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VARIABILITY OF THE GENERATION AND RELIABILITY OF THE ELECTRICAL SYSTEM.

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SimSEE

iie

FACULTAD DE INGENIERIA

UNIVERSIDAD DE LA REPUBLICA URUGUAY

ADME

Institutions.

ADME: Administración **D**el **M**erado **E**léctrico of Uruguay.

> System operation, optimal dispatch and commercial liquidation of the wholesale electric power market.

IIE: Instituto de **I**ngeniería **E**léctrica.

FING: Facultad de **Ing**eniería.

UdeLaR: Universidad **de La R**epública Oriental del Uruguay.

Optimization/Simulation Software

SimSEE

Simulation software platform for the optimal operation of electrical generation systems with modeling of renewables, transport restrictions and stochastic processes.
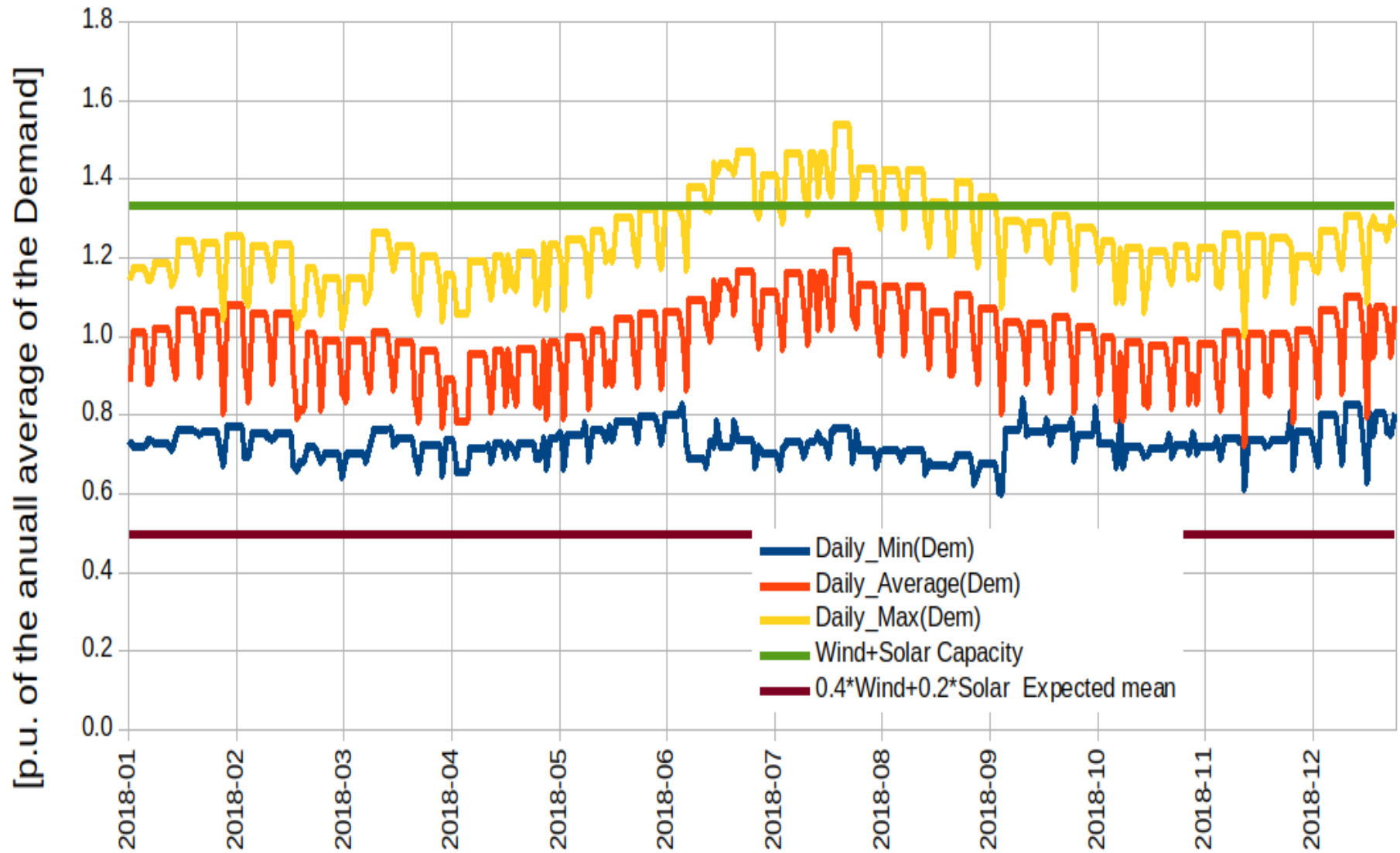
OddFace

