Facilitating grid integration of offshore renewables in the North Sea Region

Dr. Irina Temiz,
Dep. Electrical Engineering, Uppsala University
2025-09-24

Outline

- OASIS: aim and use cases
- North Sea offshore wind energy outlook
- Energy storage applications
- Current state-of-the-art

UPPSALA
UNIVERSITET

OASIS

- **OASIS**: Offshore Accelerator for System Integration and Storage
- Aim:

  Improve the capacity of SMEs developing innovative offshore system integration and energy storage solutions in the North Sea Region to contribute to the sustainable growth of the offshore wind industry
- Dep of Electrical Engineering & Dep of Chemistry – Ångström

UPPSALA
UNIVERSITET

OASIS use cases

Offshore Wind Parks

- Flexibility enabled by energy storage assets behind the meter
- Energy storage assests for improved grid integration
- Electricity or hydrogen at sea

Offshore Transmission Hubs

- Offshore-to-X: optimization beyond the electricity markets
- Grid stability and ancillary services
- Energy arbitrage

Harbors

- Electrical ships or their stopover in the harbour
- Hydrogen production, storage, and delivery
- Electrification of crane operations

https://www.interregnorthsea.eu/oasis

UPPSALA UNIVERSITET

North Sea offshore wind energy outlook

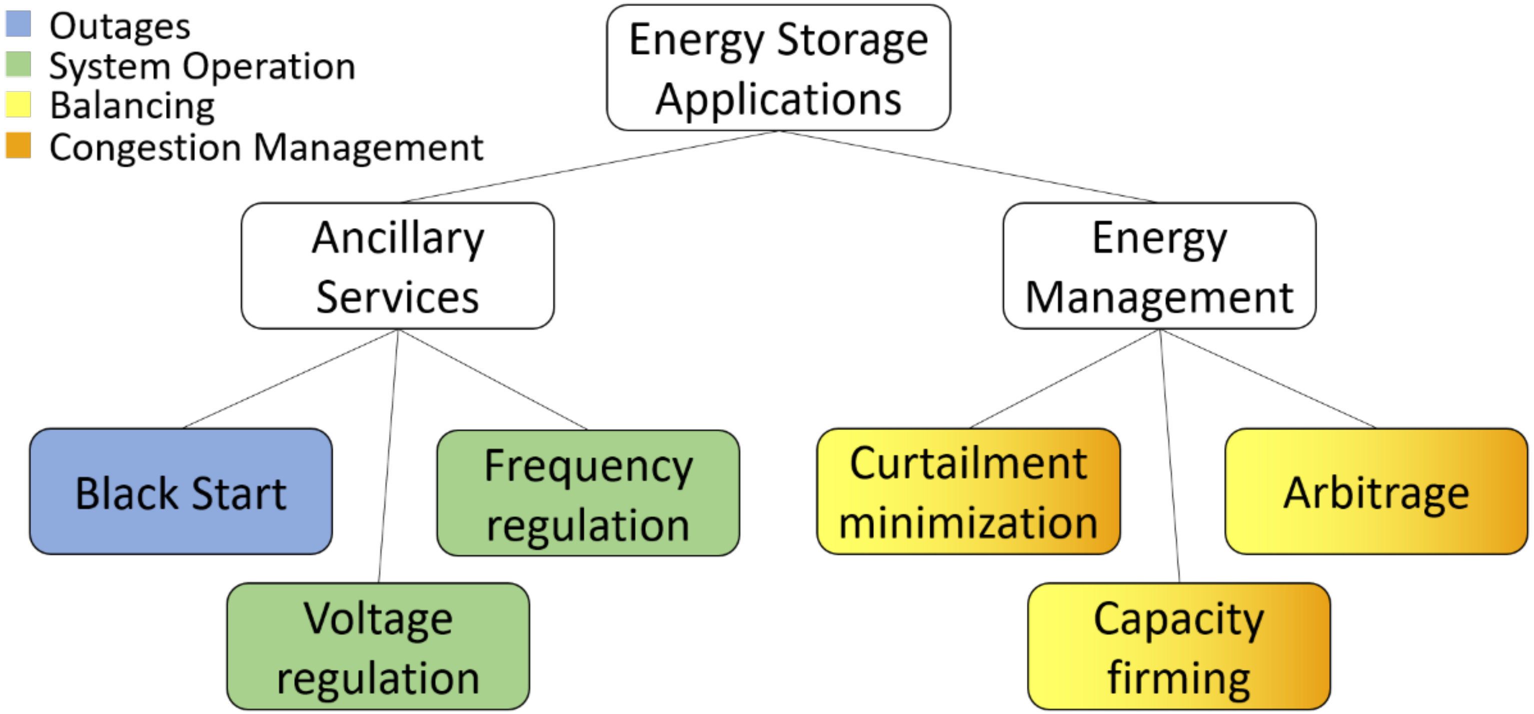
Offshore wind

- Belgium: 2.3GW in 2020 -> 5.8GW by 2030
- Denmark: 2.3GW in 2022 + 6GW by 2030
- France: 1.5GW in 2024+ 3.8GW by 2030
- Netherlands: 3GW in 2022 ->21GW by 2030
- Germany: 8.9GW in 2024 -> 30GW by 2030 -> 40GW by 2035 -> 70GW by 2045
- United Kingdom: 11GW in 2022 -> 50GW by 2030
- Norway: 5.9MW in 2022 + 30GW (year?)
- Sweden: 200MW in 2024, 13 Baltic offshore wind park projects terminated

