18th Wind Integration Workshop
International Workshop on Large-Scale Integration of Wind Power into Power Systems as well as on Transmission Networks for Offshore Wind Power Plants
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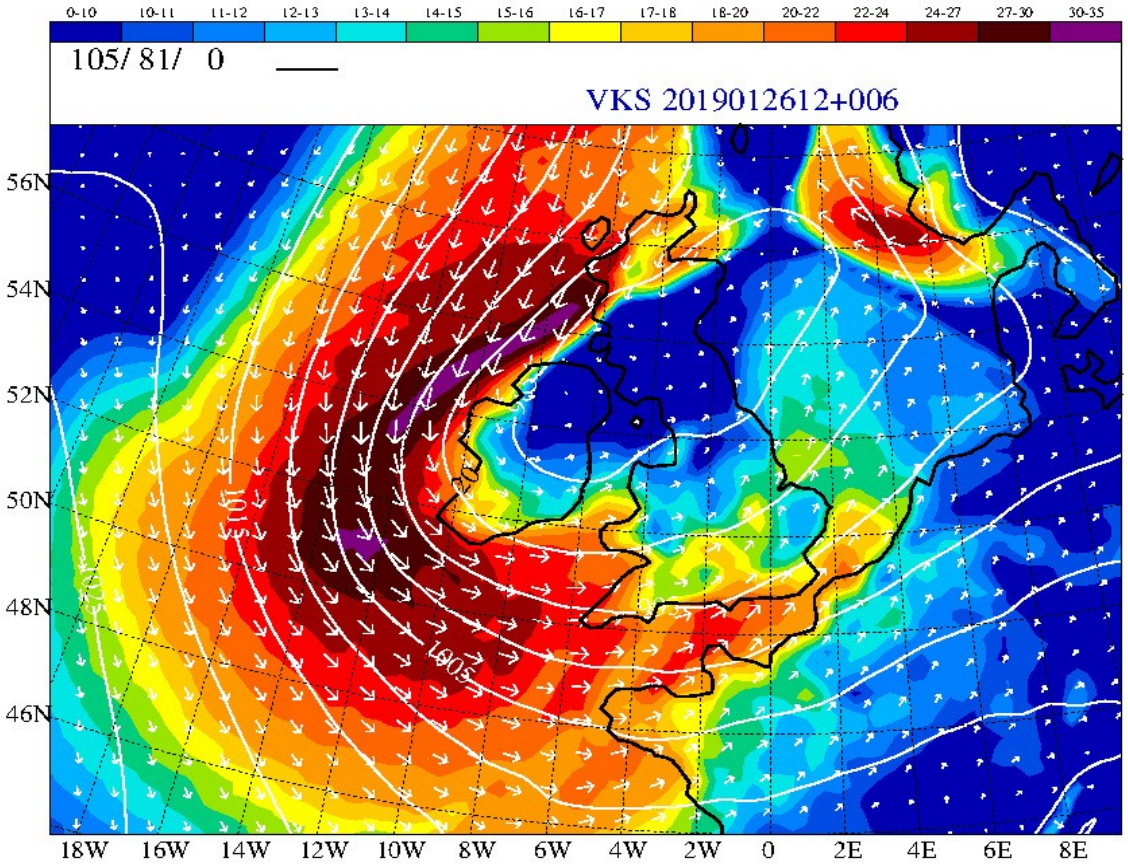
Dublin, Ireland

Probabilistic Forecasting Tools for High-Wind Penetration Areas: An Irish Case Study

SESSION 4C: FORECASTING I



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Ramping Reserve Study in Ireland

Scope of the study

Defining the level of ramping uncertainty to be covered by reserves in an All-Ireland grid

Understanding how future variable generation installations will affect such ramping uncertainties

Wind Generation on the Island of Ireland

Area	Installed MW Capacity	% System Demand (2018)
All Island	> 4900MW	31%
Ireland	> 3700MW	30%
Northern Ireland	> 1200MW	32%

Forecasts are crucial for system security – Up to 65% SNSP on All Island System

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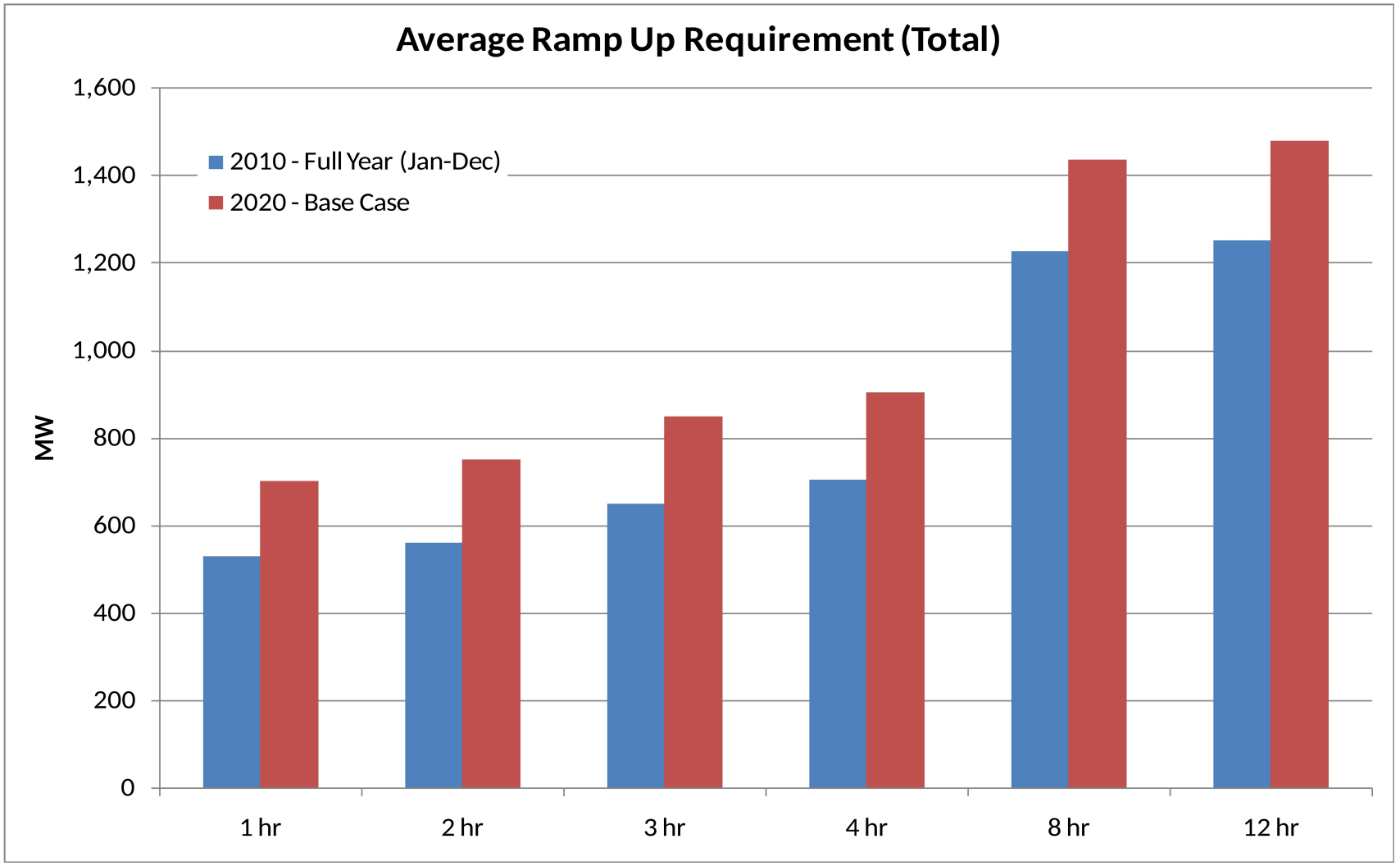
DS3 – Ramping Requirement Study (2011)



