Highview Power

FLEXIBLE LONG DURATION ENERGY STORAGE

After CCGT's

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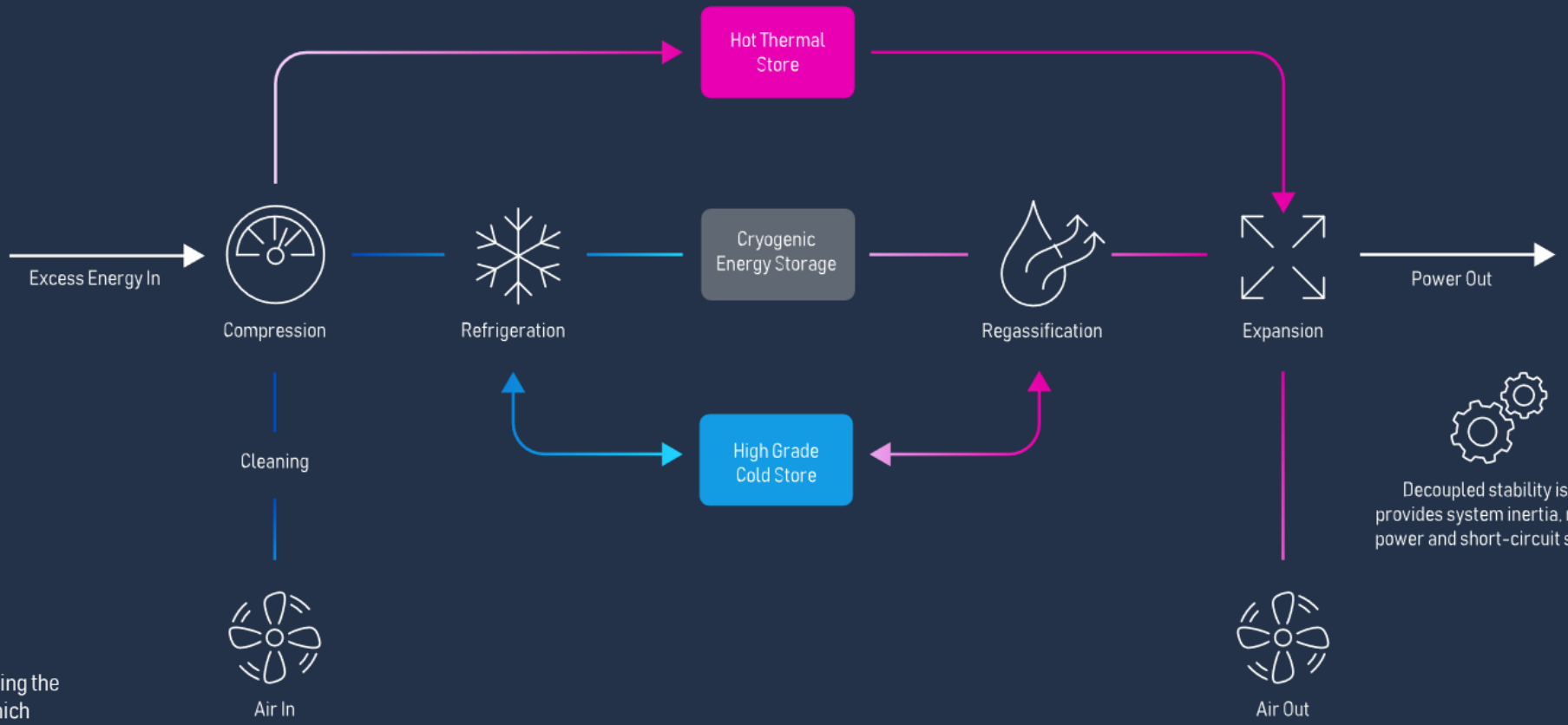
Policy Masterclass: Energy Storage, Tuesday 21st March, 2023

A BRITISH-BORN BUSINESS, BUILT TO BECOME
A WORLD LEADER IN LONG DURATION ENERGY STORAGE,
ENABLING NATIONS, REGIONS, AND CORPORATIONS TO ACHIEVE
THE GLOBAL AMBITION OF NET ZERO.

