



Challenges for the Baltic Power System connecting synchronously to Continental European Network

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ABSTRACT

The article proposes a multi-project Baltic States – Continental Europe Synchronous Interconnection Scenario for 2014–2027, with the insight to the former development of the Baltic Power System and a short listing of synchronous interconnection precedents in Europe. The study identifies and discusses the major operational challenges for the Baltic Power System in synchronously connecting the Continental European Network (CEN) via the recently commissioned Polish–Lithuanian tie LitPol Link1 and the projected LitPol Link2. The HVDC converter stations on asynchronous ties with Russia, Belarus and Nordic systems are recommended for the exchange of frequency containment and restoration reserves, notably in the DC-supported island operation condition of the Baltic Power System.

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1. Introduction

The Baltic Region is one of five synchronous areas in Europe covered by the ENTSO-E, European Network of Transmission System Operators for Electricity, together with Continental Europe, Nordic, Great Britain and Ireland areas. The Region comprises three Baltic national power systems (PS): Estonian, Latvian and Lithuanian. Their TSOs have jointly applied to the former UCTE, Union for the Coordination of the Transmission of Electricity, predecessor of ENTSO-E, in 1999 and 2007 for the synchronous interconnection with Polish PS, the only CEN member system bordering on Baltic Region (Fig. 1).

There are several peculiarities specific to the current operational situation in the Baltic Region. First and foremost, the Baltic TSOs have never carried out full operational responsibility for the

load-frequency control (LFC). The Region is not a separate synchronous area as the rest four. It is just a part of BRELL (Belarus, part of Russia within the Saint Petersburg–Moscow–Smolensk loop, Estonia, Latvia and Lithuania), a much larger synchronous area. Essentially, even the BRELL itself is only a sub-area in the synchronous IPS/UPS¹ area. The second peculiarity is the recent escape from an isolated location of the Baltic PS against the CEN. Being geographically a mainland extension of Continental Europe, the Region (Lithuania) has only in February 2016 got the first link with the mainland. These peculiarities plus electricity market integration target were likely the major drivers for European Commission to call for moving the Baltic States out of the energy island situation [1].

Nevertheless, any synchronous integration is a challenge for both connecting areas. The detailed investigation of political, technical and organizational aspects should underlie the planning and implementation phases of the integration process. The objective of this research is to identify and analyse the major challenges the Baltic national systems will encounter when connecting to the CEN in synchronous mode, the possible responses to these challenges, and the related opportunities. Section 2 outlines the Synchronous Interconnection Scenario, with short reference to the historical origin of the Baltic PS. Section 3 outlines the synchronous

Abbreviations: AC, alternating current; AGC, automatic generation control; BRELL, organization of TSOs of Belarus, Russia, Estonia, Latvia and Lithuania; CCGT, combined cycle gas turbine; CEN, Continental European Network; CHP, combined heat and power plant; EE, Estonian PS; DC, direct current; HP, hydro power plant; HPP, hydro pump power plant; HVDC, high voltage direct current; IPS/UPS, integrated power system/unified power system; KL, Kaliningrad Oblast (Region) PS; LFC, load-frequency control; LT, Lithuanian PS; LV, Latvian PS; NPP, nuclear power plant; OHL, overhead line; PL, Polish PS; PP, power plant; PS, power system; SE, Swedish PS; TSO, transmission system operator; WAMS, wide area monitoring system.

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¹ IPS/UPS – the power system consisting of a synchronous transmission grid of power systems of Russia and Commonwealth of Independent States.



Fig. 1. CEN/Baltic States synchronous interconnection scenario 2014–2027.

interconnection precedents in Europe. Section 4 identifies the challenges of interconnection, which the Baltic operators are expected to face. Discussion on results of Sections 2–4 is presented in Section 5 followed by the conclusions in Section 6.

2. Baltic Synchronous Interconnection Scenario

For the purpose of integration of the Baltic PS into Continental Europe (and partly to Nordic) areas, a large-scale extension of transmission infrastructure is necessary in the Baltic Region and Poland. Baltic Interconnection Scenario for the period 2014–2027 has been drafted envisaging new (from the state of January 2016) transmission facilities as presented in Fig. 1. The Scenario suggests two phases of the interconnection process. First one, from 2016 to 2025, deals only asynchronous links to CEN, while the second covers extended synchronous operation trial, possibly from 2025 to 2027.

