Long Duration Energy Storage Council
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August 30, 2023

TO: The Department of Climate Change, the Environment and Water; Australian Government

FROM: Long Duration Energy Storage Council (LDES Council

RE: *Capacity Investment Scheme, Public Consultation Paper, August 2023*

The Long Duration Energy Storage Council (LDES Council) appreciates the opportunity to provide feedback and participate in the public consultation on the Capacity Investment Scheme (CIS) published by the Department of Climate Change, Energy, the Environment and Water. Further, the LDES Council supports the Australian government's work to decarbonize the national energy market and design and deliver a national Capacity Investment Scheme to help accomplish this.[1]

The LDES Council is a global non-profit with over 60 members across 20 countries. The LDES Council works to accelerate the decarbonization of our world through the application of long duration energy storage (LDES). The LDES Council provides member-driven, fact-based guidance and research to governments, grid operators and major electricity users on the deployment of long duration energy storage for society's benefit by decreasing emissions, lowering costs and adding flexibility to energy systems allowing for more resiliency.

Background

The LDES Council conducted research showing least cost solutions to decarbonize energy grids require long duration energy storage.[2] Further, this research indicates global spending on long duration storage of up to $4 trillion USD and installed capacity up to 8 TW to decarbonize to net-zero levels.[3] Long duration energy storage resources are critical and when developed early, could save global systems up to $540 billion USD.[4]

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[1] Capacity Investment Scheme, Pubic Consultation Paper: https://storage.googleapis.com/files-au-climate/climate-au/p/prj2845a19ab92efac40adf8/public_assets/Capacity%20Investment%20Scheme%20-%20Public%20Consultation%20Paper%20-%20August%202023.pdf

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

[3] https://www.ldescouncil.com/news/long-duration-energy-storage-council-report-spotlights-opportunity-for-thermal-energy-storage-to-advance-the-clean-energy-transition/

[4] https://www.ldescouncil.com/assets/pdf/221108_NZH_LDES%20brochure.pdf

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There are many benefits and needs for grid connected long duration energy storage including congestion management, load following, inertia, blackstart capabilities and more.[5] Long duration energy storage also may decrease necessary build out of renewable resources or necessary new transmission and distribution infrastructure.

All storage allows for the opportunity to charge when solar and wind generation exceed demand and deliver energy back to the grid when output from renewables is less than total demand within a single operating day. Long duration energy storage connected to the grid amplifies this ability and allows for large quantities of energy to be stored during prolonged periods where generation exceeds demand. These resources also provide added system resilience, as storage resources with long durations by nature are able to provide energy for longer periods of time and thus reduce the likelihood of unserved load. This is briefly illustrated in Figure 1.

Figure 1:

Summary of existing and emerging flexibility solutions for different flexibility duration needs

