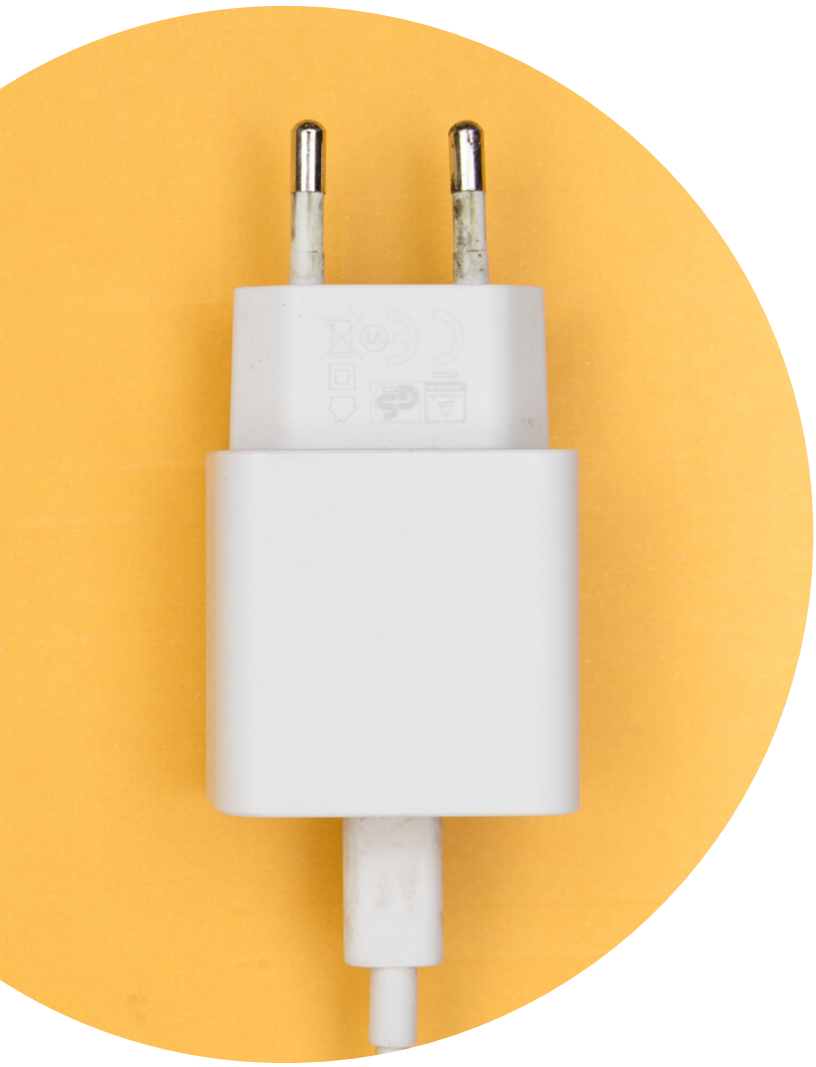
European Association for Storage of Energy

