ENSTORE

Topic …….. A smart flexible energy system a call for evidence with data from Enstore-Q2

Identification ……. Response ID "ANON-BJ6H-GNMS-Y".

Version ……. 001

Date …….. 07/ 01 / 2017

Issued to ……. BEIS and Ofgem with no restrictions on the use of the data

Signed by …… *E A Lewis* **and** *P M Lewis* **…. Company directors**

Anacronyms

- EFR. Enhanced Frequency response.
- ESS. Energy storage system.
- Fast Fault current. The provision of AC current in to an AC fault for a defined time period.
- SBSPM. Second by second performance monitoring.
- SM1 & 2. Meters for recording the SBSPM.
- PM1 & 2. Meters for recording instantaneous and average AC grid power.
- PWM. Pulse Width Modulation
- VSM. Virtual Synchronous Machine implemented in a control system

Contents

To understand this data, you need a copy of my data for Question 1.

To

2. Removing policy and regulatory barriers Enabling Storage

Have we identified and correctly assessed the issues regarding network connections for storage?

No.

Have we identified the correct areas where more progress is required?

No.

Please provide evidence to support your views.

The type of connection required to have a fully compliant Transmission connected bid for an EFR project is shown on Figure 2.1 which has a Firm connection (i.e. SQSS-compliant which is that full export is available under N-1 conditions and is not subject to Demand Management disconnection arrangements), see EFR specification section 6.22.

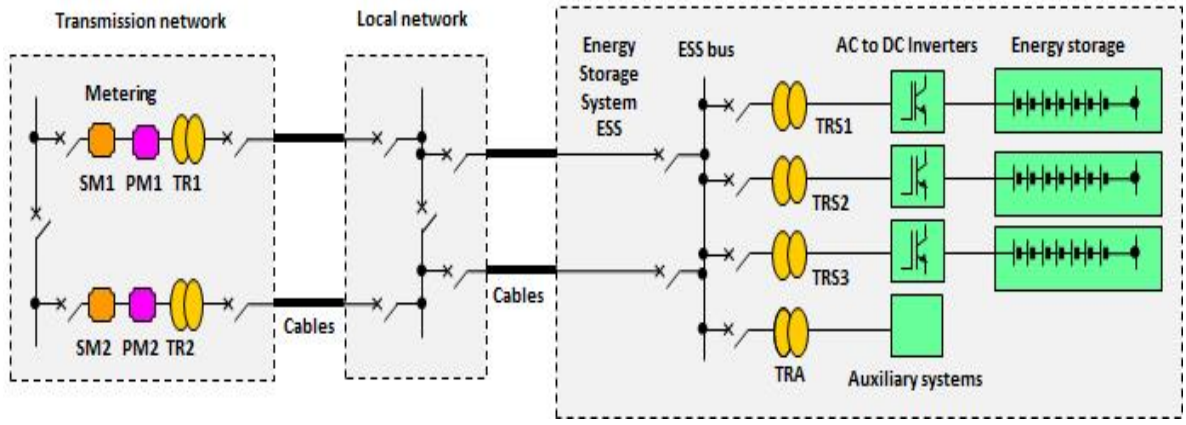

Figure 2.1.

The Figure2.1 is a very expensive option that could inhibit future projects.

The Figure 2.1 has the following features:

- Dual line connections from the Transmission network to the Energy Storage System "ESS".
- Transformers TR1 and TR2 to change the voltage from the transmission voltage e.g. 400 kV, to the Local network voltage e.g. 11 kV.
- ESS bus to supply several AC to DC inverters with the associated energy storage units.
- Using many inverters in parallel provides a high redundancy and makes it possible to use mass produced commercially available inverters as used for solar and wind energy projects.
- There are three AC to DC inverters in the Figure 2.1 but many are often needed e.g. 25 for a 25 MW rating.
- Transformers TRS1 to TRS3 to supply the inverters with the correct voltage e.g. 690 volts AC. It is not technically viable to use one transformer from the transmission voltage to the inverter's voltage.
- This makes it necessary to use of a Local network that can either be a dedicated network for a given ESS project or part of a compliant Distribution network with a Firm connection.
- There are meters PM1 and PM2 to record the energy produced or used.
- There are meters SM1 and SM2 that measure and record the Second by Second Performance Measure "SBSPM" as defined in the EFR specification section 6.28.
- The SBSPM requires meters with the performance characteristics defined in the EFR specification Section 6.6 operating every second which requires very specialised equipment with a data link to National Grid.
- The revenue paid to the ESS is dependent on the correct operation as measured by the SBSPM.
- The ESS also have a set of auxiliary circuits.

