What future for energy storage in electrical systems?

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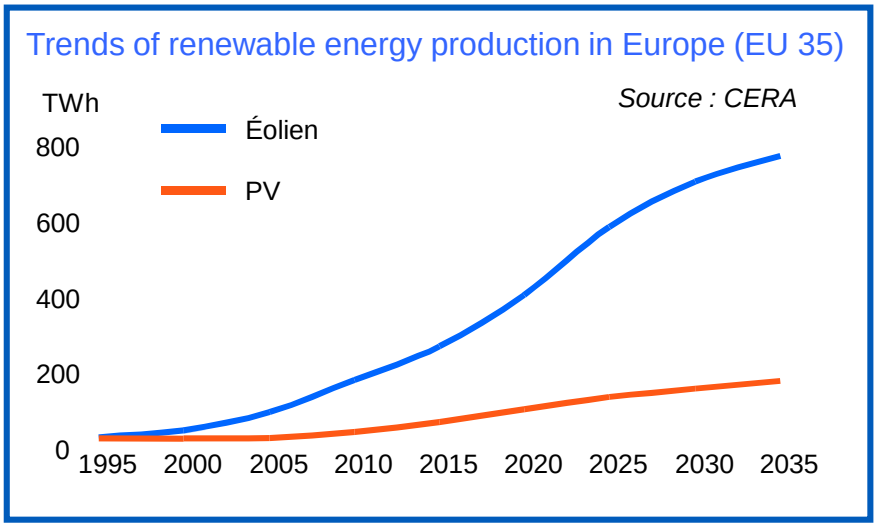
CHANGER L'ÉNERGIE ENSEMBLE

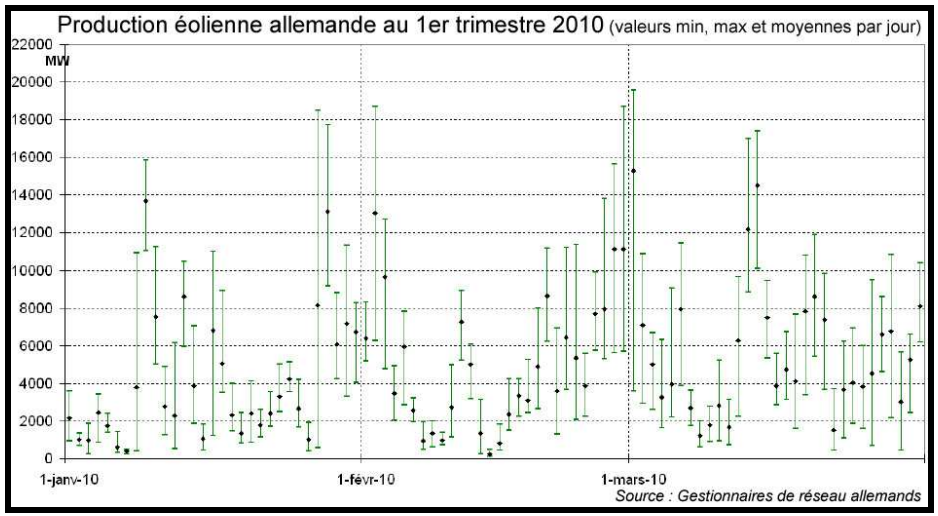
Summary

1. Storage needs for future electric networks
2. Technologies
3. International context

Flexibility is a key point for the electrical networks

- Electrical systems must have source of flexibility to guarantee at every moment the equilibrium Generation = Consumption





Political targets to decarbonise energy and development of renewable and intermittent production will increase the need for flexibility

Storage is one of the solutions to provide this flexibility

- Different solutions also provide flexibility to the system:
  - Modulation of conventional generation
  - Intermittent production management
  - Network developments and interconnections
  - Demand response
- In Europe and until 2020, +135GW of renewable and +17GW PSP will be connected to the network

Centralized storage will remain one of the major option to cope with flexibility at the scale of the interconnected European power system

Storage can provide many applications

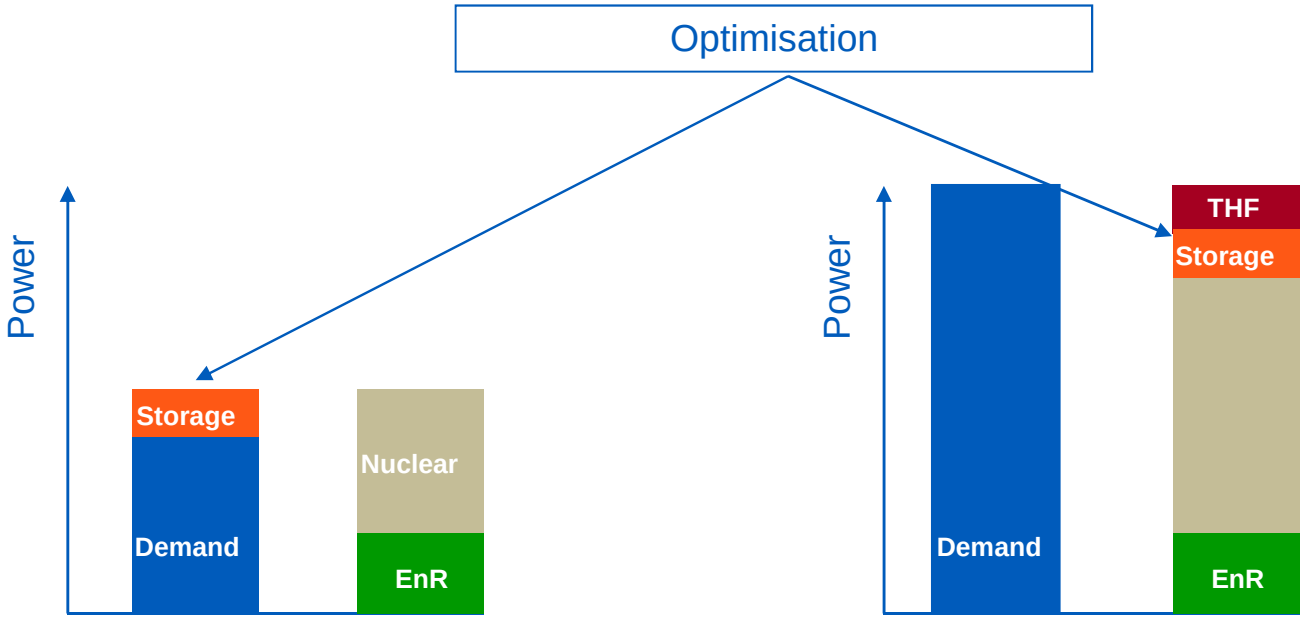
- Storage can be useful in many ways to the stakeholders of the electricity value chain

