

COIRE GLAS: A PUMPED STORAGE HYDRO PROJECT IN SCOTLAND

ERA Medium Duration
Energy Storage 2022

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SSER OVERVIEW

- Portfolio of 4GW of onshore wind, offshore wind and hydro
- Aim is to deliver enough renewable projects to generate 50TWh by 2031, a fivefold increase in output
- Largest offshore wind development and construction pipeline in the UK and Ireland at over 6GW with an onshore wind pipeline in excess of 1GW
- Rich history in hydropower dating back to the 1930s in the Highlands of Scotland
- Own and operate over 50 hydro sites across the Highlands, including the existing 300MW Foyers pumped storage station
- Hydro business generate ~3.5TWh annually
- Coire Glas, our new PS project, would be the first pumped storage project to be built in over 40 years in the UK with 30GWh of electricity storage.



Renewable Hydro energy

1,459MW

Onshore wind energy

1,936MW

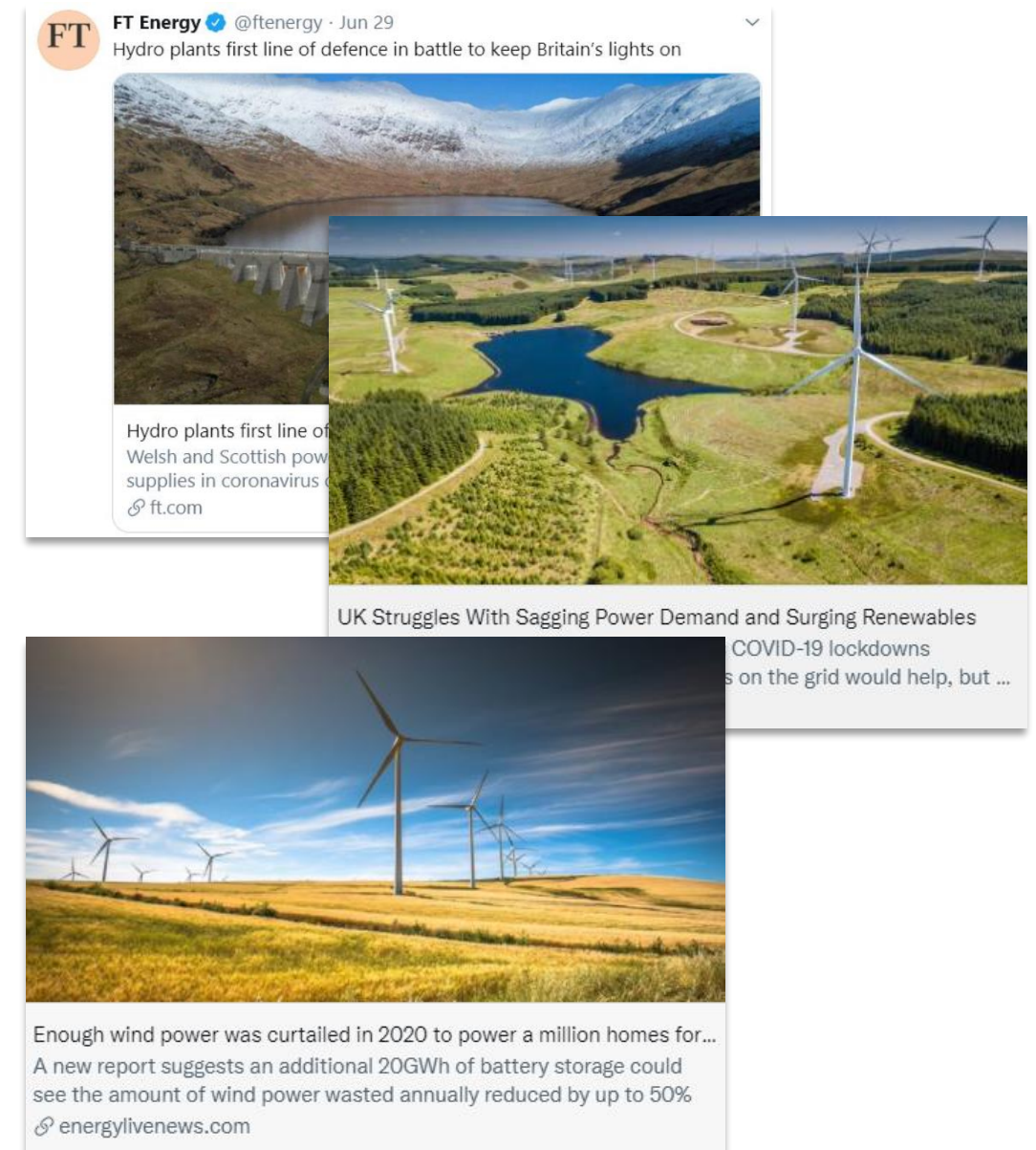
Offshore wind energy

579MW

LONG-DURATION STORAGE ESSENTIAL FOR NET ZERO

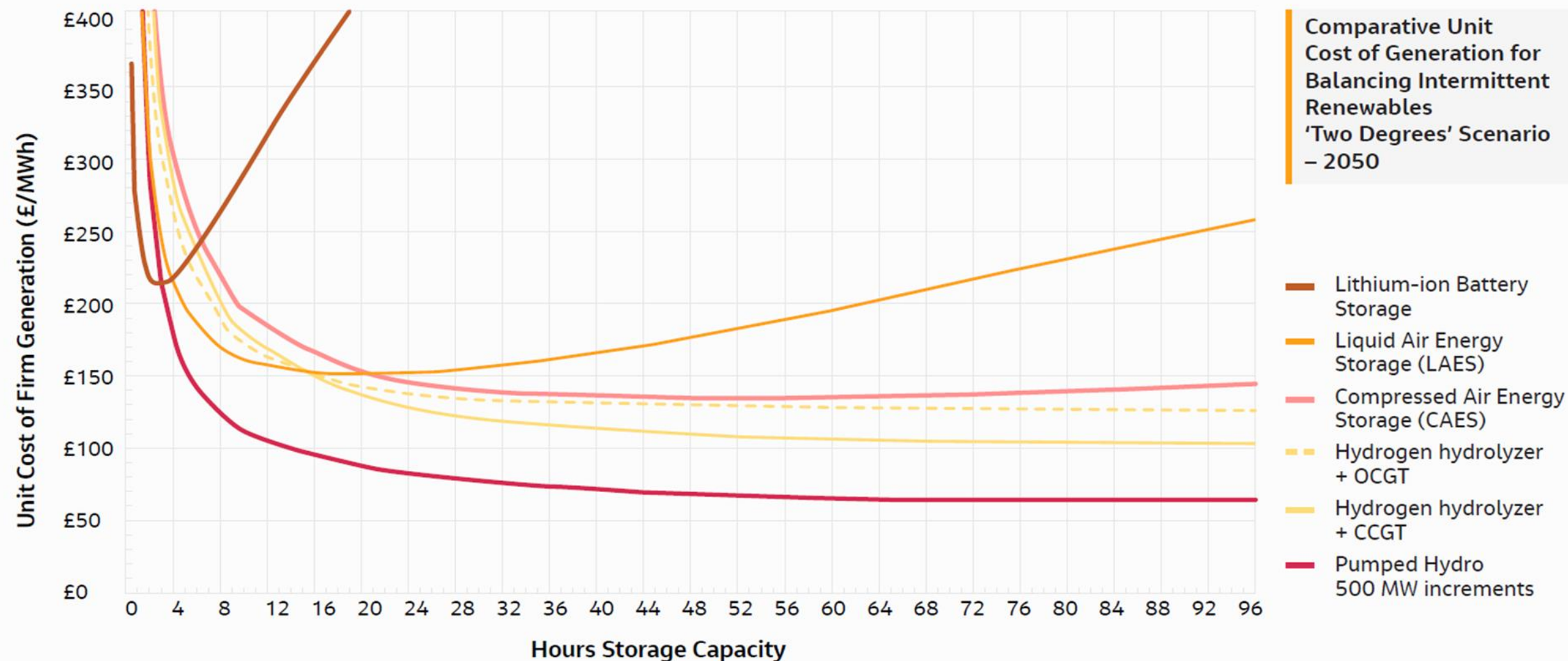
We need flexibility over multiple timescales and locations

- The speed and the scale of the net zero transition will require a suite of flexible technologies
- 2020 provided a glimpse of what the GB grid may look like with renewables dominating the generation mix:
 - Ancillary services ('essential services') trebled over the summer months to £200m as the grid experienced many operational challenges such as low inertia