AGENDA

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

OUR LIQUID AIR ENERGY STORAGE TECHNOLOGY STORES ENERGY FOR LONGER WITH GREATER EFFICIENCY

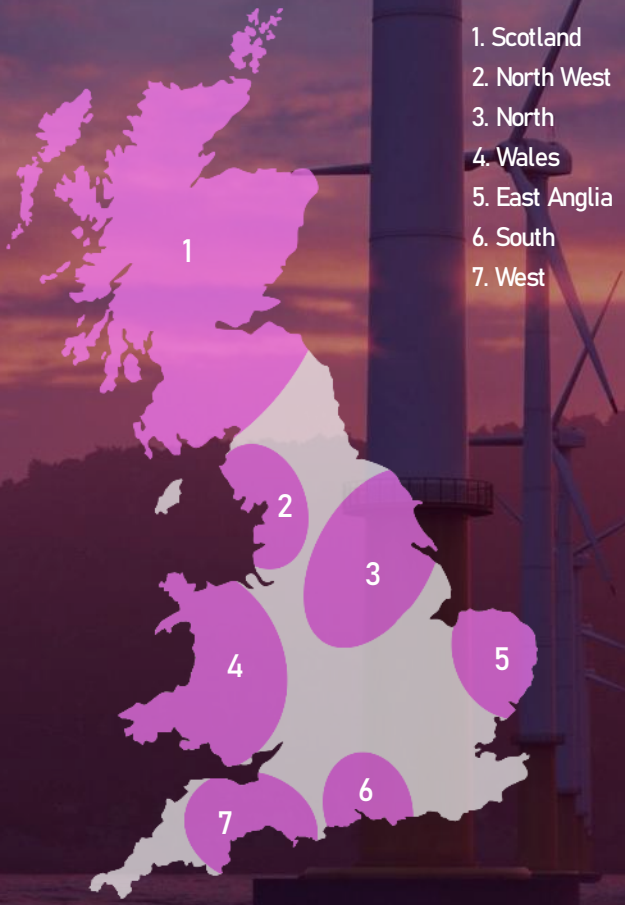


Charge
Turning ambient air into liquid

Store
Storing the liquid air in tanks

Recover
When needed, expanding the liquid air into a gas which generates electricity

