ENSTORE

Topic …….. A smart flexible energy system a call for evidence with data from Enstore – Q1

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

1. Removing policy and regulatory barriers Enabling Storage

Have we identified and correctly assessed the main policy and regulatory barriers to the development of storage?

No.

Are there any additional barriers faced by industry?

Yes.

Please provide evidence to support your views.

Energy storage systems have the potential to transform the operating efficiency of the AC grid giving lower overall costs with reduced C02 emissions, however to do this it is essential to comprehensively plan for the future and there are 4 essential factors that need to be defined:

1.1. The problems that will exists in a future AC grid that can be resolved by Energy storage systems.

1.2. The opportunities that exist for Energy storage systems that are not solving problems in a future AC grid.

1.3. The ways in which one Energy storage system can provide and be rewarded for several different functions.

1.4. That an Energy storage system is fully rewarded for all the cost saving **Benefits** that it provides.

With clear definitions on these items a business case can be put forward to enable viable Energy storage systems to be produced. The latest EFR projects are example of Energy storage system solving one problem in the AC grid.

The change to have increased penetration of renewable energy systems will lead to extra opportunities for Energy storage systems. The reason for this is that each rotary synchronous generator provides a set of **Benefits** to the AC grid that are defined in the CC section of the Grid Code.

These **Benefits** are available to the AC grid when any rotary synchronous generator is operating and are part of the payments made to an operating rotary synchronous generator. Less rotary synchronous generator will be required, in the future, as they are replaced by renewable energy systems.

The **Benefits** provided by a rotary synchronous generator are:

- **Benefit 1**. Supplying active power with defined operational limits for example +/- 10 % AC voltage changes.
- **Benefit 2**. Supplying frequency responsive power to stabilise AC grid frequency changes, e.g. EFR.
- **Benefit 3**. Supplying controlled reactive power with defined operational limits.
- **Benefit 4**. Having the ability to recover from AC grid faults at its original power level.
- **Benefit 5.** Supplying Fast Fault current in to network faults at levels more than 300 % of its rated current.
- **Benefit 6**. To provide an optional House Load mode to keep a generator ready for instant connection.
- **Benefit 7.** To provide an optional black start ability for restarting sections of the AC grid.
- **Benefit 8.** Providing significant damping of the transients between rotary synchronous generator.
- **Benefit 9**. Providing inertia to limit the df/dt of the AC grid. This is vitally important.

There is growing evidence that for a future AC grid system, with a high penetration of renewable energy, that this will reduce the number of operating rotary synchronous generators. With less rotary synchronous generator the **Benefits** are still required and they can be resolved by extra equipment connected to the AC grid. See Appendix A for additional data.

An uncontrolled reduction of these **Benefits** could give significant problems in the AC grid as shown on Figure 1.1.

