



**Planeación y la operación de los sistemas de potencia con altas cantidades de energías renovables variables.**

**Experiencia Internacional**

*Ing. Ruben Chaer.*

## *Taller: Integrando Energías Renovables en sistemas de potencia en Centroamérica*

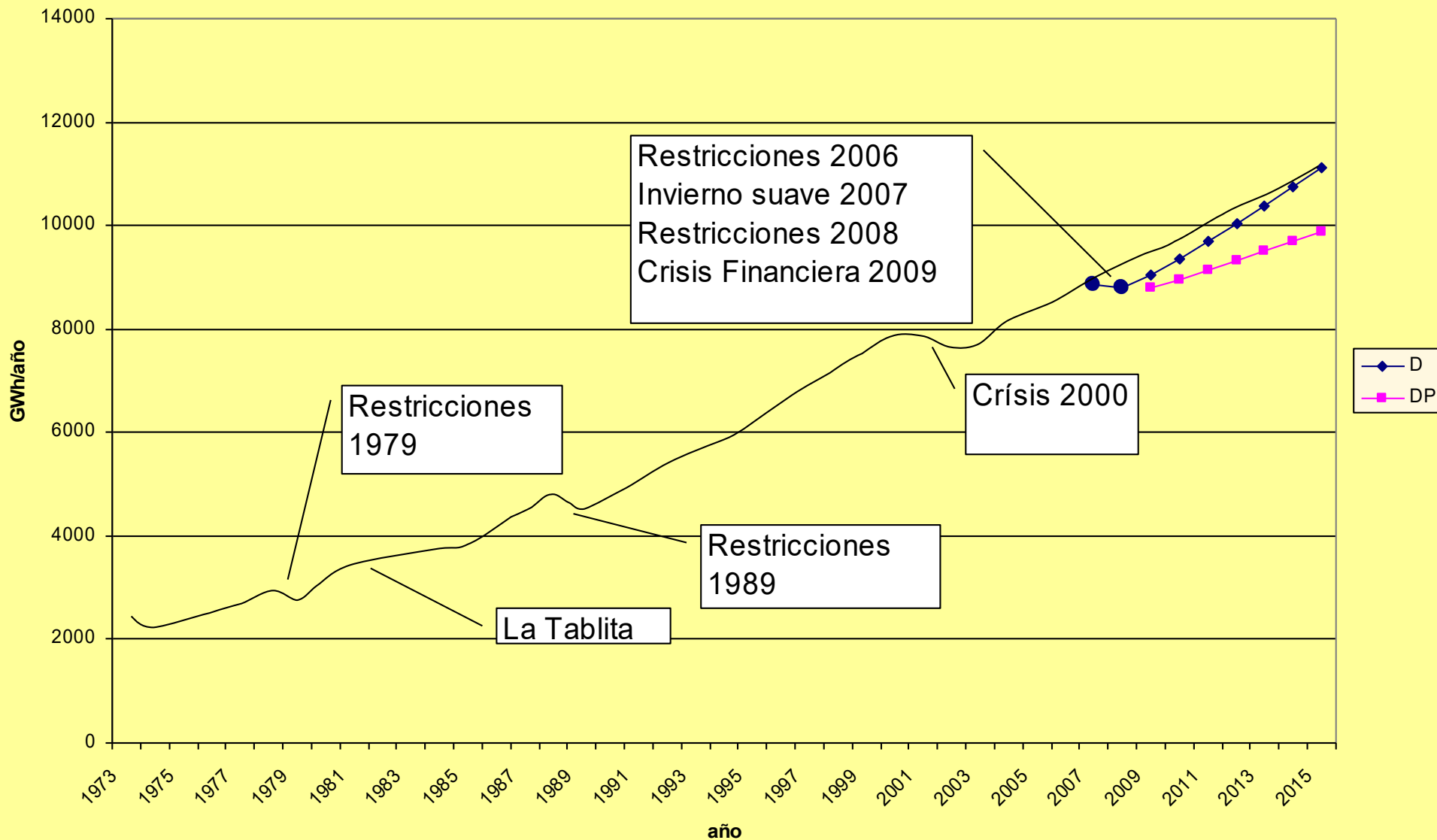
26-28 de Octubre de 2016  
Ciudad de Panamá, Panamá



# Cambio de la matriz eléctrica de Uruguay.



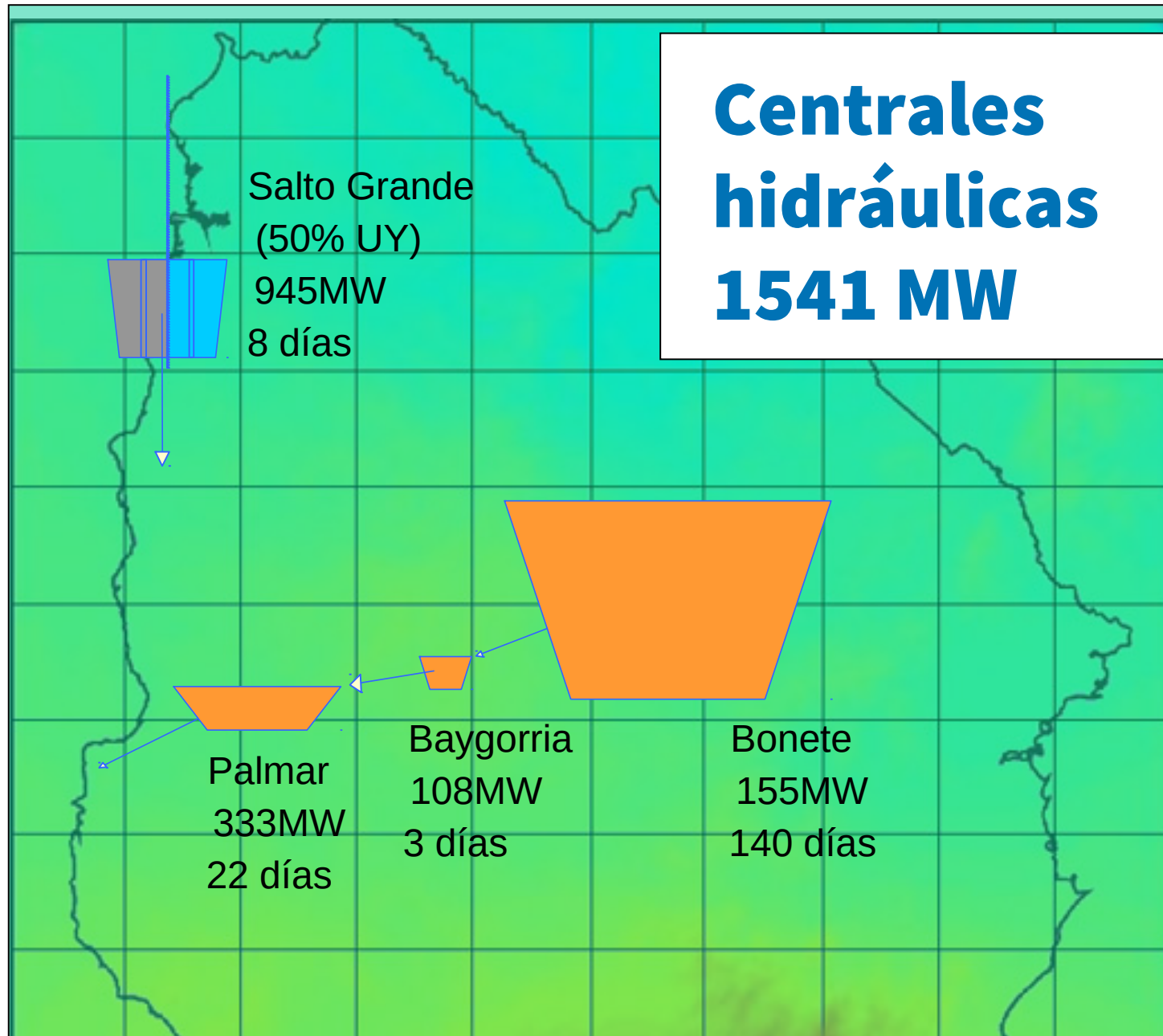
### Demanda de energía eléctrica Uruguay. Hasta el 2008 son datos reales







# Centrales hidráulicas 1541 MW



Expansión futura: No quedan grandes proyectos por realizar. Posibilidad de generación distribuida en mini y micro aprovechamientos 200 MW.  
Centrales de bombeo distribuidas 300 – 1000 MW