WE ARE READY TO DEPLOY TODAY
18 STATIONS CAN BE BUILT BY 2035 - A 4GW PROGRAMME

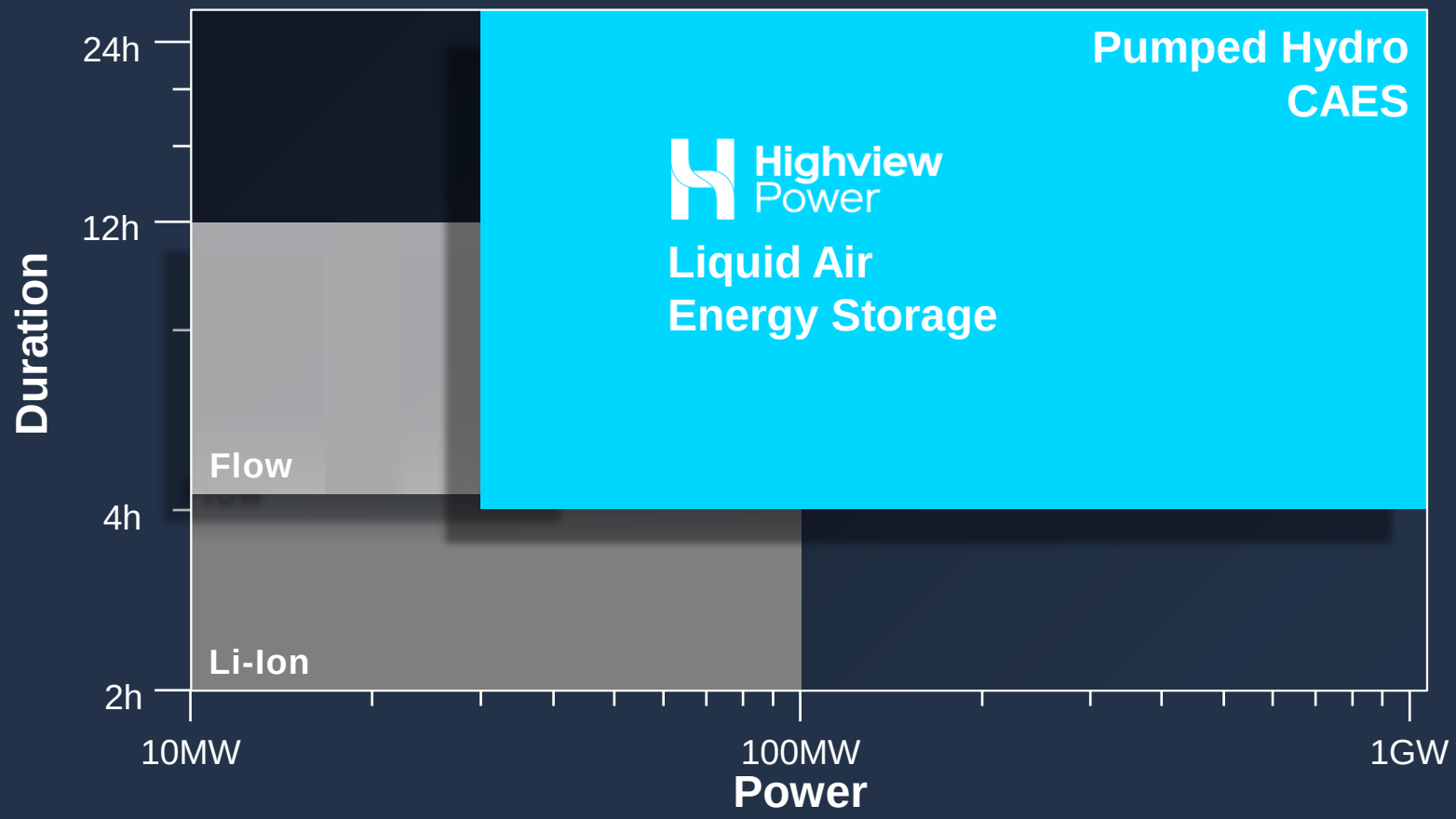


1. Scotland
2. North West
3. North
4. Wales
5. East Anglia
6. South
7. West

Shovel-ready first commercial grid-scale plant in Carrington, Manchester, a 50 MW / 300 MWh facility, COD 2024.

It supports the integration of wind and provides grid services in NW England. A second 200 MW / 2.5 GWh site planned for the North West, 2026. These sites can power 1,000 homes, non-stop for a year. Backed by the UK Government.

OPTIMAL APPLICATIONS



LIQUID AIR ENERGY STORAGE

50 MW / 300MWh & 200 /2500 MWh
Release for Construction in UK.
Construction start **2022**
Planned COD **2024**

Demonstration
Manchester, UK
Commissioned in **2018**

Pilot
Heathrow, UK
Commissioned in **2011**

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)

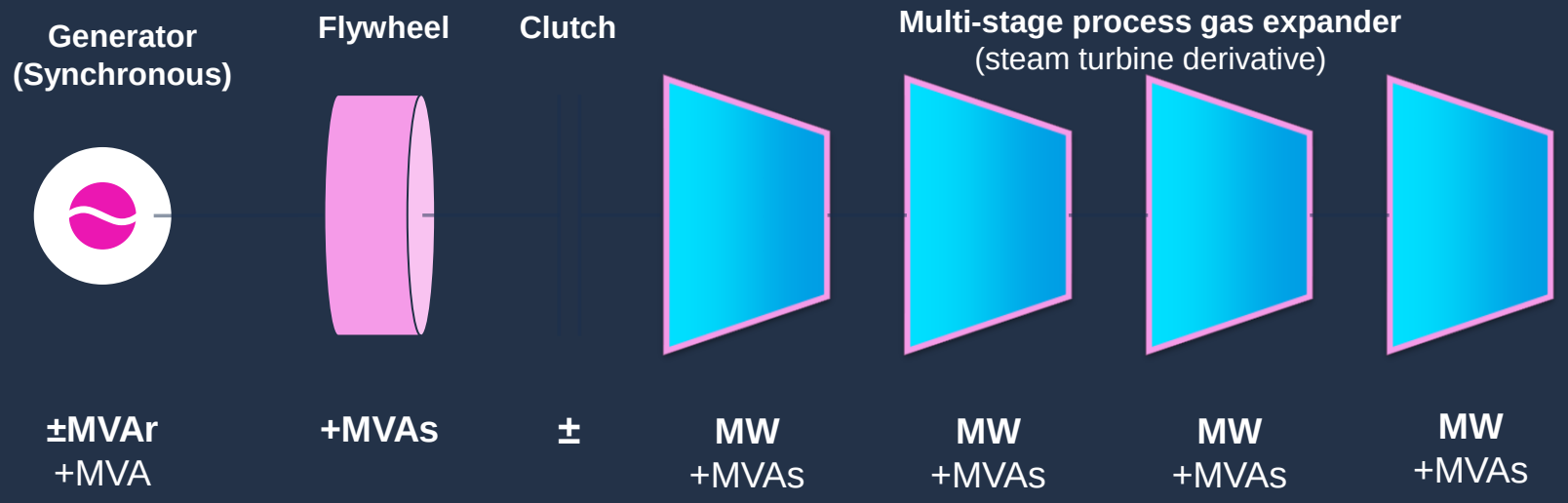
- Energy stored in the spinning mass of coupled generators
- Slows the Rate of Change of Frequency (RoCoF)

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

SYNCHRONOUS GENERATION (The Stability Island)

The Stability Island option can enhance the benefits of synchronous generation.

