

The Future of Hydropower – A Scandinavian Perspective


Presentation at the workshop: The Future of Swiss Hydropower
Bern, 12.03.2015

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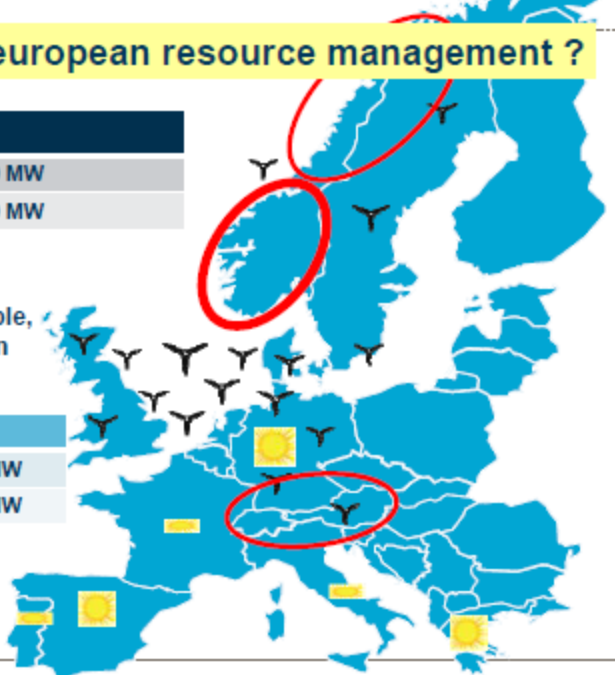
STRONG GROWTH IN INTERMITTENT ENERGY SOURCES

Increased pan-european resource management ?

EU-27	2010	2020
Wind	85.000 MW	213.000 MW
Solar (PV)	26.000 MW	84.000 MW

 Location of important flexible, renewable hydro generation

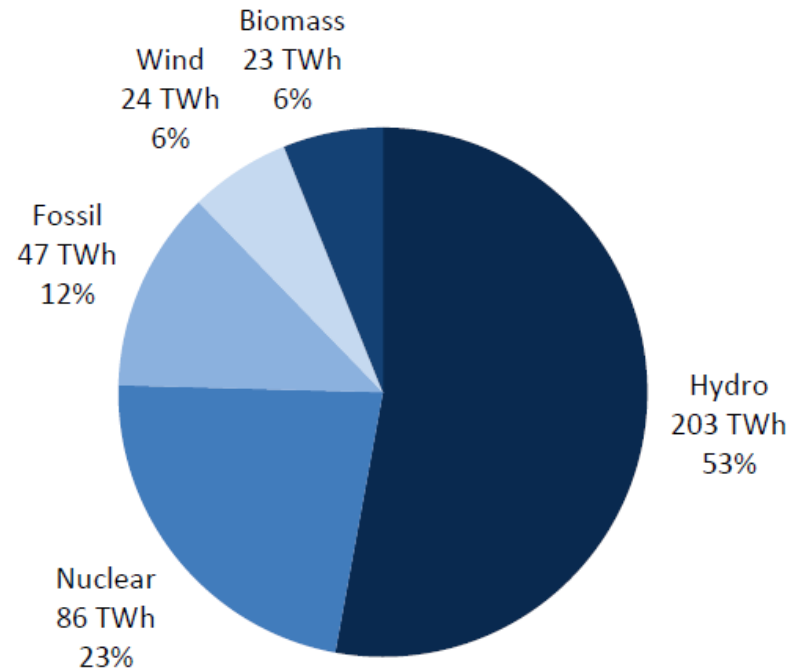
Germany	2010	2020
Wind	27.000 MW	46.000 MW
Solar (PV)	16.000 MW	52.000 MW



Sources: EEA Report on NREAPs. 2011. <http://www.ecn.nl/docs/library/report/2010/e10069.pdf>

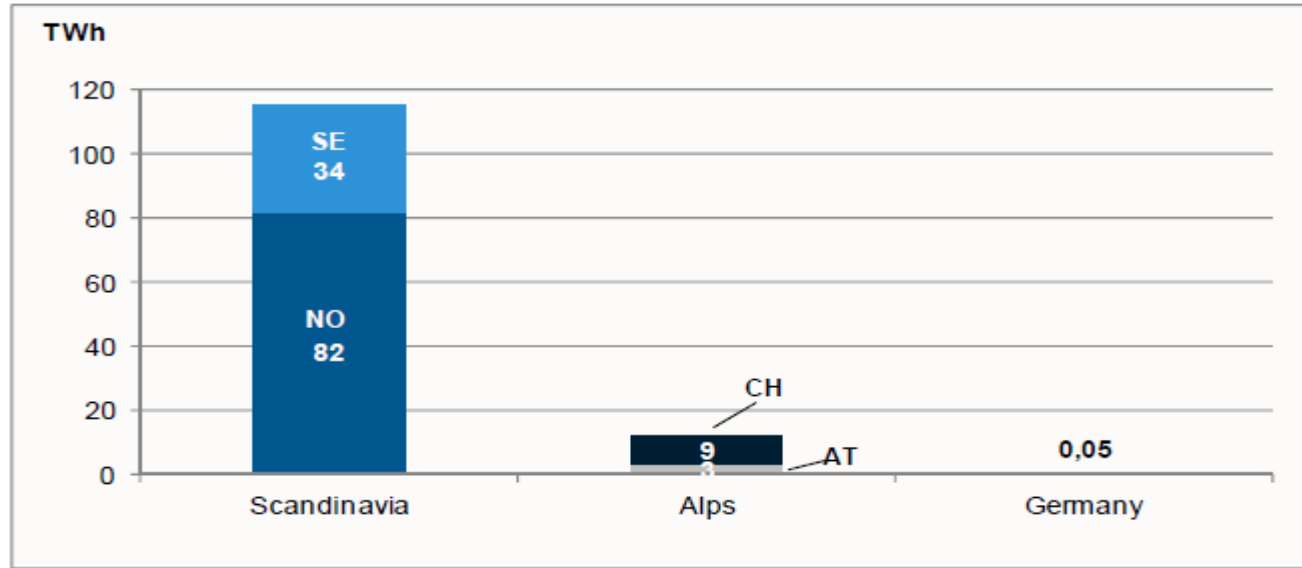
Nordic Resources

Power generation by power source in the Nordic region in 2013



Source: ENTSO-E

Hydropower storage capacity in Nordic and Alpine Regions



Source: [Nord Pool Spot], [E-Control 2012], [BFE 2011a], [SRU 2011], estimates by Prognos AG

- **Hydroelectric power in Norway (2010)**

Type	Capacity [MW]	Generation [GWh]
Hydroelectric power plants	31,004	116,946*
- Hydro storage power plants	23,405*	85,000**
- Pumped hydro storage	1,344*	
- Run-of-river power plants	6,255**	

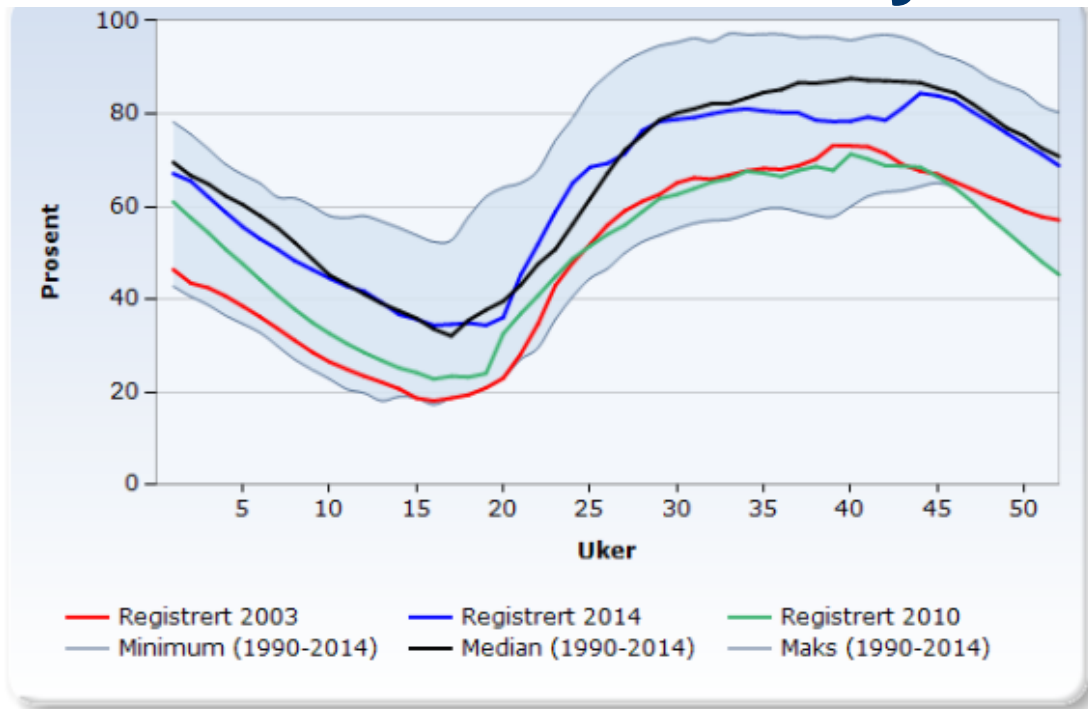
Sources: * [Eurostat], **[SINTEF] and Prognos