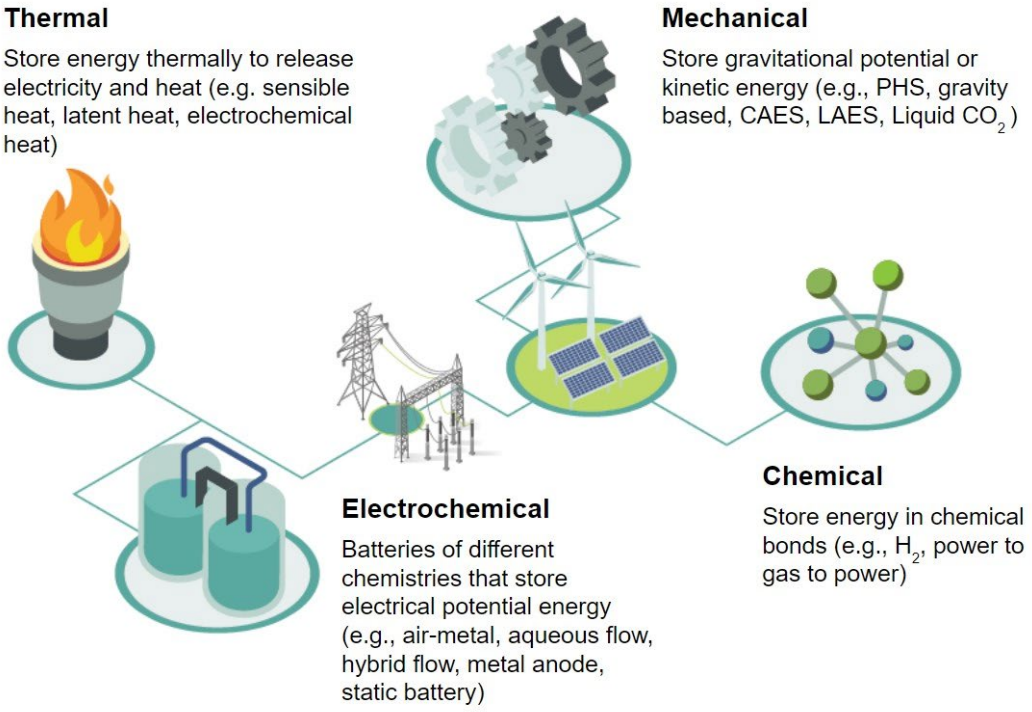
● Solution ◌ Partial solution

Flexibility duration	Power system challenge	Dispatchable generation	Grid reinforcement	Curtailment or feed-in management	Li-ion batteries	LDES	Demand-side response
Intraday	Intermittent daily generation	●		●	●	●	●
	Reduced grid stability	●			●	●	◌
Multiday, multiweek	Multi-day imbalances	●	◌	◌	◌	●	
	Grid congestion	◌	●	●	◌	●	
Seasonal duration	Seasonal unbalances	●	●			●	
	Extreme weather events	●				●	

Long duration energy storage can be achieved through different approaches, including mechanical, thermal, electrochemical, or chemical storage. Figure 2 provides a very high-level outline for these four types of technologies.

[5] Long duration storage can also provide significant benefits for applications to decarbonize operations for applications not connected to the grid.

Figure 2: The 4 Families of Long Duration Energy Storage



Since 2019, global investment in long duration energy storage exceeds $58 billion[6], and is quickly growing across the four diverse types of long duration energy storage. Today, more governments are leading the way with public/private partnerships to support the large-scale delivery of long duration energy storage needed to ensure energy can be delivered without greenhouse gas emissions. Several countries have already made large investments and/or commitments to policies fostering development of long duration energy storage including Chile, Spain, Australia, Greece, the United States, India, and the United Kingdom.

Chile is leading the way on LDES in South America by seeking to invest US$2 billion for energy storage projects beginning in 2026. The Chilean government changed laws to ensure storage could participate in the marketplace as well as created a marketplace for all types of storage.[7]

[6] https://www.woodmac.com/press-releases/long-duration-energy-storage-projects-attract-more-than-us-$58-billion-investment-over-last-three-years/
[7] https://www.energy-storage.news/chile-government-seeks-multi-gigawatts-of-large-scale-storage-for-2026-2028/

Similarly, Spain incorporated long duration energy storage into future planning and is launching €280 million for energy storage, including standalone, thermal, and pumped hydro technologies[8]. This, in addition to €160 million in grants for energy storage projects, aims to fund 600 MW of projects to go online in 2026.

Australia and the United Kingdom are also two hotbeds of innovation, driving development of grid-scale long duration energy storage technology. The United Kingdom ran several grants to stimulate the market, with almost £70 million awarded as part of the £1 billion net zero innovation portfolio program from their department for energy security and net zero.

In Australia, regional governments have a major role to play in ramping up ambition and delivery, with Victoria setting an interim target of 2.6 GW of storage by 2030[9]. The target includes eight hour or more of long duration storage - as well as targets for shorter duration - and was announced alongside an AU$157 million support package for renewables and storage projects in the state.

The United Kingdom also pioneered the deployment of long duration storage as part of its focus on decarbonization, announcing five innovative long-duration energy storage projects that will receive a share of almost £33 million of funding[10], including awards for pumped hydro and thermal storage solutions. These projects will help to meet the need for more than 50 GW of energy storage.

