Short Term Operating Reserve

Carbon Intensity Report

Executive Summary

National Grid requires reserve, amongst other balancing services in order to manage the system during both planned and unexpected events. These reserve requirements can be provided through;

- Synchronised generation with head room to increase output
- Standby generation that can start up from standstill
- Customer demand being turned down.

National Grid procures some of its reserve requirement via the tendered service known as Short Term Operating Reserve (STOR). The STOR service is provided for typically 11 hours a day, 365 days a year. The service is contracted and dispatched based on price and capability, ensuring that we minimise costs for the end consumer.

STOR is provided by a range of back-up generation and demand turn-down services as an alternative to increasing the number of synchronised units in the balancing mechanism. This report identifies the carbon emissions associated with the STOR service and provides a comparison across the alternative options available. These results are highlights below and are based on the 2014/15 STOR year.

- Providing the equivalent reserve capacity as the contracted STOR service through Synchronised generation (CCGT) would emit up to 683,213 tonnes CO_2e.
- Providing STOR via back-up diesel generation only would emit up to 170,237 tonnes CO_2e.
- Providing STOR via true demand reduction would emit 0 tonnes CO_2e.

STOR accounts for approximately 0.33% of all balancing actions taken by National Grid. 231,616MWh of STOR was utilised in 2014/15, of which 6% (13,835MWh) came from diesel. As a result of the generation mix available within STOR, the total emissions were 142,379 tonnes CO_2e.

Aims

National Grid is often asked about the carbon impact of providing STOR. This publication, as a complementary addition to the STOR Market Reports, aims to provide an insight into the carbon impact of running the STOR service.

The report aims to outline two key carbon measures; the carbon impact of providing STOR and the carbon impact or running an alternative service to STOR. It is important to note that STOR is un-synchronised until the energy is required by the control room and therefore there is zero carbon cost until that power is utilised. However, should the STOR service not exist National Grid would be required to hold the same reserve on synchronised machines in the balancing mechanism, increasing the amount of marginal plant on the system.

Background

National Grid is committed to continually reducing its carbon intensity. For 2013/14, excluding line losses this was 501 tonnes carbon dioxide equivalent per £ million of revenue compared with 569 tonnes across the company in 2012/13. Such services as STOR are a key factor in maintaining a positive response to the environmental challenges that both National Grid and the industry faces year on year.

More information about climate change can be found via the below link.

http://www2.nationalgrid.com/responsibility/how-were-doing/grid-data-centre/climate-change/

What is Short Term Operating Reserve?

As part of its key role of matching generation to demand on a second by second basis, National Grid holds a “reserve” of electrical energy at all times to act as an insurance against sudden losses in generation or unforeseen increases in demand. This reserve is made up from a number of different sources, examples of which are back-up generators and load reduction services. These are most commonly procured through STOR, where back-up generators or load reduction services can – if they are sufficiently economic when compared with other sources of reserve – get a fixed price contract for a number of months or even years.

Within STOR there are broadly two categories of back-up generator or load reducer. There are those that are connected directly to the GB Transmission System or are large enough to have to register in the Balancing Mechanism. Then there are other smaller back-up generators or load reducers connected to the lower voltage distribution networks. When these operate, National Grid sees their impact on the transmission system as a reduction in demand and for this reason these providers – whether generation or load reduction services – are known as “demand side” providers. Also as they are not in the Balancing Mechanism they are referred to as “non-BM” providers.

STOR providers are paid both an availability and utilisation payment. National Grid splits the year into a number of Seasons, for both Working Days (including Saturdays) and Non-Working Days (Sundays and most Bank Holidays), and specifies the periods in each day that STOR is required. These periods are referred to as Availability Windows. Where a service provider makes its unit/site available for STOR within an Availability Window, National Grid will pay for that availability on a £/MW/h basis if the tender is accepted. Utilisation is where National Grid instructs delivery of STOR from a unit/site, and the provider will be paid for the energy delivered on a £/MWh basis.

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Methodology

National Grid has calculated the carbon cost of running STOR by grouping the providers by fuel/technology type and the total MWh utilised for each category. Based on the fuel/technology type profiles of STOR units and utilisation data the approximate tonnes of CO_2e produced during the year can be calculated.

The carbon price rate figures have been calculated using the Government Conversion Factors for Greenhouse Gas Reporting which is produced by the Department for Environment, Food & Rural Affairs. Further details on this report are listed in Appendix 1.

Using this data, combined with industry estimates for the efficiency of each plant type, the kg CO_2e per kWh of electricity can be calculated. The data used for the calculations is noted below. Please note the fuel figure assumed for pump storage is the average UK electricity figure from the link in Appendix 1.

