Client European Commission – Directorate General for Energy and Transport – Directorate C

Subject Updating T E N-Energy- Invest study (Contract n. TREN/04/ADM/S07.38533/ETU/B2-CESI) with a particular attention paid to the future development of the Energy Market in the Baltic region –
Working Group Electricity Interconnections.
Phase I: present status of the electricity sector in the EU Member States surrounding the Baltic Sea, including Norway, Belarus, Kaliningrad region and Ukraine; main gaps and bottlenecks, qualitative assessment of new interconnection projects

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REVISIONS HISTORY

Revision number	Date	Protocol	List of modifications and/or modified paragraphs
0	20/02/2009	A9004486	First issue This issue replaces the two draft versions released on 10th Dec. 2008 (interim report) and on 27th Jan. 2009 (added new chapter on existing cross-border congestion in the Baltic region)
1	May 2009	A9012918	New comments on the LitPol and Germany-Poland interconnection projects More information added on the solutions for the offshore grid connection at Kriegers Flak in the Baltic Sea
2	June 2009	A9017214	Modifications in the description of the security criterion adopted in Baltic Member States

1 FOREWORD

The countries surrounding the Baltic Sea operate their generation and transmission systems in three different power pools: NORDEL, UCTE and BALTSO. Despite a common frequency, 50 Hz, these pools are not synchronously interconnected each other and power exchanges can take place through HVDC[1] submarine links. Whilst NORDEL and UCTE are presently connected through 9 HVDC links, the Baltic Republics of Estonia, Latvia and Lithuania can exchange energy only with NORDEL through one single interconnector between Estonia and Finland (EstLink), commissioned at the end of 2006 and with a limited capacity (350 MW). On the other hand, the transmission system of the Baltic Republics is strongly meshed with the IPS/UPS pool of the Russian Federation and the other CIS states. A further complexity derives from the geographical location of the Kaliningrad region, the transmission system of which is interconnected only with Lithuania; hence, power transfers to the Kaliningrad region from the rest of the Russian Federation will affect the loading of the Baltic Republics grids, especially in Lithuania and Latvia.

Moreover, as for the primary energy supply, it is worth mentioning that the Baltic Republics rely on Russia for the totality of their gas imports. Among the three Baltic States, Lithuania is very likely the one which will face the highest difficulties to ensure an appropriate level of energy supply, after the decommissioning of the last nuclear tranche of Ignalina PP, in particular in case of cold winter. In general, the decommissioning of Ignalina PP can make the Baltic Member States deeper dependent on import energy from Russia and Belarus.

Consequently, the three Baltic States appear to be particularly vulnerable and will have to swiftly undertake a series of actions, among which:

- identification of new sources of energy supply;
- integration with the other European power markets;
- strengthening the interconnection with the European power pools.

[1] HVDC = High Voltage Direct Current

It is clear that the present fragmented situation prevents the development of an integrated Energy Market in the Baltic region. Therefore, some priorities have been outlined by the European Commission concerning the establishing of an action plan to speed up interconnections in the Baltic region.

Since the construction of new interconnectors, which in the Baltic region will be mainly based on HVDC, is a capital intensive investment, it is of utmost importance to examine in depth the justifications for new interconnectors considering the perspective evolution in the generation sector in the concerned countries, in order to estimate the amount of energy and power exchanges and select a priority in the realisation of new interconnectors.

Cross-border infrastructures shall be seen as means to move towards the priority targets established at the European level (Fig. 1-1), i.e.:

- *competitiveness*, thanks to an effective integration of national and regional power markets. To this purpose, the full compliance of the EU Member States (MS) with the European Commission (EC) directives, regulations and decisions shall be achieved;
- *security of supply*, thanks to a diversification of power supply, a better sharing of system balance reserves and higher possibility of mutual support in case of outages;
- *sustainability*, thanks to a better exploitation of Renewable Energy Sources (RES), which by their nature are often located in sites far from the load centres.

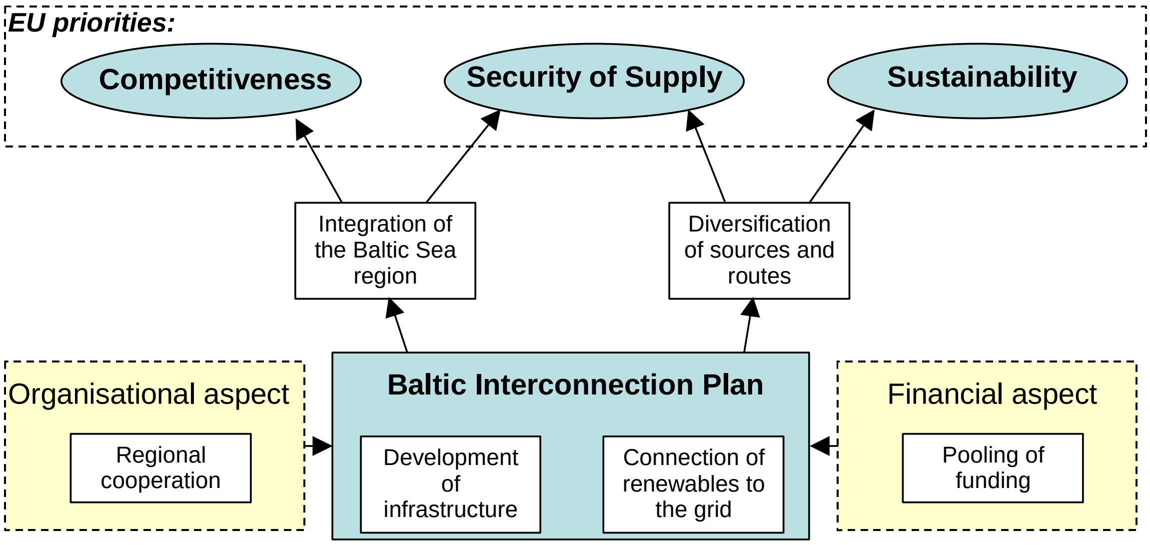


Fig. 1-1 – Baltic Interconnection Plan within the overall EU energy framework (source EC)

The above EU priorities can be attained only through a well-interconnected and well-functioning internal energy market backed up by solidarity among Member States, allowing to manage the power systems with higher security margins and power quality standards and to ensure enhanced security of energy supply in the long term. Thus, the integration of the Baltic States into EU energy networks is one of the main objectives that will contribute to the stability and economic growth of the Baltic Sea Region. In order to cope with this challenge, the EC can play a key role by proposing a series of comprehensive measures to strengthen the energy market of the Baltic area. In the Strategic Energy Review, the Baltic region is indeed among the six priority areas identified by the EC. This view is also shared by the Council, which clearly mentioned this issue in the conclusions of the last European council of October 2008. Such a regional approach is needed to address the following issues:

- replacement of the capacity of Ignalina power plant;

- meeting the growing needs for electricity in the future in the whole region;
- enabling more trade of electricity among neighbouring Member States;
- diversification of electricity production by resorting to joint projects since many countries and regions in the Baltic are too small to develop on their own a diverse power sector with different fuels, nuclear, renewables;
- reducing dependence on gas imports from Russia thanks to new interconnections with other Member Stats or a joint LNG project.

Thus, coordinated actions are needed to bring together in a global plan the (mostly existing) projects involving all countries around the Baltic Sea for the development of:

- Electricity interconnections;
- New electricity generation capacity;
- Gas diversification of routes and sources.

In this context, the EU role aims at coordination, in order:

- To bring MS and market players together with a common purpose and this explains the need to create a specific structure "High Level Group (HLG) on the Baltic Energy Market" following very positive similar examples in other areas, namely in the Southwest Regional Energy market.
- To maximize the use of different sources of funding to develop new low carbon power plants and strengthening the interconnections in the area.

To achieve a better coordination and avoid inefficiency, the European Commission launched the initiative of establishing an action plan aimed at speeding up interconnections in the Baltic region. The European Council supports the Commission initiative. The principle of setting up a Baltic Interconnection Plan based on a Baltic Energy Market as soon as possible was also endorsed by the MS directly concerned. The HLG for the Baltic Interconnection Plan is composed by representatives of each MS involved (ministries – transmission system operators – regulators). The group covers electricity and gas and it is chaired by the Commission. As a first step, the HLG shall provide a first comprehensive view of the situation focused on electricity. To this purpose, during the HLG meeting on 20th November 2008, the creation of two working groups (WG) has been agreed; one WG will address issues related to the interconnections (WG Interconnections), while the other WG will examine the conditions for the integration of the power markets in the region (WG Market).

Note: this report presents the results so far obtained working in close collaboration with the E.C. and the WG Interconnections members. Further activities shall be carried out to fully comply with the Terms of References of the WG Interconnections.

2 OBJECTIVES OF THE STUDY

For the design of a Baltic Interconnection Plan, which has to be seen as part of a Baltic Sea Regional Strategy covering electricity, gas and storage, a series of preliminary steps have to be undertaken that can be summarized as follows:

i) to have the clearest possible view on the current production/transmission capacities, including the non E.U neighbouring countries (Russia - Ukraine – Belarus);

ii) to identify the main gaps and bottlenecks;

iii) to have the clearest possible view on projects (on going / planned) in the Baltic area (transmission – generation).

iv) to identify the pending questions preventing the implementation of an integrated energy market such as pricing and market regulation.

Coherently with the objectives set within the WG Interconnections, this report addresses the following issues:

- overview of the present status of the electricity sector in the Baltic region, namely:
  - assessment of the consumption level, installed capacities and power generation;
  - energy exchanges;
  - existing cross-border congestions;
- expected evolution of the installed generation and assessment of the system adequacy levels;
- presentation of the new interconnection projects:
  - main characteristics
  - justifications.

3 OVERVIEW OF THE PRESENT STATUS OF THE ELECTRICITY SECTOR IN THE COUNTRIES OF THE BALTIC SEA REGION

Problem statement

- *identification of the current electricity consumption levels highlighting past patterns and expected future trends in the EU member States surrounding the Baltic Sea, including also Norway, Russia (Kaliningrad region), Belarus and Ukraine ("extended Baltic region");*
- *display the present generation endowment and production in the countries of the "extended Baltic region";*
- *assessment energy exchanges.*

Methodology

- *Data collection from public available documents and elaboration;*
- *Specific information provided by the Transmission System Operators, Regulatory Authorities and representatives of the Ministries of the Baltic Member States*

Major results

Major results are clustered in the paragraphs here below as follows:

- *Overall status of the power systems around the Baltic Sea;*
- *Consumption, installed capacity and yearly production;*
- *Energy balances and exchanges.*

3.1 Overall status of the power systems around the Baltic Sea

Present status of the power systems:

- *the power systems of the Baltic Member States are operated in three different synchronous power pools (UCTE, NORDEL and BALTSO, this latter is synchronously interconnected with the IPS/UPS of the Russian Federation and other CIS countries);*
- *UCTE and NORDEL are quite good interconnected through 9 submarine High Voltage Direct Current (HVDC) links, while BALTSO is interconnected only with NORDEL through a relatively weak HVDC link between Estonia and Finland*

The geographic area analysed is the territory around the Baltic Sea covering the EU Member States of Estonia, Latvia, Lithuania, Poland, Germany, Denmark, Sweden and Finland as well as the Russian Federation with special concern to the Kaliningrad region. Furthermore, in our analysis we have also considered Norway, Belarus and Ukraine, which, though not being from the geographical viewpoint "Baltic countries", are characterised by a generation endowment and a transmission grid able to affect in a non-negligible way the power flows across the Baltic countries. In the following we refer to the countries taken into account in our analyses as countries of the "*extended Baltic region*".

- The power systems of the Baltic countries are presently operated in three different synchronous power pools (Figure 3-1), namely:
  - Germany, Poland and Western Denmark as well as the continental part of the EU are synchronous interconnected within the **UCTE** pool;
  - Norway, Finland, Sweden and Eastern Denmark are interconnected within the **NORDEL** pool;
  - Estonia, Latvia and Lithuania compose the **BALTSO** pool, which in its turn is synchronously interconnected with the **IPS/UPS** system of the Federation of Russia, Ukraine, Belarus and the other CIS countries (with the exception of Turkmenistan).

- The three synchronous systems are characterized by remarkable differences in their size *(data referred to the year 2007)*:

UCTE			
Capacity	646 GW		
Peak Load	411 GW		
Consumption	2564 TWh		
Population	450 million		
NORDEL			
Capacity	97 GW		
Peak Load	68 GW		
Consumption	413 TWh		
Population	24 million		
IPS/UPS(*)	*out of which:*	BALTSO	
Capacity	337 GW	Capacity	9.1 GW
Peak Load	215 GW	Peak Load	4.8 GW
Consumption	1285 TWh	Consumption	25.5 TWh
Population	280 million	Population	7 million

(*) Data of IPS/UPS are referred to the year 2006

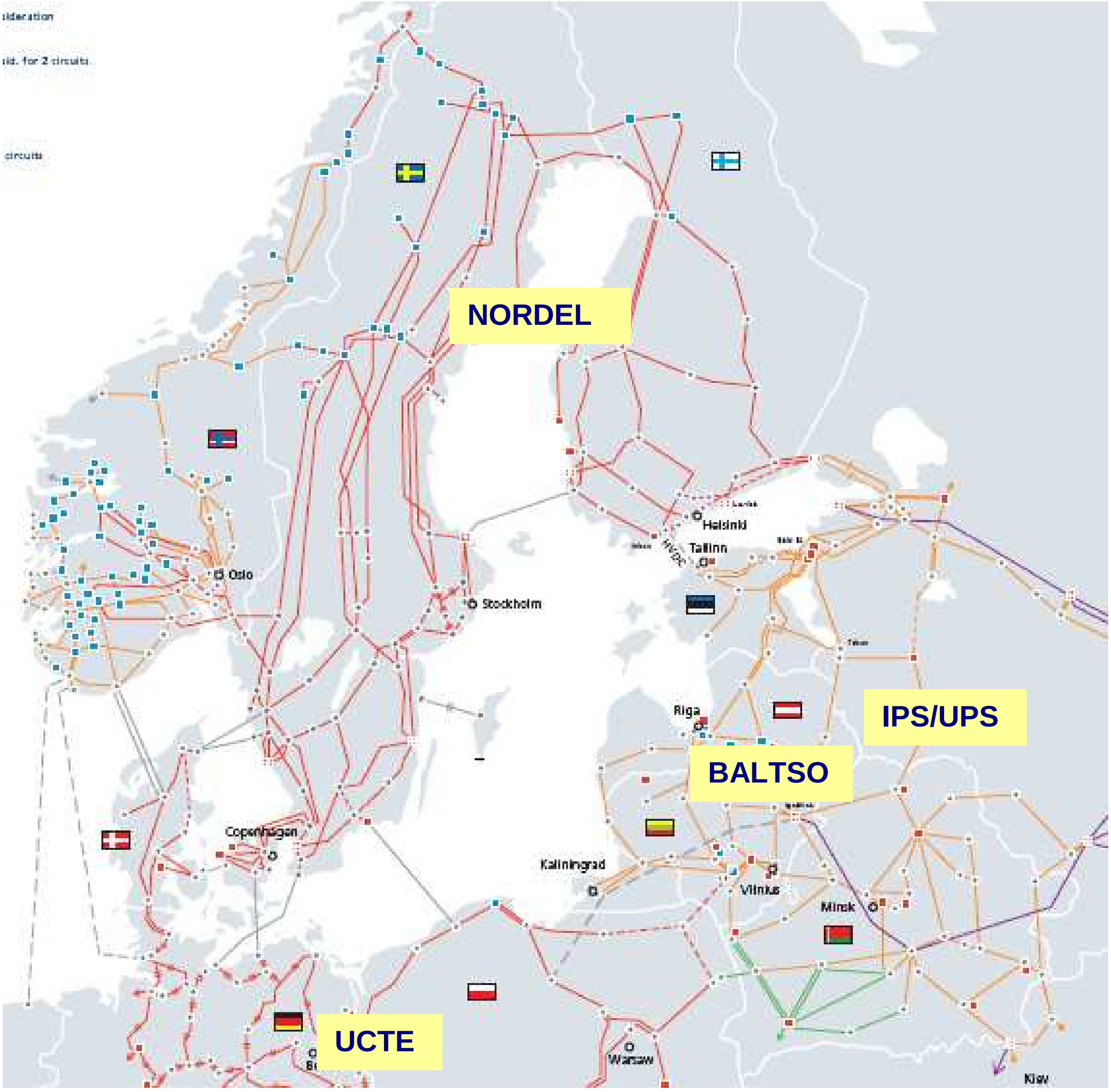


Figure 3-1 - Power pools in the Baltic region

- UCTE and NORDEL are quite good interconnected through 9 submarine High Voltage Direct Current (HVDC) links; the energy interchanges attained in 2007 15.6 TWh (≈4% of the internal consumption of NORDEL) and were basically driven by market mechanisms and generation from non-dispatchable RES.

