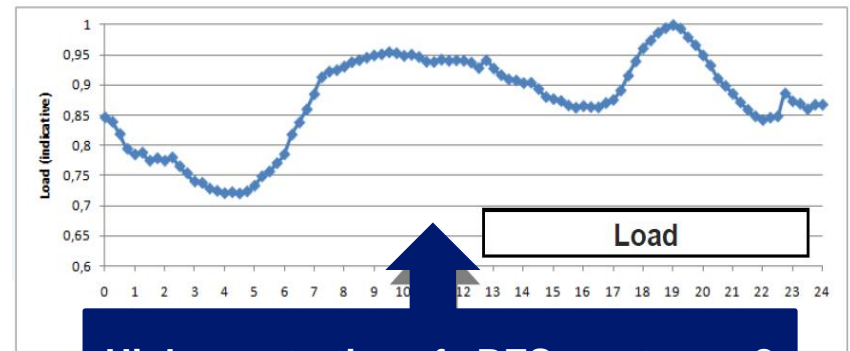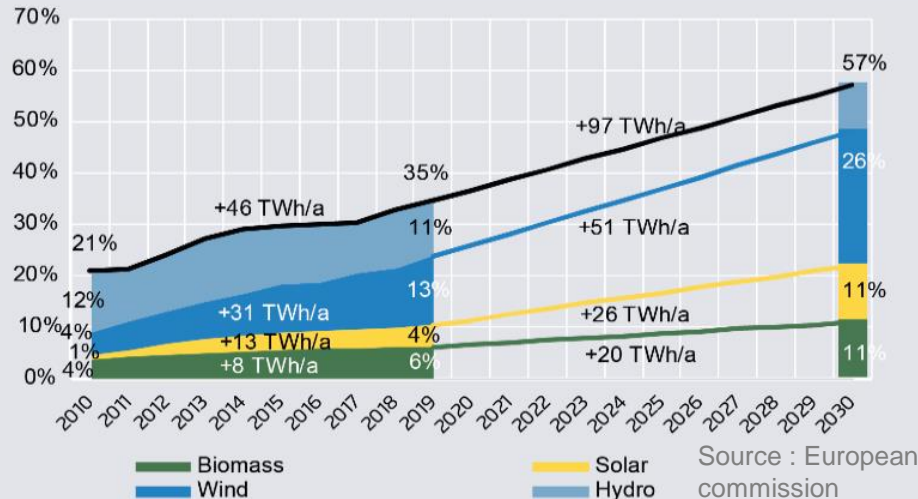# USING LEVELIZED COST OF STORAGE TO COMPARE STORAGE TECHNOLOGIES

Etienne Sorin, Fabien Bricault
EDF R&D
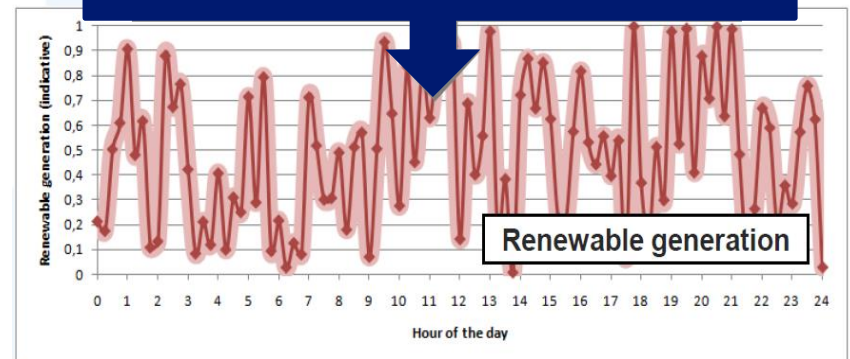
IAEE conference, June 2021

STORAGE RATIONAL, A SIMPLE STORY?