Distributed optimizer of cost functions of very high cost of evaluation using genetic programming techniques.
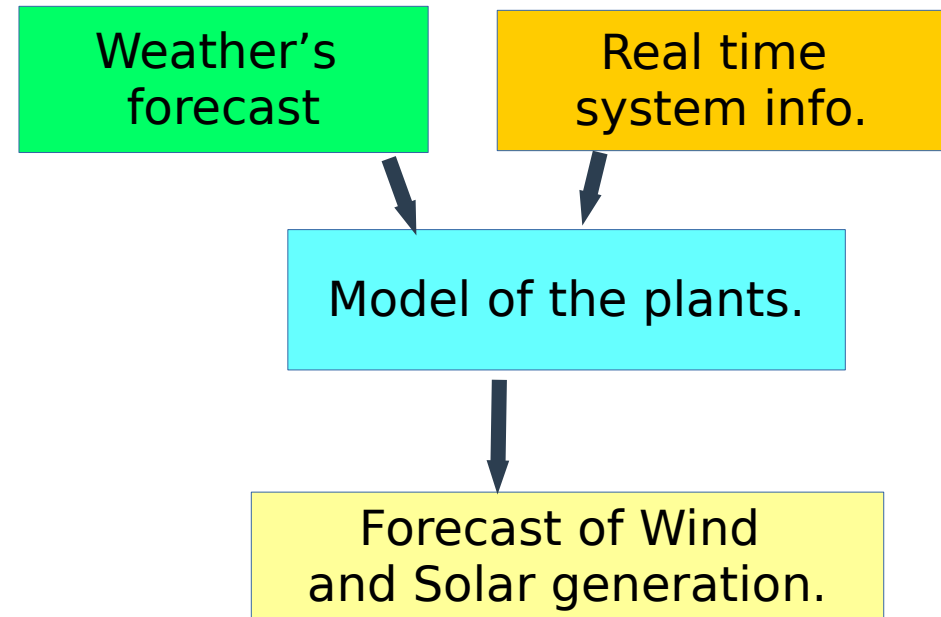
PIG

Agent for evaluation of investment plans and expansion options. PIG Agents use SimSEE and are used by OddFace to solve the problem of the optimal expansion of power generation.

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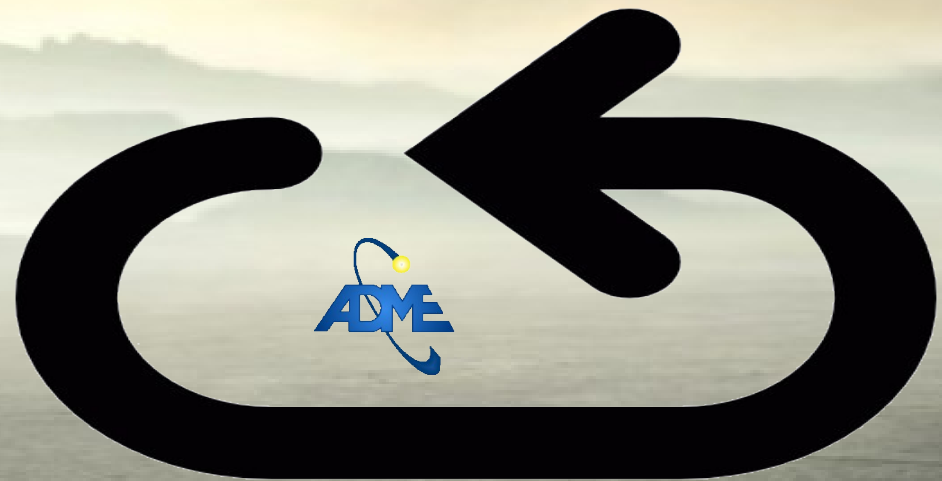## Wind and Solar installed capacity compared with daily Demand.

Legend:
- Daily_Min(Dem)
- Daily_Average(Dem)
- Daily_Max(Dem)
- Wind+Solar Capacity
- 0.4*Wind+0.2*Solar Expected mean

Y-axis: [p.u. of the anuall average of the Demand]

X-axis: 2018-01, 2018-02, 2018-03, 2018-04, 2018-05, 2018-06, 2018-07, 2018-08, 2018-09, 2018-10, 2018-11, 2018-12

SimSEE

PRONOS

Weather's forecast

Real time system info.

Model of the plants.

Forecast of Wind and Solar generation.

https://pronos.adme.com.uy

SimSEE

VATES

Forecast of the next 336 hours of the power system operation.

https://vates.adme.com.uy

SimSEE

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UTE
La energía que nos une

What about the future?
ADME, has to ensure that the expected expansion based on VRE allows us to continue with a safe operation and that the energy will be delivered with the appropriate reliability.

We imagine two scenarios:

SIP): Standard Investment Plan.
  expansion options: Solar, Wind and Gas Turbines.

DIP): Decarbonized Investment Plan.
  expansion options: Solar, Wind and Battery banks.

Optimization of the investment plan.

