European Association for Storage of Energy

Energy Storage:
a Key Flexibility Resource

Patrick Clerens
Secretary General, EASE

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1. Introduction to EASE

European Association for Storage of Energy…

…is the European **voice** of the energy storage community

…advocates the **role of energy storage** as an indispensable instrument for the energy system

…supports a **sustainable**, **flexible** and **stable** energy system

…**shares** and **disseminates** information

Strategic objectives:

1. Promotion of the role and benefits of energy storage
2. Fair market design for energy storage
3. Promotion of funding for Energy Storage (mainly RD&D)

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1. Introduction to EASE

EASE Members

ALABC
BASF The Chemical Company
BOSCH Invented for life
BSEF The International Bromine Council
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CENER
circe
cobra
DBE
DNV·GL
DTU
EDF
enel
ENGIE
EXIDE TECHNOLOGIES
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Gaelectric
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Mitsubishi Hitachi Power Systems Europe
Naturgy
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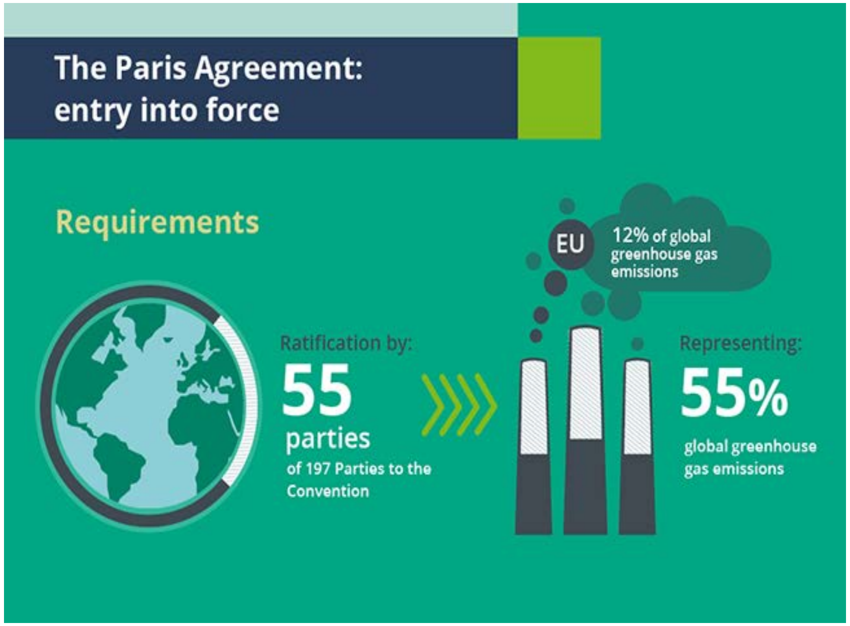
PGE Energia Odnawialna S.A.
Red Eléctrica de España
Rte
S&C
saft
seas-nve
SIEMENS
storengy
Terna
TNO innovation for life
uniper
VOITH

2. Why Do We Need Storage?

Paris Agreement and Decarbonisation Goals

- At the Paris climate conference (COP21) in December 2015, 195 countries adopted the first-ever universal, legally binding global climate deal.
- The agreement sets out a global action plan to put the world on track to avoid dangerous climate change by **limiting global warming to well below 2°C.**

➢ **The Paris Agreement will have long-term effects on governments, citizens and companies.**



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2. Why Do We Need Storage?

Decarbonisation and the Energy Union – Example: Germany

Maximum peak demand

RES installed capacity needed to cover peak demand

Source: German TSOs (2016)

