LATVIAN JOURNAL OF PHYSICS
AND TECHNICAL SCIENCES
2020, N 3

DOI: 10.2478/lpts-2020-0015

# ROLE OF BALANCING MARKETS IN DEALING WITH FUTURE CHALLENGES OF SYSTEM ADEQUACY CAUSED BY ENERGY TRANSMISSION

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The national energy and climate plans developed by the Baltic States for the period up to 2030 foresee a significant increase in the share of renewable energy in final consumption. Therefore, the development of wind, solar and distributed generation in the Baltic electricity system is expected to increase significantly in the next decade and, thus, the need for balancing capacity will increase. The planned synchronisation of the Baltic power system with the power system of Continental Europe in 2025 will also increase the need for frequency restoration and balancing reserves. At the same time, the shutdown of uncompetitive thermal power plants in the Baltics reduces centralized generation capacity. If this trend continues, the risk of electricity supply shortages will increase in the future. Therefore, it is important to identify activities that help mitigate this risk and take timely actions.
***Keywords:*** *Baltic ACE, Baltic balancing market, Baltic power system*

## 1. RENEWABLE ENERGY SOURCES REPLACE THE FOSSIL ENERGY

During the years, there is a clear trend towards increasing production from renewable energy sources and decreasing production from fossil energy sources in the Baltic States. During the past years, on average around 40 % of the produced electricity has come from renewable sources (mainly hydropower and wind energy), while about 60 % – from fossil fuels (mainly oil shale and natural gas). In 2017 and 2018, the generation of electricity from renewable energy sources exceeded 40 % of total generation threshold for the first time, exceeding 10 TWh and 8 TWh, respectively. However, in 2019 the share of renewable generation exceeded 50 % for the first time.

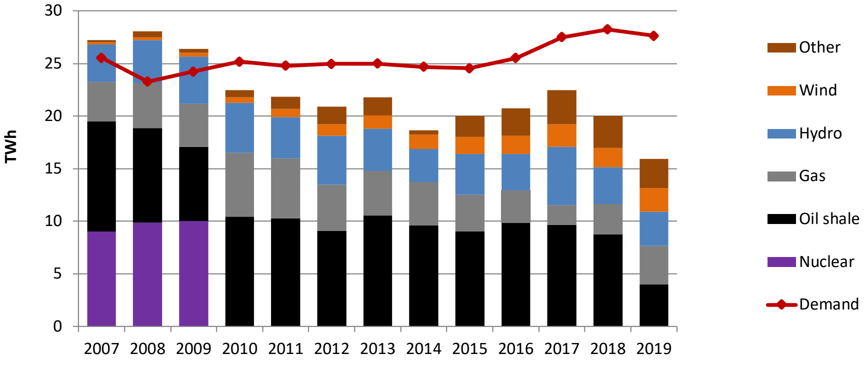


*Fig. 1.* Electricity production and consumption in the Baltic States.

Source: ENTSO-E

## 2. LARGEST $CO_2$ EMITTERS WILL BE PUSHED OUT OF THE MARKET

Estonian oil shale power plants have played an important role in the Baltic power system. In recent years, oil shale power plants have generated around 9–10 TWh of electricity annually, or about half of the total electricity output in the Baltics.

Oil shale combustion generates substantial $CO_2$ emissions; therefore, the profitability of the operation of these power plants is particularly affected by the price changes in $CO_2$ emission allowances on the European market. Low and stable $CO_2$ emission allowance prices have been contributing to stable electricity production at oil shale power plants in recent years (Fig. 2). However, since 2018 $CO_2$ emission allowance price has experienced a significant rise [1] exceeding EUR 25 [2] per tonne. As a result, electricity generation at oil shale power plants declined significantly reaching record low 4 TWh in 2019. Overall electricity production in the Baltics also reached record low 58 % of demand in 2019, while electricity generation from renewable sources reached record high 50 % in the Baltic electricity generation mix in 2019.

