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Energy Storage Ireland

A Procurement Framework for Long-Duration Energy Storage

Position Paper

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Executive Summary

Energy Storage Ireland (ESI) is a representative body for those interested and active in the development of energy storage in Ireland and Northern Ireland.

We work together to promote the benefits of energy storage to decarbonising Ireland's energy system and engage with policy makers to support and facilitate the development of energy storage on the island.

Energy storage will play an essential role in facilitating the higher levels of renewable generation on the power system required to achieve national renewable electricity targets. The flexibility of storage systems and their ability to contribute to the energy, capacity and system services markets allows them to deliver a wide range of benefits to end consumers such as wholesale energy price reductions, reduced CO_2 emissions and flexible system support services to help manage the grid with higher levels of renewables.

A coordinated strategy for energy storage is needed to ensure investment is supported through the various pillars of the market and that new energy storage technologies are fully integrated into the electricity system and market to unlock their full potential. This should bring together the relevant stakeholders such as the System Operators, Regulatory Authorities, Government departments and industry to ensure a coordinated approach to energy storage going forward.

Long-Duration Energy Storage (LDES) will be essential to decarbonising our energy system by providing a range of valuable services from congestion management, peaking capacity, alternative network solutions, increasing renewables on the grid, delivering cost benefits to end consumers, and ensuring security of supply. However current market frameworks and incentives are unlikely to be sufficient to deliver the volumes and capabilities of LDES we will need in future. This will require new frameworks to drive investment similar to how REFiT and RESS have driven investment in renewable technologies with similar high Capex/low Opex characteristics to LDES. The goal of these new frameworks should be to meet two key objectives:

1. Provide a stable long-term revenue floor under which LDES can build
2. Ensure optimal operation of LDES assets to maximise their value to the system and to consumers through existing and new services/market incentives.

To kick-start the process of developing a procurement framework for LDES we propose the publication of a Call for Evidence paper by the relevant Government departments in Ireland & Northern Ireland. This would seek views from a wide spectrum of stakeholders on potential options for a future framework, including the proposal set out in this paper.

Need for LDES

The need for long duration storage technologies has been identified in a number of studies.

In May 2022, ESI and Baringa published *'Game Changer'* a report showing the benefits that various durations of energy storage can bring to the system and to end consumers on the island of Ireland by 2030.[1] The key findings from this study are as follows:

- By participating in the Irish day-ahead energy market, energy storage can reduce dayahead carbon emissions by 50% by using long-duration storage technologies. This makes a material contribution to meeting ambitious 2030 power sector decarbonisation goals.
- Strategic deployment of energy storage in transmission constrained regions of the network reduces the dispatch-down of renewable generation from constraints without the need for network reinforcement, unlocking additional carbon savings.
- By contributing to security of supply, helping to support renewable capacity, and displacing fossil fuels in the balancing market, energy storage can deliver a net saving to end consumers in Ireland of up to €85m per year.
- These benefits are additional to the carbon, renewable curtailment, and end consumer savings offered by energy storage through the provision of zero-carbon system services.
- Energy storage helps the integration of renewables at all stages by ensuring that generation is not wasted; reducing oversupply by up to 60%, constraint volumes by up to 90%, and curtailment by 100%.

A 2019 SEAI funded study[2] examining the effectiveness of different renewable curtailment mitigation strategies included a specific work package examining the effectiveness of storage with different energy capacities (MW / MWh ratios). In this study the problem was defined by first adding wind to a 2020 system without implementing any integration / curtailment mitigation solutions until a 70% RES-E level was achieved. This is starting point of all curves in *Figure 1* below (top left corner of the graph), and every point on every line represents a 70% RES-E system. In the absence of any curtailment mitigation solution, the levels of renewable curtailment are extremely high meaning that approximately 44% of the available renewable energy cannot be utilized.

In this work package a multi scenario analysis was conducted examining the impact of gradually increasing the "idealised" interconnector capacity and "idealised" storage capacity with varying energy limitations. In this context idealised interconnectors means that the model was always able to export up to the full available capacity to mitigate curtailment. In the context of storage, it means that the model tried every other means of mitigating curtailment before charging a

[1] https://www.energystorageireland.com/wp-content/uploads/2022/05/GameChanger-ESI-Report-May2022-Web-1.pdf
[2] https://www.seai.ie/documents/research-projects/RDD-000326.pdf

storage technology (due to its energy limitation), and then once a curtailment event was over it sought to discharge the storage technology as quickly as possible to maximise its availability for the next event. The results should be considered as the theoretical maximum curtailment benefit that can be provided by each technology. The idealised interconnector could also be considered to closely represent the curtailment benefits of an energy unlimited storage technology.

