating units are governed mainly by the emissions limit set forth on the basis of the IED and Industrial Emissions Act. As of 25 October 2021, the environmental requirements of oil shale-fired power plants will be regulated by the Use of Oil Shale Energy BAT Conclusions Document. Existing generating equipment at Eesti PP, Auvere PP and Balti PP (except for the generation equipment operating on the basis of the IED limited life time derogation) are in compliance with the requirements arising from the aforementioned legislation. The requirements set out in the aforementioned BAT document will presumably remain in effect until approx. 2030 (after which they will probably be made more stringent).

In the winter period in 2030, the forecasted peak load based on the projected load scenario is 1690 MW and the usable generation capacity is 935 MW; import capability is 1050 MW (takes into account an N-2 situation). Considering the data sent by the producers and the information known to Elering, the generation reserve necessary for satisfying the power demand will be adequate up to 2030 – even factoring in the 10% reserve for extraordinarily cold winters. According to the updated forecast, it will not be possible to fully cover the Estonian electricity system's peak load using only domestic generation without taking into account international connections. Taking into account the electrical connections and generation capacity on the regional electricity market, there are adequate generation capacities for Estonia for the next ten years. Domestic generation capacity used on the electricity market, coupled with international connections, will cover the power demand during the peak winter period. In the case of failures of international connections, the capacity of Elering's emergency power plant can be used. The forecast for the generating capacity and import capacity used on the electricity market is shown on the figure below (see Figure 4.13). For more details about the adequacy of the power system in Estonia, the Baltics and the Baltic Sea region up to 2035, see chapter 4.9.3.

Figure 4.13
Expected forecast for
generation capacities to
be used and peak demand
in winter

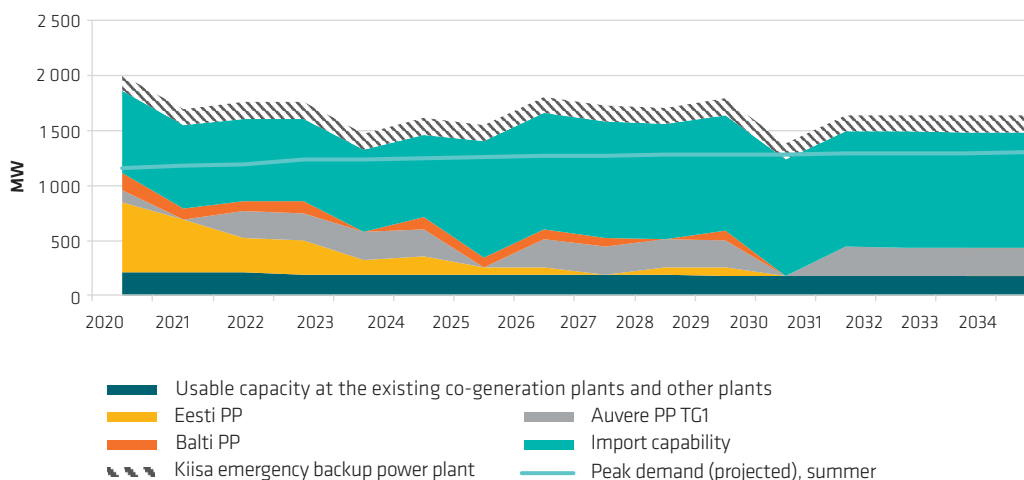


In addition to the above forecast, the electricity generation capacities of other countries in the Baltic Sea region can be counted on for covering peak load, based on the difference in the peak load period and the possibility of using cross-border electrical connections. Thanks to the third Estonia-Latvia connection to be completed in late 2020, Estonia's electricity system will have the capability of maintaining 1050 MW in transmission capacities in an N-2 situation also in the period 2020-2025, when the existing 330 kV Estonia-Latvia overhead lines and during this period the assumption is that an overhead line will be out of service while it is renovated. Upon synchronisation with central Europe after 2025 and following renovation of the Estonia-Latvia overhead lines, it is expected that transmission capacity between Estonia and Latvia will remain at the same level and that entire import capability in an N-1 situation will remain at least 1050 MW. Elering believes that the cross-border connections and generation capacities in neighbouring systems are sufficient to ensure the functioning of the Estonian electricity system in the years ahead, even in a situation where demand exceeds forecasts or the existing generation equipment is closed before the currently forecasted closure date. The precondition for use of neighbouring systems' generation reserves is a functioning regional electricity market and reliable international connections with Finland and Latvia. In the years 2031-2035, according to current forecasts, some capacity deficits would be anticipated in the event of colder winters.

2.9.2 Assessment regarding the generation reserve necessary for satisfying power demand during the summer period

Figure 4.14 describes the forecast for generation capacities and peak demand during the summer period.

