CHALLENGES OF STORAGE

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AGENDA

1. FRENCH POWER SYSTEMS : A NEED FOR MORE FLEXIBILITY
2. POSSIBLE ROLES OF STORAGE IN FRANCE
3. STORAGE TECHNOLOGIES OVERVIEW
4. CONCLUSION

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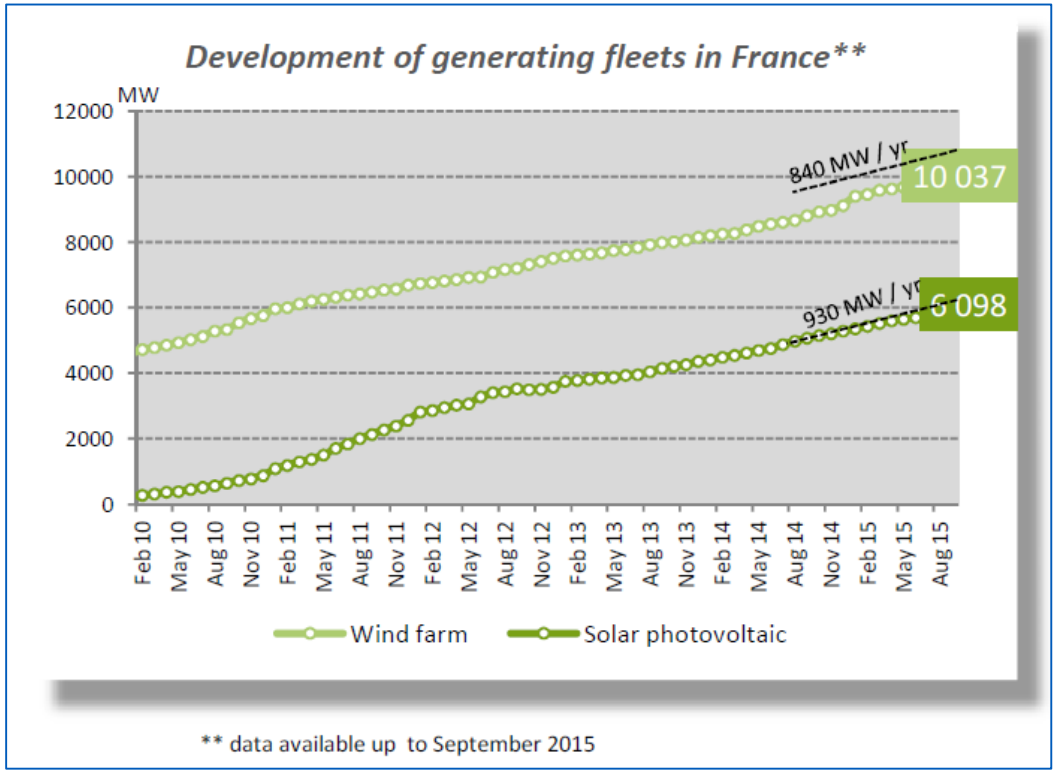
WIND AND PHOTOVOLTAIC POWER DEVELOPMENT TRENDING HIGHER AGAIN

- **The French energy mix includes more and more renewable**
  - Wind and photovoltaic power development had slowed in recent years but began trending higher again in 2014.
  - France is now home to almost :
    - 10,000 MW of wind power
    - 6,000 MW of photovoltaic capacity



Source : RTE

INCREASING SHARE OF INTERMITTENT RENEWABLES PRESENTS NEW CHALLENGES

- **Total generation in France reached 540.6 TWh in 2014**
  - Nuclear represents the main part (77 %)
  - Intermittent renewable energies account for a larger of the French generation in 2014 :

Energy produced	TWh	Change 2014/2013	Share of generation
Hydropower	68.2	-9.7%	12.6%
Wind power	17.0	+6.7%	3.1%
Photovoltaic	5.9	+27.2%	1.1%

  ➔ Challenge for the **national** energy supply / demand balance

- **95 % of the intermittent renewables are connected to the distribution grid**

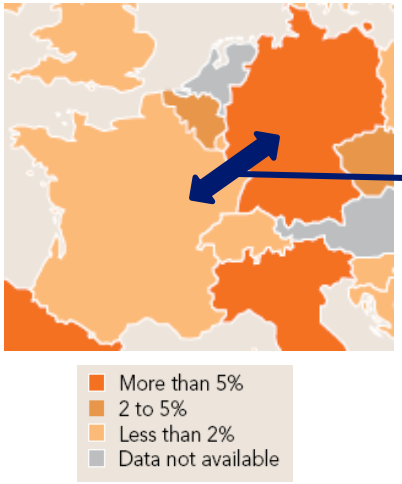
  ➔ Challenge for the integration in the **local** grids

