Development of the Baltic Power System for the utilisation of the region's vast renewable energy potential

The overall objective of the NORSTRAT project is to build knowledge and understanding among politicians, decision makers and actors in the power industry about possible carbon neutral futures for an integrated Nordic power system in a time perspective up to 2050. E.g. Estonian today's oil shale dominated power production could be based 100% on domestic renewable fuels and energy sources by 2050, if relevant policies are implemented, including the development of the transmission grid and interconnections.

Background

This communication is presenting the results of the research carried out by the Stockholm Environment Institute Tallinn Centre in cooperation with partners in assessing the development needs of the Baltic Energy Market in conjunction with the preparation of the Nordic power road map 2050. The current policy brief has a particular focus on the development of the three Baltic States' power system and what is feasible in terms of expansion of transmission grid interconnections to achieve a carbon neutral power sector, taking into account possible grid developments in neighbouring countries.

Methodology

A scenario methodology is used in order to analyse the future system. The transmission grid development scenarios were analysed by the EMPS model and an investment algorithm for profitable expansion of transmission links as presented in more detail in NORSTRAT D3.1 report by SINTEF. The EMPS is an electricity market model that can handle systems with large shares of conventional and varying electricity generation as well as long and short-term storage options such as hydropower. Each node (or region) was characterized by an endogenously determined internal supply and demand balance with distinct import and export transmission capacities to the neighbouring nodes.

Two production/consumption scenarios in combination with two scenarios varying the interconnection with Russia and Belarus were compared. In the first production scenario, the LowCO2, the production and consumption with 100% of renewable energy sources (especially wind and biomass) use for power production was foreseen for Baltic States including Estonia. For the rest of Northern Europe, the data for European Battery (EB) of the NORSTRAT project was used. For the second power production scenario (scenario MIX), the data for EB for all of Europe was used also for the Baltic States. For the interconnection development, two alternatives were compared: the first (withRUSBEL), where the interconnection to Russia and Belarus stays, without new investments as today, and the second (noRUSBEL), where the connections to Russia and Belarus are entirely eliminated as future of the Baltic power system may foresee disconnection from the IPS/UPS after integration as well as synchronisation with Continental Europe power system (CE).
The new renewable electricity production is to a large degree based on already defined projects for onshore and offshore wind and biomass. In 2012, there were 276 MW wind capacities in operation in Estonia and registered projects with approximately 1850 MW of capacities in the pipeline, of which 1820 MW were wind production and 28 MW biomass co-generation. The NORSTRAT project study focused particularly on developing a grid development scenario, which could support the shift of the Estonian electricity sector from the current oil shale dominated electricity production to a 100% renewable-based future So far the government has preferred maintaining the use of oil shale.

Results

Currently the Baltic States' energy systems are synchronously connected to the united grid system of the Commonwealth of Independent States and the Baltic States (IPS/UPS). Estonia is connected to Latvia (500-900 MW) via two 330 kV AC links to Russia (500-650 MW) via three 330 kV lines and to Finland via two DC cables (350 and 650 MW). The total interconnection capacity with neighbours is up to 2550 MW. Lithuania's transmission grid is well connected with some of the neighbouring power systems: by four 330 kV lines and three 110 kV lines with Latvia, by five 330 kV lines and seven 110 kV lines with Belarus and by three 330 kV and three 110 kV lines with the Kaliningrad Region. The Latvian transmission grid has a 330 kV (600 MW) interconnection with Russia.

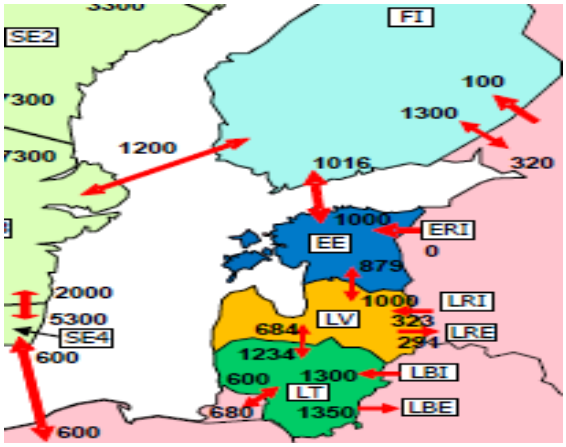

Figure 1. Maximum NTC values of interconnections in the Baltic States in 2014, MW

Source: ENTSO-E Nordic

In Estonia, the consumption of electricity increased by 2 percent in 2014 to 8.1 terawatt-hours while the net production of electricity, at 11.013 TWh, was 6% smaller than the year before. Estonia was a net exporter of electricity in 2014. Production exceeded consumption by 34%, resulting in net export of 2.754 TWh. In Latvia electricity net production shrank by 19% on 2014 to 4.857 TWh. Consumption decreased by 2% and consequently the electricity balance had a deficit of 2.315 TWh. Domestic production covered 69% of consumption. In Lithuania, at 9.84 TWh, or 2.1% more than in 2013, electricity consumption in 2014 has been the highest since 2009. A total of 72% of the electricity consumed in Lithuania last year was imported, with slightly more than half — 52% — coming from Latvia, Estonia and the Northern European countries, and 48% being imported from third countries.