- **Hydroelectric power in Sweden (2010)**

Type	Capacity [MW]	Generation [GWh]
Hydroelectric power plants	16,735*	69,610*
- Hydro storage power plants	10,802	33,700**
- Pumped hydro storage	108*	
- Run-of-river power plants	5,825**	

Sources: * [Eurostat], **[SINTEF] and Prognos

Norwegian system designed for seasonal and annual safety of supply





Picture 4 Blåsjø reservoir of the Ulla-Førre hydropower scheme in Western Norway

Source: Statkraft 2011

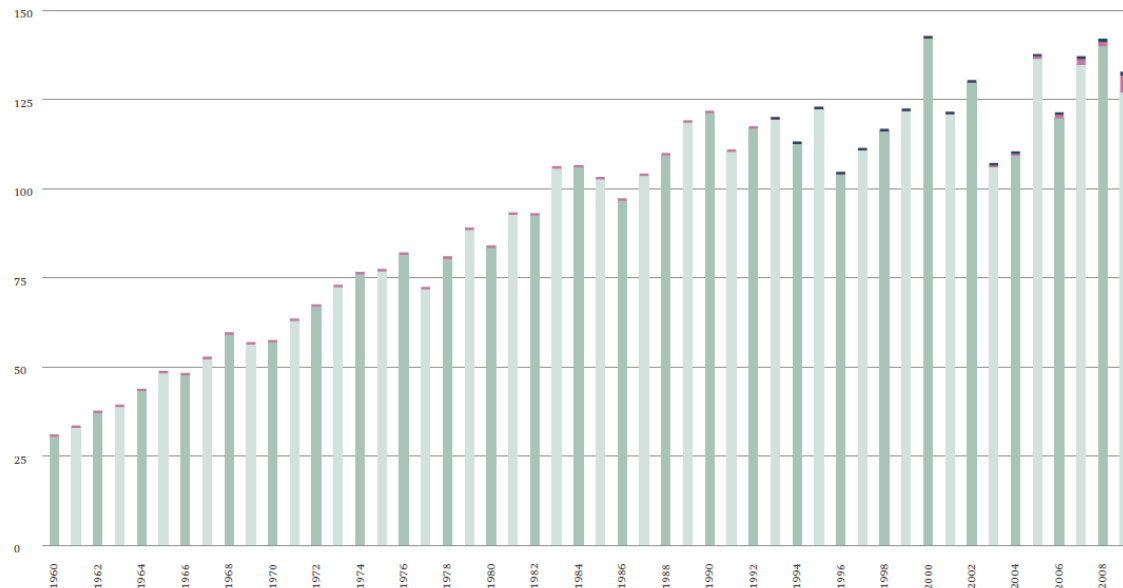




Mardalsfossen

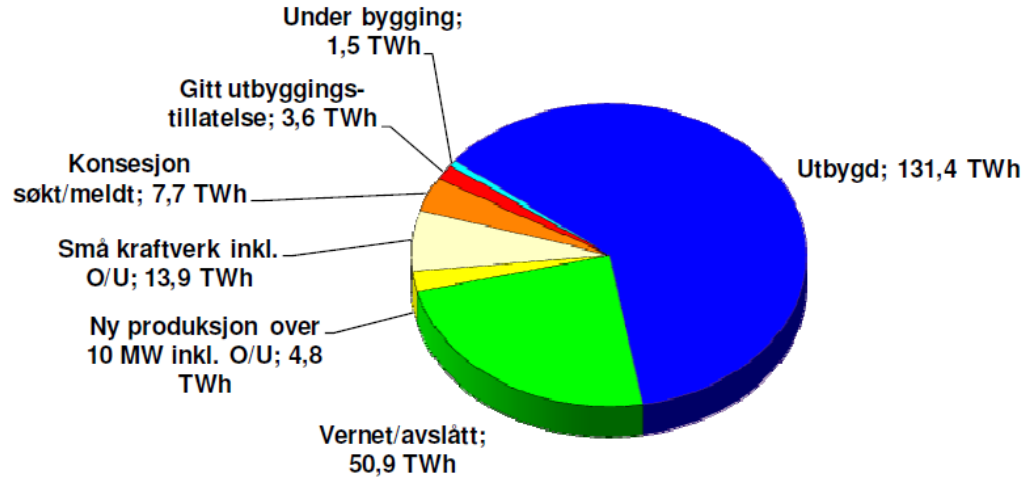


TWh



Vannkraftpotensialet pr. 1.1.2014

Midlere årsproduksjon 213,8 TWh, referert tilsigsperioden 1981-2010



Restpotensial er basert på digital kartlegging for små kraftverk med investeringsgrense inntil 3 kr/kWh og Samlet plan for vassdrag. Referert dagens kostnadsnivå tilsvarer det en investeringsgrense på 4-5 kr/kWh.

Inkluderer ikke potensial for små kraftverk i verneplan for vassdrag.

Konsesjon søkt/meldt omfatter ikke saker som ligger i kø.

More Creative Use of Hydropower Resources?

For Cont. Europe

- Flexible power to meet hourly demand variations
- Flexible power to meet variations from intermittent generation
- Import of cheaper electricity
- Export opportunities in dry years/
- Much cheaper balancing power

For the Nordics

- Security of supply in dry years – avoidance of price spikes
- Flattening seasonal variation
- Attractive earnings from peak load sales and balancing power
- Mild increase in general power prices