Figure 4.14
Forecast for generation
capacities to be used
and peak demand
during the minimum
demand period
(summer)

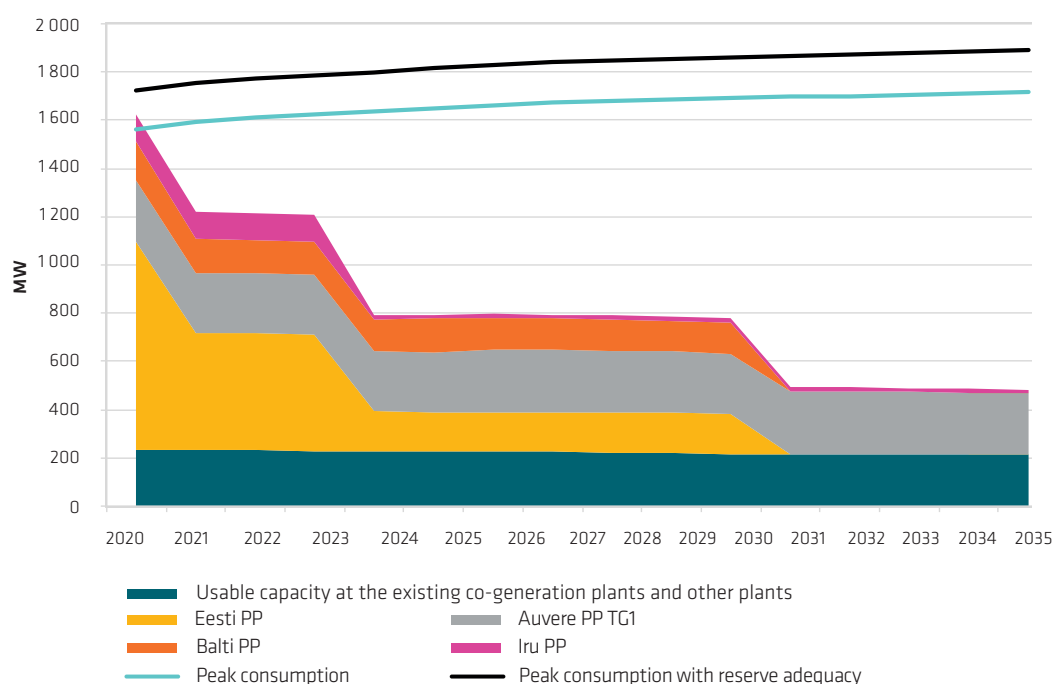


2.9.3 Adequacy of the Estonian electricity system up to 2035

The following analyses Estonian power supply adequacy up to 15 years into the future. In the conditions of a European single energy market, Elering views the Estonian security of supply in the regional perspective, as a combination of local generation capacities and transmission capacities. Elering's analysis views severe situations from the standpoint of the security of supply and does not express how power plants are used in ordinary market conditions.

Figure 4.15 expresses Elering's assessment regarding the developments of the currently known and usable generation capacities in Estonia up to 2035. Here, proceeding from the conservative position, it is presumed that some of the closures of power plants will be expedited compared to the data submitted by producers upon assessing the generation reserve necessary for satisfying the demand in the Estonian electricity system. Unlike data from producers, the possibility of outages has not been taken into consideration. The possibility of outages is taken into consideration in an N-1-1 situation (see Figure 4.16). It is presumed that the Narva Power Plants units covered by the IED derogation will be decommissioned in 2019. In reality, it is permitted to use these units for 17,500 operating hours from 2016 to the end of late 2023. This means that, as market conditions permit, the said generation capacities may be available for a longer period of time than presumed in the analysis. In addition, it is presumed that the Narva Power Plants Units equipped with deSOx filters will be closed in 2020. This is a conservative presumption, as these units could be in operation longer judging by environmental restrictions and their technical condition. In reality, the duration for which the old power plants will be kept in operation depends on market conditions – whether the costs of maintenance of and the necessary investments in the power plant can be recouped on the electricity market. Elering's task here is to consider severe security of supply situations and, as a result, this analysis relies on conservative presumptions regarding the decommissioning of power plants.

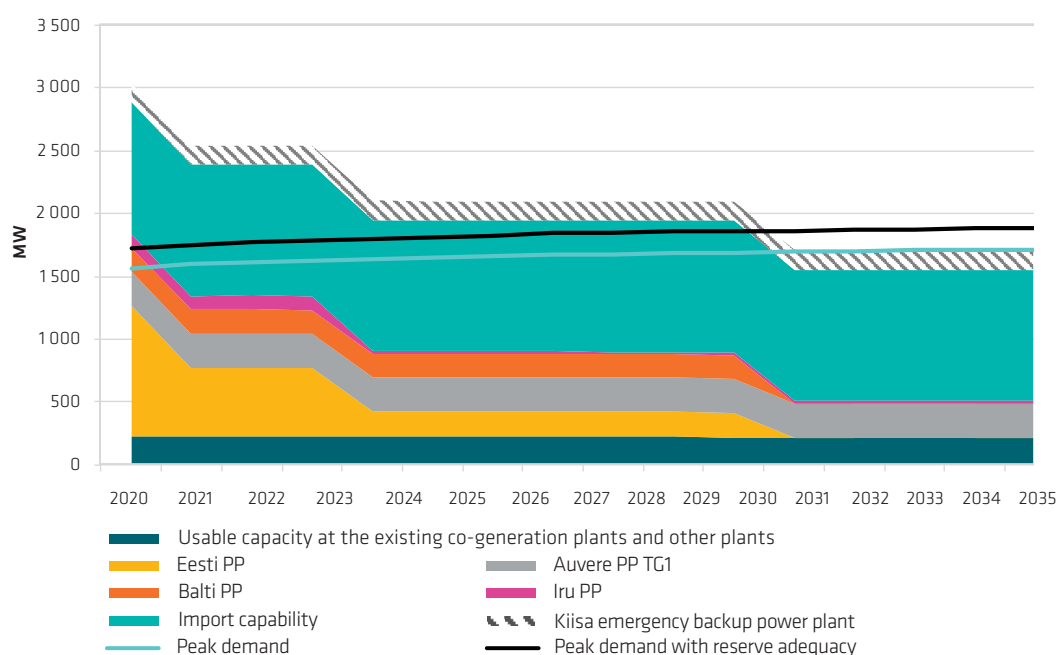
Figure 4.15
Assessment
regarding the
structure of
generation
capacities to be
used up to 2035



Starting in 2020, Estonia will have, according to current plans, over 2000 MW of international connections.⁹ That means greater import capacity than Estonian peak demand forecasted for this period and, as a result, the potential closure of local generation capacities will not cause problems for the security of supply in an ordinary situation.

