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ANEMOS+

Reserve and Congestion Management Using Wind Power Probabilistic Forecast: A Real Case-Study

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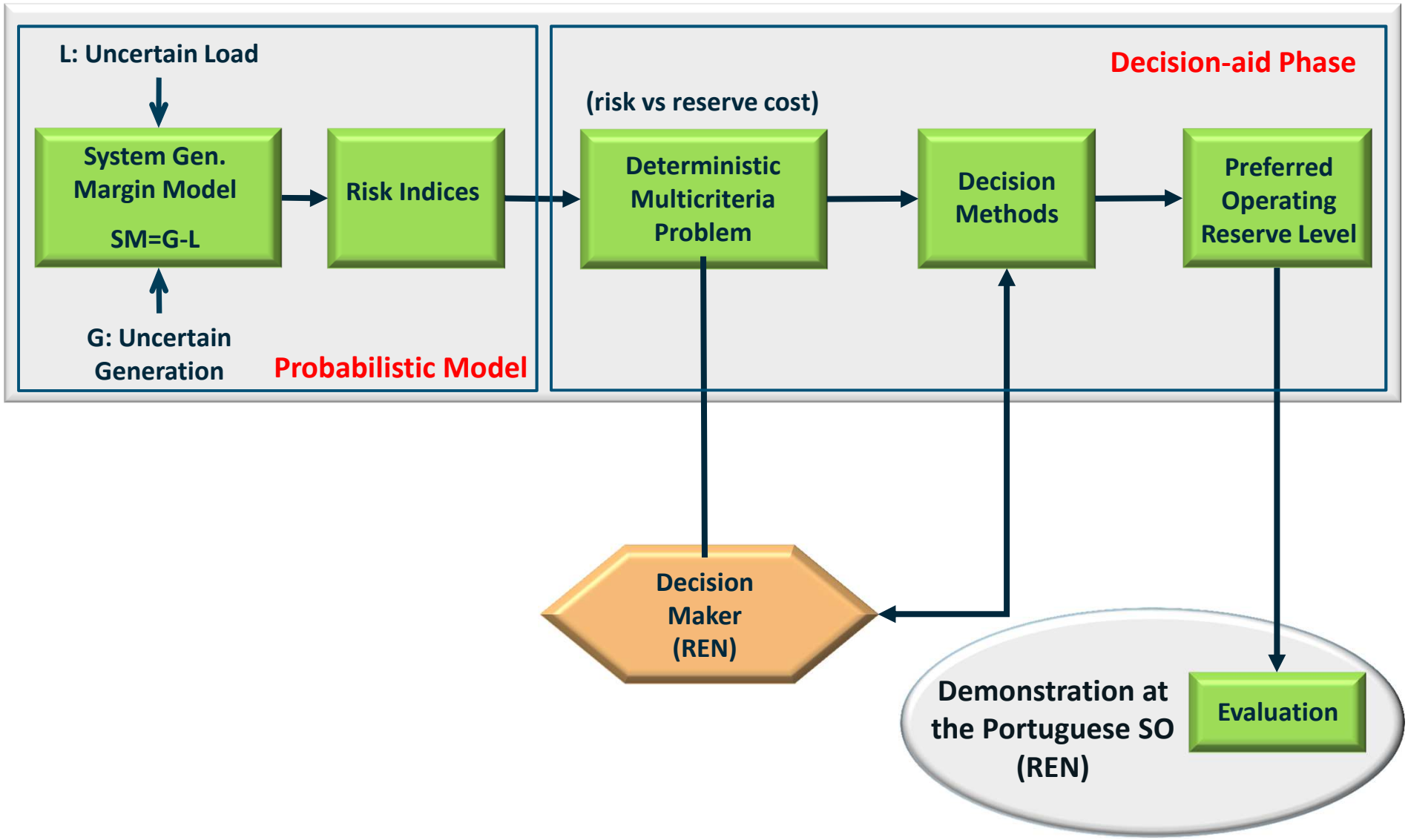
Introduction

- In the **ANEMOS.plus European project** power system management tools were developed, and are now being demonstrated at several end-users
- Two of these management tools will be presented (**on-going demonstration for REN**)
- Robust Reserve Setting (RRS) tool
  - **Objectives:** estimation of the operational reserve needs to account for units outages, wind power and load uncertainty
  - **Output:** reserve levels for each hour of a predefined period (i.e. day-ahead, intraday) obtained with different decision-aid methods
- Fuzzy Power Flow (FPF) tool
  - **Objectives:** identify possible voltage violations and branch congestions
  - **Output:** list of nodes with possible voltage limits violations and branches with possible congestions

