Estonian National Resource Adequacy Assessment 2023

Tallinn 2023

1 SUMMARY

1.1 Operational capabilities context

- *The Baltic electricity systems are ready for emergency synchronisation with Continental Europe if Russia unilaterally cuts us off from its electricity system.*
- *According to current plans, everything needed to manage the electricity system in a secure way will be ready for synchronisation in February 2025.*
- *The addition of renewable energy in the Estonian and Baltic electricity systems will increase the need for fast frequency reserves and new investments in flexible resources must be made.*
- *In order to ensure that Estonia has sufficient frequency reserves, Estonia is requesting a derogation from the European Commission for the long-term acquisition of reserves.*

The existence of the capability to manage the electricity system means that the electricity system withstands possible disruptions, the functioning of the system is planned in detail for the next day, the realtime management process is in place and there are sufficient reserve capacities. The generation capacity to manage the Estonian electricity system has been very good so far and there have been no interruptions to consumers due to management capability.

A major change in the management of the electricity system is linked to the connection of the Baltic states with the Continental European Synchronous Area (CESA). Currently Estonia and the other Baltic states are part of the frequency area controlled by Russia and the 50 Hz frequency is the key parameter of the electricity system. In order to reduce Russia's influence, it is essential to connect to the CESA in time, a plan which has been accelerated by the Baltic countries to February 2025.

The probability that the Baltic electricity system may be unilaterally cut off from the Russian electricity system has grown substantially. Elering, together with the Baltic TSOs, has been working on mitigating this risk, and an agreement has been reached with the Continental European TSOs to make it possible to extraordinarily connect to the Continental European system, even if all investments are not yet ready. This will ensure security of supply even in the event of a unilateral disconnection of the Baltic states by Russia. However, this would mean significantly higher costs for managing the system than today.

After synchronisation with the Continental European frequency area, Elering will use inertia as well as both automatic and manually activated reserve capacities – in other words, fast reserves. The local power plants must be capable of changing their production within seconds in order to ensure the balance of production and consumption in the system. For this purpose, the market of fast reserves will be created where market participants will be able to provide services to the system operators. According to analyses, , taking into account the new battery installations in Latvia and Lithuania and Elering's Kiisa emergency reserve power plant, there are sufficient units in the Baltic electricity system to provide the necessary reserves. According to proposed design, the TSO costs of acquiring the reserves, born by the balance providers.

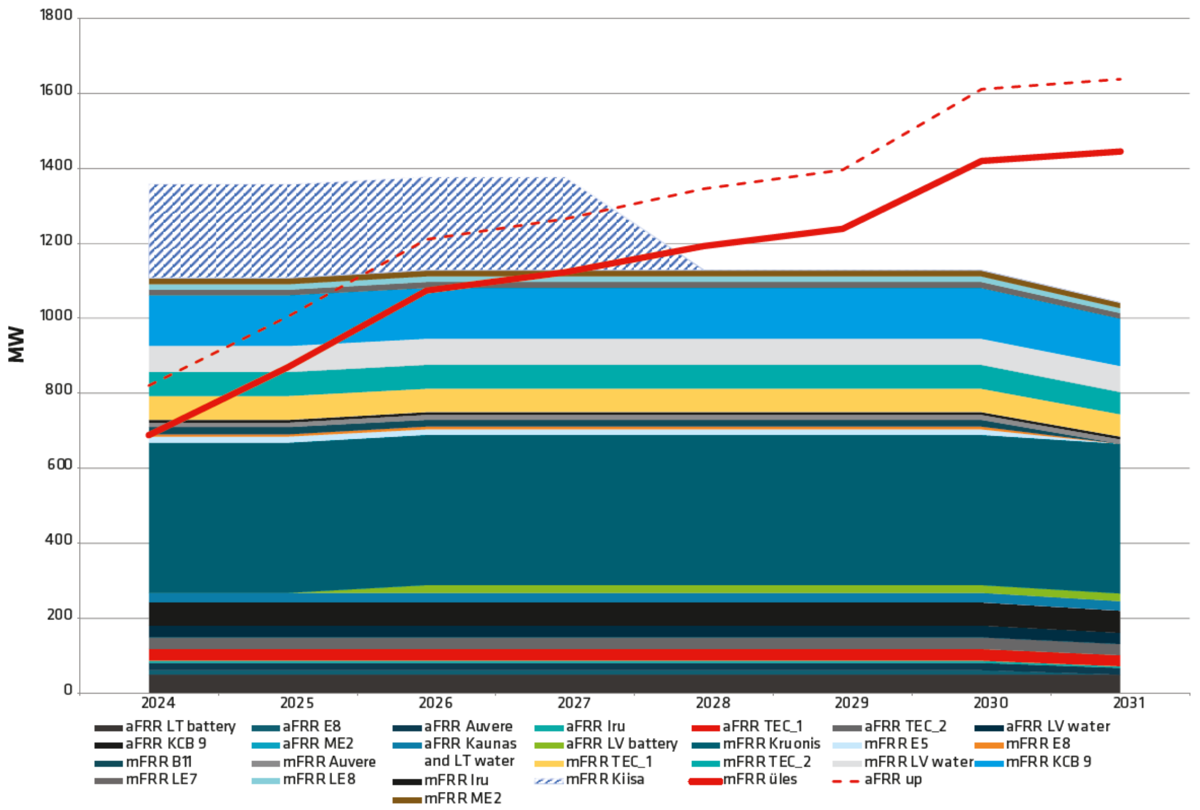

Figure 1.1 The need for upward regulation and available resources in the Baltics

The increase in renewable energy production will lead to an increase in the demand for fast reserves (Figure 1.1). This is due to an expected increase in generation forecast errors. As old dispatchable power plants are closed in the region, it means that investments in flexible resources providing frequency reserves are needed. In order to ensure the necessary investment in resources that provide the frequency reserves, which can cover emergencies over a longer period, the Baltic states are applying to the European Commission for a derogation that would allow them to acquire fast reserve capacity on a long-term basis. Such a solution would give investors greater investment certainty and ensure that frequency reserves are available in the future. Giving the Baltic states such an option is under discussion as part of the EU's electricity market reform. Preliminary estimates suggest that in the long term, there is a need to procure upwards of 250-400 MW of frequency reserves (aFRR and mFRR combined).

1.2 Resource adequacy

- *The security of supply for the coming winter is significantly better than that of last winter, as several risks have been mitigated.*
- *The electrification of different sectors has led to an increase in electricity consumption in Estonia and across Europe. Over the next 10 years, Estonia's annual electricity consumption will increase by nearly 2 TWh, and peak demand will grow by nearly 450 MW.*
- *Capacity mechanisms may need to be put in place in the medium term to ensure resource adequacy in the region. The 2027-2030 period will be particularly critical for the region, with consumption and demand for reserves growing rapidly but old power plants exiting the market.*
- *Estonia's reliability standard is fulfilled until 2027 by 1,000 MW of oil shale units kept in Narva. Analyses estimate that it is economically sustainable to keep four oil shale units on the market from 2027-2030. In 2030, only four blocks will no longer be enough and a capacity mechanism in the form of a strategic reserve will be needed. In 2033, the*

reliability standard will be exceeded, as Auvere is the only oil shale unit that will be left and, above all, there will be a shortage of automatic Frequency Restoration Reserve (aFRR) capacities.

- *If the level of dispatchable capacity in Estonia falls significantly below 1,000 MW, a strategic reserve will be introduced. Fast-ramping capacities that can provide automatic Frequency Restoration Reserve (aFRR) will be needed as of 2030.*

We consider electricity resource adequacy to constitute a situation where the expected electricity consumption is covered with the local generation, imports and consumption management possibilities.

Before last winter, there were a number of risks to the security of supply of the electricity system, many of which are much lower this winter. This allows us to face the coming winter (2023/2024) with much more confidence. Last year, the main risks were European and regional gas supply, the reliability of nuclear power plants (including the completion of Olkiluoto 3), hydropower conditions across Europe and the possibility of intentional damage to energy infrastructure. This year, European gas storage facilities are almost at full capacity in the run-up to winter, as is the case for the Incukalns gas storage facility in Latvia in our region. The outage of Balticconnector has reduced the number of supply channels but still makes it possible to cover consumption in the Baltic states as well as in Finland. Nuclear power plants across Europe are in better working order than last year. The new Olkiluoto 3 nuclear power plant, which is a very important element for our region, is now operating. Compared to last year, which was characterised by drought, the fill of reservoirs is better in the lead up to this winter. For example, the level of reservoirs in Nordic countries is about 10% better, which is more than Estonia's annual consumption. As a result of the better overall security of supply situation, we are also better prepared for a variety of possible events that may damage the infrastructure.

As in the previous year, Elering's long-term power resource adequacy analyses show that there is a risk of not meeting Estonia's Loss of Load Expectation (LOLE) from 2027 onwards. This means that after expiry of the owner's expectation in 2026, a further closure of the Narva oil shale units could lead to a shortfall in generation capacity or frequency reserves. In order to mitigate this risk, the establishment of the Estonian Strategic Reserve, for which a start was made regarding application for a state aid permit on the basis of last year's report, needs to be completed. Figure 1.2 illustrates LOLE in Estonia in a situation where uneconomic generation capacity has been closed in the Baltic states and investment in flexible consumption has increased. According to analyses, the Narva oil shale units – Estonian 5, Estonian 8, Balti 11 and Auvere – will remain on the market in Estonia in 2028 and 2030, ensuring security of supply in 2028. Estonia's reliability standard will be exceeded with current market-based resources also in 2030 and a strategic reserve will be needed. In the 2030+ perspective, as the Narva oil shale units reach the end of their technical lifetime, it will be important to add additional secure generation capacity capable of providing automatic frequency restoration reserves. Notably, despite the opening of trade at the Lithuania-Poland border in 2032, the capacity of the Estonian system remains below the standard. If such generation capacities are not added on a market basis, state aid measures must be taken to help create new capacities. In this case, it is also important to ensure that the capacities are future-proof, i.e. that certain capacities must be ready to use climate-neutral fuels.

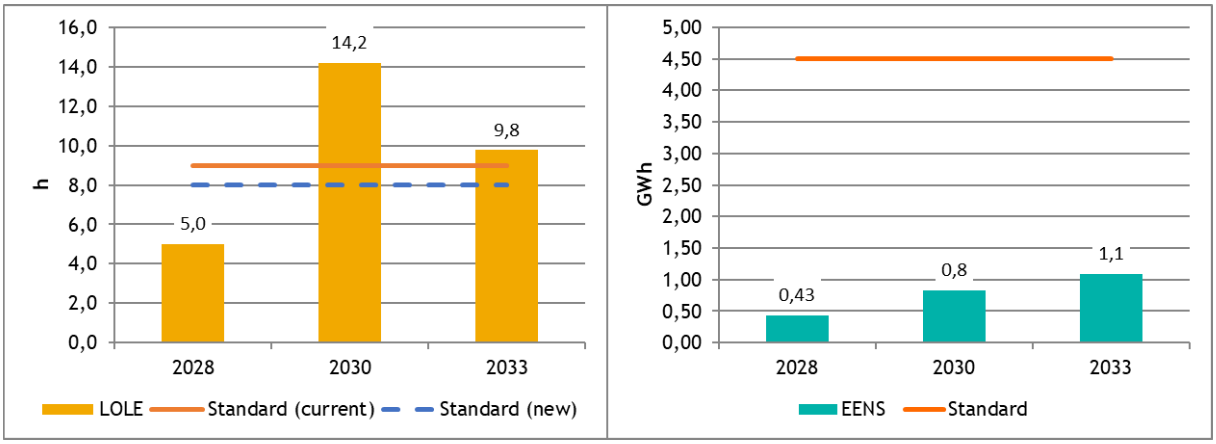

Figure 1.2 Average LOLE and EENS numbers in the baseline scenario of the Estonian resource adequacy assessment

2 Resource adequacy

2.1 DEFINITION OF RESOURCE ADEQUACY AND HOW TO ENSURE IT

In the electricity system, production and consumption must be balanced at all moments. To maintain the balance economically and ecologically, problems that come up must be anticipated long in advance and action taken so that the electricity system guarantees enough resources to cover demand. This is illustrated by Figure 2.1. The capacity of the electricity system must look several years ahead in order to make sure that the domestic electricity production, storage, import capacity and flexibility capacity are sufficient for covering consumption in different situations.

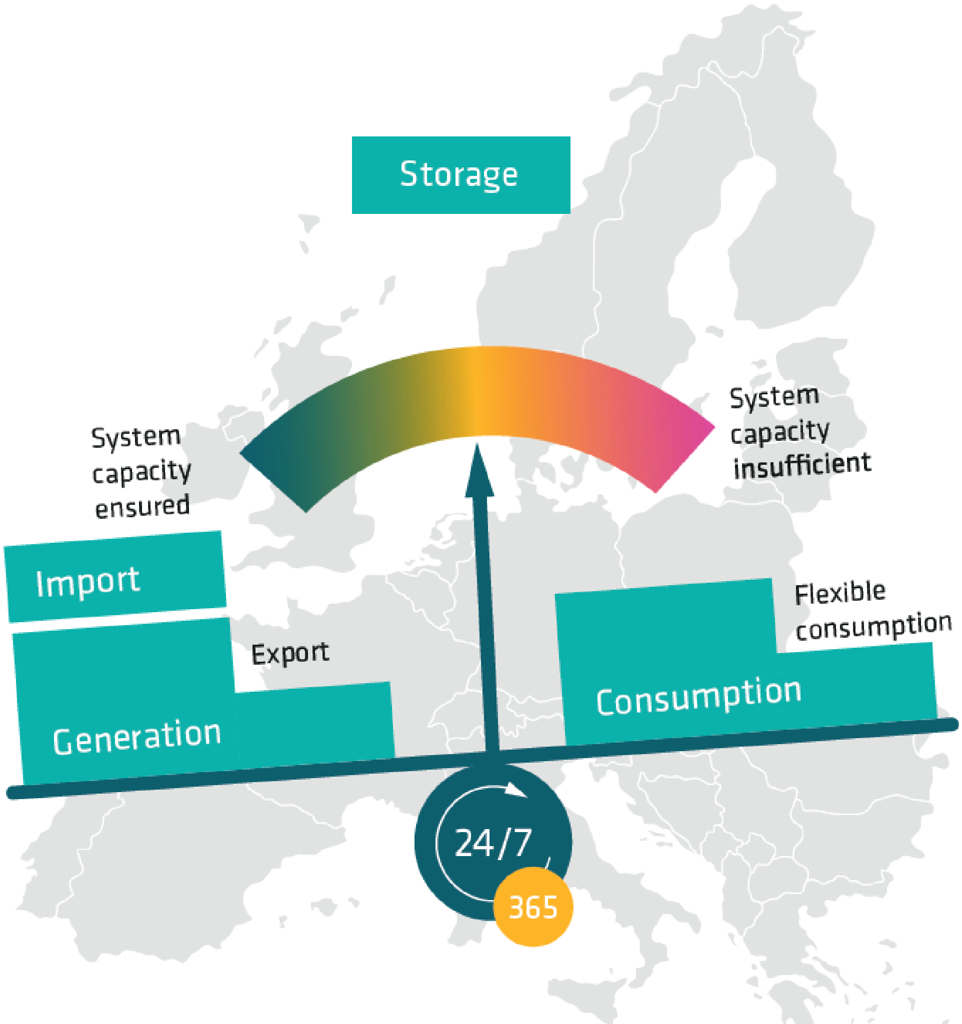

Figure 2.1 Components and balance of long-term resource adequacy

There are three significant stages for ensuring the adequacy of the electricity system:

- Establishing a reliability standard (see 2.2) pursuant to the balance between energy not supplied and investment costs on new capacities
- Evaluating the long-term electricity resource adequacy (see 2.3.1 for methodology and detailed results for countries in the Baltic Sea region);
- If the long-term assessment of the electricity system shows higher levels of resource adequacy than the reliability standard, the resource adequacy is guaranteed. If the assessment shows that the situation is worse in future than the standard allows, the European Commission guidelines require that if all market disruptions are eliminated, a capacity mechanism can be announced as last resort (see 2.3 for more details).

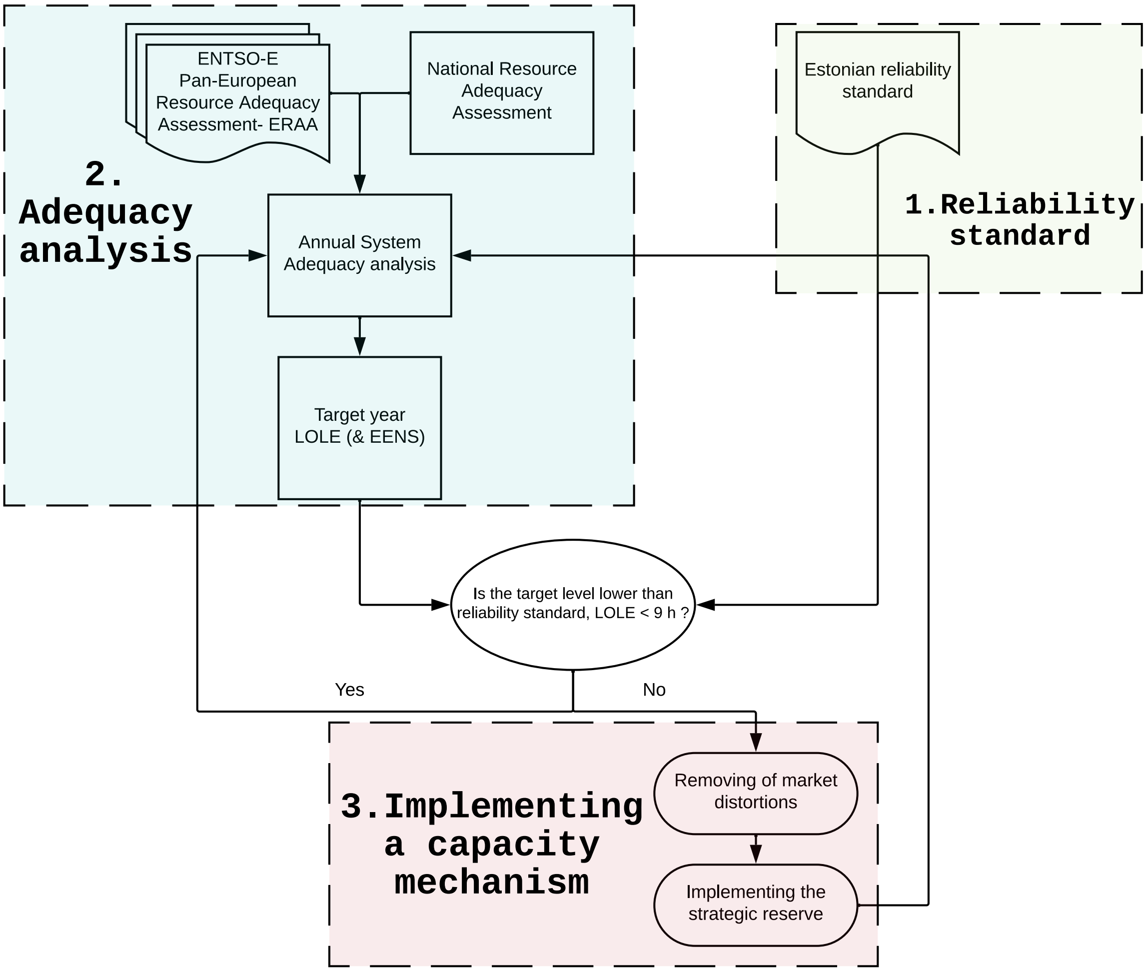

Figure 2.2 Stages of ensuring resource adequacy

Figure 2.2 shows the different stages in which the resource adequacy assessment is annually conducted. The reliability standard was established in spring 2021 (and is reviewed in 2024- referred to as “new” reliability standard)). The implementation of the capacity mechanism takes place when the capacity no longer meets the standard.