The Scenario is largely based on the EU policy guidelines [2–4] and the ten-year development plans of Baltic TSOs – LitGrid, Augstsprieguma tīkls and Elering [5,6]. Specifically, these EU guidelines promote CEN-Baltic States synchronous interconnection as European project of common interest.

The transmission infrastructure projects covered by the Scenario can be divided between three geographic zones: on-border projects, Baltic-inside projects and Polish-inside projects.

2.1. A retrospective view on the Baltic Power System

The current technical infrastructure and operational conditions of the Baltic PS are largely determined by energy development strategies in the former Soviet Union and its political goals to deepen the Region's political, economic and social integration into the Soviet Union. Therefore three Baltic systems have not been developed on a national basis, but actually as one consolidated 330 kV transmission system. Furthermore, the Region was tightly interconnected with the Belarus and Kaliningrad Oblast systems in the South (via Lithuania) and with the Leningrad and Pskov systems in the North (via Estonia). All these PSs together with Karelia and Kola systems (beyond the Finnish eastern border) had constituted the North-West IPS. It was controlled from a Dispatching Centre in Riga, Latvia.

Baltic power plants had been planned with redundant capacities for Region's demand and significantly contributed to the supply of neighbouring regions: Estonian oil-shale fuelled plants (Balti PP, 765 MW, commissioned in 1965, and Eesti PP, 1615 MW, 1973, both near Narva) supplied the Leningrad Region; Lithuanian PP (1800 MW, 1962–1972) – Belarus and Kaliningrad Oblast; Ignalina NPP (in Lithuania, 3000 MW, 1983–1986) – Kaliningrad Oblast, Belarus and Russia (Fig. 1).

The North-West IPS did not actually contribute to LFC in terms of primary control (turbine governors), only underfrequency load shedding ranks were established. It was a part of the joint Soviet Union and East Europe Unified Power System “Mir”, the world's largest synchronous area, which extended from East Germany in the West to Russian Far-East regions at Pacific Ocean in the East. As opposed to the former UCPTE (since 1999 – UCTE), UPS “Mir” used the centralized approach to primary frequency control: the frequency deviations were handled by the cascade of hydropower plants on the Volga river in the former South IPS [7].

Following the collapse of the Soviet Union in 1991, the Baltic States restored political independences and started to pursue national energy policies. They took the power systems to state ownership together with their institutional and operational control. The Baltic Region withdrew from the North-West IPS, and Riga Dispatching Centre was reorganized to Baltija Dispatching Centre. It implied the establishment of the Baltic PS. The Region's synchronous operation with the Russian IPS/UPS further continued, and Baltija Dispatching Centre remained hierarchically subordinate to IPS/UPS dispatchers. They controlled the wide-area stability, parallel operation and transits over the Baltic PS. Such practice was legally fixed in 2001, when Belarusian, Russian, Estonian, Latvian and Lithuanian TSOs founded BRELL, the organization for the coordination of joint parallel operation, and signed the BRELL Agreement [8]. This situation is *status quo* to date, despite of several new developments:

- Baltija Dispatching Centre was closed in 2007, and three Baltic TSOs cooperate directly and act jointly as a TSO forum.
- Baltic States made a significant progress on a way to European energy structures: they joined the EU in 2004; their TSOs entered the ETSO, and they were assigned to its BALTSO regional group on March 1, 2006 (ETSO was reorganized into ENTSO-E in 2009); Estlink 1, the first tie with the EU (HVDC, 350 MW) was commissioned in 2006; in 2010, 2012 and 2013, Baltic States transferred their national power exchanges to Nord Pool Spot (NPS), the Nordic power exchange operator, and, respectively, NPS Estonian, Latvian and Lithuanian price areas were established. Furthermore, the insufficiency of interconnection capacity with the EU, as highlighted by the European Economic and Social Committee [9], was significantly mitigated by Estlink 2 (HVDC, 650 MW) in December, 2013 followed by asynchronous links NordBalt

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