Energy Storage Applications Summary

Brussels, June 2020



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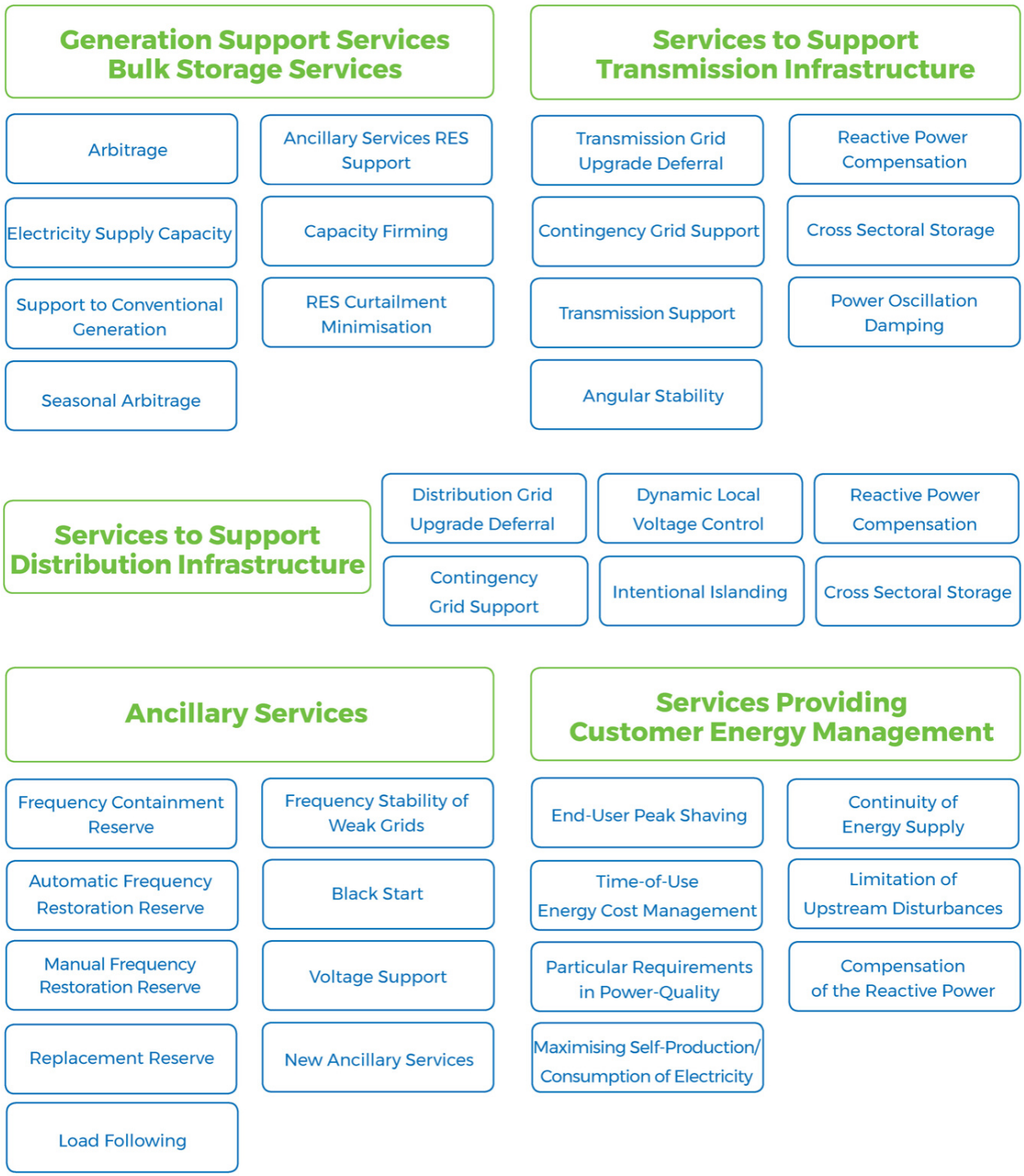
This paper was elaborated by the EASE Task Force 2.6 Segmentation of Applications, chaired by Jean-Michel Durand (EASE Technical Advisor). EASE Secretariat would like to thank all the EASE members who contributed to this document.

Introduction

This overview provides a summary of the different energy storage applications, focused mainly on the electricity system, in order to illustrate the many services that energy storage can provide. The forms are organised according to the segment of the energy system that benefits from a given service; this categorisation does not necessarily reflect the location in which the storage device is installed. The terms for individual services, as well as their maturity (existing service vs emerging or future service) varies across different EU Member States.



1. Services to Support Generation/Services to Support Bulk Storage [1]

- **Arbitrage (existing service[2])**: Practice of taking advantage of an electricity price difference in the wholesale electricity market. It is the use of storage to buy energy at a low price and sell it at a high price.

