



Demand Response Application in Europe Complementary/Competitive Character with Storage Technologies

Cortez Juan Jose¹, Bidaud Adrien², Mima Silvana¹, Mantulet Gabin², and Stolyarova Elena²

¹ Grenoble Applied Economy Laboratory, Grenoble

² Laboratoire de Physique Subatomique, LPSC/IN2P3/CNRS, UJF, INPG, Grenoble adrien.bidaud@grenoble-inp.fr

Grenoble



Grenoble : **One of the most innovative cities in the world**, cradle of French hydro/electrical/paper engineering

« Triptyque Grenoblois » = **World class research environment** (eg HighFlux Reactor has one of the highest thermal neutron flux worldwide)

+ diversified High Tech industries (RollsRoyce/Schneider Electric/StMicro/GE Hydro/...)

+ Education (**60 000 students** in a 500 000 h metropolitan area)

Plan

Introduction

1/ Electricity markets

« Merit Order »

2/ Flexibility Options Modeling

3/ Sensitivity studies option

4/ Conclusions

Plan

Introduction

1/ Electricity markets

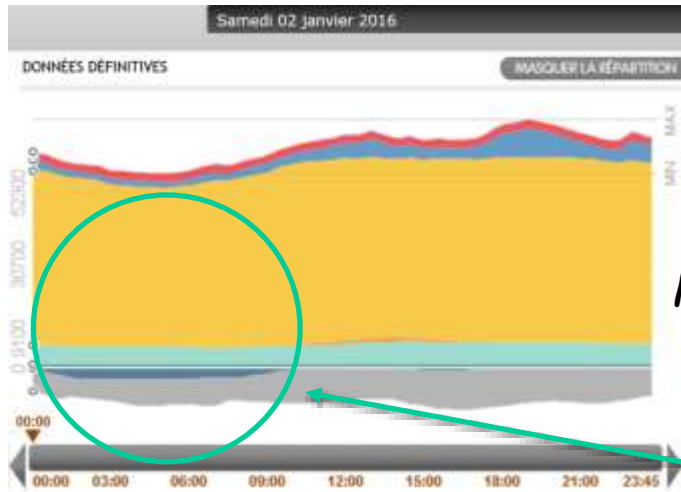
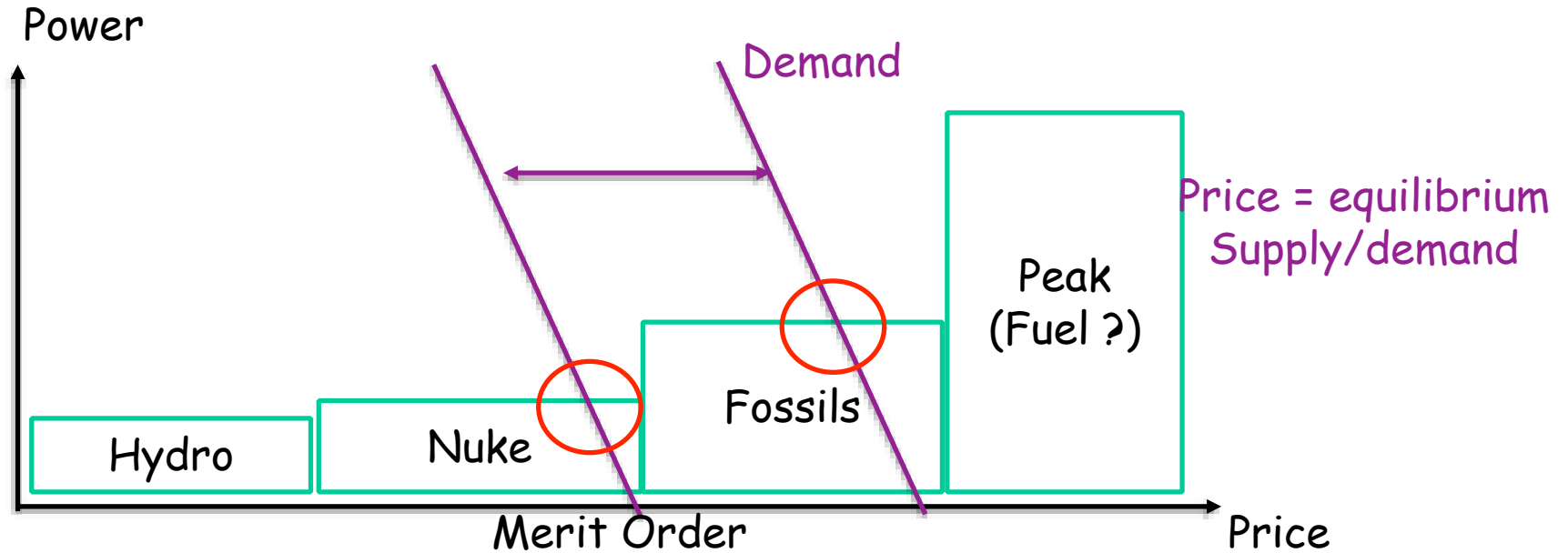
« Merit Order »

