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The North European case: liberalized multinational electricity market and using hydro power as balancing resource

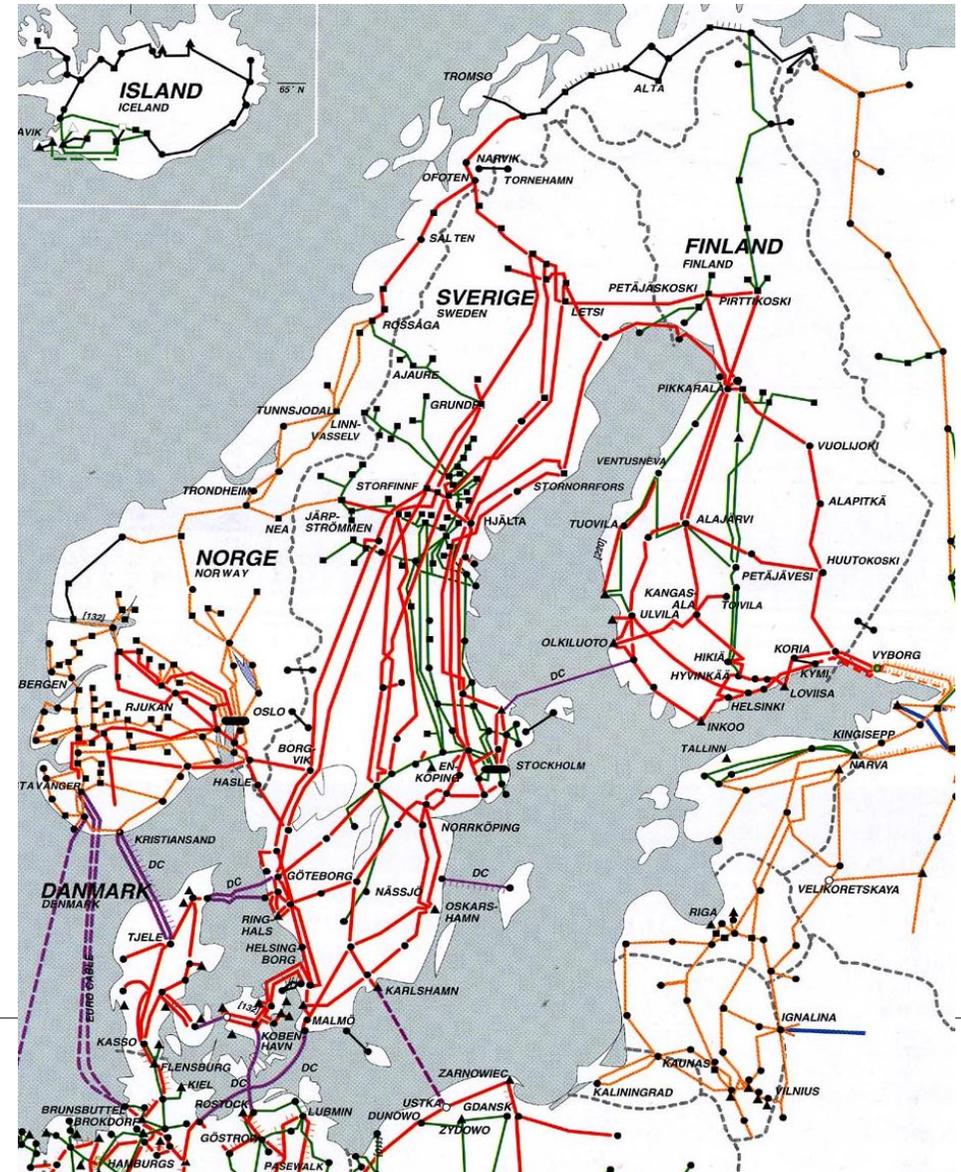
Wind Integration Workshop in Tokyo
Friday October 19, 2012

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Structure:



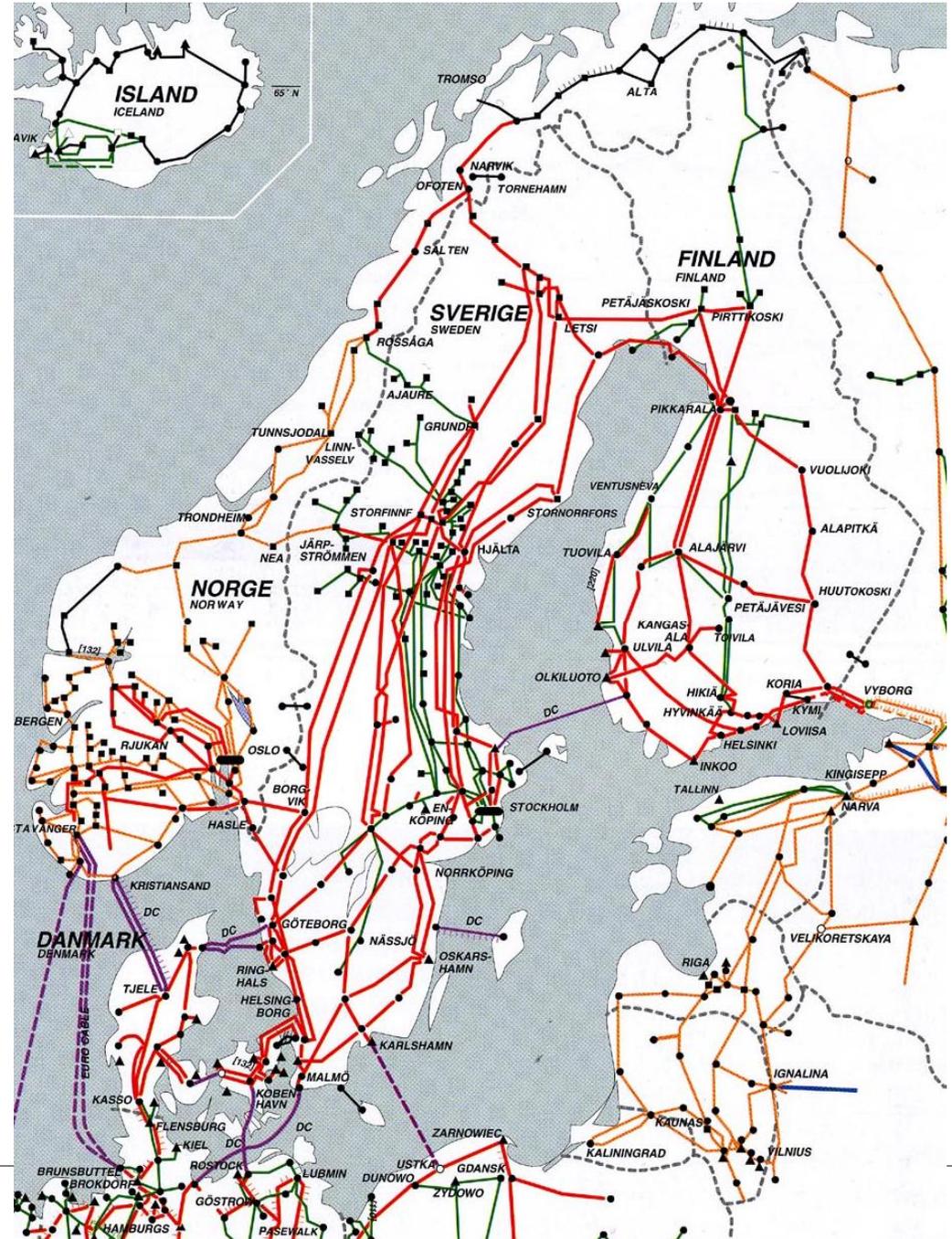
- Nordic power system - energy
- Nordic power system - operation
- Wind power balancing



The Nordic system

- Nordic system
 - 4 countries
 - 4 TSOs
 - Installed capacity: 93000 MW
 - Production: 414001 GWh
 - Inhabitants: ~25 miljons

