



Ancillary services provision by a renewable energy based virtual power plant (VPP). The REstable project.

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icem
2019





Consortium (FR, DE, PT)



1st Franco-German Innovation Award 2016

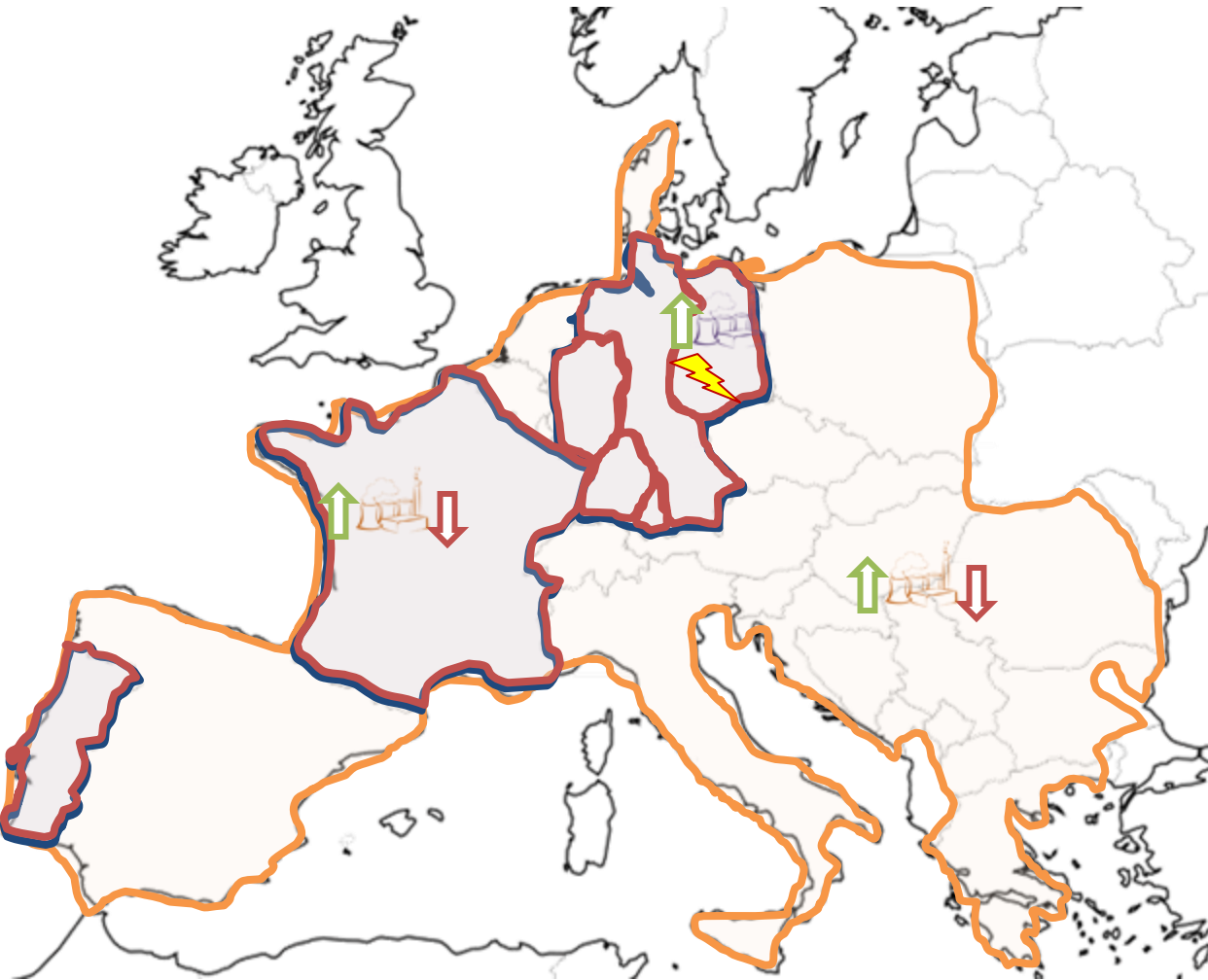
European Energy Project 2017

Context

- Partner country
- UCTE
- Fault
- 1st reserve
- 2nd, 3rd reserve
- TSOs

Renewables usually do not take part to this mechanism

- Ceiling to renewable penetration
- Missed revenue



REstable - Objectives

- To develop a renewables-based VPP able to provide ancillary services (reserve) with a reliability comparable to a thermal plant
 - Taking advantage of reduced correlation in production
 - because of distance
 - because of generation technology (wind, PV)
- To develop the necessary tools and
- To test it on a real, pan-European demonstrator

Solution

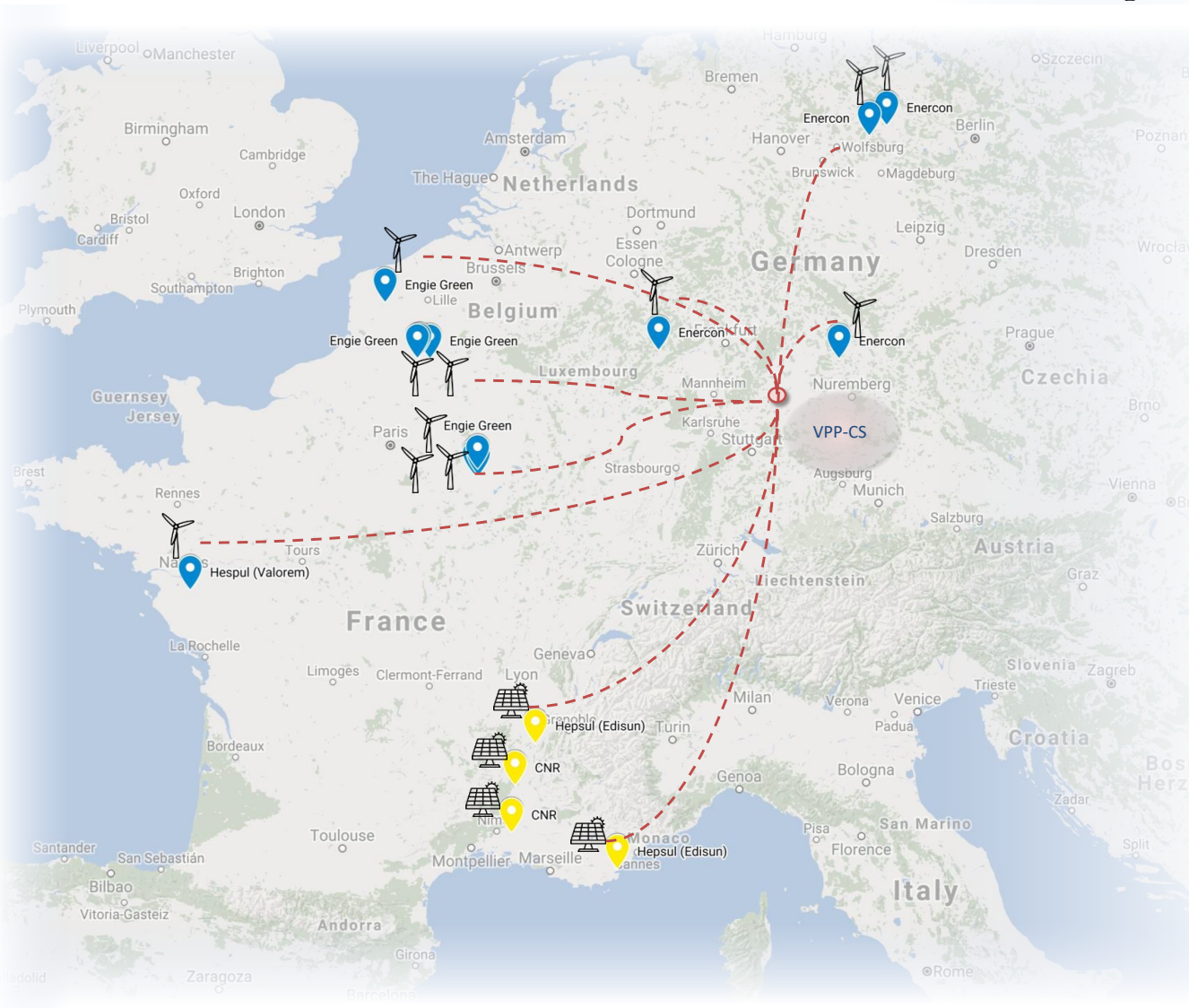
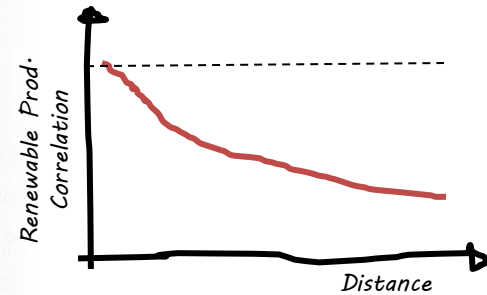


