



LAES Fit for a Renewable World

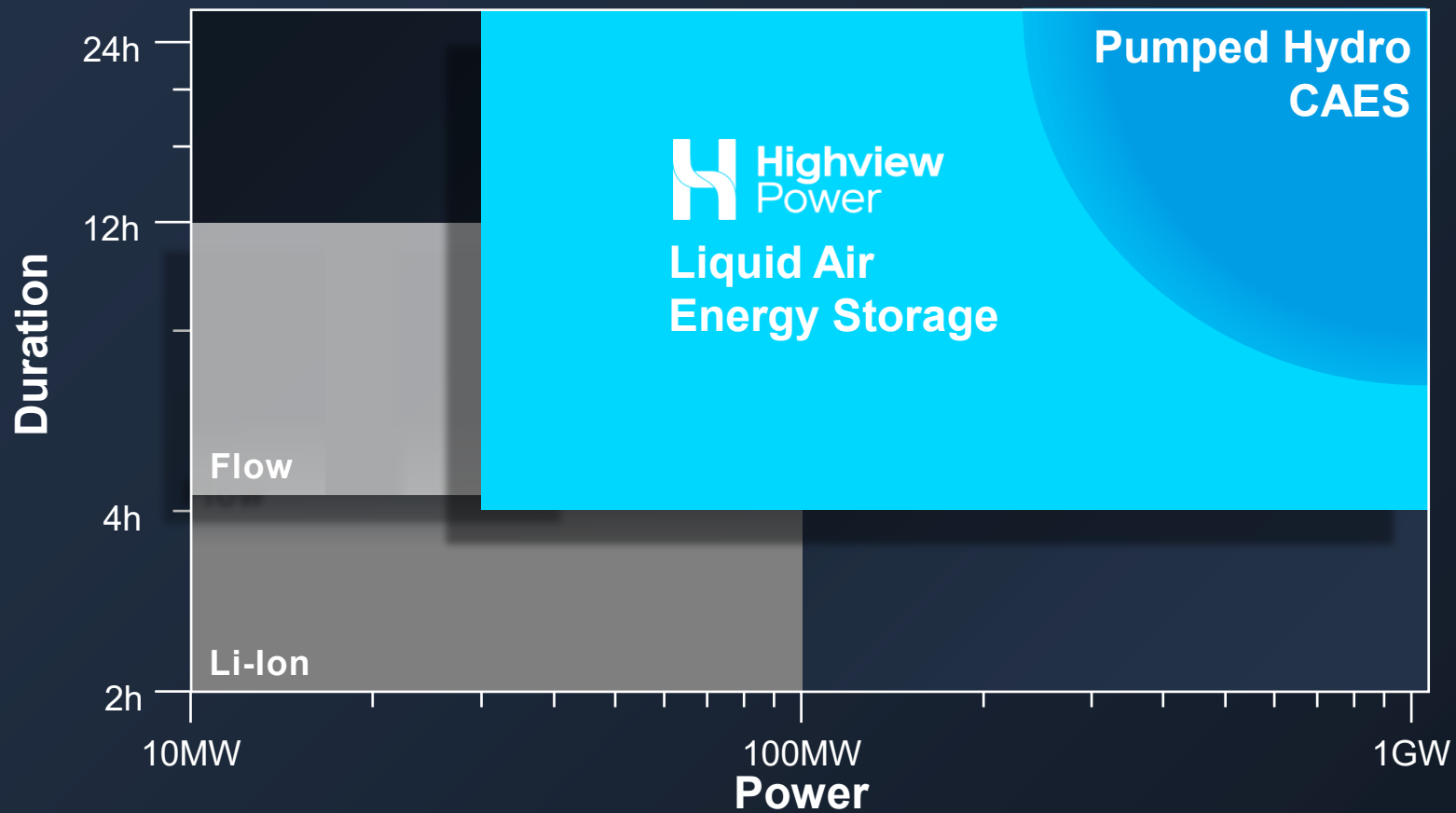
IMechE 17th March 2022

Agenda

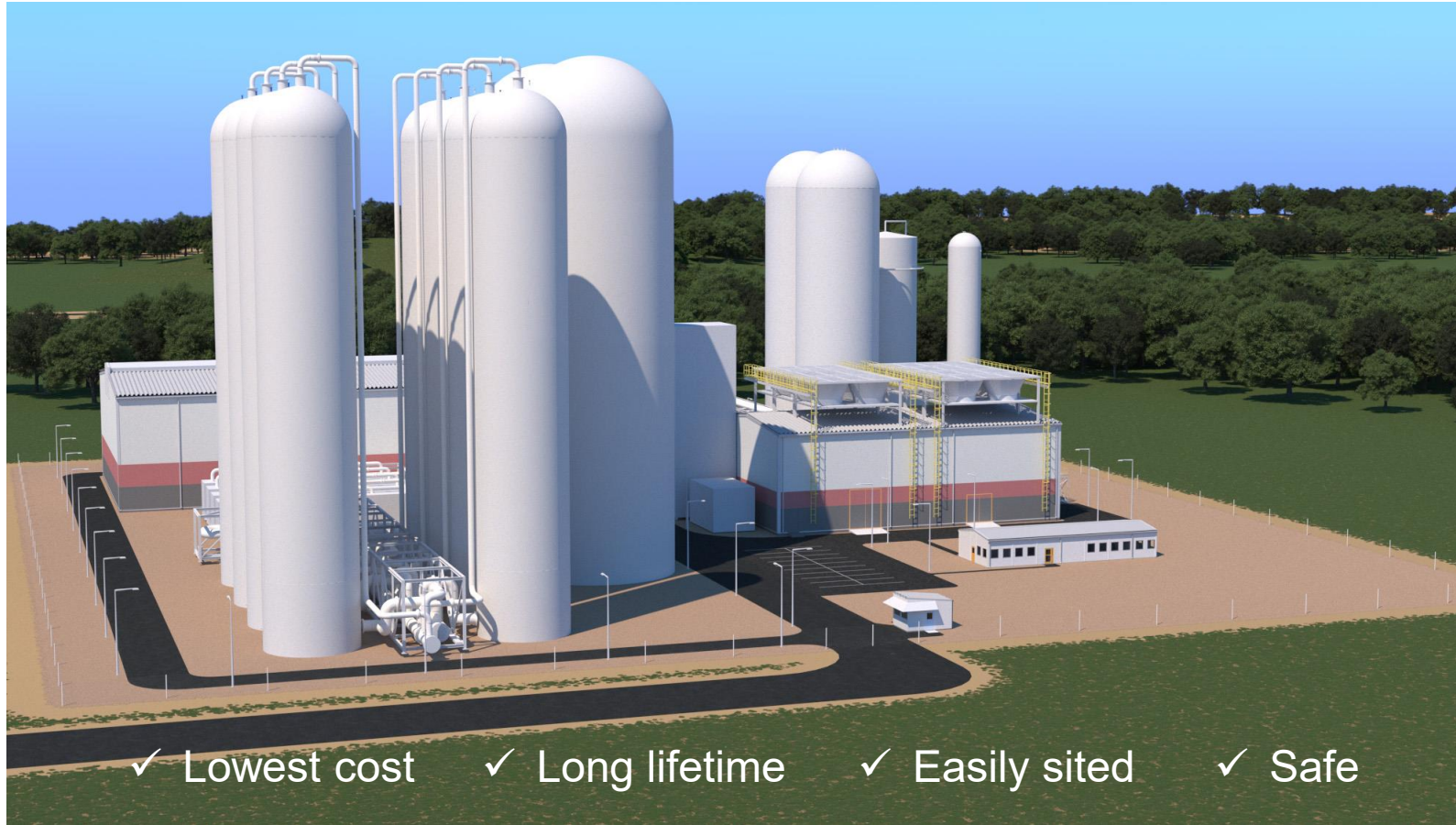
1. Brief Introduction to Highview Power
2. AC Transmission
3. AC Transmission Requirements during a Disturbance
4. Support of Asynchronous Generation and HVDC Interconnectors
5. Synchronous Storage for Black Start



Optimal Applications



Liquid Air Energy Storage



✓ Lowest cost ✓ Long lifetime ✓ Easily sited ✓ Safe

50 MW / 300 MWh

Release for Construction in Carrington.