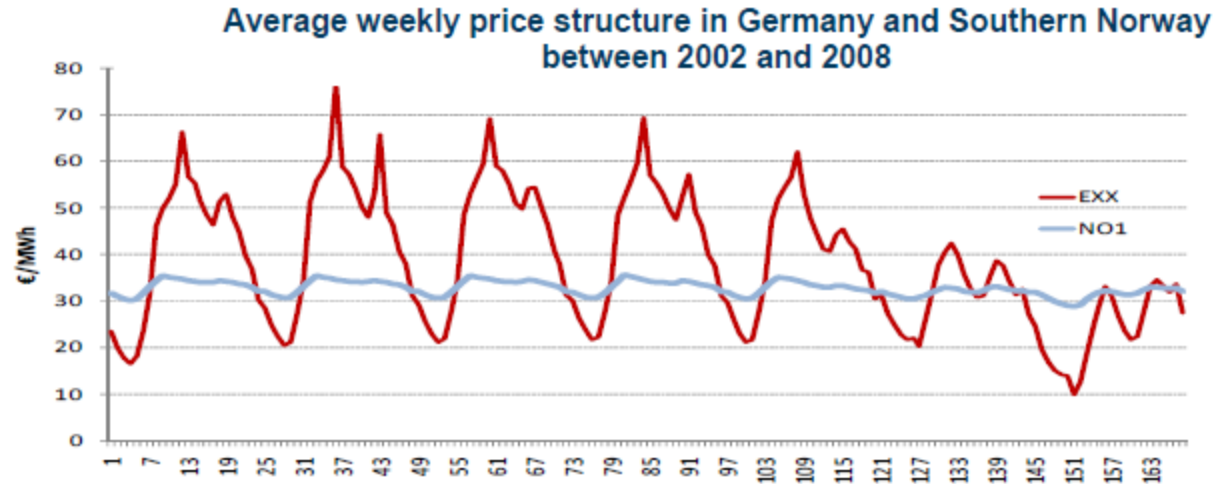
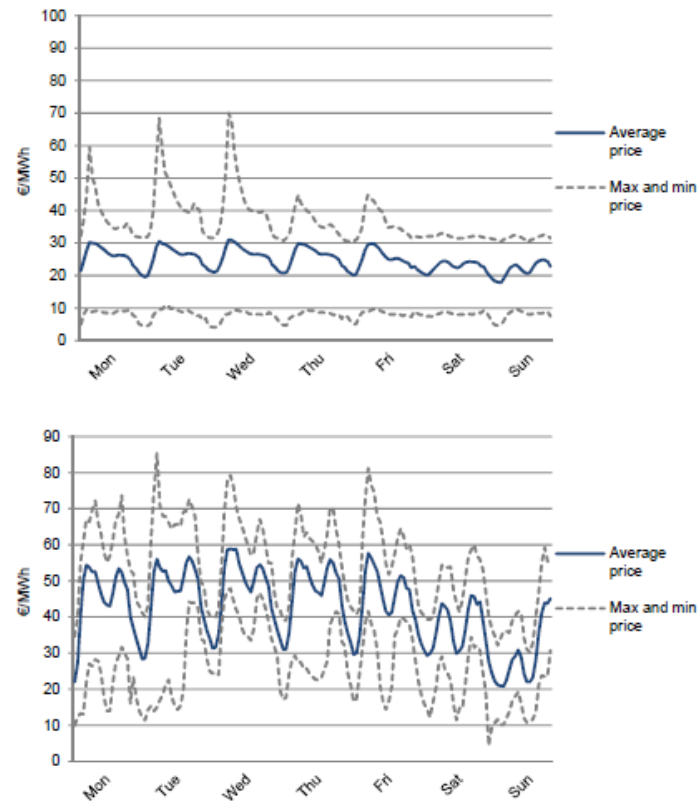


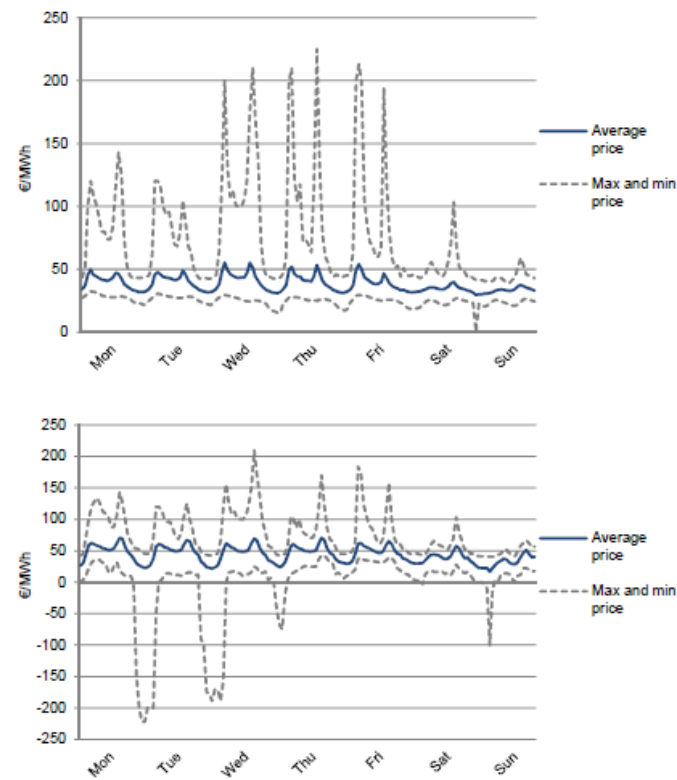
Fig. 3 Average weekly price structure in Germany and Southern Norway
Source: Statkraft 2010.

Figure 18. Comparison between the Nordic system price (upper figure, Nord Pool) and German wholesale price (lower figure, EEX) - average, maximum and minimum hourly prices during the summer (week 14-39 2012)



Source: Nord Pool Spot and EEX

Figure 19. Comparison between the Nordic system price (upper figure, Nord Pool) and German wholesale price (lower figure, EEX) - average, maximum and minimum hourly prices during the winter (week 40-13 2012)



Source: Nord Pool Spot and EEX

Figure 17. Nordic system price - average, maximum and minimum hourly prices during the summer weeks (14-39, 2013), EUR/MWh

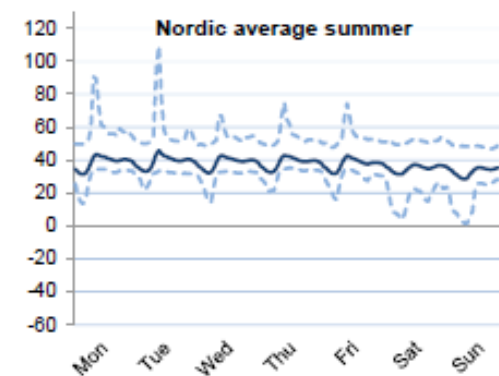
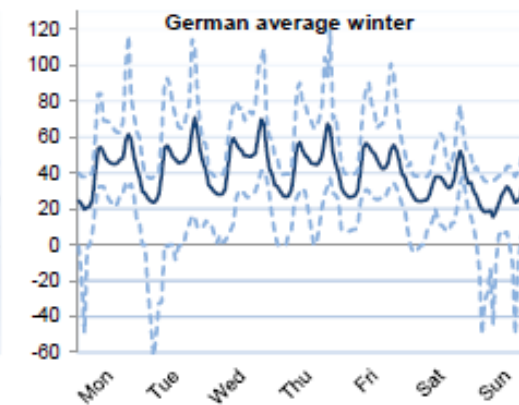
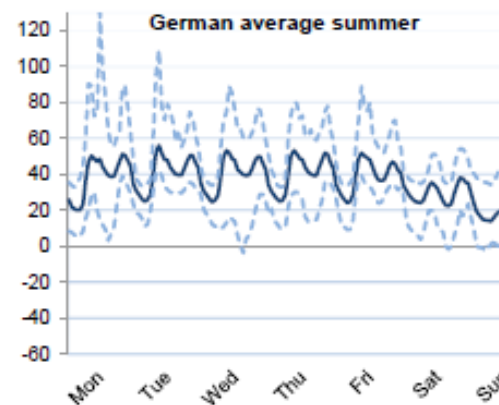
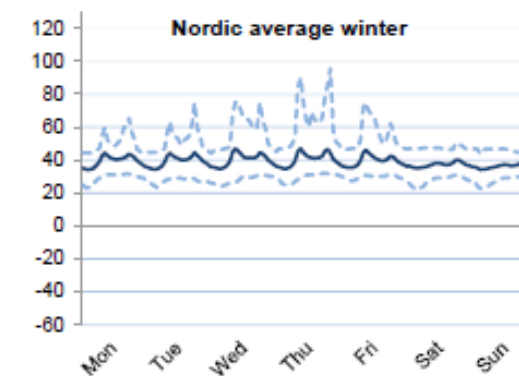