Transmission	Distribution	Generation	Retail & consumer
• Frequency control • Voltage control • Losses minimization • Congestion relief • …	• Load leveling • Local voltage control • …	• Balancing • Ancillary services • Time-shifting • Firming RE • Black start • …	• Price arbitraging • Time-shifting • Peak shaving • “On-site” power quality • Forecast hedging • …

These applications will have to prove their economic values

Storage, a useful tool for market arbitrage

- Energy is stored during offpeak hours (night or weekend) and discharged during peak hours



Offpeak hours
(marginal nuclear)
Ex : Lundi 2 janv 2012 à 3h prix **- 5 €/MWh**

Peak hours
(marginal THF)
Ex : Lundi 2 janv 2012 à 18h prix **47 €/MWh**

Storage allows to

-reduce the needs of peaking capacity investments

-reduce the start and use of peaking production device and so reduce the Co2 emissions

-eanr revenues coming from the spread between peak hours and offpeak

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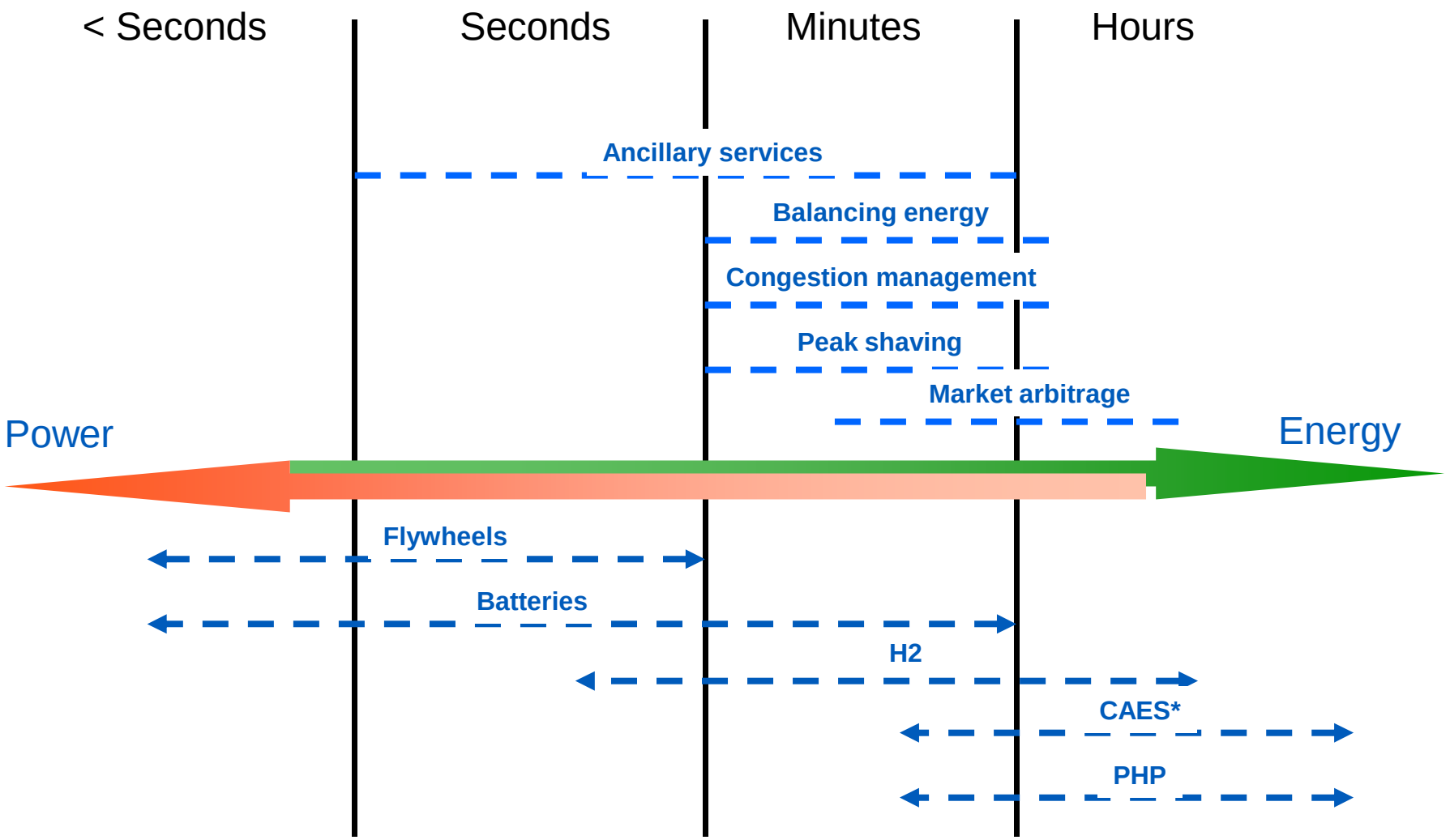
Storage technology : a distinction between power and energy