As regards the security of supply, it is important to consider emergency situations in the system as well. This analysis views the disruption situation N-1¹⁰, where the two biggest elements of the system are non-functional. In the period of up to 2035, to the best of the current knowledge, the two biggest elements in the Estonian system will be the submarine cable EstLink 2 and one of the transmission lines between Estonia and Latvia. In such a situation, the capacity of Estonian international connections will decline in the period 2020-2035 and as a result, the import capacity will drop to 1050 MW – of this, 700 MW is from Latvia and 350 MW from Finland. In the event of this scenario, Estonia will have adequate generation and transmission capacities until 2030, when the 10% reserve is also guaranteed for satisfying peak load in the case that demand experiences faster growth or an exceptionally cold winter. To the best of current knowledge, 1000 MW firm capacity will not exist in 2031, as has been set as a goal of system operation. Unless new facts to the contrary emerge in the following years, Elering must use the probabilistic method to assess whether the situation conforms to the reliability standard and consider implementing a capacity mechanism. Figure 4.16 illustrates the security of supply in an N-1-1 situation, where the two biggest elements of the electricity system are non-functional.

Figure 4.16
Adequacy of the
Estonian electricity
system in an N-1-1
situation until 2035



2.10 FUTURE TECHNOLOGIES IN ENSURING RESOURCE ADEQUACY

The European Union plans to be climate neutral by 2050. This ambition will result in extensive changes to the electricity system. It is highly probable that the change will be shaped the most by the growing share of renewable energy, various types of energy storage technologies, innovation both in business models and technology, and demand-side flexibility.

Fortunately, all of these technologies already exist and have been proved in various situations. The set goals could be achieved using solely these solutions. The main question is how much this aspiration will cost us as a society. Here the major disparities in geography between countries come into play – some have more favourable solar conditions, while others are better endowed in terms of hydro or wind. These advantages can serve everyone in the case of a well-connected and efficiently functioning electricity market. The transition period from fossil energy to renewable energy will be relatively complicated.

One of the most significant challenges in ensuring adequacy of the electricity system in future will be introducing more and more renewable energy solutions to the market, such as wind and solar. Fossil fuel-based thermal power plants will have increasing expenses for power generation due to rises in the price of carbon allowances. There is also a growing problem in the fact that cheaper and more accessible fuel deposits will be exhausted and it will be harder to access fuels affordably. If thermal power plants – whose capacity can generally be regulated – are replaced with renewable solutions that have equal capacity but are weather dependent, this will mean certain changes for operation of the electricity system.

After synchronisation with the central European frequency area, in addition to the right quantity of electricity, it will be necessary to be able to ensure network inertia and frequency regulation. At the current time, frequency regulation is guaranteed thanks to the connection to the Russian power grid, but in future, the Baltics must have their own frequency reserves capacity. This opens up a new income source for locals and the region's market participants, which favours innovation in technology and business models.

The new development trends that will be discussed in this chapter will make it possible to ease the challenges through smarter generation, demand and network operation. Even though these technologies may be mature ones, investors and decision-makers may lack the confidence or will to adopt them. Besides the differences in geographical and climatic conditions, the peculiarities of political systems and existing market mechanisms must also be factored in. The fewer market distorting mechanisms there are, the easier it will be to tap into experiences of foreign countries for making decisions.

2.10.1 Energy storage

One of the axioms of the electricity market is that generation and demand must be in balance at any moment in time. When a great deal of renewable energy (with variable output) is introduced into the system, it would be good from Estonia's perspective to create the need to store it during high-output periods and make use of it during times of lower output. Energy storage technologies are developing rapidly and coming down in price. "Energy storage" is a very broad term and covers hydrogen, gravity-based storage systems and batteries. In recent years, the prices of battery technologies have dropped, such as lithium ion batteries used in cell phones, electric cars and at the level of network stabilisation. Possibilities for hydrogen production and use continue to be explored extensively.

Gravity-based energy storage and pumped-hydro storage

Worldwide, there is about 176 GW¹¹ in installed energy storage, of which 96% is pumped-hydro storage. This is because it can be scaled and it is a relatively simple energy storage method. Water is pumped from a lower to a higher reservoir when electricity is cheaper. The water thus stores potential energy that can be realised during a period when electricity costs more, allowing it to flow down to the lower reservoir through the generator. This relatively inexpensive, efficient energy storage technology has

major geographic restrictions as it requires a body of water (preferably a river) and a location with major differences in elevation to build the reservoirs. There is an increasing effort being made develop solutions that would make this system effective in any other locations.

One such possible application is gravity-based technologies, which is likewise a fairly inexpensive way of storing potential energy using engines during periods when electricity costs less. When the price rises, the process is made to run in reverse and the mechanical energy is transformed into energy using generators. The efficiency of this storage cycle is around 75-90 %, meaning that of 10 MWh energy spent, 7.5 to 9 MWh of energy can be generated at a suitable time.