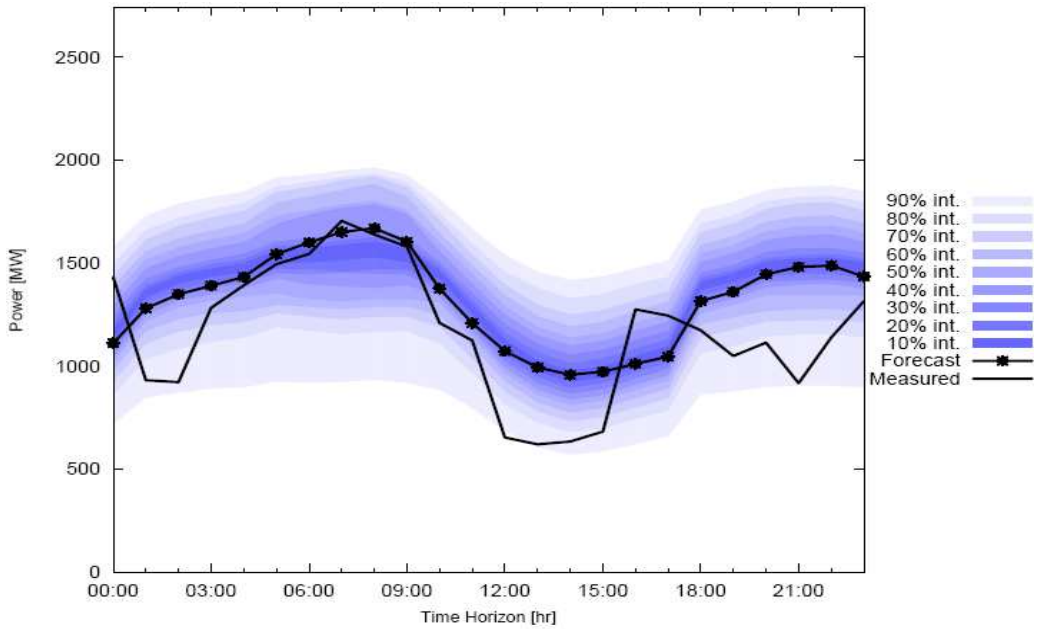
Robust Reserve Setting Tool

Robust Reserve Setting (RRS) Tool



Uncertainty Modeling

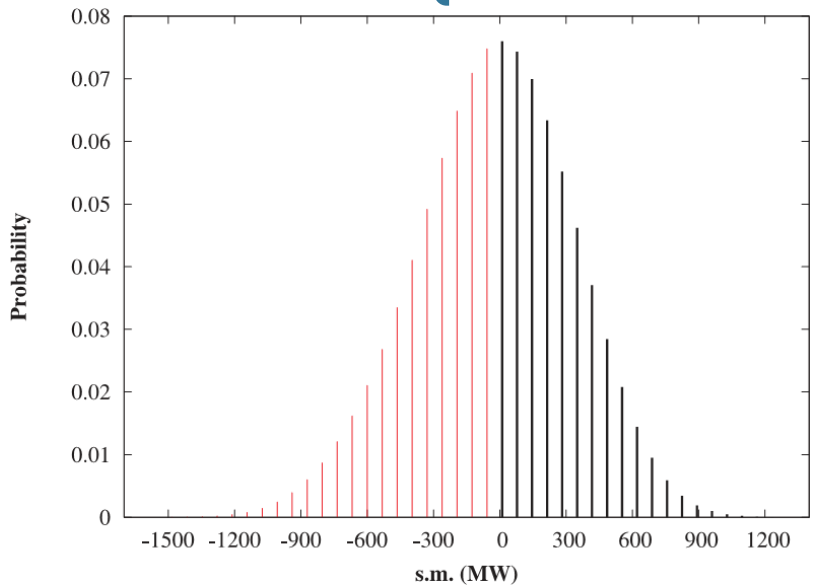
- **Conventional generation:** discrete probability distribution of the possible capacity states (capacity outage probability table, COPT)
- **Load:** Gaussian distribution with a given standard deviation and zero mean
- **Wind generation:** set of quantiles forecasted by the ANEMOS platform

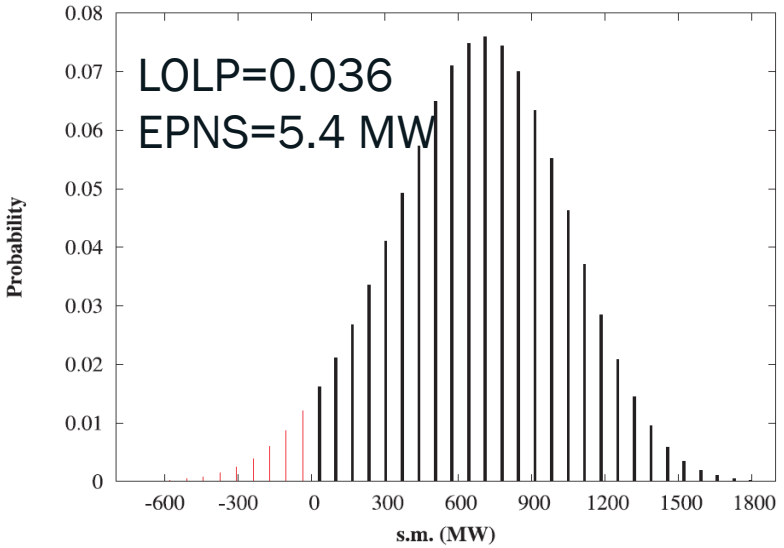


System Generation Margin Distribution (Probabilistic Model)

upward reserve
+ 700 MW

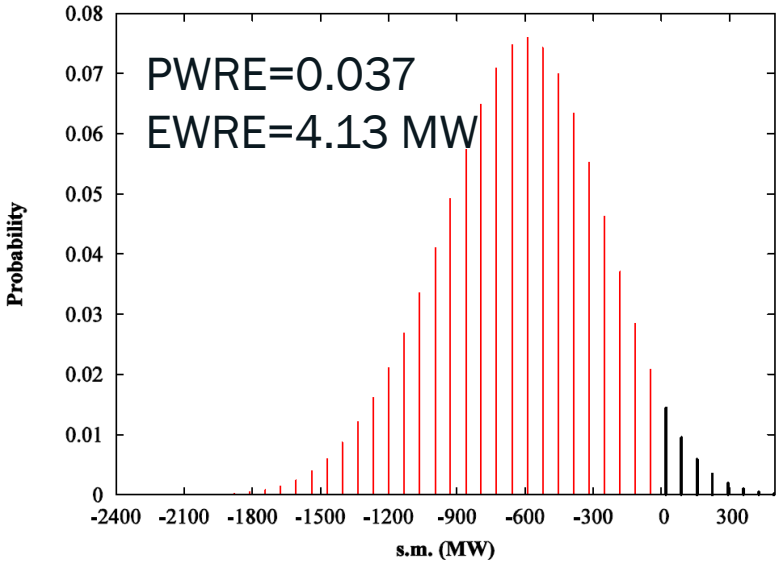
risk of loss of load
LOLP=0.49
EPNS=157.1 MW



