Transmission Networks Developments and the Role of Interconnections with Neighbouring Countries

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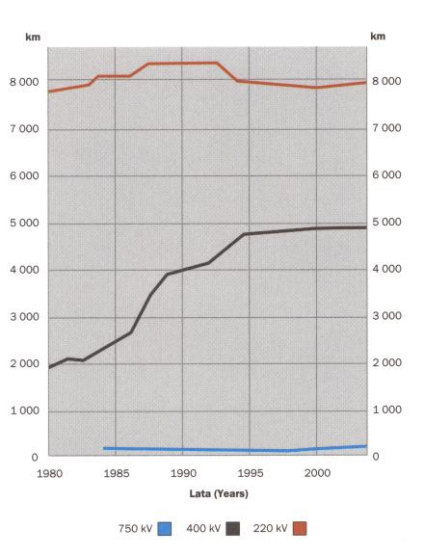
Contents of the Presentation

- Basic characteristic of the Polish transmission network
- Driving factors of the current and future network investments
- Electricity market and the power system operation in Poland
- Interconnectors, regional market integration and cross-border trade

The Polish Power Systems - Facts & Figures

- Basic characteristic of the Polish power system (2009)
  - peak demand 24.5 GW (winter), min demand 9.5 GW (summer)
  - electricity production 150.1 TWh
  - electricity consumption 148.7 TWh
  - country's balance +2.2 TWh (export)
  - cross-border transmission capacity 10%
  - Independent , transmission and system operator (PSE-Operator S.A.), state owned
  - 6 large DSO/suppliers, legal unbudling, only 2 of them fully privatized
  - 16 larger power plants, 25% own by IPP
  - transmission system: 1 line 750 kV (114 km), 68 lines 400 kV (5031 km), 167 lines 220 kV (7908 km), 106 EHV and HV substations with 174 transformers (38.5 GVA), part of UCTE (ETSO-E network since 1995)
  - distribution network: (760000 km) 110 kV, 20 kV, 15 V
- Increase of electricity consumption:
  - 2001-2007: +12% (+1.7% per year , max. 4.2% per year)
  - 2011-2015: +1.62% per year
  - 2016-2017: +2.07% per year



- In the past the development of new HV and EHV lines was deferred due to economic issues, inefficient regulatory framework (including transmission assets management model), environment protection and the lack of the social acceptance for this kind of projects.

- Only 2 GW of large generating units under construction (coal, mainly covering for units which will be decommissioned due to emission standards), additional 2 GW currently under financial analysis and 4 GW more (until 2025) under feasibility studies.

Under the Shadow of Wind

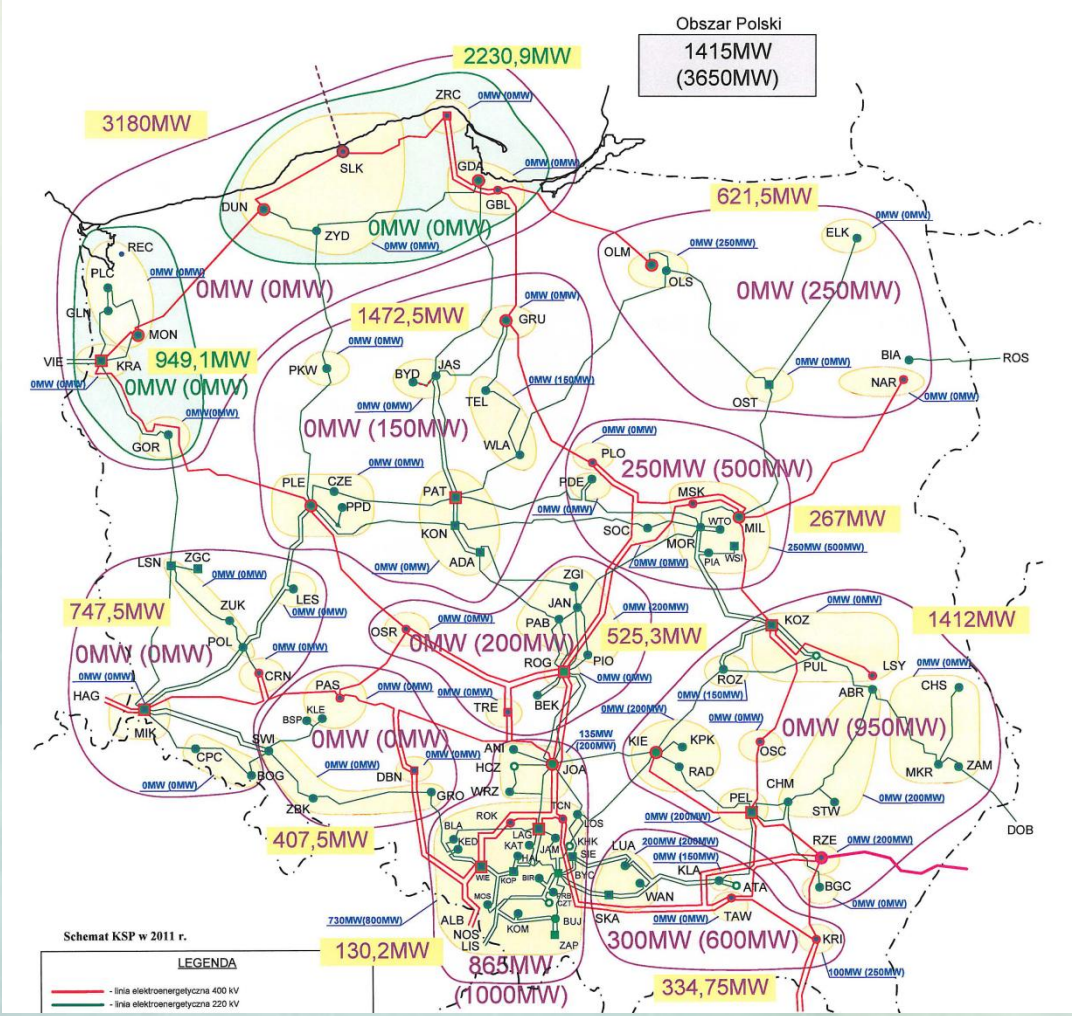
- In the past the development of new HV and EHV lines was deferred due to economic issues, inefficient regulatory framework (including transmission assets management model), environment protection and the lack of the social acceptance for this kind of projects.

