ADAPTING EUROPEAN ELECTRICITY MARKET DESIGN TO INCREASINGLY LARGER VOLUMES OF VARIABLE RENEWABLE GENERATION

NEPP-KTH seminar, January 29, 2015

Lennart Söder
Professor in Electric Power Systems, KTH

Programme

12:45 - 13:00	Registration and coffee
13:00 - 13:15	Opening words Lennart Söder, Professor, KTH Royal Institute of Technology, Electric Power Systems
13:15 - 14:00	Germany's Energiewende and electricity market design: where are we and what lies ahead? Jörg Jasper, Group Expert Energy Economics & Policy, EnBW Energie Baden-Württemberg AG
14:00 - 14:20	Coffee break
14:20 - 15:05	Four market design scenarios for Europe Johan Linnarsson, Senior consultant Sweco Energy Markets
15:05 - 15:50	Some insights into intraday trading behaviour on Elbas Richard Scharff, PhD student, KTH Royal Institute of Technology, Electric Power Systems
15:50 - 16:00	Closing remarks Lennart Söder

Electric Power Systems

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

Electric Power Systems

Power System Dynamics and Control

Mehrdad
Bertil (a. fac)
Mohammad Na.
Marina
Harold
Omar
Dimitrios
Taha

Smart Transmission Systems

Luigi
Hossein(pd)
Almas
Tetiana
Yuwa
Wei
Vedran
Jan
Francisco
Maxime

Power System Operation and Planning

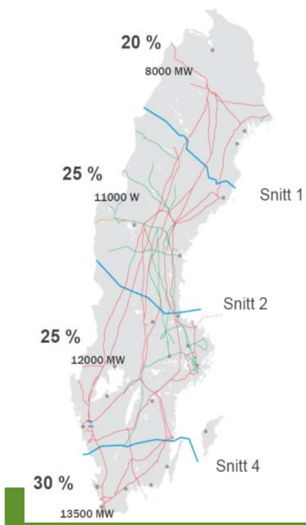
Lennart
Lars (pd)
Camille
Yalin
Angela
Christian
Ilan
Magnus(pd)
Desta
William
Martin

Mikael
Ebrahim
Ilias
Richard
Meng
Dina

Electricity Market analysis

Mohammad
Ekatrina
MohammadReza
Mahir
Richard
Yaser
Kristina
Yelena
Ezgi
Anna
Zhao

Identified wind power projects in Sweden:



Identified wind power projects:

- **45000 MW** (≈ 100 TWh/year)

Today capacities:

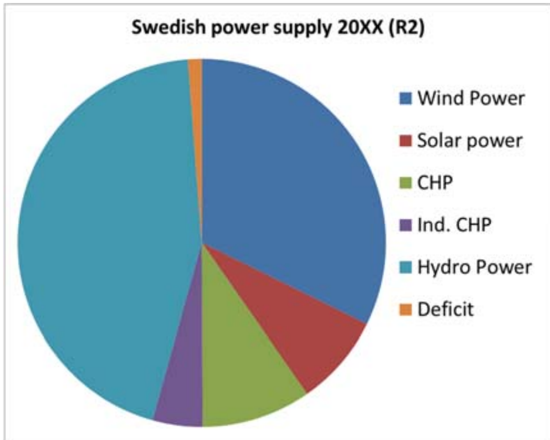
- **Hydro Power: 16000 MW** (≈ 65 TWh)
- **Nuclear power: 9000 MW** (≈ 65 TWh)
- **➔ total of 25000 MW**

Results from Swedish studies on larger amounts of wind power

Lennart Söder, KTH

Swedish production: Total: 145,6 TWh

(same as 2011)



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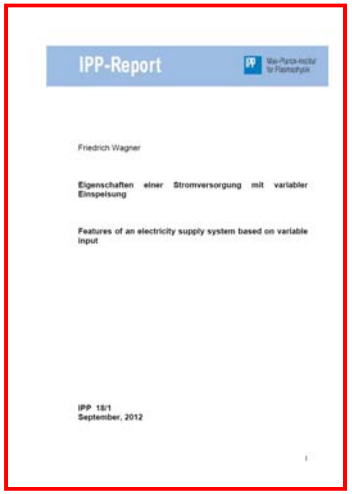
Parallell Sweden-Germany


IPP-Report

Friedrich Wagner

Eigenschaften einer Stromversorgung mit variabler Einspeisung

Features of an electricity supply system based on variable input

IPP 18/1
September, 2012

"Features of an electricity supply system based on variable input"

The major findings are:

- The use of renewable energies (RE) requires the installation of additional power capacity, which surpasses the present one of conventional thermal power systems.
- ….
- Within the boundaries of this study, we find that RE can be integrated up to a share of about 40% of the annual demand with manageable consequences.