 - 3.6 TWh of wind power was curtailed enough to power 1 million homes for an entire year
- In 2021 we experienced one of the longest spells of low wind output in many years – will need firm low-carbon flexibility providers to fill this supply gap in the future



ENERGY STORAGE: TYPE? DURATION? AND COSTS?

- New renewables is the lowest cost source of low carbon new generation
- Renewables however are non-firm generation
- Renewables coupled with Flexible Long duration storage effectively becomes firm generation



Source:
<https://www.jacobs.com/sites/default/files/2020-10/Jacobs-Strategy-for-Long-Term-Energy-Storage-in-UK-August-2020.pdf>

The comparative unit cost of generation by technology type, for a typical plant of 500 MW installed capacity at a range of different storage durations from 1 hour to 4 days

WHAT DURATIONS ARE NEEDED?

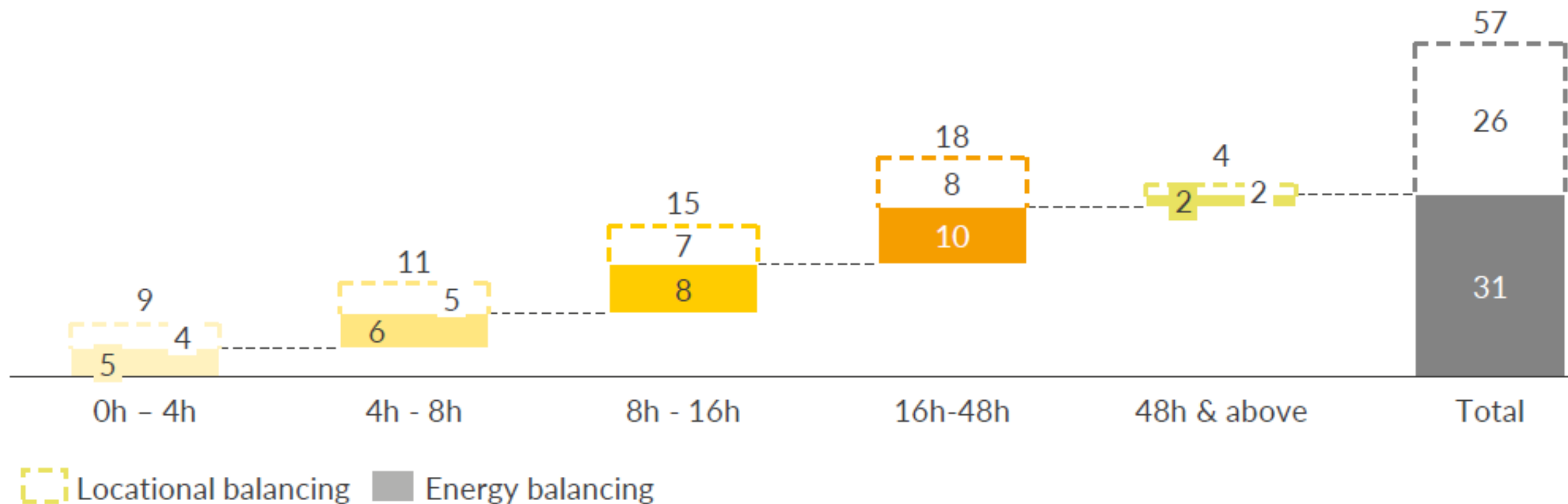
Aurora Energy Research: Long duration electricity storage in GB report 2022

To achieve a net zero electricity system by 2035 securely, GB needs 48GW / 57TWh of electricity storage - much of which over 4 hours of duration

U.K. Needs Much More Power Storage as Part of Its Green Future

- Nation needs to boost long-term power storage: Aurora report
- Storage investment can reduce U.K.'s reliance on natural gas

Energy available to be shifted by storage duration, 2035
TWh



1) Excluding storage addressing the 0h-4h bracket yields 24 GW / 48 TWh of LDES. 2) The emissions reduction achieved by introducing LDES for system management at and above the B6 boundary.