- Electricity demand forecast:
  - 2001-2007: +12% (+1.7% per year , max. 4.2% per year)
  - 2011-2015: +1.62% per year
  - 2016-2017: +2.07% per year

- The huge demand of grid connection from wind farm projects put DSOs and TSO under pressure:
  - 1.5 GW of installed capacity brought on line (June 2011)
  - Over 15 GW of wind generation has been granted grid connection (June 2011), when approximately half of that can be connected without significant reinforcement of distribution networks and transmission networks
  - Over 70 GW of wind generation in grid connection applications (middle of 2010)

- The way wind farms are using network capacity are nowhere near optimal. Better model of allocating transmission resources and RES/DG operation is expected.

Grid Connection Capacity 2010

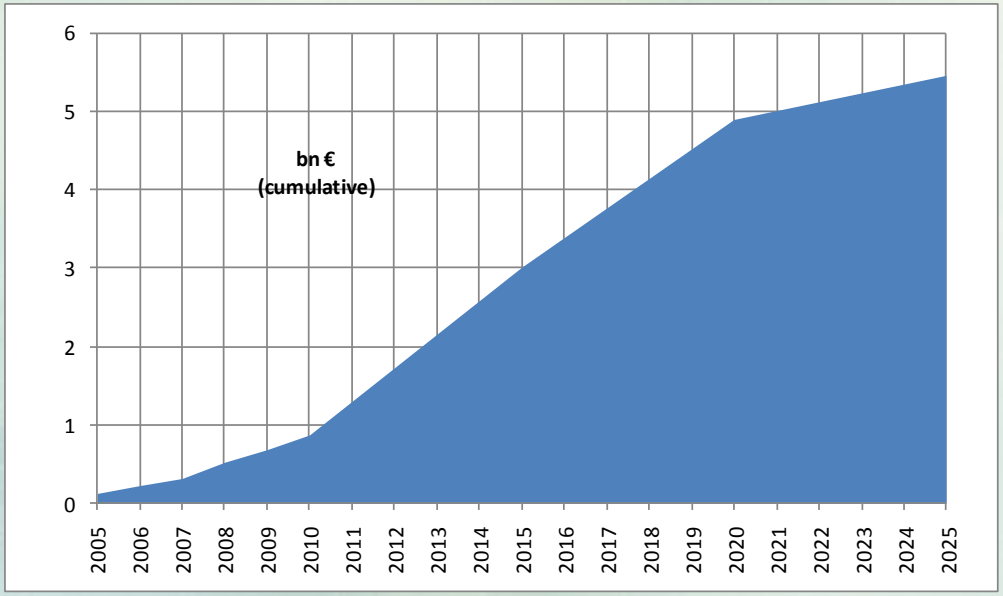


The Major Objectives of Network Developements

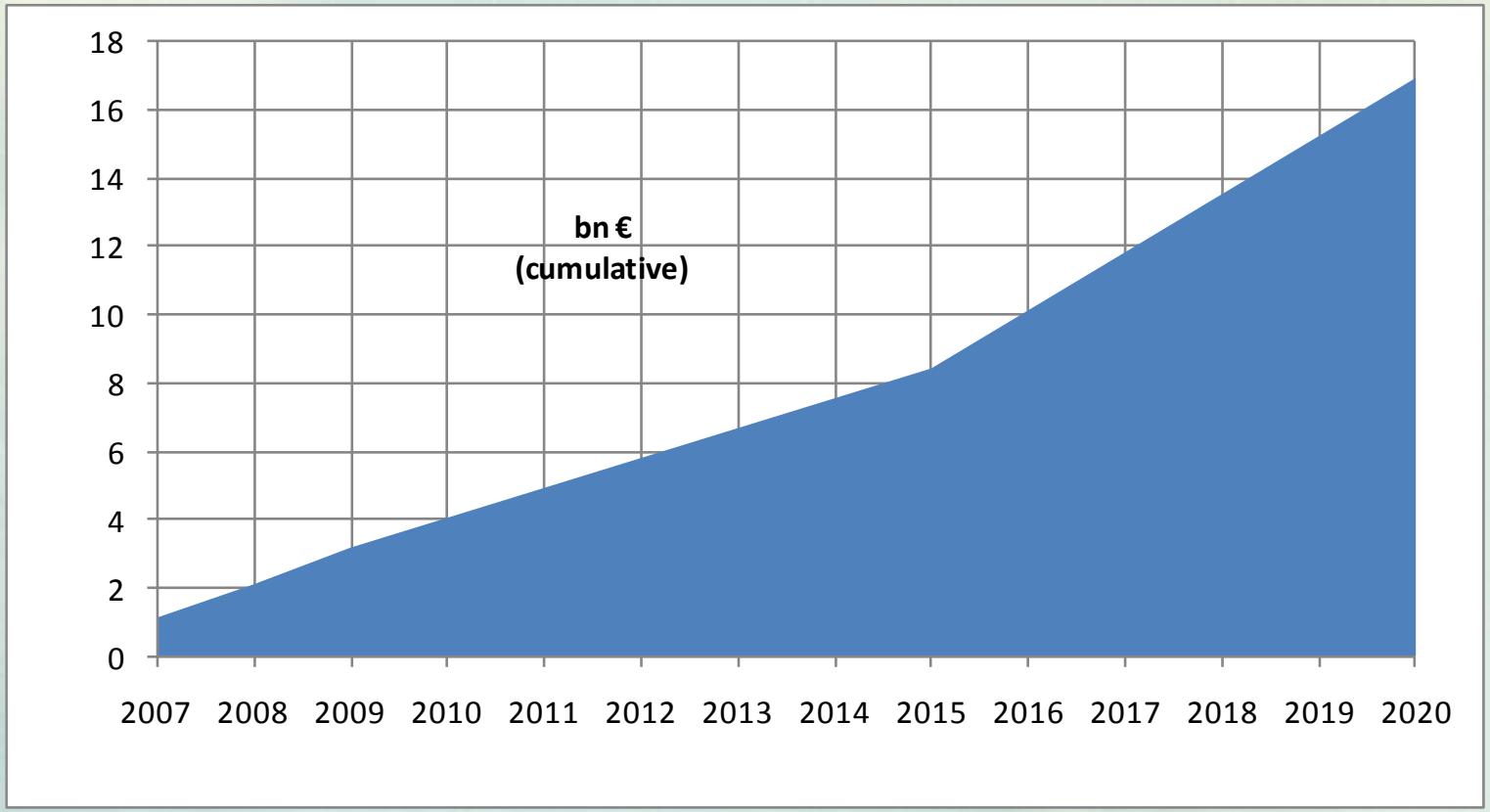
- Integration and optimization of RES/DG operation
- Improving security of supply (network reliability) and voltage conditions for growing demand centres (Warsaw, Poznan, Wroclaw, Gdansk)
- Alleviating transmission constraints in the 220 kV transmission network and in 110 kV distribution network by:
  - Replacing 220 kV network with 400 kV network using existing paths
  - Building new 400/110 kV substations
  - Upgrading 400/220 and 400/110 transformers
  - Modernization and thermal monitoring of existing 110 kV lines
- Getting network ready for connection of new bigger generating units (800-1000MW), which will replace small units (100-200 MW)
  - transient system stability problem
  - short circuit conditions
- Improving reliability of MV and LV networks (rural areas)
- Smart metering (orientated on supplier switching, neglecting DSM requirements)

Cost of Transmission Network Reinforcements

Years 2010-2015	Mln €
Grid connection of large power plants	538
Grid connection of RES/DG	318
Power system security	2168
Switching from 220 kV to 400 kV transmission lines	1035
Connection of new loads,	621
Improving reliability of supply	327
Voltage and reactive power compensation	185
Improving transmission capacity:	2829
large power plants	1545
RES/DG	1284
Increasing cross-border transmission capacity	2473
asynchronous	2043
synchronous	430