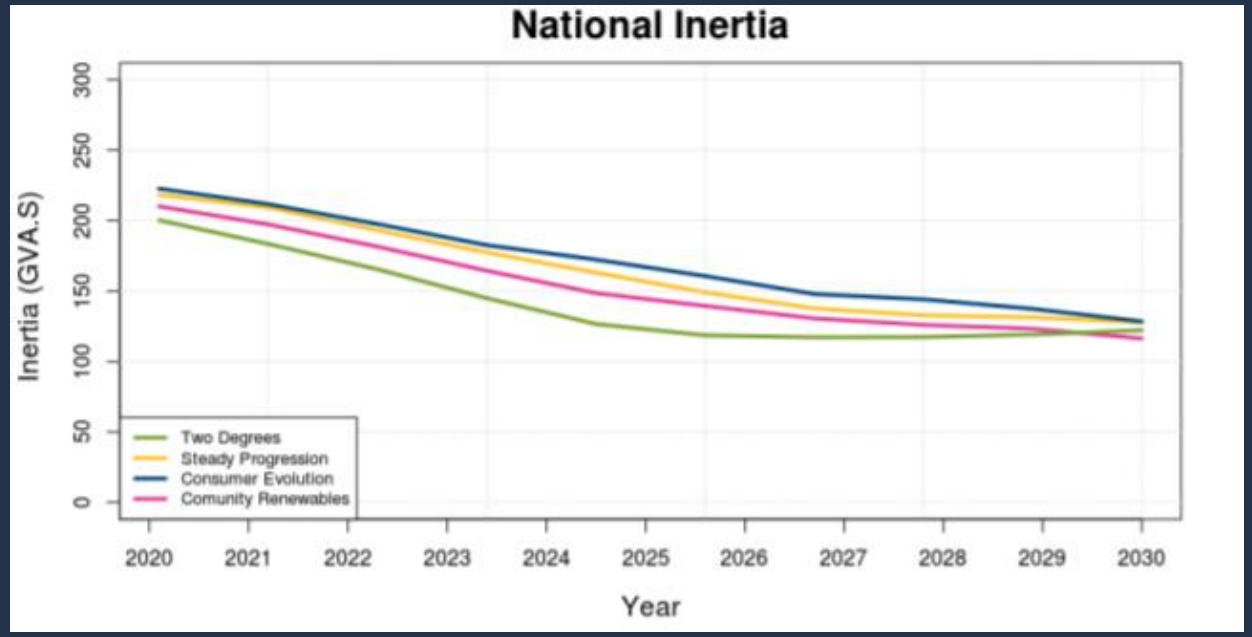


INERTIA DURING A SYSTEM DISTURBANCE

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.)

