EUROPEAN COMMISSION ELECTRICITY MARKET REFORM RECOMMENDATIONS

Background & Overview of LDES

The Long Duration Energy Storage Council (LDES Council) is a global, executive-led non-governmental organization that strives to accelerate the decarbonization of the energy system at the lowest cost to society by driving innovation and deployment of long duration energy storage (LDES). Launched at the UN Climate Change Conference of Parties (COP) 26, the LDES Council provides fact-based guidance to governments and industry, drawing from the experience of its members, which include leading technology providers, industry and services customers, capital providers, equipment manufacturers, and low-carbon energy system integrators and developers.

Long Duration Energy Storage is defined as any technology that can be deployed competitively to store energy for prolonged periods - for multiple hours, days, or even weeks - scaled up economically to sustain energy provision, and that has the potential to contribute significantly to the decarbonization of the economy. The LDES asset class encompasses a range of technologies that store energy in various forms including thermal, electrochemical, mechanical, and chemical.

Renewable energy plays a critical role in decarbonizing the power grid and increasing energy security, but this large-scale transition will require new sources of flexibility to ensure reliable energy supply.

Globally, the energy transition increasingly has multiple narratives – climate change and resiliency, energy security, and energy affordability. As the global ecosystem moves from traditional fossil fuel sources of energy – and the dispatchability they provide – to a climate dependent system with flexibility at its core, the diversity of LDES can provide essential services.

In the LDES Council's inaugural 2021 market analysis, the global need for LDES by 2040 was estimated at 1.5-2.5 TW of power capacity and 85-140 TWh of energy capacity. A subsequent study in 2022 explored the potential of thermal energy storage in delivering low-cost, reliable, clean heat and power. Factoring thermal energy storage combined with power could add 1-5 TW of additional capacity, growing the total LDES capacity to 2-8 TW. This would result in up to $540 billion of annual system savings.

The world needs new sources of flexibility that are compatible with a low-carbon society. There are a variety of sources of low-carbon flexibility, including demand response, power grid expansion and optimization, and energy storage of various durations. The precise mix of resources varies by region, but

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the path to net zero power requires combining these sources of flexibility. With greater variability both in terms of how power is consumed by different end-user segments and how power is generated from variable renewable sources, the entire power value chain needs to adapt including electricity markets to ensure long duration energy storage is participating and providing value to the electric system.

Long Duration Energy Storage improves low-carbon dispatchability of the system at any given time and plays a central role in balancing the power system and making it more reliable and efficient.

Long Duration Energy Storage plays a key role in delivering a net-zero system by storing and providing energy in a flexible, low-carbon, and low-cost way. These technologies can cost-optimally store power anywhere from half a day to a week or more in capacity, thereby filling a gap between today's batteries and seasonal storage. In the long-term, LDES provides insurance against prolonged periods with low or no renewable power output, while in the near-term, these assets can potentially act as insurance against elevated power prices such as those electricity consumers are experiencing in many parts of the world today. LDES can therefore contribute directly to the triple imperative of the energy transition, driving greater security, affordability, and lower emissions of power supply.

The LDES Council presents the following policy recommendations for the EU Electricity Market:

- **Establish clear market signals** to help existing markets improve system needs and allow for grid reinforcements and flexibility to match climate dependent generation.
- Provide access and **availability to provide ancillary services that can participate in markets** and then LDES can turn renewable energy into profits.
- Create **24/7 Clean Power Purchase Agreements** to balance supply and demand for power as renewables grow in generation capacity.
- Continued improvements to **inclusive and long-term grid planning** acknowledging the dispatchability and flexibility of LDES.
- Support for island nations **auctions** with clear price signals and diverse bid options for capacity payments.
- Allowance for **storage as a transmission** asset providing another tool for congestion management.
- Allocate LDES benefits for **load management and interconnection**, especially for cross border reliability.
- Support for **diverse LDES** technology options.
- Ensure existing policies and rules are amended to include the benefits of LDES and promote **revenue support mechanisms** to ensure rapid deployment of LDES in the EU marketplace.