Cost of Distribution Network Reinforcements



EHV Network and Existing Interconnectors

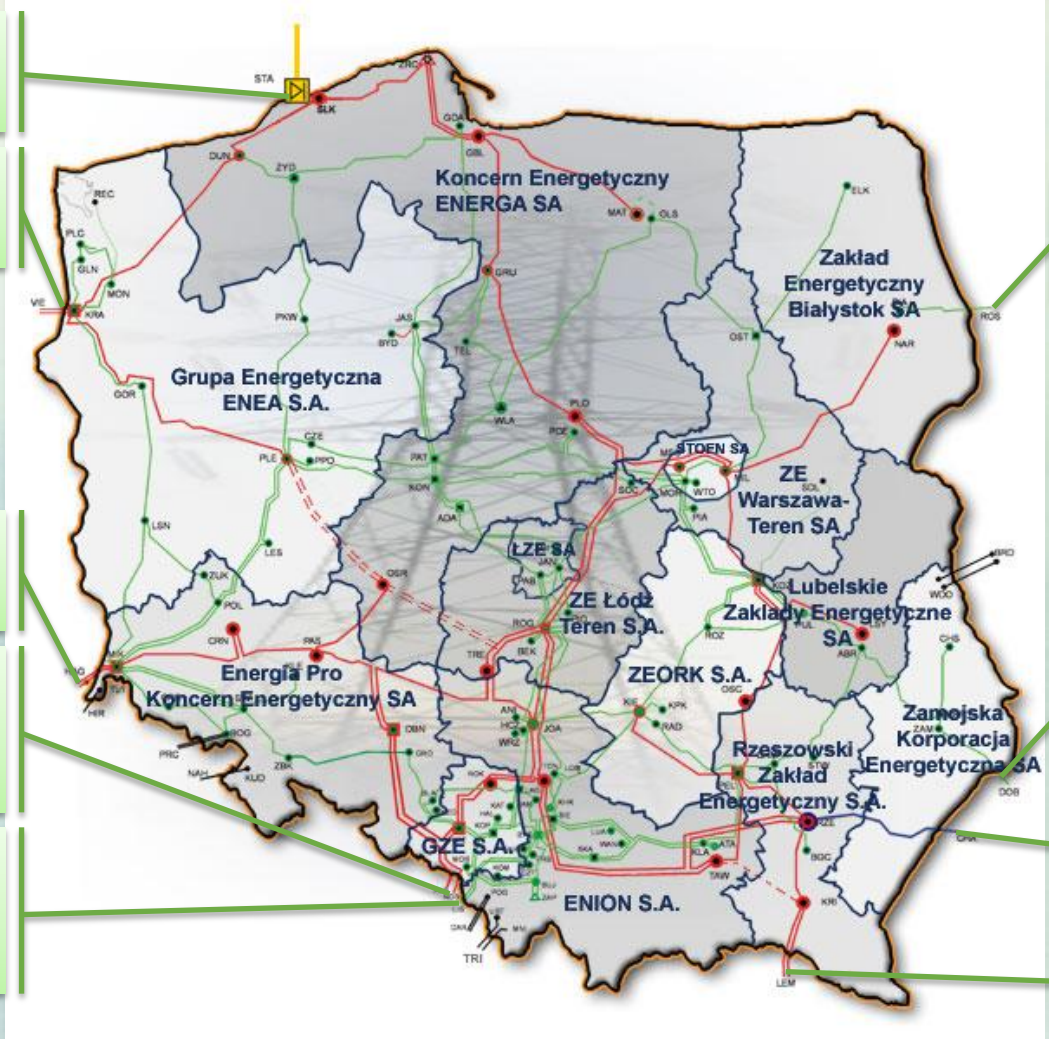
Słupsk-Starno
HVDC, ±450kV
600 MW

Krajnik-Vierraden
AC-Double, 400kV operating on 220 kV
914 MVA

Mikułowa-Hagenwerder
AC-Single/Double, 400 kV
2771 MVA

Dobrzeń-Albrechtice
AC-Single, 400 kV
1205 MVA
Wielopole-Nosovice
AC-Single, 400 kV
1205 MVA

Kopanina-Liskovec
AC-Single, 220 kV
412 MVA
Bujaków-Liskovec
AC-Single, 220 kV
412 MVA

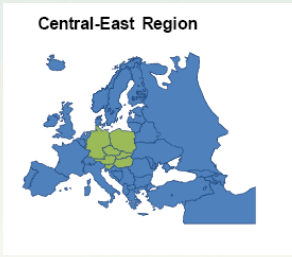


Białystok-Roś
AC-Single,220 kV
Disconnected (231MVA)

Zamość-Dobrotwór
AC-Single,220 kV
385 MVA

Rzeszów Widełka-Chmielnicka
AC-Single, 750 kV
Disconnected (2700 MVA)

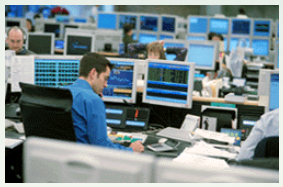
Krosno Iskrzynia-Lemesany
AC-Double, 400 kV
1662 MVA