Construction start **2020**

Planned COD **2023**



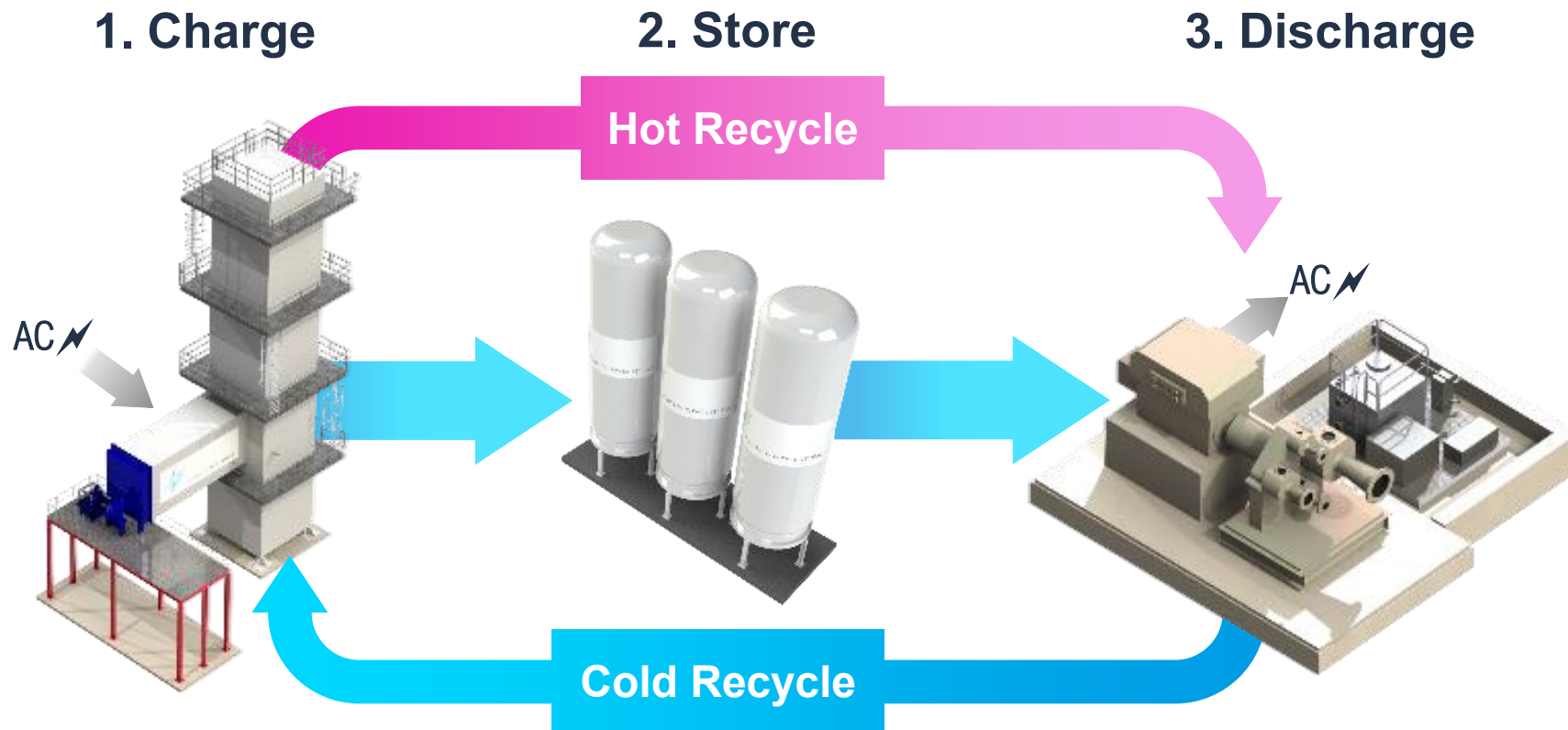
Demonstration
Manchester, UK
Commissioned in **2018**