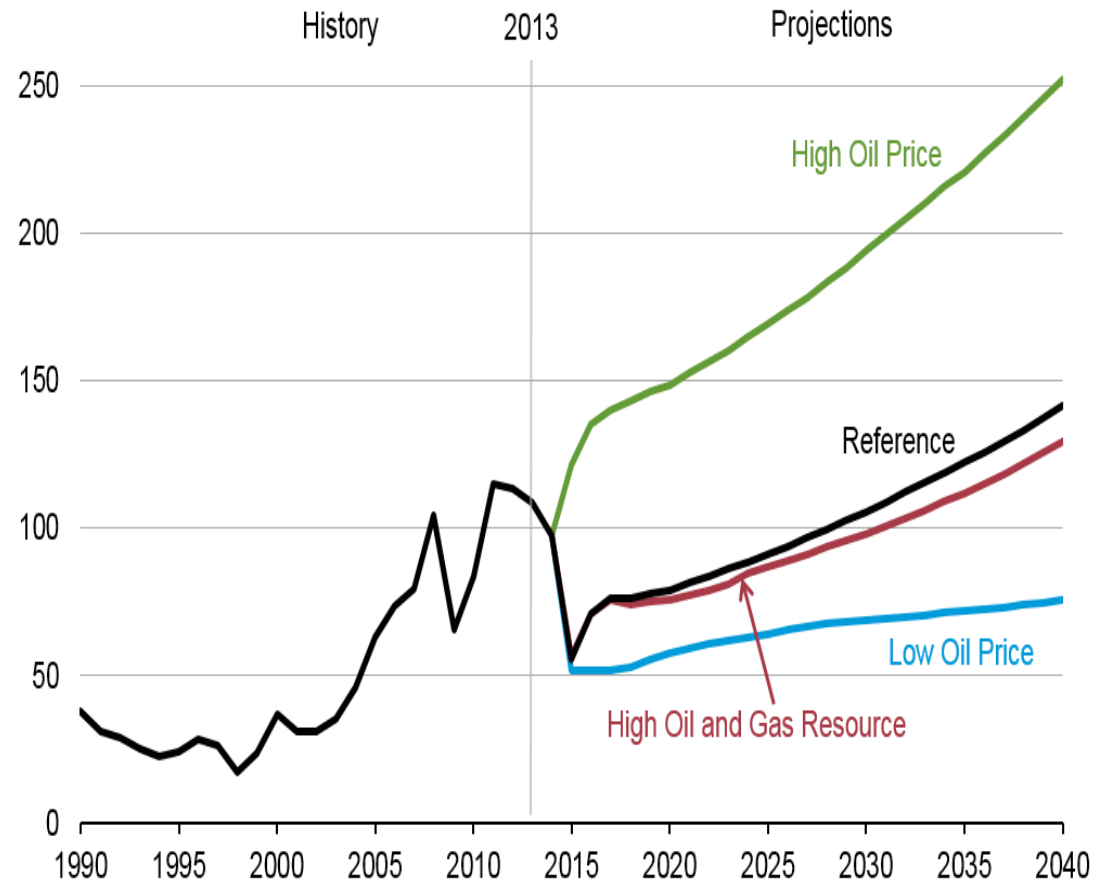
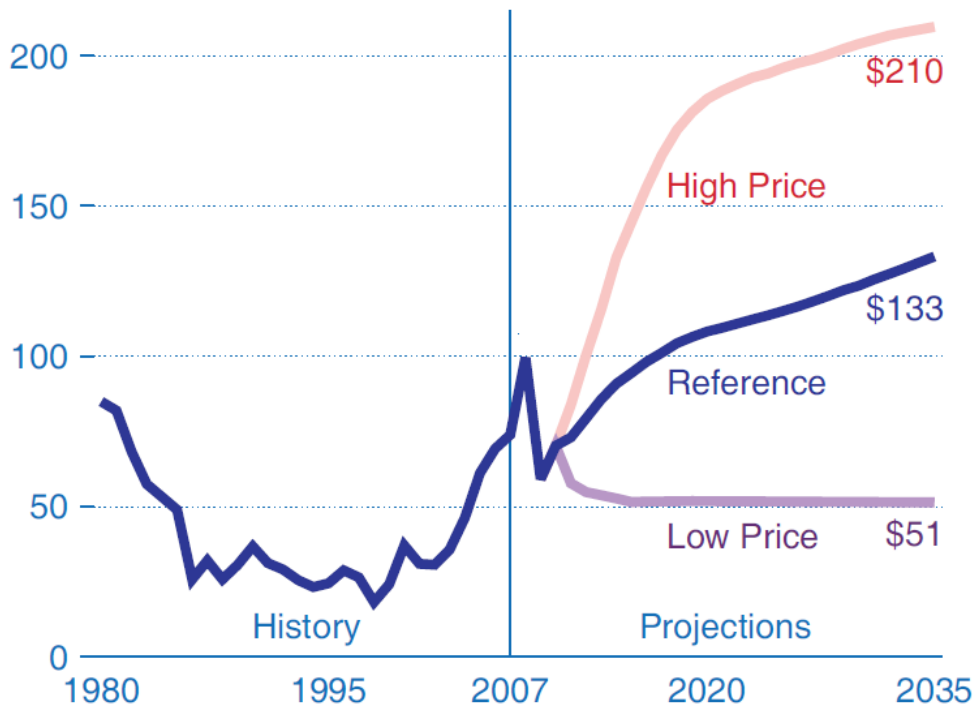
# Fósiles Brent/GNL (Largo Plazo)



AEO2015 explores scenarios that encompass a wide range of future crude oil price paths

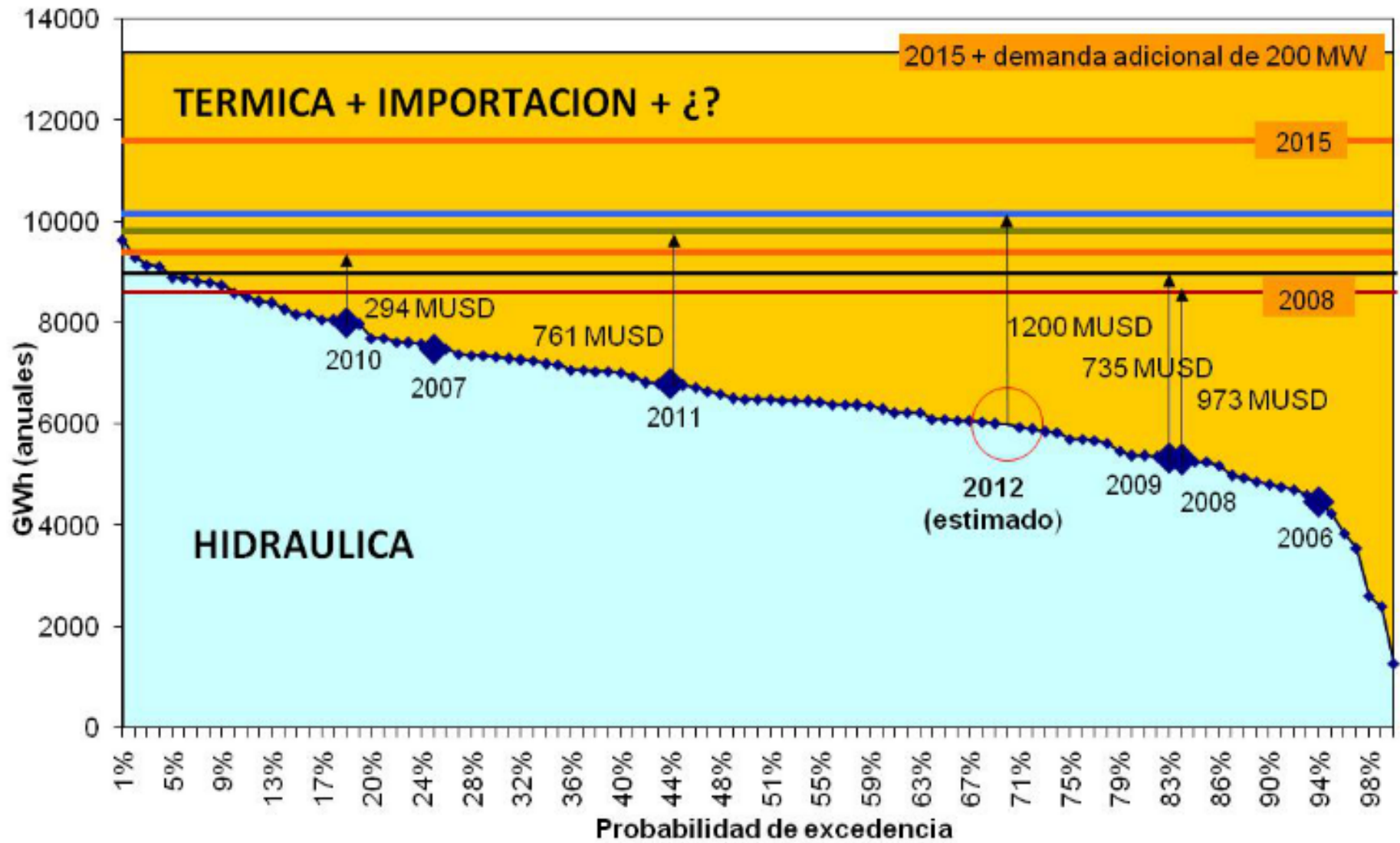
Brent crude oil spot price  
2013 dollars per barrel

Figure 32. World oil prices in three cases, 1980-2035 (2008 dollars per barrel)

