

Nordpool Market Operations



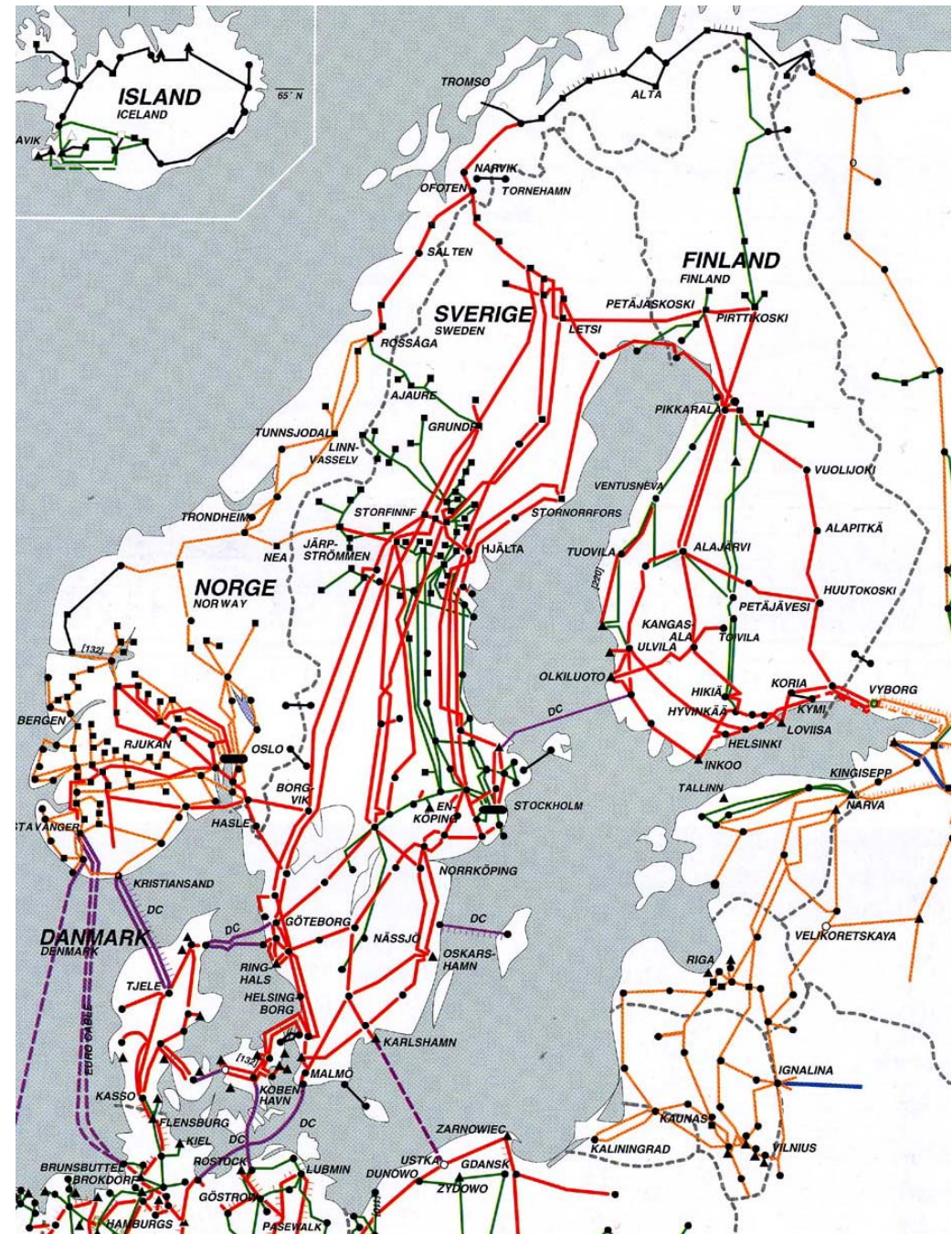
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Utility Wind Integration Group
Fall Technical Workshop
Western Roundup of Wind Integration
October 23-25, 2006
Sheraton Oklahoma City, OK

The Nordic system



- Nordic system
 - 4 countries
 - 4 TSOs
 - Installed capacity:
92574 MW
 - Production:
401913 GWh
 - Inhabitants:
~ 25 miljons
- Sweden:
 - Installed capacity:
33212 MW
 - Production:
154729 GWh