Pilot
Heathrow, UK
Commissioned in **2011**



How Liquid Air Energy Storage Works



Additional **hot** and **cold** thermal recycling increases efficiency

Pillars of AC Transmission

Active Power (MW)

Synchronous and asynchronous generation

Consumed by load

Demand/generation equilibrium keeps frequency stable and within tolerance

Reactive Power (MVar)

Controls local voltage

Enables active power flow

Supply increases local voltage

Absorption decreases voltage

Inertia (MVAs)

Energy stored in the spinning mass of coupled generators

Slows the Rate of Change of Frequency (RoCoF)

Short Circuit Power (MVA)

Supplied by electro-magnetically coupled equipment

Required to ensure protection systems operate

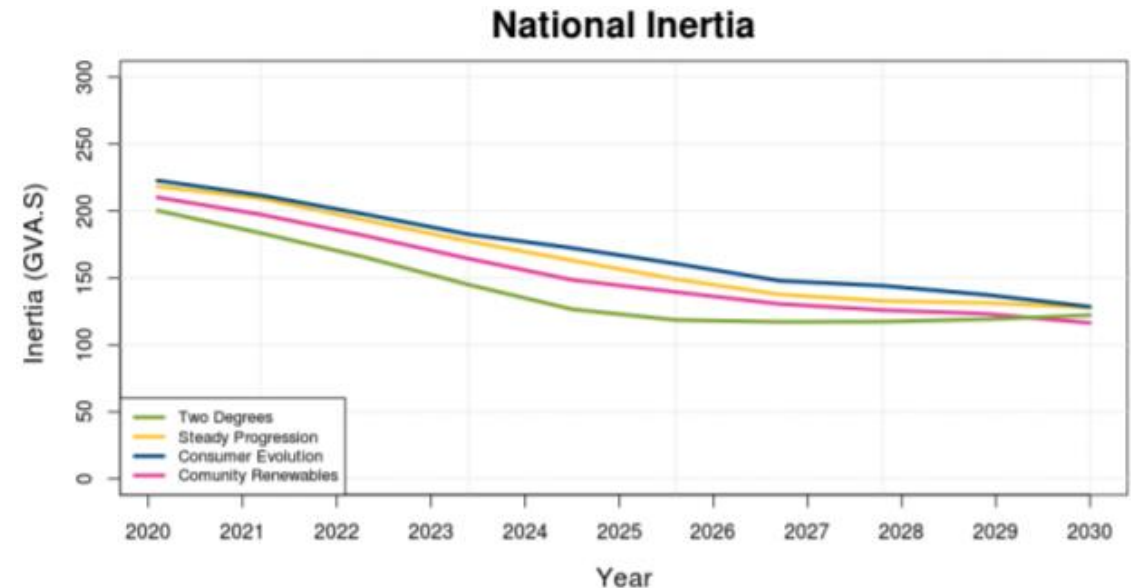
Short Circuit Levels indicate available Short Circuit Power and indicate system strength



Inertia during a System Disturbance

- The system must contain sufficient inertia to slow the rate of change of frequency and enable other systems to respond and measures to be taken in a timely manner.
- Should not be confused with synthetic inertia, inertia contribution is delayed by measurement, >80 milliseconds in some instances, upon which time the frequency could have deviated sufficiently to trigger frequency protection. (RoCoF/Vector Shift)