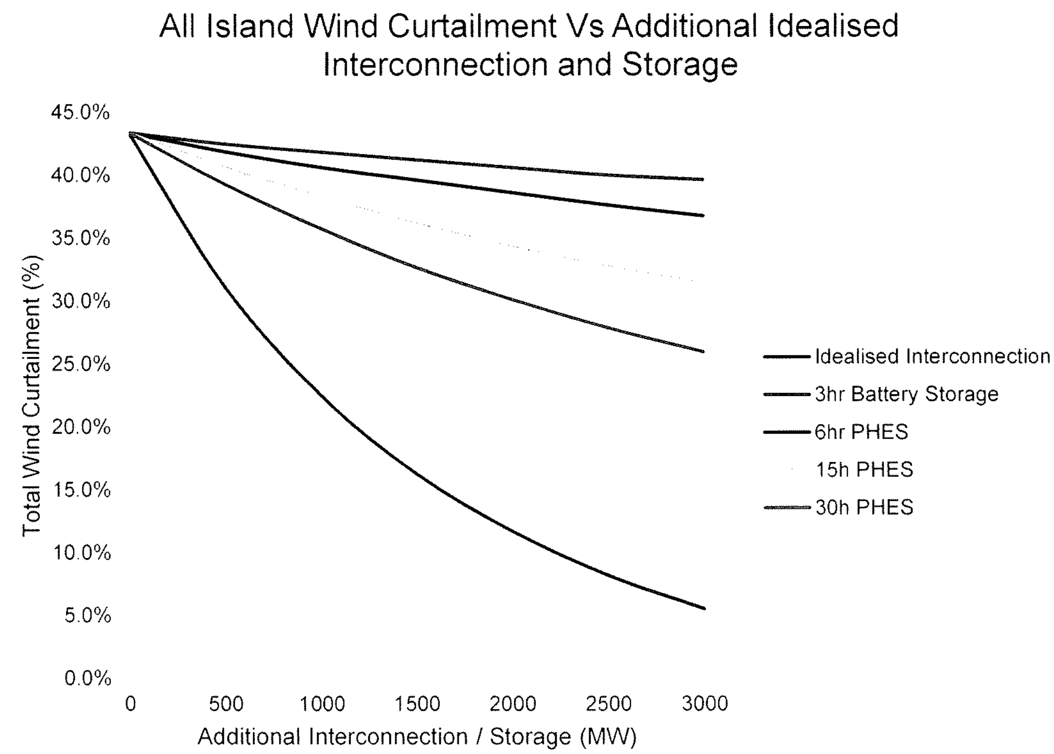

Figure 1 - Wind Curtailment vs Additional storage capacity of varying durations and idealised interconnection

These results clearly illustrate the importance of energy capacity when seeking to use storage technologies to directly absorb surplus renewables on systems with very high levels of RES-E at either a system or local network level. Due to the very large energy volumes required it is critical that the storage capex per MWh is extremely low. Techno-economic optimisations carried out by ESI members indicate that this is much more important than maximising the return trip efficiency of the technology

We would also like to note the recent formation of a new Global Long Duration Storage Council. This body includes many technology companies developing new classes of low cost long duration storage with the potential to solve local network constraints and system wide curtailment in an economic manner. This group commissioned McKinsey & Company to carry out a study[3] examining the role of LDES on net zero power systems globally. Some key conclusions from this work:

- The report notes that LDES tech becomes particularly important on power systems attempting to reach 60-70% RES-E. Irelands 80% target means LDES could become critical in Ireland earlier than many other markets.
- Significant investor interest in recent years with c.a. €2.5b invested in new / emerging LDES contender technologies.
- LDES is seen as providing four key sources of flexibility to meet future power system challenges;
    1. Intraday flexibility (<12 hours duration)
    2. Multiday and multiweek flexibility (12 hours – weeks)
    3. Seasonal flexibility
    4. Flexibility to respond to extreme weather events
- In Europe the study estimates average durations of installed storage systems will need to be 20-30 hours by 2030, and 50-60 hours by 2040. Ireland and Northern Ireland will likely be ahead of the average EU figures due to our higher RES-E targets in the nearer term.