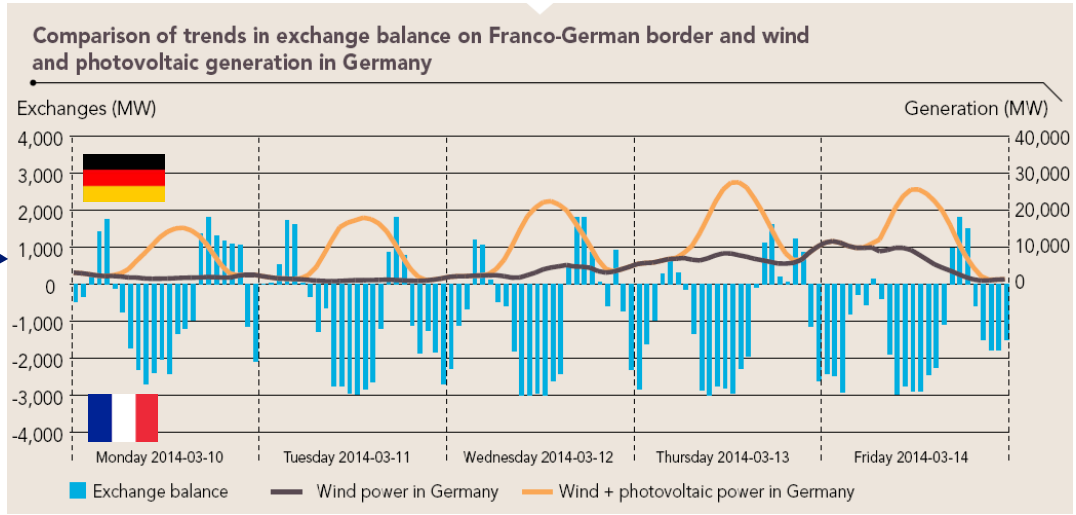
A GROWING NEED FOR LOCAL, NATIONAL AND … **INTERNATIONAL** FLEXIBILITY

- **French POWER systems : a need for more flexibility is deeply connected to the other European power systems**
  - ➔ as a consequence, France is strongly exposed to the evolution of their generation mixes

*The French balance is also dependent on the intermittent generation abroad, particularly the **German** wind and solar generations*

Coverage of consumption with photovoltaic power



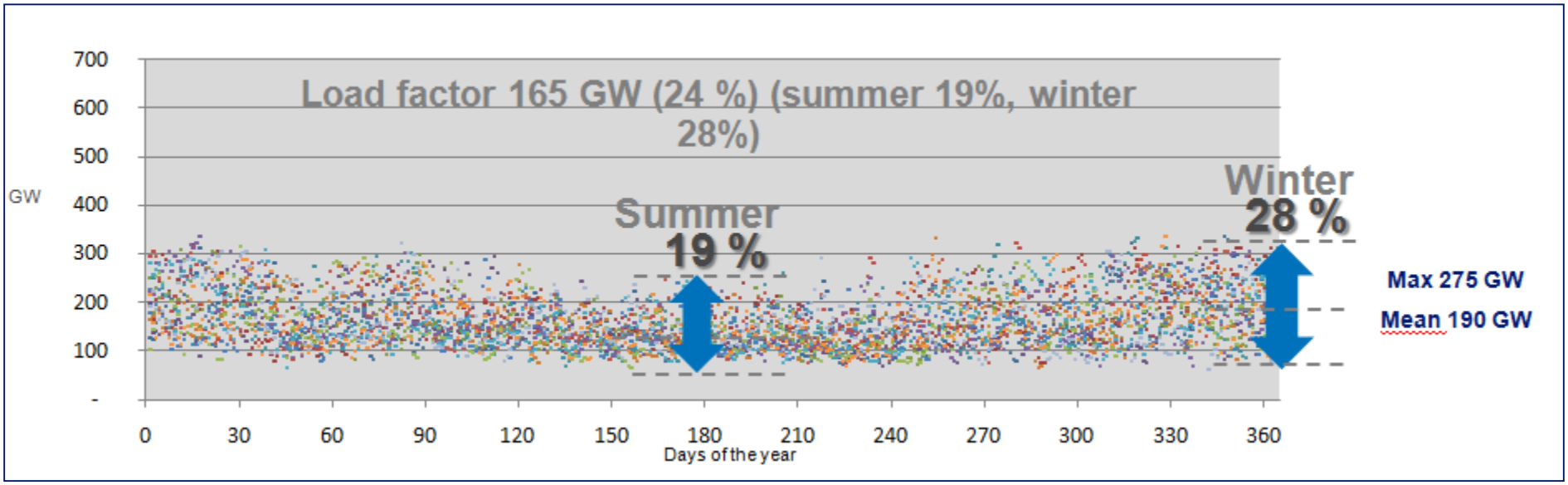


Source : RTE

- **A <u>common approach</u> on the way to deal with the need for flexibility may be profitable**

TO COPE WITH VARIABILITY OF INTERMITTENT RES: NEW NEEDS FOR FLEXIBILITY

- **To characterize variability, daily maximum output of intermittent generation can be compared over many scenarios :**
  - Ex: EC Roadmap towards 2050 (High RES), 60% of RES at 2030, of which 40% of wind and PV (700 GW). *The figure below uses 30 historical climate scenarios (1 day, 30 points)*