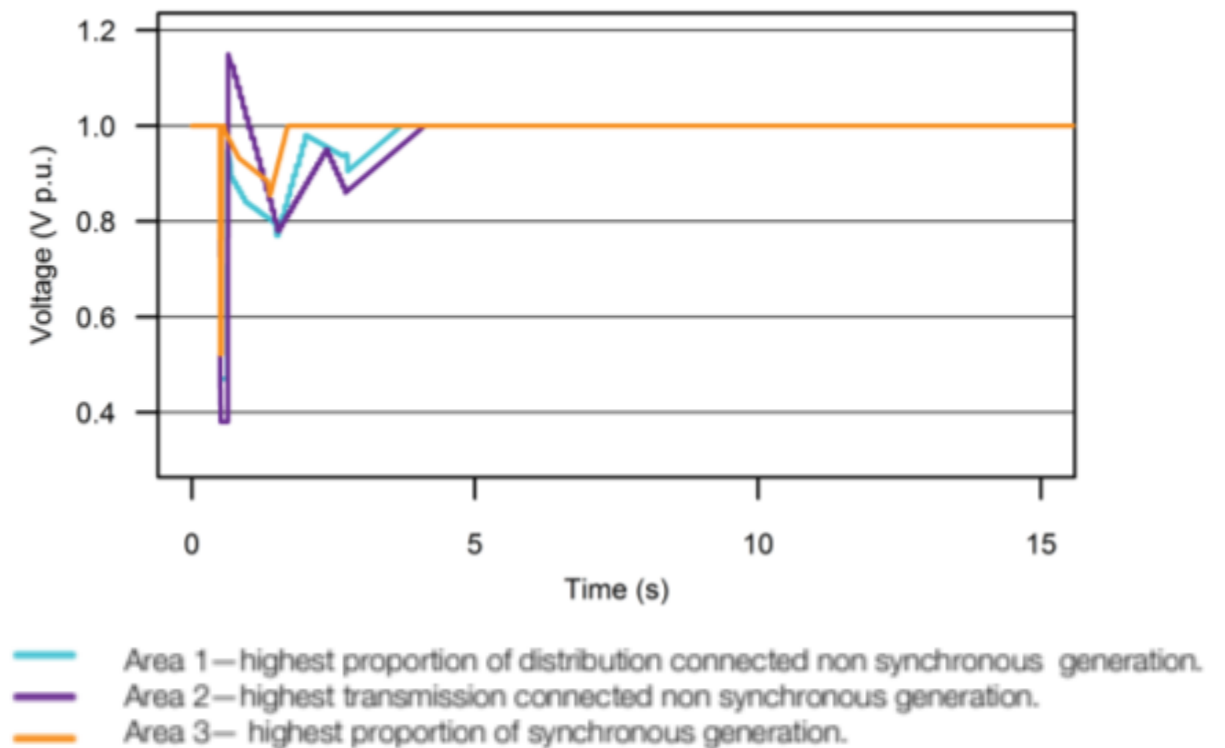
Declining Levels of Inertia (U.K.)



Dynamic Voltage Control during a System Disturbance

- The system requires instantaneous reactive power during and immediately following the fault, without the need for measurement.
- Synchronous generators and synchronous compensators can respond to changes in voltage level and provide reactive power immediately.
- Nonsynchronous technology requires measurement and cannot contribute during a short circuit and immediately after (<80 milliseconds)