The price of electricity is not analysed as part of the resource adequacy. The affordability of energy is indisputably an element of energy policy. For example, the World Energy Council (WEC) describes energy policy as a trilemma (Figure 4.3). Security of supply, affordability and environmental sustainability are parts of this trilemma. The affordability of energy is not regarded as a component of security of supply but as a separate element of energy policy. The same approach is used in Estonian and European legislation, according to which Elering assesses security of supply. Methodologies for assessing security of supply and, more narrowly, resource adequacy do not analyse the price of energy as a component. On the European single energy market, the price of energy is emerged in the conditions of a competitive free market. European rules prohibit countries from intervening in the electricity market (granting state aid) except in justified cases (proven security of supply problem), all market failures removed and where a state aid is authorised. On a free market, however, it is important to make sure that there is fair competition, or in other words, that the behaviour of market participants is monitored by market operators and regulators (in Estonia, Nord Pool and the Estonian Competition Authority). In the context of a free market, the need to help the most vulnerable consumer groups in terms of the affordability of energy, for example through subsidies during periods of exceptionally high prices, is not excluded.

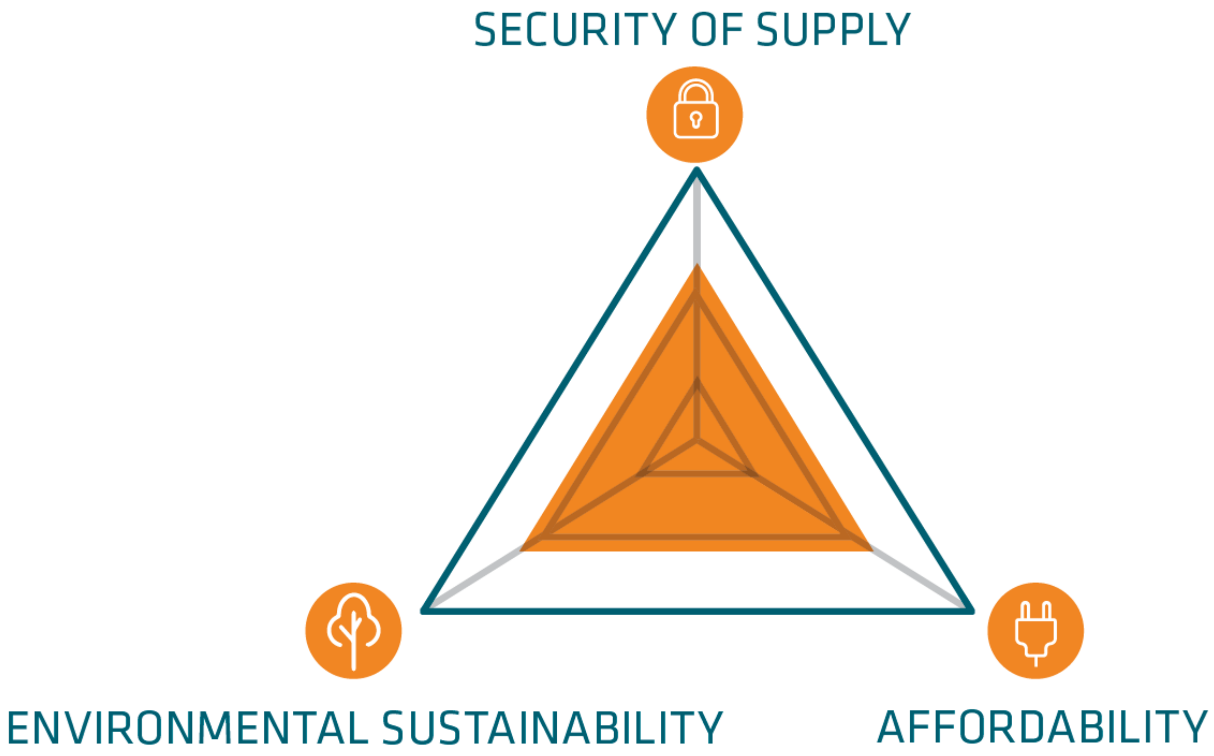

Figure 2.3 Energy Trilemma – World Energy Council (WEC)

2.2 ESTONIAN RELIABILITY STANDARD

The European Internal Electricity Market Regulation requires all countries that want to apply for the implementation of a capacity mechanism in the event of a resource adequacy problem to first establish a national reliability standard in line with the common European methodology approved by ACER. With the standard, each Member State determines the acceptable level of the adequacy of their electricity system, and the results of the analysis on the capacity of the electricity system are compared to it. If the conducted analysis indicates that the resource adequacy situation is worse than permitted by the standard, the member state may apply for permission for state aid from the European Commission and establish, once granted permission, the capacity mechanism in the state. The capacity mechanism is essentially state aid to electricity producers or for demand side response in order to render them able to offer their capacity at the required moments.

Pursuant to the regulation, the reliability standard is expressed through two parameters: Loss of Load Expectation (LOLE) and Expected Energy not supplied (EENS). The parameters used for determining the reliability standard are the Value of Lost Load (VOLL), unit [EUR/MWh], and the levelized Cost of New Entry (CONE), unit [EUR/MW]. CONE is based on standard technologies, which are the most likely production capacities added on a market basis. Detailed explanations and values for the above parameters can be found in the study on reliability standard[1].

The formula which is used to determine the optimal LOLE standard is the following:

$$LOLE_{standard}(h) = \frac{CONE\ (€/MW)}{VOLL\ (€/MWh)}$$

[1] https://elering.ee/sites/default/files/2021-10/Varustuskindluse%20standard_2.pdf

2.2.1 Established reliability standard from 2021-2024

In Estonia, the optimum security of supply level for LOLE was established at nine hours per year on average by the Government in May 2021. That means that it is less costly for society to allow there to be some hours where demand cannot be completely covered by the market than to build additional generation capacity for just those hours. Should these hours exceed more than nine, the cost to society is higher than investments on new capacity, and therefore adding new capacity is socio-economically justified. Annual analyses and special scenarios of the resource adequacy are assessed according to the aforementioned standard.

If there are deviations in the optimal nine hours, society will bear higher costs. Figure 2.4 shows to what extent annual costs will grow for society if the reliability standard were other than optimal. If more capacities were added in the desire to reduce LOLE to, say, three hours (the reliability standard in Poland, the UK and France), society would pay close to three million euros more per year in Estonian conditions.

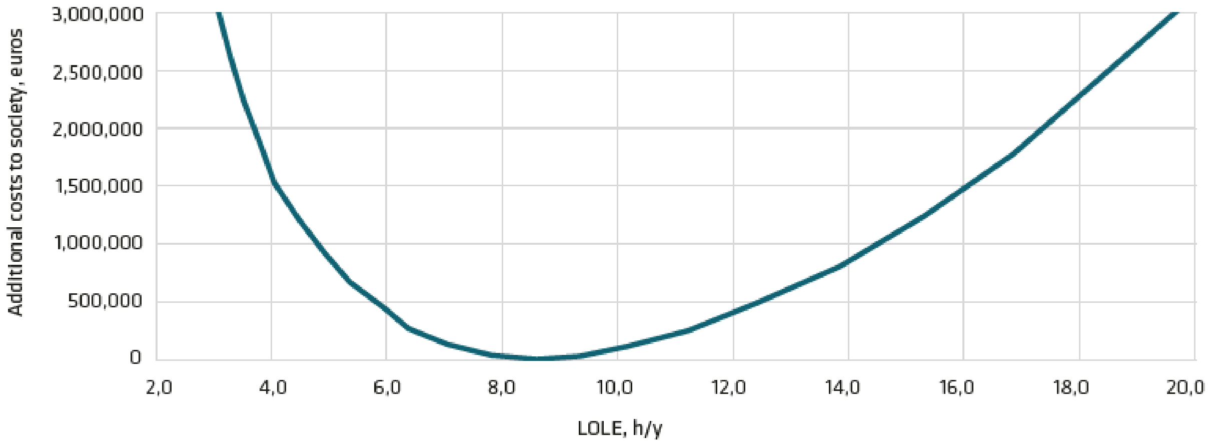

Figure 2.4 Socioeconomic cost curve pursuant to LOLE level

In 2020 the value of lost load was established to be 7287 €/MWh in Estonia. The most likely entry to the Estonian network was found to be an open cycle gas turbine, which was considered to be the most cost-effective standard technology for Estonia. The levelized cost would be in the range of 44-82 €/kW, with the average value, which was established as CONE at 62€/kW. According to the formula in the previous chapter the reliability standard LOLE was found by:

$$LOLE_{standard}(h) = \frac{62\ 000\ (€/MW)}{7287\ (€/MWh)} = 8{,}51\ h \approx 9\ h$$

These calculations were performed before the ACER's methodology for calculating reliability standard and its components was approved. This means that there are a few differences in the methodology, most significantly in the determining of VOLL as it was not found after performing interviews with various consumer classes.

2.2.2 New reliability standard from 2024

In the time of writing the Elering's Security of Supply Report 2023 including also the Estonian NRAA report, the Estonian Competition Authority is in the last stages of getting approval for updating the VOLL, CONE and reliability standard for Estonia following the ACER's guidelines and methodology to determine the values. The calculations have been performed, and it is expected that the new CONE will be open cycle gas turbine and be made up of two parts:

- CONE_fixed =72,9 k€/MW

- CONE_variable =108,8 €/MWh

The expected new VOLL will be 9206,4 €/MWh and this would make the new reliability standard LOLE to be 8 hours (by decreasing the previous value by one hour).

2.3 CONCEPT OF STRATEGIC RESERVE

In a situation where the reliability standard is not met, state aid measures may be implemented to ensure adequate capacities. Problems of resource adequacy come up for Estonia if due to extraordinary events, a peak consumption period has coincided with low local output and multi-dimensional extraordinary events in the power grid. When analysing the Estonian system, the event with the biggest consequence is the unexpected outage of cross-border connections due to the high capacity of such elements. In this situation, it would be unable to import electricity from other electricity systems. The most suitable solution to this kind of potential problem, as shown by the study on the most suitable capacity mechanism design for Estonia [2], is a strategic reserve.

A strategic reserve is a type of capacity mechanism where, on the pre-established conditions, the production capacity of electricity (or capacity for reducing consumption) is acquired for a limited period of time separate from the remainder of the electricity market. Due to the fact that the capacity is not participating in any of the electricity market timeframes (day-ahead, intraday or reserves market) as the strategic reserve resources in the measure are to be held outside the energy markets for at least the duration of the contractual period, the strategic reserve does not affect the prices on the electricity market. When launching the strategic reserve, the price on the electricity market will remain the same as it would be without the strategic reserve. The strategic reserve will only be launched in extraordinary instances when there is an actual hazard in the electricity system that the market is unable to ensure the reserves required for consumption and the security of supply of the system as transmission system operator is likely to exhaust their balancing resources to establish an equilibrium between demand and supply. The balancing energy is priced according to the rules of the balancing market, either at the maximum price of the balancing market or at least at a price higher than the price of the energy not served or the maximum intraday electricity market price. By its nature and by the qualification criteria, the strategic reserve is a mechanism targeted at a certain resource adequacy issue that helps keep the costs required for managing the mechanism lower than a capacity mechanism that exceeds the market requirements.

The major fault in other types of capacity mechanisms is that they can also constantly participate in other electricity markets and the receipt of capacity mechanism payments distorts the normal market price and competition in the electricity market. Market disruptions created by a cross-market capacity mechanism may in turn disrupt the creation of new market-based production capacities and accelerate the closure of other capacities not receiving capacity mechanism payments, including in neighbouring countries.

A strategic reserve is seen by the European Commission as the measure that has the least impact on the unregulated electricity market and is thus most compatible with the requirements and rules, provided that a definite need exists for such a market intervention. Pursuant to the Regulation on the internal market for electricity of the European Parliament, member states must analyse whether the capacity mechanism, by means of being the strategic reserve, would resolve the issue of the resource adequacy of the member state, and only if the strategic reserve is unable to do so is it possible to take into use alternative types of capacity mechanisms. In the case of Estonia, there are currently no grounds on which to consider that the creation of a strategic reserve would not be sufficient for resolving any potential problems in resource adequacy.

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[2] https://elering.ee/sites/default/files/2021-10/V%C3%B5imsusmehhanismi%20uuring_0.pdf

In spring 2022, Elering conducted a public consultation[3] on the strategic reserve strategy, during which the vision of the rules governing the strategic reserve were introduced to market participants and feedback was elicited from them. By now, the concept of a strategic reserve has been submitted to the Ministry of Climate and the Competition Authority.

In December 2023 Elering conducted an analysis[4] of potential impact of Estonian strategic reserve on neighboring countries and run public consultation with stakeholders (including Finland, Latvia and Lithuania). Analysis did not identify the impact of the strategic reserve on neighboring countries.

Table 2.1 Areas of responsibility in ensuring security of supply

Activity	Responsible party	Status
1. Identification of the problem reliability standard	Elering	December 2022 and 2023
2. Notifying the European Commission of a possible capacity shortage	Ministry of Climate	TBD
3. Carrying out a national security of supply analysis, if necessary	Elering	December 2023
4. Preparation of market failure analysis	Estonian Competition Authority	December 2023
5. Issue of state aid clearance for capacity mechanism	European Commission	TBD
6. Proposal for concept of capacity mechanism	Ministry of Climate	TBD
7. Analysis of potential impact of capacity mechanism on neighbours and public consultation	Elering	December 2023
8. Development of detailed plan of capacity mechanism and public consultation	Elering	TBD
9. Approval of detailed plan of capacity mechanism	Estonian Competition Authority	TBD
10. Possible amendments to legislation	Ministry of Climate	TBD
11. Pre-qualification of potential service providers	Elering	TBD
12. Carrying out public procurement and awarding contracts to successful tenderer(s)	Elering	TBD

2.3.1 Characteristics and technical requirements from capacity in strategic reserve

Pursuant to Article 22 of EU Regulation 2019/943, more general requirements have been set for the type of capacity mechanism to be used and more specific requirements have been specified for each type of mechanism potentially implemented. All electricity producers, storage facilities, as well as electricity consumption through consumption management measures that meet the requirements set out below, are eligible to participate in the reverse auction for the procurement of the capacity mechanism. The aim of the requirements is to ensure transparency, market-based nature, decision making through competitive processes and to minimize any additional market distortions. Specifically, any capacity mechanisms, regardless of their type, must comply with the following conditions (Article 22(1)):

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[3] https://elering.ee/loppenud-konsultatsioonid?page=2#tab2052

[4] https://www.elering.ee/en/public-consultation-impact-analysis-planned-strategic-reserve-neighboring-countries

- be temporary;
- not create undue market distortions and not limit cross-zonal trade;
- not go beyond what is necessary to address the adequacy concerns;
- select capacity providers by means of a transparent, non-discriminatory and competitive process;
- provide incentives for capacity providers to be available in times of expected system stress;
- ensure that the remuneration is determined through the competitive process;
- set out the technical conditions for the participation of capacity providers in advance of the selection process;
- be open to participation of all resources that are capable of providing the required technical performance, including energy storage and demand side management;
- apply appropriate penalties to capacity providers that are not available in times of system stress.

As mentioned, the strategic reserve must enable participation of both net electricity producers (like conventional power plants), and limited energy resources(LER), like energy storages and demand side response. In the document Concept of Strategic Reserve, there are two sets of technical requirements after the possible adequacy related situation it is expected to address:

- most likely and most serious risk would be when a similar long-term outage would take place, similar to what is happening with Estlink 2 in 2024. In such a situation strategic reserve, made up mostly of net producers are expected to work longer periods at the time, as a significant resource in the terms of import is reduced. It has been concluded that in such a situation support from strategic reserve might be needed for up to 380 consecutive hours.
- Second likely situation is where during the winter a cold spell would temporarily increase the peak demand during morning or evening peak hours where demand exceeds supply. For such a situation the energy storage and/or demand side response would be suitable solutions. It has been concluded that such peaks would normally last around two hours and would require the strategic reserve to be ready for another activation after a six hour period, which would correspond to time window between the morning and evening peak hours.

The reason why two products were differentiated was to also allow the participation of LERs in the strategic reserve. The volume of each product in the final strategic reserve capacity will most likely change.

2.4 RESOURCE ADEQUACY ASSESSMENT

Elering assesses the adequacy of the Estonian electricity system according to the diagram in Figure 2.2 and by applying different methodologies. The analysis can be divided into four parts:

1. In accordance with the European Internal Market Regulation, the European Resource Adequacy Assessment (ERAA) can be viewed as the first stage of the assessment of the resource adequacy level, as it takes into account the trends, assumptions and economic viability required at European level.

2. The regional analysis complies with the rules of the National Resource Adequacy Assessment (NRAA) and analyses in more detail the specificities and sensitivities relevant for the Baltic states. The most important addition compared to the ERAA is the more detailed modelling of the Baltic system services market, which has a significant impact on the adequacy of the Estonian system. The NRAA uses the economic viability results of the ERAA as input and adds further detail. It is also used as a ‘reference scenario’ in sensitivity analyses.

3. Sensitivity analysis – if ERAA and NRAA find the level of resource adequacy against the assumptions made in different years, the sensitivity analysis will find the amount of capacity needed for Estonia in the more critical years to ensure the resource adequacy at the limit of the LOLE.

    - If the reference scenario analysis shows that the resource adequacy does not meet the reliability standard, then sensitivity analysis will determine how big the shortage of dispatchable capacity is.
    - If the level of the resource adequacy of refence scenario is higher than the reliability standard, then it is determined how much dispatchable capacity is the minimum quantity required to keep the system's capacity level within the scope of the standard.
4. Analysis of additional scenarios by the deterministic method because one of the presumptions for the foregoing parts was a functioning European electricity market, but potential black-swan events are not taken into account. Elering also analyses additional business continuity scenarios.

The main advantage of the probabilistic analysis (Chapters 2.4.3 and 2.4.4) is that it looks at a wide range of situations – consumption profiles are created that need to be covered by different power plant generation profiles and imports. Possible emergencies at both generation units and on transmission lines are thereby also taken into account. As major electricity systems such as Germany, Norway, Sweden, Poland have a significant impact on the Estonian electricity market, the minimum geographical view for probabilistic analyses is at least the Baltic Sea area countries.

The deterministic analysis (Chapters 2.4.5 to 2.4.8.4) looks at a single forecast peak demand situation and assesses what capacity is available at that point and to what extent, essentially the 'most critical moment'. In such a peak demand situation, Finland, Latvia and Lithuania (3B+FI, i.e. the three Baltic States plus Finland) will have the greatest impact on the level of capacity of the Estonian system, as we are most closely connected to them.

The main parameters of this methodology are peak consumption, available production capacity and maximum import capacity. It is important to note that with the increasing share of renewable energy and the development of an electricity system based on flexibility, it is becoming increasingly difficult to get a realistic overview of the system's capacity by looking at just one peak hour per year. Notably, the hour with the highest consumption may not be the most critical for the resource adequacy due to the unpredictability of renewable energy generation. The deterministic approach also requires making a lot of assumptions based on the past behavior of market participants, but the operation of the electricity system in the future will be very different from that in the past and the decisions of market participants are difficult to predict. The growth of flexibility and storage means that planning for the 'most critical moment' becomes increasingly inaccurate.

