

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

## 10<sup>th</sup> International Conference on the European Energy Market

Lennart Söder  
Thursday – 30 May 2013

## Nordic Power Supply TWh 2012

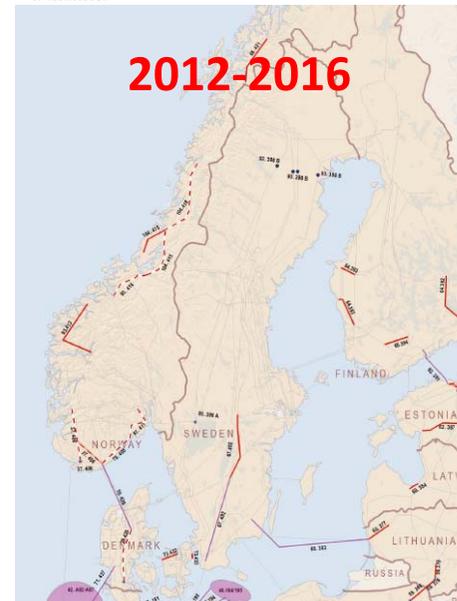
Country	Nuclear	Hydro	Fossil	Wind	Bio	Total
Norway	0	142,9	2,4	1,6	0	147,8
Finland	22,1	16,6	17,9	0,5	9,9	67,7
Sweden	61,2	77,7	4,6	7,1	10,8	161,6
Denmark	0	0,02	16,3	10,2	2,3	29,4

## 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**



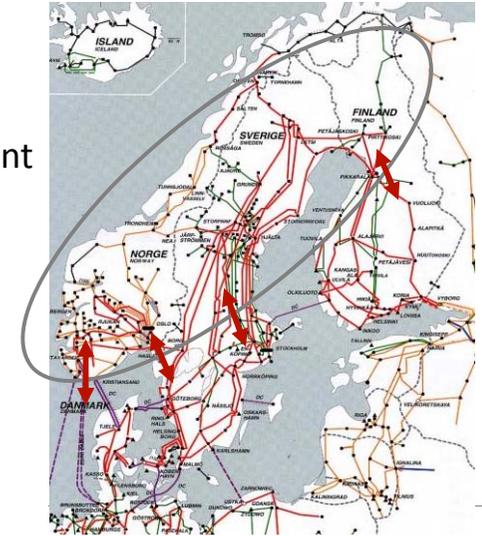
## New Nordic interconnections ENTSO-E: Ten-Year Network Development Plan 2012



- 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



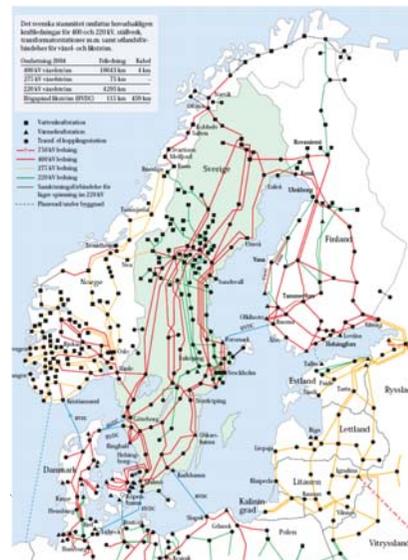
- Nordic hydro power (inflow) can vary 86 TWh between different years ( $\Delta 2001$  to 1996)
- Transport from NV to SE + continent
- Energy balancing with thermal power in i Dk+F+Ge+Pl+NL+Ee
- **Wind power gives the same variations/uncertainties (and solutions) as hydro power.**
- **But:** time perspective is much shorter!



- **Sweden-neighbours: ca 10100 MW** (continuously  $\rightarrow$  88 TWh/year)
- **Nordel-neighbours: ca 5500 MW (DC!)**

### Plans:

- Järpströmmen-Nea, S-N, ~1000 MW
- (South-West link, S-N, 2x600 MW - cancelled)
- Nordbalt, S-L, ~600 MW
- New line to Gotland
- Strengthening North to Finland
- New cut 2 line, ev. DC
- $\rightarrow$  **Sweden-neighbours: +~1600 MW**



- **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!**

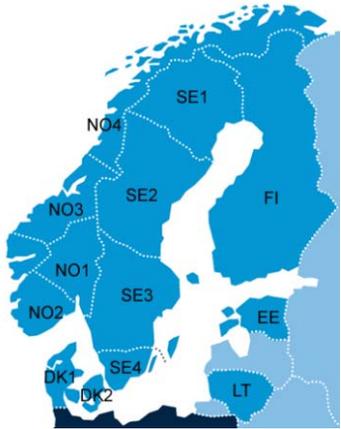
## Pricing in power systems:

### Finland



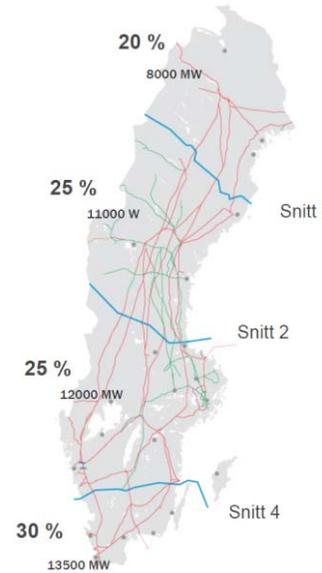
- **Nuclear + hydro + wind (58%-now)**
- **CHP + more nuclear in the future** →
- **At wind and low demand, then the prices will be low** →
- **Prices are then often not set in Finland!**

## 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**

## Identified wind power projects in Sweden:



### Identified wind power projects:

- **45000 MW (≈ 100 TWh/year)**

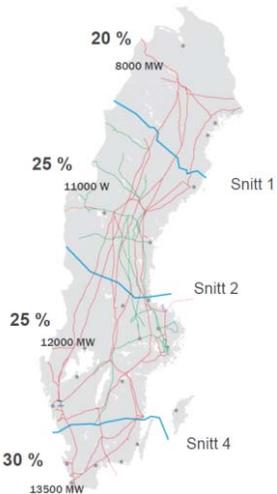
### Today capacities:

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

## Swedish system with 55 TWh wind+solar:

(towards 100% renewable)

- **Solar: 10 TWh**, installed power 10657 MW, max production: 7805 MW
- **Wind power: 45 TWh**, installed power 18000 MW, max production: 17136 MW. (→ same density as today in Spain and Portugal)

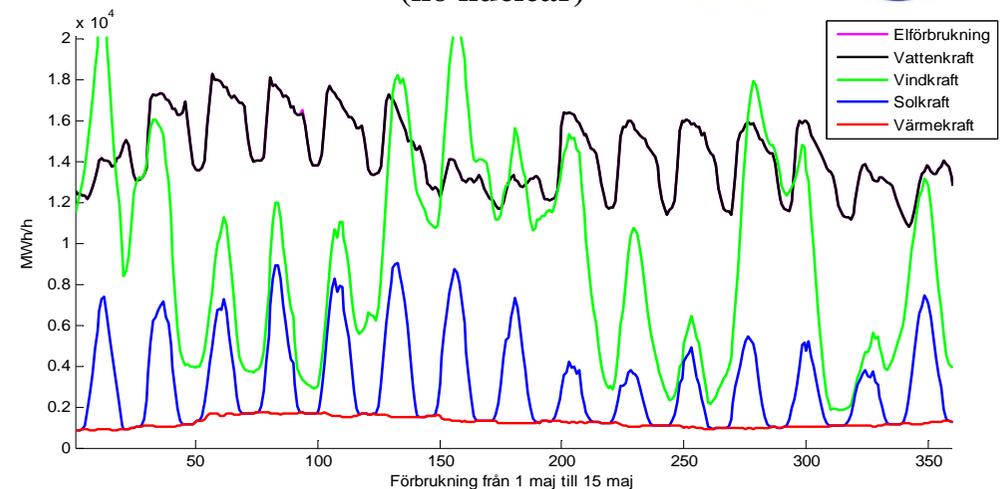


Country	Wind power [MW]	Area [km <sup>2</sup> ]	Density MW/km <sup>2</sup>
Denmark	3871	43093	0,0898
Germany	29060	356733	0,0815
Spain	21674	504782	0,0429
Portugal	4083	92000	0,0444
Sweden	18000 (in this study)	449964	<b>0,0400</b>

