HyScale: Using Liquid Organic Hydrogen Carriers for long duration hydrogen storage

SIF Alpha project outcomes

31st July 2025

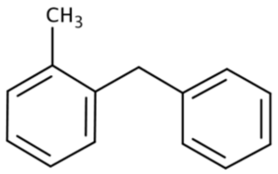
SGN

Introduction

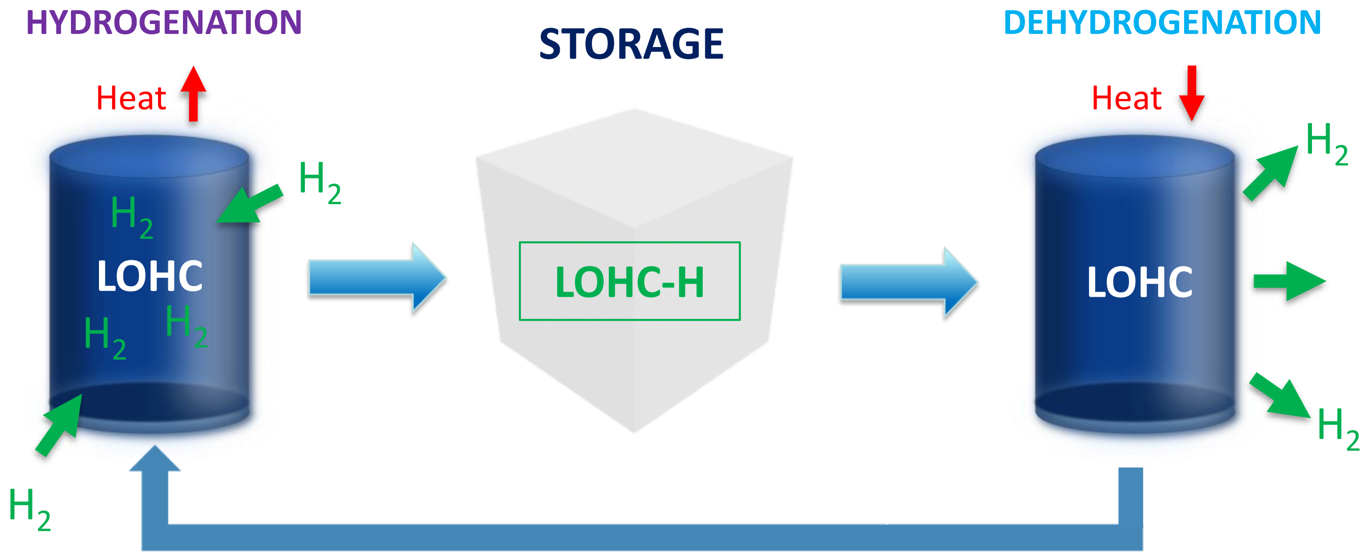
Challenge of a future energy system

Solutions offered by hydrogen storage

Liquid Organic Hydrogen Carriers (LOHCs)



- Organic compounds, liquids under ambient conditions
- Hydrogen stored by catalytic hydrogenation and dehydrogenation
- Carrier can be charged and uncharged many times



Safety

No molecular hydrogen storage
Hardly flammable and non-explosive

Flexibility

Ambient temperature and pressure handling
Compatible with existing infrastructure
No self-discharge
Tuneable withdrawal rates

Efficiency

Competitive volumetric storage density
Small footprint
Commercially available components

HyScale concept

Hydrogen generation connected to LOHC storage and a gas distribution network: enabling UK energy network benefits

Geographical storage flexibility

Flexible operation of electrolysers
- Electricity price arbitrage
- Minimising curtailment

System optimisation
- Hydrogen production capacity requirements reduced
- CAPEX reduction