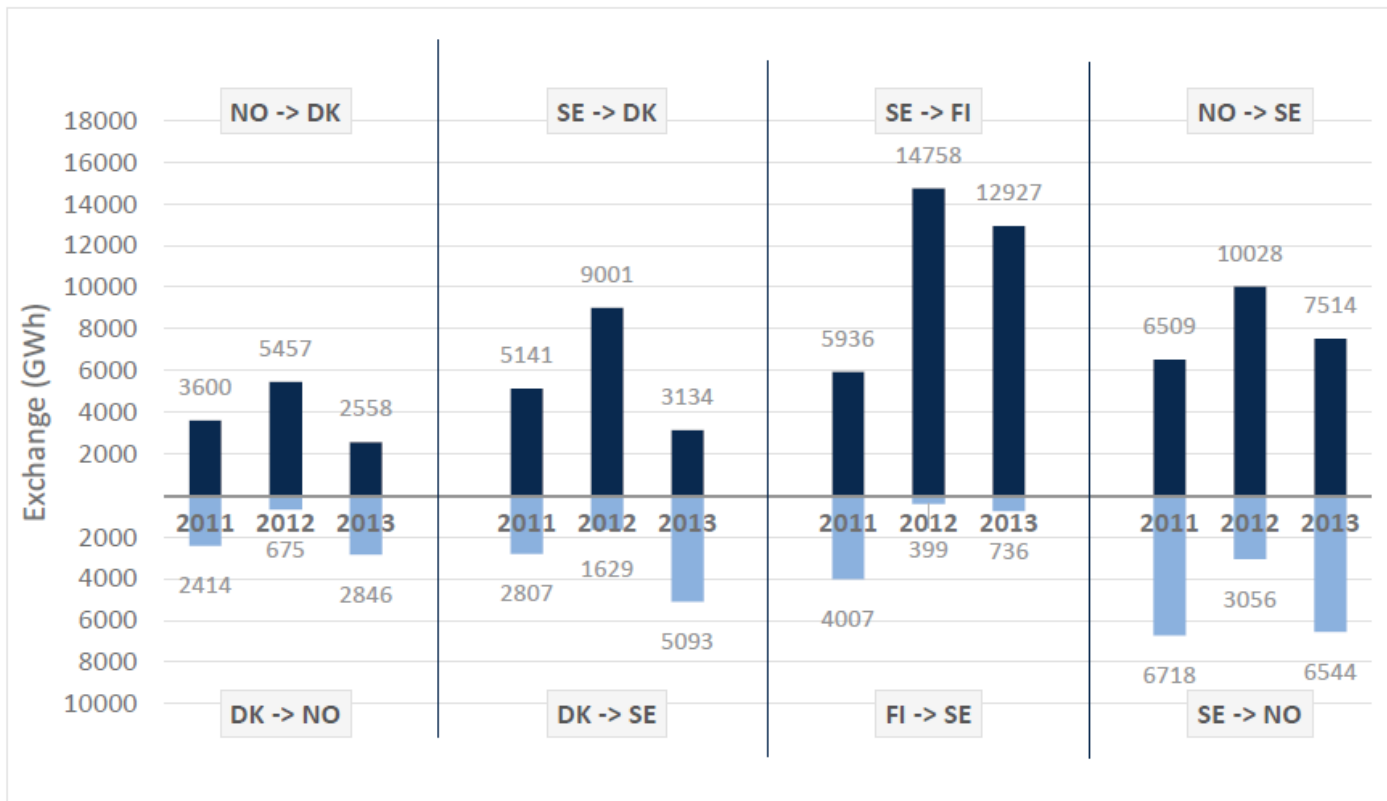
Figure 18. Nordic system price - average, maximum and minimum hourly prices during the winter weeks (40-13, 2013), EUR/MWh



— Average price - - - Max and min price

Source: Nord Pool Spot and EEX

Figure 10. Nordic power exchange 2011-2013



Source: ENTSO-E

Table 1. Import from neighbouring countries, TWh

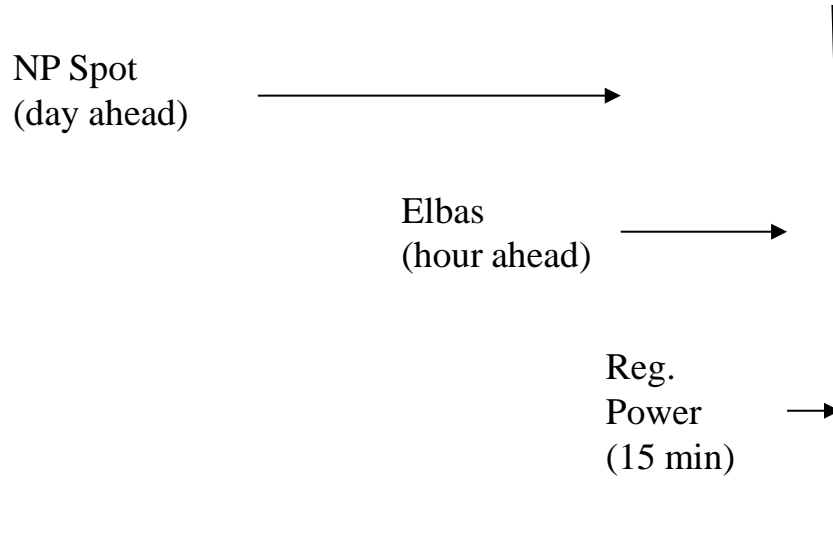
	Russia (RU)	Poland (PL)	Netherland (NL)	Estonia (EE)	Germany (DE)	Total
2005	11,5	1,2			1,0	13,6
2006	11,7	1,5			5,7	18,9
2007	10,1	0,2		1,9	2,3	14,6
2008	11,0	0,1	0,3	2,3	1,8	15,5
2009	12,1	0,3	1,3	1,8	4,8	20,3
2010	11,8	0,5	2,3	2,0	8,8	25,5
2011	11,0	0,3	1,6	1,7	3,5	18,0
2012	4,5	0,1	0,1	0,4	1,7	6,9
2013	4,8	0,8	0,2	0,5	6,8	13,1

Source: Nord Pool Spot

Table 2. Export to neighbouring countries, TWh

	Russia (RU)	Poland (PL)	Nether- lands (NL)	Estonia (EE)	Germany (DE)	Total	Net exchange	Total flow
2005	0,0	0,8			13,8	14,6	0,9	28,2
2006	0,0	0,3			7,3	7,5	-11,4	26,5
2007	0,0	2,2		0,0	9,7	11,9	-2,7	26,5
2008	0,0	2,1	3,3	0,0	11,5	16,9	1,4	32,4
2009	0,0	1,4	3,0	0,1	7,0	11,5	-8,8	31,7
2010	0,0	0,8	1,3	0,2	3,7	6,0	-19,4	31,5
2011	0,0	1,5	3,4	0,5	7,1	12,5	-5,5	30,5
2012	0,0	2,7	5,6	1,5	11,1	20,9	14,1	27,8
2013	0,0	1,0	4,2	1,5	4,3	11,0	-2,1	24,1

A Cascade of markets



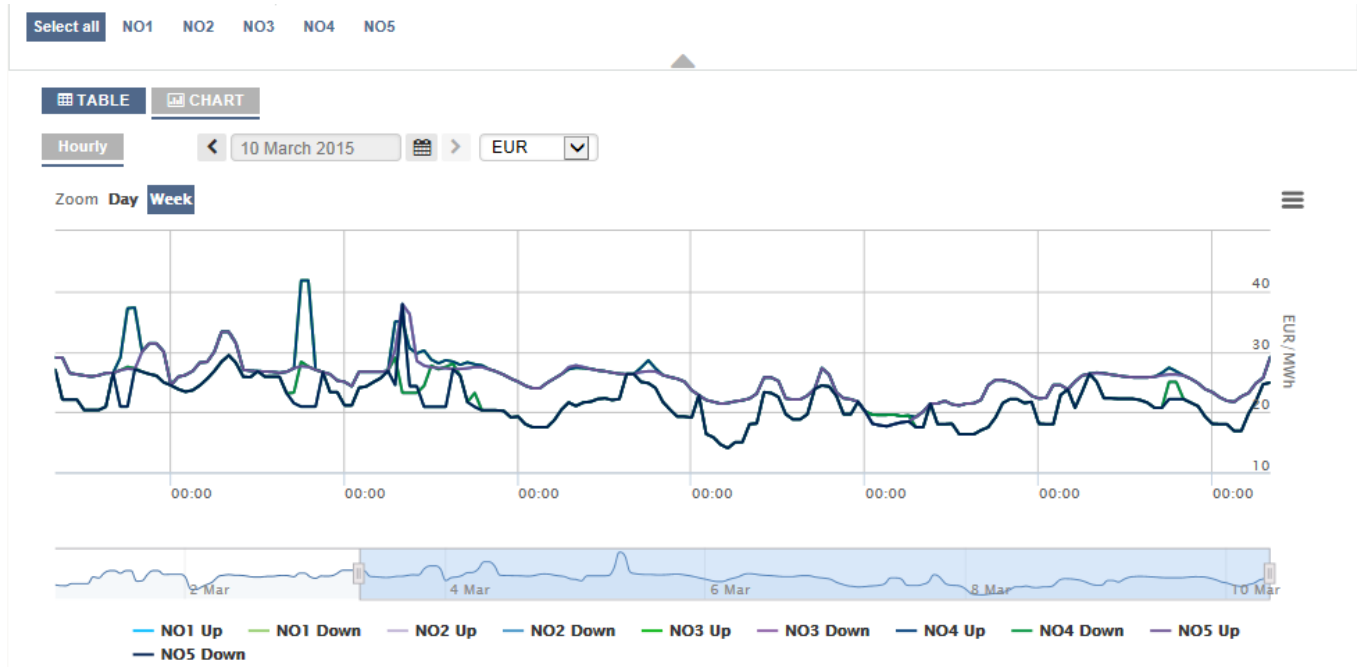
Peak capacity Continental Europe?