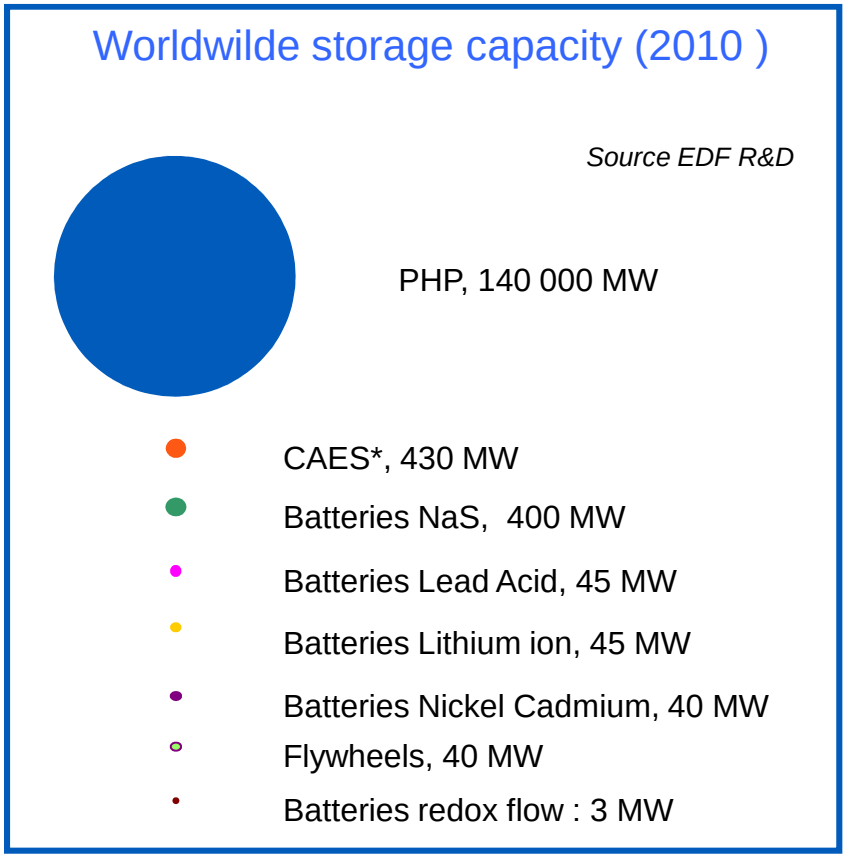
* CAES : Compressed Air Energy Storage

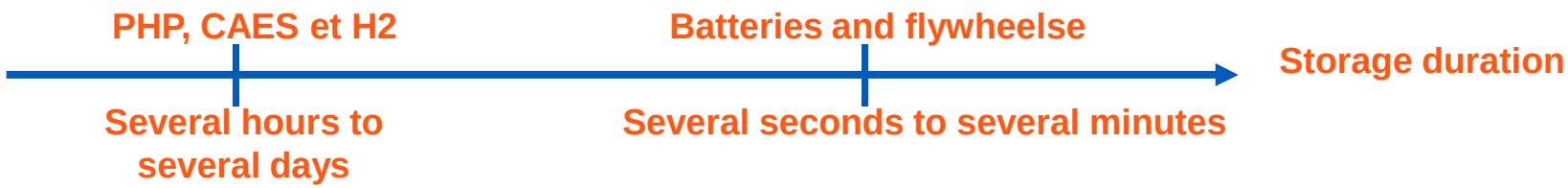
Source EDF R&D

Many storage technologies are available

- PHP, CAES and H2 are characterized by their ability to store energy over time (several hours)