- Sweden:
 - Installed capacity: 33000 MW
 - Production: 146000 GWh





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Nordic statistics

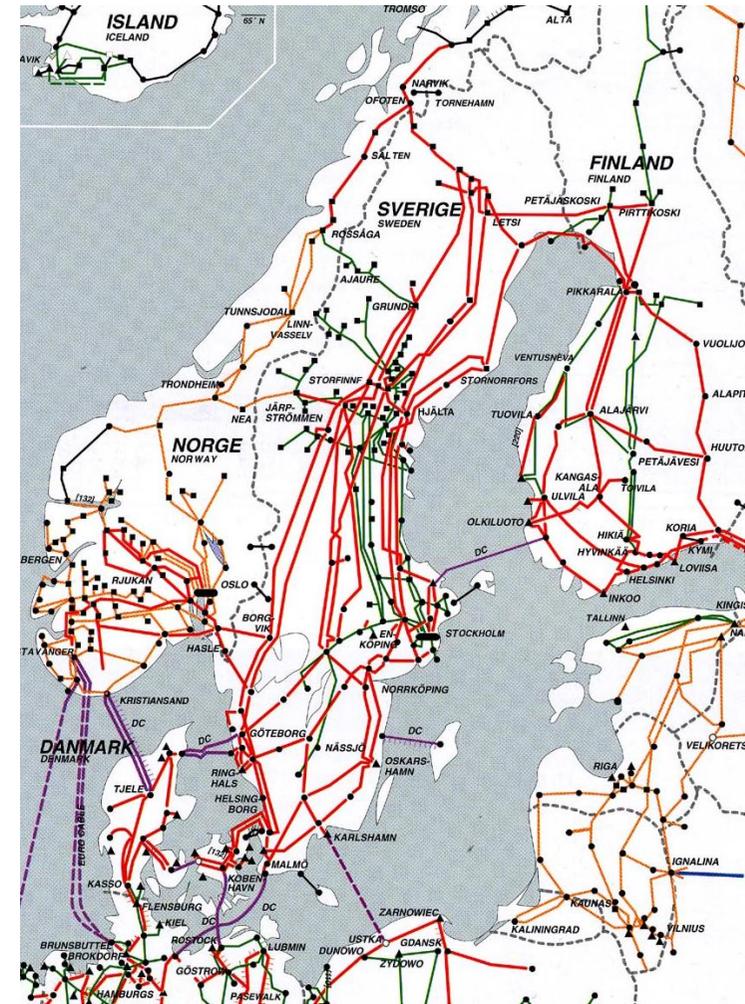
www.entsoe.org

S5 Electricity generation 2008, GWh

	Denmark	Finland	Iceland	Norway	Sweden	Nordel
Total generation	34 648	74 137	16 468	142 727 ²	146 021	414 001
Nuclear power	-	22 038	-	-	61 266	83 304
Other thermal power	27 644	34 948	3	1 147	14 331	78 073
- Condensing power	11 718	8 203	-		840	20 761
- CHP, district heating	14 034 ¹	14 659	-	119	7 209	36 021
- CHP, industry	1 879	12 080	-	596	6 256	20 811
- Gas turbines, etc.	14	6	3	432	26	481
Hydro power	27	16 889	12 427	140 663	68 429	238 435
Wind power	6 977	262	-	917	1 995	10 151
Geothermal power	-	-	4 038	-	-	4 038
Total generation 2007	37 025	77 817	11 976	137 387 ²	144 708	408 913
Change compared to 2007	-6,4%	-4,7%	37,5%	3,9%	0,9%	1,2%

Nordic statistics – summary

- 58% of energy from hydro
- 20% from nuclear power
- Hydro power, 238 TWh
- Wind power, 10 TWh
- Hydro inflow can vary 86 TWh between dry year and wet year
- Many internal bottlenecks
- Nordic export/import capacity 4300 MW



Stockholm in Tokyo (km comparison)



Renewable energy systems

- Energy is "produced" where the resource is
 - The energy has to be transported to consumption center
 - The energy inflow varies, which requires storage and/or flexible system solutions
 - This is valid for hydro power, wind power, solar power
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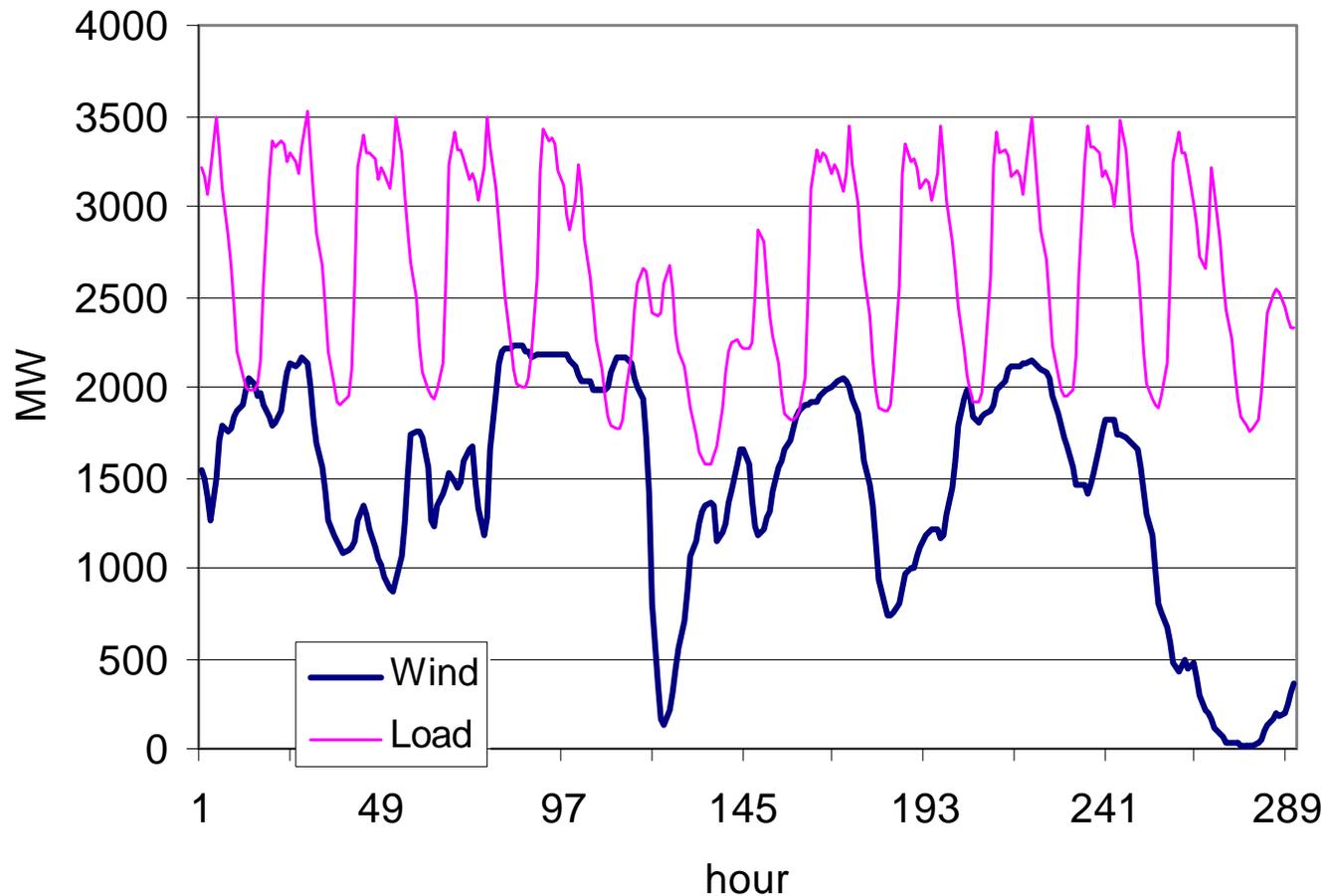
Example

