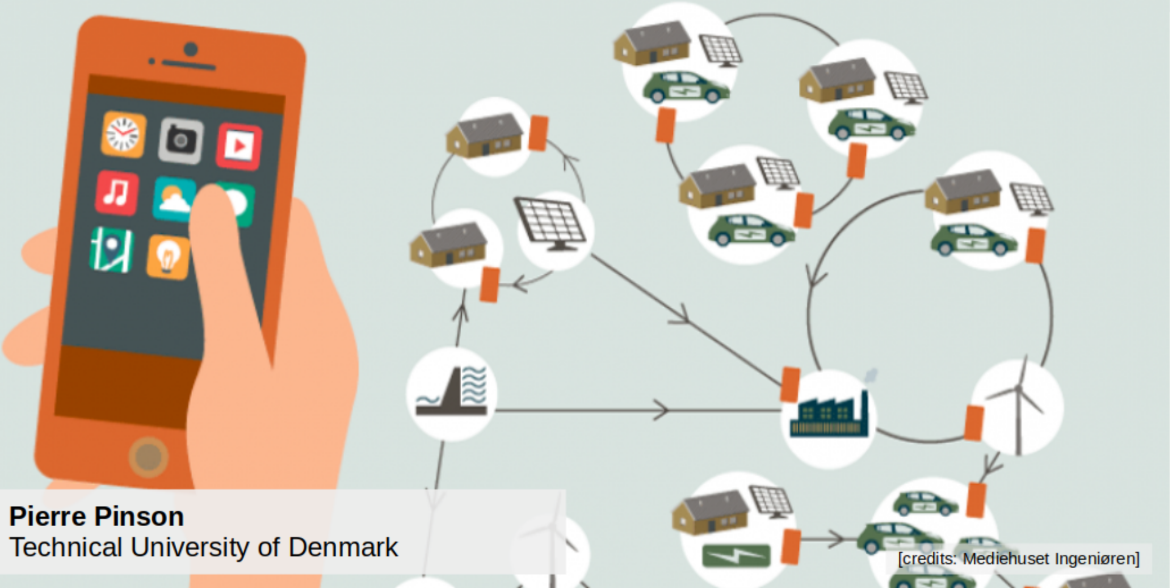
Module 6 – Participation of Renewables in Electricity Markets

6.1 What is a market participation strategy?



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The setup

- Students of the course 31761 (*"Renewables in Electricity Markets"*) got convinced to join forces and start an energy trading company: **Rogue Trading** ($\mathrm{RT}^{\circledR}$)

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- And, the course responsible suggested you first invest in that *new-generation wind farm*...
  - **Nominal capacity**: 350 MW
  - Energy production sold through the **Nord Pool (Western Denmark area)**
  - **Balance responsibility**

- From early 2016, you are to trade your energy generation through the Nord Pool

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2. Get all necessary data/info to make *informed decisions*, for instance:

   - get a good grip of market prices (e.g., how they can be influenced by neighboring zones, or the local generation mix)
   - gain knowledge of price and volume dynamics through historical data analysis
   - find ways to know how much your wind farm is going to produce for every time unit

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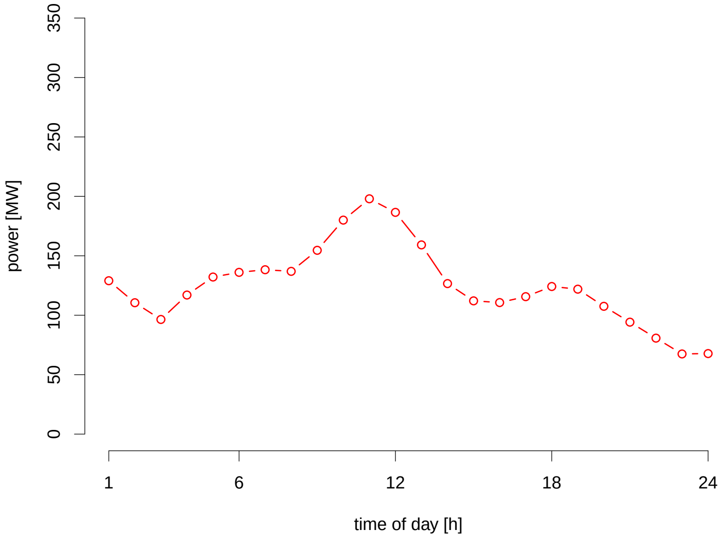
3. Design your offering strategy, which can consist of:

   - a totally improvised approach to market participation (you named your company Rogue Trading after all...)
   - a set of expert rules to decide on what to do when,
   - a well-thought optimization model

Sample trading day

27 March 2016 - 11am

- Your forecast provider gave you this wind power forecast for tomorrow: $\hat{y}_i$, $i = 1, \ldots, 24$
- From power generation estimates, one readily deduces 24 blocks of energy offered to the market
- *However, how much will you actually offer?*