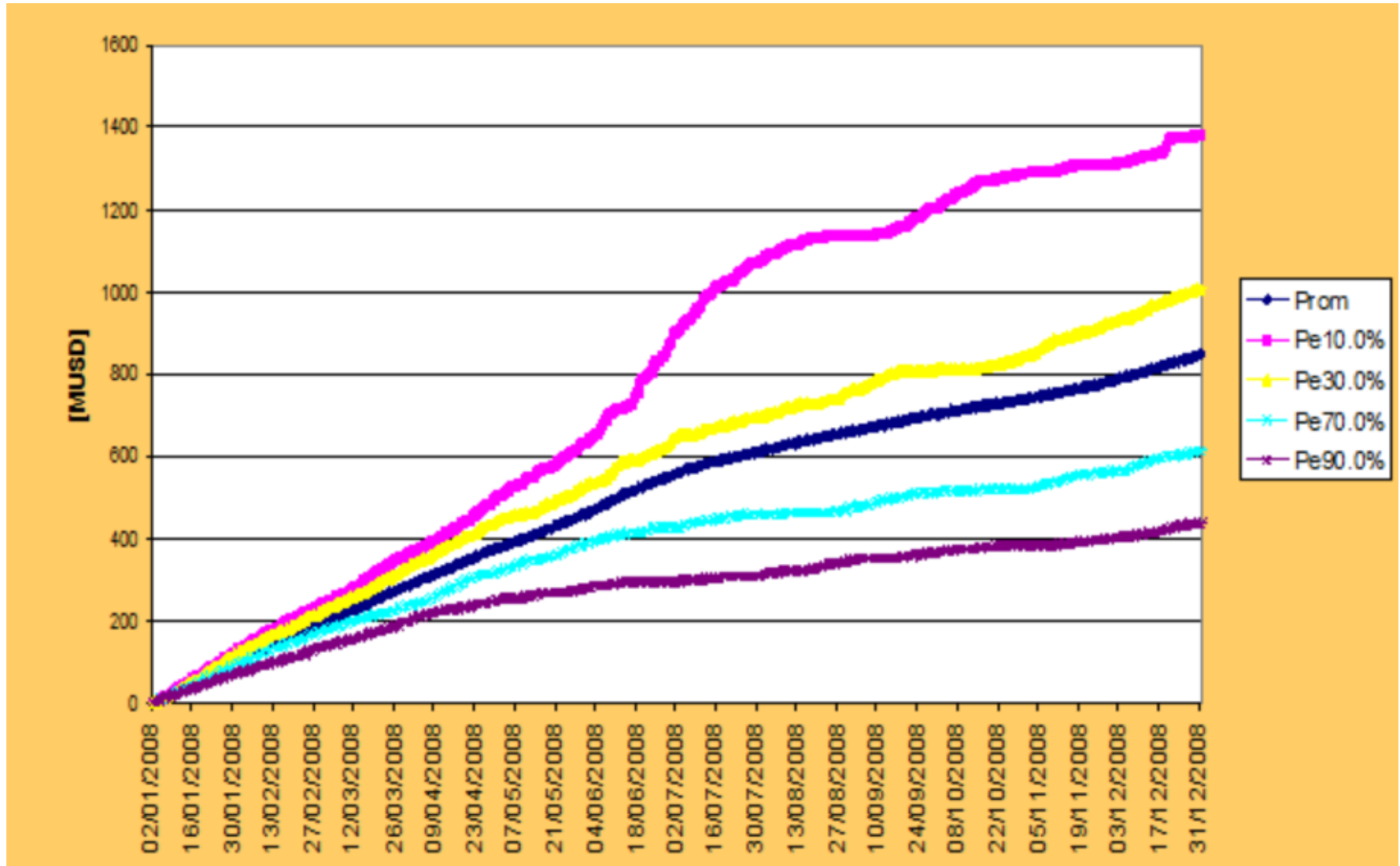


Source: EIA, Annual Energy Outlook 2015

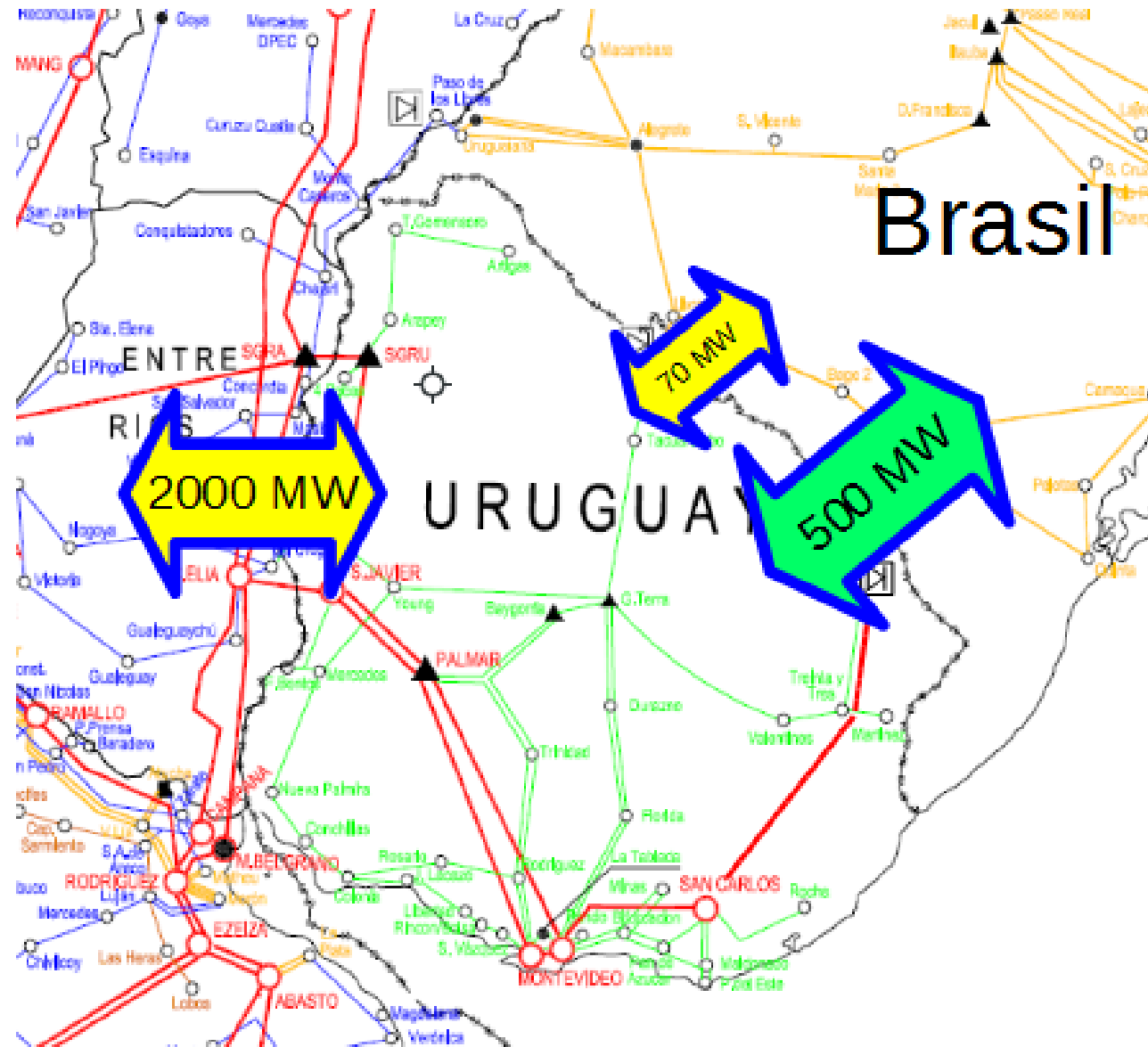
# Uruguay



# CAD proyectado 2008 (simulado en 2007)



# Interconexiones.







## **Actualidad de Uruguay y sus vecinos.**

**Exigencias a nivel de OPERACION para estabilidad del sistema.**

**Control de Potencia Activa y Reactiva.**

**Filtrado de las intermitencias a nivel país.**

**AGC + Centrales Hidroeléctricas.**

**Restricciones Operativas.**

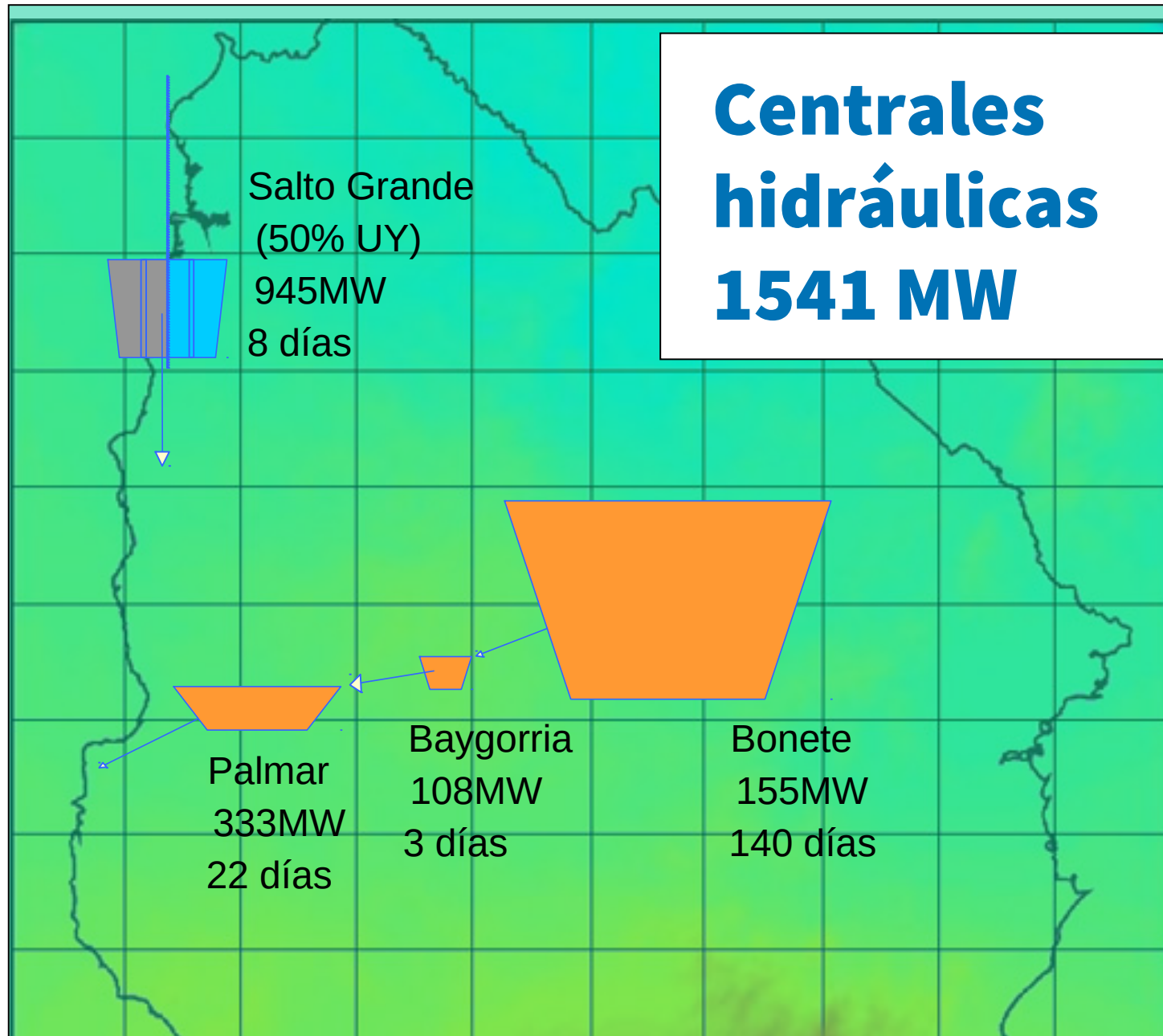
**Link UY – BR es Conversora de Frecuencia.**