Source: Aurora Energy Research

AURORA ENERGY RESEARCH REPORT 2022

Long Duration Storage in GB: Key findings

- LDES can be defined as technologies that are able to provide energy for over 4 hours at their full capacity
- LDES has the potential to manage system constraints by reducing strain on the transmission network through locational balancing and to provide other system services, including voltage and stability control, required to meet security of supply objectives
- Introducing LDES will result in up to a 10MtCO₂/a fall in power sector emissions in 2035
- Total annual system costs could be reduced by £1.13 bn (2.5%) in 2035 if LDES is introduced, due to lower costs for grid reinforcement, cutting annual household bills by £26
- LDES deployment could reduce GB's reliance on gas in the power sector by up to 50 TWh in 2035

Up to 24GW of long duration storage needed for 2035 net zero electricity system
- Aurora



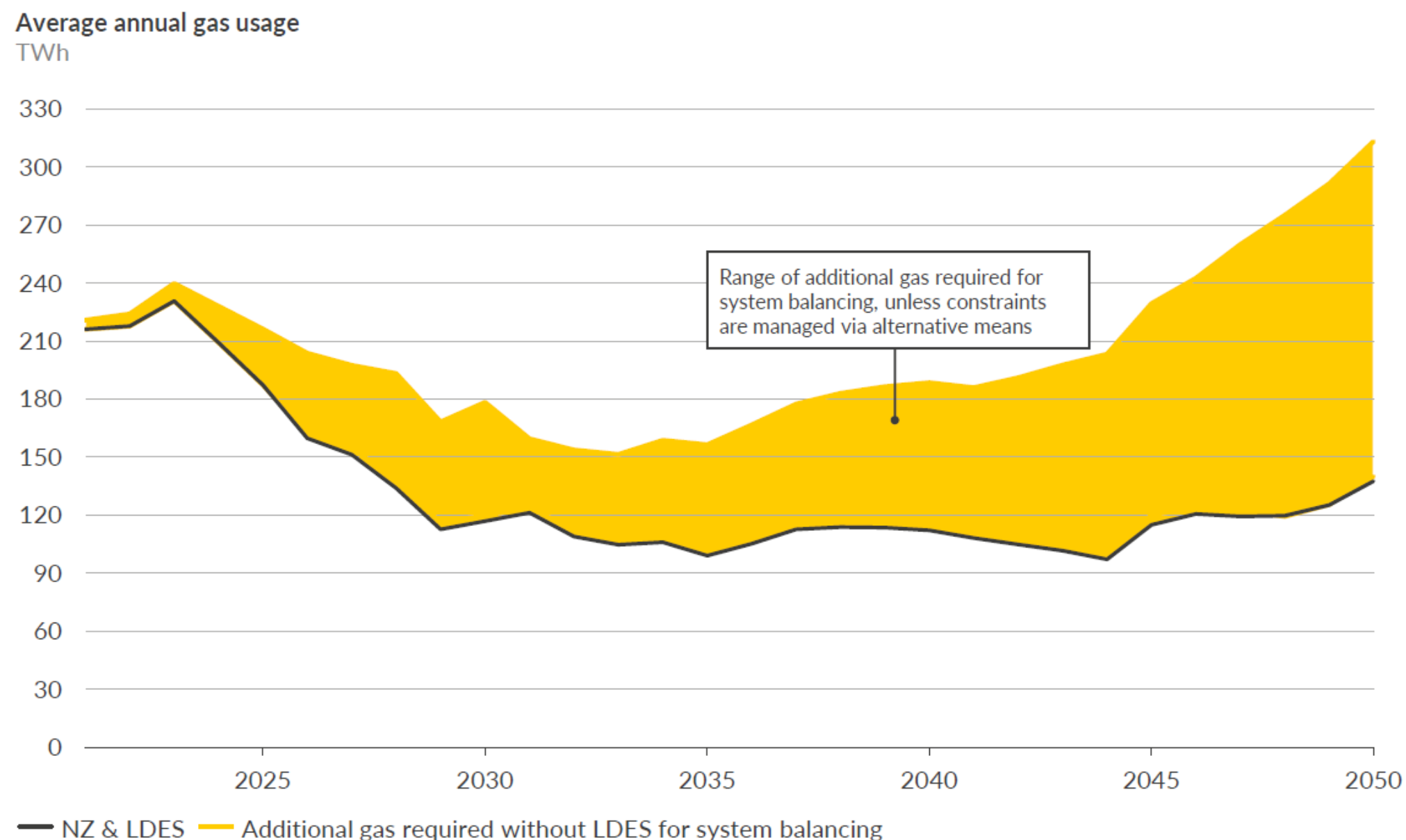
ENERGY STORAGE

Support needed to boost long-duration storage to 24GW by 2035

AURORA ENERGY RESEARCH REPORT 2022

Long Duration Storage in GB: Potential to reduce gas imports

Introducing LDES results in a reduction of 50 TWh gas used in the power sector in 2035, reducing GB's reliance on imported supply



- Gas usage in Net Zero declines rapidly out to 2035 as unabated Gas CCGTs are displaced with RES. Post 2035, gas usage remains flat and then increases slightly post 2045 as more Gas CCS enters the system and from system balancing needs
- Fluctuations in gas prices create market vulnerability, as seen in Sept 2021 when gas prices reached new highs, causing higher bills for consumers
- Introducing LDES will reduce the UK's dependence on gas imports for the power sector by up to 50 TWh in 2035 by reducing the need for unabated gas turn-up from system balancing
- However, as LDES competes with electrolyzers during low price periods, the introduction of LDES could result in higher demand for blue H2 (therefore gas) for use in other sectors

