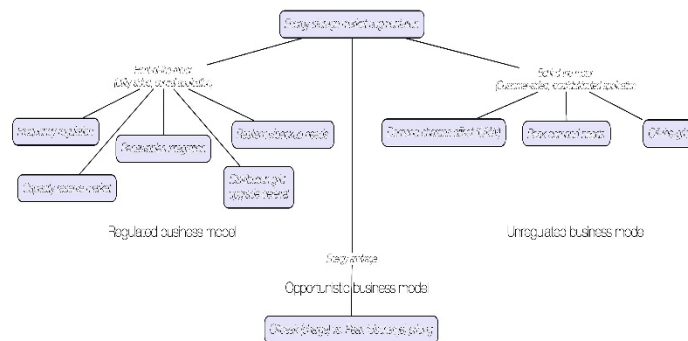


# Energy Storage Business Models in the Energy Transition



## Introduction.

The energy transition encompasses three broad market trends: decarbonization and decentralization of energy production, vehicle electrification. All of them have, to different extents, BESS (Battery Energy Storage Systems) in common.

Energy storage has been the long-awaited "Holy Grail" for intermittent, distributed renewable energies, eventually making them dispatchable and able to compete on a level-playing field with conventional, fossil-fuel fired power plants. Additionally, energy storage offers the benefit of being intrinsically flexible, scalable, efficient and expeditious with its modular deployment.

However, energy storage business models are complex and multifaceted from both a [technical](#) and commercial as well as regulatory perspective, very much depending on the local market values of the energy commodity being traded. The purpose of this post is to shed light on the business models currently being developed and deployed across different electricity markets on both side of the Atlantic.

Broadly speaking, energy storage business models can be grouped into two large markets: front-of-the-meter (utility-sided, central application) and behind-the-meter (customer-sided, distributed application). Real-world applications may blur those clear-cut segments, as hybrid business models have the advantage of higher capacity factors and [multiple revenue streams, making energy storage a more compelling value proposition.](#)

This distinction also addresses the paramount issue of [whether incumbent vertically-integrated utilities/TSOs-DSOs should own energy storage assets](#) for grid infrastructure (front-of-the-meter) or generation (behind-the-meter) purposes,

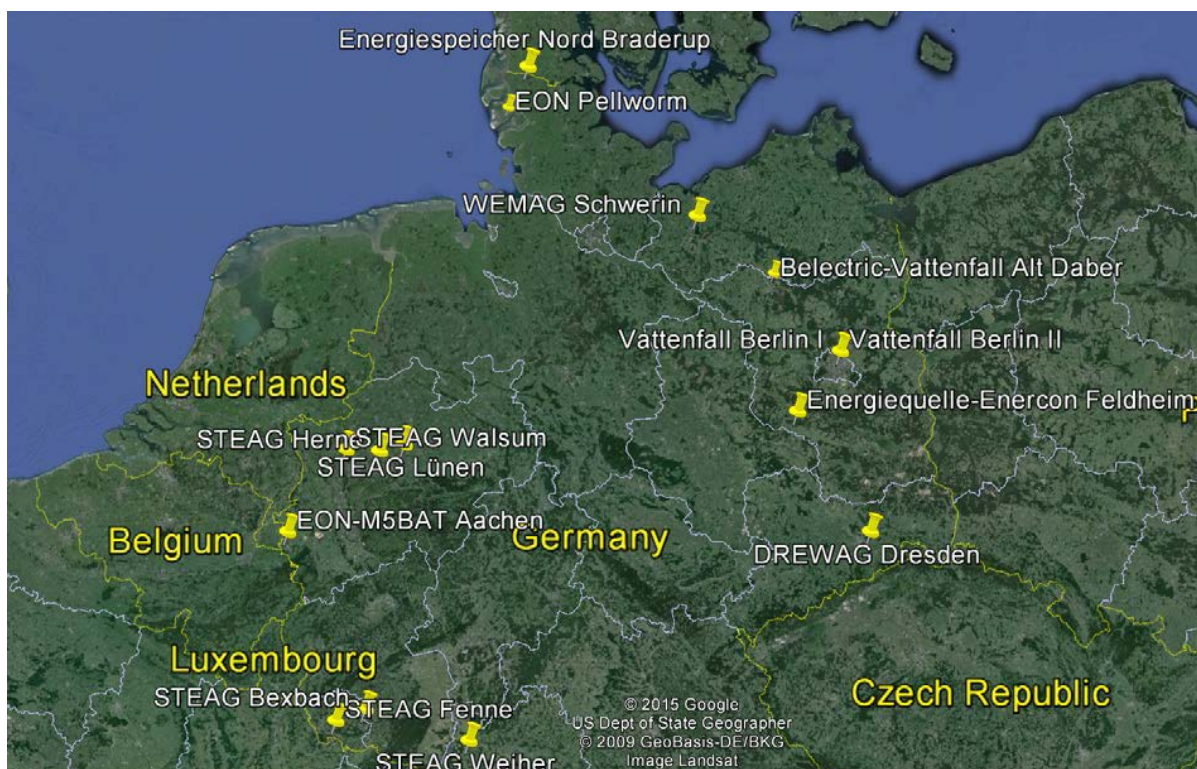
since the latter is equivalent to other DERs (Distributed Energy Resources) commercially available. The long- established opportunistic and mixed business model of energy arbitrage and peak shaving/shifting is the perfect example of such potentially arising conflicts of interest.