- On the contrary, BALTSO is interconnected only with NORDEL through a relatively weak HVDC link between Estonia and Finland; the exchanges in 2007 have been about 2 TWh (≈7% of the internal consumption of BALTSO) almost totally from Estonia to Finland.

3.2 Consumption, installed capacity and generation

Consumption:

- *The size of the countries around the Baltic region is quite different among them; Germany has the largest consumption (≈600 TWh in 2007) followed by NORDEL (≈400 TWh, excluding Iceland) and Poland (≈150 TWh), while the BALTSO countries attain as whole a consumption level slightly less than 26 TWh. As for the non-EU countries of the "extended Baltic region", the Kaliningrad region has a consumption of about 4 TWh, Belarus 36 TWh and and Ukraine 182 TWh;*
- *The level of consumption is very high in NORDEL, especially in Norway characterised by a per capita consumption as high as 24 kWh/cap/yr.*
- *In NORDEL countries the increase of consumption in the last decade has been very moderate with the exception of Finland (≈23% in 10 years);*
- *BALTSO countries are characterized by a quite high consumption growth, especially in Estonia and Latvia (increase in 2007 over 2006 exceeding 5%);*
- *Germany is witnessing a very low increase of demand (<1%/yr), while in Poland the growth rate in these last years has been around 2%;*
- *Finally, the region of Kaliningrad has recorded an average consumption growth of ≈5% in the last years.*

Generation:

- *The generation endowment is mainly based on hydro units in NORDEL, though the distribution of the hydro resources is not uniform within this area;*
- *Poland relies almost exclusively on fossil fuel resources (coal), while Germany has a more balanced composition with the largest share of generation based on fossil fuels, but with a non-negligible share of nuclear and a fast increasing generation from RES (wind power);*
- *The situation of generation in the eastern Baltic MS is varied: Estonia relies almost exclusively on fossil fuel (oil shales), Latvia mainly on hydro, while Lithuania on a mix of nuclear, fossil fuel and hydro.*
- *In general a good complementarity of generation resources has been detected between NORDEL and Germany/Poland. This generation resource complementarity is also evident within BALTSO;*
- *Power generation in the region of Kaliningrad is almost totally thermal as well as in Belarus, while in Ukraine nuclear generation is almost half of the production.*

Scope of this paragraph is to give a general view of the consumption, generation endowment, production and exchanges among NORDEL, BALTSO, Germany and Poland. Figure 3-2 and Table 3-1 depict the yearly consumption level in the countries and regions of the "extended Baltic region". As it can be seen, the countries are characterized by large differences in size and in per capita consumption.

Figure 3-3 shows the installed capacities and generation, classified according to the main energy sources. We can see that NORDEL is mainly based on hydro generation, while Poland and Germany are heavily dependent on fossil fuels, namely coal. Nuclear power is present in Germany, Lithuania and two countries of NORDEL (Sweden and Finland).

It is important to note in particular that the size of the BALTSO pool with respect to the other countries in the region is very small; f.i. the yearly generation in the BALTSO pool in 2007 attained 25.5 TWh, which less than 5% of the yearly generation in Germany (555.9 TWh). Thus, the possible commissioning of one large power plant or one single interconnector between BALTSO and one of the other power pools will likely have a remarkable impact on the generation dispatch of the three Baltic Member States.

More information on the present status of the power sector in the various countries is available in the study report, the preparation of which is in progress.

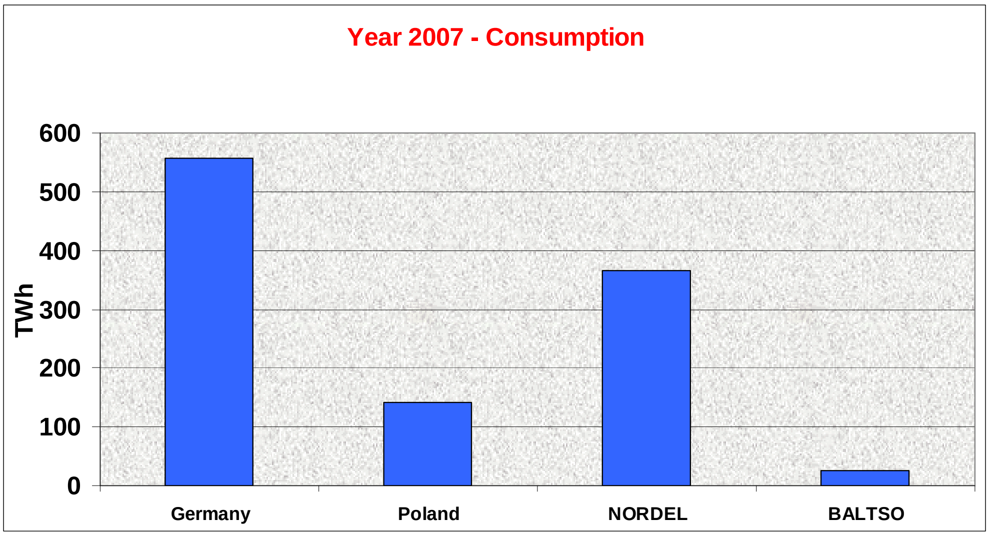


Figure 3-2 – Yearly consumption in the power pools of the Baltic region and the two coutries of UCTE belogning nto the Baltic region

Table 3-1– Yearly consumption in the countries and regions of the "extended baltic region" (values referred to 2007)

	Net Consumption GWh	Consumtion per capita kWh/year	Installed capacity (MW)	Net Generation (GWh)
Norway	110 718	23 557	30 313	137 387*
Sweden	144 510	14 509	34 068	145 087
Finland	90 434	16 432	16 900	77 769
Denmark	34 202	6 218	13 032	37 025
Estonia	7 933	5 918	2 385	10 519
Latvia	7 533	3 319	2 179	4 533
Lithuania	10 066	2 990	4 769	11 438
Germany	555 899	6 767	128 300	597 300
Poland	142 206	3 732	32 463	148 400
Kaliningrad	3 300**	3 454	643	2 445**
Ukraine***	143 400	3 103	52 199	192 331
Belarus	36 140	3 729	7 659	30 732

**Gross generation*
*** Estimation for year 2006*
****Data referred to 2006*

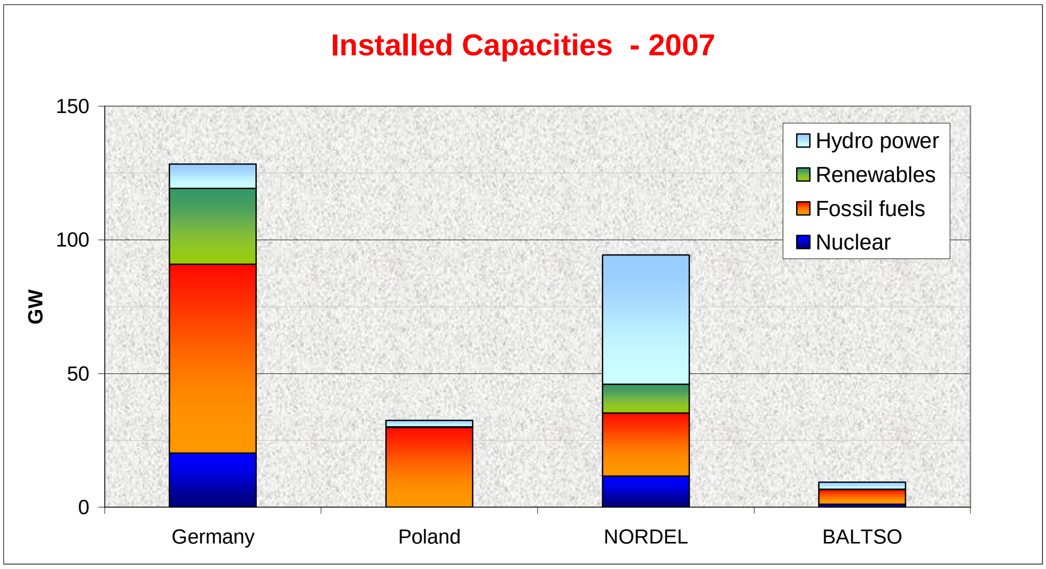


Figure 3-3 –Installed capacities

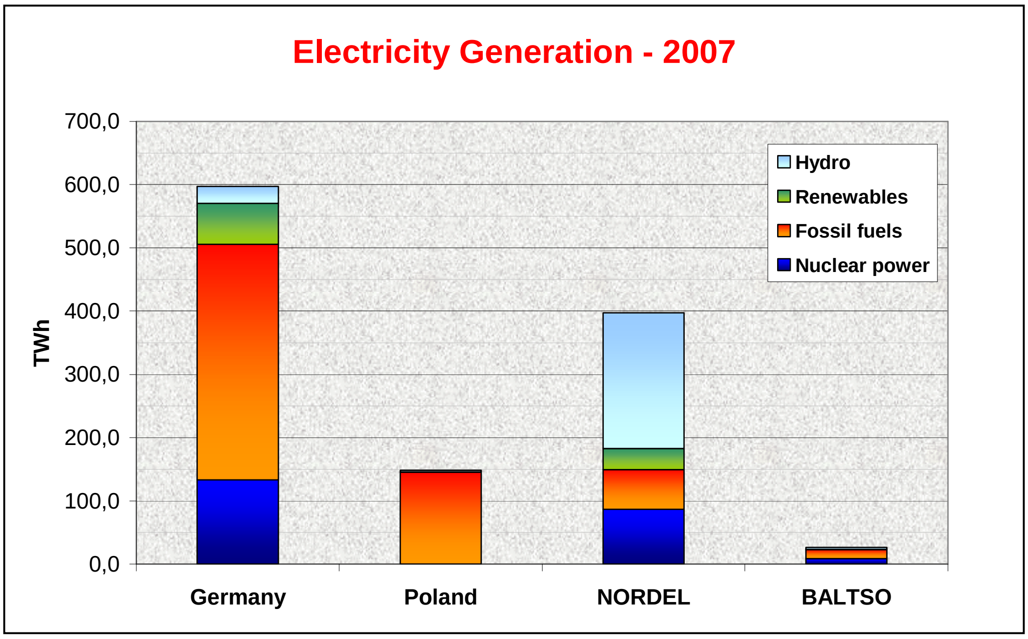


Figure 3-4 – Electricity generation

3.3 Energy balances and exchanges

Energy balances:

- *Germany and Poland are net exporters though most of the exported energy is conveyed from Poland to the Czech republic and Slovakia and from Germany to the Netherlands, Austria and Italy through Switzerland;*
- *NORDEL as a whole has shown a shortfall of energy in 2007 (-3 TWh), but with a non-uniform situation among the countries: Norway and Denmark are net exporters, though heavily dependent on non-controllable resources (hydro inflows for Norway and wind for Denmark). Sweden showed a quite balanced situation in 2007, but energy balance has been fluctuating with surpluses and deficits in the previous years. Finland is a steady heavy net importer;*
- *BALTSO is a net exporting area (+0.958 TWh in 2007), with Estonia and Lithuania net exporters and Latvia a steady net importer*
- *The region of Kaliningrad has always been a heavy importer in these last years (≈3TWh), but starting from 2006 following the commissioning of a new thermal plant, the import has been halved in 2006 (1.5 TWh) and further reduced in 2007 (1.1 TWh);*
- *Belarus is a net importing country (-4 TWh in 2007);*
- *In Ukraine the situation is more complex: the Burshtin region, synchronously connected with UCTE, is a heavy exporting area (+4 TWh in 2007) towards countries of UCTE, while the rest of Ukraine exports energy to the other countries interconnected with IPS/UPS pool (+6 TWh in 2006). However, energy export from Ukraine to IPS/UPS is declining.*

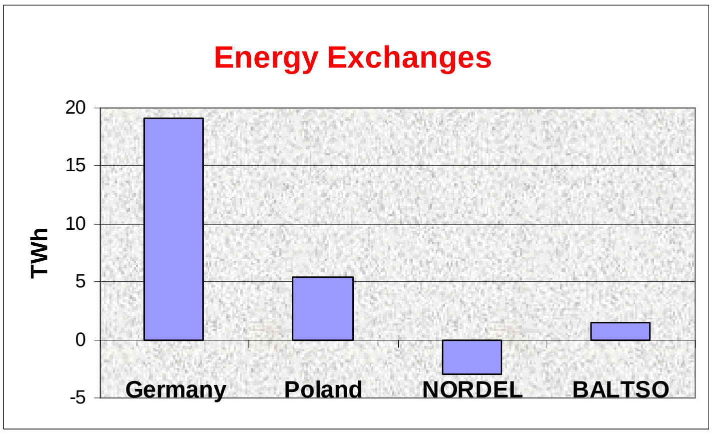
Energy flows:

- *Interconnections between NORDEL and UCTE are subject to energy flows in prevalent direction from North to South, including the SwePol link, which saw in 2007 a net flow from Sweden to Poland (2 TWh) after 4 years of energy exchanges in the opposite direction;*
- *Finland is interconnected with Russia in "island mode" and imports more than 10 TWh/yr;*
- *BALTSO exports to Finland about 2 TWh/yr through the EstLink;*
- *As for the interchanges with the rest of IPS/UPS systems, we underline a net balanced situation between Estonia and Russia (0.7 TWh exported and 0.9 TWh imported) and Latvia and Russia (0.4 TWh exported and 0.2 TWh imported). Instead, Lithuania has a net import balance with Belarus of about 1.6 TWh, most likely energy wheeling to Kaliningrad;*
- *Finally, it is worth mentioning that, having the BALTSO pool a very small size with respect to the other blocs, the possible commissioning of one new large power plant or one new interconnector between BALTSO and one of the other power pools will likely have a remarkable impact on the generation dispatch of the three Baltic Member States and the cross-border power exchanges.*

This section gives an overview of the energy balances for each country of the "*extended Baltic region*" together with a summary of the yearly energy exchanges. The scope of the analysis is the identification of the countries showing a surplus of energy, which can be traded in the Baltic region or, on the contrary, suffering of shortfall of production, hence needing to cover the internal consumption with energy import through cross-border lines.

To have a first general idea on the degree of exploitation of the existing interconnectors, a comparison shall be carried out among: the amount of yearly energy and power flows, the physical capacity of each tie line and the NTC at the borders, which is taken as reference for the international commercial transactions.

Concerning the energy balances in 2007, we note in *Figure 3-5* that on the whole the NORDEL pool is an importing area (deficit of about 3 TWh), while the remaining countries and BALTSO pool are net exporters. However, it is worth mentioning that most of the energy exported by Germany and Poland is conveyed from Poland to the Czech republic and Slovakia and from Germany to the Netherlands, Austria and Italy through Switzerland. The energy surplus of BALTSO has been about 1.5 TWh in 2007, which represents a quite negligible amount considering the consumption level of the other



countries of the Baltic region.

Figure 3-5 – Energy exchanges - (positive values mean export, negative values mean import)

3.3.1 The NORDEL Power Pool

The energy exchange of the NORDEL countries in the year 2007 are reported in Figure 3-6 (source [7]) and [8])[2], while Table 3-2 shows the energy balance for each country.

In the last year Denmark and Norway presented a positive balance. In particular, Denmark balance has been positive with Germany (+6.3 TWh) and negative with the other Countries of the pool. Norway balance has been positive with all the Countries of the pool with only a small amount of power import (-190 GWh) from the Russian Federation in the artic region. Sweden is a net importer from Norway, while Finland is a big importer of electricity (more than 10 TWh) from the Russian Federation.