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	64,9	44,5	12951
Nuclear	0	0	0
Wind	46,7	32,1	15633
Solar	12,6	8,6	9849
CHP-Ind	6,4	4,4	1240
CHP-distr.	13,9	9,5	4126
Other	1,3	0,9	5081
Total	**139,9**	**100**	**48180**

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 ➔

<u>High prices are often not set in Denmark!</u>

Pricing in power systems: Finland

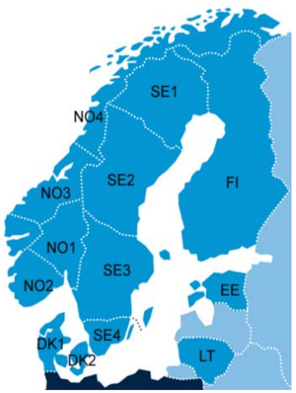
Nuclear + hydro + wind (58%-now)

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:



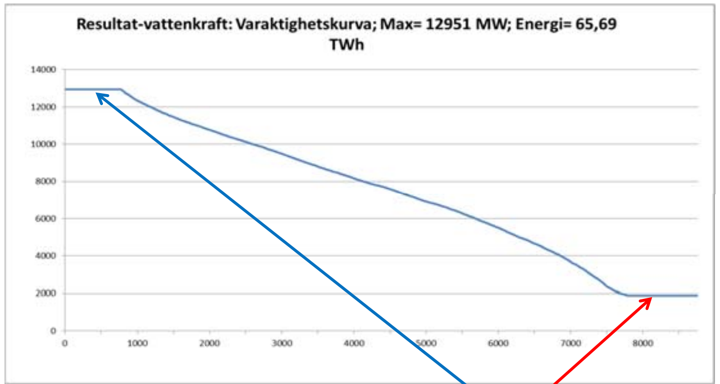
Much more often: Prices are not set by Nordic power plants.

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

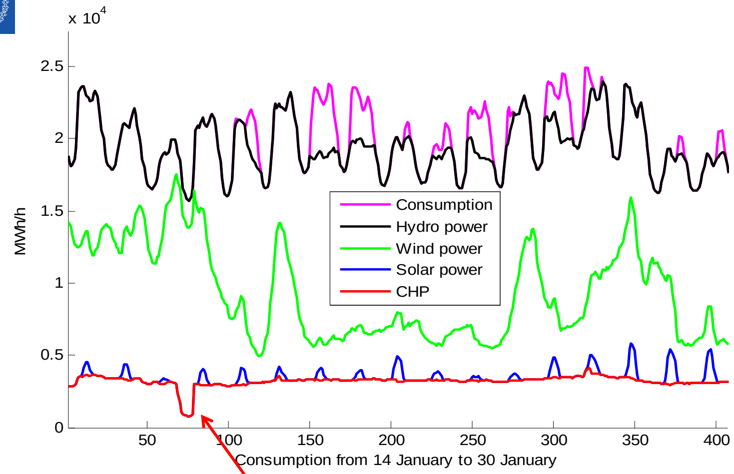
Hydro power: Duration curve



Min level: 1875 MW: Needed during 860 hours

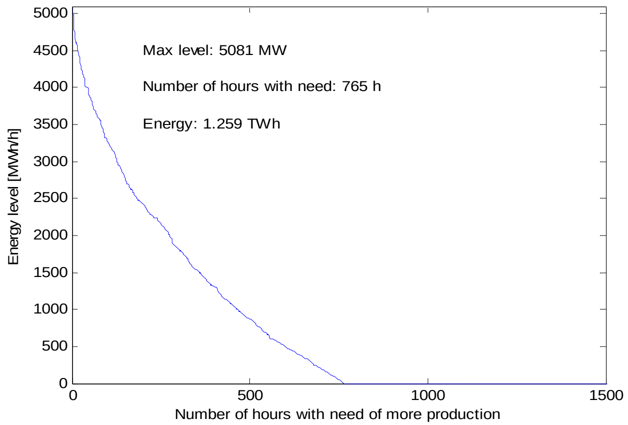
Max level: 12951 MW: Needed during 765 hours