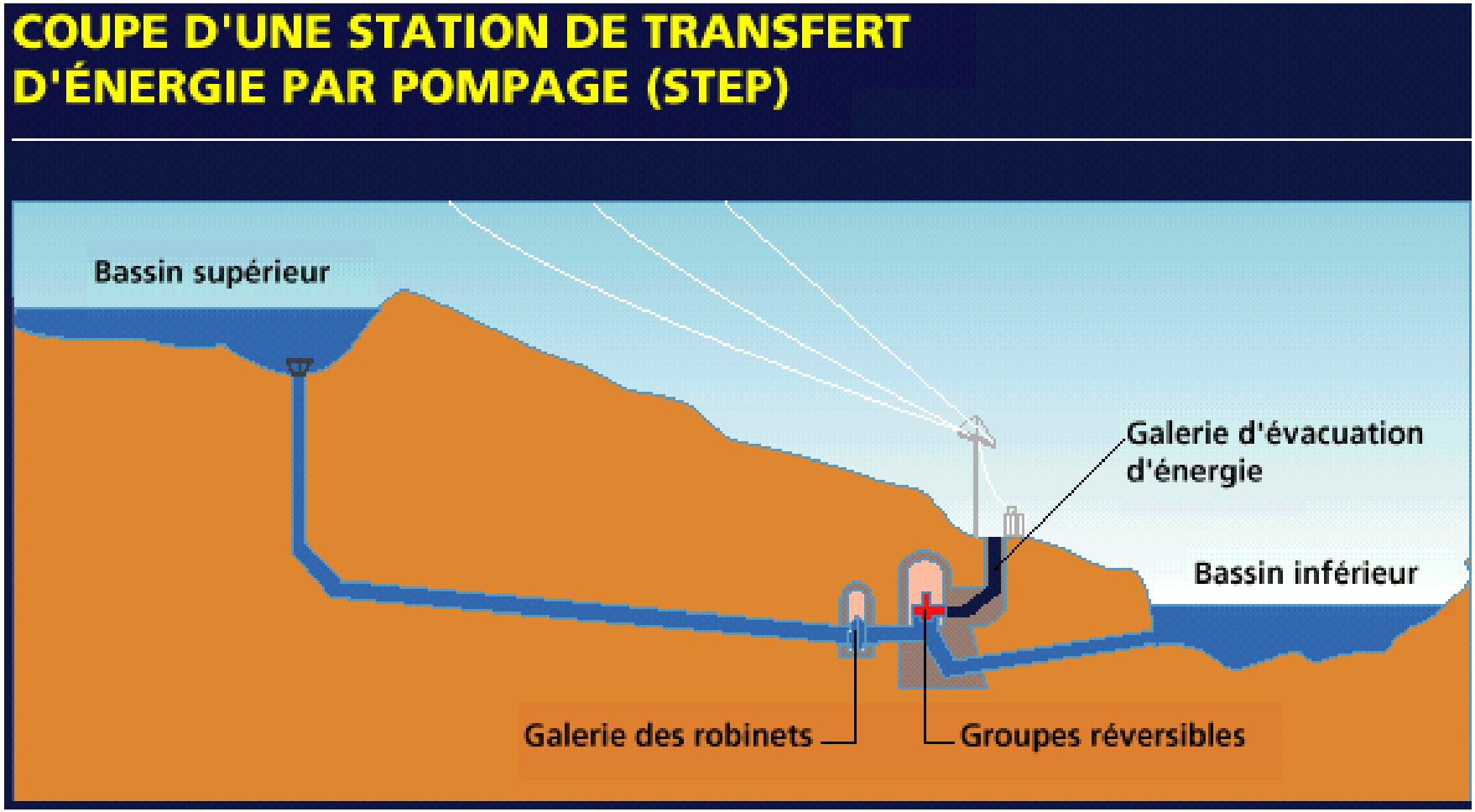
- Batteries, flywheels are characterized by their ability to deliver power very fast





CAES* Compressed Air Energy Storage

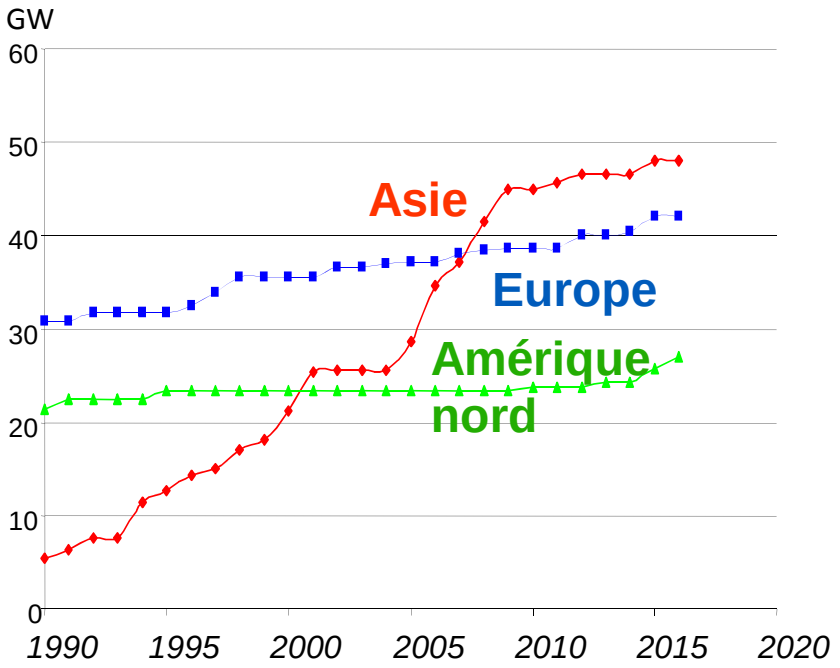
PHP concept


COUPE D'UNE STATION DE TRANSFERT
D'ÉNERGIE PAR POMPAGE (STEP)
Bassin supérieur
Galerie d'évacuation
d'énergie
Bassin inférieur
Galerie des robinets
Groupes réversibles

