Long Duration Electricity Storage

Response to DESNZ Request for Advice: Q3 (Part 1)

NESO
National Energy System Operator

Contents

Background and context

This document forms the second part of our response to a request for advice from DESNZ on the long duration electricity storage (LDES) cap and floor scheme. It is provided alongside the first part of our response (to questions 1 and 2), which also sets out the full background and context to the LDES request for advice.

Scope

Long duration electricity storage is a broad term. The government has set out that only those technologies which meet the electricity storage definition in the Energy Act 2023, as well as technical eligibility criteria (e.g. being able to discharge continually for a minimum duration of six hours), would be eligible to receive support through the scheme.[1] The types of technologies that are expected to be supported by the scheme include pumped hydro energy storage (PHES), liquid air energy storage (LAES), compressed air energy storage (CAES) and other innovative forms of storage. It is these types of technologies that we focus on in this report, and which we refer to as "LDES" throughout.

The Resource Adequacy in the 2030s report[2] published by ESO in 2022, set out the benefit that storage assets of increasing duration can provide in supporting adequacy whilst simultaneously helping to address the challenge of meeting net zero. However, it is not the expectation that these technologies alone will cover the system's needs, especially during long periods of low renewable output. That will require technologies capable of providing energy at a much larger scale for longer periods, such as unabated gas generation, power carbon capture and storage (CCS) and hydrogen to power, to ensure future critical stress events can be covered. DESNZ set out in the January 2024 consultation that *"LDES technologies supported by this scheme would be expected to complement other shorter duration technologies and operate alongside longer-scale storage facilities like hydrogen, serving different demands and customers."* As such, longer-scale storage facilities like hydrogen are not considered in the scope of this scheme and we do not consider them as part of this advice request.[3]

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[1] Long duration electricity storage consultation: government Response, DESNZ (2024)
[2] Resource adequacy in the 2030s [2022, Published as NG-ESO with AFRY]
[3] Long duration electricity storage consultation (DESNZ, 2024)

The request for advice

The details of the full advice request are provided in our report on questions 1 and 2. This report provides our response to the third question identified in the request for advice:

3. *The amount of LDES capacity, which can be expressed as a range, that would be optimal for Ofgem to support with cap and floor agreements through its first LDES allocation round to open in 2025. In particular, how much additional LDES cap and floor capacity beyond that in your clean power 2030 advice would be optimal to maintain clean power and energy security in the period from 2030 to 2035.*

Approach

Factors to consider when assessing an optimal capacity range for LDES

We interpret this request as meaning the LDES capacity range (in GW) that is optimised based on system cost, whilst delivering clean power and energy security in the context of different possible generation portfolios in the future. Defining the optimal LDES capacity is complex and depends on wider energy system factors, such as:

- **Renewable penetration (capacity and location)** - The optimal amount of LDES is broadly associated with the level of renewable curtailment (i.e. how much renewable electricity will be available to store). This is influenced by the location in which the renewable assets themselves are placed (i.e. whether or not they are located in areas of network constraint).
- **Energy demand** - Future energy system demand is assumed as part of our modelling processes and impacts the amount of generation capacity that is required. This is comprised of multiple factors including the rate at which the wider energy system electrifies (e.g. uptake of EVs and heat pumps). If demand is slow to electrify, the optimal level of LDES will differ from a scenario in which it is achieved much more quickly.
- **Availability of alternative dispatchable power options** – as shown in our CP30 and FES 2024 publications, it is possible to achieve a lower level of LDES capacity if alternative low-carbon technologies are available to provide the same function (e.g. gas CCGT with carbon capture and storage). Overall, the optimal level of LDES is dependent on the relative economics of these technologies and, in the case of energy modelling, the input assumptions employed.

In addition to the above considerations, there are also several factors associated with different modelling approaches:

- **Multi-vector considerations** – models focussing solely on electricity without accounting for interactions with other energy vectors (e.g. hydrogen, biomethane) do not fully account for the impact of LDES on the wider energy system.
- **Number of weather years modelled** - renewable output and energy demand are influenced by weather patterns. Several energy system models use a single weather year of data which can lead to inadequate variability in renewable generation and an unrealistic assessment of how much LDES is optimal.
- **Level of foresight** – many energy system models operate with near complete knowledge of future supply and demand. This creates an ideal-world scenario which does not fully account for the uncertainty that faces grid operators in the real world. This may result in underestimating the benefits of LDES in managing uncertainty.