● 4 Solar farms, 8 MW



● 13 Wind farms, 264 MW

No hydro or batteries!



Partners

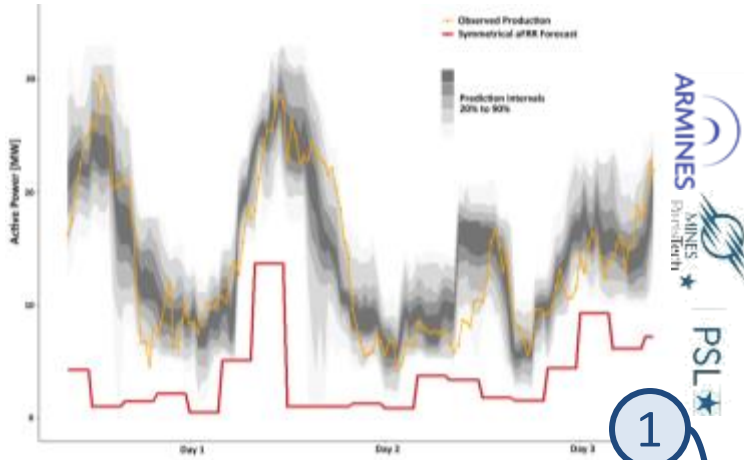


Associated



REstable's business chain

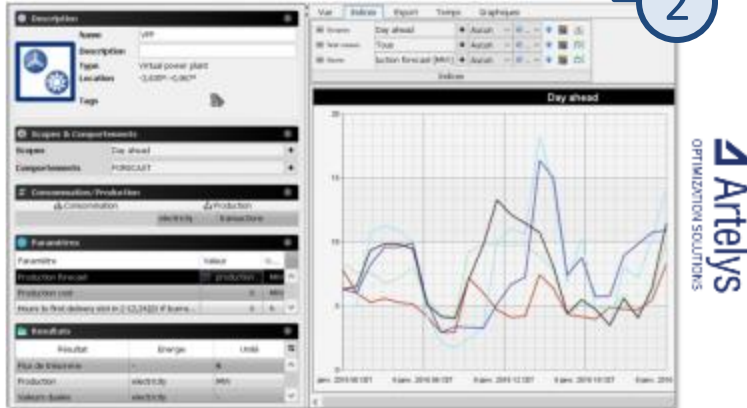
Forecasts: volume and prices



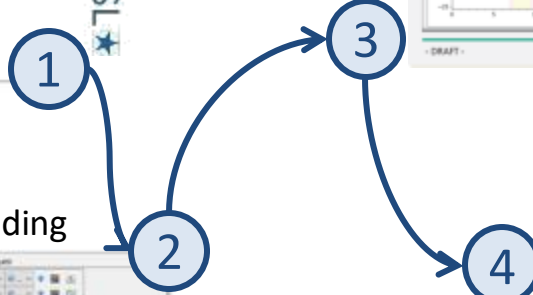
Virtual Power Plant – Control system



Energy and services markets bidding

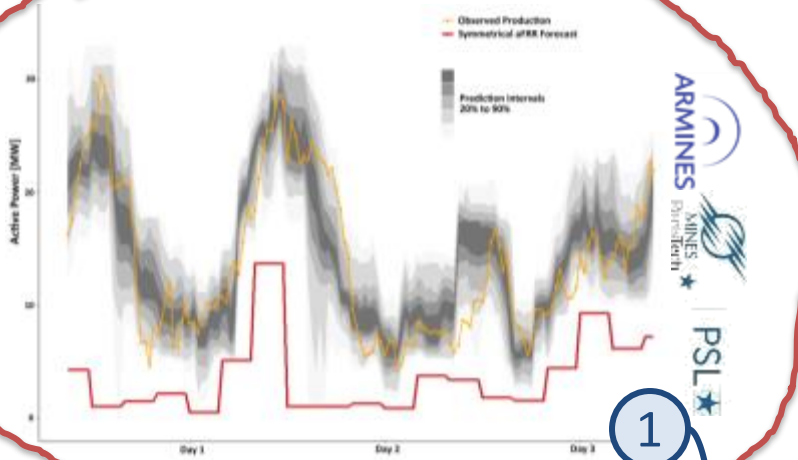


Advanced dispatch and validation

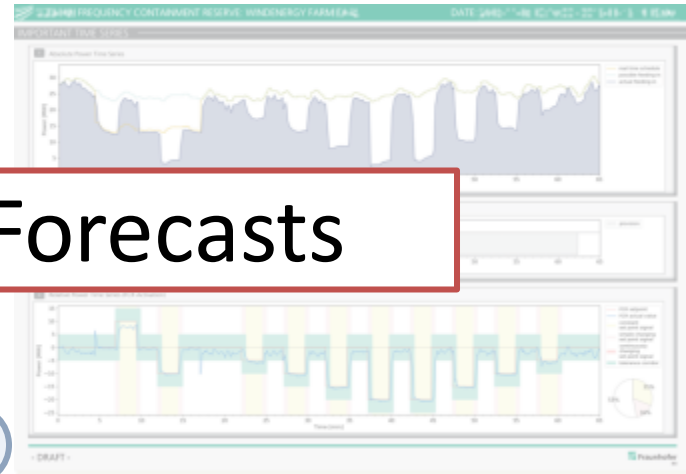


REstable's business chain

Forecasts: volume and prices