Before digging a bit deeper into the matter, it's highly important to underline that the current go-to-market path has been far more focused on electricity system integration and intelligence, project development and execution, rather than on the different technologies available (lithium-ion based batteries being the winner for the current applications), as one would expect in a transition from pilot to commercial projects.

#### Utility-sided business models.

Among the numerous front-of-the-meter business models, (primary) [frequency regulation](#) has been taking the spotlight both [in the US](#) and European markets.

In particular, the early-adopter "Energiewende" Germany features at the end of the 2015 the following large, pure commercial (no PPA), utility-sided, both operational and in construction energy storage projects:



[Belectric-Vattenfall, Alt Daber](#): lead acid battery - 1.4 MW power capacity, 2 MWh energy capacity, co-located at a privately owned 67.8 MW PV power plant and managed by Vattenfall;

[Energiequelle-Enercon, Feldheim](#): lithium-ion battery - 10 MW power capacity, 10.8 MWh energy capacity, co-located at a 81.1 MW multi- site onshore, privately owned windpower plant;

[Yunicos-Vattenfall, Berlin I](#): NaS battery, 1 MW power capacity, 5.167 MWh energy capacity, located at the Yunicos headquarters in Berlin- Adlershof;

[Yunicos-Vattenfall, Berlin II](#): LiFePO4 battery - 2 MW power capacity, 2.5 MWh energy capacity, located in the virtual power station of Vattenfall Wärme AG;

[EON, Pellworm](#): hybrid lithium-ion and vanadium redox flow battery - 1.2 MW power capacity, 2.160 MWh energy capacity, co-located at a hybrid PV and wind power plant on a tiny island and plugged into a smart microgrid;

[EON-M5BAT](#), Aachen: hybrid lithium-ion and lead acid battery - 5 MW power capacity, 5 MWh energy capacity, located at E.ON Energy Research Center facilities in Aachen;

[Energiespeicher Nord, Braderup](#): hybrid lithium-ion and vanadium redox flow battery - 2.325 MW power capacity, 3 MWh energy capacity, co-located at a 19.8 MW onshore, privately community- owned windpower plant;

[WEMAG, Schwerin](#): lithium-ion battery - 5 MW power capacity, 5 MWh energy capacity, located at the MV distribution network owned by the local utility WEMAG;

[STEAG \(Herne, Walsum, Lünen, Bexbach, Fenne, Weiher\)](#): lithium-ion battery - 90 MW power capacity, 140 MWh energy capacity, co- located and evenly spread (15 MW each) across 6 coal-fired power plants owned by the vertically-integrated utility STEAG;

[DREWAG, Dresden](#): lithium-ion battery - 2 MW power capacity, 2.7 MWh energy capacity, co-located at a CHP plant owned by the vertically-integrated utility DREWAG.

