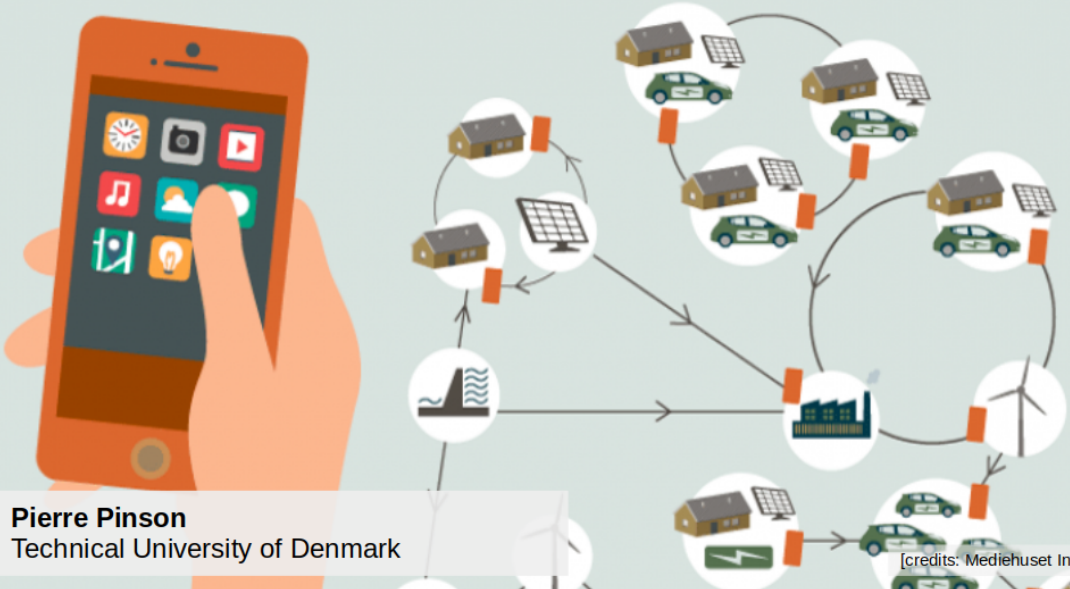
Module 7 – Introduction to Renewable Energy Analytics

7.3 Various types of forecasting products



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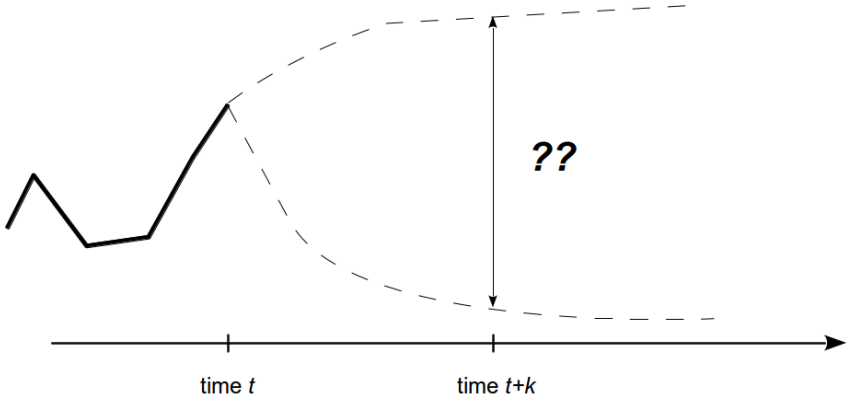
[credits: Mediehuset Ingeniøren]

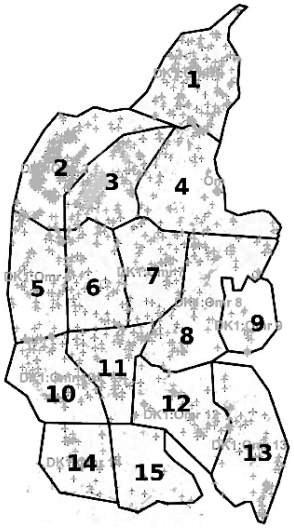
Forecast setup: Forecasting is about the future!