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In addition, the Council recommends that the following are taken into consideration.

Revenue Mechanisms

As LDES becomes more prominent, entirely new market structures might also be developed, and existing market operation frameworks could potentially become less relevant (e.g., marginal electricity prices set by highest cost plants). It is important to note, however, that these mechanisms are no substitute for **well-developed pricing signals in balancing intraday, and day ahead markets to facilitate effective participation from storage assets.**

New sources of low-carbon flexibility will need to be deployed in order to de-risk the energy transition. LDES can play an even bigger key role if the market is supportive.

Revenue mechanisms are most effective in improving project financial viability for customers and investors, including mechanisms that both enhance revenues and provide long-term revenue certainty such as **Contracts for Difference, Caps & Floors, Hourly Energy Attribute Certificates, Power Purchase Agreements (PPAs, especially 24/7 clean PPAs), and the Regulated Asset Base.**

In today's market, there is no credit or accountability for the grid services LDES provides.

Key Takeaways:

- **The new electricity market structure must have clear criteria to ensure that LDES provide the multitude of system-wide benefits including flexibility and dispatchability.**
- **LDES can provide grid system flexibility as well as remote and island system stability and security of clean energy supply.**
- **Market design must ensure that the ancillary services provided by LDES (blackstart, load following, voltage control, reactive power and congestion management) are applicable in the marketplace and given credit for their services.**
- **LDES ensures that renewable energy is never wasted.**

As noted in the LDES Council Net Zero Power report published November 2021, the European Union has a cumulative LDES installed power capacity of 290 GW and LDES installed energy capacity of 20 TWh by 2040.

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Clear Market Price Signals

The European Commission should develop a strategy with targets that allow for the multiple benefits of LDES, especially as more diverse LDES technologies for heat and power enter the market. Any market-based or publicly funded mechanism should be technology neutral and awarded in a competitive process.

The European Commission should consider the following:

1) **Account for a LDES resource's state of charge for storage providing regulation services and send the correct market signals to ensure the resources are provided when procuring service in the marketplace.** This allows for better alignment with state of charge predicted and actual charge when storage resources are providing ancillary services.
2) **Provide new bidding requirements for LDES delivering ancillary services ensuring storage resources are available to provide awarded ancillary services.** This ensures clarity when energy bids are awarded upward ancillary services while ensuring schedules for downward resources are clear – all of this allows for resources are delivering services when needed.
3) **Improve tolls (e.g. digital communications and artificial intelligence) for exceptional dispatch for LDES and enhancements to associated settlement provisions**. Ensuring adequate compensation for remaining charges so LDES can have energy and or heat to meet load during multiple hours, days, weeks and months. This ensures LDES receive adequate compensation for holding a state of charge to ensure energy available for reliability multiple hours, weeks or months later.
4) **Consider a default energy bid to allow for an opportunity cost adder to storage resources' day ahead default energy bid to more accurately reflect the resources costs and enable LDES dispatch more efficiently.** This will help prevent LDES from being scheduled to discharge too early in the day-ahead market.

Carbon Price

Consider a selection of pricing mechanisms for greenhouse gas emissions, in the form of taxes or tradeable certificates, that aim to reduce these emissions by imposing a cost on fossil fuel consumption and that may be implemented either as regulation or policy. These tools may enhance the competitiveness of LDES solutions because they impact Levelized Cost of Energy (LCOE) of marginal generation plants, which are typically fossil-fired (e.g., gas turbines). This in turn increases the market bid prices required by these marginal generators to cover their generating costs, and therefore can also increase the spread between off peak and peak electricity market prices that LDES assets can capture. Notably, this benefit

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signal is strongest in the earliest days of LDES market formation, when grids have higher penetrations of fossil generation, especially as marginal generation resources. However, while carbon pricing may improve LDES business case economics, it does not address volatility of project revenues since underlying carbon prices remain variable in most carbon markets.