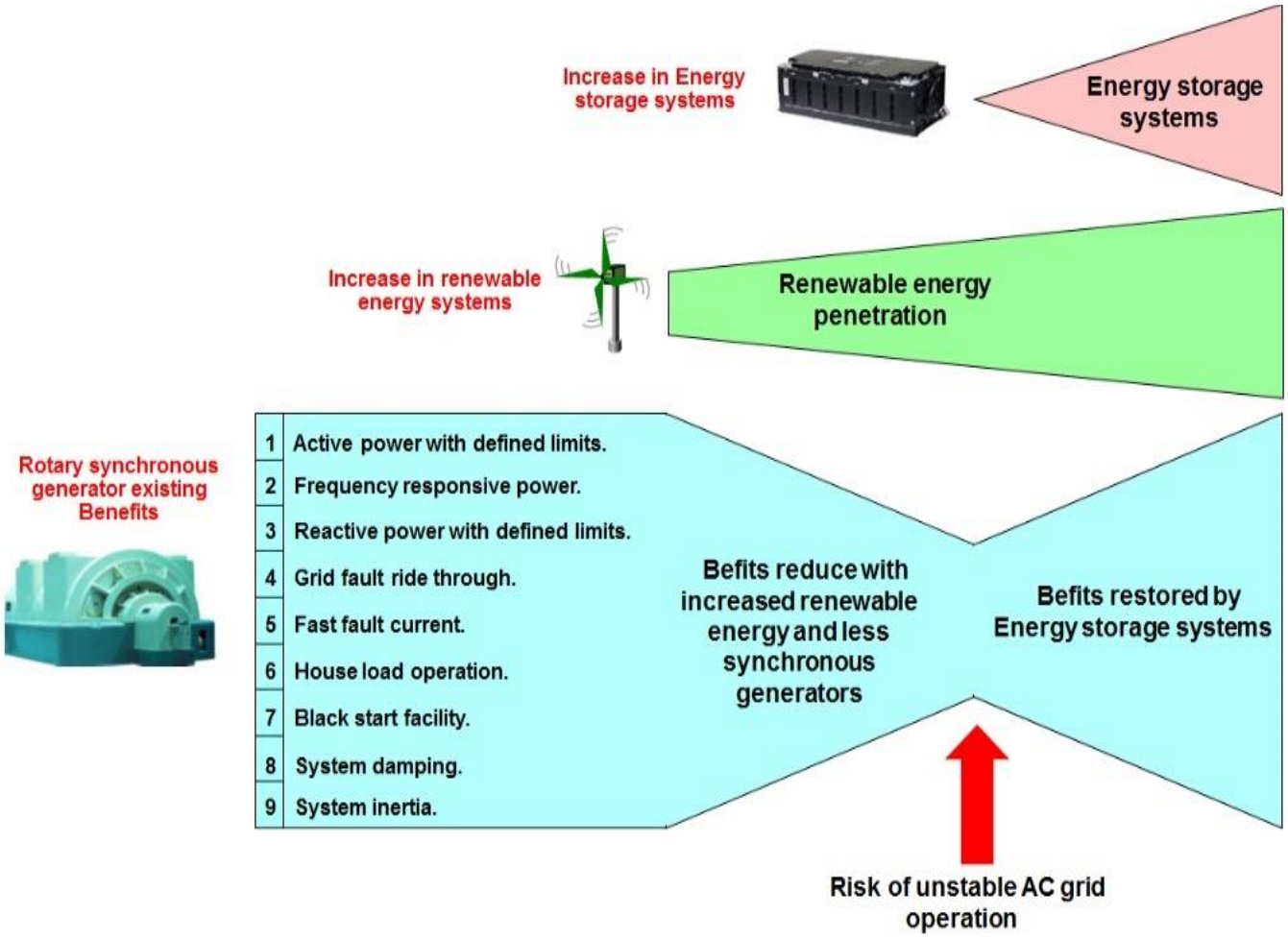

Figure 1.1

The **Benefit l**oss caused by a reduced number of rotary synchronous generators can be restored by using Energy storage systems with the requirements that are listed on Figure 1.2.

As renewable energy systems use similar power converters to Energy storage systems these systems can also restore the **Benefits** by adding the same requirements to their specifications. Selected **Benefits** can also be restored, to a limited extent, by using Synchronous condensers and even better by using advanced flywheels.

Having ways for an Energy storage system to provide the extra Benefits will be beneficially to the AC grid, will enable extra payments to be made to Energy storage systems and will also increase the number of Energy storage systems supplied at a competitive cost. This will then permit an increase in the use of renewable energy.

At present the UK Grid Code is going to be amended to include the requirements for Energy storage systems but the new EU L112/1 commission regulation (EU) 2016/631 of 14 April 2016 for establishing a network code on requirements for grid connection of generators excludes the specification of Energy storage systems.

It is essential that the requirements for UK transmission and UK distribution connected Energy storage systems are defined as soon as possible to ensure that future systems provide the maximum Benefits to the AC grid.

The Figure 1.2 presents a plan for implementing the proposed **Benefits** in Energy storage systems.