## High production wind+solar (55 TWh)

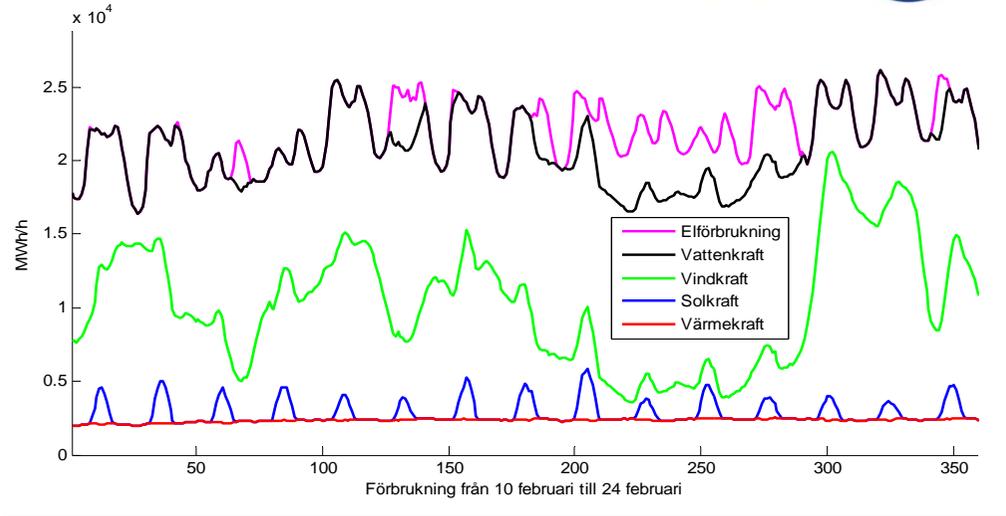
1- 15 May

(no nuclear)



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

## Low prod. wind+solar (55 TWh) No nuclear, gas turbines, oil condensing, DSM



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

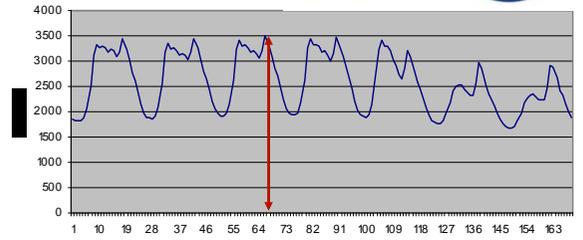
## Pricing in power systems

With an assumption of perfect competition:

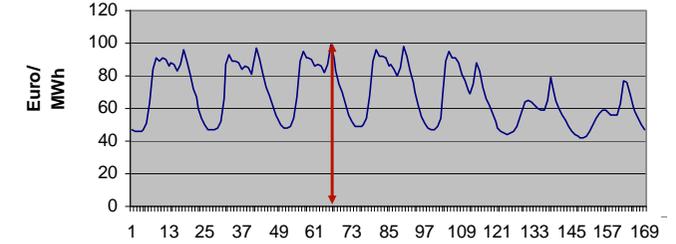
- Prices are based on production marginal costs
- Low costs units are used first
- Higher load → higher prices:



### Weekly demand

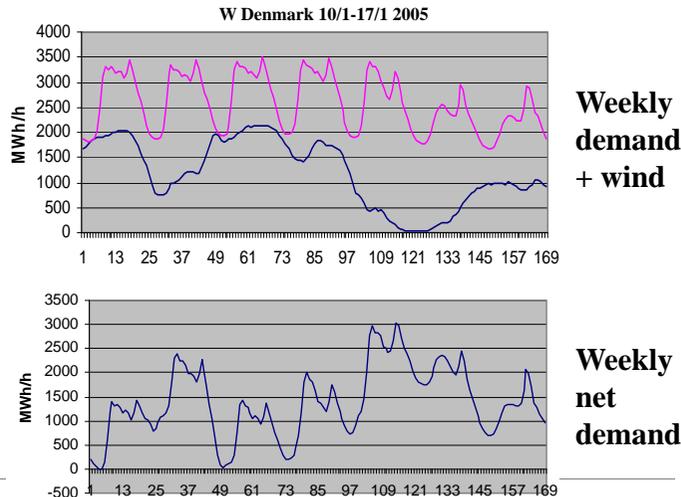


### Pricing



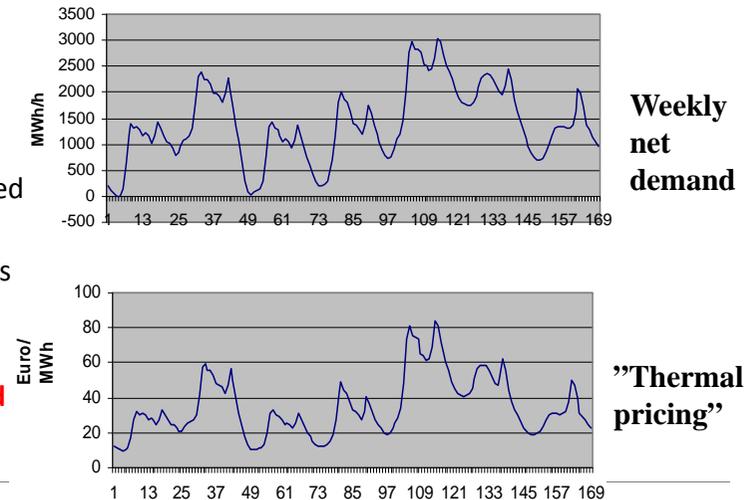
## Pricing in presence of variable sources (e.g. wind)