Nordic statistics

www.nordel.org

S11 Electricity generation 2005, GWh

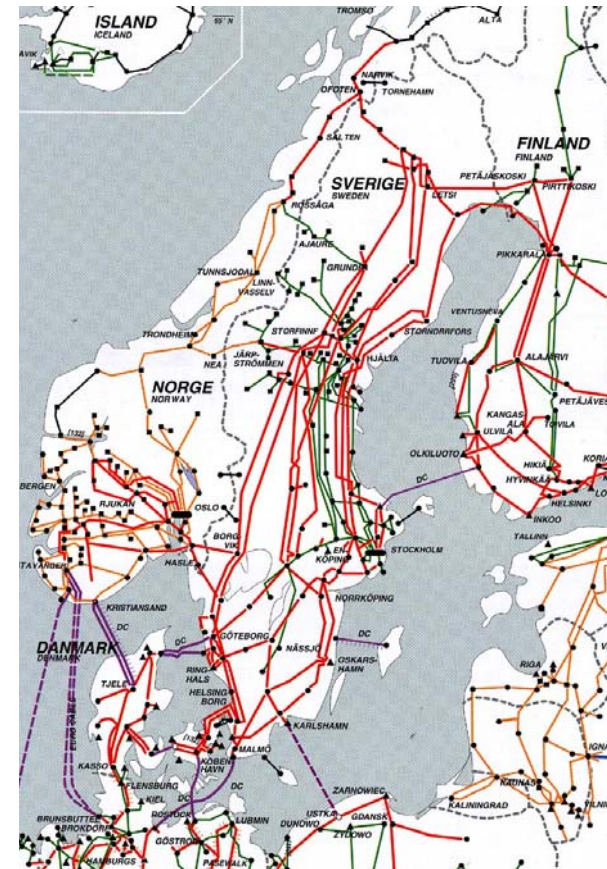
	Denmark	Finland	Iceland	Norway	Sweden	Nordel
Total generation	34,353	67,862	8,679	137,948 ²⁾	154,729	403,571
Nuclear power	.	22,334	.	.	69,461	91,795
Other thermal power	27,715	31,764	8	976	12,195	72,658
- Condensing power		5,680	.	0	513	6,193
- CHP, district heating	25,886 ¹⁾	14,446	.	89	6,315	46,736
- CHP, industry	1,829	11,623	.	531	5,336	19,319
- Gas turbines, etc.	0	15	8	356	31	410
Hydro power	23	13,597	7,013	136,465	72,143	229,241
Wind power	6,615	167	.	507	930	8,219
Geothermal power	.	.	1,658	.	.	1,658
Total generation 2004	38,370	82,155	8,621	110,545 ²⁾	148,758	388,449
Change as against 2004	-10.5%	-17.4%	0.7%	24.8%	4.0%	3.9%