- **Temporal granularity –** the use of aggregated or representative time periods (e.g. days, weeks) can fail to capture critical events that influence renewable output. A trade-off with modelling run-times is expected.
- **Spatial granularity –** the benefits of LDES can be influenced by spatial factors (e.g. where renewables are located and where LDES is located). Models with an aggregated national approach can overlook regional and local factors, underestimating the strategic value of LDES in providing local resilience and addressing congestion-driven challenges, leading to suboptimal system-wide outcomes.

Modelling LDES

The capacity range of LDES in FES 2024 is based on extensive input from stakeholders and our assessment of relevant sector and policy developments, to produce a credible range of LDES deployment. We test these LDES levels within a range of possible future energy mixes against key objectives such as security of supply, flexibility and net zero.

We used a similar approach as part of the CP30 modelling to identify the range of LDES that could be deliverable by 2030.

We are in the process of developing the capability to optimise deployment of LDES against system cost, through our capacity expansion model (CEM)[4]. The CEM was used for the first time in our Future Energy Scenarios (FES) 2024 publication. It optimised what capacity was built by type and location at the lowest system cost. LDES wasn't optimised directly in the CEM but the capacity assumptions were applied to the model as an input and the other technologies were optimised around this to ensure there was an economic and secure solution to deliver the system capacity that is needed. We will be adding further sophistication to the modelling through the ongoing work for the Strategic Spatial Energy Planning[5] (SSEP). We expect the CEM to incorporate the ability to optimise LDES alongside the other technologies on the system, enabling us to explore LDES deployment ranges when optimised against system cost.

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[4] Our CEM is implemented in the PLEXOS software; equivalent capability can also be implemented in other software used within our industry, such as Bid3.

[5] Strategic Spatial Energy Planning (SSEP) | National Energy System Operator

Our approach to this question

Considering the above limitations, we have agreed with DESNZ that our response to this question will be delivered in two parts:

- Part 1: We outline the range of LDES capacity that is captured across our existing publications and associated with various energy modelling pathways. We outline what this range offers and what its limitations are.
- Part 2: We have discussed further work to refine this range, using the enhanced modelling capabilities which are under development in NESO, throughout 2025. This is subject to further discussions with DESNZ and Ofgem and is therefore not included in this report.

Part 1 – Indicative range based on currently available analysis

LDES range in FES 2024 and CP30

NESO has previously identified LDES capacity levels as part of its CP30 and FES 2024 publications. These represent the sum of capacity provided by pumped hydro energy storage (PHES), liquid air energy storage (LAES) and compressed air energy storage (CAES) of at least 6 hours duration across both the transmission and distribution systems.

The capacity levels identified in our prior FES 2024 and CP30 publications are summarised in Annex 1. It should be noted that 'clean power by 2030' is only achieved in pathways outlined in the CP30 publication. The FES 2024 pathways (excluding the counterfactual) meet the 2050 net zero target and a decarbonised power sector by 2035 at the latest, as these were developed in line with the previous government target.

Methodology

The FES 2024 and CP30 publications represent the output of a significant body of wider work by NESO that has drawn heavily on input from key stakeholders across the energy sector and has involved consultation with technology developers.

FES 2024

The FES 2024 LDES capacity range across the pathways is primarily based on stakeholder input and an analysis of project pipelines. The FES 2024 pathways referenced in Annex 1 identify three LDES capacity levels, reflecting different assumptions about when proposed[6] LDES projects will be delivered in the 2020s and 2030s. Whilst a clean power system is not delivered by 2030 in these three pathways, all three are compliant with a net zero energy system by 2050.

FES adopts a pathway framework and a set of levers to differentiate between the pathways, demonstrating that net zero is possible but can be achieved in different ways. We assume the highest growth of LDES capacity in the Holistic Transition (HT) pathway and we see the pace of deployment increasing over time as planning barriers are removed. HT also assumes that funding and policies are available to support multiple new large projects and minimal constraints are expected such as outage maintenance and supply chain barriers. In our Electric Engagement (EE) pathway we assume similar drivers

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[6] These proposed projects refer to projects that are in the project pipeline and are under development – developers of these projects have indicated that they are awaiting the cap and floor scheme to progress to a final investment decision.

are present as HT although the pace is marginally slower with a greater focus on shorter duration storage and therefore LDES projects have reduced funding. Hydrogen Evolution (HE) assumes the push for alternative technologies, including hydrogen storage, impacts delivery of other forms of LDES.

The FES analysis is completed against average weather conditions and uses the 2013 weather year as an input. The weather in 2013 is deemed to be representative of typical year with colder and milder spells. The capacities of the individual technologies and as a whole are also tested against the Loss of Load Expectation (LOLE) criterion of 3 hours which considers de-rated capacities at peak.