IMPERIAL COLLEGE STUDY

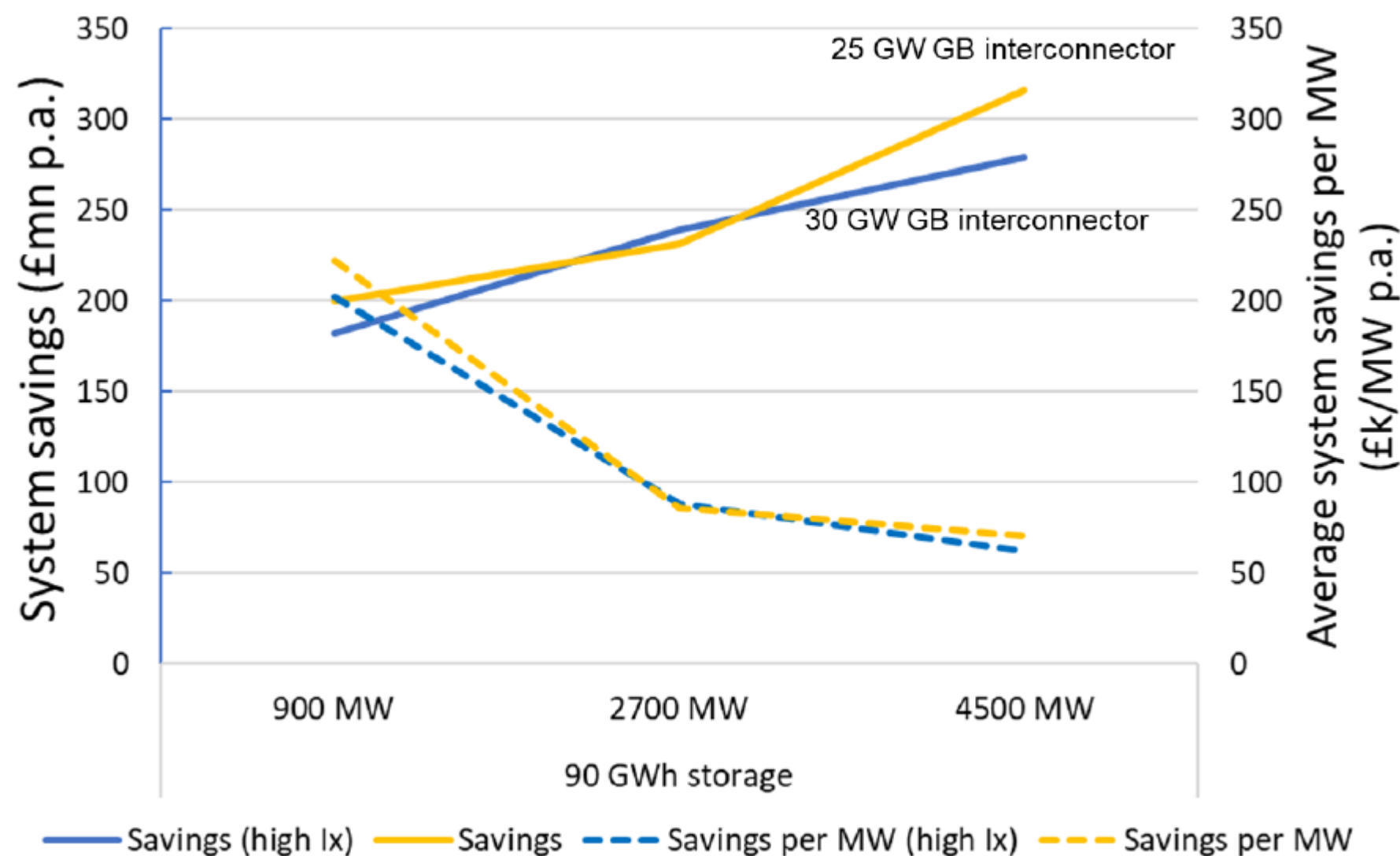
Whole system value of long duration energy storage in 2050

Imperial College
London

- SSE Renewables commissioned from Imperial College London a study into the value of longer duration storage to the GB electricity system
- Headline outputs from the study show that for LD-PHES
 - ✓ Improves integration and enables more capacity for variable Renewable Energy Sources (RES)
 - ✓ Reduces quantity of high-cost firm low-carbon energy sources such as nuclear or CCS needed
 - ✓ Provide ancillary services and capacity (displacing capacity of mid-merit and peaking plant)
 - ✓ Support network congestion management
 - ✓ Allow arbitrage that can improve the utilisation of base load or RES plant
- System savings of £44m - £690m/year in 2050 with more savings made when the energy storage volume is higher, and system flexibility is lower.
- 75% of these system savings are from the avoided capital cost in low carbon electricity generation technologies that would otherwise be needed to meet decarbonisation and security of supply objectives.
- New LD-PHES reduces wind curtailment in the GB electricity system (between 3TWh and 11TWh a year)
- Long Duration (LD) storage plays a complementary role with other flexibility technologies such as DR, hydrogen storage and interconnectors with LD storage providing significant benefits in all scenarios.

LDES: WITH MORE INTERCONNECTION?

