Mexico WindPower
EXPOSICIÓN y CONGRESO

4 - 5 MARZO 2020
Centro Citibanamex, CDMX

The probabilistic energy dispatch as a tool to maximize the integration of wind generation in the electrical system of Uruguay

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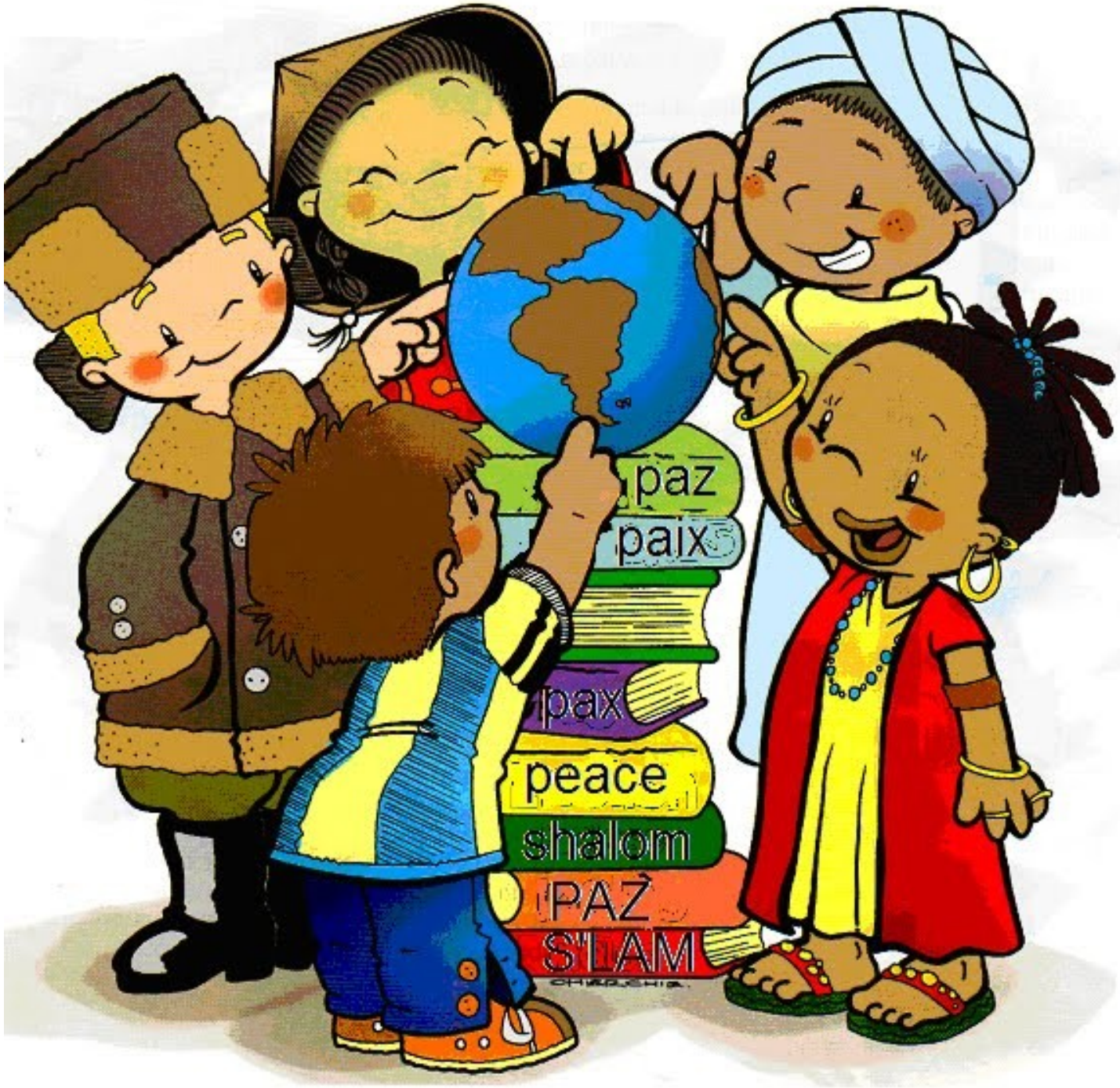
México WindPower 4-5 de Marzo de 2020

Organizado por: amdee Asociación Mexicana de Energía Eólica · GWEC · Tarsus México

República Oriental del URUGUAY

Area	176.215 km²	
Population[1]	3.450.000	inhab
Pop. Density	19	inhab/km²
GPD[2]	59.6	USD Billions
GPD/inhab[3]	14 600	USD/inhab
HDI[4]	0.808 (position 57/189)	

[1] Estimated 2018
[2] Gross National Product 2018
[3] Year 2018
[4] Human Development Index 2019

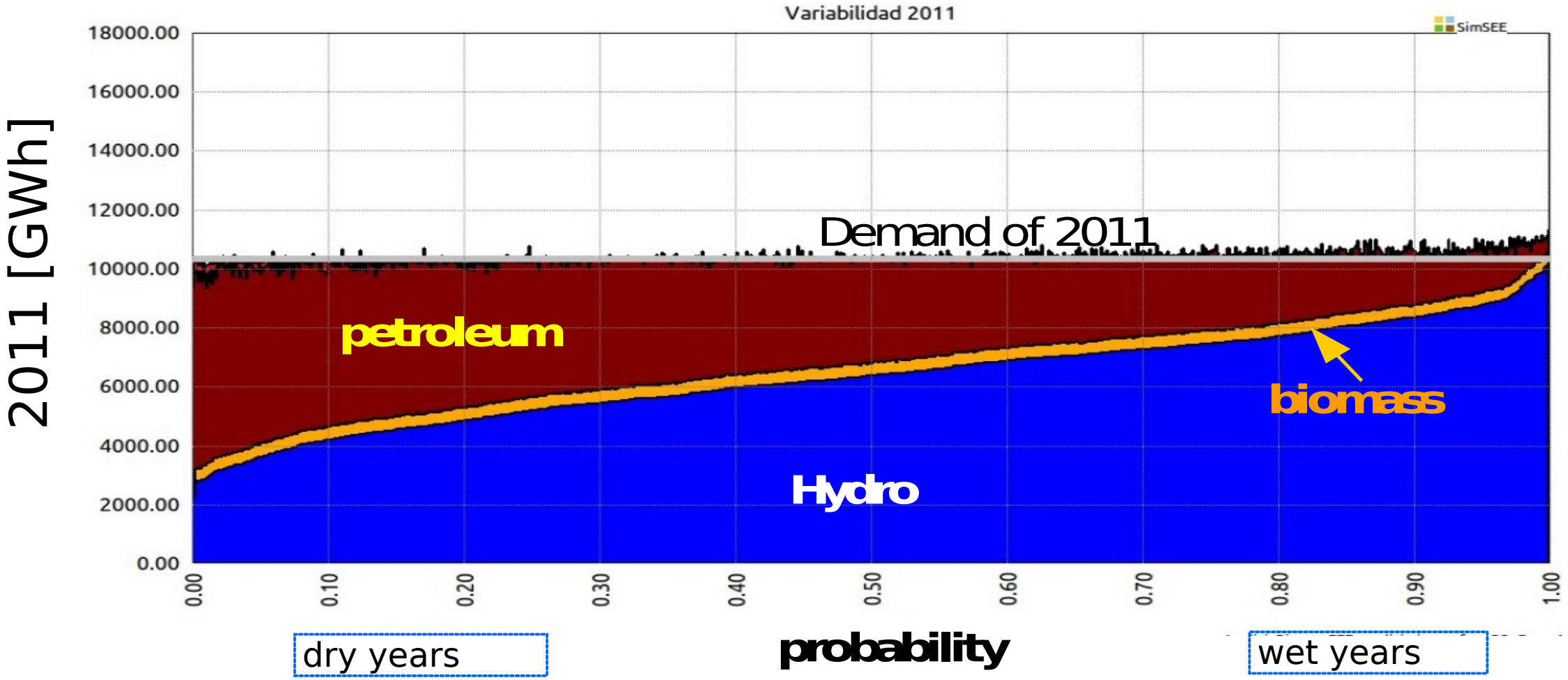


Each system has its peculiarities.

The optimal solution is surely different for each country.

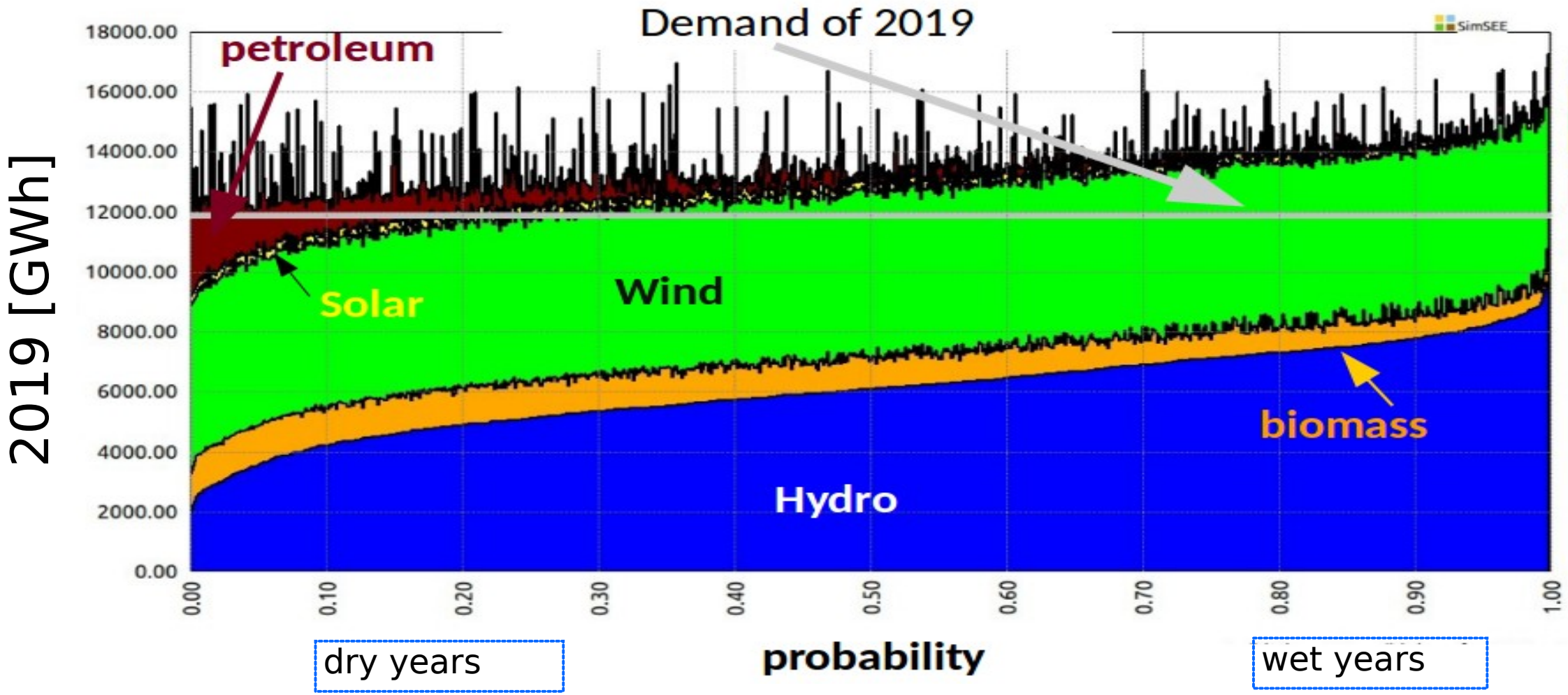
In this presentation we will show how the Optimal Operation Programming of the National Integrated System in **Uruguay** is carried out with an installed wind and solar capacity that exceeds the peak of the system load in 70% of the days of the year

What we have done in Uruguay.