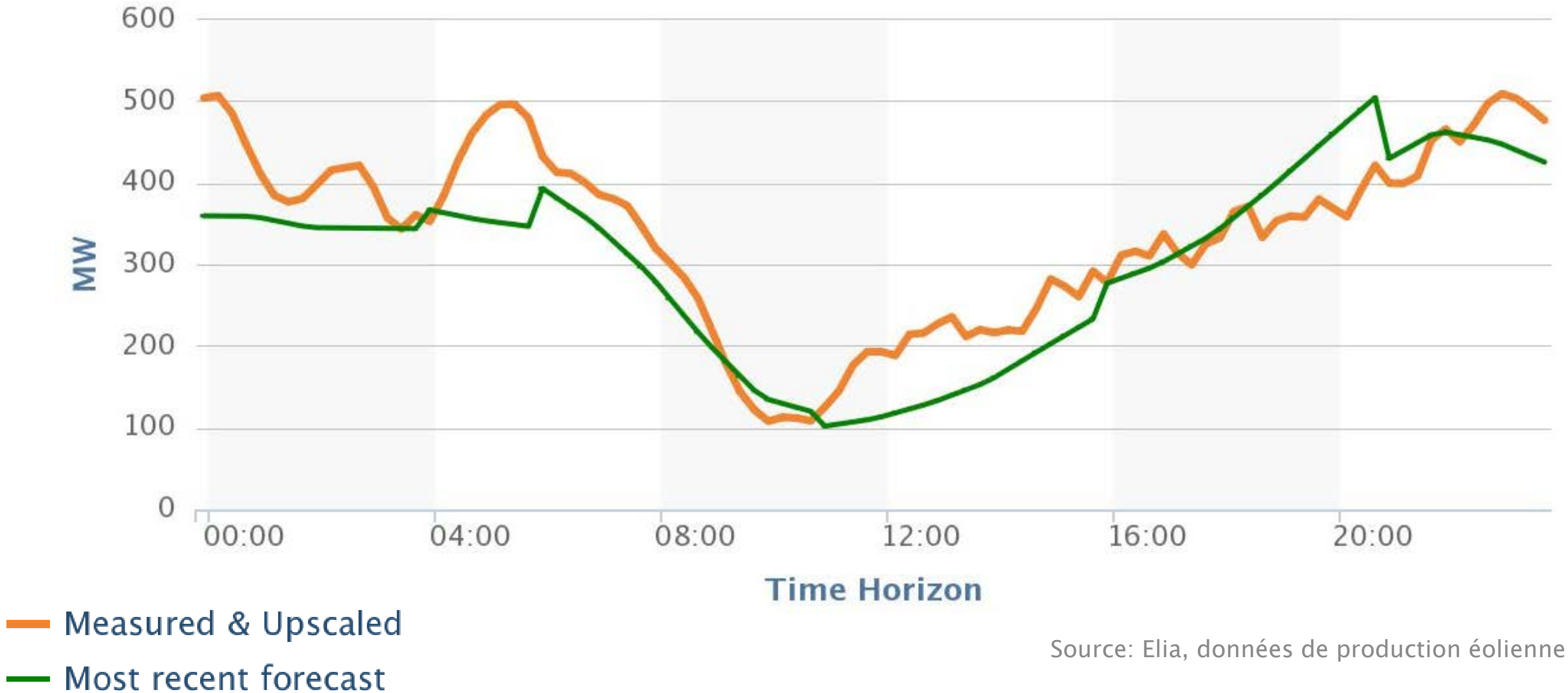
Source: Sachverständigenrat für Umweltfragen (SRU): Wege zur 100% erneuerbaren Stromversorgung.

How to maximise the use of RES to meet EU decarbonisation goals?