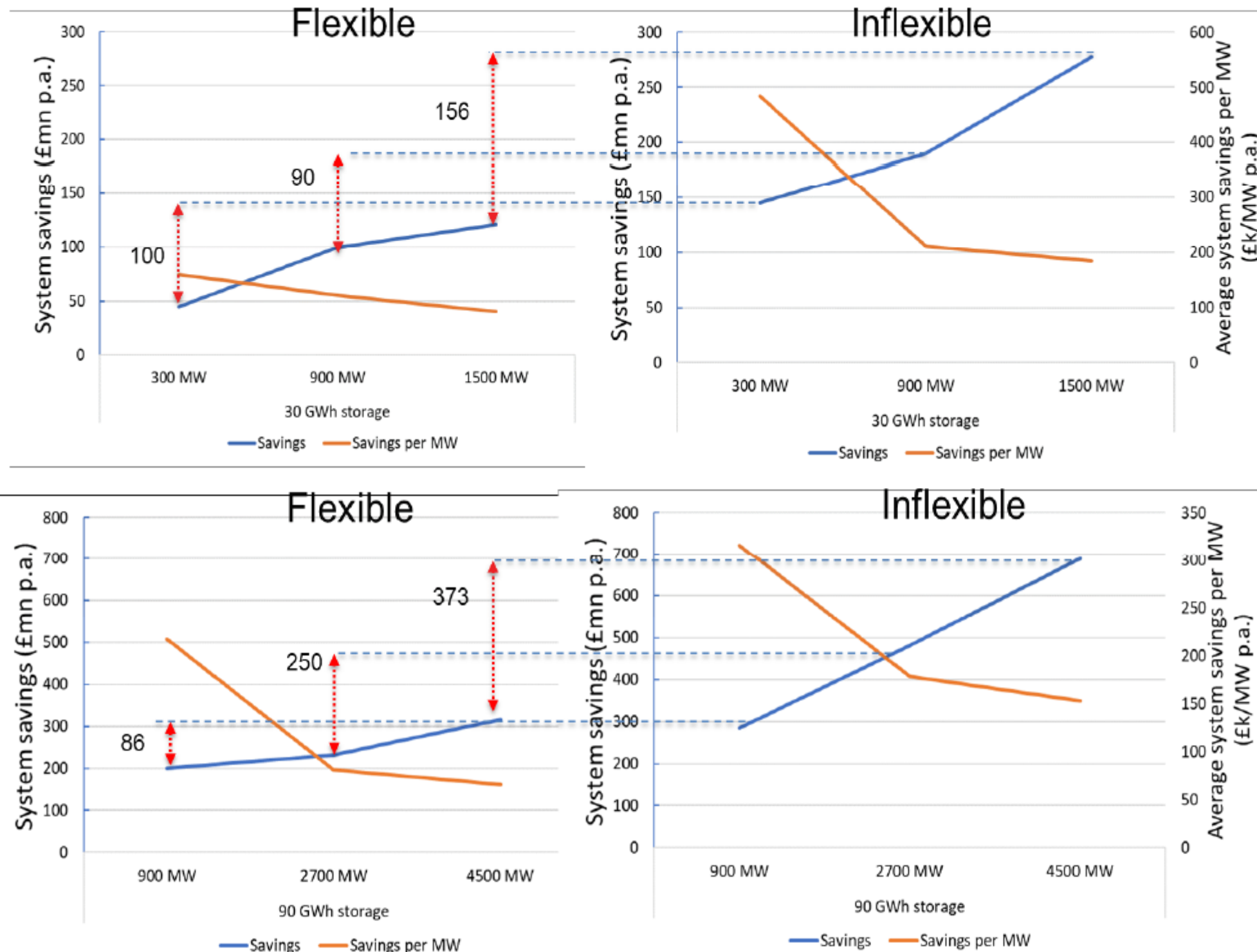
Interconnectors with Europe



- Impact of a higher interconnection capacity on the value of new LD-PHES is relatively small; it reduces the value up to £40m/year across all cases.
- Indicates there is not only competition but also synergy between the flexibility from interconnection and the long-duration energy storage.
- Value of LDES is not reduced significantly by an increase in interconnection capacity.
- Reasons?
- LDES flexibility allows better use of Interconnection capacity
- GB flexibility from LDES is also helping the neighbouring system.

LDES: WITH DEMAND RESPONSE ?

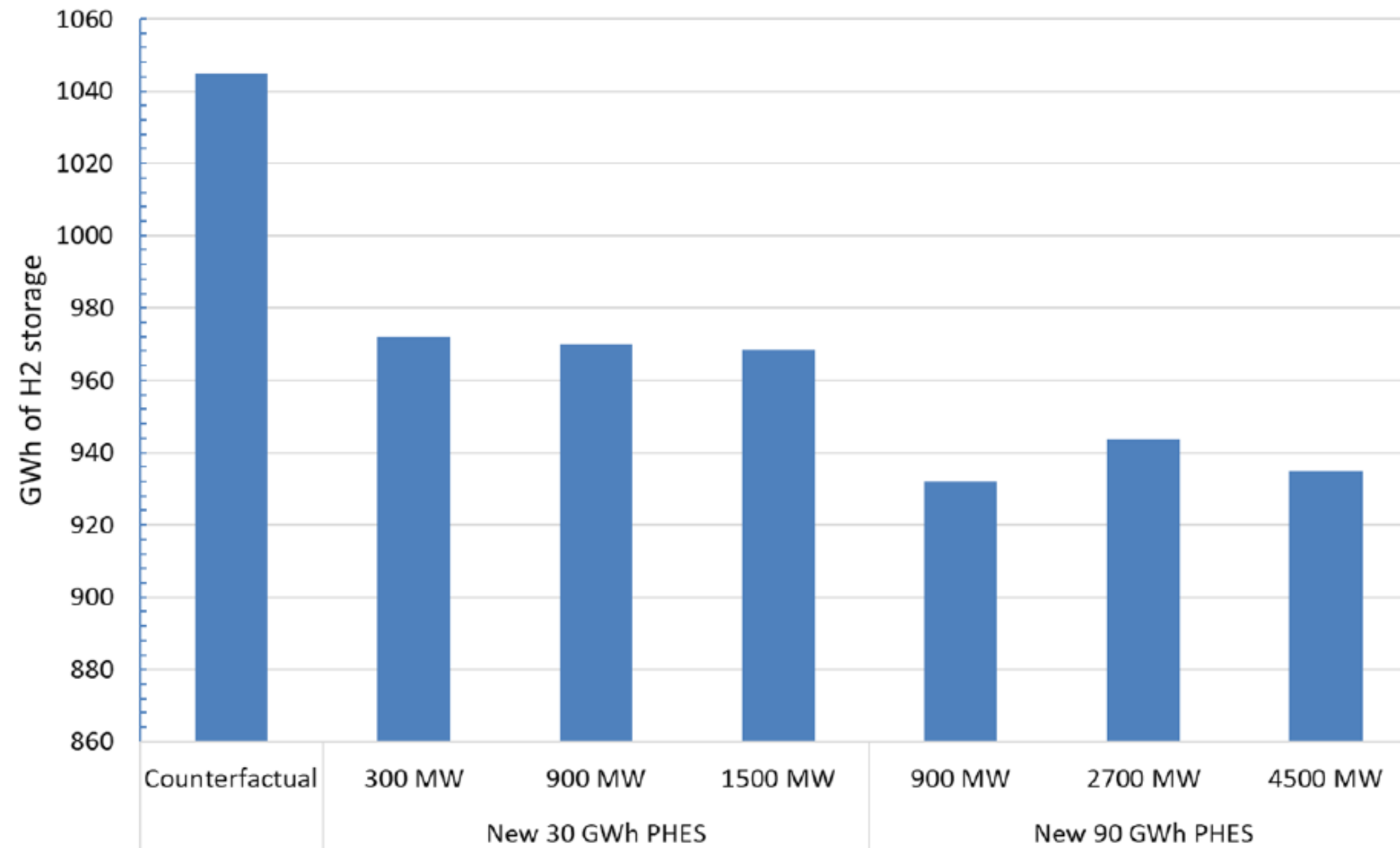
Demand side response with embedded short duration storage



- For their 2050 model ICL assumed a highly flexible system with high amounts of demand side response (DR)
- Thus, the DR-based services work with/compete to provide flexibility services from the new LDES.
- The study showed that LDES has great value even when competing with high amounts of DR
- There is significant uncertainty, at present, related to whether, when and how much distributed flexibility technologies such as demand response will be deployed in the system in future.
- The inflexible comparison assumes no increase in DR over the current 2020 levels
- The value of LD-PHES is much higher if this DR is not delivered.

LDES: WITH A GREEN HYDROGEN ECONOMY ?