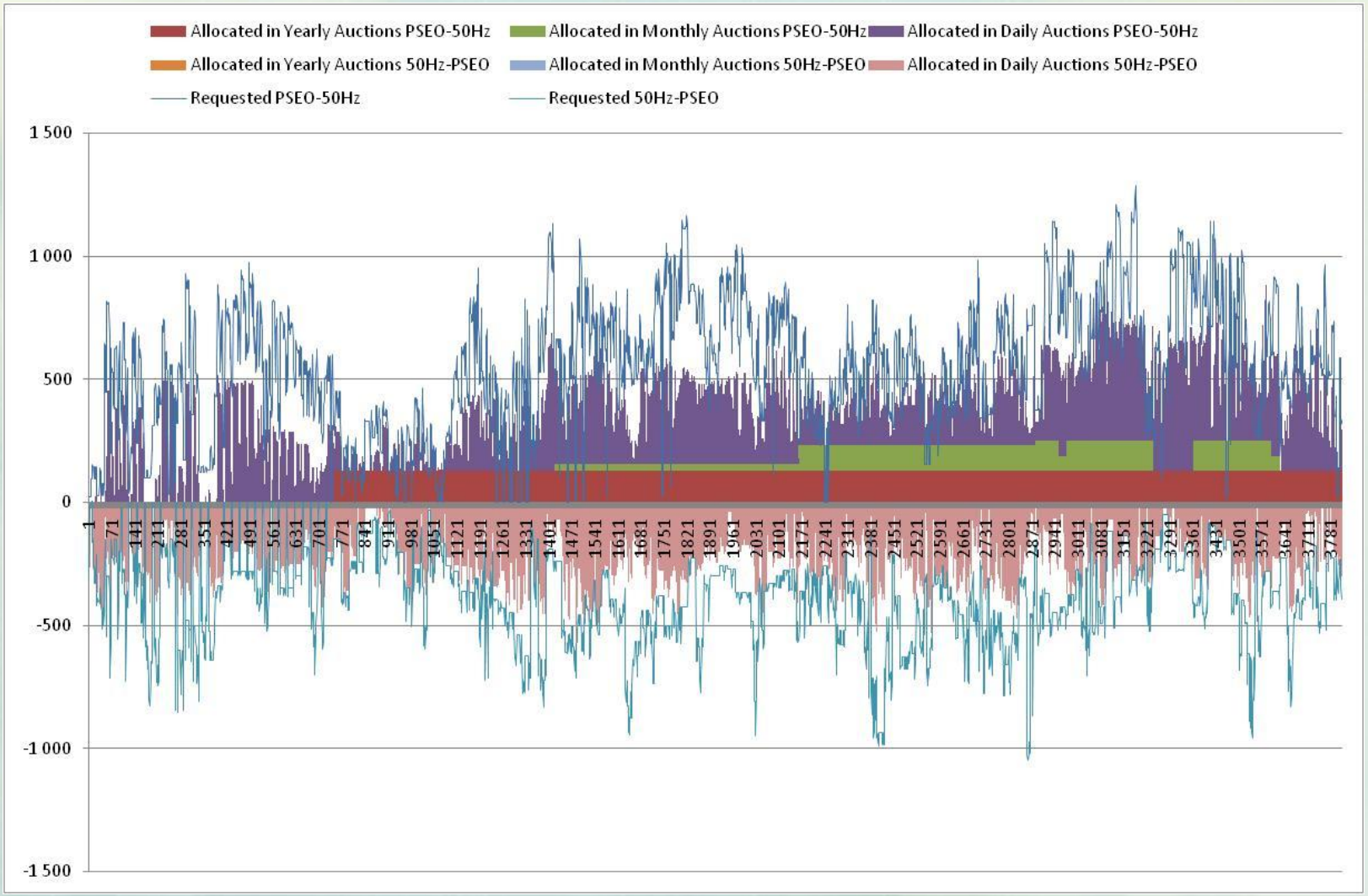
The Cross-Border Capacity Allocation

- Since the end of 2010 Poland and Sweden power exchanges (TGE and NordPool) are price coupled using HVDC Baltic cable (Northern Region*).
- The on the PL-D-CZ-SK border, the transmission capacity is traded in yearly, monthly and daily coordinated auctions, run by Central Allocation Office GmbH (Austria), using ATC model
- Moving from ATC model to flow based model is the daunting challenge for the whole Central and East Europe Region**):
  - Simplified flow based model (one system = one node) yields results, which are worse than those calculated using ATC model. Large power systems have to be split into multiple transmission zones (looking for nodal or zonal network and market model for CEE).
  - Integration of the Polish and German power system operation and market operation is the key element.

