Market challenges in the future Nordic Power System

Event on renewables integration in Lund 17 December 2013
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Electric Power Systems

- Power System Dynamics and Control
- Smart Transmission Systems
- Power System Operation and Planning
- Electricity Market analysis




Electric Power Systems

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Electricity Market analysis

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Pricing challenges in the future Nordic Power Market with large amounts of renewable low marginal cost units.

Nordic Power Supply TWh 2012

Country	Nuclear	Hydro	Fossil	Wind	Bio	Total
Norway	0	142,9	2,4	1,6	0	147,8
Finland	22,1	16,6	17,9	0,5	9,9	67,7
Sweden	61,2	77,7	4,6	7,1	10,8	161,6
Denmark	0	0,02	16,3	10,2	2,3	29,4

Nordic hydro power

In 2012 the Nordic hydro power production was **237 TWh**.

This corresponds to an inflow of around **4,5 TWh/week**

A **heavy rain** every second week implies **9 TWh**

Pricing in power systems

Thermal power systems: Price is set by marginal cost

Hydro power: Price is set by the **water value** = the expected marginal cost in the future to which the water could be stored.

Wind power: Price is set by marginal cost = negative subsidy, since subsidy is only obtained at production (e.g. -2 Euro-cent if certificate price is 2 Euro-cent.)

Pricing in power systems: Norway

Nearly only hydro power (97%) ➔

Price is set by the **water value** = the expected marginal cost in the future to which the water could be stored. ➔

Price is not set in Norway!

Pricing in power systems: Sweden

Hydro + Nuclear + wind (90%)

Large part of the rest is CHP (industrial and distr. heat) ➔

Price is set by the **water value** = the expected marginal cost in the future to which the water could be stored. ➔

Price is not set in Sweden!

Pricing in power systems: Denmark

2020: High wind power (50%)

A part of the rest is CHP (industrial and distr. heat) ➔

When it is windy, then the prices will be low ➔

High prices are often not set in Denmark!

Pricing in power systems: Finland

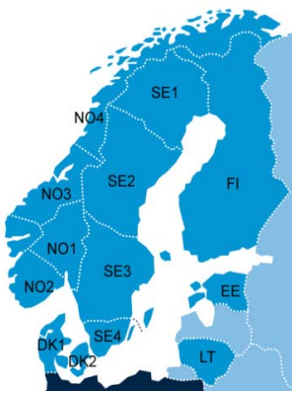
Nuclear + hydro + wind (58%-now)

CHP + more nuclear in the future➔

At wind and low demand, then the prices will be low ➔

Prices are then often not set in Finland!

Pricing in future Nordic power systems:



Much more often: Prices are not set by Nordic power plants.

At wind and low demand, then the prices can be really low

There is then a challenge to get prices that are high enough to finance all power plant.

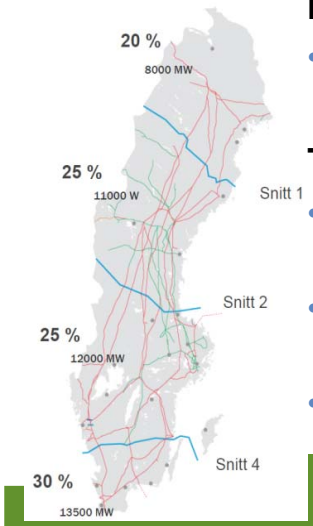
Enough transmission to high MC areas essential

Balancing challenges in a future Swedish power system based on 100% renewable power.