The provision of systems like the Figure 2.1 is justified for the development phase of ESS contract but adds a high cost and may need a long time to implement. The Figure 2.2 is a proposed solution.

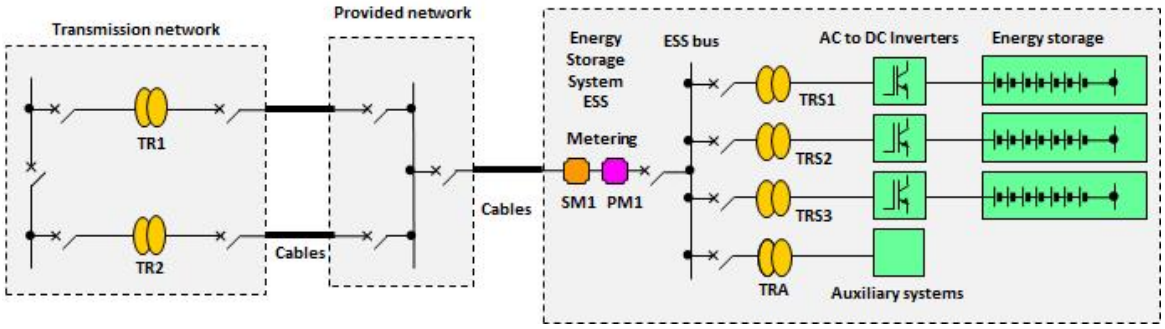

Figure 2.2.

The availability of a Pre-provided network connection as shown on Figure 2.2 for both Transmission and Distribution designs would be very beneficial in facilitating the rapid introduction of ESS projects.

The Figure 2.2 has the following features:

- Has a Pre-provided network available to simplify the connection of ESS projects.
- The Pre-Provided network would be built to have a Firm connection (i.e. SQSS-compliant which is that full export is available under N-1 conditions and is not subject to Demand Management disconnection arrangements).
- The Provided network could either be reserved for energy storage systems or part of a distribution network used by many users.
- **A single line connection from the ESS to the Pre-Provided network as this could be rapidly repaired if it experienced a failure. The benefit of a dual line connection at this point are very small.**
- **Only requires single line SM1 and PM1 metering which is a significant cost saving.**

This concept can then be extended to future projects that want to supply several of the Benefits 2 to 9 previously listed in section 1 from one large battery.

This is a viable concept as many of the **Benefits** 4 to 9 only occur infrequently and at a power that do not justify a separate battery. To retain the SBSPM metering concept per **Benefit** for a system supplying the main EFR **Benefit** 2 plus an additional 2 **Benefits** would need a system like Figure 2.3.

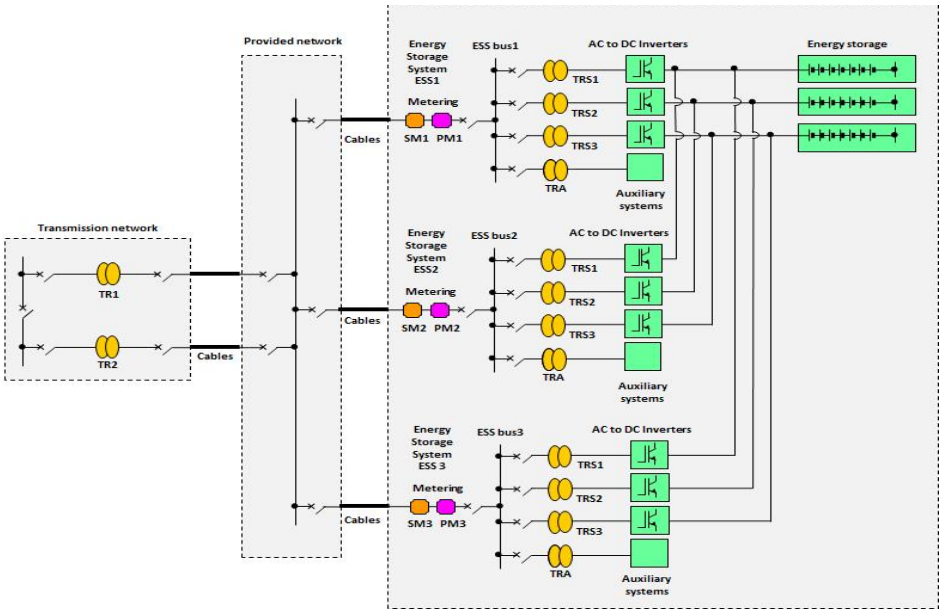

Figure 2.3.

