State of Charge of GB

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***Abstract*—This paper is a summary of the electrical energy storage installations connected to GB distribution networks by GB Distribution Network Operators (DNOs). It demonstrates the level of activity and the number of installations which have been or will be connected in the near future. Details of size, technology, purpose and some of the expected benefits being realised are provided.**

***Index Terms*—energy storage, power distribution, smart grids.**

I. Introduction

The Energy Storage Operators Forum (ESOF) was established in May 2012 as a forum to facilitate sharing of experiences between member DNOs. A number of DNOs have installed and continue to install electrical energy storage systems. The ESOF members have produced this White Paper to illustrate the level of activity in GB amongst the DNOs that has been funded by the Low Carbon Networks Fund (LCNF) and Innovative Funding Incentive (IFI) established by Ofgem, [1][2]. Currently there is 5.1 MW and 6.4 MWh commissioned with an additional 7.2 MW and 13.8 MWh either under construction or being planned.

II. Installations

Installations range from domestic systems through community-scale devices to utility-scale. Demonstrations in NPg's "Customer-Led Network Revolution", WPD's "BRISTOL" and "Falcon", UKPN's Tier 1 [3] and SSE's various LCNF (Tier 1 and 2) projects [4],[5] are all delivering learning which is being disseminated at various electricity storage and distribution network events. The relevant installation dates and project status are presented in Table 1, with their locations presented in Figure 1.

Table 1: The Present Status of GB DNO Projects

Location	Installation Status	Power	Capacity
Hemsby	April 2011	200 kW	200 kWh
Chalvey	June 2012	3x 25 kW	3 x 25 kWh
Orkney	June 2013	2 MW	500 kWh
Bristol	September 2013	6 kW	14.4 kWh
Darlington	November 2013	2.5 MW	5 MWh
Darlington	November 2013	100 kW	200 kWh
Wooler	November 2013	100 kW	200 kWh
Wooler	November 2013	50 kW	100 kWh
Maltby	November 2013	50 kW	100 kWh
Darlington	November 2013	50 kW	100 kWh
Bristol	Under construction	90 kW	up to 321 kWh
Shetland	Under construction	1 MW	3 MWh
Milton Keynes	Under construction	150 kW	450 kWh
Leighton Buzzard	Under construction	6 MW	10 MWh
Willenhall	Planned	2 MW	375 kWh
Shetland	Decommissioned	1 MW	6 MWh
Nairn	Decommissioned	100 kW	150 kWh

III. Technologies

A number of electrical energy storage technologies have been, or are being trialled. These include: sodium sulphur; zinc bromine flow cells; sodium nickel chloride; gel-filled lead acid; and various Li-ion chemistries including "second-life" EV batteries.

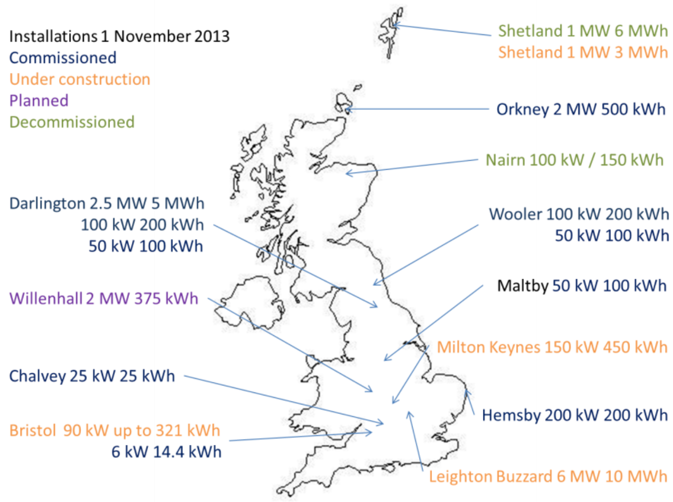

Figure 1: Locations of Energy Storage Systems

IV. Suppliers

DNOs have used a number of funding mechanisms to carry out these demonstrations. These include IFI and LCNF as well as regional or national sources of funding. Suppliers of energy storage batteries include A123, Dow Kokam, GE, NGK, Premium Power, SAFT and Samsung SDI, amongst others.

Power Conversion System (PCS) suppliers, and system integrators include ABB, Dynapower, Princeton Power, S&C Electric and Studer amongst others. Each technology has its own merits.

V. Benefits Realised

The obvious benefit has been to alter the demand profile at the substation at the next higher voltage. For example, community-connected storage impacts the secondary distribution substation whereas a grid-scale device will impact the primary substation where it is connected.

The PCS allows reactive power to be absorbed or exported as required to provide voltage support at the point of connection.

Larger storage devices are expected to provide ancillary services to National Grid in the form of frequency response.

Aggregators have shown interest in storage to form part of their portfolio and as a means to reduce their risk of imbalance.

On Orkney a third-party-owned installation is providing SSE with network services and has the potential to allow more renewables to connect to the island network, via its inclusion as part of a wider Active Network Management scheme.

VI. Knowledge Sharing

ESOF members share their experiences to benefit their collective knowledge and to facilitate replication of effective energy storage solutions.

Safety is paramount in all DNO activities. Our safety rules only allow access to equipment once it has been isolated and earthed. Batteries cannot be discharged, so special procedures have been introduced and staff trained to allow essential maintenance to be completed.

Procurement is challenging as specifications and international standards are few. Who acts as the energy storage provider? Supply and delivery contracts with battery suppliers and PCS suppliers have been shown to work. There is a third way with a system integrator who sources and integrates all the main components.

There are no clearly agreed methods to calculate the efficiency. Battery suppliers quote their round trip efficiency, but an energy storage operator has to consider the overall efficiency required to transfer energy to the electricity network. Should the energy required for the air-conditioning and cooling that is needed for battery electrical storage be included, for instance?

Large grid-scale installations are still few in number. Examples exist in the US and Chile showing large numbers of containers housing the batteries and associated equipment.

The challenge in GB is how can an installation be a good neighbour and blend into the background? Community-sized installations can occupy the size of a small distribution substation. Larger sites can be accommodated on industrial estates, but sometimes the energy store is required to be close to the original primary substation, which is now surrounded by residential areas. UK Power Networks is building a purpose-built hall to demonstrate that storage can blend into the built environment.

VII. Other Technologies

In addition to electrical energy storage developments, DNOs continue to work with other energy storage developers, demonstrating methods of energy storage for example Highview's compressed liquid air in Slough as presented in Table 2.

Table 2: Other Storage Technologies

Location	Installation Status	Power	Capacity
Highview compressed liquid air	Commissioned	350 kW	2.4 MWh
Isentropic pumped heat	Planning	1.5 MW	6 MWh

VIII. Conclusions

Energy storage systems are becoming an important part of the delivery of a low carbon future network. These installations range from domestic, community and grid scale. All the DNOs are learning from one another when they share their experiences in the Energy Storage Operators Forum.

References

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