- The practical setup:
  - we are at time t (e.g., at 11am, placing offers in the market)
  - and interested in what will happen at time $t + k$ (any market time unit of tomorrow, e.g., 12-13)
  - k **is referred to as the lead time**
  - Y_{t+k}: the random variable "power generation at time $t + k$"



- A forecast is an estimate for time $t + k$, conditional to information up to time t...
- **This motivates the notation** $\hat{\cdot}_{t+k|t}$

For illustration: the Western Denmark dataset



Agg. zone	Orig. zones	% of capacity
1	1, 2, 3	31
2	5, 6, 7	18
3	4, 8, 9	17
4	10, 11, 14, 15	23
5	12, 13	10

Figure: The Western Denmark dataset: original locations for which measurements are available, 15 control zones defined by Energinet, as well as the 5 aggregated zones, for a nominal capacity of around 2.5 GW.

Point forecast: definition

A point forecast informs of the conditional expectation of power generation

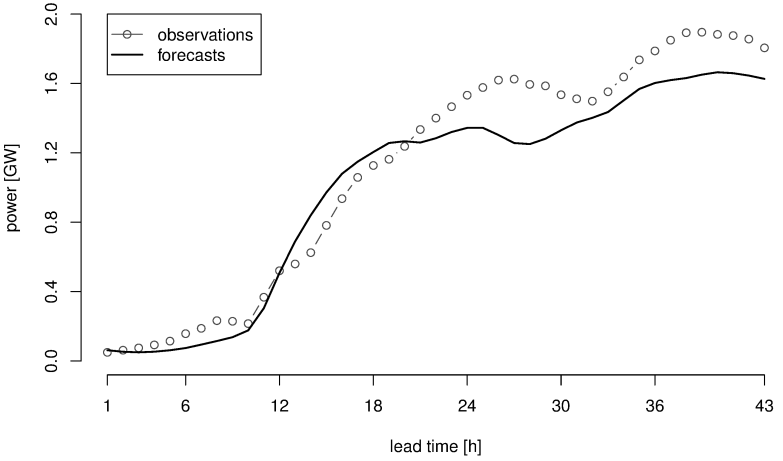
Mathematically:

$$\hat{y}_{t+k|t} = \mathbb{E}[Y_{t+k}|\Omega, M, \hat{\theta}]$$

given

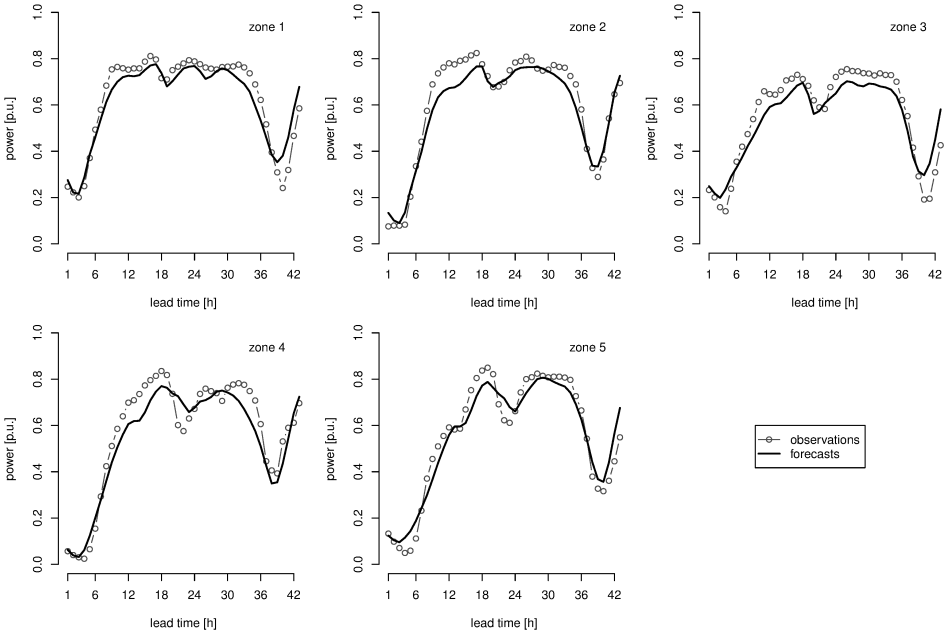
- the information set Ω
- a model M
- its estimated parameters $\hat{\theta}$

at time t



($\Omega, M, \hat{\theta}$ omitted in other definitions)