Includes condensing production

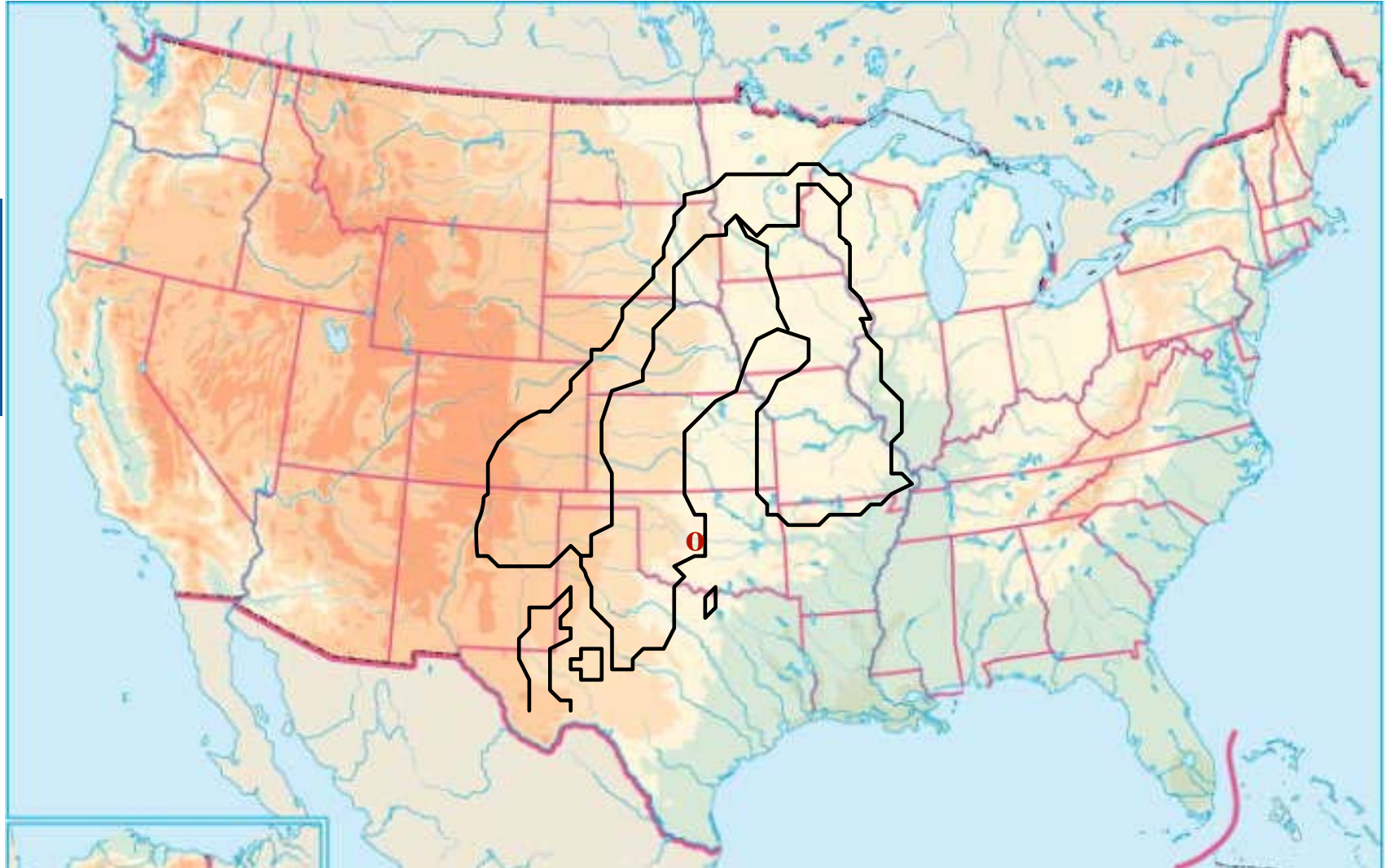
²⁾ Gross production

Nordic statistics - summary

- 56% of energy from hydro
- 22% from nuclear power
- Hydro power, 229 TWh
- Wind power, 8 TWh
- Hydro inflow can vary 90 TWh between dry year and wet year
- Many internal bottlenecks
- Nordic export/import capacity 4300 MW