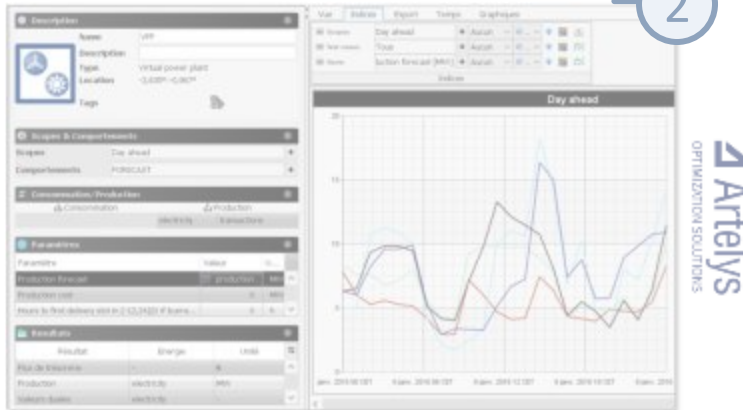
Virtual Power Plant – Control system



Forecasts

Fraunhofer
IEE

Energy and services markets bidding



Advanced dispatch and validation



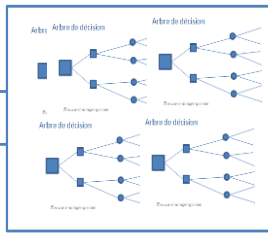
INESC TEC

Forecasts: Available volume

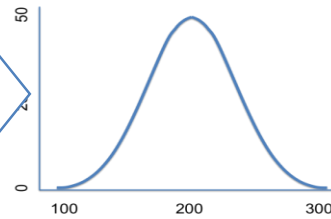
Input variables X_i

X_1
 X_2
...
 X_n

Non-parametric model

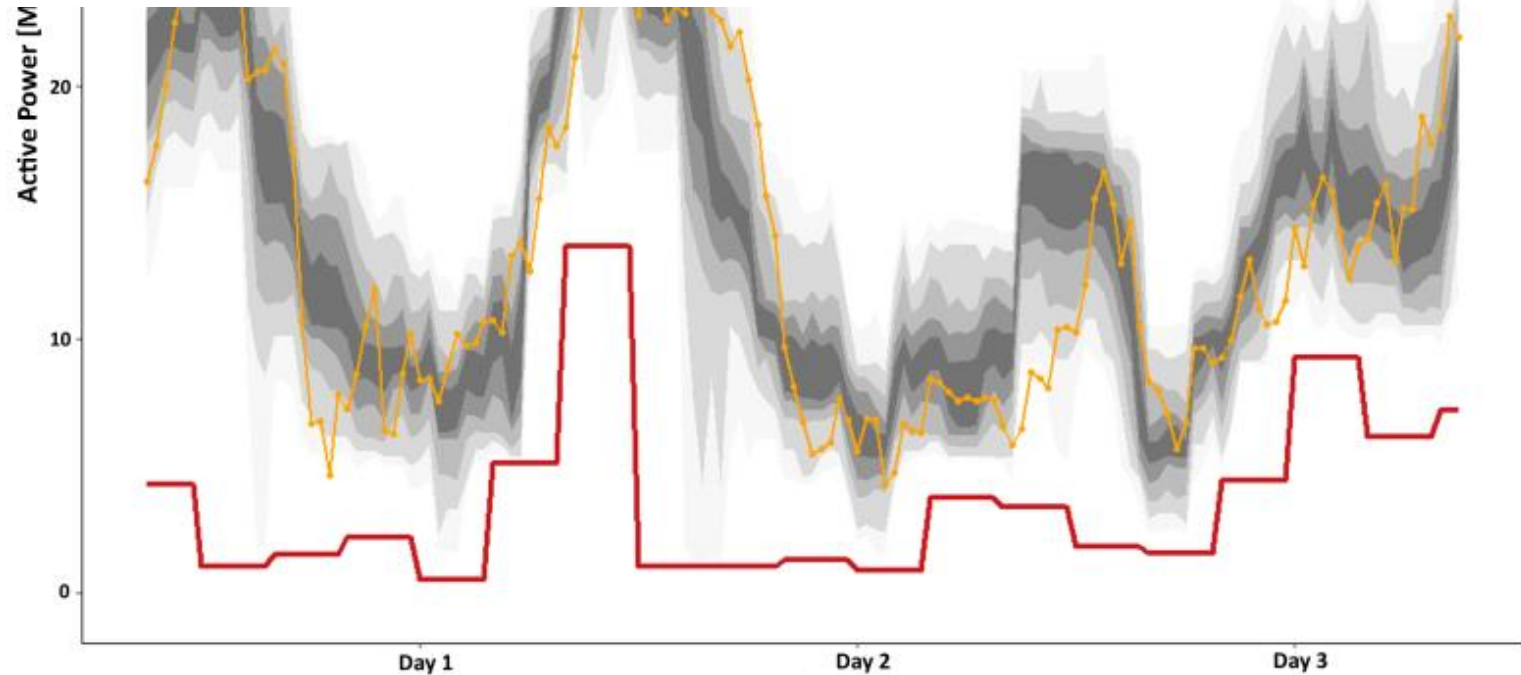


Output variables Y

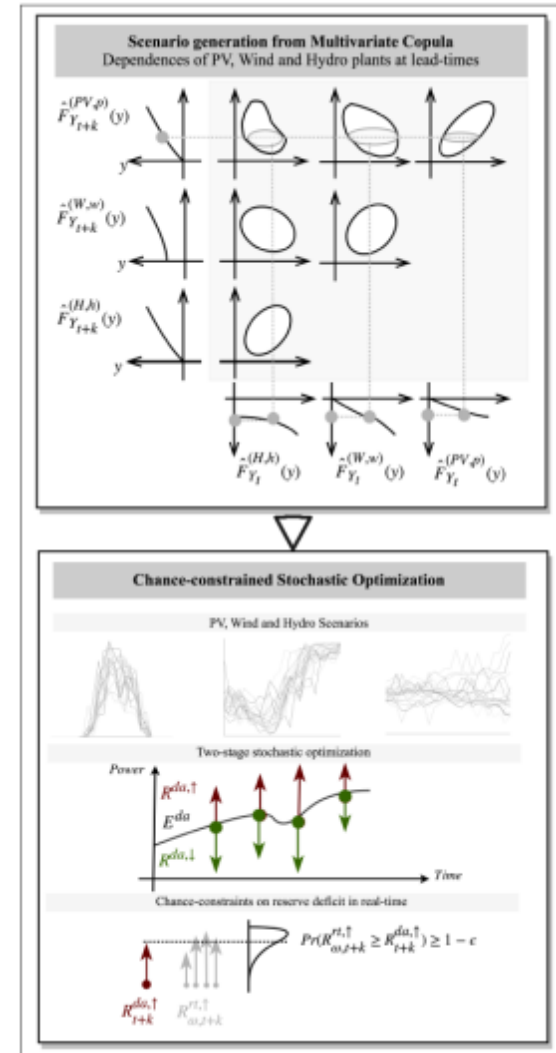
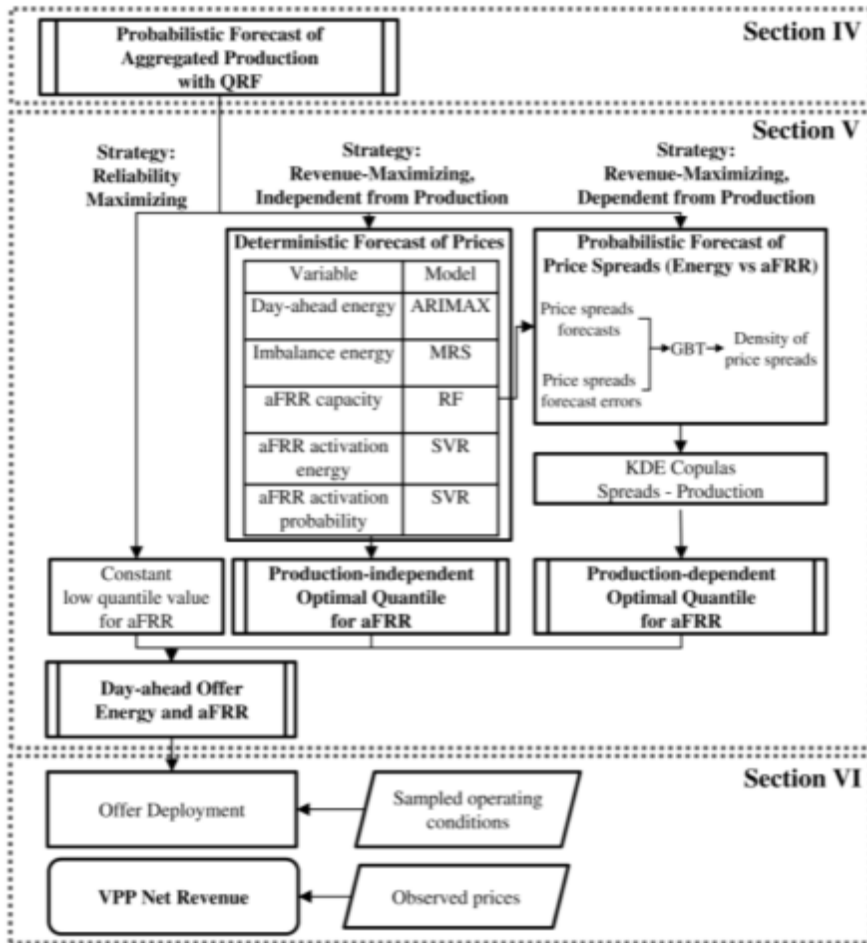


