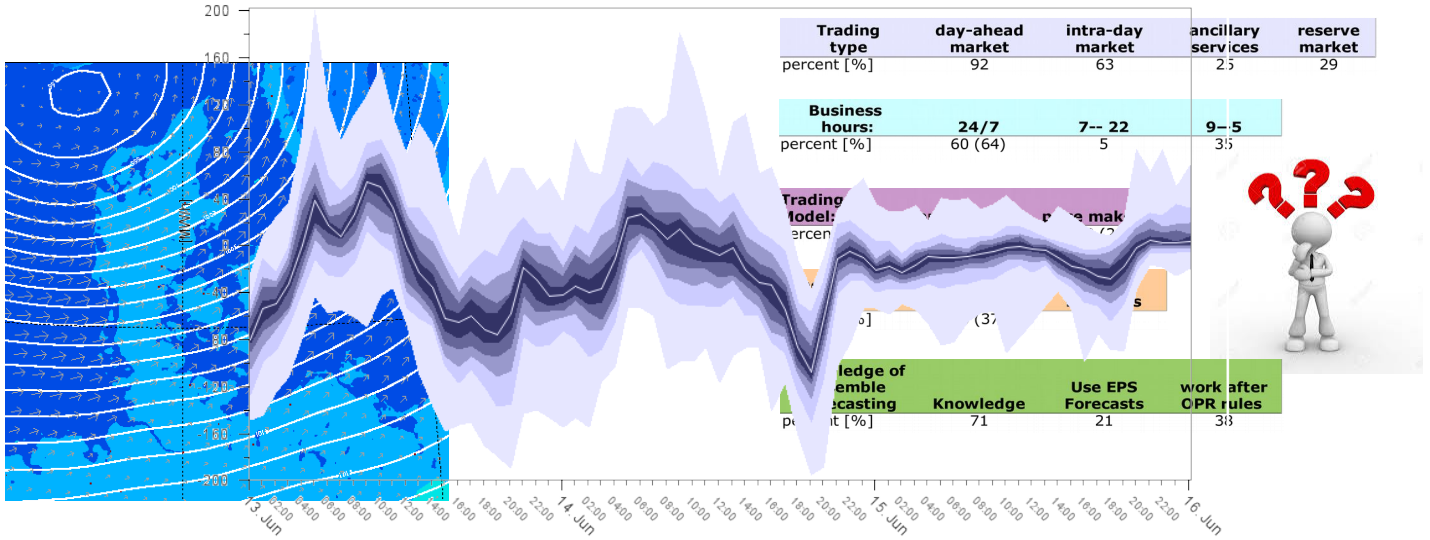
UVIG FORECASTING TUTORIAL - APPLYING METEOROLOGY IN POWER SYSTEM PLANNING AND OPERATIONS



Applications and Value of Uncertainty Forecasts

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...presented work is part of...

IEA Wind Task 36

Wind Power Forecasting

...investigations...

Task Objective is to encourage improvements in:
1) weather prediction
2) power conversion
3) use of forecasts

Task Organisation is to encourage international collaboration between:
- Research organisations and projects
- Forecast providers
- Policy Makers
- End-users and stakeholders

Task Work is divided into 3 work packages:
WP1: Weather Prediction Improvements inclusive data assimilation
WP2: Development of a benchmarking platform & best practice guidelines
WP3: Communication of best practice in the use of wind power forecasts

Questions that I want to answer….

What is the value of a forecast and how can we determine it ?

Interpretation of the results from the use of forecast uncertainty in the power business in the IEA Wind Task 36

What have we learned so far

What are the challenges that come with higher penetration levels

Some explanatory examples...

What is the value of forecasting

Determinsitic forecasting

Cost of the forecasts versus “not having a forecast”

Traditionally statistical metrics (MAE, RMSE, BIAS, STDV) are used to define “skill”

Maturity of markets, increased penetration of RES call for other products:

Uncertainty forecasts:

Quantifying value is more complex due to more complex structures & applications

Statitical tests are now used to define “reliability”, “sharpness” and “resolution”

Evaluation is then more a “process check-up” with help of decision support tools

Where does the complexity of todays power markets stem from ?

Grid security

Market

Balancing

1-6 days
Price FC
Capacity Plan
Unit commitment
Daily probability

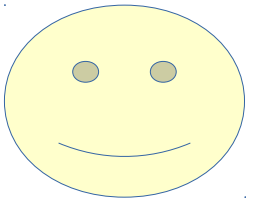
7-30 days
Futures
Weekly
Probability

Intraday Market
Max accuracy

Day Ahead Market
Smooth FC

Enduser Optimization
Probability intervals

Decision Making



Measurement Quality Control
Independence

IEA Wind Task 36 setup of industry interviews

Questions were separated into 2 categories:

General character to identify:

→ the type of business

→ the size of the organisation

→ the span of the business processes

→ the possible existing barriers

Forecasting & uncertainty to identify:

→ the forecasting products used today

→ the knowledge & awareness of probabilistic products

→ the challenges that hinder the implementation of new products

Get a broad overview of state-of-the-art use of forecasting and uncertainty in the power market

Interview & Questionnaire Results: Use of Forecasting…

Trading type	day-ahead market	intra-day market	ancillary services	reserve market
percent [%]	92	63	25	29

Business hours:	24/7	7-- 22	9—5
percent [%]	60 (64)	5	35

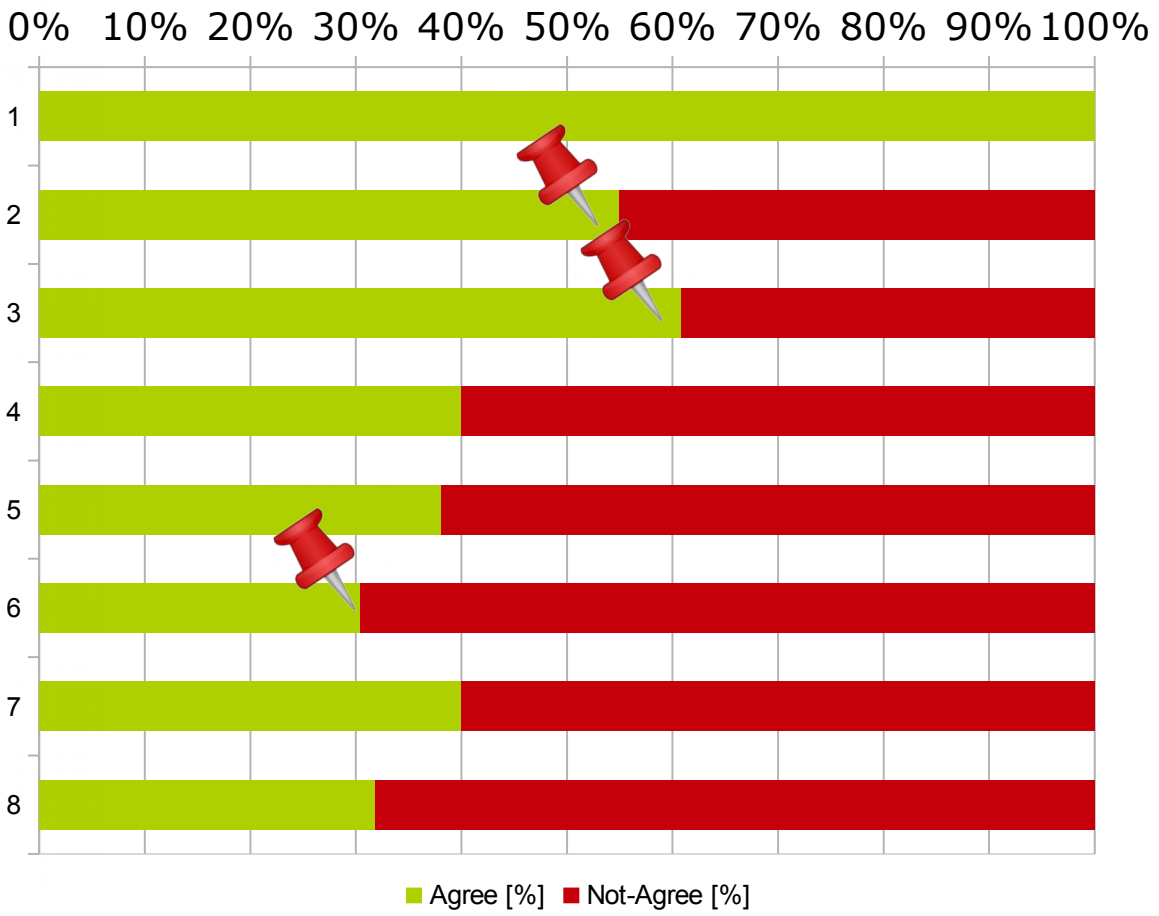
Trading Model:	price taker	price maker
percent [%]	78 (80)	22 (20)