[3] https://www.ldescouncil.com/insights

Problem Statement

Changing Nature of the System

It is critically important when considering the market framework under which power generation technologies and supporting system services (including storage) are deployed, to consider the changing nature of the system. As we transition to 80% RES-E and beyond, we are moving from a system on which the largest cost component is fuel, to one where the largest cost component is capital infrastructure. Figure 2 below provides a crude illustration of the potential change in the underlying cost of providing sufficient generation capacity and fuel to meet demand in a 40% RES-E system vs an 80% RES-E system. It is noteworthy that only the fuel element of this cost is capable of responding in an economic way to short term energy market price signals i.e. through the burning of more or less fuel. The capital infrastructure component is incapable of responding to these signals economically after it has built.

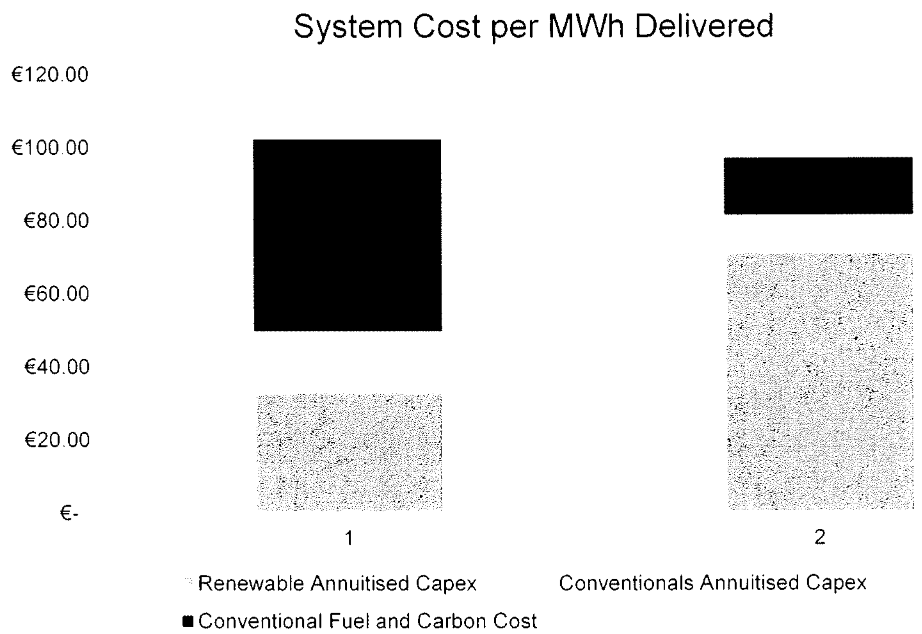

Figure 2 Illustration of Capital Cost Components vs Variable Operating Cost Components on a (1) 40% RES-E system, (2) an 80% RES-E system (crude estimate – for illustration purposes only)

On the basis that the clear global and national imperative is to decarbonise the grid as quickly as possible and at least cost, the following key questions emerge:

- Which technologies should be deployed?
- What market framework / process should they be deployed under?

This paper attempts to address these points by setting out a clear problem statement, proposed principles that should inform a storage services procurement design, and some initial proposals as to how such a procurement framework might operate.

How to Compare Different Storage Technologies at a System Level?

Existing and new LDES technologies have very different combinations of energy capacity, duration, return trip efficiency (RTE), asset lives, capital costs and fixed operating costs. Each technology has a different floor revenue requirement in order to meet a reasonable investment hurdle rate. Under any new storage procurement framework how do policy makers compare these technologies and decide which should clear? e.g. Technology A can provide 24hr discharge, 65% RTE, and is located in a region with existing network constraints of 9% and requires a guaranteed floor revenue of €50k per MW per annum to build. Technology B can provide 6hr duration, 80% RTE, is located in an area with network constraints of 3% and requires €40k per MW per annum to build. Which of these two technologies should be procured? On what basis do you make that decision?

ESI would generally take a technology agnostic approach and believes that ensuring the creation of market frameworks that reward the delivery of critical services is important. The parameters should be defined on the basis of system need, allowing the most economically viable and preferably lower/zero carbon technologies to win, ensuring economic efficiency for both the System Operators and consumers.

