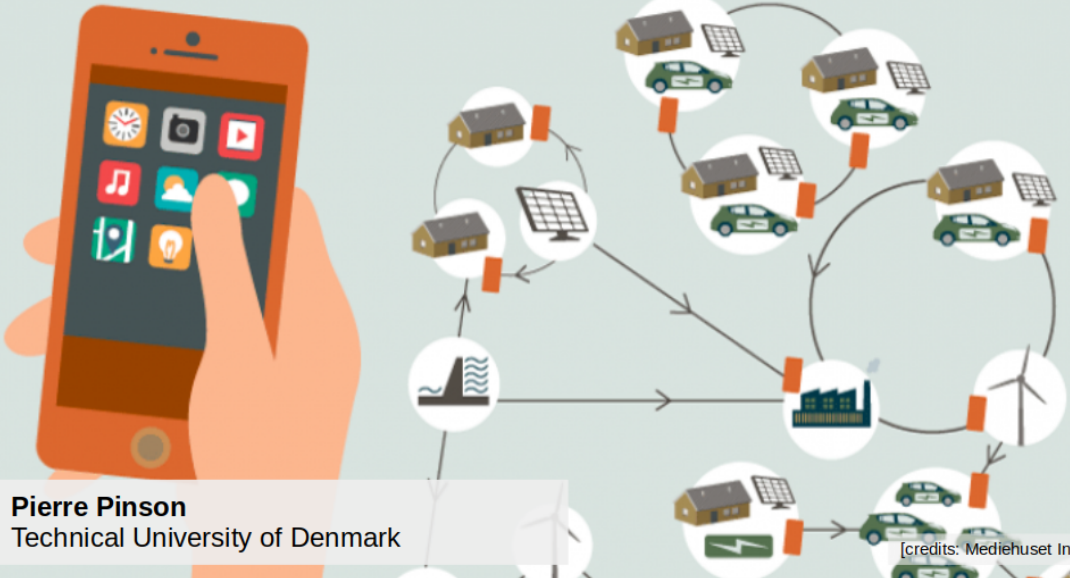
Module 8 – Verification of Renewable Energy Forecasts

8.1 What makes a good forecast?



Pierre Pinson
Technical University of Denmark

[credits: Mediehuset Ingeniøren]

The nature of "goodness" in forecasting

- Following Murphy (ref. and link below), the *nature of "goodness"* in weather forecasting (same goes for other types of forecasts) consists in:

The nature of "goodness" in forecasting

- Following Murphy (ref. and link below), the *nature of "goodness"* in weather forecasting (same goes for other types of forecasts) consists in:
    - **Forecast consistency**:

"Forecasts should correspond to the forecaster's best judgement on future events, based on the knoweldge available at the time of issuing the forecasts"

The nature of "goodness" in forecasting

- Following Murphy (ref. and link below), the *nature of "goodness"* in weather forecasting (same goes for other types of forecasts) consists in:

  - **Forecast consistency**:

"Forecasts should correspond to the forecaster's best judgement on future events, based on the knoweldge available at the time of issuing the forecasts"

  - **Forecast quality**:

"Forecasts should describe future events as good as possible, regardless of what these forecasts may be used for"

The nature of "goodness" in forecasting

- Following Murphy (ref. and link below), the *nature of "goodness"* in weather forecasting (same goes for other types of forecasts) consists in:

  - **Forecast consistency**:

"Forecasts should correspond to the forecaster's best judgement on future events, based on the knoweldge available at the time of issuing the forecasts"

  - **Forecast quality**:

"Forecasts should describe future events as good as possible, regardless of what these forecasts may be used for"

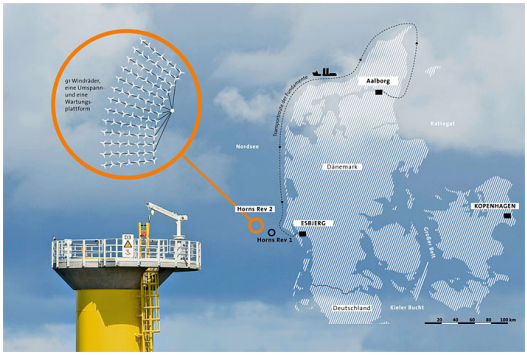
  - **Forecast value**:

"Forecasts should bring additional benefits (monetary or others) when used as input to decision-making"

[Extra reading:
AH Murphy (1993). What is a good forecast? An essay on the nature of goodness in weather forecasting. *Weather and Forecasting* **8**: 281–293 (pdf)]