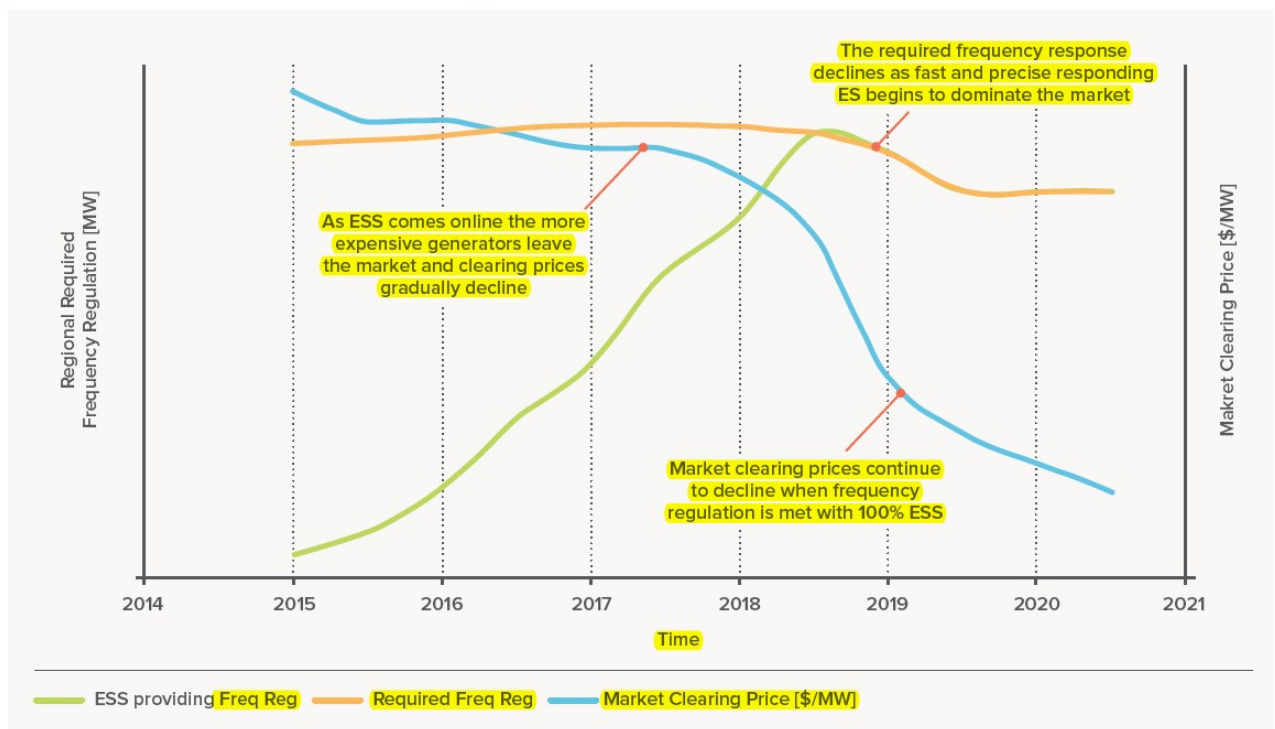
With a current total of around 120 MW power and 180 MWh energy capacity, the German market sends a clear signal to investors that battery storage provides a value-creation opportunity in the regulated market for ancillary services. Of course compared to other much less favorable EU-countries, Germany benefits from a more market-based and pro-energy-transition regulatory framework. Indeed, weekly auctions for frequency regulation remunerate power capacity made available by third parties with 2015 spikes up to [4000 €/MW per calendar week](#).

The first key takeaway from those business cases is that battery storage value-proposition is not exclusively tied to renewable energy plant co-location, which adds further to its flexibility. There is also evidence that although frequency regulation is the targeted primary application, there is a great deal of secondary applications (black- start, renewables integration, peak shifting, capacity reserve/peaking, off-grid/islanding) that can provide additional revenue streams, further increasing the net present value of these investments.

Perhaps, these incremental benefits are even more important for the longer-term viability of such projects. Indeed, battery storage features no opportunity cost and near-zero-marginal-cost-of- production (or even negative when charging is carried out during negative pricing hours in the German electricity market) in comparison with the incumbent providers to the ancillary services market. Therefore, "when storage is deployed at scale and able to meet all market calls for (frequency) regulation, the price could collapse under the current market-clearing mechanism" based on the marginal cost of production.

This is clearly represented in the figure below taken from Rocky Mountain Institute "The Economics of Battery Energy Storage - Technical Appendix A".