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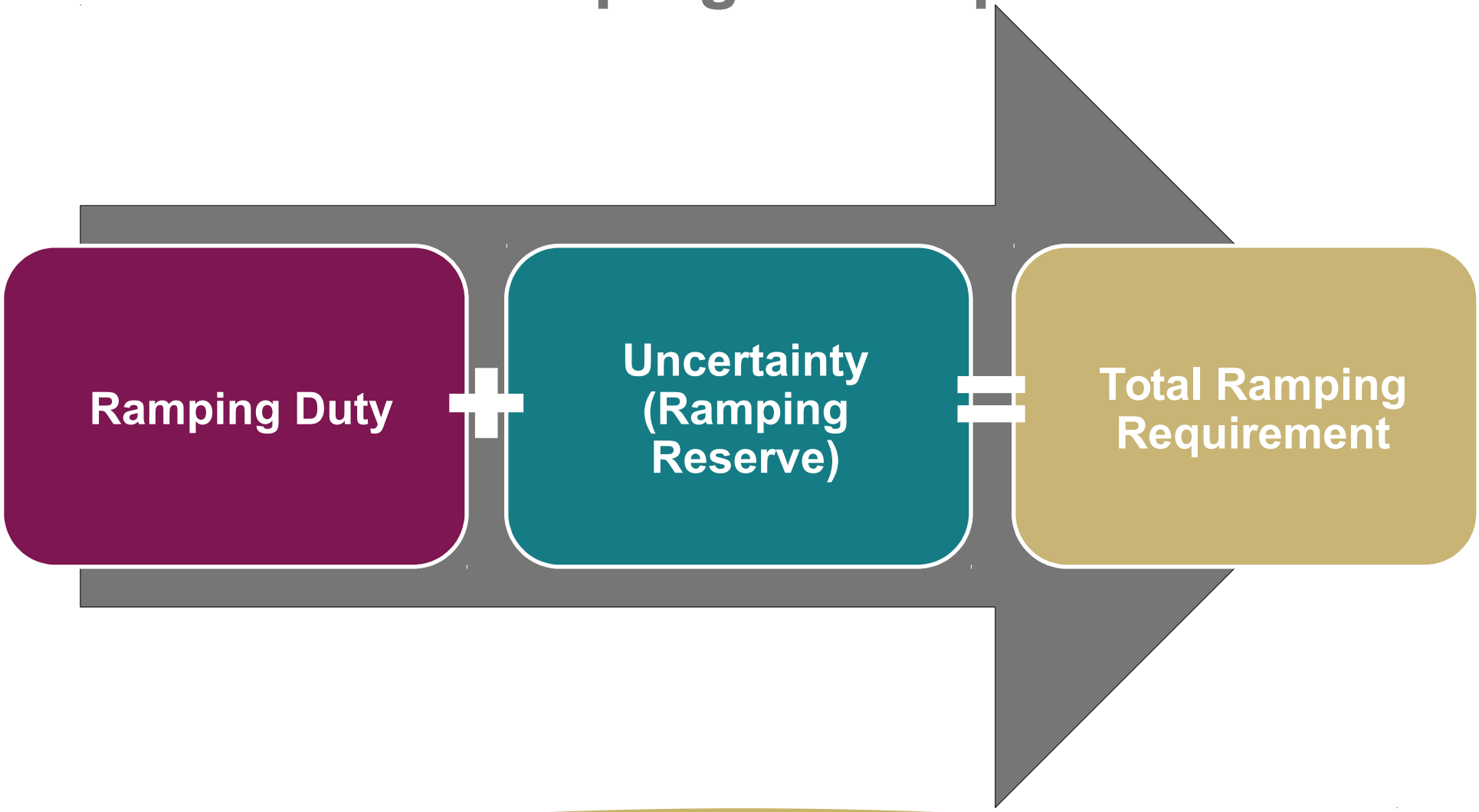
Ramping Concept



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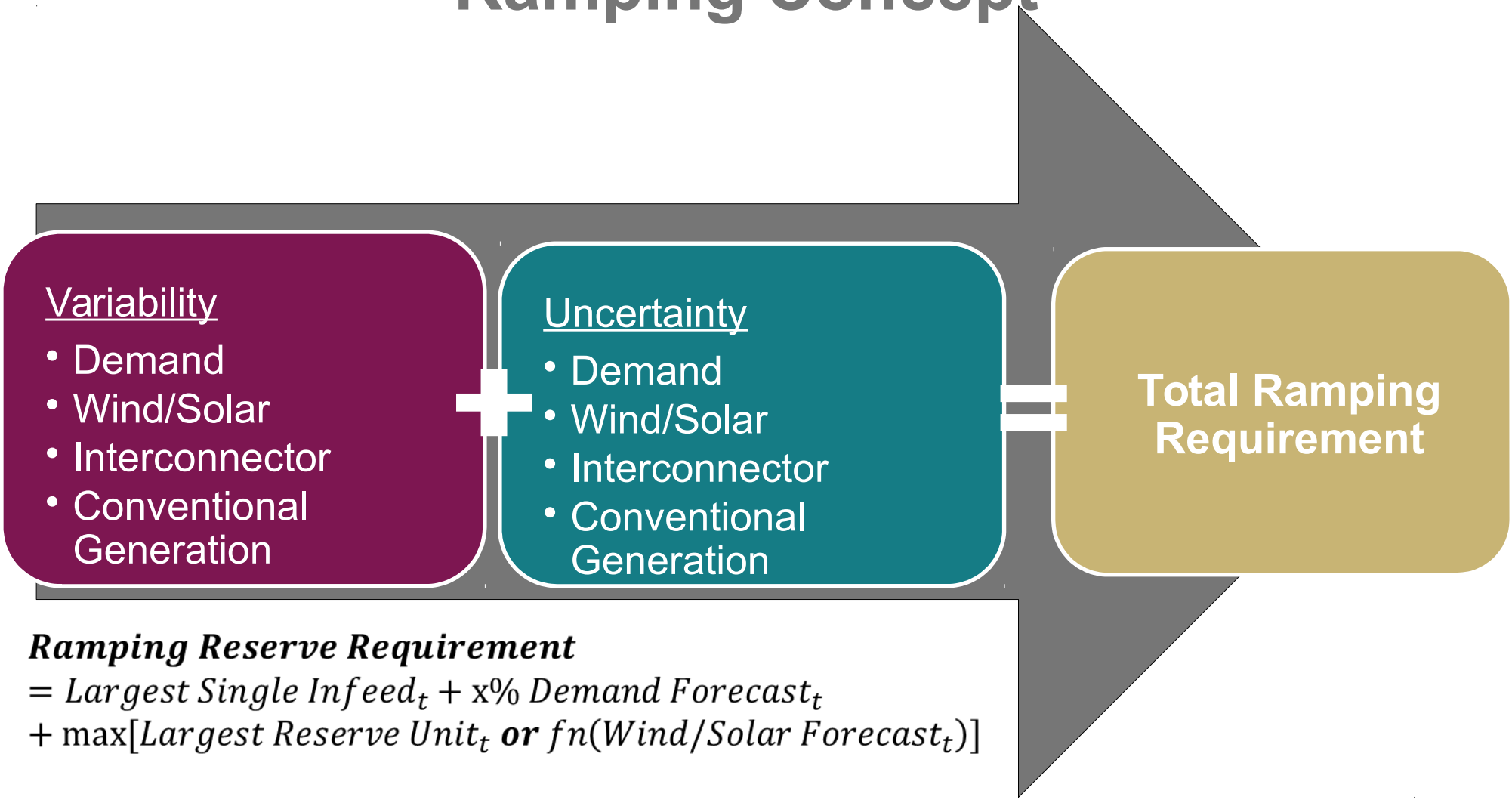
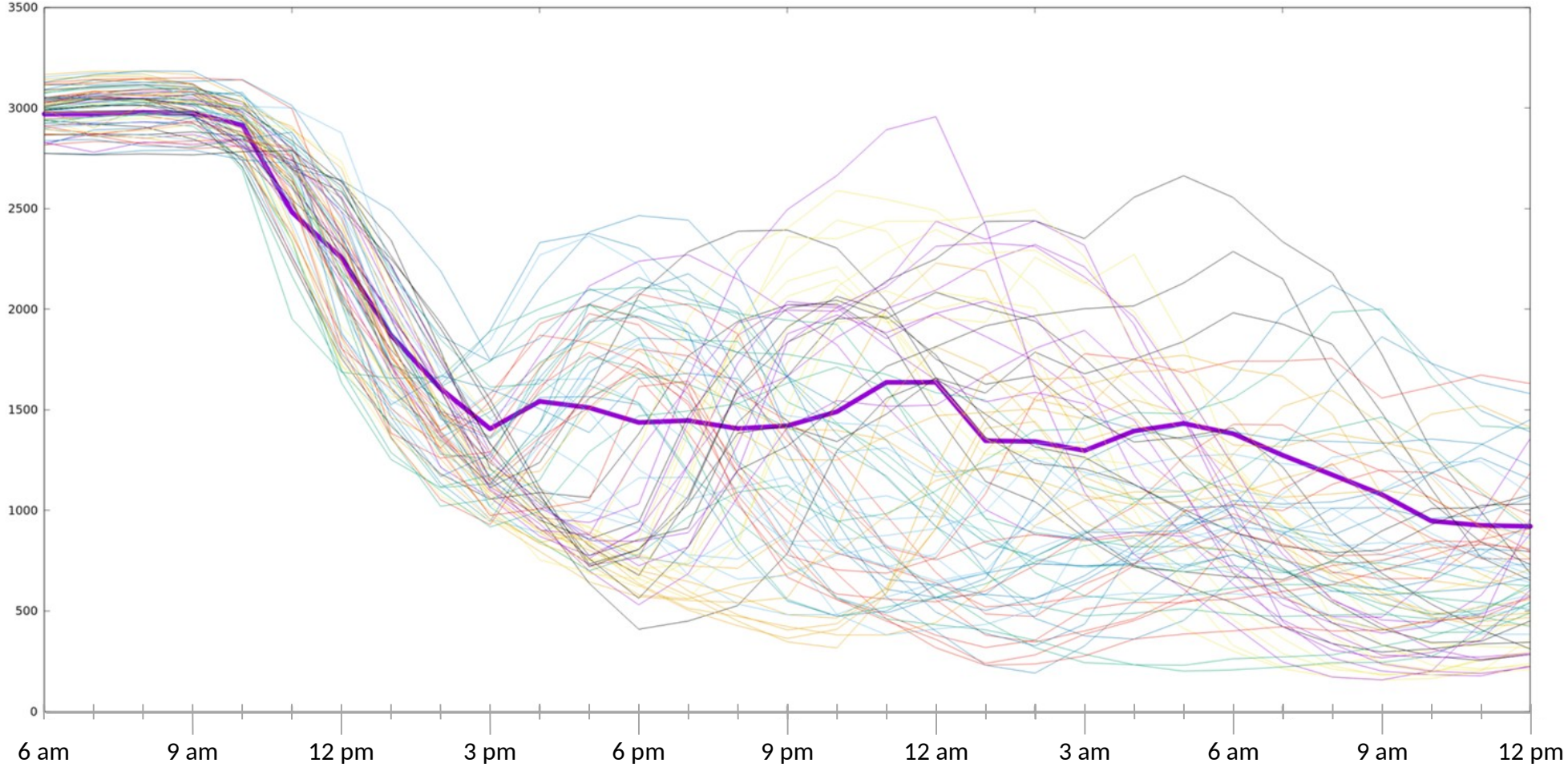
Ramping Concept