Type of forecast	single forecast	multiple forecasts
percent [%]	36 (37)	68

Knowledge of Ensemble Forecasting	Knowledge	Use EPS Forecasts	work after OPR rules
percent [%]	71	21	38

Results: Statements about uncertainty in the power market

Question
Weather is one out of many uncertainty sources
Insufficient knowledge about tools and approaches
Fear of that speculative planning may result in a loss
Lack of staff to undertake the job
Lack of IT solution(s)
More information may lead to slower decision making and loss of important time
Flexibility in real-time staff resources would be desirable, but is not feasible
Company has access to confidential market information and is not allowed to speculate



How do we have to interpret these results?

- ➔ considerable **lack of knowledge** about tools and applications to deal with uncertainty
- ➔ **gap in understanding** existing solutions & relating them to solve "own" problems
- ➔ still a **mistrust** towards uncertainty information
- ➔ still **wrong perception** of probabilistic/uncertainty forecasts associated with speculation
- ➔ **big data: no concern** for overwhelming amounts of information, but **rather lack of understanding**

Develoment of Uncertainty Forecasting: awareness and usage

Year 2011

DoE study[1] led by ALSTOM

33 system operators in 18 countries

Only 25% of respondents ranked importance of probabilistic forecast as HIGH

→ the lowest percentage of all the forecasting products

→ reason: no experience in dealing with probabilistic information?

→ recommendaton: research required!

Year 2016

IEA Task 36 Wind Energy Forecasting

WP3.1 with 30+11 participants

Probabilistic/Uncertainty forecasts

70% know something about

25% use it

Users of uncertainty forecasts are:

→ countries with high penetration level

> 30%

→ island grids

Why and where should uncertainty forecasts be used?

Meteorology;

→ Traditionally in "decision making" to safe human life

Power Industry:

- New: in "decision making" to act more safe and economic
- Grid management → situational awareness
  → unit commitment
  → balancing
  → reserve allocation
- Trading & balancing
- Operation & Monitoring

Why use Uncertainty forecasts ?

Susan Joslyn at the University of Washington and her research group have found some stunning results:

Lab experiments showed:

→ Decision making with probabilistic information is always better

→ Type of uncertainty forecast and appropriate communication is crucial

When forecast is off multiple times:

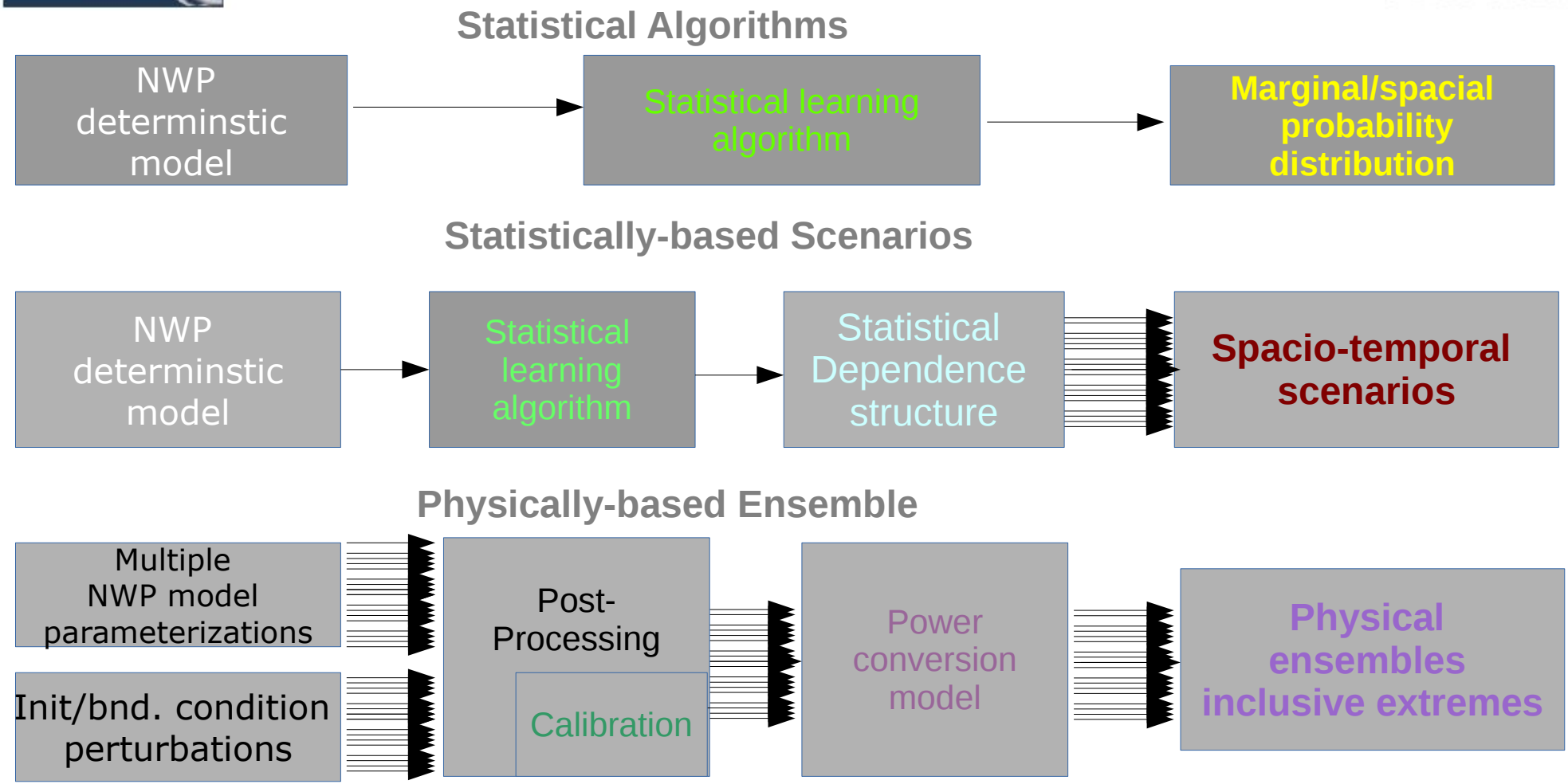
using deterministic information, people loose trust and stop acting

using probabilistic information people kept focus and confidence

IEA Task 36 Interviews confirmed:
"when we get confused we let the automatic system take the decsions"