India also signed up for Mission Innovation, and became the first member country to establish a clean international incubation center (CEIIC) for supporting and promoting clean energy-based start-ups including storage and long duration energy storage.

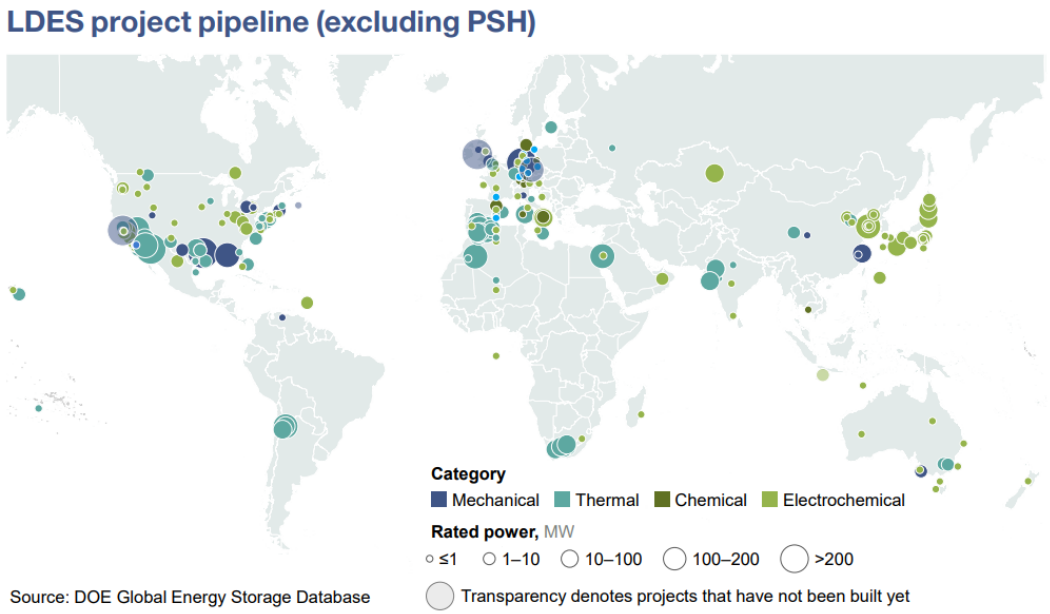
India has some of the most ambitious targets globally for scaling renewable energy. India set goals to achieve 500 GW by 2030[11], and will need to install four times the amount of renewable power than was delivered between 2010 and 2020.

[8] https://renewablesnow.com/news/spain-to-award-eur-280m-in-state-aid-for-energy-storage-projects-829095/
[9] https://www.pv-magazine-australia.com/2022/09/27/victoria-targets-6-3-gw-of-renewable-storage-by-2035/
[10] https://www.gov.uk/government/news/energy-storage-backed-with-over-32-million-government-funding
[11] https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/india-aims-to-add-500-gw-of-renewables-by-2030-70713616

Greece has an overall energy storage deployment goal of 3GW by 2030 to facilitate a 70% renewable energy target, and launched an auction for grants towards 400MW of energy storage.[12]