2.4.1 Reasoning why NRAA is performed in addition to ERAA

ERAA with its Pan-European scope is a very valuable resource to any TSO, who is able to utilize the commonly developed methodology, models and insight. The amount of research that goes into introducing details in the modelling and even developing the software for such tasks is impressive. The complexity of these models is simultaneously the strongest and weakest point of such a process as some assumptions differ between regions and centrally modelling all the specific details of them is currently not feasible. This is where a NRAA must be performed on top of the ERAA.

Estonia (and the Baltics) have several unique aspects which require a regional approach:

- The Baltics is currently in the middle of one of the biggest changes an electricity system can be- it is desynchoronizing from the IPS/UPS synchronous area and synchronizing with the CESA system. This brings uncertainty, new markets, risks and opportunities for all stakeholders. However, accurately modelling the economics within such a volatile system is very complex and instead of a single reference scenario or base case, several other sensitivity analyses must also be modelled to be prepared for when some of underlying assumptions change.
- The Baltic load frequency control block will have a much higher ratio of reserve needs to cover peak demand than most other countries/regions. Therefore, the Baltic states are going to share reserves also across the borders, while reserving some of the interconnector capacity for reserves market to ensure that reserves held in other countries would still reach the designated country if necessary. A large portion of the reserve needs is coming from the need

to prepare for the outage of the largest elements- the HVDC links, Nordbalt and Estlink 2, which are on either side of the Baltics. Modelling the reserve dispatch has a significant impact on the resource adequacy, especially as the units that are required to provide both reserves and cover electricity demand at the same time.

- The Baltics is a comparatively small LFC block compared to others, and this means that every unit and resource has a significant impact to resource adequacy, this means that the behavior and even bidding strategies of individual assets must be modelled in greater detail than in ERAA.
- Estonia has historically relied on burning oil shale for its main source of power production. Even now, over 80% of installed thermal capacity is using oil shale technology and is owned by state owned incumbent. Considering the climate goals and general trend of decarbonization most of this old oil-shale capacity is quickly becoming non-profitable and is unable to compete in the energy-only market. Furthermore, most of the units are not able to receive revenue from an important emerging reserves market to level the playing field with renewable sources due to low ramping speed. Caused by the increase of peak demand and reserve needs there is also increasing need for dispatchable capacity. Currently there are no mature projects which can replace the oil shale for the task of providing power during the dark and cold periods in the winter where solar PV and wind power are not enough.
    - Estonia is the only country in Europe that uses oil shale technology, which disqualifies it as a “standard” technology. As a TSO, Elering has information which is necessary for the modelling of the technology, however, giving the same detailed information to the Pan-European modelling is not allowed as it could be easily traced back to specific power plants and operator. In many of the cost-related assumptions default values for coal power plants are used instead to comply with data confidentiality agreements. In the NRAA, Elering does not have the same limitation and much more details can be introduced into the model.
    - The operator of most of the oil shale capacity has notified Elering of their intent to take capacity off the market much earlier than the ERAA economic viability analysis suggested. Based on the operators information currently already 60% of the capacity is operating on a loss, and furthermore some of the units need additional investments to remain operational.

Having a regional level model means that the geographical scope, and with it the computational weight, of the simulation model can be reduced, which opens the ability to perform more sensitivity analyses with a shorter running time without losing accuracy on the results.

2.4.2 Key assumptions in resource adequacy assessments

This chapter outlines the key assumptions used in the resource adequacy assessment for the Estonian (and Baltic) electricity system. Elering is conservative in its assumptions, which means that in the analyses we only consider the generation capacity that is most likely to be available in the year under analysis. Table 2.2 and Figure 2.5 explain the key assumptions in the assessments of Elering and ENTSO-E resource adequacy.

Table 2.2 Key assumptions in security of supply analyses

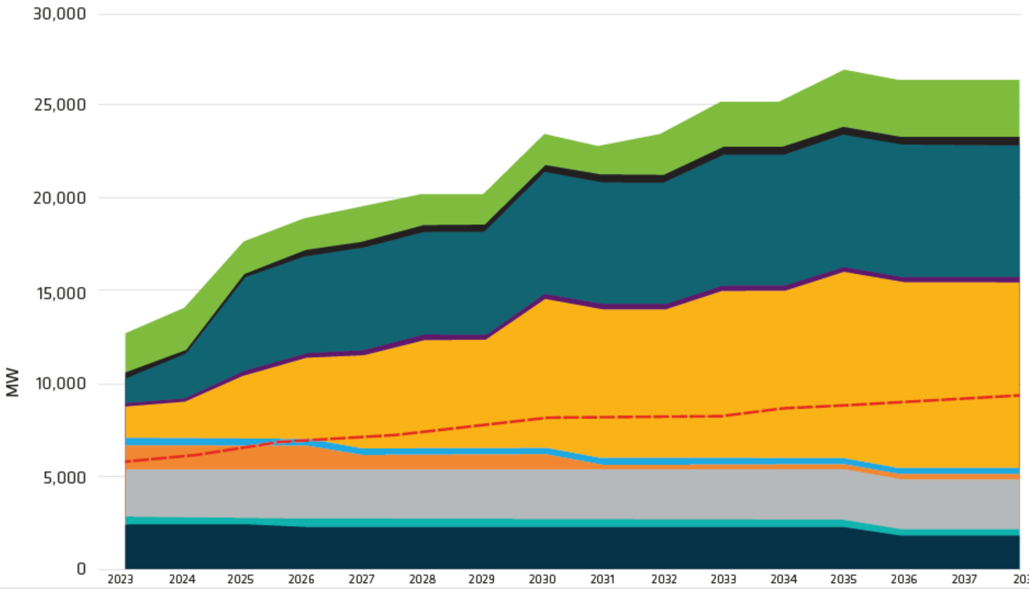
Variable	Time	Description	Comment
Estlink 3	• In ERAA analysis 2033 • In NRAA and deter-ministic analyses 203	HVDC connection between Estonia and Finland 700 MW	At the time of collecting the input data for the ERAA analysis (spring 2023), the best knowledge was that the connection would be completed in 2033, which was later updated to 2035.

Harmony link	• In ERAA analysis 2030 • In NRAA analysis and deterministic analyses 2032	HVDC connection between Lithuania and Poland 700 MW	At the time of collecting the input data for the ERAA analysis (spring 2023), the best knowledge was that the connection would be completed in 2030. The expected realisation was later updated to 2032.
Narva oil shale power plants		The baseline scenario was based on the manufac-turer's forecast of the capacity available on the market in different years.	The profitability of the plants is checked as part of the ERAA economic viability analysis.
Wind energy developments		Conservative wind energy growth. The first offshore wind farm will be added in 2035	
Pump hydro power plants-	-	Not included in the analysis	Two pump hydro plants are under development in Estonia. As there is no certainty as to when the plants will be completed, they have not been taken into account in the analysis.
Storage	-	Not included in the analysis.	Several battery plant projects are under development in Estonia. As there is no certainty as to when the batteries will be completed, they have not been taken into account in the analysis.
Estonia-Latvia 4th interconnector	In ERAA analysis 2032 In NRAA analysis and deterministic analyses 2035		At the time of collecting the input data for the ERAA analysis (spring 2023), the best knowledge was that the cable will come in 2032, which was later updated to 2035.

There are clearly emerging trends in electricity systems across Europe:

- Rapid growth in consumption (both total and peak)
- Rapid growth in non-dispatchable renewable energy generation capacity
- Closure of fossil fuel power plants

The total generation capacities (including renewable), consumption forecast figures and trends for the Baltic states can be found in the figure below (Figure 2.5), which is the baseline scenario for the assessments. The quantity of capacities installed and resources used (including electricity from renewable sources) exceeds peak demand many times and there should be no problem with annual electricity generation. As generation capacities based on renewable energy are not always definitely available and as will be shown in the following chapters, the Baltic system will need a large quantity of dispatchable generation capacities.



	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Baltic import capacity	2216	2216	1716	1716	1716	1716	1716	1716	1716	2416	2416	2416	3116	3116	3116	3116
Flexibility	260	277,5	295	350,5	332	350,5	369	387,5	400	412,5	425	437,5	450	450	450	450
Solar PV	1332	2385	4997	5220	5560	5560	5560	6570	6570	6570	7080	7080	7120	7120	7120	7120
Grid scale batteries	200	200	280	280	280	280	280	280	280	280	280	280	280	280	280	280
Wind	1726	1990	3400	4387	5037	5841	5841	8031	8031	8031	9051	9051	10051	10051	10051	10051
Waste, other	338	335	344	342	340	340	340	340	340	340	340	340	340	340	340	340
Oil shale	1330	1330	1330	1330	831	831	831	831	272	272	272	272	272	272	272	272
Water	2554	2554	2554	2664	2664	2664	2664	2664	2664	2664	2664	2664	2664	2664	2664	2664
Biomass	379	384	389	394	399	404	409	424	424	424	424	424	423	402	381	381
Gas	2498	2498	2498	2350	2350	2350	2350	2350	2350	2350	2350	2350	2350	1840	1840	1840
Peak consumption and demand for reserves in the Baltics	5917	6203	6681	7029	7222	7437	7849	8287	8331	8350	8350	8793	8972	9151	9330	9509

Gas, Waste, other, Flexibility, Biomass, Wind, Baltic import capacity, Water, Grid scale batteries, Peak consumption and demand for reserves in the Baltics, Oil shale, Solar PV

Figure 2.5 Installed generation capacities, flexible demand assets and peak demand in the Baltic electricity system

2.4.3 Pan-European resource adequacy assessment

ENTSO-E in cooperation with Elering and the other European TSOs compiles a European Resource Adequacy Assessment (ERAA) every year. This time (2023), the resource adequacy assessment goes up to 2033 and the results include the indicators for resource adequacy indicators for all European countries in the years 2025, 2028, 2030 and 2033.
The analyses of the respective years are based on the data set out in the national energy and climate plans to be submitted by all EU countries, the best knowledge of the TSOs of the generation capacities existing in the respective year and transmission capacities between countries, consumption forecasts and historical climate data. According to ERAA methodology, the simulation model calculates which power plants are economically sustainable. You can see the methodology on the ENTSO-E website[5].
Europe has many power plants that in conditions of growing fuel prices and ambitious climate goals are no longer able to cover their fixed costs with revenue from the energy-only market. There are also countries that have underinvested in their electricity systems and the model finds capacities with the necessary properties for these regions – storage in the form of batteries, flexible consumption or gas power plants may turn out to be the optimal technologies. Elering uses the ENTSO-E ERAA results as a starting point for preparing the Estonian NRAA in order to gain an even better overview of the situation ahead.
ERAA's results are based on the system capability parameters LOLE and EENS. Figure 2.6 shows the

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[5] https://www.entsoe.eu/outlooks/eraa/2023/report/ERAA_2023_Annex_2_Methodology.pdf

result of number of hours of limited service where:

- Estonia's consumption figures are based on the assumptions described in Chapter 4.5;
- generation capacity development is shown in aggregated form in Figure 4.5, but in line with the ERAA methodology, in addition to the market actors and national climate targets, an Economic Viability Assessment (EVA) has been carried out and it is assumed that unprofitable plants have exited the market and investments in new resources have been added.
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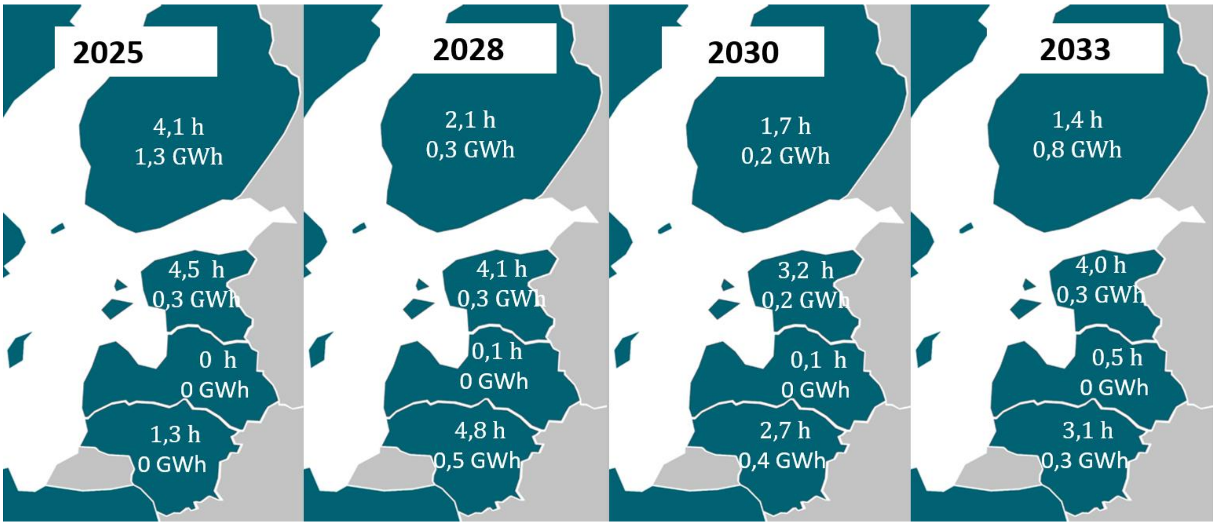


Figure 2.6 Average LOLE and EENS numbers in the region from ERAA 2023

The assumptions considered in the above figure (Figure 4.6) are that the following decisions have been made in the Baltic states and Finland, in addition to the baseline scenario as a result of the economic viability assessment:

- 2025 – Estonia will reduce the capacity of oil shale units by 420 MW; Finland will convert 240 MW of coal capacity to a conserved state and invest in 120 MW of flexible consumption; Lithuania will reduce older gas-fired capacity by 90 MW.
- 2028 — according to the baseline scenario
- 2030 — according to the baseline scenario
- 2033 – Latvia will reduce gas-fired capacity by 270 MW, Finland will reduce gas-fired capacity by 960 MW and coal-fired capacity by 620 MW.

According to the ERAA results, Finland is the only country in the region that will not meet its reliability standard LOLE in 2025 and 2028, which is one of the lowest in Europe – the average LOLE per year is 2.1. As market-based measures will have solved the problem by 2030, a capacity mechanism would be needed in Finland to improve resource adequacy, based on the current results. The security of supply levels in the other neighbouring countries in the region are within the limits of the national standard and the ERAA resolution did not identify any further resource adequacy issues. Similar to Estonia, TSOs in other countries can prepare an NRAA for their region to check the level of resource adequacy also under region-specific, more detailed assumptions.

Last year's ERAA2022 showed an average LOLE of 9.7 per year for Estonia in 2027, which exceeds the Estonia reliability standard by 0,7. Assessments suggest that this result would occur in a situation where none of the Narva units are economically sustainable. Compared to ERAA2022, there are some changes in both the input data and the survey methodology that specify these trends this year. As described in Table 4.2, one major variable has been the year of completion of the Poland-Lithuania interconnection Harmony Link. At the time the ERAA2022 was prepared, the best knowledge was that it would be completed by 2026 and would better connect the Baltic electricity system with Central Europe. A better connection with external markets brought down the prices in the Estonian price area in the 2022 ERAA and, in conclusion, the Narva units would not be competitive on the market. According to the assumptions in ERAA2023, Harmony Link will be added in 2030, which means that until then, the Baltic region will be less connected to its neighbours and prices in the region will be higher as a result. In such a situation, the Narva plants are more likely to remain competitive and to be able to keep resource adequacy below the reliability standard. The high sensitivity of Estonia's electricity supply to both project realisation as well as small changes in the methodology for assessing resource adequacy confirms that attention to detail is essential and that delays in any project can have a major impact.

2.4.4 Estonian National Resource Adequacy Assessment

For NRAA purposes it is necessary to model at least the three Baltic states and Finland. The national assessment uses the ERAA models and insight described in the previous chapter, but some changes were made to enable a more robust and flexible model, which can address the region-specific uncertainties. In addition to the reference scenario, it was decided that several sensitivity analyses needed to be performed to account for the uncertainties around decommissioning plans of most impactful oil-shale units.

2.4.4.1 Methodology

The NRAA simulation uses the ERAA economic viability assessment as input (see Figure 3.1) , but the model differs due to the following changes:

Reserve modelling
A more detailed modelling of the procurement of frequency reserves which follows the Baltic LFC block concept document. FCR, aFRR and mFRR (up and down) requirements added for each country (a total of 15 requirements for maintaining reserves) and the possibility to offer reserve capacities across the Baltics. Each powerplant has a maximum reserve procurement limitation for each of reserve types which comes from their ramping speeds and other plant specifications.

The reserves are shared across the borders, meaning that the Baltic power plants can offer reserves in all three Baltic countries and the model will decide which units, to what extent are covering demand and reserves. This also means that interconnector capacities will be divided between energy trade and reserve procurement. Such an approach increases the cross-border capacities between the countries that the model is able to use for the optimal least-cost algorithm. In ERAA each country had to hold their own proportional part of the Baltic reserve needs and as there was no exchange of reserves over the borders, the NTC-s were manually reduced to account for the possibility of enough reserves reaching the countries from the neighbors and not allowing the day-ahead market to use all of transmission capacity on the lines.

Currently there are no limiting constraints to the model on what is the maximum percentage of NTC capacity that can be reserved for ancillary services, the optimization model will decide what is the most optimal distribution of reserves across the units and cross-border capacities. In reality the limitation on how much of the interconnector capacity can be reserved for ancillary services is set by market-based allocation process allocating the XB capacity (up to 50% of internal Baltic borders may be used for reserves). In the case that the TSO's demand for reserve capacity is not covered and can be covered by NTC, up to 70% of the NTC may be used for reserves).

The participation of batteries in the Baltics was reviewed with the objective that their offers in the ancillary market would be realistic. In the model there is no activation of reserves and thus no way the batteries to lose charge if they only participate in the reserve market- it meant that the bids must be small enough to enable for the battery to charge itself in the intraday market. It was considered that the realistic bid size (MW) would be 25% of the battery capacity (MWh).

Reduced geographical scope
One major simplification to the ERAA model is that instead of modelling all European countries and neighbouring third countries with a more significant impact, the NRAA only assesses the region that has the most significant impact on Estonia. The calculation of Pan-European models is very time-consuming and resource-intensive but most of it will not affect the adequacy parameter levels in Estonia. The explicitly modelled bidding zones in the NRAA are all in the Baltic Sea area, namely Estonia, Latvia, Lithuania, Poland, Germany (with offshore market zones), Denmark (with offshore market zones), Norway, Sweden and Finland.

It is important to note that in the reduced model, the non-modelled countries connected to Germany, Denmark, Poland and Norway are considered as fixed flows, these flows were taken from results of the ERAA simulations. In the model, the contribution of non-modelled neighbouring countries to the system's capacity has been replaced by the calculated maximum flows generated from previous simulations that can be imported from these countries to prevent a shortfall.

Updated input data
The production capacities of market participants related to the modelling of reserve markets have been specified. The Lithuanian gas power plants (Lithuanian power plant units 7 and 8 –510 MW) have been taken into account in the assessment.

- The schedules for high-impact projects were updated, as they became available after the collection of input data for the ERAA2023 (see Table 2.2). The most significant changes compared to assessments from previous years:
  - Postponement of the completion of the Lithuania-Poland Harmony Link from 2027 to 2032.
  - Completion of Estlink 3 and the Estonia-Latvia 4 hybrid interconnector (with a 1 GW offshore wind farm) in 2035.

