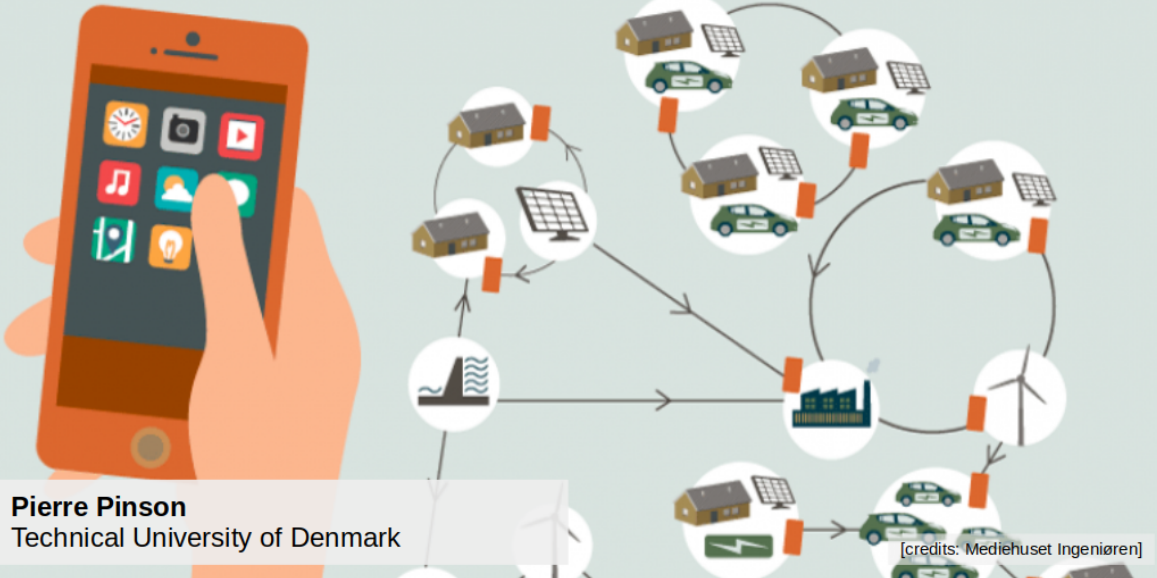
# Module 6 – Participation of Renewables in Electricity Markets

## 6.3 Offering renewable energy under uncertainty



**Pierre Pinson**
Technical University of Denmark

[credits: Mediehuset Ingeniøren]

# Remember the problem setup

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

# Remember the problem setup

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

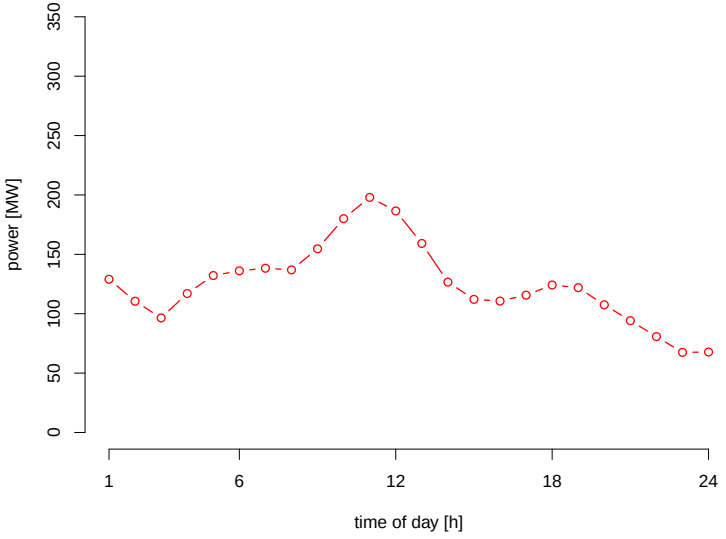
- And, the course responsible suggested you first invest in that *new-generation wind farm*...
  - **Nominal capacity**: 350 MW
  - Energy production sold through the **Nord Pool (Western Denmark area)**
  - **Balance responsibility**

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

# Remember the problem setup (2)

**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?*



# It is a newsvendor problem!

**Let us focus on a market time unit** $i$ (say, the hour between 13:00 and 14:00)

- Sets of prices:
  - day-ahead price: $\lambda_i^S$
  - downregulation price: $\lambda_i^{\downarrow}$
  - upregulation price: $\lambda_i^{\uparrow}$
- Why is it a newsvendor problem?
  - one decision to be made before gate closure (i.e., offer for various market time units)
  - actual renewable energy generation is uncertain
  - **WE ASSUME THAT** the marginal profit and loss are known...

$$\pi_i^+ = \lambda_i^S - \lambda_i^{\downarrow} \quad \text{(for any generated MWh above day-ahead schedule)}$$

$$\pi_i^- = \lambda_i^{\uparrow} - \lambda_i^S \quad \text{(for any lacking MWh w.r.t. day-ahead schedule)}$$

  - the aim definitely is to maximize expected profit!!