Point forecasting



Quantile forecast: definition

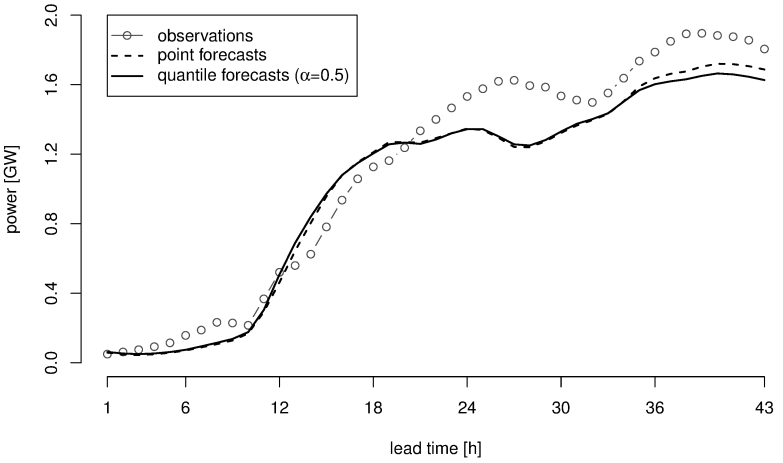
A quantile forecast is to be seen as a probabilistic threshold for power generation

Mathematically:

$$\hat{q}^{(\alpha)}_{t+k|t} = \hat{F}^{-1}_{t+k|t}(\alpha)$$

with

- α: the nominal level (ex: 0.5 for 50%)
- $\hat{F}$: (predicted) cumulative distribution function for Y_{t+k}



Prediction interval: definition

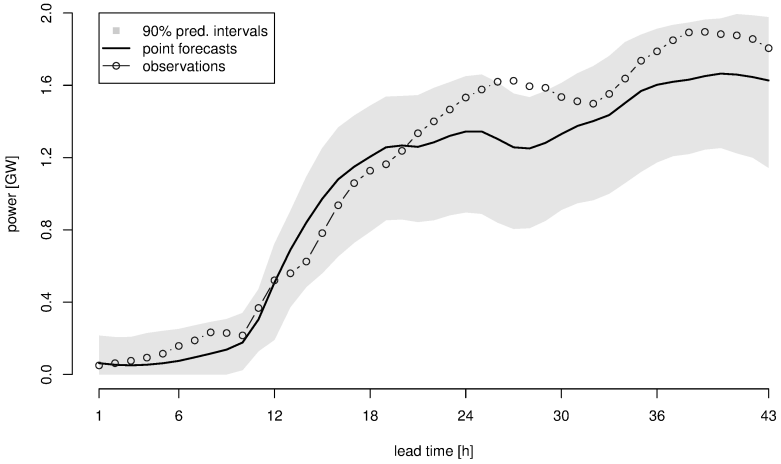
A prediction interval is an interval within which power generation may lie, with a certain probability

Mathematically:

$$\hat{I}_{t+k|t}^{(\beta)} = \left[\hat{q}_{t+k|t}^{(\underline{\alpha})},\ \hat{q}_{t+k|t}^{(\overline{\alpha})}\right]$$

with

- β: nominal coverage rate (ex: 0.9 for 90%)
- $\hat{q}_{t+k|t}^{(\underline{\alpha})}$, $\hat{q}_{t+k|t}^{(\overline{\alpha})}$: interval bounds
- $\underline{\alpha}$, $\overline{\alpha}$: nominal levels of quantile forecasts