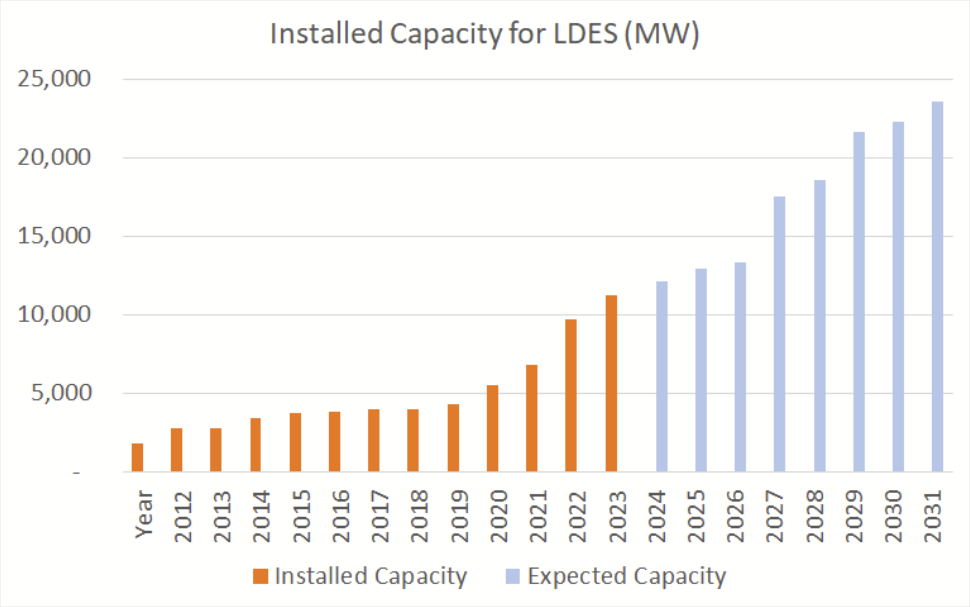
Significant amounts of storage are being developed in countries around the world. Figure 3 shows where development of long duration energy storage projects are already located and are anticipated within the next few years. Figure 4 shows quantities of storage developed in the last 10 years and the anticipated quantities in future years. The Australian government can build on these successes and challenges faced by other countries.

Figure 3: LDES Project Pipeline



[12] https://www.energy-storage.news/greece-launches-first-400mw-tranche-of-energy-storage-grant-auctions/

Figure 4: Installed Capacity of Long Duration Energy Storage



With additional investment and development, long duration energy storage technologies will experience declines in price accelerating the use and deployment of these technologies. ***It is crucial that governments around the world support the right balance of policy measures and financial support to create a marketplace for LDES which can enable its success and scalability.***

In our net zero power report[13], we took an in depth look at Australia. This report shows long duration energy storage resources provide grid services and significantly reduce anticipated renewable curtailments resulting in millions of dollars of savings for all-in costs for energy.

Key Enablers for Long Duration Energy Storage Participation

The LDES Council identified the most common barriers hindering development of long duration energy storage, and these include:

- Short-term (such as day-ahead, intraday markets) power markets
    - Do not provide long-term agreements that could de-risk capital investment
- Weak multi-day and multi-week market signals
    - Results in sub-optimal cycling

[13] https://ldescouncil.com/assets/pdf/LDES-brochure-F3-HighRes.pdf

- Lack of sufficient carbon-reduction compensation schemes

Solutions to combat these barriers and foster growth of long duration energy storage include:

- Markets capable of planning for longer durations, that capture use cases for long duration storage
- Specific storage capacity procurement targets
- Incorporation of energy storage in grid planning
- Carbon pricing and removal of fossil fuel subsidies
- Value flexibility in capacity payments
- Introduce congestion management trading platforms
- Appropriately valuing the ability of storage resources to provide peaking power
- Developing markets for products that support the grid, such as ancillary services
- Accurate counting and attribution for stand alone long duration storage resources and resources paired with renewables

LDES Council Feedback

Below, the LDES Council submits feedback directly on the questions outlined by the Department in the capacity investment scheme.

Section 1

1. *The Department is seeking feedback on what other implications the CIS might have on the energy market, and how the CIS can be designed to mitigate risks while delivering on key policy objectives.*

The capacity investment scheme emphasizes decarbonizing the Australian grid while maintaining reliability and affordability. Combinations of carbon free resources typically include renewables paired with storage - where long duration energy storage moves energy from times when generation is abundant to times when system conditions are most strained. Early adoption of renewables and energy typically necessitates little change to the mechanics of the energy market.

Deep penetrations of renewables necessitate increased use of real-time tools to maintain frequency, including regulating services. This could require additional procurement of existing services, or introduction of new services. These deep penetrations also necessitate more ramping capability, onto the system. This may need to be accounted for - and potentially compensated for - when procuring new resources in the planning timeframe, but may also require additional products in the energy markets to ensure resources are there and prepared to provide ramping services.