Impact of LD-PHES on the requirement of hydrogen storage

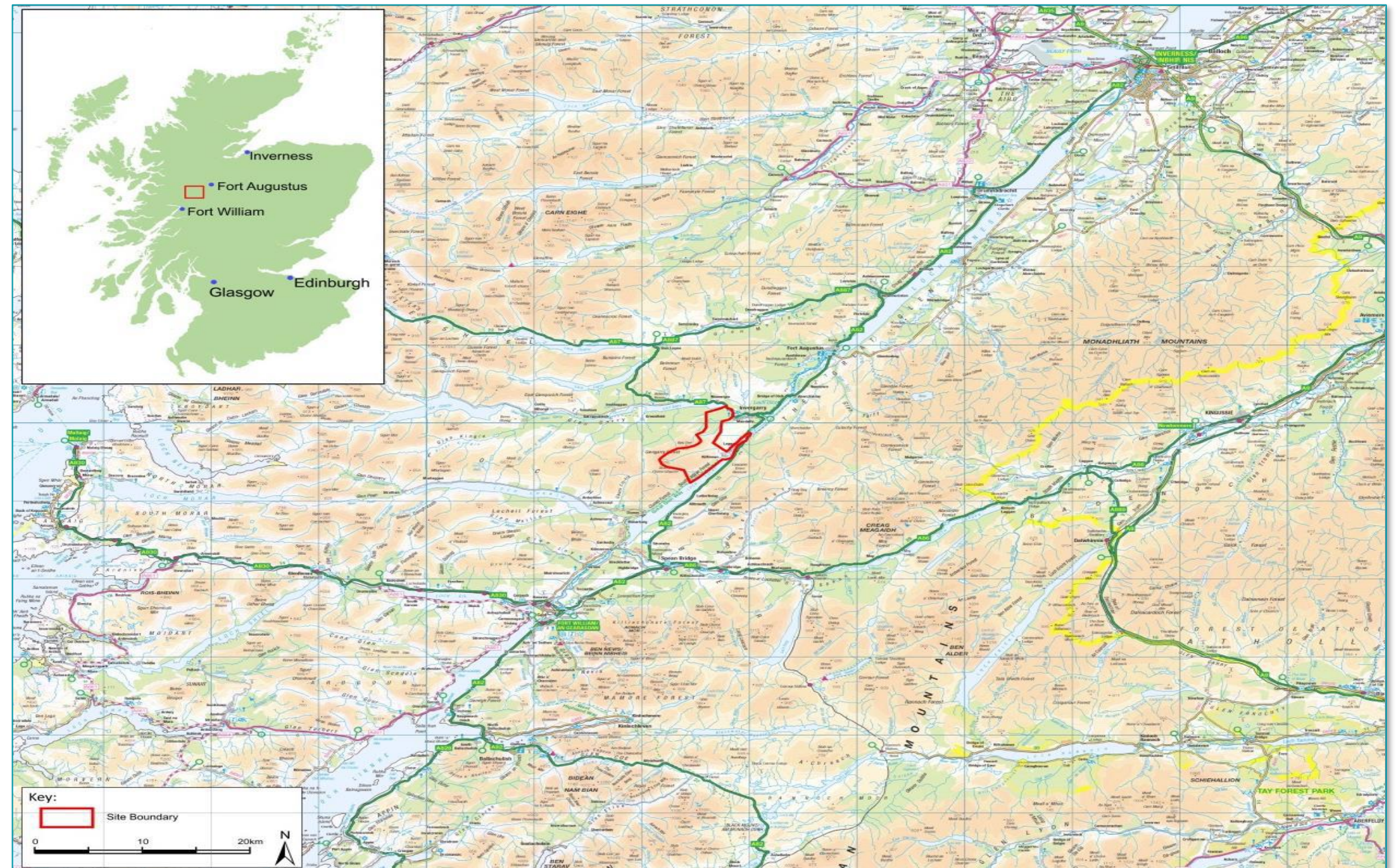


- ICL model assumption is that this hydrogen storage is used of electricity generation
- The integration of new 30 GWh or 90 GWh LDES reduces the need for hydrogen storage by around 70 GWh in the case with 30 GWh LDES.
- Increasing the installed capacity of LDES has a small impact.
- A similar pattern is found with the 90 GWh LDES; it reduces the hydrogen storage requirement by around 110 GWh.
- While hydrogen storage can provide low-cost bulk energy storage, converting electricity to hydrogen and back to electricity incurs substantial losses. Due to the low overall energy conversion efficiency @ ~50%.
- In comparison, the efficiency of LDES is above 75%.
- Therefore, it is expected that both technologies will work complementarily with LDES provided the efficient storage the system needs in 4hr to one day range rather than directly competing with the longer storage that hydrogen will provide.