- **Support to conventional generation (emerging service)**: Support to conventional generation is related to optimising the operation of conventional generation assets:
  - Generator bridging: the ability of energy storage systems (ESS) to pick up a generator load while the generator is stopping, until a new generator starts up or the same generator is restarted. ESS can also avoid stopping the unit (and the associated starting costs) by charging in moments of low load.
  - Generator ramping: the ability of ESS to pick up strong and fast load variations, giving enough time for a given generator to ramp up or down its production level according to the optimal technical recommendations to meet load variation at stake.
  - Hedging imbalance charges due to deviations of final physical notifications.
  - Provision of mandatory services (e.g. frequency control), but also apply for bids in the market.

- **Ancillary Services RES Support (emerging service)**: The use of energy storage to help variable renewable generation contribute to ancillary services by keeping some reserve power, thus "wasting" a part of the down regulation of non-dispatchable RES.

- **System Electric Supply Capacity (emerging service)**: Use of energy storage to provide the system with peak generation capacity.

[1] Services listed are not limited to those which are provided through generation.
[2] We classify services broadly into three categories: as existing (meaning they are already remunerated in some Member States), emerging (meaning that they are remunerated in very few Member States or there are plans to do so in the near future) or future services (meaning there is no clear monetisation/tendering framework expected in the coming years). Since the European energy storage market is not homogeneous, some applications may be existing for one country (self-consumption in Germany for example) and emerging for other countries (Italy or UK) or expected to emerge for other countries (France or Spain).

- Capacity firming (emerging service): Use of energy storage to render variable RES output more constant during a given period of time. Energy storage is used to store variable energy production (e.g., wind or solar) during hours of peak production regardless of demand. This energy is then discharged to supplement generation when the variable energy unexpectedly reduces its output.

- RES Curtailment Minimisation (emerging service): Use of energy storage to absorb variable RES (wind or solar) that cannot be injected into the electricity grid due to lack of demand or transmission capacity, either delivering it to the electricity grid when needed or converting it into another energy vector (gas, fuel or heat) to be delivered to the relevant grid.

- Seasonal Arbitrage (future service): The practice of taking advantage of an electricity price difference in the wholesale electricity market between two seasons: Use of storage to charge energy at low price in summer and discharge it at high price in winter.

2. Ancillary Services

- **Black start (existing service)**: The objective is to contribute to the process of recovering a power station to operation without relying on an external power network. The black start service is procured from power stations that have the capability to start main blocks of generation onsite, without reliance on external supplies. Black start services can be provided by a large power station, known as the main plant that has the capability to start main blocks of generation, and an on-site auxiliary power station.

- **Frequency Containment Reserve (FCR), prev. "Primary Reserve" (existing service)**: Use of energy storage to maintain a balance between generation and consumption (demand) within the Synchronous Area. By the joint action of all interconnected parties/TSOs, primary frequency control aims to maintain the operational reliability of the power system of the Synchronous Area and stabilises the system frequency at a stationary value after a disturbance or incident in the time-frame of seconds, but without restoring the system frequency and the power exchanges to their reference values.

- **Automatic Frequency Restoration Reserve (aFRR), prev. "Secondary Reserve" (existing service)**: Use of energy storage to adjust the active power production of the generating units to restore the frequency and the interchanges with other systems to their target values following an imbalance. In other words, while primary control limits and stops frequency excursions, secondary control brings the frequency back to its target value. Only the generating units that are located in the area where the imbalance originated should participate in this control as it is the responsibility of each area to maintain its load and generation in balance.

- **Manual Frequency Restoration Reserve (mFRR) (existing service)**: Use of energy storage to restore the primary and secondary frequency control reserves, to manage congestion in the transmission network, and to bring the frequency and interchanges back to their target value when the secondary frequency control is unable to perform this last task.

- **Replacement Reserve (RR), prev. "Tertiary Reserve" (existing service)**: Use of energy storage to restore/support the required level of FRR to be prepared for further system imbalances. This category includes operating reserves with activation time from Time to Restore Frequency up to hours.

- **Load Following (existing service)**: Use of energy storage to serve as load following capacity that adjusts its output to balance the generation and the load within a specific region or area.