$$\textbf{\textit{Ramping Reserve Requirement}} = Largest\ Single\ Infeed_t + \text{x\%}\ Demand\ Forecast_t + \max[Largest\ Reserve\ Unit_t\ \textbf{or}\ fn(Wind/Solar\ Forecast_t)]$$

12th October 2018 – Forecast Ensemble



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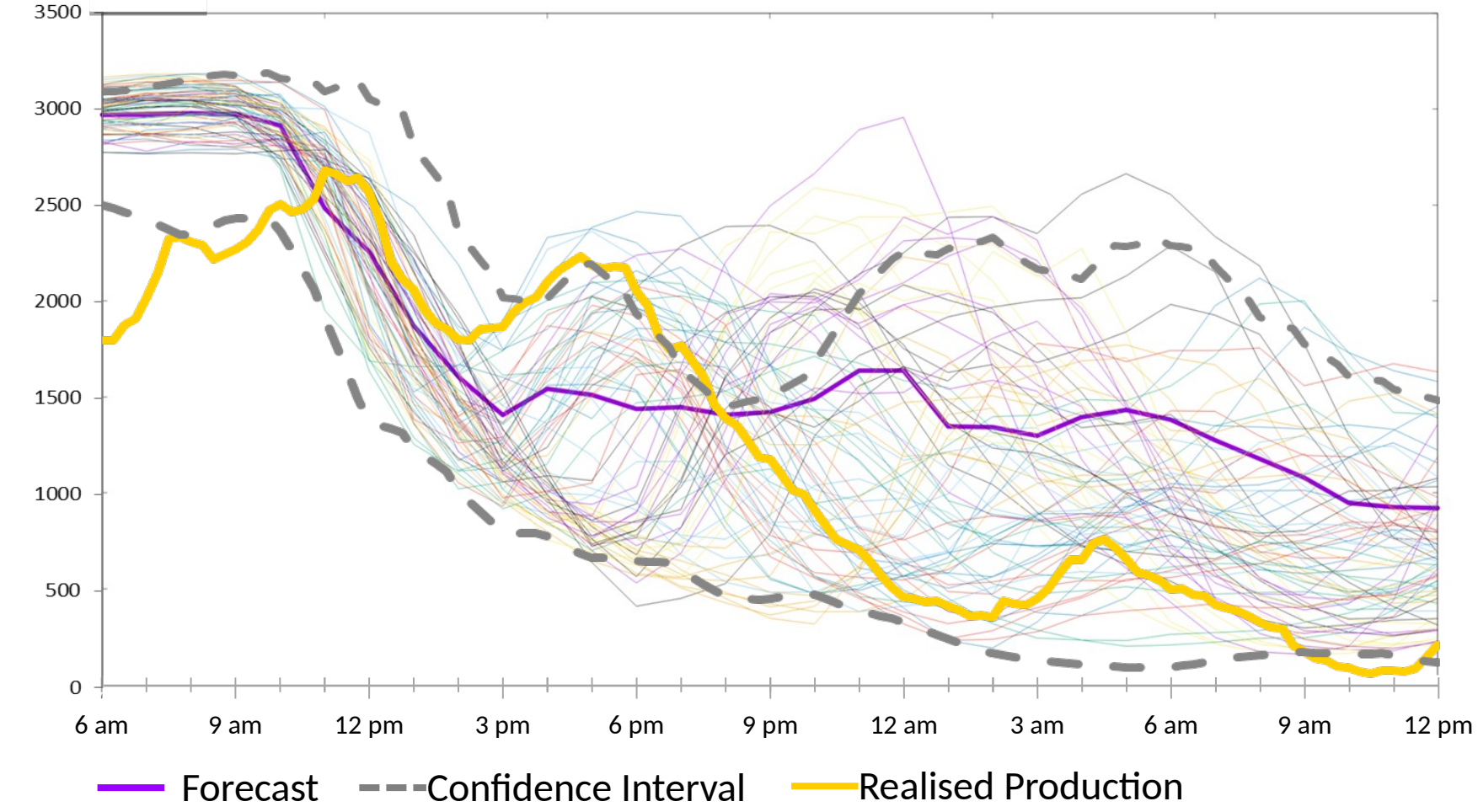
Realised Production



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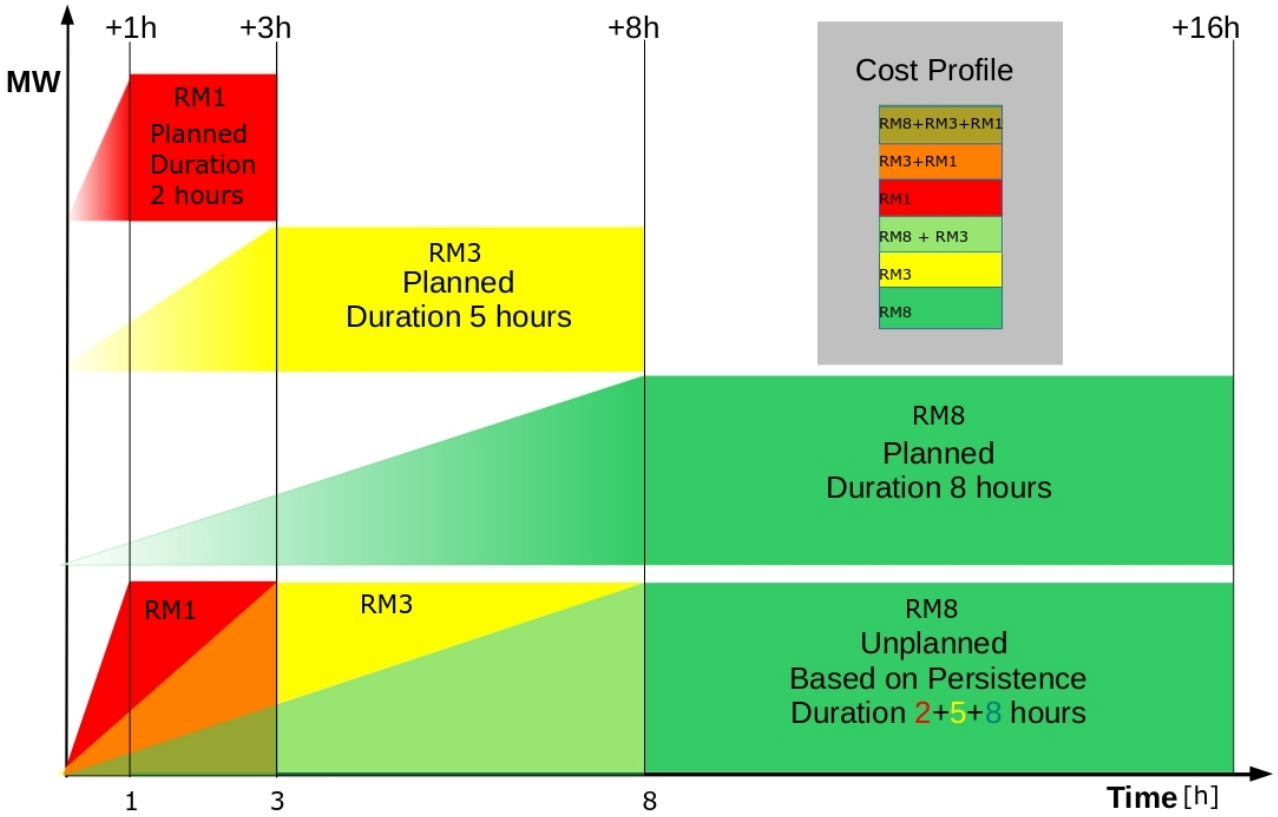
Background of the Ramp Reserve Products



Overview over the ramp products and time scales of the ramping reserve products:

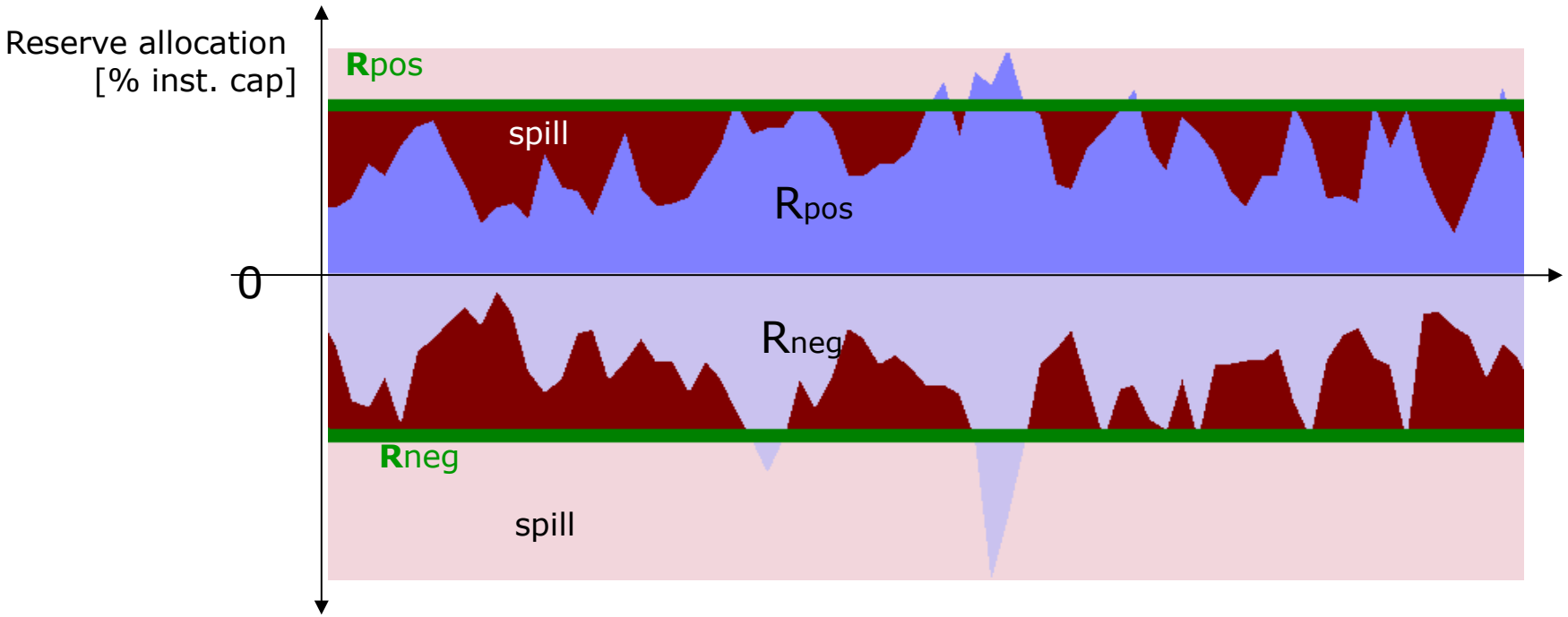
RM1 (red) for the 1-hour ramping,

RM3 (yellow) for the 3-hour ramping and

RM8 (green) for the 8-hour ramping and duration.

The first 3 horizontal bars (red, yellow and green) show planned reserve,
The last multi-coloured bar shows handling possibilities for unplanned ramping needs

Reduction of Reserve Requirements with dynamic allocation of reserves



Rpos: dynamic positive reserve
Rneg: dynamic negative Reserve
Rpos/Rneg: static reserve allocation
spill

NOTE: The goal of dynamic reserve allocation is to reduce the "spill" without reducing security of supply

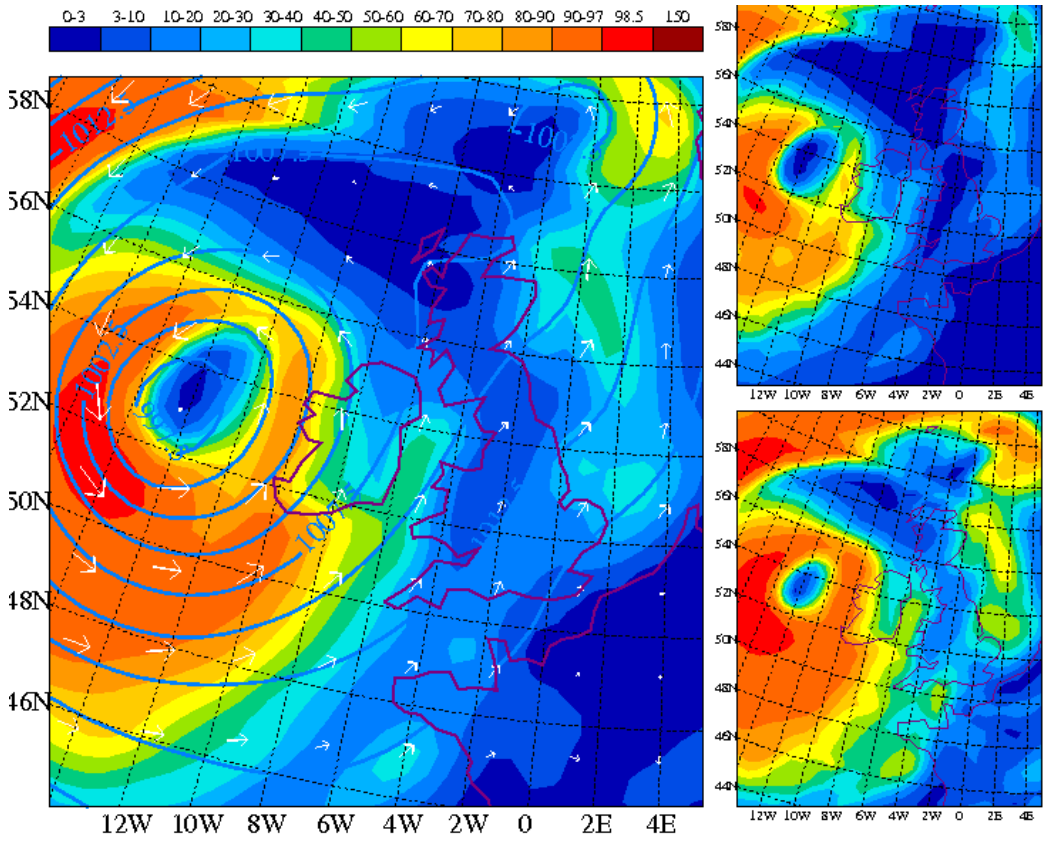
Background of the study: Forecast Uncertainty

Why is Ireland a perfect show case for ramping and uncertainty forecasts ?

Ireland is the first country in Europe to experience Atlantic storms propagating from west to east

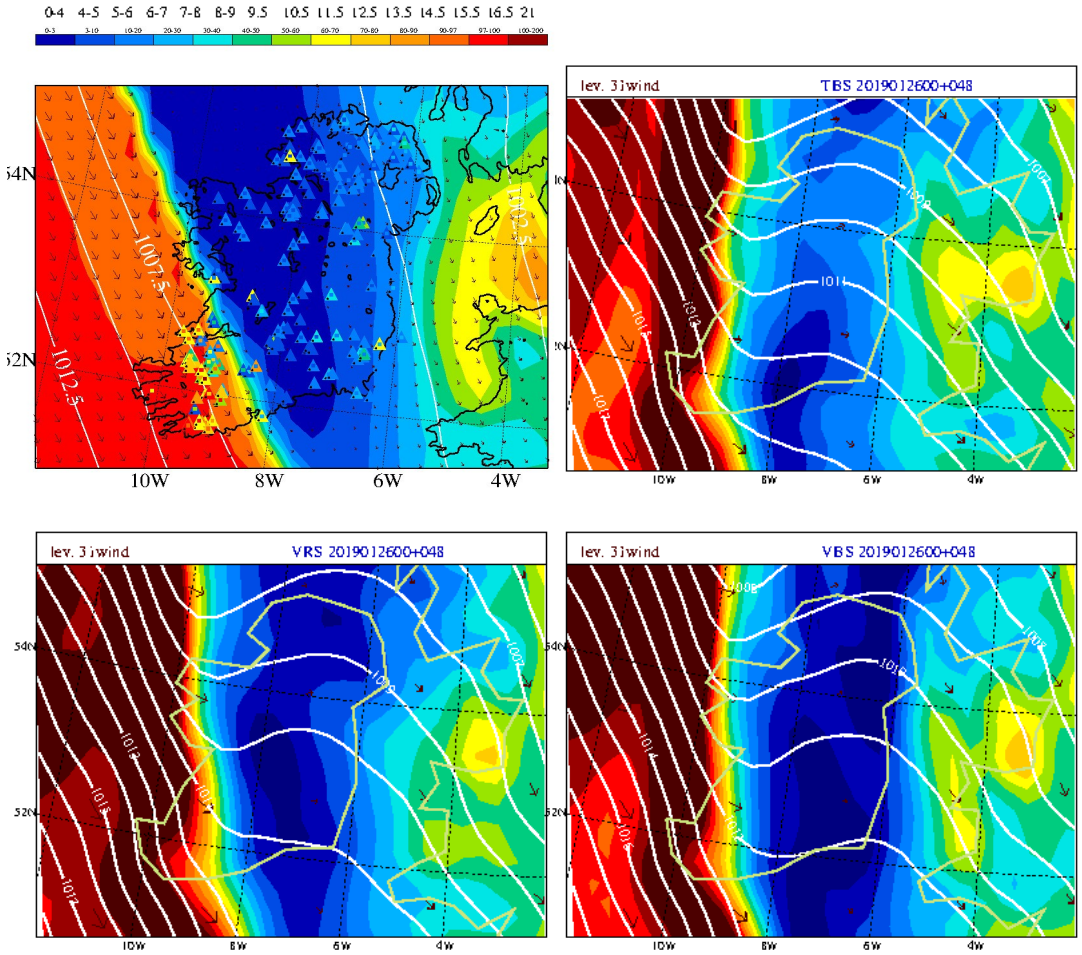
Information on the track and intensity of low pressure systems in the Atlantic is sparse.