Wind & PV forecast generation in 2030 based on historical profiles

Source : EDF R&D

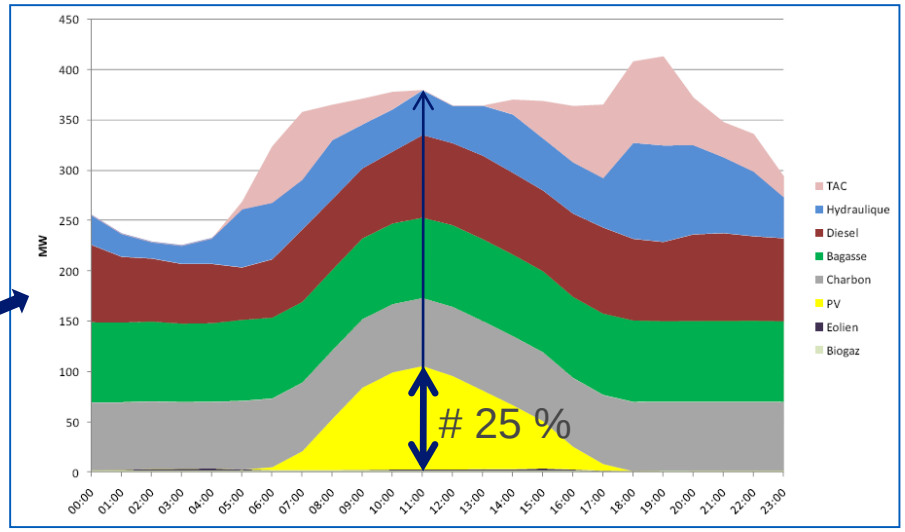
- **Variability has always existed (demand) and some solutions proved to be competitive: hydro storage, PHS, flexible thermal generation, interconnections,… Storage with high duration capacity could play an increasing role**

FRENCH ISLANDS' POWER SYSTEMS HAVE ALSO TO FACE BIG CHANGES

- **In the French island systems, wind and photovoltaic power development is quite important too.**

- **Need to monitor the <u>instantaneous</u> intermittent renewable power because, beyond a certain threshold (set at 30% by ministerial order), the <u>lack of inertia</u> of the generation mix weaken the system.**

Localization of the French islands managed by EDF SEI



Power production on a typical day during the austral winter in the "Réunion" island

Source : EDF-SEI

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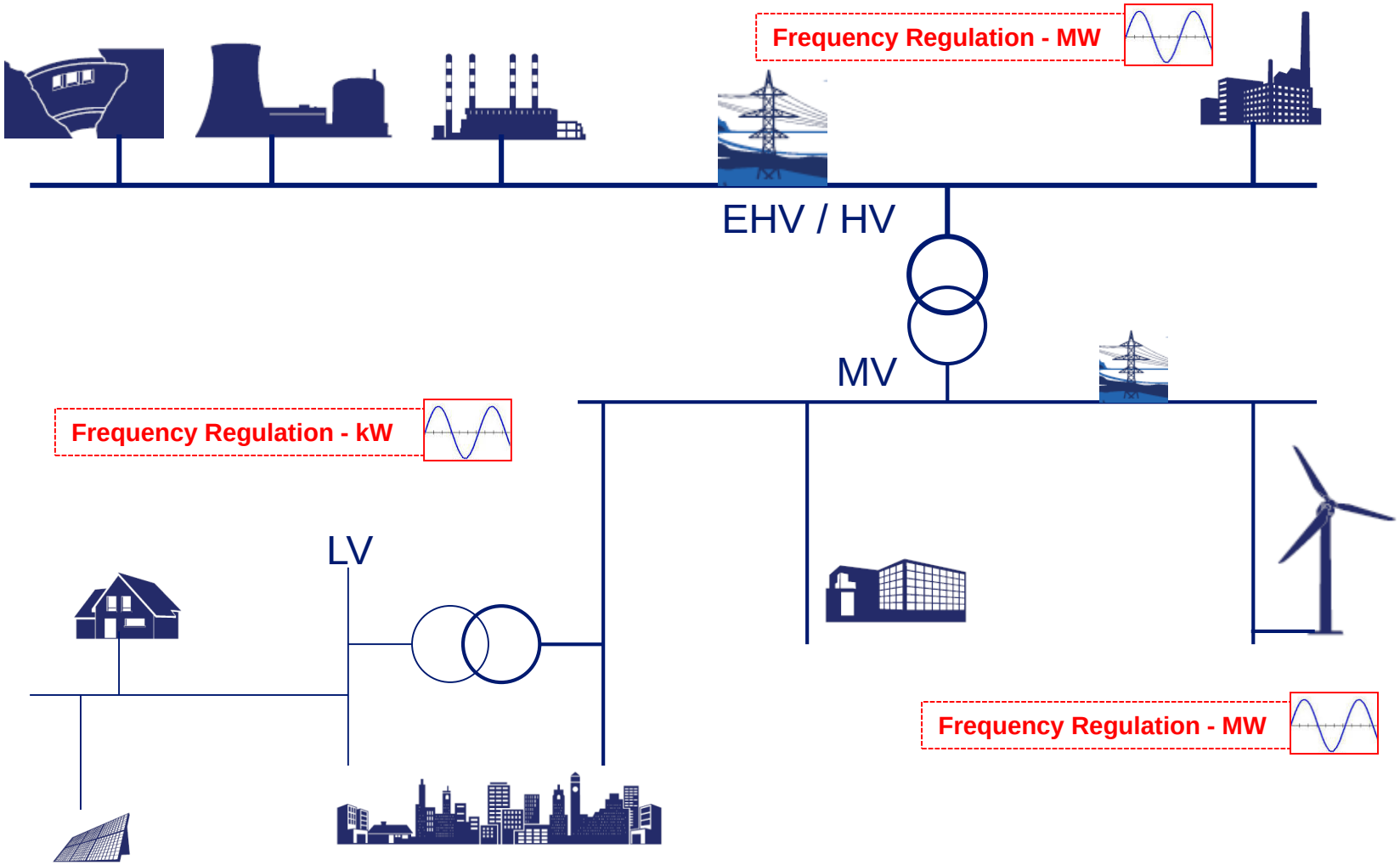
STORAGE COULD PLAY AN INCREASING ROLE IN A MORE FLEXIBLE POWER SYSTEM