*) Poland, Germany, Sweden, Norway, Denmark, Finland
**) Austria, Czech Republic, Germany, Hungary, Poland, Slovakia and Slovenia



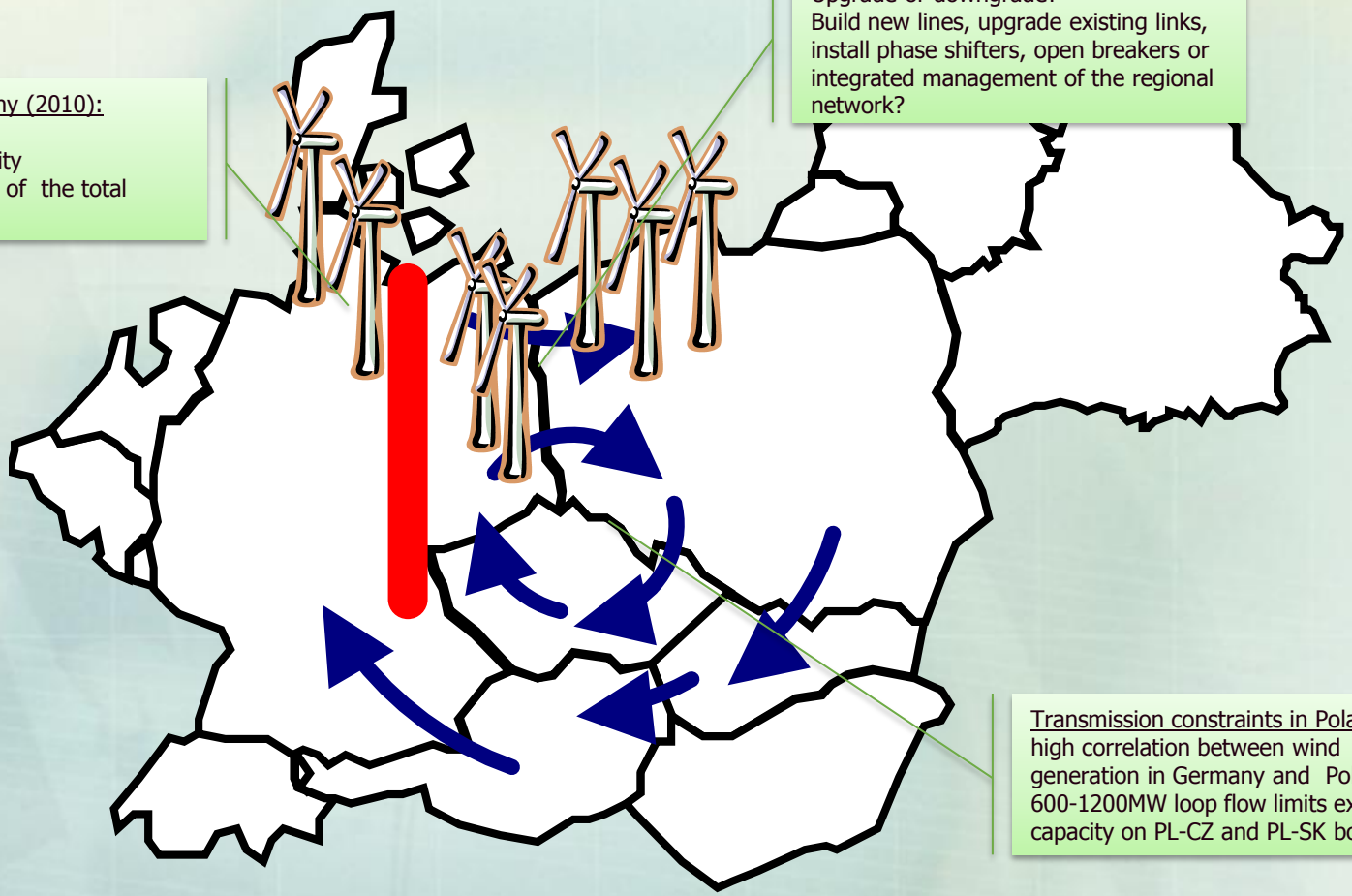
Available Export/Import Capacity



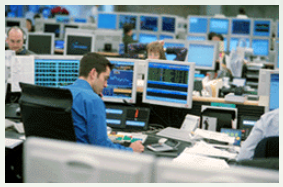
Unintended Loop Flows

Wind power in Germany (2010):
2110 wind farms
27 GW installed capacity
38 TWh of energy 7% of the total demand

