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Distributed Generation Operation in an Islanded Network (Update)

Final Report

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1 Growth of small PV units in GB since 2013

The following analysis is an update of the study '*Distributed Generation Operation in an Islanded Network*' (2015) performed by Ecofys. The first study focussed on the population of dispersed generation (DG) which was installed up to the end of 2013. At that time, more than 50% of the capacity of small DG in Great Britain (< 5 MW) were photovoltaic (PV) units. In 2014, based on an extrapolation of historical numbers, we estimated installed capacity of 3.9 GW at the end of 2015 for the PV segment. The following update provides additional quantitative numbers on the development of small PV systems (< 5 MW) up to the end of 2015. In addition, we compare them to the estimation from 2014 to assess which growth was actually realised.

1.1 Data sources and general description

As a basis for the following analysis, we used publically available datasets from Ofgem regarding for information on Feed-in Tariffs scheme (FIT)[1] and the Department of Energy & Climate Change (DECC)[2] for solar Photovoltaics deployment. The available data from Ofgem provides information on a unit basis with attributes such as installed capacity, post code, country name, commissioned date, etc. Our dataset is from February 2016 and we considered all PV units that were commissioned before 1 January 2016. The available data from DECC presents aggregated values of the installed capacity of PV in the UK on a monthly basis. In addition, the aggregated values are recorded by accreditation (FIT, RO, unaccredited) or by specific performance classes.

Following on the work done in 2014, we prepared, validated and combined the different datasets into one database in order to perform various analyses. Figure 1 presents a general overview of the monthly development of the total installed capacity of the PV population in Great Britain. In addition, Table 1 provides actual numbers of the installed capacity for specific dates.

[1] https://www.renewablesandchp.ofgem.gov.uk/

[2] https://www.gov.uk/government/statistics/solar-photovoltaics-deployment

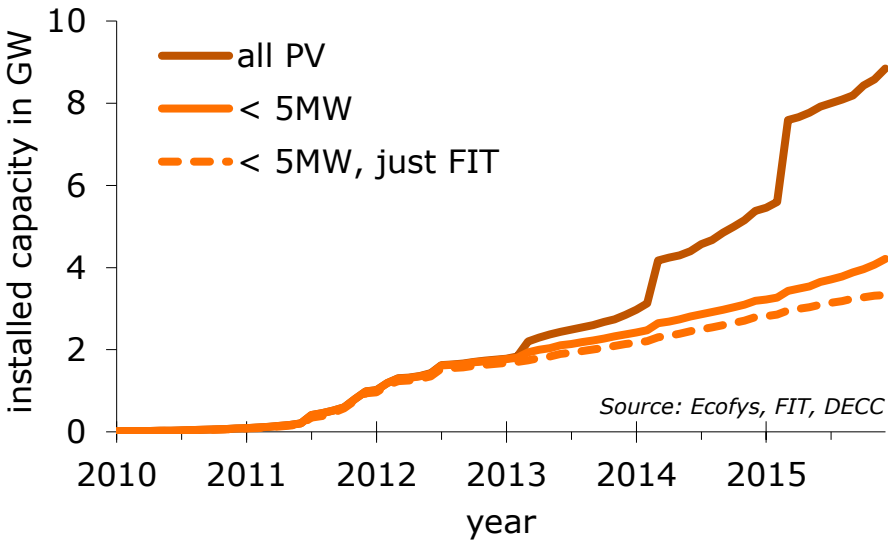

Figure 1 Development of total installed capacity of photovoltaic units in Great Britain on a monthly basis, small PV receiving support via feed-in tariffs, Sources: Ecofys based on DECC, Ofgem

Table 1 Development of the cumulated installed capacity in GW for different PV segments, Sources: Ecofys based on DECC, Ofgem

PV segment, all figures in GW	Jun 14	Dec 14	Jun 15	Dec 15	share end of 2015
all PV	4.4	5.4	7.9	8.8	100%
< 5MW	2.8	3.2	3.6	4.2	48%
< 5MW, just FIT	2.3	2.8	3.1	3.3	38%

After 2013, PV grew massively in Great Britain. Until the end of 2013 the majority (above 80%) of the PV population was allocated to small PV systems (< 5 MW). Since then the share has decreased significantly. At the end of 2015 the majority of the installed capacity in GB was allocated to big PV systems with installed capacity of more than 5 MW per entity. During the last two years the installed capacity in both segments grew to 9 GW in total. PV systems below 5 MW grew to 4.2 GW in total by less than 2 GW. This segment of small PV can be differentiated further. Before 2014 almost all installed units were accredited for FIT. Since 2014 an increasing share of small units has been accredited by other schemes like renewables obligation (RO) or not accredited at all. Finally, we compare the realised installed capacity at the end of 2015 (according to the publically available data) of 4.2 GW with our estimation from 2014 of 4.0 GW. As both values are in the same magnitude, the estimation from 2014 was robust regarding small PV systems.