Cap and Floor

Consider multi-year contracts with a defined minimum (the "floor") and maximum (the "cap") level of energy capture price (e.g., EUR/MWh) for the asset owner, also commonly referred to as price corridor. Should the energy price captured by the asset fall below the floor, the asset receives the floor price. Similar dynamics apply for the cap, except in reverse, with a "hard" cap representing the maximum energy price that can be received to protect the offtake entity's cost exposure (excess revenues are returned to the offtake entity). The intent of these caps is to limit societal exposure over the course of the policy support. Like a Contract for Difference (CfD, see below), a Cap & Floor would typically be administered and funded by a government vehicle, supported from taxes and fees imposed on the consumption of electricity. If implemented with a "soft" cap, a portion of the capture value above the cap could be shared with the asset (e.g., in pre-set diminishing portions as energy prices increase above the cap) to efficiently transfer price signals and reward assets for participation at times of greatest system need. The floor price would be set such that it enables competitive debt financing for the asset, and average payouts between cap and floor price would nominally offer returns sufficiently attractive to drive project investment. Such mechanisms are currently implemented for interconnector transmission lines in the UK and commonly applied to provide price controls for monopoly assets.

Capacity Markets for LDES

Long-term contract remunerating a facility for access to its power capacity (i.e., a payment per MW of power capacity available for dispatch) helps secure sufficient capacity in the power system to meet and maintain long-term system reliability and stability. By providing remuneration that is directly proportional to capex, capacity payments enhance the economic business case for new generators and ensure a secure, minimum return on capital. The CM may be enhanced through additional stipulations, such as a premium for zero-carbon (or a maximum emission factor per MWh, as was deployed in EU regulation dispatchable generation capacity, or by including capacity derating factors that provide different levels of compensation for assets with varying levels of duration capability. A capacity market could be modified to offer a premium for lower carbon solutions (which could in theory be sufficiently high to preclude the need for significant additional revenue stacking) or to require a clean electricity standard, in which case the mechanism could also drive greater carbon impact over time.

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Carbon Contract for Difference (CCfD) is a long-term government contract providing additional remuneration for LDES assets defined based on a carbon strike price per ton (i.e., the marginal cost of carbon abatement) and the carbon savings from the use of these assets.

Traditional Energy Attribute Certificates (EACs) consist of certificates that indicate a given unit of energy production was generated from renewable resources. EACs are typically designed as liquid assets that can be traded between generators and energy consumers (principally commercial and industrial customers, intermediary power retailers, and with possible extension to small-scale or residential consumers). They are used by energy consumers to meet mandated or voluntary renewable energy procurement targets, providing more precise incentives than annual targets. Hourly EACs would require amendment of these existing EAC schemes to assign a timestamp to certificates for renewable energy production, allowing energy consumers to move from volumetric matching of power consumption on an annual basis to an hourly basis. Such an EAC scheme could be accompanied by centrally-mandated procurement targets, liquid spot and derivative markets, and long-term supply and offtake contracts.

Entering into long-term pricing support contracts for LDES can reduce exposure to volatile natural gas prices, as revenues above cap or CfD strike prices are returned to the funding pool, thereby also ensuring societal value of policy and regulatory support.

It is also helpful to consider different options such as Germany and California, comparing the different market archetypes to the various implications as variations change depending on system flexibility, long term planning and revenue mechanisms.

Barriers and Areas for Change

In the above categories of carbon price, capacity markets and cap and floor, most current markets generally do not capture the full value of LDES.

Common barriers are as follows:

- Power markets are mostly short-term (such as day-ahead, intraday markets) and generally do not provide long-term agreements that could de-risk capital;
- Multiday and multiweek market signals are weak compared to intraday, and therefore storage technologies are incentivized to cycle multiple times per day;
- Carbon-reduction compensation schemes either do not exist or are insufficient to compensate investors for the additional funding.

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However, changes can be made, and solutions are provided as there are several mechanisms by which clear market price signals can contribute to the growth of the LDES markets.