Deficit situation



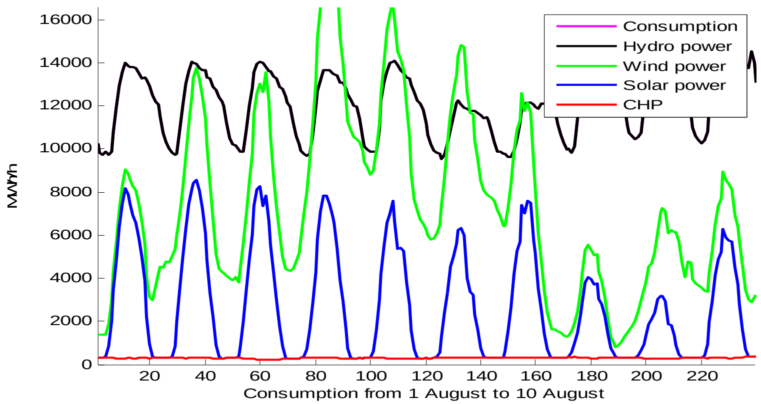
High wind → decrease in CHP

Deficit situation (yearly basis) Assumed need of OCGT



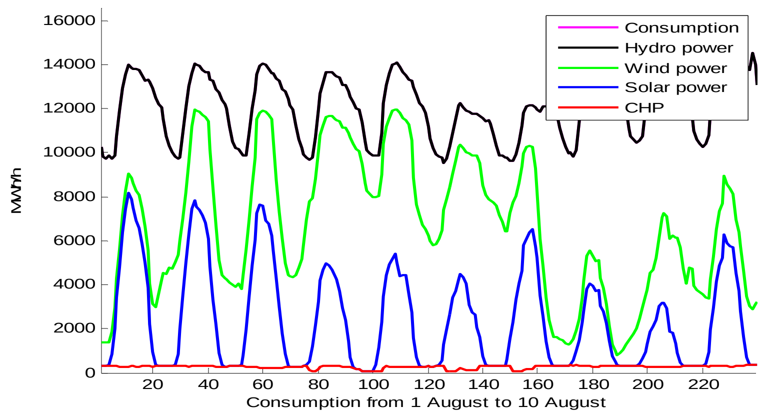
Cost for this: 2 öre/kWh = 0,2 Eurocent/kWh

Surplus situation (August)



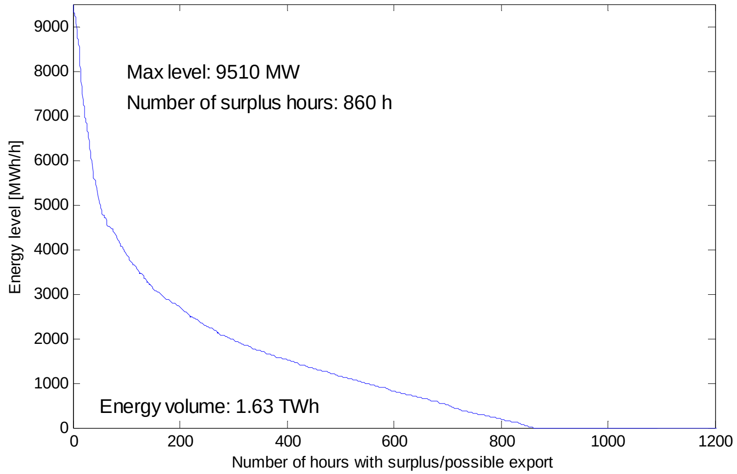
Not OK: 83% limit, min-hydro, min-CHP

Surplus situation (August)