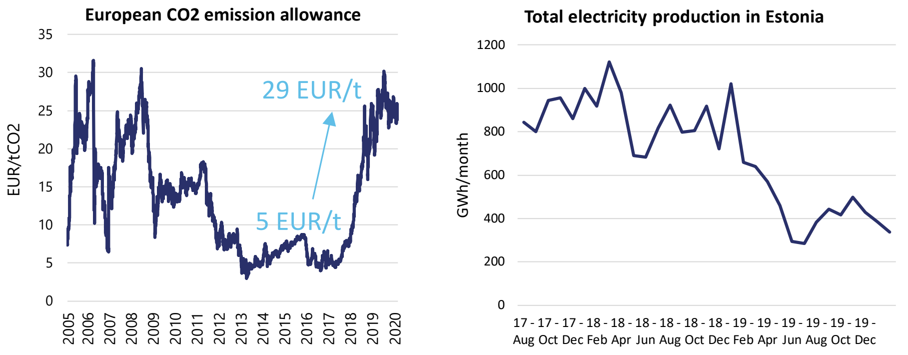


*Fig. 2.* Price of $CO_2$ emission allowances in Europe (EUR/t) and electricity production in Estonia.

Source: EEX and Nord Pool market data

## 3. CENTRALIZED, CONTROLLABLE PRODUCTION CAPACITY IS SHRINKING IN THE REGION

During the past five years, the total installed capacity of power plants in the Baltics has been relatively stable and now exceeds 9000 MW, which is about twice the peak of the Baltic consumption peak.

During the past five years, the installed capacity of gas power plants has decreased by 25 % (or about 1000 MW), mainly due to the closure of the oldest gas power plant units in Lithuania [3]. The most significant increase in production capacity was due to commissioning of new wind [4], [5] and biomass power plants (with a total capacity of 600 MW), as well as commissioning of a new 300 MW Auvere shale power plant (Estonia) in 2015 [6].

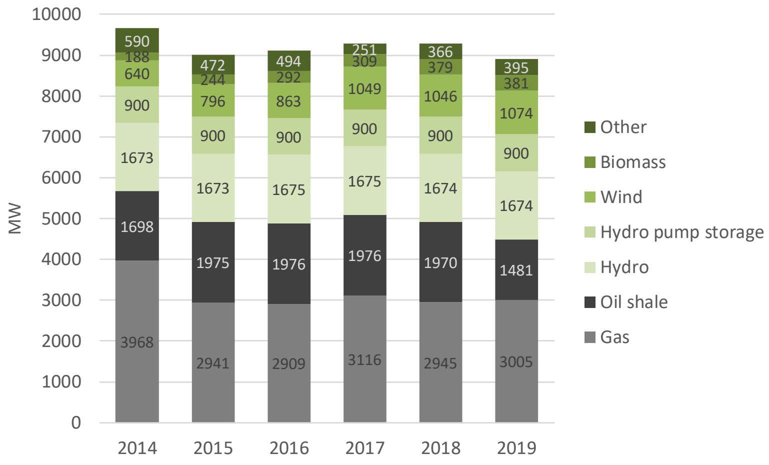


*Fig. 3.* Installed power capacity in the Baltic States.

Source: ENTSO-E

In 2019, the Baltic mix of installed capacity consists of approximately 50 % of fossil and 50% of renewable capacity. The capacity of centralized power plants in the Baltic countries is expected to decline in the coming years – mainly due to uncompetitive old thermal power plant units in Estonia and Lithuania.

## 4. GROWING SHARE OF INTERMITTENT GENERATION INCREASE DEMAND FOR BALANCING RESOURCES

Although the overall installed generation capacity is expected to grow in the Baltic region, the proportion of centralized, controllable generation capacity is expected to decrease, while the proportion of intermittent and distributed generation is expected to increase [7]. The biggest increase is expected for wind generation capacity – from approximately 1000 MW in 2020 to 4000 MW by 2034 [8] (Fig. 4).

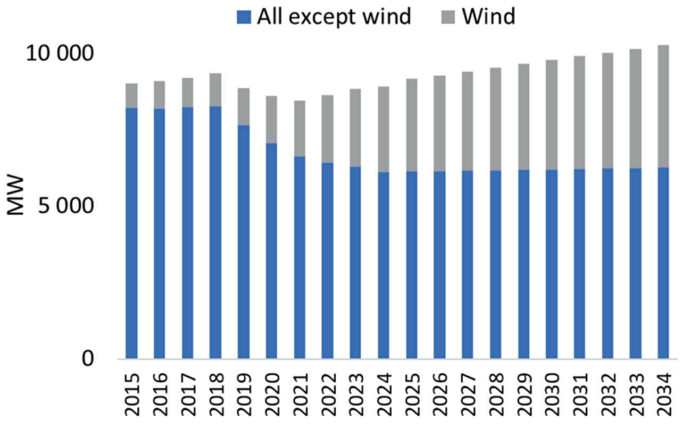


*Fig. 4.* Forecast of installed generation capacity in the Baltics.