* http://depts.washington.edu/forecast/

What type of methodologies are available for uncertainty forecasts



Attention not every method fits all purposes

Examples of Uncertainty Applications in the Power Sector

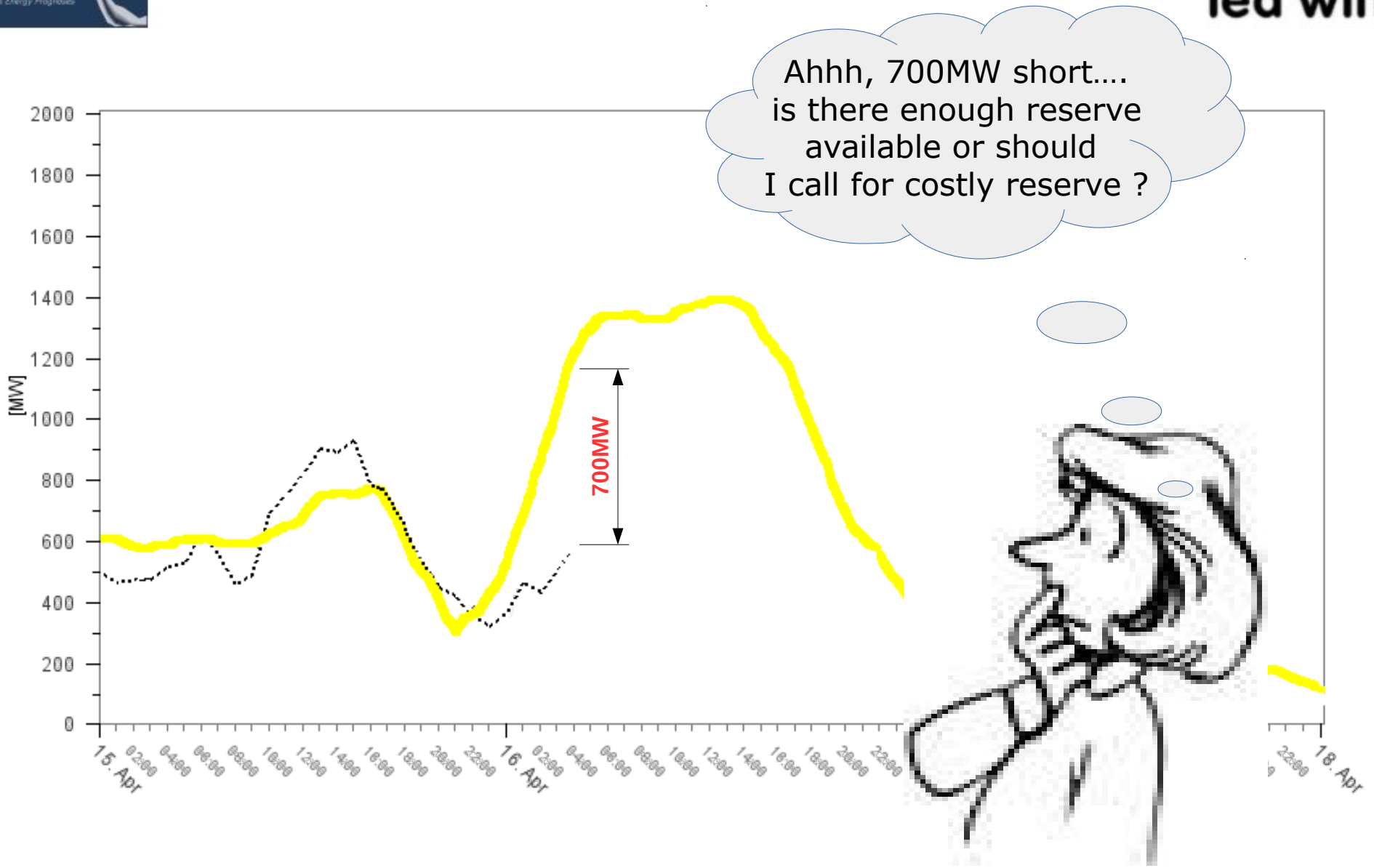
Balancing/Trading of wind/solar power

Reserve Forecasting

Situational Awareness

High-Speed shut down warning system

Example: what do we do, when the forecast is off ?



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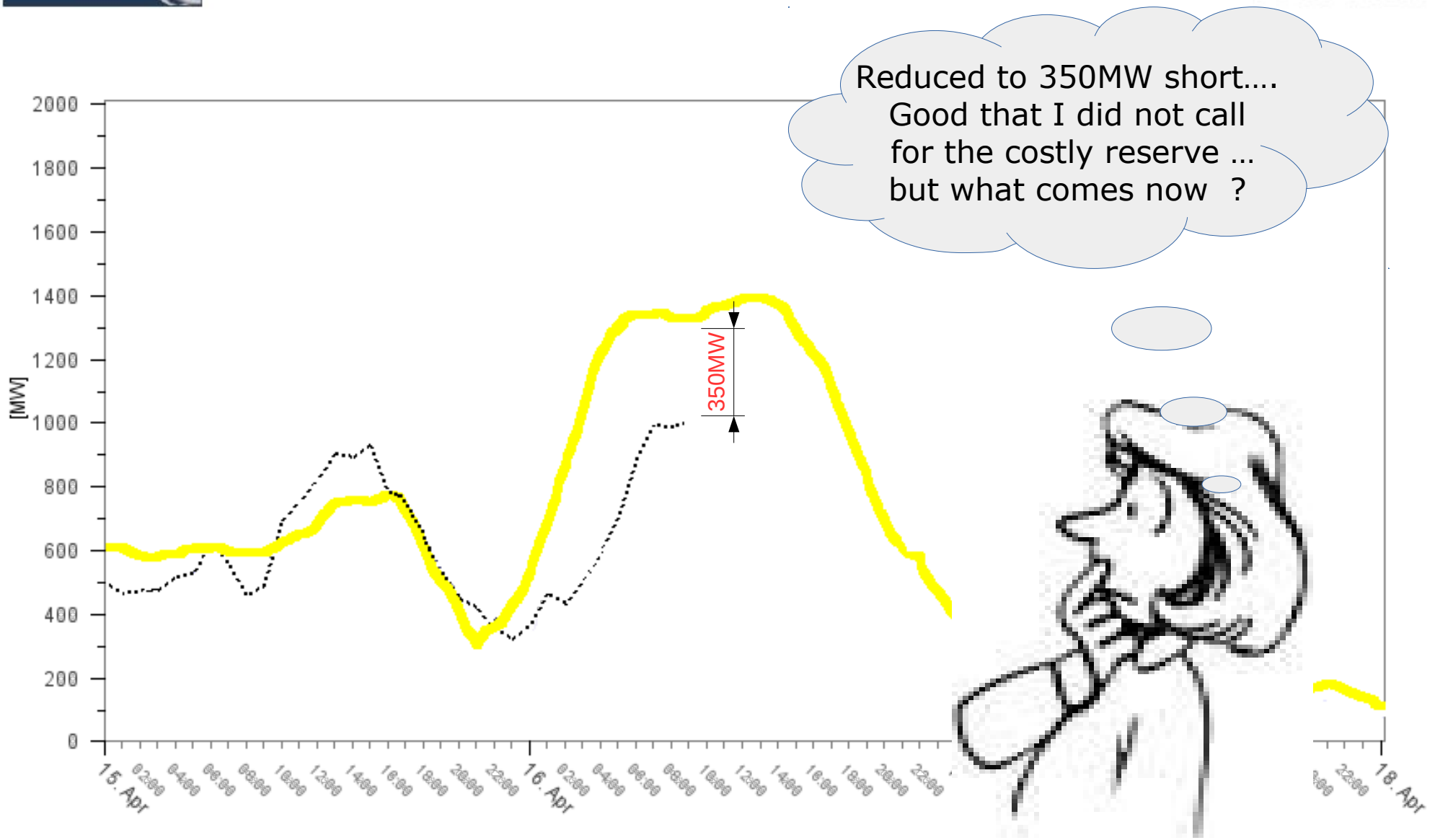