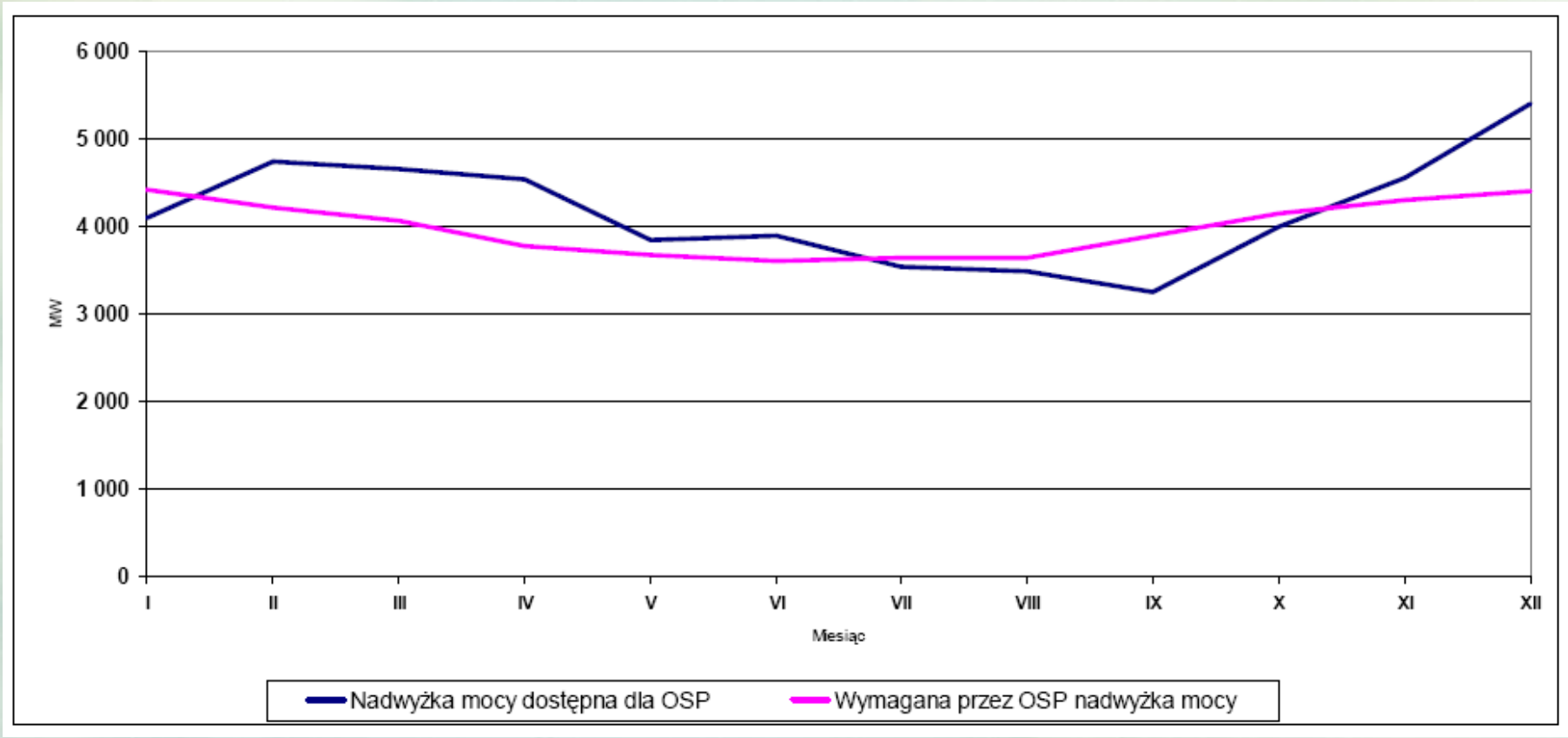
Use of the cross-boder capacity:
Upgrade or downgrade?
Build new lines, upgrade existing links, install phase shifters, open breakers or integrated management of the regional network?