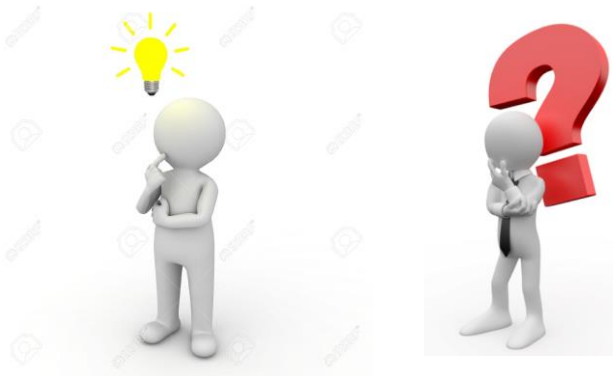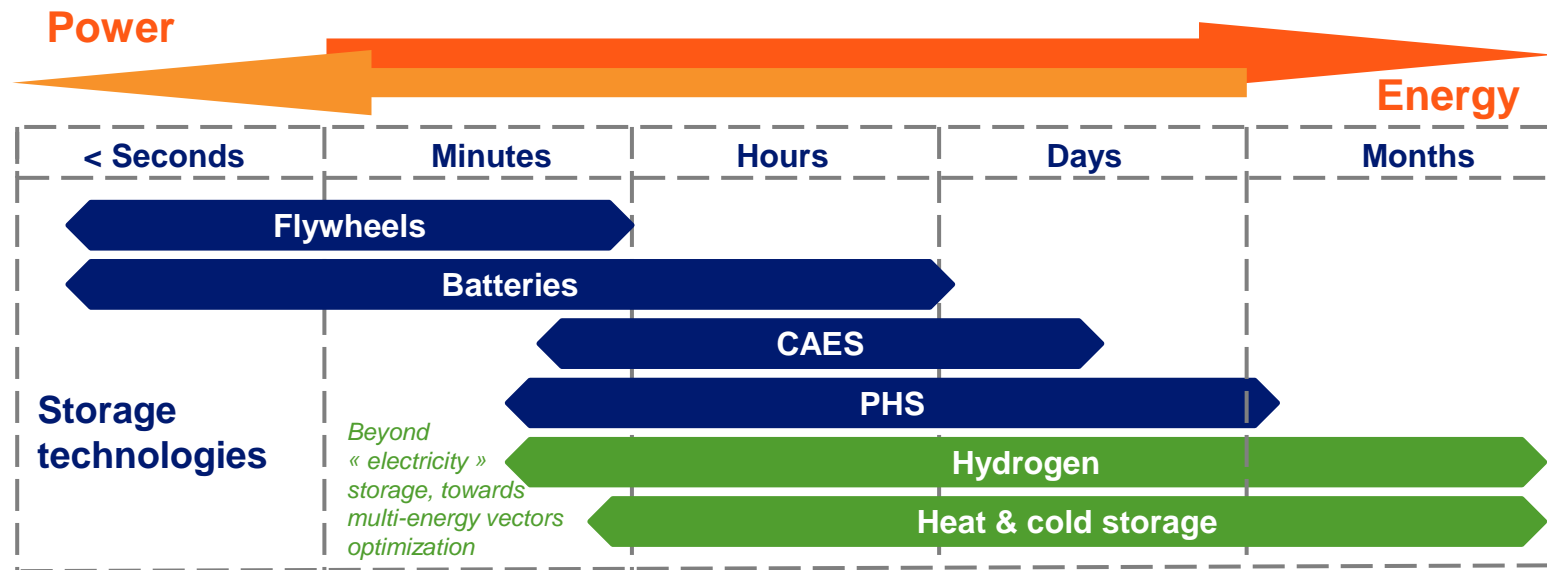## 2030 projection of renewable electricity share in European Commission's Long Term Strategy

Source : European commission

Legend:
- Biomass
- Wind
- Solar
- Hydro

Load

High penetration of vRES => storage?