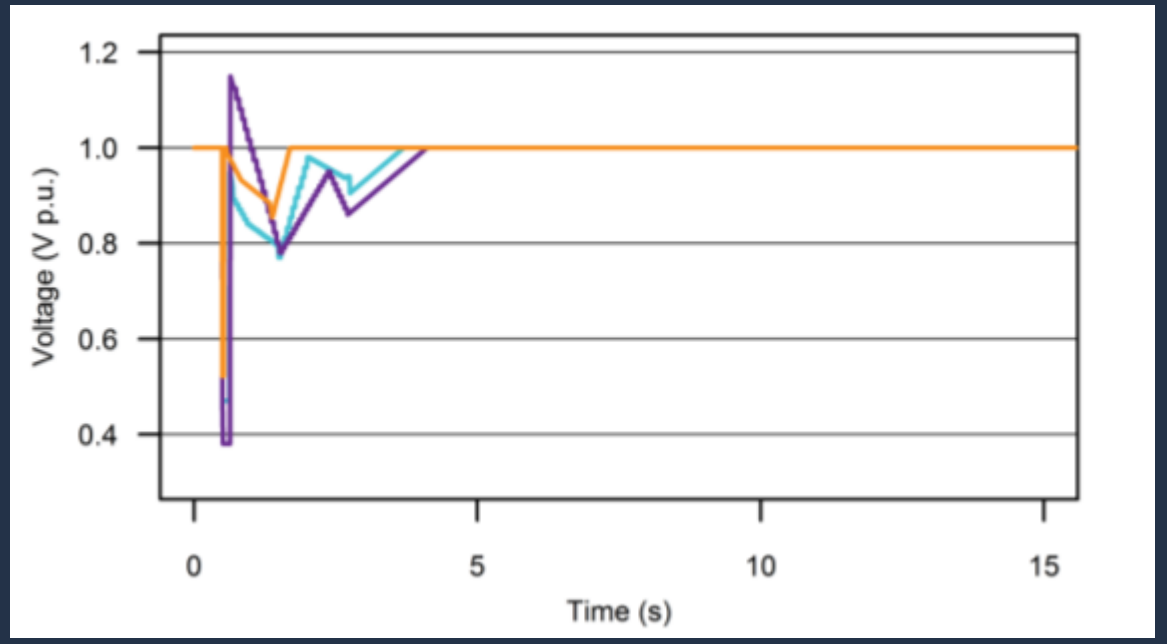


DYNAMIC VOLTAGE DURING A SYSTEM DISTURBANCE

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.

Recovery of Voltage Sync v Non Synchronous



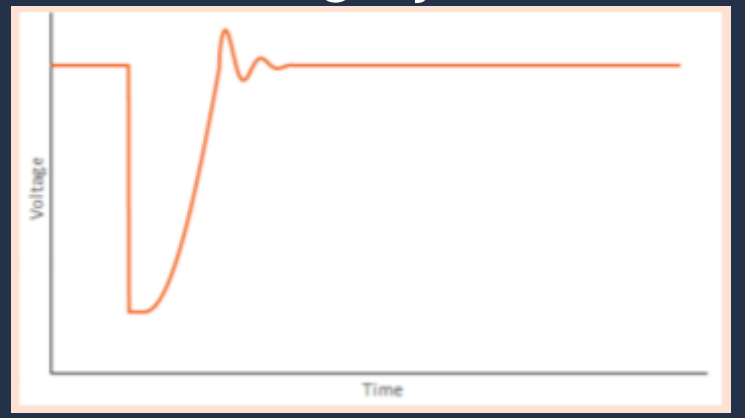
SHORT CIRCUIT POWER DURING A SYSTEM DISTURBANCE

The system requires a significant availability of short circuit power (Short Circuit Level) so that faults can be located and protection system can operate in a timely manner (Strong System)

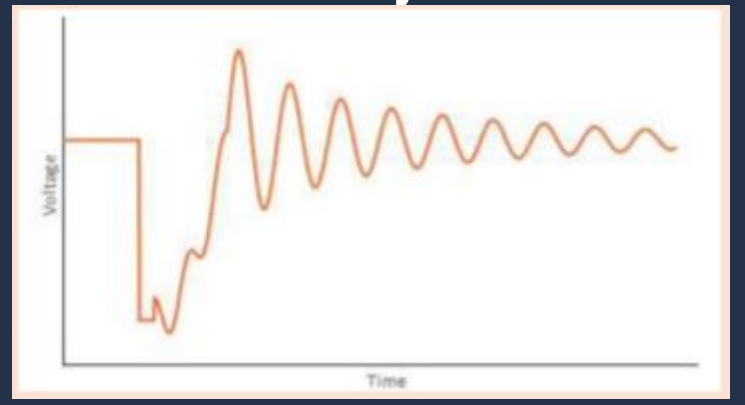
Synchronous generation is the largest contributor to Short Circuit Levels.

Voltage recovery is prolonged when Short Circuit Levels are low (Weak System), at significantly low levels voltage cannot recover.

Strong System



Weak System



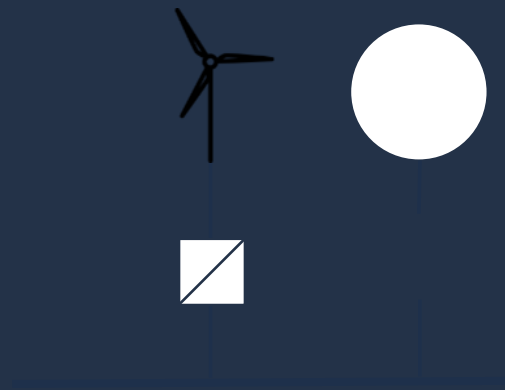
SYNCHRONOUS GENERATION SUPPORTING ASYNCHRONOUS GENERATION AT THE POINT OF CONNECTION (POC)