**Link UY – AG es Duro --- un solo sistema --- REG. FRECUENCIA.**





# Centrales hidráulicas 1541 MW

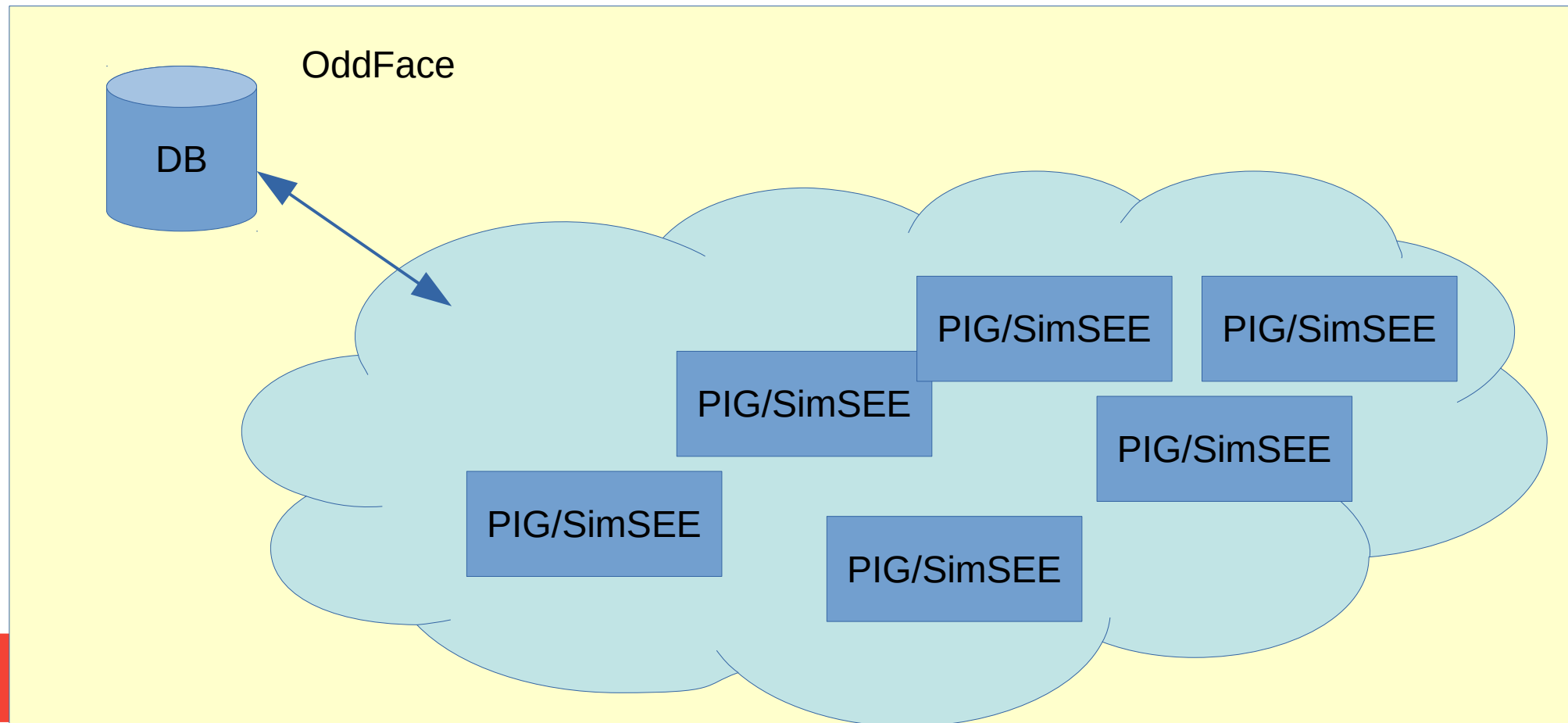


Expansión futura: No quedan grandes proyectos por realizar. Posibilidad de generación distribuida en mini y micro aprovechamientos 200 MW.  
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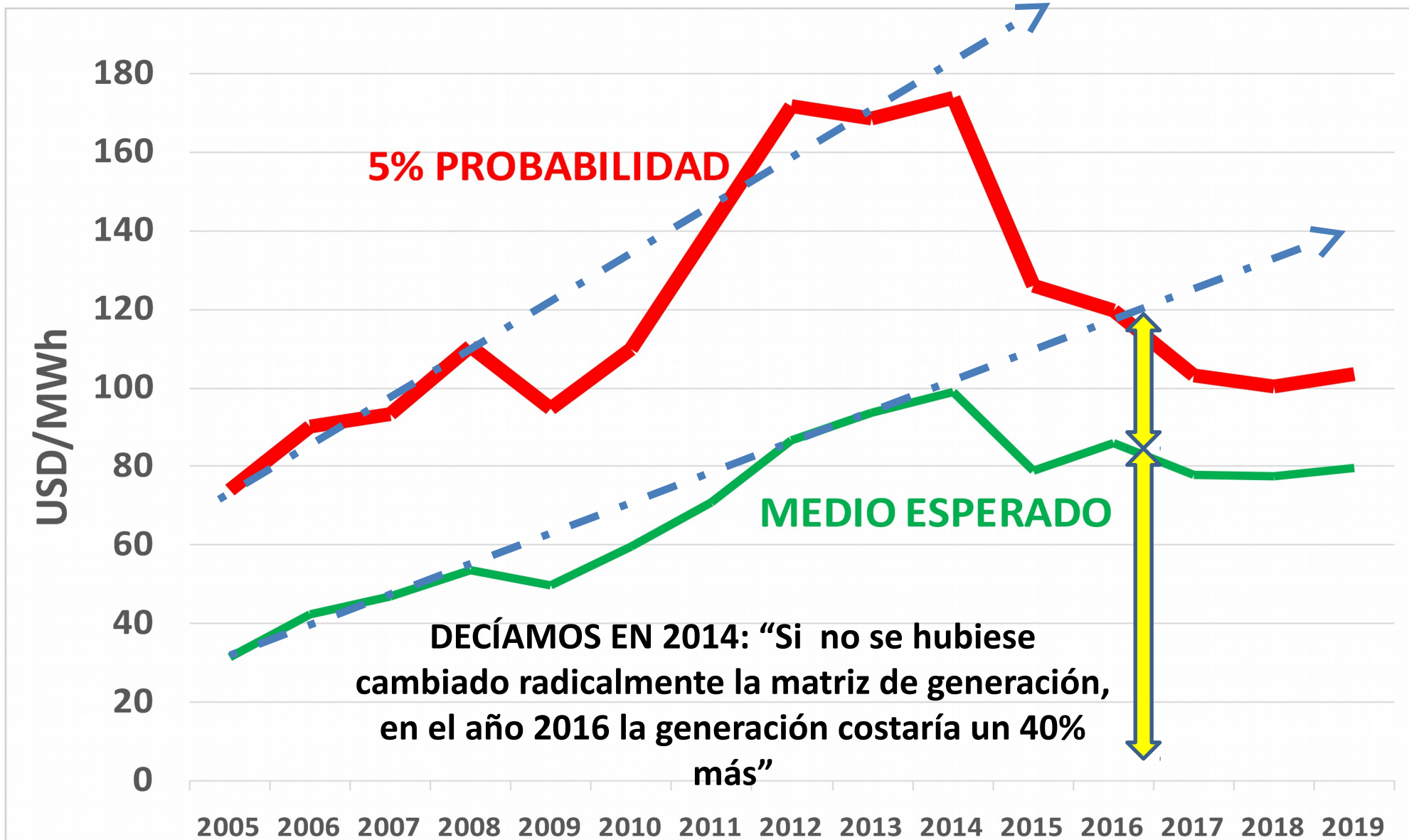
# OddFace + PIG + SimSEE

Optimizador distribuido de funciones de alto costo de evaluación.

Planificación de Inversines de Generación.

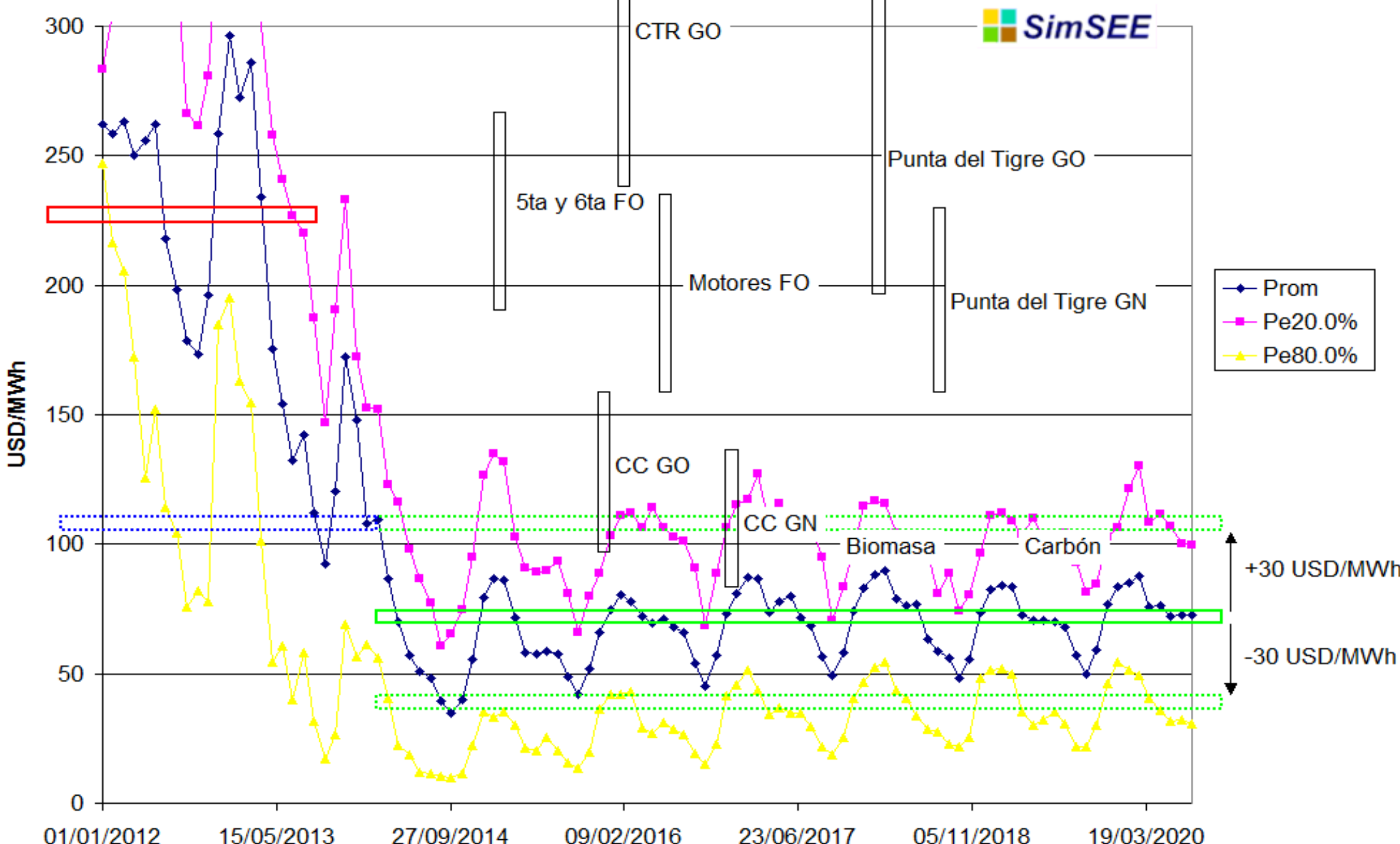


# Pronósticos 2014: costos de generación



# Costos Marginales Medios Mensuales - Uruguay 2012-2020

(Plan: CC470+1200MWEólica al 2015+Brasil 500MW en Nov2013 con delta de 30 USD/MWh+DemandaPlus)