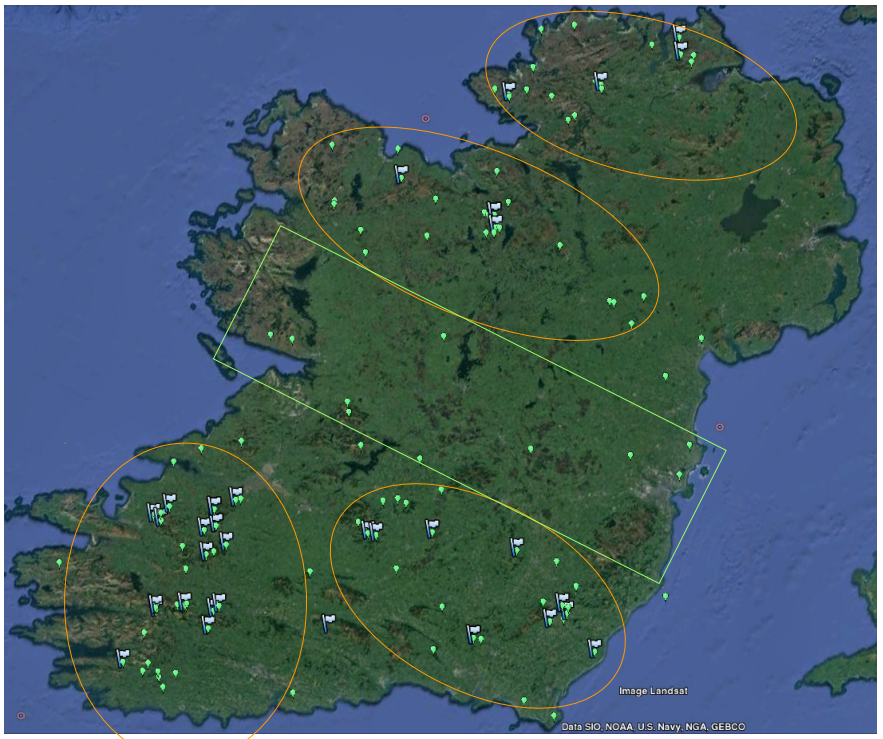
The growth rate of the uncertainty is mostly high during storm events



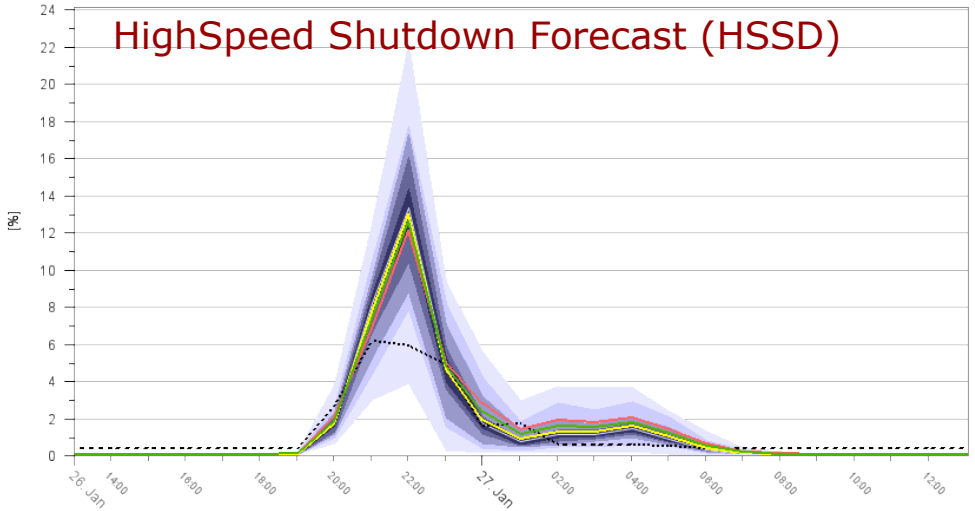
… and at some stage, the growth rate of Renewables penetration limits the available reserve for mitigation actions…

Why and when forecasts are uncertain...





4 main clusters of Windfarms
almost empty middle part

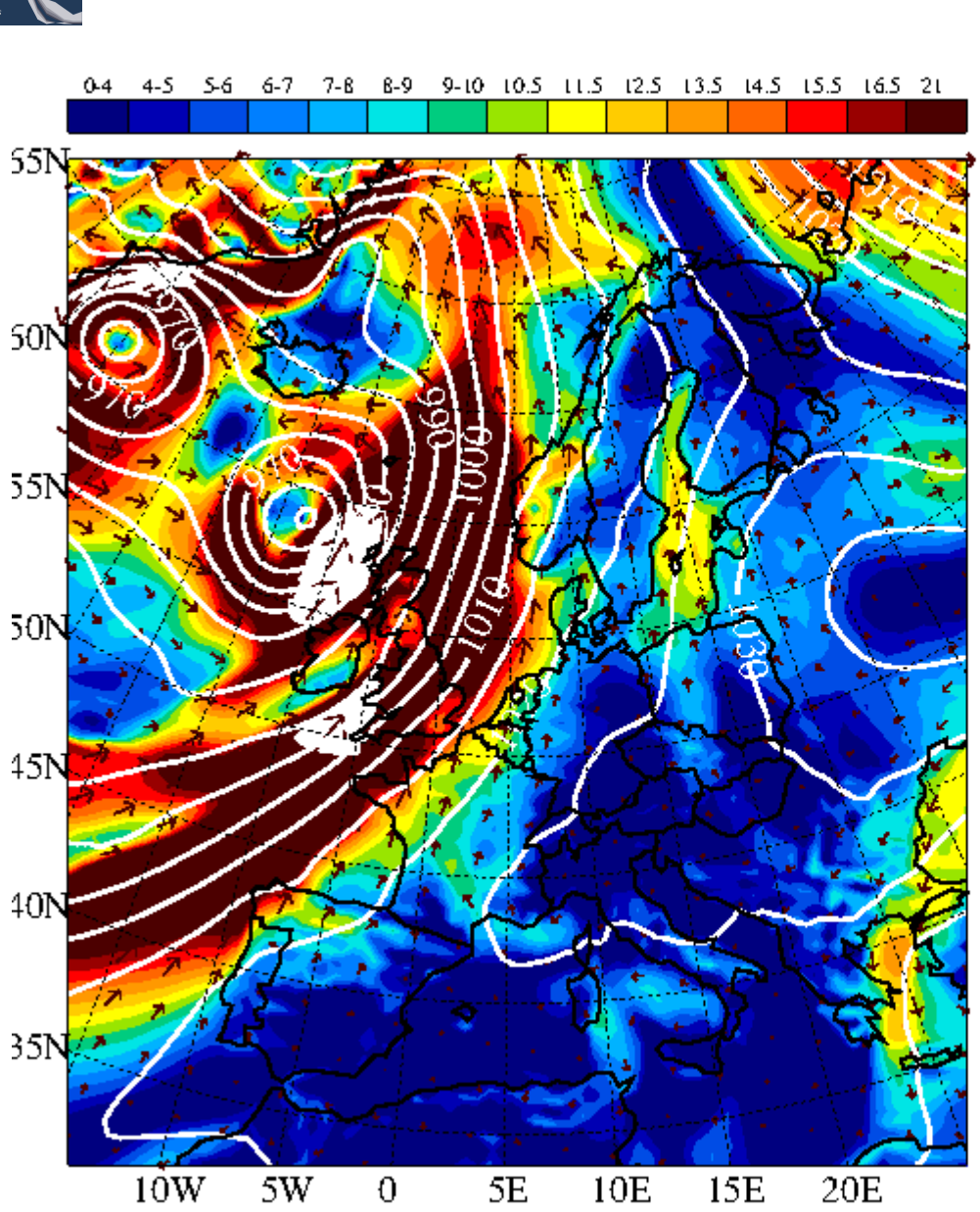


...unresolvable small scale phenomena
... small errors in sharp fronts or fast moving lows can cause large errors with uneven distribution of wind farms...