OddFace

SimSEE
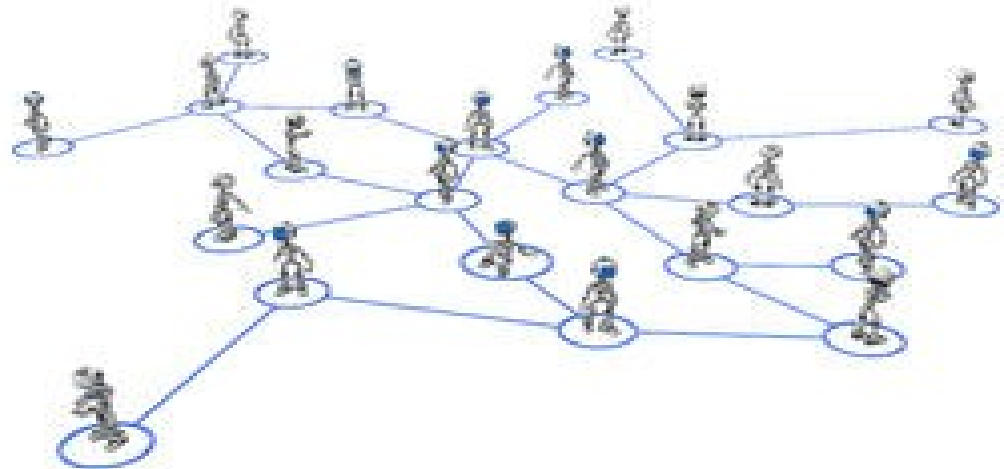
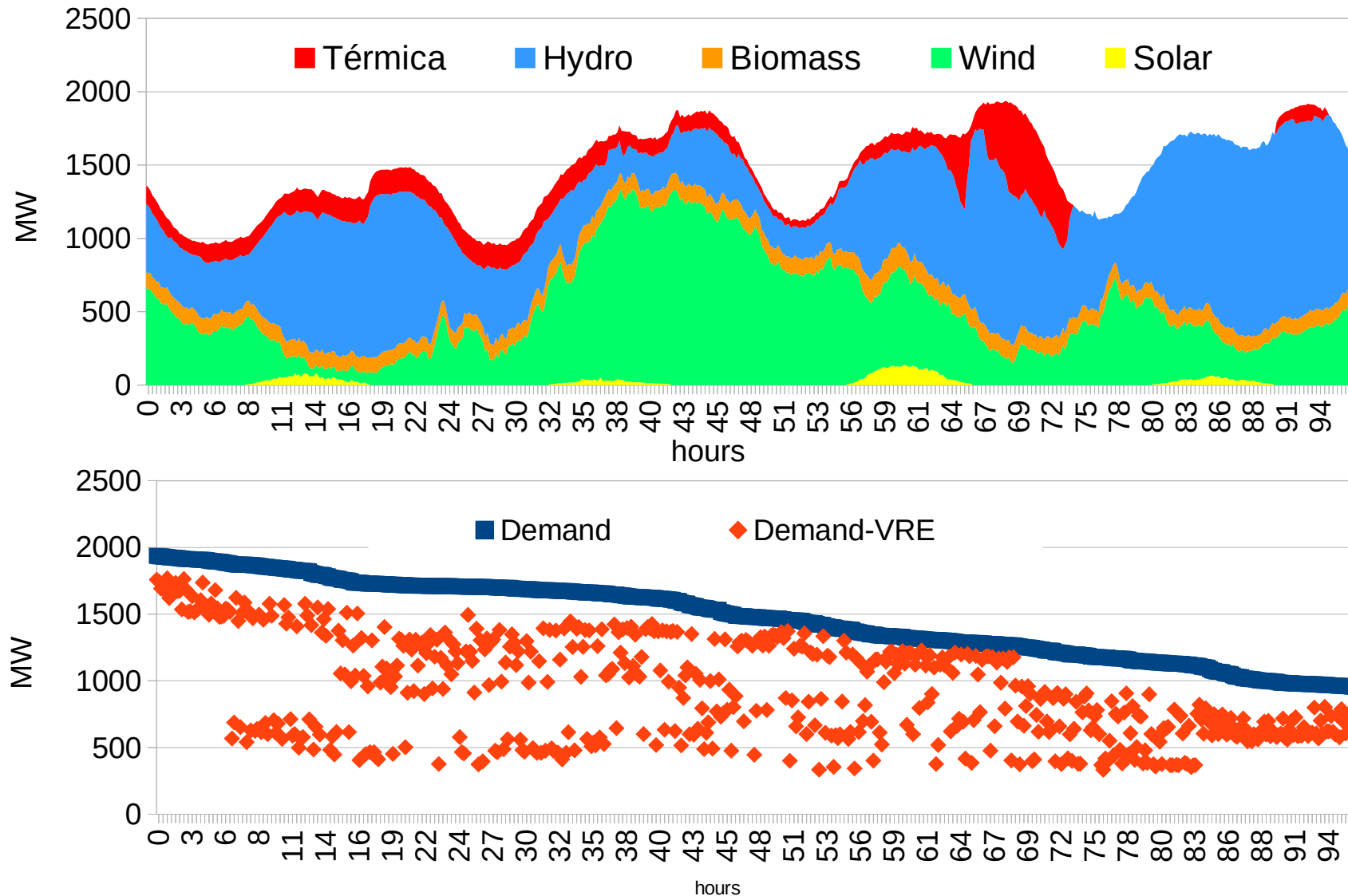# Characterization of the variability in Uruguay.

water inflows

16 years

wind & solar

ws

2 month

averaging time to we get the expected value
width a tolerance of 10% and 90% confidence
as a measure of filtering effort.

SimSEE

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

SimSEE

Representation of uncertainty.