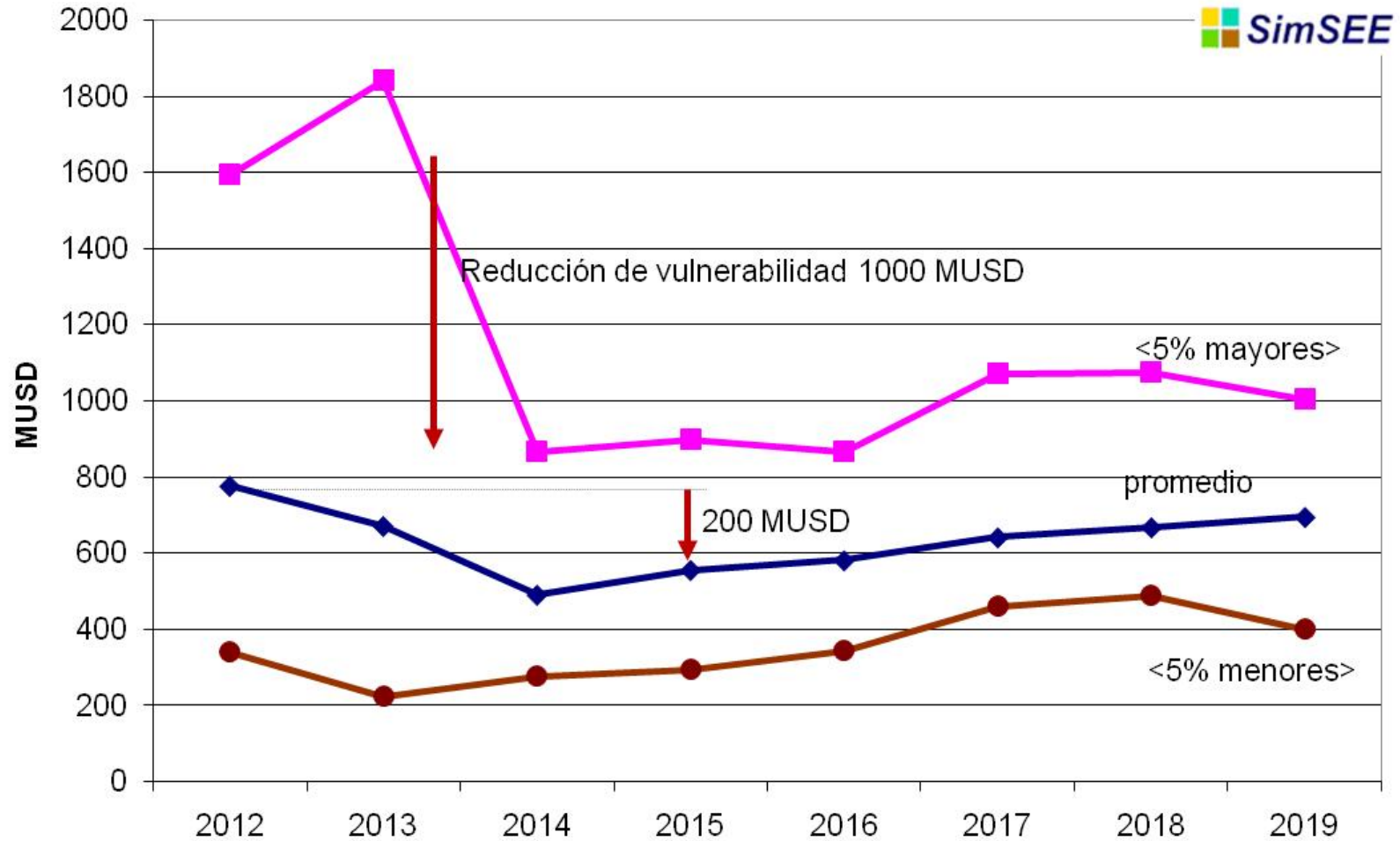




# The design - 2010-2011

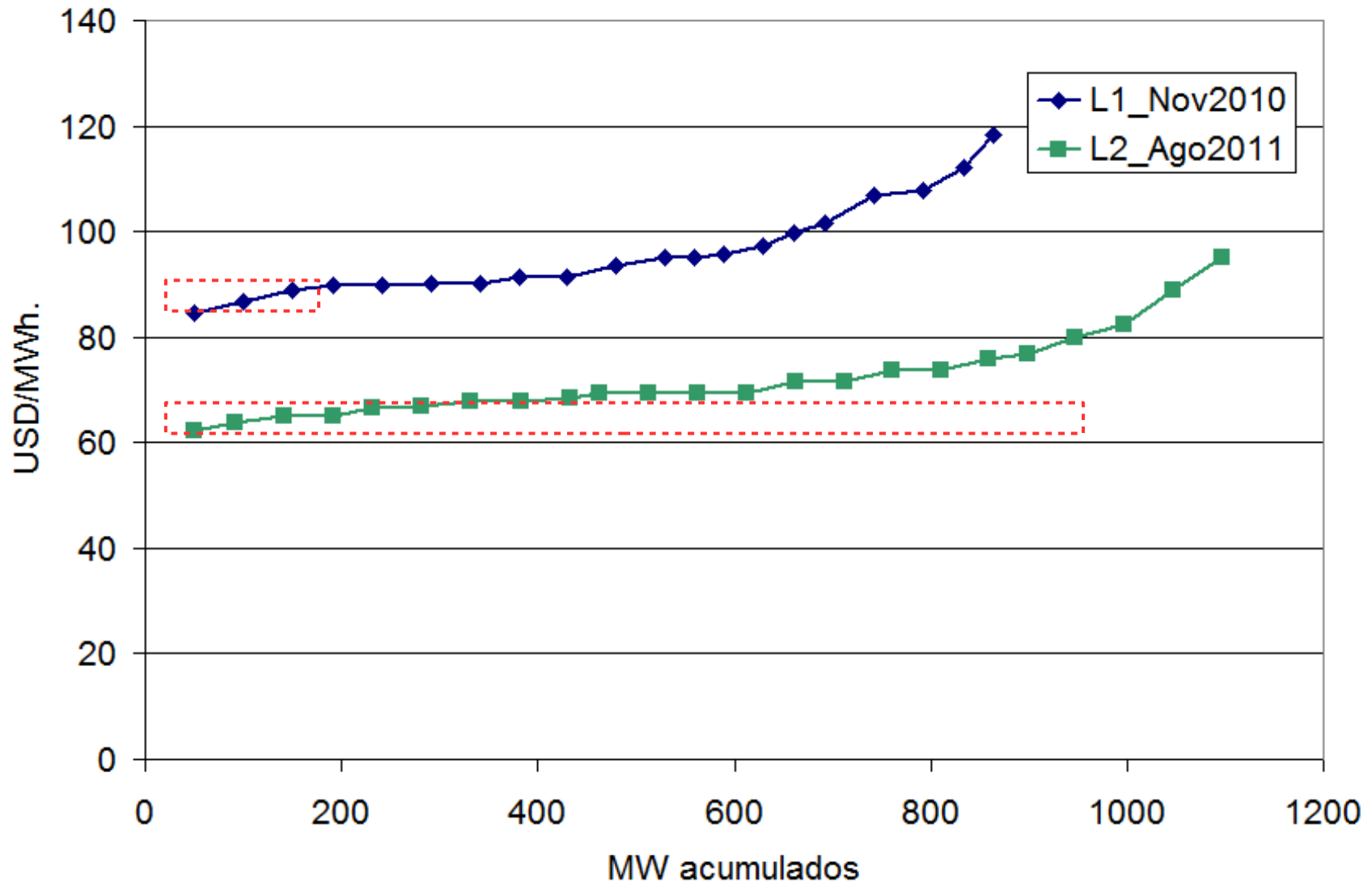


CAD = Combustibles + Compras a agentes nacionales + Importación  
(dólares 2011 sin IVA).