- **The technical and economical progress of some storage technologies could give it a more and more important role in the power system management**

- **But storage is a solution to bring more flexibility to the system, but it is <u>one solution among others</u>:**
  - Grid development
  - Very flexible power plants
  - Demand side management

- **Storage has two challenges to take up :**
  - Economical challenge: to find profitable business models
  - Technical challenge: to identify the services to the system

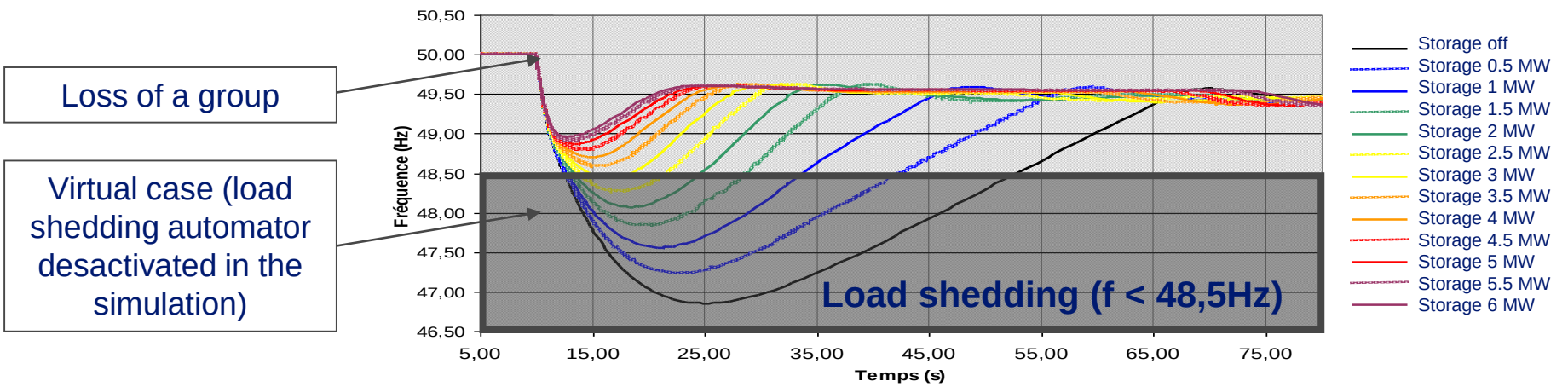
STORAGE CAN GIVE SERVICES AT DIFFERENT LEVELS OF THE GRIDS



STORAGE AND FREQUENCY REGULATION IN ISLANDS

- **In island systems, the very prompt response of storage is interesting to provide "dynamic frequency control support"**
  - Even with enough primary reserve, a loss of a group in isolated systems can lead to load shedding (Primary Reserve not available fast enough)
  - Requires a short response time (<1s) and a discharge duration of a few 10s

- **In the simulation below, load shedding is avoided with a storage capacity of 5-10 MW, a total of primary frequency reserve of 20-25 MW and a peak demand of 250 MW**

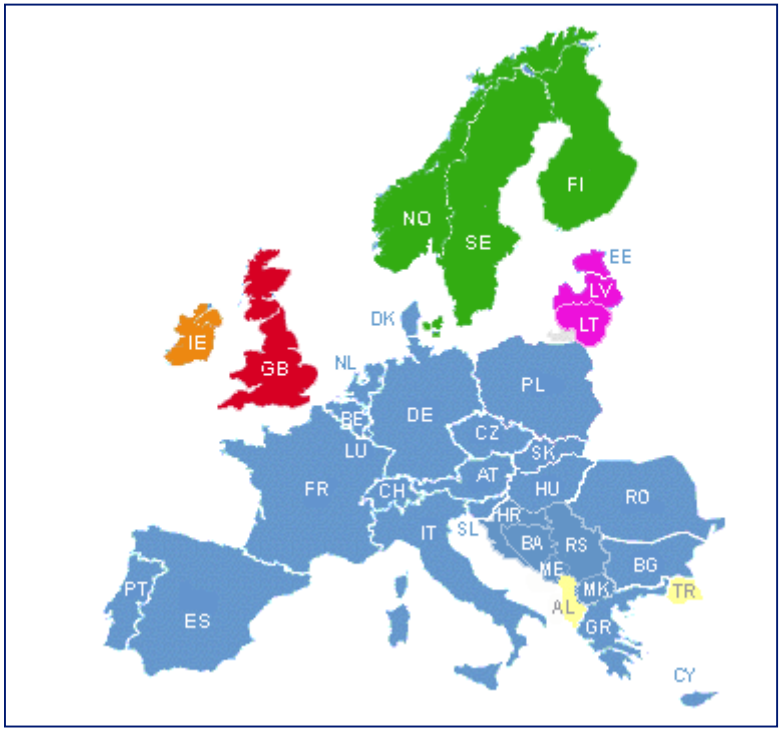


Source EDF R&D Delille G, et al., « Dynamic frequency control support », IEEE oct 2010