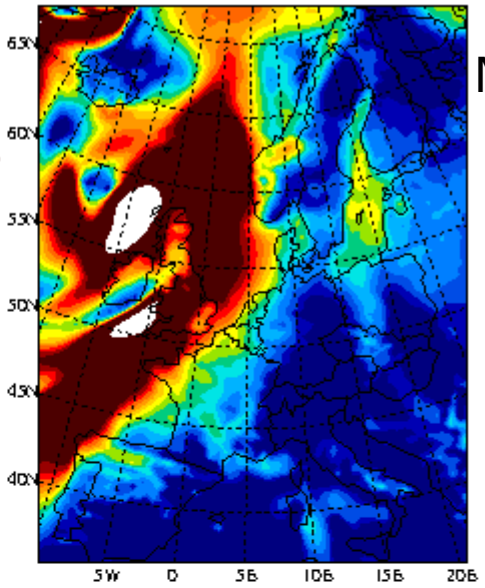
Typical winter situation in Ireland: strong jet stream, fast moving lows with sharp fronts

Wind Speed [m/s]

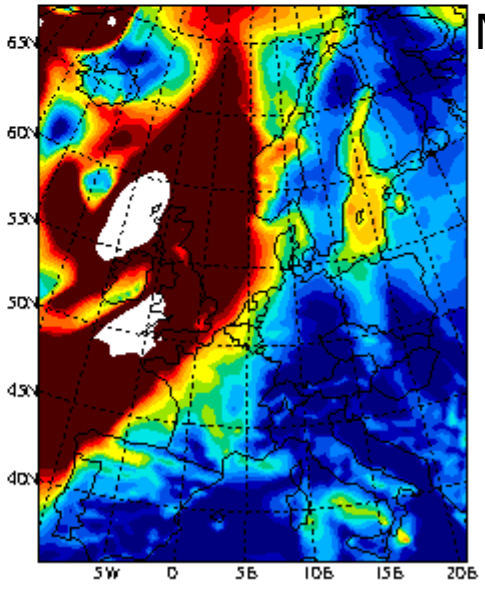
MEAN



Min



Max



→ white areas mark wind speeds > 22m/s
with **risk** for high-speed shut down
→ **risk** areas look similar, but produce very different power outut ...

Ramping Reserve Forecast study reveals…

Wind generation on the Irish system continuously ramps up and down due to:

(1) the wind speed is seldom constant over large areas
(2) the capacity density varies across the Irish system

Large scale wind speeds with variations of 16 to 22 m/s: Oct/Nov → Feb/March

Paradigm change for forecasting required
optimizing (DA) forecasts → optimizing forecast error balancing

Reason:
- wind power capacity is increasing, expecting a "perfect" weather forecast unrealistic

- Ireland's direct exposure to the Atlantic + high penentration + island grid =>
  system balance can only be maintained economically with:
  - **ST forecasts on the 0-2 hour horizon**
  - **dynamic allocation of reserve to balance VG forecast errors**

Relationship between Ramping and Reserve

Purpose of RM product:
To ensure balance between Load, VG, Scheduled Primary Power Generation (SPPG) and Import/Export over the product's deployment horizon.

$$\mathbf{LOAD = VG + SPPG + Import - Export + RM_{max} \cdot D} \quad [1]$$

where $\mathbf{RM_{max} \cdot D}$ is the deployed reserve
SPPG is the synchronous primary power generation.

During the ex-ante scheduling process, as in equation [1], the equation is balanced when D has a value of zero.

$$\mathbf{scLOAD = scVG + SPPG + Import - Export} \quad [2]$$

where sc=scheduled and r=reserve

$$\mathbf{scLoad + scLOADr = SPPG + scVG + scVGr + Import - Export + scRM} \quad [3]$$

Relationship between Ramping and Reserve

Solving equations [2] and [3] for the scheduled reserve marginal product we find:

scRM = scLOADr - scVGr [4]

scRM is the load (and VG) following capability that is known to be required due to the load and VG varying throughout every scheduling interval.

To avoid allocating new RM every hour, scRM will be computed as the maximum required value between several auctions:

RMmax = scRM + nsRM [5]

The non-scheduled reserve marginal product nsRM part contains uncertainty around the schedule of all terms in equation [1], thus

nsRM = max(Largest-Single-Point-of-Failure, LOAD - VG - scLOAD + scVG) [6]

Where **all terms in the second part are weather dependent.**

Relationship between Ramping and Reserve

$$\mathbf{nsVG = VG - scVG} \quad [7]$$

With nsVG there exists a risk of missing reserve capacity in cases where the capacity available on short notice is limited and large amounts required.
If risk based forecasting is used for forecasting nsVG it is possible to order RM products in advance.

In Ireland, RM3 and RM8 are available, **only nsVG downramps can increase nsRM**!
This allows us to define a non scheduled ramp down over 3/8 hours to:

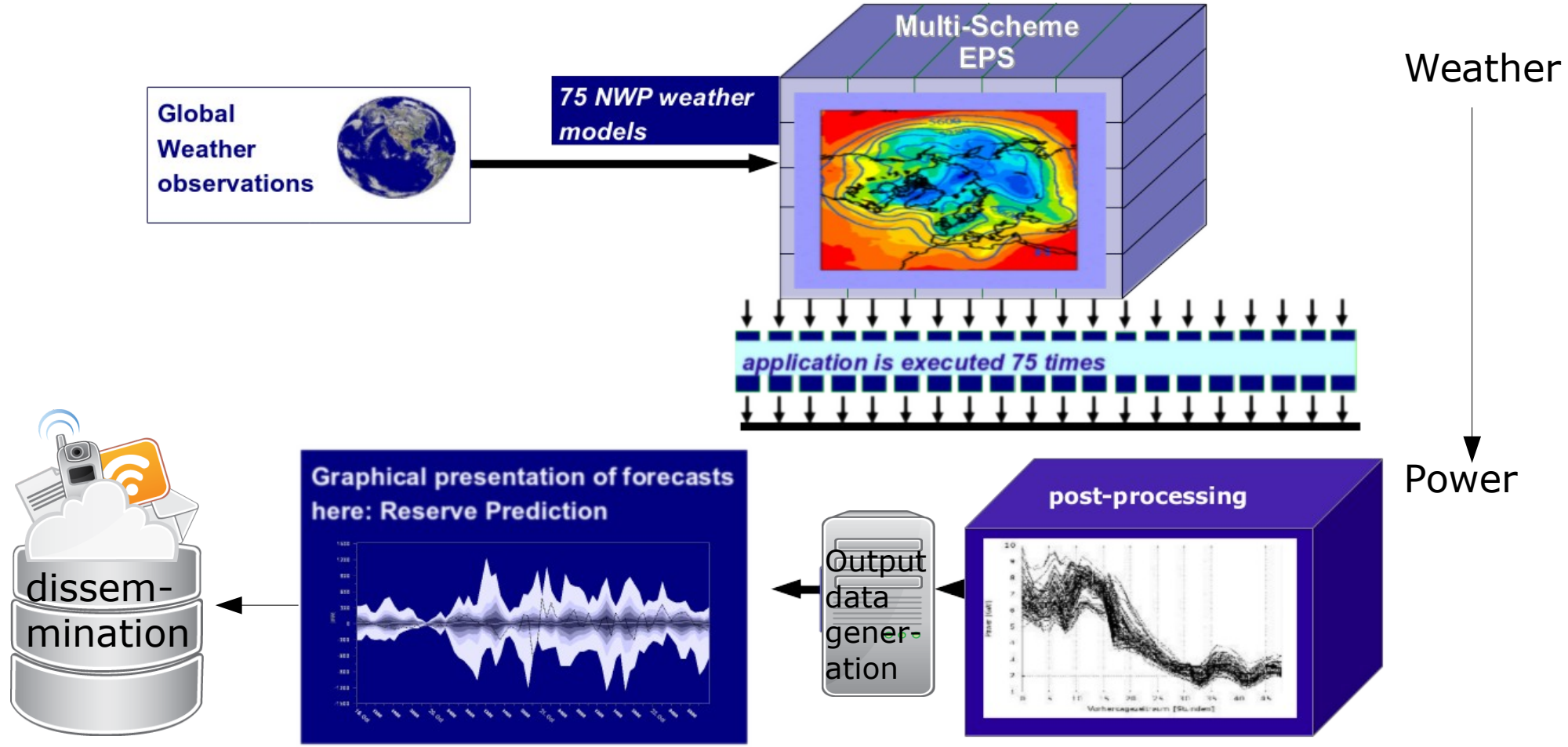
$$\mathbf{NsVGrd1/3/8 = max(nsVG_t - nsVG_{t\text{-}3h/8h/1h} , 0)} \quad [8]$$

The optimal allocation of RM products can be determined from a cost function or from a profile of the uncertainty.
When using an ensemble of forecasts, equation 8 provides us with a probability distribution.