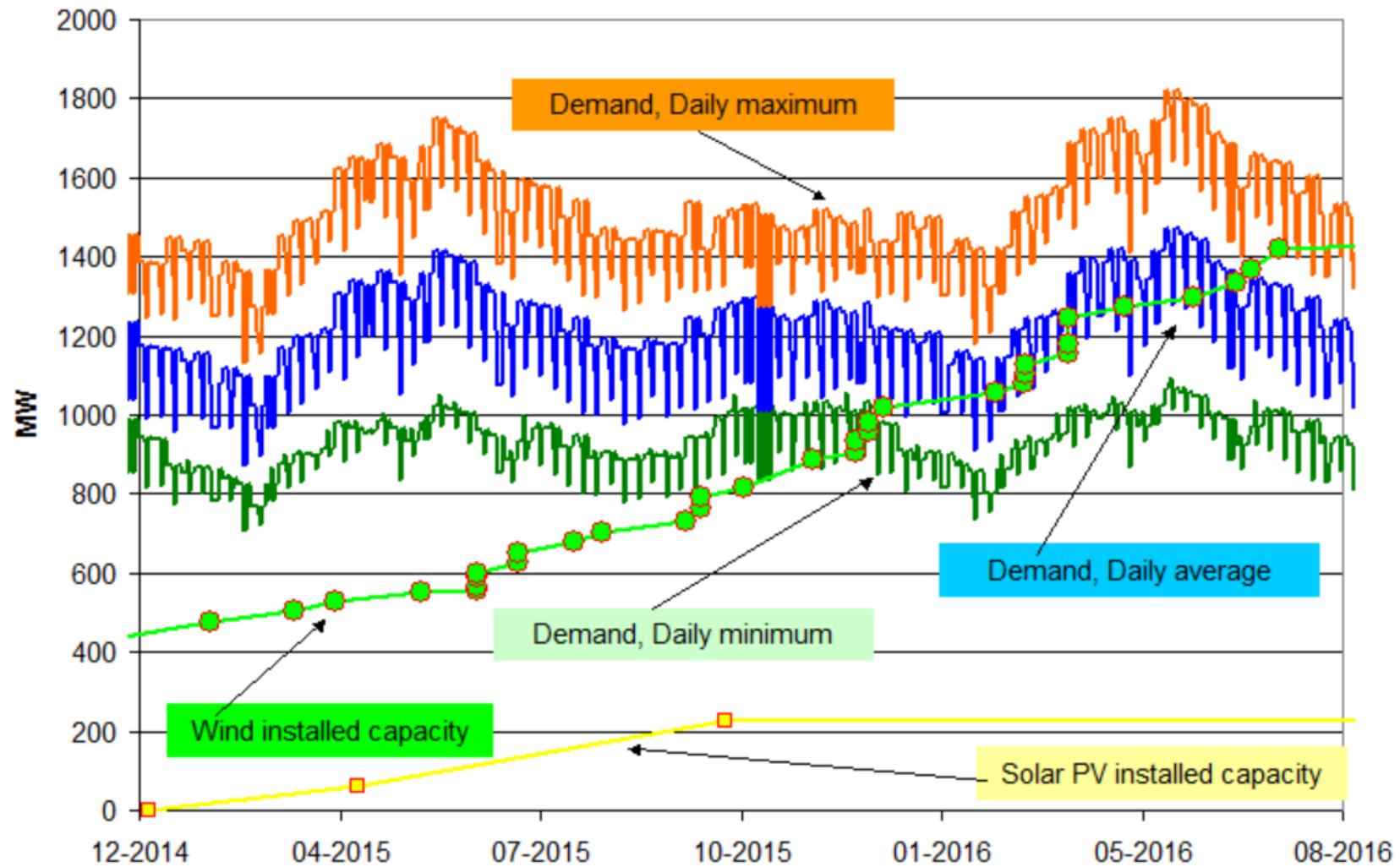


# Wind power biddings

## 20 years PPA, each offer is for 50 MW.



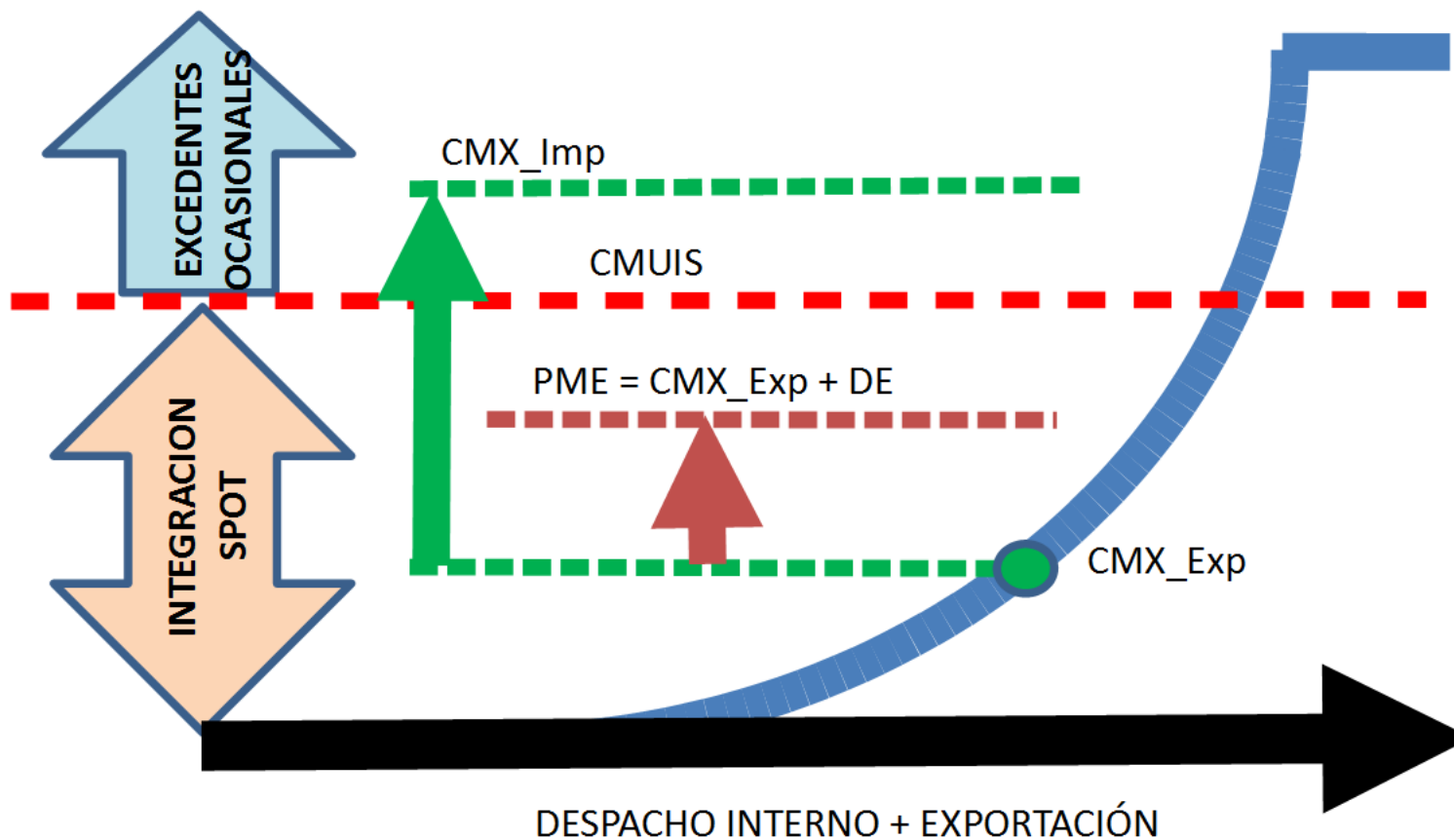
# Eólica vs. Demanda



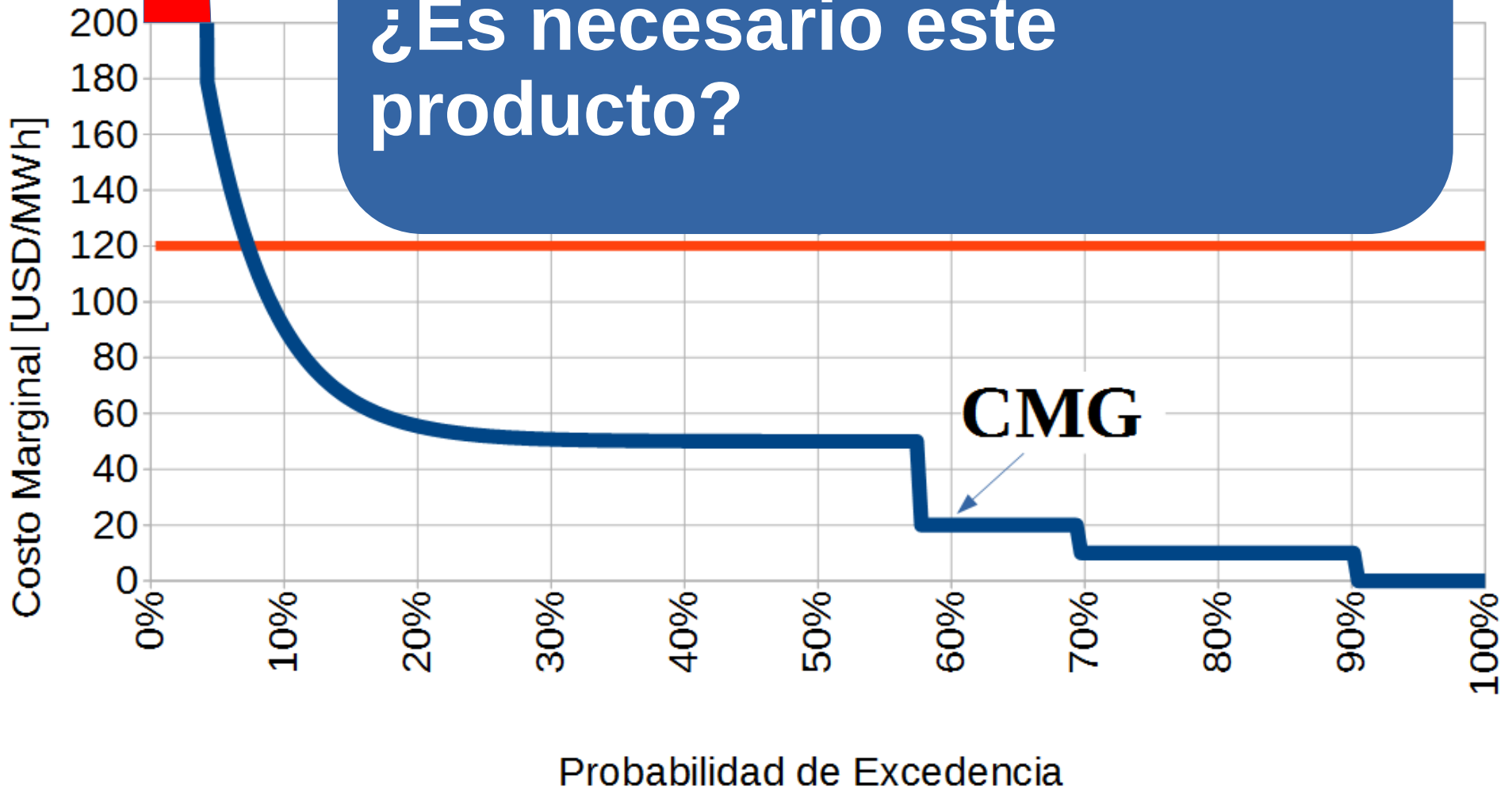
# MIG



## Modelo de Integración Grdual



**“Potencia Firme”  
¿Es necesario este  
producto?**





# We need new loads capable of defer/advance the consumption...





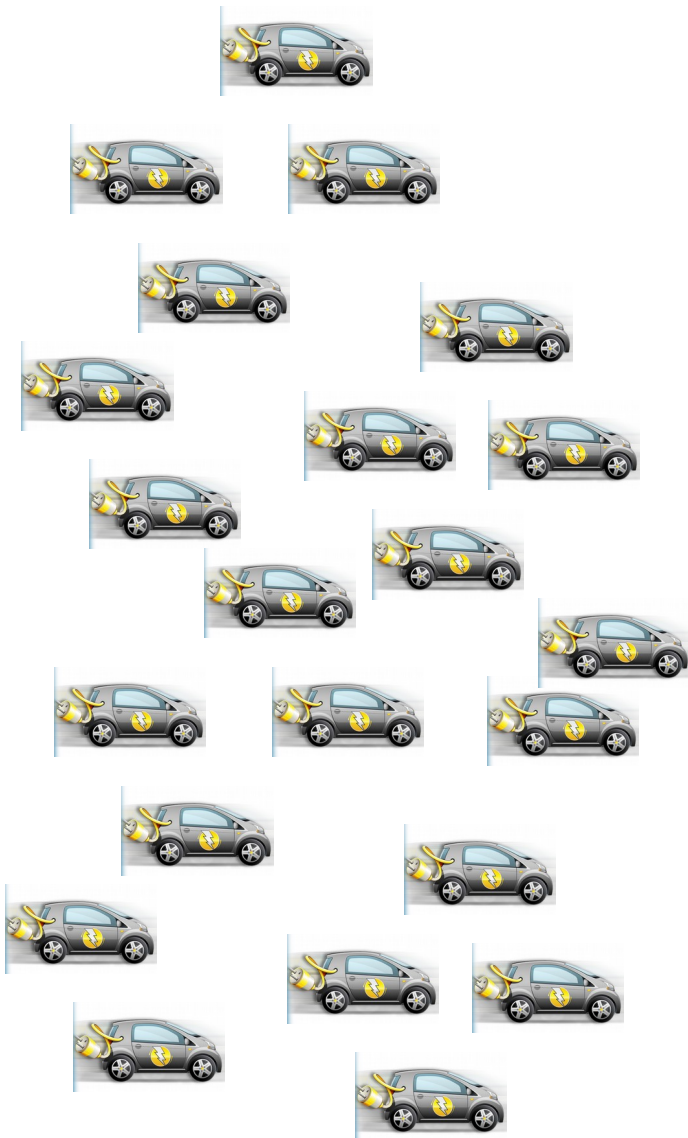
Water heater.

60-90 lt storage capacity.

Daily target temperature for a programmed hour.