2.4.4.2 Reference scenario results

When comparing the resource adequacy parameters for Estonia shown on Figure 2.6 and Figure 2.7, it can be seen that a more detailed implementation of reserve markets according to the conditions of the Baltic LFC block and the postponement of Harmony link, create significantly more LOLE in Estonia even in the baseline scenario. As a result of the regional simulations, the LOLE numbers in Estonia will almost double in 2028 from 2.6 to 5 hours, and in 2030 the LOLE numbers will increase from 1.9 to 14.2 hours, also exceeding the reliability standard. In 2033, the LOLE numbers will increase from 0.9 to 9.8 hours, exceeding the reliability standard. A significant difference between the ERAA and NRAA stems from the changing schedules of major projects, with any change having a negative impact on resource adequacy. There is enough time until 2033 for market players to respond adequately and find the best solution to compete in an energy market with a high share of renewable energy.

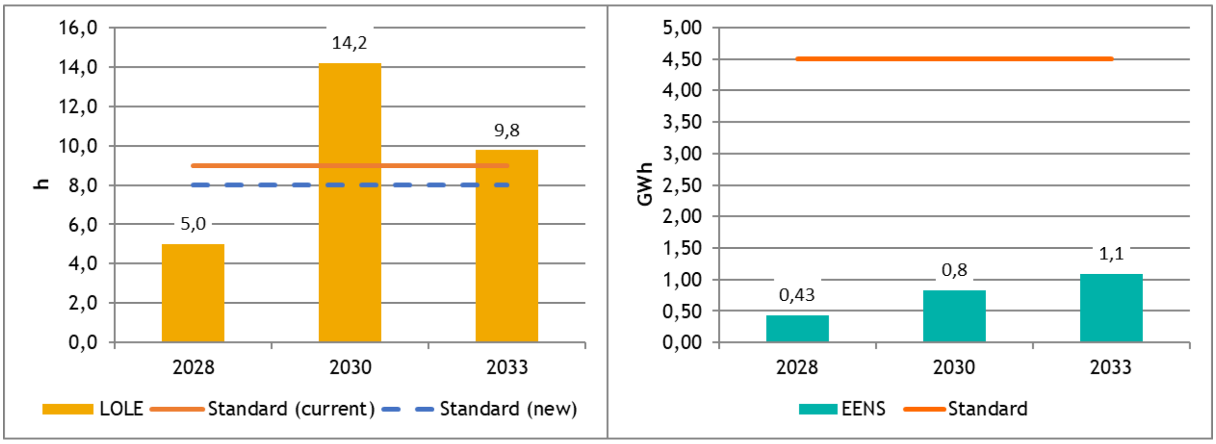


Figure 2.7 Average LOLE and EENS numbers in the baseline scenario of the Estonian resource adequacy assessment

On the figure there are two different reliability standard values as explained in 2.2.2.

2.4.4.3 Sensitivity analysis results

Additional sensitivity analyses were carried out to determine the required amount of dispatchable capacity in Estonia to meet the reliability standard. No sensitivity analysis was carried out until the end of 2026, as the owner's (State) expectations for Eesti Energia (owner of the oil-shale generation) are that Estonia's domestic dispatchable generation capacity of at least 1,000 MW will be guaranteed until the end of 2026, regardless of the water level in the Narva River and reservoir, except during the routine maintenance and repairs or emergency repairs. At the same time, capacities of at least 900 MW will be stored in the cold reserve from 1 November to 28 February and at least 600 MW from 1 March to 31 October[6].

Furthermore, as Eesti Energia has notified Elering of the intention to take many units offline much earlier than initially expected due to economic reasons, means the sensitivity analysis will show what is the minimum capacity that is needed to comply with the reliability standard.

While Figure 2.7 assumed in the baseline scenario for 2028 that there would be 1,100 MW of dispatchable capacity on the market, some of which would be cogeneration plants, the sensitivity analysis in Figure 2.8 showed 831 MW of dispatchable capacity on the market, and the LOLE numbers came close to the standard (and exceeding the expected new 2024 standard). Based on this, it can be concluded that some 1,000 MW of dispatchable capacity would be required in 2028 to ensure security of supply.

In particular, due to the postponement of the Lithuania-Poland interconnection (Harmony Link), the 2030 resource adequacy does not meet the reliability standard. By adding 250 MW of generation capacity to Estonia (corresponds to the capacity of the Kiisa Emergency Reserve Power Plant, which is not included in the analysis in the baseline scenario), the resource adequacy complies with the reliability standard. Based on this, it can be concluded that in 2030, Estonia would need about 800 MW of oil shale units and 250 MW of additional generation capacity in addition to the existing smaller power plants to ensure security of supply.

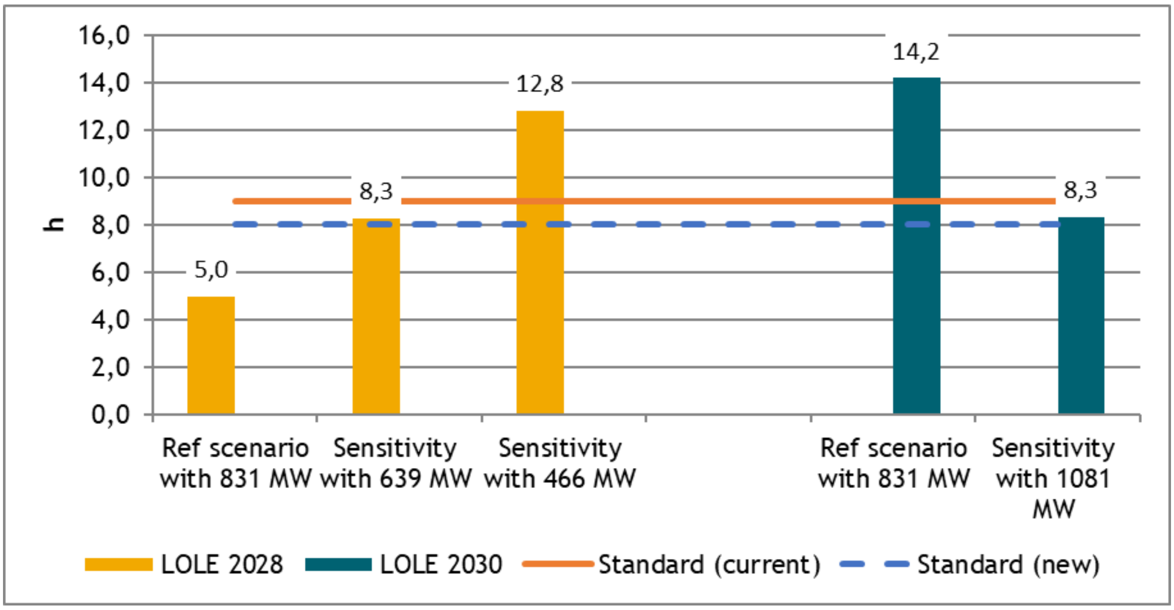


Figure 2.8 Average LOLE of Estonia with sensitivity analyses

6 https://fin.ee/riigihanked-riigiabi-osalused/riigi-osalused/rahandusministeeriumi-valitsetavad-uhingud#eesti-energia-as

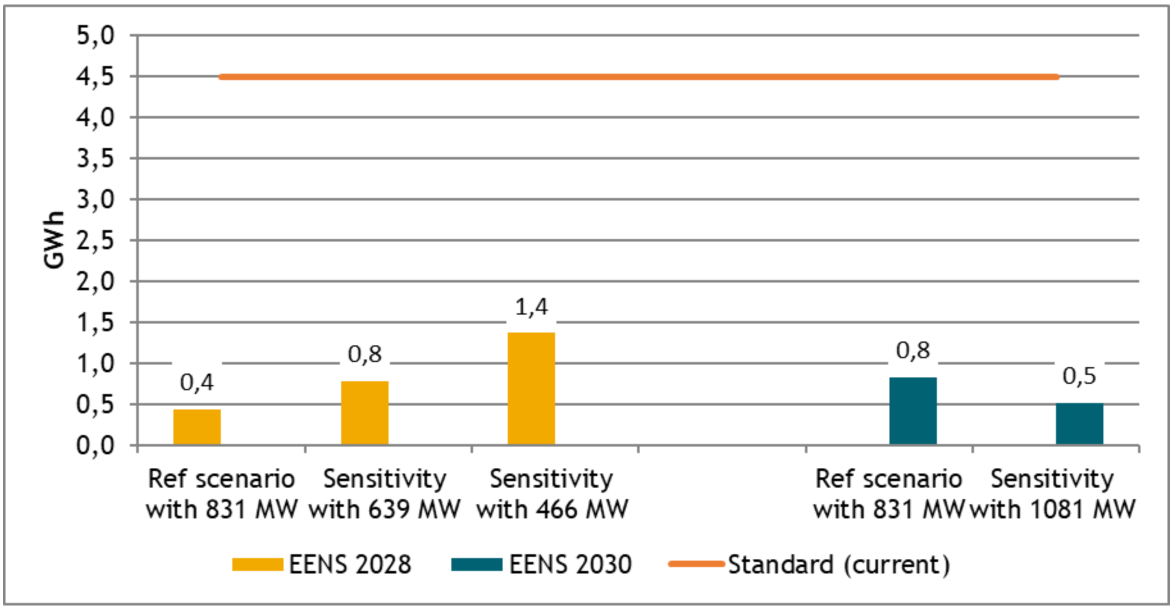


Figure 2.9 Average EENS values of Estonia with sensitivity analyses

According to ERAA and NRAA, Estonia will need to maintain around 1,000 MW of dispatchable capacity to ensure security of supply in 2028. As the owner's expectation for the Narva oil shale power plants expires at the end of 2026, the risk concerning capacity adequacy arises in 2027. Therefore, it is important to be ready to implement the strategic reserve in Estonia as early as in 2027. From 2030 onwards, additional dispatchable generation capacity will be needed in the region to replace old capacities exiting the market and to provide fast reserves in the context of growing renewable energy generation. At this point, it is worth recalling that these simulations were carried out with conservative renewable energy growth; if Estonia is able to meet the goals of Estonian Renewable Energy 100%, then it would have a positive effect on resource adequacy.

2.4.5 Deterministic analysis of the resource adequacy of the region

The deterministic analysis methodology visually compares the expected available generation and transmission capacities in the countries under study with the projected peak electricity demand and the required amount of reserves. The advantages of this methodology are its simplicity and annual resolution.

The analysis anticipates the functioning of a single electricity market as a whole. As of the start of 2025, the analysis takes into account the synchronisation of the Baltic countries with the Central European electricity system. The expectations of production capacities are based on the data presented by the electricity producers and the assessment of the system operator, taking into consideration the climate policy objectives and developments in the field of renewable energy.

More detailed presumptions:

- The generation capacity for wind used during peak loads in Baltics and Finland up to 2027 is 7% of installed capacity and starting from 2027 it will be 8%. According to estimates, this is firm generation from wind farms and is available at all times. The growth stems from the fact that the wider the area in which generation capacities are deployed, the greater the probability that if the wind is blowing somewhere; in addition, new added capacities are more efficient.
- Solar energy has not been factored in for covering peak hours.
- Pursuant to the owner's expectations, Estonian oil shale capacities will be at least 1000 MW until the end of 2026 and thereafter according to the forecast submitted by the manufacturer.
- Flexible consumers are capable of reducing their consumption during peak hours. Flexible consumption volume has been estimated based on price sensitivity of consumption during the

periods with high prices in 2021 and 2022. In the following graph, it has been added as a generation unit to better convey the size visually, but in reality, it would actually decrease of peak consumption by increasing flexible consumption.

- Synchronisation has taken place according to the updated plan in early 2025.
- The Harmony link is delayed and is expected to be completed in 2032. No trade takes place on the Lithuanian and Poland AC connection from 2025-2032; the line is set aside for reserves.
- 'Other' capacities comprise the production capacities of smaller electricity generators. (For example, biomass, waste incineration and fuel oil plants.)
- Hydro power plants generally do not generate during peak hours at their maximum installed capacity and therefore 50%, 24% and 77% were used as the installed capacity for Lithuanian, Latvian and Finnish hydro power plants.
- Batteries are estimated to contribute 25% of their capacity. Storage will most likely participate in the reserve market, and based on Elering's analysis, this is a realistic quantity in which market participants would offer reserves.

In the figure below (Figure 2.10), it can be seen that the Baltic and Finnish regions are heavily dependent on import capacity throughout the period to cover peak consumption with their own reserves. Without international connections with Sweden, Poland and Norway, the peak consumption of Finland and the Baltics would not be covered. The most critical period for the region will be 2027-2030, when the shortfall at the peak moment will be up to 465 MW (in 2029). The most important variables within this range would be:

- Three years after synchronizing with CESA, the possibility to offer upregulation reserves with the Kiisa emergency power plant will end, which will reduce the available resources by 250 MW;
- the Lithuania-Poland transmission line Harmony Link, which was previously due to be completed in 2026, has been delayed. This 700 MW of import would have been sufficient to cover the deficit;
- at the end of 2026, the owner's expectation that Eesti Energia will keep the Narva oil shale units, which are important for Estonia, will end, which lead to their closure;
- consumption and the quantity of reserves held will grow faster than the amount of new firm capacities;
- In 2031, the situation will be alleviated by the addition of the new Finland-Sweden transmission line Aurora line 2.

In the figure, the generation capacities of the hydro power plants are shown as lined areas, as in the actual peak hour the contribution may be significantly higher depending on the situation, but the more conservative assumption mentioned earlier is used here. Finnish consumption potential is also lined to draw attention to the fact that the electricity system will become much more flexible in future. The natural resource consumption decrease depends on the price of electricity formed during peak hour, the weather patterns and the length of the high demand period, but the entirety of the resources will have likely been implemented before the TSOs impose constraints on consumption.

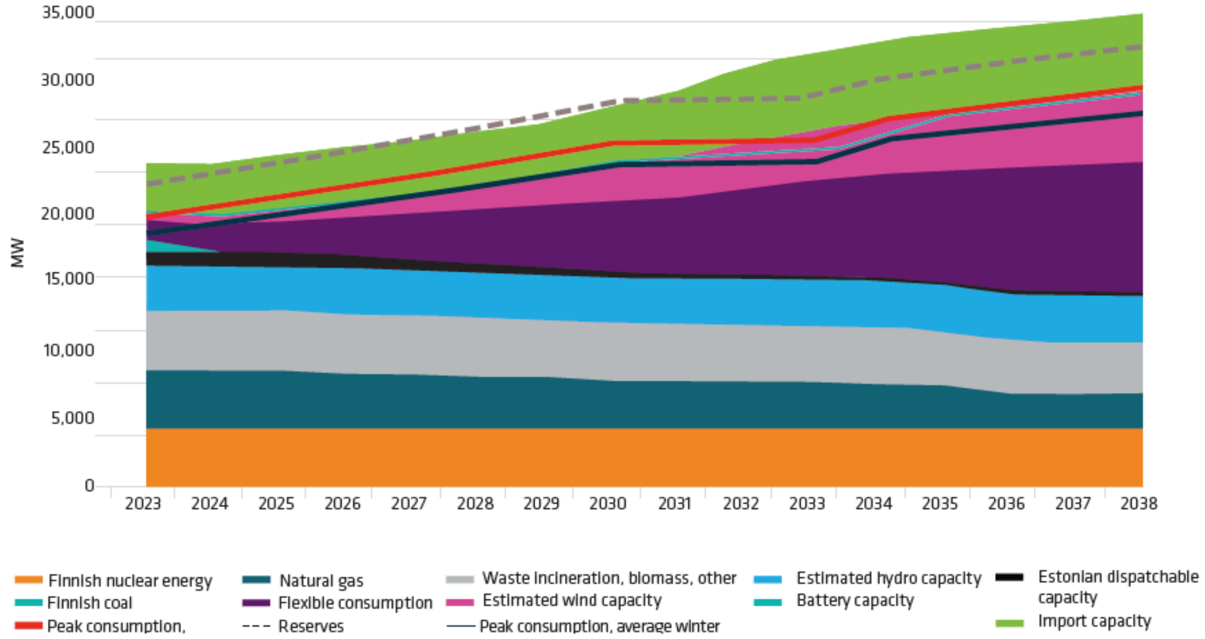


Figure 2.10 Available capacities in the Baltics and Finland 2023-2038

When assessing security of supply, Elering takes into account the different possible outages in the system. Figure 2.10 presents a deterministic analysis of a situation where the first and second element in the Baltic and Finland region are not available, i.e. an N-2 situation has occurred.

Compared to the situation presented in Figure 2.11, the following additional assumptions are taken into account for N-2:

- The largest elements loss is taken into account: the Olkiluoto-3 (1,600 MW) and Olkiluoto 2 (890 MW) nuclear power plants in Finland.
- Should the capacity of Olkiluoto 3 be unavailable, the constraint on the Sweden-Finland border will disappear and import capacity will increase by 300 MW. Consumption will also decrease by 300 MW, which was previously agreed with Finnish consumers.
- Finland uses the reserves held in gas stations to balance the system, which are triggered in an N-2 situation, and therefore the demand for reserves in the 3B+FI region has decreased. As both N-2 emergencies will occur in Finland and the Baltic states still need to keep reserves to cover the emergencies, the amount of reserves held in the Baltic States will not change.

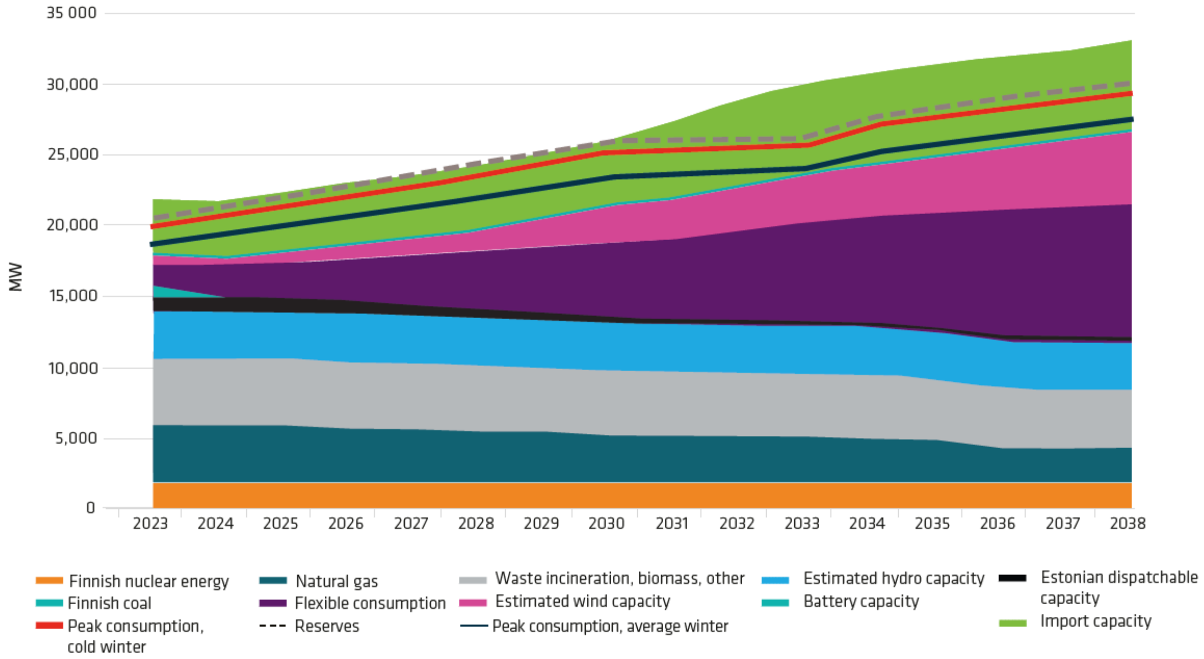


Figure 2.11 Available capacities in the Baltics and Finland 2023-2038 under N-2 situation

In an N-2 situation, the peak shortfall is identified only in 2029 against the four previous years. The improvement of the situation is the result of an agreement with Finnish consumers that consumption will be reduced by 300 MW in the case of such an emergency and that Finland will no longer keep reserves.