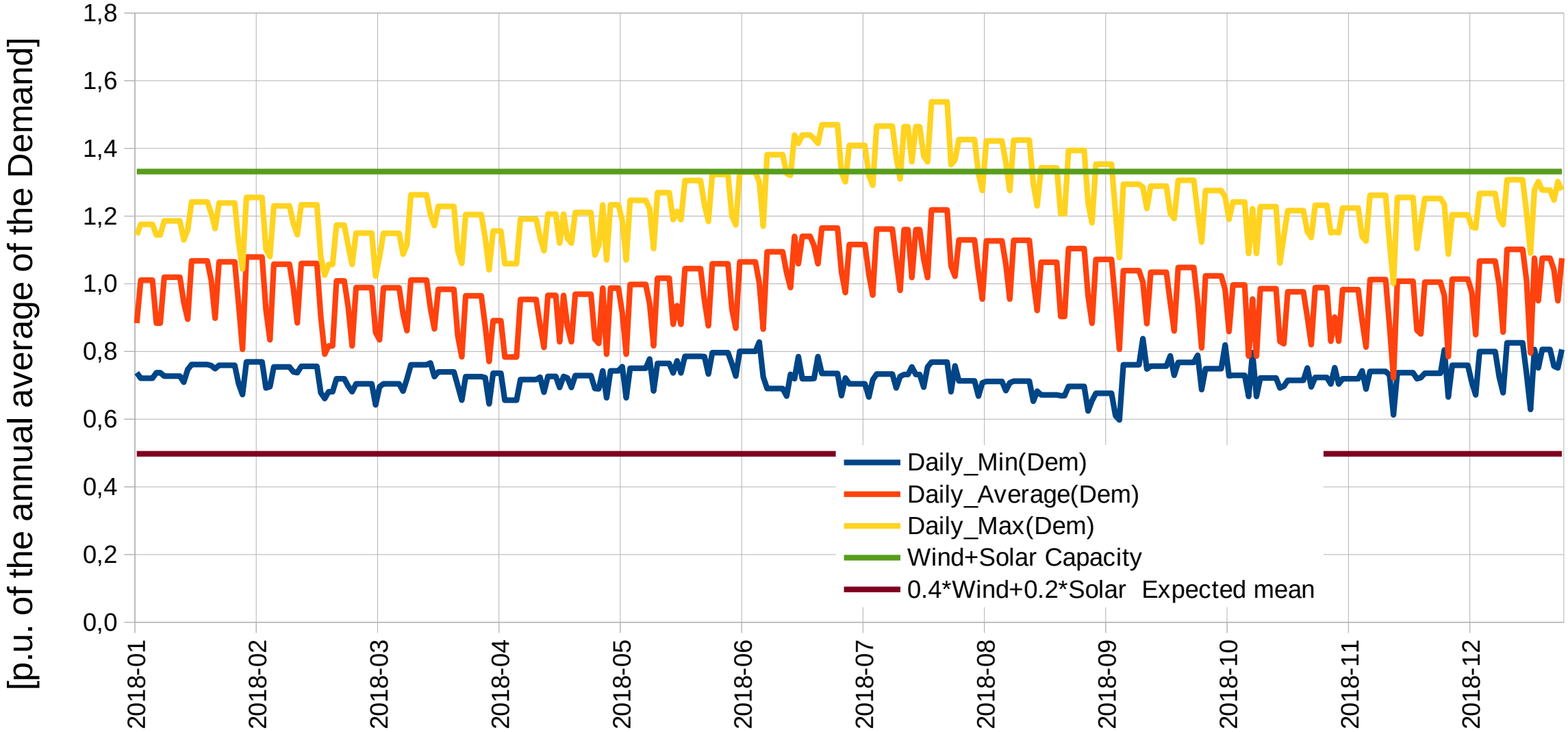
Source: The risk images are from the IIE studies carried out in 2010 and 2018 respectively.

What we have done in Uruguay.

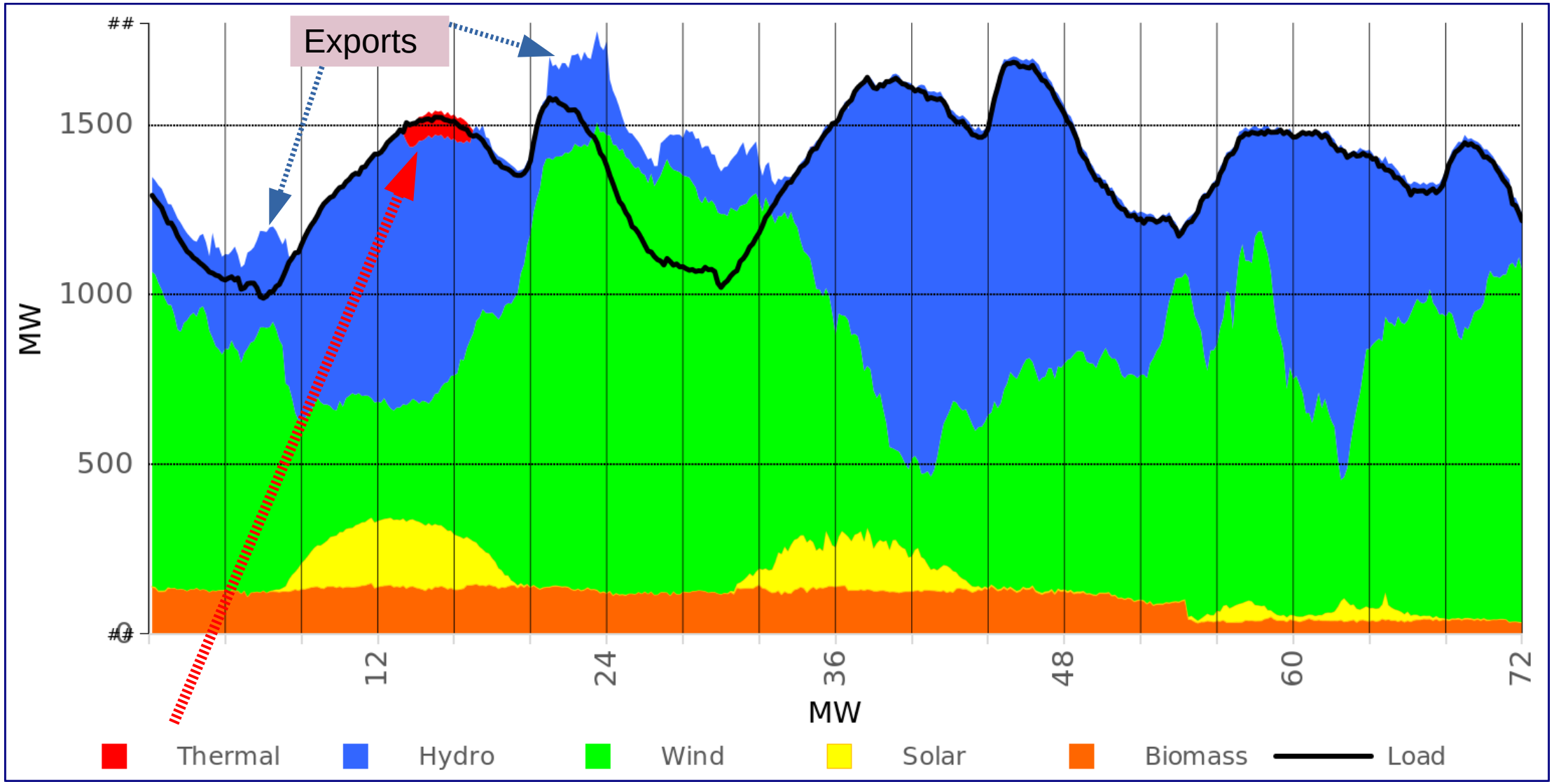


Source: The risk figures are from the IIE studies carried out in 2010 and 2018 respectively.

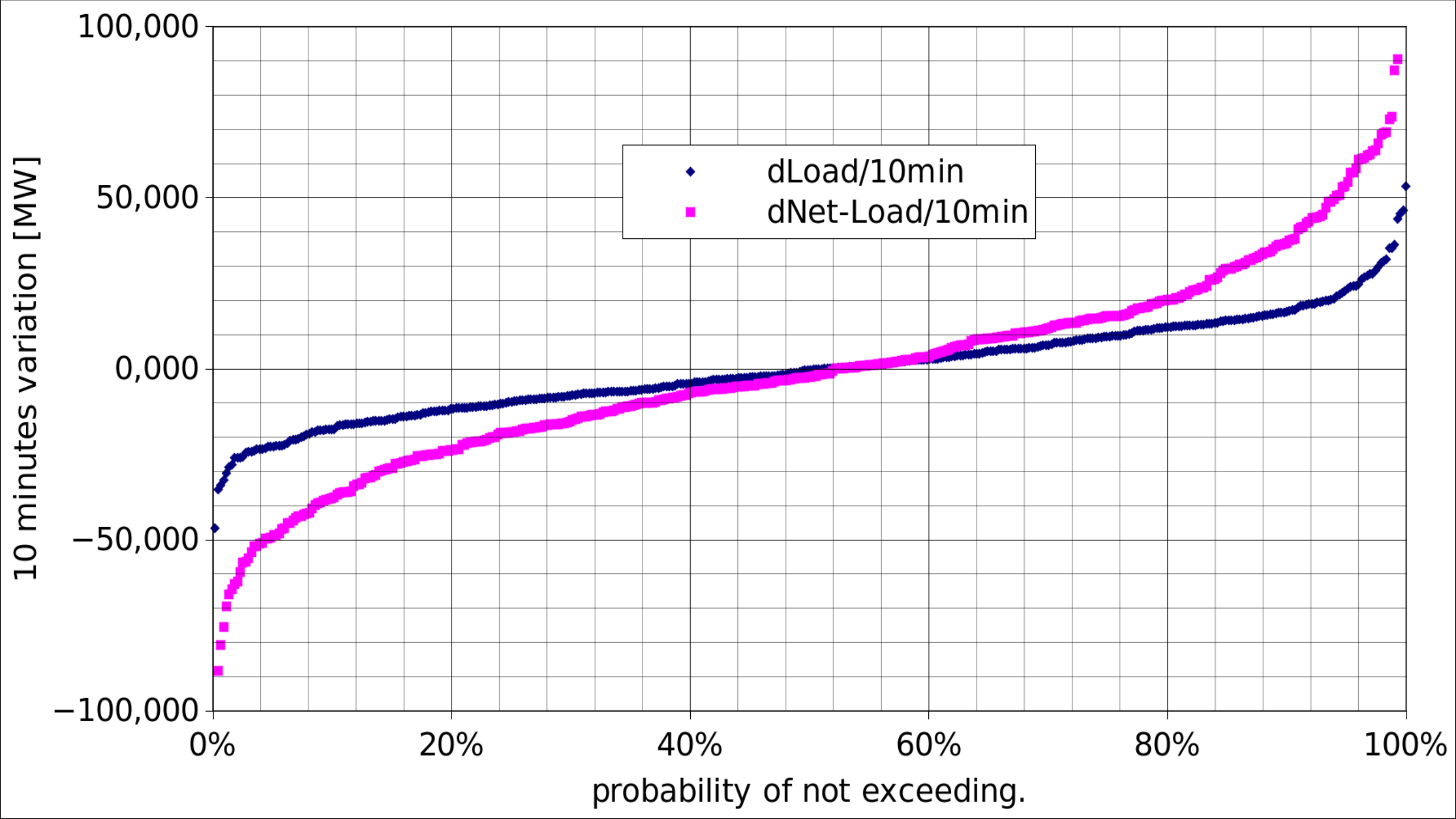
Uruguay 2018.
Wind and Solar installed capacity compared with daily Demand.