# Cloud of loads with statistic behavior



# Real time tariff.

In real time forecast to the next 72 hours

The Smart Controllers will try to allocate consumption in the cheaper hours.

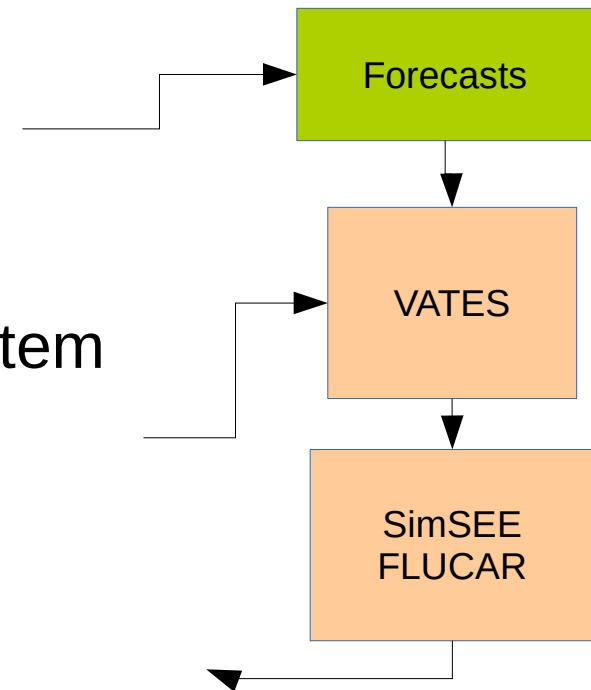


# Starting building blocks



Hydro-Solar  
Temperature

Real time system  
Status info.

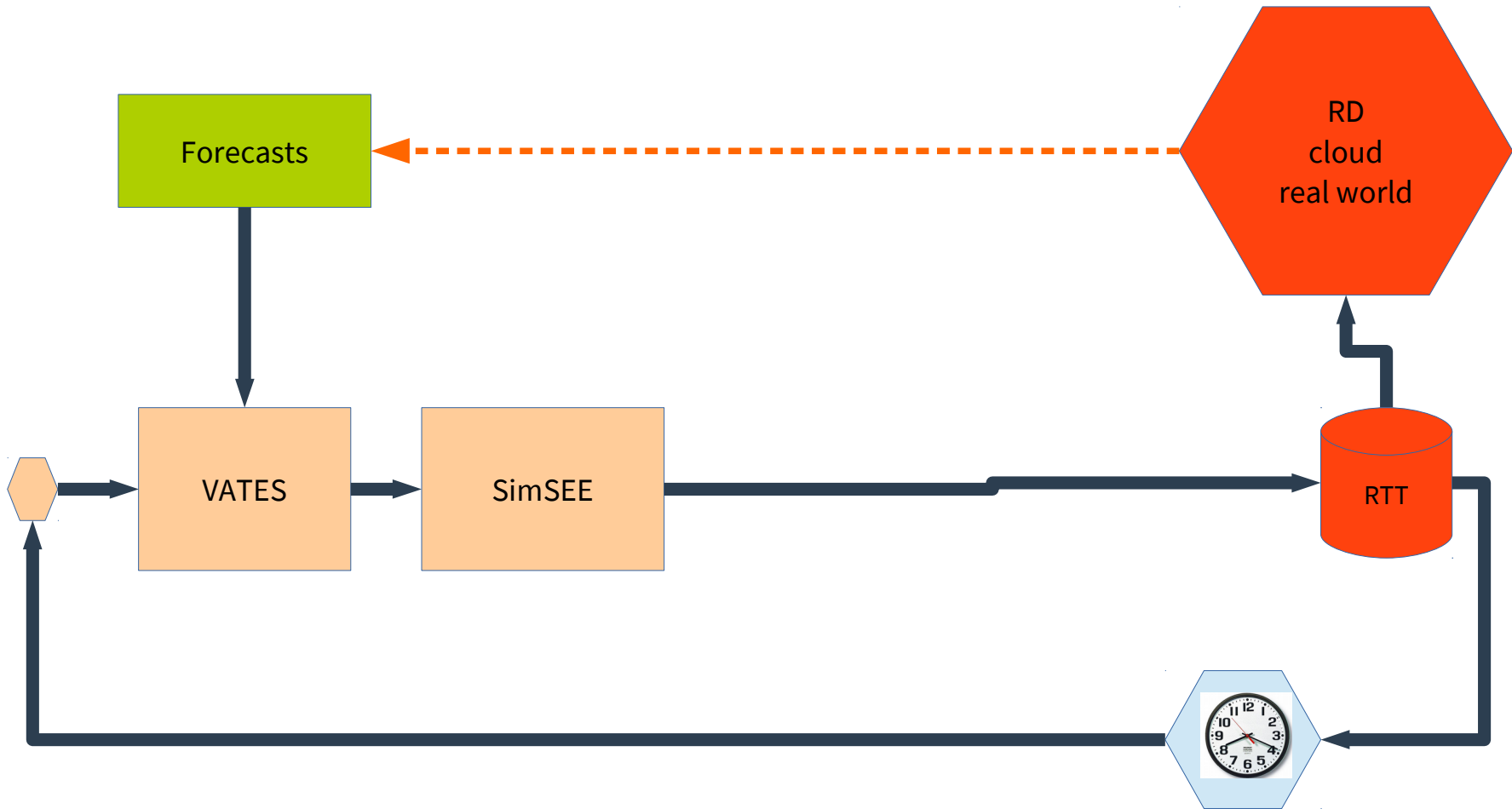


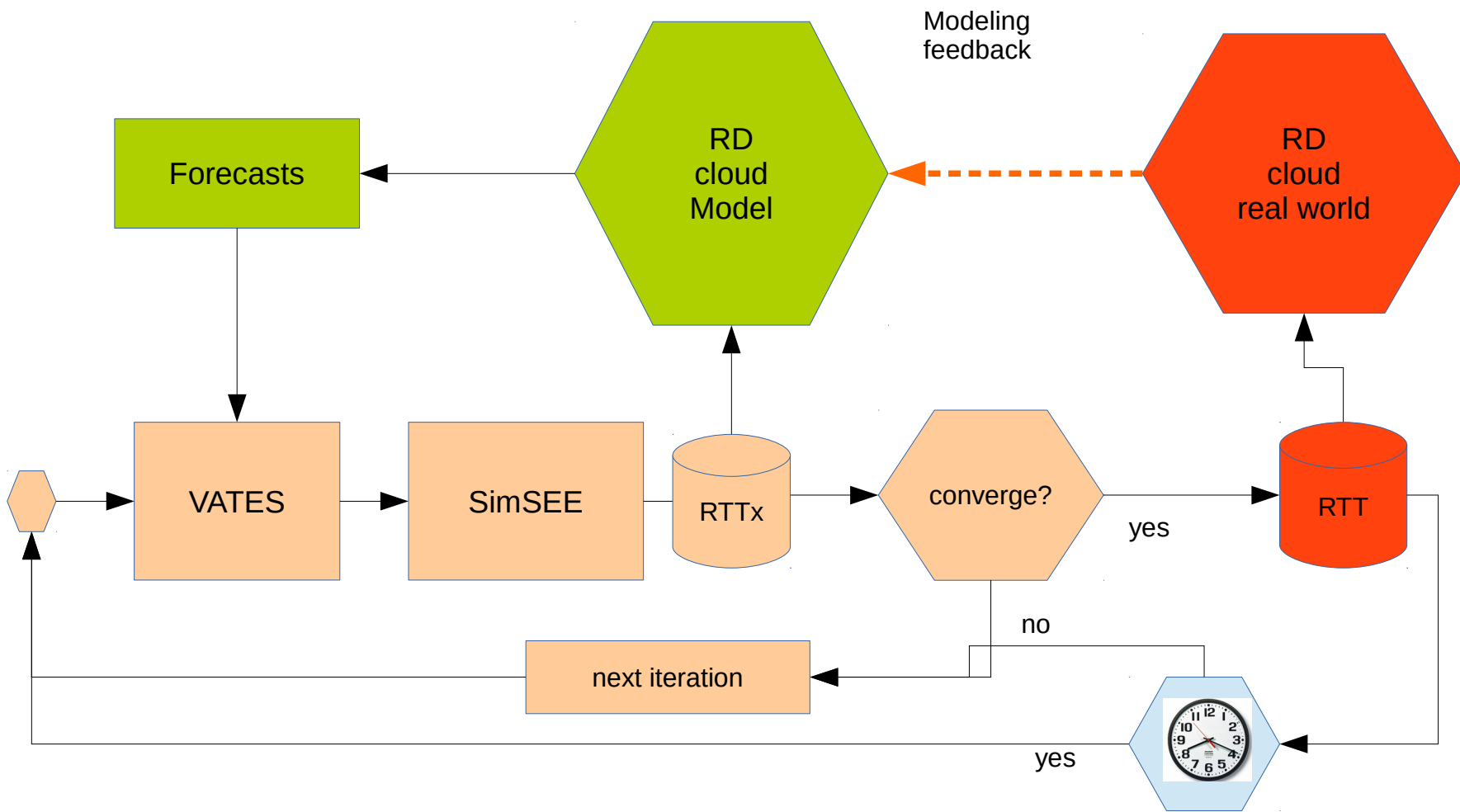
Hourly marginal cost at  
each Node of the grid for  
the next 72 hours.