This decomposition and the required allocation time of RM products explain why VG forecast uncertainty turns into ramp forecasting

Ramp Reserve Forecast for the Irish case study: The forecasting solution

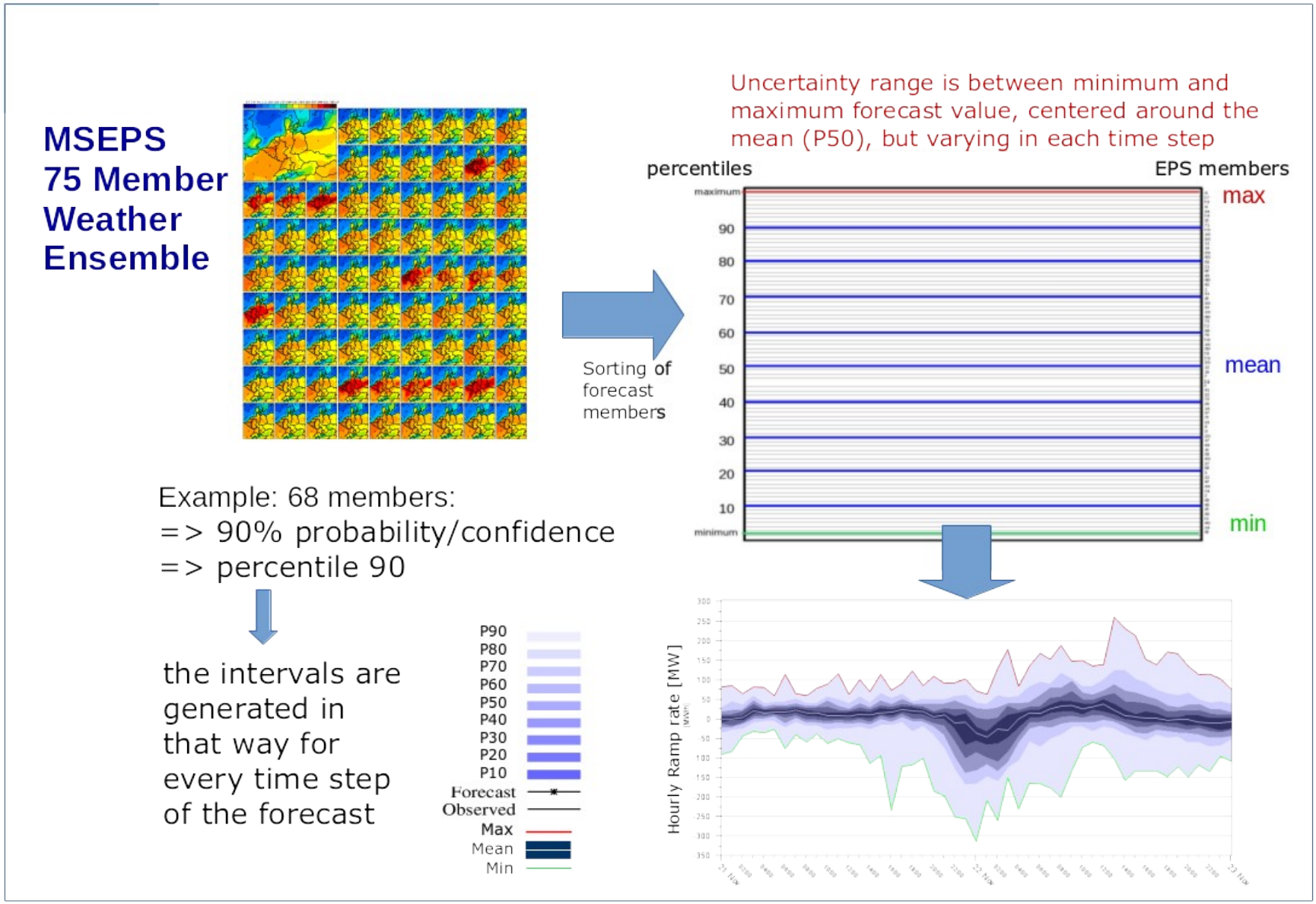
WEPROG's Multi-Scheme Ensemble Prediction System (MSEPS)



From forecast uncertainty to Ramp Reserve Forecast …

→ physical approach: No statistical correction or calibration

Uncertainty results from difference in each ensemble member



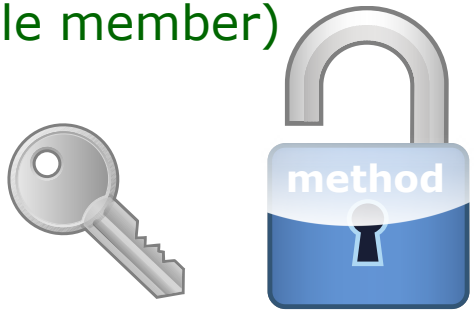
Ramp Reserve Forecast for the Irish situation:

Summary of the characteristics of the forecast method used in this study..

Raw ramp forecast output from a multi-scheme EPS (75 ensemble member)

MW-difference forward in time per ensemble member

No statistical methods needed to tune the output data

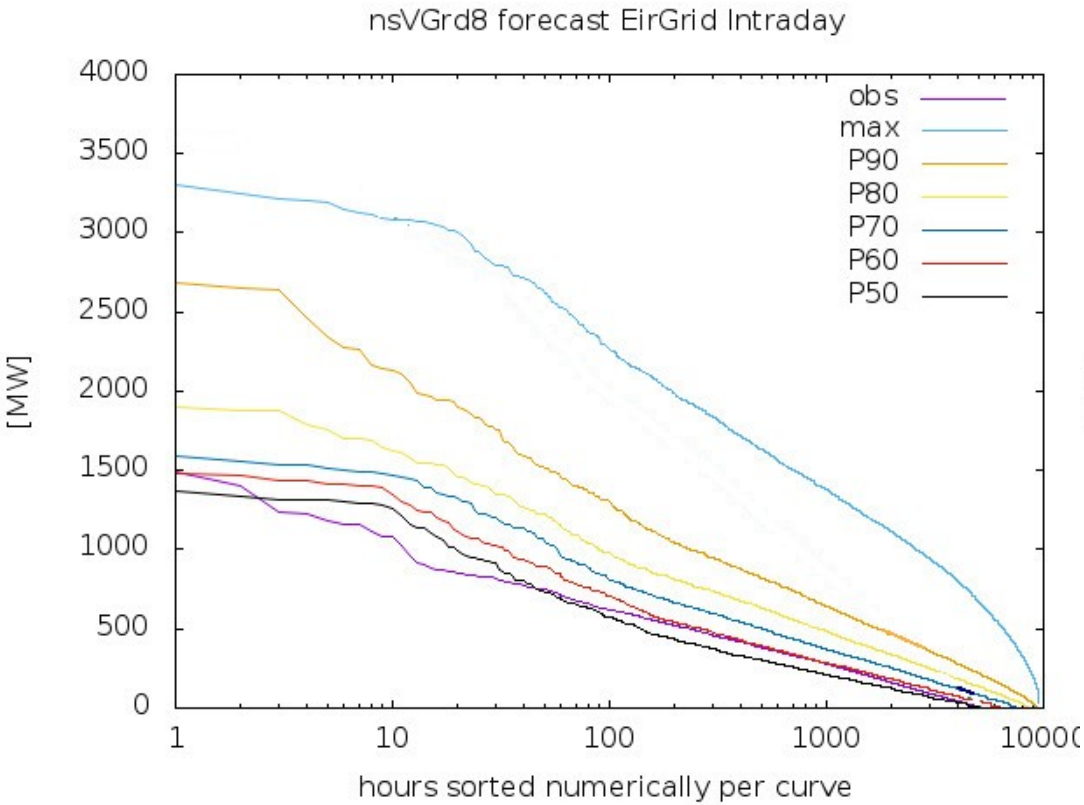


The positive wind power ramps are set to zero

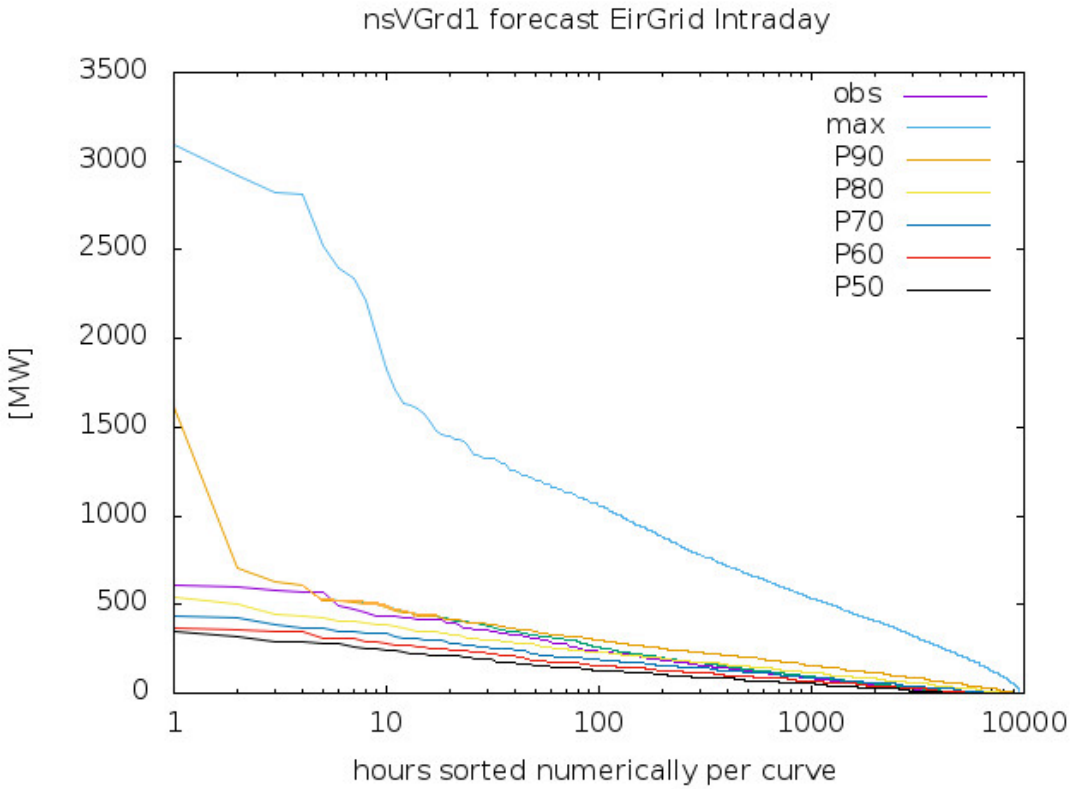
All values are computed for the potential generation