How should Locational Benefits & Interactions with Renewable Generation and Demand be Considered?

Intuitively there are interactions between the cost of available renewable energy in different locations, the level of network constraints and the value of storage services of different durations. For example, If there is a renewable generation resource with a very low cost of available energy but facing high network constraints, it is likely that longer duration storage services deployed in that location will provide greater system value, compared with the same technology deployed in an area facing demand side congestion issues, or in areas with low renewable constraints. Should policy makers be willing to procure LDES at a different price in areas of high renewable transmission constraints? If so, what should inform that decision? For example, consented wind energy projects exist with an underlying LCoE based on availability of €50.00 in the same region as technology A above. Wind energy projects in the same region as technology B have an LCoE based on available energy of €80.00. How should these interact with the storage procurement process?

Similarly, there are likely to be interactions with locational applications. E.g. In areas of high demand (Dublin), the demand side transmission congestion issues are likely to be of shorter duration. In these locations, intuitively, storage technologies of shorter durations and higher efficiencies are likely to be more optimal. Again, how should policy makers compare bids and decide what clears where?

Finally, any storage solution which targets a network constraint should be evaluated against two remaining options to deal with this constraint:

1. Building new grid infrastructure to remove all or part of the constraint, noting timelines for deployment need to be included in the evaluation. It is also noted that other jurisdictions, notably GB, are looking at encouraging System Operators to consider flexible alternatives to new grid infrastructure to see if they are cost/time effective.
2. Taking no action to alleviate the constraint and accepting that the costs associated are either built into future renewable energy auction bids or are compensated for by the System Operator.

Remuneration Gaps / Revenue Certainty

It seems clear that existing market systems don't fully remunerate storage for the services that they provide. Some examples include:

- Network congestion management– no product or incentive exists.
- Carbon abatement (energy storage is a source of clean dispatchable capacity that displaces fossil fuels)
- Managing renewable oversupply and contributing to RES-E targets.
- Inequitable treatment in the energy market i.e. no ability to bid in negative PN or to be included fairly in scheduling and dispatch.

With the exception of capacity market revenues, the majority of available revenues come with limited medium to long term certainty:

- o DS3 tariff arrangements end in 2024. No detailed design yet on future arrangements but short-term auctions are a key feature. Opportunities for long-term revenue certainty may be limited
- o Energy Arbitrage – energy market revenues are volatile and difficult to forecast with accuracy
- o Capacity - does allow for 10-year contracts but structural issues disadvantage long duration storage e.g. de-rating factors do not recognize LDES and price caps are based on new fossil fuel plant. The Capacity Market as currently structured will not make up the 'missing money' needed to drive investment in LDES.

These uncertainties result in higher investment hurdle rates and makes it very challenging to develop an investable business case for LDES assets.

Operational Signals vs Investment Signals

Existing market structures are reasonably good at incentivizing appropriate / optimal operation of constructed assets but are not good at sending investment signals to the new low to zero marginal cost assets needed to decarbonize the power system.

How should policy makers provide the needed revenue certainty to new LDES assets without removing / reducing the effectiveness of short-term price signals driving optimal operation of assets? E.g. If you provide LDES with a simple Contract for Difference structure, where is the incentive to trade optimally when any revenue above the strike price will be handed back?

Interactions with RESS, Clean Energy Package and Firm Access Policy

Under existing RESS auction design, constraint, curtailment and oversupply risk are principally with the generator. This means that generators will price in a certain level of dispatch / re-dispatch into their bids. This in turn means that subsequent storage deployments that serve to reduce levels of dispatch will increase revenues to RESS generators and not create consumer cost savings to the extent that would otherwise be the case. This diminishes the level of incentive for regulators acting on behalf of consumers to support storage deployments as high re-dispatch and oversupply costs are baked in for the period of support.

The recent SEMC decision on Clean Energy Package Electricity Regulation Articles 12 & 13 implementation is very unclear. Potential positives are:

- Compensation proposals for firm RESS generators might represent a partial fix of the issue noted above.
- A move to market based re-dispatch could also help support the case for storage if the intention is to allow all bidders to bid in their opportunity cost in this new regime.