SimSEE

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.
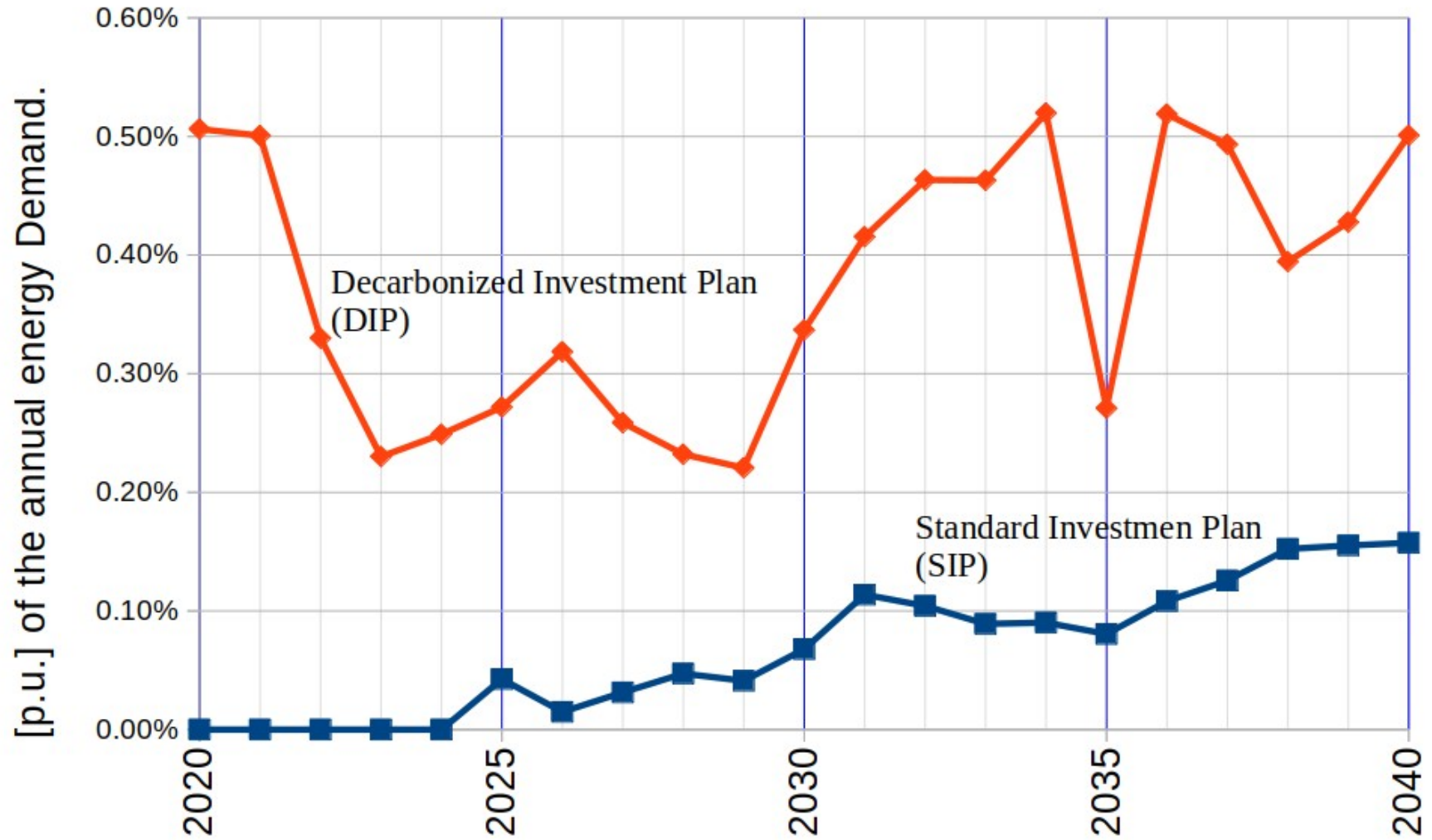That is, we have to represent the inertia behind the stochastic variables.
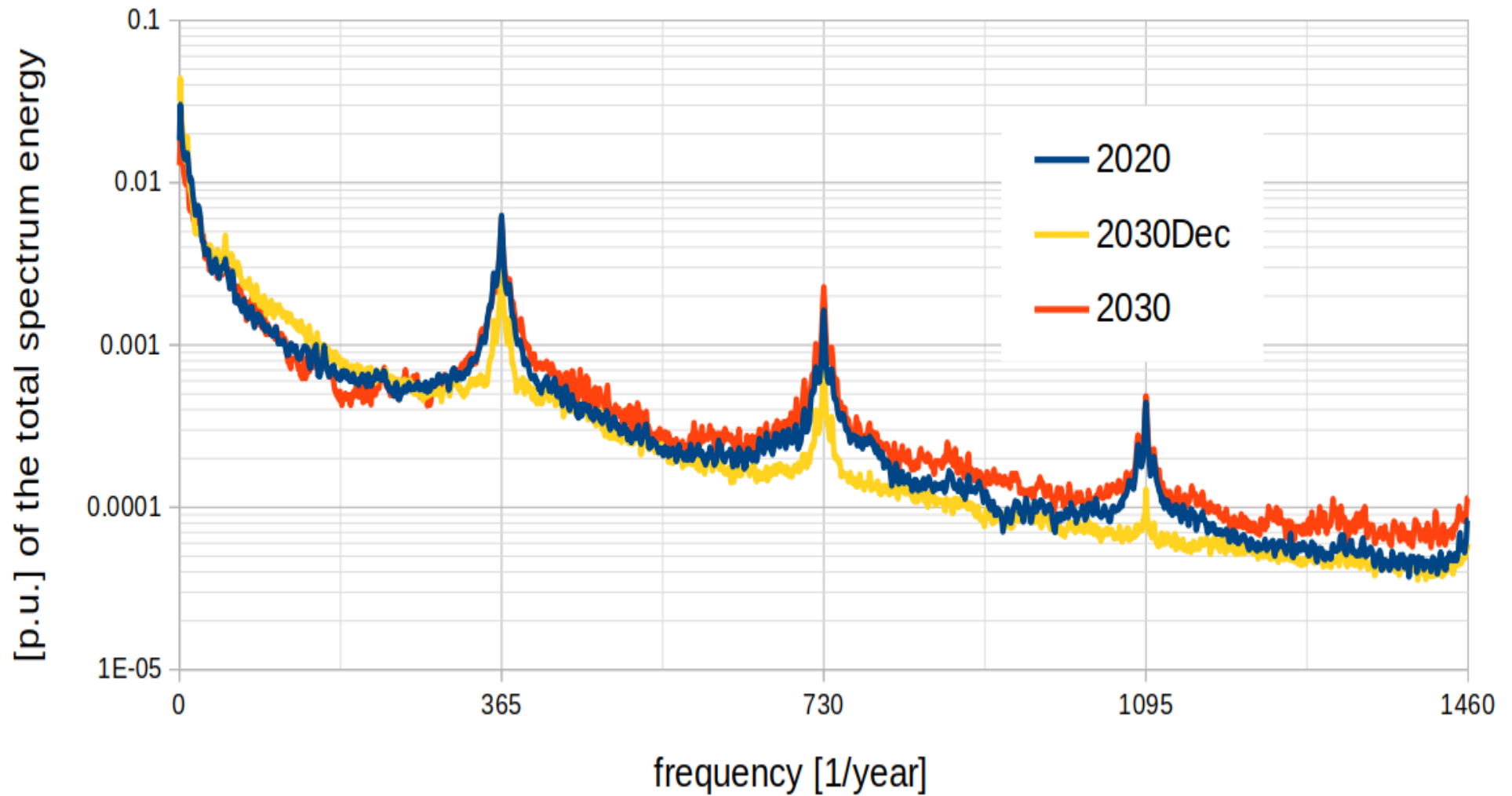
Main results.