Supply diversification
- Low cost of transportation

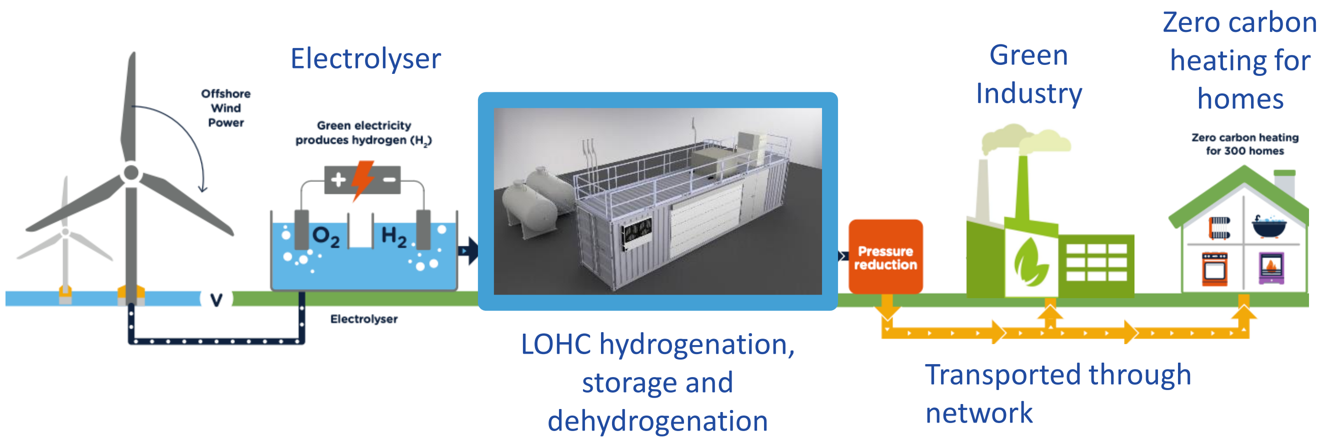
Reduced cost of H_2 | **Network optimisation** | **Security of supply**

SIF Alpha project overview

Innovation challenge 4: Enabling power-to-gas to provide system flexibility and energy network optimisation

Six month project led by SGN
Nov 24 – Apr 25

- Cost benefit analysis
- Assessment of electrolyser technology
- Evaluation of proposed sites
- Planning authority assessment
- Reactor optimisation
- Research roadmap creation
- Design of SIF Beta phase

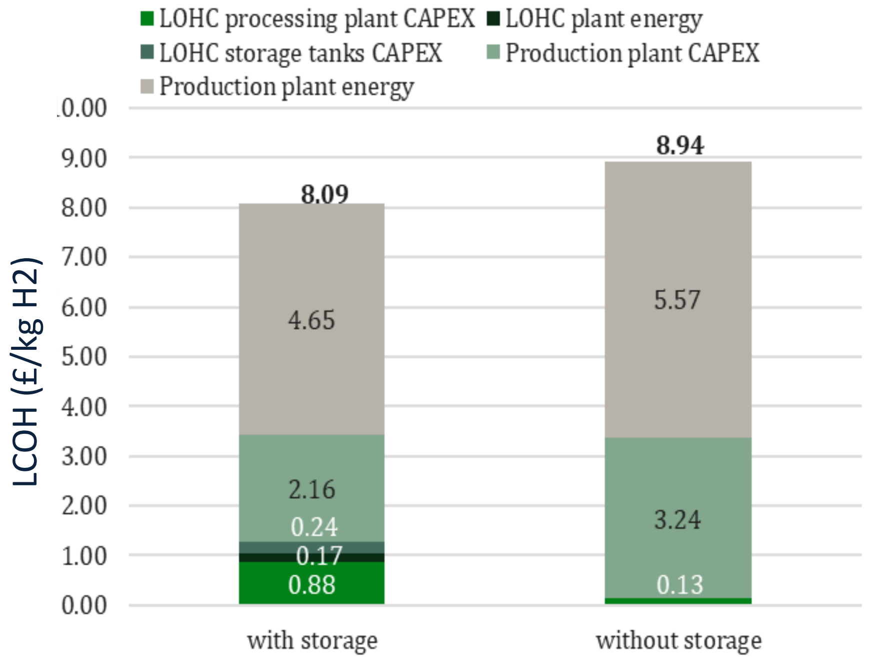


Northern Gas Networks
Cadent Your Gas Network
national gas
WALES&WEST UTILITIES
Blue Abundance
framatome
JÜLICH Forschungszentrum
ERM