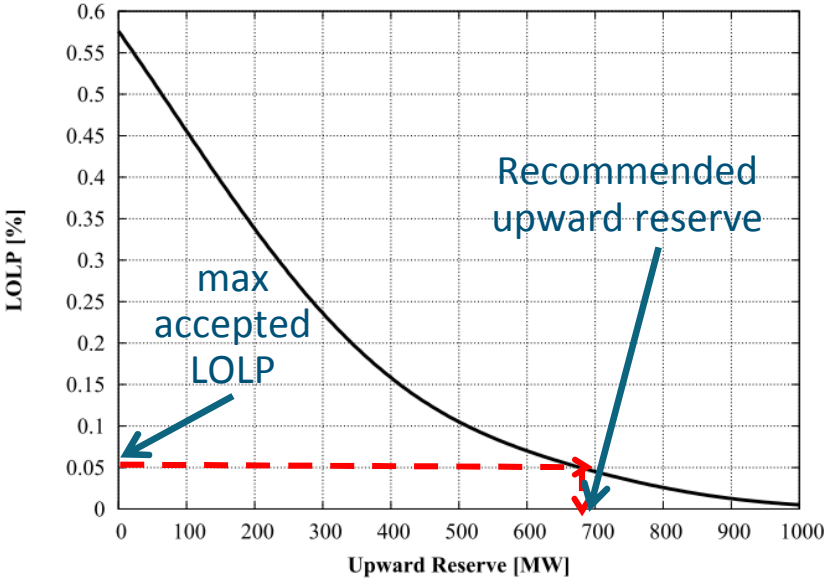


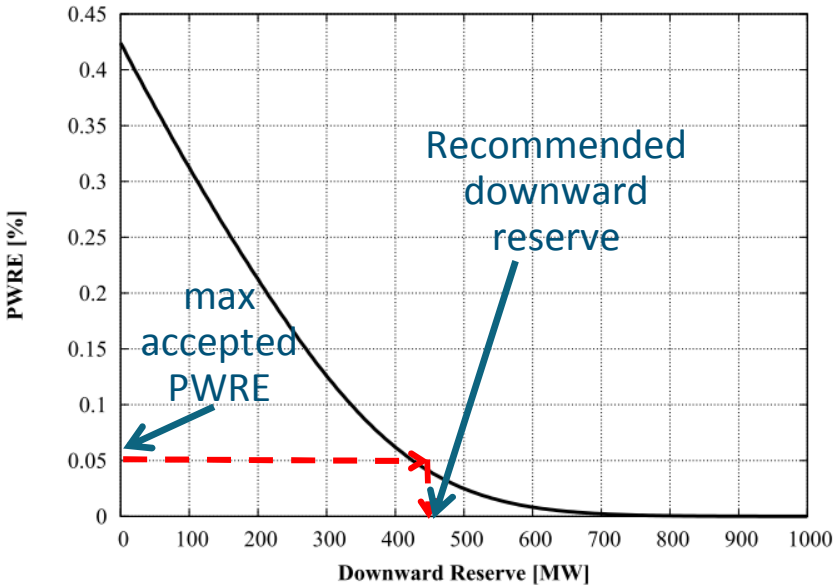
risk of generation surplus
PWRE=0.51
EWRE=129.1 MW

