

## Executive summary of Project “Feasibility study on the interconnection variants for the integration of the Baltic States to the EU internal electricity market”

### The Baltic States integration to the EU internal electricity market

A thorough *Feasibility study on the interconnection variants for the integration of the Baltic States to the EU internal electricity market* for the target year 2020 has been performed by the Baltic States TSOs together with the Swedish consultancy company Gothia Power AB.

It is concluded from the study that synchronous operation with the Continental Europe synchronised power system (CE) is feasible, from a technical point of view, i.e. with respect to power flow, control and stability. However, reinforcements are needed in the present power system of the Baltic States, in Poland, and in Kaliningrad (when synchronous with CE), control and reserves have to be upgraded and a number of back-to-back converters towards Russia and Belarus have to be installed. Special attention has to be paid to the design parameters for the planned Visaginas power plant, since it would be the limit setting unit in many operational situations, especially in island operation. The large size of the planned Visaginas unit also requires quite large reserves. No major legal or regulatory obstacle against a synchronisation has been identified, but a number of issues have to be negotiated, resolved and agreed on. The investment costs and annual costs for a change of synchronous operation are high, compared to the market benefits. Although, no traditional technical or economic argument has been identified that can justify a change of synchronisation from the present IPS/UPS system to the CE system, there might very well be other driving forces, e.g. strategic or political.

The project addresses five different areas, presented in separate reports: 1) Review of previous studies, 2) Power system study outline – definition of interconnection scenarios and generation cases, 3) Load flow calculations, 4) Regional and Wide area stability analysis, 5) Gap analysis with respect to operational issues, Socio-economic analysis, including market modelling and benefit evaluation, as well as Legal and regulatory issues. Three main interconnection variants, and variations thereof, have been investigated:

- Scenario A: Baltic States synchronous with IPS/UPS
- Scenario Ba: Baltic States and Kaliningrad synchronous with Continental Europe
- Scenario Bb: Baltic States synchronous with Continental Europe, but asynchronous with Kaliningrad.

Synchronous operation of the Baltic States power system with the CE system has been found feasible for year 2020 from a **Load flow** contingency point of view, considering reasonable connection variants and reinforcements. Based on the current situation,

generation expansion plans, network extension and reinforcement plans, load forecasts, and preliminary market analyses, a number of initial load flow cases are identified.

From the load flow study it is concluded that:

- Synchronous operation of the Baltic States power system with the CE system is feasible from a load flow contingency point of view.
- Some new transmission lines should be established to overcome identified bottlenecks within the Baltic States. Reinforcements of the Polish system close to Lithuania are also presumed and specified.
- The proposed connections and reinforcements are designed with respect to the present and planned system capacities in the affected areas, resulting in import/export restrictions only for extreme operational conditions.
- As the existing IPS/UPS transmission system ring will be broken, it is found that the western part of the Russia/Belarus transmission grid has to be strengthened.
- If Kaliningrad joins the Baltic States in synchronous operation with CE, LitPol Link 1 converted to AC and a double circuit AC connection between Kaliningrad and Poland is recommended.
- If Kaliningrad will be asynchronous with the Baltic States, LitPol Link 2, double circuit AC connection between Lithuania and Poland, is necessary to provide sufficient operational security.
- To enable power exchange with IPS/UPS, HVDC back-to-back links should be established; Lithuania-Belarus, Estonia-Russia, Latvia-Russia.

The purpose of the **Regional stability** analysis is to identify any risk for transient instability (first swing), as a consequence of a power system primary fault, for synchronous operation of the Baltic States with CE. Furthermore, island operation of the Baltic States is studied. The critical fault clearing time for the most important network elements, the frequency response to trip of generation and trip of HVDC import/export, and the transient stability of major Baltic States generators are investigated. No major obstacles against synchronous operation of the Baltic States with CE, with respect to transient stability, have been identified. The transient stability of Visaginas NPP might be an exception that has to be addressed.

In the **Wide area stability** analysis of the connection of the Baltic States power system to Poland and the CE power system, the damping of new oscillation modes, i.e. generators or groups of generators in the system oscillating against each other causing power oscillation on the interconnecting transmission lines, is investigated to ensure sufficient damping, to prevent instability and split of the power system. Eigenvalue analysis and dynamic simulations have been used for the analysis of oscillation modes regarding oscillation frequency and damping. The inclusion of the Baltic States dynamic power system model to the dynamic model of the CE system and Poland does not seem to introduce more modes in the frequency range 2-6 rad/s (0.3 – 1 Hz). The damping of the oscillations identified is found to be acceptable. The necessity of well-functioning power system stabilizers on major generators in the Baltic States is emphasised.

The **Gap analysis** is part of the socio-economic analysis. It reviews the operational differences between the current situation in the Baltic States and the CE system requirements. Moreover, the changes that the Baltic States, as ENTSO-E members, must implement according to the upcoming network codes are identified. The main difference between the current situation in the Baltic States and in CE, is found to be the issue of reserves. If the Baltic States would join the CE system, delivering its share of about 25 MW to the total Primary Control Reserve will probably not be an issue, but ensuring enough transfer capacity to transmit Primary Reserve, in case of trip of the largest unit, might be. Also the issue of secondary and tertiary reserves might be considerably costly, especially if Visaginas NPP will be built at 1350 MW. Finally data sharing might be an obstacle in some situations, e.g. if ENTSO-E will require sharing of confidential BRELL data in Scenario A.