- Wind power has a marginal cost ≈ zero
- The production level is depending on wind speed
- It is not easy to make good long term (hours) forecasts
- Other units have to cover the net load = demand - wind

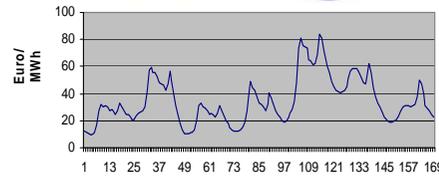


## Pricing in presence of variable sources

- Other units have to cover the net load = demand - wind
- The other units production is controlled by price!
- → more volatile prices
- **Note: This is independent of "fixed price" etc**



- 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



- **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"

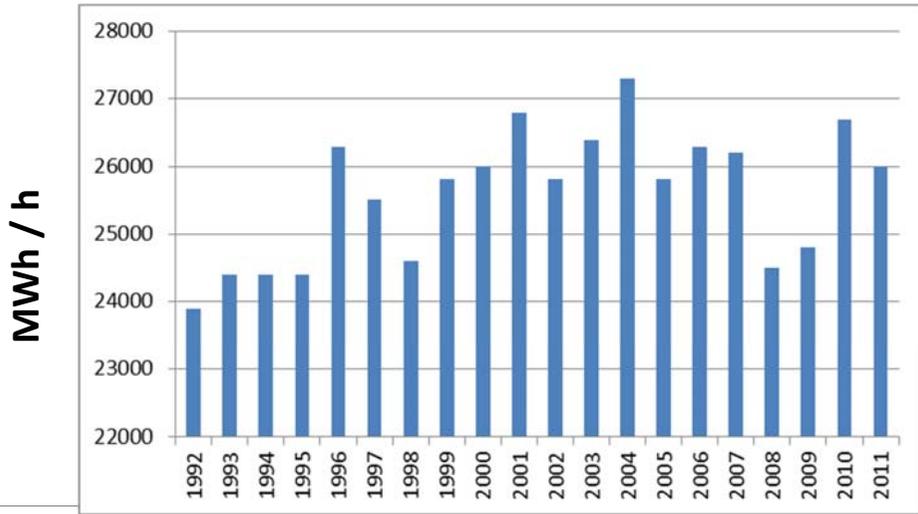
## Peak capacity responsibilities example 1

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 have 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?

## Peak loads in Sweden 1992-2011



Year 1992 - 2011

## 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  $\approx$  **2300 Euro/MWh**
- 
- **Australia:** Max price 12000 AUD  $\approx$  **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
<b>TOTAL</b>		<b>464</b>

## On market interest to invest in "last" unit

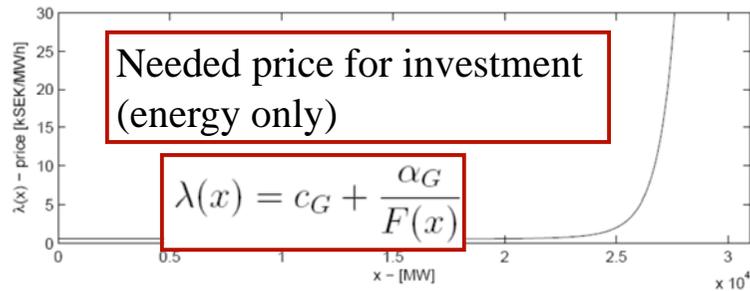
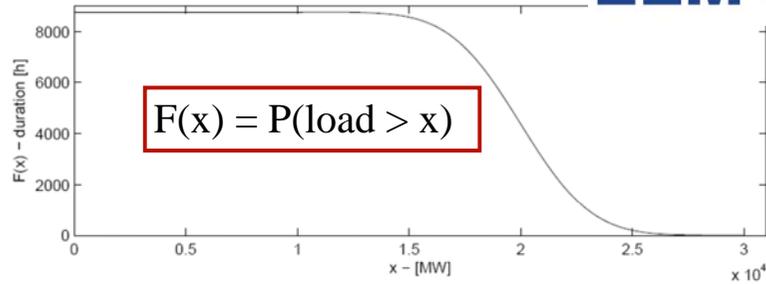
IEEE TRANSACTIONS ON POWER SYSTEMS, VOL. 25, NO. 3, AUGUST 2010

## Analysis of Pricing and Volumes in Selective Capacity Markets

Lennart Söder, *Member, IEEE*

- Published in 2010.
- Describes the challenges and an analysis of the Swedish approach.