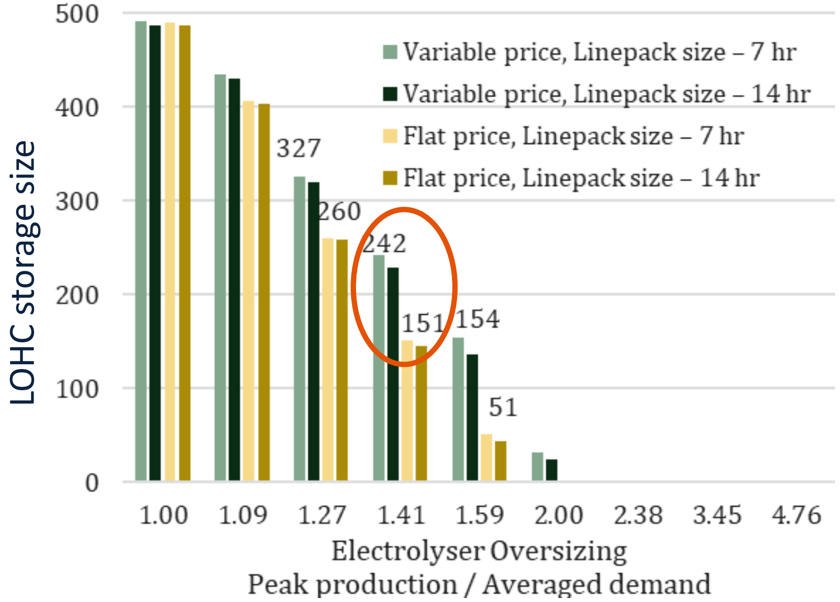
Cost Benefit Analysis – Introduction

Our previous work demonstrated qualities of the LOHC storage system that indicated it would be able to address Ofgem's challenge.

Adding storage reduces LCOH…



…and enables energy price arbitrage.



Electricity from renewables that would otherwise be curtailed can be stored as hydrogen in the form of LOHC. As renewable power generation grows in capacity, the need for long-duration storage will increase. LOHC storage systems could be increasingly valuable.

Cost Benefit Analysis – Scenarios

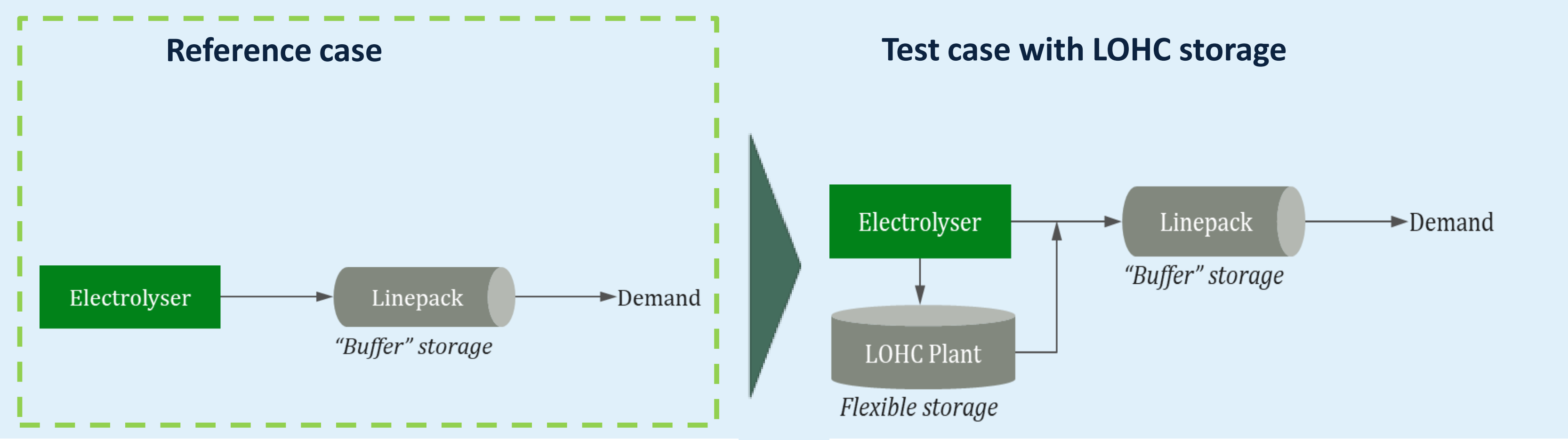
We designed two different scenarios to test LOHC storage systems for fulfilling different aspects of the challenge: system flexibility and long duration energy storage.

Scenario 1

LOHC storage enabling flexible electrolyser operation for system benefits

Expectations:

- Reduced overall system cost.
- Reduced energy demand (and cost).