2/ Flexibility Options Modeling

3/ Sensitivity studies option

4/ Conclusions

« spot » price fixing

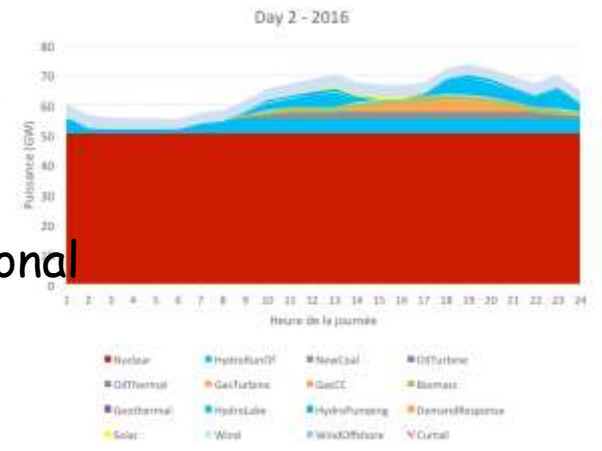


Real

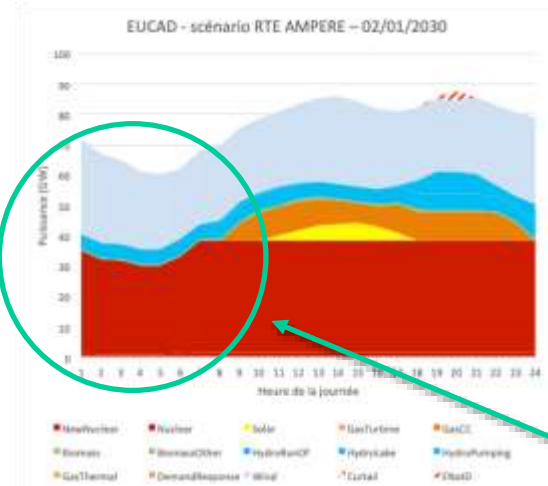
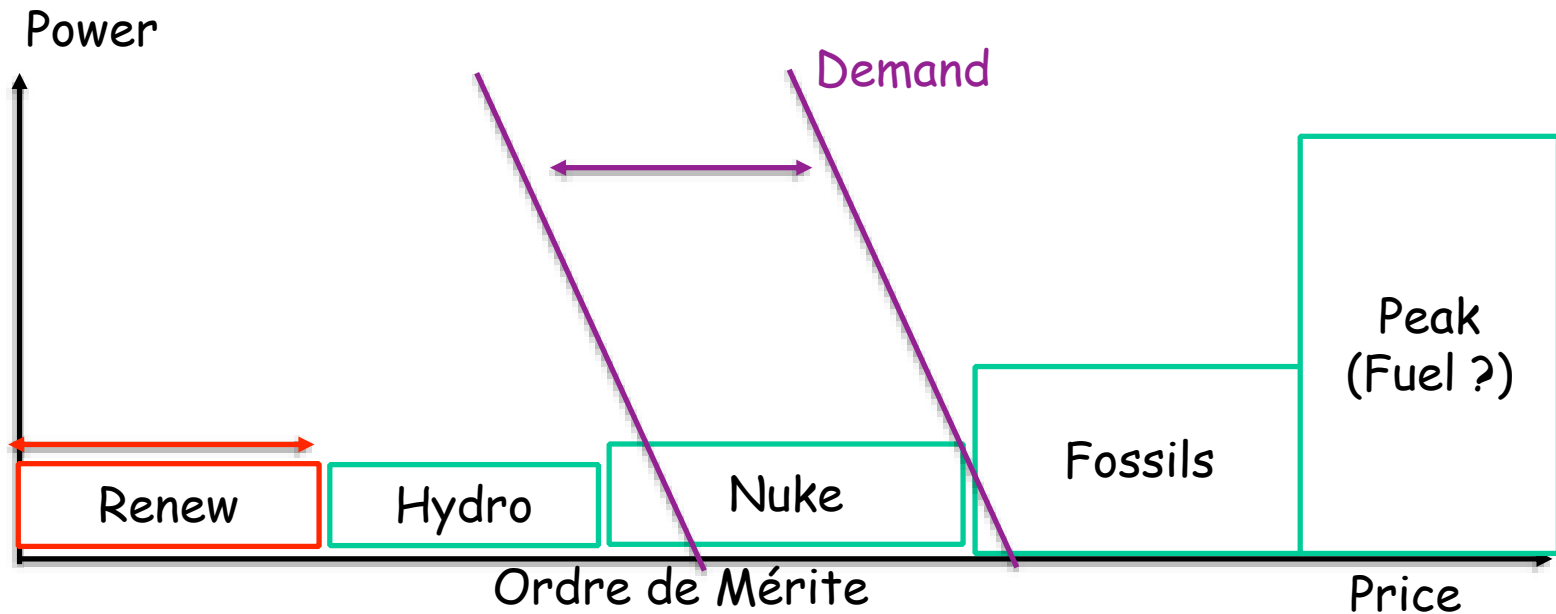
Simulation =

Minimising daily operational costs in Europe

By using storage ?



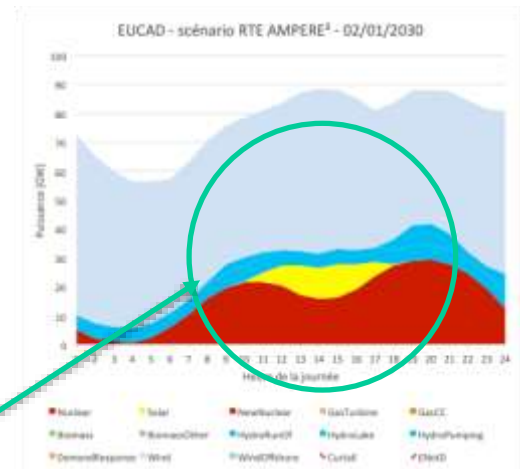
With Variable Renewables



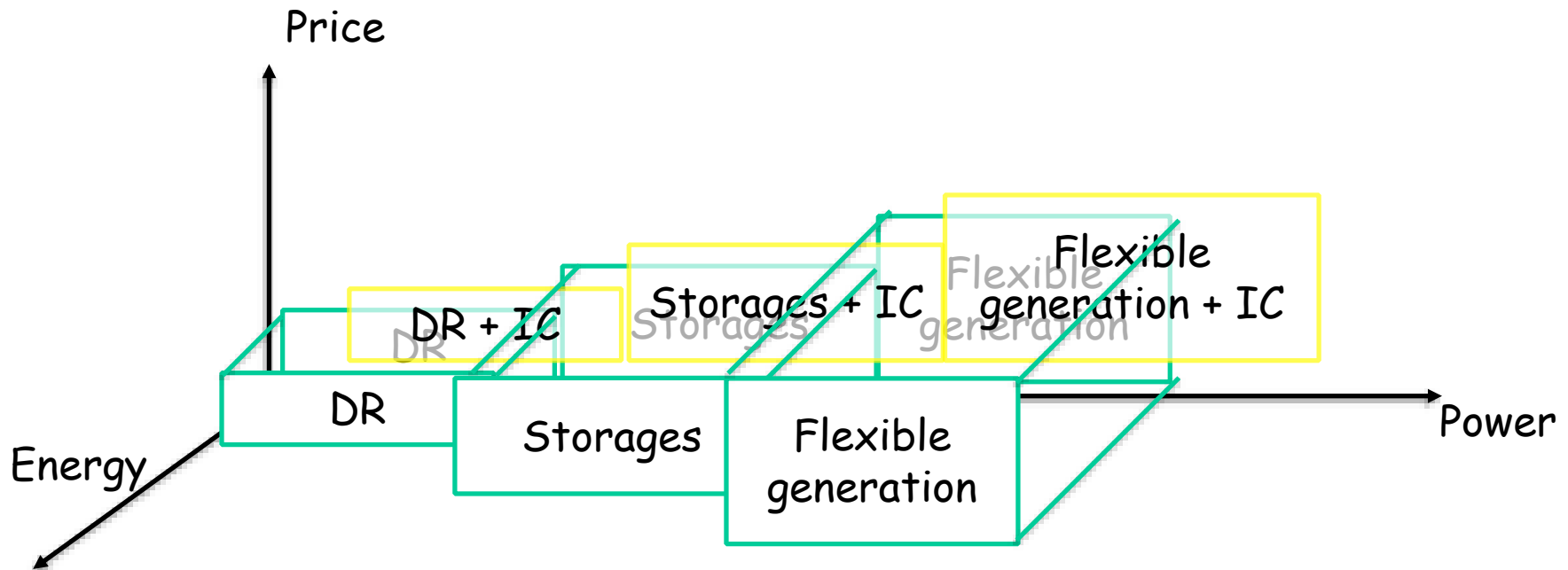
France 2030

Renewable *2

Dispatchable flexibility



Can we define a Merit Order for Flexibility Options ?