INTERMITTENCY **FLEXIBILITY**

CURTAILMENT **CONGESTION**

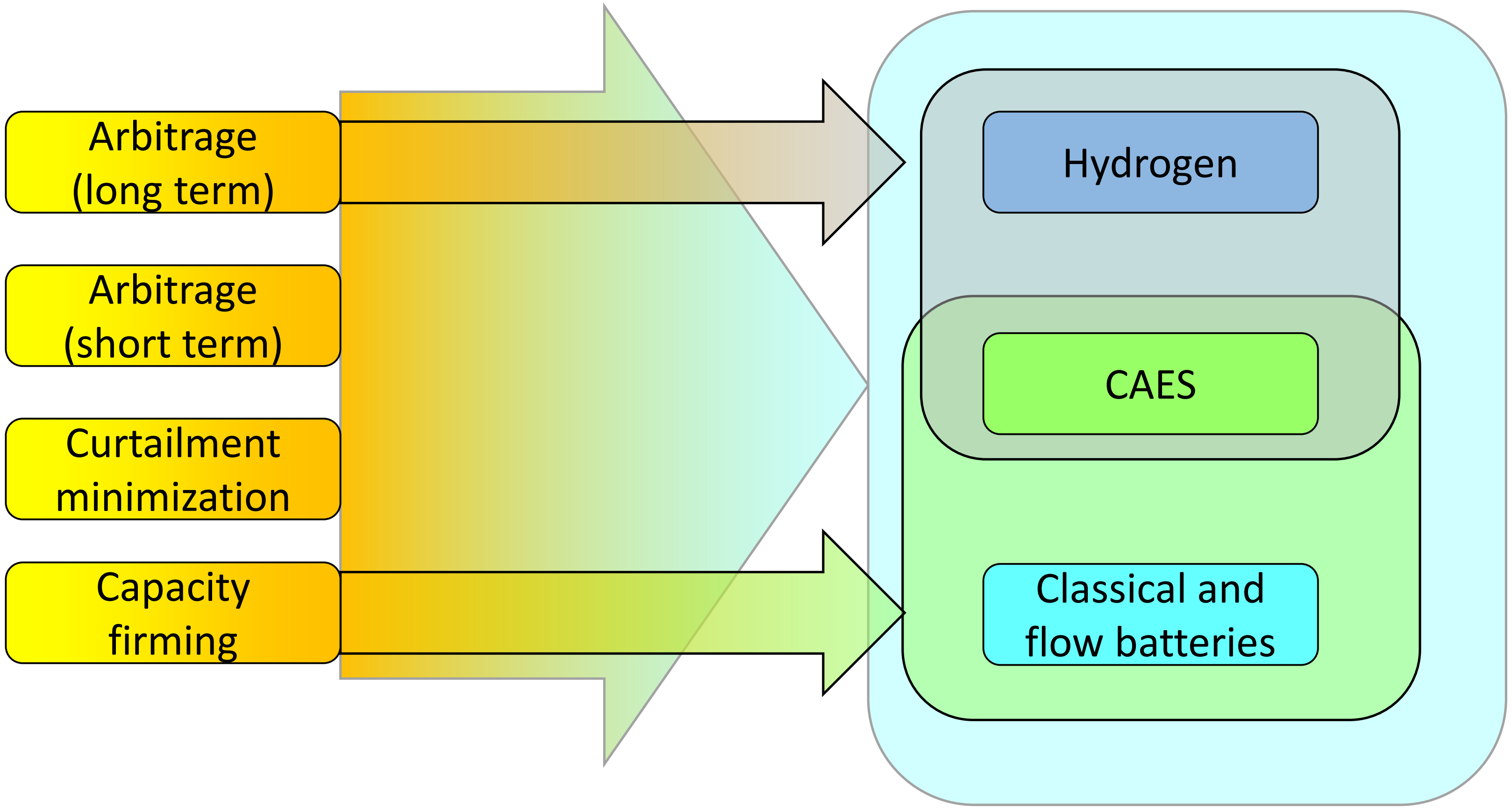
Energy storage applications



Classification of energy storage applications in relation to grid services in a grid with a large share of VRE.*

Based on: S. Sahoo and P. Timmann, "Energy Storage Technologies for Modern Power Systems: A Detailed Analysis of Functionalities, Potentials, and Impacts," (2023).

