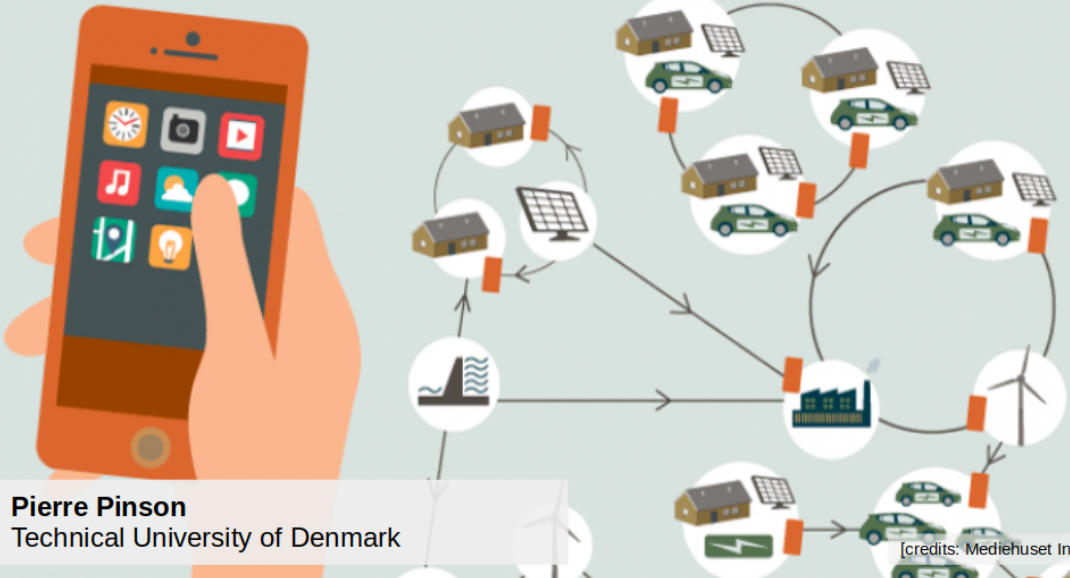
Module 5 – Impact of Renewables on Electricity Markets

5.3 How do renewables impact electricity markets?



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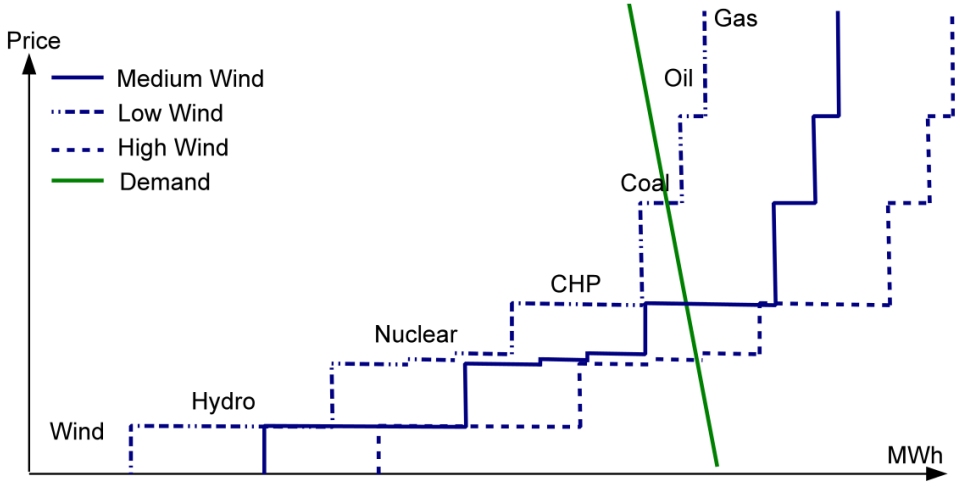
The merit-order effect