Any 72 hours of January 2020 of the dispatch just as an example



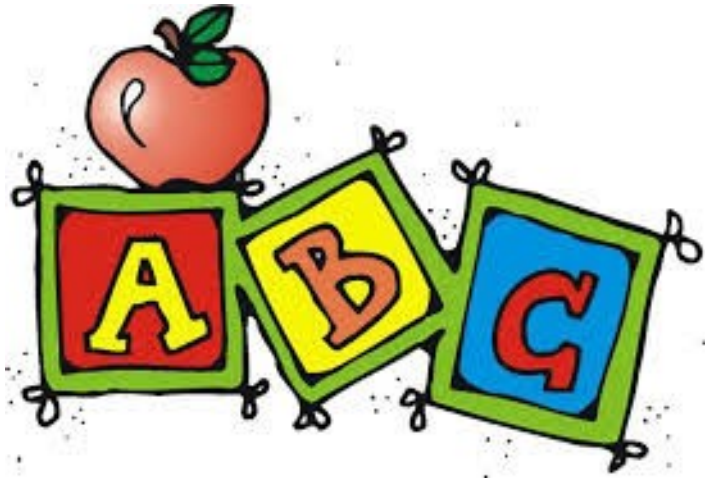
Source: https://adme.com.uy


100,000
50,000
0,000
−50,000
−100,000
10 minutes variation [MW]
0%
20%
40%
60%
80%
100%
probability of not exceeding.
dLoad/10min
dNet-Load/10min

ADME

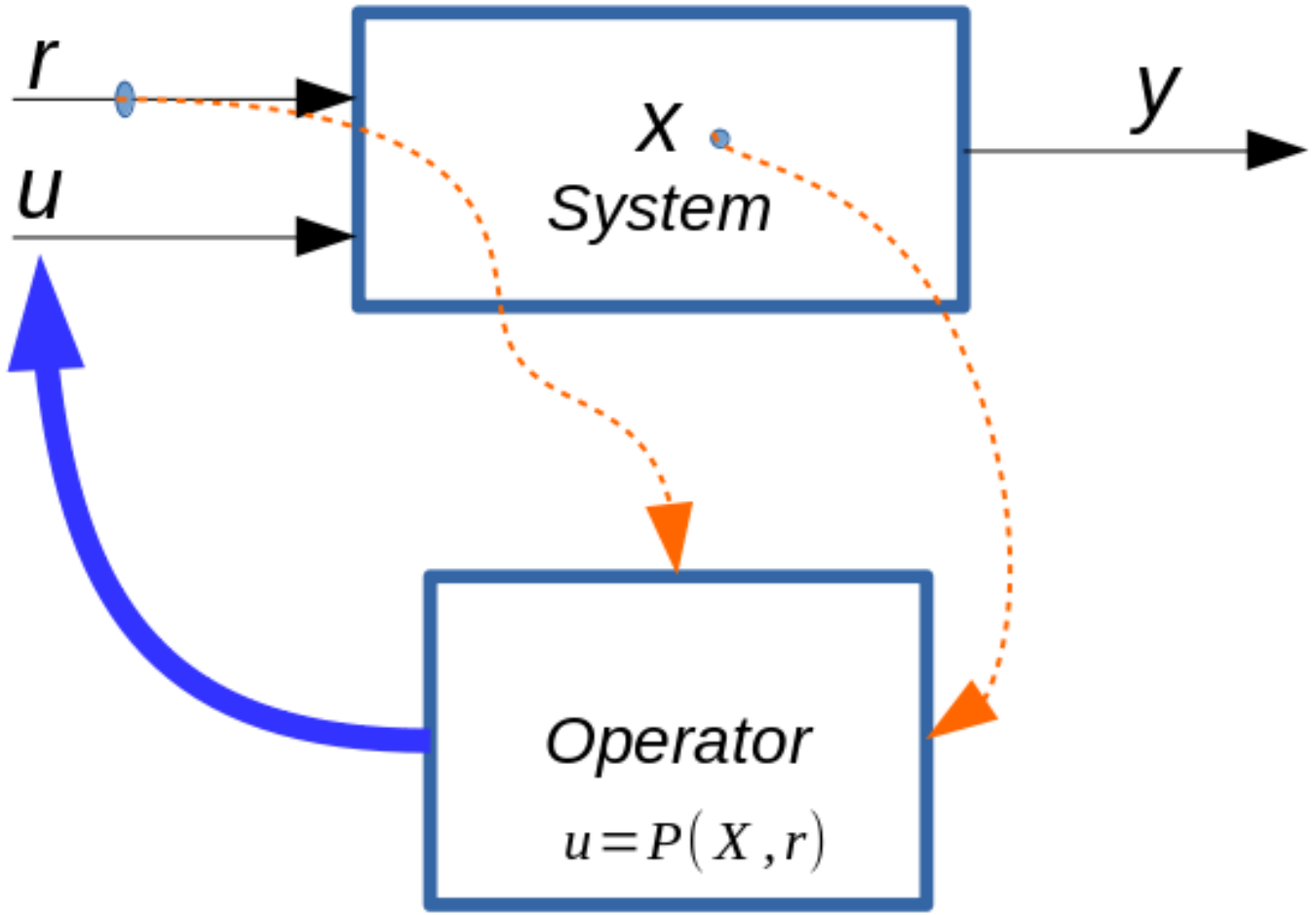
Objective of the operation of the national interconnected system.

Provide energy with acceptable reliability and quality at the minimum cost.



- Centralized Dispatch.
- Only Variable Costs.
- Contracts are papers.

The System, The Operator and The Operation Policy



Operation Policy and The Cost of The Future

$$u = P\left(X, r, t\right)$$

$$CF_{PO}\left(X_{ahora}\right) = \left\langle \int_{ahora}^{+\infty} ce\left(X, r, u, t\right) dt \right\rangle$$

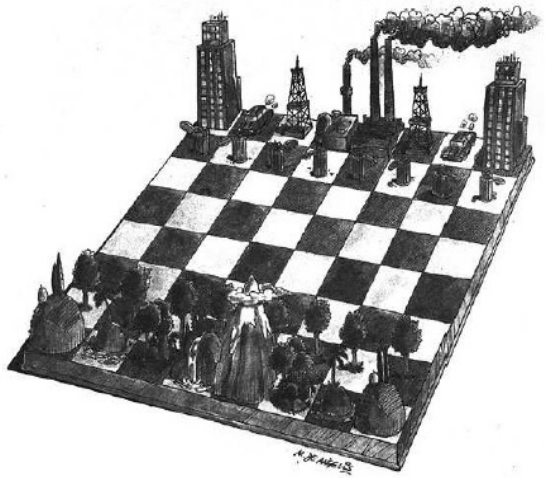
Temporary linking of decisions.

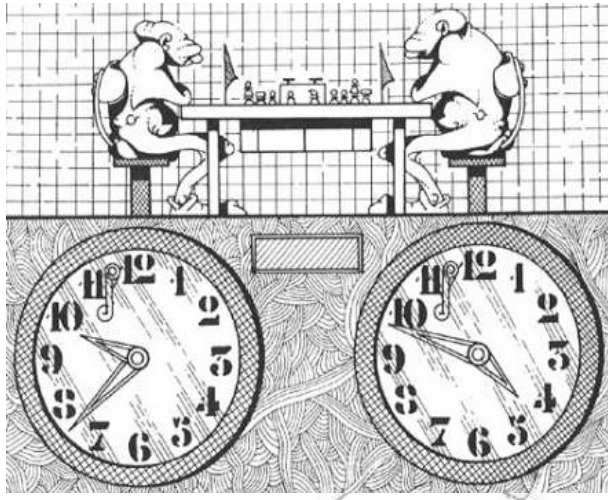
The use of stored resources (water) in the **present** produces an increase in **future** operating costs. The postponement of the use of a stored resource produces an increase in the costs of the present.

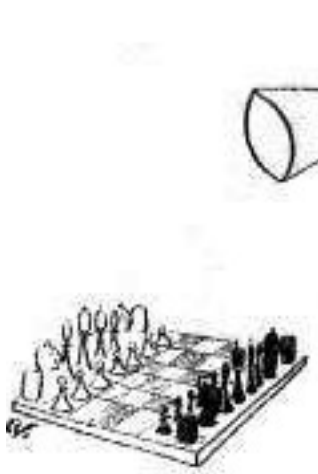
The **Optimal Policy** is the one that balances the cost impact between present and future.

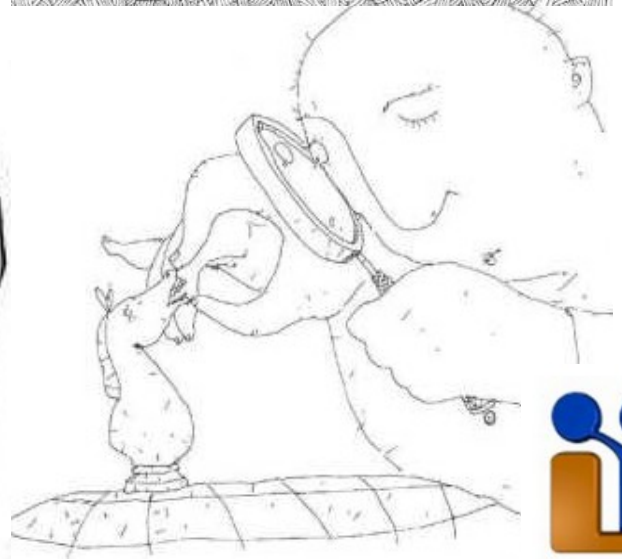
SimSEE

https://simsee.org









Platform for simulation of optimal operation of the energy dispatch.

100% OOP

Actors
Playroom
Dynamic parameters
Monitors

Free & OpenSource

FACULTAD DE INGENIERIA

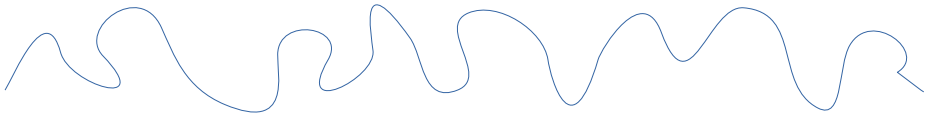
UNIVERSIDAD DE LA REPUBLICA URUGUAY

Characterization of the variability in Uruguay.

water inflows

16 years

wind & solar



ws

2 month

Time-Step used for simulation.

Big time step / implicit inertia

balance restrictions
overestimate filtering capacity

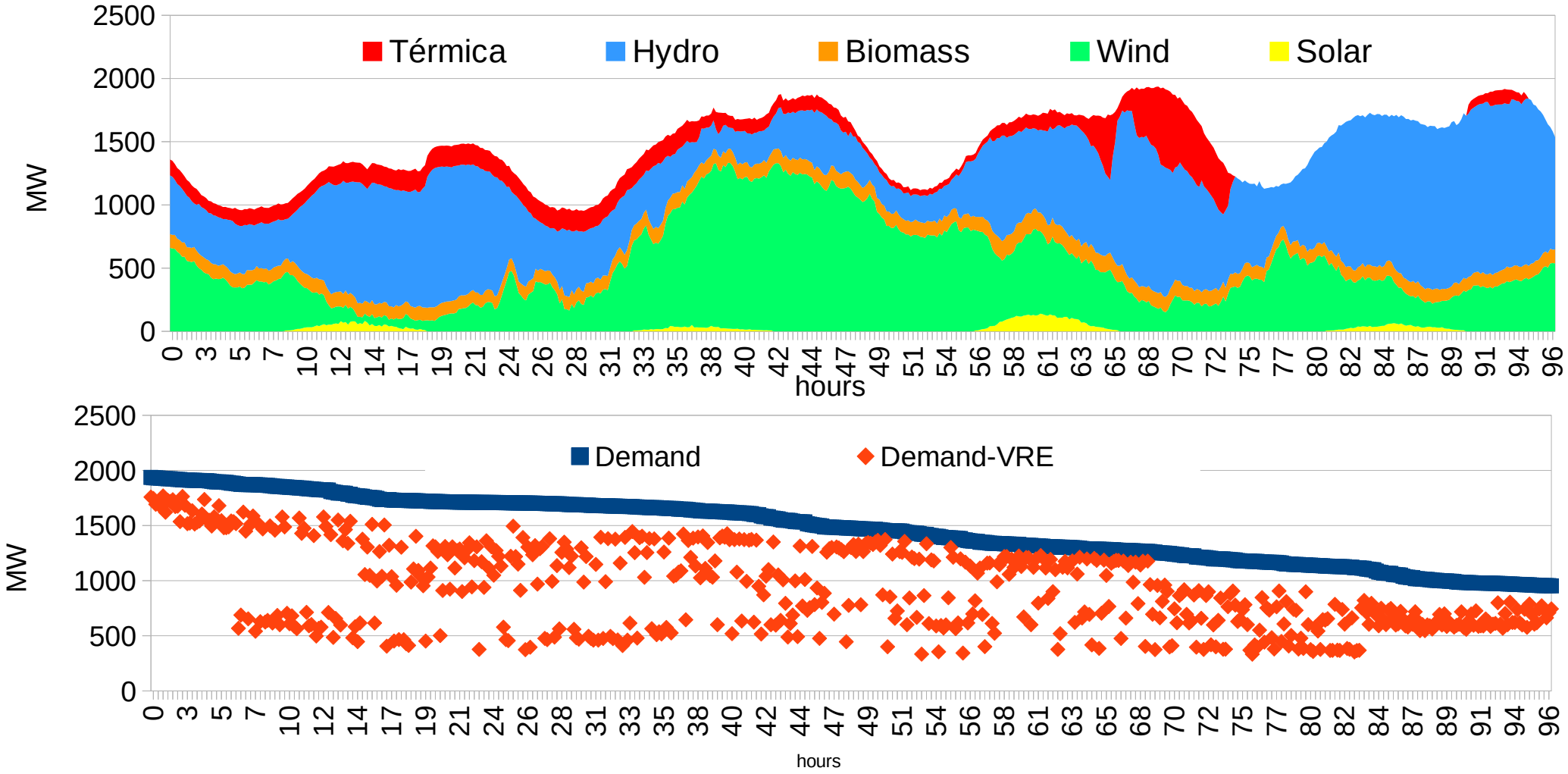
need of availability models to represent
fail/repair inertia

Small time step / more state variables

Time-Bands (Patamares) defined by the Monotonous Load Curve ...