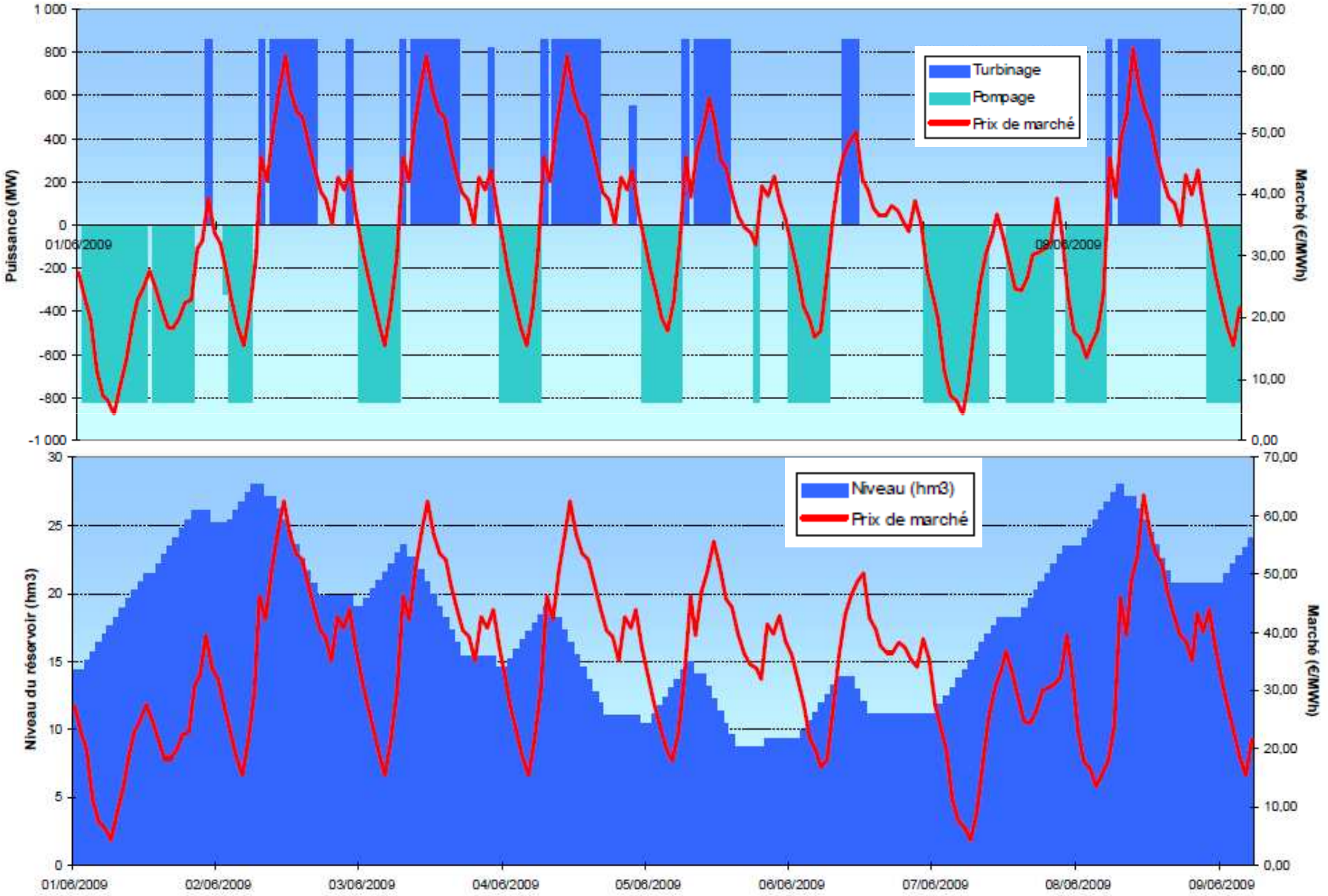
The current French PSP market and its worldwide Development growth

	Montézic MSI 1982	Revin MSI 1976	G.Maison MSI 1985	S.Bissorte MSI 1987	La Coche MSI 1977	Le Cheylas MSI 1979	Total
Puissance en turbine	910 MW	720 MW	1790 MW	730 MW	330 MW	460 MW	**4940 MW**
Puissance en pompage	870 MW	720 MW	1160 MW	630 MW	310 MW	480 MW	**4170 MW**
Nb de pompes	4	4	8	4	2	2	
Constante de temps	40 h	5 h	30 h	5 h	3h	6 h	
Productible gravitaire	STEP pure	STEP pure	216 GWh	250 GWh	426 GWh	670 GWh	