Negatives:

- Majority of RESS generators don't yet have firm access, and firm access policy is unclear. Under existing policy, storage wouldn't be able to create additional firm space
- The thrust of the Art12&13 decision is towards compensation being allowable for re-dispatch of firm generators only. This could make it much more challenging for non-firm generation to be deployed and this could also reduce the business case for more storage.

Energy Storage and Firm Access

Firm access as it applies to storage devices on the grid is an important point to consider. In Ireland, the TSO is obliged to plan and develop the grid infrastructure to provide for firm access to all units using the transmission grid (per their license conditions and the Transmission

Planning Standards). Connection to the grid is allowed prior to the completion of all grid infrastructure upgrades required so generators or demand units do have an option to connect initially on a non-firm basis until the necessary grid upgrades (known as Associated Transmission Reinforcements or ATRs) are complete to provide them with firm access.

Storage technology is an important element of Ireland's technology mix in working towards our 2030 target of 80% RES-E. The reason that storage is so vital to achieving this target is that it presents the opportunity to 'smooth' the profile of our abundant, but variable, renewable resource and match it better to the demand profile. In other words, storage projects can be used to charge (or import) energy at times of high renewable output and discharge (or export) at times of low renewable output. This very use-case of storage means that storage will tend to act against the normal flows on the grid i.e. storage is basically a contra-flow device on our grid. Therefore, applying a 'firm access' standard to build out grid for storage connections and impose network charges on them for this purpose is not rational.

Instead, storage projects should be provided with two new connection types as options for their connection. They can either connect in a 'permanent non-firm' manner, meaning they drive no grid reinforcements and the TSOs retain the right to constrain the units as needed. This connection type might be particularly suitable for a storage project looking to generate most of its' revenue via trading and capacity contracts. Or they can connect as 'contra-flow' units where they effectively create new firm capacity and the TSOs retain the right to operate the unit proactively in order to maximise its impact in a constraint scenario. This connection type would be particularly suited to storage projects located behind a specific network constraint. The incentive for storage developers to connect by one of these methods is that they can either avoid network charges or even be paid negative charges for acting as an enabler to increase grid capacity. Since network charges are a considerable cost to a storage project this would have a significant benefit for the project's business case. For the TSOs, they can provide a real incentive for the deployment of multi-hour storage while maintaining operational security and avoiding difficult network build-out.

The below table describes the existing connection types and two new types we propose:

Connection Type	Status	Network flows	Financial Firmness	Physical Firmness	Network upgrades	TUoS	Grid Connection Capacity	Congestion payment	Examples
Normal unshaped	Existing	Adding to existing peak flows	Firm	Firm	Must complete	Positive	Reduces	None	Typical large industrial demand or conventional generator
Temporary non-firm	Existing	Neutral	Non-firm initially	Non-firm initially	Must complete	Positive	Neutral	None	Wind farms or Dublin data centres policy
Permanent non-firm	Proposed	Neutral	Non-firm	Non-firm	Can ignore	Zero	Neutral	None	Battery prepared to take the risk of non-firm
Contra-flow	Proposed	Contra-flow at all peak time	N/A	N/A	Avoided	Negative	Increases	Payment to unit	A long duration storage plant built to offset network upgrades

It is also important to note that this discussion relates primarily to physical firmness and we note that ESI has submitted position papers in recent months in relation to making storage units financially firm in order to ensure that they are treated equitably in the energy market.

However, we see this as a temporary measure to fix and existing issue in the market and that should not distract from the longer-term proposal described above.

Proposed Principles of the LDES Procurement Framework

We propose the following principles for the LDES Procurement Framework

- The LDES procurement framework should be technology agnostic and support investment in an appropriate broad portfolio of storage technologies and capabilities that meet the needs of the system and national decarbonisation objectives.
- The procurement process should maximise long term certainty for a floor revenue for winning technologies. This will reduce investment hurdle rates enabling easier, greater and more cost effective deployment.
- The procurement should be based on an estimation of overall system value vs cost taking account of any locational benefits.
- The selection of "winning" technologies needs to be based on a transparent full system & network model[4] that bidders can understand and replicate. This doesn't have to be perfectly optimized, but it is critical that it is consulted on and is transparent / replicable. The process should clear projects with the highest deltas between overall system value and bid cost first.
- The process should be designed in a manner that recognises the hedging value of storage. LDES investment will be Capex driven rather than Opex which means more stable pricing and less exposure to gas price volatility.