# Obtaining the optimal offer

- As for the "Roskilde ticket pusher" example, the optimal generation offer of the renewable energy producer for the market time unit $i$ is

$$\boxed{E_i^* = F_i^{-1}(\alpha^*)}$$

with

$$\alpha^* = \frac{\pi^+}{\pi^+ + \pi^-}$$

- The problem is... that we do not know $F$, $\pi^+$ and $\pi^-$

- We definitely need some forecasts (!), so that

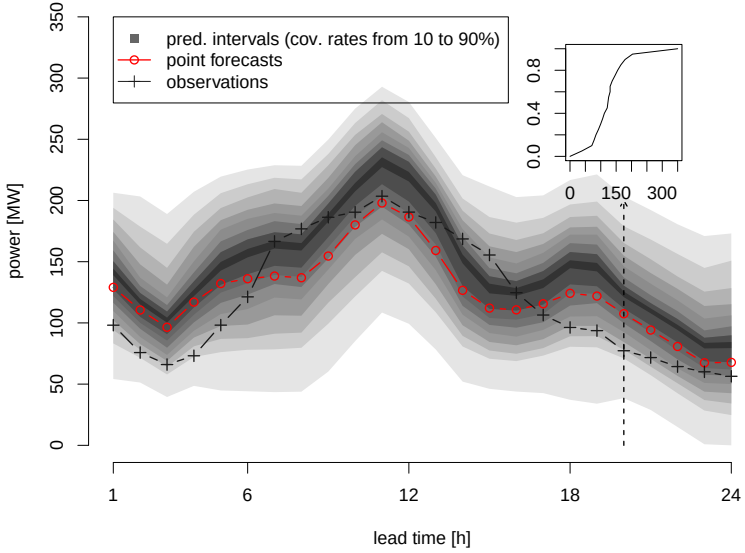
$$\boxed{E_i^* = \hat{F}_i^{-1}(\hat{\alpha}^*)}$$

with

- $\hat{F}_i$: a predicted distribution for renewable energy generation at time unit $i$
- $\hat{\alpha}_i^*$: a "predicted" optimal quantile based on forecasts for the marginal profit and loss $\hat{\pi}^+$ and $\hat{\pi}^-$

# We can get probabilistic renewable energy forecasts!

- *To be discussed more specifically in the next Modules...*




- In short, one can get a description $\hat{F}$ of the cumulative distribution function of renewable energy generation for every market time unit

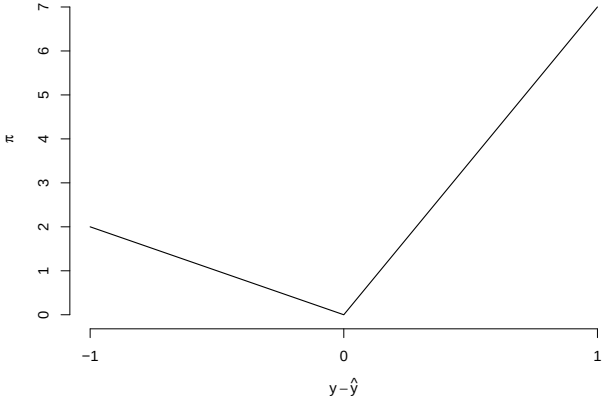
# And expert assessments/forecasts on market penalties

- The same forecast provider or your own market expert could give you a best guess on evolution of penalties for up- ($\pi^-$) and down-regulation ($\pi^+$)

- This can be represented as a general *loss function*, here with:

$$\begin{aligned} \pi_i^+ &= \lambda_i^S - \lambda_i^\downarrow \\ \pi_i^+ &= 7, \quad i = 1, \ldots, 24 \end{aligned}$$