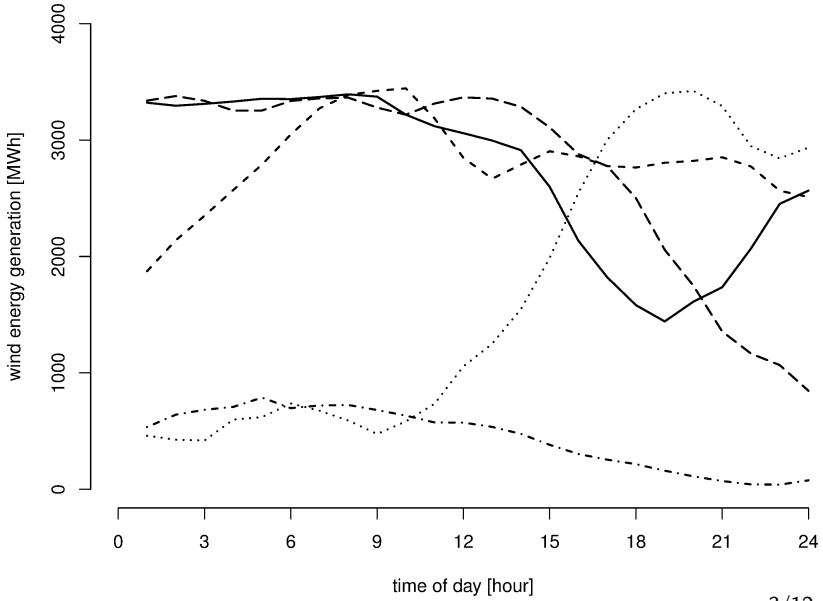


- On the day-ahead market, wind acts as a **stochastic driver** since having the lowest short-run marginal cost, with quantities based on forecasts (13-37 hours ahead)

Variability of wind power generation

5 days randomly chosen over December 2011 - Danish wind power generation

- In some places (Crete, Egypt, etc.), wind shows quite similar patterns from one day to the next...
- It does not seem to be that true for Denmark, and also for most places around the globe!



Illustrating the impact of renewables in the day-ahead market

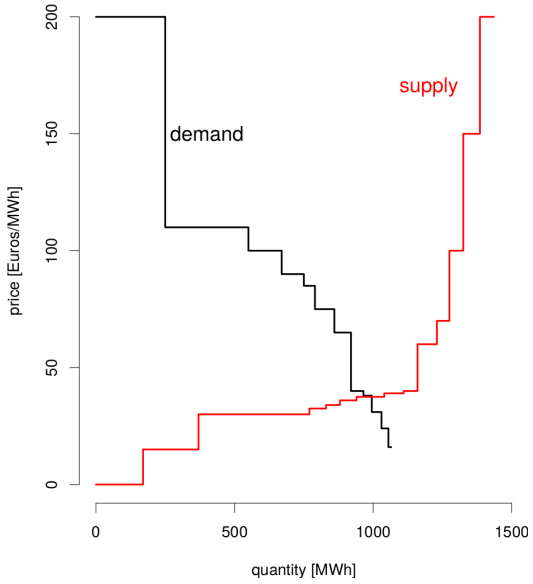
- **We use the same setup as for previous Modules on e.g. day-ahead markets!**
- Two participants on the supply side have wind farms:

Company	Supply/Demand	id	Nominal Power (MW)
$\mathrm{RT}^{®}$	Supply	G_1	350
WeTrustInWind	Supply	G_2	250
... the others	Supply	$G_{...}$	...

- Now, let us simulate outcomes of the day-ahead market,
  - assuming that all the others are always offering the same (both supply and demand)
  - solving the market-clearing using the simple LP formulation given in the lecture on day-ahead markets (no network consideration...)

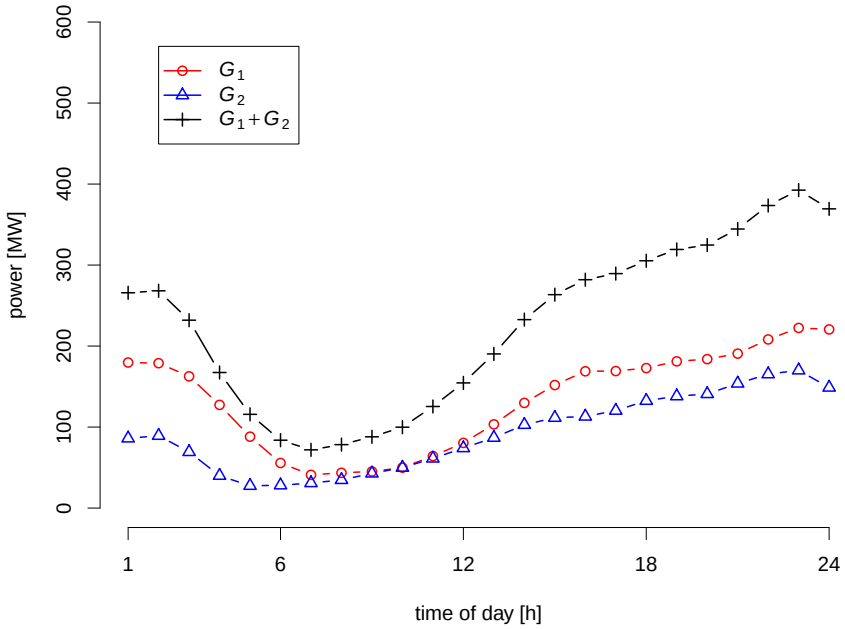
Reminder of the supply and demand curves

- The market outcome being:
  - a list of demand and supply offers scheduled
  - a system price of 37.5€/MWh
  - a total energy volume of 995 MWh



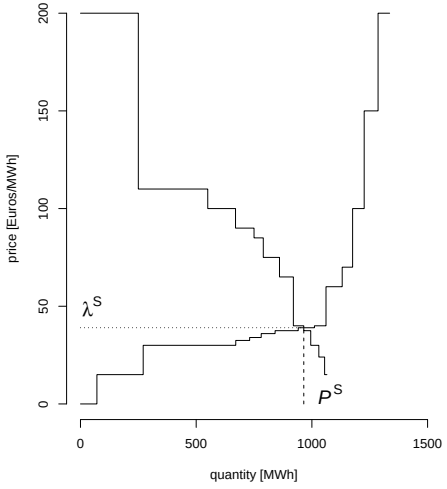
We are going to perturb this equilibrium by pushing the supply curve around...