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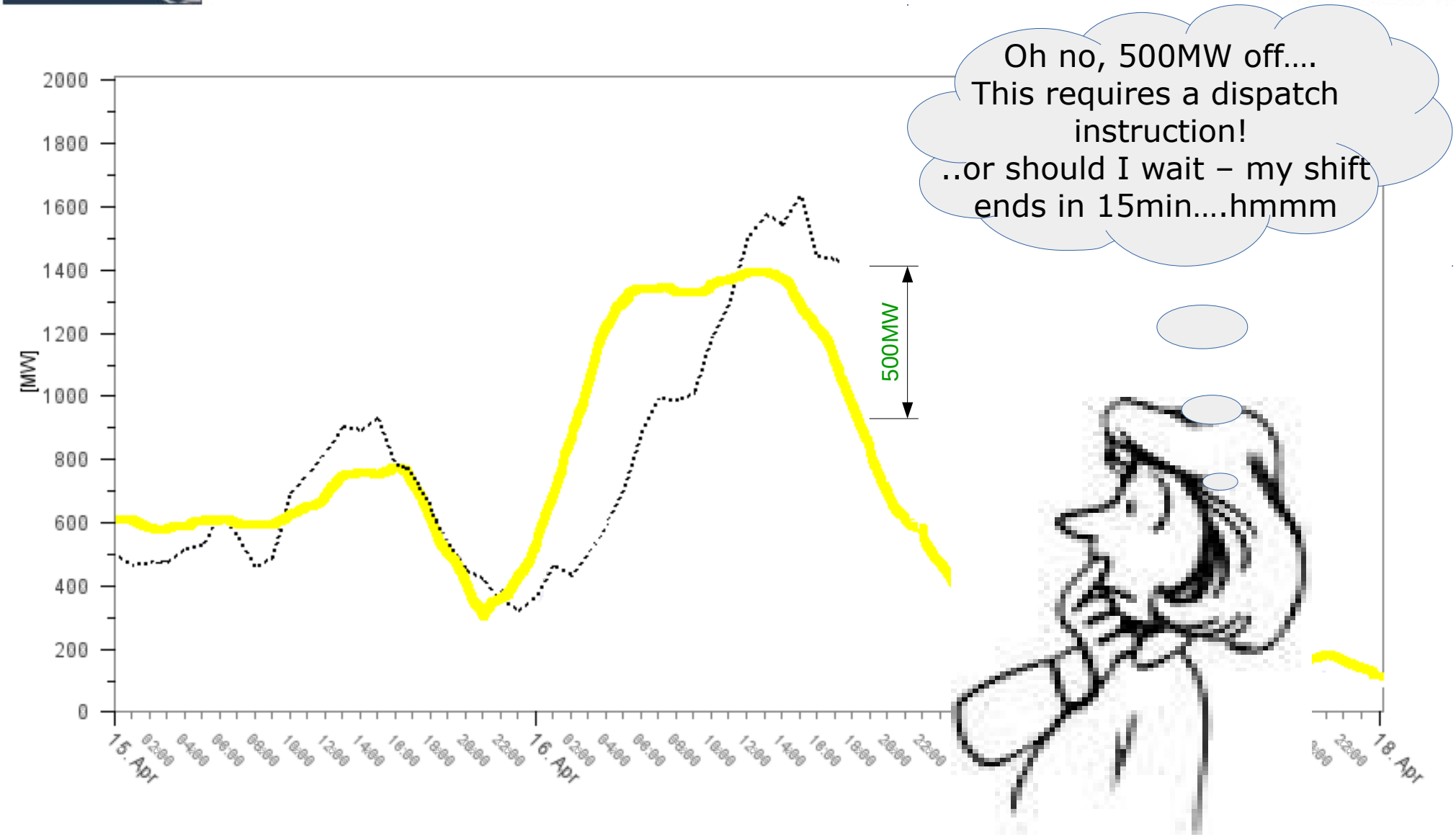
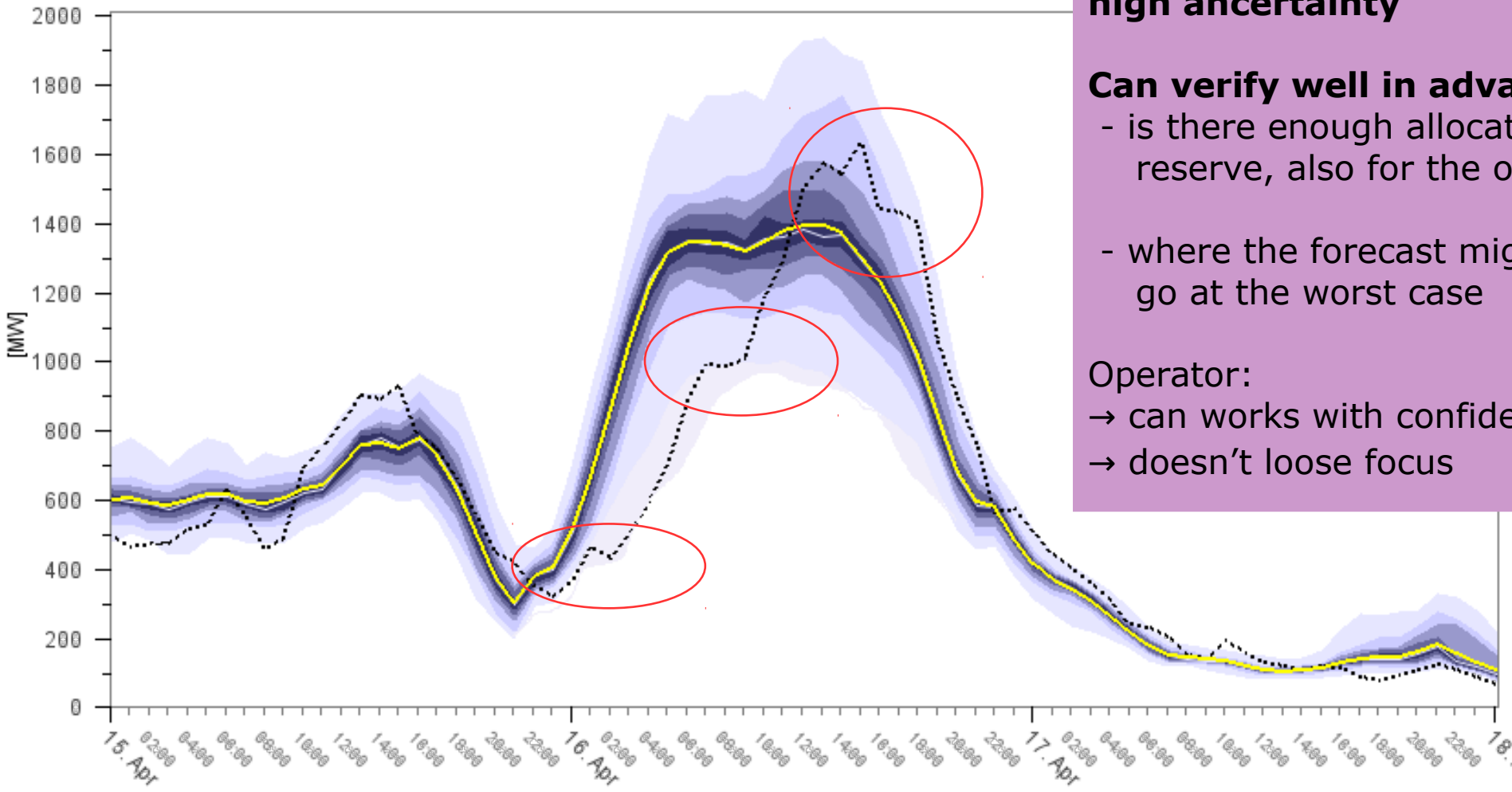


Example having uncertainty intervals at hand!