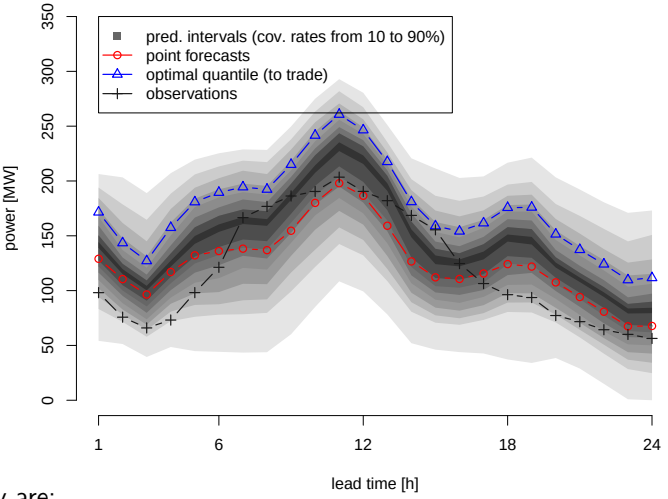
$$\begin{aligned} \pi_i^- &= \lambda_i^\uparrow - \lambda_i^S \\ \pi_i^- &= 2, \quad i = 1, \ldots, 24 \end{aligned}$$




- The optimal quantile to trade is that for which: $\alpha_i = \dfrac{7}{7+2} = 0.78, \ i = 1, \ldots, 24$

# Results for the newsvendor strategy

- The optimal quantile to trade can be extracted for each market time unit, individually
- Similar to other strategies, it tends to *offer more energy than what you expect to produce*




- The results from this trading strategy are:

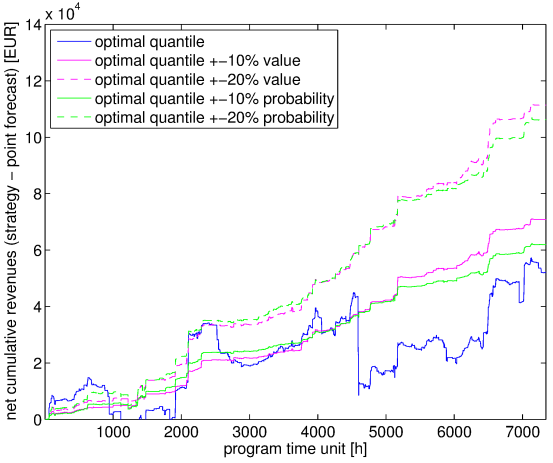
$$R_{\text{DA}} = 122.771,40€ \quad R_{\text{B}} = -36.030,97€ \quad R_{\text{DA}} + R_{\text{B}} = 86.627,50€$$

$$\gamma_{\text{newsvendor}} = 100\%$$

# Be ready for a bumpy ride...!

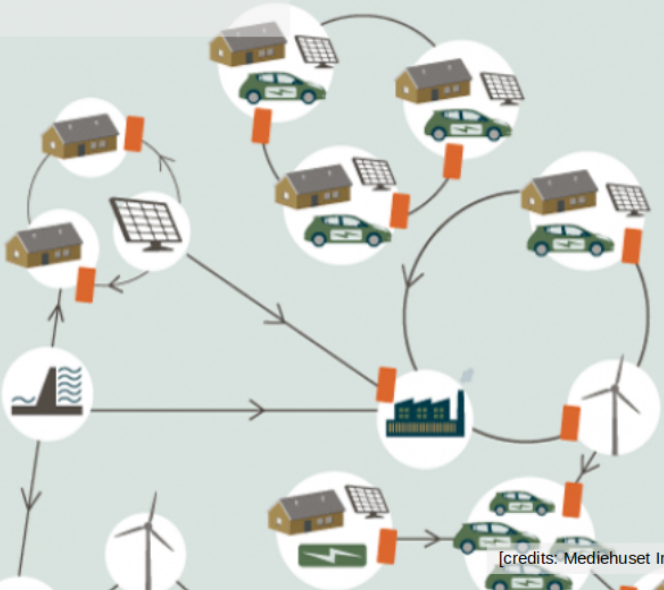
- The outcome of a "newvendor-type" offering strategy can highly fluctuate from one market time unit to the next, and from one day to the next
- Since being the optimal strategy *in expectation*, it is only best in the long run, under **A LOT of assumptions...**

- In practice, it was observed that this could lead to a bumpy ride
- Simple ways to control the "agressivity" of trading strategies (or account for risk-aversion) can be beneficial




[Source: M. Zugno et al. (2013) Trading wind energy on the basis of probabilistic forecasts both of wind generation and of market quantities. *Wind Energy* 16(6): 909-926]

**Use the self-assessment quizz to check your understanding!**



[credits: Mediehuset Ingeniøren]