Makes sense?

Only an example, 4 days of july-2018-Uruguay



Source: ADME - SCADA ten-minute time series

Representation of uncertainty.

Sources of randomness
Stochastic processes

- Demand and temperature
- Flows of water contributions
- Wind speed
- Solar radiation
- Price of interconnected markets
- Fuel prices
- Availability of fuels
- Availability of generating plants
- Availability of transport lines

El Niño, Hydro, Wind, Solar, Demand, Temperature. (correlated processes)

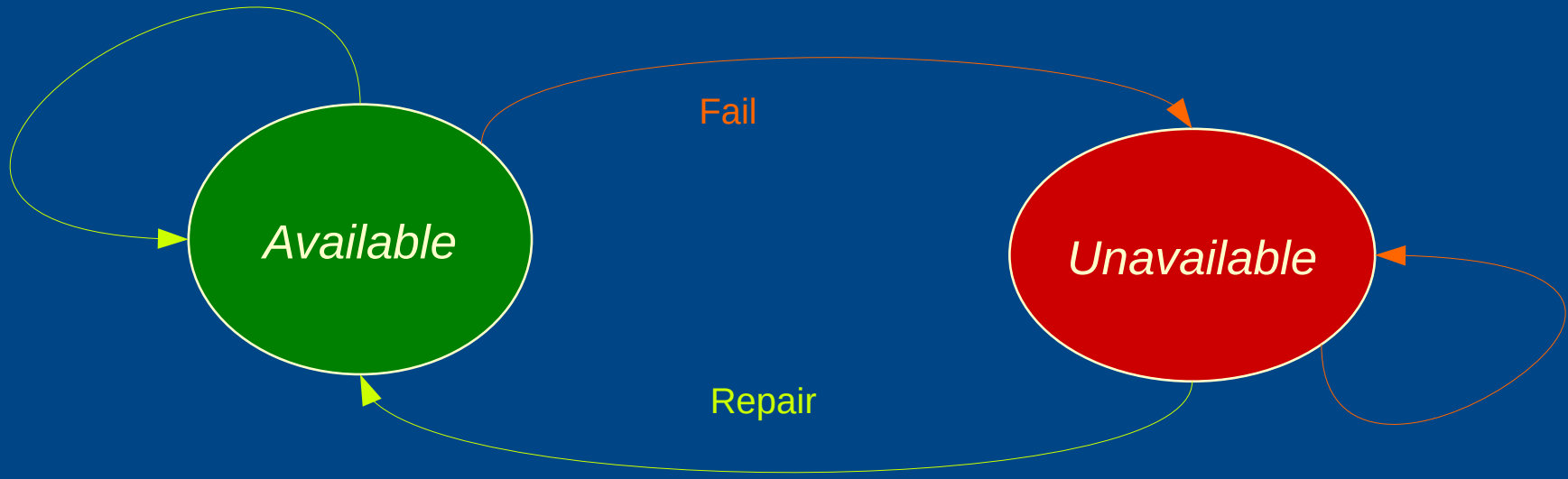
Equipment availability (independent booleans)

We are managing faster dynamics, therefore, the correlation between the different resources has greater importance.

We need models of variability that correctly represent the correlation between resources and the correlation with the past.

That is, we have to represent the inertia behind the stochastic variables.

Availability of generators, power transmission lines, etc.



If we do not represent the state of the availability when simulating with small time-steps, the consequences of the inertia of the fault-repair process are underestimated.

Each generator, transmission line, etc. adds a Boolean state variable to the system.

CEGH modeling.

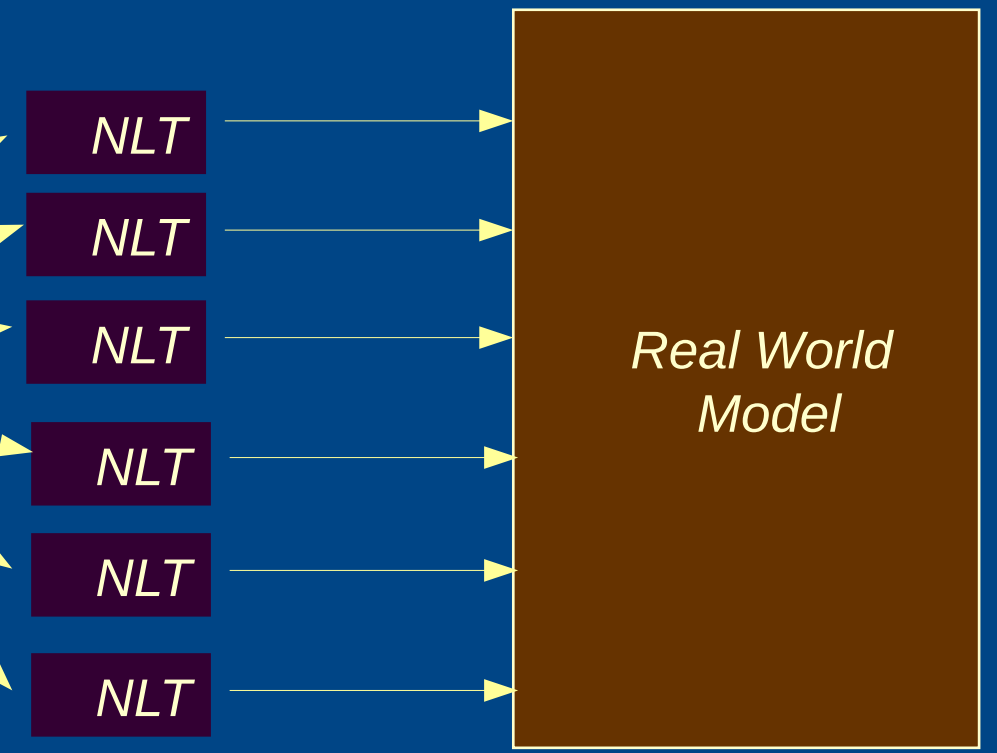
- reproduces the amplitude histograms of the original processes.
- reproduces the spatial and temporal correlations in a gaussian space.

Gaussian World:
Multi-variable linear system
fed with
Gaussian independent white noise

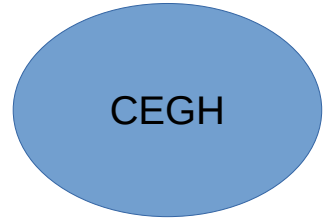
$$X_{k+1} = \sum_{h=0}^{h=n-1} A_h X_{k-h} + \sum_{h=0}^{h=m-1} B_h R_{k-h}$$

Accept state space reductions.

Accept forecast information.



Bellman's curse of dimensionality.



Ease of integration of FORECAST.

$$X_{k+1} = \sum_{h=0}^{h=n_r-1} A_h X_{k-h} + S_k + F_k \sum_{h=0}^{h=m-1} B_h R_{k-h}$$

The biases (S) change the 50% probability guide and the attenuation factors (F) regulate the noise injection, allowing to go from a Deterministic Forecast (null noise) to the disappearance of the forecast (historical noise).

$$S_k = \begin{bmatrix} s_{1,k} \\ \dots \\ s_{n,k} \end{bmatrix}$$

$$F_k = \begin{bmatrix} f_{1,k} & 0 & \dots & 0 \\ 0 & f_{2,k} & \dots & 0 \\ 0 & \dots & 0 & f_{n,k} \end{bmatrix}$$

PRONOS 2016-2017

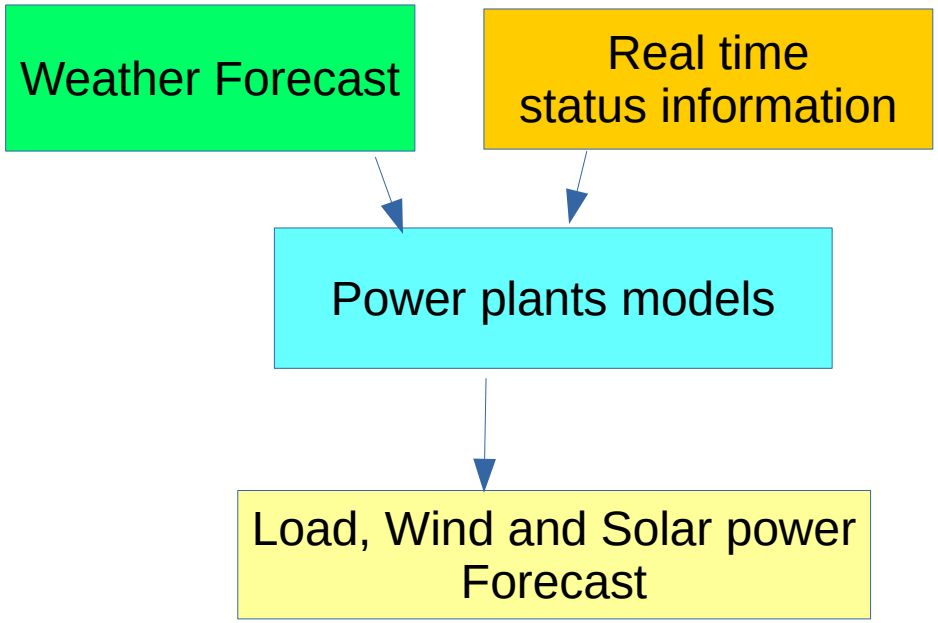
https://pronos.adme.com.uy
https://pronos.adme.com.uy/svg/

ADME

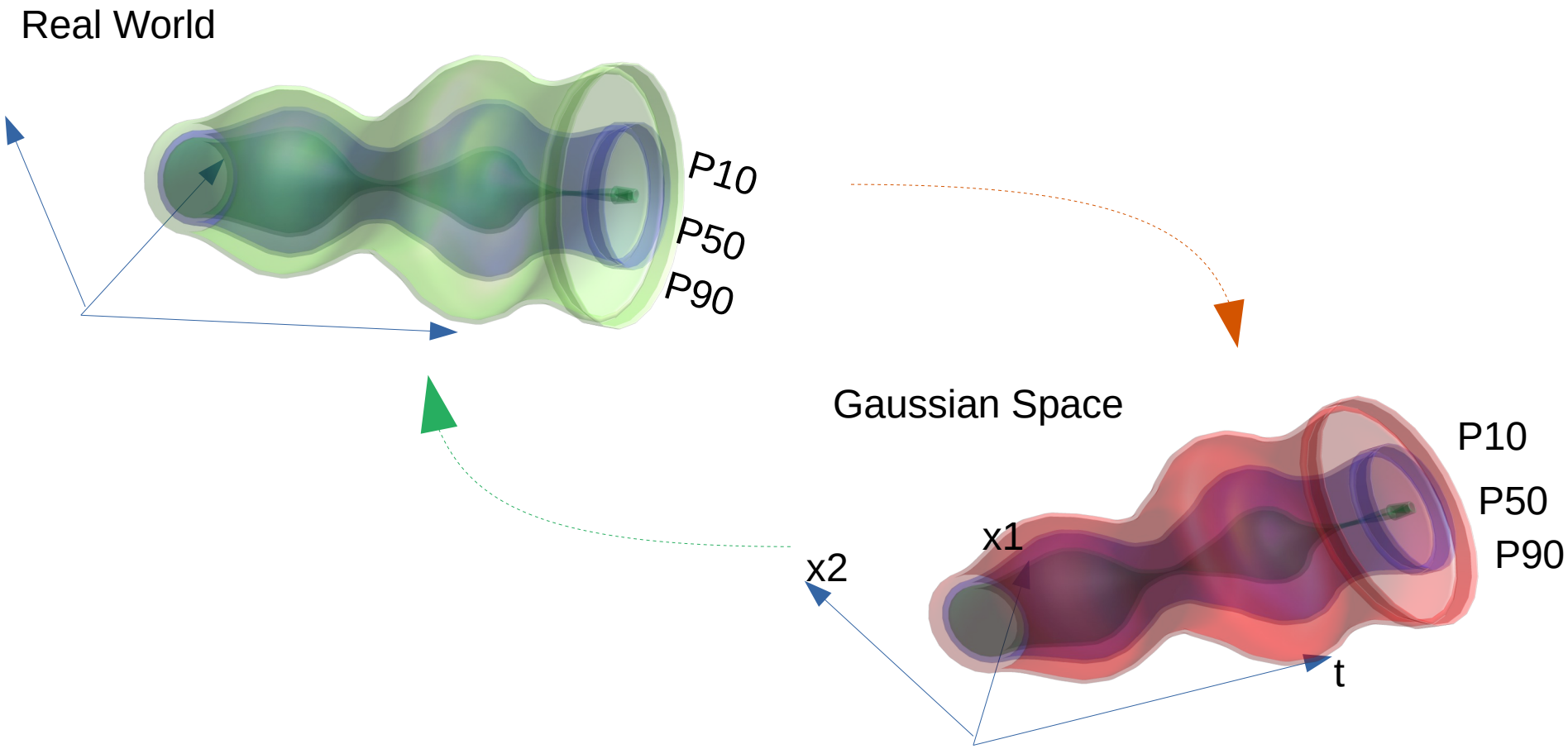
Fundación Julio Ricaldoni
INGENIERIA EN EL URUGUAY