Example of frequency evolution in case of a loss of group

STORAGE AND FREQUENCY REGULATION IN CONTINENTAL EUROPE

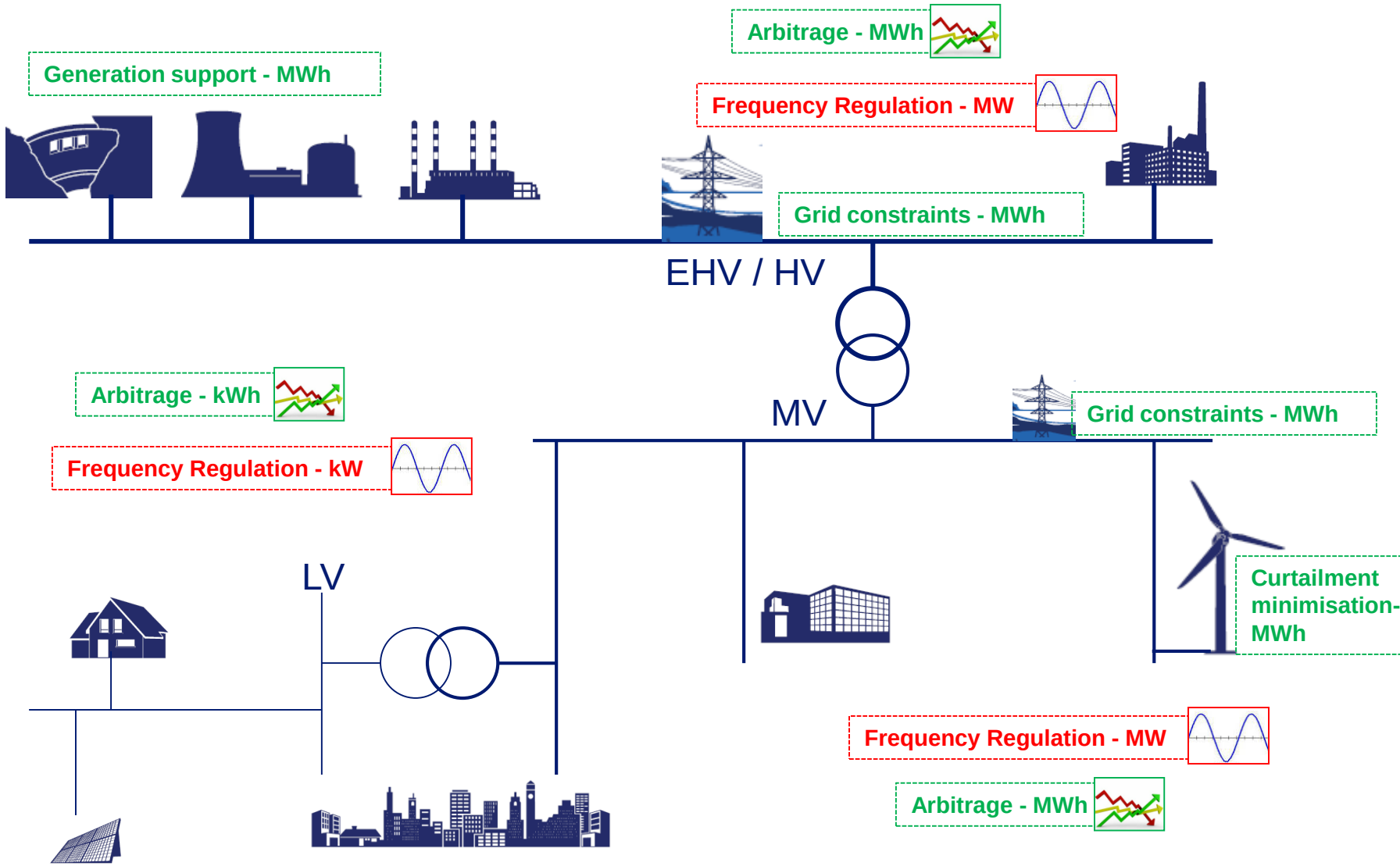
- **In Europe, "frequency regulation" is regularly referred to as one of the most promising opportunities for storage development but…**
  - The market is …
    - … limited : 3000 MW in Europe
      - 600/700 MW in France
    - … uncertain : very different regulations depending on the country
    - … competitive : storage compete or complement to other existing and proven solutions
  - Demonstration is still needed
    - Experimentation launched with a 1 MW / 30 minutes Li-ion battery on the "*Concept Grid*" of EDF R&D