Success stories

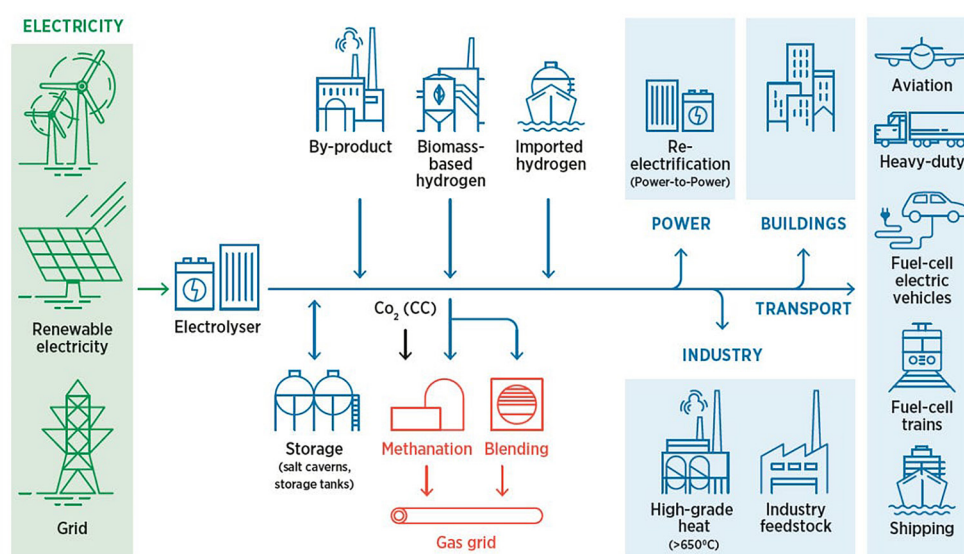
Energy Vault, which generated much talk in 2019, uses precisely the gravity principle to store energy. By lifting and lowering concrete blocks, it claims to be able to create a storage system with a capacity of 20, 25 or 80 MWh, which can provide 4-8 MW electrical output for 8-16 hours. Such a tower is robust and reliable enough to have a lifespan of 30+ years at 90% efficiency of its storage cycle. The concept has received positive coverage from tens of energy and tech media channels.¹² The prototype was developed in 2019 and the first full-scale storage system is planned in 2020.¹³

Also gravity-based but using a slightly different approach, a California company is developing an ARES (Advanced Rail Energy Storage) system. A number of small “trains” with electrical engines are placed on an inclined rail and transport heavy concrete weights uphill during periods of surplus solar generation, thus storing electricity. During periods when electricity is in greater demand, the “trains” are allowed to roll back downhill. Generators in the train output electricity, which is fed back to the power grid.

Market maturity

Working prototypes have been created, but Estonia currently has too low a proportion of renewable energy for such projects to pay off. If Estonia develops offshore wind farms with an output significantly higher than domestic demand, utility scale storage technologies will become more competitive. During better wind conditions, Europe has often seen situations where the price of electricity becomes negative in some countries and consumers are in fact paid to use power. It is very likely that if such offshore wind farms are operated optimally, Energy Vault type storage systems would have many applications.

Figure 4.17
Potential P2G
processes



12 <https://energyvault.com/>
13 <https://www.bloomberg.com/news/videos/2019-08-16/energy-vault-clean>

Power to gas

One of the development areas with the most potential is Power-to-Gas (P2G). Surplus electricity is transformed to hydrogen and methane that can be fed into the gas network. Hydrogen is a versatile fuel and can be stored and used for other purposes (see Figure 4.17). Hydrogen can be used in fuel cells to generate power on demand, and this is indeed the main advantage hydrogen possesses over batteries – it can be stored in large quantities and for a long term. It is the main reason that P2G technologies are considered energy storage, as energy that is surplus at one point is used to produce a different source of energy, which later enables flexible generation of electricity.

Hydrogen can also be used as a fuel in the transport sector and in the methane production process. Methane is the primary element in natural gas (approximately 97%); natural gas/methane can likewise be combusted to generate electricity on demand. If desired, the methane step in the process can be omitted altogether and instead feed hydrogen directly into the gas pipeline, but at concentrations initially low enough to ensure that natural gas powered equipment remain operational. There is currently a lack of uniform view among gas network operators regarding the precise amount and corresponding studies are attempting to find consensus. At the moment, in Great Britain hydrogen limit is 0.1% by volume while the Netherlands allows 12%.¹⁴ In cooperation with TalTech and gas TSOs in the region, Elering is analysing what the current capability of the gas system is for transmission of hydrogen through the gas pipelines and how the capability could be increased in future.

Success stories

Ontario, Canada has an entity called the Markham Energy Storage Facility, which offers system operators in that region regulation services using P2G technology. They have a 2.5 MW Enbridge-Hydrogenics system that can fulfil functions related to electricity system reliability, such as flexible demand and hydrogen storage, which can later be used for power generation.¹⁵

Most electricity in the province of Ontario (~60%) is generated by nuclear plants, which cannot be easily regulated upward or downward. It also has Canada's biggest share of wind energy and 98% of total installed solar energy. At times when nuclear plants cannot regulate their capacity upward or downward and there is much renewable energy at the same time, there may be situations where renewable energy output should be limited or consumers paid to use the energy. In the solution in use, the P2G plant essentially takes the excess electricity from renewable energy and converts it to fuel, which is very versatile and valuable.

Market maturity

Various ways of using hydrogen have been studied for decades, but proportional success has not yet been achieved. The biggest concerns are the low efficiency of the whole process and the high price of infrastructure. Still, with falling electricity prices and European climate policy, the topic is salient once again and P2G is seen as potentially offering great support for resource adequacy and reduction of carbon emissions in both the power generation and transport sector.