- Nordic hydro power (inflow) can vary 86 TWh between different years
- Transport from NV to SE + continent
- Energi balancing with thermal power in i Dk+SF+Ge+PI+NL
- Wind power gives the same variations/uncertainties (and solutions) as hydro power.
- **But:** time perspective is much shorter!



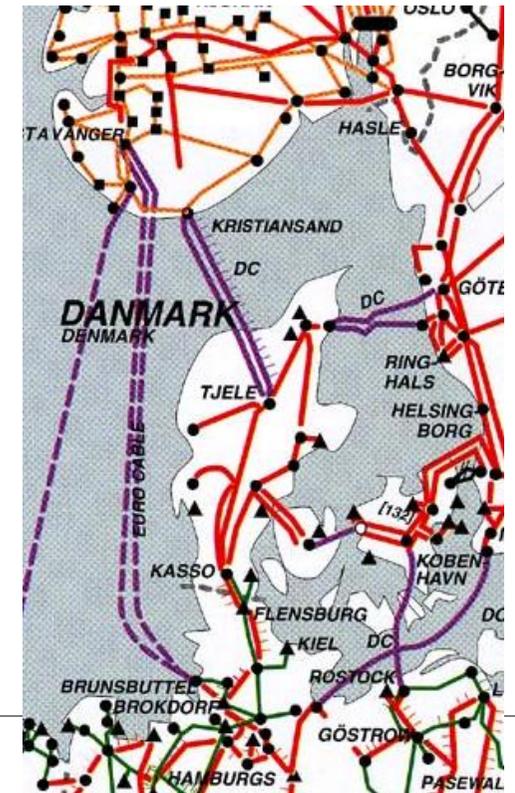
Real wind and load in western Denmark

West Denmark January 3-15, 2005



Trading capacity:

- Sweden, 600 MW
- Norway, 1000 MW
- Germany, 1000 MW



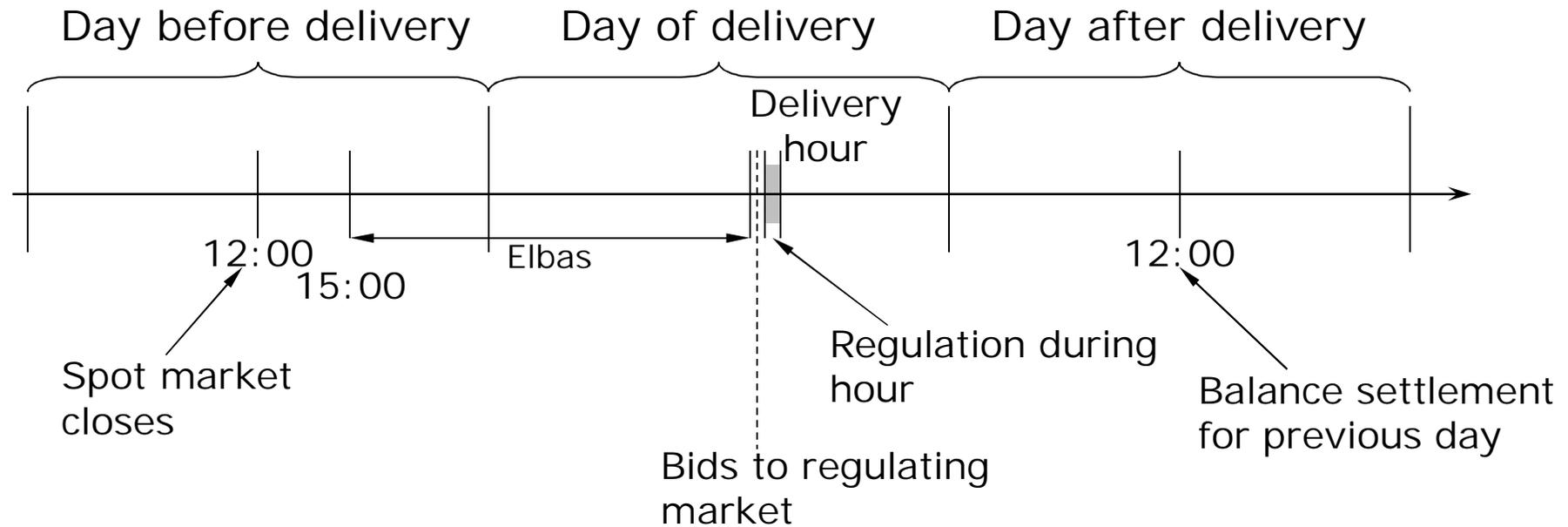
Power trading overview - 1



Physical trading:

- Ahead markets.
 - Nordpool spot, strike price, closes 12.00 day before
 - Elbas, closes 1 hour before delivery hour
 - Bilateral trade up to 1 hour before delivery hour
 - Real-time market. The TSO:s coordinate actions to keep the physical balance between all Nordic producers and all consumers.
 - Post trading. Imbalances caused by imperfect forecasts are traded between surplus and deficit players.
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Nordic power market



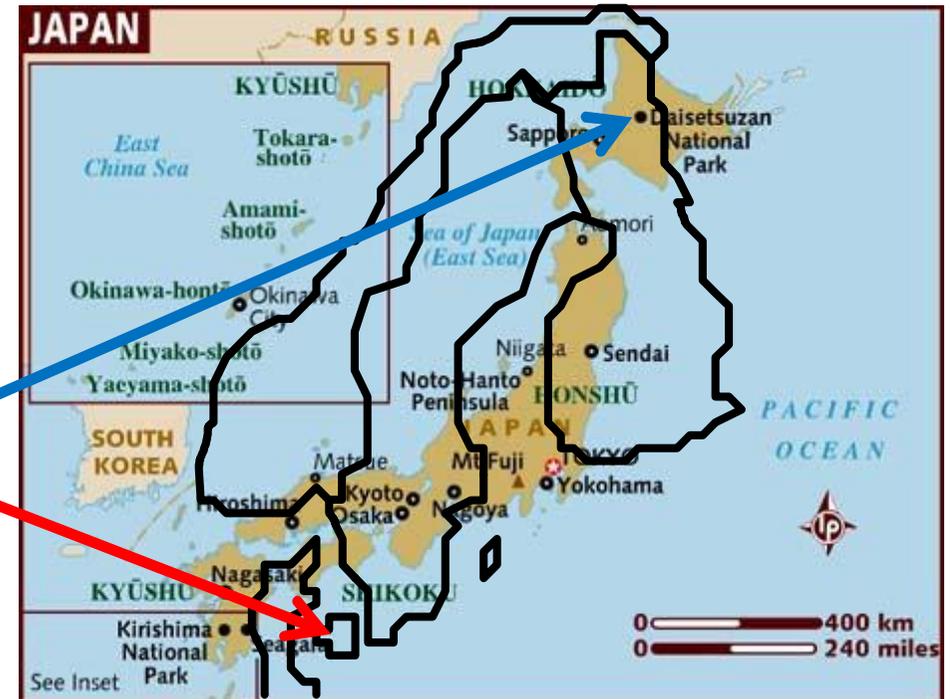
Wind power in Nordic system

- Currently a relatively large part in Denmark
 - Large plans in Norway and Sweden (Sweden, forecast is ≈ 13 TWh/year $\sim 9\%$, 2011: 6 TWh)
 - Swedish applications: Currently 80-100 TWh/year
 - The coordinated regulating market lowers the regulating prices and lowers imbalance costs.
 - A: For Nordpool spot forecasts of 12-36 h are needed.
 - B: Small volumes on Elbas
 - A+B => All wind power production is traded via larger power producers.
 - Denmark: TSO is Balance responsible for most wind power
-