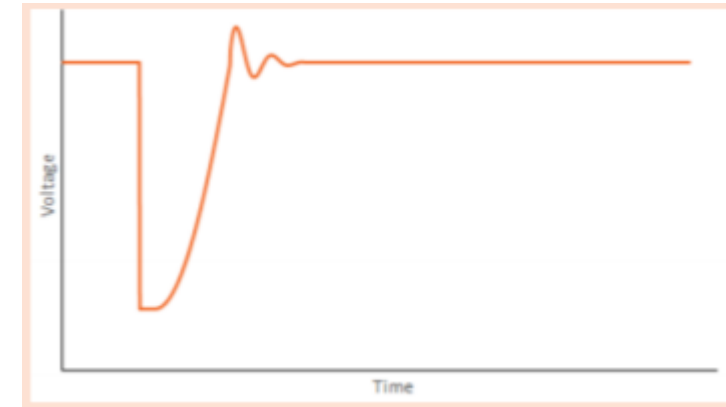
Recovery of Voltage Sync v Non-Sync



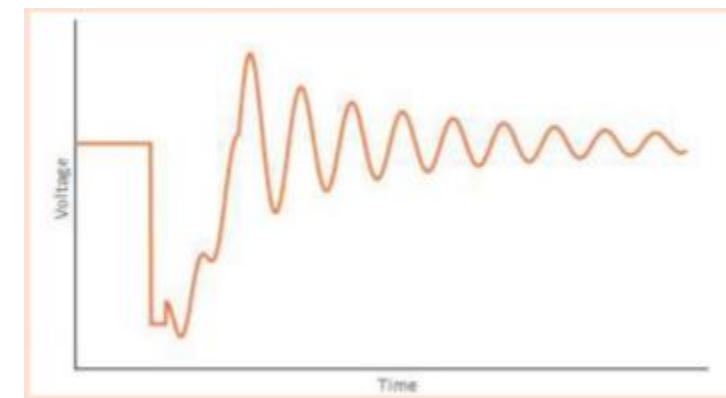
Short Circuit Power during a System Disturbance

- The system requires a significant availability of short circuit power (Short Circuit Level) so that faults can be located, and protection systems can operate in a timely manner (Strong System)
- Synchronous generation is the largest contributor to Short Circuit Levels.
- Voltage recovery is prolonged when Short Circuit Levels are low (Weak System), at significantly low levels voltage cannot recover.

Strong System



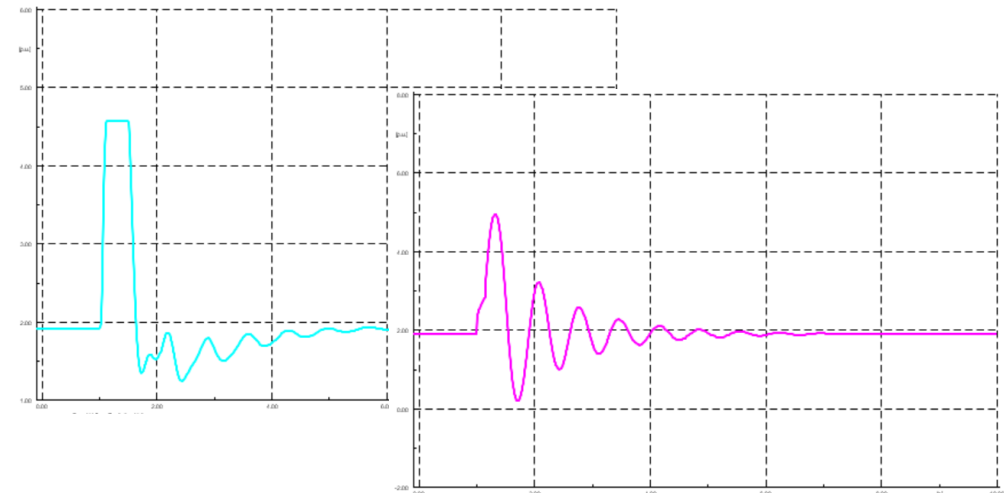
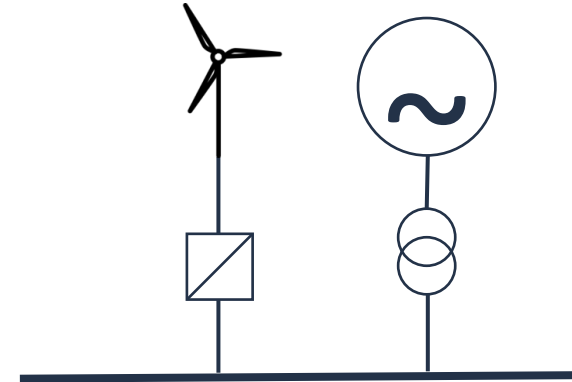
Weak System