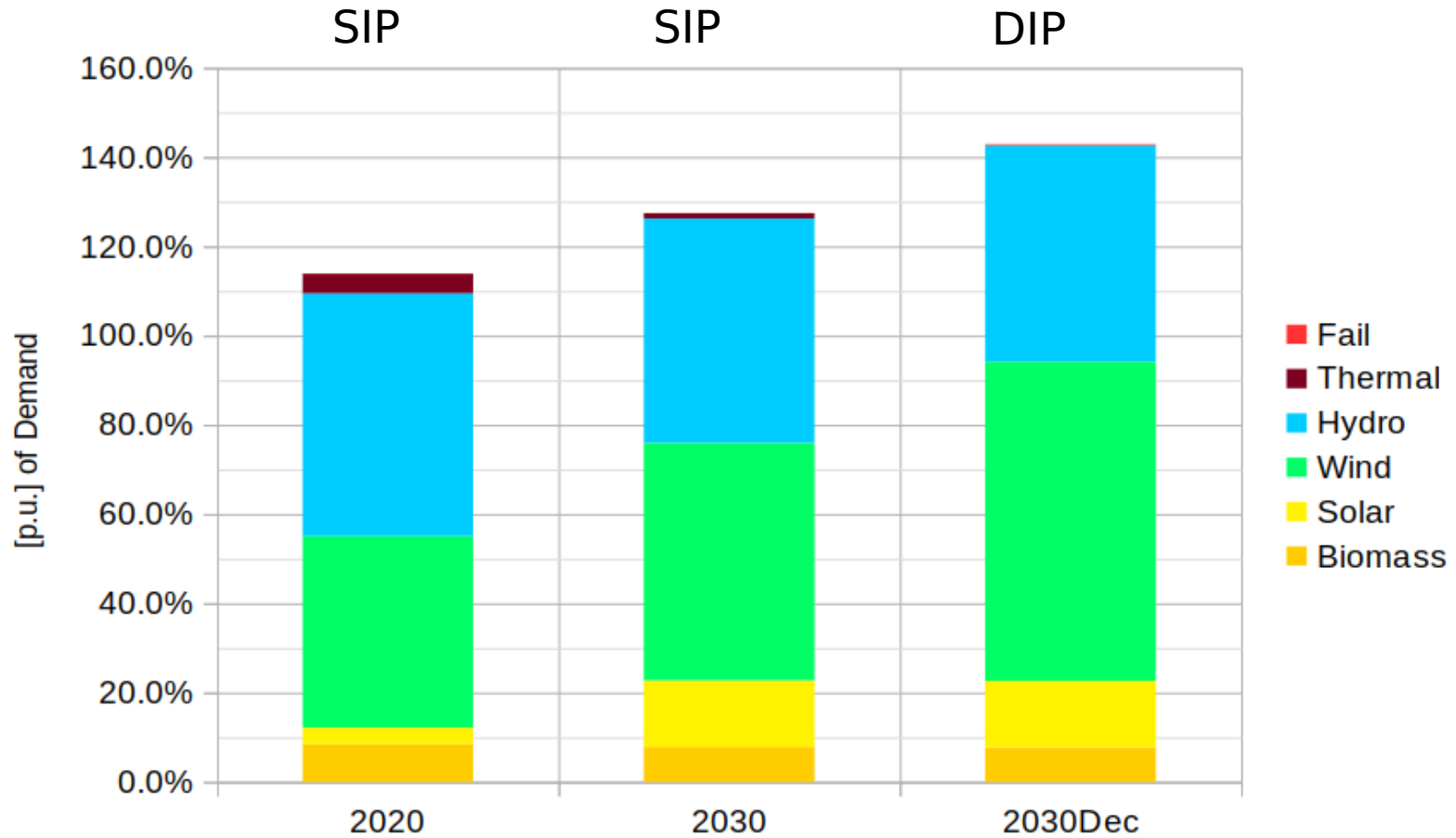
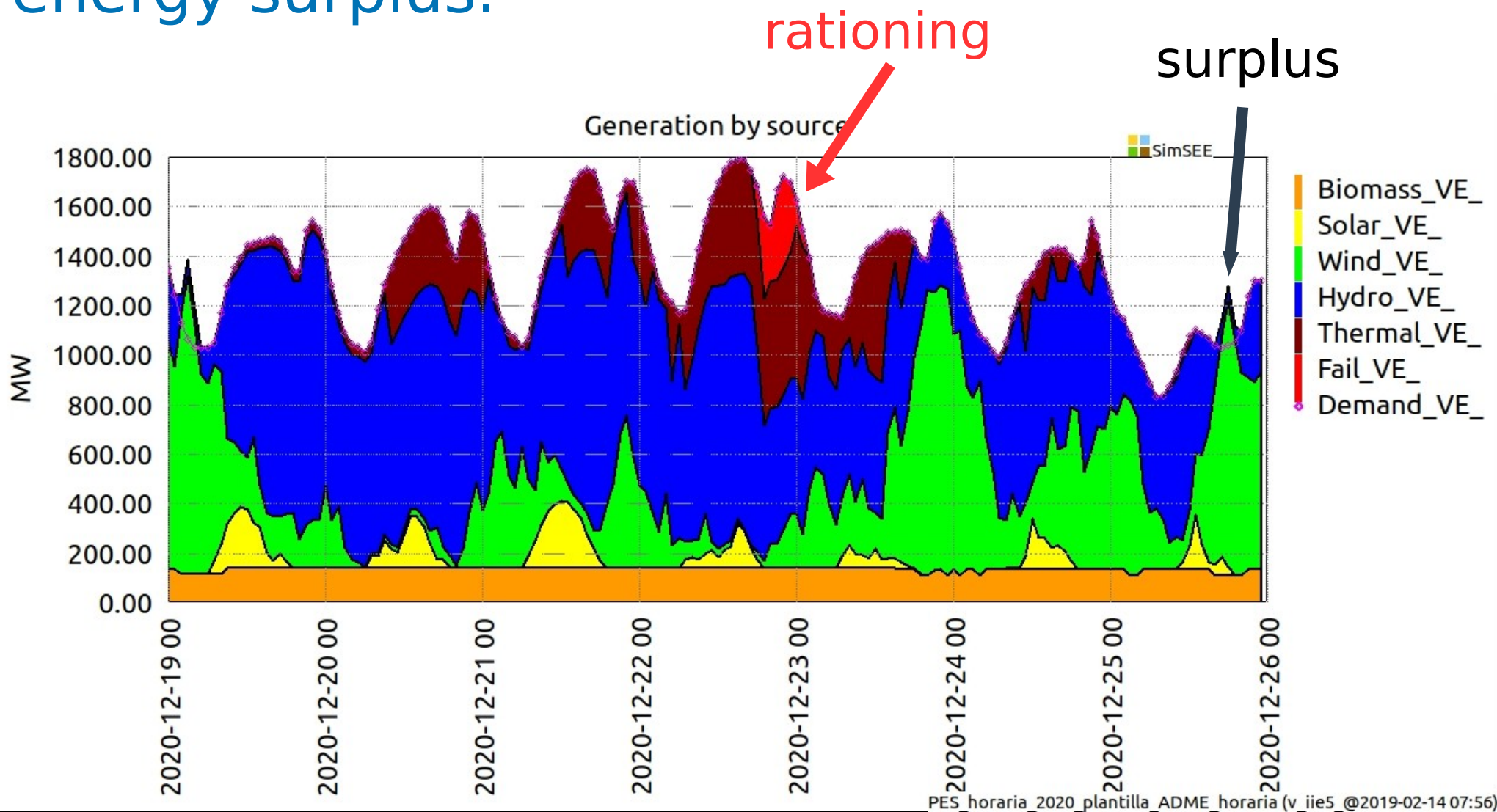| Case	Biomass	Solar	Wind	Hydro	Thermal	Fail	Surplus
2020	8.5%	3.6%	42.9%	54.4%	4.4%	0.06%	13.9%
2030	7.9%	14.9%	53.2%	50.3%	1.2%	0.04%	27.5%
2030Dec	7.7%	14.9%	71.5%	48.5%	0.0%	0.29%	42.9%