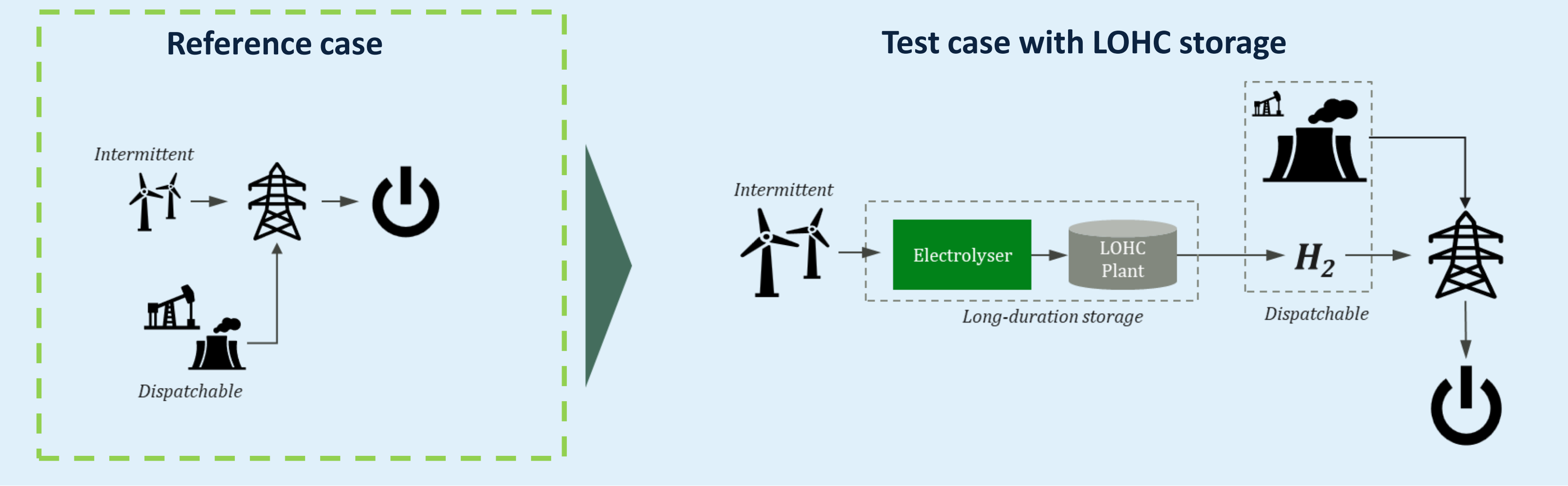


Scenario 2

Long duration storage for the energy sector

Expectations:

- Reduce required dispatchable generation capacity.
- Replace unabated peaking gas generation.
- Reduce renewable curtailment.



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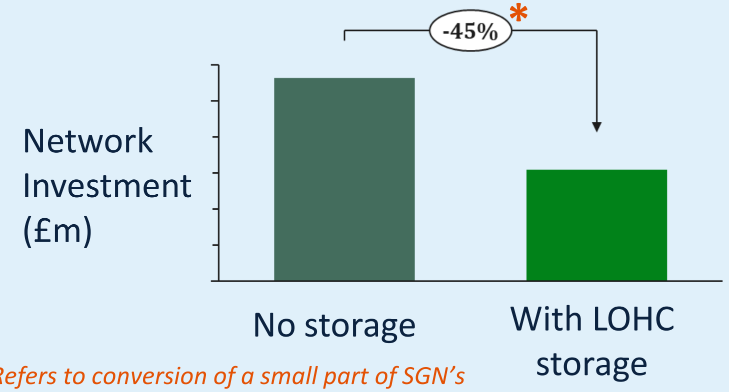
Cost Benefit Analysis – Findings

Flexible LOHC storage can provide significant financial savings over an electrolyser without storage and enable flexible operation that reduces curtailment and increases network utilisation.

Scenario 1 - LOHC storage enabling flexible electrolyser operation for system benefits

Quantified benefits:

Project costs	15% saving
Environmental net benefit	13% greater environmental benefits



**Refers to conversion of a small part of SGN's network, providing tens of £millions in savings.*

Non-quantified benefits:

- Contribution to price stability.
- Hydrogen economy skills development.
- Potential to reduce spatial constraints.

Scenario 2 - Long duration storage for the energy sector

Financial benefits:

- Relatively high levelized cost of energy but accounts for a small proportion of overall energy generation.

Environmental benefits:

- Decarbonisation of peaking power resulting in a positive lifetime NPV based on the avoided emissions and assumed carbon price.