About new nuclear power

- The government in UK has agreed with EDF group"about an offer to construct new nuclear power in UK.
- The key terms include a "Strike Price" of £89.50 /MWh (96-99 öre/kWh)
- A contract difference payment duration of 35 years, from the earlier of the point at which each reactor at Hinkley Point C becomes commercially operational.
- https://www.gov.uk/government/news/initial-agreement-reached-on-new-nuclear-power-station-at-hinkley

Identified wind power projects in Sweden:



Identified wind power projects:

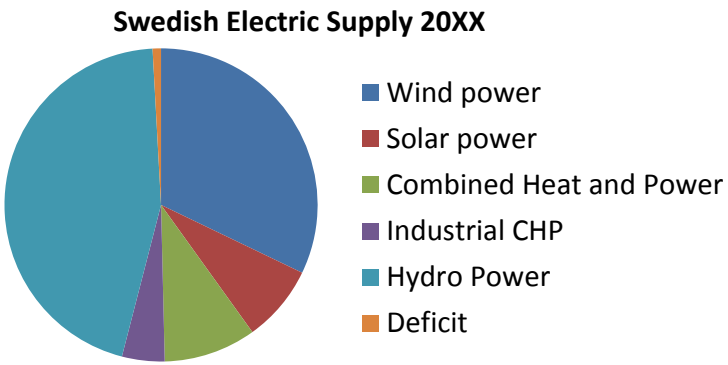
- **45000 MW (≈ 100 TWh/year)**

Today capacities:

- **Hydro Power: 16000 MW (≈ 65 TWh)**
- **Nuclear power: 9000 MW (≈ 65 TWh)**
- **➔ total of 25000 MW**

Swedish Power production: Total 145,6 TWh

(same as 2011)



Current (2011) Swedish Power System

Source	TWh - 2011	Energy % - 2011	MW-capacity - 2011
Hydro	66,0	44,9	16197
Nuclear	58,0	39,5	9363
Wind	6,1	4,2	2899
Solar	0	0	0
CHP-Ind	6,4	4,4	1240
CHP-distr.	9,4	6,4	3551
Condens	1,01	0,7	3197
Total	**146,9**	**100**	**36447**

Studied Swedish Power System

Source	TWh	Energy %	MW-max
Hydro	65,7	45,1	12951
Nuclear	0	0	0
Wind	46,8	32,1	15633
Solar	11,6	8,0	9148
CHP-Ind	6,4	4,4	1240
CHP-distr.	13,9	9,5	4127
Other	1,3	0,9	5081
Total	**139,9**	**100**	**48180**

New report: Published 21 Oktober 2013

NEPP north european power perspectives


ROYAL INSTITUTE OF TECHNOLOGY

På väg mot en elförsörjning baserad på enbart förnybar el i Sverige

En studie om kraftsystemets balansering

Version 3.0

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Studies:

- Balancing from hour to hour in **"isolated" Sweden**!
- High wind+solar / low consumption
- Low wind+solar / high consumption
- Hydro power regulation
- Can be downloaded from KTH:s home page
- **EXCEL-file for calculat.**

http://kth.diva-portal.org/smash/record.jsf?searchId=1&pid=diva2:657544

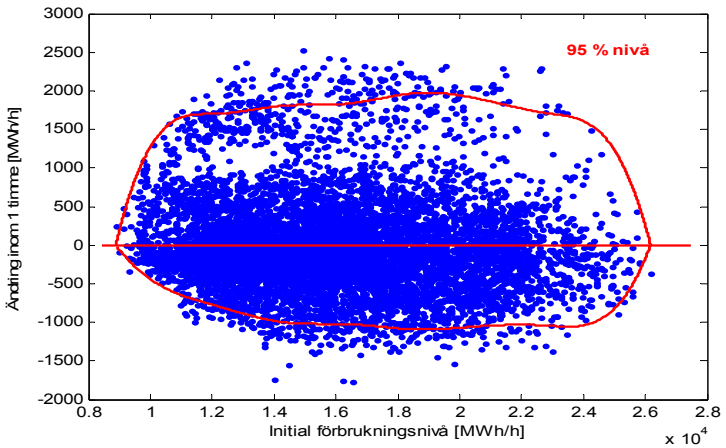
Three challenges in power systems with large amounts of solar + wind:

C1: Keep the **continuous balance**

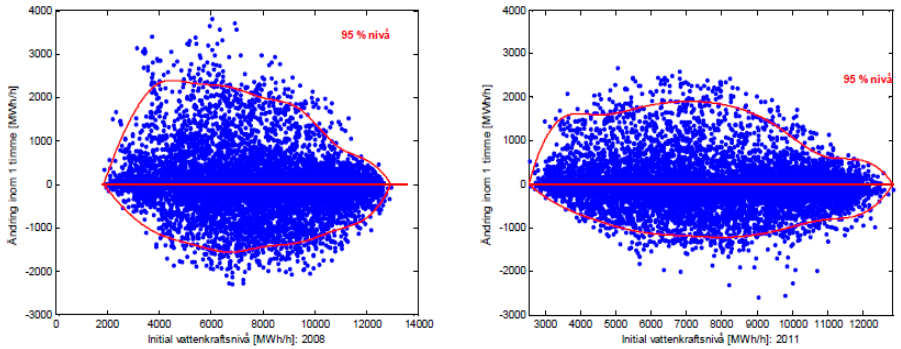
C2: Handle situations with **large** amounts of variable production

C3: Handle situations with **small** amounts of variable production

C1: Changes within 1 hour
Swedish consumption 2011, (+ 2300 MW)



C1: Changes - 1 hour
Today hydro power, (+ 2500-3500 MW)

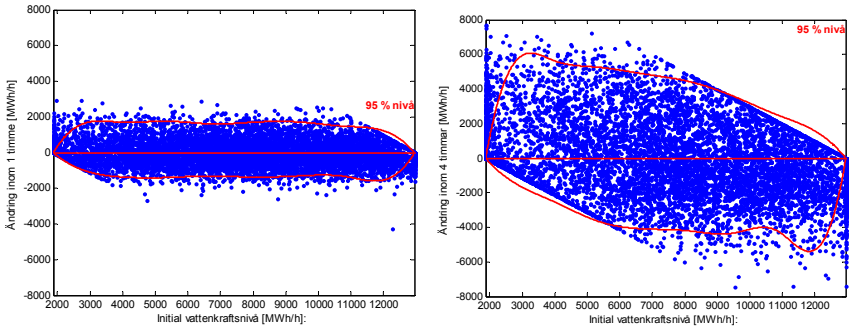


2008 **2011**

Figur 11 Ändringar av vattenkraftens produktion inom en timme för 2008 (vänster) och 2011 (höger). Data från (Svenska Kraftnät, 2001-2011)