[4] Note there is some precedent for this approach. ECF's in RESS differentiate between the expected system value of technologies, the calculation of these ECF's had to be based on system modelling. Similarly locational scalars are considered in system service and capacity markets based on different locational values of technology deployment. This proposal would make this process more transparent in the context of storage technology procurement.

High-Level Design of a Potential Procurement Framework

Revenue Floor with Shared Upside

Bidders could bid in a required revenue floor with any upside on actual aggregated market[5] revenues shared proportionately with consumers for the length of the contract. "Floor" revenues to be bid and cleared based on the system Cost Benefit Analysis (CBA) at the bid floor price using a full system model as envisaged above. The objective shouldn't be to minimise the gap between revenues earned under existing market arrangements and the floor price, rather to maximise the projected net system value that the LDES asset can deliver. The existing/new system services and energy markets should just be used in conjunction with the broader long-term procurement to ensure efficient near-term operation of assets.

A cap and floor mechanism has been proposed in Great Britain to incentivise long-duration storage. This is a regulated long-term contract framework, used to incentivise investment in interconnectors, which provides a guaranteed floor price, supported via Use of System charges where project revenues fall below the floor, and a cap above which excess revenues are handed back to end consumers. This type of framework could be feasible for LDES but the downside of this is that assets are only incentivised to trade optimally and manage near-term operation up to the cap. The incentive to gain more revenue and add more value to the system is lost beyond this. A floor and shared upside mechanism does not set a fixed cap but a fixed proportion of revenues above the floor price that would be shared with consumers so the incentive remains for assets to trade optimally and try to maximise revenues from existing and new services, and in doing so maximising consumer savings.

We also think there is merit in discussing whether such a system could be added to existing RESS auctions (noting that storage would be floor + shared upside rather than CfD) and allow technologies to clear based on the marginal system value vs cost.

New Services

New services, in addition to existing DS3 services, energy arbitrage and capacity market contracts, should be introduced to incentivize locational/strategic deployment and optimal operation of LDES. For instance:

- Congestion management service, (potential TUoS payment)
- Curtailment management service
- New Ramping services- e.g. 12-hour

[5] In this context market revenues include arbitrage, capacity, systems services including any new services or products designed to remunerate storage for the value it provides. A shared upside model incentivises storage providers to participate appropriately in all existing market structures.

- Carbon abatement service
- Oversupply management service

These services would be in addition to but complementary to the long-term floor price certainty provided by the LDES procurement framework and could be designed to incentivize optimal operation of built assets.

Auctions for long term revenue floors would allow new storage assets to be deployed with relatively low cost of capital. The addition of new services combined with the continued operation of existing market structures will ensure that these newly deployed assets are operated in a way that maximizes their overall system value. Where revenues exceed the floor price, consumers would share in this upside as a reward for providing the floor.

Interactions with Existing Market Structures

- RESS: Storage and RESS procurement processes should be complementary – e.g. Assigning very significant re-dispatch risks to RESS bidders and driving up RESS prices, and then fixing the problem with a storage procurement after the RESS assets have built, is not efficient or in consumers interests. Separately, if we have a system model for storage procurement, should or could this be used to determine appropriate ECF's for RESS clearing. Could this involve moving to a system where bidders bid in based on availability and locational ECF's are determined that account for expected levels of re-dispatch compensation (noted that this could interact with EU energy policy and this could be very challenging)
- **Firm Access:** Storage deployment should result in the creation of new "firm" capacity for renewable generators.
- **Energy Market:** Existing market structures will incentivise optimal near-term operation of LDES assets.
- **System Services:** Existing and new system services will incentivise optimal near-term operation of LDES assets.
- **Capacity Market:** Should a storage technology that has cleared for a revenue floor in the LDES auction be required to be a price taker in capacity auctions?

Conclusion

The development of an LDES procurement framework has the potential to provide significant benefits to Ireland & Northern Ireland in terms of achieving our RES-E targets and broader decarbonisation objectives.

To kick-start the process of developing a procurement framework for LDES we propose the publication of a Call for Evidence paper by the relevant Government departments in Ireland & Northern Ireland. This would seek views from a wide spectrum of stakeholders on potential options for a future framework, including the proposal set out in this paper.