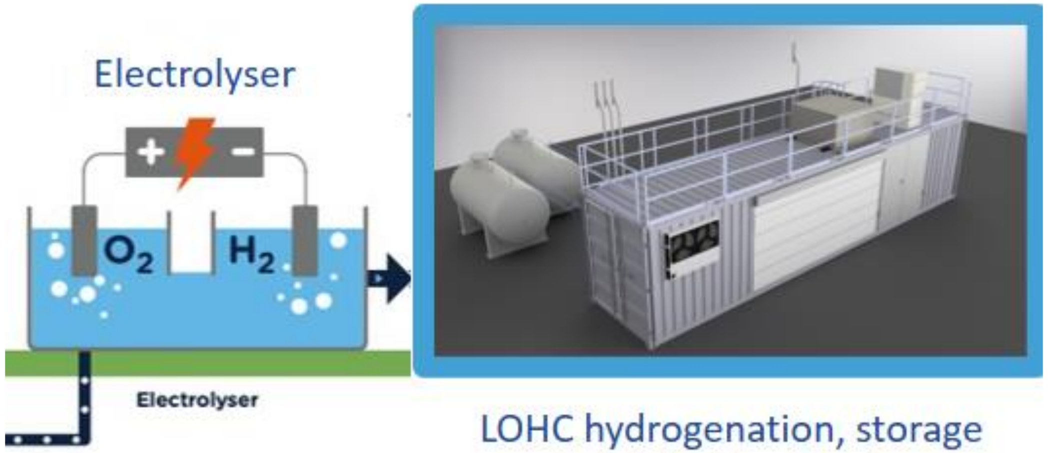
Societal benefits:

- Non-quantified benefits to energy security by reducing reliance on gas imports.

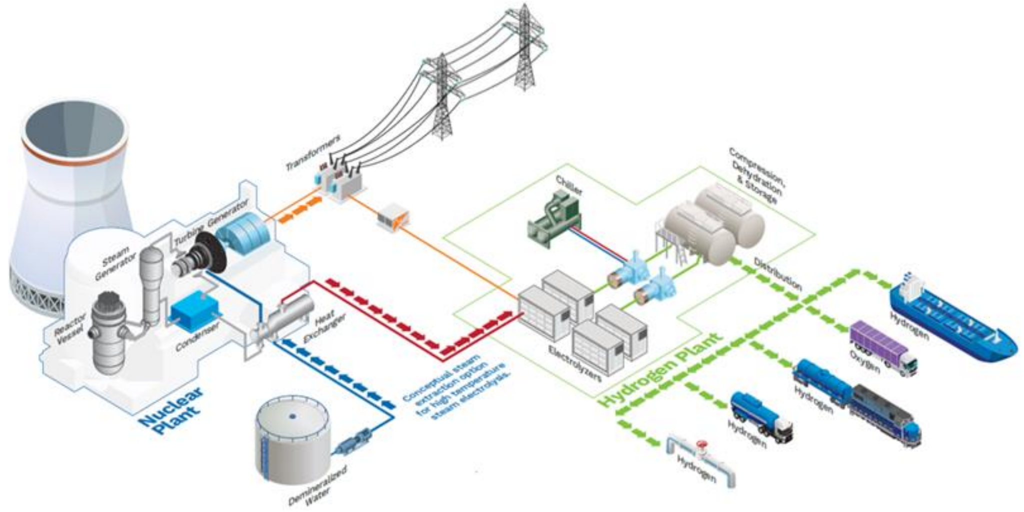
Electrolyser – LOHC Integration

LOHC – Electrolyser Coupling (HyScale)

- Compared to conventional hydrogen storage technology (pressure, cryogenic) LOHC can increase system flexibility of power-2-gas, by allowing for long term storage and / or transport at ambient conditions with lower footprint and simpler infrastructure
- This can reduce the cost of hydrogen