In 2019, worldwide, there were 56 various P2G projects and operational hydrogen production plants and 38 methane production plants. Most of them are low capacity pilot or model projects, however.¹⁶

¹⁴ <https://www.powermag.com/why-power-to-gas-may-flourish-in-a-renewables-heavy-world/>

¹⁵ [https://p2gconference.com/news/north-america%E2%80%99s-first-power-to-gas-energy-storage-facility-using-hydrogen.html#:~:text=The%20Markham%20Energy%20Storage%20Facility,\(ESO\)%20of%20Ontario%2C%20Canada.](https://p2gconference.com/news/north-america%E2%80%99s-first-power-to-gas-energy-storage-facility-using-hydrogen.html#:~:text=The%20Markham%20Energy%20Storage%20Facility,(ESO)%20of%20Ontario%2C%20Canada.)

¹⁶ <https://www.powermag.com/a-review-of-global-power-to-gas-projects-to-date-interactive/>

2.10.2 Personal solar panel and battery systems

As to security of supply, it is also worth noting that regardless of whether or not all standards are met on the national level, there still may be cases where end consumers who depend 100% on the power grid experience outages. The reason could be downed trees or some other unforeseen event. Most consumers accept occasional cuts as this is compensated for by the relatively low price of electricity, but other consumers want the power to always be on, no matter what the cost.

In its decision of 3 July 2020, the Competition Authority approved the price of energy not served at 7287 EUR/ MWh, meaning that this is the value ascribed by the average consumer. Nevertheless, the price sensitivity of consumers is subjective and not all will necessarily put as much importance on the existence of electricity. If consumers want to depend less on the power grid and have a backup system to increase the security of supply, in Estonia's climate that means they should be prepared to make substantial investments. A personal system of solar panels and batteries ensure less consumer dependence on high electricity prices and less vulnerability to outages.

While it depends on the system's dimensions, the use of a personal solar panel will likely lead to situations where own demand is lower than the output, in which case the excess can be sold to the grid. The price of the electricity sold to the grid is at wholesale price, which may be significantly lower than the retail price ordinary consumers buy power at. This depends on each consumer's electricity plan. Besides smarter management of electricity bills, a battery system will increase security of supply, as in case of a power outage, power stored earlier can be used and electricity from solar generation can offer material support for essential procedures. The integration of solar panels and batteries will open many possibilities for consumers, TSOs and third parties, such as aggregators of many such systems. When aggregated, such small storage-ready generation units can improve resource adequacy at both the consumer and grid level.

Success stories

Successful examples of the functioning of such a system can be found in California and Australia, which of course have very favourable conditions for generating solar energy. Tesla has developed the Green Mountain Power (GMP) programme, where one aggregator has control over 1000 batteries and can use them – pursuant to terms of service – to offer flexibility or to better supply consumers. The GMP programme proved its usefulness in October 2019, when 115,000 homes were left without power in the state of Vermont in October 2019, but GMP participants continued to use electricity for an average of nine hours, some even over 80 hours.¹⁷

Market maturity

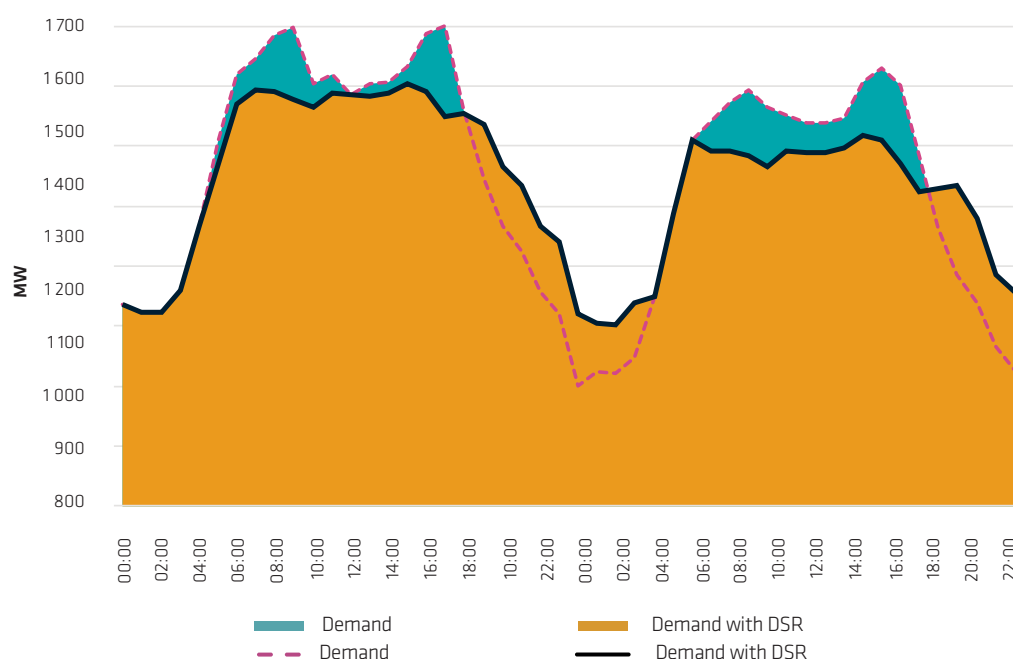
This is a mature technology and is also in use in Estonia. Depending on climate conditions, market rules and the stability of electricity prices, the profitability of the system varies greatly in different countries, which provides an opportunity for innovative business models. The aggregated model is in use in few places with favourable conditions, such as Australia and the US, but the subject is becoming more and more popular.