COIRE GLAS HYDRO PSH PROJECT

SSER PROJECT LOCATED IN THE SCOTTISH HIGHLANDS

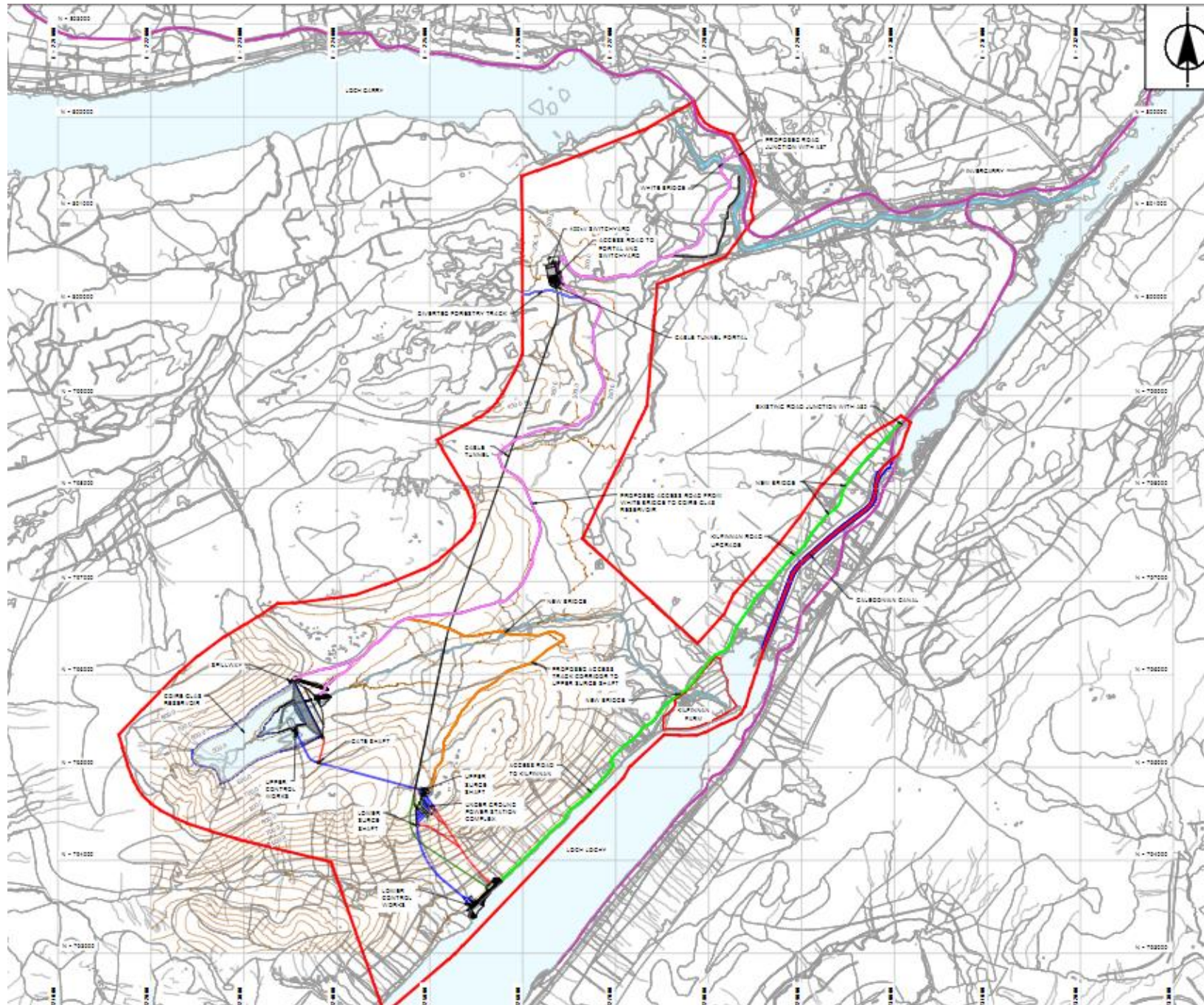
- Planning consent secured for up to 1,500MW and 30GWh of storage capacity
- More than doubles the total existing electricity storage capacity in GB
- Project of international significance located in Scotland – It is one of the largest such schemes in the Europe in terms of energy storage capacity



To watch a video on the Coire Glas project, please visit our website: <https://www.coireglas.com/>

COIRE GLAS PS PROJECT

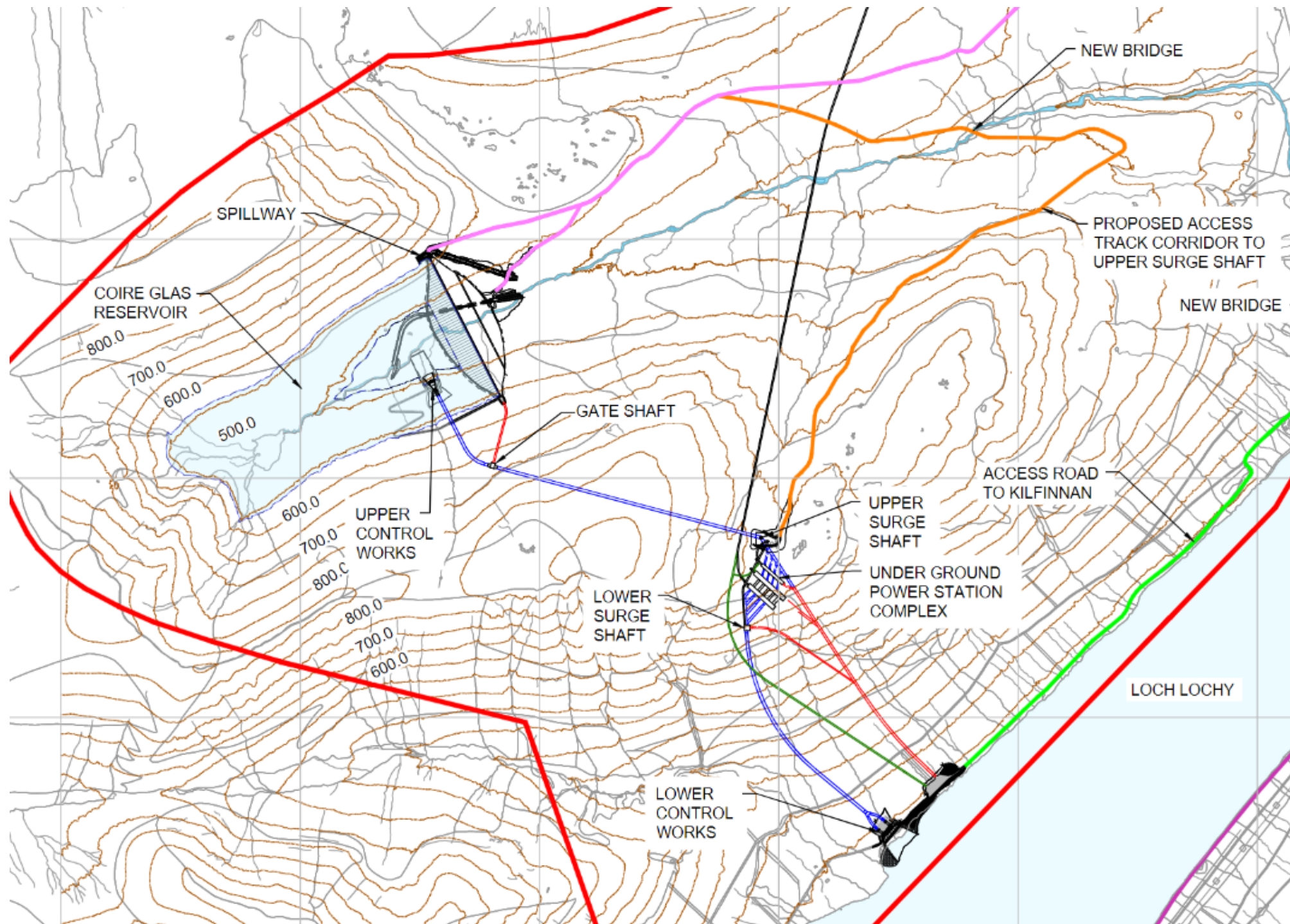
SSER PROJECT LOCATED IN THE SCOTTISH HIGHLANDS



- Over a £1.5 bn capital investment, approx. 70%-80% of which will be spent within the UK creating hundreds of jobs during construction.
- Working towards FID and construction commencing in 2023/4 and fully operational by 2030.