LOHC hydrogenation, storage and dehydrogenation

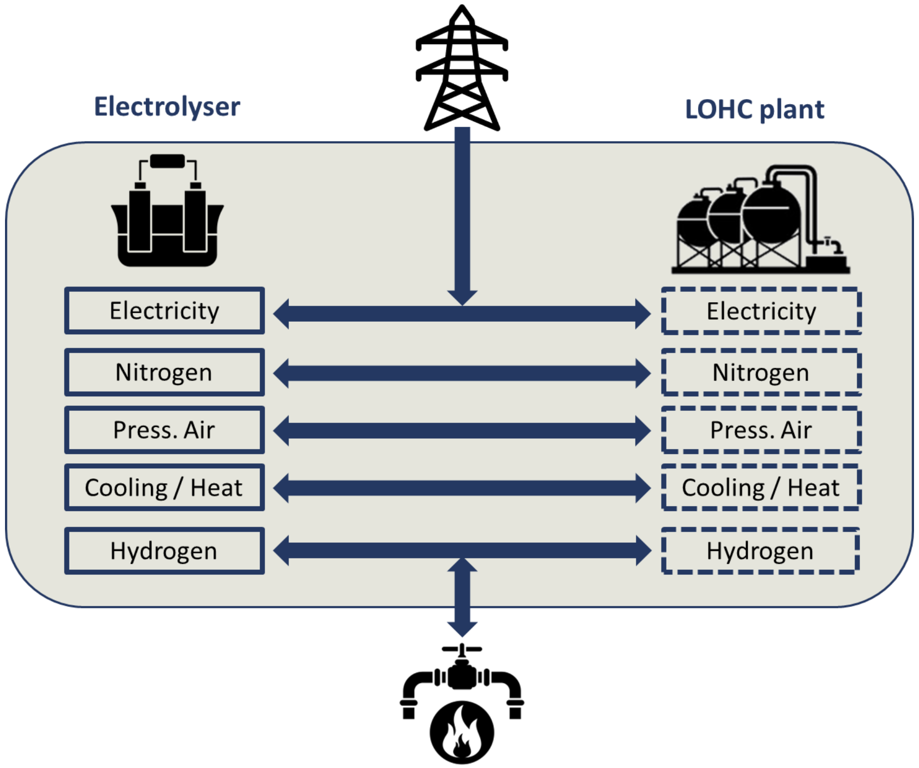


Nuclear Powered Hydrogen Cogeneration NPHyCo (EU funded) - "sister project"

- NPPs are designed for **base load** --> Increased amount of volatile renewable energy in the grid leads to NPPs having to reduce power output
- **Alternatively: curtailed energ**y can be used to generate hydrogen via electrolysis
- Project set out to investigate the **technical, economic and operational feasibility** & focus on existing H_2 generation technologies and existing and willing NPPs

Electrolyser – LOHC Integration

Joint use of electrolyser and LOHC plant auxiliaries have been assessed



Technology

- Both processes and interfaces have been evaluated by match & compare analysis
- Electrolyser technologies considered: **PEM, Alkaline, High Temperature Steam Electrolysis (HTSE)** - thorough manufacturer data study conducted on all 3 technologies
- Full integration of electrolyser & LOHC plant possible --> **technology agnostic**

CAPEX

- CAPEX savings are marginal and independent of the chosen electrolyser technology
- Additional investment savings can be achieved at larger scale by: Reduction in certification and approval expenses, aligning safety policies and systems (e.g. gas & fire alarm), etc.

OPEX

- **HTSE** stands out as it can achieve **major operational savings in heating & cooling** (up to 80%) when coupled to LOHC plant
- Minor benefits can be gained by shared supply of auxiliaries
- Additional operational savings can be achieved at larger scale by reduction of staff (overlapping qualifications), reducing replacement equipment / spare parts

Site Evaluation

An **evaluation** of sites was conducted across multiple disciplines and focus areas

- Evaluation of criteria for meeting **HyScale Project Goals.**
- **Engagement with site teams** to scope site project configuration and tie-ins .
- **Engineering interface** for system interoperability for shortlisted sites.
- **Planning Permission**: received confirmation of permitted development for a potential site.
- **Regulatory considerations**: Environmental and HSE, including COMAH thresholds considered in the roadmap for consent.

Final site selection will be part of our SIF Beta bid.

SGN's H100 site

NGN's NeRV site

Conclusion & Next Steps

JÜLICH
Forschungszentrum

Lab data for catalyst → Digi Twin / Mini One →  → Scale Up to Grid Scale

LOHC technology could play a key role in providing long duration seasonal energy storage

Economic feasibility has been demonstrated – the use of LOHCs could enable flexible electrolyser operation, reduce curtailment and reduce the levelised cost of hydrogen

LOHC technology is flexible and electrolyser agnostic

Planning is underway for a SIF Beta demonstration to provide the evidence base to support larger scale development

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