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

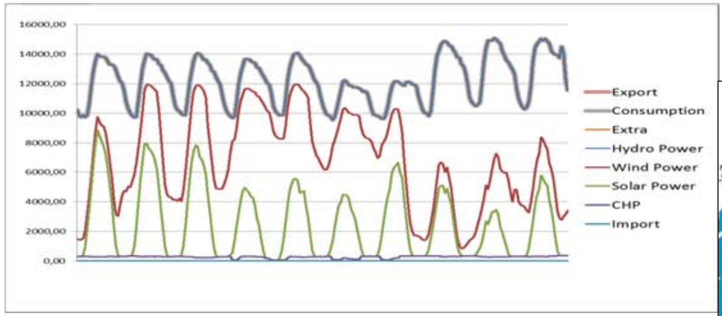
Surplus during a year

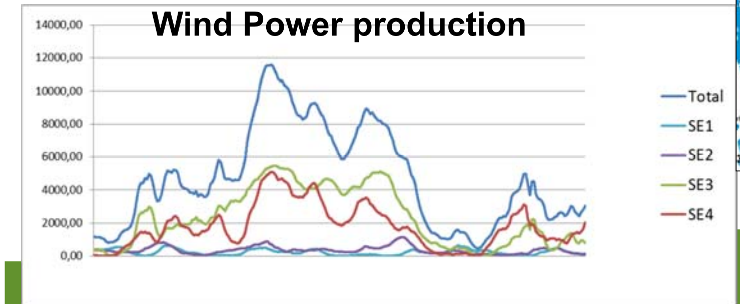


General transmission challenge

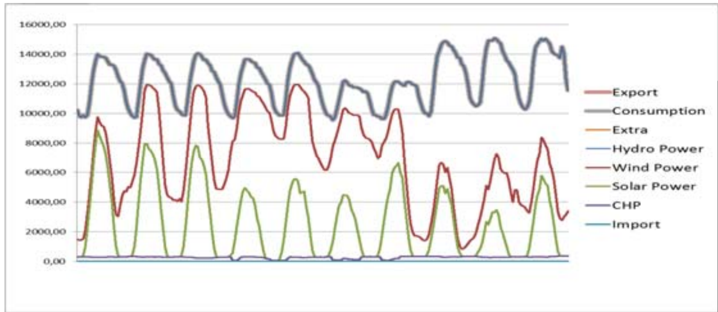
A. Voltage stability limits between areas
B. Q-control important
C. More transmission required, but low utilization time
D. Challenge to identify future transmission capacity with less nuclear
E. Detailed hydro simulation takes 10 minutes per week.

Surplus situation (August 1-10)

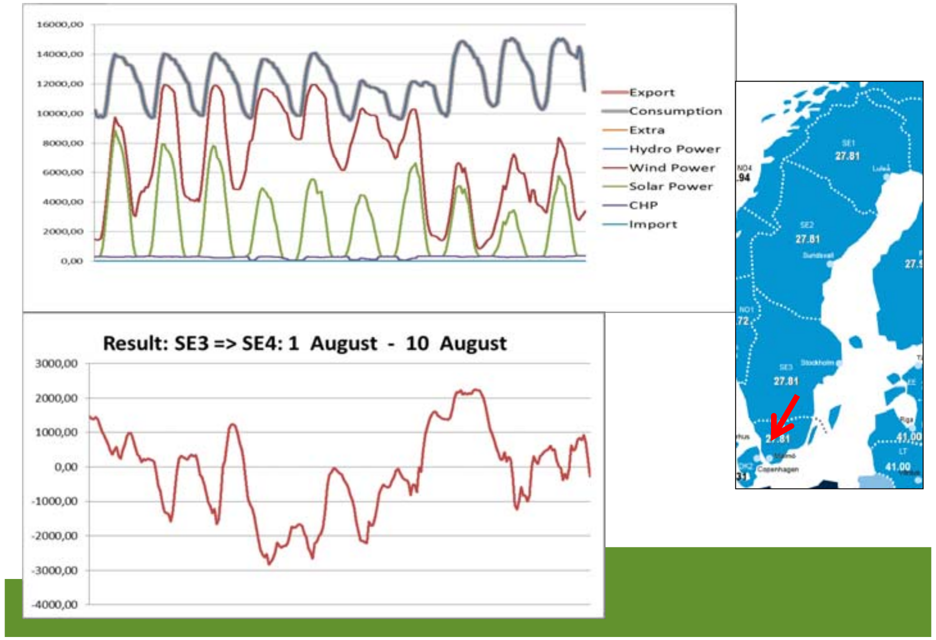




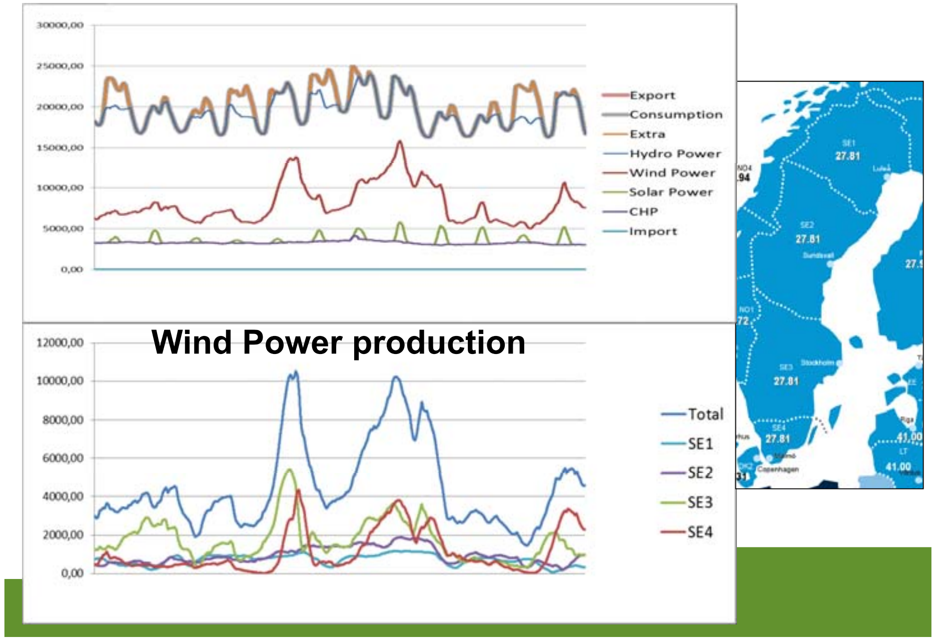
Surplus situation (August 1-10)



