nationalgrid

Solar PV

Options for integrating increased levels of solar PV generation

Introduction

As electricity Transmission System Operator, National Grid is obliged to operate the system safely, reliably, and efficiently. We balance the grid – matching supply and demand in real time. Achieving this balance has locational, timing and volume elements. Electricity supply and demand is changing. The connection of new types of electricity generation and new demand patterns to meet legally binding targets for renewable energy and carbon reduction will have implications for the way we manage the electricity system.

One such development that will impact the way in which we manage the system is the uptake of distributed solar PV, which is continuing at a fast rate. Solar PV that is embedded on the distribution network is not visible to us as the Transmission System Operator and so acts as a demand reducer, rather than provider. Furthermore, as output from solar PV is unmetered, their full contribution is unknown and has to be estimated.

Through the DECC Solar PV Task Force, we are working with DECC, Distribution Network Operators and the solar PV industry to identify and address barriers to the deployment of solar PV generation.

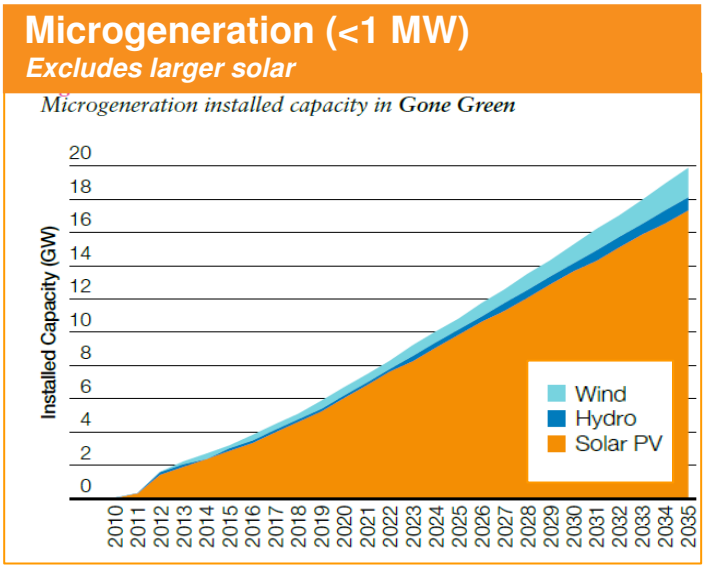
Our previous briefing note published in October 2013, *Solar PV: Assessing the Impact at Minimum Demand*[1], suggested that, as the volume of solar PV increases, there would be challenges and costs associated with balancing electricity supply and demand, unless we look at a range of solutions. Those solutions and opportunities included shifting usage to times of high generation, additional electricity storage, exporting excess electricity to other countries through interconnectors and solar PV installations that are designed to reduce their output progressively.

[1] http://www2.nationalgrid.com/UK/industry-information/future-of-energy/

This briefing note builds on our previous note and explores the approaches that could be taken in order to integrate increasing levels of solar PV generation into the GB generation mix. It suggests a hierarchy of actions, with the intention of enabling higher levels of solar generation while minimising costs.

Solar PV

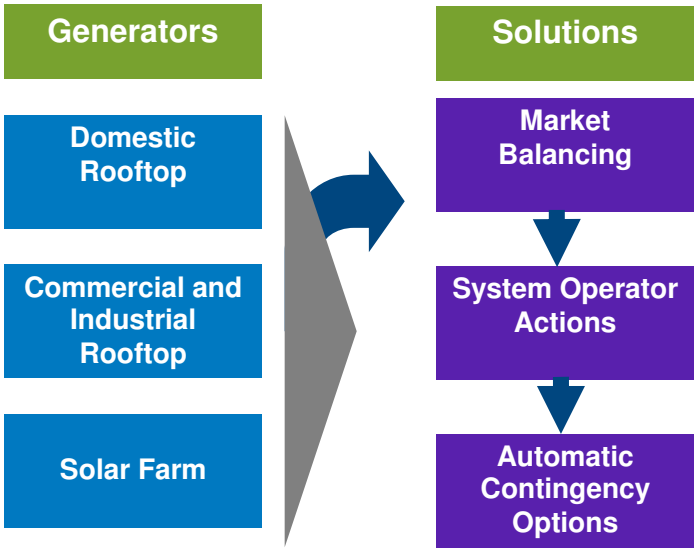
There is currently around 2.8 GW installed capacity of solar PV[2]. National Grid's 2013 UK Future Energy Scenarios[3] project this increasing to between 6.1 GW and 15.8 GW by 2030 (see diagram below). Greg Barker, Minister of State for Energy and Climate Change, has an aspirational target of 20 GW installed capacity by 2023. Therefore, it is important to look ahead to see what measures could help with integration, whilst also meeting the two objectives of maintaining appropriate levels of security of supply for consumers and minimising the costs they bear.