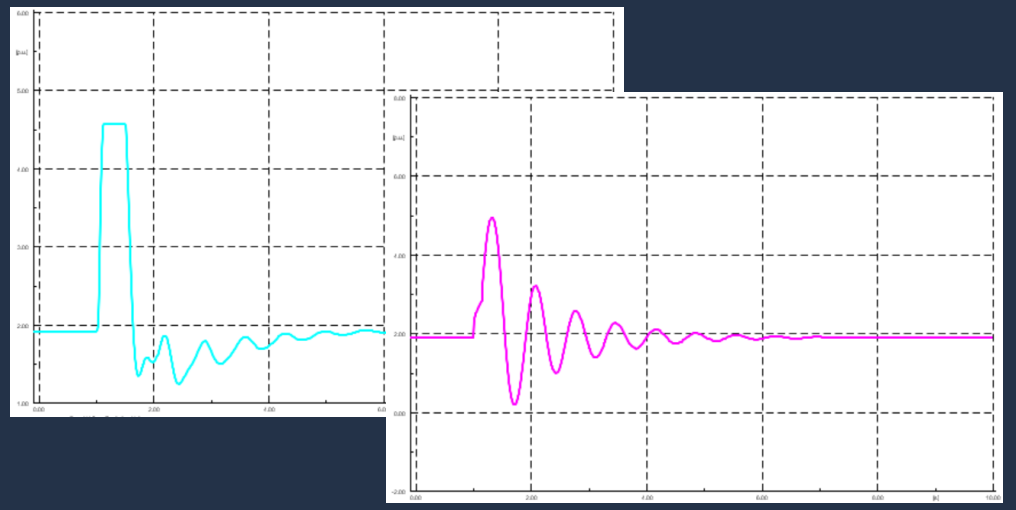
Example: Wind

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.

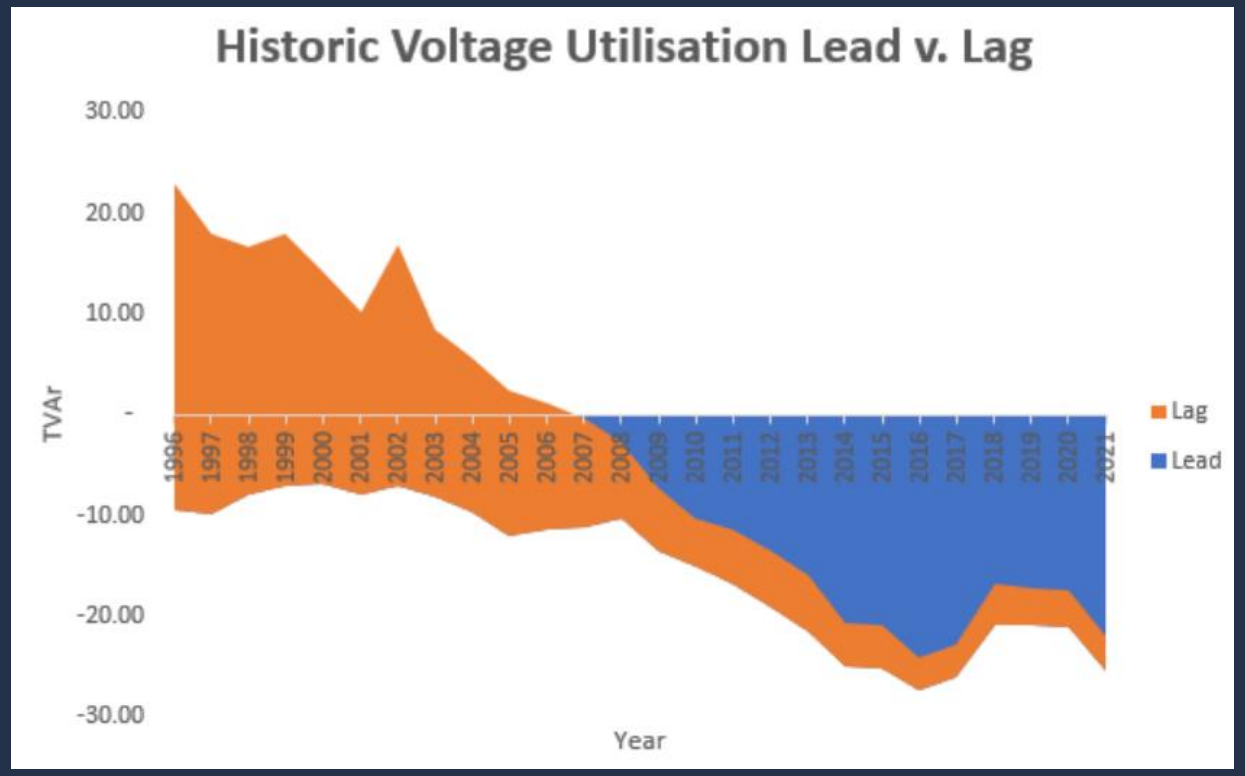
Reactive Power Support

- Commutation failure main cause of instability.