In all 3 cases, the operator

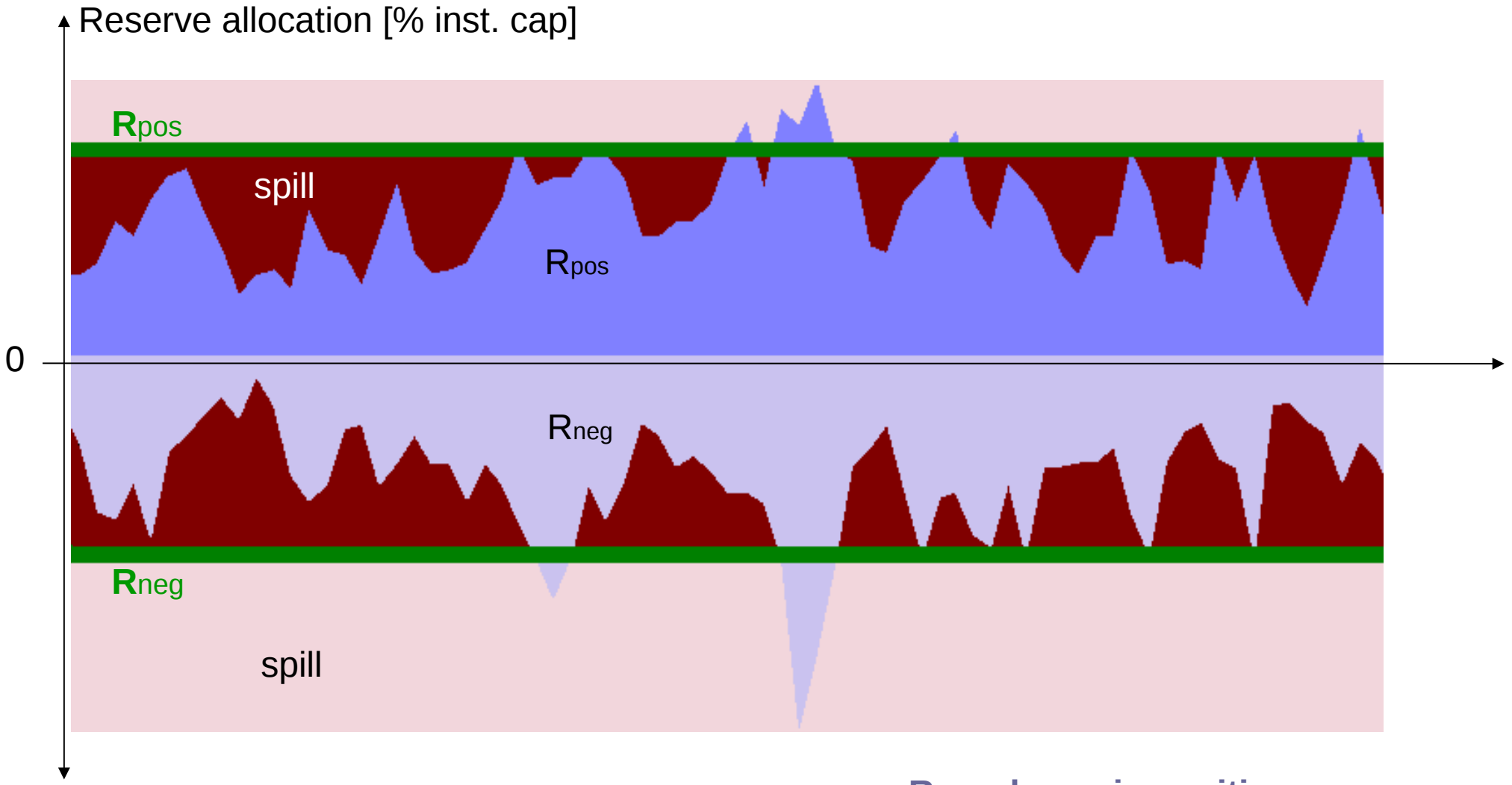
is aware of a time slot with high ancertainty

Can verify well in advance:
- is there enough allocated reserve, also for the outliers ?

- where the forecast might go at the worst case

Operator:
→ can works with confidence
→ doesn't loose focus

Why we need uncertainty forecasts to be able to allocate dynamic reserves



Rpos: dynamic positive reserve

Rneg: dynamic negative Reserve

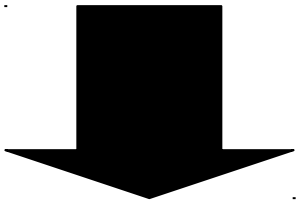
Rpos/Rneg: static reserve allocation

spill

Definition of Error Conditions for Reserve Allocation

- Without defining the target for the error allowance, forecasts of dynamic reserve will disappoint...

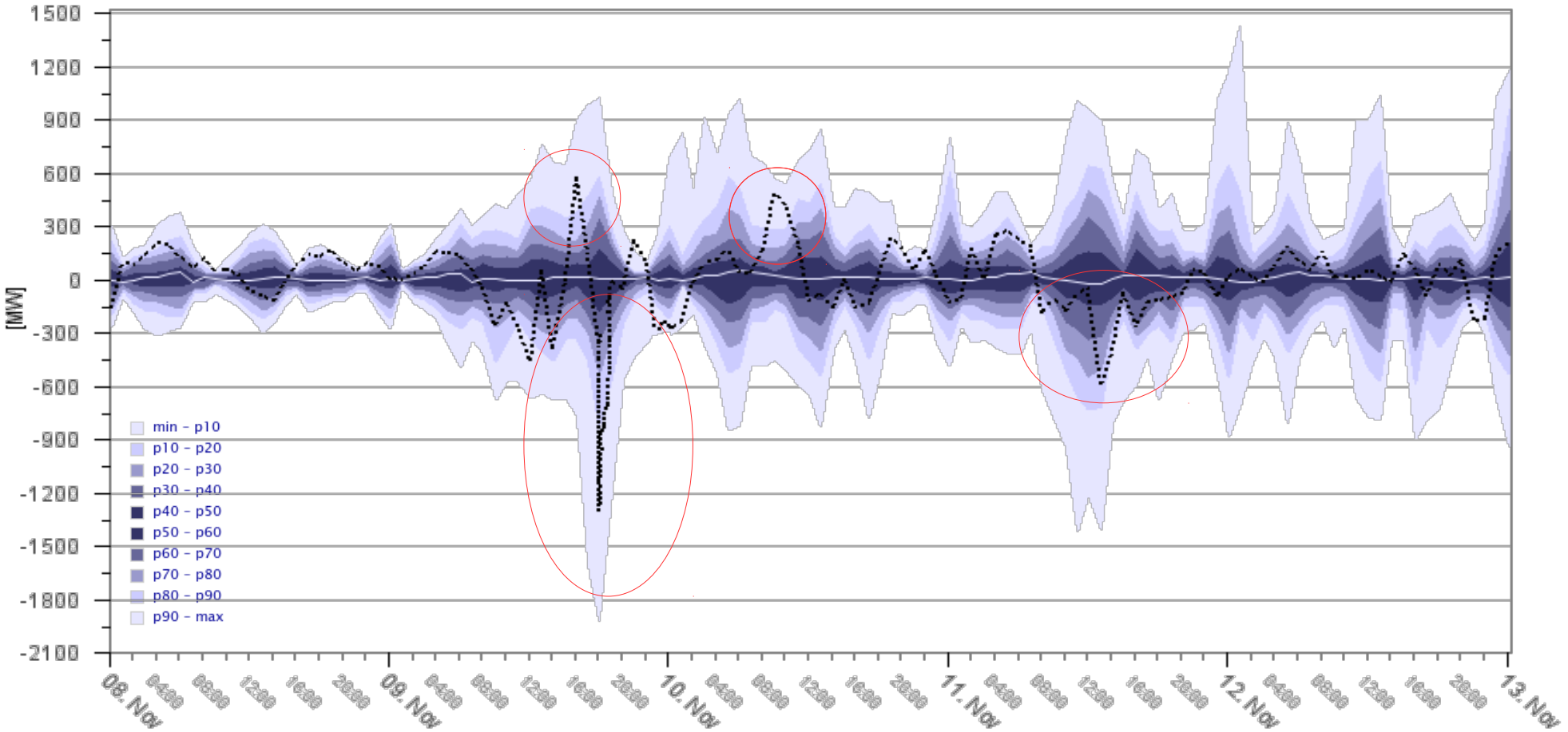
If we want to reduce costs and ensure that there is always enough available reserves



Questions to be asked for the design of reserve forecasts:

How many failures can be tolerated ?
What is the allowed maximum error ?
Which frequency of reserve under/over-prediction is allowed ?
What is the cost of spilled reserve ?