As a summary of the region's deterministic analysis, the region needs investments into either generation units or technologies that shift consumption, such as flexible consumers and batteries, in order to reduce its dependence on imports. Investments into wind and solar capacities will make an important contribution to cover peak consumption, but in terms of their variable generation cycle, this is lower than the contribution made by dispatchable generation. From the standpoint of planning the capability of the electricity system, more weather-independent solutions like thermal power plants, storage capacity or consumption management would be required.

2.4.6 Deterministic analysis of the resource adequacy of Estonia

The resource adequacy situation of Estonian in winter from 2023-2038 (Figure 2.11) shows that Estonia will need electricity imports from neighbouring countries to meet peak demand each year. According to consumption forecasts, the winter peak consumption 15 years from now will increase to 2,187 MW, which is around 30% higher than the peak forecasted for 2023, 1,514 MW. Along with a reserve of 10% of generation adequacy, the peak consumption in 2038 would be 2,406 MW. According to the data provided by electricity generators and the forecasts of Elering, the installed market-based dispatchable generation capacity will amount to ca 873 MW in 2030 and ca 346 MW in 2038, plus the Kiisa emergency reserve power plant and possible strategic reserve.

There will be an N-2 situation in Estonia until 2035, with Estlink 2 and one of the three Estonia-Latvia transmission lines down. After 2035, Estlink 2 and Estlink 3 will be in an N-2 situation. When the synchronization with the Continental European frequency area takes place in early 2025, Estonia will have 1,200 MW of interconnections in an N-2 situation, and with the realisation of the new international connections – Estonia-Latvia 4 and Estlink 3 – Estonia's import capacity will increase to 2,616 MW.

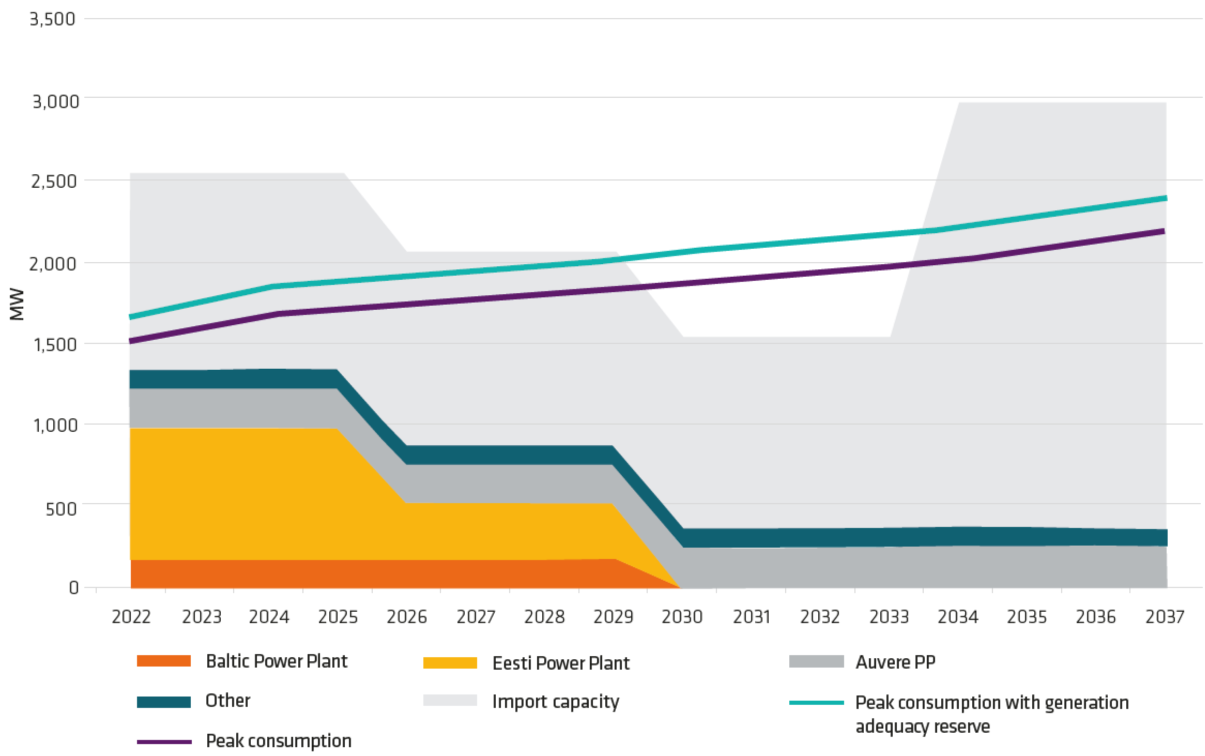


Figure 2.12 Available generation capacity, import capacity and forecast of peak demand in the winter

According to current forecasts, summer peak consumption by 2038 will be up to 1,543 MW (Figure 2.12). The available generation capacity corresponding to Section 14 of the Grid Code on the functioning of the electricity system will amount to around 589 MW in summer 2030 and around 389 MW in 2038. The usable production capacity is lower in the summer than the winter due to the maintenance of power plants and the lack of the heating load required for the operation of some cogeneration plants. According to the summer generation capacity adequacy assessment shown on figure, Estonia will have enough local generation capacities and import capability to cover summer peak consumption. In addition to the resources in the graph, solar and wind capacities have not been taken into account here.

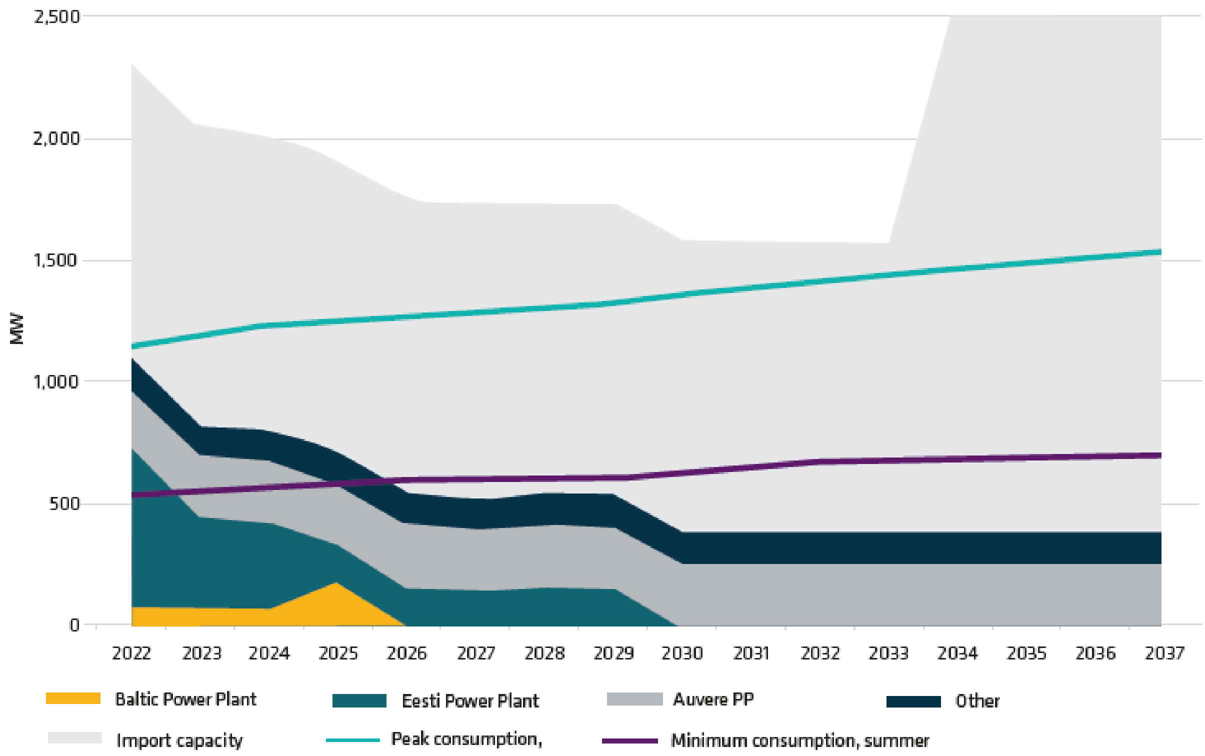
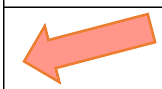
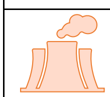


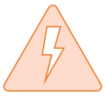
Figure 2.13 Available generation capacity, import capacity and forecast of peak demand in summer

2.4.7 Assessment of resource adequacy in the coming winter

The state of systemic adequacy before last winter (2022/2023) was the tightest in recent history in the Baltic Sea region, as a number of high-impact risks were mapped in a short period of time (lighter in Figure 2.14) and a number of high-impact events had already realised (darker). Fortunately, the winter of 2022/2023 was warmer than usual and high gas and electricity prices made consumers take a critical look at their consumption patterns (consumption control), which reduced the stress on the electricity system. This autumn, the outlook for the coming winter (2023/2024) is better.

Table 2.3 Security of supply risks last winter compared to this winter (see Figure 2.14)

	Winter 2022/2023	Winter 2023/2024
	Both the Swedish and the French nuclear power plants were under maintenance at the same time. Regular generation at Finland's Olkiluoto 3 nuclear power plant was repeatedly postponed.	The availability of nuclear power plants is good and long-term maintenance of French plants has been carried out
	Norway's hydro reservoirs were very low throughout the summer, only starting to fill in autumn	The level of hydro reservoirs in Nordic countries is at the median level of the last 20 years (Figure 4.14). According to the latest data, Nordic countries have 13.4 TWh more energy in their hydro reservoirs.
	The uneven resource distribution created bottlenecks in the network and large price differences between neighbouring price zones.	
	Gas, coal and lignite supply chains were hampered or available reserves were low in several countries at once.	In Poland, coal and lignite levels remain low but better than last year.

		At the time of writing, gas reservoirs across Europe are at 98% full, with the Latvian reservoir at 96% full[7].
		The BalticConnector accident has disrupted gas supplies between Finland and the Baltic states.
	Suddenly, the need to restrict energy imports from Russia emerged, and it was difficult to find alternative sources of supply in a short time.	Everyone has adapted to the new situation.
	Extraordinary synchronisation from the IPS/UPS power system would have entailed high risks, as the necessary actions for safe operation had not been finished.	Great efforts have been made to ensure that the extraordinary synchronization with the continental European frequency area does not jeopardise power supply, activities are still ongoing but preparedness is higher than last year.

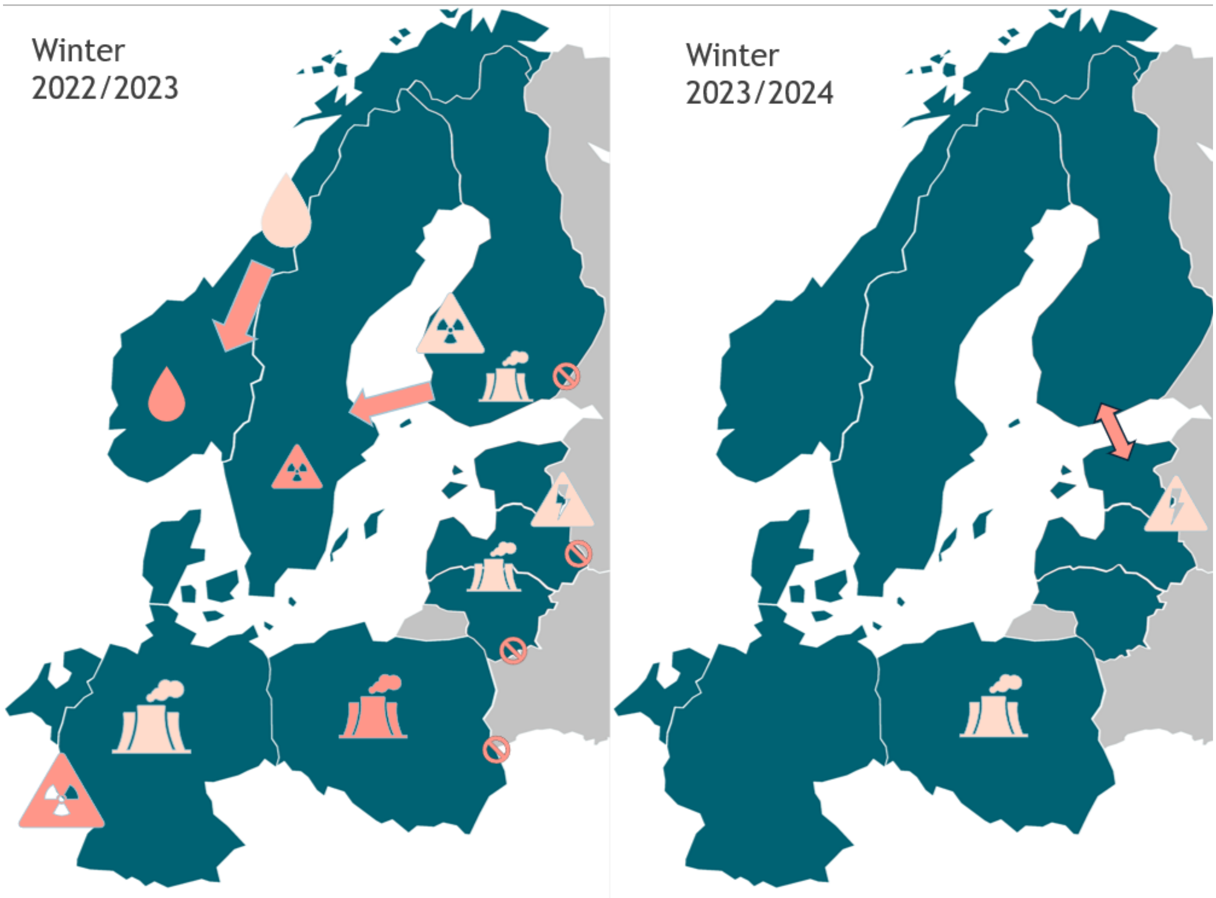


Figure 2.14 Mapping of winter risks in autumn 2022 and 2023. Darker red have already realized, lighter is identified risks

In the Nordic countries, hydro reservoirs have the highest electricity generation capacity in the last 23 years with 121 TWh. This level was reached in January 2012. At the time of writing, the level of reserves was 86% (Figure 2.15), or 109 TWh. In an average winter (October-April), electricity consumption in the Nordic countries (Norway, Sweden, Finland) is 218 TWh.

7 https://agsi.gie.eu/#/

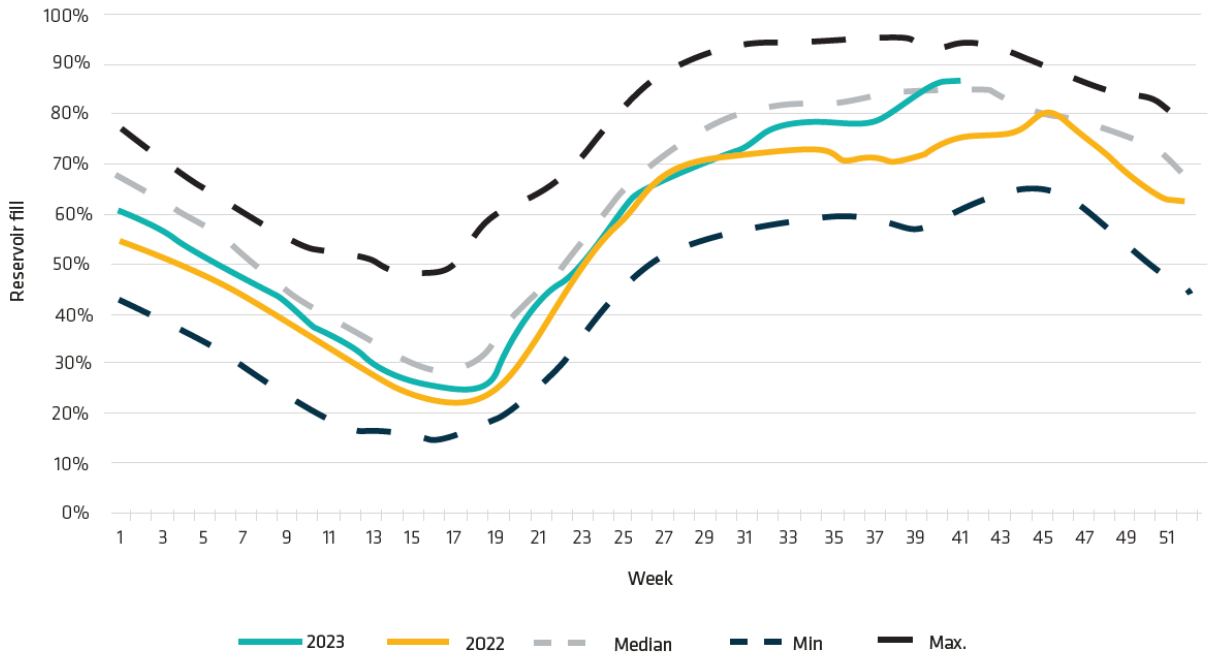


Figure 2.15 Reservoir fill in Norway, Sweden, Finland 2001-2023

Similar to the long-term resource adequacy assessment, a probabilistic analysis for the upcoming winter – Winter Outlook 2023/2024 – will be carried out throughout Europe. At the time of writing, only preliminary results are available and they may still be specified, but there was no energy not served (EENS) in Estonia or neighbouring countries. This also confirms the qualitative assessment that risks are lower and that no problems are foreseen at the moment.

2.4.8 Extraordinary scenarios

One of the assumptions of the previous resource adequacy assessment was a normal functioning European electricity market, which does not describe potential low probability events such as intentional or unintentional damage to physical infrastructure or market failures that could cause long term disturbances in the operation of the electricity system. For those reasons, Elering has also analysed additional continuity scenarios. When analysing these scenarios, we use the deterministic method.

2.4.8.1 Baltic islanded mode scenario

In situations where the Baltic states' electricity system will no longer have AC connections to a larger synchronised area, they will need to operate in 'island mode'. Such a situation might arise if the AC connection to the Russian electricity system is lost or after synchronisation with the continental European synchronous area.

Pursuant to the extraordinary synchronisation plan, when the Baltic states desynchronise from the Russian frequency areas, the synchronisation of the Baltic states with Continental Europe will happen within a matter of hours. Thus, it is not likely that the Baltic states will have to operate in island mode.

Island mode can last longer if there is a desynchronisation from the Continental Europe frequency area. It could be triggered above all by a outage in the Lithuania-Poland connection. In such a situation, there must be readiness to operate in island mode until the outage is eliminated.

Prerequisites:

- The Baltic states must be prepared for an islanded Baltic synchronous area scenario at every moment in time.
- A separation of the Baltic states from the Russian frequency area during a period when the Baltic states are still part of that area. If that should happen, they will be capable of synchronising with the Continental European frequency area, the actions for this purpose having been agreed beforehand.
- During a period when the Baltic states are part of the Continental European frequency area, the Lithuania-Poland AC connection is cut off and the Baltic states must get by on their own until the AC connection is restored. This situation may last longer until such time as the cause of the disconnection is resolved.
- Being in the Continental European synchronous area until 2032, the transmission capacity on the Lithuania-Poland border is 0 MW, with only frequency reserves being exchanged through that

connection. When the Harmony link is completed, trading will start taking place there and the existing Litpol link will be reserved for products needed for synchronous operation.