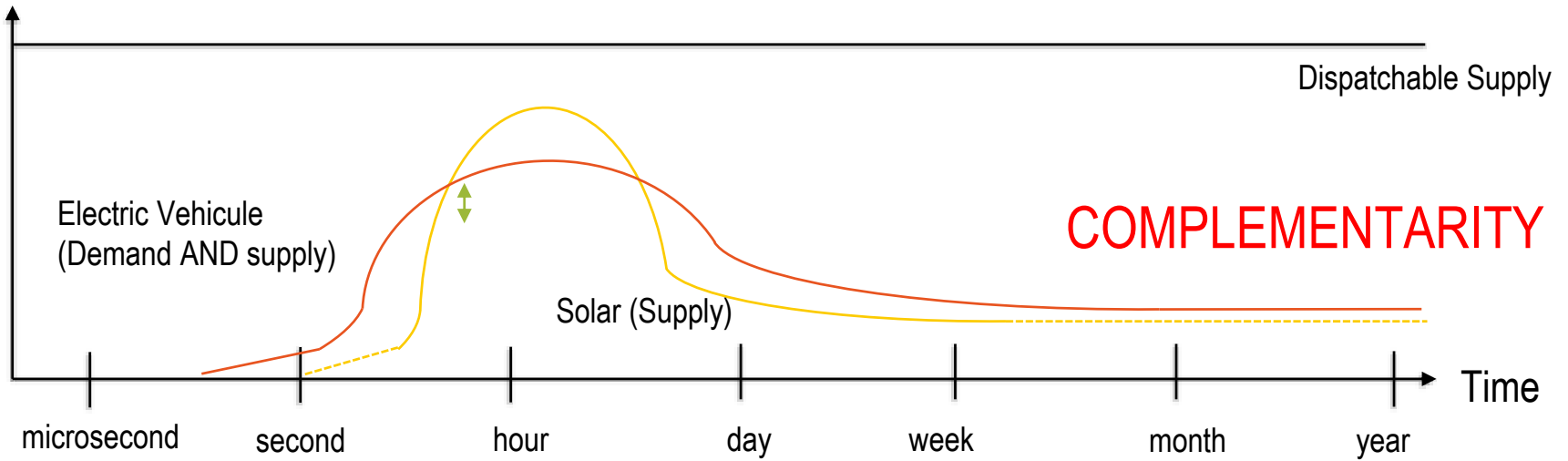


BUT

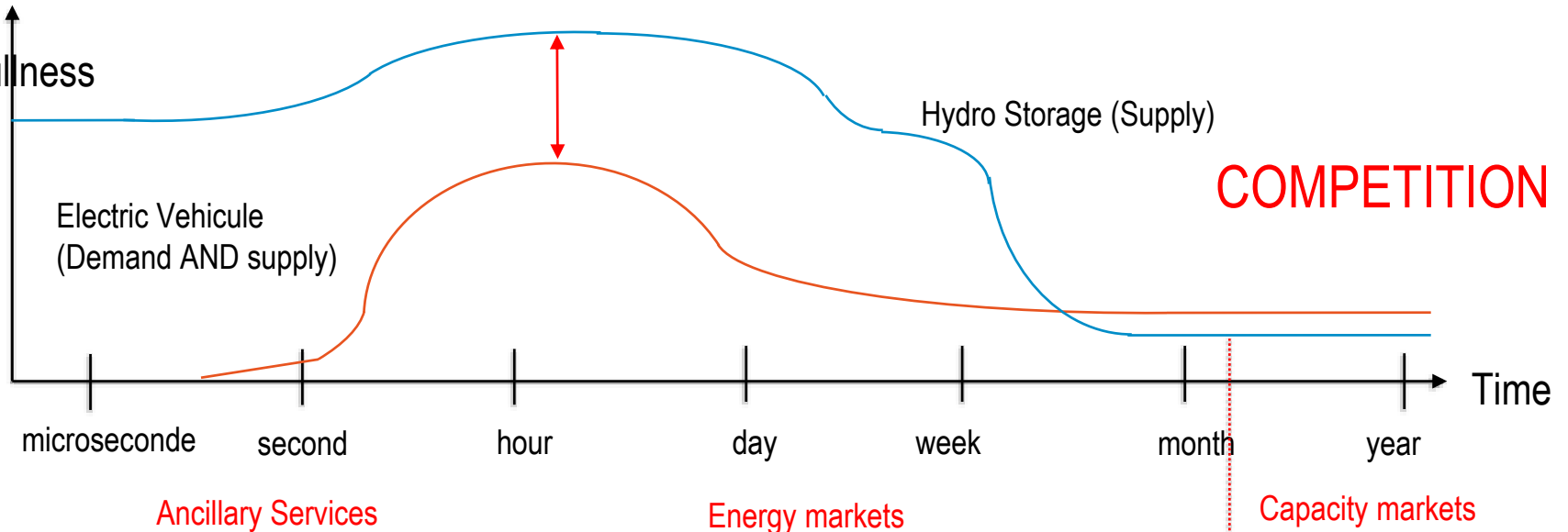
Time constraints (Demand cannot be postponed forever)
Energy limits (limited storages)
Difference in Efficiencies
=> Fascinating open question !

Complementarity or Competition ? Domino effect

Usefulness



Usefulness



Plan

Introduction

1/ Electricity markets

« Merit Order »