Australian energy markets may need to expand to accommodate operating attributes of long duration storage resources. This includes modeling long duration energy storage resources do that the model allows for: resources to charge from the grid, discharge to the grid, accounting and modeling changes in state of charge, and accounting for round trip efficiencies. These models should also accommodate typical operational challenges for these resources, for example potential for times necessary to switch from charging to discharging.[14]

Long duration energy storage resources also typically locate and operate at the same facilities and the same point of interconnection as renewable resources. Building robust models for these scenarios, like hybrid and co-located models, can improve resource operation and market outcomes. For example, solar plus storage generation may be 'oversized' relative to physical interconnection hardware, and grid models should be set up in such a way to never dispatch these combined resources at values above rated interconnection limits.

Energy markets are designed to use marginal cost of generation to inform energy prices for resources across the grid. Most long duration energy storage resources do not actually generate electricity and therefore lack a corollary concept of marginal cost to generate.[15] When long duration energy storage resources are present in small quantities on the grid - i.e. when they are price takers - this does not matter very much because costs can be computed by an estimate of the cost to buy energy form the market, round trip efficiencies and marginal costs from wear and tear on the resource. However, when large quantities of long duration energy storage are interconnected to the grid, and these resources have potential to set prices when both charging and discharging, these constructs may not result in the most efficient solutions for final system prices. Larger changes to market pricing design will be necessary in the future, and may include products like call-options to price energy from long duration energy storage.

Finally, many electric energy systems and grid infrastructures around the world often do not have sufficient look-ahead time horizons to optimally dispatch long duration energy storage resources. Energy markets tend to make dispatch decisions for long duration energy storage resources based on current market prices and current bids submitted to the market from market participants. Storage resources can make this problem more challenging by introducing an intertemporal element. For storage resources with shorter duration, awards at 3pm on a very stressed system day, unless recharged, that resource will not be available at 8pm for discharge, which could lead to reliability concerns. For long duration storage resources,

[14] Not all long duration storage resources need time to switch from charging to discharging.
[15] Some thermal energy storage resources can create energy.

dispatch may be even more challenging. Under normal circumstances long duration energy storage can often help grids during challenging times because of larger energy storage capacity.

However, similar problems can arise when for systems that may need to prepare for multi-day events where grid conditions are threatened, or conditions where long duration energy storage resources have low levels of state of charge. Adding additional guardrails or market products may be necessary to optimize use of long duration energy storage resources and minimize reliability risks.

The LDES Council encourages the Department to begin work on these modeling improvements soon, as they are necessary to unlock the full value of long duration energy storage and other resources to decarbonize the grid.

2. *The Department is seeking feedback on WA implementation of the CIS, including interaction with the existing Reserve Capacity Mechanism. This will be further canvassed in a WA-specific consultation paper.*

The LDES Council has no feedback to this comment at this time, and appreciates the opportunity to discuss with the Department in the future.

Section 3

1. *What minimum storage duration should be required for tender eligibility, to achieve CIS policy objectives?*

Full decarbonization of a grid is challenging, and requires a combination of renewable technologies and storage resources of varying duration, as correctly pointed out by the capacity investment scheme. The 'correct' procurement of storage duration may not grow organically even with derating factors applied to different durations of storage. Derating factors in other markets tend to be relatively constant until a certain threshold of capacity of that duration is achieved, then the values drop precipitously. This could result in over-procurement of shorter duration capacity early in the investment process, and necessitate significantly larger amounts of longer duration resources later in the process. Then, this next increment would be subject to the same problem. Further, as the capacity investment scheme notes, some of the technologies that are better equipped to provide long duration resources may require longer lead times to cite and build because the underlying technology is newer.

The LDES Council suggests creating tender targets explicitly requiring certain thresholds of capacity of certain duration to help to avoid these problems. For example, New South Wales

and Victoria have already begun setting targets explicitly for long duration energy storage.[16] The LDES Council suggests that the Department also set explicit targets for long duration energy storage in this and future tenders.