CAF BANCO DE DESARROLLO DE AMÉRICA LATINA

UTE
La energía que nos une



Treatment of forecasts in CEGH modeling. Gaussianization

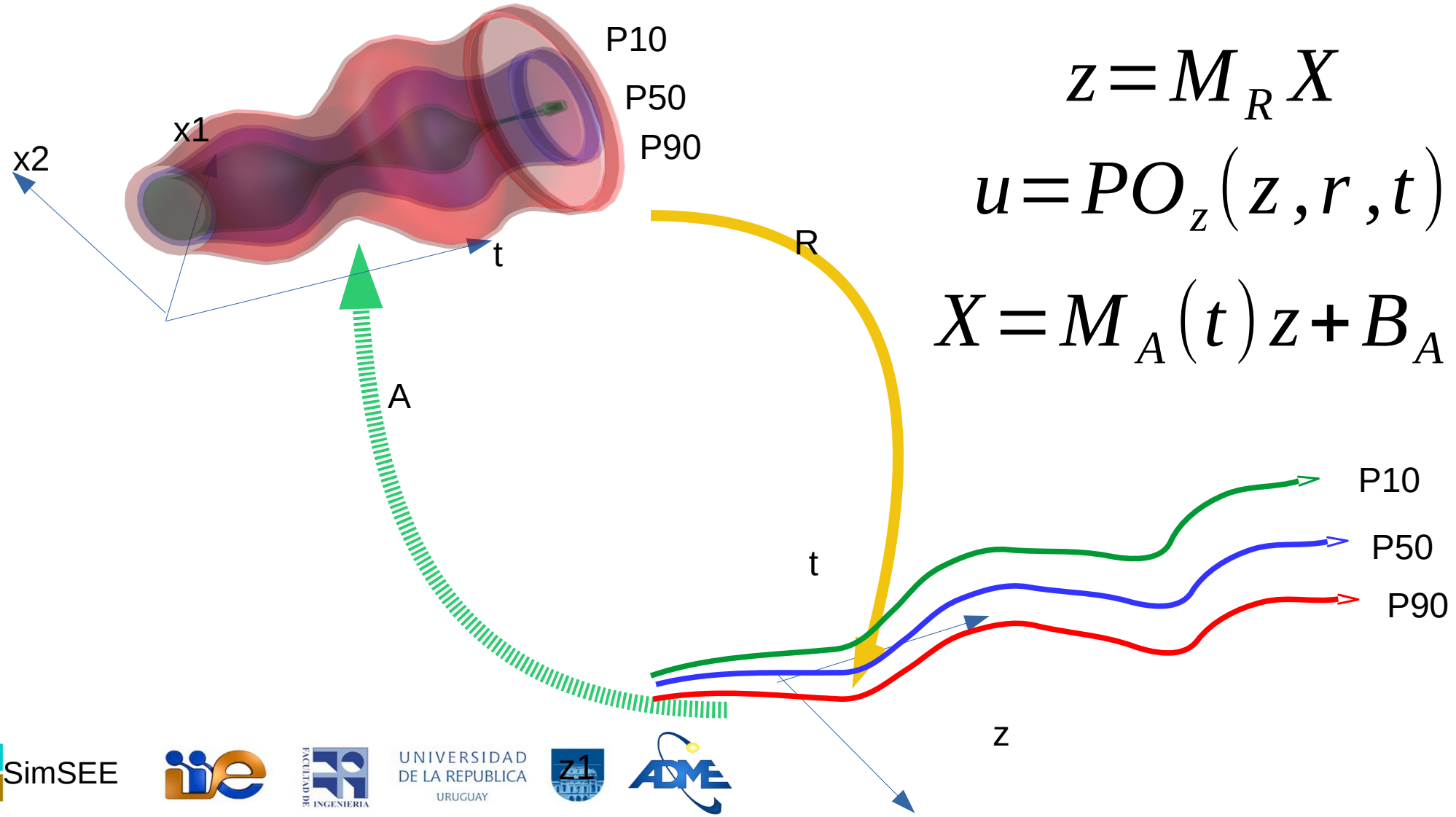


Treatment of forecasts in Gaussian space with reduction.