Example of Nordic cooperation

Nordic regulating market:

- No AGC (except Dk-W)!
- Assume that wind power decreases in Denmark with 100 MW
- The bids to the regulating market (tertiary control – up-regulation in 15 minutes) are coordinated in the Nordic system
- If an up-regulating bid from northern Finland is the cheapest and transmission limits are not violated, then this one is used!
- Distance: ~1400 km



20-20-20 goals:

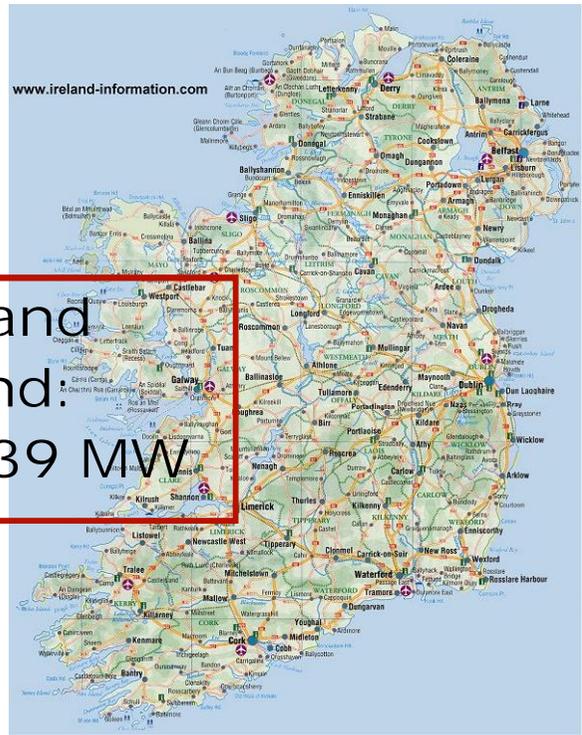
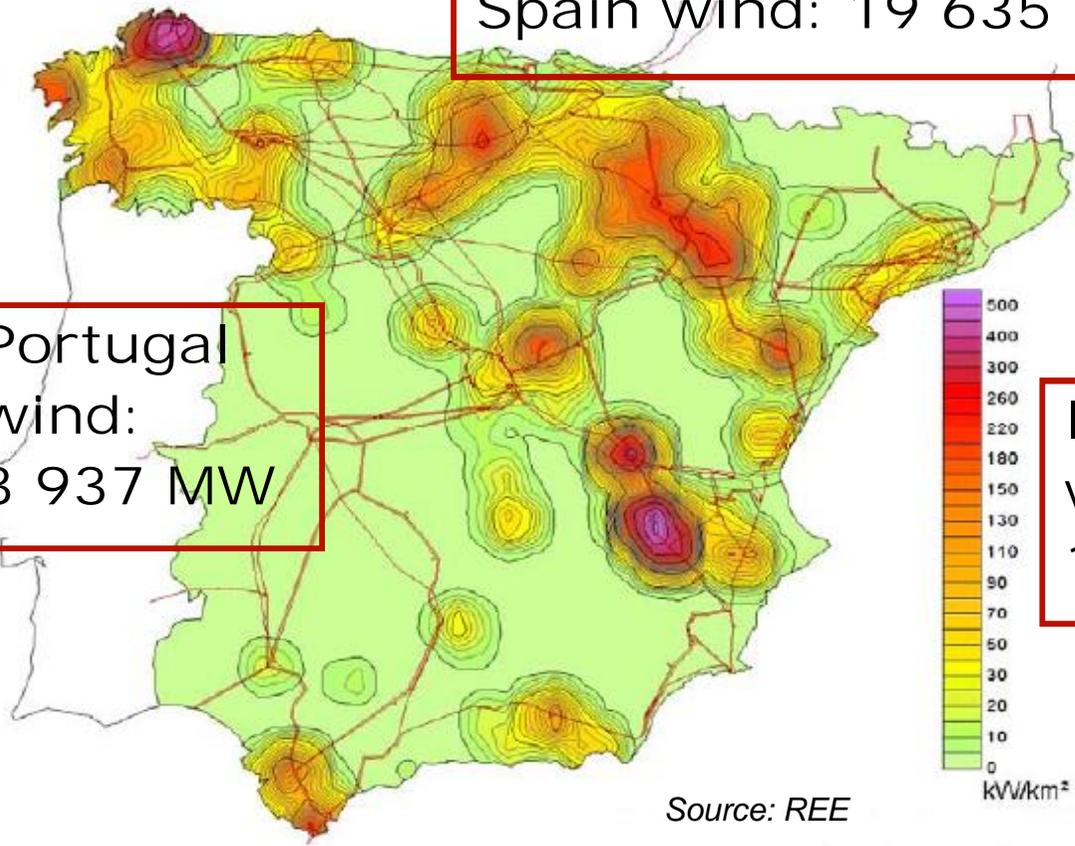
Wind power and transmission capacity