[2] 2.8 GW installed capacity includes 2.2 GW micro generation i.e. <1 MW (source: December 2013 OFGEM FITs Database) and 0.6 GW embedded generation i.e. >1MW (source: 25 March 2014 DECC Restats Database)

[3] https://www.nationalgrid.com/NR/rdonlyres/2450AADD-FBA3-49C1-8D63-7160A081C1F2/61591/UKFES2013FINAL3.pdf

The diagram below illustrates the solutions available to rooftop solar PV and solar farm owners. It is likely that the solutions would be best implemented in a hierarchy, with each option being deployed in addition to the previous option, in order to help to overcome a number of commercial and technical barriers to the efficient balancing of electricity and minimise the cost to electricity consumers.



The first step in the hierarchy of actions would be balancing by the GB electricity market where possible. This allows interested parties to make their own decisions about how or whether to adjust their behaviour in response to a commercial driver. The next step is commercial action by the System Operator. There is currently no 'turn down' service in place for solar PV; however this service could be developed for all generators to participate in, providing it was possible to control their output remotely. If commercial actions do not result in sufficient solar PV reducing their output when there is limited demand or capacity to accommodate it, automatic options may be necessary, through the use of smart inverters, which can be used to automatically reduce the output from solar PV in response rises in system frequency.

Market Balancing

The design of the GB electricity market is intended to result in the most cost effective solution for consumers. Suppliers and generators are incentivised to balance their position and at gate closure, one hour ahead of real time, these market participants will notify us of their intended generation or demand and no further changes to that can be made. This leaves the system operator to carry out the fine tuning, or residual balancing activities[4]. The market balancing approach for integrating increased levels of solar PV generation, discussed in the following section, assumes current market rules remain in place and that self balancing stops at gate closure.

Whilst market participants are incentivised to balance their position, the price signals on the need for generation are removed for all solar generators as a result of subsidy schemes[5]. These schemes provide solar generators with a strong incentive to generate whenever possible as payment is received for every unit of electricity generated, irrespective of whether there is a customer for the energy produced. This is similar to other generation types which are supported by subsidy schemes.

The majority of the incentive to balance currently lies with the supplier who is buying the solar output. The usual market signals remain for suppliers and these signals should become stronger following the implementation of Ofgem's Electricity Balancing Significant Code Review[6]. This seeks to improve price signals, make them more reflective of the cost of balancing, incentivise participants to balance and improve overall efficiency of balancing arrangements. It is not currently known to what extent solar portfolios are taken into account when suppliers balance their positions.

It is likely that subsidies will change over time as the European Commission has indicated that it does not expect mature technologies, such as solar PV, to require subsidies in GB by the end of the decade. Reducing subsidies may alter the way in which suppliers interact with the market and the behaviours seen by solar operators.

It may be possible to encourage owners of rooftop solar to self consume, that is for owners to consume electricity when their panels are generating in order to take advantage of the greater savings from

[4] https://www.ofgem.gov.uk/electricity/wholesale-market/gb-electricity-wholesale-market
[5] Those with installed capacities of more than 5MW participate in the Renewable Obligation (RO) scheme; between 50kW and 5MW can choose between the Feed in Tariff Scheme (FITS) or the RO; and less than 50kW receive the FITS
[6] https://www.ofgem.gov.uk/electricity/wholesale-market/market-efficiency-review-and-reform/electricity-balancing-significant-code-review

avoided electricity purchase. New demand loads from technologies such as electric vehicles could provide further opportunities for this approach, which may also be supported by time of use tariffs (TOUTs) in future. This will require a big enough difference between prices at different times of the day to encourage this behaviour.

Market balancing is reliant on generators having the technical ability to reduce the amount of electricity exported onto the grid. Whilst this is not currently possible for most owners of PV based systems, the European network code Requirement for Generators (RfG)[7] is likely to require all new solar PV installations to be fitted with a port to control power output when instructed. This requirement could be utilised with a communications channel, potentially a smart meter, to turn output on or off. This requirement is likely to come into force in the next 3-4 years.