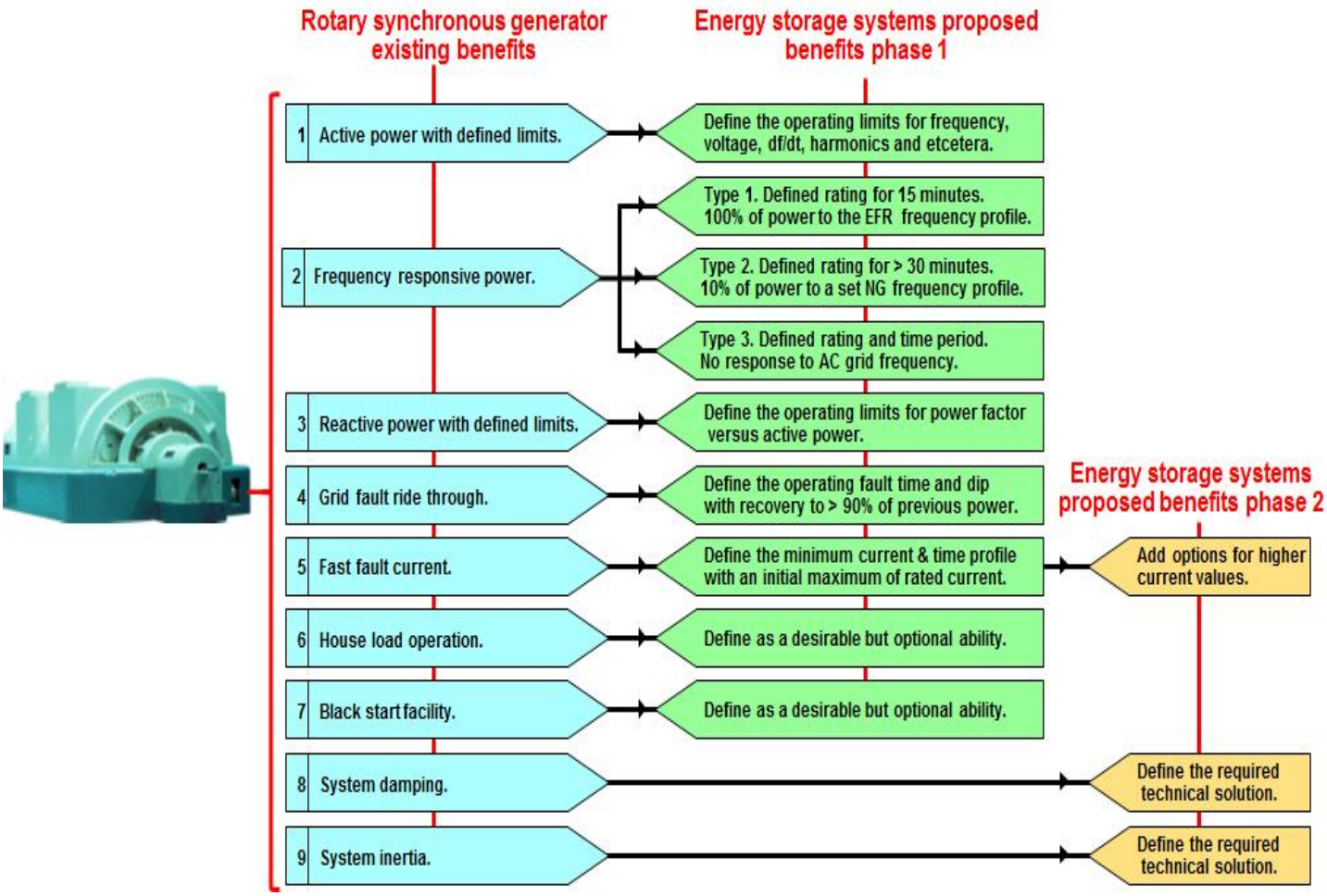

Figure 1.2

The proposed **Benefits** will need to be implemented in two phases. The phase 1 is for the **Benefits** that can be defined based on existing experience and the phase 2 is for the **Benefits** which require developments to be carried out.

The details for the proposed phase 1 and 2 **Benefits** are:

- **Benefit 1**. This is to supply active power with defined operational limits.

  The voltage should be the normal Grid code values of +/- 10 % AC voltage changes for transmission connections and +/- 5 % AC voltage change for distribution connections.

  The AC frequency limits at rated power can easily be increased for Energy storage systems to a proposed value of 50 +/- 2 Hz to give an increased ability.
  This should be mandatory for all Energy storage systems.

- **Benefit 2**. There are three **Types** listed and other **Types** may be needed in the future.

  The **Type 1** applies to projects like EFR with 100% power for 15 minutes with the EFR output power versus AC grid frequency response.

  The **Type 2** applies to projects with a defined output power for 30 minutes or longer with the frequency response as normally defined in the Grid Code. These Energy storage systems are then fully compatible with the existing systems connected to the AC grid.

  The **Type 3** is needed for the applications that want to provide energy storage but do not want to have any defined frequency response.

- **Benefit 3**. This is to supply controlled reactive power with defined operational limits.
  This should be for the normal power factor range of +/- 0.95 per unit.
  This was not part of the EFR specification but should be used for future projects as the extra cost is viable and it will give compatibility with other systems on the AC grid.

- **Benefit 4**. This is to having the ability to recover from AC grid faults at its original power level.
  This should be the standard GFR Grid code specification.