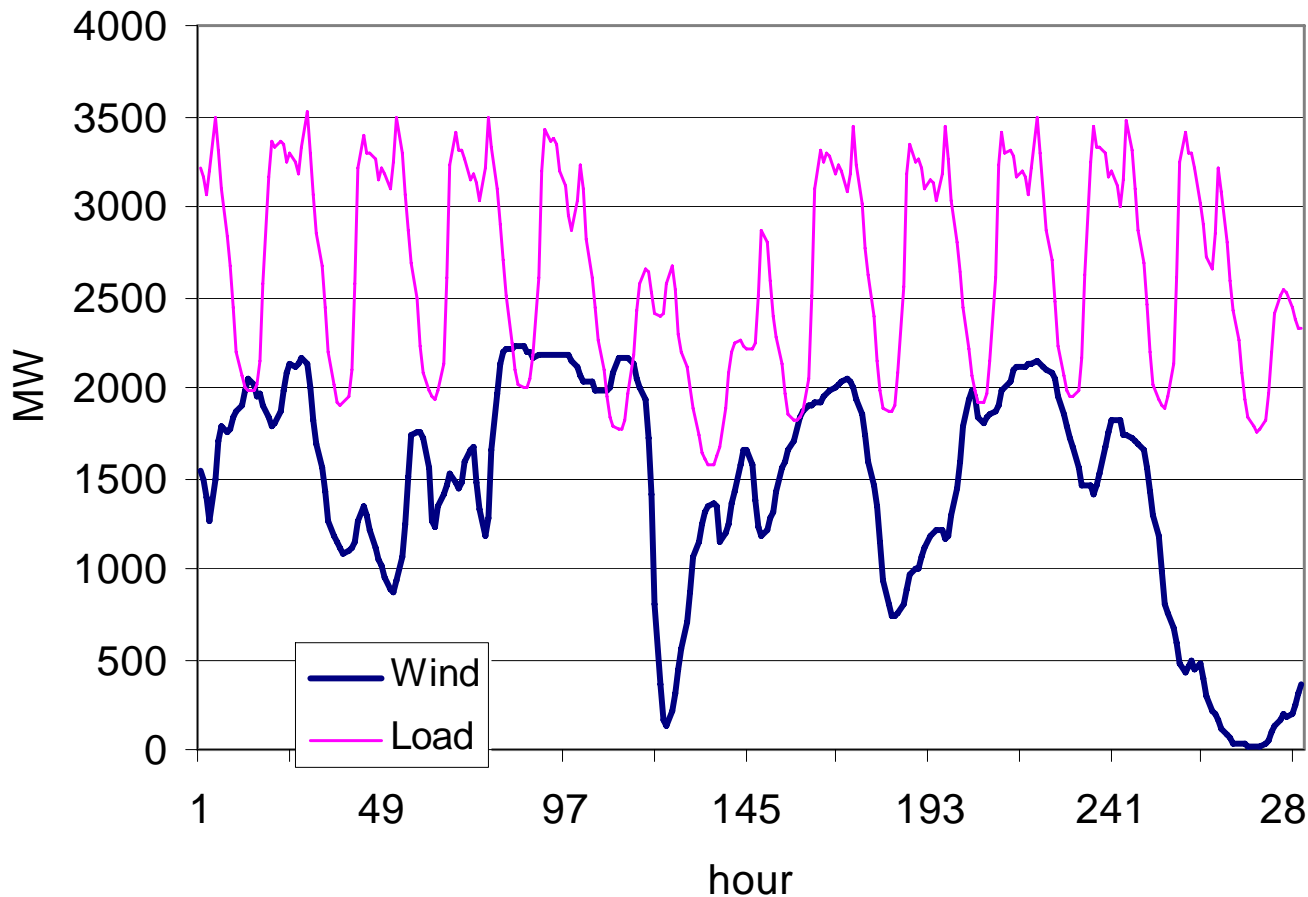


Stockholm in Oklahoma



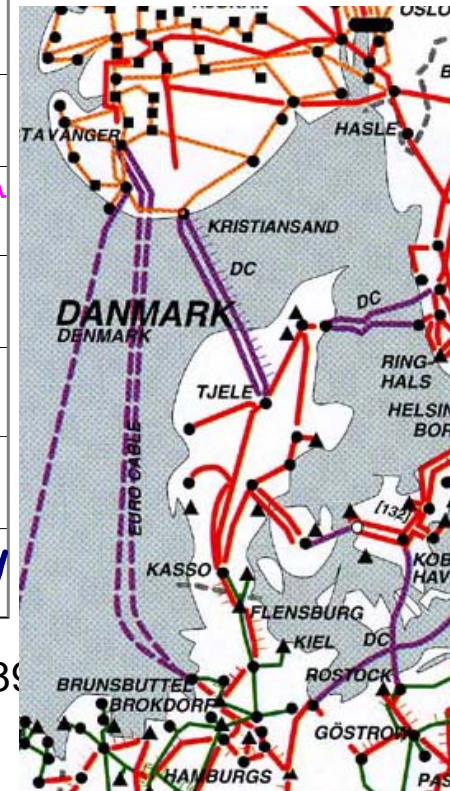
Real wind and load in western Denmark

West Denmark January 3-15, 2005



Trading capacity:

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



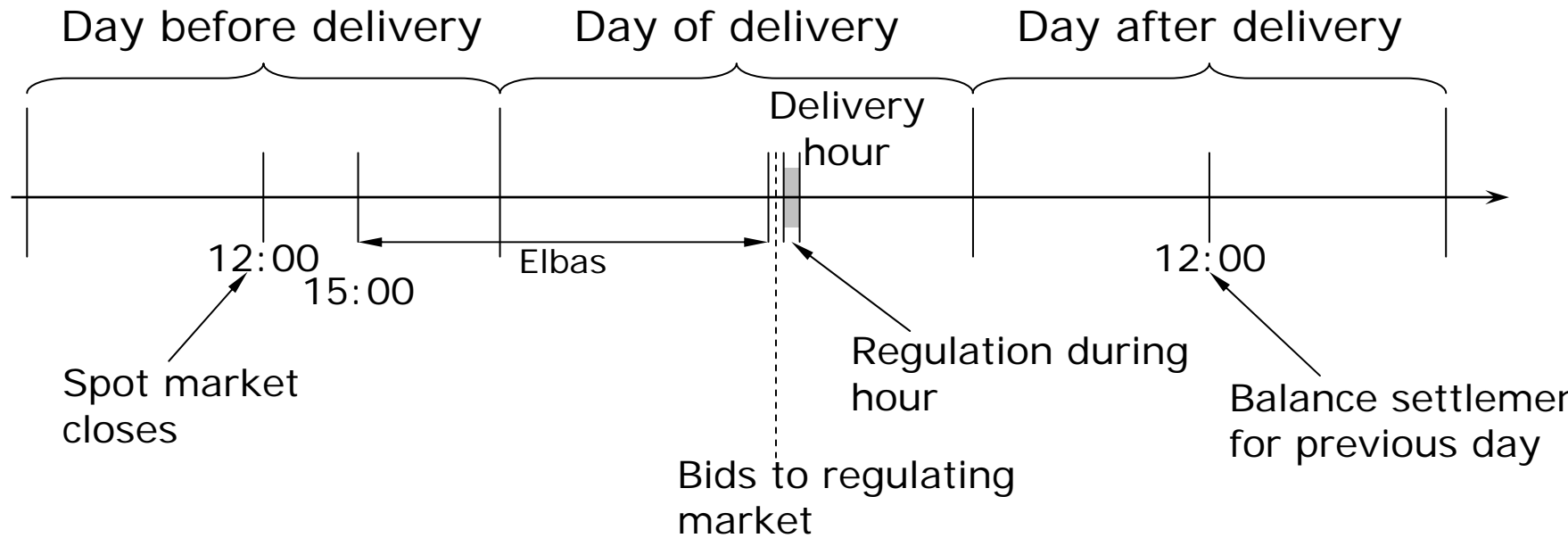
Power trading overview - 1

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.



Nordic power market

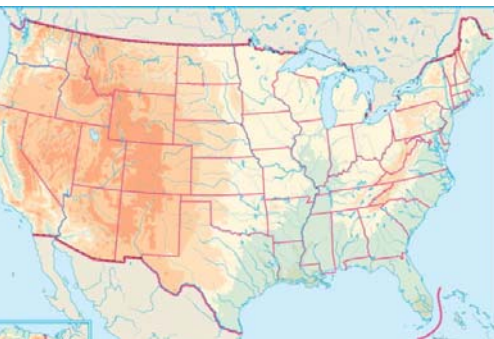


Balance responsibility:

A consumer is responsible to have a contract with a company (the balance provider) who is economically responsible for that the national power system is provided with the same amount of power (MWh/h) that the consumer consumes.



Nordic system structure



US (?)	Nordel
<ul style="list-style-type: none">• ISO• AGC• Node pricing• Transmission contracts• Control areas	<ul style="list-style-type: none">• TSO:s• Bids/manual• Area pricing• Multinational spot market• Multinational regul. market



Ahead market (Nordpool spot) - 1

Nordic market:

- **Bids.** Purchase (and sell) bids (MWh/h, price in Euro/MWh) to the spot market for a certain hour has to be delivered not later than 12.00 the day before.
- **Price setting.** The price is set by the *strike price*, so you have to bid higher than this price to get your bid. All Nordic bids together results in the *system price*
- **Price areas.** When there are congestions in the Nordic system then the price becomes different in different areas. Spot market is based on *area prices*