- In terms of long-term market signals, storage capacity targets, procurement targets, and incorporation of energy storage into grid planning efforts will be key.
- Carbon pricing and removal of fossil fuel subsidies will level the playing field versus conventional forms of fossil-fired flexibility.
- Develop standardized flexibility service market based on capacity payments.
- Introduce congestion management platforms where flexibility providers, energy suppliers and network operators can all participate in trading.
- Co-located storage and renewable energy should share the same priority dispatch rules as renewable-only facilities. Acknowledging when solar and LDES and/or wind and LDES and even wind + solar + LDES can also offer grid services such as peaking power. Create market regulations allowing for additional revenue streams to incentivize grid support assets (such as ancillary services).

Improved grid planning

Long-term system planning tools play an important role across both unbundled and vertically-integrated systems as they set the overall direction respectively for the cluster of companies or single entity responsible for delivering the power system.

The roles of long-term market signal policies and near-term direct support and enablement schemes become more pronounced in such environments. Power markets comprising principally private investor-owned entities may require greater support in the form of revenue support mechanisms that improve viability of assets and reduce investment risk. Notably, these markets will also need clarity in terms of long-term policy direction (as established by system planning) to make significant, long-lived infrastructure bets.

Implications for policy and regulatory actions: Markets with low levels of flexibility endowment will need to more aggressively pursue support mechanisms that secures additional flexibility resources, especially those with high levels of decarbonization ambition and/or existing renewable penetration (as described below). This implies a need for both direct support and enablement schemes and revenue support mechanisms to catalyze the creation of the sector, as well as long term system planning to create milestones commensurate with the overall energy policy. Markets with high levels of flexibility endowment would be under less pressure to catalyze the creation of a new sector.

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Inclusive grid and system planning should be transparent and address the flexibility needs of a renewable energy infrastructure. Storage-only auctions should be considered to ensure renewable energy can be delivered.

The European Commission should also consider addressing the lengthy development timeframes for grid connected assets due to permitting and interconnection queues. While there are behind-the-meter LDES use cases, the majority of LDES assets will be grid-connected and therefore are subject to similar physical constraints as renewable power plants. In many markets, these interconnection timelines can extend to several years due to limitations in existing power networks that need to be resolved before new assets can be connected to charge and discharge from that local network. This challenge is particularly pronounced in markets that are targeting significant buildout of renewables, which is also where LDES will be most critical in the near-term to provide temporal flexibility.

Long Duration Energy Storage can be classified as an asset category of its own with its flexibility, grid services and energy shifting abilities ending discriminatory grid fees, permitting barriers and double taxation. Energy storage operators should be able to sign multi-year contracts with system operators to provide a bundle of ancillary services. **LDES should be more prevalent in system planning**.

24/7 Clean PPA and the Role of LDES

The challenge customers face is that current voluntary market systems neither cultivate the full menu of procurement options nor provide incentives necessary to empower customers to play an even more powerful role in reaching a future state where the grid is carbon-free every hour of every day or they year everywhere.

Policies should encourage the use of long-term contracts such as 24/7 Clean PPAs[1] that support and encourage more public private partnerships as well as providing guarantees to developers ensuring the needed large scale deployment of energy storage throughout Europe.

24/7 clean PPAs have the potential to address key problems in balancing supply and demand for power as renewables contribute an increasing proportion of generation capacity. In the process they can help providers and off-takers accelerate the overall decarbonization of the power sector. 24/7 clean power PPAs measure electricity consumption and greenhouse gas emissions on a granular basis — e.g., by the hour — and provide time-matched clean power.

Long Duration Energy Storage is expected to reduce the cost of 24/7 renewable power to below 100 USD per MWh in the near future if deployment accelerates. 24/7 clean PPAs are an essential non-

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

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regulatory tool to support this acceleration by enabling investments in clean, dispatchable capacity that will drive down costs.