Predictive densities: definition

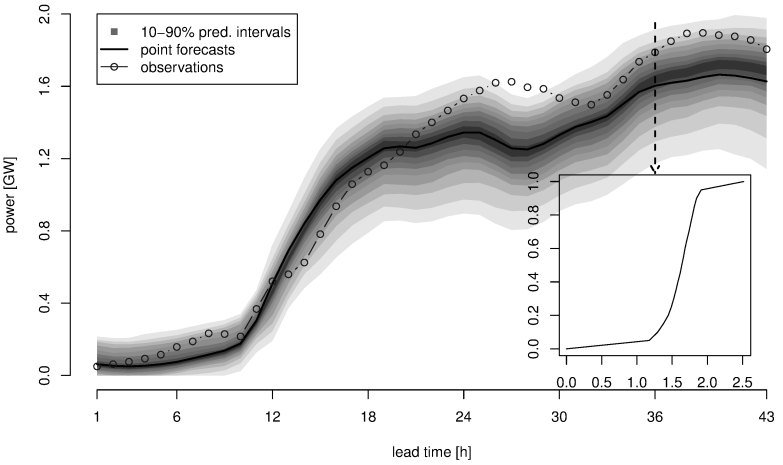
A predictive density fully describes the probabilistic distribution of power generation for every lead time

Mathematically:

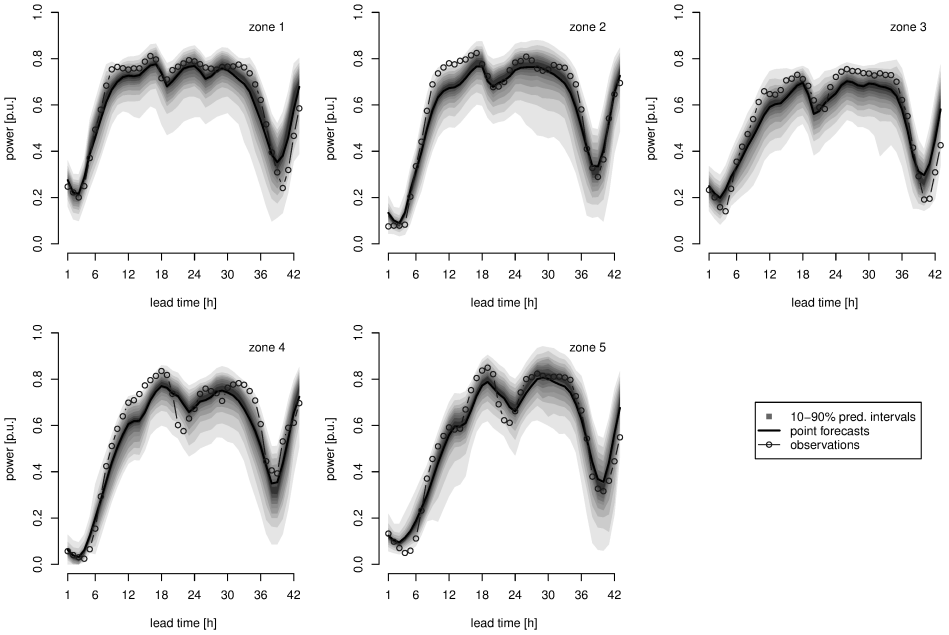
$$Y_{t+k} \sim \hat{F}_{t+k|t}$$

with

- $\hat{F}_{t+k|t}$: cumulative distribution function for Y_{t+k} (predicted given information available at time t)