Table 3-2 – Electric energy balance in NORDEL countries in 2007 -(source[8])

	Denmark	Finland	Norway	Sweden	NORDEL
Balance (in TWh)	0.95	-12.7	10.0	-1.3	**-3.0**
Balance/ Total consumption (in %)	2.6%	-14.0%	7.9%	-0.9%	**-0.7%**

[2] *Note: exchange data between NORDEL and the other power pools have been crosschecked by referring to the Annual Reports of UCTE and BALTSO: a full coherency of exchange data between NORDEL and UCTE is confirmed, whilst a slight incoherency is detected in the exchanges between Finland and Estonia: 1921 GWh from Estonia to Finland declared by NORDEL against 2016 GWh declared by BALTSO.*

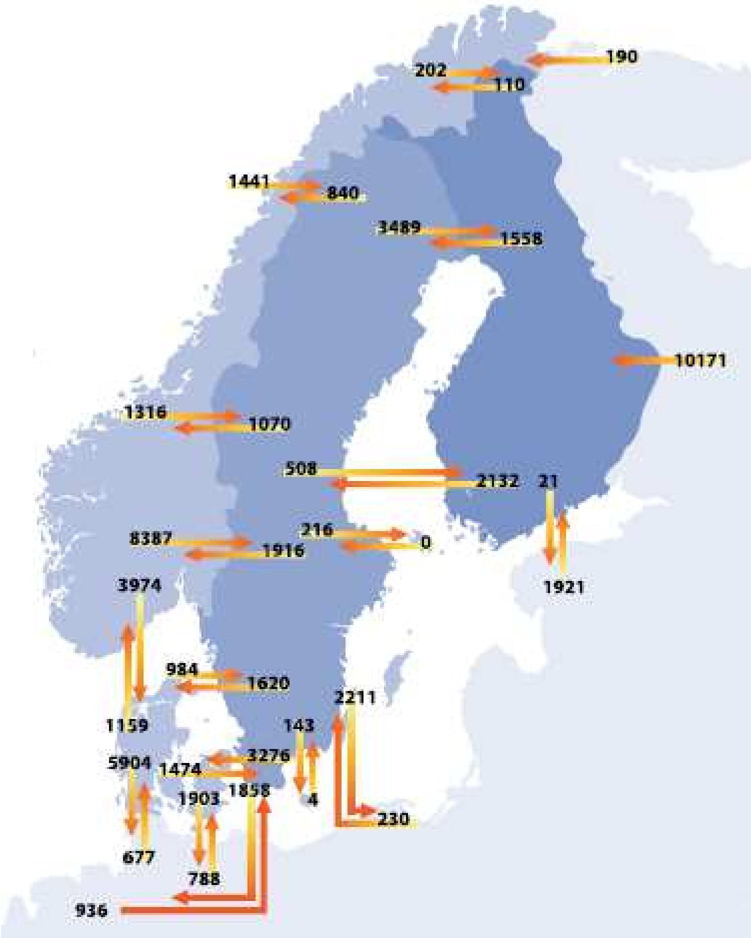


Figure 3-6 – Energy balance for NORDEL – 2007 – (source[8])

Examining the past pattern of country energy balance in the last years, it is possible to observe that:

- **Denmark** has been a net exporter except than in the year 2005 (-1.4 TWh), with a max in the year 2003 of about 8.5 TWh. The volatility of energy balance for Denmark is closely related to the high share of generation from non-dispactable RES, namely wind generation.

- **Norway** has been an electricity importer in the year 2003 and 2004 and a large exporter in 2005 and 2007. It is worth mentioning that the energy export in Norway is heavily affected by the water inflows; moreover, a higher volatility on the cross-border exchanges is expected in the forthcoming years due to the integration of the Norwegian generation system with other countries characterized by a large share of generation from non-dispatchable RES, namely wind (Denmark and the Netherlands).

- **Sweden** has been an importing country in the year 2006, while in 2007 the shortfall of energy has been very small. The reasons for energy import shall be investigated: probably, energy import was driven by market mechanisms (price differentials among the generating units of the Nordpool market). We remark that the country energy balance has been fluctuating with surpluses and deficits in the last five years.

- **Finland** has been a steady net importer all over the examined period, with an increasing deficit from 2005. Lack of sufficient generation margin has been recognised by the competent authorities and actions for the commissioning of new generation (namely nuclear) have already been undertaken.

3.3.2 The BALTSO power pool

The energy balance data of the BALTSO pool [10] in the year 2007 are shown in Figure 3-7 and in Table 3-3. In the figure, data about exchanges (in GWh) are referred to the different electric interconnections between the Countries of the pool. Table 3-3 shows the total values of the exchanges between the countries.

Figure 3-7 – Energy balance for BALTSO in 2007(GWh) – (source [10])

Table 3-3 – Exchanges of electricity 2007 (GWh) – (source [10])

	Estonia	Latvia	Lithuania	BALTSO
Balance (in TWh)	3.1	-4.4	2.8	**1.5**
Balance/ Total consumption (in %)	39.0%	-58.4%	27.8%	**5.9%**

Looking at the data related to the last two years, it is possible to observe that Estonia and Lithuania are net electricity exporters, though, considering the relatively small size of the countries, the country energy balance can change remarkably following the decommissioning of even one single power plant (e.g.: Narva TPP based on oil shales in Estonia or Ignalina NPP in Lithuania).

Latvia is a heavy net importer of electricity; moreover, it is worth noting that the largest share of production is based on hydro resources with limited modulation capacity (no large reservoirs): hence, the yearly generation is heavily dependent on the water inflows.
The large surplus and deficits among the country of BALTSO pool reflect the integrated development of the generation (and also the transmission system) undertaken in the past. Indeed, the ratio between the total physical cross-border flows among the three BALTSO countries and their consumption is as high as 19%; taking into account the exchanges with Russia and Belarus, this ratio attains 62% to be compared with only 13.5% in UCTE, which has been developed in the past on a country-based level with a progressive integration started in the late 60's and later on in the 70's.
The high level of integration of the BALTSO countries, which is reflected in high values of NTC[3] (compared to the internal load), shall be seen as a very positive aspect for the creation of a future regional power market. From this point of view, one shouldn't examine exclusively the energy balance for each country, but should rather have a broader approach considering the whole region. Only examining the requirements for power supply at regional level one can optimise the generation development as well as the needs for new interconnections allowing consequently to catch the full benefits from the related investments taking into account the enhancement of security of supply and the effectiveness of the regional power market.

3.3.3 Germany and Poland

As for Germany and Poland, both the countries are net exporters (+19.1 TWh for Germany and +5.3 TWh for Poland in the year 2007), mainly southwards (towards Czech Republic and Slovakia for Poland and towards the Netherlands, Austria and Italy through Switzerland for Germany).

3.3.4 IPS/UPS Countries: Belarus, Kaliningrad region (Russia) and Ukraine

Belarus

Belarus is net importing country (-4.3 TWh, i.e.: -11.9% of the internal consumption) from Russia and recently also from Ukraine. More than 1 TWh of energy is conveyed from Belarus through Lithuania to supply the region of Kaliningrad.

Kaliningrad region

The region of Kaliningrad has always shown a large shortfall of energy in these last years. Up to 2005 the energy import was about 3 TWh; however the new power plant of TPP-2, commissioned in October 2005, allowed halving the energy import, which is presently around 1.5 TWh.

Ukraine

The power system of Ukraine is split in two electric islands:

- Burshtin area, synchronously interconnected with UCTE since 2002,
- Rest of the Ukrainian power system interconnected with IPS/UPS.

The Burshtin area is exporting a quite large amount of energy towards Hungary (4.8 TWh) and, to a lesser extent, to Romania (0.8 TWh). We underline that this area is subject to power wheeling from Slovakia to Hungary, i.e. energy enters the Burshtin area from Slovakia (-1.6 TWh) and is conveyed to Hungary.

[3] NTC: Net Transfer Capacity

The rest of the Ukrainian power system exports energy mainly to Moldova and from 2006 also to Belarus.

4 MAIN GAPS AND BOTTLENECKS

This chapter addresses the main constraints preventing the desirable energy and power exhanges among the various countries of the Baltic region. The analysis presented in this report is referred to the existing cross-border net capacities and the estimation of congestions in terms of duration (hours/year) and entity (congestion rent). A second report [22], prepared in the framework of the WG Electric Market Integration, illustrates the barriers to be removed for the creation of a power market in the Baltic M.S. and for its integration with Nord Pool.

4.1 Existing cross-border congestion in the Baltic region

Existing cross-border congestion:

- *Nordic region: the congestions in the Nordic power system vary a lot depending on the amount of hydropower availability. High congestion rents are recorded between Sweden-Norway, Denmark-Norway and Denmark-Sweden. Lower congestion entity exists between Sweden-Finland.*
  The decision of network reinforcements to remove structural congestion is derived by applying a number of different scenarios up to the year 2025: Business As Usual (with relevant variants), Climate&Integration, National Focus. On the basis of the above scenarios, reinforcements between Sweden-Norway and Sweden-Finland have already been decided, while for the reinforcement Norway-Denmark a letter of intent was signed.
- *Sweden-UCTE:*
  - the HVDC link between Sweden and Germany is quite heavily exploited with a high volatility of power flows, which reverse very frequently from North to South direction and vice versa. Congestion is detected in both directions;
  - the HVDC link from Sweden to Poland is subject to more stable power flows with power reversal occurring only periodically.
- *Denmark-Germany: the border between Denmark and Germany is characterised by a high level of congestion, but in this case, though the duration of congestion is very high (89% in 2008), the congestion rent is quite limited.*
- *Estonia-Latvia-Lithuania: presently, there are no permanent congestions among the three Baltic Member States. However, congestion can arise following the decommissioning of Ignalina NPP. Indeed, congestions in Baltic area have already been experienced during Ignalina NPP maintenance time, when Lithuania, Latvia, Kaliningrad and Belarus import electricity from Russia. In such a situation the congestion exists 80-100% of the time.*
- *Estonia-Finland: Estlink has got exemption from third party access until 2013 according to article 7 of the EC Regulation 1228/2003. Consequently, the available capacity in both directions is allocated to the Owners of Nordic Energy Link (the company owning and operating Estlink), according to the shares specified in the Capacity Purchase Agreement signed between the Owners.*

This section gives an overview of the congestions recently recorded across the borders of the Baltic Countries. The assessment of the duration (nb of hr/yr) of the congestion and the amount of curtailed energy (GWh/yr) is usually helpful to highlight the most critical cut-sets and to provide a first warning of the need for the enhancement of the cross-border transfer capacity, though we are aware that, for a ranking of the most profitable network reinforcements, more detailed analyses shall be applied to agreed scenarios referred to a mid-long term horizon.

In the analysis of the congestion level presented hereafter we refer to the congestion rent (M€/yr), which is an indicator directly correlated to the amount of the curtailed energy.

Nordic region (Norway, Finland, Sweden and Denmark)

The congestions in the Nordic power system vary a lot depending on the amount of hydropower availability. Fig. 4-1 shows the congestion rent across Nordic countries in the last eight years.

Examining more in detail a specific section, the cut-set between Sweden and Finland, one can clearly see the yearly variation due to the different availability of hydro power (Tab. 4-1).

Tab. 4-1 – Congestion level at the border between Sweden and Finland

Year	2001	2002	2003	2004	2005	2006	2007	2008
Congested hours (%)	1	5	27	24	9	7	5	3
Congestion rents (M€)	0,4	7,3	9,8	3,9	9,9	9,1	2,6	1,3

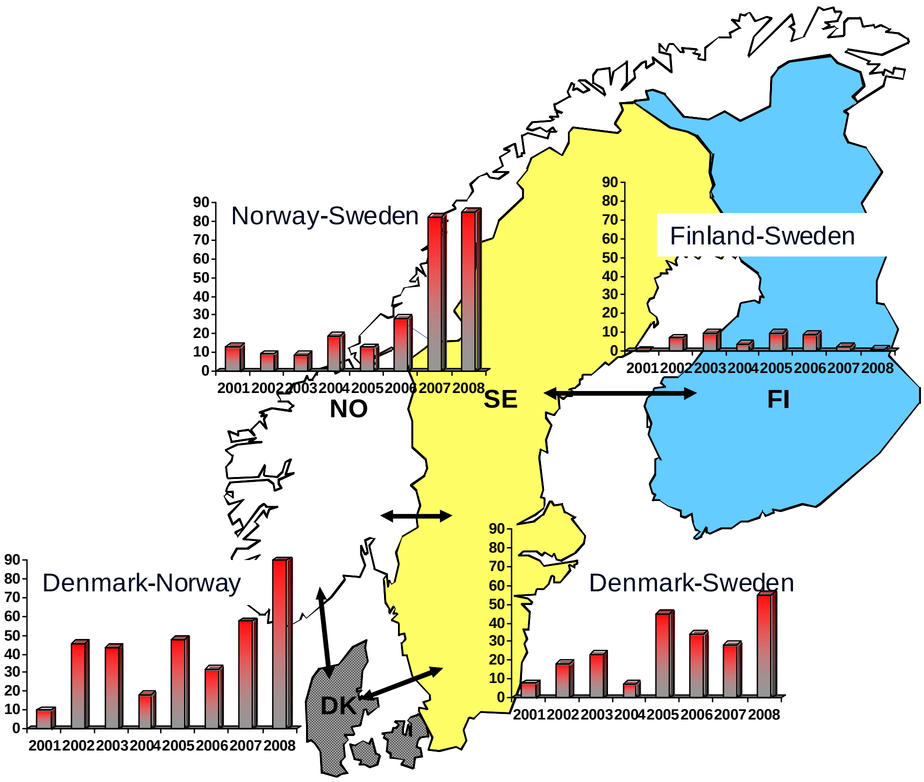


Fig. 4-1 – Congestion rent among the Nordic Countries in the last eight years (in M€/yr)

From the scheme of Fig. 4-1 it can be noted that some borders are already heavily congested now, namely Sweden-Norway and Denmark-Norway.

The principles for congestion management in the Nordic grid are the following [6]:

- congestions are in general handled where they are physically situated,
- structural congestions are removed or reduced by grid investments whenever socio-economically viable, otherwise market splitting is applied, i.e. dividing the market into separate price areas,
- temporary congestions shall be handled by counter trade (redispatching), if counter trade is possible.

The decision of network reinforcements to remove structural congestion is derived by applying a number of different scenarios up to the year 2025, namely.

- Business As Usual (BAU) with two variants: positive Nordic energy balance in 2025 (+2 TWh) and negative energy balance (-8 TWh),
- Climate & Integration;
- National Focus.

The estimation of the energy balance in the different scenarios is shown in the following picture.

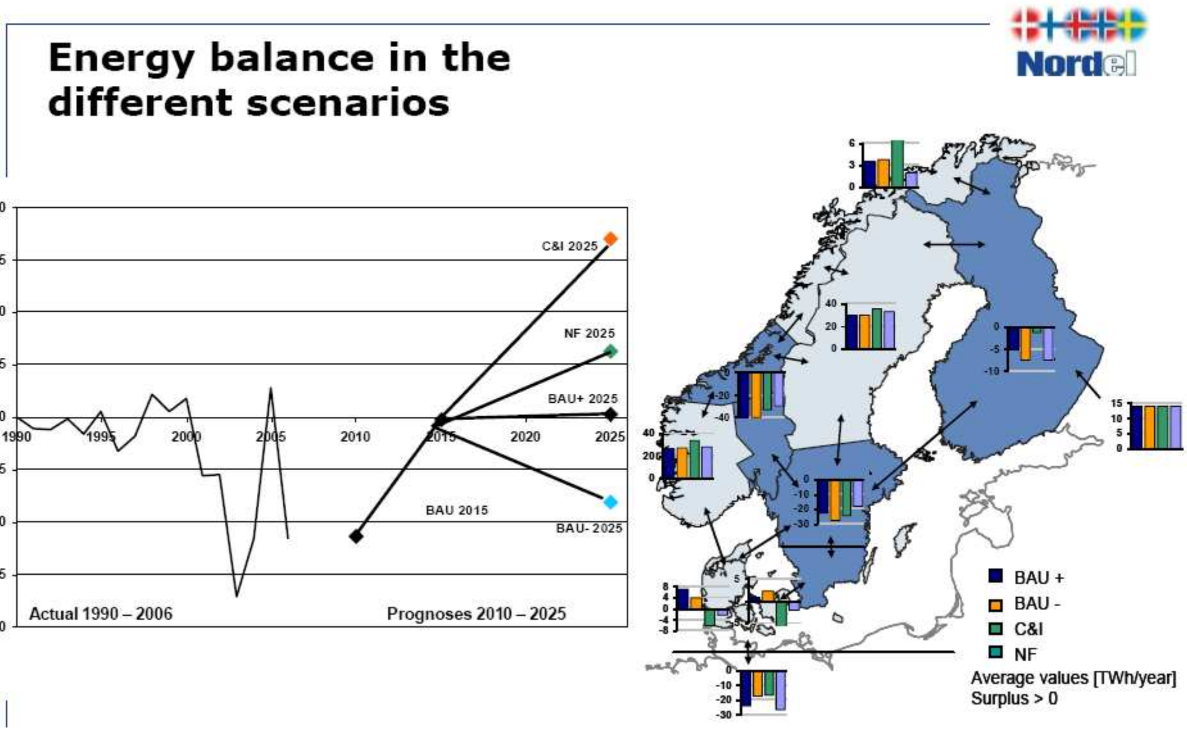


Fig. 4-2 – Energy balance in the different scenarios examined in the Nordic Grid Master Plan [6]

The cost-benefit analysis carried out within the Nordic Grid Master Plan issued in March 2008 allowed prioritising a series of network reinforcements in addition to those already decided in the previous master plan. Fig. 4-3 shows the proposed reinforcements within the Nordic grid[4]. A number of additional interconnections between Nordel and neighbouring systems may be profitable, but specific studies have to be executed before prioritising some of these potential interconnections (see in particular the multiregional study between Nordel, BALTSO and Poland [23]).