2. Why Do We Need Storage?

Balancing Generation and Consumption at all Times

Belgian Wind Power Forecasting – 02.09.2018



Source: Elia, données de production éolienne

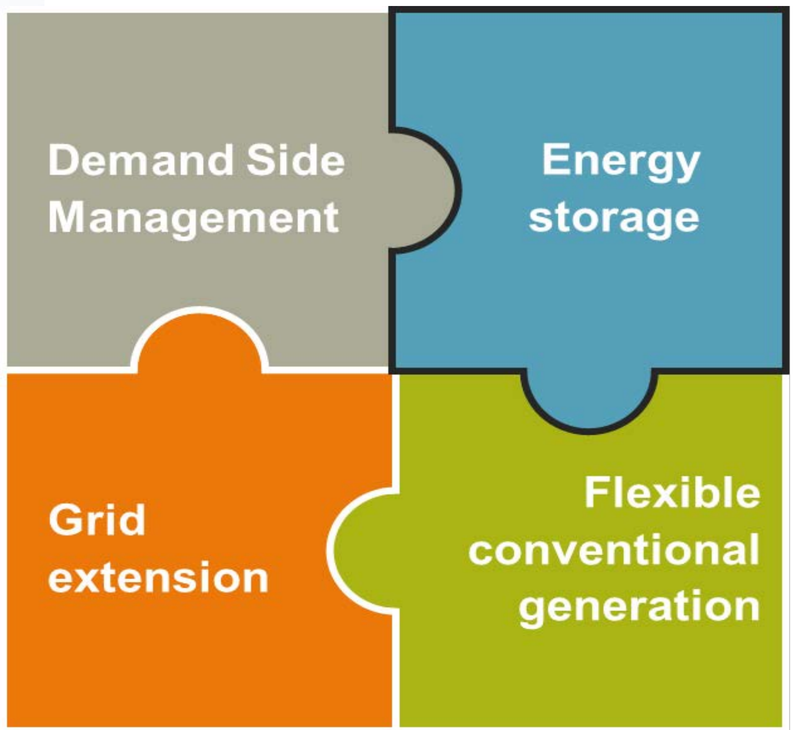
This challenge becomes more difficult the more variable renewables (vRES) you have in the system.

2. Why Do We Need Storage?

Available Flexibility Options to Integrate Variable Renewables

Uncertainties about practicability…has yet to demonstrate full potential

Social acceptance becoming increasingly limited



Many available technologies, value for host of different applications and locations.

Concerns about the environmental impacts and sustainability

3. Technologies and Applications

Many Energy Storage Technologies on the Market and in R&D

Chemical

- Ammonia
- Drop-in Fuels
- Hydrogen
- Methanol
- Synthetic Fuels
- Synthetic Natural Gas

Electrochemical

- Classic Batteries
  - Lead Acid
  - Li-Ion
  - Li-Polymer
  - Li-S
  - Metal Air
  - Na-Ion
  - Na-NiCl$_2$
  - Na-S
  - Ni-Cd
  - Ni-MH
- Flow Batteries
  - Vanadium Red-Ox
  - Zn-Br
  - Zn-Fe
- Hybrid Supercapacitors

Electrical

- Supercapacitors
- Superconducting Magnetic ES (SMES)

Mechanical

- Adiabatic Compressed Air
- Diabatic Compressed Air
- Liquid Air Energy Storage
- Flywheels
- Pumped Hydro

Thermal

- Latent Heat Storage
- Sensible Heat Storage
- Thermochemical Storage

3. Technologies and Applications

Energy Storage can provide many valuable services across the energy system.

Conventional Generation	Transmission	Distribution	Customers Services
Black start	Participation to the primary frequency control	Capacity support	End-user peak shaving
Arbitrage	Participation to the secondary frequency control	Dynamic, local voltage control	Time-of-use energy cost management
Support to conventional generation	Participation to the tertiary frequency control	Contingency grid support	Particular requirements in power quality
Renewable Generation	Improvement of the frequency stability of weak grids	Intentional islanding	Continuity of energy supply
Distributed generation flexibility	Investment deferral	Reactive power compensation	Limitation of upstream disturbances
Capacity firming	Participation to angular stability	Distribution power quality	Compensation of the reactive power
Limitation of upstream perturbations		Limitation of upstream perturbations	
Curtailment minimisation			

3. Technologies and Applications

Short-term energy storage applications

Today, there are many short-term (second-minutes) energy storage applications for reserve services and frequency regulation:

- **Enhanced frequency response (UK):** providing frequency response in one second or less
- **Frequency containment reserve (EU):** increasing/decreasing power output at very short notice, within 0 to 30 seconds
- **Synthetic inertia:** inertia-like response via super fast active (milliseconds) power injection and import → This is increasingly being considered across Europe

➢ Many of these shorter-term services are tendered on the market.