Source: Baltic transmission system operators

While the rising amount of wind power entering the electricity grids greatly contributes to the climate goals [9], [10], it also makes the operation of the power system systematically more complex. Wind is an intermittent energy source [11] and output fluctuations must be offset to maintain continuous power balance in the system. Therefore, demand for balancing resources in the power system is expected to increase [12].

Analysis of data from the Baltic power system indicates the relation between growing wind generation and growing area control error ACE (Figs. 5, 6, 7). Analysis of statistical data for period from 2015 till 2019 suggests that increasing wind generation by 400 % during the next decade could increase the average Baltic ACE by 50 %.

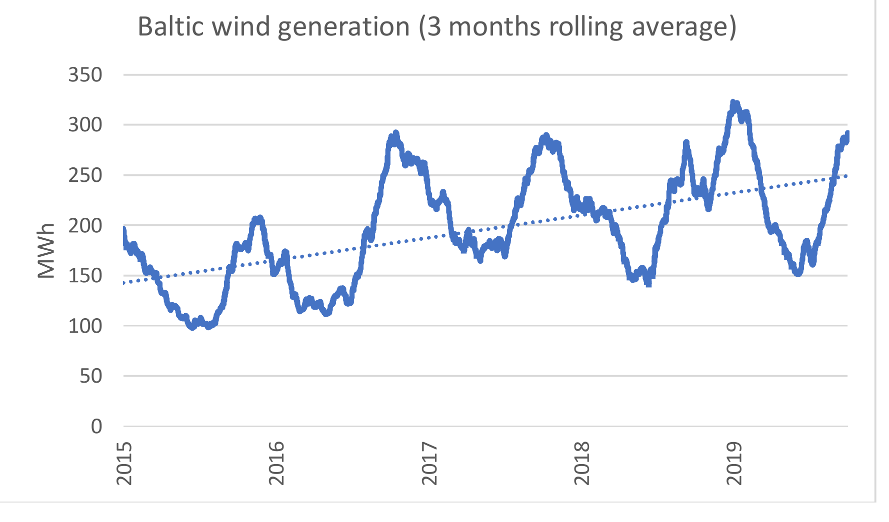


*Fig. 5.* Baltic wind generation (3 months rolling average).

Source: Baltic transmission system operators

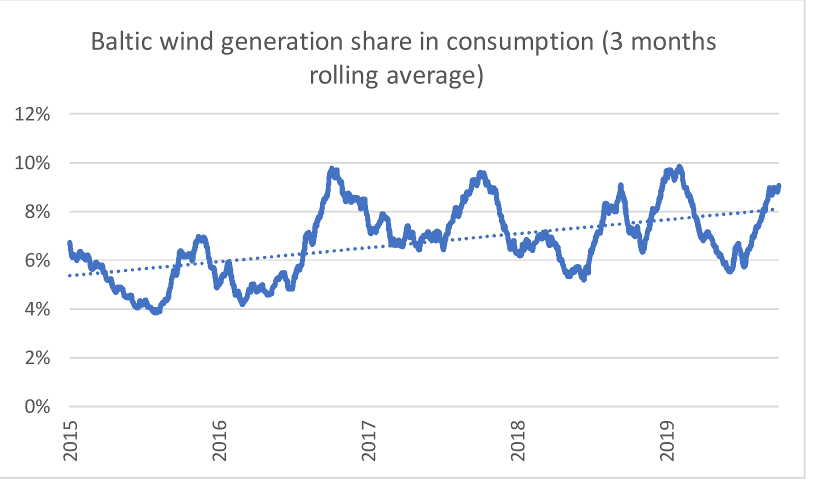


*Fig. 6.* Baltic wind generation share in consumption (3 months rolling average).

Source: Baltic transmission system operators

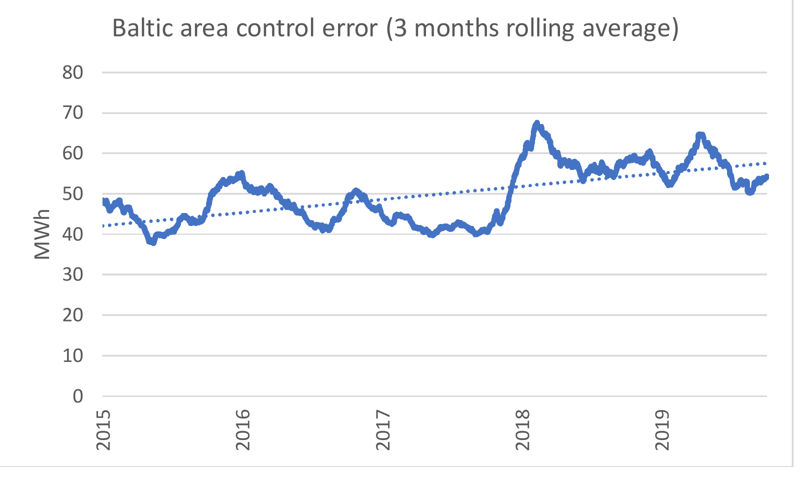


*Fig. 7.* Baltic area control error (3 months rolling average).

