

## **The executive summary on pre-feasibility steady – state load flow study on synchronous operation of Baltic power systems with the UCTE**

### **Background**

On June 11<sup>th</sup>, 2007 the Prime Ministers of the Baltic States signed the Communiqué calling TSOs from Estonia, Latvia and Lithuania to undertake a full feasibility study on the synchronization of the Baltic electricity transmission system with the UCTE synchronous area and to report back to the Prime Ministers by the end of the year on the cost and possible timetable of the synchronization. PSE-Operator SA as UCTE TSO adjoining Baltic TSOs was invited to the cooperation. On October 30<sup>th</sup>, 2007 the Cooperation Agreement among three Baltic TSOs and PSE-Operator was signed with the aim to work jointly within the framework of the TSOs scope of activities, competences and responsibilities with the aim to analyze, investigate, assess and evaluate all possible scenarios of integration of the Baltic electricity market into CEE regional electricity market.

As a first step of cooperation the Task Force with representatives of OÜ Põhivõrk, AS Augstsprieguma tīkls, Lietuvos energija AB and PSE-Operator SA was established with the task to conduct a pre-feasibility study. The Task Force was under the obligation to perform the preliminary calculations based on simplified assumptions and to deliver first conclusions and recommendations concerning investigated scenario of synchronous interconnection.

This paper, being the Executive Summary of the work, done by the Task Force, gives in a brief and condensed form the assumptions and first conclusions.

It must be stressed that the obtained so far results should be treated as preliminary for final evaluation of feasibility of the synchronous operation and its costs.

To assess full scale of necessary investments and actions related to synchronous interconnection the following next steps are required:

1. Dynamic stability analysis – necessary to evaluate system behavior in case of frequency disturbance and to identify the inter-area oscillations in the extended interconnected system of UCTE;
2. Evaluation of costs related to disconnection of Baltic power systems from IPS/UPS interconnection based on agreements with eastern neighbours Russia and Belarus.

### **Model and assumptions**

In order to perform calculations with indicative results in the required timeframe it was agreed to use the existing, actual summer and winter reference network models of all TSOs for the year 2007. However certain network reinforcements needed to be included.

As far as the connections with neighbouring countries are concerned there has been agreed as follows:

- additionally to the existing Estlink I, the Estlink II has also been modeled;
- no connection between Baltic TSOs and Swedish TSO included in the model, because of more soft regime in compare with Finland – Poland and back power flows;
- asynchronous operation of Baltic TSOs with IPS/UPS (Russia and Belarus);
- Kaliningrad area operating synchronously with Baltic TSOs.

As a precondition, to merge the models the interconnection between Polish and Lithuanian power systems had to be included with different scenarios of network development.

Calculations were performed for three network development cases in the interface Lithuania-Poland:

Case 1: 400 kV Alytus - Ełk double circuit line, 400 kV Narew - Ełk line;

Case 2: Case 1 enforced by 400 kV Ełk – Ostrołęka double circuit line, 400 kV Ostrołęka – Miłosna double circuit line, and 400 kV Kaunas – Ełk line;

Case 3: Case 2 enforced by 400 kV Ostrołęka - Olsztyn Matki double circuit line.



## Results of analysis

First of the Task Force recommendations is that for the further analysis the models including power systems developments planned for 2015 should be used because load and generation patterns as well as the number of transmission lines can change, for certain cases significantly enough in comparison to 2007. The year 2015 is the date when the implementation of the first interconnection stage is the earliest possible taking into consideration the time needed for constructing new power plants or transmission lines. Therefore, according to the Task Force, it is necessary to perform additional steady state load flow calculations with the year 2015 models and to complete these calculations with the dynamic stability analysis - especially to get a knowledge on system performance during and after frequency disturbance and to identify the issue of inter-area oscillations in the interconnected system.

The preliminary results for case 1 (winter and summer model), obtained within the scope of work of the Task Force show that the connection between Baltic TSOs and UCTE is feasible only through the back-to-back station (asynchronous connection). Thanks to such connection TSOs can have a possibility to control power flows exchanged between power systems, otherwise sudden disconnection of generating units in Baltic countries can lead to severe overloads and voltage violation in Polish north-east part of grid and possible blackout in Baltic countries. Synchronous operation of Baltic's with the UCTE is not excluded from the technical viewpoint for cases 2 and on condition that necessary reinforcement of Polish and Baltic countries' internal grids will be implemented including construction of two additional links between Baltic's and UCTE.