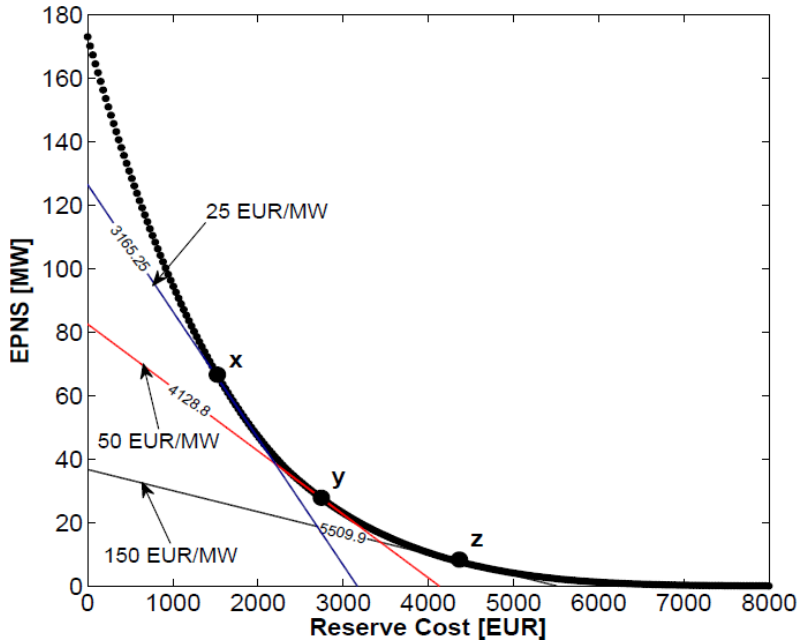
downward reserve
- 600 MW



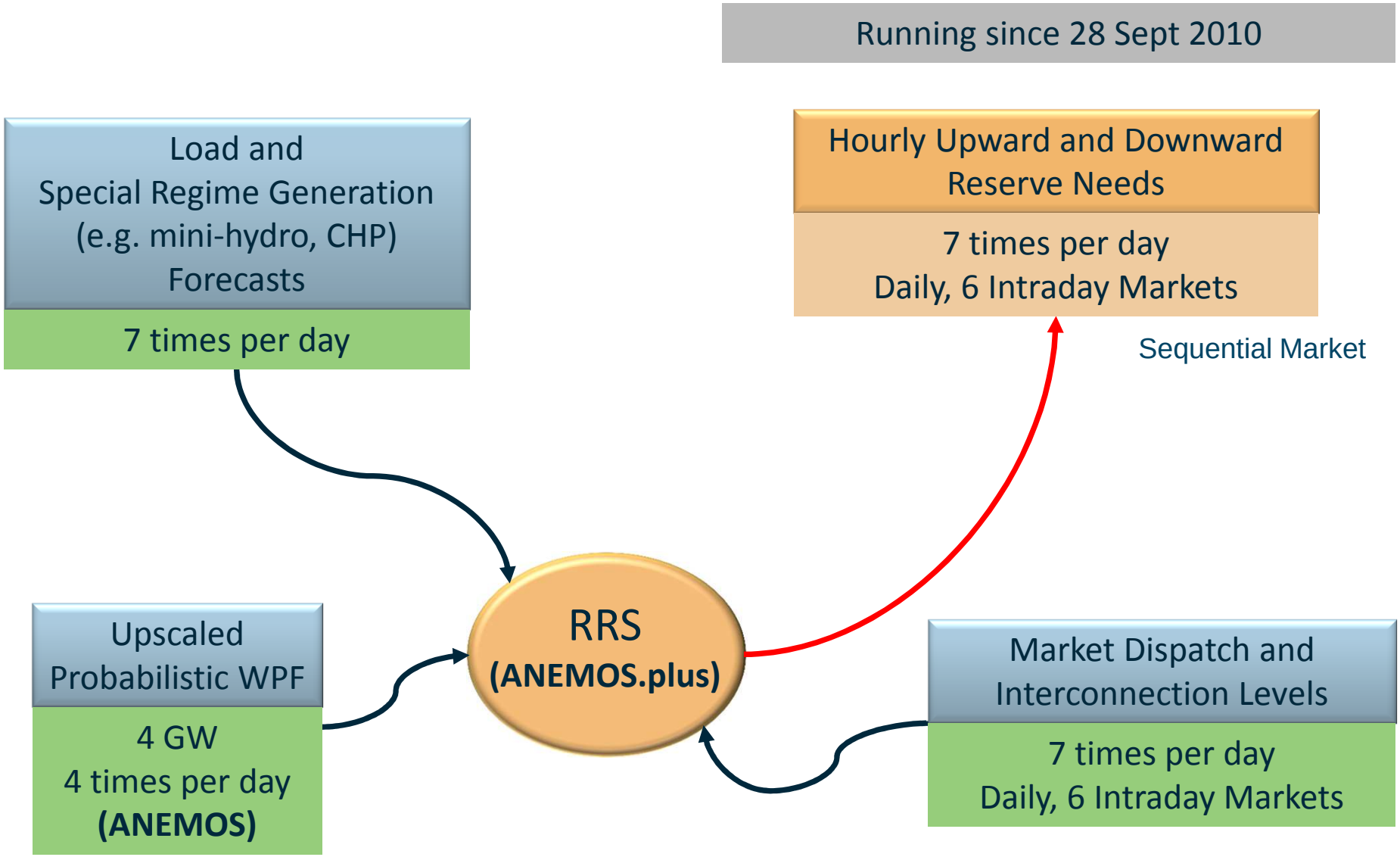
Risk/(Reserve or Cost) Curves and Decision-aid