Strategy 1

- We call it **"Let's trust the forecast!"**: directly take the forecasts and make them our offers (E_i, $i = 1, \ldots, 24$) for the 28th of March

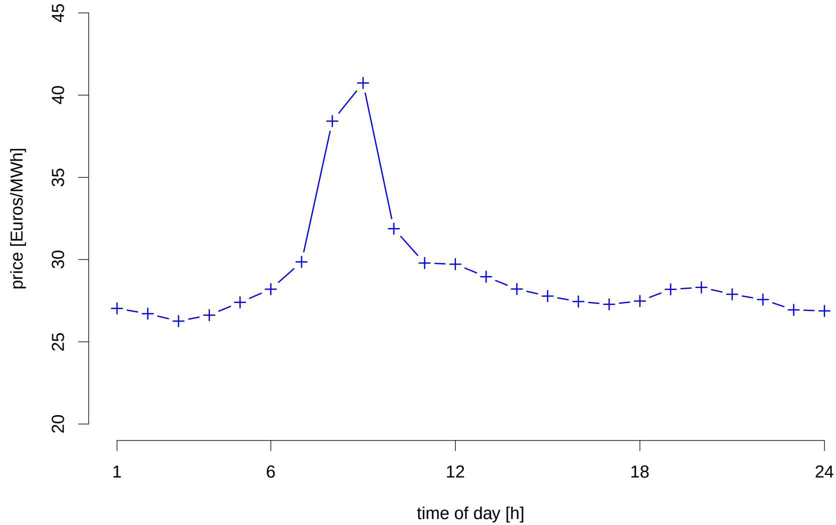
$$E_i = \hat{y}_i, \quad i = 1, \ldots, 24$$

hour 1	129 MWh	hour 7	138 MWh	hour 13	159 MWh	hour 19	122 MWh
hour 2	110 MWh	hour 8	137 MWh	hour 14	127 MWh	hour 20	108 MWh
hour 3	96 MWh	hour 8	155 MWh	hour 15	112 MWh	hour 21	94 MWh
hour 4	117 MWh	hour 10	180 MWh	hour 16	111 MWh	hour 22	81 MWh
hour 5	132 MWh	hour 11	198 MWh	hour 17	116 MWh	hour 23	67 MWh
hour 6	136 MWh	hour 12	187 MWh	hour 18	124 MWh	hour 24	68 MWh

- Now, we wait for market-clearing, to receive our cash...

Settlement after market clearing

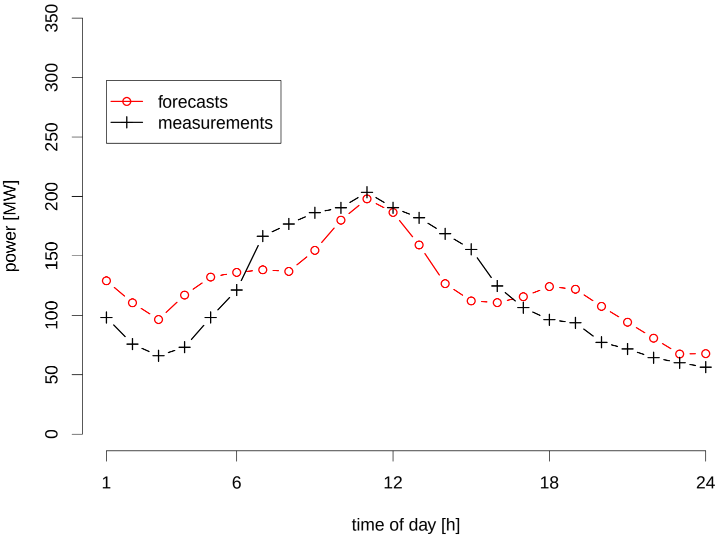
- **28 March 2016** - prices after market clearing



- Revenue: $R_{\text{DA}} = \sum_{i=1}^{24} \lambda_i^S * E_i$
- In the present case: $R_{\text{DA}} = 88.334, 49$€... not a bad day!