SimSEE
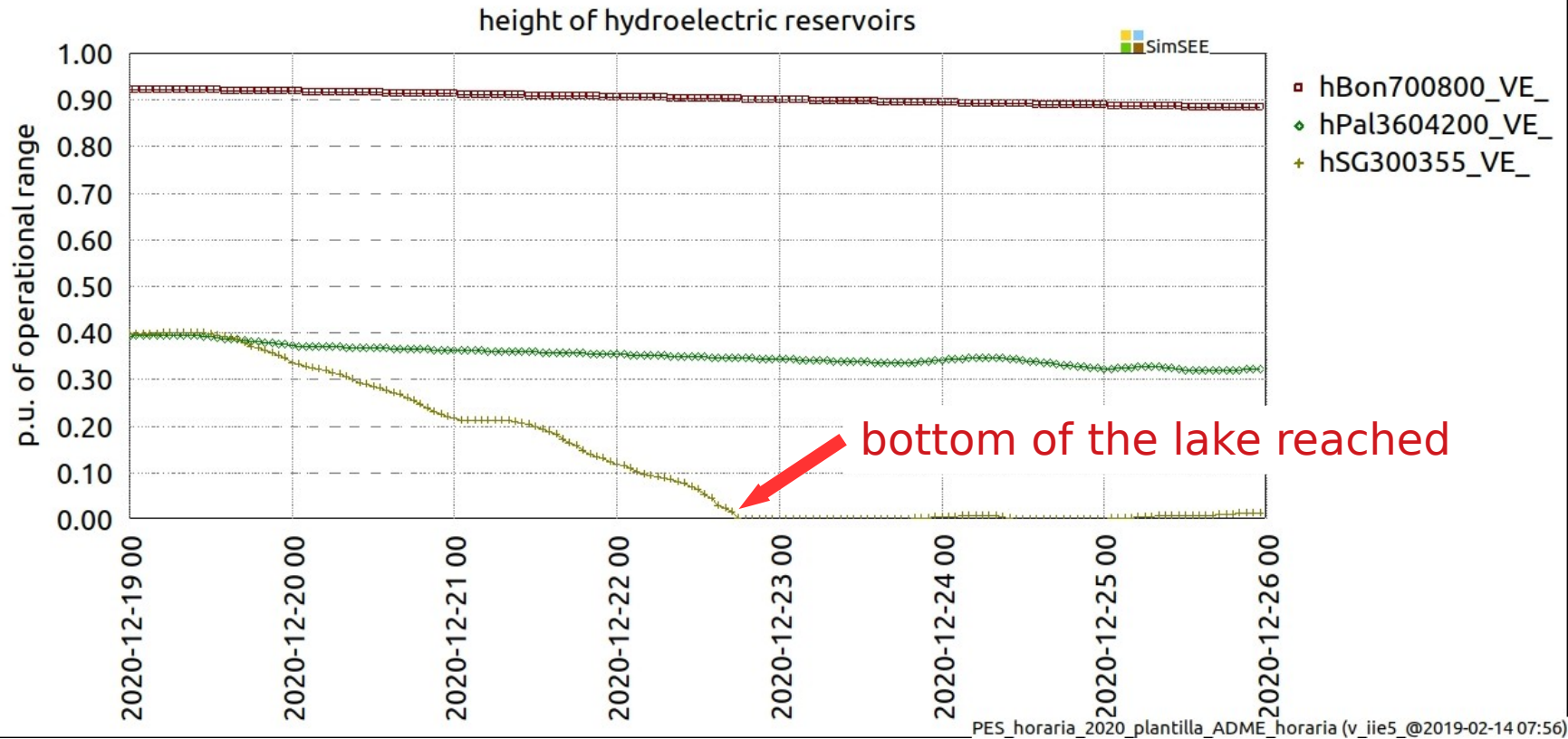
Annual energy failure PE(10).