Renewable generation

EDF R&D

NOT THAT SIMPLE… <u>DIFFERENT TECHNOLOGIES</u> AND DIFFERENT SERVICES

Power ←————————————————————→ **Energy**

	< Seconds	Minutes	Hours	Days	Months
	Flywheels				
	Batteries				
			CAES		
			PHS		
			Hydrogen		
			Heat & cold storage		

Storage technologies have different technical characteristics…

Storage technologies

Beyond « electricity » storage, towards multi-energy vectors optimization

Flywheels

Compressed Air

HP: H2
BP: B3
HT: Ha
BT: B3
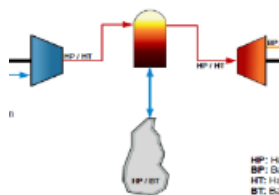
Pumping

Batteries

Lithium (Li-ion, Li-Métal)

Sodium (NaS, Zebra)

Redox flow

Lead Acid (Pb, VRLA…)

Stationnay battery system

Modules & *Converter*

NOT THAT SIMPLE… DIFFERENT TECHNOLOGIES AND DIFFERENT SERVICES.

Power ← → **Energy**

	< Seconds	Minutes	Hours	Days	Months

Storage technologies have different technical characteristics…

Storage technologies

- Flywheels
- Batteries
- CAES
- PHS
- Hydrogen
- Heat & cold storage

Beyond « electricity » storage, towards multi-energy vectors optimization

They can provide different services regarding technical characteristics…

Services or use cases

- Frequency regulation
- Congestion management
- Peak shaving
- Hourly Energy shifting
- Daily energy shifting
- Weekly Energy shifting
- Seasonal energy shifting

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THE LCOS, A SIMPLE INDICATOR TO ASSESS THE PERFORMANCE OF A STORAGE ASSET

Levelized cost of…

… Electricity (LCOE)

Generation assets

$$LCOE = \frac{Costs\ (Capex, Opex)}{Lifetime\ generation}$$

… Storage (LCOS)

Storage assets

$$LCOS = \frac{Costs\ (Capex, Opex) + \mathbf{recharge\ costs}}{\mathbf{Lifetime\ discharge}}$$

* Detailed formula in annex if needed
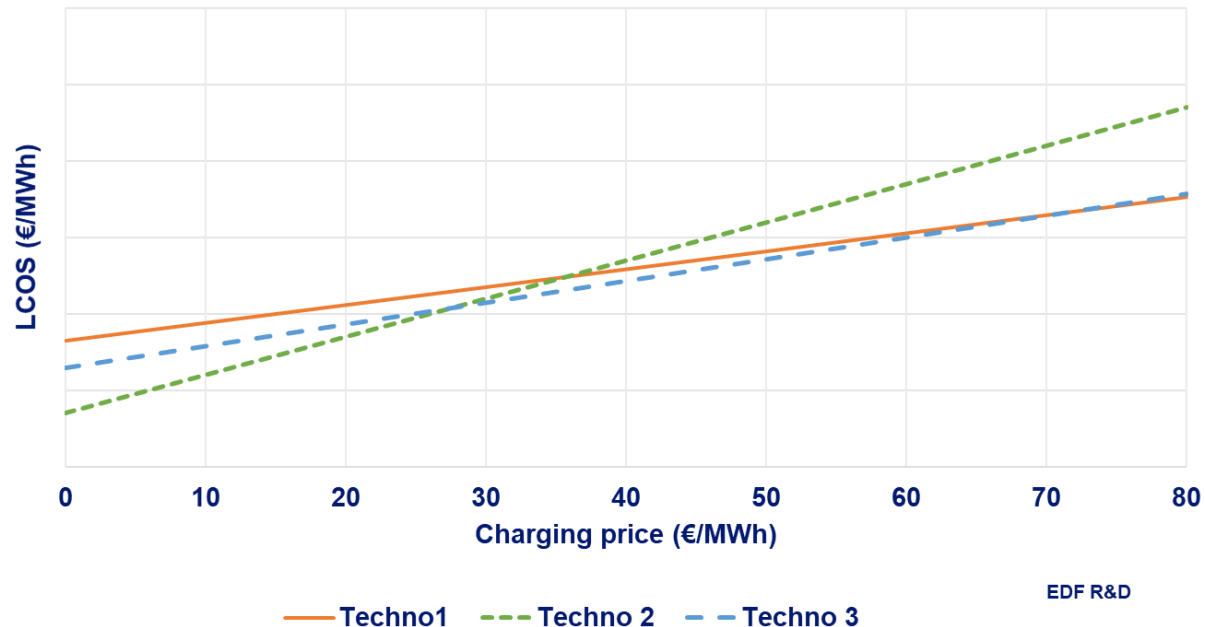
STRONG ASSUMPTIONS BEHIND LCOS CALCULATIONS