Reinforcements additional to construction of the transmission lines already incorporated in the models for 3 cases calculations must include:

- reinforcement of transmission grid supplying Warsaw area and 110 kV lines in north-east area of Poland.
- construction of Harku – Sindi - Riga and Ignalina - Kruonis transmission lines and reinforcement of interconnection Latvia - Lithuania in Baltic countries.

Asynchronous interconnection (case 1) of Baltic countries and Poland is possible by the year 2015 at earliest, because of construction time of 400 kV Ełk - Narew transmission line. During this stage Baltic power systems should remain synchronously interconnected with IPS/UPS.

Considering scenario of synchronous operation of Baltic countries with the UCTE the additional substantial reinforcements in Polish and Baltic countries' grids have to be done. Taking into account only time for preparation of right-of-way and construction time for transmission lines it seems that up to 12 years is needed to fulfill this condition. Preliminary estimated horizon of time for all necessary preparations for synchronous operation to be implemented seems to be 2020-2025.

As a first step towards synchronous interconnection, asynchronous interconnection (DC interconnection) should be implemented. According to preliminary analysis it is recommended to remain asynchronous interconnection operation on the one of interconnection after synchronous connections will be constructed, thus improving stability of interconnection and power exchange possibilities. The third interconnection line between Poland and Lithuania (Ełk - Kaunas) will not improve significantly power exchange possibilities between Baltic countries and Poland. According to the Task Force, other additional transmission lines with different connection points in Poland and Lithuania or Kaliningrad should be studied in the scope of further feasibility study on UCTE – BALTSO synchronous interconnection.

In addition to the conclusions on technical feasibility it is necessary to underline that the transfer capacity of UCTE – BALTSO interconnection as well as Baltic countries' ability to

operate synchronously with UCTE are directly linked with the size of largest generating unit in Baltic countries or DC connections between Baltic countries and Nordel or IPS/UPS.

### **Preliminary assessment of associated costs**

Present long-term development plan of Estonian transmission system includes construction of 330kV line Harku – Sindi with cost of 32 million EUR and construction of 330 kV line from Sindi to Riga (Latvia) with cost of 10 million EUR from Estonian side. The implementation of mentioned lines is also precondition for synchronous interconnection scenario with UCTE and totals to 42 million EUR

The estimated costs for Latvian power system to be ready for synchronous operation include necessity to construct two power plants in Riga and Kurzeme region. The reason for this is because Latvia is significantly lacking of available generation capacity. The cost for both power plants 400 to 500MW each plus construction of 300km 330kV circuits for Kurzeme power plant connection is estimated about 1 billion EUR. In addition it is necessary to strengthen Latvia – Lithuania connection with new line to Ignalina that results to 17 million EUR from Latvia part. The only more or less predicted project is Riga - Sindi line where Latvia's share is about 25 million EUR. For Latvia preliminary estimated costs total to 1050 million EUR.

Present development plan for Lithuanian includes 330kV lines Vilnius - Neris, Telsai - Klaipeda, Panevezys - Musa, Kruonio HPP -Alitus double circuit with back-to-back station and totals to 290 million EUR. In addition to existing plans it is construction of Ignalina - Kruonio HPP double circuit with cost of 65 million EUR and line from Ignalina to Latvia with cost of 6 million from Lithuania side is required and with cost of two additional lines to Poland it sums up to 260 million EUR. Cost of these investments being the preconditions for synchronous scenario are at the level of 550 million EUR.

In addition the cost of implementation of primary control in old power plants that fulfils requirements of UCTE should be considered with total cost for all three Baltic power systems of 80 million EUR.

Based on the technical assumptions that were made in the past the total cost for Polish power system was estimated at 654 million EUR. This estimation has covered three major groups of necessary investment. The first one, which was around 54 million EUR concerned the Polish – Lithuanian cross-border double-circuit line itself. The second group was related to the massive development of the transmission infrastructure in the north-eastern Poland and its estimated cost was 430 million EUR. The third group of around 170 million EUR was related to indispensable strengthening of some parts of the system due to the interconnection effect, enabling equal possibilities of electricity exchange for both sides.

Mentioned above components of costs associated with necessary investments in Baltic and Polish power systems which are identified so far as minimum preconditions for synchronous operation with UCTE sum up to 2,5 billion EUR.

The total costs could be higher depending on possible additional external costs related to separation of Baltic power system from IPS/UPS.

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