Ahead market (spot market) - 2

SEK/MWh

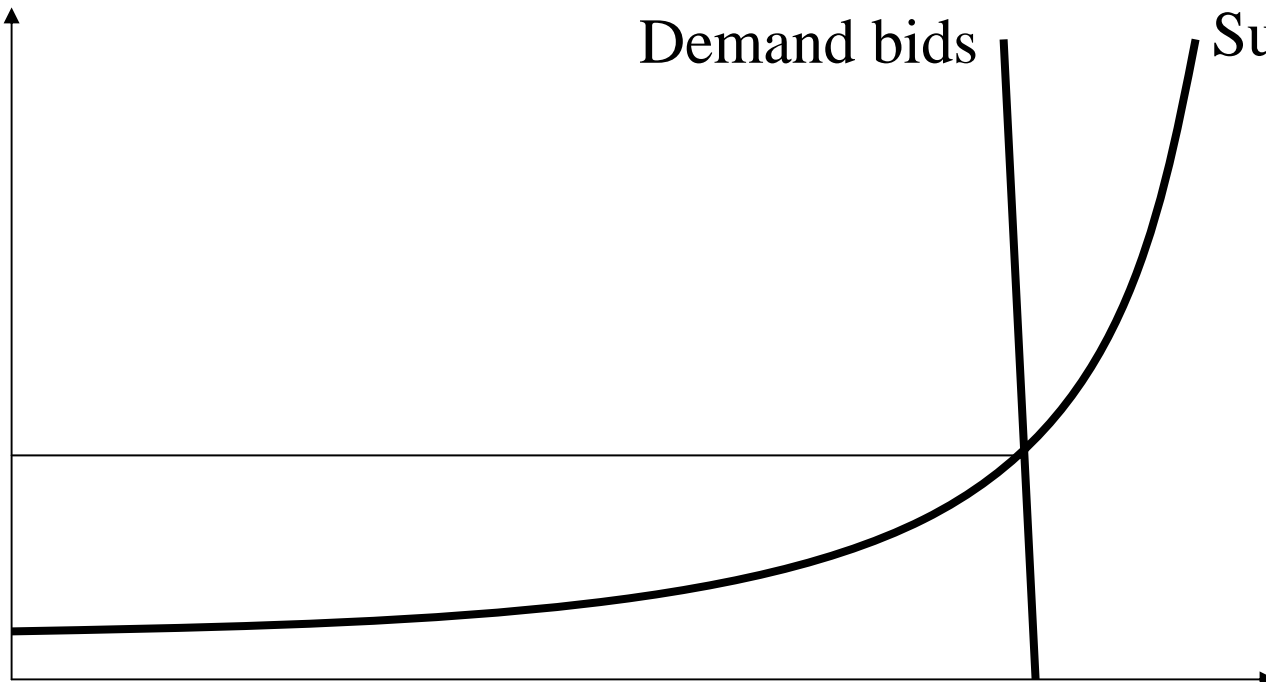


Strike price

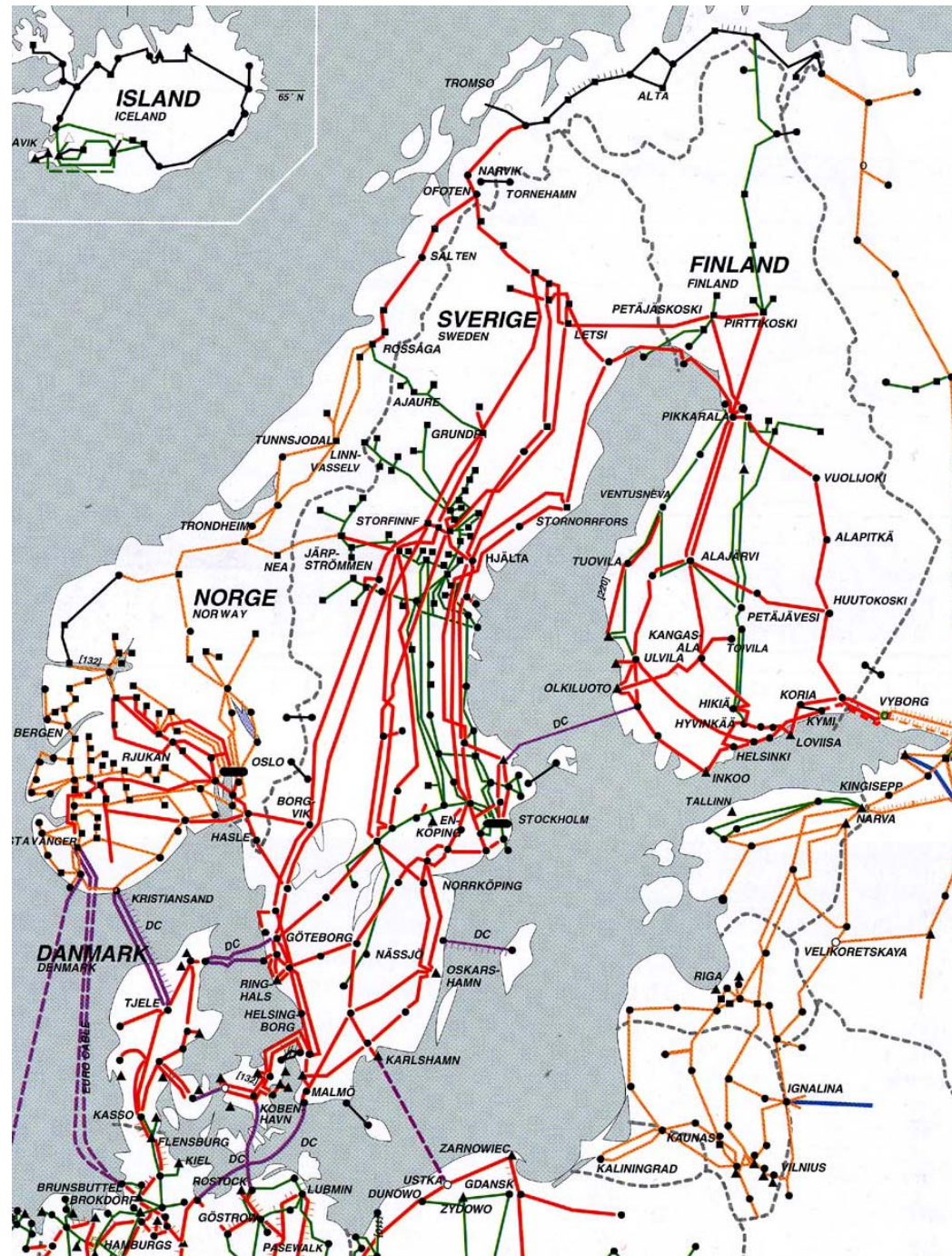
Demand bids

Supply bids

MWh/h



The Nordic transmission grid



Price areas

- Sweden: 1
- Norway: 3-5
- Finland: 1
- Denmark: 2

Internal bottlenecks:

- Counter trade

Ahead market (Elbas) - 3

Nordic market:

- **Bids.** Purchase (and sell) bids (MWh/h, price in Euro/MWh) to the spot market for a certain hour (or blocks) are published.
- **Price setting.** If one accepts a bid then “click” on it and then you have accepted it
- **Price areas.** When you log on the system you only see the bids that you could accept in your area, including bids in other areas. Active areas: Sweden, Denmark-E, Finland, East Germany (600 MW to Denmark-E)



Real time market

Nordic market:

- **Bids.** *Upward and downward regulation* bids (MW, price in Euro/MWh) for a certain hour has to be delivered not later than 10 minutes before each hour. The cheapest bids are called by the *system operator* during the hour to keep system physical balance.
- **Price setting.** The *price* for upward and downward regulation is set by the price of the last accepted bid. The price can be different for different areas.



Price for imbalances - 1

Nordic market:

- **Imbalance calculation:** All ahead bids are registered and the consumption of all consumers is measured (or estimated) on hourly basis. The difference is denoted *imbalance*. *Positive imbalance* means that you have bought more than your consumers consumed. The opposite is *negative imbalance*.
- **Price setting.** The *imbalance price* is set by the prices on the *regulating market* and on the *spot market* for the actual hour.



Price for imbalances - 2

- Sweden: Imbalance prices are different depending on if your imbalance is in the same direction as total system imbalance or not.
- Norway: Same price independent of actors imbalance



	TSO buy upward-regulation	TSO buy downward-regulation
You did not buy enough (negative imbalance)	C = upward-regulation price C > spot price	C = spot price <u>Not in Norway</u>
You bought too much (positive imbalance)	C = spot price <u>Not in Norway</u>	C = down-regulation price C < spot price