Table 1. Baltic States electricity balance in 2014 (TWh)

	Estonia	Latvia	Lithuania
Electricity production	**12.444**	**5.058**	n.a.
Electricity supply to transmission grid	11.013	4.857	4.054
Renewable energy production	1.151	2.095	2.122
Electricity import	**3.730**	**5.338**	**7.779**
Electricity consumption	**7.417**	**7.172**	**11.676**
Net consumption	10.171	n.a.	10.715
Transmission grid losses	0.842	n.a.	0.870
Electricity export	**6.484**	**3.023**	**0.156**
Import-export Balance	**+2.754**	**-2.315**	**-7.623**

Source: Statistics Estonia, Central Statistics Bureau of Latvia, Litgrid

Altogether, the Baltic States consumed 25.9 TWh of electricity in 2014, more or less the same amount as a year earlier. The aggregate electricity production, at 18.8 TWh, was 11 percent smaller than in 2013. The combined electricity deficit amounted to 7.1 TWh. Imports from the Nordic countries covered an estimated 49 percent and imports from third countries, 51 percent of the shortfall. In the Nordic countries the production of electric energy grew by 2 percent, totalling 387 TWh, and consumption remained at the level of the previous year. The summarized electricity balance of the Nordic countries showed a surplus of 11.6 TWh. Of the Nordic countries' net exports 31 percent moved to the Baltic States and 69 percent to Continental Europe.

The renewable energy production potential in the Baltic States is vast. Total energy production potential of domestic renewable resources in Estonia in 2050 according to the National Long-Term Energy Strategy are estimated to be 31.9 TWh, including 5.84 TWh off-shore wind, 4.57 TWh on-shore wind, 3.71 TWh biogas, 3.87 TWh solar and 12.31 TWh wood biomass. According to the reference scenario of the Latvian NREAP, the RES-E generation is planned to grow from 3 TWh in 2010 to 5.1 TWh in 2020. Hydro power generation is planned to increase to 3.05 TWh in 2020, wind generation is planned to grow to 910 GWh in 2020 (+1468%), solar will play a negligible role, while other renewables, i.e. mainly biomass are planned to increase to 1.2 TWh in 2020 (+1600%). According to the GAIN report of 2011, in Lithuania the potential of wood and agriculture bio-waste exceeds 1.5 TWh, potential of power production in small hydro plants (installed capacity in 2009 was 26 MW) could double, wind turbines could generate 10% gross electricity production and there is also potential for wider use of geothermal and solar energy as well as the production of biogas and other biofuels.

The potential of domestic renewable resources cannot be fully utilised without determined transmission grid developments as the grid today in areas with most wind resource potential (the west coast, islands and the EEZ marine area) is underdeveloped and in Estonia there is a lack of suitable electricity production capacities (e.g. hydro plants) for balancing wind fluctuations. If Baltic States would be better connected with Nordic Power System (NPS), Norwegian and Swedish hydropower capacity could be used to balance new wind power capacities in the region. The EU Commission Communication on Long term infrastructure's vision for Europe and beyond (COM(2013)711 final) sets out the Union list of about 250 EU projects of common interest (PCI) in the fields of electricity and gas transmission and storage, LNG, as well as in smart grids and in oil. For Estonia, the three projects listed for development of the transmission grid's capacity are: a) the third 330 kV power connection (500-600 MW) with Latvia; b) synchronisation of the Estonian, Latvian and Lithuanian grids with Central European Power System, and c) the Hydro Pump Station in Muuga near Tallinn. In Latvia BEMIP foresees atop of a 3rd interconnection between Estonia and Latvia also the construction of new 330kV lines in the central and western part of Latvia. In Lithuania, three of the BEMIP energy infrastructure projects belong to the electricity sector: the "LitPol Link" between Lithuania and Poland, the HVDC submarine cable of 700 MW capacity between Nybro (SE) and Klaipeda (LT), and the capacity increase of hydro-pumped storage in Kruonis.

Currently the investments into the interconnections between the countries are driven more by energy security and security of supply concerns e.g. maintaining the dependency from fossil oil shale as the primary energy source, than by the climate goals and the need to switch to low-carbon energy production. In order to enable the Baltic States' transmission grid to support the full utilisation of the country's vast renewable energy potential, further investments into interconnections beyond BEMIP's approved grid connection projects have to be taken. From the four production and transmission grid investment options in the Baltic energy system, compared with the EMPs model, least investments are foreseen in the scenario MIXnoRUSBEL, where connections to Russia and Belarus are excluded, but

the scenario delivers least production of renewable electricity and continued dependency on oil shale and natural gas in the Baltic energy market. Maximum utilisation of the renewable energy potential in Estonia and in the rest of Baltic States is achieved with investing within the Baltic States 2118 MW and between Baltic and Nordic countries 2232 MW of new interconnections.