A real example:
Definition of uncertainty bands and extreme value probabilities also need to be visible to the operators



Static reserve allocation generates a lot of spill and still does not cover outliers

Uncertainty bands are useful to define dynamic allocation ==> percentiles

Do not forget the outliers and how to setup warnings for them!!!

What are the pre-requisites when starting to develop dynamic reserve predictions

Use the correct type of ensemble data input

- Physical NWP ensemble: e.g. multi-scheme approach
- deterministic reserves do not provide uncertainty
- it is the weather uncertainty that generates the errors

Clear definition of the forecast objective

- which types of errors are critical
- how to handle outliers
- what type of reserve fits to my objective:
  typical scenarios are: static, security or dynamic/economic

Define the time scales that needs to be forecasted

- required ramping capabilities

Request forecast uncertainty of all weather dependent sources & sinks

- built the uncertainty term on load+wind+solar

Define a “noise term” to handle the non-local imbalances

- imbalances from interconnections (small system <-> large system)

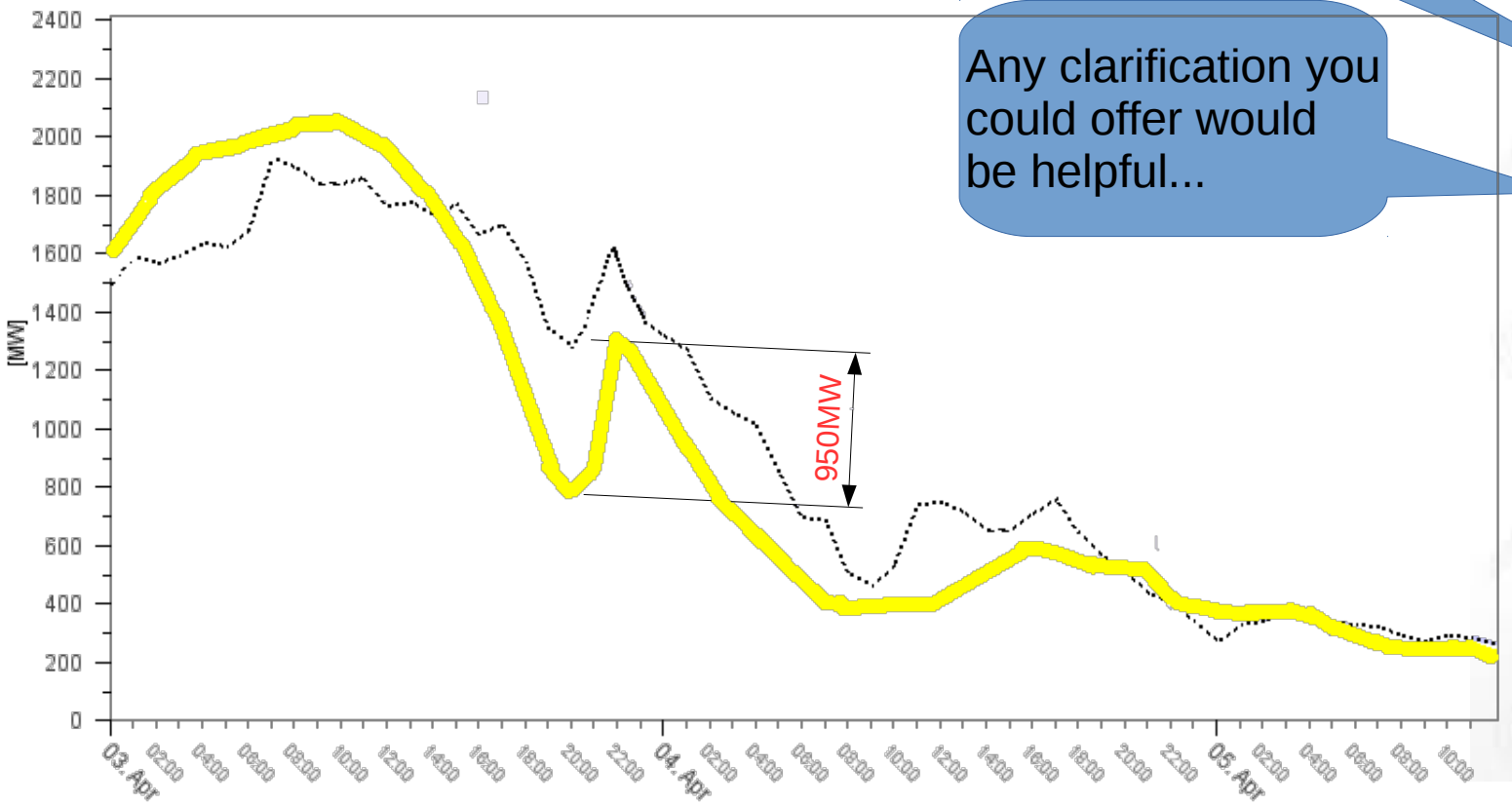
Situational awareness….

Questions from an operator working with 1 forecast…

What was the weather Situation at the time and would this have caused the error?

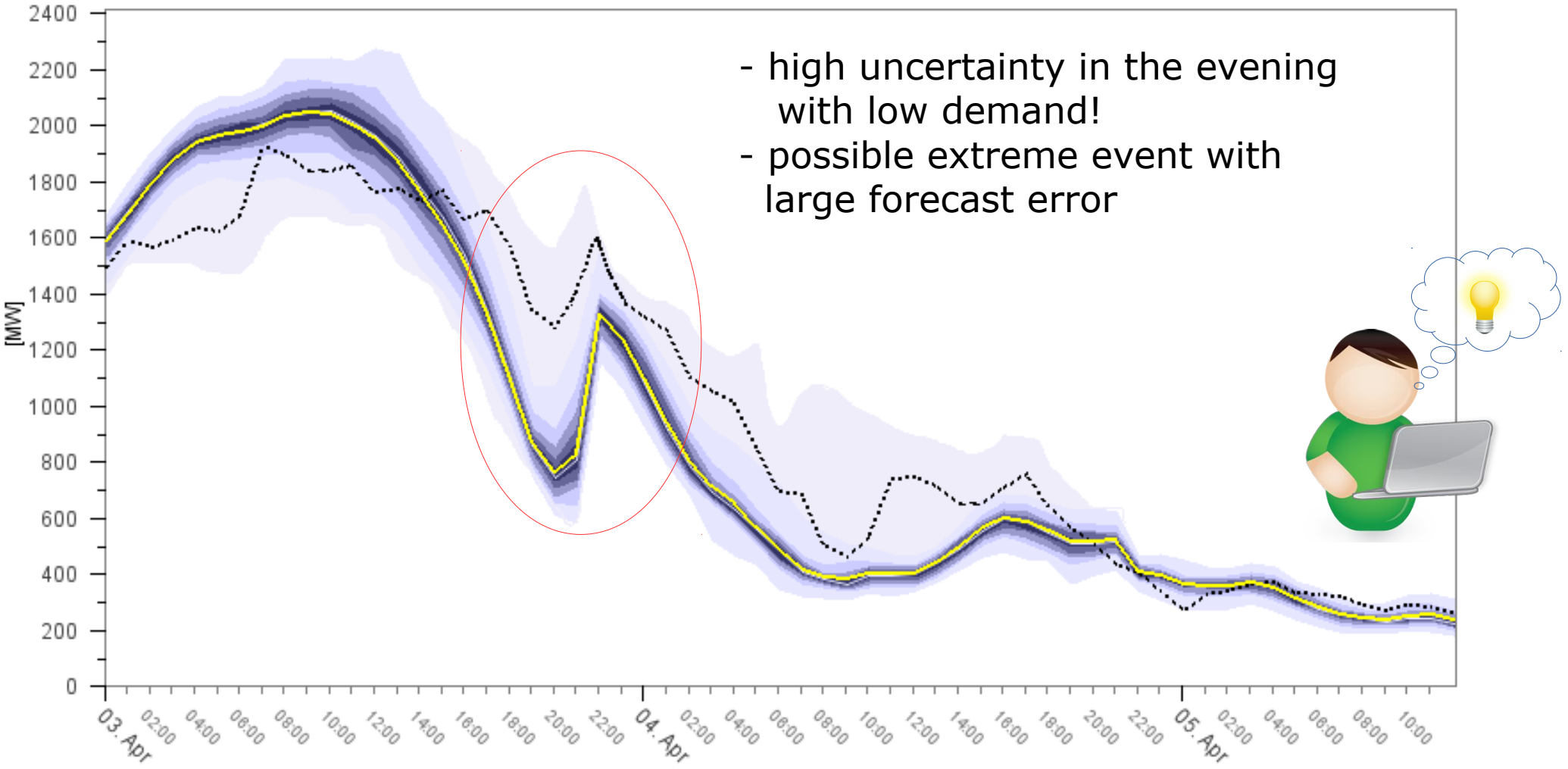
Does the actual value lie within the confidence bands of your model?