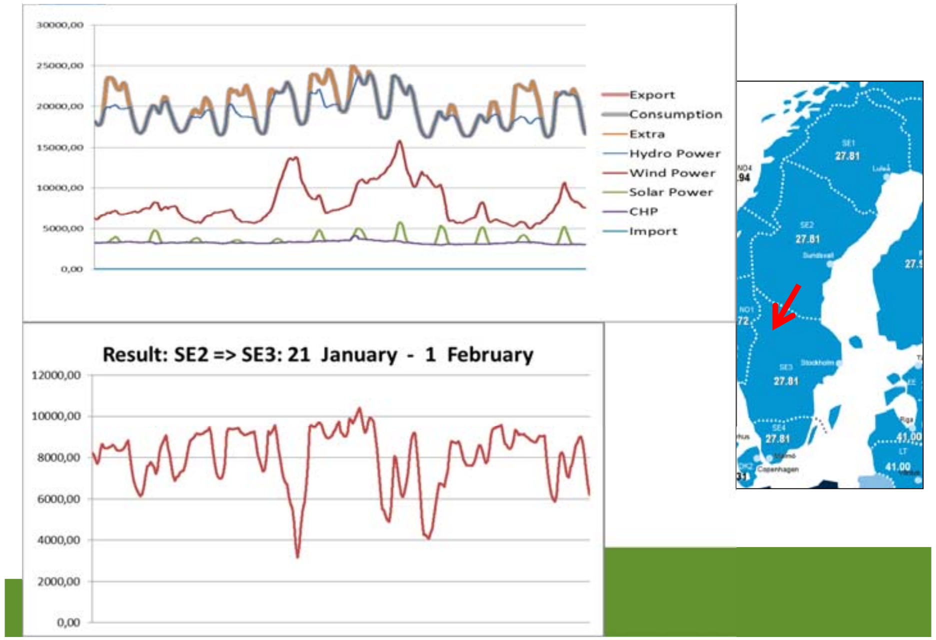
Surplus situation (August 1-10)



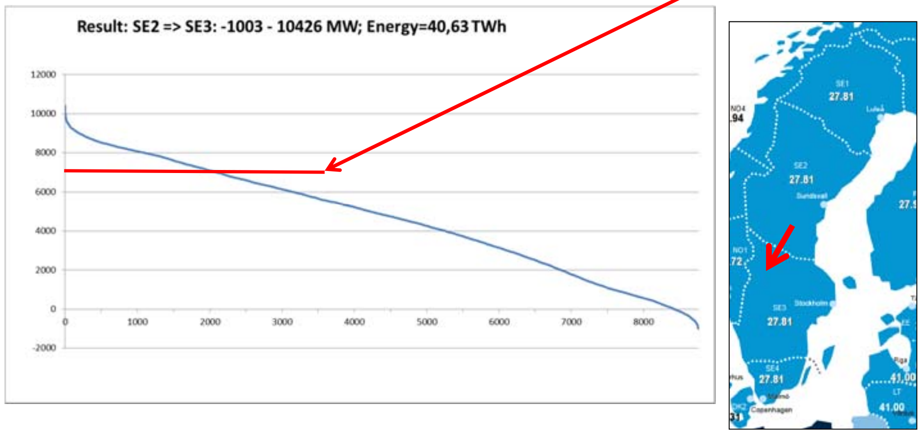
Transmission situation (Jan 21 – Feb 1)



Transmission situation (Jan 21 – Feb 1)



Transmission: Yearly duration : today ≈ 7000 MW



On transmission needs

A. Increase production in receiving end (= thermal, currently OCGT)
B. Capacity is available, small energy increase for first GW.
C. Since limit is voltage stability, SVC may be enough
D. Discussion on exchange of AC to DC
E. Optimization approach may be interesting