2. *What methodology for modeling and measuring duration requirements for various technology durations would be appropriate?*

The LDES Council is encouraged by the high degree of modeling sophistication suggested in the capacity investment scheme and looks forward to working with the Department on sharing our modeling improvements we are building from our discussions with other grids around the world. Detailed modeling is critical to understanding how grids can decarbonize and how they could evolve over time to meet climate goals. This modeling is critical to increasing tender targets and developing a runway for ensuring the right mix of long duration storage resources are joining the grid in a timely manner to meet greenhouse gas emission and other climate goals.

3. *How could the CIS eligibility criteria and assessment methodology change and adapt over time?*

Ideally, a system with sophisticated modeling methodologies for informing new tenders for buildout would require little adaptation over time. Specifically, it is important that models include aspects of benefits from all potential sources including frequency regulation, black start capability, system inertia, and a potential to provide transmission and distribution solutions. Modeling and ensuring that these requirements are satisfied - in addition to analysis for assuring that supply continues to serve demand - is essential in an assessment methodology and can prevent a need to greatly modify or adapt over time. This will allow for the transition away from legacy resources that may already provide these capabilities, even though they may not be modeled or expressly compensated today.

As the grid and forecasts change, inputs to the model change, but the process for sharing results and requesting tenders could remain relatively constant. As already noted, including specific tender requirements for certain amounts of storage capacity of a specific duration is important for developing robust eligibility requirements.

[16] https://www.energy-storage.news/australia-seeks-public-input-on-tenders-for-dispatchable-renewables-generation-and-storage/.

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Section 4

1. *What methodology for considering a project's contribution to zero scope 1 emissions would be appropriate?*

The LDES Council has no feedback to this question at this time, and appreciates the opportunity to discuss with the Department in the future.

2. *How could this criteria and assessment methodology adapt as technology matures over time?*

One key value of long duration energy storage is the ability to buy energy when prices are low and sell energy later when prices are high. Measuring emission impacts accurately can be achieved by modeling the marginal resource generating resource when a long duration energy storage resource is charging, and comparing that value to the marginal resource not running when the resource is discharging. Storage resources also have imperfect round trip efficiencies, and the losses associated with a storage resource must be factored into this calculation.[17]

If carbon prices are not accurately accounted for in energy prices, calculations for carbon offset from long duration energy storage could appear smaller than they should be.[18] If, for example, a coal resource with high emissions that are not priced is the marginal resource charging a storage resource, a storage resource could actually contribute to increased carbon emissions.

Ensuring that these methodologies are advanced and specific initially or early in the process, will help to ensure a robust methodology that will not need to change over time.

3. *What types of demand response would be consistent or inconsistent with the CIS objectives?*

The LDES Council has no feedback to this question at this time, and appreciates the opportunity to discuss with the Department in the future.

4. *How can the CIS design be future-proofed for an evolving/changing technology mix?*

As suggested in the responses from Section 3, the LDES Council suggests robust modeling including assumptions about frequency regulation, black start capability, system inertia, and a

[17] Note that some long duration energy storage technologies have very high round-trip efficiencies.
[18] The LDES Council suggests that energy markets should properly account for emissions when pricing energy.

potential to provide transmission and distribution solutions within the capacity investment framework. This will help ensure orderly retirement of traditional resources and seamless

transition to clean resources. Frequent feedback via written responses similar to this, in person meetings, webinars, and check-ins on phases will help keep stakeholders involved and allow opportunities to raise issues to the Department as the process evolves. This will also help stakeholders like the LDES Council and its members informed on current activity.

5. *The Department is seeking feedback on the eligibility requirement of projects in the NEM for equal to or greater than 30MW registered capacity.*

The LDES Council has no feedback to this comment at this time, and appreciates the opportunity to discuss with the Department in the future.