— Observed Production
— Symmetrical aFRR Forecast

Prediction intervals
20% to 90%



Forecasts: prices and scenarios

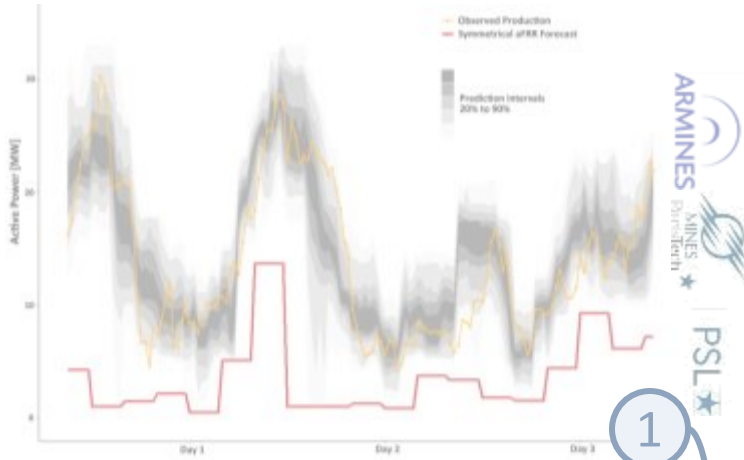


Price forecast and optimal FRR offer

Scenarios creation

REstable's business chain

Forecasts: volume and prices

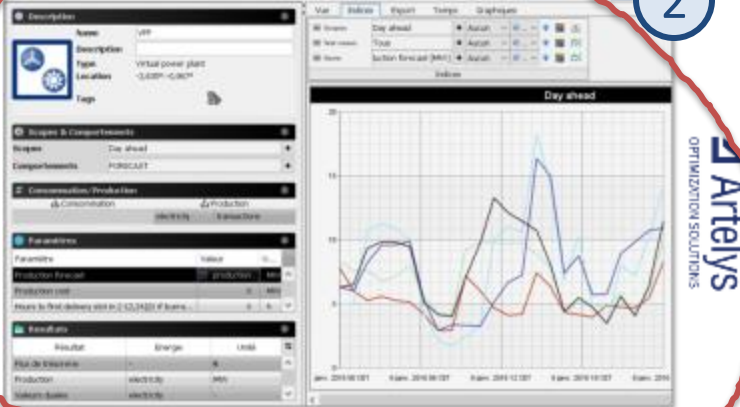


Virtual Power Plant – Control system



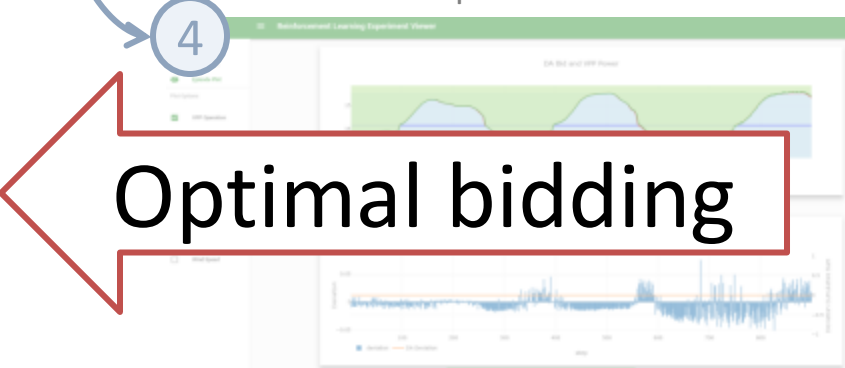
Fraunhofer
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Energy and services markets bidding



Artelys
OPTIMIZATION SOLUTIONS

Advanced dispatch and validation



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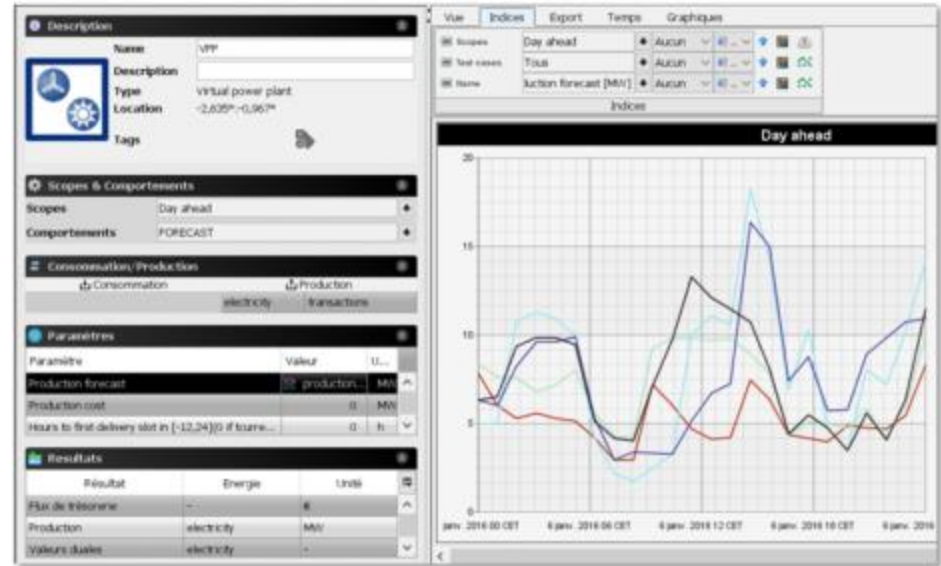
Optimal bidding



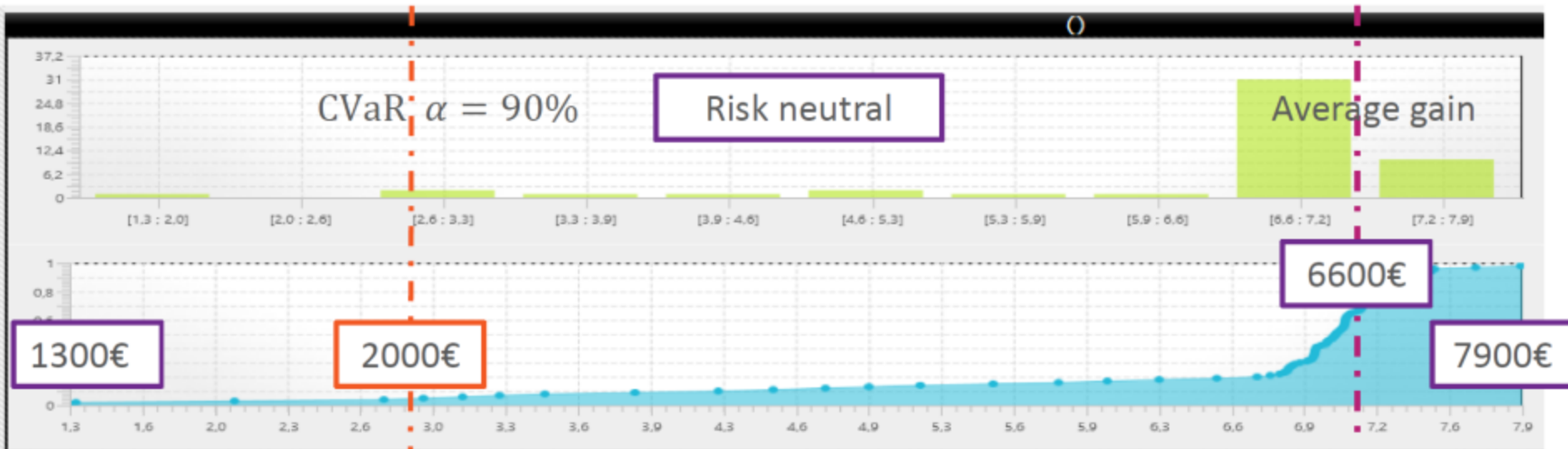
Energy and services markets bidding

Optimal bidding

- of energy and reserve
- Uncertainty (through scenarios)
- Operator risk appetite

