

7<sup>th</sup> April 2011

## **RenewableUK Position Paper on Inertia (V3-0)**

### **1. SUMMARY - RenewableUK policy position**

- a) The needs case for inertia has to be established and agreed across the whole industry, taking account of the levels of inertia being provided within the system at present and properly establishing its impact on system operational costs and stability.
- b) Inertia should be provided by ancillary services market and not by a Grid Code requirement (either as an obligation or as a capability).
- c) We welcome TSOs entering into voluntary bilateral contracts with parties to test and develop synthetic inertia offerings from wind turbines in an ancillary services market.

### **2. Introduction**

- a) This paper has been produced by the Grid Strategy Group at RenewableUK to set out the association's position on inertia.

### **3. Background**

- a) Inertia on an electrical power system helps stabilize frequency for any instantaneous imbalance between load and generation. I.e. in the case of a large disturbance (typically the loss of a large nuclear power station) the frequency change is smaller for a system with high inertia compared to a system with low inertia, and hence a high inertia system is more stable.
- b) Until recent years all generators (as rotating machines) have "naturally" provided some form of inertia (in addition to inertia provided by demand e.g. motors) and therefore there has never been any need for an Ancillary Service or Grid Code requirement on either load or generation to provide inertia in GB or Europe.
- c) It is worth noting that inertia is a requirement associated with synchronous machine based systems and it is possible to run stable systems without any inertia. E.g. most UPS (uninterruptible power supplies) systems do not have inertia and many new island systems running on inverters (e.g. Eigg, Foula) can operate without any inertia.

#### **4. How is system inertia changing?**

- a) Most rotating machines in modern wind turbines are decoupled from the grid by an inverter (to facilitate variable speed operation) so they do not provide the “natural” inertial response that older and smaller directly connected induction generator wind turbines provide and that other conventional generators provide.
- b) Interconnectors with HVDC do not provide “natural” inertia.
- c) Less inertia is being provided by demand as there are fewer directly coupled motors (due to demand changes and variable speed drives).
- d) Other generation such as solar PV (photovoltaics) does not provide “natural” inertia.

#### **5. Can inverters provide inertia?**

- a) There are two aspects to this provision, firstly a response from the inverter and secondly a source of energy from which the extra power can be extracted.
- b) All these inverter coupled generators can in theory be designed, modified, operated and programmed to provide a fast frequency response which is also called variously “synthetic inertia” or “inertial response” . However, this response is not identical to “natural” inertia. It does not operate as rapidly. If not properly defined or controlled, it could lead to unforeseen problems in relation to the control, operation and stability of current power systems.
- c) In order to deliver the additional power of an inertial response, the inverters will need to be oversized if all other affected capabilities are retained. I.e. the total real and/or reactive power capabilities of the generation plant may need to be compromised in order to provide headroom for the inertial response.
- d) For wind turbines, the extra energy can be extracted from the rotating inertia of the rotor, generator (and drive-train if it has one). However, this process slows the rotor and affects the subsequent power output of the wind turbine.
- e) For solar PV there is no rotating energy source from which to extract the extra power. An energy store could be provided by increasing capacitance on the DC bus, but this is one of the most expensive forms of energy storage.
- f) For HVDC interconnectors the extra power would have to be extracted from the AC power system connected to the other end of the HVDC link.
- g) Therefore an inertial response from inverters would impose additional capital costs or operational costs or both on providers. In some cases (e.g. for solar PV) these extra costs would be extreme.

## 6. Why has Inertia become a topic of review recently?

- a) There are two main drivers for the concern in the GB system, which are the potential for large wind penetrations and the increase in the largest allowable infeed loss (driven by new larger power stations) from 1320MW of late to 1800MW.
- b) The concern from National Grid as System Operator is the system performance during a high wind, low demand period (e.g. windy summer night). In such a scenario there may be just wind and a few very large (nuclear) power stations connected. If one of these large power stations were to trip, the low inertia in the system would mean (using current operation principles) that system frequency would fall to an unacceptably low level before the fast frequency response (spinning reserve) could kick in. There is also a threat to the transient stability of the isolated synchronous machines in such a scenario.
- c) The system frequency could fall far enough to either trigger under frequency relays disconnecting demand, or to trip other generation on under frequency which would cause further frequency drops and load disconnection.

## 7. What can be done?

- a) There are a number of options listed below.
- b) National Grid as System Operator is responsible for managing and contracting frequency response and reserve. The response and reserve must be able to replace the largest planned infeed loss (currently 1320MW but increasing to 1800MW). The system inertia will dictate the speed of response that is required to replace that loss. If inertia is lower, the response must be provided more rapidly and vice-versa. So if the System Operator is faced with a reduction in inertia they can respond by contracting a faster frequency response or they have an option of contracting for inertia and keeping the same response. Therefore, for any situation, there is a trade off between inertia and frequency response costs. In which case National Grid can contract both inertia and frequency response in the most cost effective combination.
- c) Demand response could be developed to provide frequency response.
- d) Wind which voluntarily provides the capability could contract with NGET (as System Operator) to provide “synthetic inertia”.
- e) Wind can be operated in reduced power mode (curtailed down) to provide fast frequency response, providing an effective response to frequency deviations. This may be a cost effective solution given that inertia will only be needed at high wind periods (which is when we expect market prices will be low) and where

there could be a surplus of wind generation for other system reasons such as transmission constraints.