- Direct current connections to the Nordic countries and Poland are available, but at a reduced volume, taking into account the maximum element limit of 400 MW. The largest generation capacities are also limited to 400 MW.
- An N-1 situation means the switch-off of one more direct current cable.
- In such a situation, the Baltic countries depend on fast frequency reserves on direct currency connections with neighbouring systems.

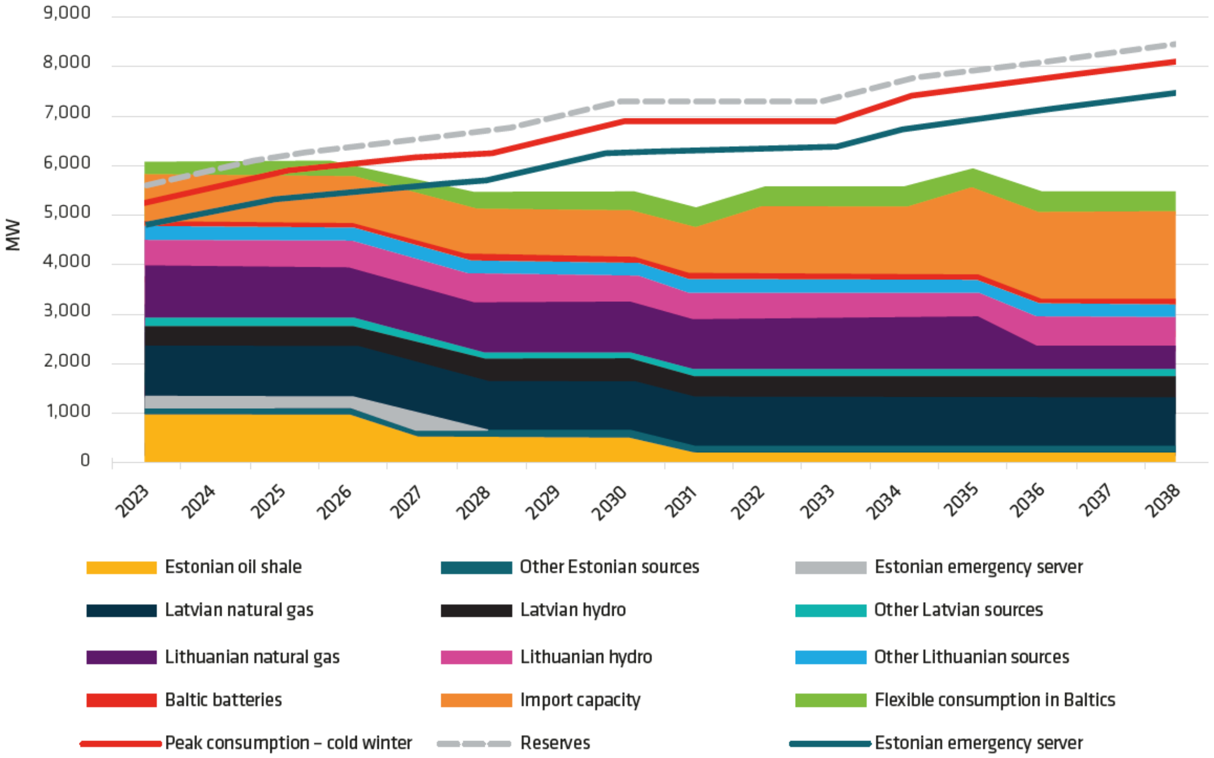


Figure 2.16 Baltic island mode scenario

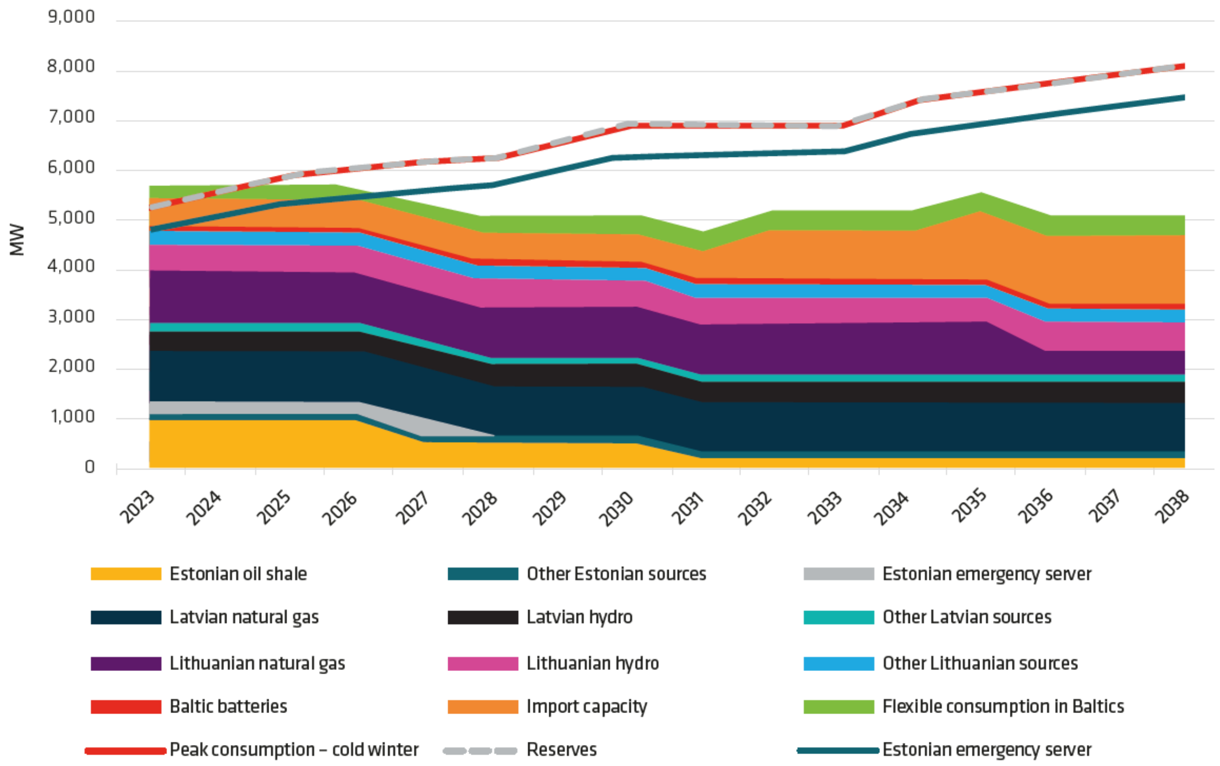


Figure 2.17 Baltic island mode N-1 scenario

The analysis of the island mode scenario of the Baltic synchronous area given on figures 4.15 and 4.16 shows that with known dispatchable generation capacities and transmission capacities, the Baltic resource adequacy level would only be covered until late 2024. After that, there would be a shortfall in the reserve coverage during the peak consumption hour in 2026. After 2026, it will not be possible to fully cover either the peak consumption or the reserve needs. It is important to note that neither wind nor solar farms, which are the main new generation capacity currently being invested in, have been taken into account in this graph. It is important to keep in mind that wind and solar have a positive effect on covering peak hours in winter, but as the geographical area is quite limited, peak consumption and a period of no wind can occur at the same time. As the annual peak consumption in winter usually takes place either in the morning or evening, it is also the dark time and solar parks do not generate electricity.

Elering, together with the other Baltic TSOs, is increasing the readiness to operate in island mode that will be created by investments in the synchronisation project. The impact of the risk of ending up in island mode on the stability of our electricity system will be reduced by gradual investments, but the best mitigation of the risks of islanding would be investment in dispatchable generation capacities or storage that would allow the use of solar and wind resources.

2.4.8.2 Extraordinary synchronisation with the Continental European frequency area

The Baltic region will be connected to the IPS/UPS, or the Russian power grid until February 2025, when the last new transmission line between Estonia and Latvia will be completed and synchronisation with the Continental European frequency area will take place. For more details on synchronisation, see Chapter 2.2. Given current events in Ukraine, as well as deliberately caused or unintentional accidents against various critical infrastructure objects, a situation could arise where the Baltic region is disconnected from the Russian power grid before all the necessary preconditions are met.

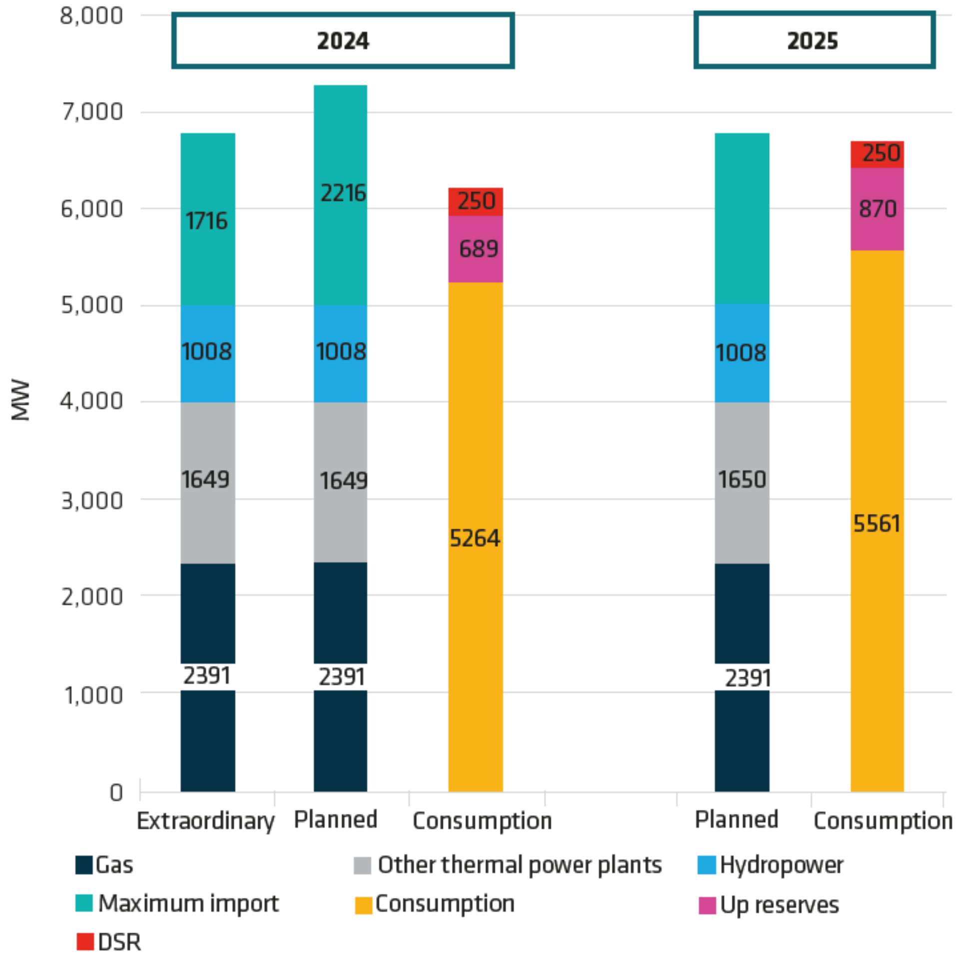


Figure 2.18 Power balances for planned and emergency synchronization

Figure 4.17 describes the situation where, in the event of emergency synchronisation, the Baltic region is switched to the Continental European frequency area for a few hours and the Lithuania-Poland transmission line is used only for system services. In 2024, the capacity of the transmission lines between Estonia and Latvia would also decrease, as the Estonia-Russia transmission line currently allows more trading volume to be delivered on the Estonia-Latvia line. If emergency synchronisation were to take place and the Estonia-Russia lines were to be disconnected, trade on the Estonia-Latvia line would have to be restricted to ensure the safe operation of the system.

After synchronisation, the demand for the reserves to be procured will increase significantly and the capacity balance between supply and demand will become more critical. The TSOs also expect overall electricity consumption to grow rapidly in the coming years, thanks to various trends described in more detail in Chapter 4.5. The growth in consumption and the need for reserves is faster than the growth in additional capacities and, similar to the analysis of the other scenarios in the preceding chapters, Figure 4.17 also shows that the level of resource adequacy will deteriorate.

2.4.8.3 Baltic emergency continuity scenario

A more severe situation than the Baltic island mode scenario is the Baltic emergency scenario, where in addition to island mode, there are no DC connections to neighbouring systems. The probability of such a scenario being realised is low and would probably take a coordinated attack against energy infrastructure.

Prerequisites for preparing the analysis:

- The Baltic States are in island mode in respect to the European energy system and make up a separate Baltic synchronous area in island mode.
- There are no connections with other regions.
- The estimated duration of the scenario is two months, during which time it would potentially be possible to restore at least one direct current connection.
- The consumption data of the sectors have been found from the databases of statistical offices of the Baltic countries, through which the share of the sector in the total end consumption has been found and it has been estimated that the share of the sector will also remain the same during peak consumption.

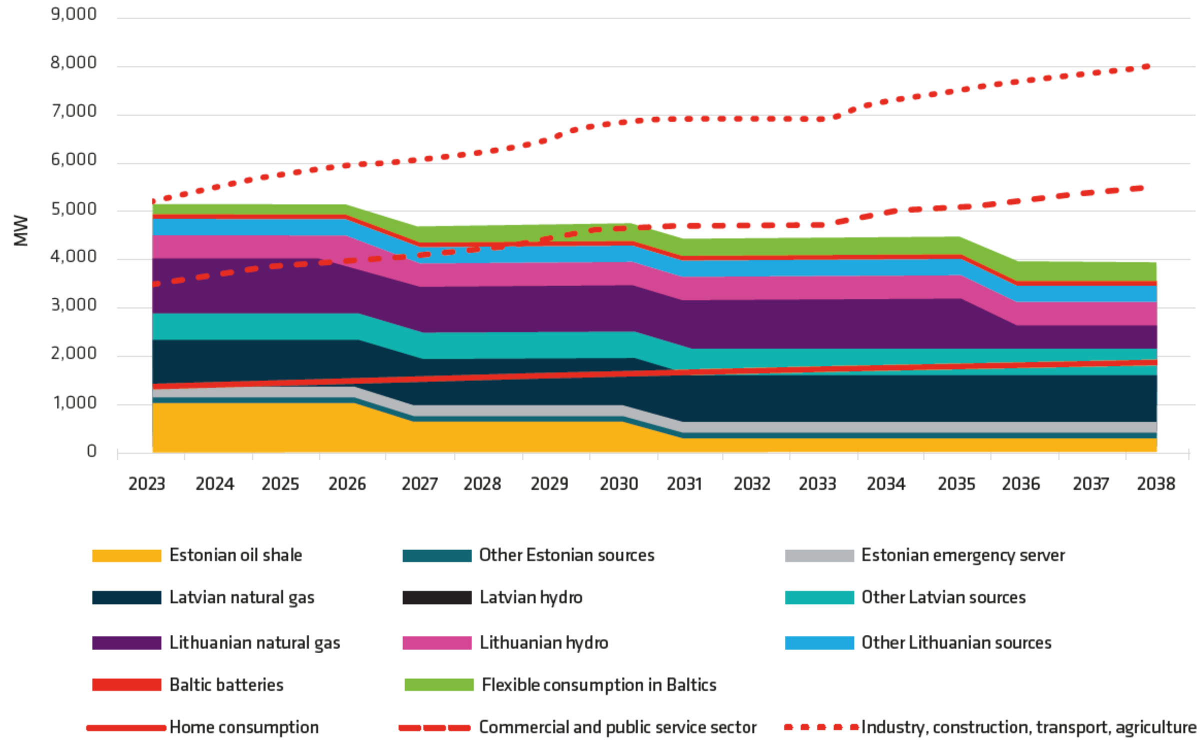


Figure 2.19 Baltic emergency continuity scenario

In this scenario, where none of the DC connections of the Baltic states are available, dispatchable generation capacities are out of service, wind and solar output is zero and the forecasted consumption load is growing, it will not be possible to cover all consumption with generation capacities at every moment in time (Figure 2.19). Analysis shows that in the absence of DC connections, the Baltic electricity system would be adequate for ensuring households, business and public services with a supply of electricity, while other sectors would have to be limited during peak load times: Due to the increasing electricity consumption, the electricity supply of the industrial sector should be more and more limited if this scenario is realised. In such a scenario, it should also be taken into account that the quality of the electricity supply would be significantly disturbed. Without transmission capacities, it is currently not possible for the Baltic states to simultaneously ensure that consumption is covered and sufficiently fast frequency reserves, due to which outages may result in additional automatic cut-off of consumption. More information about the frequency reserve capacity in the Baltic states is available in Chapter 2.2. The respective capacities are obtained within the framework of the synchronization project. It should be emphasized that this scenario has a low chance of occurring. It would be an extreme case if many low-probability events coincided: an interruption in operating in synchronization with the IPS/ UPS or continental Europe frequency area and the interruption of at least four DC connections at the same time as well as sufficiently high consumption in the winter period.

2.4.8.4 Estonia’s emergency continuity scenario

Prerequisites for preparing the analysis:

- Estonia has been left in island mode due to extraordinary circumstances.
- There are no electrical connections with 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 consumption of vital services and the consumption of general-interest services.

Figure 2.20 shows that vital service and general-interest service consumption in Estonia is around 300 MW, which is covered many times over during the entire period under observation. This value was found in cooperation with the transmission networks, to which most of the vital service and general-interest service providers are connected. The actual peak consumption of vital services and general-interest services is lower but since there are a few other consumers at connection points besides vital service providers, distinguishing them and disconnecting them is a complicated manual task from the viewpoint of the network and thus 300 MW is considered here. Although this scenario covers all the essential consumers, a critical situation may come about due to ensuring the stability of the electricity system and ensuring the balance of production and consumption.

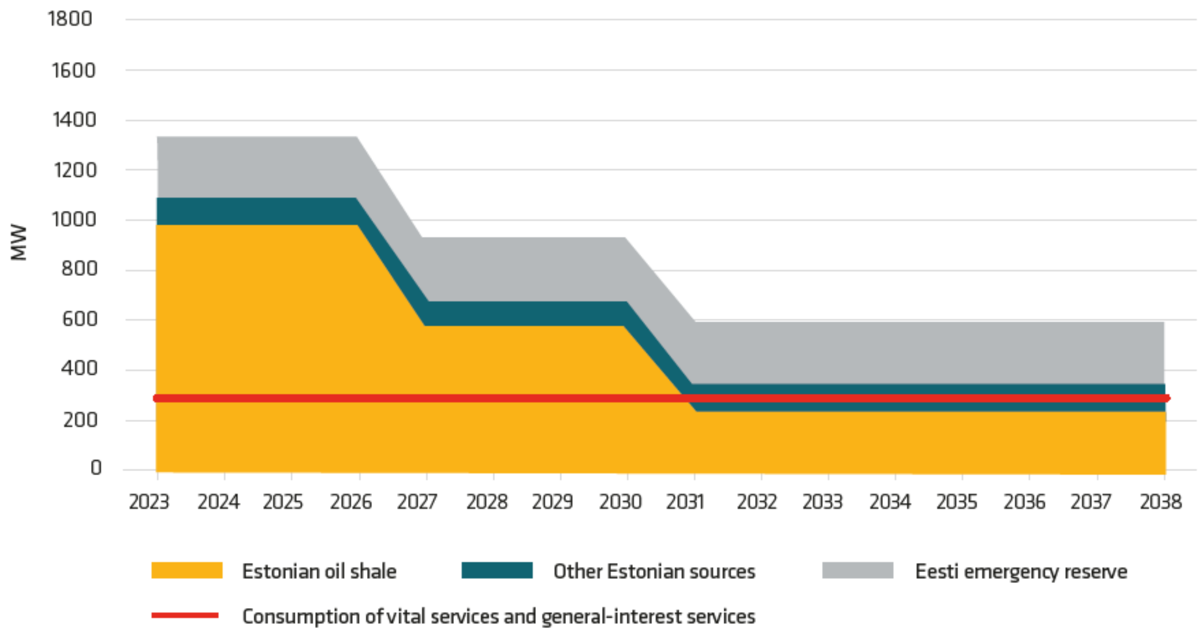


Figure 2.20 Estonian vital service scenario

2.5 DEMAND FORECAST

The following sub-chapter gives an overview of the forecast for Estonian end-consumer consumption and potential influences on consumption. The forecasts will be updated according to updated statistics, the results of completed studies and updated climate targets. Electricity consumption in the future will be influenced by many factors, several of which are based on the European Green Deal, the Fit for 55 package proposed by the European Commission and fossil energy competitiveness compared to energy generated from renewable sources.