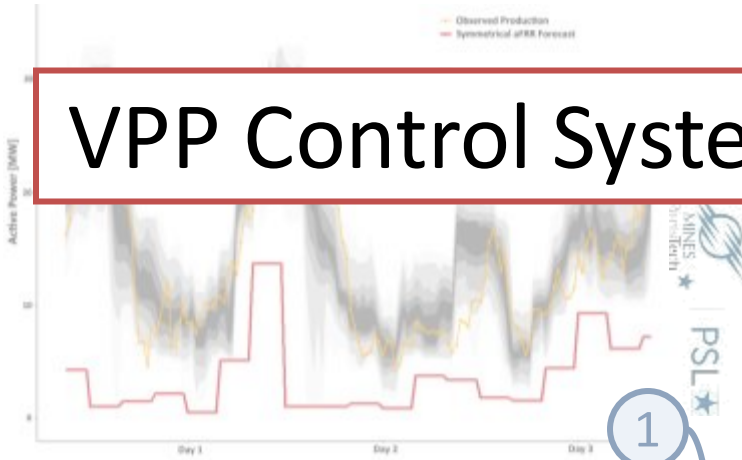


Artelys
OPTIMIZER SOLUTIONS



REstable's business chain

Forecasts: volume and prices



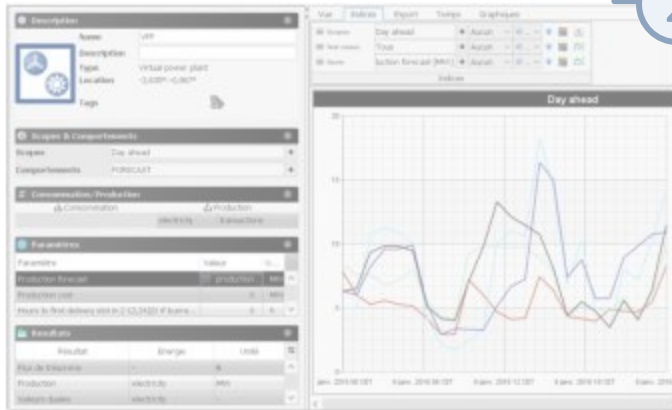
VPP Control System

Virtual Power Plant – Control system



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Energy and services markets bidding

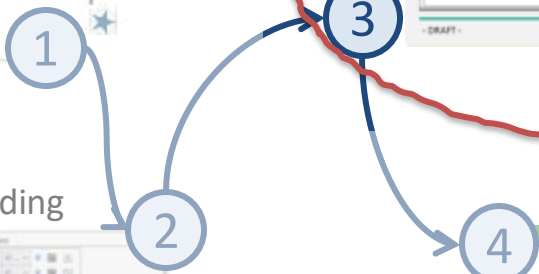


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OPTIMIZATION SOLUTIONS

Advanced dispatch and validation

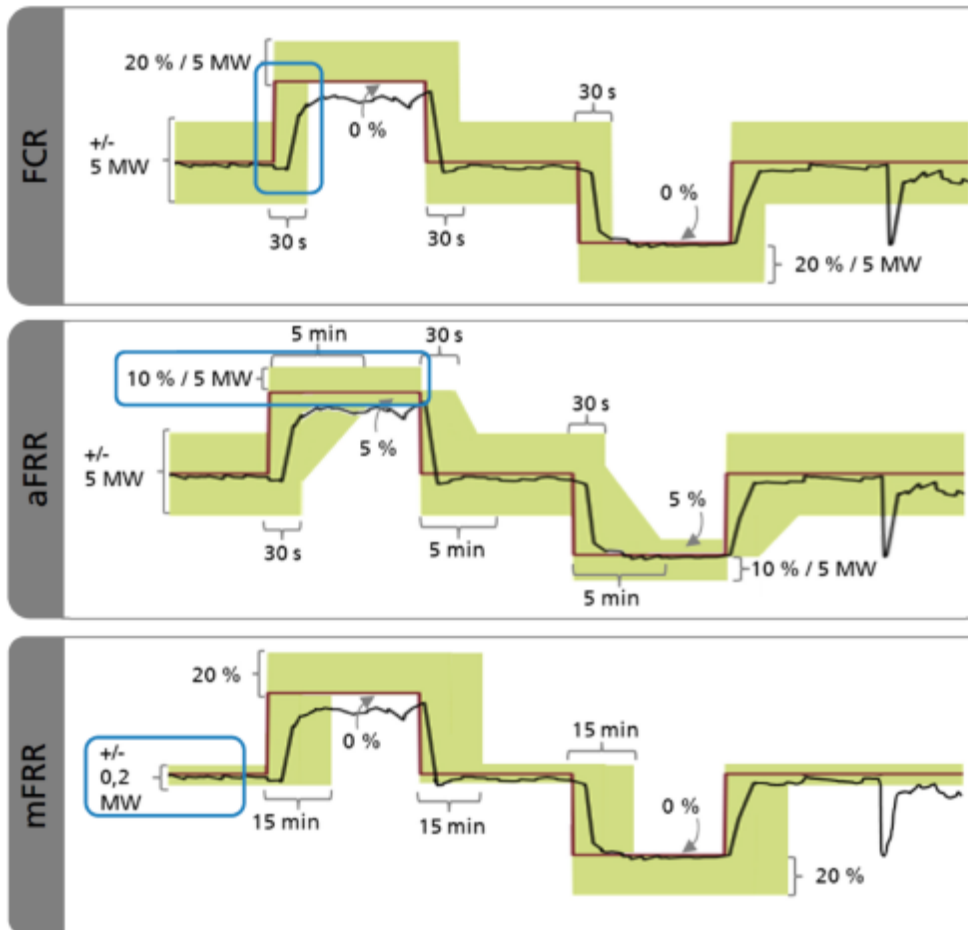


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Virtual Power Plant – Control system (requirements)