- f) Inertia can be provided by gas and peaking generation operating in synchronous compensation mode. This mode of operation will also facilitate reactive power delivery and provide fault current infeed, which is another system issue with large amounts of power fed from inverters (HVDC links or generators with inverters). The income from these ancillary services will help those generators stay in service to provide security of supply, for example at times of low wind and high demand.
- g) A synthetic inertia requirement is being proposed for Grid Codes.

#### **8. What is being proposed for Grid Code changes?**

- a) A generic “inertia” requirement has been added into the ENSTO-E Draft Network Connection Code<sup>1</sup> which could allow an “inertial” response to be specified by TSOs for all generators. When implemented this Code will become EU Law and the GB Grid Code will have to be modified to ensure alignment.
- b) A joint working group of the GB Grid Code Review Panel and Balancing Services Standing Group was instigated in May 2008 and continues to date (March 2011) having held 15 meetings<sup>2</sup>. A subgroup to determine “synthetic inertial requirements” was formed in November 2010<sup>3</sup> and has held 4 meetings to date.

#### **9. Why is a new Grid Code requirement a concern?**

- a) A GB Grid Code requirement can be written in two ways. Either as an obligation to provide and deliver; or as a requirement to provide the capability with the delivery subject to an additional voluntary contract. In the case of synthetic inertia either option is a significant concern.
- b) Any new Grid Code requirement requiring technology change creates uncertainties, additional costs and delays in procurement and finance – this could have a very significant impact on offshore wind deployment and effect manufacturing and supply chain development in the UK with a massive potential knock impact on the future UK economy.

---

<sup>1</sup>

[https://www.entsoe.eu/fileadmin/user\\_upload/library/news/110322\\_Pilot\\_Network\\_Code\\_Connections.pdf](https://www.entsoe.eu/fileadmin/user_upload/library/news/110322_Pilot_Network_Code_Connections.pdf)

<sup>2</sup> <http://www.nationalgrid.com/uk/Electricity/Codes/gridcode/workinggroups/freqresp/>

<sup>3</sup> <http://www.nationalgrid.com/uk/Electricity/Codes/gridcode/workinggroups/freqrespTSG/>

- c) It is possible that synthetic inertia techniques are the subject of patents and IP and therefore a Grid Code requirement may exclude some players from the market or hand significant market power to one or more players.
- d) In the past changes to the Grid Code have followed identifiable and quantifiable system requirements. At present, whilst it is acknowledged that inertia currently plays a part in delivering stable system operation, the extent of its delivery and impact on system operation remains unquantified. In the case of synthetic inertia, both delivery by wind generators and use in system operation has yet to be established and requires a proven cost benefit analysis and wide industry acceptance before a Grid Code requirement is proposed.
- e) HVDC links do not provide inertia so generators providing power in the market via these links (e.g. from overseas) could have a commercial advantage.

#### **10. Would synthetic inertia from wind solve National Grid's problem?**

- a) Increased inertia doesn't reduce the amount of fast frequency response (spinning reserve) needed – it merely allows it to respond more slowly for a given frequency change.
- b) There is a major drawback with providing synthetic inertia from wind. As a by-product, after delivering a short term injection of power from energy stored in the rotor, wind generation subsequently becomes less efficient (because the rotor has been slowed to sub optimum speed). Therefore by providing the inertial response the wind fleet subsequently reduces its power output.
- c) For example if we assume a 5% loss of efficiency, a 30GW wind fleet would lose 1.5GW from the system post inertial response delivery. If the initial frequency drop was due to the instantaneous loss of 1.8GW of conventional generation, this means the frequency response requirement would become 3.3GW and not 1.8 GW; albeit over a longer period. A slower frequency response will be required, but 3.3GW of slower response is not necessarily lower cost than 1.8 GW of fast response.
- d) No case has been made as yet to show that synthetic inertia is necessary, more secure, or is the lowest cost option.
- e) A paper analysing the Ireland System<sup>4</sup> (with much higher wind penetrations) has not shown any clear benefit of, or need for, synthetic inertia provision by wind and EirGrid in Ireland has already achieved 50% wind power penetration without synthetic inertia.

---

<sup>4</sup> “System inertia and wind power – impacts and options for maintaining system robustness”  
Karsten Burges, Jens Boemer; Ecofys.

## 11. RenewableUK policy position

- a) The needs case for inertia has to be established and agreed across the whole industry, taking account of the levels of inertia being provided within the system at present and properly establishing its impact on system operational costs and stability.
- b) Inertia should be provided by ancillary services market and not by a Grid Code requirement (either as an obligation or as a capability).
- c) We welcome TSOs entering into voluntary bilateral contracts with parties to test and develop synthetic inertia offerings from wind turbines in an ancillary services market.