- **Frequency stability of weak grids (emerging service)**: Use of energy storage in island systems to maintain the frequency stability by helping to avoid load shedding.

- **Voltage support (existing service)**: The objective is to maintain voltage by injecting or absorbing reactive power by means of synchronous or static compensation. Different kinds of voltage control are implemented by individual TSOs, based on their own policies:
  - Primary voltage control is a local automatic control that maintains the voltage at a given bus at its set point.
  - Secondary voltage control is a centralised automatic control that coordinates the actions of local regulators in order to manage the injection of reactive power within a regional voltage zone.
  - Tertiary voltage control refers to the manual optimisation of reactive power flows across the power system.

- **New Ancillary Services (services only currently used in some countries such as Ireland or UK)**:
  - Enhanced Frequency Response (EFR): Use of Energy Storage to deliver active power to the grid within 500ms as a proportional response to a change in system frequency outside of the deadband. Proportionality of the response means that active power increase/decrease has to be proportional to the frequency deviation from 50Hz. Within the deadband, the assets do not have to deliver proportional response. However, managing state of charge is increasingly questionable in markets that have this service.
  - Synchronous Inertial Response (SIR): Use of synchronous energy storage to provide instantaneous active power output (within 5 ms) and synchronising torque during a short time to cope with disturbances. This service enables system operability by ensuring frequency does not deviate beyond operational limits while frequency response assets become operational following a disturbance. EFR will be operational within 500 ms and primary frequency control within 1 second.
  - Synthetic Inertia (SI): Use of non-synchronous energy storage (a grid connection power converter, power park module, or HDVC) to provide near instantaneous active power output, replicating the effects of inertia, in case of frequency change in the system within a timeframe of up to 5 ms. The control could be derivative or proportional.
  - Dynamic Reactive Response (DRR): Use of energy storage to deliver a reactive current response for voltage dips in excess of 30% that would achieve at least a reactive power in Mvar of 31% of the registered capacity at nominal voltage. The reactive current response shall be supplied with a rise time no greater than 40 ms and a settling time no greater than 300 ms.
  - Fast Frequency Response (FFR): Use of energy storage to provide an additional increase of power supply or reduction in demand following a frequency event that is available within 2 seconds of the start of the event and is sustained for at least 8 seconds. Known in the UK as dynamic containment.
  - Fast Post-fault Active Power Recovery (FPFAPR): Fast Post-fault Active Power Recovery is defined as having been provided when, for any fault disturbance that is cleared within 900 ms, a plant that is exporting active power to the system recovers its active power to at least 90% of its pre-fault value within 250 ms of the voltage recovering to at least 90% of its pre-fault value. The generator must remain connected to the system for at least 15 minutes following the fault.
  - Ramping Margin (RM): Ramping margin is defined as the guaranteed margin that a unit provides to the system operator at a point in time for a specific horizon and duration. There are horizons of one, three and eight hours with associated durations of two, five and eight hours respectively. The ramping margin is defined by both the minimum ramp-up and output durations. Thus, the ramping margin represents the increased MW output that can be delivered by the service horizon time and sustained for the product duration window.

3. Services to Support Transmission Infrastructure

- **Transmission grid upgrade deferral (existing service)**: The objectives are:
  - To use energy storage to defer or avoid transmission infrastructure upgrades and solve transmission congestion issues by installing energy storage systems instead of new lines.
  - To use energy storage as a transmission grid component in order to decrease the "traditional" grid size during the grid planning process by basing its design on a medium power value and not a peak power value.

- **Contingency Grid Support (existing service)**: The objective is to use energy storage to provide capacity/voltage support in order to reduce the impacts of the loss of a major grid component. It refers to redundancy provisions to cover the trip of the largest transmission element into an area.

- **Transmission support (existing service)**: The objective is to use energy storage to improve the performance of the transmission system by compensating for electrical anomalies and disturbances such as voltage sag, unstable voltage, sub-synchronous resonance, and power quality.