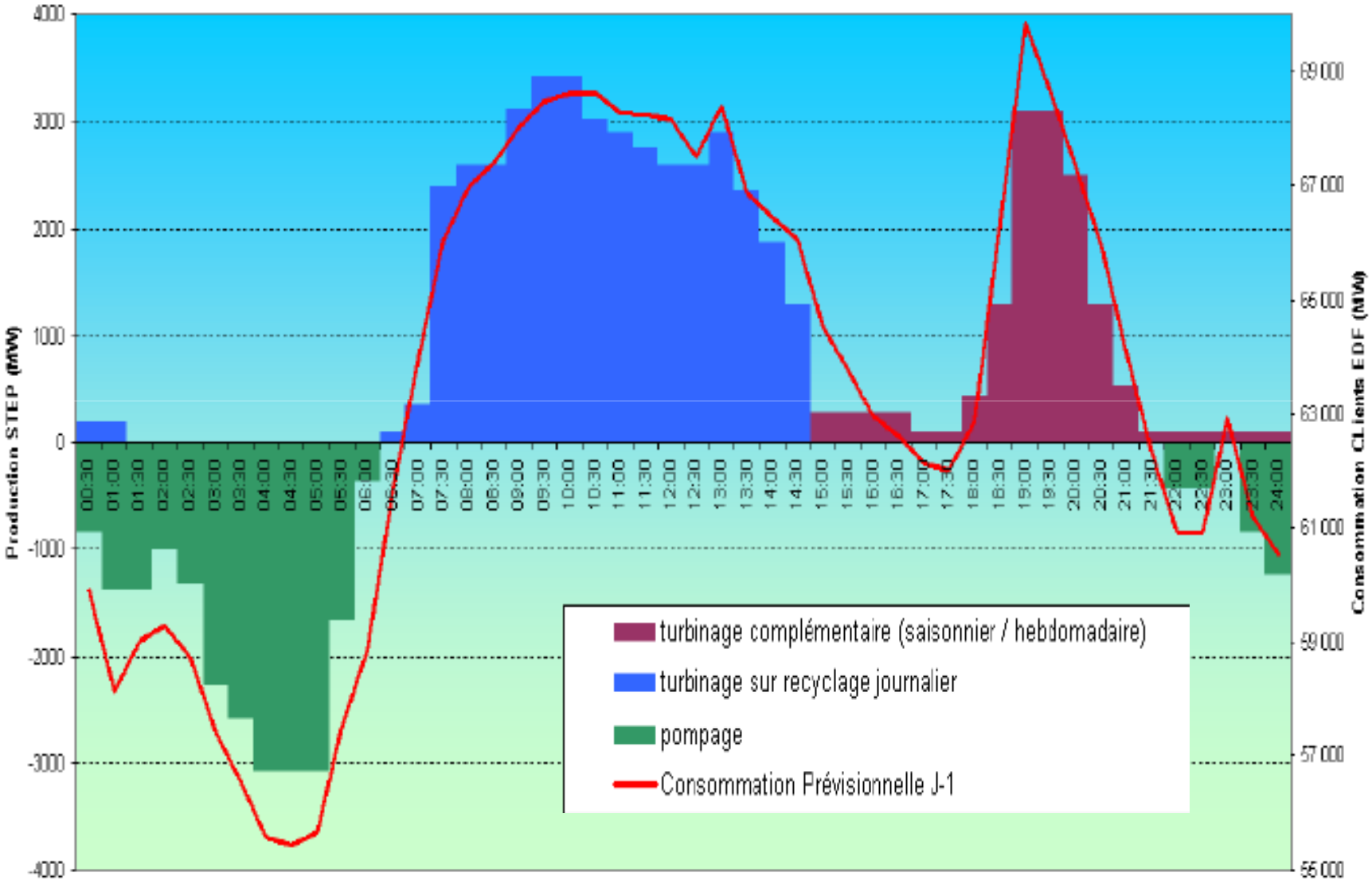
Development growth



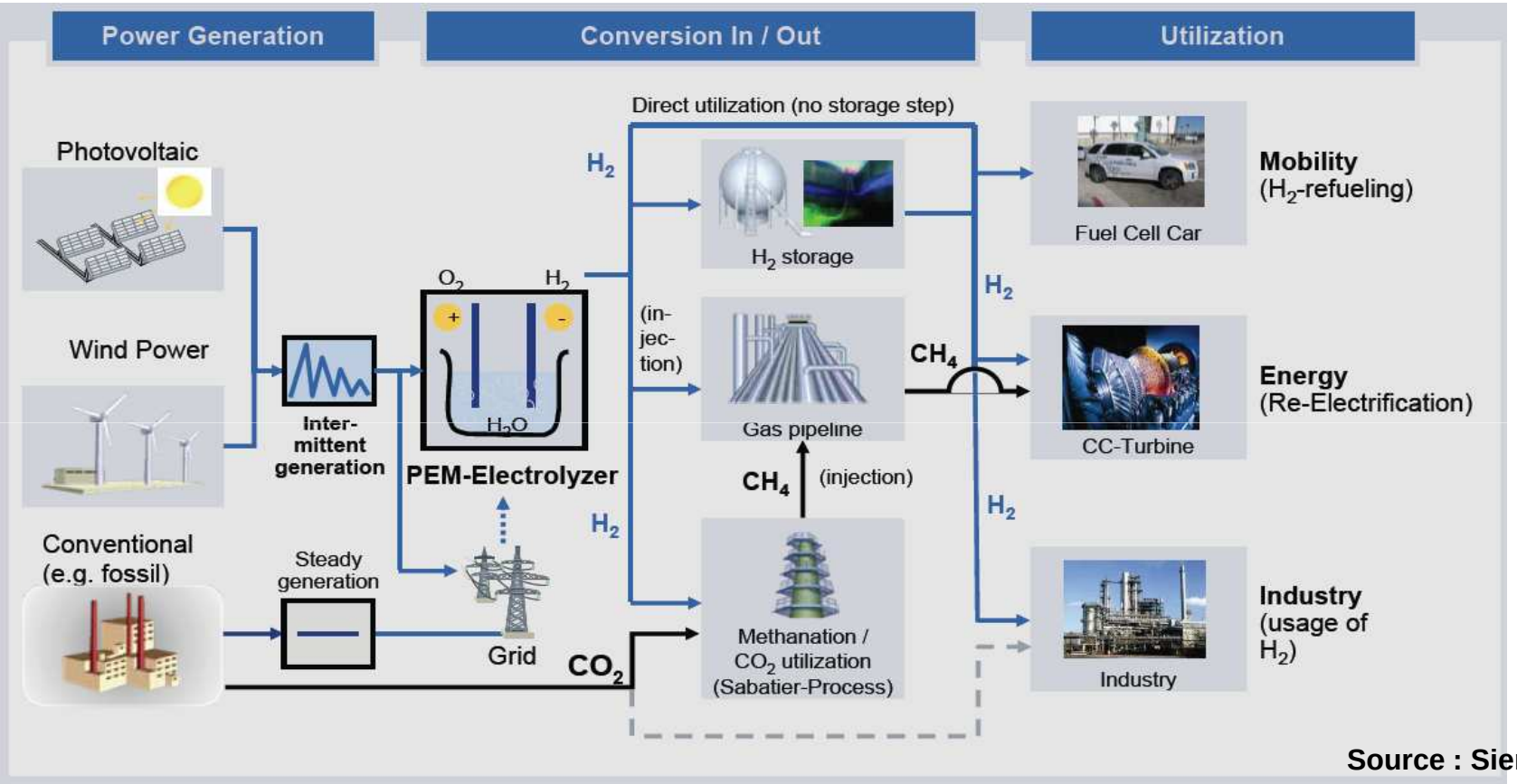
PHP used weekly: example of charge/discharge