Ramping Reserve Forecast study: result examples

8-hour non-scheduled downramp forecast



1-hour non-scheduled downramp forecast



Numerically sorted time series observed ramps and percentiles of ramps for EirGrid at Intraday forecast for non-scheduled VG 8-hour (left fig.) and 1-hour (right fig.) ramping reserves (nsVGrd8)

Provides information for decision making on allowance of "spill" and "misses"
→ Economic optimised (small "spill") versus security (no/few "misses")

Study Results from a forecasting perspective

Key Findings…

Varying forecast quality due to uncertainties in the weather

With increasing penetration level knowing and understanding uncertainty is key

With ramping forecasts uncertainty can be dealt with secure, stressfree and economic

Ramping up events can be curtailed: only if load allows it is economically responsible!

Ramping down events need reserve: allocation needs to be planable!

To built an effective reserve forecasting tool requires analysis of:

(1) the weather conditions
(2) the grid situation
(3) available reserve capacity
(4) the current load

Ramp Reserve Forecast for the Irish situation:

Lessons Learned…

Forecast paradigm shift from deterministic → probabilistic forecasts
EirGrid is being provided with 9 percentiles for the 3 ramp horizons instead of only one value.

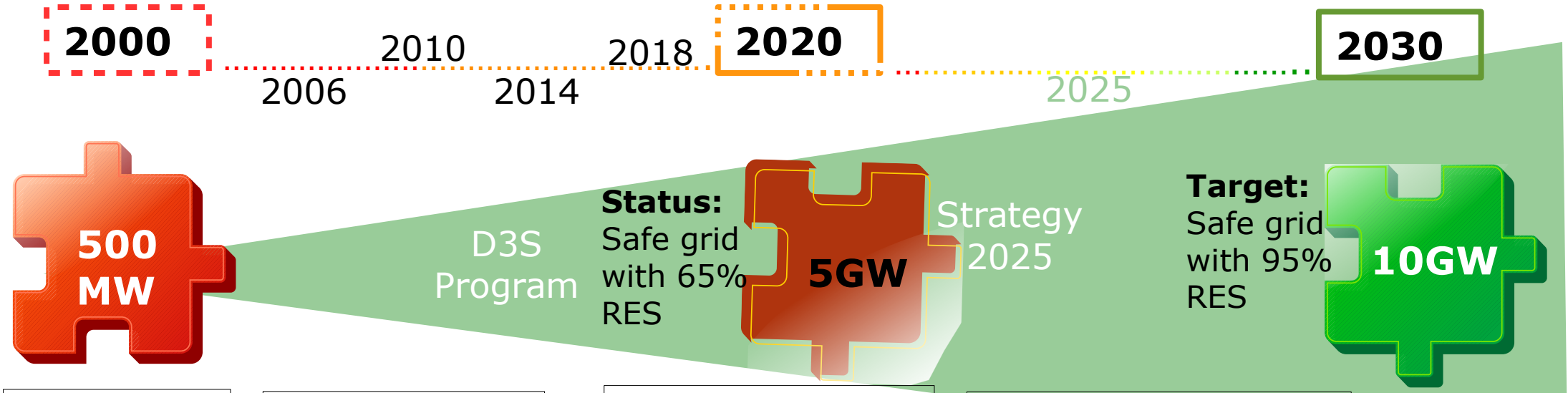
Forecast paradigm shift from static solutions to optimisation problem solving
Such data will allow EirGrid to choose the ”optimal” percentile for the grid situation at hand

Forecast paradigm shift from single simulations to strategic scenario analysis
Ongoing and future work suggests that EirGrid are now looking into strategies for the choice of percentile for various grid situations.

…there is still lots to learn …
Further research work is however required to assess how cost versus reliability trade offs should be handled

Outlook after the ramping reserves study

Next Steps in the Irish Race into a sustainable Future…



No forecasting

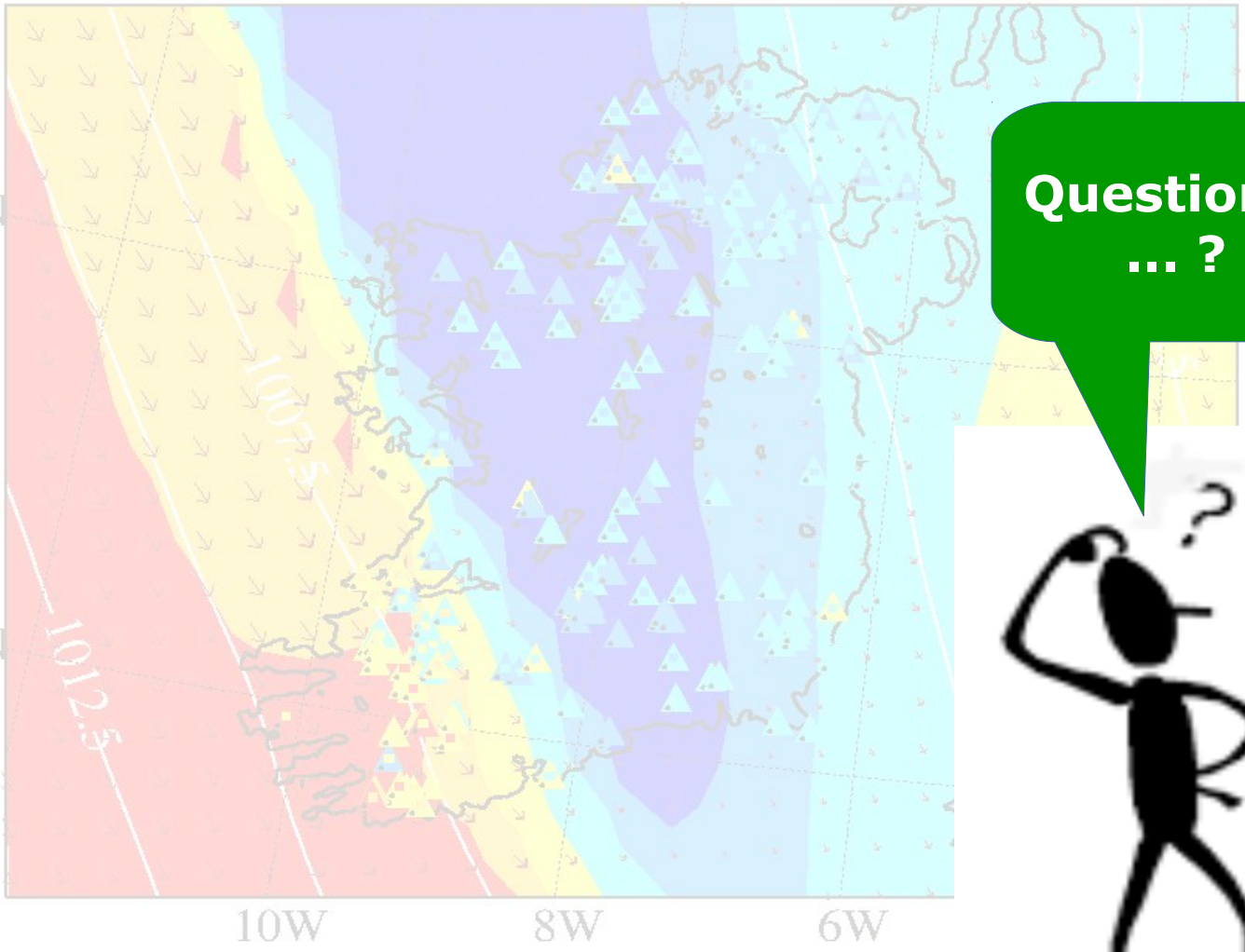
Development and inte-gration of forecasting tools into operation:
- Day-ahead
- Short-term

Development and imple-mentation of advanced forecasting tools:
- HSSD* Tool
- Ramping Reserve Tool

Implementation of probabilistic forecast tools into operation:
- gaining experience
- adjusting
- analysing
- trusting
- improving

* High Speed Shut Down

Thank you for your attention…



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Backup slides...

Decomposition of Reserve requirments