Another way to facilitate market balancing is through exporting excess power via interconnectors with other countries. However, this method does depend on the recipient market having a higher price for electricity or arrangements being made between the two system operators, which cannot be guaranteed.

Electricity storage is an option to smooth supply throughout the day and over longer time periods, and would be expected to develop in response to market signals, either co-located with the generation or elsewhere on the network if it is a cost effective solution.

While the electricity market is designed to achieve a balance between energy supply and demand, there is still a requirement to ensure system security and meet physical requirements such as system inertia, frequency response, reserve and transmission constraints. This is the role of the System Operator, and therefore it follows that market balancing alone is not a complete solution to the issue.

[7] https://www.entsoe.eu/major-projects/network-code-development/requirements-for-generators/

System Operator Actions

Currently, the System Operator fine tunes the balance of electricity supply and demand using the Balancing Mechanism and balancing services[8]. These services are ways of asking generation or demand to turn up or down whenever we anticipate that there will be a discrepancy between the amount of electricity generated and the demand during a certain period[9]. If large enough themselves, or through an aggregated service, PV owners could participate in the Balancing Mechanism or a future turn down balancing service, where by the system operator would pay the solar PV owner to reduce generation, and compensate them for the revenue lost as a result.

This approach would require a control and verification system, which is likely to have logistical, security and financial challenges. We would only expect a mechanism like this to be implemented if there was confidence that the benefits outweighed the costs. As mentioned previously, the RfG European network code and smart meters may enable such a system.

Automatic Contingency options

If commercial options cannot be guaranteed to result in sufficient solar PV reducing their output at times of peak output and low demand, an automatic approach may be an additional option. This would require a smart inverter, which can be used to automatically

[8] http://www2.nationalgrid.com/uk/services/balancing-services/

[9] http://www2.nationalgrid.com/UK/Our-company/Electricity/Balancing-the-network-FAQ/ http://www2.nationalgrid.com/UK/Our-company/Electricity/Balancing-the-network/

reduce the output from solar PV in response to rises in system frequency. This action could minimise oversupply.

Although it is not expected that smart inverters would be required to reduce output on many occasions throughout the year, this automatic approach would have a minor impact on solar generators through a slight reduction in free electricity and their subsidy. A system to reimburse owners for lost revenue could be explored.

Such a mechanism responding directly to system frequency would be inherently robust and would provide a form of automatic back up protection at times of high frequency. A similar mechanism already exists to control demand and protect the wider network in event of a very low system frequency.

Summary

There are several approaches that could be taken to integrate increased levels of solar PV generation. These approaches apply to domestic, industrial and commercial rooftop solar PV and solar farm owners, and should be viewed as a hierarchy of actions.

A desirable solution would be to allow market forces to balance where possible. This is likely to be the most cost effective solution as it should result in the most cost effective generation being asked to generate at any one time. To help understand the effectiveness of this solution, it would be beneficial to understand better how suppliers bring domestic and other solar PV into their portfolio when balancing their position. It must be recognised that, as the electricity market does not take account of issues such as system inertia or frequency response, it cannot provide a complete solution.

In the event of continued strong growth in solar PV installations and the masking of signals to solar generators to balance, approaches that go beyond market forces and System Operator actions may be helpful. In this situation, automatic options could be considered in addition. This may offer an effective method to control the large amount of solar PV and, if specified appropriately, could provide a high value solution for a limited volume of curtailment.

The options discussed are largely dependent on generators' technical capability to turn down, either automatically or via a communication signal. The European network code, Requirements for Generators (RfG), which is likely to come into force in 3-4 years time, will require all new solar PV installations to be fitted with a port to control output when instructed.

Whilst current levels of solar PV in GB are manageable, it may be beneficial to consider the lessons that can be learnt from elsewhere. This could help in developing approaches in advance of issues emerging, to avoid costly solutions in future and therefore minimise costs to electricity consumers. We develop our assessment of future network issues and potential solutions on a continuous basis through our UK Future Energy Scenarios (UK FES) and Electricity Ten Year Statement (ETYS) work. We will seek to provide further and improved visibility of solar PV related network issues along with quantified possible solutions where feasible to do so.

Further information

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