COIRE GLAS PS PROJECT

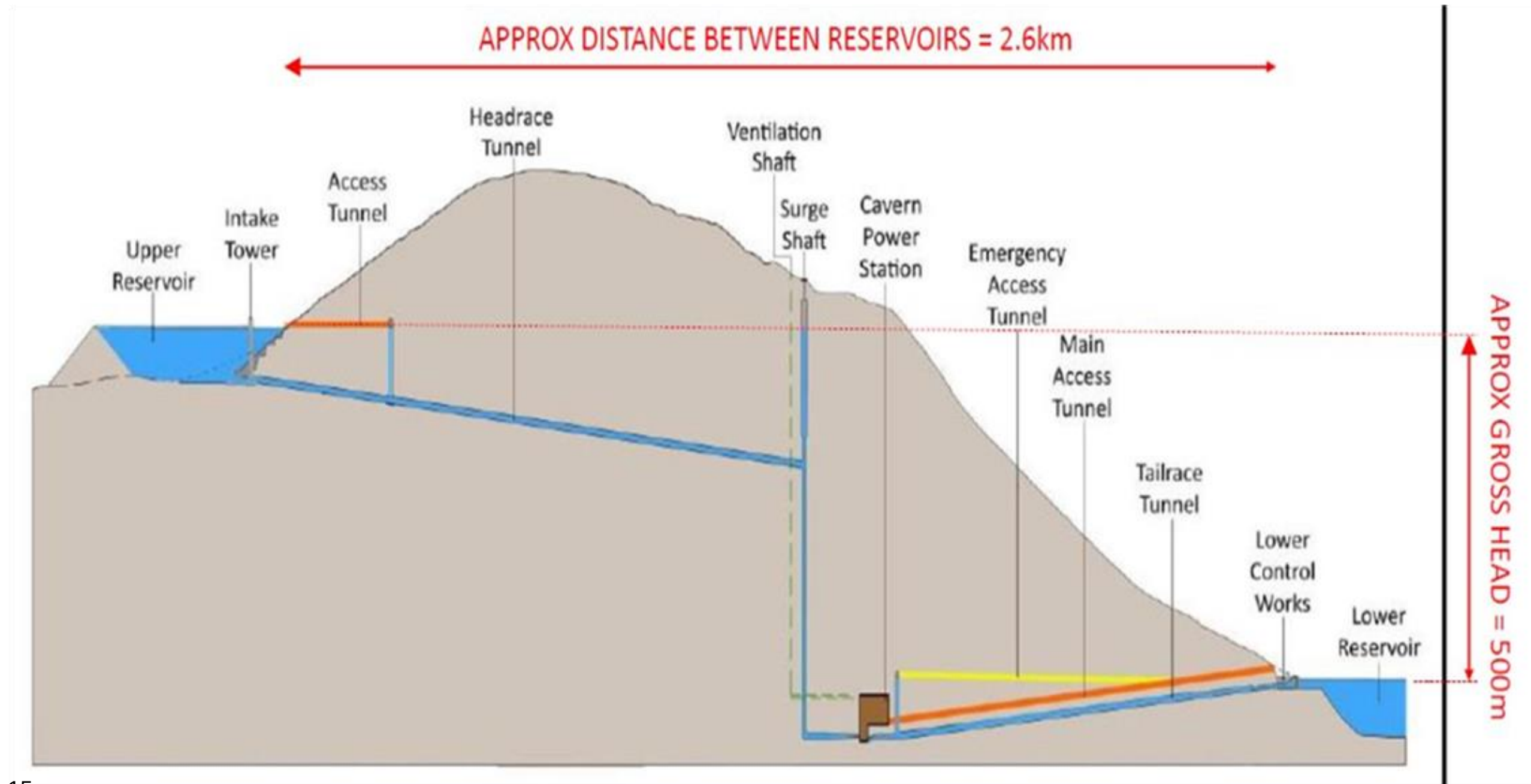
SSER PROJECT LOCATED IN THE SCOTTISH HIGHLANDS



- Dam to approx. 92 metres at its highest point
- 4 reversible Pump turbine units
- Location in large underground cavern approx. 1 Km from the shore of Loch Lochy
- 500m head difference between upper and lower reservoirs

COIRE GLAS PS PROJECT

SSER PROJECT LOCATED IN THE SCOTTISH HIGHLANDS



COIRE GLAS PS PROJECT

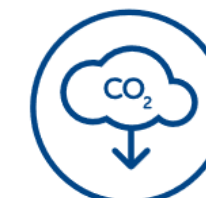
SSER PROJECT LOCATED IN THE SCOTTISH HIGHLANDS



HUGE OPPORTUNITY FOR COIRE GLAS

The UK energy system with increased offshore wind will need LDES flexible storage

BENEFITS	CHALLENGES
- Studies by Imperial College London and Aurora Research have found that new LDES energy storage offers significant value to the net zero GB system and ultimately savings to consumers : - Could save up to £690m p/a in system costs - Reduce wind curtailment by up to 11TWh - Reduce the need for up to 2GW of new transmission between Scotland and England - Integrate and ‘firm up’ an additional 3GW of low cost wind reducing the need for higher cost forms of firm low-carbon generation - A proven and long life asset, pumped storage is also the least-cost LDES technology over longer durations	- Large capital investments and long construction periods - combined with <u>significant revenue uncertainty</u> and a <u>lack of long-term market signals</u> - Current market revenues are largely contracted on a short-term basis and fragmented, making large projects difficult to finance - No pumped storage project has been built in the UK for 40 years



Pumped storage brings significant benefits over its lifetime to the system and consumer – but needs a revenue stabilisation mechanism to get built

WHAT NEXT?

How do we get Large-Scale Long-Duration Energy Storage projects deployed?

- There is currently no viable route to market for large-scale and long-duration electricity storage technologies
- We welcome the UK government's recognition of the challenges and potential approaches to facilitate the deployment
- SSER believes that an adapted Cap and Floor mechanism is the most appropriate intervention to give the necessary market investment signal
- Need government decision as soon as possible to ensure Coire Glas is operational by 2030



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