In addition, we compared the published installed capacity from Ofgem and DECC with FIT on a monthly basis. The difference between both datasets is less than 100 MW and seems to be passable.

1.2 Numbers and capacity per performance class for PV

At the end of 2015 more than 800,000 small PV units with a total capacity of 4.2 GW were installed. Table 2 shows the numbers of PV installations according to different sources of information. The majority of PV units were connected to the low voltage level. As the available datasets do not provide explicit information on the system level, we allocated all units in the FIT register below 300 kW to the low voltage level. This approximation is based on the analysis of datasets from distribution network operators (see chapter 2). We propose that DECC may introduce appropriate thresholds in its monitoring reports to facilitate the monitoring of the distribution between the low and high voltage levels in the PV segment. Currently DECC publishes only aggregated numbers using the following thresholds: 4, 10, 50 and 5,000 kW. Adding a threshold of 300 kW for example would enable the distribution network operators to easily monitor the development of the whole PV population at the different system levels on a monthly basis.

Table 2 Overview on the PV fleet with less than 5 MW at the end of 2015, HV: high voltage level >=300kW, LV: low voltage level <300kW, year: end of 2015, Sources: Ecofys based on DECC, Ofgem

Technology	Installed capacity in MW			Number of investigated/ registered power units		
	Sum	HV	LV	Sum	HV	LV
PV, ≤ 5 MW, DECC	4,200			825,000		
PV, FIT	3,200	400	2,800	703,300	200	703,100