**FIGURE 3:**  
**ILLUSTRATIVE EFFECTS OF INCREASING ENERGY STORAGE PENETRATION ON FREQUENCY-REGULATION WHOLESALE-MARKET CLEARING PRICES**



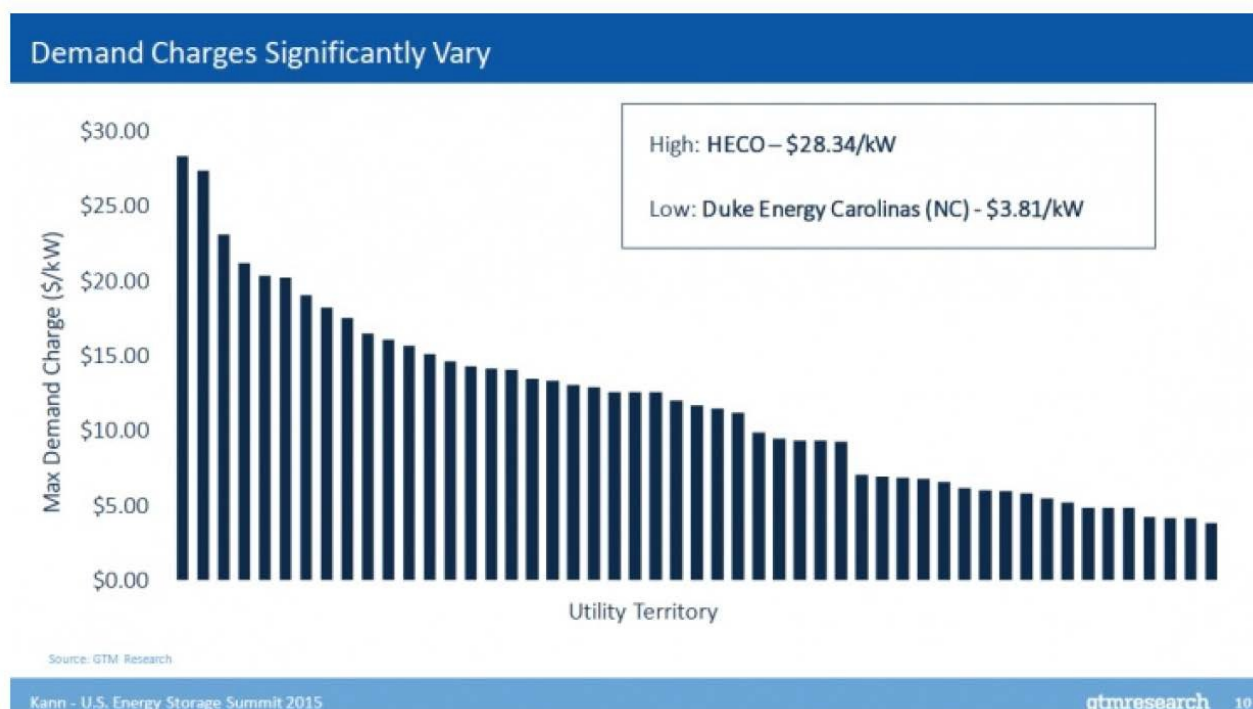
Besides CAPEX and OPEX (including inverters replacement) - which are both going to benefit from larger economies of scale arising when these investments become mainstream - there are some technical issues worth considering when evaluating the feasibility of stacking ancillary services.

Frequency regulation is an energy storage application based on MW (power) capacity rather than on MWh (energy) capacity, while the contrary applies to other applications such as capacity/reserve peaking, distribution grid upgrade deferral and renewables integration. This can have an impact on the life expectancy of the battery (in particular lithium-ion based ones), as battery degradation goes hand in hand with higher levels of cycling and greater depth of discharge (DoD); for instance, limiting DoD to 50% doubles the required battery capacity other things being equal, leading to a

proportional CAPEX increase. Those technical issues adversely affect the bankability of the projects as well, which is greatly enhanced by at least [a 10-year warranty backed by a larger corporation, an O&M contract of same time length, and a performance guarantee.](#)

Customer-sided and hybrid business models.

Among the different behind-the-meter business models, offsetting demand charges has been taking so far the [lion's share in electricity markets where demand charges require a significant premium like in certain US states.](#)



The market for demand charges offset is strongly dependent on the tariff structure and load profile of the customer site where storage is going to be located. Unfortunately, demand charges are not that high across Europe to make these investments financially feasible yet.