[4] More details are presented in chapter 6.

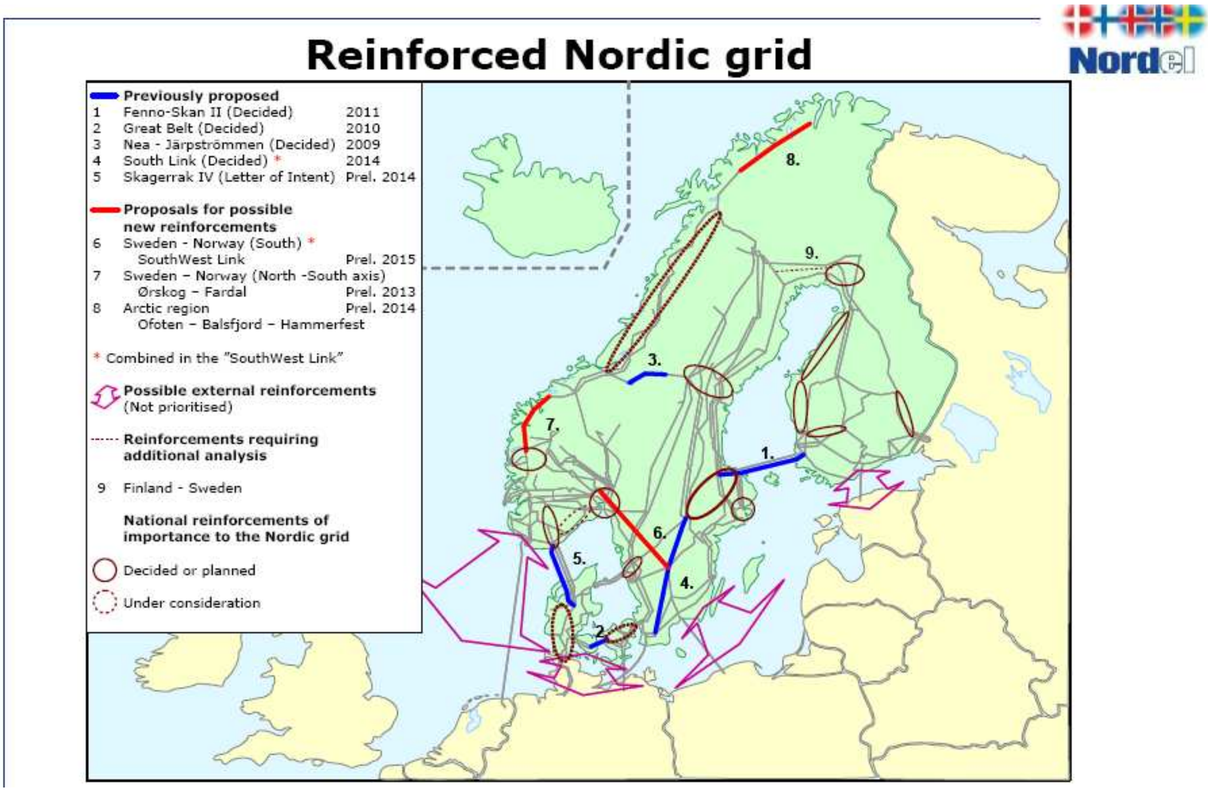


Fig. 4-3 – Previous and new proposals for reinforcements in the Nordic grid [6]

Sweden-UCTE

The HVDC link between Sweden and Germany is quite heavily exploited with a high volatility of power flows, which reverse very frequently from North to South direction and vice versa. Congestion is detected in both directions as it can be seen in Fig. 4-4.

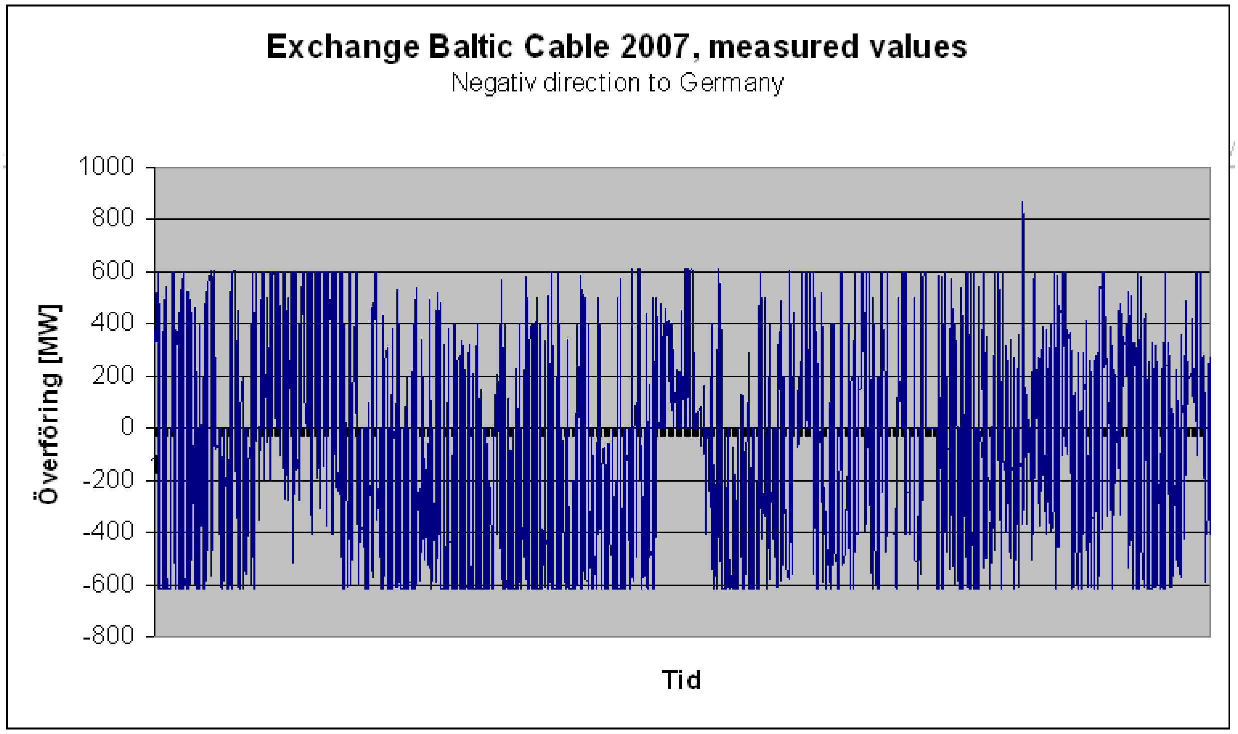


Fig. 4-4 – Power flows between Sweden and Germany in 2007 (source Svenska Kraftnät)

The HVDC link from Sweden to Poland is subject to more stable power flows with power reversal occurring only periodically (Fig. 4-5).

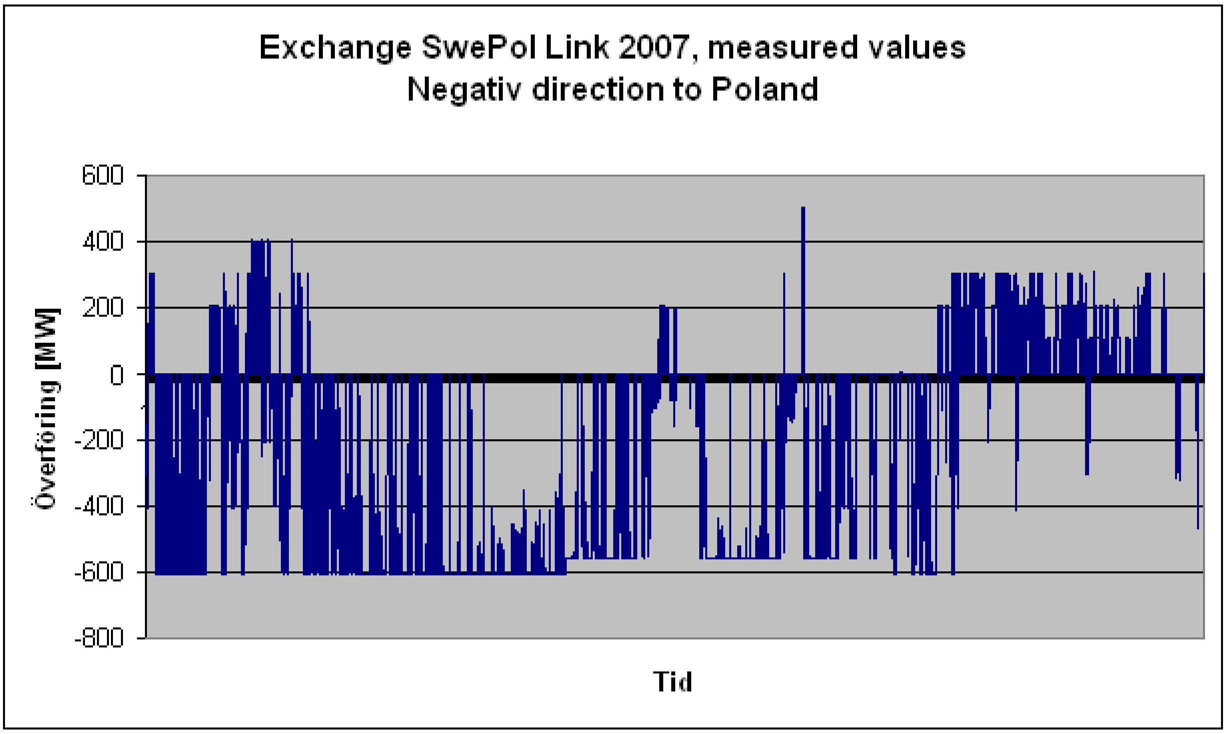


Fig. 4-5 – Power flows between Sweden and Poland in 2007 (source Svenska Kraftnät)

Denmark-Norway and Denmark-Germany

The cross-border section between Denmark and Norway is heavily congested, as already shown above. Also the border between Denmark and Germany is characterised by a high level of congestion, but in this case, though the duration of congestion is very high, the congestion rent is more limited (Tab. 4-2).

Tab. 4-2 – Congestion level at the border between Denmark-Norway and Denmark-Germany

Year 2008	Denmark-Norway	Denmark-Germany
Congested hours (%)	79%	89%
Congestion rents (M€)	99,6	25,2

Baltic Member States

In the BALTSO area the NTC at the country borders is defined with reference to the maximal thermal and stability transmission limits. From now on, the NTC at country borders is being evaluated applying the N-1 security criterion already adopted within UCTE[5].

The basic structure of the BALTSO interconnected system, including the BRELL ring, is shown in Fig. ***4-6***. More in particular, the Estonian transmission grid is operated with three 330 kV lines towards Russia, belonging to the BRELL ring, and two lines with Latvia, in BRELL ring. The Latvian transmission grid is interconnected to North with Estonia, eastwards with Russia through one 330 kV line, in BRELL ring, and southwards with Lithuania through four 330 kV lines (two lines in BRELL ring and two lines in load feed). Finally, Lithuania, in addition to the interconnections with Latvia, has interconnections with Russia (three 330 kV lines with the Kaliningrad region) and Belarus (four 330 kV and a fifth line, Ignalina NPP-Belarusskaja, designed for 750 kV, but presently operated at 330 kV, in BRELL ring). Furthermore, the three Baltic Member States are interconnected each other and with Russia and Belarus through several 110 kV lines for local electricity supply.

[5] E.g.: The N-1 criterion is already included in the Lithuanian grid code, which is approved by the Ministry of Economy.

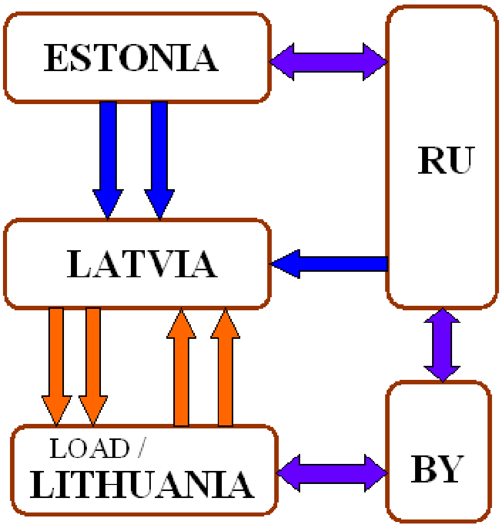


Fig. 4-6 - Basic structure of the BALTSO interconnected system

Presently, there are no permanent congestions among the three Baltic Member States (Fig. 4-7), since there isn't in place a regional market yet, and the generation schedule is coordinated among the three TSOs.

The application of the N-1 criterion reduces the available capacity for the market to only 400 MW between Estonia and Latvia, 400 MW between Latvia and Lithuania (in BRELL ring), 400 MW between Latvia and Lithuania-load and 0 MW between Latvia and Russia.

According to estimations of Latvian TSO, after Ignalina NPP closure, flows via all Latvian BRELL ring corridors will be shifted in south direction on 300–400 MW (estimated) and high overloadings, especially from the North, can occur across the Latvian transmission grid.

The existence of congestions when Ignalina NPP is out of service is confirmed by the Lithuanian TSO, who highlights that "*Congestions in Baltic area exist only during Ignalina NPP maintenance time, when Lithuania, Latvia, Kaliningrad and Belarus import electricity from Russia. The congestion exists 80-100% time during this period. Congestion exists on Russia territory at Smolensk interface. This will be a heavy congested area after closure of Ignalina NPP, starting from January 1, 2010. Maximum possible flow from Russia is 1500 MW.*
Other limiting section is Latvia – Estonia interface. Maximum possible flow on this interface is 1000 MW from Estonia to Latvia and 1200 MW from Latvia to Estonia[6]*. Congestions on this interface are quite seldom; however, from 2010 after closure of Ignalina NPP the load of this interface will increase*".

[6] NTC values with the presently adopted security criteria

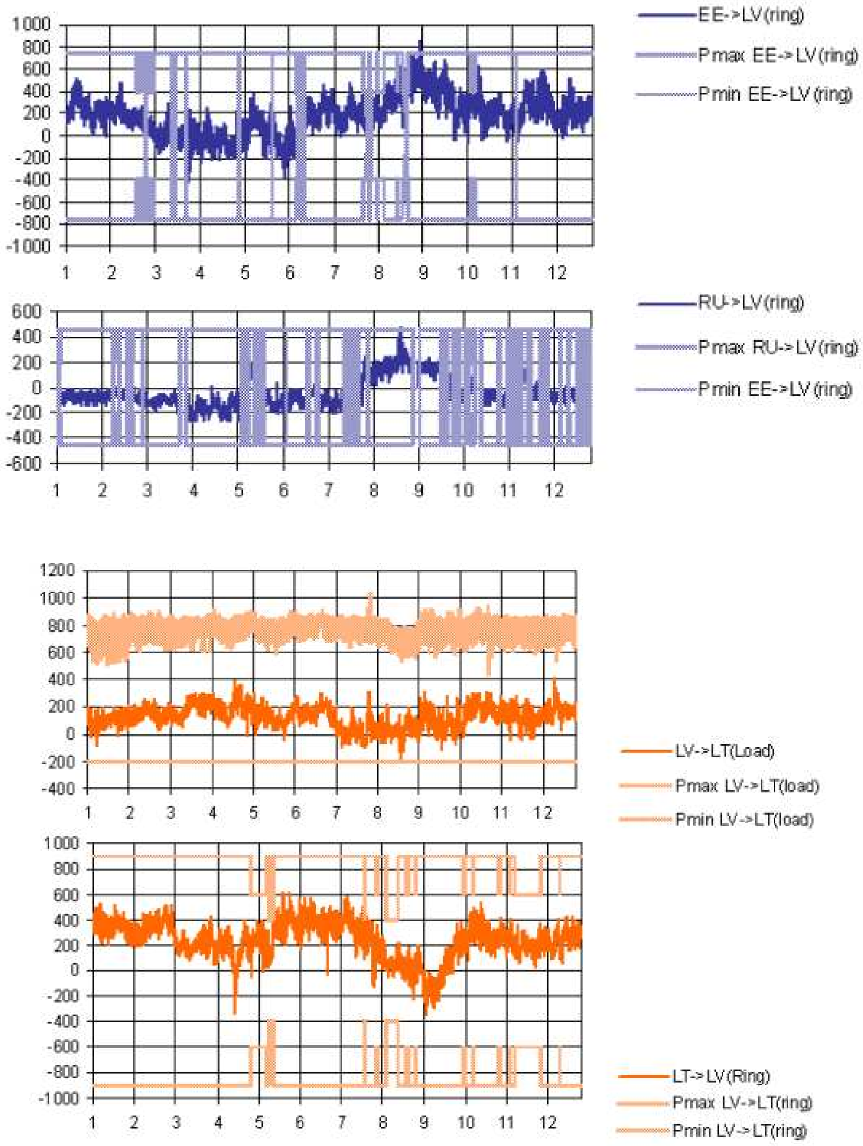


Fig. 4-7 - Physical power flows via Latvian corridors [MW] during the year 2008 (source Latvian TSO)

A detailed description of the expected bottlenecks in the Latvian transmission grid in the year 2025 is provided in Annex 2.