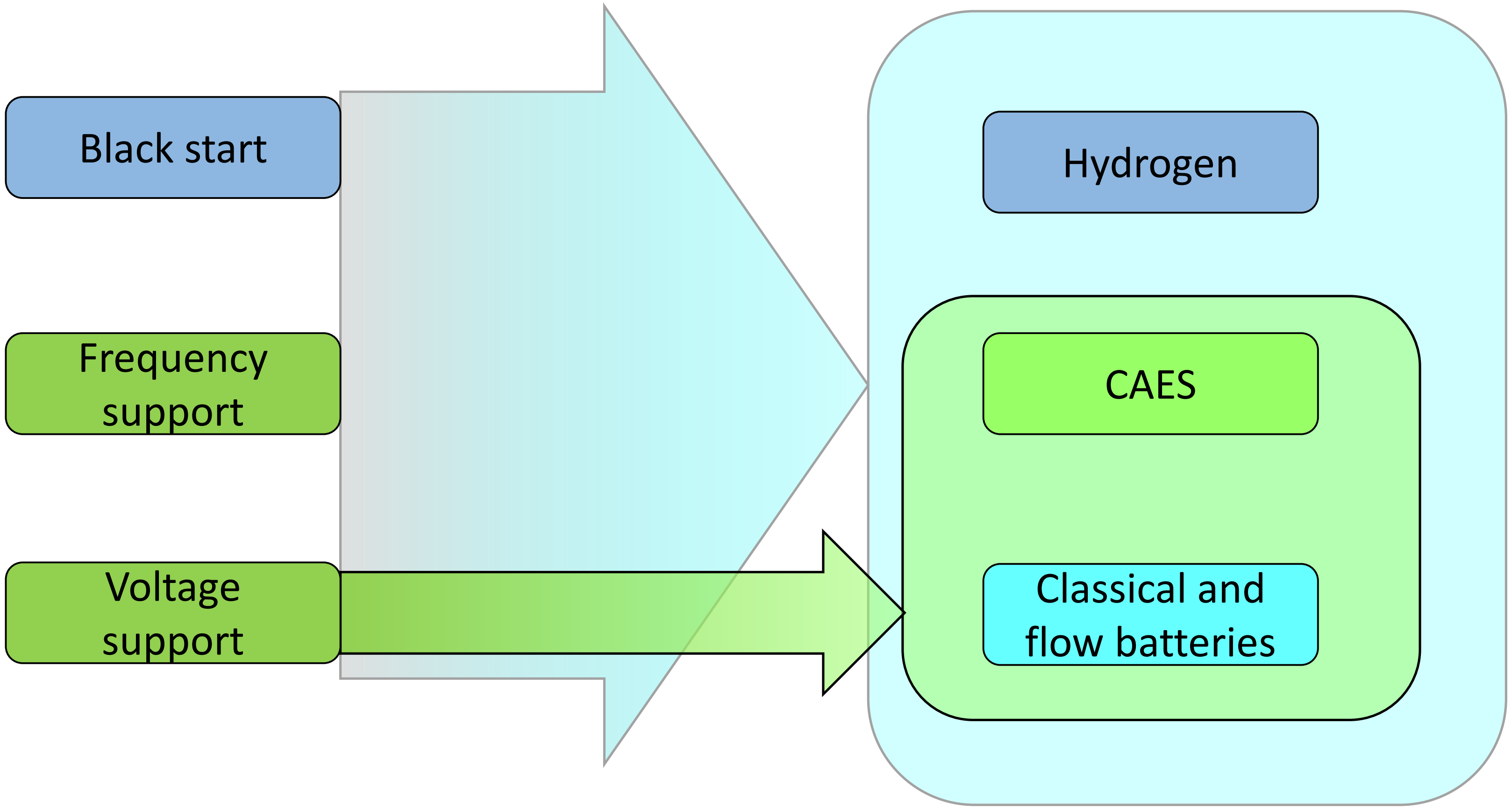
Energy management



CAES = Compressed air energy storage

EASE: https://ease-storage.eu/wp-content/uploads/2020/11/Services-to-Generation_Bulk-Storage.pdf