Inertia (Low RoCoF)

- Significant rate of change will operate protection.

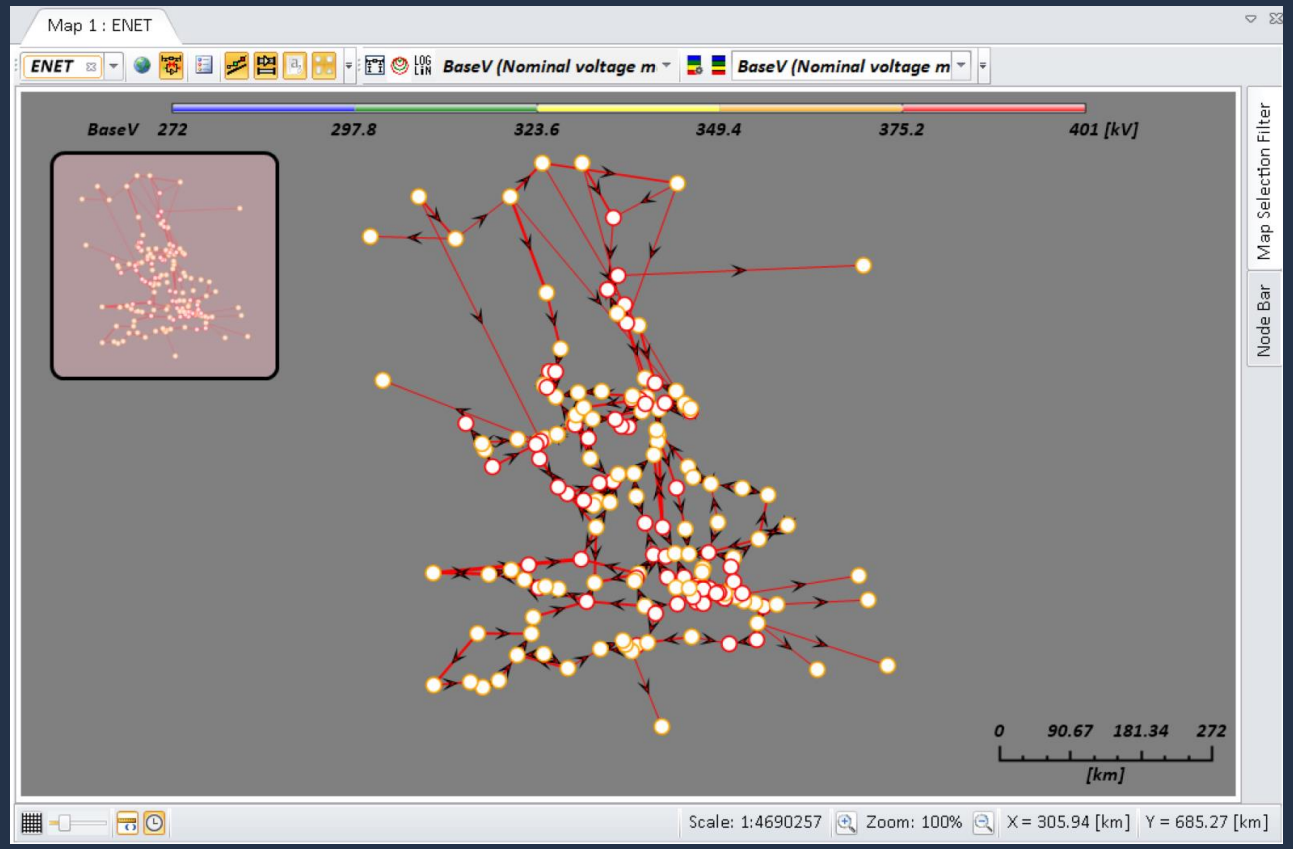
Reactive Power



- Voltage levels are managed through the injection and absorption of reactive power.
- Maintaining voltage levels across the transmission network has become increasingly challenging as decreasing reactive power demand and reducing power flows across the transmission drive the need to absorb reactive power.
- Closure of thermal power stations are driving the need to increase access to MVAr's outside of a delivered MW.

