THE DEPLOYMENT OF BATTERY STORAGE IN GB AND EUROPE

JANUARY 2021
WORKSHOP PRESENTATION
BUSINESS AND INVESTOR ADVISORY

ARUP
The United Kingdom leads the way in the deployment of utility-scale battery storage in Europe with Germany second.

**Fast Paced Growth in Battery Storage**

Batteries are the fastest growing large energy storage form, favoured by developers and investors ahead of pumped hydro energy storage.

**European Installed utility scale battery storage capacity**

- United Kingdom
- Germany
- Italy
- France
- Netherlands
- Belgium
- Switzerland
- Spain
- Slovenia
- Ireland
- Czechia
- Hungary
- Portugal
- Finland
- Sweden
- Others

**Source:** Quarterly Report on European Electricity Markets (Q4 2019), European Commission
The deployment of Battery Storage in GB and Europe

Location of Batteries in Electricity/Energy Systems

In GB and in Europe more generally, well before 2035, we are already seeing battery storage routinely deployed at multiple places in the electricity system.

**Location of Batteries in Electricity/Energy Systems**

**Transmission:** Grid-scale batteries connected to the transmission network (400 kV).

**Distribution:** Grid-scale batteries connected to the distribution network (<33, 132 & 275 kV).

**Behind the Meter:** We have seen batteries deployed in businesses, the industrial and commercial (I&C) segment as well as in homes, the residential segment. In businesses/I&C batteries have been deployed to reduce network charges related to peak.

**Vehicle to Grid (V2G):** Plug-in electric vehicles, such as battery electric vehicles (BEV), plug-in hybrids (PHEV) or hydrogen fuel cell electric vehicles (FCEV), communicate with the power grid to sell demand response services by either returning electricity to the grid or by throttling their charging rate.

Source: Energy Systems: A view from 2035, ARUP, 2017
Battery Storage can provide valuable services to a number of different market players including generators, utilities, system operators and traders, capturing a number of revenue opportunities.

**Revenue Stacking**

Illustration of how revenues from different markets are stacked to deliver returns to investors:

- **Ancillary & Balancing Markets**
  - Trading / Arbitrage
  - Up/Down Regulation
  - Frequency Containment
  - Reserve
  - Voltage Control
  - Black Start

- **Wholesale Markets**
  - Hedging / Risk Management
  - Portfolio Optimisation

- **Capacity Renumeration Markets**
  - Capacity Market
  - Strategic Capacity Reserve

- **Embedded Benefits**
  - Network Charging
  - Time of Use

- **Network Charging**

- **Up/Down Regulation**

- **Trading / Arbitrage**

- **Frequency Containment**

- **Reserve**

- **Voltage Control**

- **Black Start**

- **Reactive Power**

- **Constraint Management**

- **Stability Services**

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Karnataka Power System Transformation Workshop
21 January 2021 |
**Battery Storage** is well placed to compete in Wholesale and Imbalance markets which are bigger and growing at a faster rate than Control Power markets where it competes across all of the control power markets.

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**Legend**
- Capable of providing the service
- Providing the service
- Not capable of providing the service
- Not Providing the service

**Wholesale & Imbalance**

- **Day-Ahead Market (DAM)** – Generators (typically sellers) and Suppliers (typically buyers), voluntarily trade electricity, traditionally for hourly strips of electricity, a day before delivery.
- **Intra-Day Market** – Once again, Generators and Suppliers, voluntarily trade electricity up to an hour ahead of delivery, taking the opportunity to adjusting their in response to closer to real-time information.
- **Imbalance Market & Voluntary Balancing** – The System Operator accepts Bids to reduce generation / increase consumption and Offers to increase generation / reduce consumption.

**Balancing Services**

- **Primary Control (PC)** – Generator/demand side response within seconds either due to a deviation in the system frequency or a signal from the system operator.
- **Secondary Control (SC)** – An automatic centralised or decentralised service provided by the generator or a demand side responder to adjust the output of a unit if frequency deviation lasts for a longer period.
- **Tertiary Control (TC)** – An automatic or manual change of generator output, in order to restore reserve within minutes.
Both Hybrid Renewables + Storage and Hybrid Energy Storage Systems (HESS) can unlock additional value and reduce system integration costs.

**HYBRIDISATION UNLOCKED ADDITIONAL VALUE**

- In GB and Europe battery storage development has largely been in response to a lack of system flexibility exposed by increased intermittent generation.
- We haven’t yet seen significant examples of hybrid systems where renewables is paired with energy storage.
- Renewables and energy storage generation hybrid systems support the delivery of ‘near firm’ renewable generation. Regularising the output and therefore reducing the system integration costs.
- Hybrid Energy Storage Systems (HESS) typically combine fast-acting with slower-acting storage solutions. Enabling them to combined frequency response with energy arbitrage.
There are a number of lessons which can be learned from the deployment of Battery Storage in GB and Europe

**KEY CONSIDERATIONS**

The creation of flexibility markets, for wholesale, imbalance and control power, will give developers, investors and lenders the confidence to invest to support the deployment of battery storage.

Procurement of flexibility needs to evolve in order to ensure consumers are getting value for money. Start with longer duration products before moving procurement closer to real time.

Assuming that there isn’t further deregulation and unbundling, moving to ‘near firm’ renewables / low carbon generation procurement should encourage developers to hybridise renewables with battery storage and other electricity storage forms.

*SOURCE: ARUP ANALYSIS*
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