60 TWh wind+solar:
Hydro power: Change during

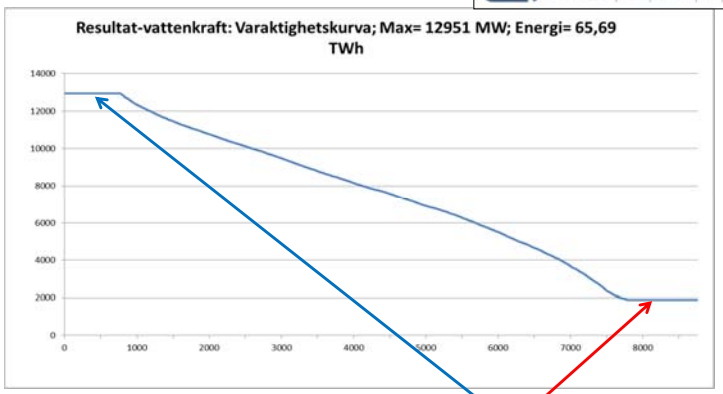
1 hour **4 hours**



During 2008 changes hour-to-hour: 3500 MW

During 2008 changes between 4 hours 7000 MW

Hydro power: Duration curve

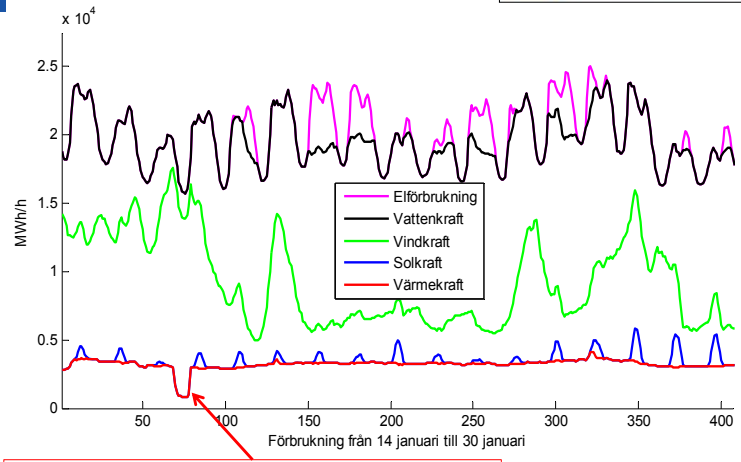


Min level: 1875 MW: Needed during **860** hours

Max level: 12951 MW: Needed during **765** hours

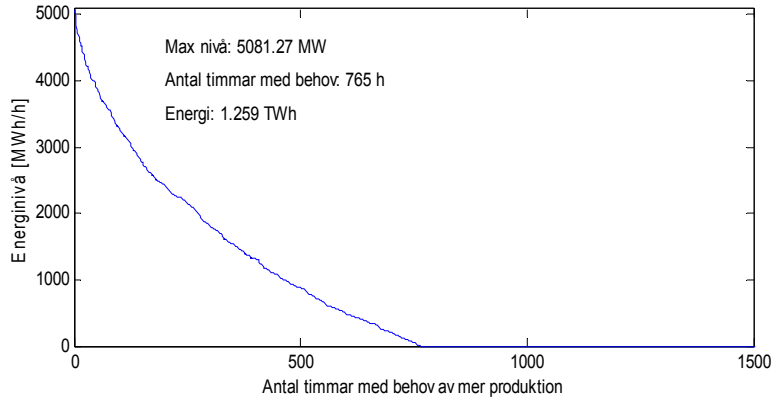
Deficit situation

low solar+wind: January



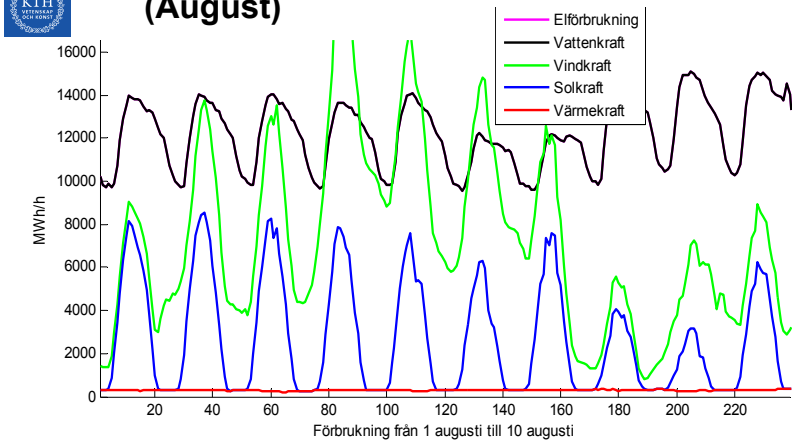
High wind ➔ decrease CHP

Deficit situation (yearly basis)



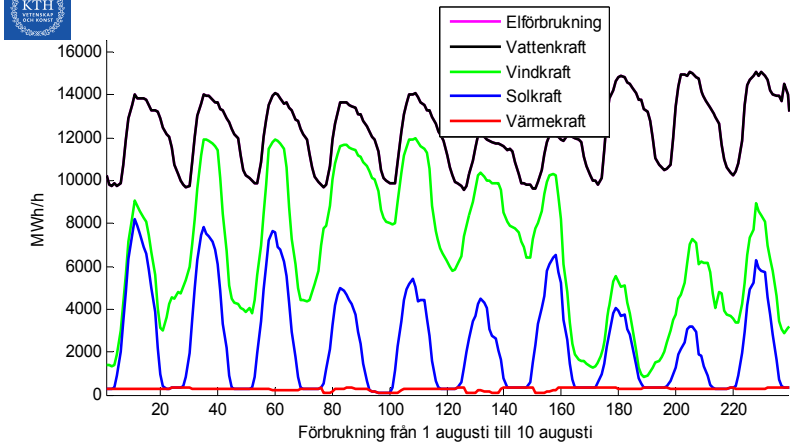
Cost for this: 1,5 öre/kWh

Surplus situation (August)