Nevertheless, a favorable regulatory framework in Germany allocates a premium to the normal EEG-feed-in-tariff (FIT) for smaller residential solar PV installations with higher amounts of self-consumption. This has prompted [some highly complex commercial offers at the end of 2015](#), which feature a nationwide energy trading, "P2P sharing" platform for DERs, with the potential upside of providing aggregated, utility-scale frequency regulation services. The critical issue for these business models to be meaningful is having to deal with a potentially extremely high number of Points of Delivery (PoD), its related dispatching and distribution costs, and - outside Germany - its compatibility with existing FIT and net-metering regimes.

In the US the utility ConEdison [is piloting a similar scheme](#), but on a pure commercial basis and only in New York City. The value proposition of this commercial offer for storage to residential customers is going to be tested

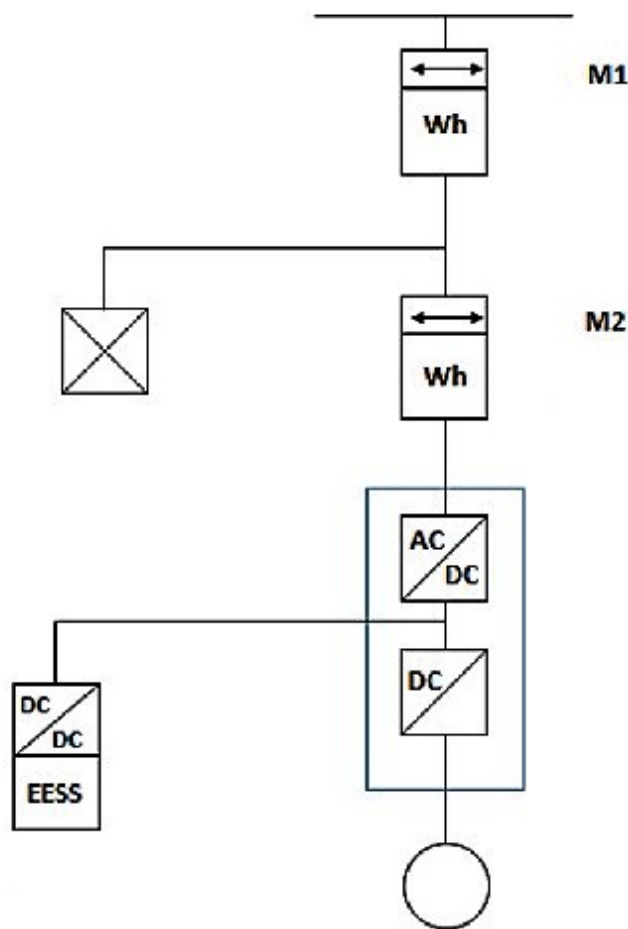
with SunPower along the following guidelines:

- value to the customer for resiliency/backup power;
- development of new electricity retail market rates for time-of-use tariffs, critical peak and demand response pricing;
- aggregation of solar PV with storage into a Virtual Power Plant (VPP) to offer ancillary services to the local DSO.