CONSTRAINT MANAGEMENT

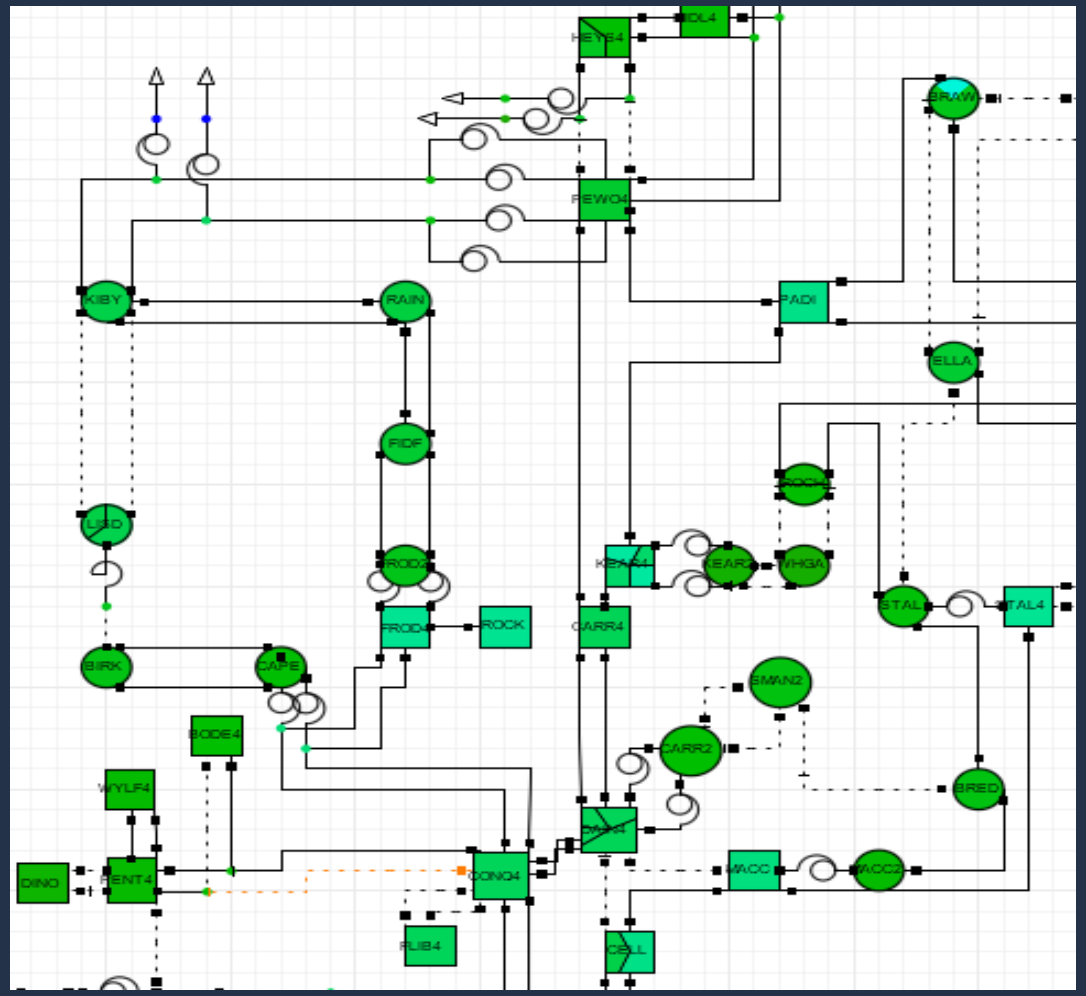
Capturing wind volumes due to transmission constraints and demand/generation imbalance



- Optimal Power Flow analysis.
- Detailed nodal model.
- Multiple scenarios (FES etc)

CONSTRAINT MANAGEMENT

Alleviating both the Thermal and Stability Constraint within a transmission system



- Static and Dynamic Analysis
- Load Flow
- RMS and EMT Analysis

ENERGY STORAGE FOR Grid Restoration

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-50)
- ✓Multiple Start capability
- ✓Safe shutdown under internal supplies
- ✓Minimum of 6/12Hrs onsite fuel at full output

SUMMARY

Synchronous generation has always provided the critical elements of stability underpinning the AC system

The LAES deployment will see multiple plants reducing curtailment, delivering flexible generation promoting system security with no compromise to system services such as SCL, Inertia and voltage control.

Highview Power

THANK YOU