Power spectrum of Failure/Demand signal.

A realization with energy rationing and energy surplus.

# Evolution of the height of hydro-reservoires.

height of hydroelectric reservoirs

bottom of the lake reached

SimSEE

- hBon700800_VE_
- hPal3604200_VE_
- hSG300355_VE_

PES_horaria_2020_plantilla_ADME_horaria (v_iie5_@2019-02-14 07:56)

In the future, when the filtering capacity of the hydroelectric subsystem is exhausted, regional integration, Responsive Demands and Battery-storage will be the key to filter the variations of energy availability within the week.
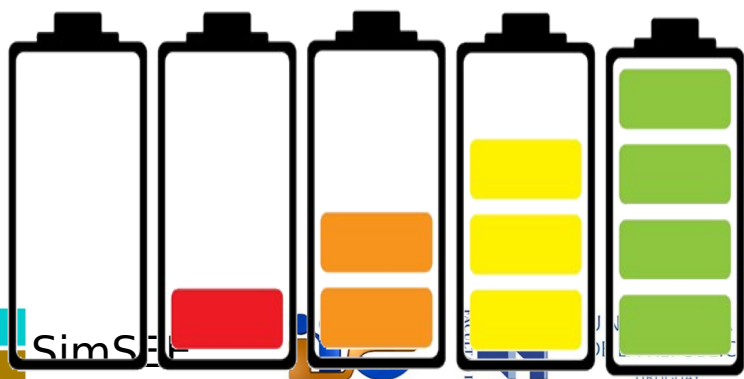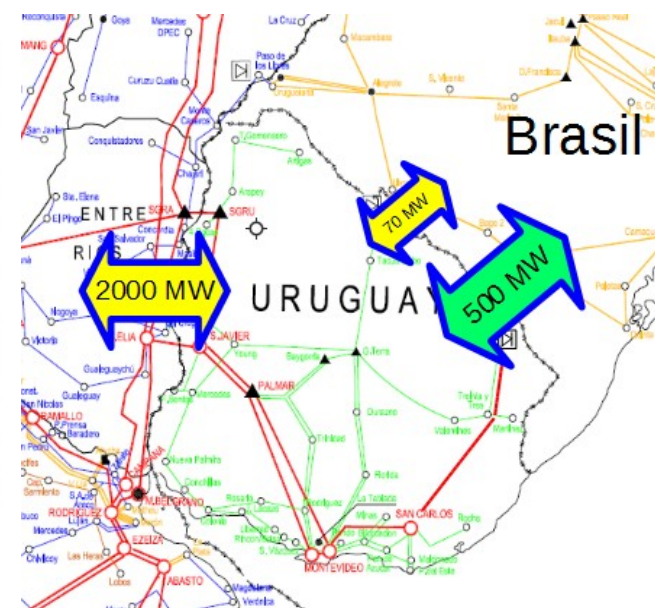
Final remarks.

Based on the results obtained, it can be affirmed that the Uruguayan system could maintain the reliability of supply at levels similar to the current ones, even in a horizon such as the year 2030, with a expected 65% of the supply based on VRE.

From the point of view of the operation then we conclude that until 2030 we can be calm.

Thinking in the long-term, no one knows what will be the available technologies and their costs from 2030 onwards nor the speed with which electric mobility and intelligent networks will allow new demands to be used as filtering elements for variability.