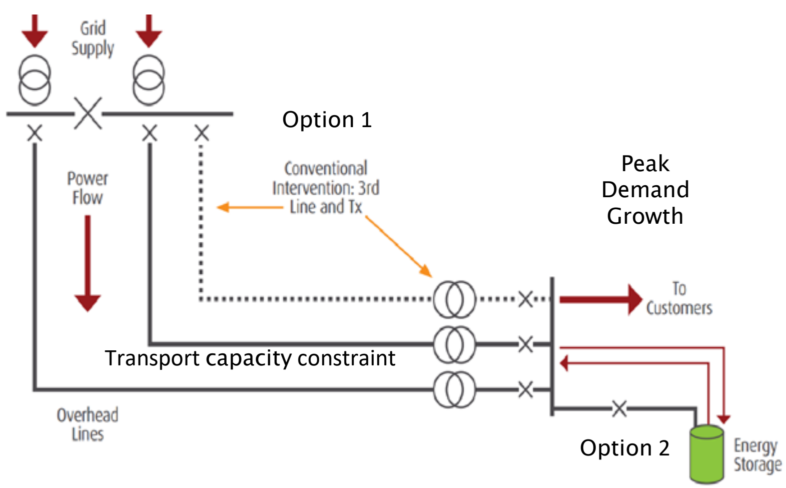
➢ More needs to be done to clarify possibilities to stack multiple services on one device, allow for long-term contracts, clarify TSO/DSO ownership for provision of infrastructure services.

Seconds and Minutes

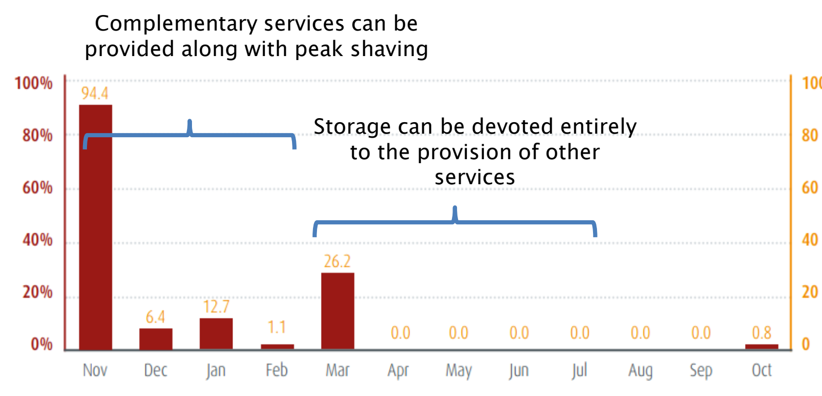
3. Technologies and Applications:

Network reinforcement deferral: peak demand growth triggers power network reinforcements

- Option 1: Traditional network reinforcement (overhead or underground power lines)
- Option 2: Energy storage can be used to provide security of supply when required while providing additional services to the TSO at other times



Energy capacity allocated to serve peak load at the Leighton Buzzard ESS



Source : UKPN, 2016. Successful Demonstrations of Storage Value Streams

Possible Technologies:

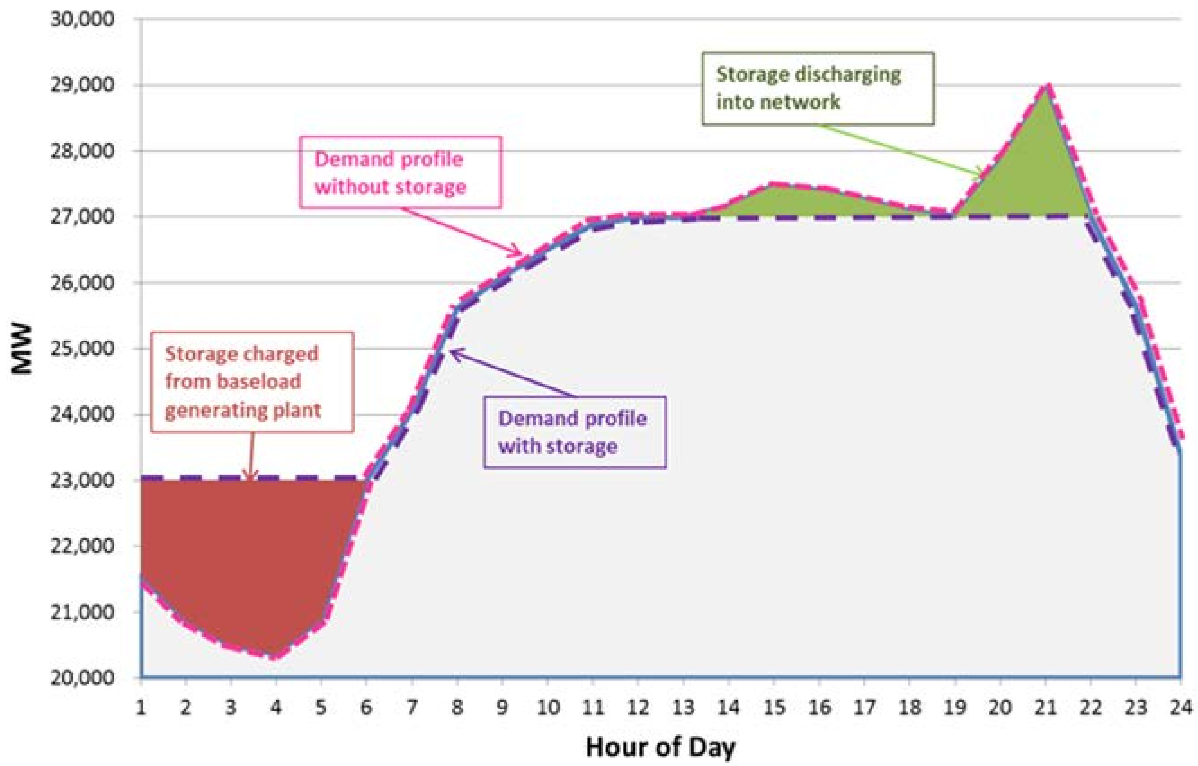
- Mechanical: Compressed Air Energy Storage, Liquid Air Energy Storage
- Electrochemical: Lead Acid, Li-Ion, NaS, Flow batteries

3. Technologies and Applications

Balancing

Possible Technologies:

- Mechanical: Compressed Air Energy Storage (CAES), Liquid Air Energy Storage (LAES), Pumped Hydro Storage
- Electrochemical: e.g. Lead Acid, Li-ion, NaS, Flow batteries (e.g. Vanadium, Zinc-Bromine)

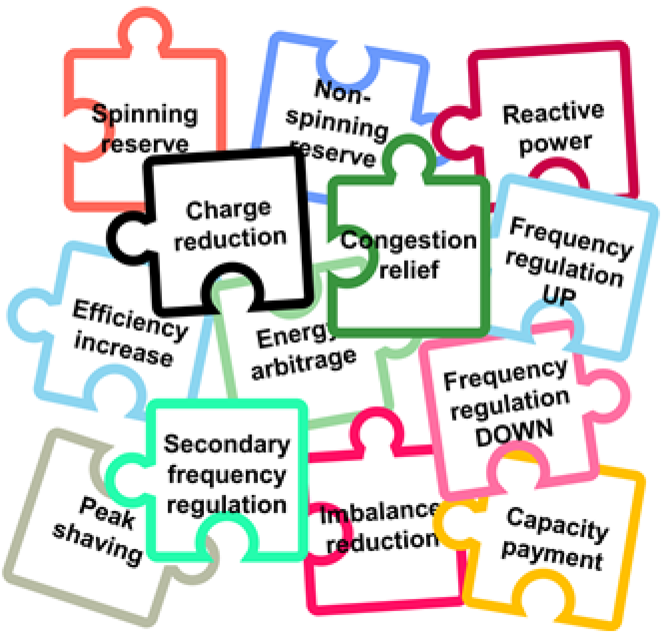


Source : http://energyclub.stanford.edu/wp-content/uploads/2013/06/kavousian-3.png