PHP used daily: example of charge/discharge



Hydrogen (H2), an outlet for the management of fatal renewables ?



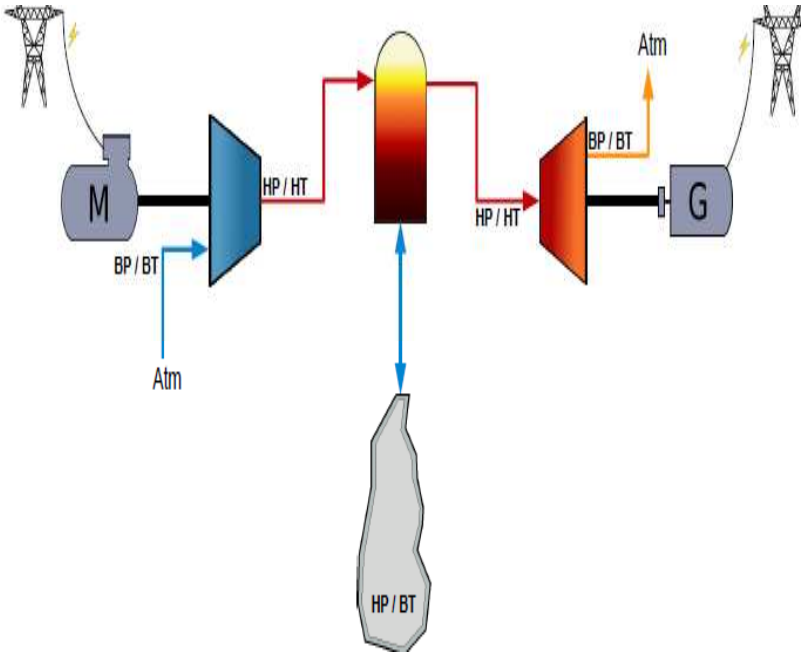
Source : Siemens

Storage of H2 has also a strong potential, but the conversion into electricity (low efficiency ~ 30%) is just one of the possibility

CAES, a possible alternative to the PHP

- Diabatic: during the compression phase, the heat is lost, cold air is stored in a cavern and is heated up with fossil fuel before expansion
- Adiabatic: the removed heat of compression is stored in a thermal energy storage device. Later the stored heat is reused to warm up the cold compressed air before being expanded

Process scheme of adiabatic CAES



CAES has a strong potential (efficiency~ 70%), the cost are close from those of the PHP but adiabatic technology needs a demonstrator to validate the concept

Electrochemical batteries, a worldwide offer

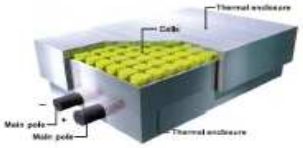
- Key criteria for a battery :
  - Cost and potential reduction
  - Number of cycles and life duration
  - Reliability
  - Environmental acceptability
  - Industrial maturity
- Battery sector under deep mutation with the investments of several public plans for Electric vehicles market development

Lead acid

Alcalines batteries (NiCd, NiMH, NiZn)

Lithium batteries (Li ion, Li Métal)

Natrium Batteries (Zebra, NaS)



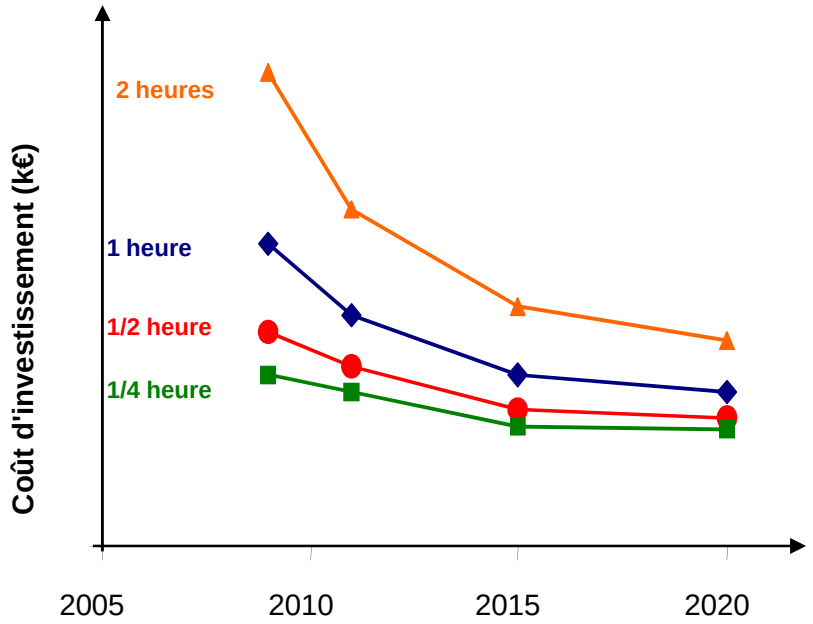
Asia leads the market, USA makes big efforts to start a new battery industry