Source: Baltic transmission system operators

## 5. SUPPLY OF BALANCING RESERVES DECREASES AS CONVENTIONAL, CENTRALIZED POWER PLANTS EXIT THE MARKET

The creation of new Baltic balancing market and more active power system control have been implemented since the beginning of 2018. It has resulted in a more active usage of balancing resources [13], more active balance control and lower ACE after balance control (Table 1). Average Baltic ACE after balance control in 2019 was two times smaller than in 2017 and the number of hours with Baltic ACE after balance control within 50 MWh limit increased from 65 % in 2017 to 94 % in 2019 [14].

**Table 1. Indicators of the Baltic Power System Balancing Accuracy and ACE after balance control**

| Period | 2019 | 2018 | 2017 |
|---|---|---|---|
| Average ACE, MWh | 18.81 | 23.99 | 41.99 |
| Hours with Baltic ACE inside 50MWh | 94 % | 89 % | 65 % |

The oldest conventional, centralized power plants in the Baltics have been gradually decommissioned during the past years. However, 2019 was particularly significant as generation decreased by 29 % in 2019 compared to 2018. Particularly, power generation from oil-shale – the largest source of power generation in the Baltics – decreased by more than a half in 2019. Since the conventional thermal power plants are also a significant source of balancing power, this fact affects the availability of balancing reserves in the Baltic market. Amount of balancing energy from the Baltic balancing reserves decreased by 1/3 in 2019 compared to the previous year (Fig. 8).

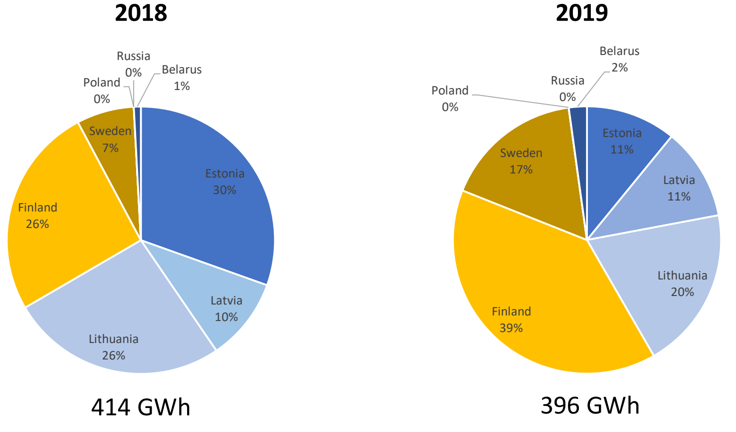


*Fig. 8.* Origin of used balancing energy in the Baltic market.

Source: Baltic transmission system operators

## 6. THE RISK OF SHORTAGE OF GENERATION CAPACITIES WILL INCREASE IN THE COMING YEARS

According to the TSO evaluation [8] after 2020, the adequacy of electricity supply in the Baltic States will highly depend on imports through interconnections from neighbouring power systems. The peak load capacity will be significantly reduced after 2025 [5], when the Baltic transmission system will disconnect from the unified Russian power system and start synchronous operation with the continental Europe power system. After 2030, however, generation and import capacities of the Baltic power system are expected to be insufficient to cover peak loads and provide an adequate level of safety in the Baltic electricity system in normal operation, with a capacity deficit of up to 360 MW.