$$LCOS = \frac{Costs\,(Capex, Opex) + \textbf{recharge costs}}{\textbf{Lifetime discharge}}$$

Assumptions :
- Number of yearly cycles
- Yearly cost of recharge
- Storage duration (Capex and opex)

LCOS three storage technologies depending on charging prices

LCOS (€/MWh) vs Charging price (€/MWh)

— Techno1   --- Techno 2   – – Techno 3

EDF R&D

Hypotheses :The storage devices charge for 6 hours every day at a constant price given in the x-axis

THESE ASSUMPTIONS ONLY CORRESPOND ONLY SOME SPECIFIC USE CASES

PPA or detailed call for tender

➢ Some or all of use case's key parameters are well defined for all eligible technologie

Market exposed assets

➢ Technology specific caracteristics affect the key parameters:
  - Round trip efficiency
  - Ageing
  - Self discharge
  - Specific power and energy costs…

➢ Some of these parameters are taken into account on the cost side but not in the use case description
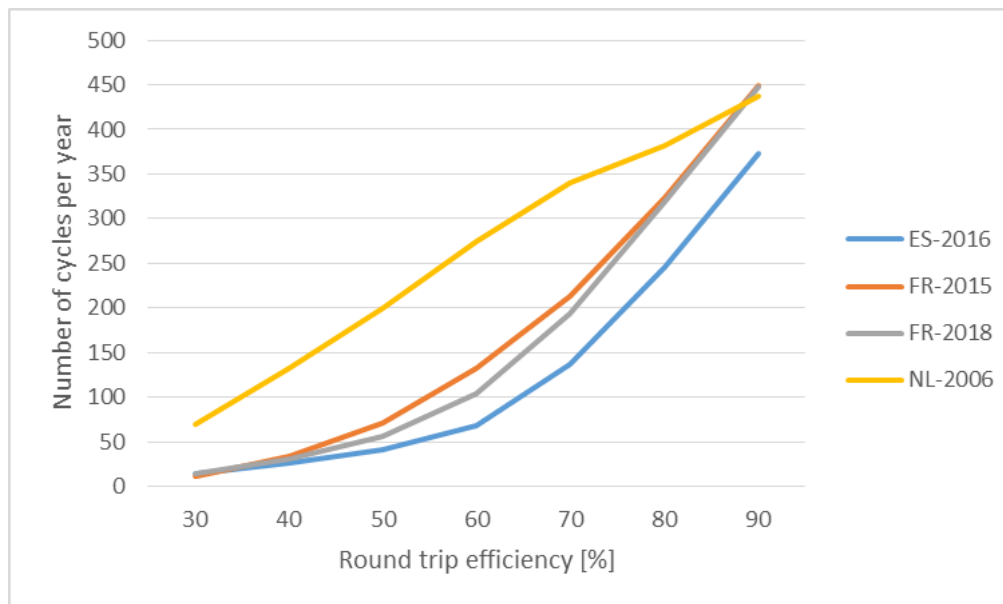
use case's key parameters
  - Number of yearly cycles
  - Yearly cost of recharge
  - Storage duration (Capex and opex)

TECHNOLOGY CHARACTERISTICS AFFECT KEY USE CASE PARAMETERS

Example 1:
Wholesale arbritrage

PHS

Example 2:
Frequency containment reserve (FCR)

