From: [redacted]
To: Drax Re-power
Subject: 20011847 - response to EN010091-000948-8.5.12 Written Summary of Applicants Oral Case at ISH (Environmental Matters) D4
Date: 09 January 2019 23:50:51

"3.30 [...] in the boundary area where Drax power station is located, if there is a high penetration of renewable energy from the north and Scotland, this results in a large security requirement which has to be met from fossil fuel plants in the SO Stack (currently coal and other lower efficiency plants)..."
The demand on thermal plants to provide adequacy of supply (balancing supply and demand) will ultimately go down to below 15% of the time (Zero Carbon Britain Report; and Get It Forom The Sun simulation (among others)), during which they will take a share of provision. If we were to solely rely on thermal plants for ancillary services, we would be forced into must-run scenarios 85% of the time which are excessively expensive and wasteful. The danish grid ran into this issue before us, it became unsustainably expensive. On top of that it would negate some of the carbon savings created by renewable generation in the first place.
The ancillary services required by National Grid are: reserve, frequency control and voltage control. Both reserve and frequency control are not localized requirements, only voltage control and with it power factor correction (reactive power) can be linked to transmission of renewable energy.
The compensation of REACTIVE power is realized by regulating the excitation current of the generator. Any torque on the shaft of the generator however, coming from the turbine, only provides ACTIVE power. To run the whole power station when already "the transmission capability [of the network] can be highly stressed" (NG_ETYS_2018_Document_v1.pdf, p46), does not sound like a good idea. Hence it would be sensible to consider (if these services are at all required), whether a clutch or disconnect of some sort could be implemented, that would allow the generator to run independently, powered by the grid. This sort of technology is called a synchronous condenser, and it is what ultimately the Danish grid installed to deal with their voltage fluctuations.
If reactive power compensation and voltage control is what the applicant is talking about in the above mentioned comment, it would be helpful if a figure could be provided. After all this area has a rather high density of thermal generation stations that provide the same services.
Helpful quotes:
"A synchronous condenser is a device that supports network voltage by providing reactive power compensation and additional short circuit power capacity. Fundamentally, a synchronous condenser is a synchronous generator operating without a prime mover. Generation/consumption of reactive power is achieved by regulating the excitation current."
(Synchronous condensers for voltage support in AC systems - ABB, Product_note_Synchronous_condensers_9AKK105859_RevA_EN_lowres.pdf, p.1)
"A growing number of network operators and renewable energy developers, especially in Southern Australia, are now turning to synchronous condensers (SCs) to provide additional short-circuit power to strengthen their grid. SCs also help maintain power quality and provide fault ride-through capability. SCs are rotating electrical machines that closely resemble synchronous generators. However, they are not a generator as they are not driven by an engine or turbine. They’re also not a motor, as they do not drive a load. ABB has been manufacturing SCs for around a century. They were used widely to provide reactive power to networks to compensate for induction motors and other highly inductive loads. However, advances in power electronics led to a decrease in their use over the past two decades. This trend is now in reverse – with SCs being on the uptake – as today’s networks evolve to handle the increased penetration of renewable energy. This is because short circuit power and kinetic reserve are only available from rotating machines such as SCs."

(ABB_Synchronous condensers support Australia's clean energy transformation.pdf, p.1)
New SynCons - Purpose and requirements
•To significantly reduce the number and duration of ”must-run” requests for conventional thermal power stations, i.e. significant savings.
–Short circuit level contribution
–Dynamic and continuous voltage regulation
–Fault-ride-through capability
•High level of availability and reliability
–Well proven equipment
Summary and outlook
•The market share for the conventional generation in the energy market continues to fall leading to mothballing and decommissioning
•The necessary system support is built into the grid
–A level playing field in the energy market
–Lower socio economic costs
–Maintain high security of supply

"...The current projections of the total transfer requirement (i.e. the energy needed to transmit renewable energy around the system to where it is needed) for the boundary area in which Drax operates is 16GW, hence there are still significant levels of gas generation projected for 2030."
This statement does not seem to make much sense, if any of what I mentioned above or below does not address the meaning of the above comment comment by the applicant, explanation is needed.
The Boundary concept uses imagined boundary LINES on the UK map, often in places where the transfer capability is limited. I assume the 16 GW figure was taken from the projection of the boundary capacity needed for the boundary line north of the area Drax operates in (B7(a)). We are talking about the transfer capacity of power lines and offshore High Voltage DC links that geographically crosses this boundary line (and may or may not connect to land within the adjacent areas), NOT about projections of any generation capacity required in any AREA.
It is worth mentioning that there are at present the three 400kV double circuit at the boundary B7 (B7a only differs in the west of the country), one of which is at the west coast, two pass close to Drax. Their combined boundary capacity (all three) seems to be somewhere between 4,1 and 4,5 GW, as the total is 6,5 GW and the rest is made up by a HVDC link in the Irish Sea. Besides some reinforcement of existing power lines and a potential new HVDC link from Stella West (North East England) to Padiham (Lancashire) (National Gird - Network-Options-Assessment-2017-18.pdf p.70), the bulk of new capacity is likely to be provided offshore by HVDC links that potentially bypass the whole area.