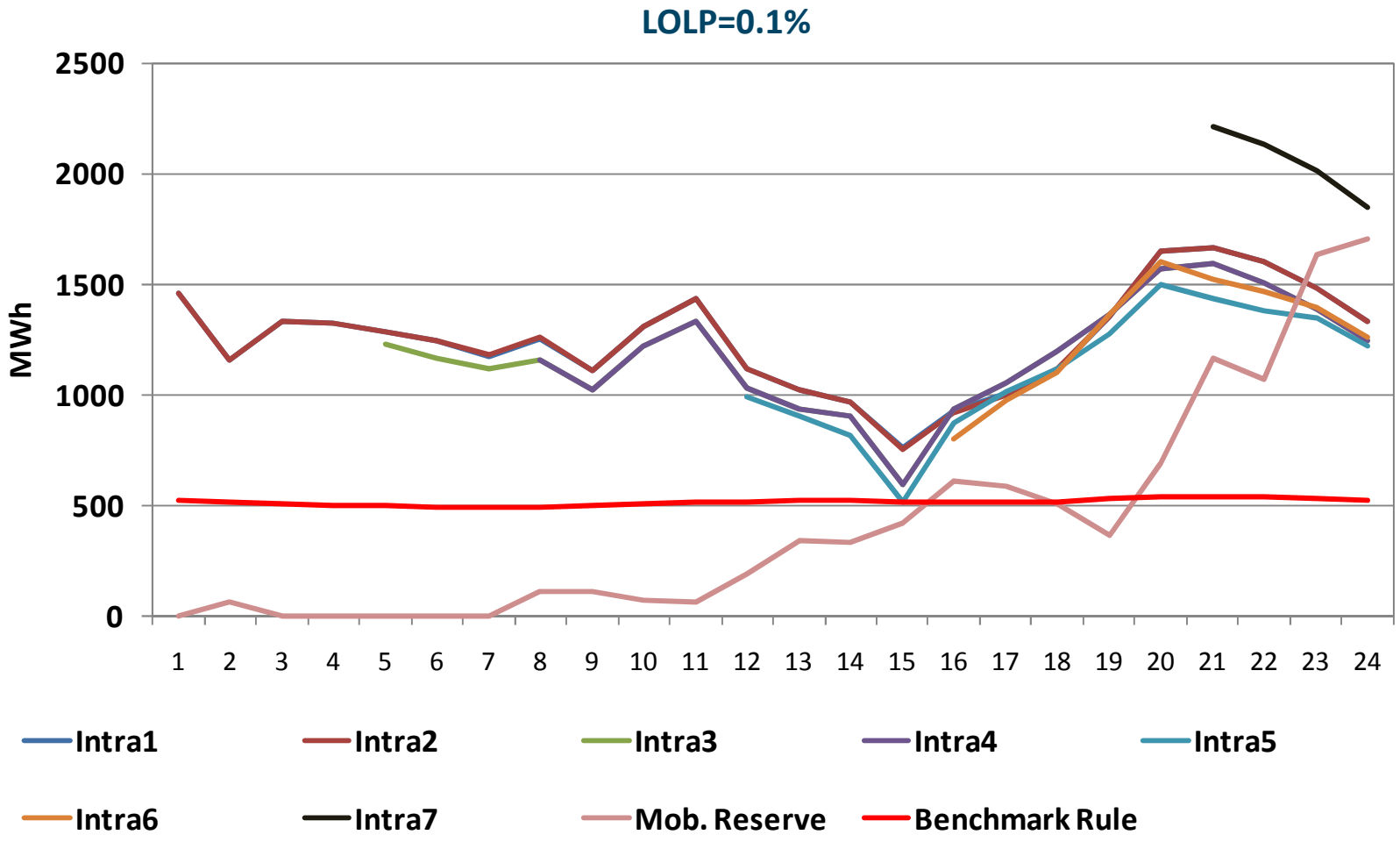




Demonstration Case Design



Output Results (Upward Reserve)



Upward Reserve Results (Oct-Feb, 4 Months)

Market Session	LOLP=0.1%	LOLP=0.5%	LOLP=1%	Benchmark Rule
Daily	1.44 %	2.25 %	2.76 %	4.34 %
Intraday 1	0.83 %	1.39 %	1.79 %	3.13 %
Intraday 2	1.23 %	1.76 %	2.14 %	3.18 %
Intraday 3	1.15 %	1.77 %	2.33 %	2.47 %
Intraday 4	1.28 %	2.02 %	2.51 %	2.08 %
Intraday 5	1.18 %	1.72 %	2.37 %	2.35 %
Intraday 6	0.70 %	0.70 %	1.10 %	2.47 %

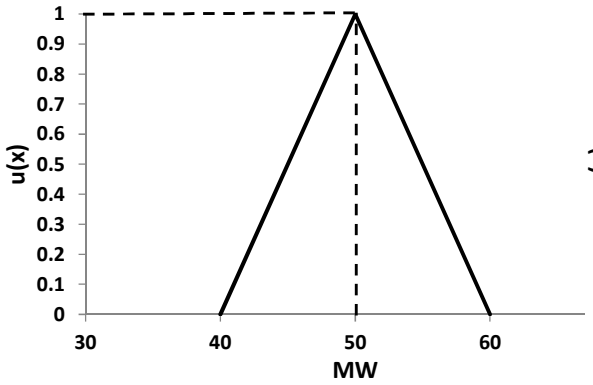
Reliability (or calibration) of probabilistic forecasts is the key requirement

Sharpness is important, but it is not the critical factor

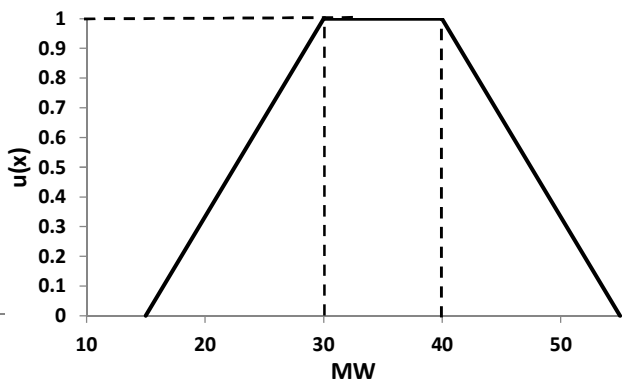
Fuzzy Power Flow Tool

Fuzzy Power Flow (FPF)

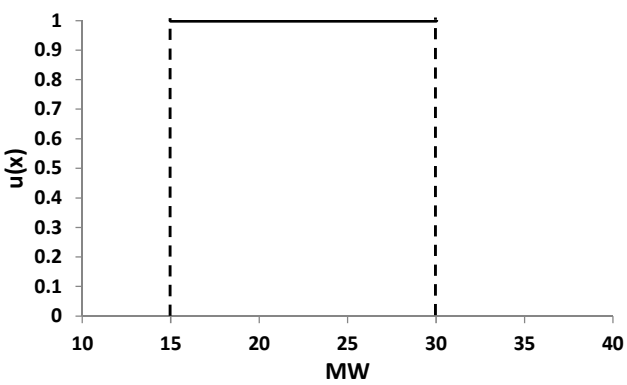
- Fuzzy numbers for generation and load (active and reactive)



