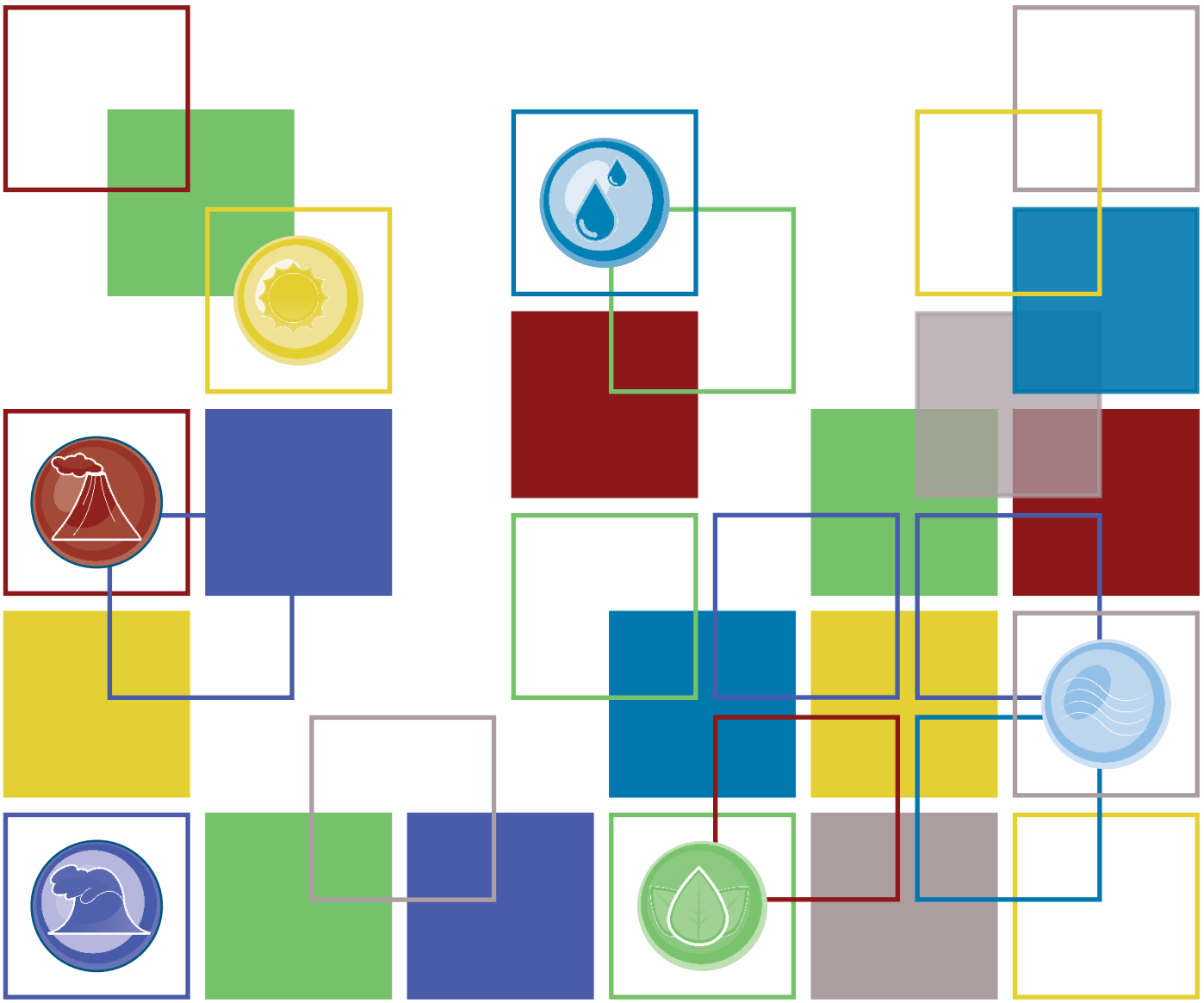
IRENA
International Renewable Energy Agency

Measurement and estimation of off-grid solar, hydro and biogas energy



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About IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future, and serves as the principal platform for international co-operation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity. www.irena.org

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1. INTRODUCTION

In many countries, the production of off-grid electricity from renewables is largely unrecorded, but is believed to be expanding rapidly. For example, IRENA estimates that the number of people served by off-grid renewables globally has expanded six-fold since 2011, reaching nearly 133 million people in 2016. Similarly, capacity has witnessed a three-fold increase from under 2 GW in 2008 to over 6.5 GW in 2017.

This trend has been driven by numerous factors, such as: falling costs; technological and financial innovation; and supportive public policies and measures. It has resulted in an explosion in the use of small, self-powered devices such as solar lights, lighting kits, solar home systems and street lights, as well as growing interest in the use of renewables for larger applications, such as to provide power for public buildings, irrigation schemes and mini-grids.

Many of these new electricity producers are households and enterprises generating electricity for their own use (autoproducers) and measuring this production is nearly always more difficult than collecting data from power plants supplying the grid. However, given the growth in this part of the sector and the current lack of information, the collection of such data is important to monitor progress towards universal energy access and inform policy action.

This note describes some recent work at IRENA to measure or estimate recent trends in off-grid renewable energy production and use. It explains how IRENA approached the challenges of data collection and the methodologies used to produce IRENA's estimates of off-grid energy production and use. It finishes by presenting a brief overview of the data collected so far, followed by detailed tables of the off-grid data by country, technology and year.