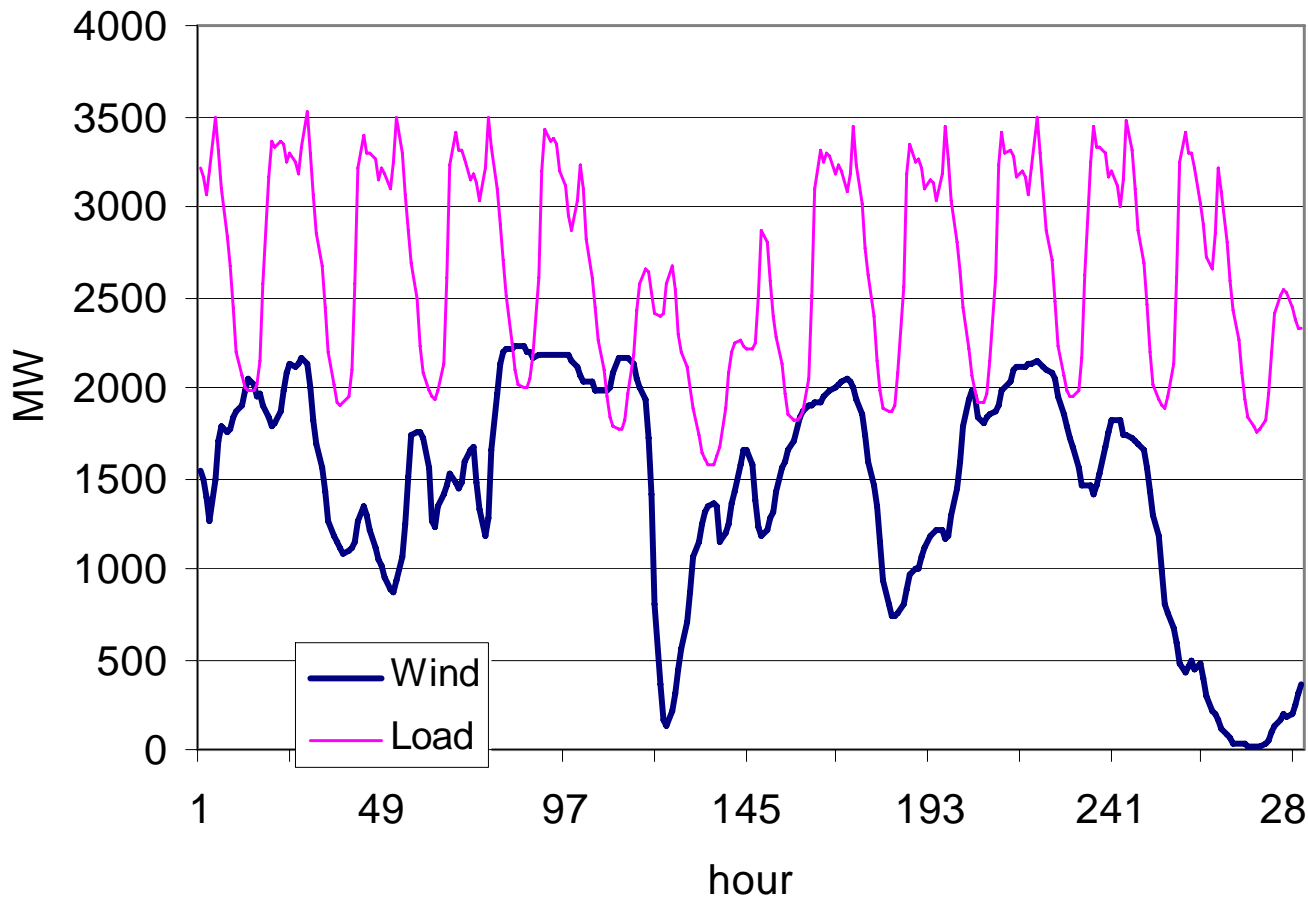
Wind power in Nordic system

- Currently a relatively large part in Denmark
- Large plans in Norway and Sweden
- 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



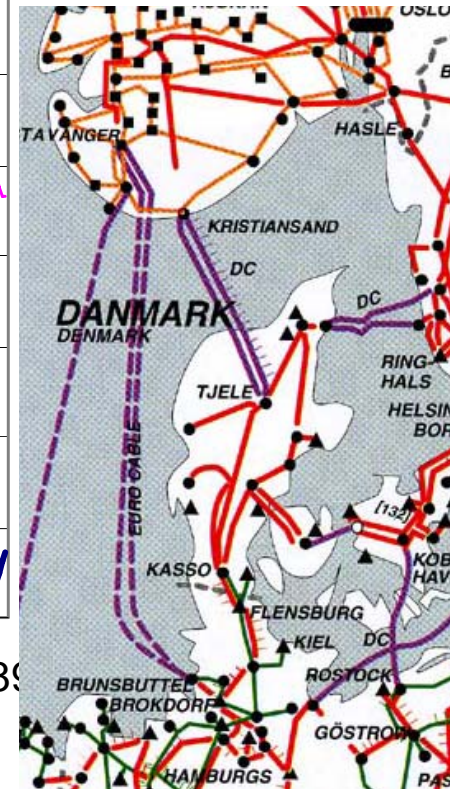
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About “share of wind power”

The large challenge to integrate wind power is

- At high wind
- At low load
- At low export capabilities

Therefore I think the “share of wind power” should be calculated as (Denmark-W):

Maximal share of wind power =

$$\frac{\textit{Maximal wind power}}{\textit{Lowest consumption + possible exchange}} = \frac{2380}{1266 + 2830} = 58\%$$