Load about 50 MW



Load more or less between 30 and 40 MW

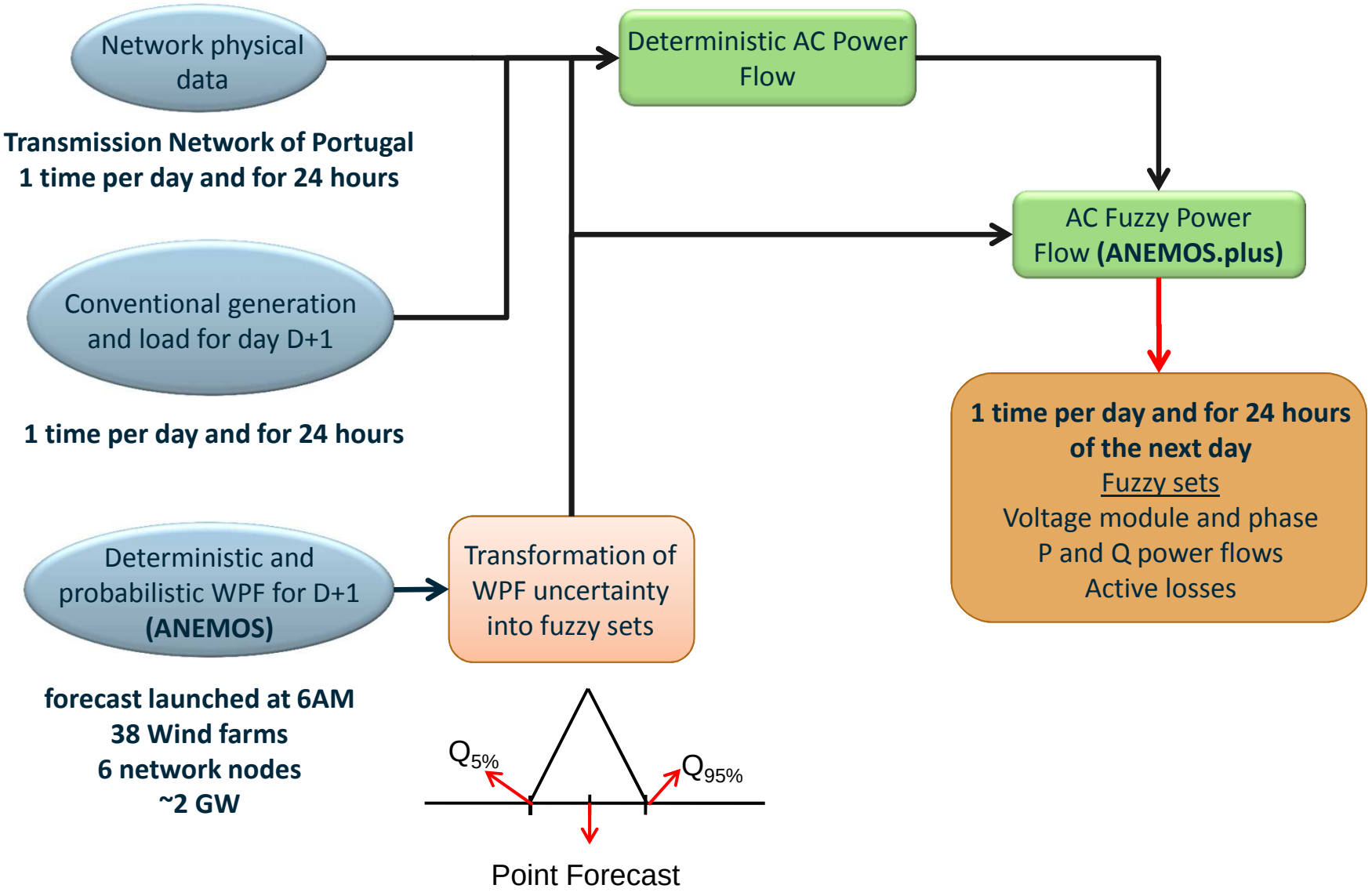


Load between 15 and 30 MW

- The midpoint is computed by the deterministic AC power flow
- The FPF consists of a linearization step and a non-iterative algorithm to deal with uncertainties
- Output data
  - e.g. fuzzy node voltages' magnitudes and angles; fuzzy active and reactive power flows; fuzzy active and reactive losses and currents