A first daily profile for G_1 and G_2 offers



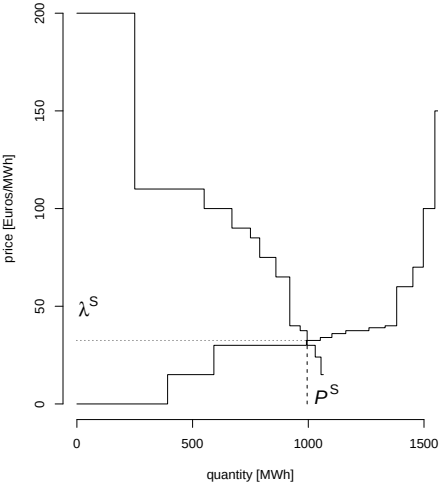
Market-clearing outcomes for sample hours

Hour 7 (72 MWh wind):



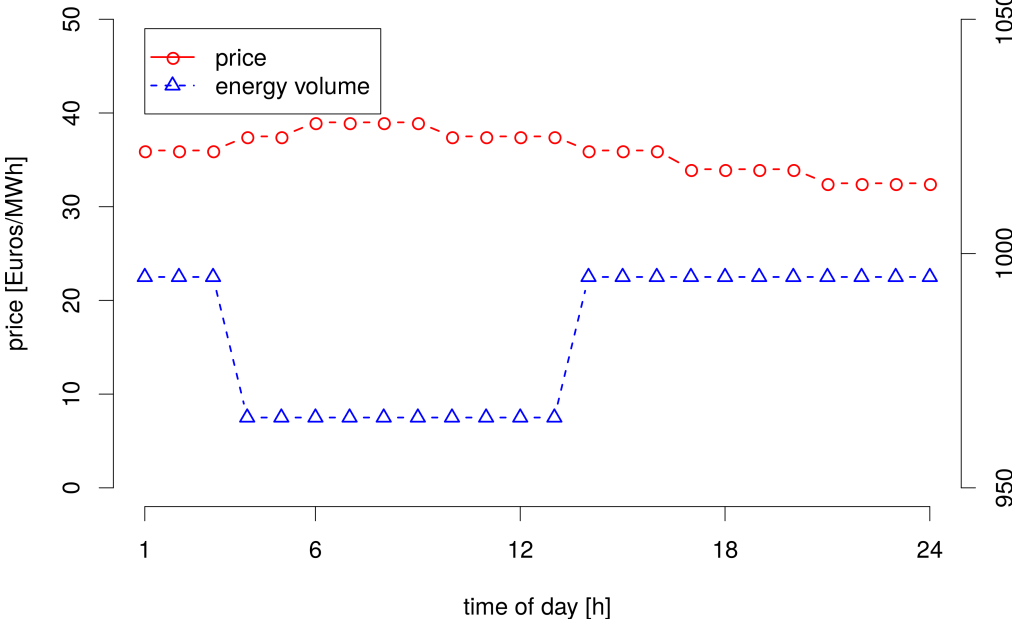
$\lambda^S = 39€,\ P^S = 965\text{MWh}$

Hour 23 (392 MWh wind):



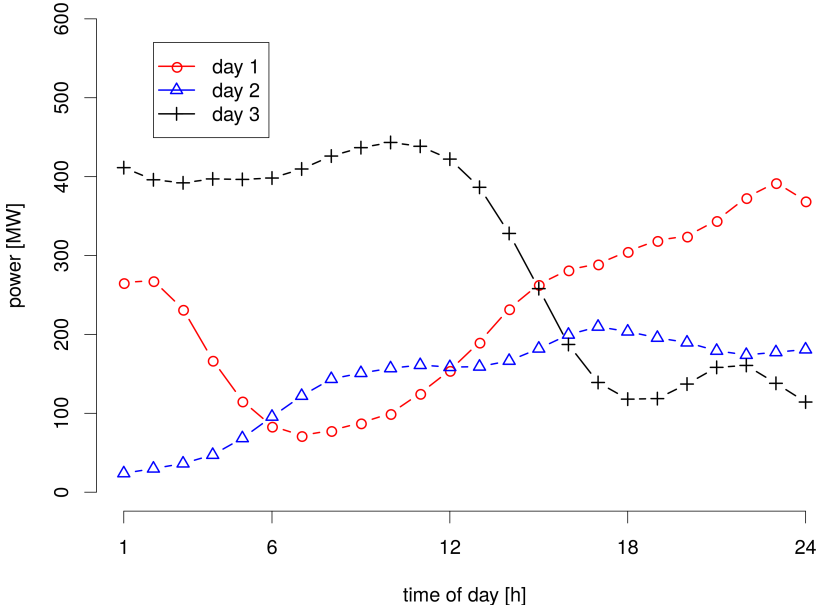
$\lambda^S = 32.5€,\ P^S = 995\text{MWh}$