Finland-Estonia

In normal operation, the HVDC interconnection between Estonia and Finland (Estlink) can transfer up to 350 MW electricity in each direction.

Estlink has been exempted from third party access until 2013 according to article 7 of the EC Regulation 1228/2003. Consequently, the available capacity in both directions is allocated to the Owners of Nordic Energy Link (the company owning and operating Estlink), according to the shares specified in the Capacity Purchase Agreement signed between the Owners. By submitting their Usage Notification, each Owner can choose to use or not to use the capacity allocated to them in a particular hour. The Usage

Notification of each Owner must be submitted before 13:30 on the previous day. These submitted Usage Notifications become binding to both Nordic Energy Link and the Owner.

In order to ensure third party access, all capacity that remains unused after the deadline for the Usage Notification (13:30 on the previous day) will be automatically offered on the Free Capacity Auction (results of this auction will be published at 15:00 on the previous day). The Free capacity Auction includes both the capacity that is unused by the Owners, but also the capacity which offsets the usage specified in the submitted Usage Notifications.

In case an Owner does not want to use the capacity available to him, he can also choose to offer the capacity on the Day Auction, Month Auction or Year Auction (on the Year Auction and Month Auction, the capacity offered must be constant for all the hours of the period; on the Day Auction, the capacity offered can be different for each hour). The Day Auction takes place every day (before the submission deadline of Usage Notifications) for the capacities of the next day. The Month Auction and Year Auction take place once a month and once a year, respectively.

Contrary to the Free Capacity Auction where Owners and third parties participate on equal terms, the Owners have priority rights on the Day, Month and Year Auction. Namely, before the actual Day, Month and Year Auction, there is a Purchasers Auction where only Owners can participate. In this Purchasers Auction, the capacity that is put up to the Day, Month or Year Auction, will be offered on the same terms, but with the exception that the bids for this capacity will only be accepted, if the whole of the offered amount is bought by the other Owners. If bids for only part of the capacity offered are made, the bids on the Purchasers Auction are deemed to be rejected and all of the offered capacity is sent to the Day, Month or Year Auction.

The Owners of Nordic Energy Link are Eesti Energia AS, AS Latvenergo, AB Lietuvos Energija, Pohjolan Voima Oy and City of Helsinki/Helsingin Energia.

Third parties that have joined the auction scheme and use Estlink in addition to the Owners are Nordic Power Management OÜ and Baltic Energy Partners OÜ.

5 GENERATION EVOLUTION AND SYSTEM ADEQUACY

Problem statement

- *Generation adequacy analyses the ability of the generation assets to cover the peak load taking into account uncertainties in the generation availability and on the load level;*
- *Appropriate Adequacy Reference Margins shall be ensured in each country or bloc of country*
- *The most recent study on generation adequacy has been carried out in 2008 by the European TSOs with a time horizon up to the year 2020 and adopting two different scenarios:*
  - *a conservative scenario (scenario A) where only the commissioning of new power plants considered as "sure" is taken into account;*
  - *a best estimate scenario (scenario B), which takes into account the capacity evolution of scenario A and, in addition, future power plants whose commissioning can be considered reasonably credible.*

Major results

- *BALTSO pool will risk suffering of poor generation adequacy in the period under examination following the shut down of Ignalina NPP and the Narva TPP. The situation appears to be particularly critical in winter peak load conditions. On the basis of these evaluations, the BALTSO region, which is presently a net exporter, will become an importing area, quite dependent on energy import from Russia;*
- *NORDEL: the decided investments in power generation will increase the remaining capacity[7] to about 12% of reference load by 2013. After 2013 the two scenarios diverge from each other. In Scenario A the remaining capacity decreases to 6% by 2020 while in Scenario B it remains above 10% to the end of the study period. The remaining capacity is such to allow power export outside NORDEL. By comparing the remaining capacity with the import and export capacity between NORDEL and other power pools, we see that in both scenarios all available surplus cannot be exported to the neighbouring areas in reference load conditions, because of limits in the NTC of the interconnections. Only in peak load related to cold conditions (probability once in ten years) the remaining margin is below the export capacity;*
- *Germany: the adequacy reliability margin and the remaining capacity are balanced in both scenarios, especially when adopting load management measures;*
- *Poland belongs to the UCTE North Eastern region, which will have a remaining capacity above the adequacy reference margin up to 2013. From 2013 ahead, the margins become insufficient in the conservative scenario "A" with many fossil fuel plants likely to get closed and fossil fuel capacity decreasing –25% in the period 2010-2020. Particularly, in Poland in the scenario "A" remaining capacity decreases, as the result of decommissioning caused by environmental constraints. In the scenario "B" remaining capacity, in general, remains at the present level: in this scenario part of additional capacity derives from rehabilitation activities, mostly connected with environmental upgrading.*

The analysis of the profitability of new interconnection projects and the identification of the conditions for the power market integration [22] among the concerned countries cannot disregard the expected mix of generation endowment in the coming years. The importance of a clear view of the expected generation evolution is also recognised by the European TSOs, who, in these recent years, started a periodical assessment of the system adequacy with a horizon of at least ten years. In the past, each TSO association used to carry out its evaluations only for the power system under its control, but this year for the first time all the TSO associations (UCTE, NORDEL, BALTSO, ATSOI, UKTSOA and ETSO) started a joined studies and issued in July 2008 a power system adequacy report with an assessment of the interconnected European power systems in the time period 2010-2020 [19]. The outcomes of this

[7] *Remaining capacity: difference between available generating capacity and load at the selected reference operating points calculated under normal conditions*

study can serve as a basis to anticipate the needs in some countries for new generation or, alternatively, for strengthening the interconnections to ensure an adequate security of supply.

5.1.1 BALTSO Power Pool (Estonia, Latvia and Lithuania)

The countries of the BALTSO power pool will risk suffering of poor generation adequacy in the next years following the closure of the last unit of Ignalina NPP in 2009 (1300 MW) and the shut down by 2016 of the oil-shale units in Narva PP (948 MW).
The situation appears to be particularly critical in winter peak conditions with a Remaining Capacity (RC) well below to the Adequacy Reference Margin (ARM) in the conservative scenario (Scenario A), but also when adopting the best estimate scenario (Scenario B) the RC will be below the ARM in the mid-term. On the basis of the results obtained in the adequacy study, it is evident that the BALTSO pool, which is presently a net exporter, will become an importing area.
In the best estimate scenario the poor generation adequacy is partially relieved after the year 2015 by assuming the commissioning of new oil shale units at Narva PP in Estonia, while it is assumed that the existing oil shale pulverized combustion units will not work after 2015 to comply with the EU directive on Large Combustion Plants.

Other remarks are the following:

- *Estonia*, which is presently a net exporting country, mainly towards Finland, will become an importing country in the period 2016-2020 unless an adequate number of new generating units will be built. In this context, the envisaged commissioning of quite large amount of wind farms (≈500 MW in 2020 in Scenario A and ≈1800 MW) will not be helpful to increase the Remaining Capacity, being this form of energy non-dispatchable;
- In *Latvia* the future new generation is expected to be mainly gas-fired CCGT plants (400 MW); in scenario B also a coal-fired power plant in the town of Liepaja or Ventspils is foreseen to be built at 2016. An increasing share of RES is also expected, especially in scenario B (wind, biomass CHP, biogas CHP, other small CHP and additional hydro generation on the Daugava river). Nevertheless, the RC for Latvia will be below the ARM;
- In *Lithuania* the generation adequacy is expected to be quite poor at the beginning of the study period. In scenario A the situation will further worsen after 2015 considering the aging of the existing Lietuvos Power Plant, built in 1962-1974. On the contrary, in scenario B the generation endowment shows a RC higher than the ARM, since several new CCGT plants are foreseen together with a new nuclear plant expected to be finished in 2018.

5.1.2 NORDEL Power Pool

The adequacy of the NORDEL pool has been analysed by comparing the remaining capacity to the regional load at reference time and by comparing the remaining margin in cold temperature conditions to the regional peak load. Indeed, temperature has a major impact on the demand and, hence, is the most critical factor for the adequacy of the Nordic system. Compared to normal temperature conditions the demand can be about 5 % higher in cold conditions corresponding to a probability of once in ten years. Reference load corresponds to a probability of once in two years.

The outcomes of the study highlight that the decided investments in power generation will increase the remaining capacity to about 12% of reference load by 2013. After 2013 the two scenarios diverge from each other. In Scenario A the remaining capacity decreases to 6% by 2020 while in Scenario B it remains above 10% to the end of the study period.

The remaining margin calculated as a percentage of the peak load will increase from the current level of 1 % to about 6 % by 2013 and thereafter reducing back to the current level by 2020 in Scenario A and remaining on the level of about 6 % in Scenario B.

No indicative Adequacy Reference Margin (ARM) according to the UCTE methodology has been defined for the NORDEL region. However, the comparison of the remaining margin in cold conditions to some extent can be considered to correspond to a similar approach.

In conditions of reference load the remaining capacity is such to allow power export outside NORDEL. By comparing the remaining capacity with the import and export capacity between NORDEL and other power pools, we see that in both scenarios all available surplus cannot be exported to the neighbouring areas in reference load conditions, because of limits in the NTC of the interconnections. Only in peak load related to cold conditions the remaining margin is below the export capacity.

5.1.3 Germany and Poland

Germany belongs to the North Western UCTE region, which shows a positive difference between the RC and the ARM. Generation adequacy can be further enhanced by adopting load management actions. More specifically, in Germany the Adequacy Reference Margin and the Remaining Capacity area balanced in both scenarios.

Poland belongs to the UCTE North Eastern region, which will have a Remaining Capacity above the Adequacy Reference Margin up to 2013. From 2013 ahead, the margins become insufficient in the conservative scenario “A” with many fossil fuel plants likely to get closed and fossil fuel capacity decreasing –25% in the period 2010-2020. In this conservative scenario, to keep adequacy at the level of 2008, about 30 GW of additional Net Generating capacity should be necessary before 2020.
Particularly, in Poland in the scenario “A” remaining capacity decreases, as the result of decommissioning caused by environmental constraints. In the scenario “B” remaining capacity, in general, remains at the present level: in this scenario part of additional capacity derives from rehabilitation activities, mostly connected with environmental upgrading.

5.2 System adequacy at short term: winter 2008-2009

A description of the system adequacy forecast for winter 2008 is reported in [20]. This report presents UCTE, UKTSOA, ATSOI, BALTSO and NORDEL TSOs’ views as regards national or regional System Adequacy Forecast for the coming winter and possibilities of the neighbouring countries to contribute to the balance in critical situations.
The report shows that on the whole, no particular risk of shortage is expected for the winter 2008 under normal conditions. For Baltic Member States the report underlines that under normal conditions, Latvia has negative Remaining Capacity between weeks 49-10 and may require imports to meet peak load (with highest dependency in weeks 50-51 and 1-3), Estonia has negative Remaining Capacity in weeks 2-10 and may require imports to meet peak load.

Conversely, under severe conditions, due mainly to low temperature or unfavourable hydro conditions, the power systems might be stressed, especially when the same periods are critical for neighbouring countries as well.

The most critical period is the annual winter peak period (usually December-January, except during the holiday period), but in some cases it may also extend to February or even towards the end of March under severe conditions In such periods, unfavourable conditions could reduce the export capabilities from exporting countries and could lead to tight situations at the regional level. Among the Nordic countries, Finland, Sweden and Eastern Denmark will have a deficit under severe conditions, but the total Nordic generation capability exceeds the simultaneous peak demand.

In Poland the amount of potential power that may be available of export in favourable conditions, may be reduced due to congestion on the grid.

6 INTERCONNECTION PROJECTS

To alleviate the present fragmentation among the power systems of the MS surrounding the Baltic Sea and to allow effective power market integration, a series of interconnection projects have been proposed by the concerned countries.

For the optimisation of the development of cross-border infrastructures a strong international cooperation shall be warranted. Presently, planning of transmission grids is coordinated within each synchronous power pool, while new interconnectors across asynchronous power pools are usually studied on a bilateral level between the concerned countries. Nevertheless, such a limitation shall be overcome following the set up of a ENTSO-E (European Network of Transmission System Operators for Electricity) association, which among the various objectives shall address a pan-European coordinated planning. The set up of the ENTSO-E association is envisaged in the Third Energy Package draft proposed in September 2007 by the EC [9]. As a proactive step ahead of the Third Legislative Package draft, the Chief Executive Officers of 36 European TSO companies from 31 countries signed on 27th June 2008 in Prague a Declaration of Intent to create a new association, ENTSO-E, before the end of 2008. As a matter of fact, the new ENTSO-E association has been created on 19th December 2008 at the Brussels meeting by the Chief Executive Officers of 42 European TSO companies from 34 countries. It is expected that "*The establishment of ENTSO-E will further strengthen TSO cooperation in a number of key areas, such as the development of technical and market-related network codes, and the coordination of system operation and grid development, with the aim of enhancing the integration of the European electricity market, contributing to a sustainable energy environment and ensuring secure and reliable operation of the European power transmission system. ENTSO-E will work with a clear mandate based on full consultation with European Commission, Regulators and stakeholders*" [23].

Meanwhile, in the Baltic region the first joint multiregional study has been finalized and is now in its final stage. The study is being carried on by the following transmission system operators:

- PSE Operator S.A. (Polish TSO, UCTE)
- Svenska Kraftnät (Nordel)
- Fingrid Oyj (Nordel)
- Lietuvos Energija AB (Baltso)
- AS Augstsprieguma Tikls (Baltso)
- OÜ Põhivõrk (Baltso).

The study was started in November 2007 and the results will be issued according to the following schedule:

- Phase 1: The first part of the multiregional study has been finalized and was published in February 2009 [23]. It evaluates the market-based long-term profitability of three interconnections from the Baltic Members States towards Finland, Sweden and Poland.

- Phase 2: The multiregional work will continue during spring 2009 to assess the benefits of the interconnections related to the improvement of the security of supply. Based on the results (combined with phase 1), a coordinated timetable will be drawn for the new interconnections as well as other possible reinforcements needed.

- Phase 3: After summer 2009 the ENTSO-E regional planning activities will begin. They will not be based on synchronous areas any more but they will be performed on a Baltic Sea level including all Nordel and BALTSO countries as well as Poland and Germany. All the regional plans will be combined into ENTSO ten-year network development statement, the first one of which will be published in 2010.

The multiregional study above mentioned includes the assessment of the investment costs of the potential new interconnections, including other needed grid reinforcements. However, it is worth mentioning that the realisation of the evaluated investments requires a transparent market price for electricity. The materialization of the estimated monetary benefits requires that the Baltic market is able to interact with other markets via power exchange.