Spain wind: 19 635 MW

Portugal wind: 3 937 MW

Ireland wind: 1539 MW

Source: REE



	wind energy 2010
Sp	16 %
Po	17 %
Ir	13 %

	wind max share
Sp	54 %
Po	81 %
Ir	52 %

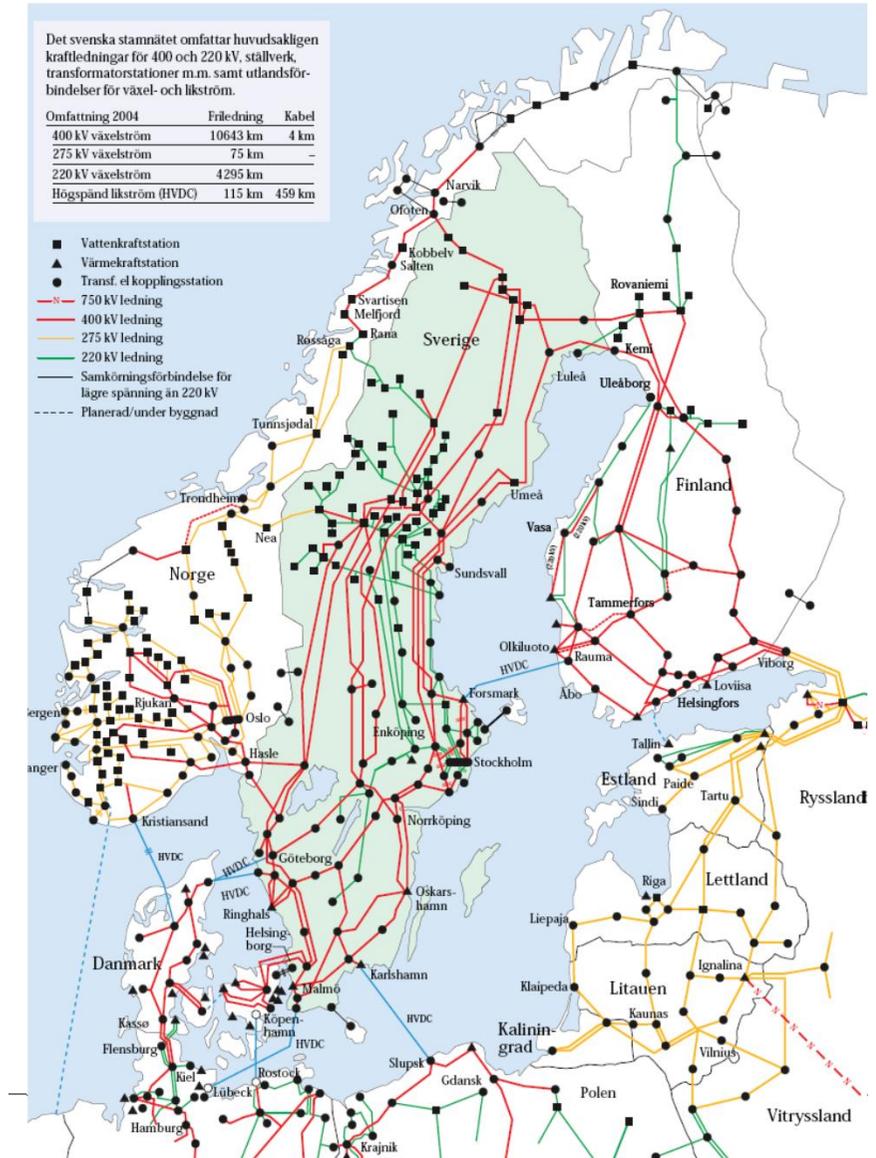
- Portugal –Spain: 1200 MW
- Spain – France: 1200 MW
- Spain – Marocco: 650 MW

- Ireland - Scotland: 450 MW
- Planned: +850 MW

Transmission capacity - today

- Swe-Nor: 3500 MW
- Swe-Fin: 2800 MW
- Swe-Dan: 2600 MW
- Swe-continent: 1200 MW

- Sweden-neighbours:
ca 10100 MW (*continuously*
➔ 88 TWh/year)
- Nordel-neighbours: ca 5500 MW
- ➔ Balancing of wind power is a North European challenge.