The synchronous zones of ENTSO-E

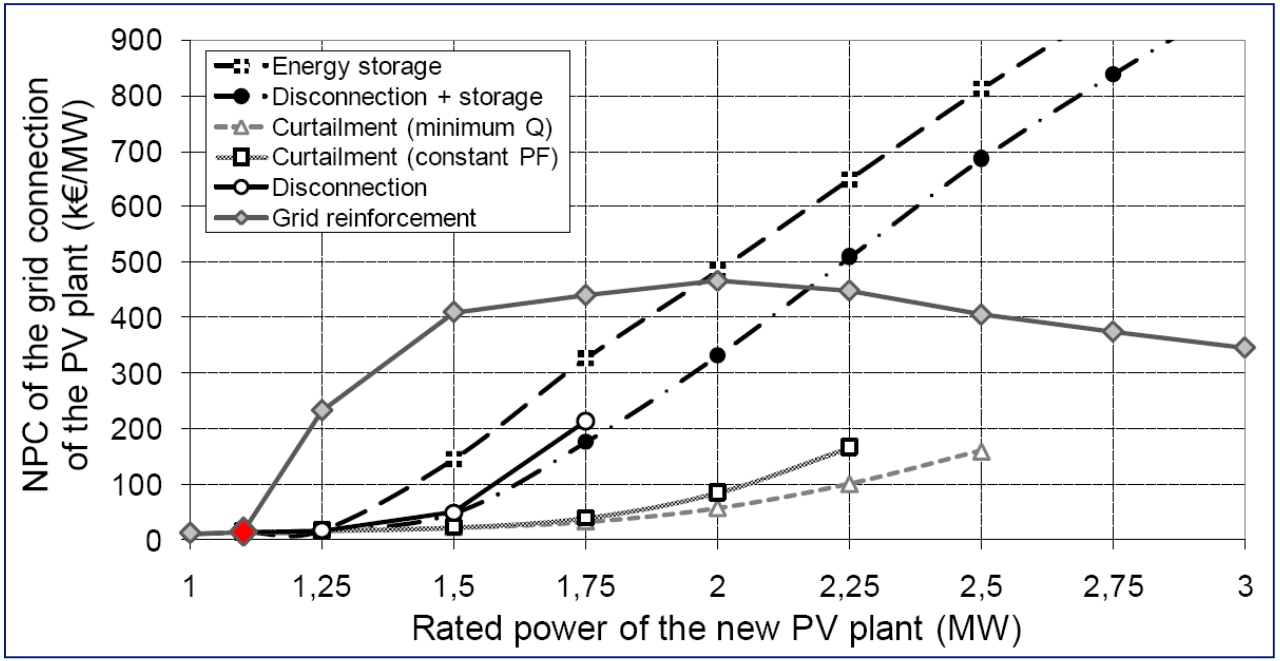
- **In the United States, some specific regulations have been settled for "frequency regulation"**
  - "Power for Performance" has been created for very effective "frequency regulations"
    - Very reactive flywheels and batteries are eligible

STORAGE CAN GIVE SERVICES AT DIFFERENT LEVELS OF THE GRIDS



GRID INVESTMENT DUE TO NEW PV GENERATION (REINFORCEMENT POSTPONED OR AVOIDED)

- **This service is a case by case analysis : each feeder is specific**
- **However, some research suggest storage is not the only option**
  - Not the most economical option (but no mutualization considered)

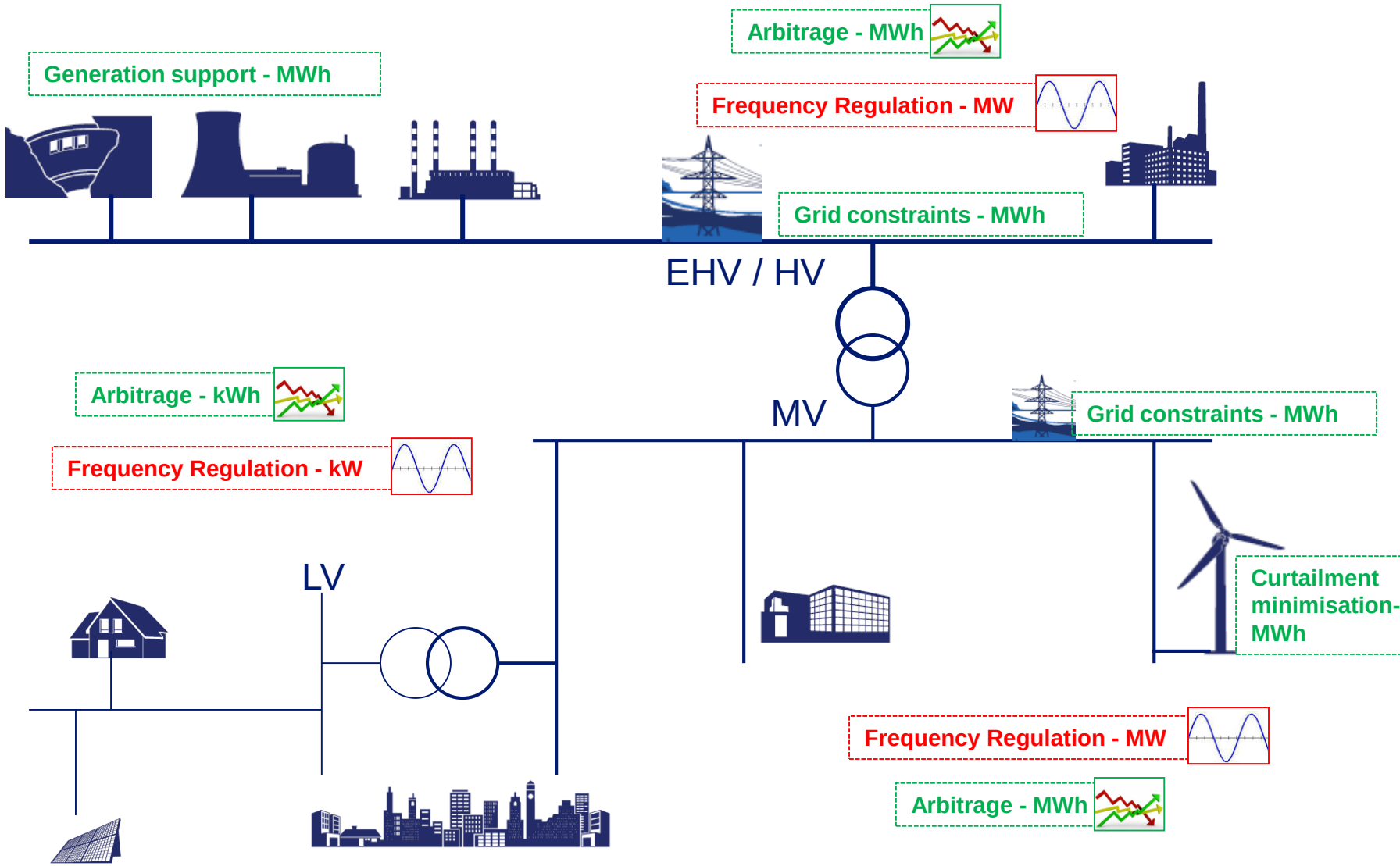


Net Present Cost (NPC) of different solutions vs. rated power of the new PV plant

Source : Delille et al, CIRED 2013

  - The storage may be a temporary solution to manage grid constraints but the <u>grid development remains the most appropriate solution in the long term</u>.