# Closing the loop.





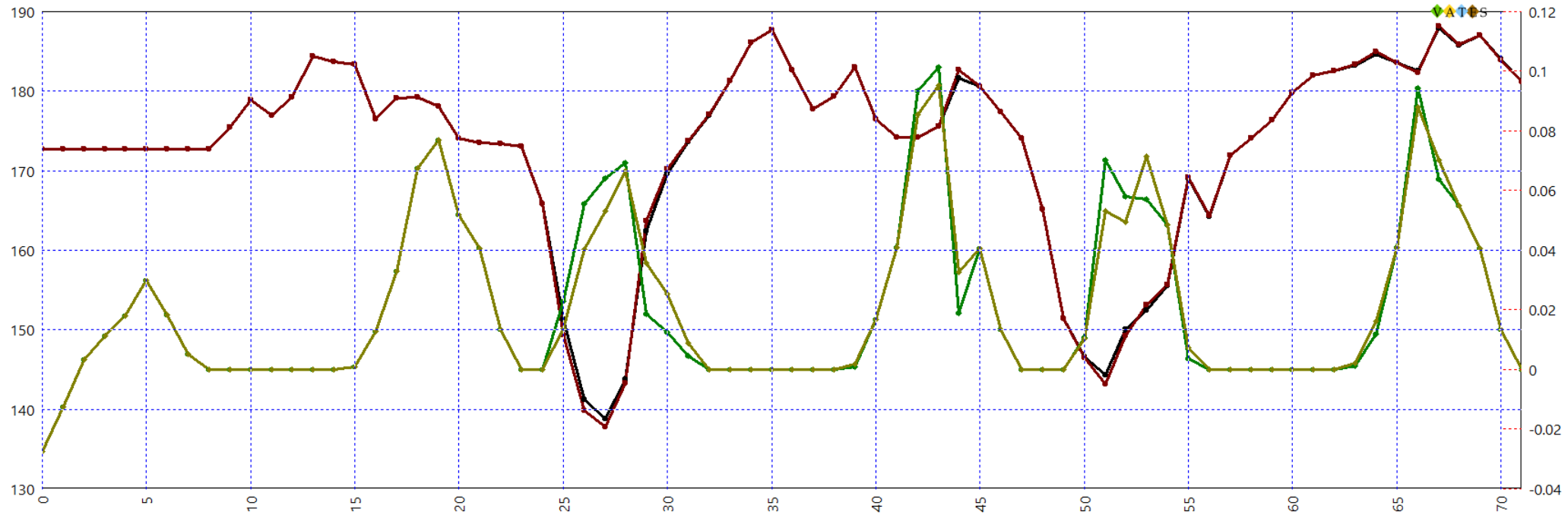
# Avoiding oscillations

Model of the cloud of RD with self-learning mechanism.

The distributed controllers ask for the tariff forecast no more than one time every hour.

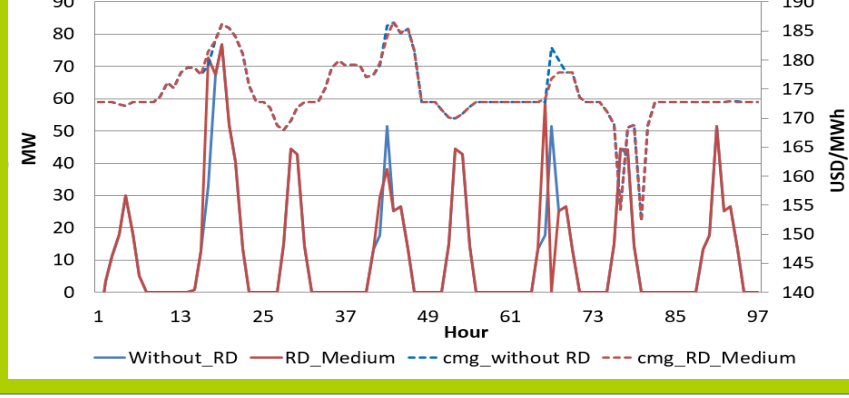
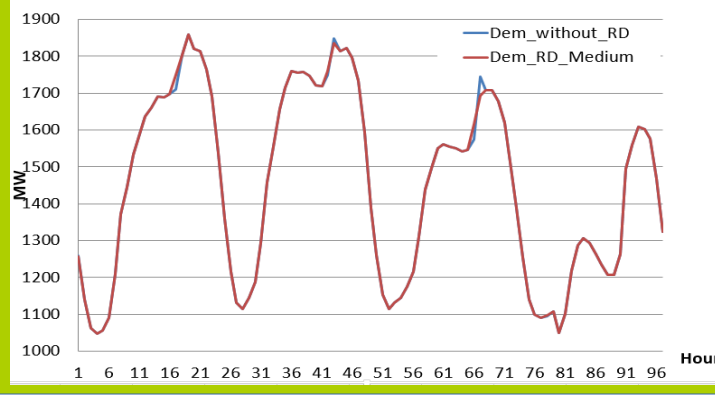
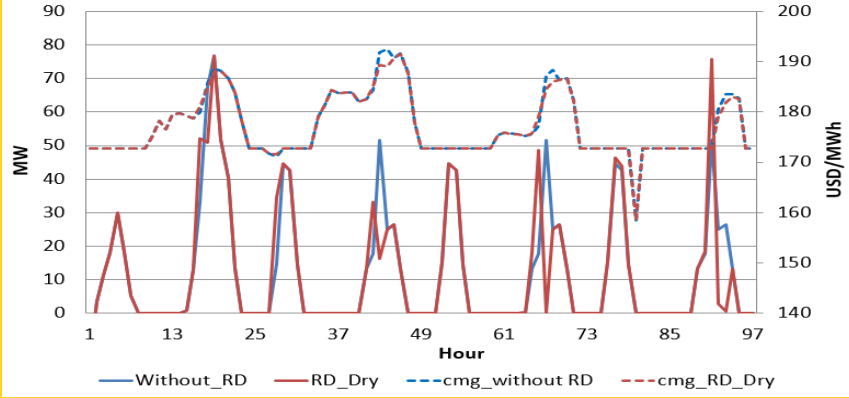
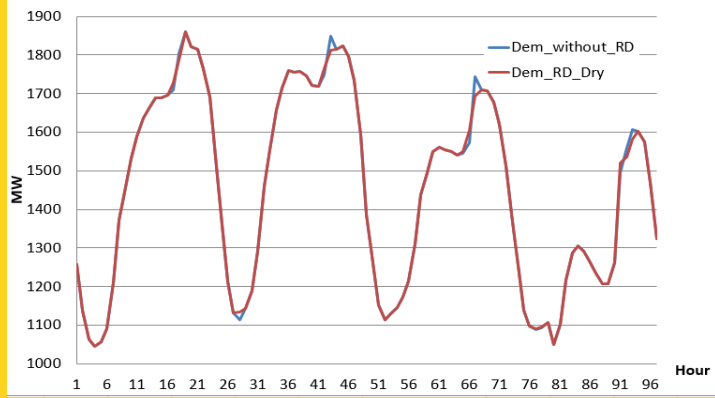
The best forecast is given any time.



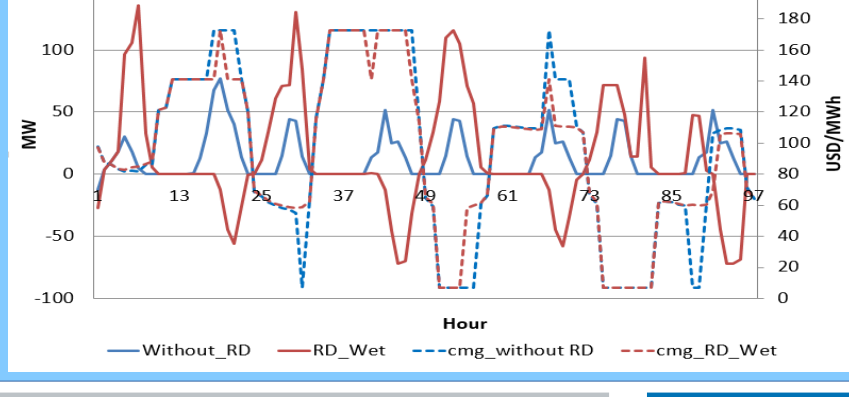
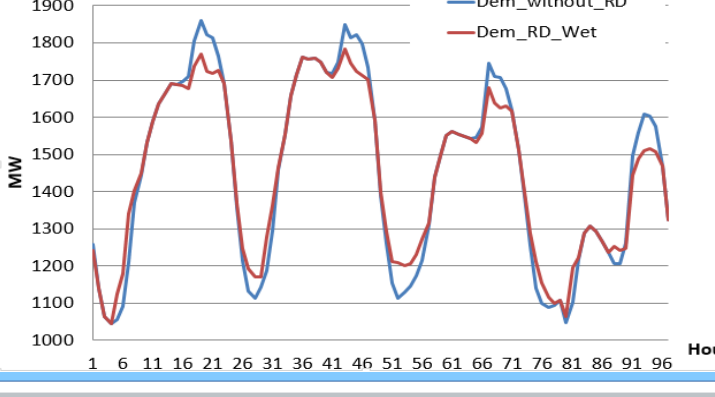




# Dray



# Medium



# Wet



We must be agile to keep the train  
... and not get on the wrong.



Thanks a lot for your time!