German Requirements for FCR, aFRR and mFRR
Fulfillment Corridor



— Set point
— Actual value
■ Fulfillment corridor

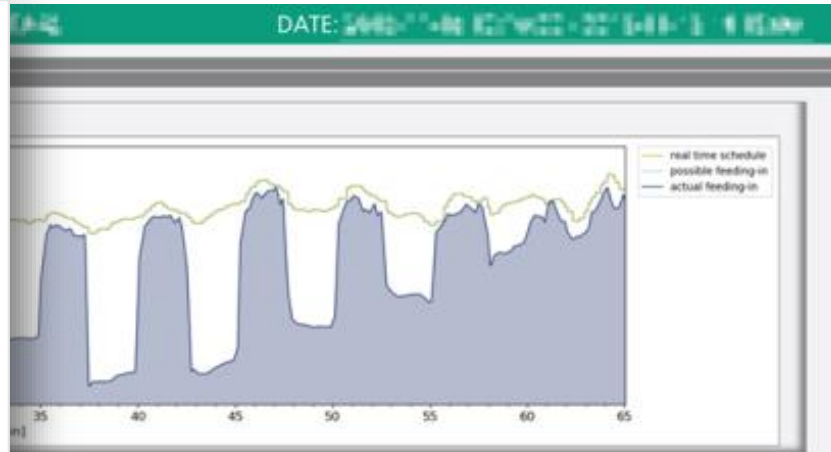
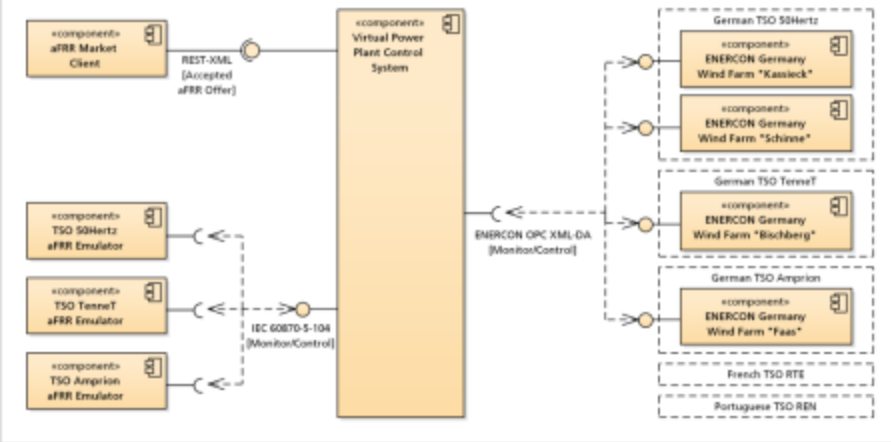
(De-)activation time
Reaction time
Power Gradient
Overfulfillment
Underfulfillment

partly inconsistent, incomplete
or contradictory requirements

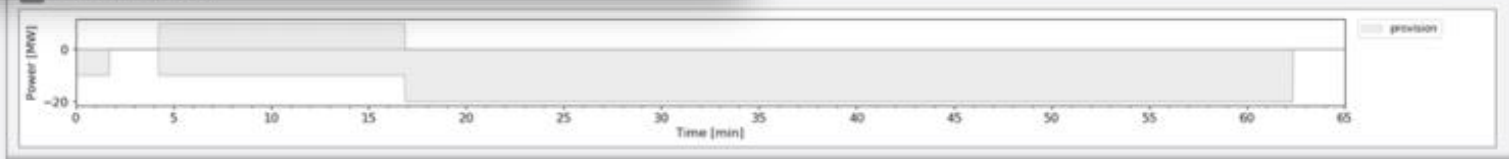
- FCR gradient
- aFRR tolerance overfulfillment
- mFRR tolerance set point zero

Virtual Power Plant – Control system (tests)

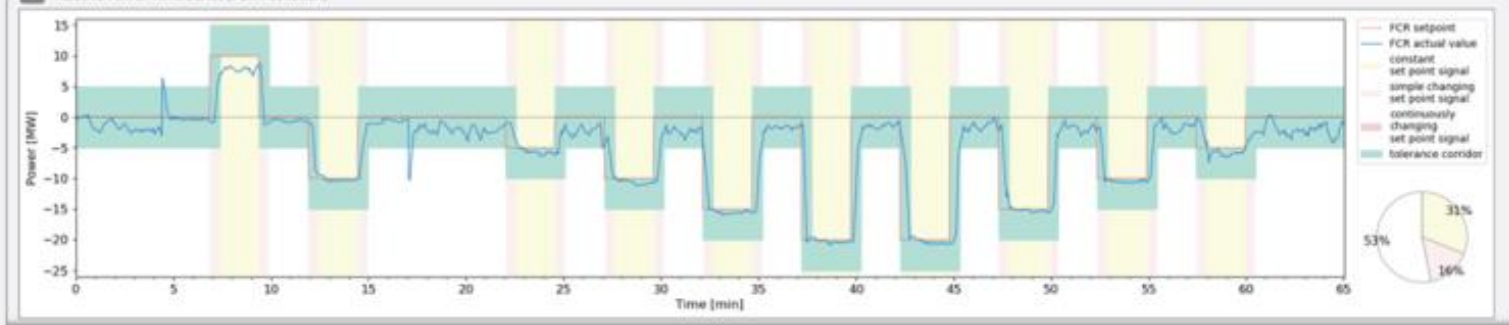
cmp REstable Field Test Architecture for Automatic Frequency Restoration Reserve (aFRR)



2 FCR Provision Time Series

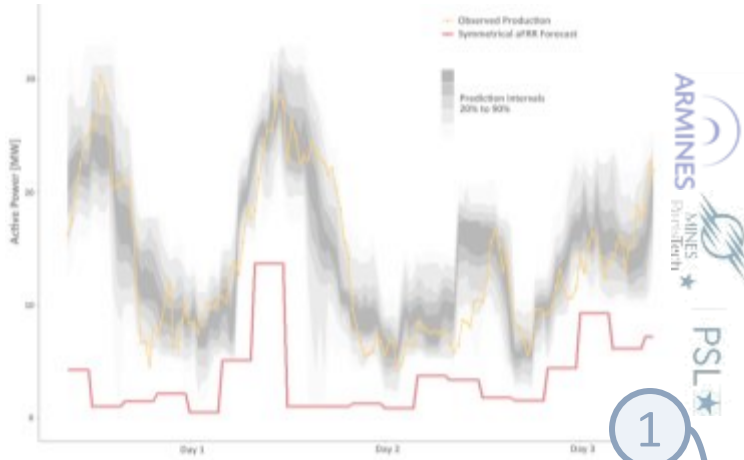


3 Relative Power Time Series (FCR Activation)



REstable's business chain

Forecasts: volume and prices

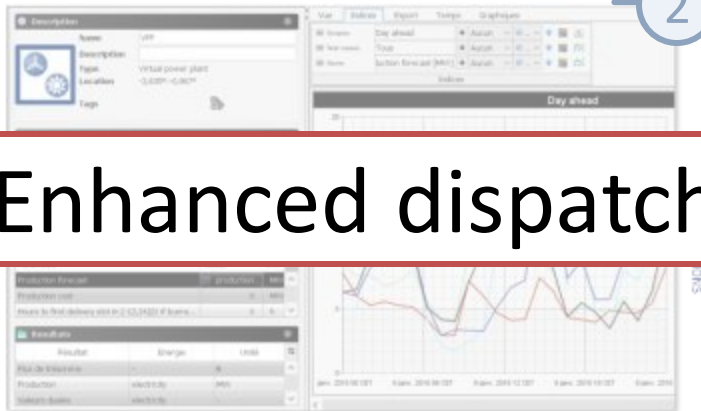


Virtual Power Plant – Control system



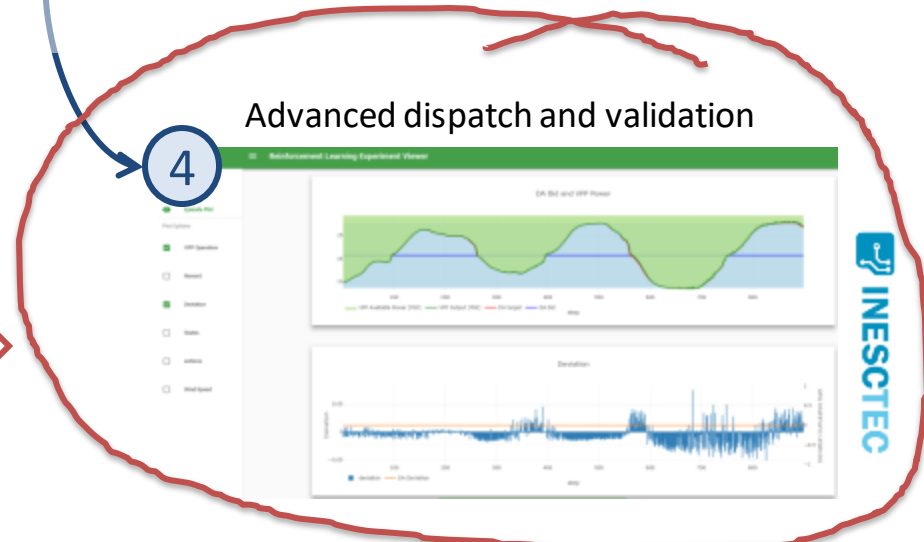
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Energy and services markets bidding