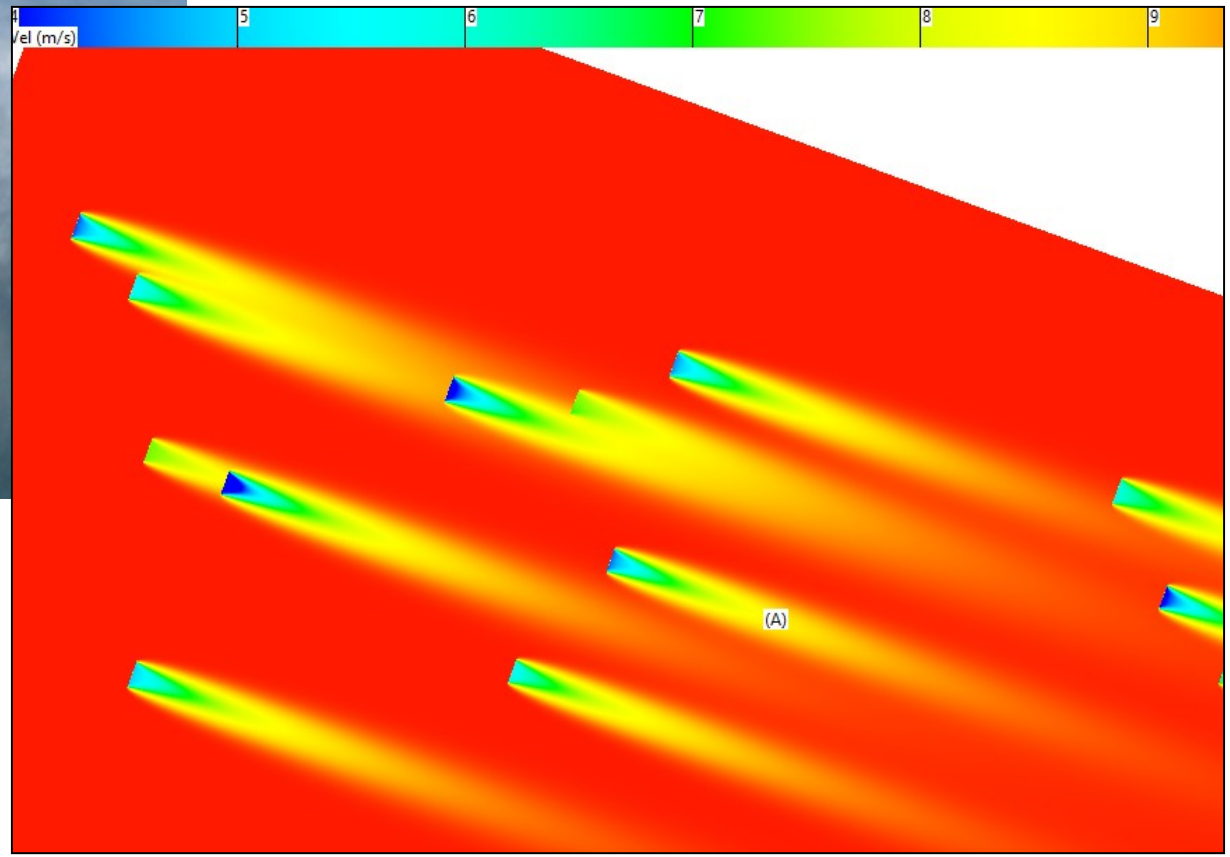
$$z = M_R X$$

$$u = PO_z(z, r, t)$$

$$X = M_A(t)\, z + B_A(t)\, w$$



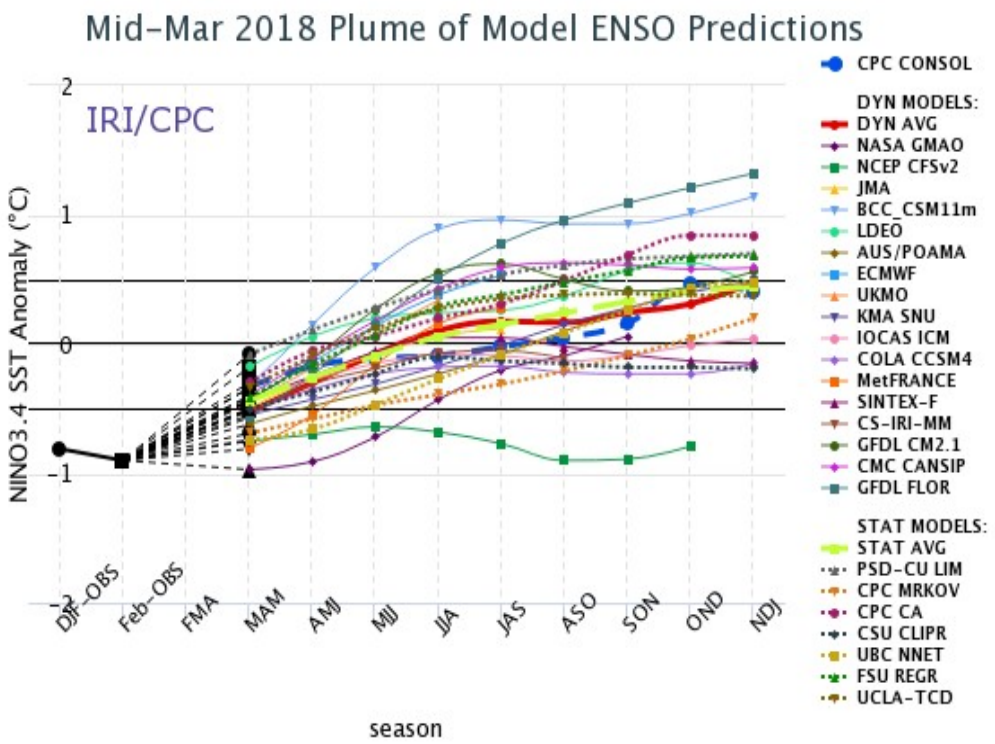
ADME_Data y ADME_WindSim

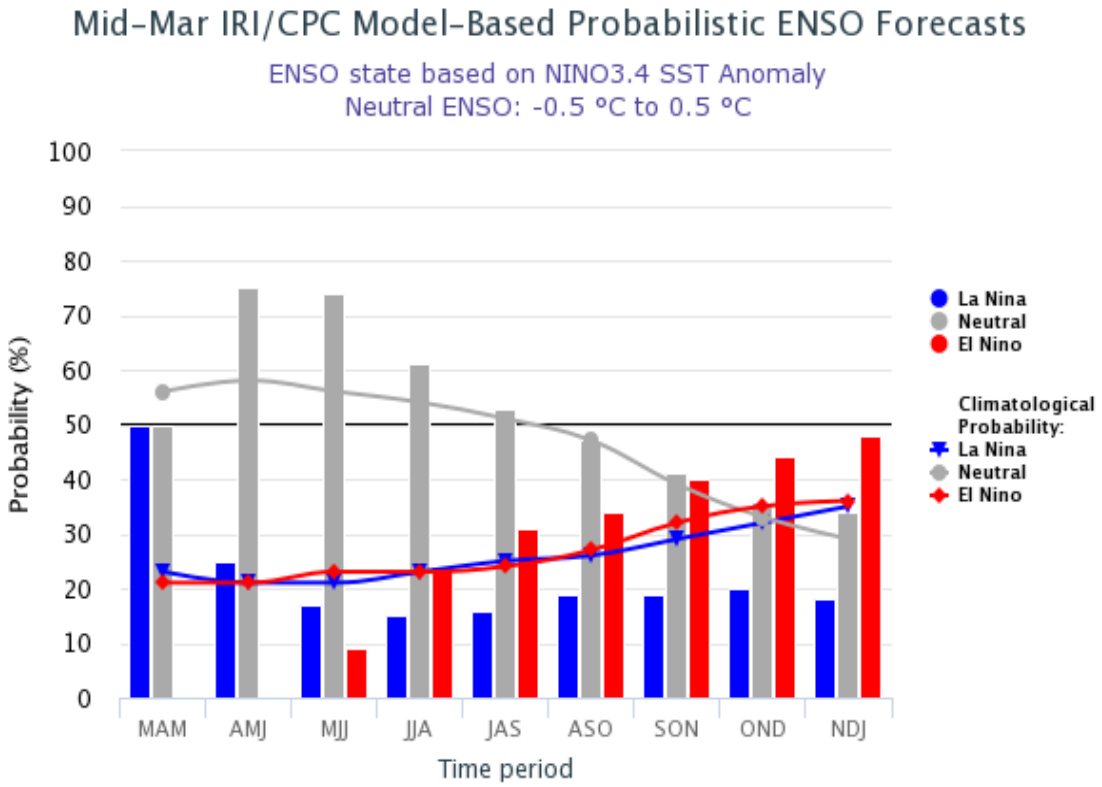


Operator without forecasts

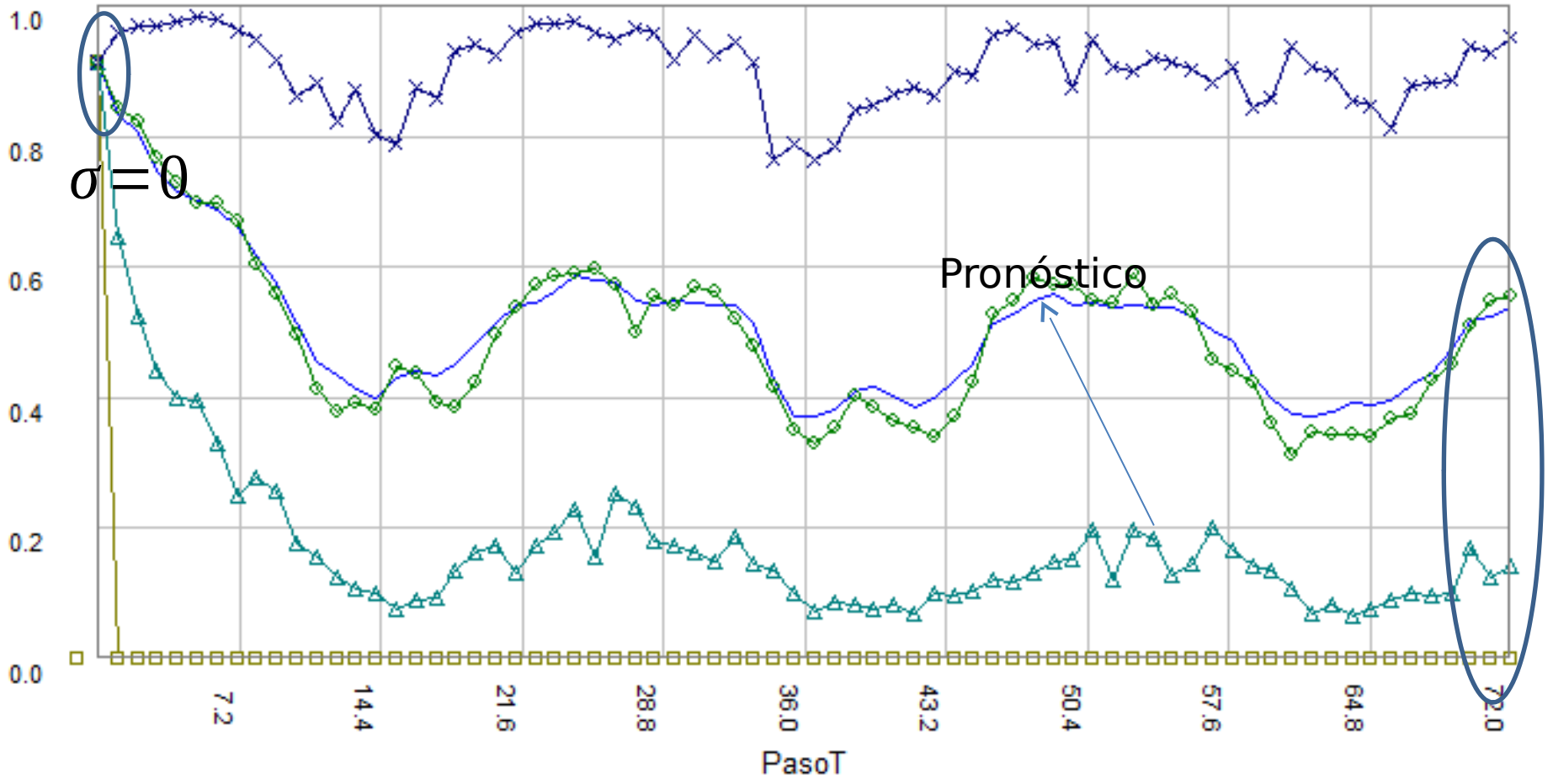
Operator with forecasts

Considering the ENSO Forecasts

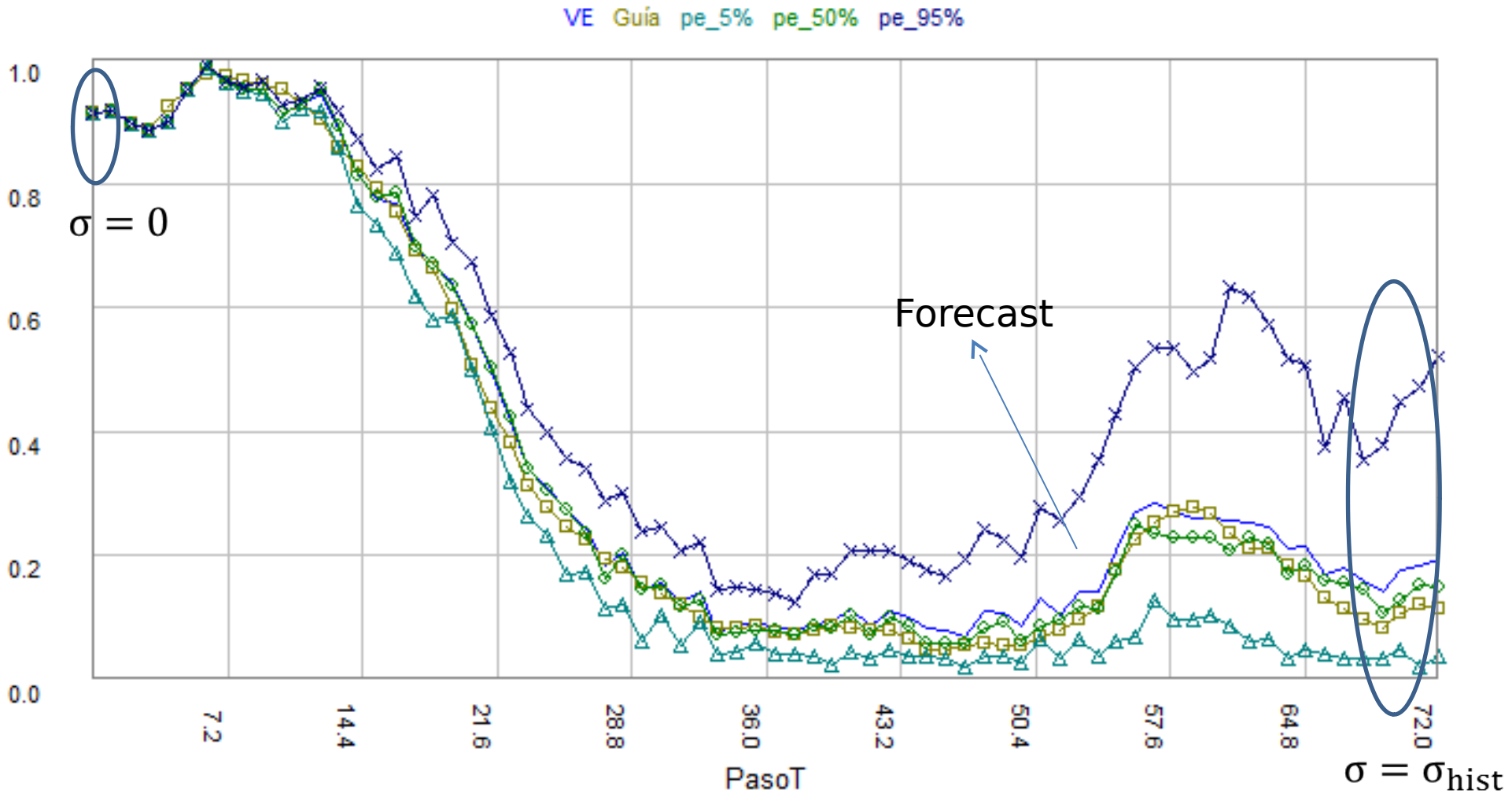




Programming the enegy dispatch without windpower forecasts.



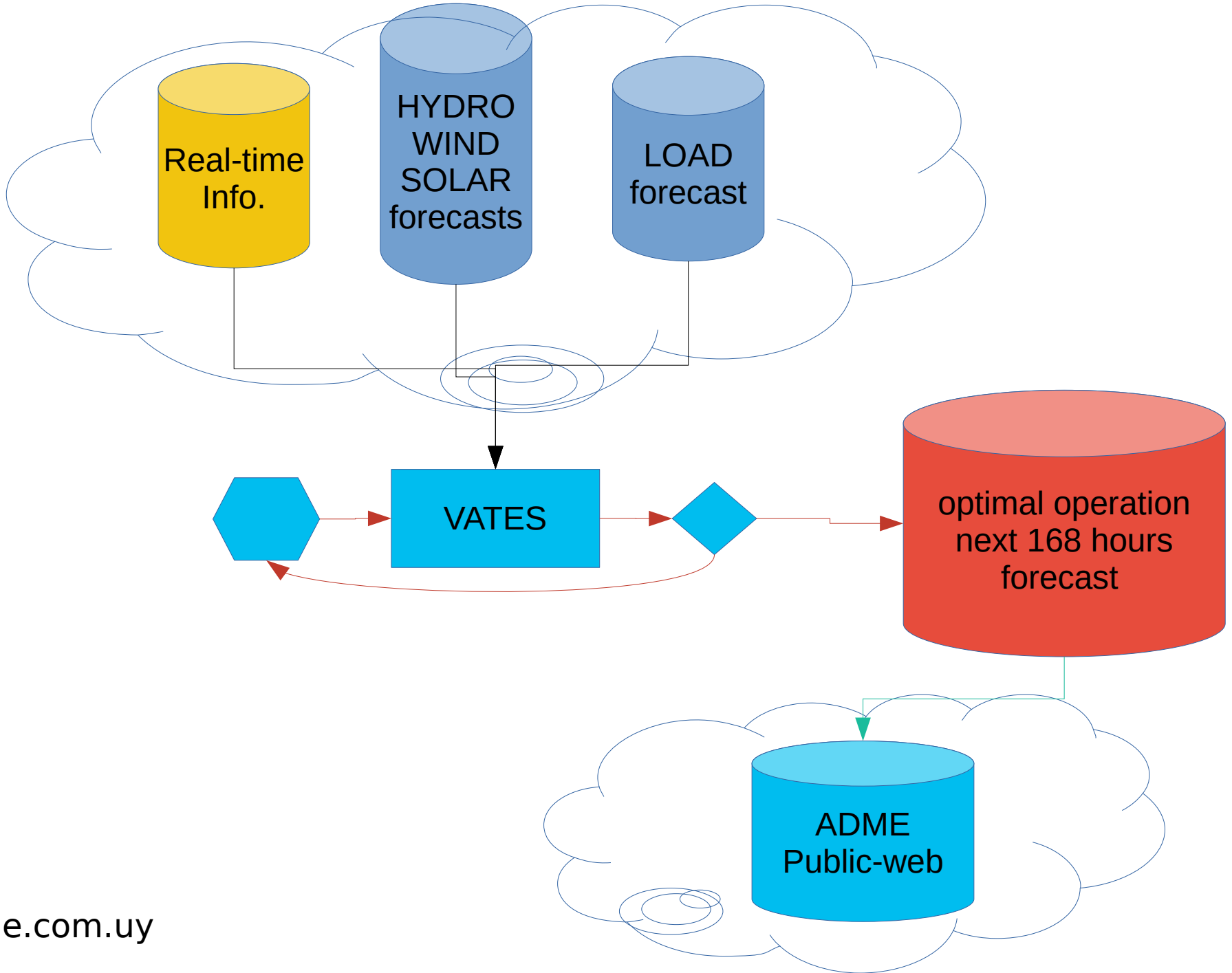
Programming the enegy dispatch with 72h of windpower forecasts.