Illustrative example (1)

- You are in charge of **optimal maintenance planning at Horns Rev**, and have booked both a vessel and an helicopter for onsite service (for a cost of 100.000€)
- The conditions for this to happen at time $t + k$ are
  - wind speed: $u_{t+k} \leq 15$ m.s^{-1}
  - wave height: $h_{t+k} \leq 1.8$ m



- 24 hours before service (time t), this is your last chance to cancel before huge financial penalties (another 100.000€)
- Your two forecasters (*Foresight* and *Blindspot*) tell you that:

	Foresight	*Blindspot*
$\hat{u}_{t+k\|t}$	12.6 m.s^{-1}	3.4 m.s^{-1}
$\hat{h}_{t+k\|t}$	1.6 m	0.2 m

- In both cases, you go ahead with the planned service...

Illustrative example (1, continued)

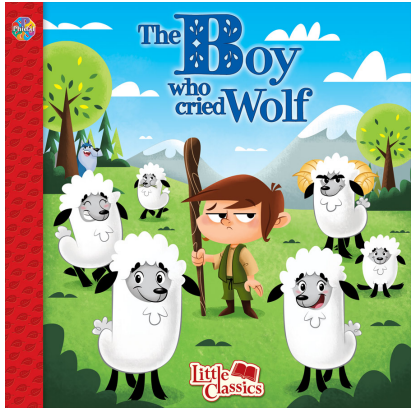
- At time $t + k$, this is what actually happened:

	Foresight	Blindspot
$\hat{u}_{t+k\|t}$	12.6 m.s^{-1}	3.4 m.s^{-1}
$\hat{h}_{t+k\|t}$	1.6 m	0.2 m
u_{t+k}	12.3 m.s^{-1}	
h_{t+k}	1.45 m	

- In both cases, your overall cost is 100.000€,
- Both *Foresight* and *Blindspot* served their purpose, since you made the right decision... **Forecast value is good**
- You might want to have a chat with *Blindspot*, since its **forecast quality appears to be far from good!**

Illustrative example (2)

The boy who cried wolf (Tale from Ancient Greece) - revisited.



- ROGUE TRADING® made huge losses last year, due to expensive upregulation events...
- It is therefore decided to get a new forecaster that would be good at predicting them
- *Foresight* and *Blindspot* are in competition for the job

- The score is simple:

$$\text{Sc} = 100 \cdot \frac{\#\{\text{events leading to upregulation predicted}\}}{\#\{\text{events leading to upregulation}\}}$$

- the higher the better! (0 is worst, 100 is best)

Illustrative example (2, continued)

If you were *Foresight* and *Blindspot*, what would you do?

Illustrative example (2, continued)

If you were *Foresight* and *Blindspot*, what would you do?

- The two competitors have sharpened their strategy:

	Foresight	*Blindspot*
Strategy	Always predict need for upregulation!	Do your best to find when upregulation will occur...

- The results on the benchmarking exercise are such that:
  - #{market time units} = 8760
  - #{events leading to upregulation} = 3237
  - #{events leading to upregulation predicted by Foresight} = 3237
  - #{events leading to upregulation predicted by Blindspot} = 2500
- Their scores:

	Foresight	*Blindspot*
Sc	100%	77.2%

Illustrative example (2, continued)

If you were *Foresight* and *Blindspot*, what would you do?

- The two competitors have sharpened their strategy:

	Foresight	*Blindspot*
Strategy	Always predict need for upregulation!	Do your best to find when upregulation will occur...

- The results on the benchmarking exercise are such that:
  - #{market time units} = 8760
  - #{events leading to upregulation} = 3237
  - #{events leading to upregulation predicted by Foresight} = 3237
  - #{events leading to upregulation predicted by Blindspot} = 2500
- Their scores:

	Foresight	*Blindspot*
Sc	100%	77.2%

- *Foresight* **gets the job!**

Illustrative example (2, continued)

- The consequences are:
  - even though never missing on upregulation events, ROGUE TRADING® will always miss the down regulation ones
  - eventually, the financial loss may still be there... and possibly much higher than expected

Illustrative example (2, continued)

- The consequences are:
  - even though never missing on upregulation events, ROGUE TRADING® will always miss the down regulation ones
  - eventually, the financial loss may still be there... and possibly much higher than expected
- A more **consistent** way to evaluate these forecasters would be to consider:

	event *happens*	*no* event
event *predicted*	**HIT**	**FALSE ALARM**
event *not predicted*	**MISS**	**CORRECT REJECTION**