Thus the 300 most expensive hours would need on average to clear at/or above 260 €/MWh in order to make this type of backup capacity attractive. One has to bear in mind that i.e. in 2006 the average of the 300 most expensive hours at EEX was 167,25 €/MWh, so insufficient to cover fixed costs for building those units.

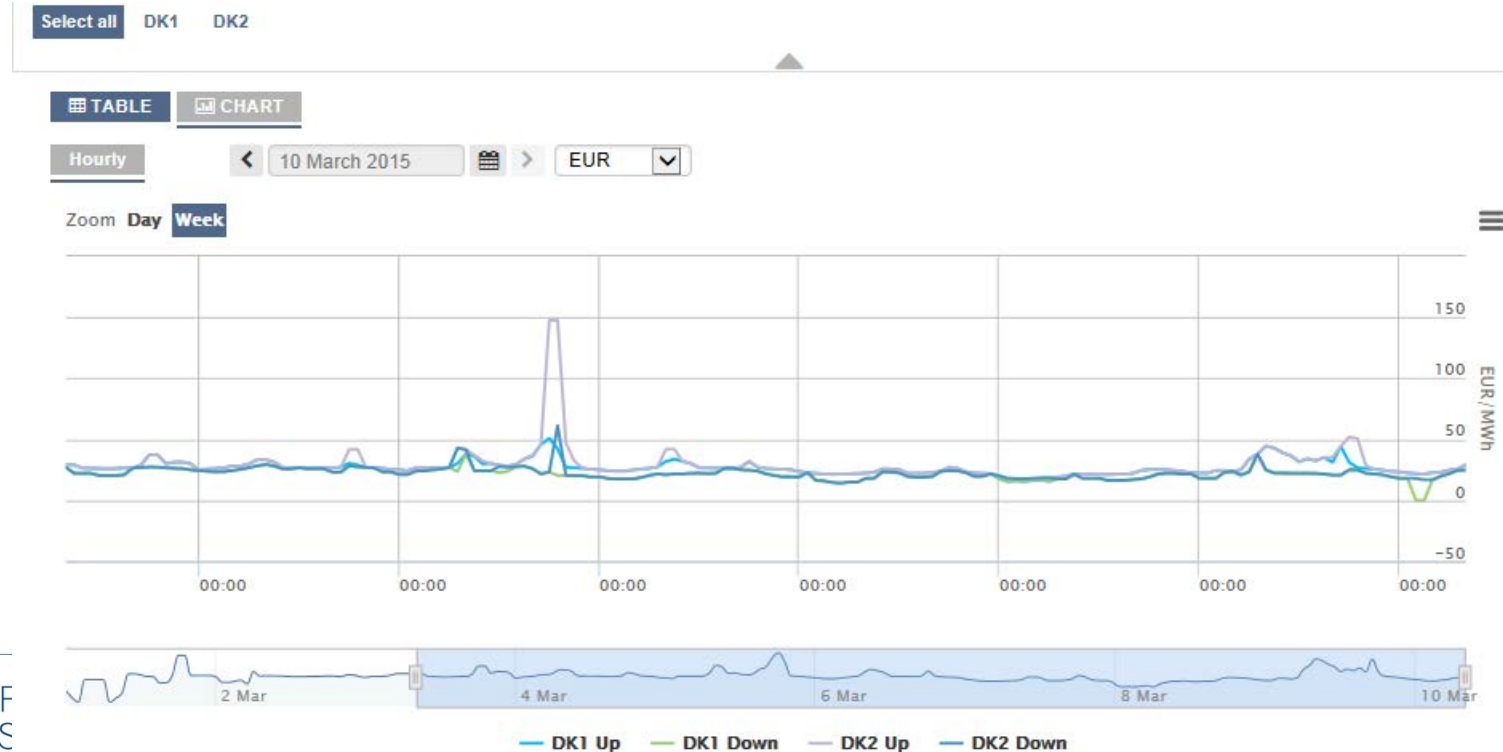
Capacity Markets:
Relevant for Europe and appropriate for Germany?
Dr. Guido Cervigni, Dr. Thomas Niedrig
December 2011



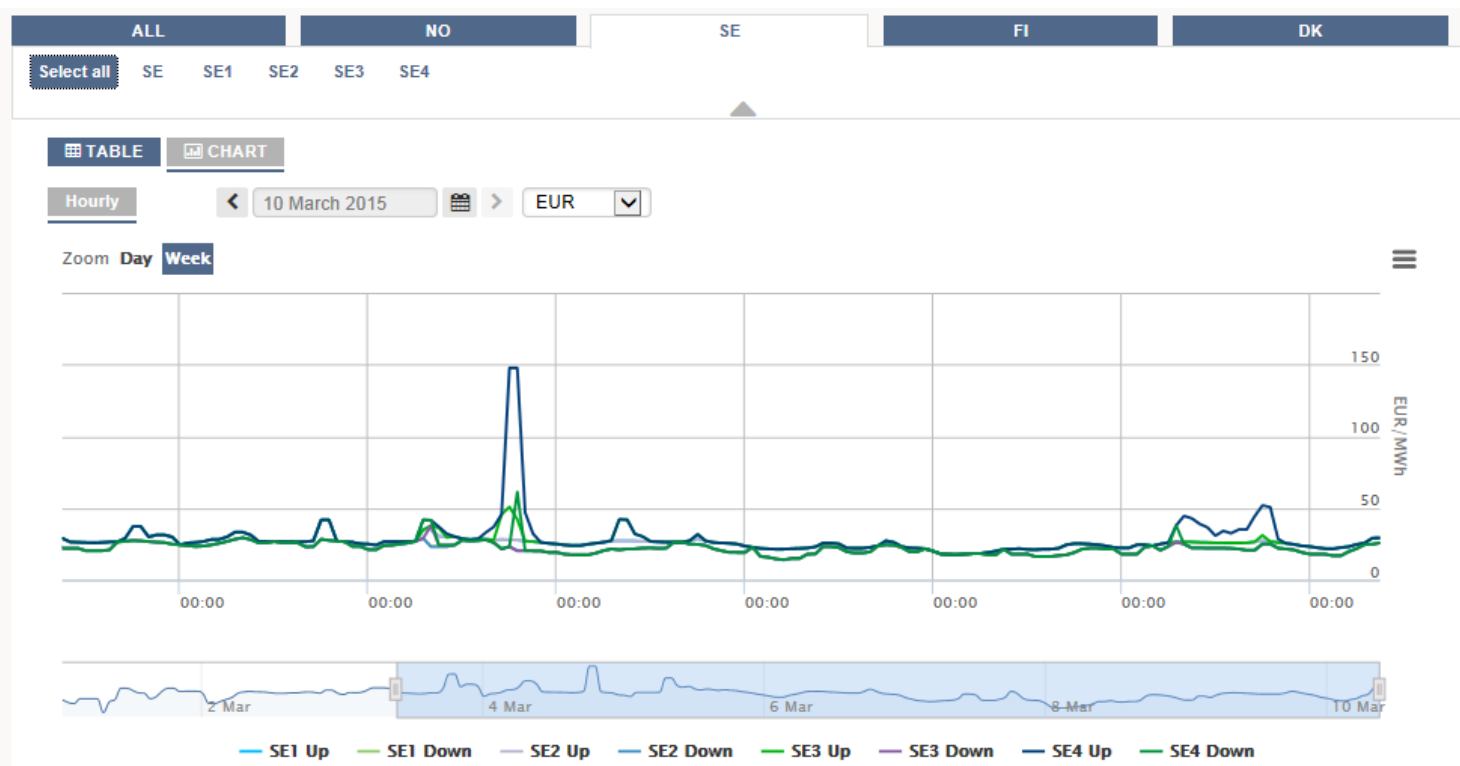
Balancing Power Prices in the Nordic Regulating Power Market - Norway