VATES

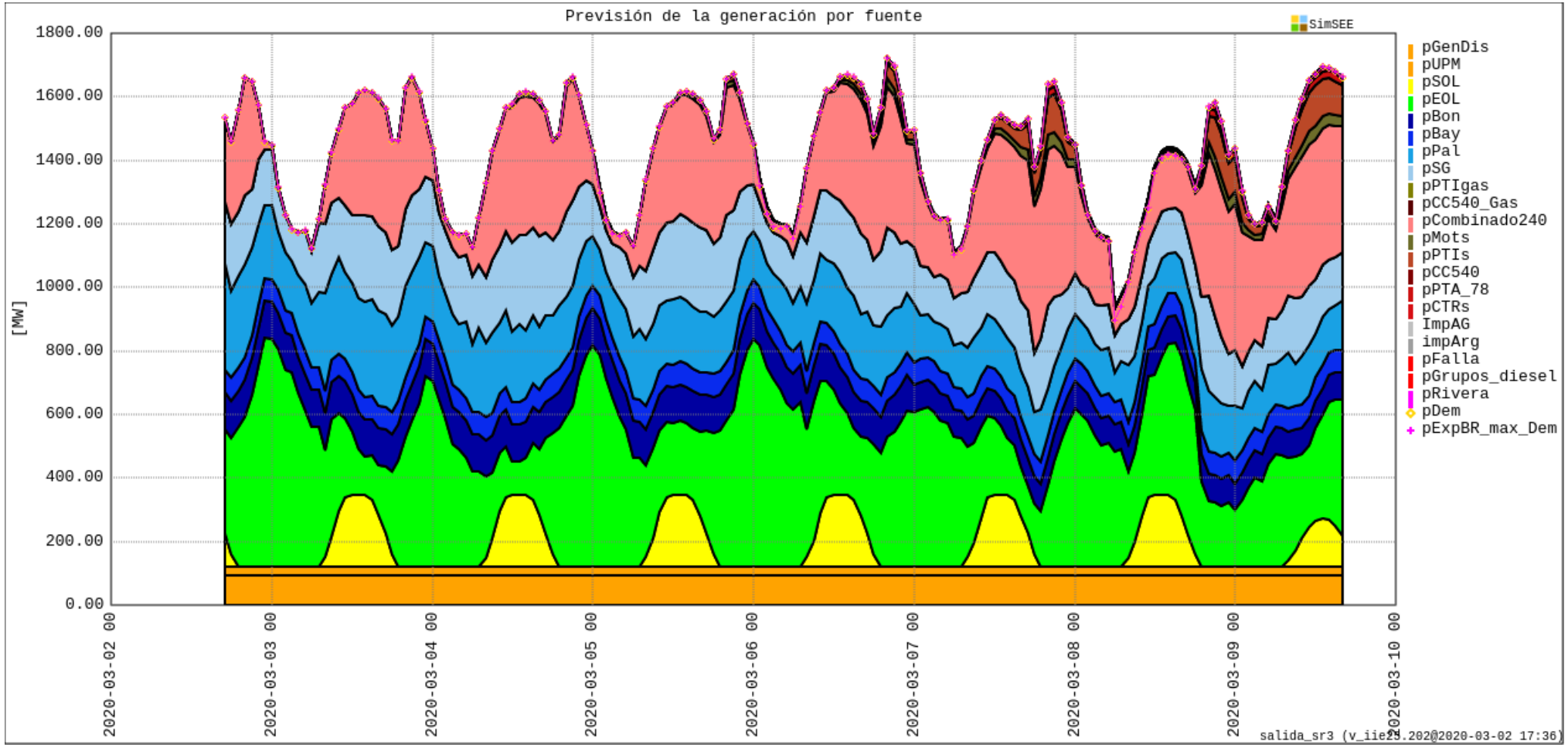
Continuous forecast of the next 168 hours of optimal operation.

https://vates.adme.com.uy



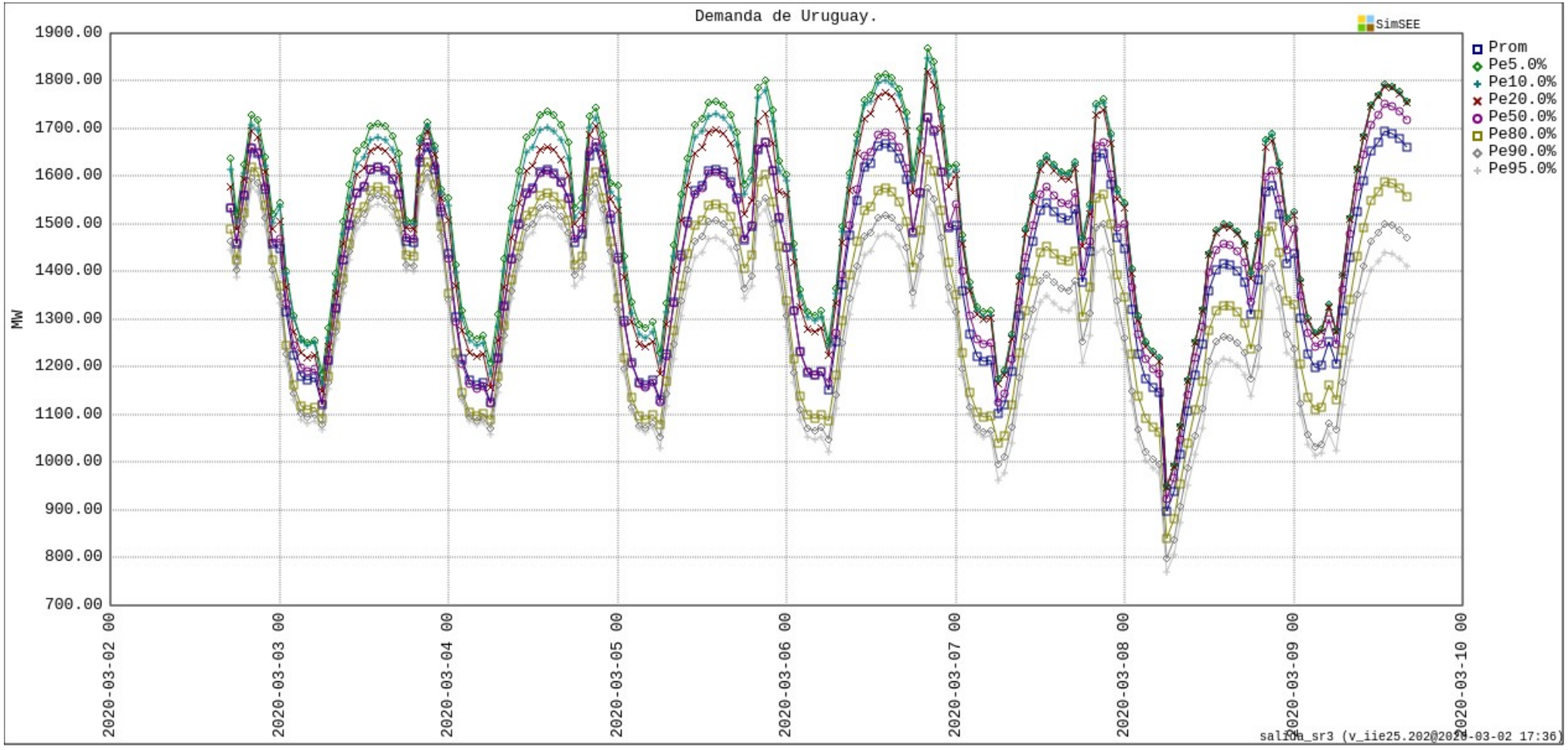
http://vates.adme.com.uy

Espected generation by source. (Example from ADME's WEB)



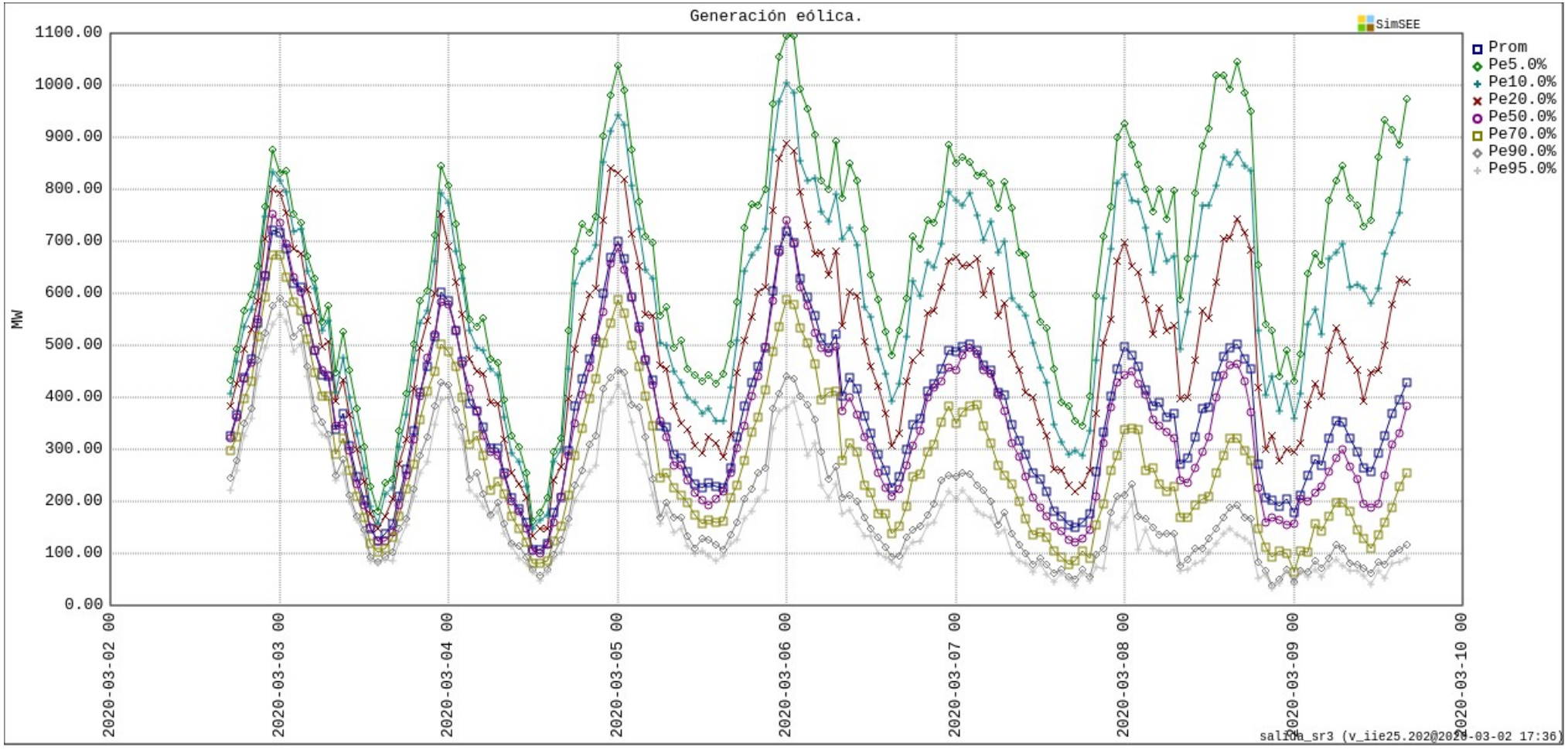
Next 168 h, System Load forecast.