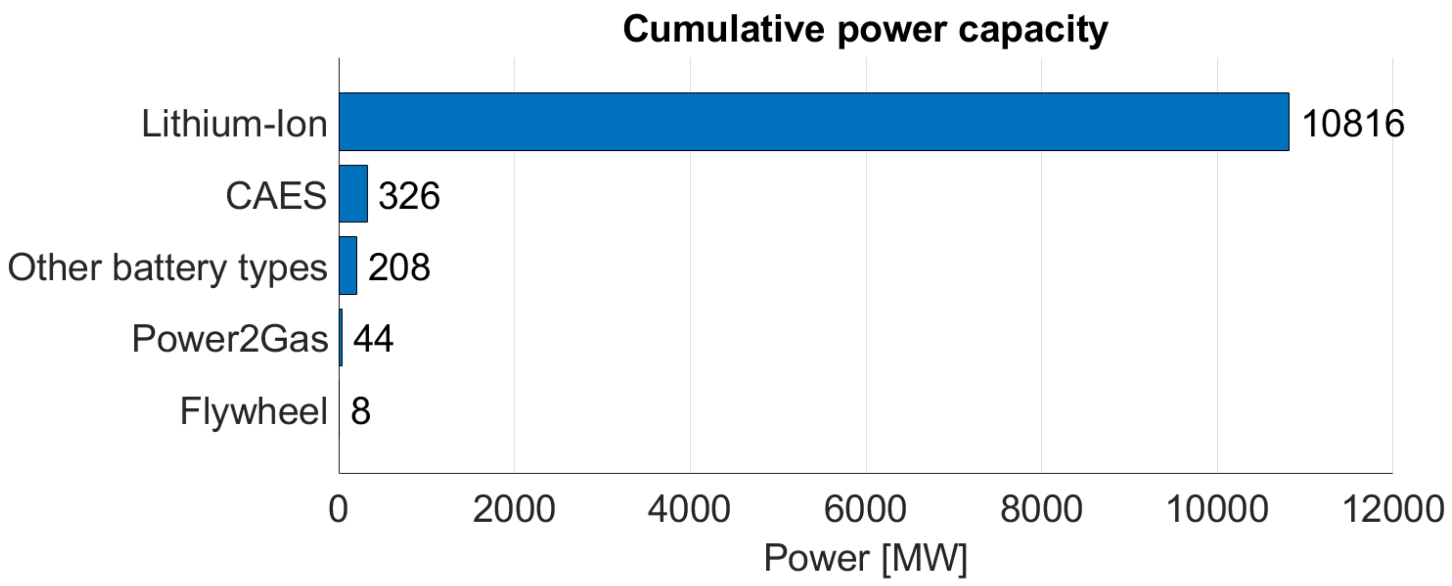
Ancillary services



CAES = Compressed air energy storage

EASE: https://ease-storage.eu/wp-content/uploads/2021/08/Ancillary-Services.pdf

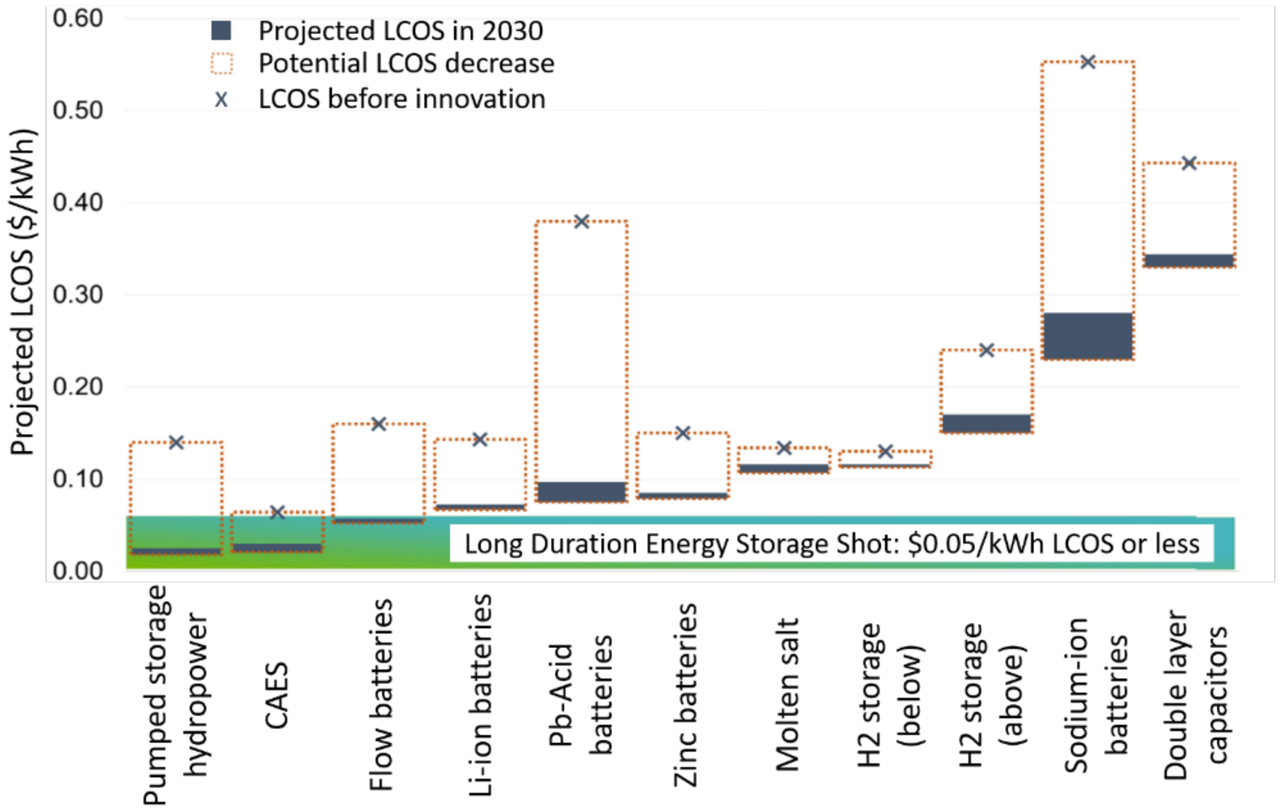
Energy storage technologies



Different energy storage systems installed in Europe, showing their cumulative power capacity. https://ses.jrc.ec.europa.eu/storage-inventory

UPPSALA UNIVERSITET

Energy storage technologies



Impact of innovations on the storage costs with respect to current projected LCOS level.*

*Office of Electricity, "Achieving the Promise of Low-Cost Long Duration Energy Storage," 2024.

UPPSALA UNIVERSITET

Conclusions

- Large offshore wind installations
- Challenges: intermittency, curtailment, flexibility and reliability
- Commercially viable solutions: Li-ion, CAES, pumped hydro-storage
- Cost of ES needs to be taken down
- Location (onshore/offshore) is an open question

Thank you for attention

UPPSALA UNIVERSITET