- **Benefit 5.** This is to supply Fast Fault Current in to network faults.
  For the phase 1 systems this is to supply 100 % of its rated operational current.
  For the phase 2 systems developments are needed to define the optimal design that should be in the range of 150% to 300 % of its rated operational current.

- **Benefit 6**. This is to provide an optional House Load mode.
  This is to keep a disconnected Energy storage system ready for instant connection with a defined time period for example 1 hour.

- **Benefit 7.** This is to provide an optional black start ability for restarting sections of the AC grid.

- **Benefit 8.** This is to provide significant damping of the transients between all connected systems.
  This is a phase 2 activity which requires the development of a Virtual Synchronous Machine "VSM" that requires validation via a prototype. See data in question 47 and Appendix B

- **Benefit 9**. This is to provide the vitally important synthetic inertia to limit the df/dt of the AC grid.
  This is a phase 2 activity which requires the development of a Virtual Synchronous Machine that requires validation via a prototype. See data in question 47 and Appendix B

When a specification is available for all the **Benefits** 1 to 9 this will increase the earning potential of these systems which will enable an optimum business case to be produced. This will then maximise the **Benefit**s produced for the AC grid and the UK as a whole. The validation of all the **Phase 2 Benefits** can be carried out on either a new demonstrator or by short time tests on one of the EFR projects.

To implement these concepts will require changes to metering, connection methods and reward mechanisms that are defined in the following sections. It will then be possible to hold auctions to procure the systems with an increased set of **Benefits,** in a way similar to the initial EFR auction.

With an AC grid with the appropriate number of Energy Storage Systems added an extra set of savings will result including:

- **Saving 1**. Can have a high penetration of renewable energy generation without any curtailed production.
- **Saving 2**. Can smooth the intermittent renewable energy generation to minimise the power flow variations.
- **Saving 3.** To minimise the associated transmission infra structure costs.
- **Saving 4.** To have essentially steady generator power demands to optimise their performance.
- **Saving 5**. Can have the minimum of rotary generators operating in real time with no reserve power margins.
- **Saving 6.** Will have time to start up rotary generators when extra units are needed.
- **Saving 7.** Will not need rotary generators operating below optimum efficiency to have spare capacity.
- **Saving 8.** Can operate the rotary generator at their optimal efficiency.
- **Saving 9.** Will need fewer rotary generator saving significant investment costs.
- **Saving 10.** Will have lower fossil fuel burn to reduce the C02 produced.
- **Saving 11**. Will not have abnormal system transients even with trips of a nuclear power station.
- **Saving 12**. To store the renewable energy for significant time periods to stabilise pool prices.

There are also uses for energy storage that provide advantages for their operators that do not directly provide frequency responsive AC grid power and these are the **Benefit 2 Type 3** designs listed on Figure 1.2

For example, adding an Energy Storage System to a renewable energy system can have uses that:

- **Use 1.** Enable accurate pool price bidding without wasting any renewable energy.
- **Use 2.** Store renewable energy for later use to avoid paying constraint payments.
- **Use 3.** Store renewable energy at low pool prices to sell at higher pool process.

These systems will also contribute to the operation of the AC grid and should help to stabilise the pool price variations.

The **Benefits** of the **Savings** 1 to 6 and **Uses** 1 to 3 will give savings that are not easily passed back to the Energy Storage Systems that are providing the savings. It is essential that this is addressed so that Energy Storage Systems receive their just rewards which will then facilitate a rapid deployment of Energy Storage Systems with reduced overall costs to the UK as a whole.

This shows the need for a high-level government policy giving the appropriate rewards based on all the relevant Benefits, Savings and Uses to promote energy storage systems.

This could then enable an energy storage system as part of a wind farm that provides all the **Benefits** 1 to 9 plus the **Savings** 1 to 6 with the **Uses** 1 to 3 which be a very challenging but interesting project using one large battery.

There are also Energy Storage systems that can be used for the benefit of their operators that may produce negative impacts on the AC grid for example:

- Systems to store renewable energy at low pool prices to sell at higher pool process that are not providing the **Benefits** 2 to 9.
- A home-based Energy Storage System to keep a house system operating with a large disturbance in the AC grid. These could demand a power change in opposition to the EFR profile.
- A home-based Energy Storage System to store solar energy for use at night could demand a power change in opposition to the EFR profile.

These negative effects have already been observed in the USA so it is essential that a viable performance standard is in place of all energy storage system that are connected to the AC grid at all voltage levels even for the Benefit 2 Type 3 designs.