Table 2. Investment scenarios to electricity interconnections of Baltic States to enable low-carbon electricity, MW

Interconnections/Scenarios	**CO2withRUSBEL**	**LowCO2noRUSBEL**	**MIXwithRUSBEL**	**MIXnoRUSBEL**
Internal Baltics, Poland, Russia and Belarus				
Estonia - Latvia	59	284	0	0
Latvia - Lithuania	10	314	5	0
Lithuania - Poland	2049	2227	5005	1614
Estonia - Russia	0	0	0	0
Latvia - Russia	0	0	0	0
Lithuania - Russia	0	0	0	0
Lithuania - Belarus	0	0	0	0
Total Internal Baltic	**2118**	**2825**	**5010**	**1614**
Between Baltic and Nordic countries				
Estonia - Finland	599	397	950	824
Estonia - Sweden	255	155	379	0
Latvia - Sweden	1155	426	1487	401
Lithuania - Sweden	223	0	637	0
Total Baltic - Nordic	**2232**	**978**	**3453**	**1225**

From four scenarios the LowCO2withRUSBEL scenario for the Baltics – 100% renewables based with keeping the connections to Russia and Belarus, was more than other scenarios, ensuring the shift to low-carbon power production in Estonia and in the other Baltic States. By investing a total of 2232 MW into new interconnections in the three Baltic States including the new 600 MW link between Estonia and Finland and the 255 MW link between Estonia and Sweden, 10,525 TWh renewable electricity could be produced in Estonia by 2050 including 7.250 TWh from wind (mostly off-shore) and 2.803 TWh from biomass. The three Baltic States together could produce 35.806 TWh renewable electricity, almost fully covering the domestic demand in these countries with low-carbon power. Production deficit could be easily covered with import of cheaper hydro electricity from the NPS countries. With the existing ENTSO-E 10-year network development plan (TYNDP 2014), transition to low-carbon energy system in the three Baltic States could not be achieved, as it proposes only the NordBalt 700 MW DC interconnector between Sweden and Lithuania.

Table 3. Scenario LowCO2withRUSBEL for 100% renewable electricity production in Baltic States by 2050, TWh

Production mode	**Estonia**	**Latvia**	**Lithuania**
Hydro	0.025	2.887	0.357
Wind	7.250	5.376	8.707
Solar	0.447	0.560	0.570
Biomass	2.803	2.307	4.442
Gas	0	0.072	0.003
Coal/Oil shale	0	0	0
Oil	0	0	0
Nuclear	0	0	0
Other	0	0	0
Total production	**10.525**	**11.202**	**14.079**
Demand	11.043	11.567	14.171
Grid loss	0.201	0.244	0.377
Total Consumption	**11.244**	**11.811**	**14.548**
Balance	-0.719	-0.610	-0.468

If implementation of the scenario LowCO2noRUSBEL, where 100% RES electricity production in the Baltic States is aimed without connections with Russia and Belarus, is delivering almost the same amount of renewables based electricity (35.422 TWh in total, 10.449 TWh in Estonia) as by the scenario of maintaining grid connections to non-EU neighbours, the need for investments into a new interconnection between the Baltic States and between Lithuania and Poland is higher. Implementing scenarios MIXwithRUSBEL (NORSTRAT Susplan scenario in the Baltics; EB scenario in the Nordics, with today's connections to Russia and Belarus) as seen in Table 4 below and MIXnoRUSBEL (above and without the Russia and Belarus connections) would deliver significantly less renewable electricity production in all three Baltic States. Most of the electricity to cover demand will be imported from Russia and Belarus, thus increasing dependency from non-EU supplies and reducing energy security.

Table 4. Scenario MIXwithRUSBEL for 100% renewable electricity production in Baltic States by 2050, TWh

Production mode	**Estonia**	**Latvia**	**Lithuania**
Hydro	0.000	0.000	0.000
Wind	0.000	0.000	0.000
Solar	0.187	0.178	0.163
Biomass	2.436	2.662	3.417
Gas	0.174	4.083	1.772
Coal/Oil shale	0.000	0.000	0.000
Oil	0.000	0.000	0.325
Nuclear	0.000	0.000	0.000
Other	0.860	2.980	0.709
Total production	**3.657**	**9.903**	**6.387**
Demand	11.750	11.853	15.866
Grid loss	0.243	0.292	0.458
Total Consumption	**11.993**	**12.145**	**16.324**
Balance	-8.336	-2.242	-9.938

The key for the full utilisation of the vast renewable energy resources of the Baltic States and at the same time increasing energy security is integration with the Nordic Power System by investing into new interconnections with Sweden and Finland. Not only Baltic States but also whole Nordic-Baltic region will win from a better-connected and integrated power system capacity to balance production fluctuations of possible new large-scale offshore wind power capacities in the Baltic Sea.

Further Information

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More detailed results are available in: www.sintef.no/norstrat/.