- **Power oscillation damping (POD)**: To use energy storage to damp electromechanical oscillations. Oscillation frequency could be between 0.15 Hz (inter area oscillation) and 2.5 Hz (local oscillation).

- **Participation to angular stability (expected to emerge)**: Use of energy storage to charge and discharge high levels of energy in short periods when a fault/angle change occurs; this may contribute to reduce the load-angle variations, thereby improving angular stability of the system.

- **Reactive Power Compensation**: Use of energy storage to reduce the amount of reactive power, by decreasing voltage fluctuations within the transmission network.

- **Cross Sectoral Storage (emerging service)**: Practice of coupling the electricity sector with other energy sectors (gas, fuel, heat) by converting excess supply of electricity to the grid into energy carriers, synthetic fuels, and heat, thus avoiding curtailment of running power generators (RES, thermal power plants, etc).

4. Services to Support Distribution Infrastructure

- **Distribution grid upgrade deferral (existing service)**: The objectives are:
  - To use energy storage to defer or avoid distribution infrastructure upgrades and solve transmission congestion issues by installing energy storage systems instead of new lines.
  - To use energy storage as a distribution grid component in order to decrease the “traditional” grid size during the grid planning process by basing its design on a medium power value and not a peak power value.

- **Contingency grid support (existing service)**: Use of energy storage to perform some capacity/voltage support in order to reduce the impacts of the loss of a major grid component, or to support the grid during planned maintenance, asset replacement, and connection works.

- **Dynamic, local voltage control (existing service)**: Use of energy storage to maintain the voltage profile within admissible contractual/regulatory limits.

- **Intentional islanding (existing service)**: Use of energy storage to energise a non-loopable feeder during an outage.

- **Reactive power compensation (emerging service)**: Use of energy storage to reduce the amount of reactive energy drawn from transmission and charged by the TSO to the DSO.

- **Cross Sectoral Storage (emerging service)**: Practice of coupling the electricity sector with other energy sectors (gas, fuel, heat) by converting excess supply of electricity to the grid into energy carriers, synthetic fuels, and heat, thus avoiding curtailment of running power generators (RES, thermal power plants, etc).

5. Services to Support Customer Energy Management

- **End-user peak shaving (existing service)**: Use of energy storage to minimise the part of the customer invoice that varies according to their highest power demand, and reduce the overall customer costs for electric service by reducing demand charges during peak periods specified by the utility.

- **Time-of-use energy cost management (emerging service)**: Use of energy storage to be charged when the rates are low to be discharged during peak times, with the aim of reducing the invoice of final users.

- **Particular Requirements in Power Quality (existing service)**: Use of energy storage to provide a high level of power quality above and beyond what the system offers (e.g., critical load) to some customers.

- **Maximising self-production & self-consumption of electricity (emerging service)**: Use of energy storage to maximise self-production and self-consumption of electricity, especially when energy storage is associated with PV.

- **Continuity of energy supply (existing service)**: Use of energy storage device to substitute the network in case of interruptions.

- **Limitation of upstream disturbances (emerging service)**: Use of energy storage to limit the disturbances caused by distribution grids on upstream HV grids to contractual values.

- **Compensation of the reactive power (emerging service)**: Use of energy storage to locally compensate the reactive power.

- **EV integration (emerging service)**: The objective is to use EV or PHEV to provide Vehicle-to-Grid (V2G) functions to contribute to grid balancing.

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About EASE:

The European Association for Storage of Energy (EASE) is the leading member - supported association representing organisations active across the entire energy storage value chain. EASE supports the deployment of energy storage to further the cost-effective transition to a resilient, carbon-neutral, and secure energy system. Together, EASE members have significant expertise across all major storage technologies and applications. This allows us to generate new ideas and policy recommendations that are essential to build a regulatory framework that is supportive of storage.

For more information please visit www.ease-storage.eu

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Disclaimer:

This content was elaborated by EASE and reflects a consolidated view of its members from an energy storage point of view. Individual EASE members may adopt different positions on certain topics from their corporate standpoint.

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