For the justification and the prioritisation of the interconnection projects the full set of possible alternatives shall be examined (screening phase) by considering the whole region involved in the energy and power exchanges across a new interconnector. The construction of a new interconnector can be justified by several reasons among which:

- *Enhanced competitiveness by pooling national/regional electricity markets*. Indeed, direct monetary benefits for the market participants, i.e. benefits for consumers and producers, is one of the strongest driving force towards a better integration of national and regional power systems;
- *Security of supply*. This issue is indeed closely related to the previous one, since in a market-based environment whenever the security of supply is endangered regionally, the electricity price differences also tend to increase. Smoothing price differences through new interconnections creates in turn economic benefits to market participants, which TSOs have to take into account when assessing the socio-economic value of new interconnectors.
  Additionally, within security of supply it worth recalling the higher security margins attainable with new interconnections to cope with the outage of generating units or network components: reduction of the probability of energy non-supplied.
- *Diversification of energy resources* and namely those less polluting (low carbon generation resources): sustainability, through a higher penetration of RES.
- *Trading of regulating power and ancillary services*.

One of the aims of the WG Interconnections is namely the identification of the main key drivers and justifications for new interconnections among Baltic countries on the basis of an accurate diagnosis of the present situation (e.g.: existing or incipient congestions, poor remaining generation capacity) and with reference to shared scenarios of consumption and generation evolution (usually a baseline scenario and a series of sensitivity against a number of parameters are considered).

This chapter gives a view of the proposed interconnection projects on the basis of the development plans carried out within each power pool and among the three Baltic pools (UCTE, Nordel and BALTSO). For each project a qualitative description of the related justifications is provided. A more quantitative analysis taking into account the overall costs (investment and operation) and benefits shall be carried out with common assumptions in order to prioritise the projects.

6.1 Germany and Poland

UCTE worked out in 2008 a Transmission Development Plan [5] having a time horizon ahead of 10 years, coherently with what foreseen in the EC draft of the Third Energy Package. The study addresses specifically the needs for cross-border and internal reinforcements on the basis of a scenario of consumption growth and evolution in the generation endowment in each UCTE country.
As for Germany and Poland, the study highlighted:

- the need for reinforcements of the transfer capacity between Germany and Poland;
- a new interconnection between Germany and Norway;
- a new interconnection between Poland and Lithuania.

Moreover, the resumption of the existing and not used 750 kV line between Poland and Ukraine is foreseen: It is worth mentioning that the re-energisation of this high capacity line is foreseen while keeping a decoupling between the frequency of UCTE and that of IPS/UPS of the CIS countries. To maintain the decoupling of the frequency between the two power pools, a back-to-back station is envisaged in the Polish substation of Rzeszow 750 kV.
Fig. 6-1 shows the geographical locations of the proposed cross-border reinforcements.

Fig. 6-1 – Interconnection reinforcements proposed at the borders of Germany and Poland in the UCTE Transmission Development Plan [5]

Country from	Country to	Substation From	Substation To	Status	Expected year of commissioning	Description of the Project
Germany	Poland	Vierraden 400 kV (now at 220 kV)	Krajnik 400 kV (now at 220 kV)	Part of project in permission process (Germany side)	2010/2011 (at the German side) Overall project after 2015 according UCTE TDP	This project is the upgrading of an existing 220-kV-double-circuit line into a 400-kV-line. To ensure the desired enhancement in the NTC between the two countries, following the commissioning of the Neuenhagen (DE) – Vierraden (DE) – Krajnik (PL) corridor, a series of upgrading in north-west part of the Polish transmission system have to be foreseen, namely: - construction of the new 2-circuit 400 kV lines: Krajnik–Morzyczyn, Krajnik–Baczyna, Baczyna–Piła Krzewina and Żydowo–Gdańsk Błonia, and 400 kV substation Baczyna, connecting the existing 400 kV line Krajnik–Plewiska to the new substation Baczyna, modernization of the 400 kV line Krajnik–Morzyczyn–Dunowo, - switching from the existing 220 kV line Vierraden-Krajnik to 400 kV voltage level, - installation pf power shifting transformers in substation Krajnik on the line Krajnik–Vierraden, - installation of power shifting transformers in substation Mikulowa on the line Mikulowa–Hagenverder. TSOs in charge: VE Transmission (DE) & PSE Operator (PL) Financing scheme: for German part, financing via network tariffs; for Polish side, financing via network tariffs or congestion rent (not yet decided)
Germany	Poland	Eisenhütten-stadt 400 kV	Baczyna/ Plewiska 400 kV	Preparation on German side in 2009	Overall project after 2015	3rd 400 kV interconnection between Poland and Germany. On the Polish side this corridor requires the construction of a new 2-circuit 400 kV line (250 km). TSOs in charge VE Transmission (DE) & PSE Operator (PL).
Germany	Norway	-----	-----	Feasibility study	----	NORD.LINK HVDC transmission system 700 – 1400 MW.
Poland	Ukraine	Rzeszow 750 kV	Khmelnitskaya 750 kV	Planning	After 2010	Modernisation and resumption of 750 kV Rzeszow (PL) – Khmelnitskaya (UA) OHL and installation of back-to-back 2 x 600 MW -converters in the Rzeszow 750 kV (PL) substation TSOs in charge: Subject of decision. Financing scheme: not yet decided

Country from	Country to	Substation From	Substation To	Status	Expected year of commissioning	Description of the Project				
Poland	Lithuania	Elk 400 kV	Alytus 330 kV	Planning TSOs in charge: subject of decision. Financing scheme: not yet decided	2015 (PL-UCTE) 2015 (LT-BALTSO)	Lithuanian grid reinforcement	1st stage	2010-2015	28 M€	Construction of 330kV line Alytus - Kruonis
							2nd stage	2014-2020	65 M€	Construction of 330kV line Ignalina - Kruonis
						Interconnector Elk – Alytus	1st stage	2009-2015	166 M€	Construction of 400kV line Alytus-Lithuanian border (double circuit) Construction of 2x500MW BtoB converter station with reconstruction of Alytus substation
							2nd stage	2014-2015	95 M€	Construction of 400kV line Elk-Polish border (Alytus direction)
						Polish grid reinforcement	1st stage	2010-2015	425 M€	Internal PL transmission grid reinforcement (for import of 600MW from LIT to PL)
							2nd stage	2016-2020	374 M€	Additional PL transmission grid reinforcement (for power transfer of 1000MW)
Poland	Slovakia	Byczyna	Varin	under study	after 2018	2nd 400 kV interconnection between Poland and Slovakia				

Tab. 6-1 Interconnections reinforcement at German and Polish borders according to the UCTE Transmission Development Plan [5] and information received from PSE Operator and Germany.

Project justifications

- ***Germany-Poland: Vierraden 400 kV-Krajnik 400 kV***

Increasing the NTC at the country borders is needed because of:

- very high volatile and unpredictable (more than some hours before) flows caused by wind generation in Northern Germany. To quickly achieve an increase of the NTC, in a first stage the installation of phase shifting transformers is foreseen;
- the increase of wind generation in Northern part of Germany and insufficient capacity in the German grid to force the flow southwards (quite low load in Eastern part of Germany);
- the widespread increase of wind generation in Baltic area.

The new interconnection will also allow an enhancement of security of supply in synchronously connected power systems, especially in emergency situations in Polish or German (VE-T, but not only) systems.

This project is directly related to the interconnection Neuenhagen-Bertikow/Vierraden on German side (TEN-E project, ca. 130 M€). This line shall become operational in 2010/2011 (permission procedure started). VE Transmission aims at ensuring in parallel the construction of the upgrading of 380 kV to Poland (on German side: upgrading of 5 km, < 10 M€).
This project requires additional investments in Polish grid (see details in Tab. 6-1):

- in a first stage, installation in substation Krajnik on the line Krajnik – Vierraden of power shifting transformers (PFs) and installation of PFs also in substation Mikulowa on the line Mikulowa – Hagenverder (55-60 M€, depending on the €/Zloty exchange rate). The time of commissioning depends on investments in Germany (commissioning 380 kV OH line Neuenhagen – Vierraden) and upgrading (from 220 kV to 400 kV) OH line Vierraden – Krajnik (this can be done very quickly , since the line has already been designed for the 400 kV voltage level for most part);
- in a second stage, construction of the new 2-circuit 400 kV lines: Krajnik – Morzyczyn, Krajnik – Baczyna, Baczyna – Piła Krzewina and Żydowo – Gdańsk Błonia, and 400 kV substation Baczyna, connecting of the existing 400 kV line Krajnik – Plewiska to the new substation Baczyna, modernization of the 400 kV line Krajnik – Morzyczyn – Dunowo (PSE Operator has already finished its analysis – the investments expenditures are not decided; there are some options).

Further justifications for increasing the NTC at the country borders are related to:

- relieve congestions caused by loop flows from Germany to Poland-Czech Republic and back to Germany (see Fig. 6-2);
- planned development of new generation in northern part of Poland (base load and wind);
- allow a higher penetration of wind farm generation in the area between Berlin and Poznan, especially generated by wind farms situated in North-East part of Germany and North-West part of Poland, besides a higher penetration of wind generation in Northern Germany, as mentioned above.

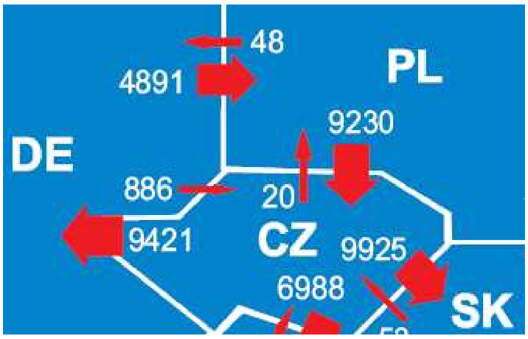


Fig. 6-2 - Physical energy flows in 2007 between Germany, Poland and Czech Republic (values in GWh)

- ***Germany-Poland: new 400 kV double-circuit line Eisenhüttenstadt–Baczyna/Plewiska***

The main justifications of this project are:

- smoothing the congestion level in northern and southern PL-DE interconnections ;
- further enhancement of security of supply in synchronously connected power systems, especially in emergency situations in Polish or German systems;
- allowing a higher penetration of RES.

PSE Operator has finished grid analysis on Polish side (construction of the new 2-circuit 400 kV line, about 250 km, will be needed as well as some upgrading of existing transmission assets).

On German side 13 km (30 M€) have to be upgraded by VE Transmission. VE Transmission starts in 2009 with an extension of the 380 kV station in Eisenhüttenstadt (border town) jointly with a power station connection project.

- ***Germany-Norway: new HVDC submarine link***

The main justifications of this project are based on:

- market integration: coupling of the hydro-dominated Norwegian electricity system and the wind and thermal dominated electricity system in northern Germany;
- enhancement of security of supply (consequence of the above point).

According to the Nordic grid Master Plan a high positive cost-benefit has been found for this connection. Additional costs of reinforcing the internal grid have to be investigated, and possible Continental bottlenecks are not included in the analysis.

Statnett and E.ON Netz have launched a joint feasibility study for a DC cable between Norway and Germany called NORD.LINK. The capacity of such a new interconnector is expected to be in the range from 700 to 1400 MW. Statnett and E.ON. Netz intend to finalize their feasibility study by 2008.

A similar initiative for a cable between Norway and Germany has been launched by NordGer AS between Norwegian producers (Lyse/Agder) and EWE (Germany).

A cable between Norway and Germany is listed in the EU's programme for trans-Europe electricity networks (TEN-E programme).

♦ ***Poland-Ukraine: Rzeszow 750 kV- Khmelnitskaya 750 kV***

The justifications of this project, according to the information provided by PSE Operator, can be summarized as follows:

- import of cheaper energy from Ukraine to Poland (imported energy can be from nuclear source, but not exclusiverly);
- to close the gap between the future Ukrainian power market and the Internal Electricity Market (IEM) of the EU with the target to allow the integration of the Ukrainian power systems with the IEM;
- enhancement of security of supply in connected power systems, especially in emergency situations in Polish or Ukrainian systems;

The commissioning of this UHV interconnector will also open the possibility for implementation of TPA rules and market-oriented congestion management for energy exchange between Ukraine and Poland

♦ ***Poland-Lithuania: Elk 400 kV-Alytus 330 kV via back-to-back (LitPol)***

The overall justifications of this project can be summarised as follows:

- integration of the Baltic power systems with the Internal Electricity Market of the EU;
- ensuring security of supply in the Baltic region;
- better use of power resources in the Baltic Countries and in UCTE.

More specifically, depending on the development of new generation in the Baltic region, especially the commissioning of a new NPP in Lithuania (i.e. Visaginas NPP) and in North-East part of Poland, the following benefits are expected:

- after commissioning of Visaginas NPP
  a. enhancement of security of supply in the North-East part of Poland;
  b. energy import to Poland and the IEM;
  c. enhancement of security of supply in the interconnected power systems, but for Lithuanian power system only in emergency situations;
- after commissioning of Visaginas NPP and new generation in North-East part of Poland
  a. enhancement of security of supply in connected power systems, especially in emergency situations in Polish or Lithuanian systems;
  b. bi-directional energy exchange between systems, i.e. export/import with better use of power resources in the Baltics and in UCTE;
  c. integration of Lithuania (and the rest of the Baltic region) into IEM
- without starting operation by Visaginas NPP and with new generation in North-East part of Poland (present situation after closing Ignalina NPP)
  a. enhancement of security of supply in the interconnected power system, but only in emergency situations in Polish or Lithuanian systems;
  b. use of the interconnector for cross-border power transfer in peak-load conditions for limited time.

It is evident that the LitPol interconnector shows the highest benefits when combined with the commissioning of the new Visaginas NPP. The high annual market benefits of the Lithuania-Poland interconnection are also put in evidence by the Multiregional study "*Market based analysis of interconnections between Nordic, Baltic and Poland areas in 2025*" [23] carried out jointly by the 6

TSOs of the Baltic region. Moreover, this conclusion is also coherent with what stated by the EU project Coordinator, prof. Wladyslaw Mielczarski: "*The timetable for the power line construction should be coordinated with the plans for a new Ignalina power plant*" [21]. In fact, the new interconnector will be basically exploited to convey power from Lithuania to Poland, at least for a certain number of years after the commissioning.

It is worth mentioning that both cross-border lines Poland-Lithuania and Poland-Germany are "projects of European interest" according to the EC decision 1364/2006. These projects are listed in the annex I in the priority axis EL 7. Moreover, the interconnection projects between Lithuanian and Polish power systems and between Germany and Poland are classified as "projects of common interest" according to annex III of the EC Decision 1364/2006 and are included into the "quick start" program.

Concerning the technical characteristics of the LitPol interconnector, it is planned to construct a double circuit 400 kV line Alytus (LT) – Ełk (PL) with a projected transfer capability of 1000 MW, i.e. up to 8 TWh per year could be exported or imported via such line. For the implementation of this project it is required to build a back-to-back converter station near Alytus substation and an additional 330 kV double-circuit transmission line Kruonis – Alytus. To enable the full exploitation of the interconnection capacity (1000 MW) a series of reinforcements internal to the Polish grid are necessary (see Fig. 6-3).

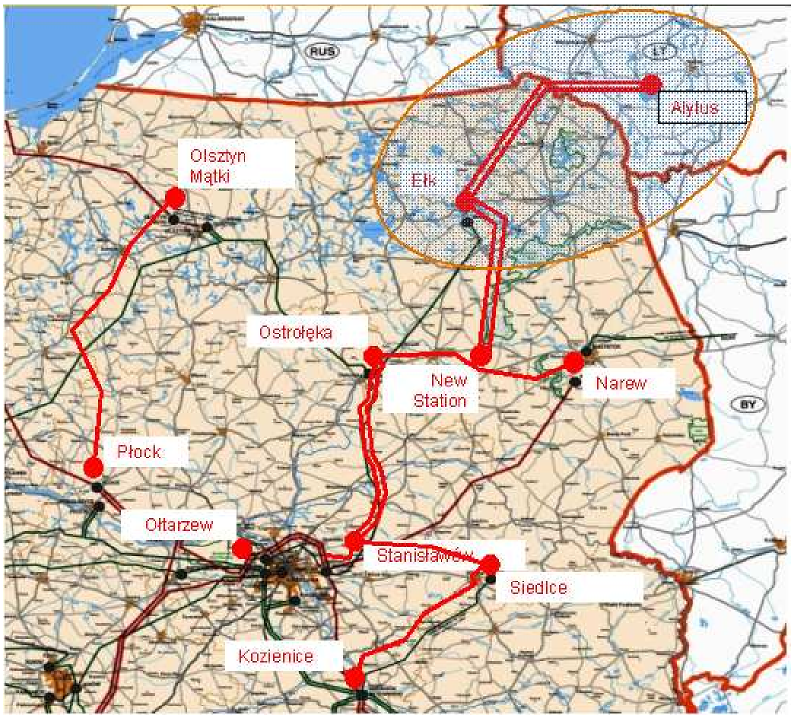


Fig. 6-3 Reinforcements needed internal to the Polish grid following the commissioning of the LitPol interconnector (source LEO LT AB)[8]

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[8] Note: the upgrading (from 220 kV to 400 kV) of the OH line Ostrołęka – Ełk in the Polish grid can be needed for the power export from Poland to Lithuania exploiting the full capacity of the LiPol interconnector (Polish grid reinforcement subject to further analysis)

- ***Poland-Slovakia: Byczyna 400 kV-Varin 400kV***

Justifications of this project to be clarified:

- increasing of the power transfer capacity on the southern synchronous profile, especially in the export direction from Poland to Slovakia;
- enhancement of security of supply in connected power systems, esp. in emergency situations in Polish or Slovakian systems;
- widening the possibility of market mechanisms for trade (energy and power) and balancing.