"Kg CO_2e per kWh electricity produced" = "kg CO_2e emitted per kWh fuel" / "Technology Efficiency"

Eg Bio-Diesel = 0.0021 / 0.35 = 0.006kg CO_2e / kWh electricity

Technology Type	kg CO_2e emitted per kwh fuel	Fuel description	Technology Efficiency	kg CO_2e per kwh electricity produced
Load Reduction	0	Demand shift	100.00%	0
Hydro	0	Rainfall/run of river	100.00%	0
Landfill gas	0.0002	Landfill gas	40.00%	0.001
Bio-Diesel	0.0021	Bio Diesel	35.00%	0.006
Biomass	0.0143	Average of Wood logs/chips/pellets, Grass/straw	30.00%	0.048
CCGT	0.185	Natural gas	46.00%	0.402
CHP	0.185	Natural gas	65.00%	0.285
OCGT	0.2721	Gas oil	35.00%	0.777
Gas Reciprocating Engine	0.2721	Gas oil	45.00%	0.605
Diesel	0.2721	Gas oil	37.00%	0.735
Pump storage	0.4943	Average UK electricity	70.00%	0.706

Results

Using the above emissions calculations, the "kg CO_2e per kwh electricity produced" can be multiplied by the utilisation hours of STOR by fuel type to provide the tonnes CO_2e for the total MWh of utilisation.

Primary Fuel Type	Total MWH Utilisation	CO_2e tonnes
Load Reduction	203	0
Hydro	1,916	0
Bio-Diesel	28	0
Biomass	2,302	110
CHP	8,697	2,479
Diesel	13,835	10,168
Gas Reciprocating Engine	27,849	16,849
CCGT	57,557	23,138
Pump storage	42,319	29,877
OCGT	76,909	59,758
Total	**231,614**	**142,379**

Comparison with Providing Reserve through Marginal Plant

An estimate of how much CO_2e would have been produced if NG did not run STOR and instead utilised a marginal generator has been calculated for comparison purposes. The base assumption is that the marginal generator for 2014/15 is a generic gas CCGT with 0.402kg CO_2e /kWh. By multiplying the carbon cost of this alternative plant for the same utilisation volumes we are able to make a direct comparison between the utilisation impacts of running the STOR service and the alternative. This provides a direct comparison of the impact of using the contracted STOR portfolio versus a marginal BM machine.

Additionally, having STOR units contracted to be available for ~3865 hours per year reduces the volume of synchronised reserve that we require on the system. If NG did not contract this volume of STOR there would be no change to the energy generated but this would require more units to be running part loaded to provide the synchronised reserve required over the year. This has an impact for two reasons, generally speaking at any time the next unit to be synchronised will be less efficient than the units that are already running. Secondly, units running part loaded are less efficient than those running at full load. From published technical studies (Appendix 2) it is estimated that there is an increase in CO_2e emissions of 10-20% when operating at 50% to 75% load. This can be used to calculate a range of CO_2e from holding the reserve on synchronised units.

STOR is unsynchronised therefore the reliability in delivery is less than 100% across the multiple units. As a result National Grid reserves excess STOR to cater for this gap in reliability on un-synchronised units. Synchronised plant is more reliable, so in order to calculate a STOR alternative, the MWh of reserve required can be reduced by 15% to factor the reliability shift. This new figure can be multiplied by the carbon factor of our assumed marginal plant.

This calculation would provide the CO_2e if the reserve was being provided as energy, but does not take into account the reduced efficiency from bringing on the next marginal plant.

Total STOR Utilisation MWh	Tonnes CO_2e assuming CCGT
231,614	142,379

Contracted STOR MWh Availability	Equivalent MWh of Synchronised Reserve	equivalent CO_2e assuming CCGT and 10% increase for part load	equivalent CO_2e assuming CCGT and 20% increase for part load
8,634,833	7,339,608	295,052	590,104

	Utilisation Tonnes CO_2e	Availability Tonnes CO_2e	**Total Tonnes CO_2e**
STOR total CO_2e	142,379	0	**142,379**
CCGT total assuming 10%	93,109	295,052	**388,161**
CCGT total assuming 20%	93,109	590,104	**683,213**
Total assuming all STOR is Diesel	170,237	0	**170,237**

Summary

The analysis from the 14/15 data shows that providing STOR through a range of non-synchronised units provides an estimated carbon offset of 79% over the synchronised equivalent (CCGT). This is directly due to the increased emissions as a result of having synchronised units in a state of readiness for 3865 hours per year, as per the systems requirements.

Alongside the 14/15 data National Grid have run the same calculations for the previous year, for comparison. The tonnes of CO_2e per MWh reduced from an estimated 0.6181 in 13/14 to 0.6147 in 14/15. This is a reduction of 3.37kg CO_2e per MWh, a significant annual impact noting that STOR was utilised for 231,615MWh during 14/15.

Looking ahead as the systems margins tighten and traditional plants continue to close it is anticipated that increased reserve will be required by the System Operator in order to successfully balance the system and maintain security of supply. As a result, STOR is likely to increase its reserve requirements. With this expectation of increased utilisation, such carbon reductions per MWh are going to significantly contribute to the company's goals of reducing its carbon footprint. A positive outlook for the industry is that National Grid is seeing an increasing trend of low carbon plant entering the STOR market which will ultimately ensure that we have the suitable reserve requirements available at the lowest possible carbon impact for consumers.

Appendices

Appendix 1

Greenhouse Gas Conversion Factor Repository produced by the Department for Environmental Food & Rural Affairs

http://www.ukconversionfactorscarbonsmart.co.uk/

DCFCarbonFact...

Appendix 2

Combustion Engine vs. Gas Turbine: Part Load Efficiency and Flexibility

http://www.wartsila.com/en/power-plants/learning-center/combustion-engine-vs-gas-turbine-part-load-efficiency