Enhanced dispatch

Advanced dispatch and validation



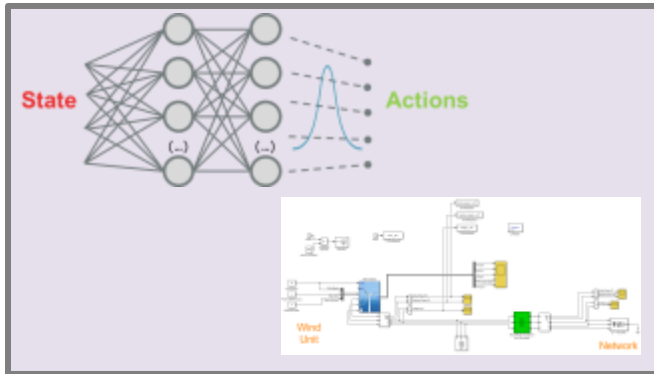
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Advanced dispatch and validation (process)



1. Train the agent

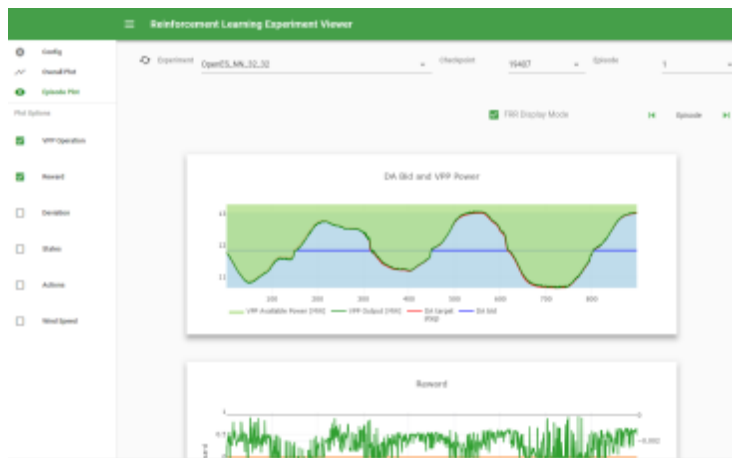


2. Evaluate the performance

Evaluation Module

- Runs a set of test episodes (reproducible)
- Collects data
- Exports through the REST API in JSON format

4. Access and Visualize results



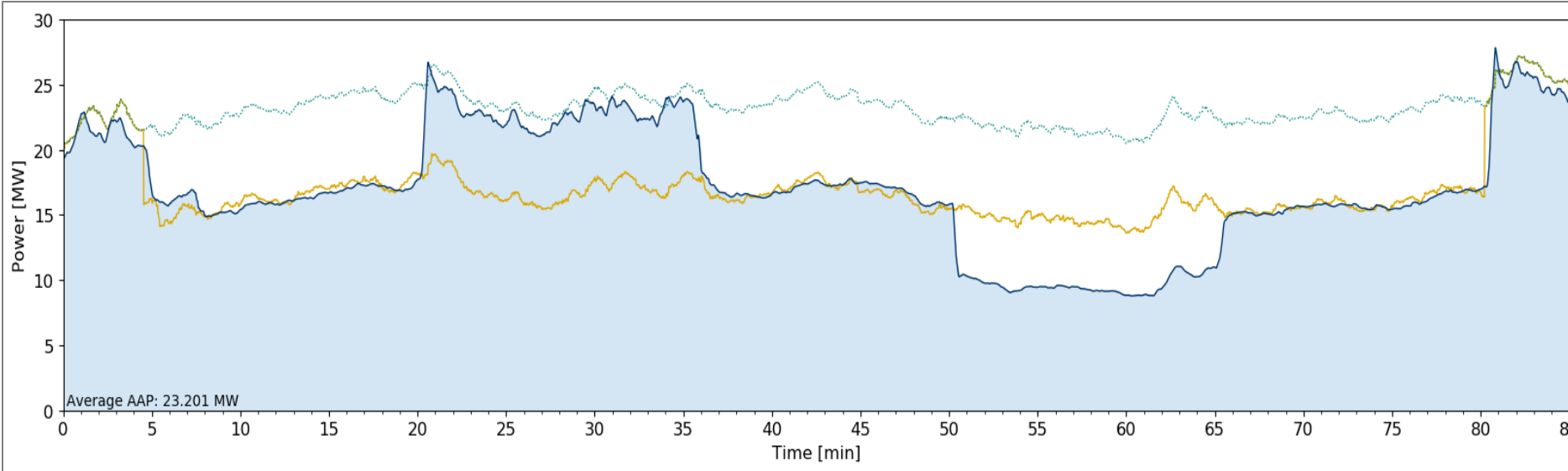
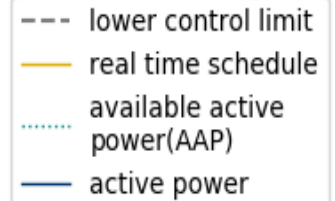
3. Store simulation results

REST API + Database

- Receives data in JSON format and stores it in the PostgreSQL database
- Provides easy access through the REST API, i.e:

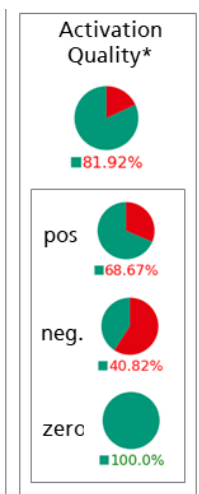
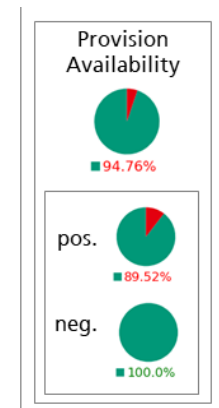