2.10.3 Demand side response – DSR

When it comes to the adequacy of the electricity system, the most critical points are peak demand when industry, ordinary consumes and weather-dependent demand profiles coincide. Usually, at least part of demand is of a nature that can be deferred or omitted. Today, this type of demand management is not common, because the volatility of electricity price is not that great, plus there are no convenient options for doing so from the standpoint of consumers. With the extensive adoption of IoT solutions, the creation of a special flexibility market and the rise of aggregators that units smaller consumers, it is possible to create supply for a flexibility market. Today's flexibility providers are major electricity consumers who are able to time their demand and thus offer services to the existing regulation market.

With a slightly different approach, ordinary consumers can also participate competitively with major consumers. In order for small consumers to be able to supply their own flexibility to the market, they should enter into an agreement with an aggregator, who combines their capabilities and can supply them jointly to the market. At that point, aggregated supply can be launched, by putting more or less load on consumers. Figure 4.18 illustrates the demand curve with and without DSR. Often, two demand peaks form during a given day: morning after waking up and evening meal preparation. Fortunately, these peaks are rather predictable and they can if necessary be flattened if DSR is activated. The new profile is represented in orange, where the load has been more evenly distributed over the course of a day.

Figure 4.18
Demand profile
with and without
flexibility



Success stories

One of the most notable companies engaged in projects pertaining to the flexibility market is NODES. NODES is an independent market operator that focuses specifically on addressing bottlenecks in the electricity system. The focus is on challenges related to adding renewable energy, decentralised production and consumers' variable profiles, and of course integration of flexible consumers.

To cite one of many projects: In 2019, in cooperation with Western Power Distribution and Smart Grid Consulting, NODES established a project called IntraFlex in the UK, the aim of which is to offer flexibility products for the day-ahead and within-day market. A challenge in its right is to do this without posing any disruption to the ordinary operation of the energy market. A recent summary of the IntraFlex project noted that the market created is operating efficiently, using the NODES flexibility platform. It has proved possible to align flexibility supply and demand at an acceptable speed – some bids within 10 minutes, while others take longer. Thus, the first phase of creating such a flexibility market was considered a success and the plan for the next phase (spring 2021) is to increase the volume of supply and to continue developing the platform and other key reference system.¹⁸

Market maturity

For Elering the technology and market model are mature enough to make noteworthy efforts into creating a flexibility market in our region. Specifically, Elering's efforts are detailed in chapter 2.4.2 on the INTERFACE project. Elering is one of the project partners leading the development of the regional market platform for flexibility services and demonstration of the solution. The goal is to create regional solutions for involving demand and production based flexibility for power markets. The goal of the INTERFACE flexibility services market platform is to pilot the market framework and flexibility services. After the successful pilot, the final goal is a functioning regional flexibility services market.

2.10.4 International Baltic offshore grid

Given the Nordic climate, wind energy has the greatest potential of any renewable energy source, but since there are many limitations on land in regard to wind conditions, protected infrastructure and residential districts, offshore wind farms are a promising solution. Expenses on maritime wind project development and connections are much higher than those on land-based wind farms, and this is also one reason why due to economy of scale, offshore wind farms are being planned with much greater capacity than on land. However, greater power output also poses challenges. First of all, electricity must be transported from offshore to consumers, and even if there is a submarine cable, the land network is not usually dimensioned for accepting multiple GW output from a single substation. There was not previously a need for such high generation-oriented capacities to use it. One possibility for reducing costly network connections is to establish a Baltic offshore grid where connections linking wind farms allow energy to be transported to several countries simultaneously. Such an international solution will create value not only for the broader market but for security of supply.

The Baltic Sea network is an energy network that connects the countries by the Baltic Sea and the offshore wind farms, which helps achieve the climate goals cost-effectively whilst guaranteeing security of supply. It will create preconditions for large-scale generation of wind energy, which in turn will increase long-term security of supply in Estonia and stimulate the Estonian economy. The Baltic offshore grid is a realistic way of fulfilling Estonia's renewable energy targets. Considering the restrictions stemming from the living and natural environment and national security on Estonian land areas, the most expedient approach will be to develop large-scale wind energy installations out at sea. A offshore grid will make Estonia more competitive as a location for development of market-based and climate-neutral energy generation.

Studies on offshore networks^{19,20,21,22} lay out various combinations of technical solutions for network infrastructure depending on the maturity and timeframe of technology, developing a Baltic offshore grid stage-by-stage. These stages are:

1. international connections from one point to another;
2. radial connections between offshore wind farms and land-based energy systems;
3. radial connections between multiple wind farms and substations, which are radially connected to land-based systems;
4. hybrid connections (international connection where a substation is located, to which offshore wind energy generation has been connected);
5. Baltic offshore grid – a meshed grid, i.e., multiple connected offshore substations, simultaneously connected with multiple countries.

The stage-by-stage approach also means that existing or planned radial wind farms could later be connected to the Baltic offshore grid. This will let these developments always connect, with the least restrictions, to the bidding area where the best price is being offered. The Baltic offshore grid allows a deficit associated with large-scale, fluctuating renewable energy generation along certain trajectories and in certain time periods to be avoided. In future, the network must be more flexible than it is now and allow energy to be transported from where it is least costly to generate and direct it to places where demand is highest.

The stages can also be seen as development stages toward creation of P2G plants, where in periods of plentiful generation, it would be wiser to turn electricity generated at sea into other energy media, allowing true integration of the energy sector. Generating energy in the form that offers greatest value added will also contribute to flexibility.