PSE Operator has started grid analysis (construction of the new 2-circuit 400 kV line and some, light, upgrading of existing transmission assets in Polish grid). Discussion between PSE Operator and SEPS is going on (some investments in Slovakian system will be needed). Decision has not been taken yet.

6.2 Estonia, Latvia and Lithuania

Fig. 6-4 shows the present structure of the transmission grids of the Baltic Republics including the interconnection lines with the IPS/UPS system and the HVDC link towards Finland.

Fig. 6-4 – Transmission grid of the Baltic Republics (source [10])

The main characteristics of the ongoing and planned projects can be described as follows

- **Estonia**

According to the BALTSO Annual Report 2007 and the BALTSO Report "Baltic Grid 2025", a third connection between Estonia and Latvia is planned.

The analysis of the interconnection between Estonia-Latvia is now on stage 2 of the feasibility study organized by Estonian Transmission System Operator (TSO) *Põhivõrk* together with Latvian TSO *Augstsprieguma Tīkls*. Three alternative routes (right-of-ways) are being investigated and compared economically for the Harku-Sindi-Riga 330 kV corridor and the results shall be ready by end March 2009. In parallel, a complete estimation of the socio-economic benefits (market analyses) has started and will be achieved by end April 2009.

After estimation of achieved results the pre-engineering studies could be tackled. Next studies must cover investigation of the cable seabed Estonia – Latvia and study of relevant DC technologies.

At the same time *Augstsprieguma Tīkls* is planning to start designing the reinforcement of the transmission grid in the Western part of Latvia. This project must include 330kV overhead line Ventspils-Liepāja and the new 330kV substation Ventspils. This reinforcement plan shall solve reliability issues of power supply in the region, provide reliable connection of new 400MW TPP in Liepāja and planned on-land and off-shore wind power. An area of the land for the new 330kV substation in Ventspils has been reserved to satisfy construction of the cable tie with Estonia as well as with Sweden, if a relevant decision will be made. The above construction must be completed by the middle of 2015.

The final investment decision can be taken after completing the economic and technical analysis of the interconnector. Benefits of the line can be quantified in terms of socio-economic benefits deriving from a larger NTC The earliest possible completion date is in 2020, considering the time for the selection of the right-of-way, the authorisation process and the erection.

Moreover, a second connection between Estonia and Finland – Estlink-2 (from Pussi s/s in Estonia to Anttila s/s in Finland with capacity around 650 MW) is planned for the year 2012. This additional interconnection should increase the reliability of the Estonian power system, while decreasing the dependency on Russia of Estonia and the other countries of BALTSO. In emergency situations it will be possible to import a higher amount of power from Nordic countries. Furthermore, the enhancement of the interconnection capacity will be helpful to integrate the future power market of BALTSO area with Nord Pool. At the moment the right-of-way selection of the Estlink-2 is in progress in Estonian side. The arrangement for selecting the right-of-way for the new HVDC submarine cables is started as well.

- **Latvia**

In addition to the third interconnection with Estonia, a further HVDC interconnection is being proposed between Latvia and Sweden (the AMBERGATE project).

The following possible routes of HVDC interconnection Latvia – Sweden were considered in the Assessment report prepared by AS Latvenergo and AS Augstsprieguma tīkls (Fig. 6-5):

1. Ventspils – Norrköping (390 km);
2. Ventspils – Stockholm (310 km);
3. Ventspils – Ygne – Oskarshamn (325 km);
4. Grobina (Liepaja) – Oskarshamn (300 km);
5. Grobina (Liepaja) – Nybro (325 km).

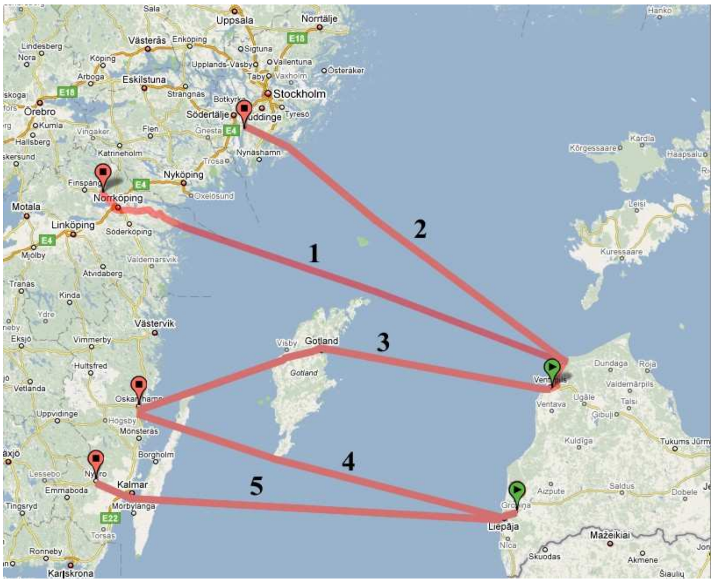

Fig. 6-5 – Possible routes of the AMBERGATE project

The construction of new HVDC links towards Sweden and/or Estonia will require reinforcements of the internal transmission grid in Latvia, namely the corridor Grobina-Ventspils-Tume-RTEC1/2 as shown in the following scheme.

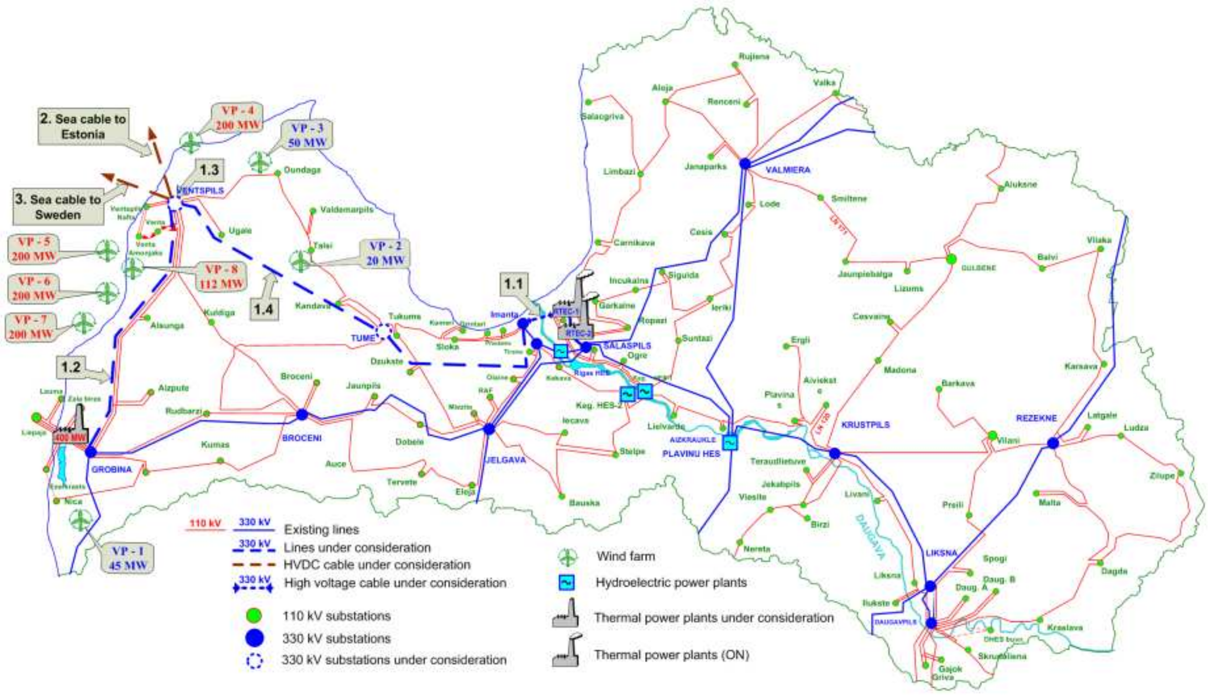

Fig. 6-6 – Possible new interconnections and network reinforcements in Latvia (source Latvian TSO)

- **Lithuania**

<see above the description of the Lithuania-Poland interconnection project>

An interconnection between Lithuanian and Swedish power systems is proposed via a submarine HVDC cable (~340 km). The interconnection would have a capacity in the range of 700 – 1000 MW The possible connection points are Klaipėda on the Lithuanian side and Hemsjö or Nybro on the Swedish side (Fig. 6-7).

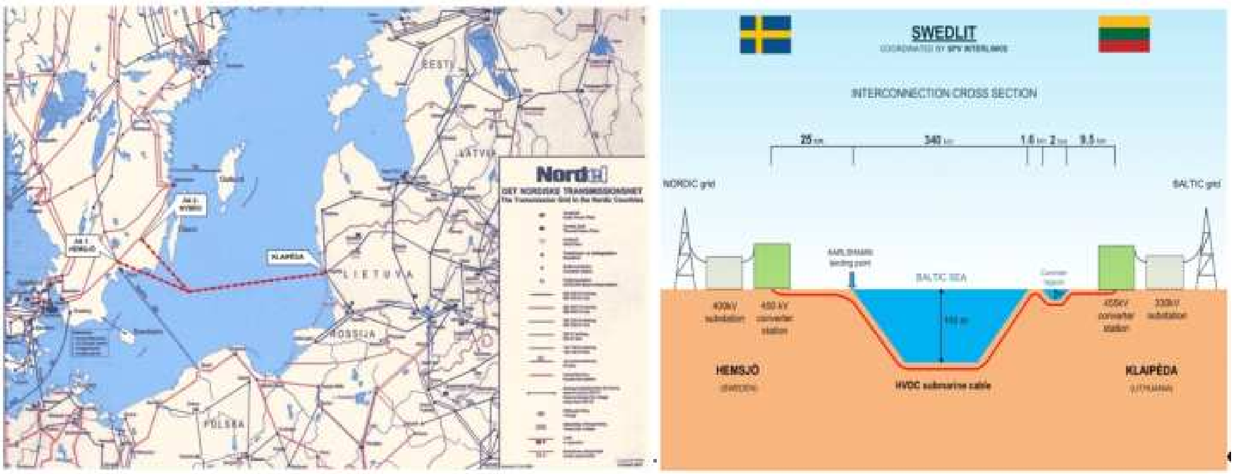

Fig. 6-7 - Possible routings of the interconnection project (SwedLit) (source LEO LT AB)

The Lithuanian TSO emphasises the "technical readiness" of the power system on the Lithuanian side (well developed and high reliable 330kV grid) and duly upgraded by 2013 according to the development plan shown in the following one-line diagram (Fig. 6-8). Since no major additional investments into the Lithuanian grid are required, at the Lithuanian side the interconnection project with Sweden can technically be ready by the year 2014. A longer time period for the commissioning of this interconnector is envisaged at the Swedish side, due to the process related to EIA, the authorisation process and the land expropriation in Sweden.

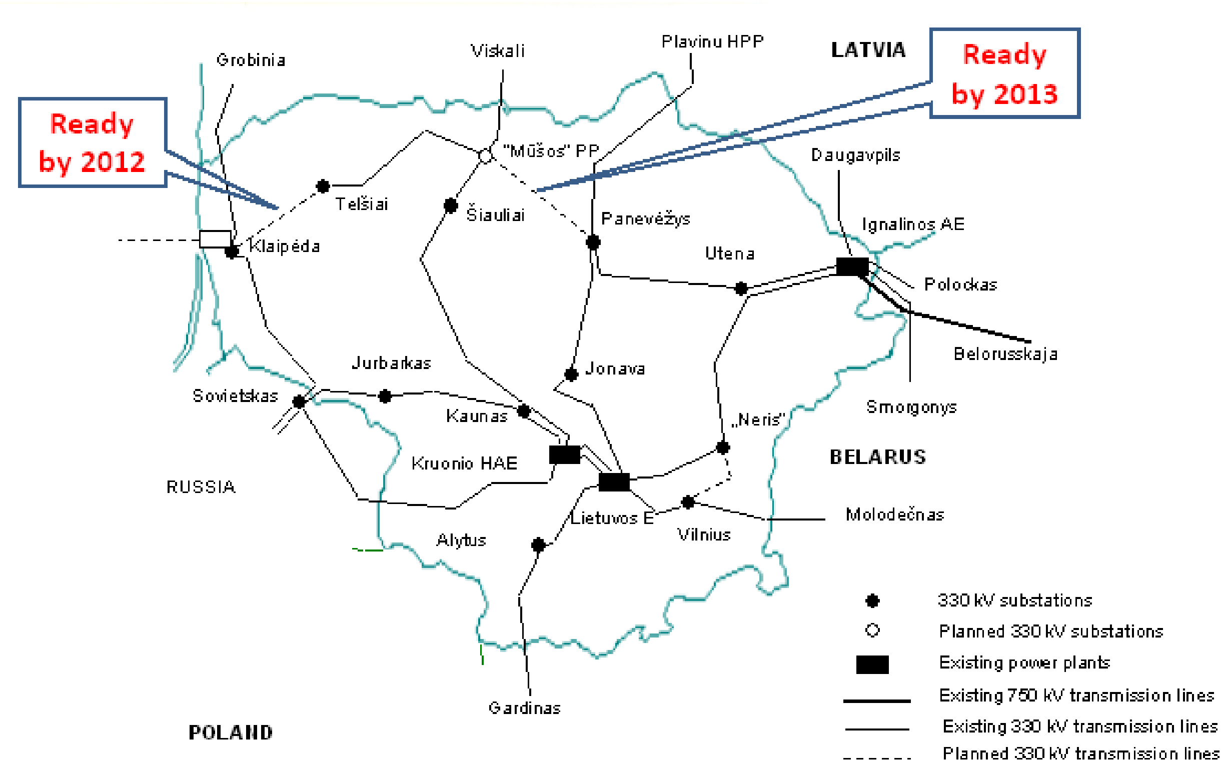

Fig. 6-8 – Internal network reinforcements foreseen in Lithuania (source LEO LT AB)

On 2nd June 2007 an Agreement was signed between Lietuvos Energija AB, Svenska Kraftnät and SWECO International AB "On preparation of Feasibility Study for an electrical interconnection between Sweden and Lithuania". The study addressed technical, economical and environmental issues and was achieved in March 2008.

Moreover, the Sweden-Lithuania link is one of the project considered in the Multiregional Nordel/BALTSO/Poland Study investigating the market benefits at the year 2025.

A summary of the ongoing and planned project is reported in the tables below.

Country from	Country to	Substation From	Substation To	Status	Expected year of commissioning	Description of the Project
Estonia	Latvia	Harku-Sindi / Saaremaa island 330 kV	Ventspils / Riga 330 kV	pre-engineering studies	In 2020 at the earliest	Economic, technical study and line route selection in progress. Final investment decision for this connection not made. Designing of Latvian network reinforcements is planned to start this year (2009).
Estonia	Finland	Püssi 330 kV	Anttila 400 kV	planned	2012	Estlink-2 – capacity about 650 MW Right-of-way selection in Estonian side is in progress The arrangement for selection of the right-of-way for the new HVDC submarine cable has started as well.
Latvia	Sweden	Ventspils or Globina 330 kV	Norrköping/ Stockholm/ Ygne-Oskarshamn/ Nybro 400 kV	planned	After 2018	Submarine HVDC link- Technology (LCC or VSC) to be chosen. Size in the range from 500 to 1000 MW.
Lithuania	Sweden	Klaipeda 330 kV	Hemsjö or Nybro	Planned	2014-2016	HVDC submarine cable ≈ 340 km Capacity: 700÷1000 MW Status of the project: - SPV InterLinks, UAB created; - Cable route and connection point on Lithuanian side located; - Seabed survey initiated; - Technical requirements for converter station issued by TSO Lietuvos Energija - Environmental impact assessment procedure started; - Land acquisition issues are being solved (*ready for converter station, ongoing for cable route*)

Tab. 6-2 –Interconnections reinforcements according to BALTSO Annual Report 2007 [10]

Project justifications

- ***Estonia-Finland (EstLink 2)***

Main justifications of the project:

- integration of the future power market of the Baltic Member States with Nord Pool;
- enhancement of the security of supply, particularly in the BALTSO area, thanks to possible power import from Nordic countries in emergency conditions;
- increased reliability of the Estonian power system,
- decrease of the dependency of Estonian and other Baltic republics from Russia power supply.