Test 1 Wind DE/FR

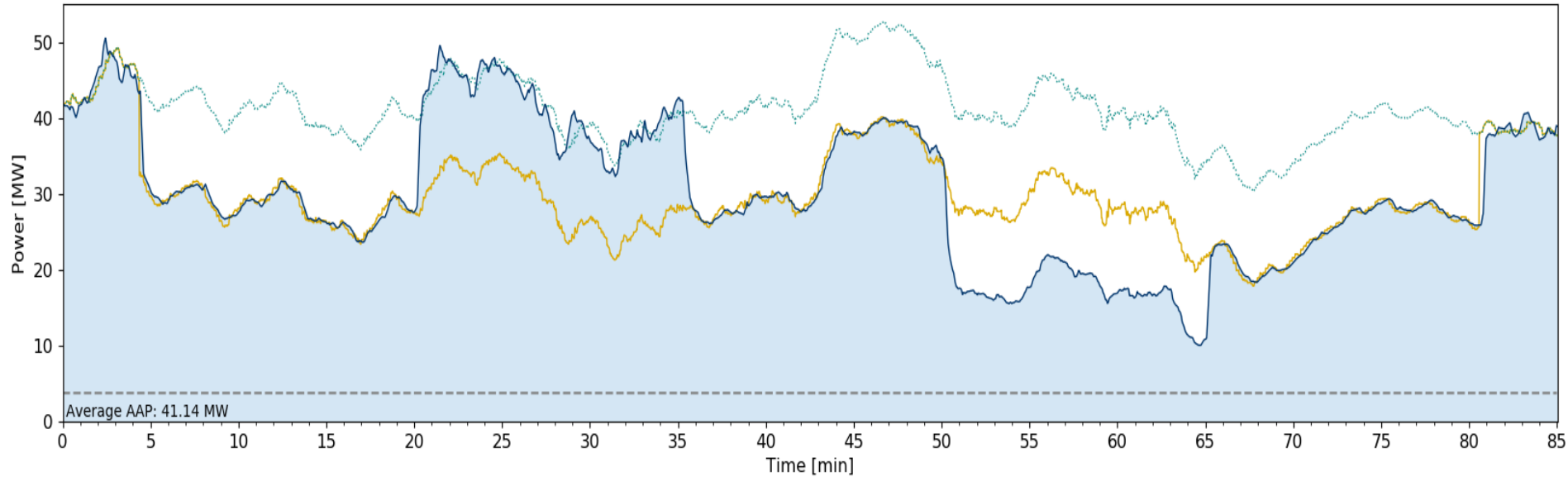
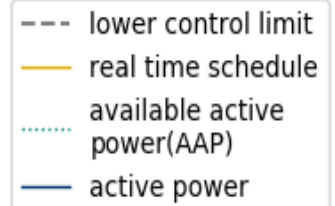


129 MW capacity, 3 wind farms in DE, 2 wind farms in FR

- **Good availability, observed problems on activation quality**
- **Availability** – The 6 MW reserve band is always available, deviations due to overestimation on the available power in DE
- **Activation quality** – Long reaction time for downward regulation

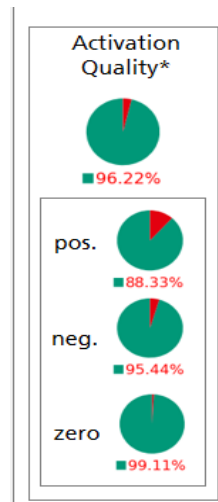
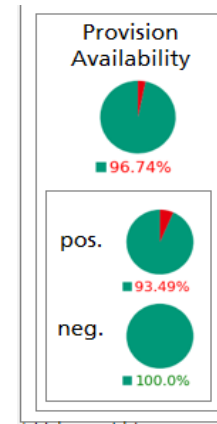


Test 2 Wind DE/FR

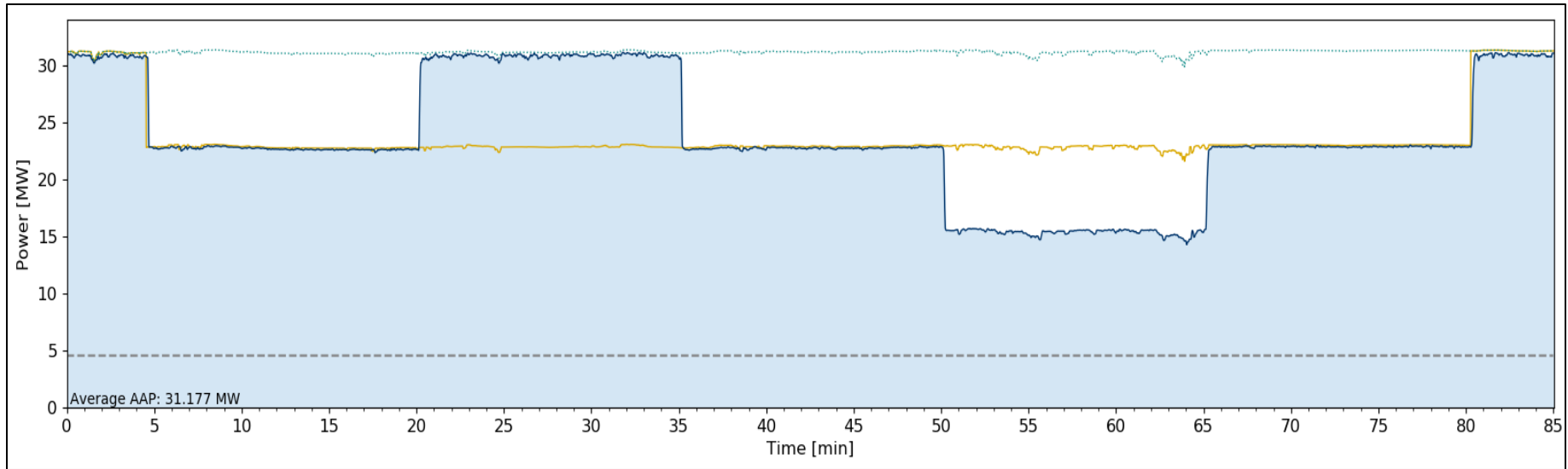
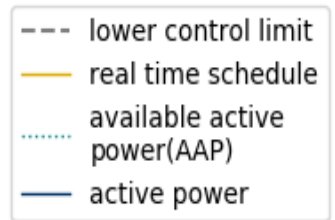


75 MW capacity, 2 wind farms in DE, 2 wind farms in FR

- Improved communication delay
- Activation quality – remaining error on the available power

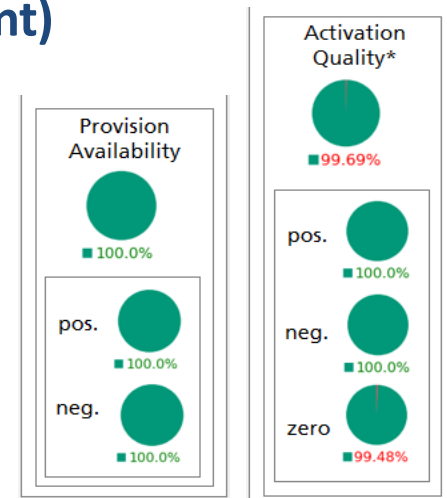


Test 3 Wind-PV FR



32 MW capacity (3 Wind farms, 1 MW PV plant)

- Steady high wind conditions, optimized communication protocols
- Very high performance in availability and activation quality





Dissemination

Website

<https://www.restable-project.eu> (news, factsheet, deliverables)

Follow us on LinkedIn:

<https://www.linkedin.com/company/restable-project/>

Publications

- 1) Simon Camal, Andrea Michiorri, Georges Kariniotakis, Andreas Liebelt. « Short-term Forecast of Automatic Frequency Restoration Reserve from a Renewable Energy Based Virtual Power Plant ». *The 7th IEEE International Conference on Innovative Smart Grid Technologies - ISGT Europe 2017*, Sep 2017, Torino, Italy. 2017.
- 2) José R. Andrade, Jorge Filipe, Marisa Reis and Ricardo J. Bessa “Probabilistic Price Forecasting for Day-Ahead and Intraday Markets: Beyond the Statistical Model”, *Sustainability* 2017, 9(11), 1990; doi:10.3390/su9111990
- 3) Ricardo J. Bessa , Corinna Möhrlein, Vanessa Fundel Malte Siefert, Jethro Browell, Sebastian Haglund El Gaidi, Bri-Mathias Hodge, Umit Cali, and George Kariniotakis, « Towards Improved Understanding of the Applicability of Uncertainty Forecasts in the Electric Power Industry”, *Energies* 2017, 10(9), 1402; doi:10.3390/en10091402
- 4) [Simon Camal, Andrea Michiorri, George Kariniotakis, Optimal Offer of Automatic Frequency Restoration Reserve from a Combined PV/Wind Virtual Power Plant. IEEE Transactions on Power Systems 2018;99. doi:10.1109/TPWRS.2018.2847239.](#)