The three main factors that influence electricity consumption:

- Increase in building renovation and dispersed generation – in July 2020, the Government approved a long-term strategy for the reconstruction of buildings, the main goal of which is to renovate all buildings built before 2000 in full by 2050. Minimum energy efficiency requirements for new and renovated buildings were established with the strategy. The minimum requirement for the energy efficiency of new buildings is class A – nearly zero-energy buildings, and a part of complying with this is to install local renewable energy generation systems (solar panels). These measures will ensure an increase in energy efficiency by reducing the heat loss of the buildings but will result in increased power consumption due to the installation of ventilation systems as part of the reconstruction. The installation of solar panels for the buildings will reduce the speed of the increase in energy consumption but will result in greater volatility in the consumption of energy from the grid unless local energy storage (batteries or heating system accumulation tanks) is installed, or consumption timing is used. The impact on electricity consumption in Estonia from the reconstruction of buildings and the increase in distributed generation has been assessed in a study on electricity consumption scenarios in Estonia commissioned by Elering.

- The partial replacement of natural gas consumption with electricity consumption – due to the energy efficiency requirements for buildings, the number of small and less efficient district heating networks that to this point used natural gas will decrease and a changeover to local electric heat pumps will take place. No new buildings with local gas heating will be built, as according to the building energy efficiency methodology, it is not possible for them to attain an energy class higher than C. Larger district heating networks like cities of Tallinn, Tartu and Pärnu will adopt large electric heat pumps in addition to cogeneration plants, and these will be able to use the heat from local bodies of water or city wastewater. In May 2023, the European Parliament approved the directives establishing a separate emissions trading scheme (ETS 2) for fuels used for heating buildings and motor vehicles from 2027. The introduction of said system is likely to make the use of renewable electric heat pumps even more competitive compared to the use of fossil natural gas. The extent of the transition from natural gas to electricity was assessed in the 2021 Estonian gas consumption study and the study of Estonian electricity consumption scenarios. The volume of the final decrease in natural gas consumption and the extent and speed of the transition to electricity will largely be determined by the price of natural gas and its economic competitiveness compared to alternatives such as electricity. The consumption forecast assumes that an average of 800 new heat pumps will be added in the coming years, and an average of 4,500 heat pumps will be added to replace older heating systems. It is also worth noting here that the trends in electricity consumption associated with heat pumps are moving in both directions – the replacement of older electric radiators with newer and more efficient heat pumps will lead to a decrease in consumption due to increased energy efficiency, while the switch from wood and other heating sources to heat pumps will lead to a rapid increase in consumption.
- Electrification of the transport — in the first half of 2022, more than 10% of vehicles sold are fully electric in more than 10 European countries and, in 2021, 19% of vehicles sold in Europe were fully electric or plug-in hybrids. The respective percentages in Estonia were 3% and 5%, but the share of electric vehicles in the overall fleet can be expected to increase in Estonia as well. The developments in charging infrastructure, the increase in people's awareness and the relatively high price level of liquid fuels will be contributing factors. In addition to the aforementioned European Commission proposal to introduce an obligation for motor vehicle fuel sellers to buy emission quotas, it is proposed to impose an obligation on car manufacturers to sell only zero-emission passenger cars and small vans in the EU from 2035. The study of Estonian electricity consumption scenarios found that the electrification of the transport sector would amount to around half of the increase in power consumption.

Consumers are categorized by sector:

- Service sector
- Industrial sector
- Households
- Transport sector

According to the historical statistics and future projections of Estonia, the energy consumption is the biggest in the service sector. The growth of consumption can be foreseen in all sectors, but the greatest growth potential is seen in the transport sector. Due to climate policy and higher cost-effectiveness, we envision gradual replacement of vehicles with internal consumption engines with EVs, which will lead to a noteworthy increase in the percentage of electricity consumption in the transport sector. Figure 4.20 shows how the forecasted consumption share will be distributed by sector up to the year 2050.

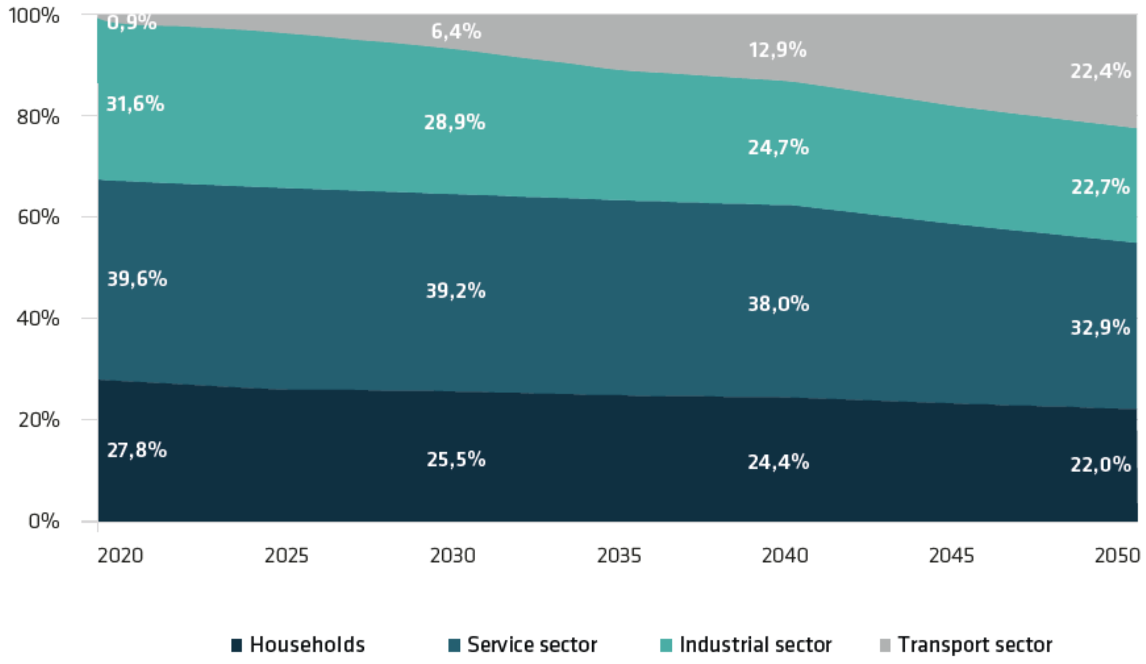


Figure 2.21 Forecasted share of consumption by sector

In various sectors there are a certain number of electricity consumers who are responsible for providing vital services and they must ensure that there is a supply of electricity in all cases to ensure that society is able to function.

The values in Table 2.4 are a statistical aggregation of the last 10 years and forecast for the next 15 years. The forecast of consumption provides average peak consumption values for various years. The resource adequacy analysis also takes into account climate years with extraordinarily high and low consumption.

Table 2.4 Consumption statistics and peak consumption forecast up to 2038

Statistics		
Year	Annual consumption, TWh	Peak demand, MW
2013	7,9	1510
2014	8,1	1423
2015	8,1	1553
2016	8,4	1472
2017	8,5	1474
2018	8,7	1544
2019	8,6	1541
2020	8,4	1409
2021	9,0	1570
2022	8,5	1464

Forecast		
Year	Annual consumption, TWh	Peak demand, MW
2023	8,6	1514
2024	9,0	1591
2025	9,2	1668
2026	9,3	1705
2027	9,5	1742
2028	9,7	1779
2029	9,9	1800
2030	9,9	1829
2031	10,3	1870
2032	10,5	1910
2033	10,8	1950

2034	11,1	1984
2035	11,3	2018
2036	11,7	2075
2037	11,9	2131
2038	12,3	2187

The consumption statistics in Table 2.4 are based on the components shown in Figure 2.22. This approach allows network losses to be taken into account without measuring them separately. Figure 2.23 shows the components of the consumption forecast. It is worth noting that the methodology for calculating the statistical consumption and the forecast consumption takes into account the electricity generation in the distribution network and behind the consumption points differently. In the case of the forecast, generation and storage are modelled separately in the security of supply analyses and the impact of these components in the modelling of electricity consumption would lead to double counting. This means that, due to the growth of distributed generation (in particular solar power generation on the roofs of buildings), there will be an increasing difference between the amount of energy that passes through the power grid and the amount of energy of end consumption, which cannot be treated as equal.

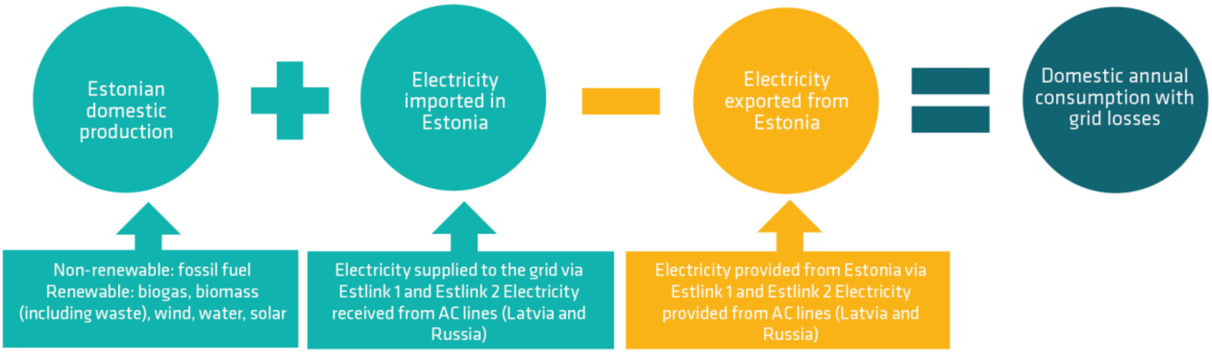


Figure 2.22 Components of formation of consumption statistics

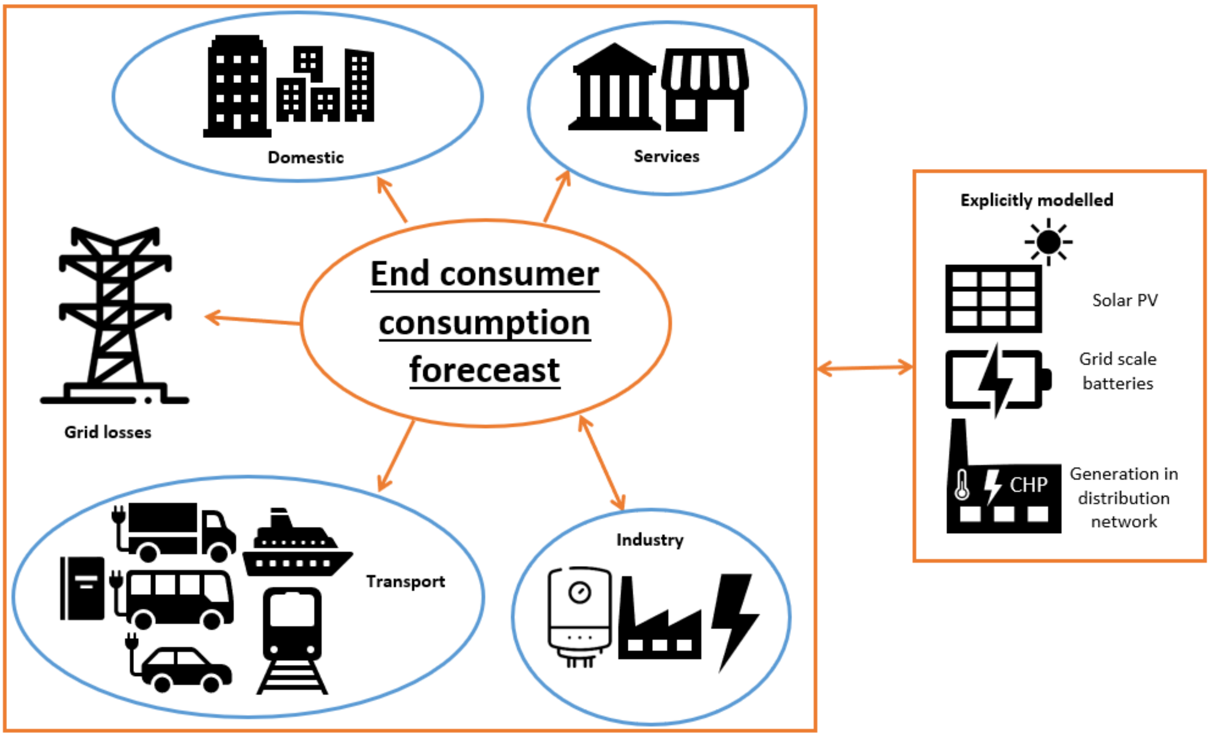


Figure 2.23 Components of consumption forecast

The forecasts in Table 2.4 are based on the results of the consumption modelling for the ENTSO-E resource adequacy assessment and the study of electricity consumption scenarios in Estonia commissioned by Elering. Each year, ENTSO-E prepares several dozen hour-based consumption profiles that take into account various direct variables such as number of electric cars, number of heat pumps, historical consumption and other factors such as weather conditions and rising temperatures caused by climate change according to climate years (the nature of a climate year is explained in the ERAA methodology document). Once all these variables have been compiled in the Demand Forecasting Toolbox, unique hourly consumption profiles for all climate years of each target year are obtained, using the results of a study commissioned by Elering. They take into account the different developments in Estonia and the European Union, climate and energy policies aimed at reducing the use of fossil energy and the gradual electrification of the energy economy.

Figure 2.24 illustrates the consumption trend and the volume of the generation reserve necessary for meeting consumption demand according to § 14 of the Estonian Grid Code. The historical peak consumption value has varied greatly from year to year, but the trend has clearly been upward. In future, we can expect peak consumption to accelerate due to the electrification of energy consumption. The rise in peak consumption may be boosted by the long-term high price of fossil fuels used to generate heat, which may increase the adoption of electric heat pumps and heating elements.

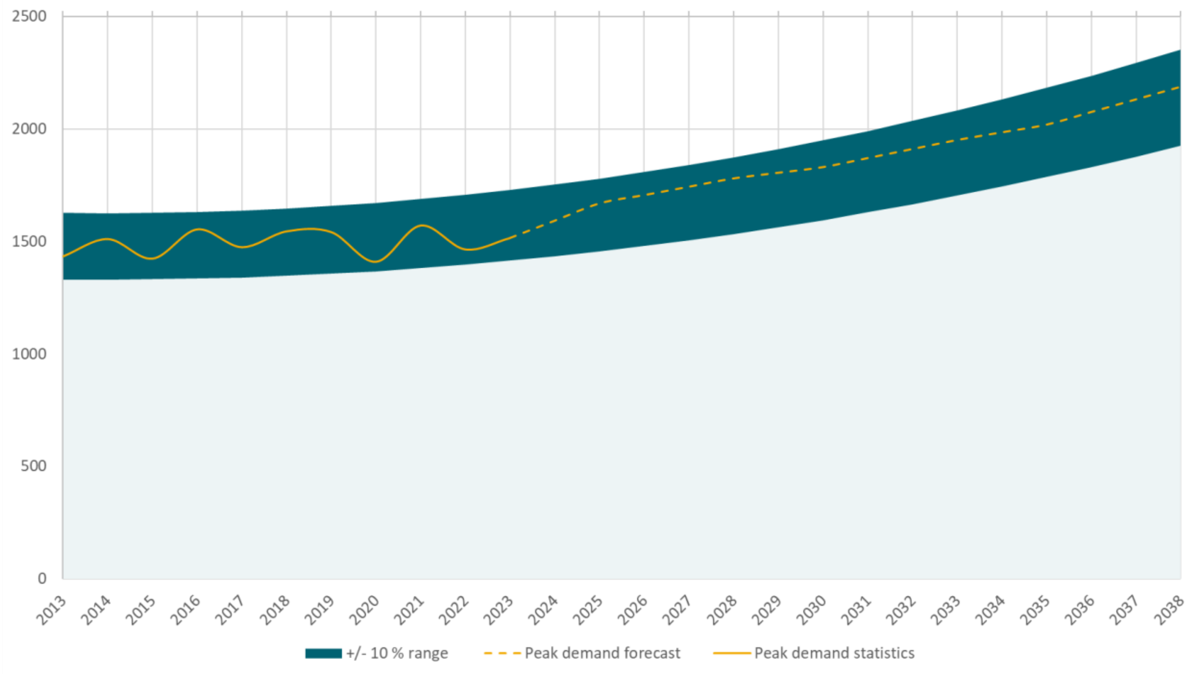


Figure 2.24 Peak consumption statistics and forecast up to 2038

While overall electricity consumption statistics show a slight upward trend, peak loads on the electricity system have remained essentially unchanged over the last decade, ranging between 1,400 and 1,600 MW. The peak load of 1587 MW was recorded 13 years ago in 2010, which coincided with an extraordinarily cold winter period, and in February 2021, the peak was again approached – 1570 MW.

In the case of growth of electricity consumption, it should be remembered that general electrification will increase the annual end consumer's volume of consumption. The volume of consumption of grid power will grow at a slower pace due to the increase in distributed consumption. Together with electrification and introduction of electric transport, the flexibility of electricity consumption will grow (the capability to control, time and store electricity), which will support the transition to renewable energy sources and a general reduction in GHG emissions and price volatility and prevent peak consumption from becoming concentrated at the same time. Diverting consumption to a non-peak hour is supported by the adoption of smart technology, such as smart chargers for electric cars, use of heat pumps' accumulation tanks, heat storage devices in central heating areas, battery storage and bidirectional charging of EVs. The higher price formed at peak hours and the increase in flexibility of consumption will to a certain extent slow the speed of growth in peak consumption. The growth in the share of renewable energy in energy generation will create volatility in the grid consumption profile and electricity prices, which favours the introduction of energy capture technology such as batteries and pump hydro accumulation plants and active participation in the electricity market – this in turn will equalize the grid consumption profi le and reduce volatility of electricity prices.

Nevertheless, it should be taken into account that due to electrification of energy consumption, peak loads can be expected to rise in the years ahead. Table 2.4 shows that the projected peak consumption will grow around 45 MW in the next 15 years and, from 2030, we can expect peak consumption to grow by around 10 TWh each year. The security of supply simulations have also used more extreme years, with peak winter consumption higher than the average shown in the table and annual consumption higher than the average shown.

2.6 KEY CHANGES RELATED TO GENERATING CAPACITIES IN ESTONIA

In the annex to this security of supply report lists all generation units (excluding solar parks) in Estonia above 0.5 MW.

Pursuant to subsection 13 (3) of the Grid Code on the functioning of the electricity system, on generation reserves for satisfying consume demand, electricity producers must submit to TSO Elering by 1 February of each year the data specified in Annex 3 to the Grid Code on the next 15 years for assessment of the capability of the electricity system.