2/ Flexibility Options Modeling

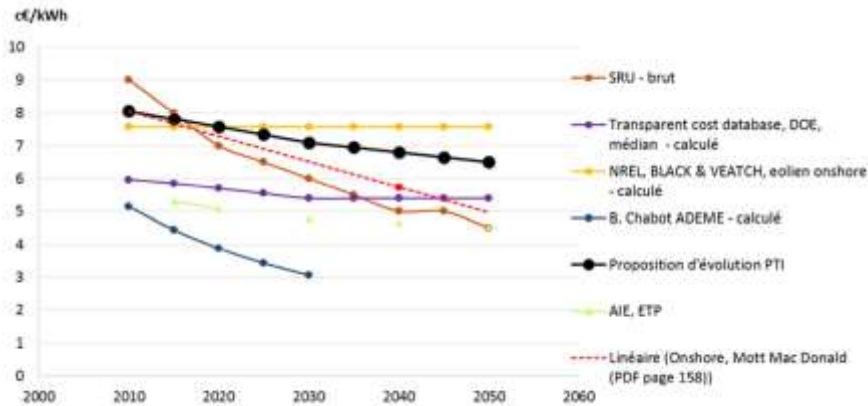
3/ Sensitivity studies option

4/ Conclusions

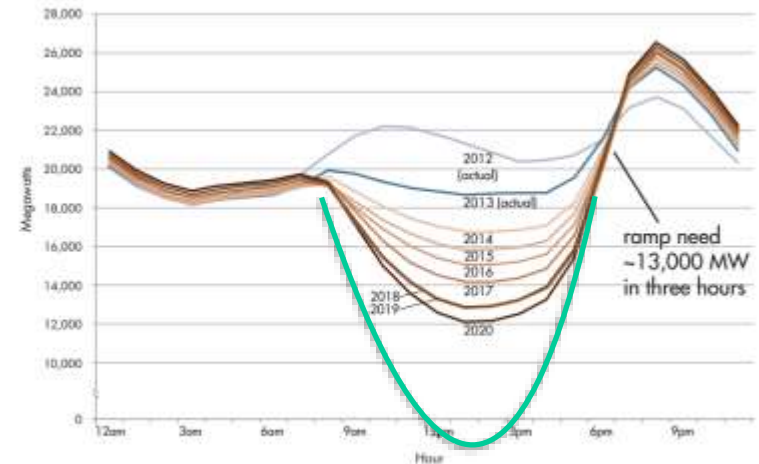
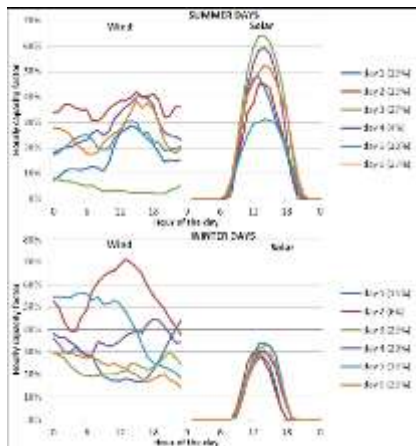
How high can the variable renewable go ?

California « duck Curve »

Decarbonation + Costs decrease =
+ Renewable contribution ?



Wind and Solar Flexibility



Market Share Ceiling Theorem (?) @A. Bidaud
% Market Share < Load Factor

Demo : Demand < MaxP => Curtailment SO...

$P_{sold} < P_{Max} < Demand$, which after integrating over a year and divide by annual demand :

% Market Share < Load Factor

Ex France nuclear : $(75+10\%export) < 75 \%$

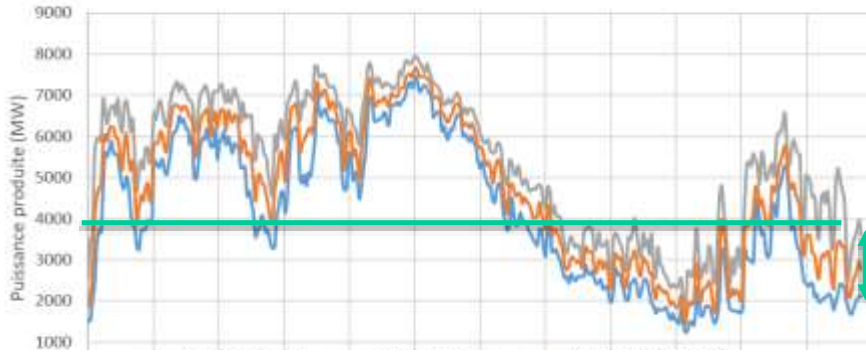
CQFD

NEW flexibility needs

+ « Flatten the duck » (Storage) or « Fatten the duck » (DSM) ?

Hydro Models

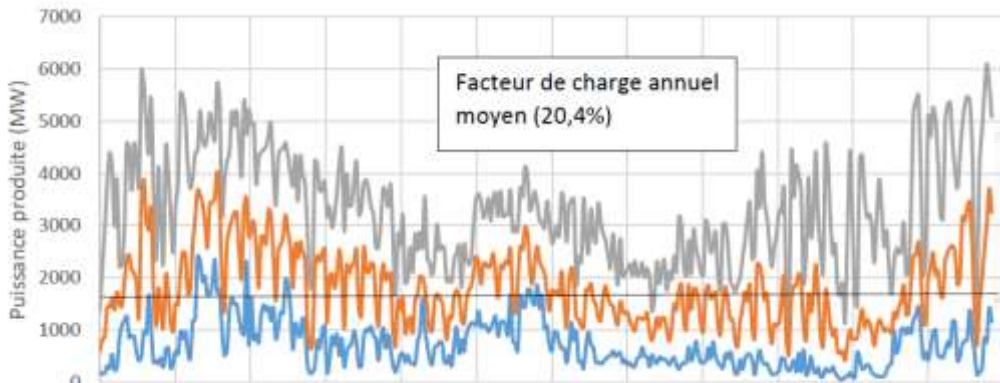
Fil de l'eau + éclusé



« Must-run »

Assumed Flat ! => Wrong because of High seasonal variability !

Lac



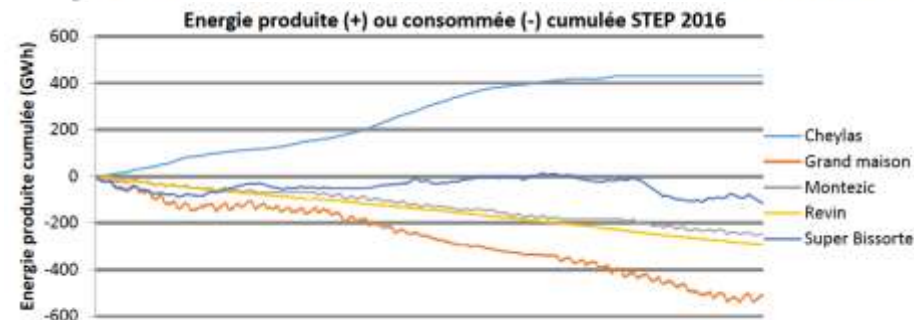
« Lakes »

« Daily stock » assumed

Difficulties =

Seasonal variability

Other water uses (irrigation, tourism, flood control, minimum flows...)