19 The North Seas Countries' Offshore Grid Initiative - https://www.benelux.int/files/1414/0923/4478/North_Seas_Grid_Study.pdf

20 Baltic InteGrid: towards a meshed offshore grid in the Baltic Sea

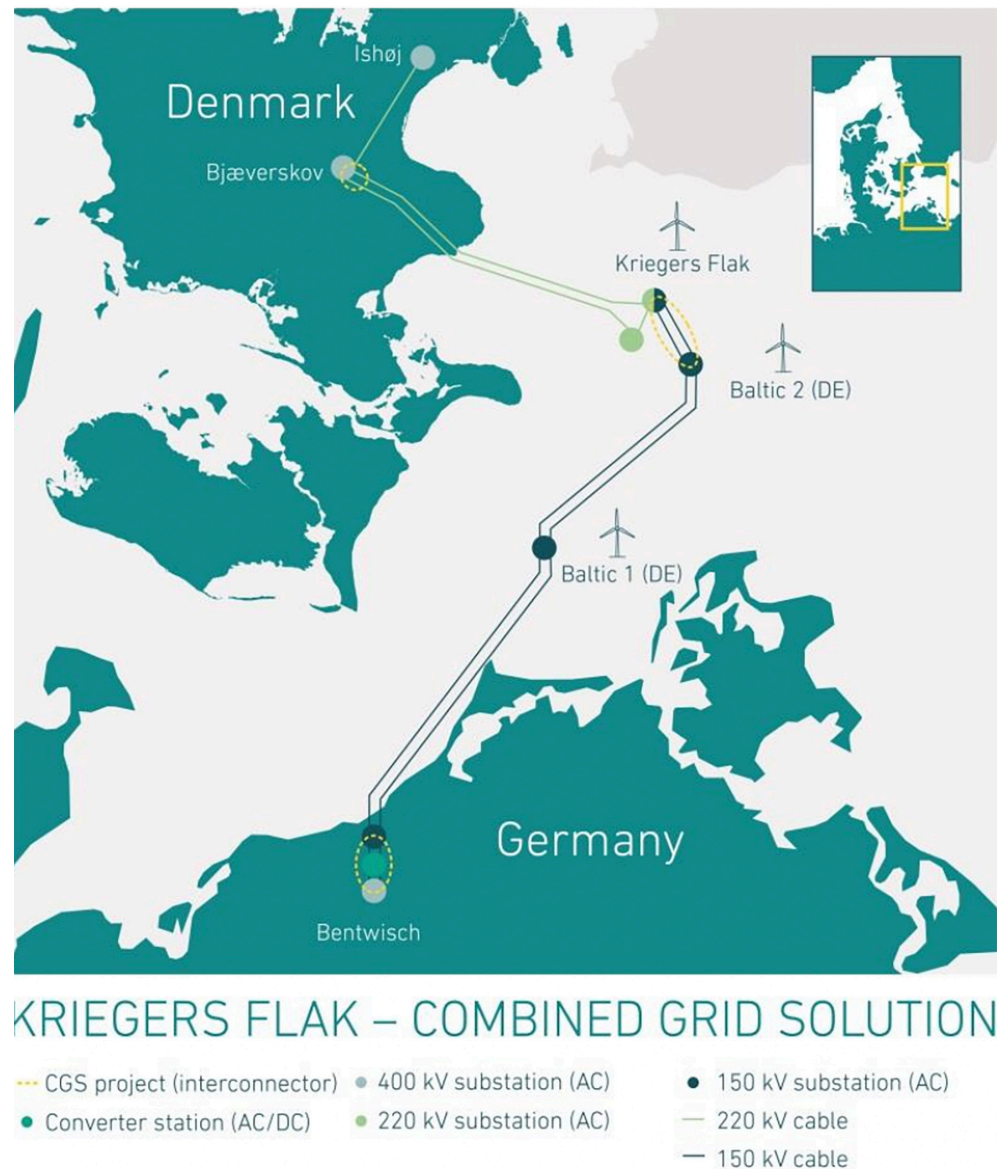
21 ENTSO-E TYNDP 2018; Regional Group Northern Seas Regional Investment Plan 2017 (RGNS RegIP17) ja Northern Seas Offshore Grid (NSOG) Report 2018

22 STUDY ON BALTIC OFFSHORE WIND ENERGY COOPERATION UNDER BEMIP Final Report

Success stories

The first wind farm to employ such a solution, KriegersFlak, is currently under construction and should be ready by the end of 2021. KriegersFlak is a 605 MW offshore wind farm located in the Baltic Sea between Denmark and Germany. Once it is connected, the connection will be through three wind farms: KriegersFlak, Baltic 1 and Baltic 2 (see Figure 4.19)

Figure 4.19
Maritime hybrid
network between
Denmark and
Germany²³



Market maturity

Estonia is one of the countries on the periphery of Europe. Estonia is located by a fairly narrow and shallow arm of the sea, allowing maritime connections to be established with, say, Sweden, Finland and Latvia. Discussions are under way with neighbouring system operators and ministries to define more precisely the interest and potential benefits from such a system for all stakeholders. To plan a joint Baltic offshore grid, Elering has proposed to the other TSOs that a memorandum of understanding for the Baltic Sea offshore network initiative be signed so that joint network connection studies and Baltic offshore grid feasibility studies be started.