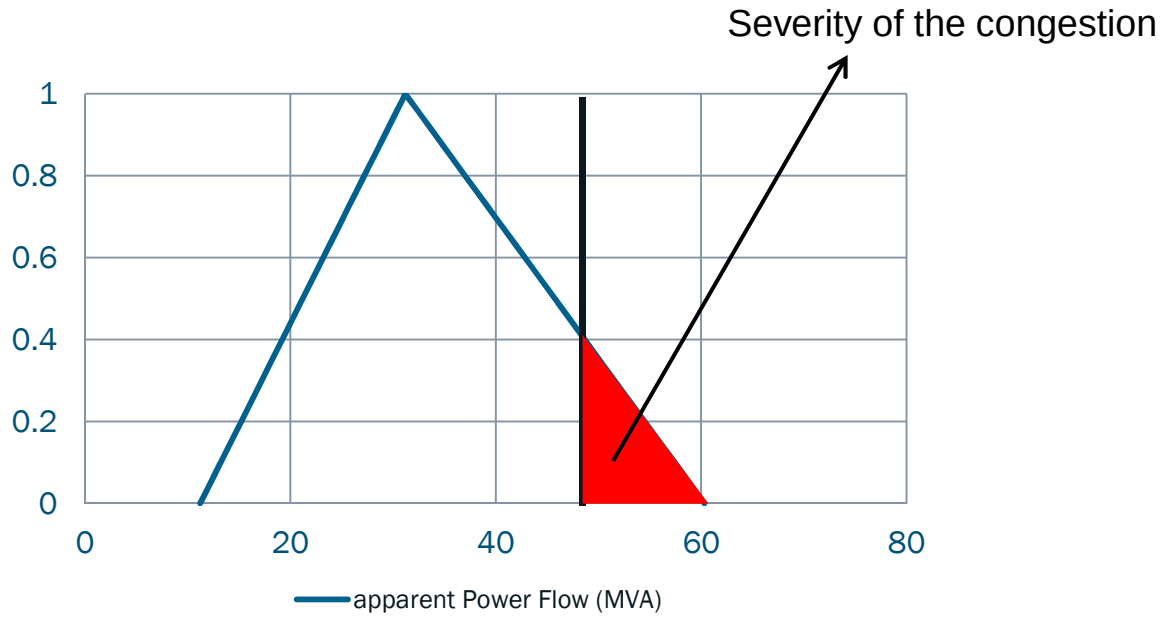
Demonstration Case Design

Running since 25 Oct 2010



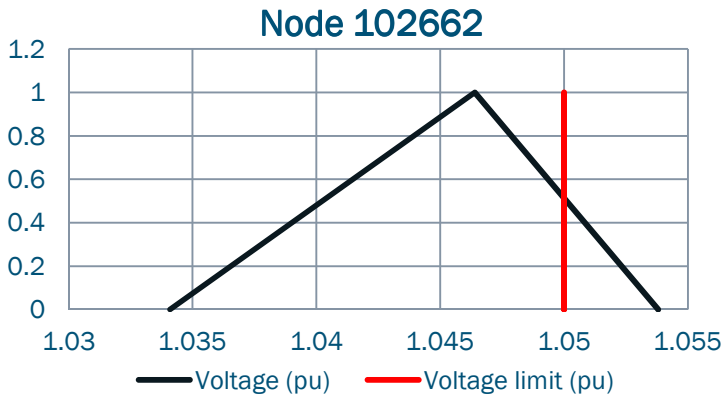
Output Information

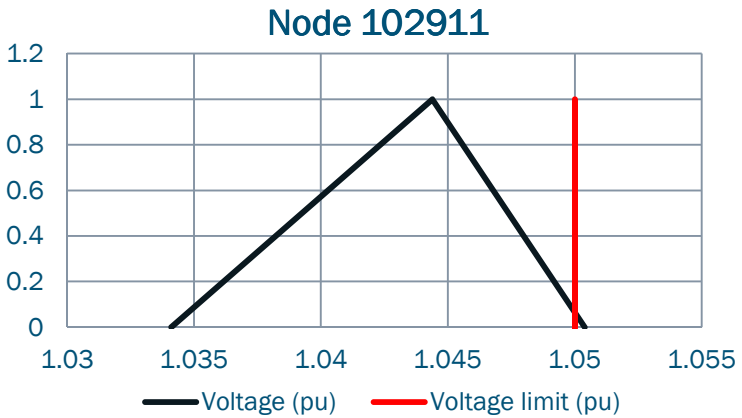
- List of possible bus voltage violations and branch congestion
- Voltage violation: >1.05 pu and <0.95 pu
- Congestion: greater than line limit power
- Severity index of the congestion and voltage violation (in %)



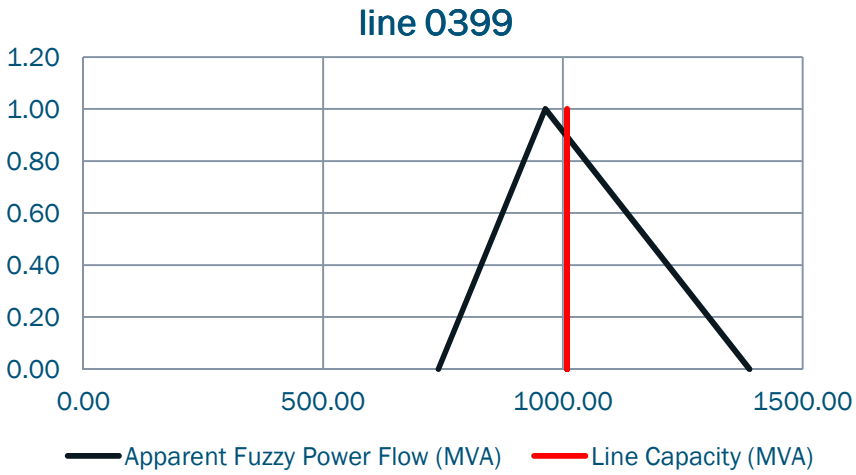
Output Results

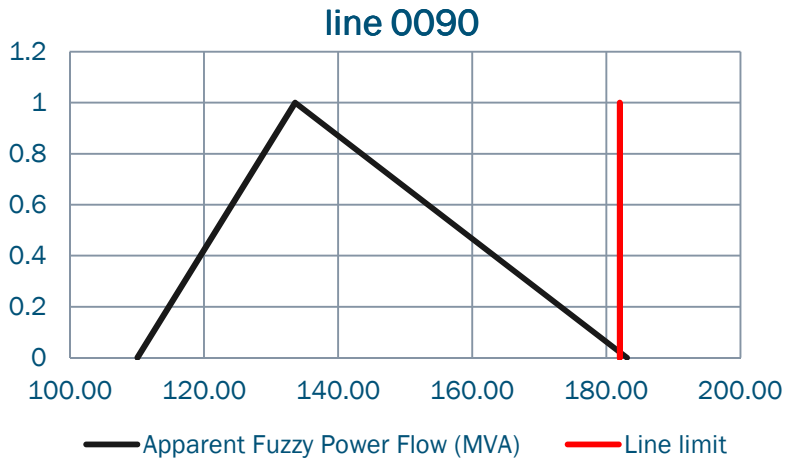
- Possibility of overvoltage situations in two nodes at 9PM 31 Oct