"3.31 The Proposed Scheme's efficiency, flexibility to offer enhanced services, and its location would mean it sits high on the SO Stack."
Efficiency and flexibility are two things that don't go well together with regards to gas power stations. It is quite costly to start up a gas power station, and initially it will run in open cycle mode for several hours at correspondingly reduced efficiency (of at best 40%?). On top of that it's likely to be outside it's maximum efficiency window most of the time, even if optimized for part load.
The demand of flexible generation means a lot of fluctuations, part load and ons-and-offs, if other technologies like flow- and other batteries, compressed air, ocean gravity and hydros with no start up or standby cost will be able to bridge the shortfall, they will be utilized first. Due to there low and extremely low start up times (down to a few hundred milliseconds in the case of batteries) these technologies would be the preferred choice for frequency response.
"[...] battery storage and demand response provide adequacy, reserve and frequency response, the system needs that ensure reliability." (Thermal generation

and electricity system reliability - imperial college London consultants, p27)

"3.39 [...] [redacted] from Drax Power Limited explained that a projected increase in renewable energy does not result in decreased demand in thermal generation, because of the security requirements for thermal generation to back up the large penetration of renewables."
In future the primary source of energy will be from intermittent renewables, and hence in accordance the ENERGY demand from thermal power stations will drop down drastically, falling below 10% (the Zero Carbon Britain Report mentions 5%) and turning them into backup generation stations. In case of a prolonged shortfall of renewable supply however (when cheaper short term storage is depleted) most of the demand will at present still be met by thermal generation, calling for capability to cover a relatively big share of the potential national demand - a high POWER output (installed capacity)..
It is therefore inaccurate to generalize by stating that a "projected increase in renewable energy" generation would "not result in a decreased demand in thermal generation".
Beyond that it is worth noting that selling electric ENERGY is the main income source of power stations, installed capacity (POWER output capability) and consequential capital investment probably one of the biggest cost factor, which makes this technology a quite costly solution to provide backup, creating incentive to reduce reliance on it using other solution (e.g. tidal power with short term storage - see developments in tidal flow)
The length and magnitude of the shortfalls in supply from intermittent renewables has been studied and simulated, estimates on the ability of a 'smart mix' of new solutions to cover these shortfalls reliably however vary.

"3.44 [redacted] explained that inertia was just one of the system requirements for the grid to run safely and efficiently. [redacted] further explained that the current rate of change of frequency is set at 0.25Hz/sec, the requirement to maintain this value is 135GWs of which 70% comes from large generation (which means it must be synchronous generation such as from gas, coal or nuclear, above 100MW) , this can be somewhere in the region of 24 generating units, even in summer when demand is low."
From 'Thermal generation and electricity system reliability': "National Grid's system upgrades to raise the threshold rate of change of frequency [to 0,5Hz/sec], due to be completed in 2021, will allow the electricity system to tolerate relatively low levels of inertia, and will reduce the need for synchronous generators." (p.29, Thermal generation and electricity system reliability - Imperial College London Consultants)
Inertia is a byproduct of thermal generation, provided by the spinning mass in turbines and synchronous generators. It slows down frequency variations on the grid and is a quality that National Grid currently doesn't pay for. Inertia provision however is not bound to thermal generation or even any generation at all, solong as a spinning mass is connected to the grid via a synchronous machine, which may be used for voltage control, which brings us back to a synchronous condenser.
"Synchronous condensers can support the power system voltage during prolonged voltage sags by increasing the network inertia."(ABB - Synchronous condensers for voltage support in AC systems; Product_note_Synchronous_condensers_9AKK105859_RevA_EN_lowres.pdf, p1) or.
"The inertia provided by the new SynCons is one third of a typical steam unit.– If required additional rotating mass can be fitted to an external flange"(p16/17, Synchronous Condensers for reliable HVDC operation and bulk power transfer - IEEE PES; PESGM2015P-003046.pdf)
If inertia were to be a reason of consideration, it would be helpful to know the actual levels of inertia that we currently experience on the grid, and expect to experience in the future to compare it to future minimum requirements.

Other interesting developments to support low inertia grids (source and explanations to come):
"While battery energy storage technologies can cover a wide spectrum of applications, ranging from short-time power quality support to hours-long energy management, the supply of primary control reserve has been identified as the application with the highest value for the owner of the BESS [6].
Energy support for frequency management is short in nature and many solutions are based on super and ultra-capacitors. Ultra-capacitors are well-suited to supply as such a pulse of power. The reason is obvious: high energy discharge capability and long life. Synthetic inertia generation using ultra-capacitors has been demonstrated successfully on grids such as in island networks [3], and the extension to micro-grids and larger smart grids using DESS is a distinct possibility which has been considered by numerous networks.
Fig. 3: Response of BESS to an under-frequency event [7]. Dynamic frequency control support (DFCS)
In electrical islands, frequency excursions are sizeable and automatic load shedding is often required in response to disturbances. By injecting active power in the timeframe of hundreds of ms up to a few seconds after the loss of a generating unit, fast-acting storage can support the conventional production assets during the activation of their primary reserve, and with larger DESS units, can provide the primary reserve itself.
BESS frequency support in conventional networks
BESS has been used in conventional networks to provide frequency support. In 2009, a 12 MW, 4 MWh BESS was installed in northern Chile in order to offload some of the reserve obligation of a 277 MW generation station. The system, in operation since 2009, operates autonomously using local control and monitoring.
(Synthetic inertia in grids with a high renewable energy content HTML)