The planned Baltic offshore grid would contribute to security of supply by establishing additional connections and generating capacities. The Baltic offshore grid would contribute directly to security of supply in the following ways:

- It would create additional networks and capacity facilities with neighbouring systems through Baltic offshore grid nodes through which electricity supply could be ensured in hours where there is not enough own generation and conventional import through existing links.
- The Baltic offshore grid integrates a large maritime area linking different wind farms in different parts of the Baltic Sea. The probability that electricity will be generated in this interlinked region is high enough to contribute to security of supply and this contribution could be relied on similarly to conventional power plants in planning security of supply in future. The more extensive the Baltic offshore grid, the greater its value to security of supply. Efficiently generated electricity will also flow through the Baltic offshore grid based on price signals to where it is needed the most.
- HVDC links are very reliable,²⁴ and the probability that two links will fail at the same time is exceedingly small. If the Baltic offshore grid becomes part of the transmission network, it will significantly increase the average reliability of the entire network.
- A parallel offshore network will make it possible to maintain the existing land-based network as during maintenance periods, part of the capacity flows can be diverted via the Baltic offshore grid.
- The closely meshed integration of the Estonian electricity system through a Baltic offshore grid with multiple connections will ensure that it has a positive impact on the security of supply of the Estonian electricity system if any connection to the offshore connection is interrupted.

In addition to ordinary transmission of capacity, DC connections can also be used to ensure stability of the system and for various urgent regulation reserves (in effect, integration with the offshore network is capable of offering the entire range of fast and ultrafast regulations).

Figure 4.20
The Baltic Offshore
Grid concept 2050²⁵

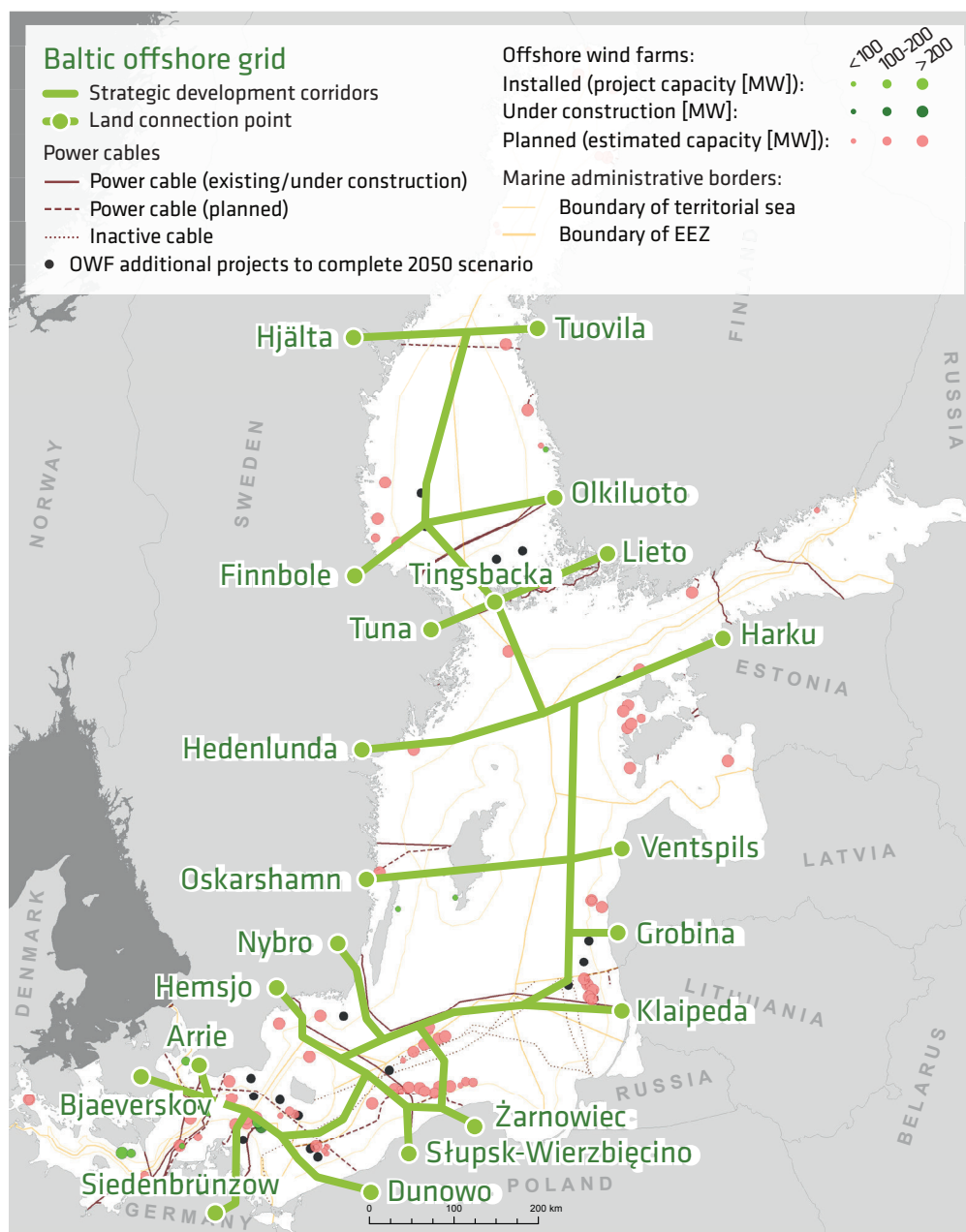


Figure 4.20 Baltic Offshore Grid Concept 2050 illustrates, to the best of current knowledge, what the international offshore grid would be like by 2050. Prospective offshore wind projects have been added to it as well.