Market and drivers for batteries

- Electric mobility is the main driver today for batteries
- This will have a huge price effect on certain electrochemical batteries
- This gives a good perspective for the Lithium ion

Coût d'investissement d'un système de stockage Li-ion 1MW - X h

Source EDF R&D



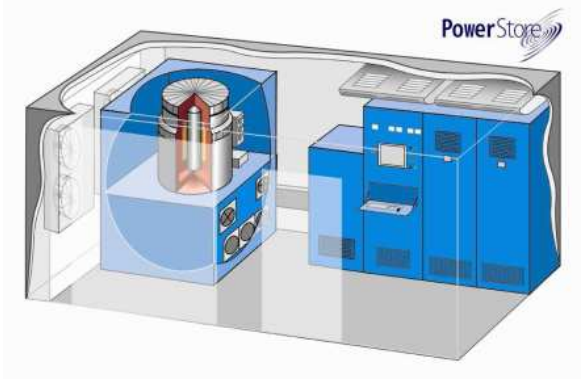
Battery sector is under deep mutation with the Electric vehicles market development

Flywheel, a technology for certain niche applications

- A flywheel is a mass to store kinetic energy
  - In charge, the speed increases / in discharge, the speed decreases
  - Limited in energy (~30 min max.)
  - Almost unlimited in terms of number of cycles
- Very expensive technology (3 M€ / MW)

Beacon Power (NY, U.S.A.) 20 MW / 15 min

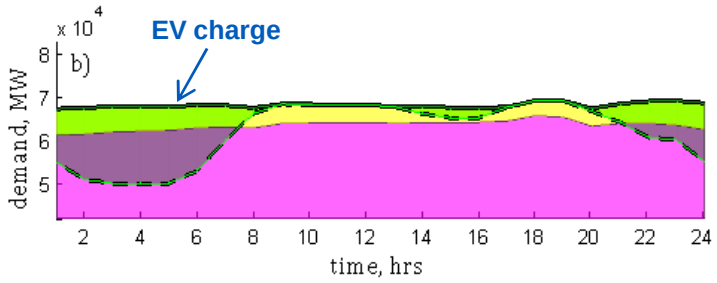
PowerCorp (Azores) 500 kVA/30 s



Impact of large dissemination of Electric vehicle

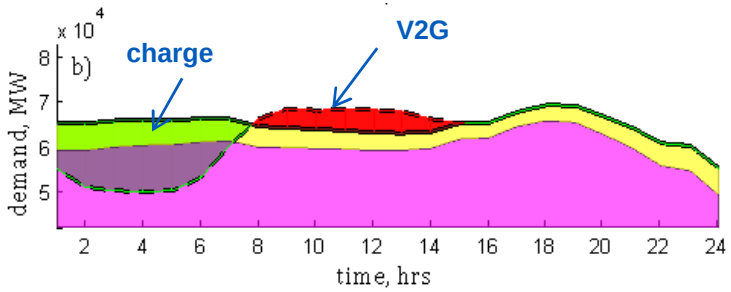
- The mass development of EVs will represent an increase in demand
  - additional network constraints
- But Evs can become a flexible demand
  - If the load is controlled, EV charge during off-peak hours
  - Less impact on peak demand
  - But constraints network may appear during off-peak hours
- And a storage asset (V2G):
  - EVs can provide services to the electrical power system

Steering load



Source G4V – Ortega-Vazquez – Chalmers Institute of Technology

Concept Vehicules to grid (V2G)



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The concept of V2G could add flexibility but practically the sustainability of the business model has to be demonstrated

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Development of energy storage in the world

USA: political & regulatory impulse

- ARRA law (American Recovery and Reinvestment Act, 2009) in favor of investments in storage used to bring benefits to electrical power systems (2.4G$ DOE awards for construction of new
- Storage recognized as a tool for T&D electricity grids operation since 2002
- Various demonstrations projects under construction or operation (CAES, batteries, flywheels…)

Development of energy storage in the world

Japan: power system security and operation drivers

- No merchant mechanisms for storage and no storage targeted regulations
- Grid constraints hamper the development of renewable in some regions (tight interconnections) that leads to specific technical requirements for grid connection
- National roadmap on energy storage technologies
- Horizon 2010-2020: NaS batteries commonly used the 1 MW range
- Horizon 2030: bigger batteries, 30 MW range, with 70% expected cost reduction compared to 2010
- Gives high perspectives for storage development: expectations for 40 GW by 2030 (mainly batteries)

Development of energy storage in the world

Europe: what future for energy storage?

- Global drivers: 3x20 targets, renewable shares
- Energy storage appears high in European political agenda (European Commission + Member States)
- European regulations towards energy storage apply only on PHP in some Member States
- Large and highly interconnected power system, able to cope to a certain share of renewable, but with raising consequences on both generation operation and T&D grids
- Large share of flexible generation
- Quite good level of annual investments in European power systems (grid,generation,…) but large additional investments are needed to cope with renewable and market integration

Thanks for your attention