Actual production from the wind farm

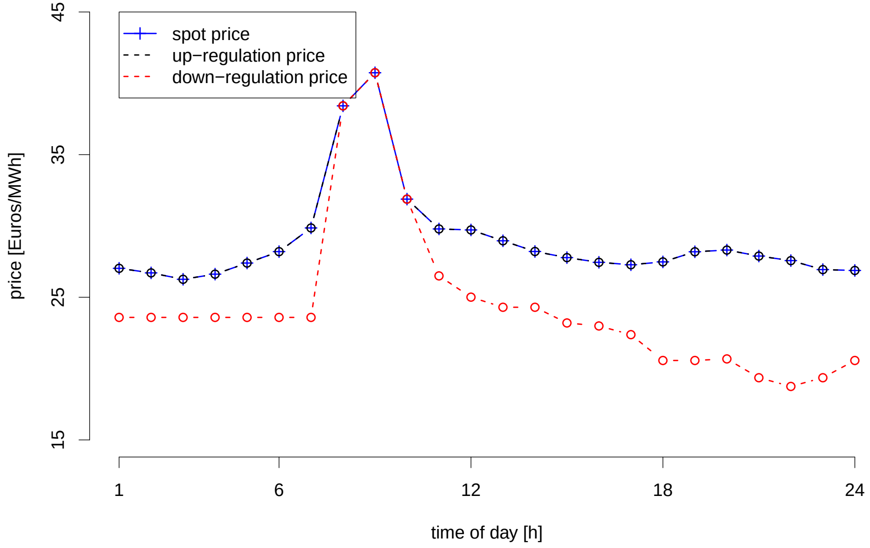
- **28 March 2016** - Comparing forecasts ($\hat{y}_i$, $i = 1, \ldots, 24$) and power measurements (y_i, $i = 1, \ldots, 24$)



- Is there a chance our revenue reduces due to balancing costs?

Balancing needs and prices

- **28 March 2016** - Nord Pool & Energinet data:



- Need for downregulation on most of the hours of the day

Rules for settlement after balancing

- Remember the basic rules of the two-price balancing system:
  - If producing *more than expected* ($y_i > \hat{y}_i$), each *extra* energy unit is sold at **down-regulation price**
  - If producing *less than expected* ($y_i < \hat{y}_i$), each *missing* energy unit is bought at **up-regulation price**
  - When the system is in balance, one simply buys (if $y_i < \hat{y}_i$) or sell (if $y_i > \hat{y}_i$) at the spot price λ^S
  - Only those putting the system off-balance are to be penalized!

- Resulting revenue from the balancing market:

$$R_{\mathrm{B}} = \sum_{j \in \mathcal{L}_{\mathrm{down}}} \lambda_j^{\downarrow} (y_j - \hat{y}_j) - \sum_{i \in \mathcal{L}_{\mathrm{up}}} \lambda_i^{\uparrow} (\hat{y}_i - y_i)$$

- From the graph in slide 7:

$$\mathcal{L}_{\mathrm{up}} = \{1, 2, \ldots, 6, 17, 18, \ldots, 24\}$$
$$\mathcal{L}_{\mathrm{down}} = \{7, 8, \ldots, 16\}$$

Balancing settlement

- Based on:
  - rules described in the previous slide
  - differences between hourly contracts and actual delivery
  - hourly balancing prices

  we can calculate balancing revenues and costs for every market time unit.

hour 1	-837.93 €	hour 7	684.11 €	hour 13	558.90 €	hour 19	-789.32 €
hour 2	-934.85 €	hour 8	1536.80 €	hour 14	1020.60 €	hour 20	-877.61 €
hour 3	-787.80 €	hour 8	1262.94 €	hour 15	997.60 €	hour 21	-613.58 €
hour 4	-1171.28 €	hour 10	318.80 €	hour 16	321.86 €	hour 22	-468.69 €
hour 5	-931.60 €	hour 11	132.50 €	hour 17	-272.80 €	hour 23	-188.58 €
hour 6	-423.00 €	hour 12	100.04 €	hour 18	-769.44 €	hour 24	-322.56 €

- This gives an **overall balancing cost** $R_{\mathrm{B}} = -2.454, 89€$
- And therefore a revenue for that day of $R_{\mathrm{DA}} + R_{\mathrm{B}} = 85.879, 60€$

- *Are you satisfied with your revenue?*

Understanding and analysing revenues

- The optimal revenue one could get from **BOTH**
  - day-ahead market, **AND**
  - balancing market

  is obtained if being able to offer your *actual* renewable energy generation to the day-ahead market...

$$\boxed{R^*_{\text{DA}} = R_{\text{DA}} + R_{\text{B}} = 86.627,50€, \qquad \text{(with } R_{\text{B}} = 0\text{)}}$$

- Let us then define a *performance ratio* for our trading strategies:

  $\gamma = (R_{\text{DA}} + R_{\text{B}})/R^*_{\text{DA}}$, $0 < \gamma < 1$ (then expressed in percentage)

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- The performance ratio for Strategy 1 ("Let's trust the forecast!") is $\gamma_1 = 99.1\%$ (quite good already since forecast error is low...)

- **Having perfect foresight will never happen** - Is there any other way to improve our revenue?
  - your proposal for a strategy no. 2 (*hint:* increase a bit your offer)
  - your proposal for a strategy no. 3 (*hint:* let's be bold)
  - etc.