All electricity producing 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 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. Therefore, Elering reserves the right and the option to remain conservative with the data taken into consideration for analysing the resource adequacy.

Table 2.5 Estonian generation capacities in 2022 and 2023

Dispatchable market-based capacity

Power plant	Installed net capacity 2022, MW	Installed net capacity 2023, MW	Firm capacity, MW
Eesti Power Plant	866	866	652
Balti Power Plant	192	192	144
Auvere Power Plant	272	272	204
Iru Power Plant — gas unit	94	94	0
Iru Power Plant — waste incineration unit	17	17	110*
Põhja thermal power plant	77	77	
Sillamäe thermal power plant	23	23	
Tallinna Power Plant	39	39	
Tartu Power Plant	22	22	
Pärnu Power Plant	21	21	
Enefit 280	10	10	
Other industrial and CHP plants	75	73	
SUM	**1708**	**1706**	**1110**
Non-market capacity			
Kiisa emergency reserve gas power plant	250	250	250
Renewable capacity			
Hydro power	8	8	0
Wind power	317	377	0
Solar PV	510	680	0

*The contribution of these generation capacities to the firm generation capacity is aggregated, as it is made up of the output of 30 smaller power plants at peak hour, which varies widely and is difficult to forecast depending on the situation (weather, business decisions, maintenance schedules, etc.). The value shown was obtained by analysing the historical average peak-hour output of smaller power plants.

Biggest changes compared to 2022

- Bids for the generation of 1,070 GWh of renewable energy were received in the reverse auction for renewable energy generation organised by the state and carried out by Elering. A total of 10 bids from seven companies were received in the reverse auction. The producers plan to generate 893 GWh of this energy from wind and 177 GWh from the sun. The price difference of the bids is €21,89 to €44.9 per MWh. If all the received bids meet the conditions of the reverse auction, all the bids with a price of €39.8 per MWh or less would be successful. The offered price is guaranteed sales revenue per hour from which the exchange price of the respective hour is deducted upon payment of the support. The maximum support according to the conditions of the reverse auction is €20 per MWh. The objective of the reverse auction was to obtain 650 GWh of renewable electricity for the market, of which at least half must be produced in the first and fourth quarter. Successful bidders will have to start production no later than on 1 July 2027.

2.7 ASSESSMENT OF RESOURCE ADEQUACY

Compared to last year, Estonia's short-term resource adequacy is significantly higher. The generation capacities and national connections in the region are in good shape, allowing the market to direct electricity to where it is most needed at any given time. Nuclear power plants across Europe are in better working order than last year. The new Olkiluoto 3 nuclear power plant, which is a very important element for our region, is now operating.

The Estonian-Finland gas pipeline BalticConnector accident in the autumn has disrupted gas transmission between Estonia and Finland, but both countries nevertheless have sufficient supply channels to cover their gas consumption.

The assessment of the long-term capacity of the electricity system was carried out through various analyses, which provided an increasingly accurate picture of the level of security of supply:

• the ERAA found that only Finland will not meet its reliability standard in the region in 2025 and 2028. As the problem has been solved in Finland with market-based measures by 2030, a capacity mechanism would be needed in Finland to improve resource adequacy. The security of supply levels in the other countries in the region are within the limits of the standard and the ERAA resolution did not identify any further resource adequacy issues. Compared to the results of last year's ERAA, it is important to note that this year's ERAA estimates that the four Narva oil shale units are economically sustainable until 2030 and that their closure would not be economically feasible.

• A more detailed NRAA, together with sensitivity analyses, identified the need to maintain around 1,000 MW of dispatchable capacity in Estonia to ensure security of supply. The importance of dispatchable capacity will increase significantly with the growth in consumption and reserve demand, so additional dispatchable capacity will be needed in the region from 2030. Ensuring upregulation reserves (aFRR and mFRR up) is the most critical, as the need for these is growing rapidly with the increase in renewable energy generation and the related error in forecasts.

• If the level of installed dispatchable capacities in Estonia falls below 1,000 MW, a capacity mechanism in the form of a strategic reserve is needed to ensure security of supply during peak hours. The capacities most needed by 2030 would be those that are able to offer fast up regulation (aFRR and mFRR up).

• Deterministic analyses identified that the future level of capacity of both the region (Baltic states and Finland) and the Estonian electricity system will be highly dependent on wind energy and imports from neighbouring countries. The most critical period will be between 2027 and 2030, when demand will grow rapidly but the decisions to invest in firm capacity have not yet been made. Significant quantities of renewable energy will be added in the coming years, which will have a significant impact on clean electricity generation, but unless complemented by storage, their contribution to security of supply at peak hours will be quite limited.

The electrification of different sectors has led to a rapid increase in electricity consumption in Estonia and across Europe. In Estonia, the growth is mainly due to electric transport and the replacement of fossil fuels with electricity in heat generation. Over the next 10 years, Estonia's annual electricity consumption will increase by nearly 2 TWh, and peak demand will grow by nearly 450 MW. The rapid growth in electricity consumption across Europe has created a situation where long-term resource adequacy analyses have identified omissions in many countries that need to be addressed immediately. Elering has taken the first steps in this direction and a study has been commissioned to identify the most suitable type of capacity mechanism for Estonia. The result of the study51 indicated that the most economically efficient and least market-distorting option for Estonia is a strategic reserve. A strategic reserve concept document was prepared on the basis of the results of the study, and studying the impact of the mechanism on neighboring markets has started.

In order to avoid a situation where, after joining the Continental European frequency area, not enough frequency reserves are offered on the market, Estonia is applying for a derogation allowing us to procure reserves for a longer period in advance. According to today’s best knowledge, the total aFRR and mFRR capacities to be procured in the long term would be approximately 200 MW of upregulation capacity.

3 ANNEX- OVER 0.5 MW INSTALLED GENERATING CAPACITIES IN THE ESTONIAN ELECTRICITY SYSTEM

The table below lists the installed generation capacities as reported by producers for the largest Estonian- based generating units in 2023. Many of these installations have noteworthy restrictions due to which Elering uses conservative, 'firm' capacities to assess security of supply, based on experiences from the years before. The percentage of firm capacity in installed capacity is separately listed in Table 4.5 in Chapter 4.6.

Name of the power plant	Generation technology	Fuel	Capacity as of 2023 (MW)
POWER PLANTS			**1340 MW**
Eesti power plant	Condensing turbine	Oil shale	**866**
Eesti TG 3	Condensing turbine	Oil shale	163
Eesti TG 4	Condensing turbine	Oil shale	163
Eesti TG 5	Condensing turbine	Oil shale	173
Eesti TG 6	Condensing turbine	Oil shale	173
Eesti TG 8	Condensing turbine	Oil shale	194
Auvere power plant	Condensing turbine	Oil shale	272
Balti power plant TG 11	Condensing turbine	Oil shale	192
Enefit power plant	Waste heat-utilizing steam turbine	Oil shale	10
COMBINED HEAT AND POWER PLANTS			**365,6 MW**
Iru power plant	CHP	Natural gas	94
Iru power plant	CHP	Waste	17
Põhja thermal power plant	CHP and Condensing turbine	Natural gas	77
Utilitas Tallinna power plant	CHP	Biomass	39
Tartu power plant	CHP	Biomass	22,1
Pärnu power plant	CHP	Biomass	20,5
Horizon tselluloosi ja paberi AS	vasturõhuturbiin vaheltvõttudega	must leelis/Biomass	13,9
Sillamäe thermal power plant	CHP	Oil shale	10
Imavere CHP	CHP	Biomass	10
Osula CHP	CHP	Biomass	10
Mustamäe CHP	CHP	Biomass	9,3
Sillamäe I CHP	CHP	Biomass	7,1
Sillamäe II CHP	Gas engine	Natural gas	5,8
Helme CHP	CHP	Biomass	6,5
Grüne Fee Eesti AS	Gas engine	Natural gas	4,1
Kiviõli Keemiatööstuse OÜ thermal power plant	CHP	Shale gas	1,4
Kuressaare soojuse ja elektri CHP	CHP	biomass	1,8

Paide CHP	CHP	biomass	1,7
Jämejala CHP	Gas engine	Natural gas	1,8
Repo Vabrikud AS	Gas turbine	Natural gas	1,8
Ilmatsalu biogas PP	Gas engine	Biogas	1,5
Vinni biogas PP	Gas engine	Biogas	1,4
Oisu biogas PP	Gas engine	Biogas	1,2
Tallinna Prügilagaas OÜ	Gas engine	Biogas	1,9
Põlva elektri ja soojuse CHP	Gas engine	Natural gas	0,9
Rakvere CHP	CHP	biomass	1
Rakvere Päikese CHP	CHP	biomass	0,9
Kopli CHP	Gas engine	Natural gas	0,9
WTC Tallinn AS	Gas engine	Natural gas	0,6
Tartu Aardlapalu landfill CHP	Gas engine	Biogas	0,5
HYDRO POWER			**8 MW**
Jägala hydro power plant	hydropower turbine	water	2
Linnamäe hydro power plant	hydropower turbine	water	1,1
Other small	hydropower turbine	water	4,9
WIND CAPACITY			**377 MW**
Aulepa wind farm	wind turbine	wind	48
Paldiski wind farm	wind turbine	wind	45
Tuhavälja wind farm	wind turbine	wind	39,1
Saarde wind farm*	wind turbine	wind	38,7
Aseri wind farm	wind turbine	wind	24
Purtse wind farm	wind turbine	wind	21
Viru-Nigula wind farm	wind turbine	wind	21
Pakri wind farm	wind turbine	wind	18,4
Tamba-Mäli wind farm	wind turbine	wind	18
Tooma I wind farm	wind turbine	wind	16
Skinest Energia Esivere wind farm	wind turbine	wind	12
Varja wind farm	wind turbine	wind	10
Vanaküla wind farm	wind turbine	wind	9
Esivere wind farm	wind turbine	wind	8
Tooma II wind farm	wind turbine	wind	7,1
Virtsu II wind farm	wind turbine	wind	6,9
Virtsu III wind farm	wind turbine	wind	6,9
Ojaküla wind farm	wind turbine	wind	6,9
Saaremaa wind farm	wind turbine	wind	6
Nasva wind farm	wind turbine	wind	5,9
Aburi wind turbine	wind turbine	wind	1,8
Nasva port wind farm	wind turbine	wind	1,6
Sikassaare wind farm	wind turbine	wind	1,5

Virtsu wind farm	wind turbine	wind	1,4
Virtsu I wind farm	wind turbine	wind	1,2
Türju wind turbine	wind turbine	wind	0,9
Peenra wind turbine	wind turbine	wind	0,7

The installed solar plant capacities change extremely rapidly at the time of this report. Estonia had installed solar plant capacity of 680 MW, which was distributed across counties as shown in the table.

SOLAR CAPACITY	**680 MW**
County	**Capacity as of September 2023 (MW)**
Harju	120
Tartu	83
Pärnu	74
Viljandi	64
Lääne-Virumaa	61
Ida-Virumaa	53
Jõgeva	45
Valga	39
Võru	31
Järva	26
Rapla	26
Põlva	25
Saare	24
Hiiu	5
Lääne	4

Annex 2

Table 3.1 Comments on how NRAA complies with regulation

Article 24 National resource adequacy assessments		How NRAA is complying with the requirements?
National resource adequacy assessments shall have a regional scope and shall be based on the methodology referred in Article 23(3) in particular in points (b) to (m) of Article 23(5). National resource adequacy assessments shall contain the reference central scenarios as referred to in point (b) of Article 23(5). National resource adequacy assessments may take into account additional sensitivities to those referred in point (b) of Article 23(5). In such cases, national resource adequacy assessments may:	Article 23 3. By 5 January 2020, the ENTSO for Electricity shall submit to the Electricity Coordination Group set up under Article 1 of Commission Decision of 15 November 2012 (21) and ACER a draft methodology for the European resource adequacy assessment based on the principles provided for in paragraph 5 of this Article. 5. (b) is based on appropriate central reference scenarios of projected demand and supply including an economic assessment of the likelihood of retirement, mothballing, new-build of generation assets and measures to reach energy efficiency and electricity interconnection targets and appropriate sensitivities on extreme weather events, hydrological conditions, wholesale prices and carbon price developments; (c) contains separate scenarios reflecting the differing likelihoods of the occurrence of resource adequacy concerns which the different types of capacity mechanisms are designed to address; (d) appropriately takes account of the contribution of all resources including existing and future possibilities for generation, energy storage, sectoral integration, demand response, and import and export and their contribution to flexible system operation; (e) anticipates the likely impact of the measures referred in Article 20(3); (f) includes variants without existing or planned capacity mechanisms and, where applicable, variants with such mechanisms; (g) is based on a market model using the flow-based approach, where applicable; (h) applies probabilistic calculations; (i) applies a single modelling tool; (j) includes at least the following indicators referred to in Article 25: — 'expected energy not served', and — 'loss of load expectation';	3. Done by using reliability as the reference point for adequacy levels 5.(b) by using ERAA model and EVA outputs all requirements are fulfilled (c) Done by using different sensitivity analyses, ,climate years, samples (d) Done by complying with input data guidelines to ERAA and using EVA outputs (e) Impact of assessed by notifying of a possible adequacy issue to NRA and relevant Ministries in order to comply with this point (f) The including of units that are participating in capacity mechanism are considered by complying with data collection guidelines. (g) not applicable for regional scope (h) done, a statistical sample of approximately 600 simulations were performed for every scenario and target year (i) Plexos modelling tool was selected (j) both LOLE and EENS are included in the report (k) most likely reasons are listed in the report

	(k) identifies the sources of possible resource adequacy concerns, in particular whether it is a network constraint, a resource constraint, or both; (l) takes into account real network development; (m) ensures that the national characteristics of generation, demand flexibility and energy storage, the availability of primary resources and the level of interconnection are properly taken into consideration	(l) done by complying with ERAA input data guidelines and sensitivity analyses on projects that might have a delay in commissioning (m) done, lack of national characteristics was identified as the main shortcoming of ERAA, NRAA was performed precisely to make it more detailed.
(a) make assumptions taking into account the particularities of national electricity demand and supply; (b) use tools and consistent recent data that are complementary to those used by the ENTSO for Electricity for the European resource adequacy assessment. In addition, the national resource adequacy assessments, in assessing the contribution of capacity providers located in another Member State to the security of supply of the bidding zones that they cover, shall use the methodology as provided for in point (a) of Article 26(11).		(a) done by performing long term electricity demand study based on current relevant trends. Supply trend is considered by asking future plans from existing generator operators and perspective supply is taken either from climate goals or considered as TSO best estimate. (b) done by complying with ERAA input data guidelines. Same model as ENTSOE ERAA was used as a starting point for the analysis.
2.National resource adequacy assessments and, where applicable, the European resource adequacy assessment and the opinion of ACER pursuant to paragraph 3 shall be made publicly available		2. Elering's "Varustuskindluse aruanne" was published in the beginning of December 2023 and a public seminar was held to introduce both ERAA and NRAA results. Link: https://elering.ee/varustuskindluse-aruanded
3.Where the national resource adequacy assessment identifies an adequacy concern with regard to a bidding zone that was not identified in the European resource adequacy assessment, the national resource adequacy assessment shall include the reasons for the divergence between the two resource adequacy assessments,		3. Relevant authorities have been notified, explanations on the differences is ongoing

including details of the sensitivities used and the underlying assumptions. Member States shall publish that assessment and submit it to ACER. Within two months of the date of the receipt of the report, ACER shall provide an opinion on whether the differences between the national resource adequacy assessment and the European resource adequacy assessment are justified. The body that is responsible for the national resource adequacy assessment shall take due account of ACER's opinion, and where necessary shall amend its assessment. Where it decides not to take ACER's opinion fully into account, the body that is responsible for the national resource adequacy assessment shall publish a report with detailed reasons.		

Annex 3. Methodology flow chart

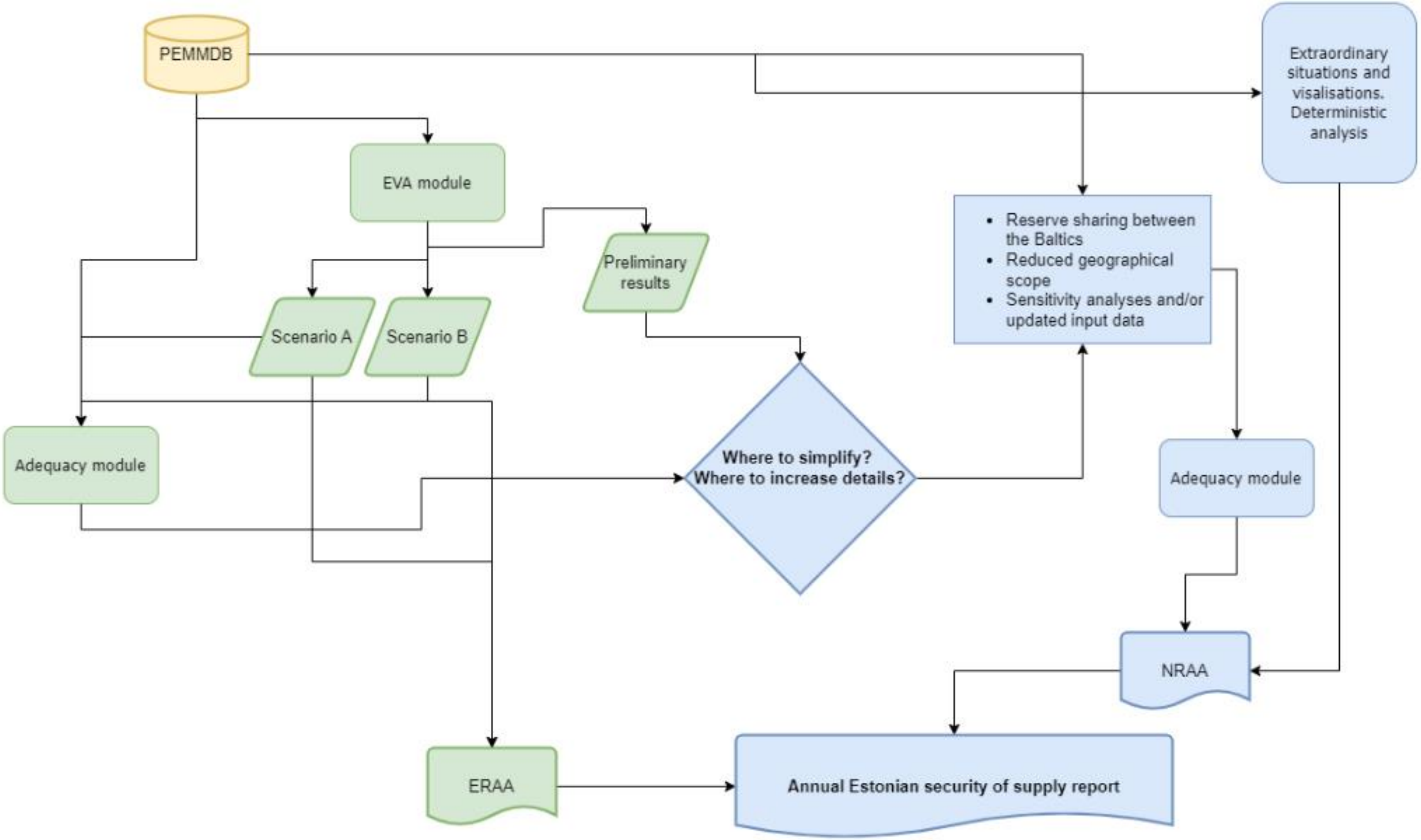


Figure 3.1 Methodology flow chart