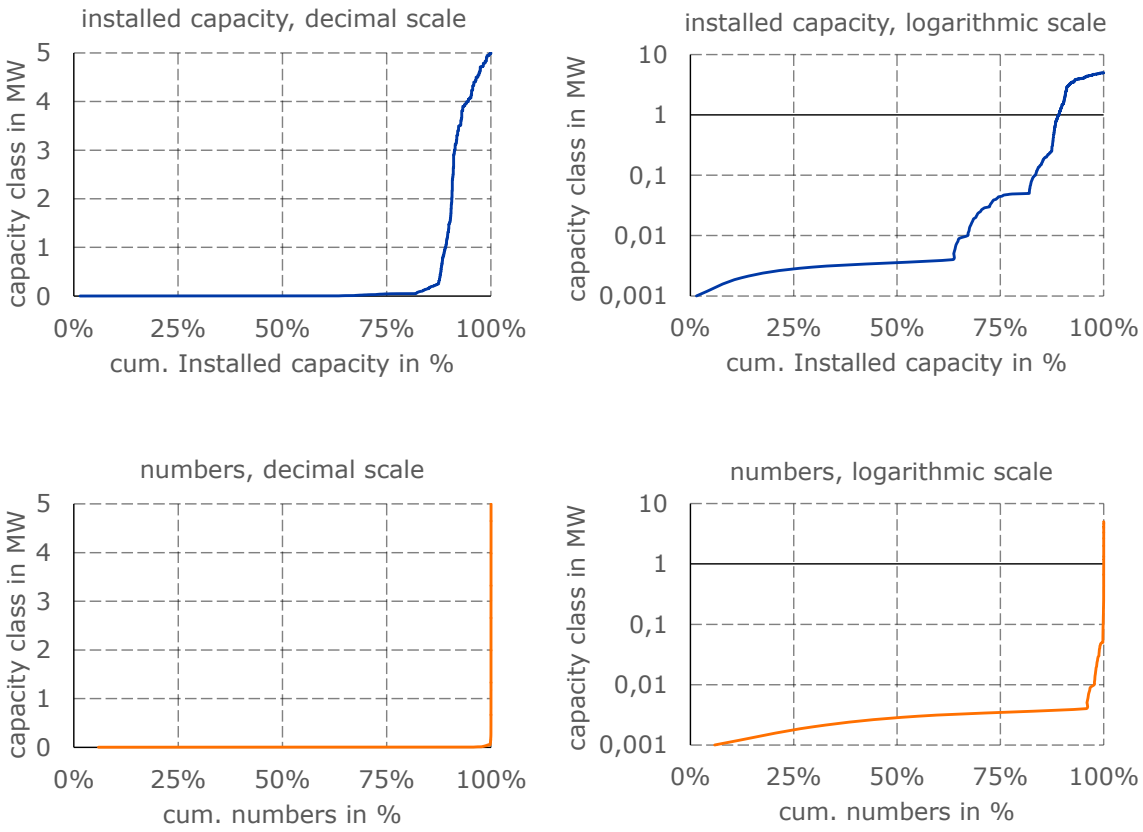

Figure 2 Allocation of the power class for PV registered in FIT in linear (left) and logarithmic scale (right) along their cumulated installed capacity (top, blue line) and cumulated numbers (down, orange line), year: end of 2015, Source: Ecofys based on Ofgem

Figure 2 shows the allocation of the power class for small PV registered for FIT along percentages. In general, the PV segment is dominated by very small power units. More than 60% of the installed capacity is allocated to units below 4 kW. The clusters highlighted in the figure (see logarithmic scale at 4, 10, 50 and 250 kW) are mainly related to the applied rates of the support schemes. Regarding the numbers of units, the graph looks even more extreme and is clearly dominated by small units. 95% of all units are up to 4 kW. In comparison to the characteristic of the PV population at the end of 2013, the distribution of the performance class at the end of 2015 did not change significantly. The average unit size was about 5 kW.

1.3 Geographical distribution

In the next step we used available geographical information to analyse the geographic distribution within GB. Therefore, we used Ofgem's FIT register, as only this register provides detailed geographical information. FIT data covers approximately 3.000 MW with valid ZIP code and

geographical information. Covering more than 70% of the installed capacity of 4.200 MW this data set may be considered representative for small PV units below 5 MW across GB. Since 2013 the coverage decreased slightly from 75%, as the share of FIT decreased.

Up to 90% of the total capacity of small PV in GB is installed in England (see Figure 3). Among Scotland and Wales the installed capacity is evenly distributed. In addition, 90% of the growth since 2013 was realised in England.

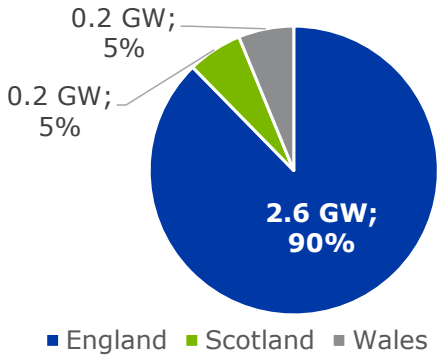

Figure 3 Share of total amount of small PV (<5 MW, FIT), year: end of 2015, Source: Ecofys based on Ofgem

Figure 4 illustrates the detailed distribution of small PV units in GB and is based on ZIP code information[3] from Ofgem. Regions with high amounts of small PV are concentrated in South-West and East England. Also the growth of small PV since 2013 is concentrated in these regions.

[3] Based on the postal code, we aggregated the installed capacity for each Nuts-3 Region. - Nomenclature of Territorial Units for Statistics (NUTS) on level 3 represents *Areas of Upper or lower tier authorities* (England), *Council Areas or Islands Areas* (Scotland) and *Principal Areas* (Wales)