Any clarification you could offer would be helpful...



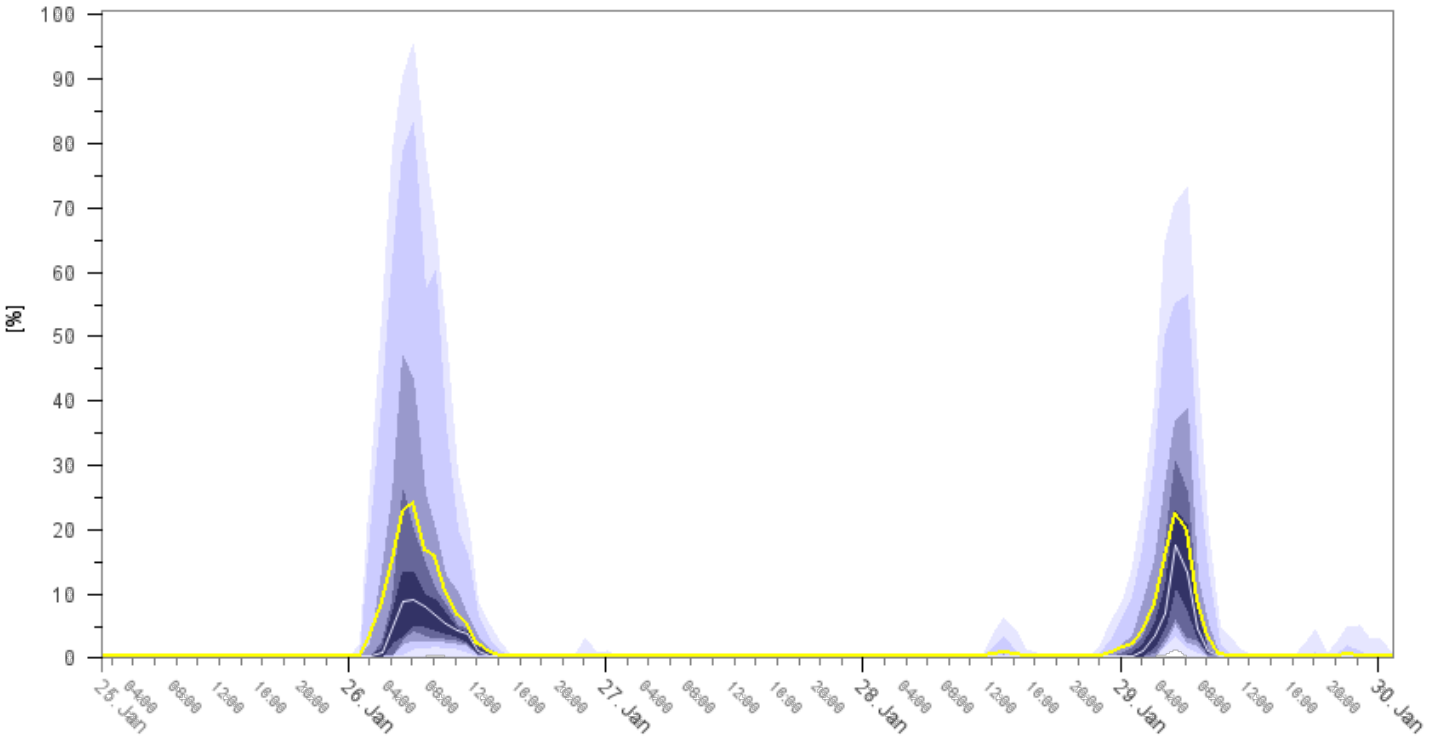
Forecast off with 950MW at 22 hours in a grid with 4500MW peak demand

What he would be able to see and know in advance with uncertainty forecasts….



High speed shutdown events

Communication is crucial for the interpretation of the probability for a certain event to take place



The operator needs to be able to interpret the probabilities !!!

Guide lines & experience required

Warning example:

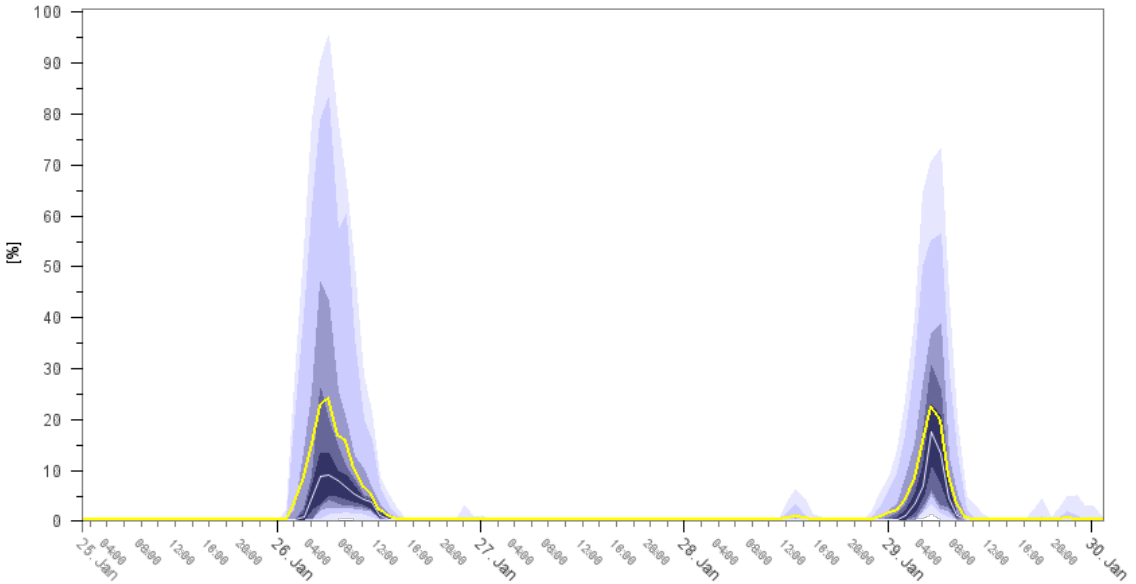
10% probability of a 50% high-speed shutdown event