(Example from ADME's WEB)



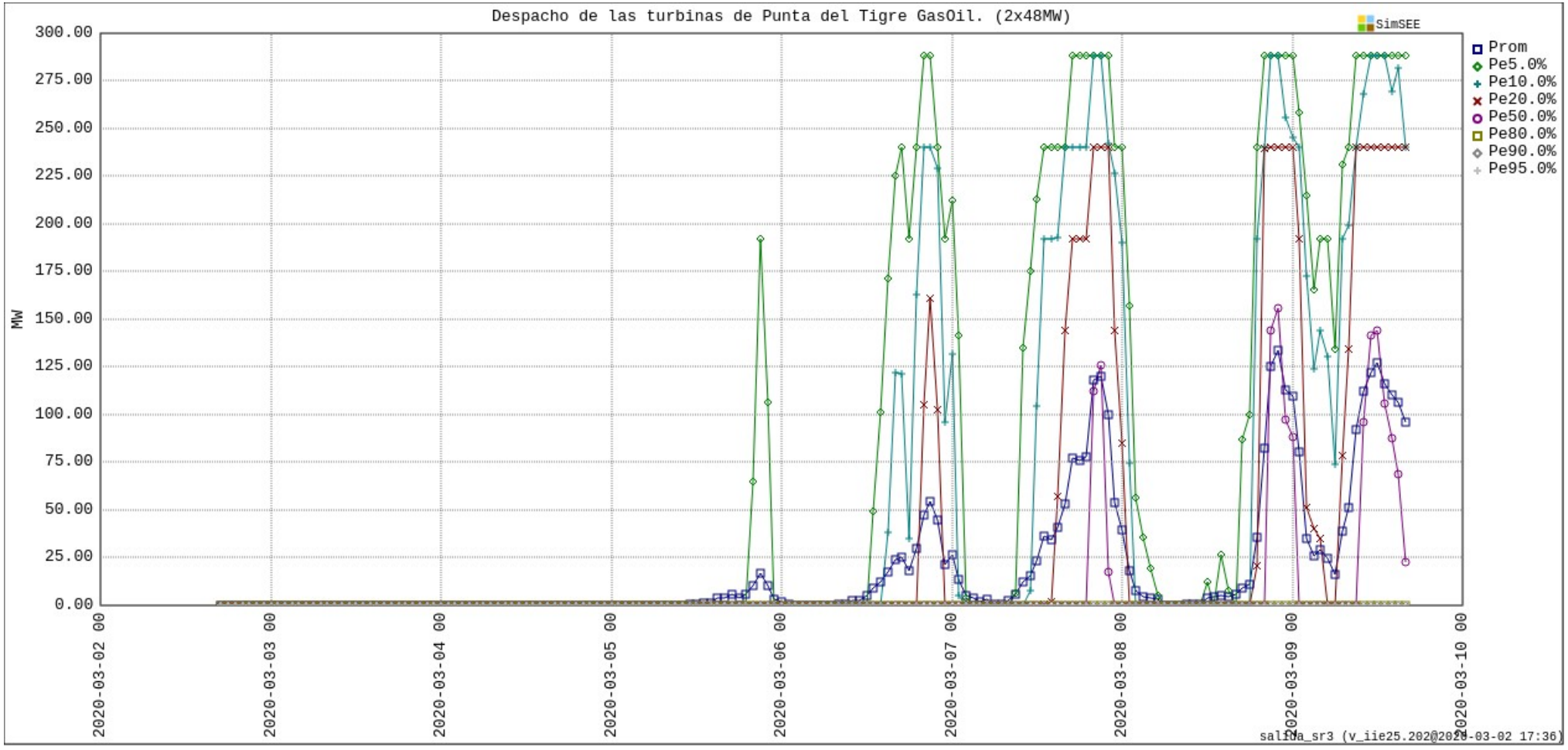
Next 168 h, Windpower forecast.

(Example from ADME's WEB)



Next 168 h, “Punta del Tigre” energy-dispatch forecast.

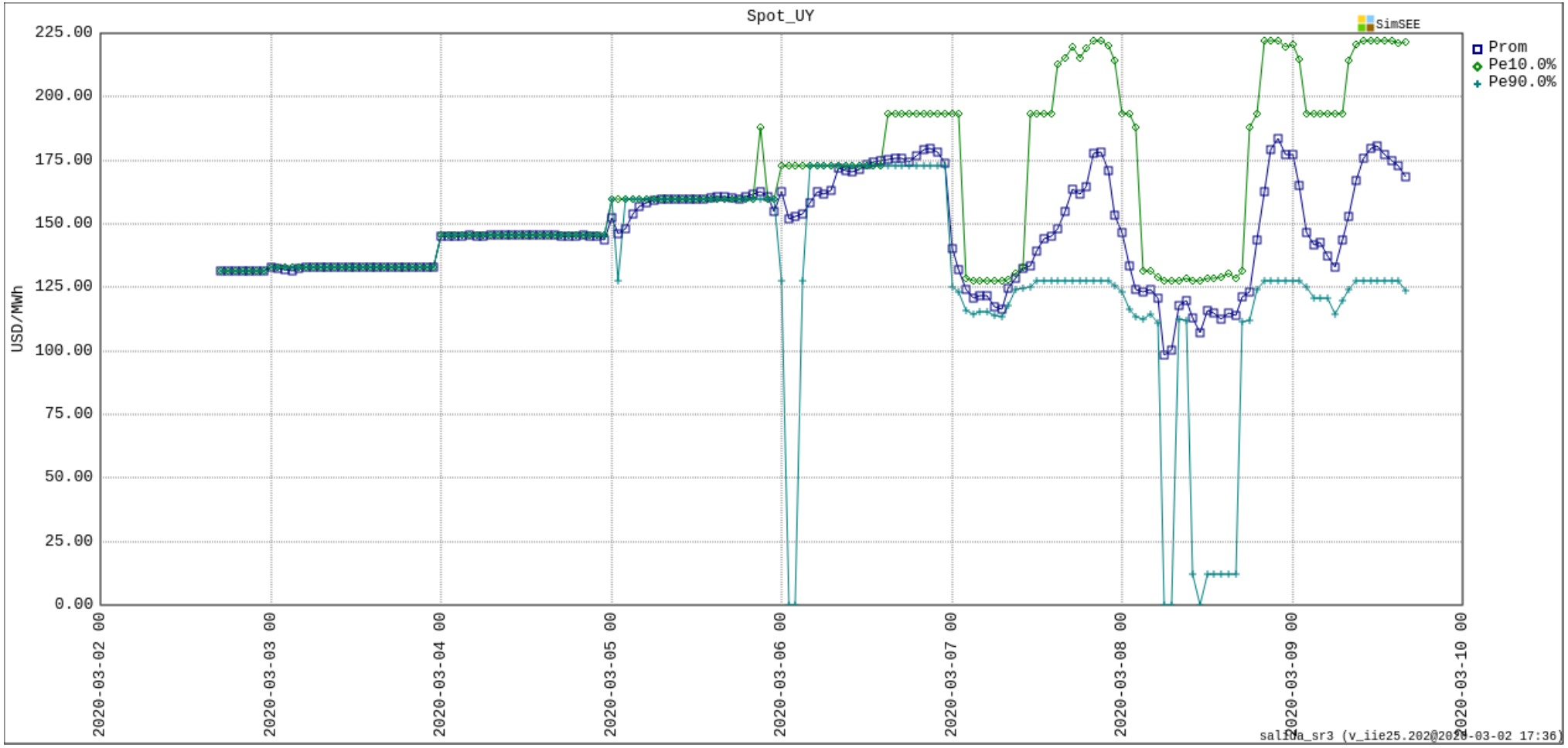
(Example from ADME’s WEB)



Punta del Tigre is a power plant with 6 turbine generator units burning diesel.
This information is very usefull for the system’s operators.

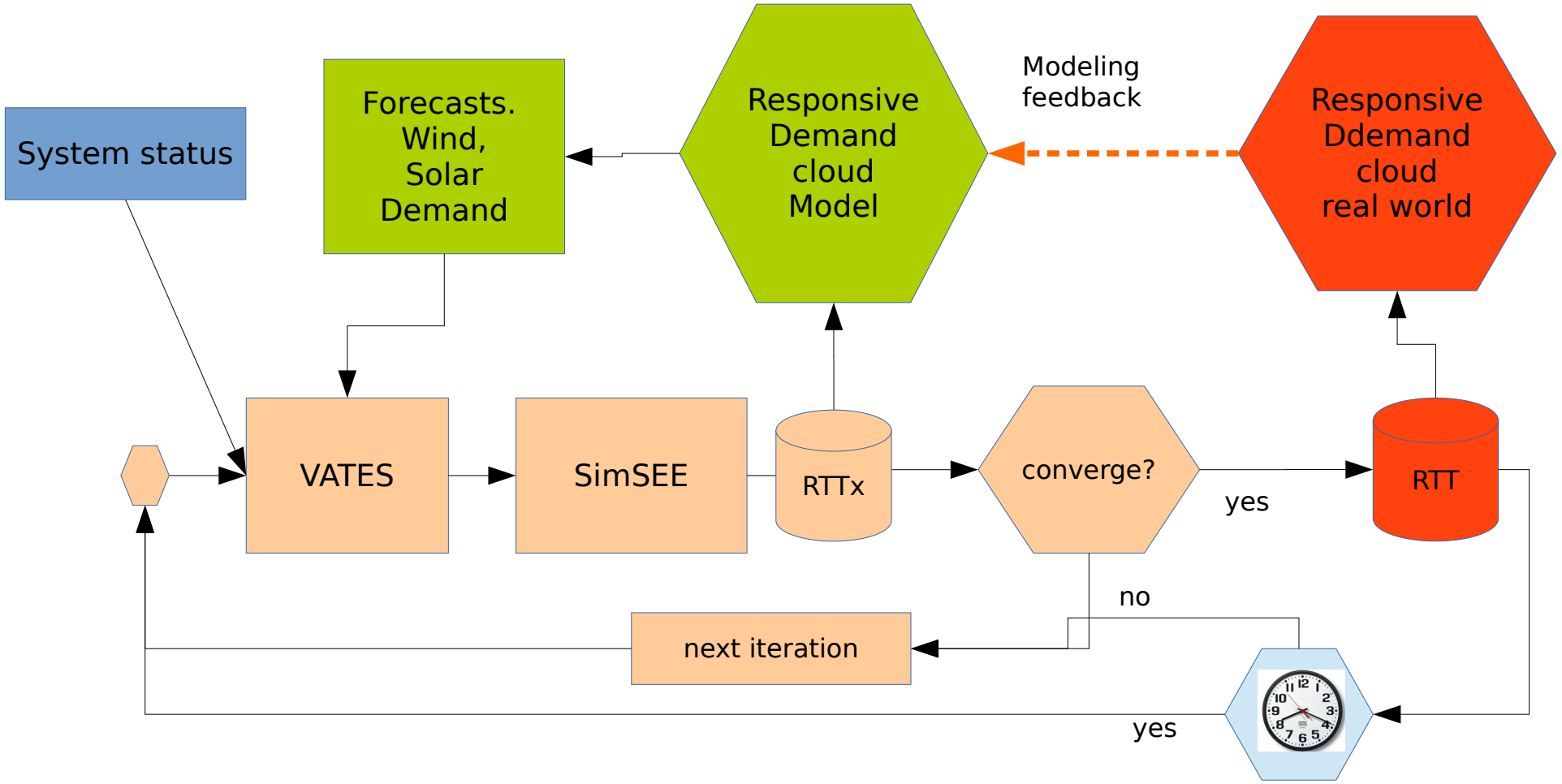
Next 168 h, Spot Price forecast.

(Example from ADME's WEB)



This information is published to allow Responsive Demand projects to grow.

In the future, VATES will close the loop with a self-learning model of Responsive Demand to avoid spot price oscillations.



That's all folks.
Thank you so much for your attention!

... and let's continue exploring the future!

Ruben Chaer
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