Balancing Power Prices in the Nordic Regulating Power Market - Denmark



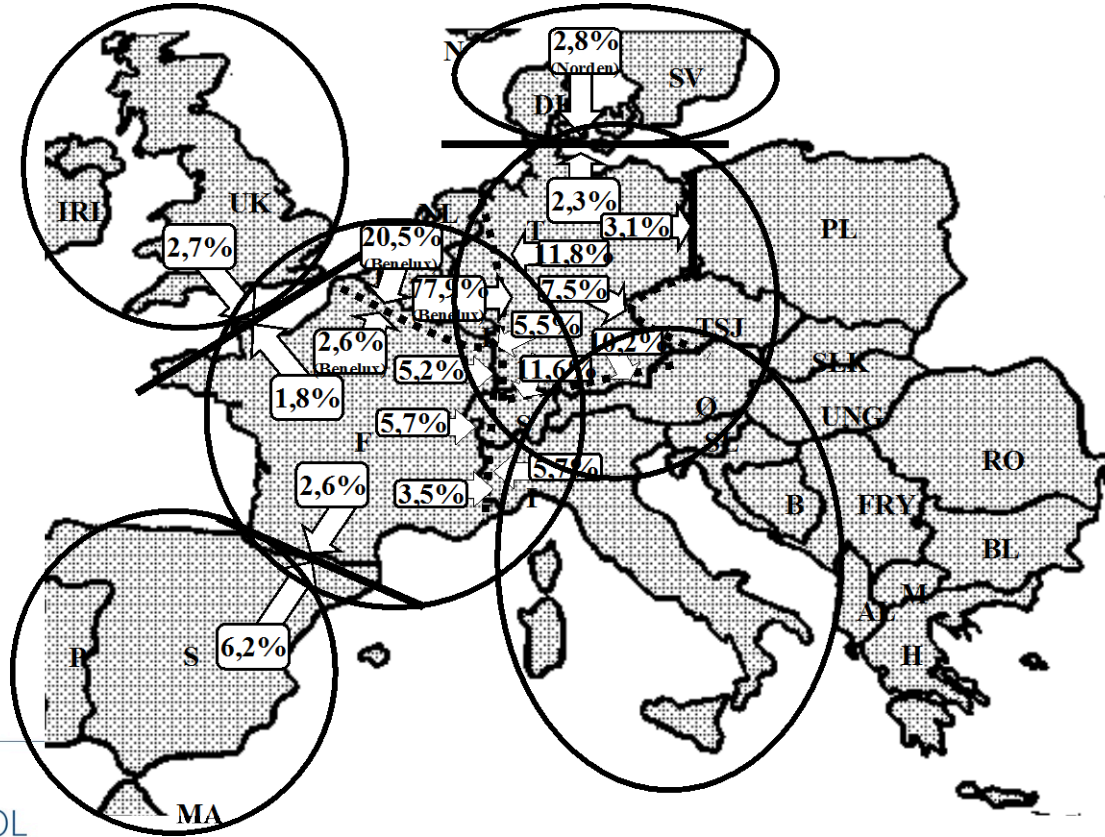
Balancing Power Prices in the Nordic Regulating Power Market - Sweden

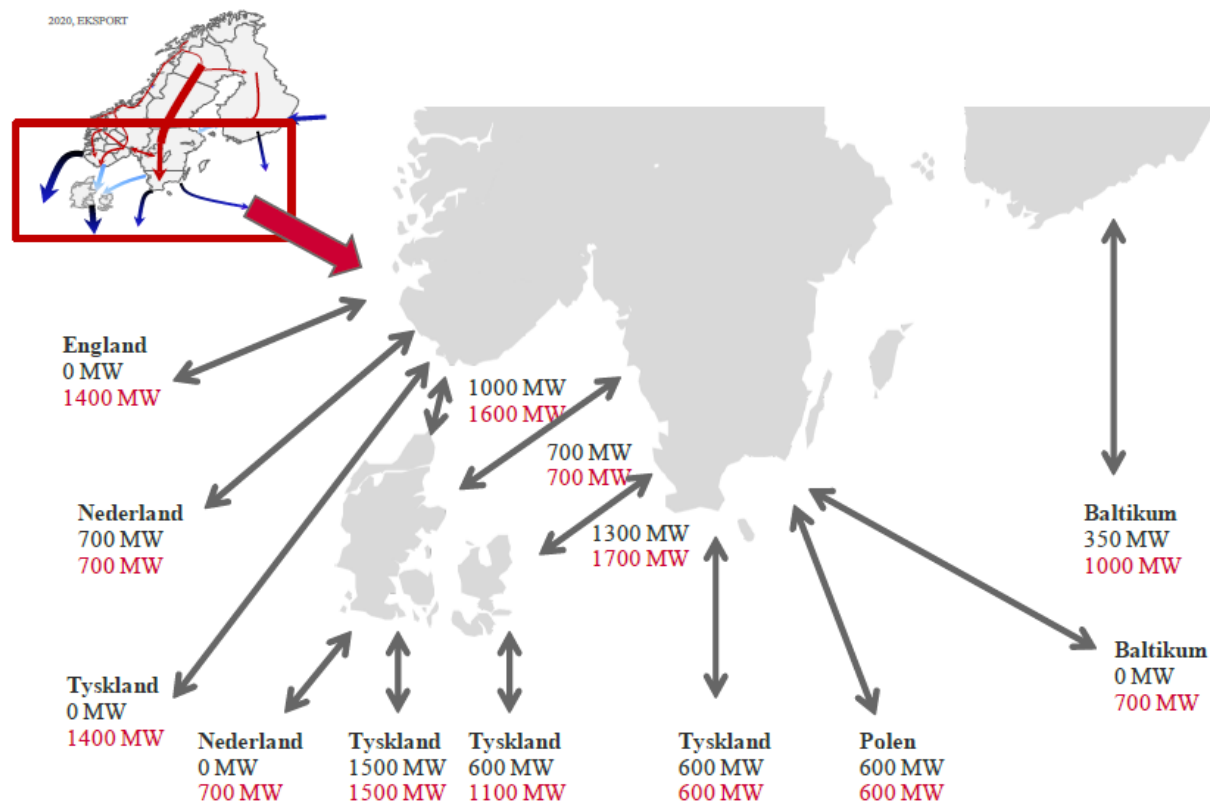


A Potential for Extensive Increase in Capacity in Norway

	Antall	Installasjon	Produksjon	Bruktid	Magasin	Ny total	Økning
		MW	TWh	timer	%	MW	MW
> 50 MW	143	23 000	95	4150			
"Mulige"	89	17 000	66,4	3910	82	44500	27500
Region							
Øst	13	2 000	8,1	4050	73	5400	3400
Sør	18	4 900	17,0	3480	92	11400	6500
Vest	30	6 100	23,3	3800	64	15700	9600
Midt	8	1 000	4,6	4660	60	3100	2100
Nord	20	3 000	13,4	4520	93	8900	5900

European crossborder transmission capacities





Figur 2.1 Utvikling i overføringskapasitet fra 2011 (grå skrift) til 2020 (rød skrift)

New links with Germany and Britain

- Northern Link is planned to be completed by 2018. This connection between Norway and Germany is to be developed and owned 50% by Statnett and 50% of a constellation consisting of grid operator TenneT and the German investment bank KfW. The undersea cable will have a capacity of 1400 MW and go between Tonstad Vest-Agder and Schleswig-Holstein in Germany.