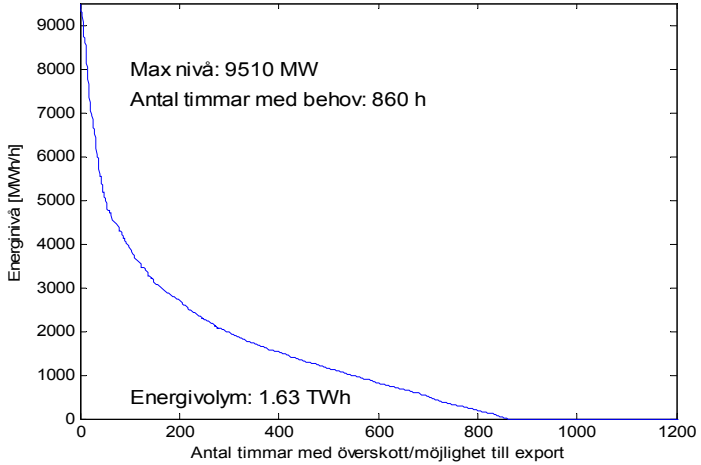
Not OK: 83% limit, min-hydro, min-CHP

Surplus situation (August)



Now OK: 83% limit, min-hydro, min-CHP

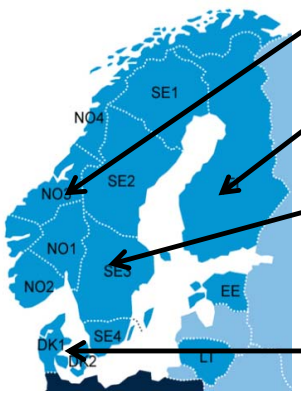
Surplus during a year



Peak capacity

responsibility challenges.

Peak capacity responsibilities



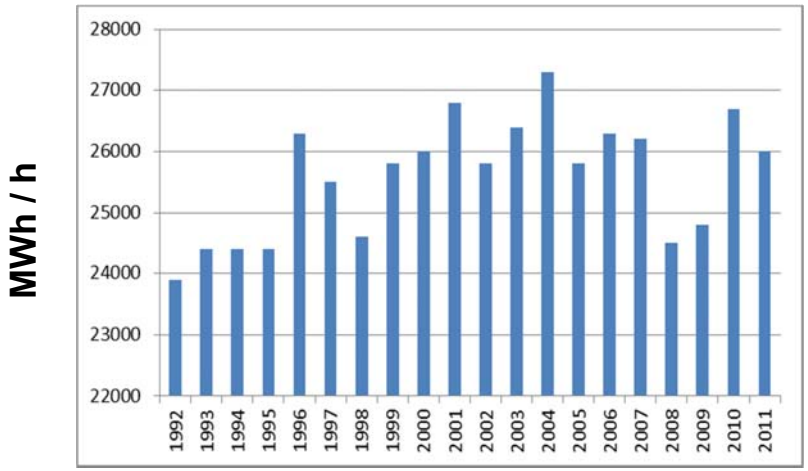
Norway: TSO-Statnet is responsible for "enough capacity"

Finland: TSO-Fingrid is NOT responsible for "enough capacity"

Sweden: TSO-Svenska Kraftnät is NOT responsible for "enough capacity". But: "up to 2000 MW"

Denmark: TSO-Energinet.dk is responsible for "enough capacity"

Peak loads in Sweden 1992-2011



Year 1992 - 2011

Peak capacity responsibilities example 1

1. Assume that there is a "capacity problem" in South Sweden and Denmark exports 1000 MW to Sweden.
2. Assume that there is an outage in Denmark so they have to decrease consumption.
3. According to EU legislation "non-discrimination" Denmark cannot prioritize Danish consumers before Swedish ones.
4. Does this has as a consequence that Denmark is also responsible for Sweden?