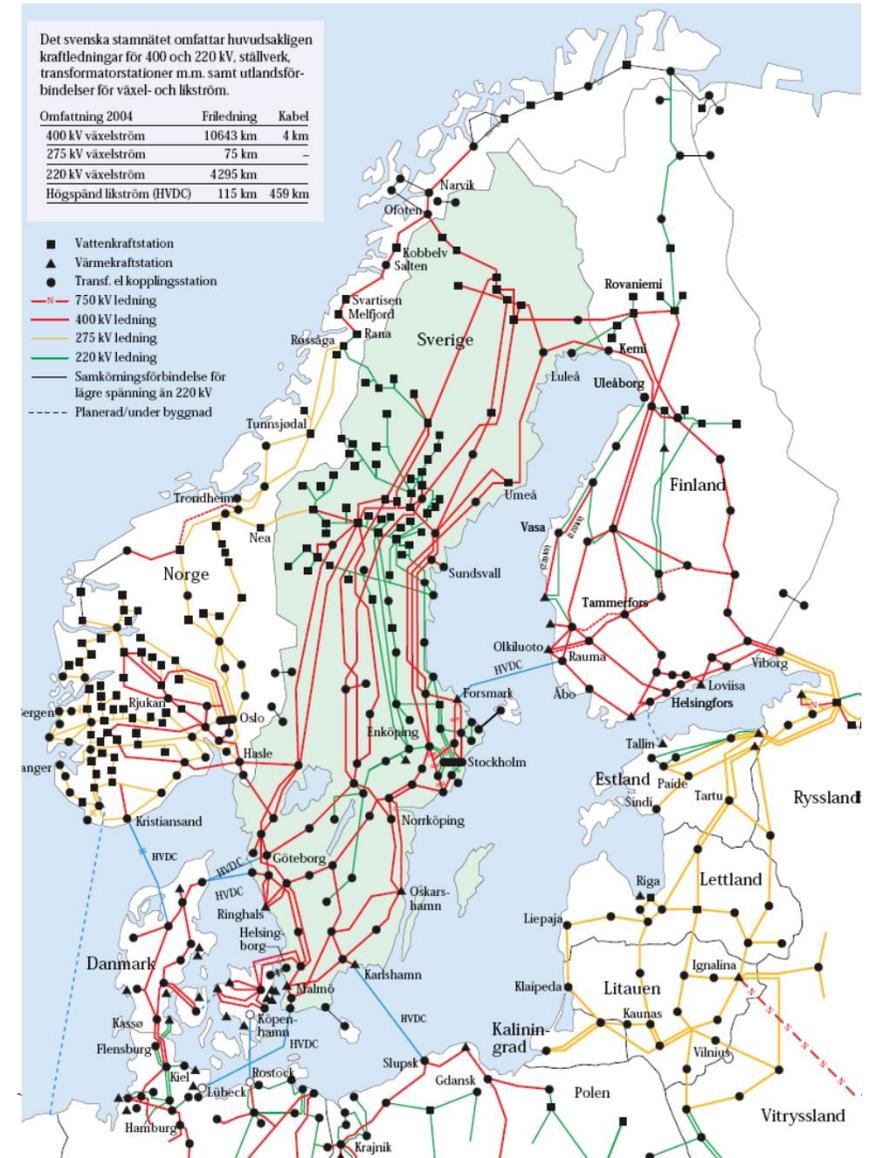


Transmission capacity - plans

- **Sweden-neighbours: ca 10100 MW**
(continuously → 88 TWh/year)
- Nordel-neighbours: ca 5500 MW

Plans:

- Järpströmmen-Nea, S-N, ~1000 MW
- Sydvästlänken, S-N, 2x600 MW
- Nordbalt, S-L, ~600 MW
- New line to Gotland
- Strengthening North to Finland
- New cut 2 line, ev. DC
- ➔ **Sweden-neighbours: + ~2800 MW**



Study of up to 30 TWh wind power

Comments

- One question is which prices this will result in
- The price has to be low enough so other areas are interested to import.
- When the price is low enough, other power plants in Sweden/North Sweden will be operated on lower levels.
- When price differences are high between two neighboring areas then it is profitable to extend transmission between these areas.
- Larger price variation makes it more profitable to install, e.g., pumped hydro stations and/or apply pumping within a river system.
- Low prices (at high wind + low load) increases the interest to install, e.g., electric district heating.
- Better model for flexible seasonal hydro planning and uncertain seasonal planning needed.