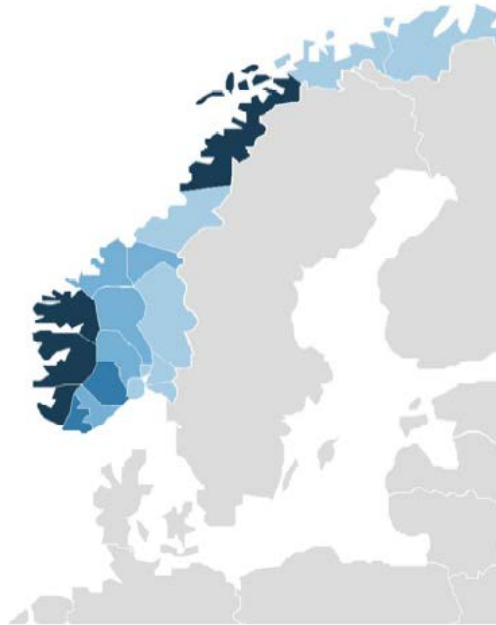
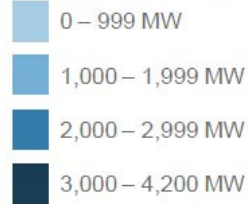
NSN is scheduled for completion by 2020. This connection between land to be developed and owned 50% by Statnett and 50% of the UK energy company National Grid. The undersea cable will have a capacity of 1400 MW and go between Kvilldal in Rogaland and Blyth in Britain.

- Taken together, these extensions will increase Norway capacity for power exchange with foreign countries by almost 50 percent.

Figure 29. Maximum transmission capacities and interconnections congested over 50% of the time (red) in 2013

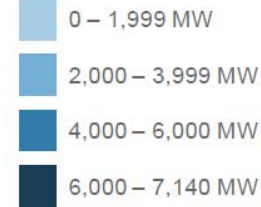
Location of hydropower in Norway and Sweden

Legend filling of regions



Source: Own presentation according to [NVE 2009]

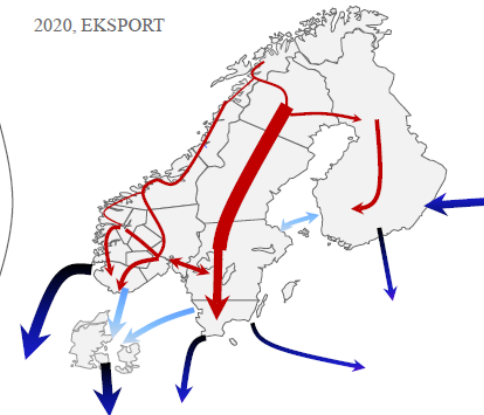
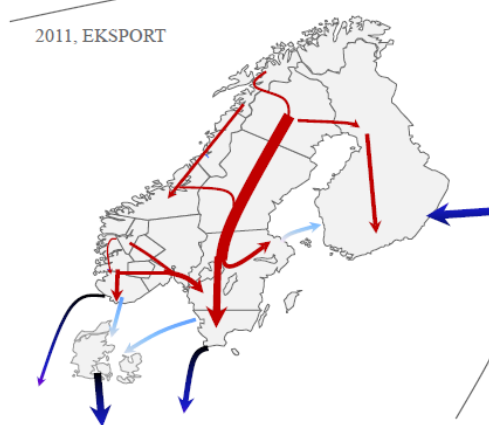
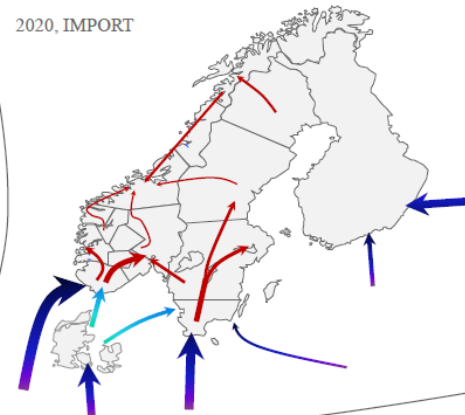
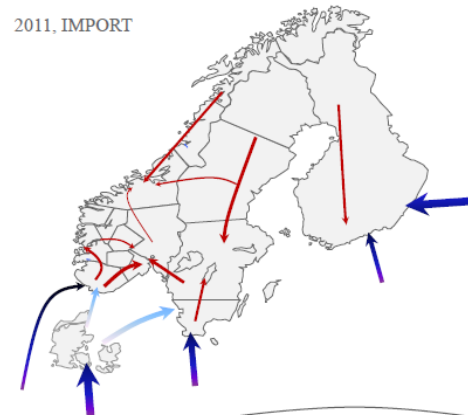
Legend filling of country regions



Source: Own presentation according to [Svensk Energi]

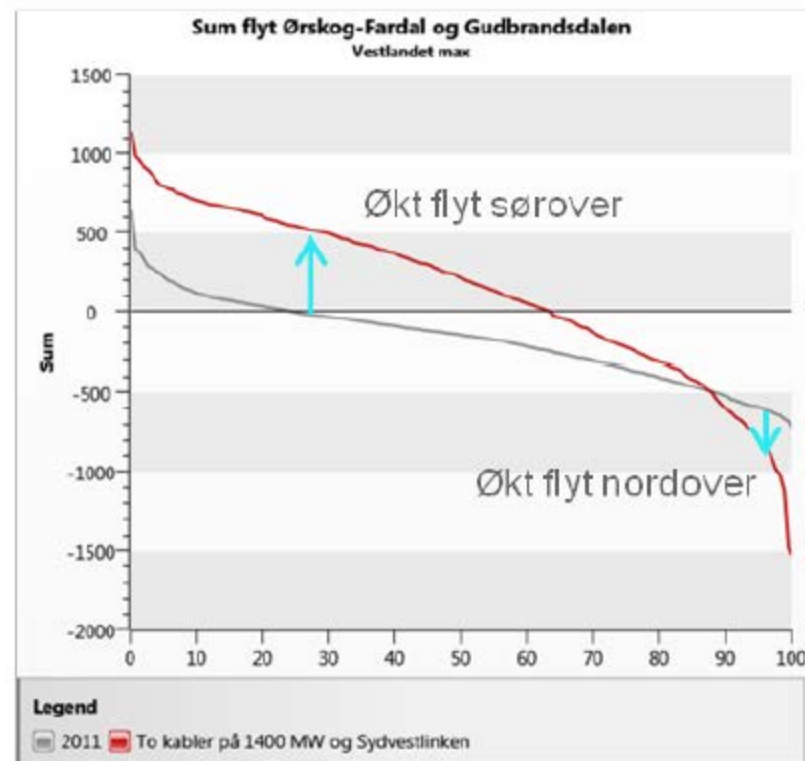
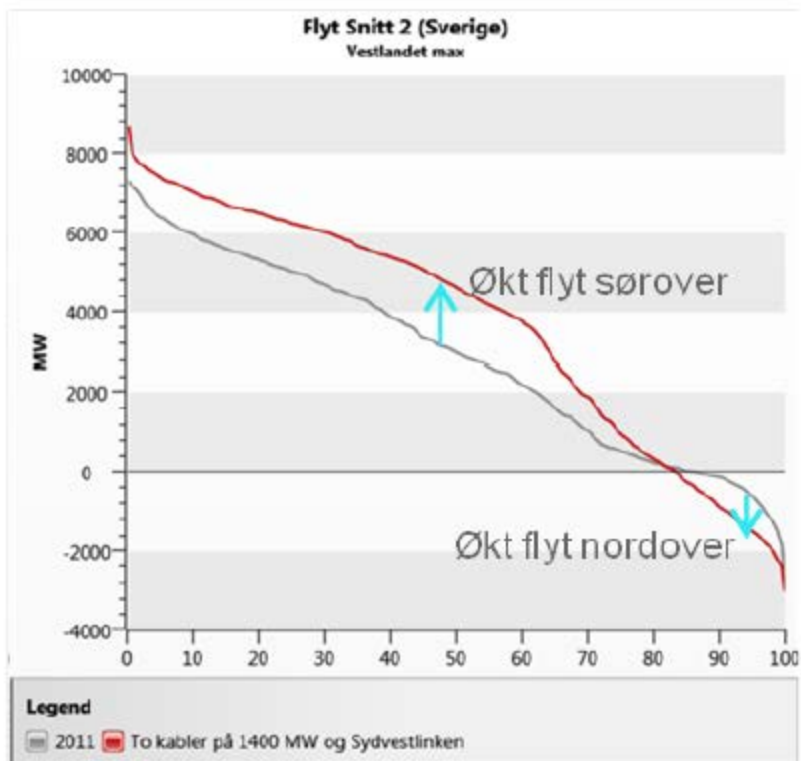
Previous failed Interconnection Projects