The quantification of the market based benefits deriving from a second interconnection between Estonia and Finland is highlighted by the multiregional study among Nordel, BALTSO and Poland.

- ***Estonia-Latvia (third interconnection)***

Main justifications of the project:

- fostering the penetration of wind generation in the western regions of Latvia and Estonia (Saaremaa island).

- ***Latvia-Sweden (AMBERGATE project)***

Main justifications of the project:

- Improvement of the security of supply of Latvian consumers and improvement of the system operation service provision. As a matter of fact, Latvian power supply system has the most negative balance situation in whole EU. Yearly imports of electricity are from 30% up to 50 %. Unfortunately, possibilities of the electricity purchases from the neighboring countries will not increase. By the end of this year, Ignalina nuclear power plant in Lithuania (1300 MW installed capacity) will be closed down. No new power plants to replace its power are being constructed and will not be constructed in the near future. Estonia is gradually refurbishing and modernizing its oil-shale burning power plants diminishing installed capacity at the same time. In both these Baltic countries power export possibilities to Latvia will be limited. Russia could provide Latvia with electric energy, but interconnection between Latvia and Russia consists of one 330 kV power line only. Besides, in Russia itself power transmission in the western direction is facing serious overloads and bottlenecks;
- Integration of the future power market in the Baltic Member States region with Nord Pool, with overall lower average electricity prices and higher competitiveness (this justification is in fact common to the other interconnection alternatives EstLink 2 and SwedLit);
- Fostering the development of wind power generation;
- Better exploitation of the generation endowment in Latvia by transferring through the new Latvia-Sweden interconnection the excess energy from the planned Kurzeme TPP (coal+biomass) to the Nordic power systems if the market prices will allow for that;
- Improvement of the local security of power supply in Kurzeme (western Latvia), especially in the big transiting sea-ports of Liepaja and Ventspils;

- Lower risk of dependency of electricity import from Russia, who might exert the role of the dominating power supplier and dictate the electricity prices.

♦ ***Lithuania-Sweden (SwedLit)***

Main justifications of the project:

- Development of Baltic electricity market and increased competition (justification in common with the other interconnection alternatives EstLink 2 and AMBERGATE);
- Increased security of supply;
- Better utilization possibilities of Kruonis HPSPP (900 MW installed capacity) for balancing load.

A further advantage of this project consists of no need for major additional investments into grid at Lithuanian side, thus diminishing the risk of delays in the project commissioning. Moreover, the Lithuanian grid has strong interconnections with Latvia, Belarus and Russia, for possible regional power trade.

6.3 Denmark, Norway, Sweden and Finland

In 2007 new interconnections and reinforcement of the existing ones have increased the transmission capacity between the Nordic countries and Europe and several projects are in the planning phase as shown in the following map.

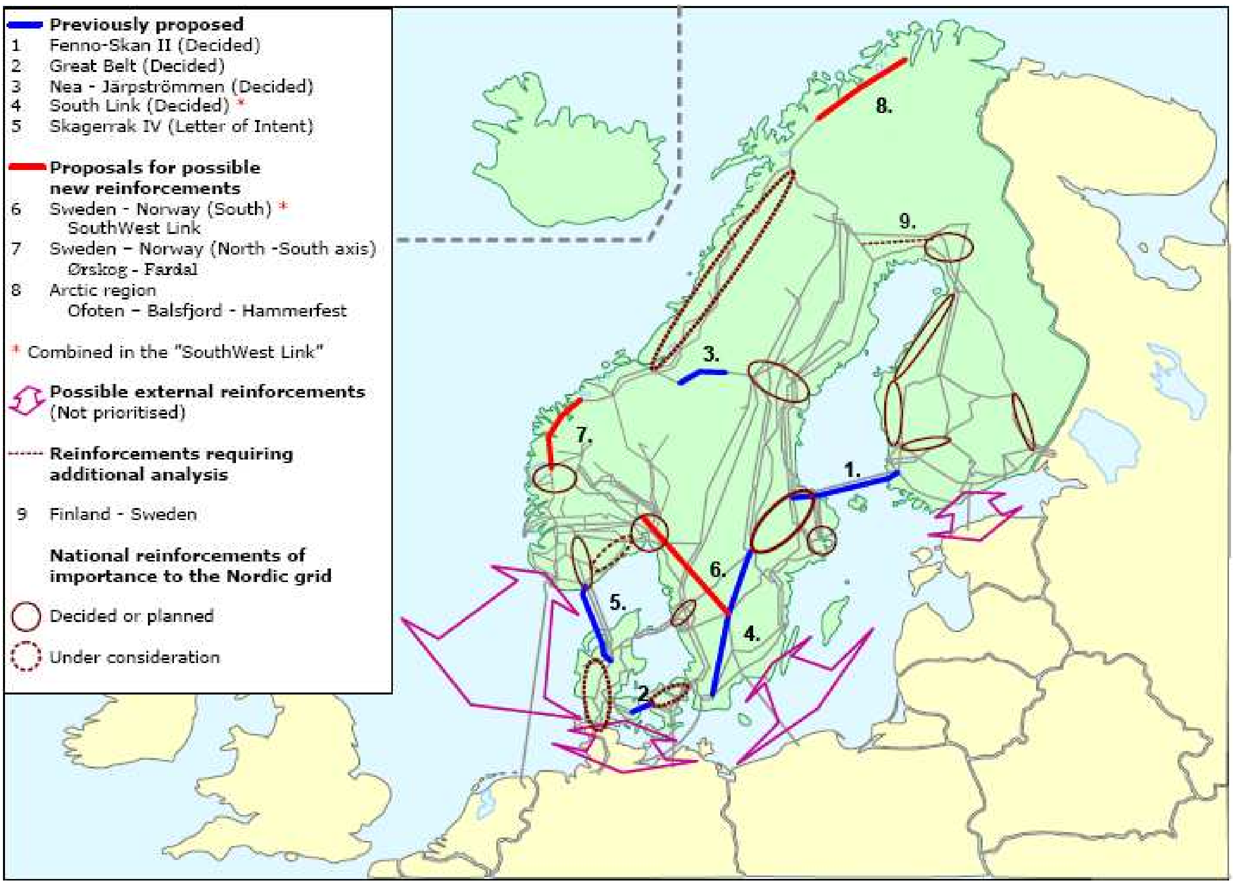

Fig. 6-9 – Previous and new proposals for reinforcements in the Nordic grid and to neighbouring system (source[6]).

REINFORCEMENTS BETWEEN SWEDEN, NORWAY, DENMARK AND FINLAND

The development of the Nordel grid is coordinated among the concerned TSOs, who periodically update the Master Plan. The last Nordic Grid Master Plan has been issued in March 2008. A summary of the already decided projects and the new proposals for the strengthening of the interconnected Nordic grid is shown in Tab. 6-3. Further details are available in the Nordic Grid Master Plan [6].

EXTERNAL NORDIC GRID INTERCONNECTIONS

Denmark West- Germany

In February 2007 the trading capacity between Western Denmark and Germany was increased from 800/1200 to 950/1500 MW MW respectively in the north/south direction. This is only the first step in a joint grid project between E.ON Netz and Energinet.dk aiming at a considerable increase in the transmission capacity during the next decade, e.g.: reinforcement of the Kasso-Hamburg corridor.

Denmark East/Sweden- Germany

Energinet.dk, Svenska Kraftnät and VE Transmission have recently achieved (May 2009) a pre-feasibility study on "*Offshore Grid Connection at Kriegers Flak in the Baltic Sea*" [26]. The Kriegers Flak area in the Baltic Sea is well-suited for offshore wind power plants and in the pre-feasibility study a total of 1600 MW future wind power generation capacity has been assumed. The analysis addressed the best connection schemes from the off-shore wind farms to the onshore grids (Fig. 6-10). The basic concept consisted of a "*classical*" solution where the offshore power plants are connected nationally: three separate direct links from the national transmission systems of Germany, Denmark East and Sweden to Kriegers Flak. This basic solution was compared with three "*combined*" solutions where the grid connection of the offshore wind power plants would also function as an interconnector between the three countries. The "combined" solution would "*bring renewable energy to the European consumers, strengthen the energy markets and increase the security of supply by providing transmission capacity*" [26].

The pre-feasibility study showed that the "combined" solution offers a higher benefit/cost ratio in comparison with separate grid connections between Kriegers Flak and the national systems. However, for a final decision on this project a series of aspects shall be deeply investigated concerning: coordination of priority feed-in tariffs, balancing, congestion rent, national support schemes of wind generation, permitting and authorisation process.

As for the technological issues, the HVDC-VSC solution looks to be the most appealing, but multi-terminal schemes adopting this technology haven't been realized yet and further developments on its practical feasibility and standardisation shall be considered.

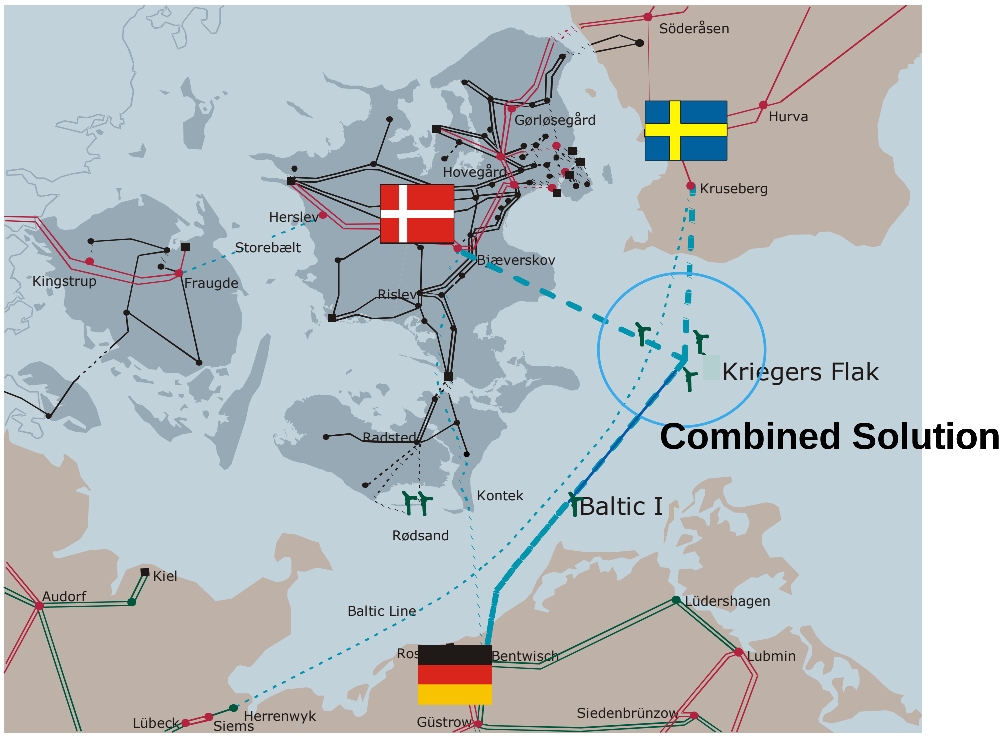

Fig. 6-10 – Location and sketched connection of Kriegers Flak. The thinner dashed line indicates the existing connections between Sweden and Germany (Baltic Cable). *(source[25], [26])*

Norway – Germany

<see above the description of the Germany-Norway interconnection project>

Finland – Russia

The commercial capacity of the cross-border connections is presently 1300 MW in one-way only, i.e. from Russia to Finland. The Russian parties have been interested also in importing electricity from Finland. Consequently, the TSOs have analyzed preliminarily how the present connection could be converted partly into a two-way link. In the autumn of 2007, Federal Grid Company of Russia and Finland launched a technical study to investigate the possibilities of bi-directional operation on one of the 350 MW HVDC converter bridges in Vyborg. Later on, the Russian TSO has informed Fingrid that development of a two-way operation is not a topical issue in the present situation. Hence, so far any estimation isn't available on the amount of energy to be traded towards Russia and the costs related to the conversion of the existing converter stations for a bi-directional operation mode.

Country from	Country to	Substation From	Substation To	Status	Expected year of commissioning	Description of the Project
Sweden	Finland	Dannebö	Rauma	decided	2011	FennoSkan II – HVDC submarine link
Sweden	Norway	Järpströmmen	Nea	decided	2009	AC 400 kV OHL
Denmark West	Denmark East	---	----	decided	2010	Great Belt – HVDC submarine link
Norway	Denmark	---	---	Letter of intent	Earliest commissioning date	Skagerrak IV – HVDC submarine link
Sweden	Sweden / Norway	Hörnby (South Sweden)	Jönköping / Oslo	decided	unknown	South Link (Sweden-Sweden) combined with the South Western link (Sweden-Norway) South Link will be realised with a 400 kV AC line, while the South-West link will be a tri-terminal HVDC link with VSC technology
Sweden	Norway	Ørskog	Fardal	proposed	unknown	AC 400 kV OHL to strengthen the Swedish-Norwegian North-South capacity and at the same time decrease potential capacity problems related to cress-section 2 in Sweden. The full benefits of this project can be achieved provided that the new line Järpströmmen-Nea will also be commissioned.
Arctic region		Ofoten-Balsfjord-Hammersfest		proposed	unknown	AC 400 kV OHL to face the expected increase in consumption and production in the region. New petroleum-related activities are expected and large wind-projects are at planning stage.

Tab. 6-3 –Interconnections reinforcements according to NORDEL Master Plan 2008 [6]

Country from	Country to	Substation From	Substation To	Status	Expected year of commissioning	Description of the Project
Denmark East	Sweden / Germany	Bjæverskov	Bentwisch	under consi-deration	unknown	Combination of a new HVDC link between Germany, Sweden and Eastern Denmark with the grid connections of the planned off-shore wind farms at Kriegers Flak replacing three single by one common solution.

Tab. 6-4 –Interconnections for Kriegers Flak project [25]

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ANNEXE 1

- Installed capacity in the Baltic region (annexed sheet 1)
- International energy interchanges in the year 2007 in the Baltic region (annexed sheet 2)
- Past patterns of the international energy interchanges in the Baltic region (annexed sheet 3)

ANNEXE 2.

Estimated needs of future NTC level in the Baltic Members States and main bottlenecks in the Latvian grid (source Latvian TSO).

The estimations of the expected congestions in Latvia and needed NTC levels have been derived from the Baltic Grid 2025 study launched in 2007.

Bottleneck No 1 – Line No 309 Rezekne – Velikoretskaya. The only tie-line between Latvian and Russian power systems. Any type of maintenance or accident causes immediate bottleneck between two power systems.

Bottleneck No 2 – Interconnection between Latvia and Estonia. Interconnection is comprised of two 330 kV OHL but both of them are connected to the same 330 kV substation Valmiera. Possibility to loose whole interconnection as the n-1 case. Operational bottlenecks are frequent in the case of generation redispach in BRELL electric ring, for example during the outages of Ignalina NPP.

Bottleneck No 3 – Lines No 303 and No 320. Internal 330 kV lines of Latvian power system being the limiting factor for the interconnection between Western part of Latvia and Western Lithuania (Pmax=1000 MW). Operational bottlenecks that are frequent and influenced by the total consumption of the connecting regions in conjunction with the output of the Kaliningrad TPP, Kruonio PSP, and operational state of internal 330 kV double circuit line No 307 and No 308 in Lithuanian power system.

Bottleneck No 4 - Line No 450 Ignalina – Līksna: one of the four tie lines between Latvian and Lithuanian power systems. Bottleneck currently revealed in simulations only after the commissioning of the new power plant with the installed capacity of 3000 MW on the site of the former Ignalina NPP.