The **Socio-economic** analysis comprises associated investment costs and an electric energy market model for the different interconnection variants to derive the corresponding benefits. It should be noted that from an electric energy market point of view, it is irrelevant if an interconnection is synchronous or asynchronous. Furthermore, other costs than investments, such as costs for operation, reserves, control, administration, etc., as well as costs related to socio-economic risks, are included in the cost-benefit analysis.

Sensitivity analyses with respect to eastward trading capacity for the scenarios with synchronous operation with CE, as well as with respect to synchronous operation with Kaliningrad and LitPol Link 2, have been included in the study. Furthermore the sensitivity of increased asynchronous capacity towards Poland and Europe has been investigated for the synchronous operation with IPS/UPS.

Based on a traditional cost-benefit evaluation of the different scenarios, synchronization with CE might be hard to justify.

Even though, no technical or economic argument to justify a change to synchronous operation with CE has been identified in this study, there are always arguments to stay strong on the expanding Northeast European electricity energy market. Increasing the internal generation capacity and controllability, and the trading capacity towards CE, seems to be an efficient way to prepare for future uncertainties, to avoid large investments and to take advantage of the present conditions.

The **Legal and regulatory** part of the study is very much based on the fact that the Baltic States have expressed their interest in and intentions to connect their electricity systems with the CE power system for synchronous operation. The analysis of the legal and regulatory issues focuses on evaluation of the differences in the regulatory environment applicable for RGCE members compared to regulation of activities of Baltic TSOs. In order to perform the thorough investigation of possible scenarios of the Baltic power systems operation, legal implications of remaining synchronised with the IPS/UPS are also considered.

Legal implications related to maintaining synchronous operation of the Baltic power systems with the IPS/UPS:

- (i) In case the political decision to synchronise the Baltic power systems with CE is withdrawn, the respective legal acts and development plans of the Baltic States should be amended or revoked accordingly.
- (ii) No binding decision for the Baltic States TSOs to implement synchronisation has been made on European level.
- (iii) Transposition of the NCs requirements into the BRELL framework may be complication if agreement negotiated by the EU, Russia and Belarus is not concluded.
- (iv) Confidentiality conflicts may arise while the Baltic TSOs must comply with NCs requirements.

The process of extension of the CE and legal requirements related thereto is regulated to a very limited extent by the RGCE ToR while de-synchronisation from the IPS/UPS and other issues related to synchronisation with the CE should be further coordinated by the agreements between the involved TSOs.

Legal risks and implications related to the synchronisation with the CE together with the power system of the Kaliningrad Oblast:

- (i) The strength of the political decisions to seek synchronous operations with the CE differs among three Baltic States and a clear expression of the political will would be recommendable on national and/or international level.
- (ii) Issues related to the status of the Kaliningrad Oblast and applicability of EU law and functions of the TSO of the power system of Kaliningrad Oblast should be solved.
- (iii) Liability of the Baltic States under the international agreements may arise.
- (iv) In case the Baltic TSOs decide to refrain from prolongation of the BRELL Agreement, the parties should agree in writing so that liability for termination thereof does not arise
- (v) In case the option for interconnecting Lithuanian and Polish electricity systems by the AC line from Poland via the territory of Belarus (without any connection in Belarus) to Lithuania is required from the technical perspective in order to ensure sufficient capacity, this would raise a number of legal issues related to ownership, maintenance and protection of such line.
- (vi) Amendments of local legal acts to facilitate the ability of the Baltic TSOs to fully comply with the OH requirements may be necessary.
- (vii) TSOs shall negotiate and conclude a number of documents or agreements referred to in the OH with the neighbouring or adjacent TSOs on bilateral or multilateral level related to various operational issues.

In general, the actions to be taken by the Baltic TSOs in order to connect the Baltic power systems with the CE in synchronisation mode without the power system of the Kaliningrad Oblast are similar to those as in case of synchronisation with the Kaliningrad Oblast. It can be reasonably assumed that in case the synchronisation of the Baltic power systems with the CE is implemented without the Kaliningrad Oblast, the synchronisation process will be more time-consuming. The conclusions identified under paragraphs (i), (iv), (v), (vi) and (vii) above remain unchanged in respect of the scenario

of the synchronous parallel operations of the power systems of the Baltic States with the CE including existing and planned interconnections with IPS/UPS and RGN without synchronous operations of Kaliningrad Oblast. Additionally, the following legal risks are identified related to the synchronisation with the CE without the power system of the Kaliningrad Oblast:

- (i) In case the option of constructing the AC corridor from Kaliningrad Oblast to the IPS/UPS without any connection within the Baltic States is preferred from the technical and financial perspective, this will bring a number of legal issues related to ownership, maintenance and protection of such line.
- (ii) In case of operation of the power system of the Kaliningrad Oblast in asynchronous mode with both the CE (and the Baltic States) and the IPS/UPS, the questions related to reinforcement of the power system of the Kaliningrad Oblast should be solved.
- (iii) Liability of the Baltic States under the international agreements (such as ECT, WTO documents, bilateral investment protection agreements) may arise.