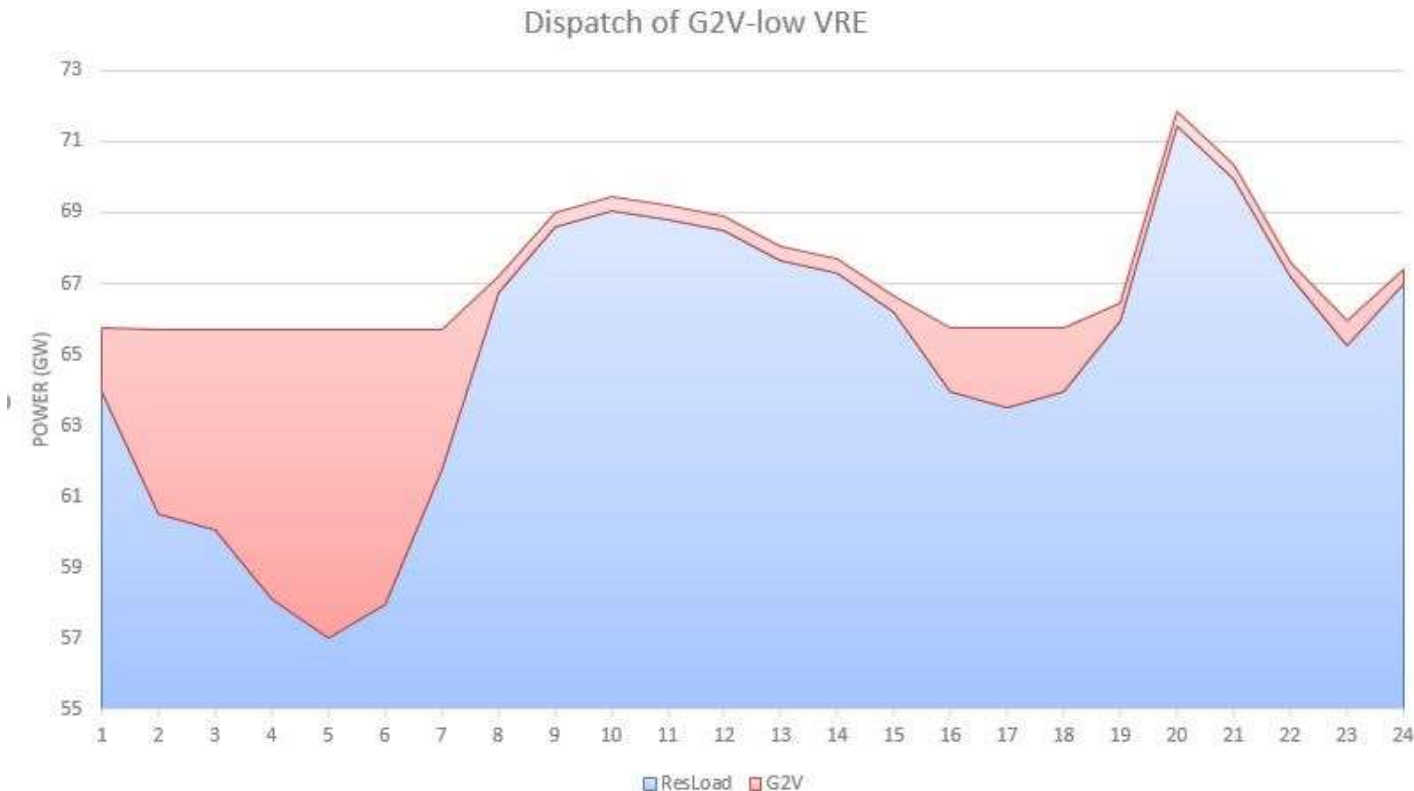


« Pumped energy Storages »

Unknown efficiency!

May receive inflows !

Smart charging of EV



Filling the gaps (fatten the duck) in residual demand

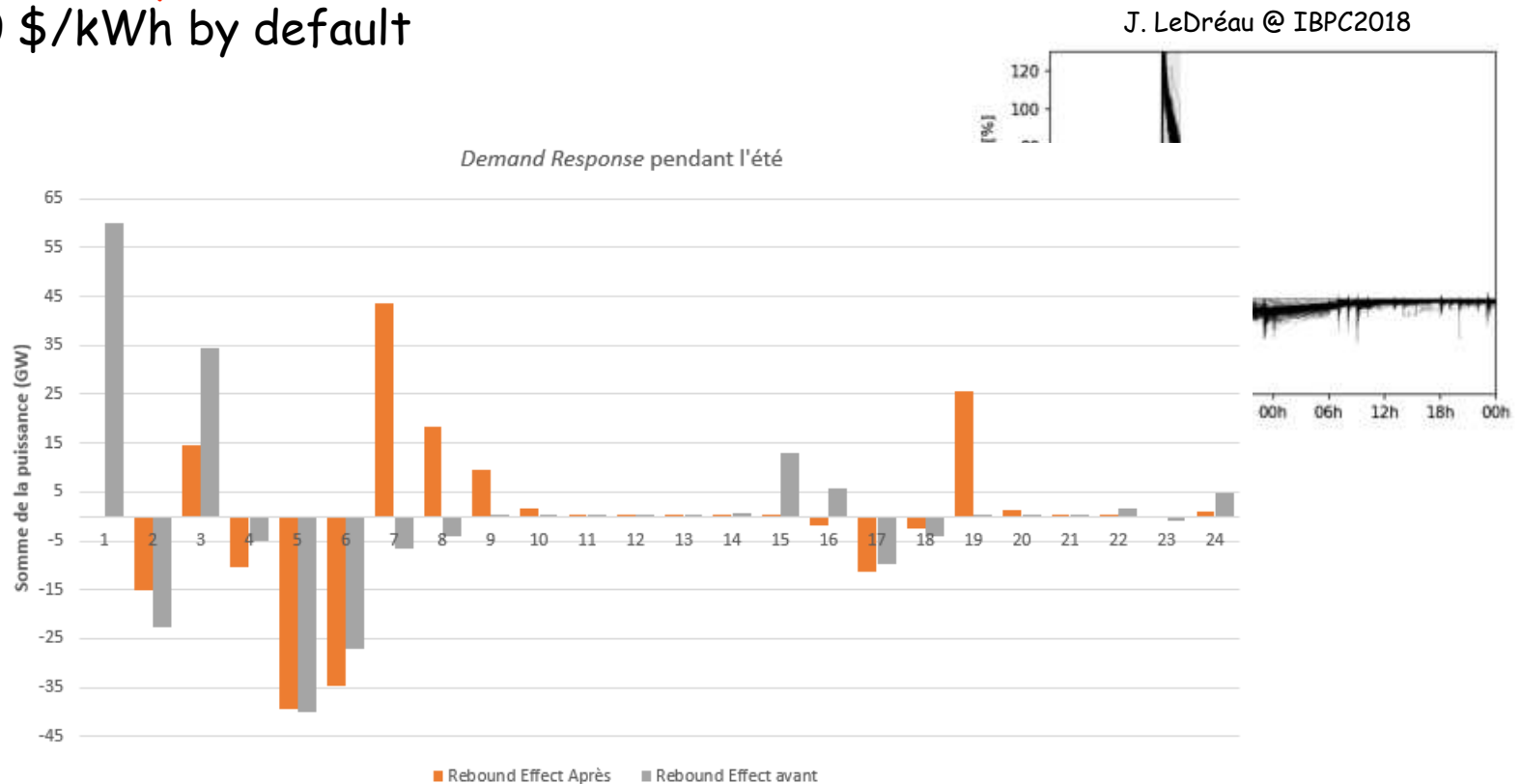
Probably a HUGE potential

Vehicules 2 Grid (V2G) => lack of data, probably limited ? (low cycle efficiency = h

Demand Side Management

Assumptions

1. Available power = (Small) % of demand
2. Available energy = 1h / day
3. Rebound effect = Part (1/3 ?) of displaced energy moved by 1h
4. 100% efficiency
5. Cost = 0 \$/kWh by default