Peak capacity responsibilities example - 2

1. There are discussions of capacity payments to a rather large volume in UK
2. Probably this then leads to comparatively low energy prices compared to a case with no cap. payments
3. Both Norway and Denmark plan new cables to UK.
4. Does this mean that Denmark and Norway can import and only pay the energy price?

High load reserves in Sweden "Selective capacity market"

TSO responsible to purchase "**up to 2000 MW**" of "reserves" for peak load situations.

There is a bidding process where the cheapest offers are accepted.

Pricing:

The bids are placed on Nordpool spot. They are only used if all other bids are accepted.

The Net Regulation Price should not be allowed to exceed **5,000 Euro/MWh**.

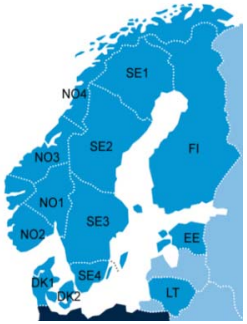
TSO can immediately impose a Disconnection Price in The event of Critical Power Shortage of 20 000 SEK/MWh ≈ **2300 Euro/MWh**

Australia: Max price 12000 AUD **≈ 9000 Euro/MWh**

Reserves in Sweden 2012-13 Consumers accepted to reduce consumption

Company	Area	MW
Stora Enso AB	3-4	210
Höganäs Sweden AB	4	25
Rottneros Bruk AB	3	27
Befesa Scandust AB	4	18
Vattenfall AB	3-4	92
Göteborg Energi AB	3	25
AV Reserveffekt	3-4	+ 67
TOTAL		**464**

Summary of (some) Nordic market challenges



Risk for prices so low so power plants cannot be financed

Large amounts of renewables ➔ often very low prices

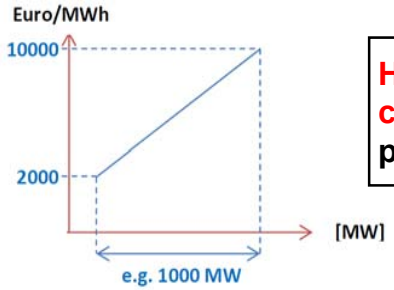
But still other units are needed

➔ need of either (very) high prices or some kind of capacity payment mechanism.

Large amount of transmission is one part solution, but perhaps also large amounts of solar/wind power on the other end?

Idea to market solution to "last" unit

There should be a (renewable) unit (biogas?) with MC as



High operation cost (or bid price) essential

- Call it a "market maker unit" ➔ reduced need of cap. payment.
- If DSM is cheaper then it will be used instead
- As low LOLP as requested can be obtained (= size of unit)

Integration of RES – Focus Wind Systems

Bonus slides

Slutsatser:

- **Detaljsimulering** av extremsituationer har gjorts
- **Vattenkraften klarar** dessa situationer med den modell som använts (tim-simulering inkl domar)
- Viktigt att **vattenkraften kan regleras** (dagens domar)
- Ännu **inga oöverstigliga hinder** funna
- Dock **intressanta utmaningar** / möjliga effektiviseringar. Dvs **Hur** ska man göra?

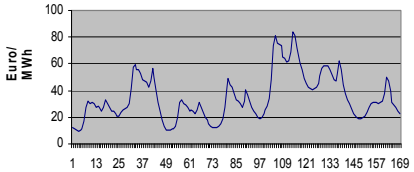
Nästa steg =
= planer inför Version 4:

- Samarbete med Swecos Nord-Europa-modell
- Beakta transmissions-begränsningar inom Sverige / behov av utbyggnad
- Kombination: Kraftvärme-minskning + elpatroner i fjärrvärme vid ”överskott”
- Möjligen laststyrnings-uppskattning vid ”underskott”
- **Fler viktiga förslag?**

Balancing solutions and competition

Assume a system with large price variation:

➔ Three types of ”business opportunities”



More trading with neighbors

Demand side management

Flexible plants

- There is a competition between these methods.
- Much transmission reduces price changes ➔ less interest in DSM