Li-ion batteries

➢ Energy sizing is strongly impacted by exogenous factors
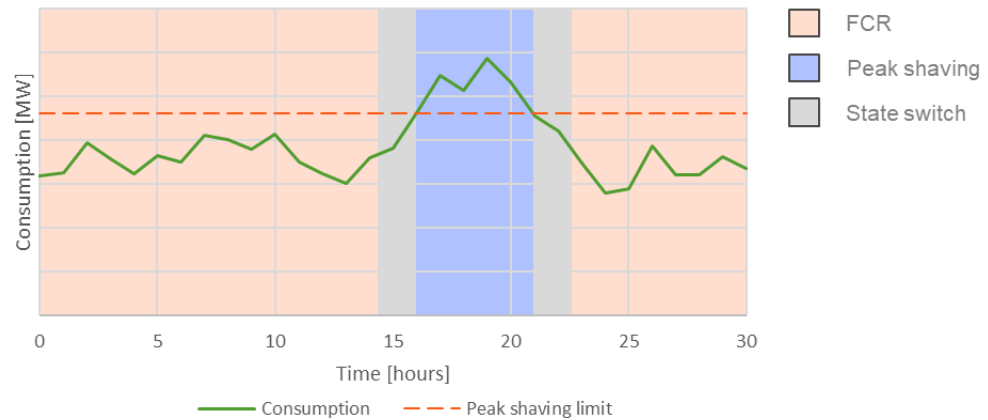➢ Power sizing is independant

➢ Power and energy sizing is the result of a combined optimisation process that relies on the recharge strategy

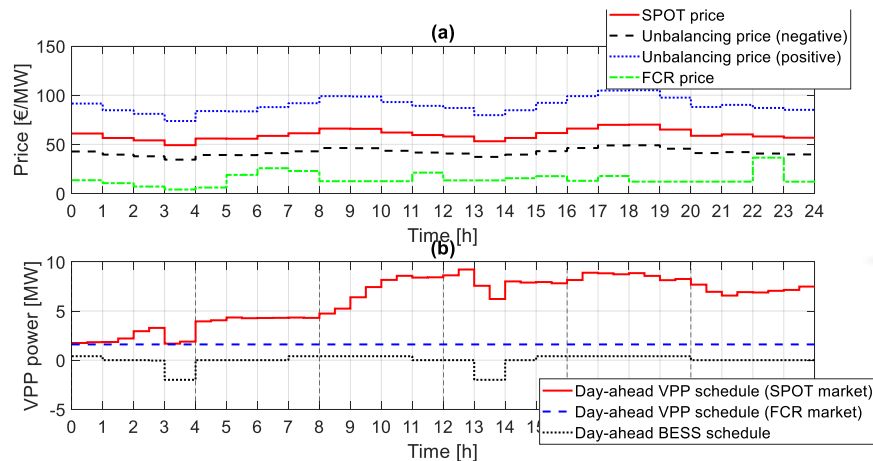# COMPETITIVE STORAGE PROJECTS TODAY ARE OFTEN THE RESULTS OF MULTI-SERVICE APPROACH (1/2)

Example 1
Behind the meter battery
FCR + Peak Shaving
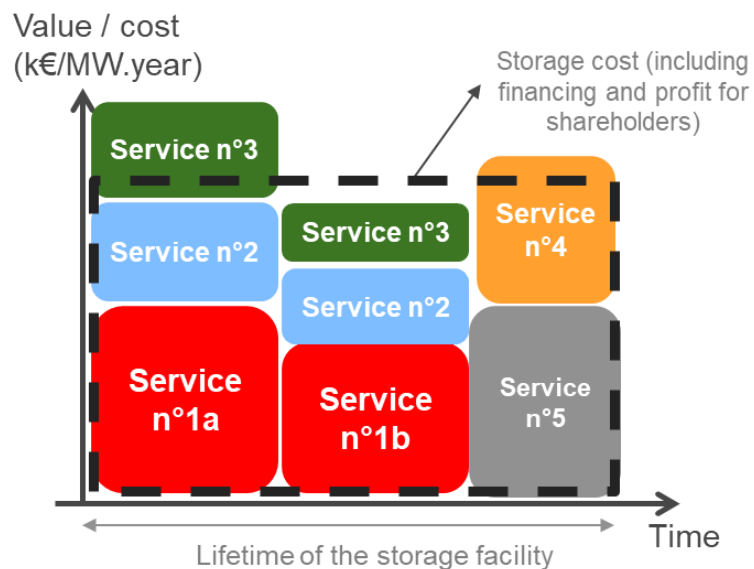