STORAGE CAN GIVE SERVICES AT DIFFERENT LEVELS OF THE GRIDS



IS MUTUALISATION OF A STORAGE DEVICE FOR VARIOUS SERVICES FEASIBLE?

- **The key is to limit simultaneous request**
  - Not all services can be well provided by a same device (see *Delille, PhD thesis 2010*)
  - If services are well picked, simultaneous request can be limited
    - *Example* : voltage smoothing, outages reduction from a DSO perspective and Arbitrage

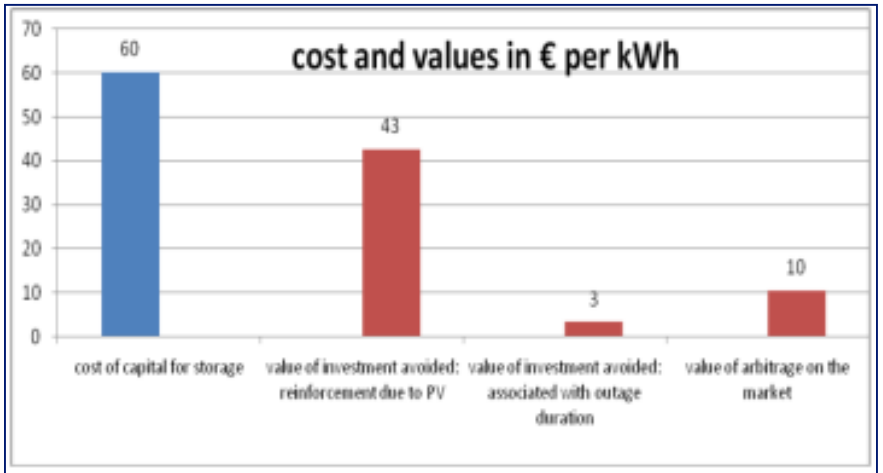
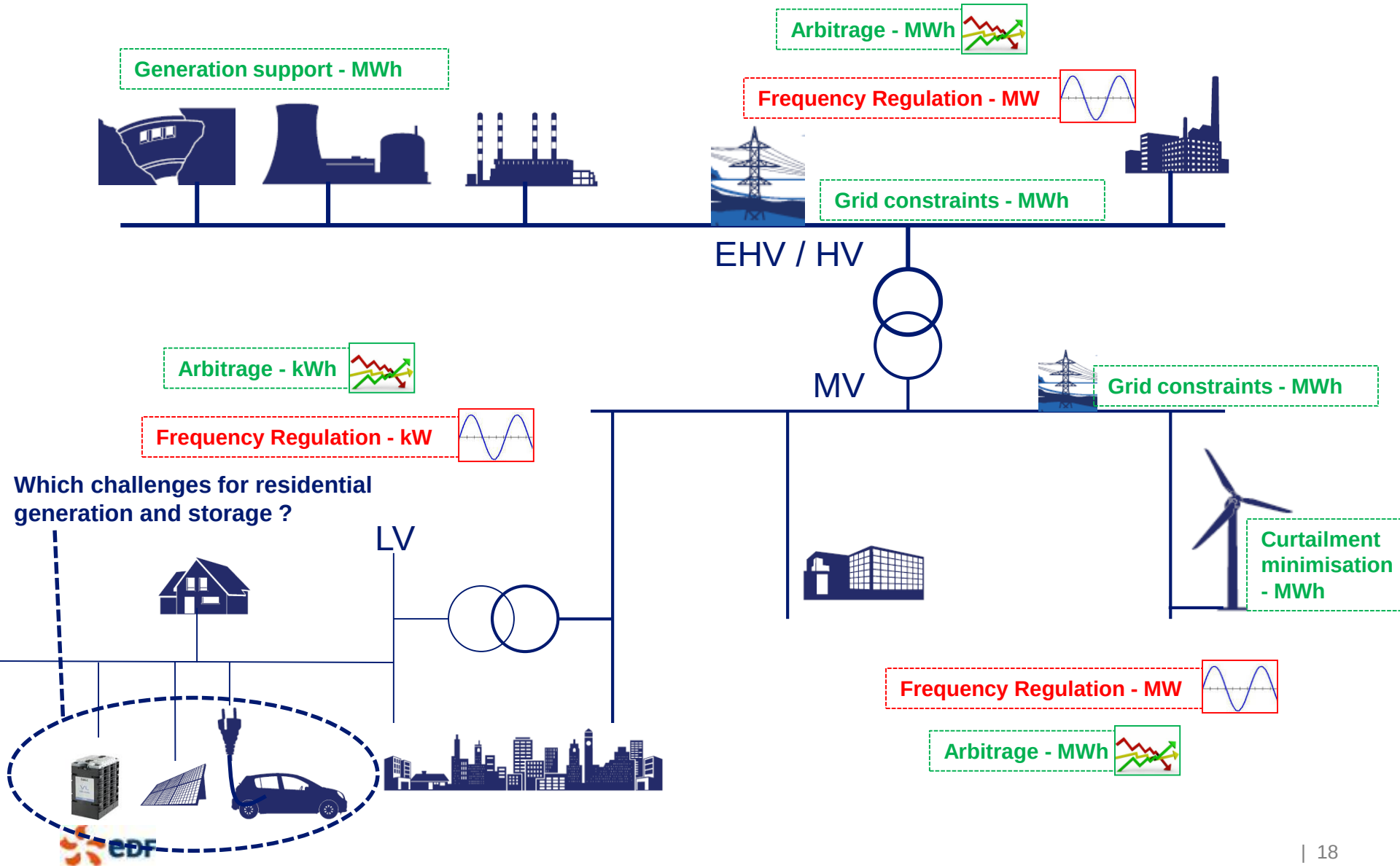