6. *The Department is seeking feedback on each of the eligibility requirements including:*
   • the focus on a base level of development status of land tenure, planning and connection approvals.
   • the impact of participation in other government schemes on CIS eligibility.
   • the eligibility of existing projects to bid into the CIS, and questions of CIS additionality that result from this approach.
   • the technology risk appetite of the CIS

The LDES Council has no feedback to this comment at this time, and appreciates the opportunity to discuss with the Department in the future.

7. *The Department is seeking feedback on the evaluation criteria, on the appropriate structure to assess a project's contribution to system reliability and feedback on the potential development and application of de-rating factors.*

As noted earlier, the LDES Council suggests that basing reliability impacts on current derate factors, which are based on current grid makeup could be problematic. Taking a holistic view of necessary procurement through a target year for full decarbonization and using estimates of those weather and load forecast to generate future target procurements for storage with a specific log duration storage - such as 10+, 24+, 100+, 150+ hour duration resources - will result in better success during capacity investment and reaching decarbonization goals.

8. *The Department is seeking feedback on the appropriate structure and sizing of performance requirements necessary to deliver on the policy objectives of the CIS without distorting storage market participation.*

It is important to support a variety of revenue mechanisms such as 24/7 Clean power purchase agreements[19], nodal and locational pricing, capacity markets, long term bilateral contracts for balancing and ancillary services, contract for difference, and public and private partnerships for co-funding.

9. *The Department is seeking feedback on all aspects of the high-level commercial model including:*
   - the floor price support mechanism
   - the use of a single net revenue floor for both VRE and scheduled generators (including storage)
   - the term of the contract, including financing requirements around revenue tenor
   - the performance requirements, including the LOR3 performance requirements
   - the milestone requirements, penalty provisions and termination provisions
   - A contract structure that divides development/construction and operating periods into two contracts, similar to the NSW Project Development Agreement and LTESA division

The LDES Council suggests finance and revenue recovery are critical for the successful development of long duration energy storage. Ensuring net revenues through floor and ceiling mechanisms, such as the one suggested in the capacity investment scheme, helps enable funding for long duration energy storage projects. This is critical to growing and evolving the industry. Financing is critical for development of long duration storage solutions, and keys to finance include commercial viability of similarly situated projects and assurance for revenue streams - including fixed payments, energy revenues, other market revenues and ancillary service revenues - to ensure financial viability of a project. Ensuring a floor on annual revenue helps reduce risk for financing, which in turn helps enable financing and reduces prices that long duration energy storage resources face for financing, which in turn helps reduce overall costs for grid decarbonization. The LDES Council is encouraged to see this as an aspect of the capacity investment scheme.

10. The Department is seeking feedback on the commercial model's applicability to pumped hydro energy systems.

The model proposed is not explicitly incompatible with pumped storage, but the detail on key factors such as contract length, the value placed on longer duration storage, and the timeframe in which projects must be completed will all affect the relative competitiveness and viability of pumped storage participation in the capacity investment scheme.

[19] https://ldescouncil.com/assets/pdf/2205_ldes-report_247-ppas.pdf

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Conclusion

As noted in the consultation, clean renewable generation and storage - especially long duration energy storage - fills reliability gaps, provides flexibility, security, energy shifting, increased dispatchability, and reduces the risk of price shocks. To avoid curtailment of future and current solar generation, the anticipated offshore wind generation, and to meet the public policy goals in Australia, long duration energy storage is critical.

It is important to ensure the value of long duration energy storage is incorporated today into all phases of the capacity investment process. Enabling mechanisms for adaptability and flexibility over time will help to maximize the diverse attributes and benefits of long duration energy storage projects and deliver maximum benefits to all stakeholders.

Thank you for your time and consideration. LDES Council members are looking forward to applying for this investment opportunity and helping to decarbonize the Australian grid. We are happy to discuss LDES Council research with you and provide additional insights, and look forward to working with the Australian government to accelerate the markets for long duration energy storage and continue to support Australia's leadership as a renewable energy leader.

Sincerely,

Julia Souder
CEO
Long Duration Energy Storage Council