CP30

The modelling work conducted by NESO during the CP30 project was based on the FES24 Holistic Transition (HT) pathway. Capacity across the different technologies was brought forwards from the HT trajectory to be delivered earlier, in line with meeting the "clean power by 2030" metric[7]. These choices were based on extensive stakeholder engagement and wider analysis of deliverability.

The LDES range identified in these pathways was not optimised for whole system cost and instead represents the range that was considered deliverable within the 2030 timeframe, albeit pushing the limits of what is feasible at the upper end of the range. The higher level of LDES in 2030 in the Further Flex and Renewables pathway compared to FES24 HT assumes the ability to accelerate and bring-forward specific LDES projects.

The LDES range used across these pathways remains a component of a wider energy mix that includes rapid buildout of other low carbon technologies to achieve clean power by 2030. The two pathways represent one future with higher renewables and levels of flexibility, and another future with higher levels of low carbon dispatchable power.

Recommended LDES range

Based on our prior publications, the LDES capacity ranges outlined in Table 1 (below) are proposed as an interim range to provide guidance on the amount of LDES that should be targeted through the cap and floor scheme. For 2030, these ranges are defined by the upper and lower levels identified across the two CP30 pathways. For 2035, the range is taken as the lower and upper amount of LDES across the three pathways in FES24 that achieve net zero by 2050. **These numbers include existing assets that are already in operation (2.8 GW / 28 GWh).**

When setting the target in the Technical Decisions Document (TDD), providing a range (as opposed to a single figure) enables government, Ofgem and NESO sufficient flexibility to

[7] In our CP30 publication we define a clean power system as one in which (1) clean source sources produce more power than Great Britain consumes in total and (2) unabated gas provides less than 5% of Great Britain's generation in a typical weather year

account for the development of the Strategic Spatial Energy Plan (SSEP), which will set out a preferred pathway to meet future energy needs. **Ofgem and DESNZ should consider the potential for aligning decisions on Window 1 with the SSEP through the assessment process. Once the SSEP is published it can be used to help set capacity and power ranges for future LDES cap and floor windows.**

Separate to this request for advice, the connections reform process will align with the government's Clean Power Action Plan. In this plan, the LDES range for 2030 is 4-6 GW, and the range for 2035 is 5-10 GW (which is based on the FES 2024 Holistic Transition pathway). Consideration will need to be given on how the connections reform process and the cap-and-floor scheme ambitions will align if there are differing maximum figures in the range.

If projects with connections agreements in the 2031-2035 period do not deliver, the subsequently available connection capacity will not be offered to other projects until the publication of the SSEP, which any such further connection offers will align with. This allows for a balance between longer-term certainty and enabling an optimal energy mix to be determined via the SSEP.

The power capacity range set out in Table 1 represents the interim range to inform DESNZ's TDD. The energy range is also included for information.

Table 1 -Summary of total LDES capacity ranges for 2030 and 2035 in terms of both power and energy capacity. Both total (including 2.8 GW/28 GWh of existing capacity) and 'additional' values are shown.

Year	Based on	Total capacity (including existing LDES assets)		Additional capacity required	
		Power capacity	Energy capacity	Power capacity	Energy capacity
2030	Range in CP30	4.6 – 7.9 GW	50.1 – 98.5 GWh	1.8 – 5.1 GW	22.1 - 70.5 GWh
2035	Range in FES 2024	5.5 – 10.5 GW	62 - 120 GWh	2.7 – 7.7 GW	34 – 92 GWh

Annex 1: Overview of pathways across NESO Publications

Overview of pathways across NESO publications, FES 2024 [published as NG-ESO] and CP30. 2033 ranges from FES are included for reference. NOTE: lower level of GWh-capacity in the New Dispatch scenario is corrected from the CP30 publication.

Publication	**Scenario**	**Delivers clean power by 2030?**	**Delivers Net Zero by 2050?**	**LDES Capacity (GW)**			**LDES Capacity (GWh)**		
				2030	**2033**	**2035**	**2030**	**2033**	**2035**
FES 2024	Holistic Transition	No	Yes	5.9	8.0	10.5	81	98	120
	Electric Engagement	No	Yes	4.1	5.4	6.5	48	57	66
	Hydrogen Evolution	No	Yes	3.7	4.7	5.5	45	54	62
CP30	New Dispatch	Yes	N/A	4.6	N/A	N/A	50	N/A	N/A
	Further Flex & Renewables	Yes	N/A	7.9	N/A	N/A	98.5	N/A	N/A