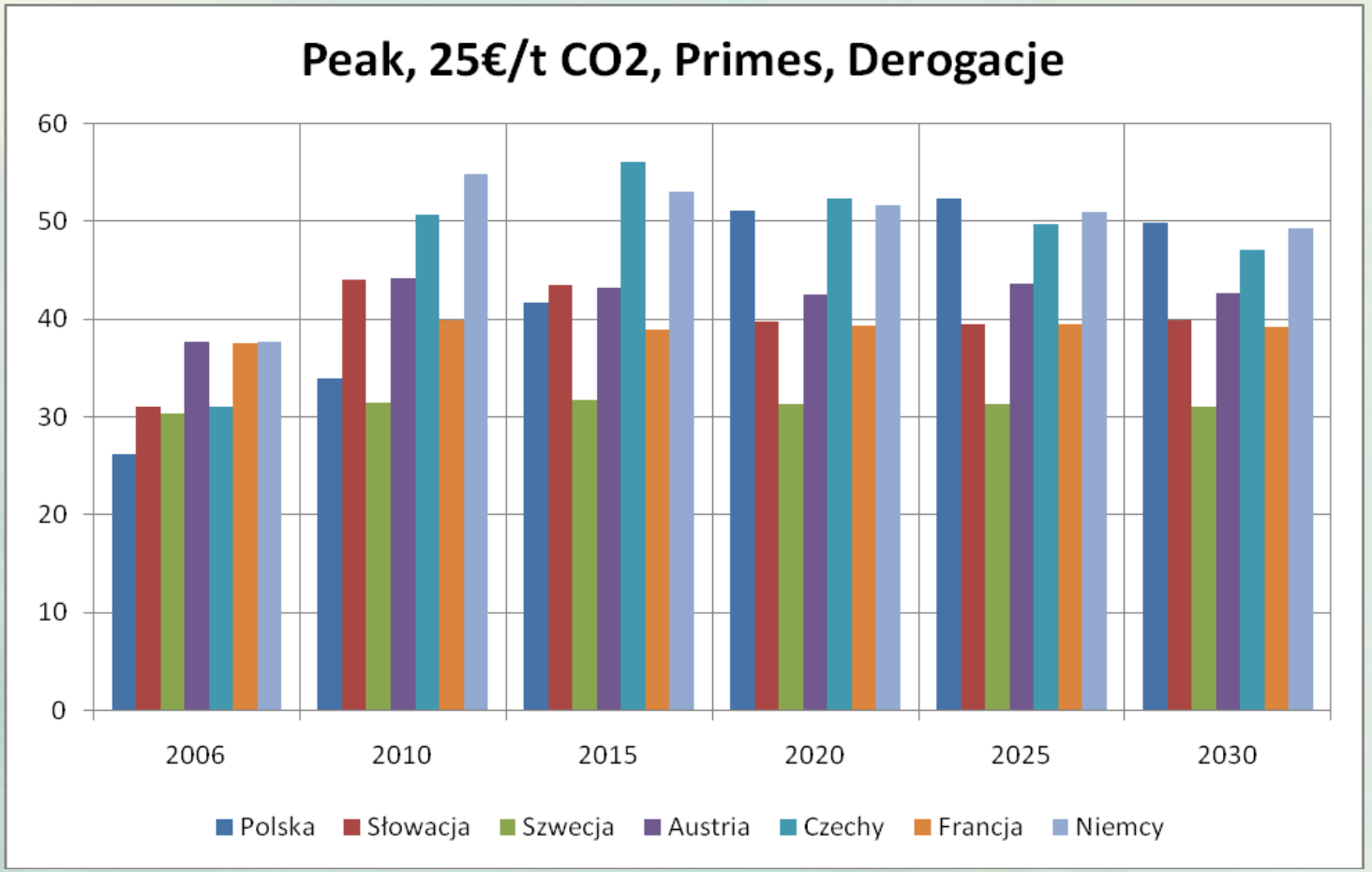
Transmission constraints in Poland:
high correlation between wind generation in Germany and Poland
600-1200MW loop flow limits export capacity on PL-CZ and PL-SK border



Adequacy Reliability Margin



The Impact of Carbon Free Economy



New investments in the cross-border capacity

Krajnik-Vierraden
Switching to 400 kV
Installation of 2 phase shifters to curb the loop flow
+500MVA (2016)

Eisenhuttenstadt-Plewiska
AC Double 400 kV (phase shifters)

Mikułowa-Hagenwerder
Installation of 2 phase shifters to curb the loop flow (2016)

Ełk-Alytus
AC-Double, 400 kV (154 km)
Cost: 500 mln € (including 200 mln € UE funds)
+500 MW (2015),+1000 MW (2018)

Narew-Roś
AC-Single, 400 kV using existing 220 kV line corridor, HVDC back-to-back station
+600MW

Rzeszów Widełka-Chmielnicka
Installation of the HVDC back-to-back station (2x600MW), reinforcement of the transmission line. Cost: 230 mln € inlcuding 158 mln HVDC link
+1200MW

New connection with Slovakia
AC-Double, 400 kV

The Electricity Market Model in Poland

- The electricity market in Poland has been implemented 20 years ago with only minor adjustments to the original blueprint:
  - Copper plate model both in regulated (transmission, distribution) and competitive (energy trade) business activities
  - OTC (bilateral)
  - Based on day ahead trade (DAM)
- Ownership structure:
  - Independent TSO
  - Market dominated by four large, vertically integrated (legal unbundling) companies focused on inside trading
- Market efficiency:
  - Insufficient investments in generation → capacity market?
  - Lack of proper locational signals and soaring cost of constraints alleviation in the transmission network (RES/DG development, electricity wheeling) → nodal pricing?
  - No private and public partnership in transmission and distribution → new grid asset management model?
  - Implemented RES support scheme is inefficient (too expensive?) → wait or change it now?
- Long term stability in the regulatory framework and the common network management model and market standard model for the EU

Conclusions

• Developement of RES/DG, repowering and new large power plants call for transmission and distribution reinforcements to be completed in the nearest future. Business as usual is no more an option.

• At least 20 bn € have to be invested in transmission and distribution network. The current regulatory framework, including transmission asset management model and lack of stability in the long term financing results in pure stimulation of the grid development (no third part financing)

• With a high degree of probability Poland will soon become net electricity importer and the construction of new cross-border transmission lines will be the question of the security of supply.

• Since early nineties, when the electricity market in Poland has been implemented, the model hasn't changed much and it is not up to the ultimate challanges we came to face with.

Thank you for the attention… Questions?

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