- And a *proper* score, ensuring forecast consistency, is:

$$\mathrm{Sc} = 100 \cdot \frac{\#\{\text{hits}\}}{\#\{\text{hits}\} + \#\{\text{misses}\} + \#\{\text{false alarms}\}}$$

- The higher the better! (0 is worst, 100 is best)
  (This score is called the *Threat Score* (TS))

Illustrative example (2, continued)

- In the present case:

	Foresight	*Blindspot*
#{hits}	3237	2320
#{misses}	0	917
#{false alarms}	5523	180
#{correct rejections}	0	5343

- The resulting *Threat Score* (TS) values are:

	Foresight	*Blindspot*
TS	36.9%	67.9%

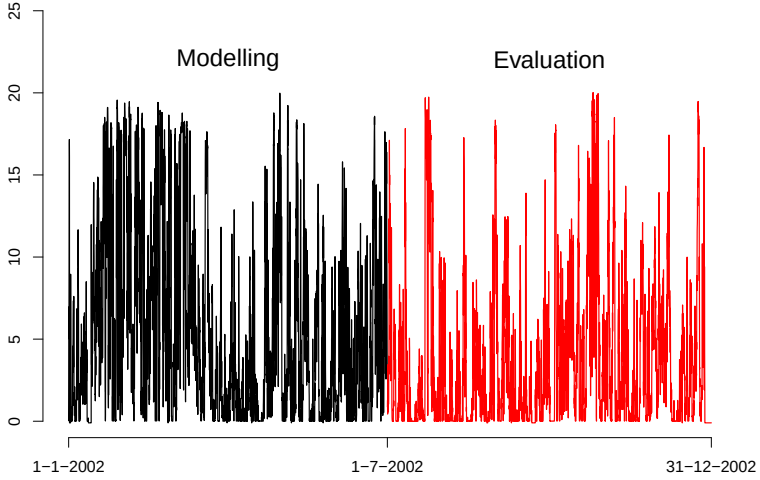
- **Conclusions:** if using a proper score...
  - *Blindspot* should have gotten the job!
  - I can promise that ROGUE TRADING® would have lower financial losses

Test case: the Klim wind farm

- The wind farm:
  - *full name*: Klim Fjordholme
  - *onshore/offshore*: onshore
  - *year of commissioning*: 1996
  - *nominal capacity* (P_n): 21 MW
  - *number of turbines in farm*: 35
  - *average annual electricity generation*: 49 GWh
  - *data available*: 1999-2003 (for some researchers)
  - *temporal resolution*: 5 mins, and hourly averages
  - *forecasts*: deterministic and probabilistic
- A link to the online description: Vattenfall's Klim wind farm
- The wind farm has been recommissioned recently: NordJyske online article

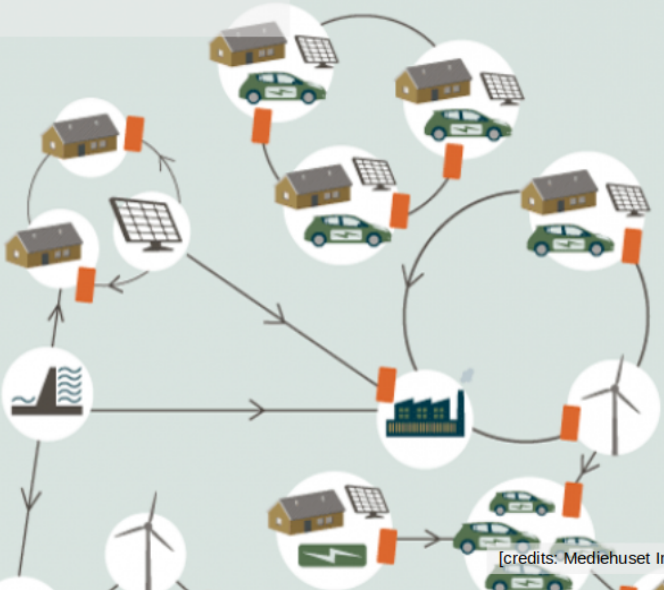
Splitting of available data

- Forecasting is about
  - being able to predict future events, in new situations
  - not only explain what happen in the past...
- **One need to verify forecasts on data that has not been used for the modelling!**



- In this Module we focus on the last 6 months of 2002, with other examples for some other periods

Use the self-assessment quizz to check your understanding!



[credits: Mediehuset Ingeniøren]