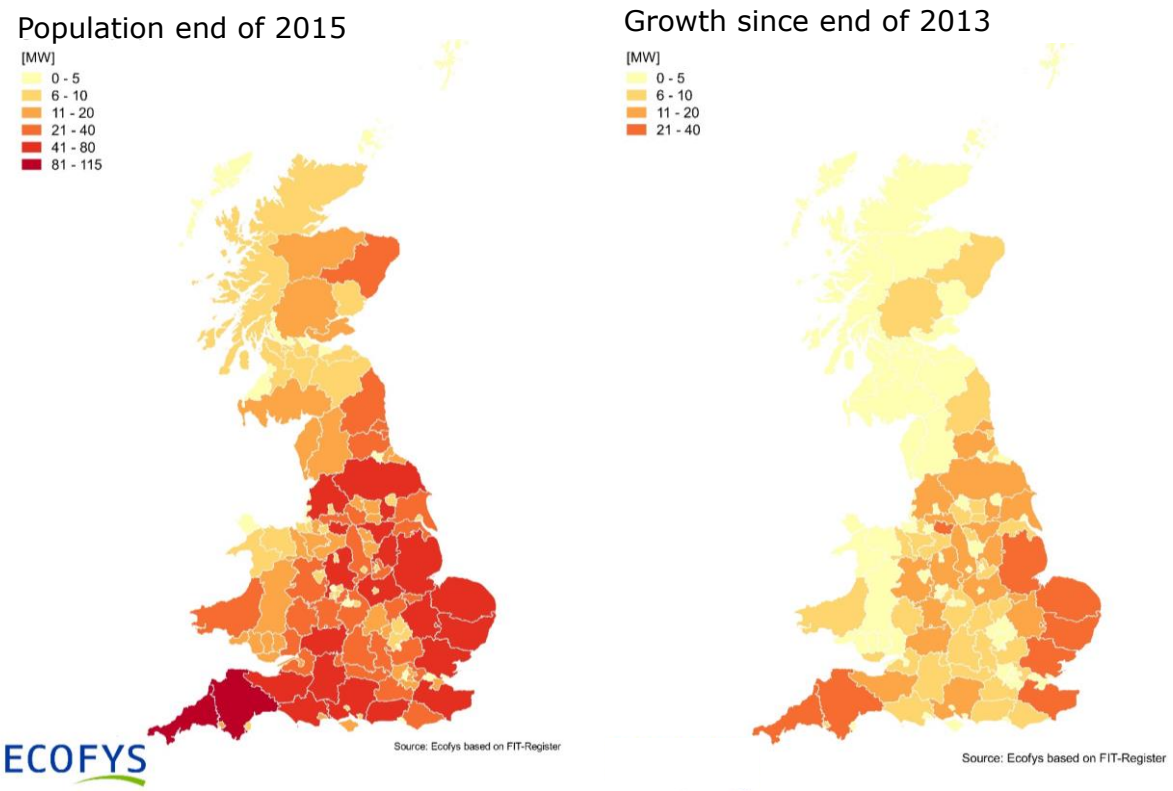

Figure 4 Geographical distribution of small PV installations in Great Britain, Sources: Ecofys based on Ofgem

1.4 Summary and conclusions

Based on the analysis, we can conclude, that the realised installed capacity of small PV grew in line with our estimation from 2014. Although small PV almost doubled since 2013, PV units above 5 MW represents the largest share of the growth. By the end of 2015, the population of small PV units consisted of up to 830,000 units with an installed capacity of 4.2 GW and an average unit size of 5 kW.

Regarding units below 5 MW, the share of the FIT-population is decreasing. As only the FIT dataset currently provides disaggregated data (like unit based geographical information), additional datasets may be necessary in the future to ensure extensive analysis on distributed generation in GB. Regarding the increasing relevance of distributed generation, using especially profound and valid datasets or registers are important. However, we see that the quality and scope of the aggregated dataset from DECC is increasing. Currently, the reported installed capacity by DECC is close to the aggregated amount of the FIT register. In addition, DECC is now also providing information on the distribution between various support schemes and power classes. Regarding the power classes, we propose that DECC introduce a threshold of around 300 kW in its reports to facilitate the monitoring of the distribution between the low and high voltage level in the PV segment.

2 Update on international experience

The distribution network operator in East Germany *Mitteldeutsche Netzgesellschaft Strom mbH* indicated, that unintended islands have occurred and were monitored recently. In the last year various unintended islands appeared during maintenance in the medium voltage system. According to the network operator, the islands were stable for several minutes. One event was analysed in detail. As a source of the island PV units were identified and several adjustments of maintenance and safety processes were concluded. A public report is not available at the moment.

Current research in Germany indicates that some industrial networks with auto-generation and conventional power plants apply disconnection settings close to 49.5 Hz due to technical constraints and intended changeover into islanded operation. This may have a serious (and unexpected) impact on system stability in the case of frequency excursions.

Also in continental Europe, there is a growing awareness related of RoCoF withstand capability (new ENTSO-E report). The working group may effectively contribute to this process by providing information and knowledge. This will be in particular beneficial for manufacturers serving both markets and trying to prepare themselves for emerging requirements.

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