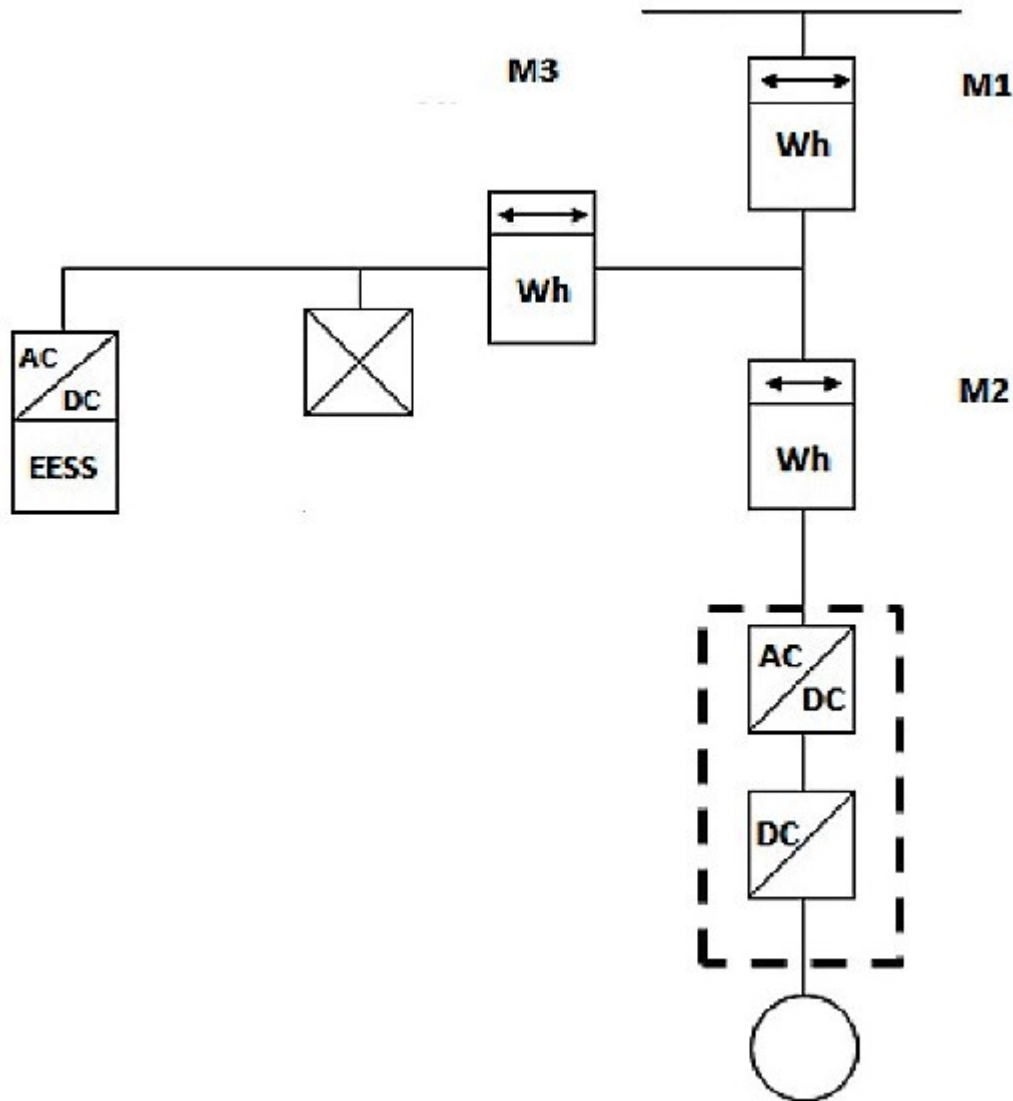
[Commercial offers for mass-market VPPs are being developed in Germany as well](#), which provides the advantage of combining a portfolio of both distributed generation and demand resources ["with different operating attributes and cost structures into a standard commodity that can participate in the wholesale power market"](#).

There is an important technical warning for such customer-sided commercial offers though. In order to save on upfront costs/CAPEX, battery storage might be paired on a single inverter with DERs instead of being co-located with them.

Battery storage paired on a single inverter with DERs.



## Battery storage co-located with DERs.



In this case, when DERs such as solar PV need the shared inverter during peak times (midday) of production, paired battery storage could not bid for, e.g., frequency regulation markets in those times, diminishing the added value of stacking revenue streams both upstream/front-of-the-meter and downstream/behind-the-meter.

This is particularly valuable to vertically integrated utilities, which using bilateral contracts could capture different revenue streams for behind-the-meter energy storage across all the different business models. The Rocky Mountain Institute in its already mentioned report makes a good point here: "The further downstream from central generation stations energy storage is located, the more services it can offer to the electricity system at large."

## Conclusions and recommendations.

Storage is an infrastructure business, which supply services to the electricity markets. Usually, such capital-intensive industries require a long-term commitment (at least as long as the battery life expectancy) for the investor.

In the electricity retail markets battery storage should provide increased convenience (such as back-up, resiliency, peak and load shifting) for users/*prosumers*, and hedging against adverse regulatory changes in, eg., net-metering and time-of-use rates. Hedging against upcoming climate regulations and retiring fossil fuel-fired power plants should provide investment guidance for upstream investors.

Other national and international markets should follow suit with more favorable regulatory frameworks towards storage deployment, paving the way for a level playing field with incumbent technologies and service providers. In particular, TSOs and DSOs should provide aggregated operational data of their electricity networks, in order to allow commercial developments of storage applications by third parties and IPPs.