Example 2
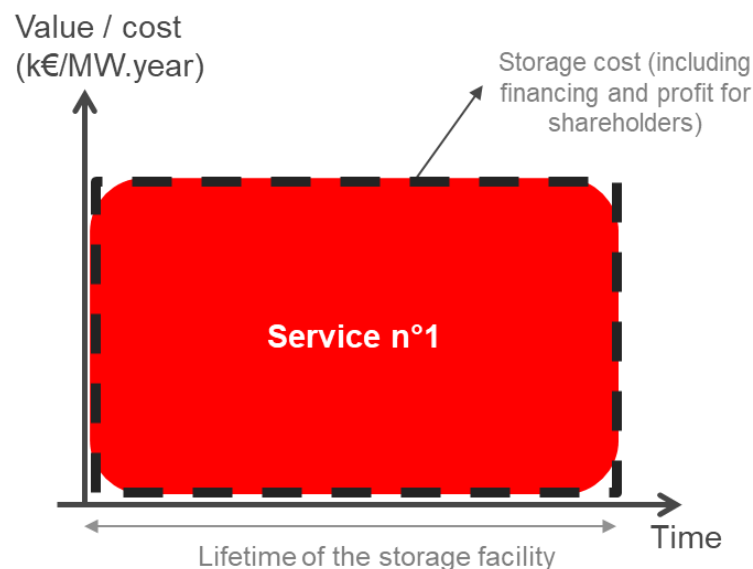VPP (ENR + Battery)
FCR + Spot

Source

EU-**Sys**Flex

Other examples : V2G EVs, Short term PPA…

COMPETITIVE STORAGE PROJECTS TODAY ARE OFTEN THE RESULTS OF MULTI-SERVICE APPROACH (2/2)

In practice

Value / cost (k€/MW.year)

Storage cost (including financing and profit for shareholders)

Service n°3
Service n°2
Service n°3
Service n°4
Service n°2
Service n°1a
Service n°1b
Service n°5

Lifetime of the storage facility

Time

LCOS formula

Value / cost (k€/MW.year)

Storage cost (including financing and profit for shareholders)

Service n°1

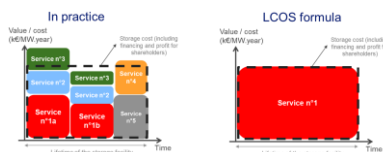Lifetime of the storage facility

Time

Valid for a fully defined PPA

CONCLUSION : WHAT TO TAKE FROM THE LCOS?

➢ The LCOS is an interesting indicator because it brings the storage **competitiveness** down to something **tangible**
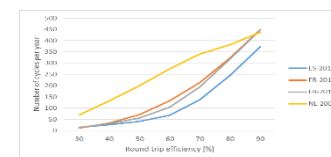
➢ Same as the LCOE, it **simplifies** some of the **cost-benefits elements** for storage assessments

➢ It is a good indicator for **microeconomic analysis** of competition between storage technologies but on a use case by use case approach and with a **dedicated method** for each use case and technology

➢ It should be used with **caution** to drive **policies**.

➢ It gives a **distorted view** of competitiveness of **market exposed assets**

THANK YOU

LCOS FORMULA

$$LCOS\left[\frac{€}{MWh}\right] = \frac{Capex + \sum_{y=1}^{L} \dfrac{Opex^y + \lambda^y V * \dfrac{1}{\rho}}{(1+i)^y}}{\sum_y^L \dfrac{V}{(1+i)^y}}$$

L: Lifetime [years]
λ^y: average charging price for year y [€/MWh]
V: yearly volume discharged [MWh]
ρ : round trip efficiency
i : actualisation rate

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