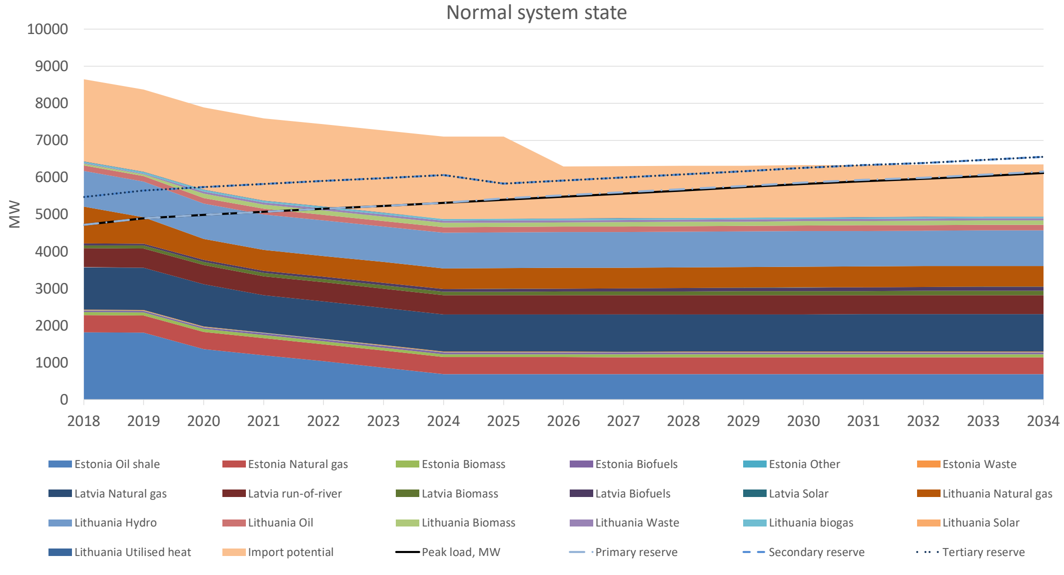


*Fig. 9.* Capacity adequacy (peak load) evaluation on normal system state.

Source: Baltic transmission system operators

## 7. BALTIC SYNCHRONISATION WITH POWER SYSTEM OF CONTINENTAL EUROPE WILL INCREASE DEMAND FOR BALANCING RESERVES

Currently, the Baltic electricity transmission system is integrated into the unified Russian power system BRELL. Due to the planned Baltic desynchronisation from the BRELL system and synchronous operation with the Continental Europe system as from 2025, the Baltic transmission system operators will have to be able to participate in frequency regulation both in normal conditions and in the event of a major generator or cross-border interconnection outage. Synchronisation with Continental Europe grid will require changes in network balancing routines by reacting to changes in quicker and more automatised way by using frequency containment reserves and automated frequency restoration reserves. Desynchronisation from BRELL will require additional balancing reserves to the Baltic transmission system operators. Table 2 shows the indicative reserve requirements, which will be required by the Baltic TSOs in accordance with the operational guidelines of the power system of Continental Europe.

**Table 2.** Indicative Reserve Requirements for Baltic TSOs after Synchronisation with the Continental European Power System in 2025 (MW)

| Reserve type | Baltic | Estonia | Latvia | Lithuania |
|---|---|---|---|---|
| FCR | 30 | 7 | 11 | 12 |
| aFRR upward | 100 | 32 | 23 | 45 |
| aFRR downward | 100 | 32 | 23 | 45 |
| mFRR upward | 600 | 218 | 148 | 234 |
| mFRR downward | 600 | 279 | 21 | 300 |

FCR – *frequency containment reserve*
aFRR – *automated frequency restoration reserve*
mFRR – *manual frequency restoration reserve*

## CONCLUSIONS

Supply of balancing reserves is expected to decrease in the Baltic power system in the coming years because the oldest, centralized power plants (mainly oil-shale and natural gas) are expected to exit the market. Rising price of $CO_2$ emission allowances and low electricity price are important factors.

Demand of balancing reserves is expected to increase in the coming years due to the growing share of intermittent and distributed generation in the Baltic power system. Quadrupling the installed wind generation capacity during the next decade could increase the area control error of the Baltic power system by 50 %.

Synchronisation of the Baltic power system with the grid of Continental Europe will further increase demand for balancing reserves as Baltic TSOs will have to participate in frequency control process and ensure availability of additional frequency containment reserves and automated/manual frequency restoration reserves.

The Baltic power system could face the increased risk of a shortage of generation capacities for covering peak load and shortage of balancing capacities in the next decade if the current trend of capacity decommissioning continues without new adequate, controllable capacities replacing them. One of the activity that help mitigate the risk is implementation of the Balancing capacity market and Capacity remuneration mechanisms.

## ACKNOWLEDGEMENTS

The research has been funded by the Ministry of Economics of the Republic of Latvia, project No. VPP-EM-INFRA-2018/1-0005 “Future-proof Development of the Latvian Power System in an Integrated Europe (FutureProof)”.

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