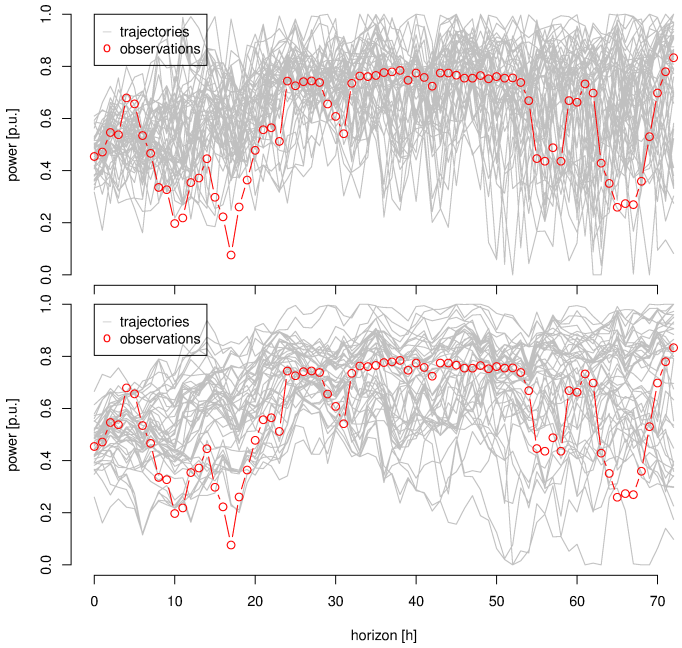


Predictive densities



The conditional importance of correlation

- almost no temporal correlation
- appropriate temporal correlation



Trajectories (/scenarios): definition

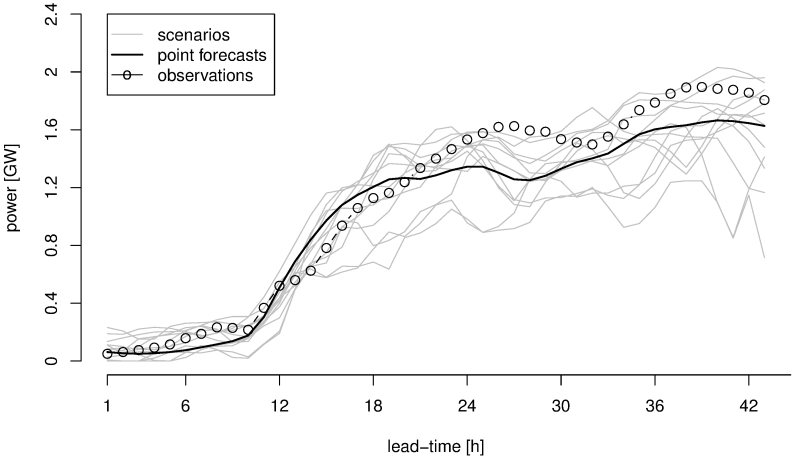
Trajectories are equally-likely samples of multivariate predictive densities for power generation (in time and/or space)

Mathematically:

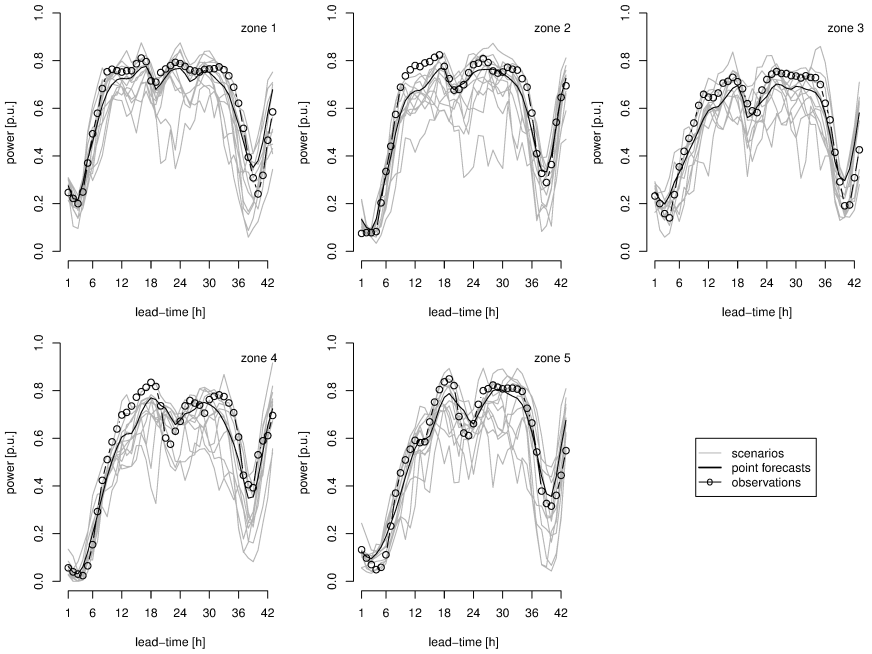
$$z_t^{(j)} \sim \hat{F}_t$$

with

- $\hat{F}$: multivariate predictive cdf for $\mathbf{Y}_t$
- $z_t^{(j)}$: the j^{th} trajectory



Space-time trajectories (/scenarios)



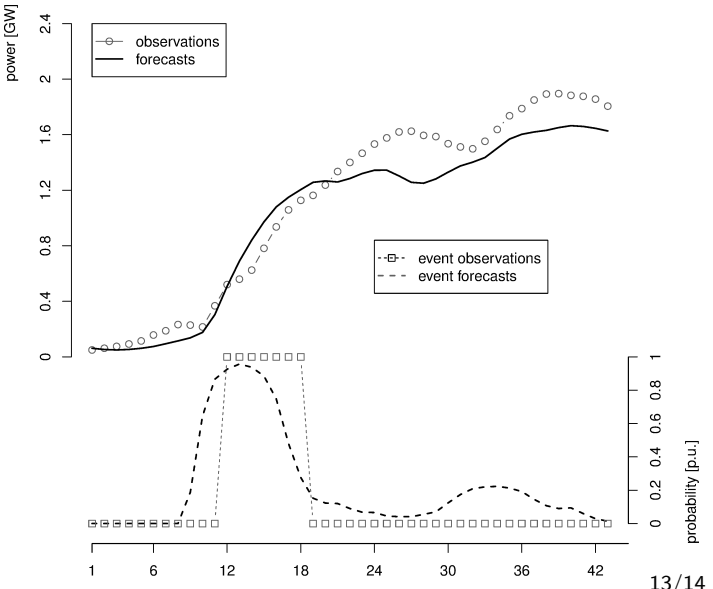
Bonus track: event-based forecasts!

Some decision-makers only want forecasts for user defined events

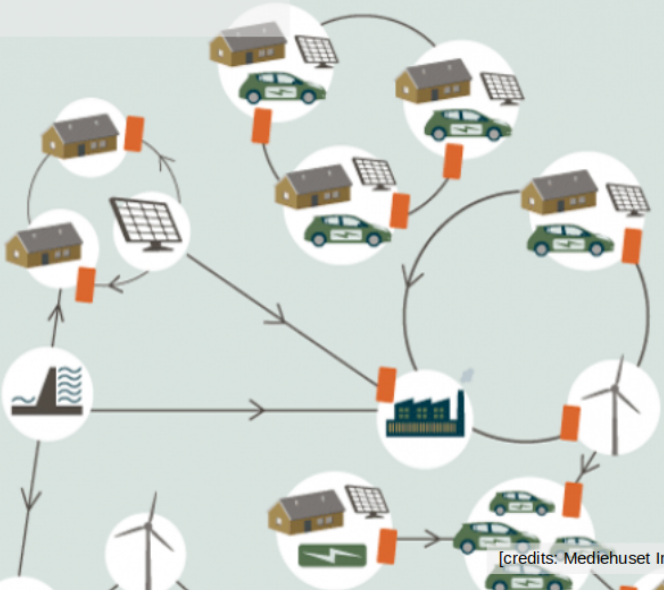
Examples are:

- ramp forecasts
- high-variability forecasts
- etc.

On the right: **probability of ramp forecasts (more than 500 MW swing in 6 hours)!**



Use the self-assessment quizz to check your understanding!



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