Plan

Introduction

1/ Electricity markets

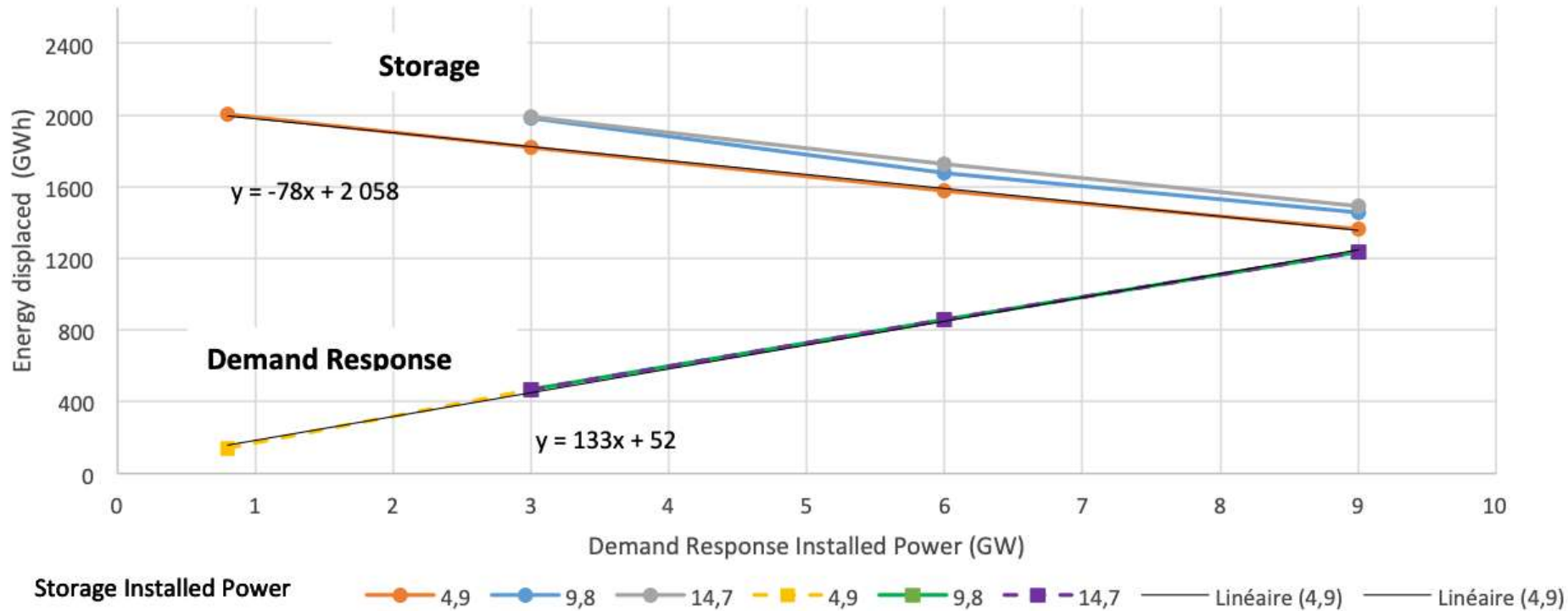
« Merit Order »

2/ Flexibility Options Modeling

3/ Sensitivity studies option

4/ Conclusions

Sensitivity to Installed power

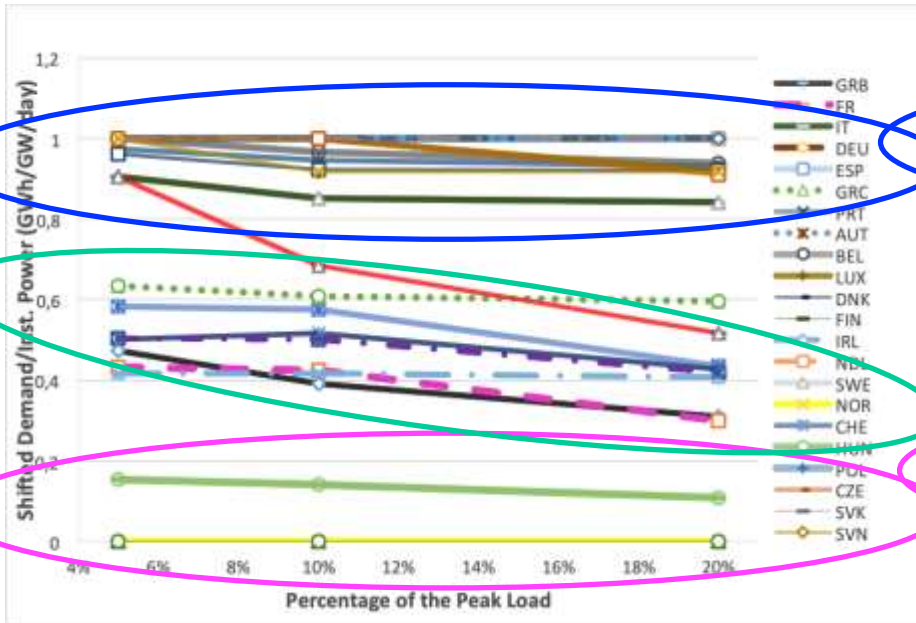


DR use increases linearly with installed power
 Storage use decreases but not as fast as DR use increases
 => no frontal competition (Rebound effect ?)

Demand side Management

« close » future

Lots of VRE, less dispatch able

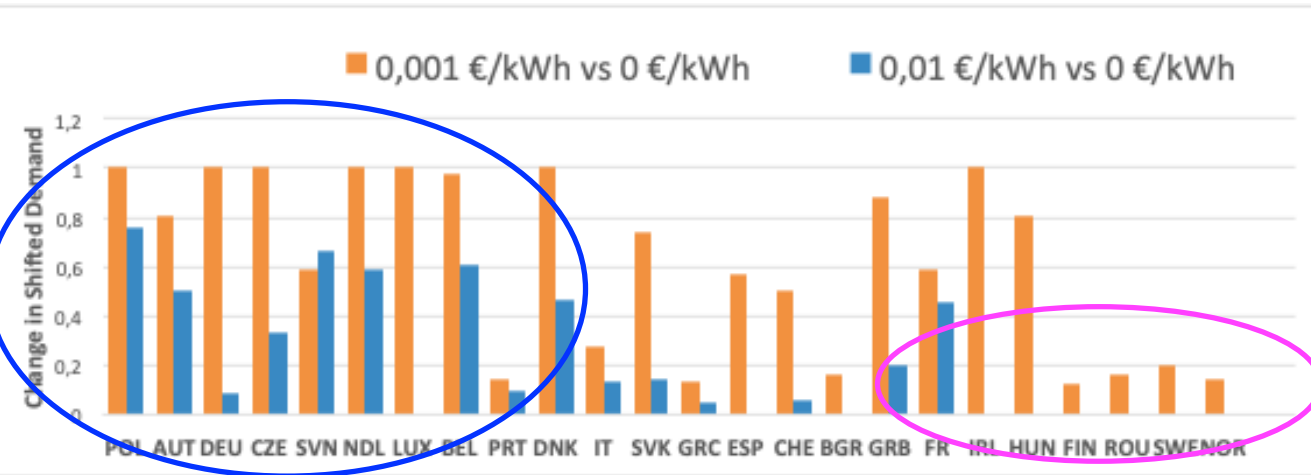


Different behavior
 (Different uses
 Different slopes)
 = Competition with other flexibility options ??