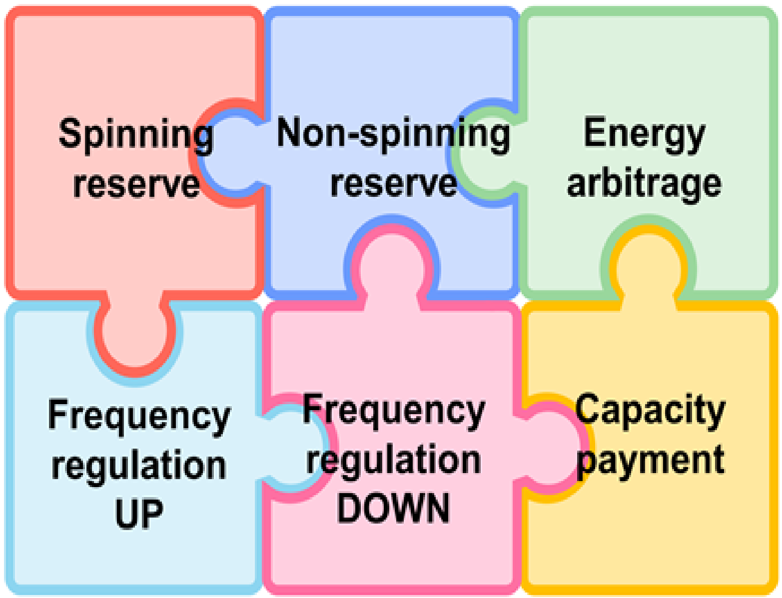
4. EU Energy Storage Policy

Importance of Revenue Stacking

Applications and revenues



Applications by ESS in California



Source: ENEL – EASE Investor Workshop 2017

- Energy storage technologies have multiple applications and can derive revenue from multiple stacked revenue streams.
- **To implement multi-service business cases, it is paramount to allow storage to provide all services it can deliver and to allow revenue stacking**

4. EU Energy Storage Policy

Example: use of a Li-Ion ESS in Ireland 1/3

- **Li-Ion Energy Storage System (ESS)**:
  - Energy: 55 MWh or 5*11 MWh
  - Power: 100 MW or 5*20 MW
- **Services provided by ESS**:
  - Ancillary services: operating reserves (POR, SOR & TOR)
  - Capacity services
- **4 scenarios were considered to calculate the total cost of such ESS** :

Scenario A	Scenario B	Scenario C	Scenario D
Historical Reference Price	High End of the Current Price Range	Low End of the Current Price Range	Indicator of Near Future Price
€2.0 Million/MWh	€1.5 Million/MWh	€1.0 Million/MWh	€0.75 Million/MWh

Source: Financial Viability of Lithium-Ion Based Energy Storage Systems for Ancillary Services in the Secondary Market, Jason Omer, 2015
POR: Primary Operating Reserve
SOR: Secondary Operating Reserve
TOR: Tertiary Operating Reserve

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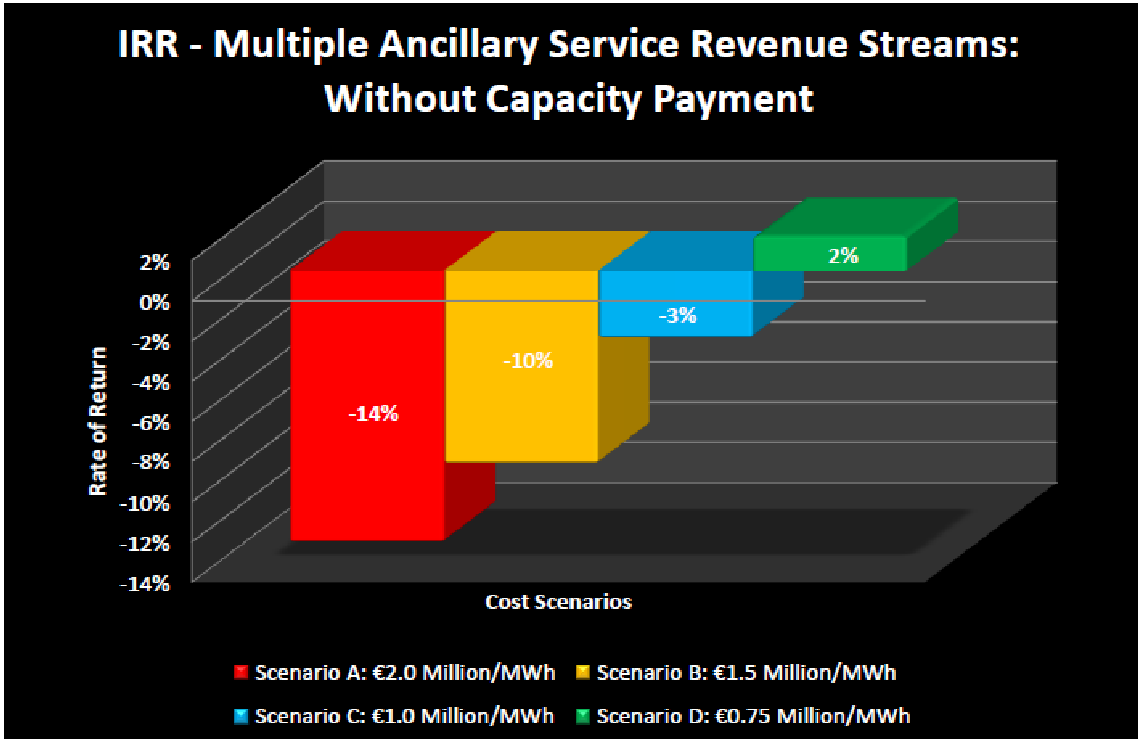
4. EU Energy Storage Policy