## On market interest to invest in "last" unit

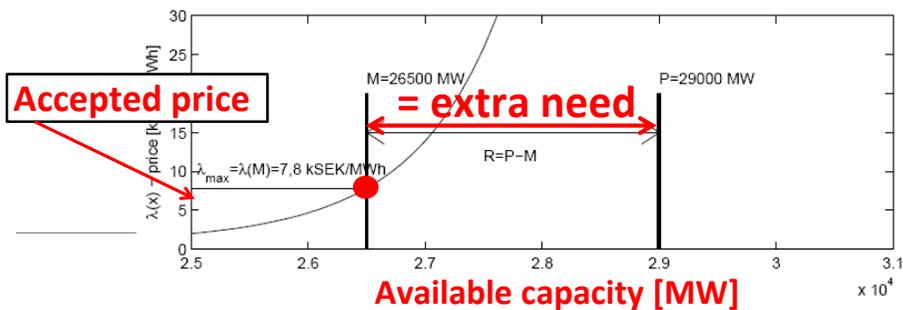
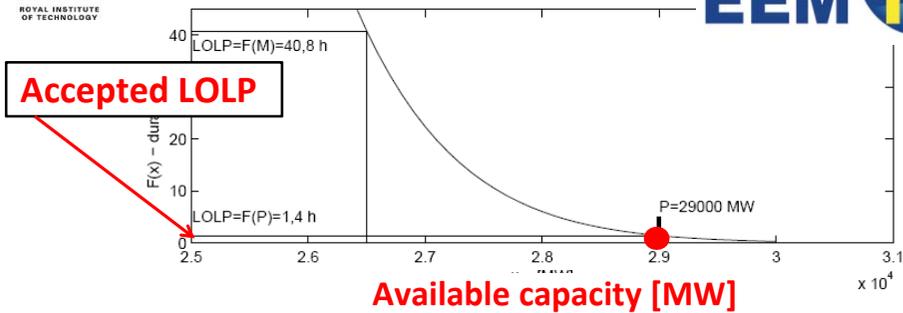


## On market interest to invest in "last" unit

Relevant questions are:

- A. How much installed capacity,  $P$ , is needed?  
This is the same question as: What reliability level,  $LOLP = F(P)$ , is required?
- B. How high prices,  $\lambda_{max}$  can be accepted?  
This is the same question as to ask how much power,  $R$  that has to be subsidized.

## On market interest to invest in "last" unit



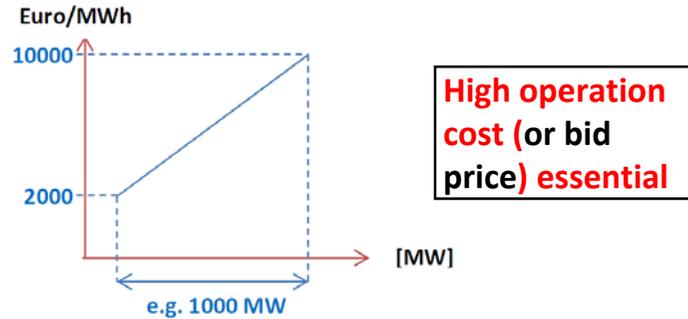
## Summary of (some) Nordic market challenges



- 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



- 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)

## Comments to Nordic market challenges



How high costs should we allow to "make market work":

- **Costs for** "market-making plants"
- **Costs for** "new lines are needed to increase the number of participants and to decrease risk of use of market power"
- **Costs for** "IT solutions for consumer flexibility since this is essential to make the market work".

## Comments to Nordic market challenges



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- **Costs for** "IT solutions for consumer flexibility since this is essential to make the market work".

(But what is the alternative?)

## What is a "good" market? - 1

- **Static allocation efficiency** (=are available resources used as efficient as possible? E.g. in deficit situations)
- **Management efficiency** (= is the administrative organization efficient?)
- **Plant operation efficiency** (= is each plant operated in an efficient and reliable manner?)
- **Production optimization** (= correct merit order = is cheapest possible operation, including externalities, applied?)

- **Transaction cost efficiency** (= the amount of transactions costs, as measurements, spread of information and contracts)
  - **Dynamic investment efficiency** (= are the correct investments done at the right time?)
  - **Risk management efficiency** (= are risks and uncertainties handled in an efficient way?)
  - **System reliability** (= is it on a correct level?)
-