Different behaviors
 (less Different uses
 Constant slopes)
 = Competition with other flexibility options ?
 Bigger potential for DSM

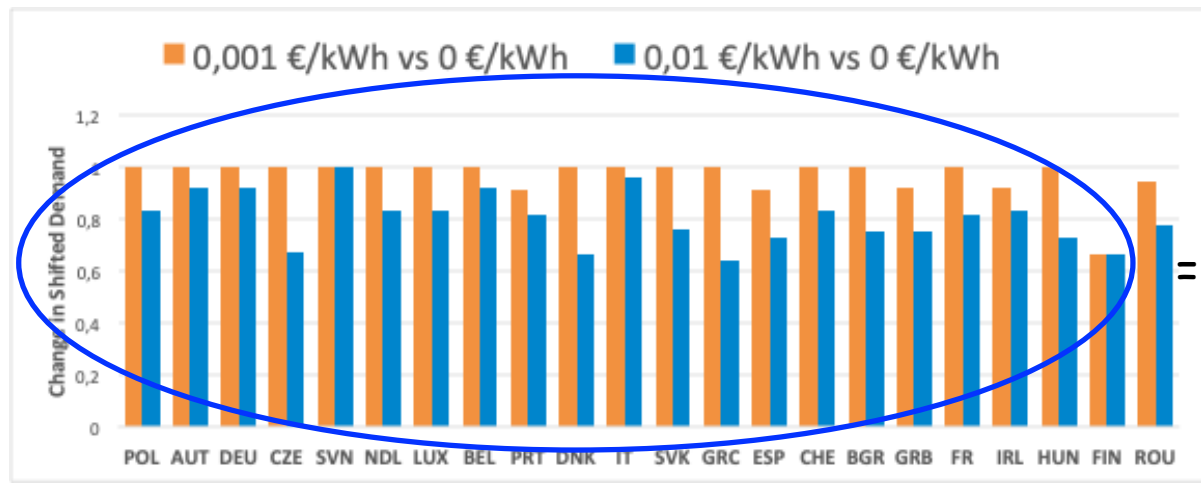
Price Elasticities

« Close » future



Different elasticities
 (Different uses
 Different slopes)
 = Competition with other flexibility options ??

High VRE, low dispatchable power



LESS Different elasticities
 (less Different uses
 Constant slopes)
 = Competition with other flexibility options ?
 Bigger potential for DSM

CONCLUSIONS

Complementarity or Competition ?

Paradoxe of Demand Side management : Small available Power and displaced energy BUT high and growing rate of use !

Competitions (dispatchables/storages/DemandSideManagement) only incomplete => Dependant on energy mix !

Can we define a Merit Order for Flexibility Options ?

Strong dependance on energy mix / market design

Costs, customer behavior, technical limits, are unknown...

=> Difficult !

To go further :

What the creaming curve look like ? ? => « smart grids » / « prosumers » => need for interdisciplinarity !

How will evolve « Power 2 X » (Vehicules, H2, heat...) ?

Impact of interconnections / Local congestions => need for multi scale models

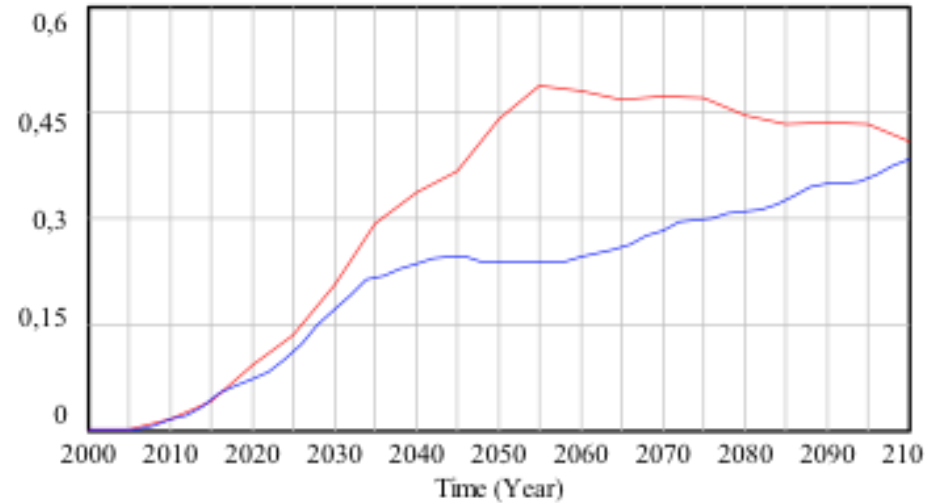
Multiscale time variability (second -> yearS) => need for stochastic modeling

Interested in Setting up a common Research Project ?

Merci de votre attention !