Example: use of a Li-Ion ESS in Ireland 2/3

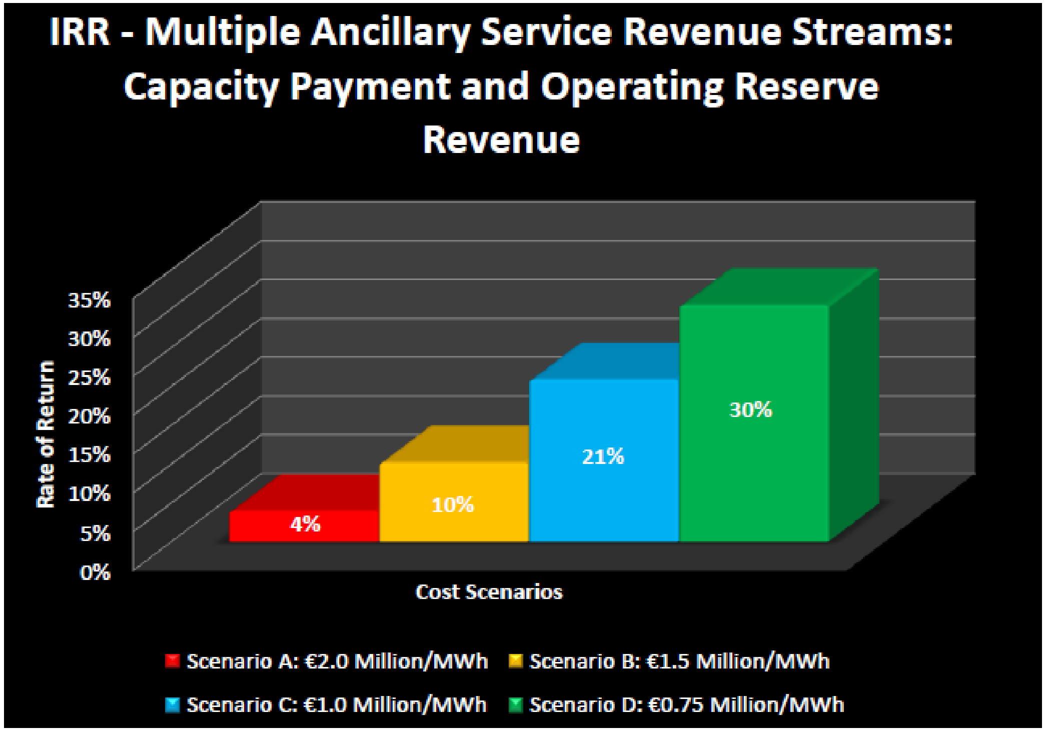


- Profitability analysis for the ESS providing a single service to the market.