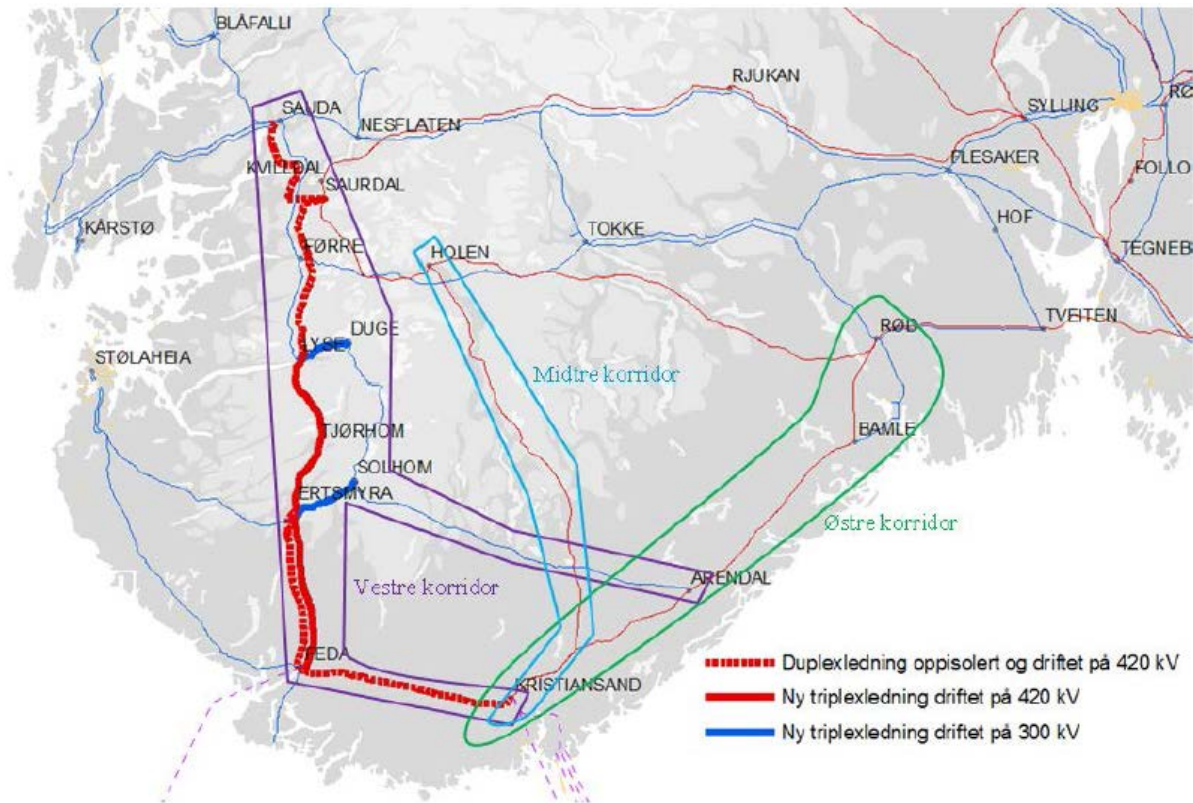
Euro Cable	Viking Cable	North Sea Interconnector
<ul style="list-style-type: none">• 600 MW planned capacity• Power exchange agreement between Eurokraft Norge AS and Eurostrom Trading GmbH received concession in 1995.• Statnett SF established Eurokabel together with Eurostrom in 1995• Eurokabel received investment concession in 1997• Eurostrom terminated the power contract in 1999• Eurokraft annunced arbitration case in 2000	<ul style="list-style-type: none">• 600 MW planned capacity• Power exchange agreement between Statkraft and PreussenElectra (E.ON)• A 50/50 joint venture between Statkraft and Preussen Elektra named Viking Cable was established in 1994• Viking Cable received investment concession in 1997• Preussen Elektra terminated the contract after declared hardship in 2001	<ul style="list-style-type: none">• 1200 MW planned capacity• Statnett SF and Natural grid Transco decided to develop the project in 1996.• Based on long term auction of physical transmission rights• The project did not receive concession by the Norwegian Authorities in 2003



http://www.statnett.no/PageFiles/7166/Dokumenter/S%C3%B8r-Norge%20og%20to%20nye%20kabler%20innen%202021_off_sept.pdf

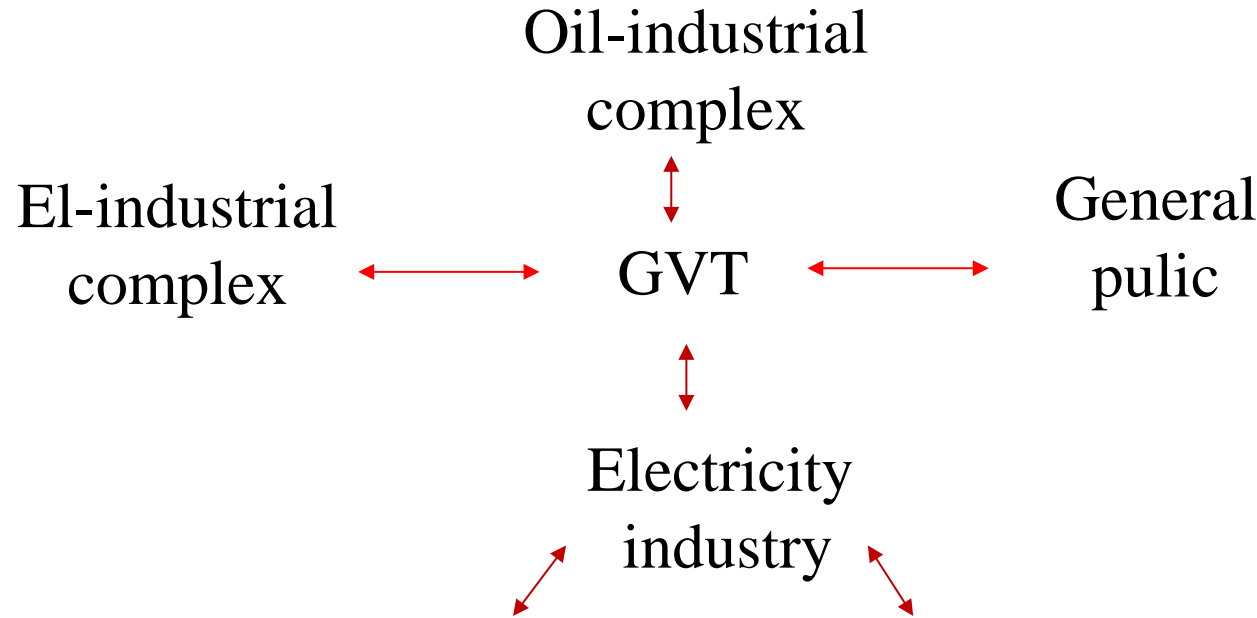
Figur 1.1: Figuren illustrerer hovedtrekkene i kraftflyten i Norden i dag og i 2020





Figur 4.2: Nettet og de ulike korridorene på Sørlandet

The Politics of El-Exchange in Norway



Low Oil Price and a North Sea Grid Revival???