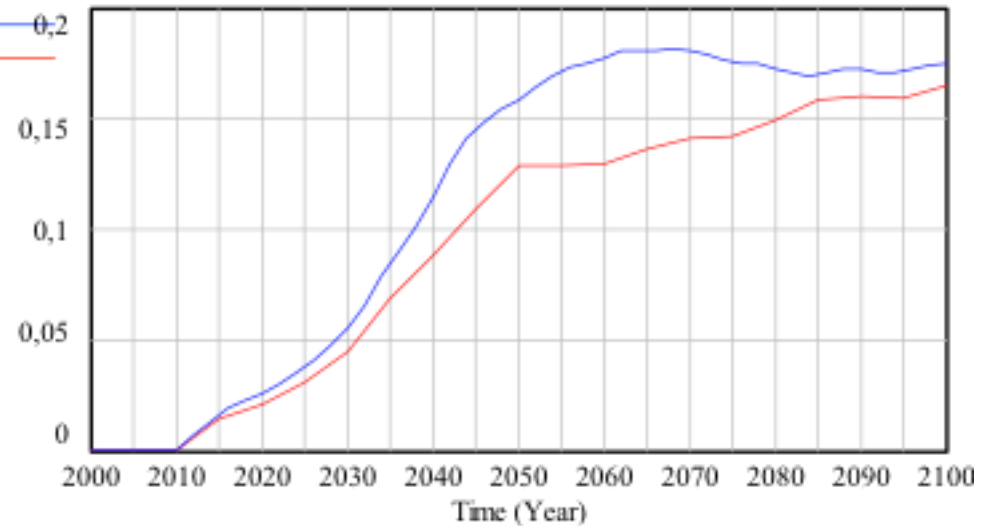
Availability ceiling

SHEPWIN



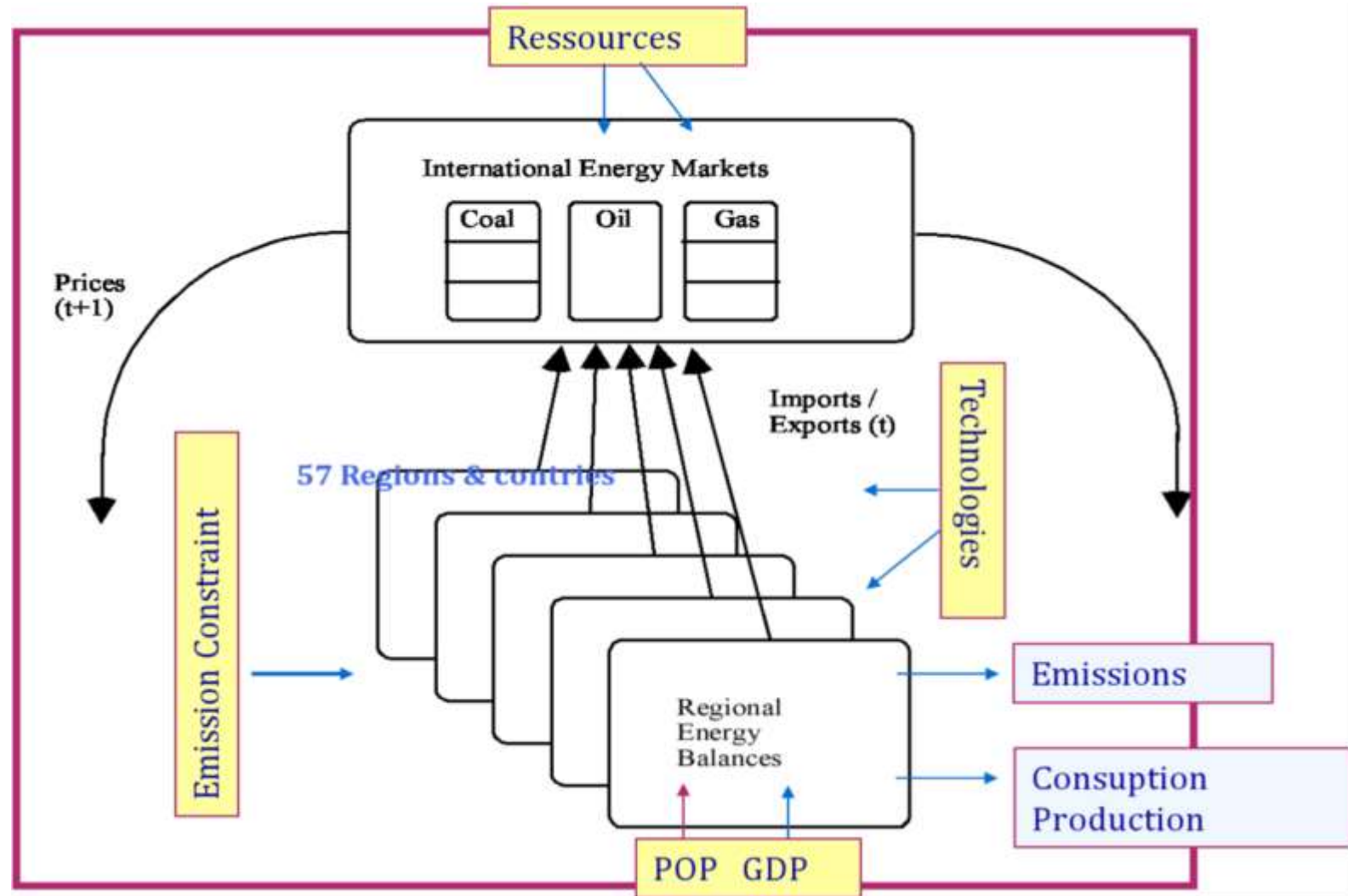
SHEPWIN[FRA] : CP2016 — 0,2
SHEPWIN[FRA] : CP10fev — 0,2

SHEPSOL



SHEPSOL[FRA] : CP2016 — 0,2
SHEPSOL[FRA] : CP10fev — 0,2

POLES : « Prospective Outlook on Long Term Energy System » partial equilibrium model of world Energy System



2 Nuclear technologies simulated : Thermal Neutron Reactors using natural U and Fast Neutron Breeders using recycled TR used fuels as startup inventories

EUCAD

European Commitment And Dispatch

Minimize the **daily marginal cost**

Integrate a **very high cost for « Energy Non Distributed »**

Include some **« ramping cost »** + Minimal on/off time => very limited impacts

Model some storage/dispatchable prod or consumption/DR/interconnections

Need data/models for **daily demand + renewable production profiles**

France

A few full past years available

No interconnections

Europe

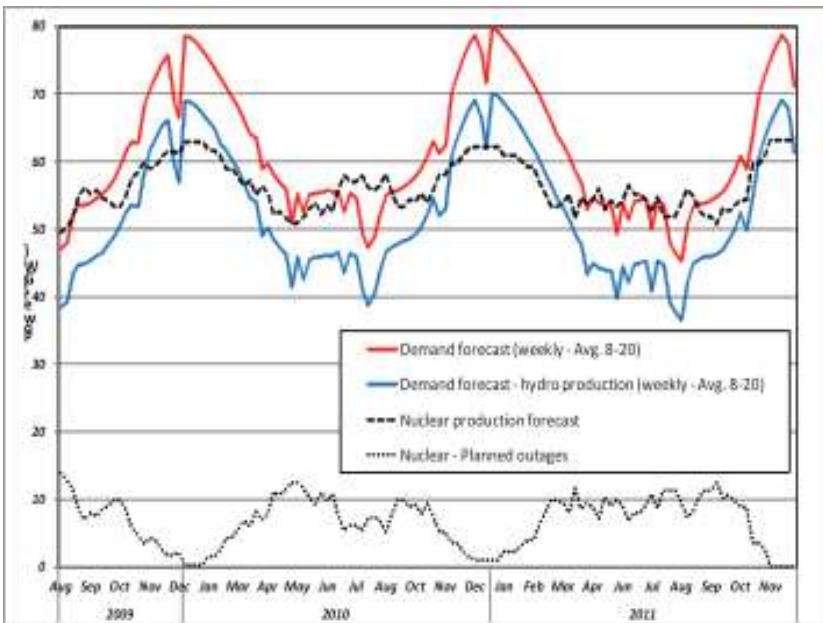
A few full past years available

One « point per country » (option = France Regions)

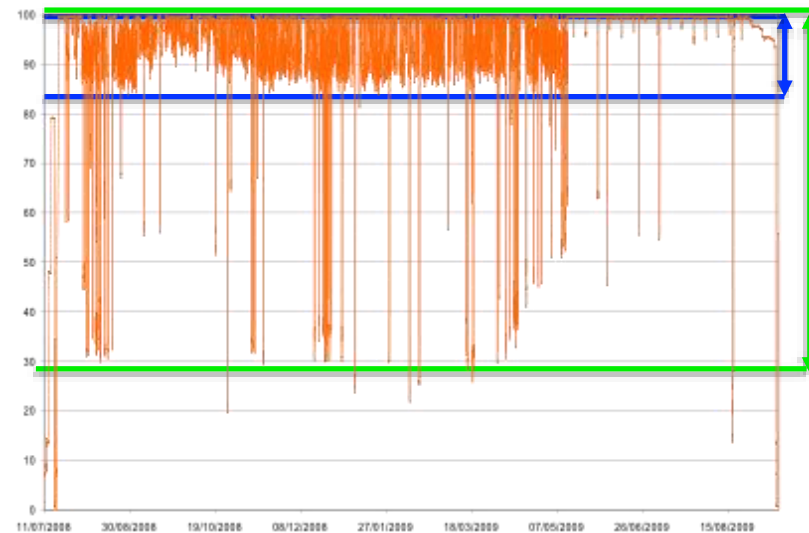
Interconnections

option = model of congestions for transport / distribution

Nuclear Flexibility



Seasonal nuclear availability



Production history of 1 reactor

OECD NEA Nuclear and Renewables