The Figure 2.3 has the following features:

- Has three separate systems so that the correct SBSPM is provided and monitored for each of the 3 **Benefits.**
- Three separate power converter circuits to supply the correct second by second power in line with the 3 separate **Benefits.**

The Figure 2.3 is not commercially viable as the extra power converters are not required as the two extra B**enefits** only happen at a lower power and on an infrequent basis compared with the main EFR **Benefit** 2.

This is not a viable concept and as far as the transmission system is concerned all the three Benefits are applied as one net service.

The circuit shown on Figure 2.4 is the viable way to provide the 3 Benefits in one system.

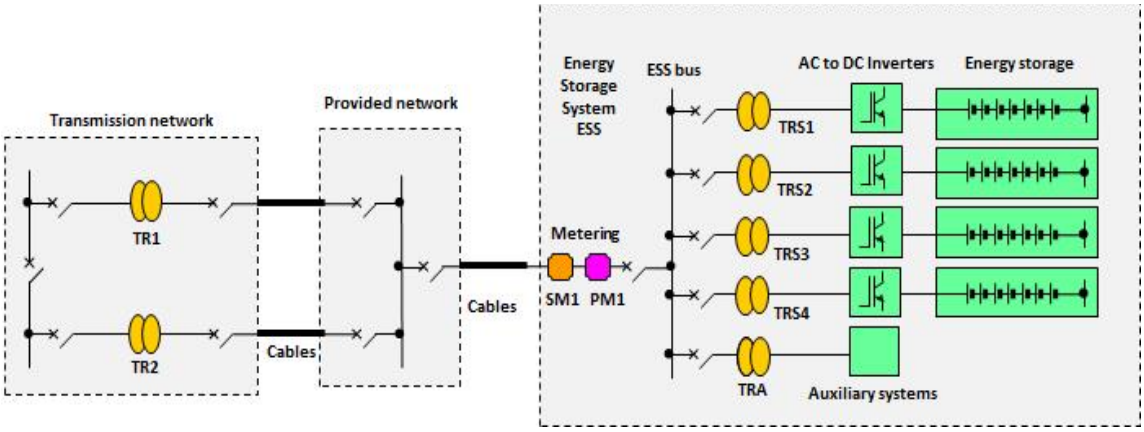

Figure 2.4.

The Figure 2.4 has the following features:

- One extra power converter, if needed, to supply the 3 **Benefits**.
- Only one set of SM1 and PM1 metering.

This is a viable concept and more importantly can be extended to provide the full set of Benefits.

Many studies have shown that having a system to facilitate supplying multiple Benefits from one battery will significantly lower costs and increase the installations of energy storage systems as shown on Figure 2.5.

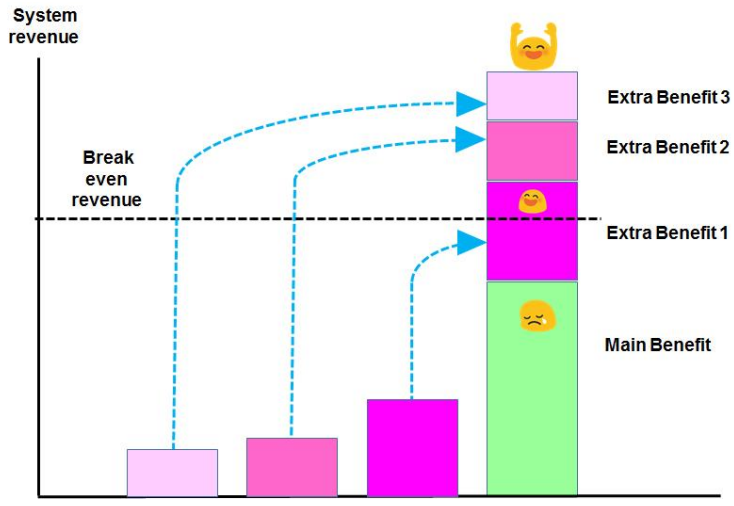

Figure 2.5.

The SPSPM concept used by the EFR project will need a major change to facilitate the adoption of the Figures 2.4 and 2.5 as the SM1 is seeing the net result of several **Benefits**.