Strategy 2

- We call it **"Let's tweak a bit the forecast!"**: makes a small adjustment to the forecasts, to reflect your gut feeling about potential balancing needs and costs
- Offers (E_i, $i = 1, \ldots, 24$) for the 28th of March then become

$$E_i = \tau \hat{y}_i, \quad i = 1, \ldots, 24$$

with τ close to 1.

- For instance with $\tau = 1.05$ (increase offers by 5%):

hour 1	135 MWh	hour 7	145 MWh	hour 13	167 MWh	hour 19	128 MWh
hour 2	117 MWh	hour 8	144 MWh	hour 14	133 MWh	hour 20	113 MWh
hour 3	101 MWh	hour 8	163 MWh	hour 15	118 MWh	hour 21	99 MWh
hour 4	123 MWh	hour 10	189 MWh	hour 16	117 MWh	hour 22	85 MWh
hour 5	139 MWh	hour 11	208 MWh	hour 17	122 MWh	hour 23	70 MWh
hour 6	143 MWh	hour 12	197 MWh	hour 18	130 MWh	hour 24	71 MWh

- The results from this trading strategy are:

$$R_{\mathrm{DA}} = 92.751,21€ \quad R_{\mathrm{B}} = -6.680,79€ \quad R_{\mathrm{DA}} + R_{\mathrm{B}} = 86.070,42€$$

$$\gamma_2 = 99.3\%$$

Strategy 3

- We call it **"Let's just be bold about it!"**: fully trust your gut feeling and push it to the bound...
- Offers (E_i, $i = 1, \ldots, 24$) for the 28th of March then become

$$E_i = 350\text{MWh}, \quad i = 1, \ldots, 24$$

- The results from this trading strategy are:

$R_{\text{DA}} = 243.449,50€$	$R_{\text{B}} = -156.822€$	$R_{\text{DA}} + R_{\text{B}} = 86.627,50€$
	$\gamma_3 = 100\%$	

(Isn't it a nice miracle?)

- This most certainly deserves a little discussion and explanation...

Key assumptions and issues

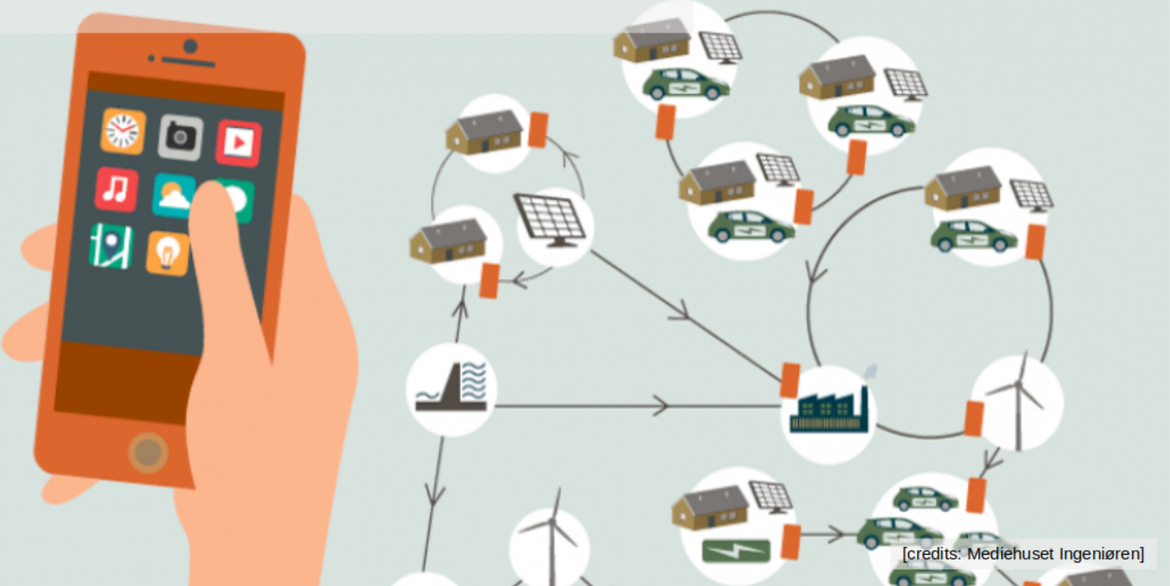
- In this practical example, we only illustrated the potential (monetary) consequences of our own decisions, all the rest being the same, i.e.,
  - prices (both day-ahead and balancing)
  - energy volumes
  - others' offering strategies
- *Is that realistic?* ...)
- Definition:

> A market participant is a **price taker** if his decisions and resulting offers (buying or selling) do not affect the market outcomes

You can then imagine what a **price maker** is...

- Also, **you will never know the balancing prices in advance!!!**

Use the self-assessment quizz to check your understanding!



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