The European Commission should establish a pathway to 24/7 clean PPAs with increasing levels of clean supply-demand matching[2]:

- "Entry Level" 24/7 clean PPAs are defined to have low entry barriers and cost in the range of today's average power market prices in many regions (around 70 USD per MWh), which should accelerate adoption.
- "Platinum" PPAs represent the highest ambition level (approaching 100% clean supply-demand matching) and are designed for those looking to accelerate decarbonization and technology deployment: the cost levels of those high-quality 24/7 clean PPAs is expected to decline by 30 — 40% over the next 10 years as technology matures and scale increases, closing the gap to market prices.

Current 100% renewable pay-as-produced PPAs also do not fully hedge price volatility risk for the off-taker, which is accentuated by high penetration of variable renewable energy sources and volatility of commodity prices. A case example shows 10 — 30% cost reduction potential and an uplift of around 100% system-level CO2 abatement when dispatch is partly based on power market prices and hourly marginal grid emissions factors. This shows that deviations from consumers' 24/7 load matching can unlock system-level benefits and avoid sub-optimal solutions that may emerge from 100% load matching for each off-taker.

As the EU moves to a new market, attention needs to be paid to five quality dimensions: the level of clean supply-demand matching, time granularity, geographical granularity, and additionality of renewables and flexible or clean dispatchable capacity.

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

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The LDES Council recommends the European Commission continues to be a catalyst in leading customer purchasing to consider the five-action supporting widespread adoption of 24/7 Clean PPAs:

1. Establishment of an agreed international framework overseen by an independent governance body;
2. Creation of incentives to spur wider corporate adoption, for example through inclusion of 24/7 PPAs in carbon accounting standards;
3. Development of a transparent data ecosystem, with supportive regulation;
4. Creation of supportive regulations to eliminate barriers and catalyze deployment;
5. Definition of measures that lower barriers to entry for smaller and less sophisticated corporate players, including innovative business models that enable asset sharing and the involvement of intermediaries or aggregator platforms.

The EU can ensure successful implementation of a 24/7 Clean PPA system to promote the critical role of LDES meeting decarbonization targets.

Conclusion

The new EU market design must be able to **support energy security, maximize renewables penetration and use, replace fossil fuels with greener alternatives,** and **attract new investments for innovative technologies**. This must be done in a **cost-effective manner** to achieve a **just transition** and **meet climate targets** for societal benefit. **Long Duration Energy Storage is a key enabler of effective power decarbonization and will help de-risk the clean energy transition.**

The EU acknowledges large deployments of LDES is required in the next few years in order to build, scale, and realize the cost projections and societal benefits of renewable energy. **Governments need to establish a supportive ecosystem including long-term planning, economic incentives and appropriate market designs that include LDES.**

While there are many obstacles to overcome, the key messages are 24/7 Clean PPAs work, system energy and heat planning must include Long Duration Energy Storage**, LDES procurement must be made today, clear market signals and criteria to account for LDES ancillary services are essential to a successful market.**

In a world where rapid decarbonization of the power grid is an increasingly important priority, there is an urgent need to manage the fluctuations of supply, demand, and price risks associated with renewable power generation. With the right policy structure, Long Duration Energy Storage can showcase its essential role in the marketplace.

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Sources are from the Long Duration Energy Storage Council reports:

NOVEMBER 2022: NET-ZERO HEAT: LONG DURATION ENERGY STORAGE TO ACCELERATE ENERGY SYSTEM DECARBONIZATION 221108_NZH_LDES brochure.pdf (ldescouncil.com)

JUNE 2022: THE JOURNEY TO NET-ZERO: AN ACTION PLAN TO UNLOCK A SECURE, NET-ZERO POWER SYSTEM journey-to-net-zero-june2022.pdf (ldescouncil.com)

MAY 2022: A PATH TOWARD FULL GRID DECARBONIZATION WITH 24/7 CLEAN POWER PURCHASE AGREEMENTS 2205_ldes-report_247-ppas.pdf (ldescouncil.com)

FLAGSHIP 2021 NET-ZERO POWER REPORT LDES-brochure-F3-HighRes.pdf (ldescouncil.com)

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