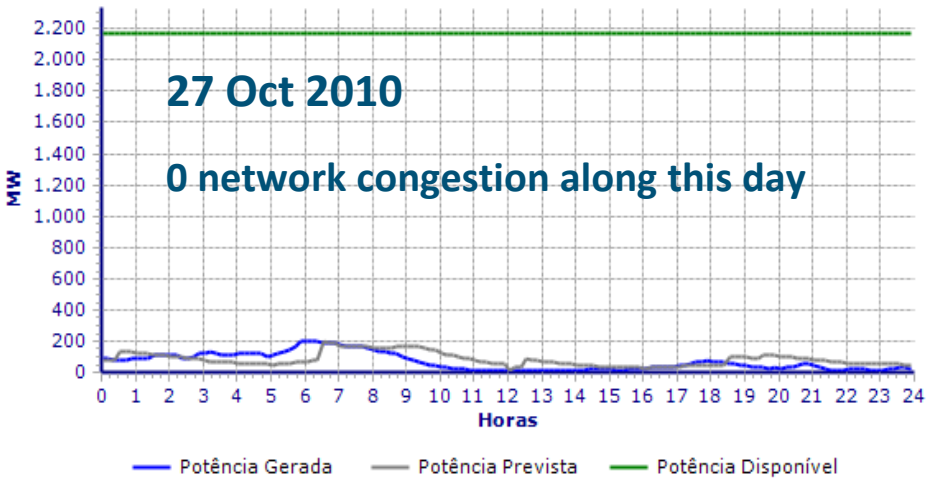


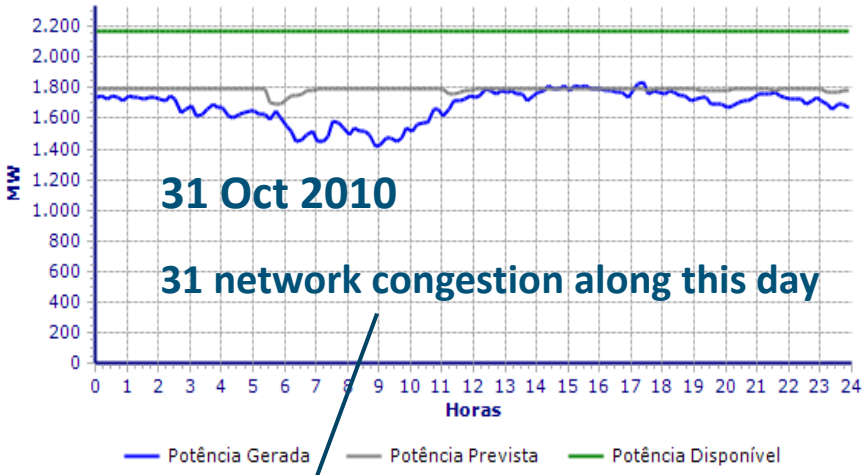
- Possibility of network congestions in two lines on 31 Oct at 9PM



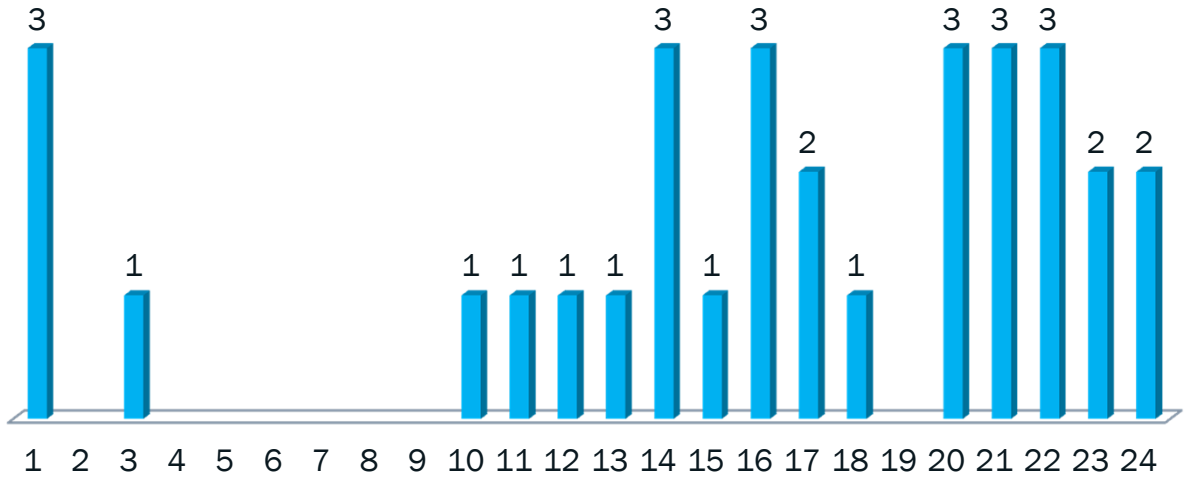


Output Results





Number of network congestions



Conclusions

- The tools were developed according to the end-users prerequisites and necessities
- Robust reserve setting tool
  - avoids making assumptions on the errors distributions
  - defines the reserve dynamically
  - models different attitudes and values of the decision-maker
- Fuzzy power flow tool
  - allows the inclusion of probabilistic WPF in day-ahead security evaluation
  - contribute to identify weak points of the transmission network during operational phases
- **Next step:** quantitative and qualitative evaluation results for the whole demonstration period (until June 2011)