Synchronous Generation Supporting Asynchronous Generation at the Point of Connection (POC)

Example: Wind

- Increased Short Circuit Level at the point of connection contributes to greater controller performance under short circuit conditions, when riding through the fault.
- Dynamic voltage support at the POC to support the active power flow from the Wind Farm during, and immediately after a disturbance.
- Synchronous storage can reinforce the POC as well as manage active power from intermittent sources.



Synchronous Generation Supporting HVDC Interconnectors

Critical Requirements

- Short Circuit Ratio (AC System Strength) is significant for HVDC system performance
 - Significant waveform disturbance during fault, reducing converter performance.
- Reactive Power Support
 - Commutation failure main cause of instability.
- Inertia (Low RoCoF)
 - Significant rate of change will operate protection.

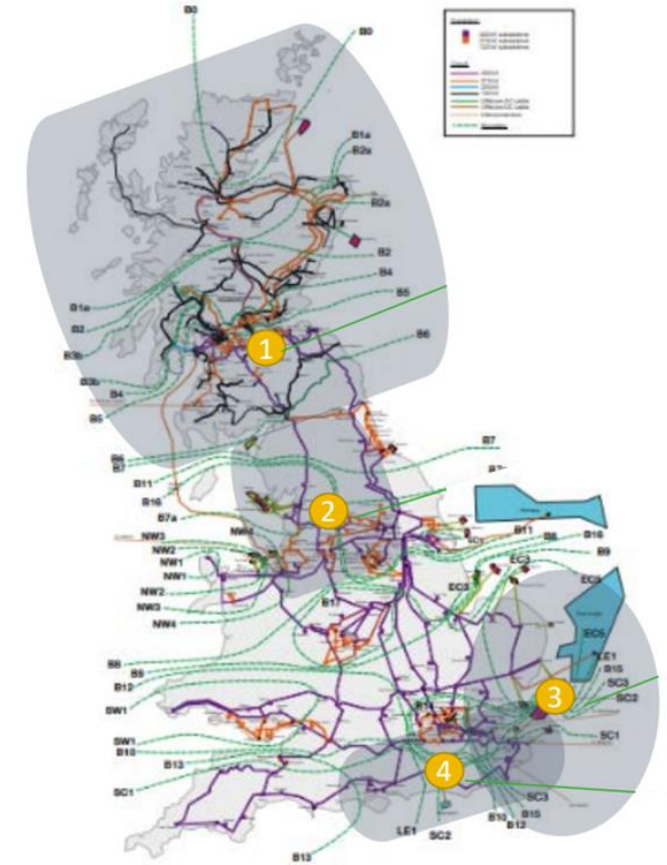
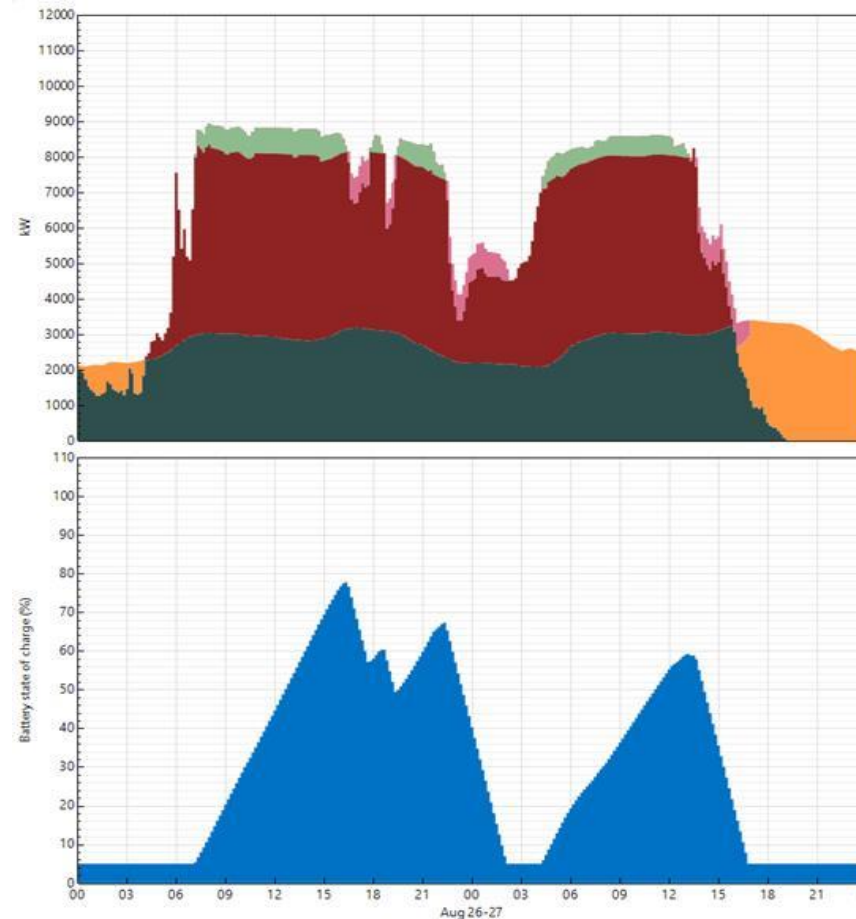
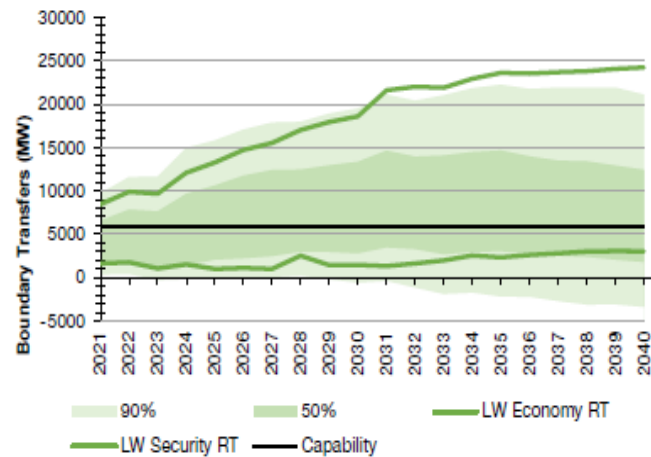


Constraint Management with LAES

Alleviating both the Thermal and Stability Constraint within a transmission system

- **Issue:** Rising Constraint Costs.
- **Solution:** Deploying effective Long Duration Energy Storage.

B6 Boundary Capability ¹



1) Electricity Ten Year Statement 2020: <https://www.nationalgrideso.com/document/181711/download>

Energy Storage for Black Start

- Synchronous energy storage can provide black start by providing the conditions to which other generation can synchronize.
- Liquid Air Energy Storage provides the scale and characteristics required for Black Start.

Requirements

- ✓ High availability
- ✓ Internal start capability
- ✓ Reactive Support (-100MVAR)
- ✓ Block load capable (25MW-50MW)
- ✓ Multiple Start capability
- ✓ Safe shutdown under internal supplies
- ✓ Minimum of 5Hrs onsite fuel at full output



Summary

- Synchronous generation has always provided the critical elements of stability underpinning the AC system
- Planners will need to maintain this inherent stability as synchronous generation is replaced
- This is particularly important during a fault occurrence when any delay due to measurement could allow the system to become unstable.
- Synchronous storage can perform these functions while also shifting active power.
- New technologies can mimic elements of stability, but levels are greatly reduced.



gary.preece@highviewpower.com

Thank you !