The data from the SM1 can still be transmitted to National Grid for monitoring but the calculation of the revenues paid need to be re-defined compared with the EFR concept.

For the circuit shown on Figure 2.4 there are four main ways to implement the calculation of the extra revenues paid compared in addition to the frequency response revenue:

- To have a full set of equations for the SM1 metering that defines on a second by second basis the power that the system should produce allowing for all the **Benefits** in use.

  This will be a very complicated set of equations that will become more and more complex as extra **Benefits** are provided. **This is not a viable way to proceed.**

- To hold auctions like the EFR initial projects but it is mandatory to include all the **Benefits** 1- 9. This could attract very few bids and could be seen as ant-competitive.

- To hold auctions for all the possible combinations of the **Benefits** 1 – 9. This could be very complicated to organise and adjudicate.

- To validate by a yearly test that the system provides the agreed set of **Benefits** and then pay the revenue in the way done for rotary synchronous generator that only depends on the service being on line and operating as detected by the SM1 metering. To make this proposal work:
  - Every Energy storage system would provide a standard set of the **Benefits** 1, 3 and 4.
  - The **Benefits** 5, 6,7, 8 and 9 could be optional Benefits each with a pre-defined MWh reward to permit a wide range of companies to bid for Energy storage projects.
  - The main **Benefit** 2 would still be paid in a way similar to the initial EFR auctions by allowing companies to nominate the £ per MWh for the specific design offered to the auction.

This will then allow auctions to be held with suppliers and National Grid fully aware of the method used and the extra payments that will be added for the extra Benefits offered.

This concept can also be used to reward energy store systems for Benefits they provide in overall systems.

The circuit of Figure 2.4 can also provide the **Benefit** 5 but at a rating of typically 100 % of its normal rating.

To provide the **Benefit** 5 with a 200 % rating the design would be as shown on Figure 2.6.

This is why the **Benefit** 5 should have options to allow for different current levels for example, 100 %, or 200 % or 300 %.

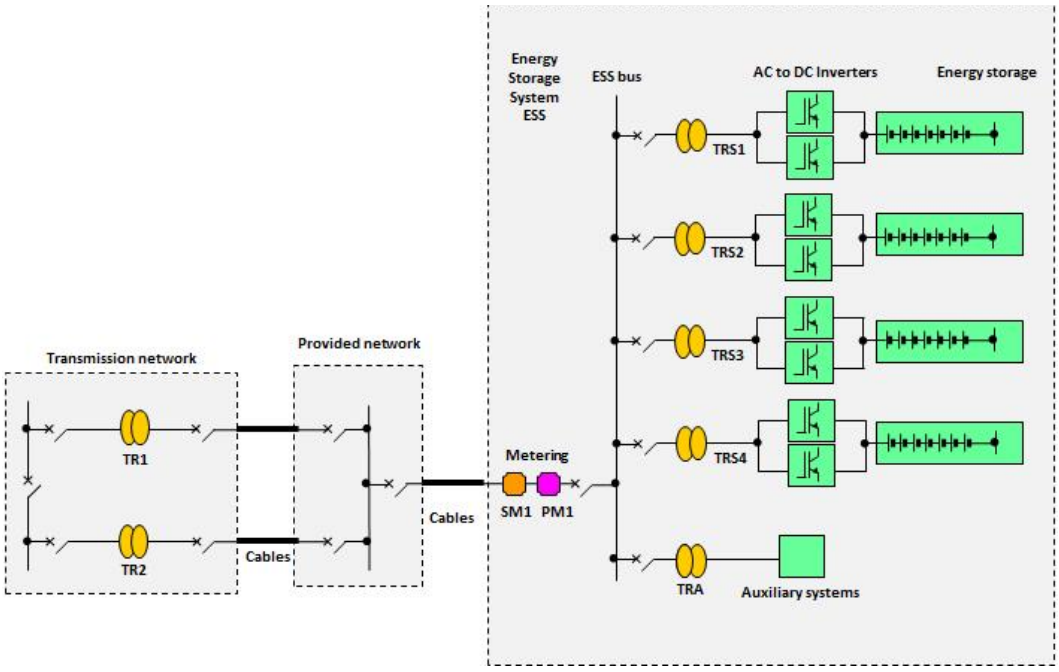

Figure 2.6.

The Figure 2.6 is viable if the appropriate revenue is paid for ESS and solar power systems as they are land based, but it is more difficult to implement for wind turbine systems due to a lack of room per tower.