Figure1: Cost of capital for investment in storage (annualised over 10 years at a rate of 7.25%), and the value of services per battery kWh

Based on Loevenbruck, CIRED 2013

- **There seem to be possibilities for mutualize a storage device among services**
  - But there is generally one main service – the other services add less value
    - Most interesting services: grid investment deferral and reserve => residential ES the best option?
  - More analyses are needed
    - What if the residential customer uses the storage for his benefits first?

STORAGE CAN GIVE SERVICES AT DIFFERENT LEVELS OF THE GRIDS



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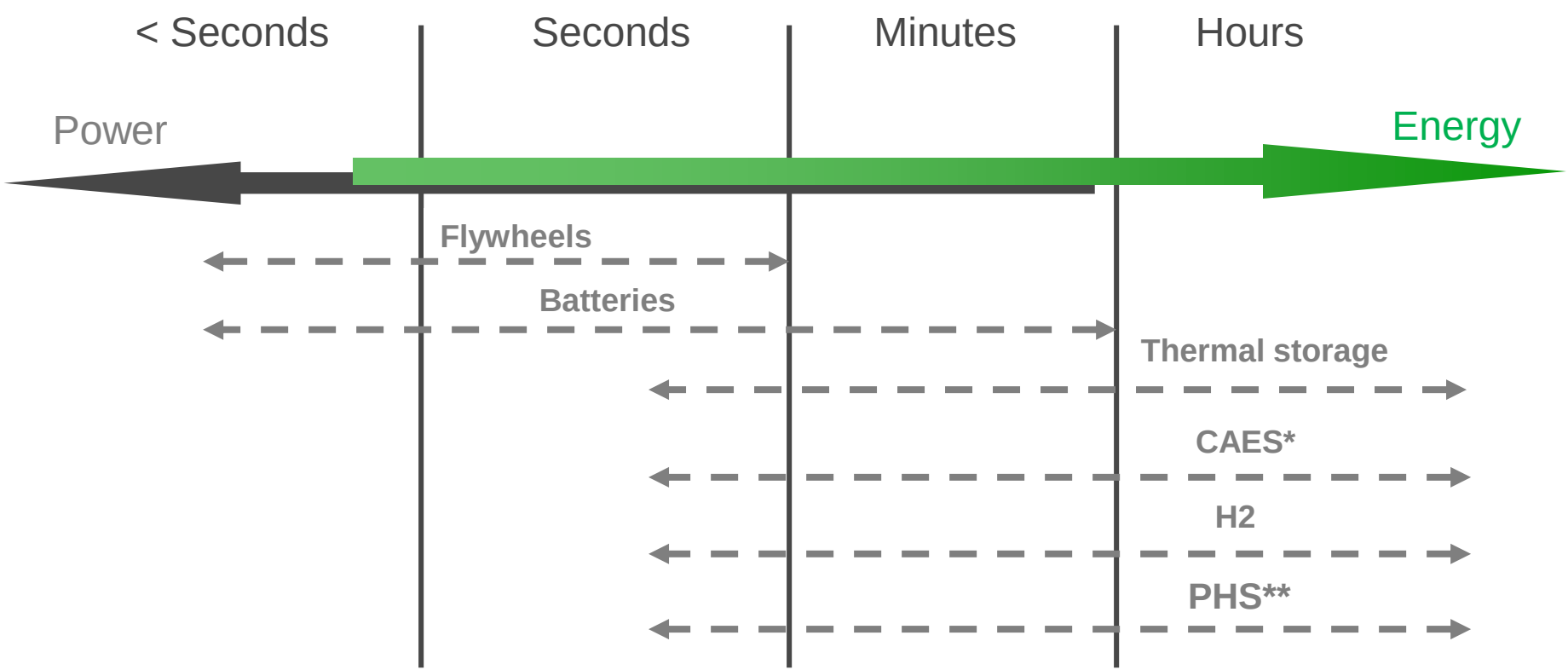

*CAES : Compressed Air Energy Storage

**PHS : Pumped Hydro Storage

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CONCLUSION

- **To assess the storage markets we need:**
  - to understand the applications, their potential and their associated revenues
  - to establish the merit orders of the technological solutions

- **The context is very important:**
  - interconnected system vs. isolated system
  - existing generation mixes
  - development of demand-response

- **To be profitable, storage devices will have to propose different services to different actors**

- **The future transport mutation towards electric mobility and the emergence of smart grids could place batteries in the heart of the future power system**

Thank you