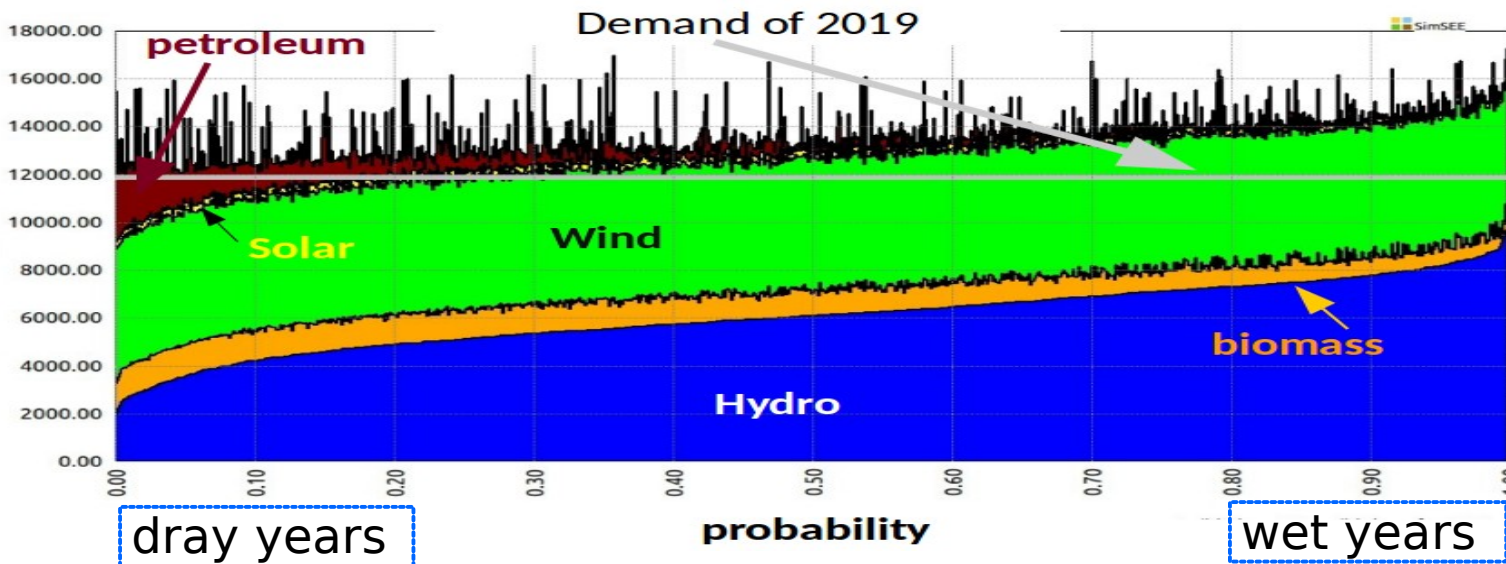**As always, a challenging and fun future is coming.**

Muchas gracias por su atención.
Muito obrigado pela sua atenção!
Thank you so much for your attention!

What we have done in Uruguay.
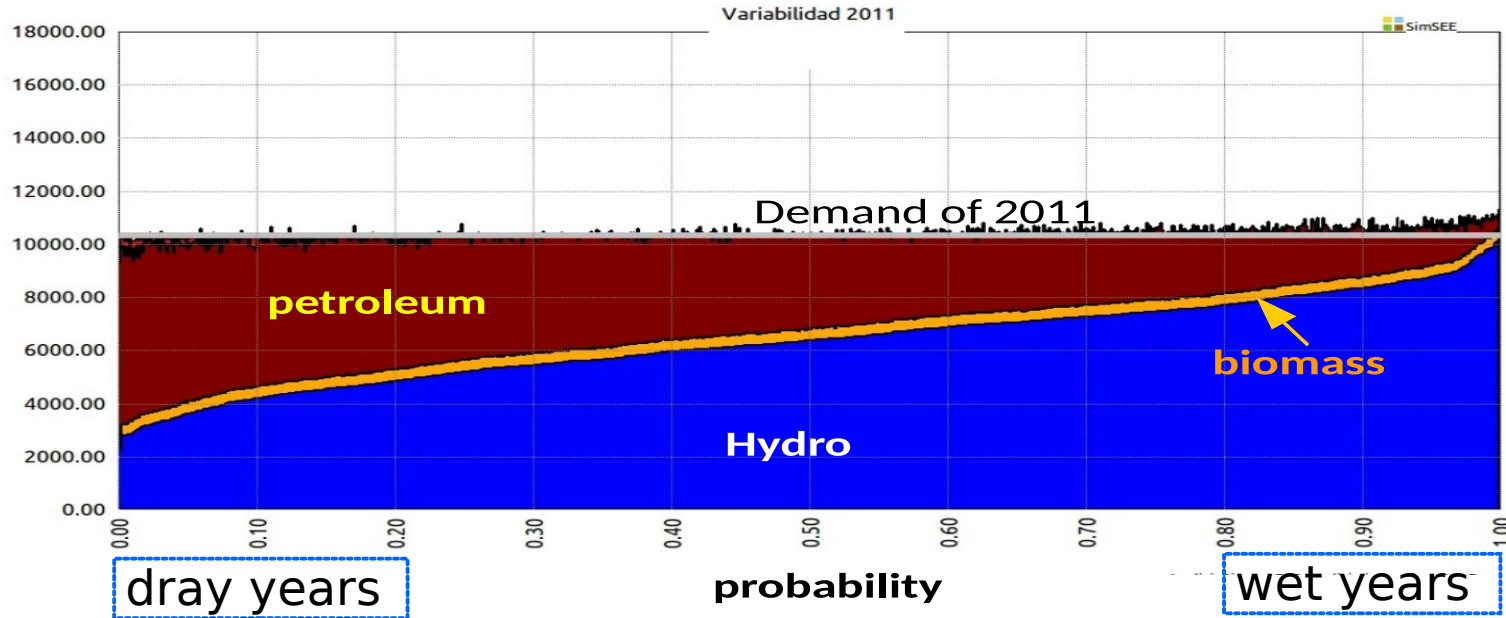
Source: The risk images are from the IIE studies carried out in 2010 and 2018 respectively.