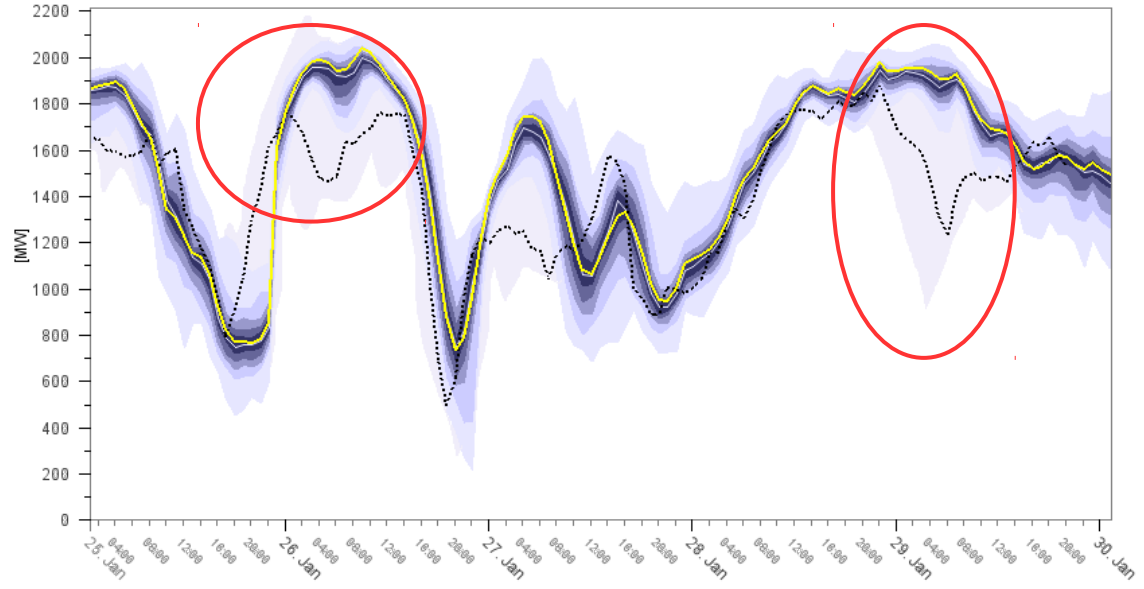
5% probability of 90% shutdown

90% probability of a 10% shutdown

High speed shutdown events

Communication is crucial for the interpretation of the probability for a certain event to take place





Warning example:
Case 1:

- 10% probability of 50% shutdown
- 8% probability of 90% shutdown
- 90% probability of 5% shutdown

Case 2:

- 10% probability of 50% shutdown
- 15% probability of 90% shutdown
- 90% probability of 10% shutdown

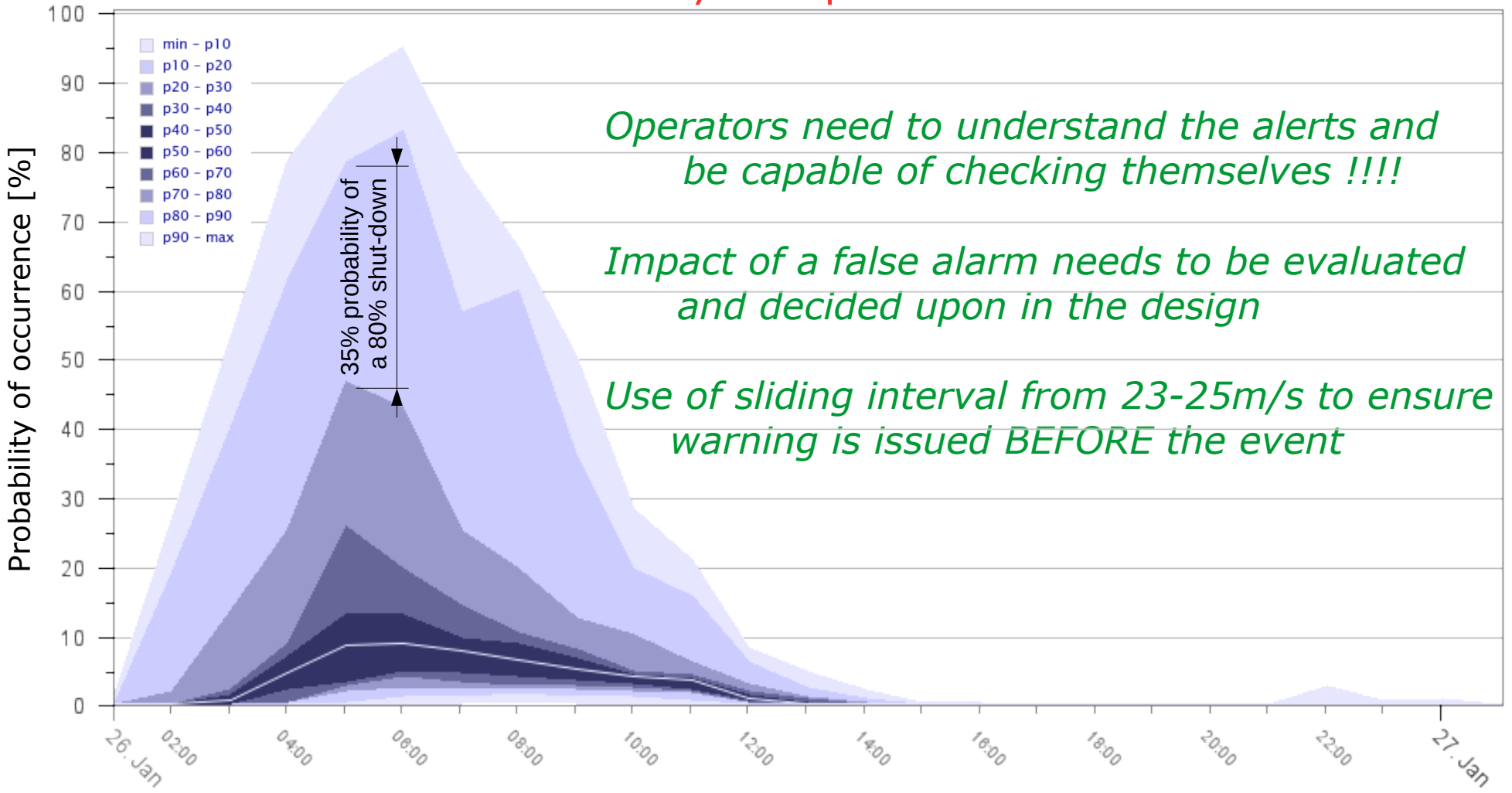
Result:

Case 1: peak value = 35% high-speed shut-down

Case 2: peak value = 45% high-speed shut-down

High speed shutdown events
- how to build up a warning system -

Appropriate communication is crucial for the alerts to be correctly interpreted!



Operators need to understand the alerts and be capable of checking themselves !!!!

Impact of a false alarm needs to be evaluated and decided upon in the design

Use of sliding interval from 23-25m/s to ensure warning is issued BEFORE the event

High speed shutdown events
- how to build up a warning system -

Communication is crucial for the alerts to be taken serious when required !

Technically, frequency of alert generation should be adjusted to:

- lead time of the alert
- change of severity level since previous alert
- initial week day
- valid week day
- time of day
- severity of the event computed from a ramp-rate perspecitve
- the actions required
- the need and possibility to call back and/or revert actions

Strategy of alert issuing:

- → issue every alert according to a simple scheme
- → reduce the amount of alerts to prevent that critical alerts are not accidentally overlooked

How can Uncertainty forecasts create value for the user ?

- Automatic filtering of unpredictable weather phenomena
- Limits double punishment and thereby volatility and consequently risk
- Allows the end user to strategically prepare for the increased risk
- Faster interpretation of conditions with a suitable presentation
- Increased forecast confidence by bridging models and measurements
- Flexible decision making with various objective formulae
- Forecast uncertainty without use of historical measurements

Overcoming barriers

IEA Wind Task 36 Workpackage 3 is dedicated to communicate via:

→ Publications
→ Workshops
→ Webinars
→ User guideline

How to

→ make use of uncertainty forecasts
→ which approach is appropriate for given applications
→ how to integrate uncertainty forecasting

Follow us or join us...

http://www.ieawindforecasting.dk/

WP3: End Use and Communication

http://www.ieawindforecasting.dk/topics/workpackage-3/task-3-1

THANK YOU FOR YOUR ATTENTION

Questions ?

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http://www.ieawindforecasting.dk