Looking at the whole day...



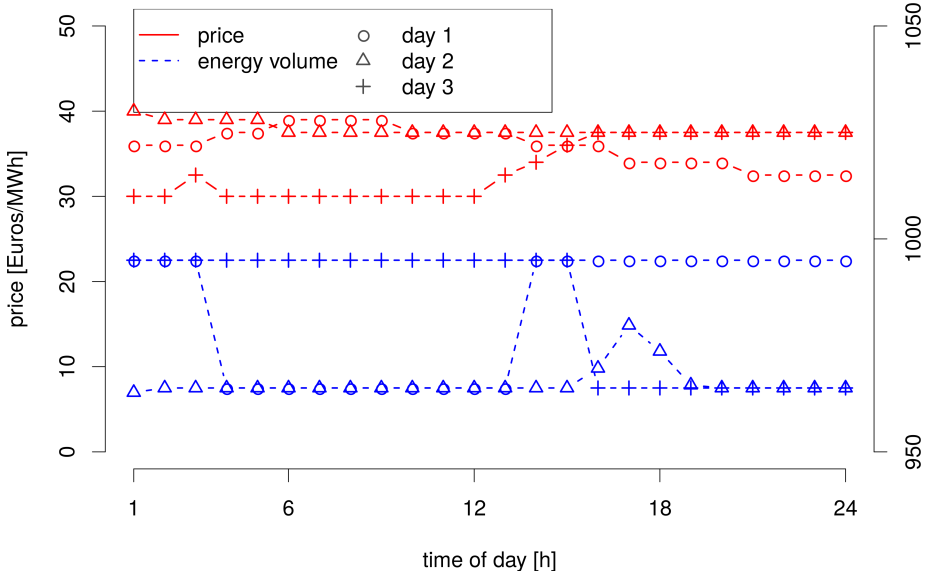
Now comparing several days

Wind profiles for 3 different days:



Market outcomes for these days

In terms of prices, and energy volumes:



Important properties to remember!

- Remember our notations (for a given market time unit):
  - λ^S: market-clearing price
  - P^S: energy volume cleared through the market
- For convenience, they are denoted as function of overall amount P^R of renewable energy offered, i.e., $\lambda^S(P^R)$ and $P^S(P^R)$.
- Two key properties when clearing a market with renewable energy offers:

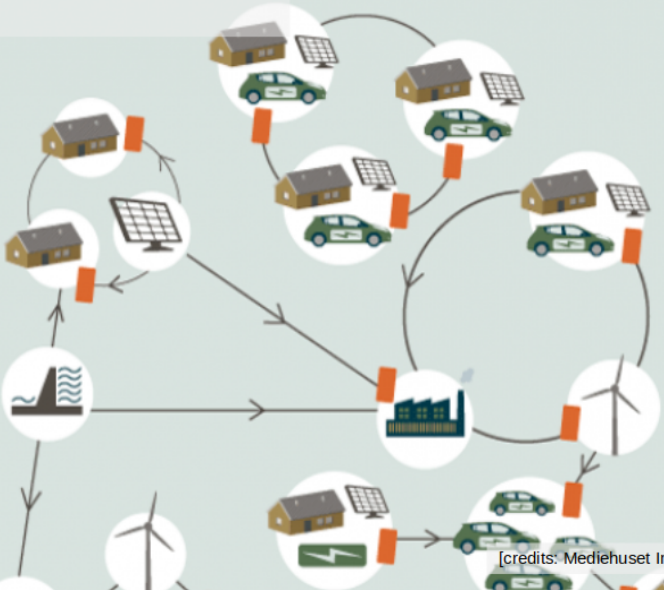
1. The cleared energy volume is at least as much as in the case of no renewable energy:

$$P^S(P^R) \geq P^S(0), \quad P^R \geq 0$$

2. The clearing price is at worst the same as in the case of no renewable energy:

$$\lambda^S(P^R) \leq \lambda^S(0), \quad P^R \geq 0$$

Use the self-assessment quizz to check your understanding!



[credits: Mediehuset Ingeniøren]