Source: Financial Viability of Lithium-Ion Based Energy Storage Systems for Ancillary Services in the Secondary Market, Jason Omer, 2015

4. EU Energy Storage Policy

Example: use of a Li-Ion ESS in Ireland 3/3



- Profitability analysis for the ESS providing several services to the market
- **Revenue stacking is crucial for the profitability of storage projects**

Source: Financial Viability of Lithium-Ion Based Energy Storage Systems for Ancillary Services in the Secondary Market, Jason Omer, 2015

4. EU Energy Storage Policy

Multi-Service Business Cases

- The EU institutions are currently clarifying the framework under which regulated entities could own, develop, manage and operate energy storage facilities (Articles 36 and 54 of the recast Electricity Directive):
  - Council: derogation for energy storage facilities “which are fully integrated network components”
  - Parliament: exception for the operation of energy storage facilities for “local short-term control of the distribution system”
- It appears that regulated entities will be allowed to own, manage and operate storage facilities in specific, non-market cases
- Therefore it is crucial to explore different ways to maximise the value of the storage facility when a regulated entity will have been allowed to build it, e.g. by looking into multi-service business cases

Multi-service business cases see a regulated entity share operation and/or ownership of one energy storage device with a non-regulated entity

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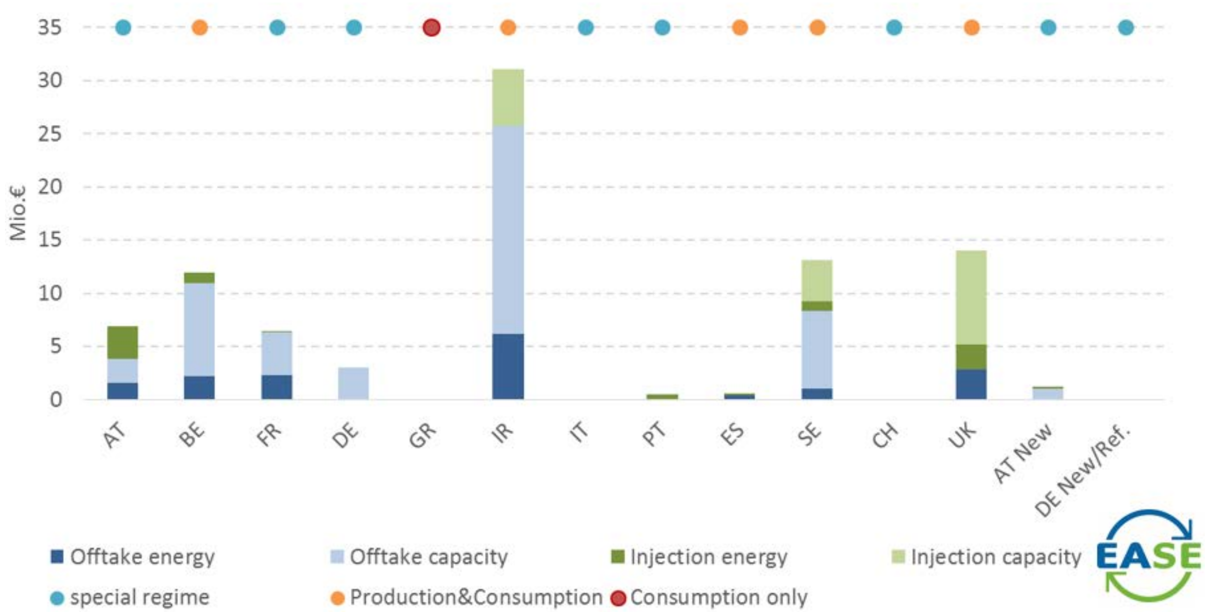
4. EU Energy Storage Policy

Example: Grid Fees for Energy Storage Systems

Indicative grid charges for a fictive large-scale PHS plant



Source: EASE Position on Energy Storage Deployment Hampered by Grid Charges, 2017
PHS: Pumped Hydro Storage

- **Significant variance between countries creates distortions** in cross-border energy trade: investment in PHS plants not only depends on where they are most needed, but also where grid costs are lower.
- EASE calls for a joint EU approach to grid charges, taking into account the contributions of energy storage to grid stability.

CONTACT DETAILS

EASE – European Association for Storage of Energy

Avenue Adolphe Lacomblé 59/8

BE – 1030 Brussels

Tel: +32 2 743 29 82 | Fax: +32 2 743 29 90

@EASE_ES

info@ease-storage.eu

www.ease-storage.eu

Secretary General: Patrick Clerens

Senior Policy Officer: Brittney Elzarei

Policy Officer: Marine Delhommeau

Communications Officer: Doriana Forleo

Project Officer: Emin Aliyev

Technical Advisor: Jean-Michel Durand

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