2. SCOPE OF THE DATA COLLECTION

IRENA currently collects off-grid capacity and generation data from a variety of sources. These include IRENA questionnaires, national and international databases and unofficial sources such as: project reports; news articles; academic studies; and websites. For some countries, IRENA also estimates off-grid solar PV capacity, based on solar panel import statistics obtained from the United Nations COMTRADE Database (see Box 1).

During the second half of 2017, IRENA made a concerted effort to systematically organise and improve its off-grid renewable energy data. This exercise had three main aims:

1. To validate and expand the information already collected about off-grid renewable electricity plants (including small solar devices).

2. To identify the end-uses of electricity generated in off-grid renewable plants, so that this can be correctly added to the electricity flows in a country's energy balance.

3. To estimate the numbers of people served by these sources of off-grid electricity and the level of electricity access provided.

In addition to off-grid electricity, the data collection exercise also aimed to improve the bioenergy statistics held in IRENA's main renewable energy database. Biogas was a major focus of this work, as the database currently includes very little data for biogas production (except where used to generate on-grid electricity) and it was believed that much more information may be available in countries.

GEOGRAPHICAL SCOPE

The data collection covered countries and areas in Africa, Asia, South and Central America, and the Pacific and Caribbean islands. China was included in the collection of biogas data, but was excluded from the collection and analysis of off-grid electricity data because this information is already included in the electricity statistics sent each year to IRENA.

TECHNOLOGIES AND PLANT TYPES

Data collection focused on off-grid solar PV, hydro and biogas electricity plants, as well as biogas digesters. Plants producing off-grid electricity from wind and other types of bioenergy were not a focus of attention, as these technologies are mostly implemented at a medium to large scale and are likely to be already captured in IRENA's main database. However, where previously unknown plants were discovered, they were investigated and will be included in the main dataset for each country.

To ensure that the dataset only included genuinely off-grid plants, the exercise followed IRENA's definition of off-grid electricity plants, which is that these are plants not connected in any way to the main electricity grid in a country. Thus, the database includes both stand-alone systems (down to the level of individual solar home systems, lights and lighting sets), as well as isolated grids (labelled mini-grids here, although some are several MW in size).

Electricity plants providing backup power or used to reduce electricity bills in an establishment were not included in the off-grid database if the establishment also has a grid connection.[1] Similarly, mini-grids that can operate in both an island or connected mode were excluded from the analysis. Where information about such plants was discovered, it was set-aside for inclusion in each country's main dataset.

Most of the electricity data in IRENA's main database comes from national statistics and is, therefore, aggregated at the country level. However, to facilitate data management and further analysis, the off-grid data collected in this exercise was recorded and stored at the level of individual plants (or groups of plants)[2] and each observation was also identified as one of the following plant types:

- Off-grid hydropower plants
- Solar lights (<11 W capacity)
- Small solar home systems (11-50 W)
- Large solar home systems (>50 W)
- Solar pumps
- Solar mini-grids
- Other off-grid solar PV plants
- Biogas digesters
- Off-grid biogas power plants

[1] Such plants were excluded even if they never provide power to the grid or if they meet most of the establishment's electricity requirements.

[2] Each record (observation) in the database can contain information about a single plant or a collection of plants that have the same fundamental characteristics (country, technology, year of commissioning). Thus, if 5,000 solar lights were distributed in a country in a year, this is recorded in the database as one record (of 5,000 units) rather than 5,000 records (of individual plants).

Box 1: Estimation of solar PV capacity from trade data for solar panels and related technologies

Solar panels and related technologies can be recorded in several places in the Harmonized Commodity Description and Coding Systems (HS) used to standardise and report international trade statistics. The most important code (854140) covers all photosensitive semi-conductor devices (solar cells, modules and panels, plus LEDs and a few other types of equipment). In addition to this, solar lights and solar home systems should be recorded as part of much broader product groups for electrical generators (850130 and 850160), portable lights (851310) or other types of lighting (940500).

Since solar panels account for almost all trade under HS Code 854140, import statistics for this product group are a good indicator of the amount of solar panels imported into a country. For the other solar devices, the product categories are too broad to be used for estimation, so imports of such devices can only be identified if they have been assigned a more detailed code (e.g. some countries have specific 8 or 10-digit codes for solar lights). Furthermore, mis-classification may also be a problem if customs officers are not very familiar with these products and record them under a different code.

Numerous countries report little or no solar PV capacity in their official energy statistics, but many of those same countries do report solar panel imports. Therefore, for 35 countries with a significant amount of imports and little or no officially recorded capacity, IRENA currently estimates solar PV capacity from the weight of solar panel imports.

To produce these estimates, IRENA uses a default assumption of a weight-to-power ratio of 10 W/kg, which reflects the average power rating per kg across a broad range of solar panel sizes. However, a lower value is used if it is suspected that other solar devices may have been recorded under HS Code 854140 by mistake. For example, devices such as solar lights and solar home systems can be mis-classified as solar panels, because these are the most easily identified component of these devices. Trade statistics usually include information about weight, value and number of units imported, which can be used to identify where this may have occurred. In such cases, a much lower power-to-weight ratio of about 2-3 W/kg is used as an estimate.

The solar PV capacity estimated from trade statistics amounted to 310 MW in 2016 and all of this is currently classified as off-grid capacity in IRENA's statistics (where it accounts for about 15% of the total off-grid solar PV). However, it is possible that some of this capacity is used by autoproducers to partly replace or supplement power taken from the grid, so it would be more correct to say that these are estimates of off-grid and other unrecorded capacity.

The solar PV data collected in this exercise should help to clarify how much of this estimated capacity is genuinely used for off-grid power production and how much remains unclear in terms of its grid connection status and end-use.

3. DATA SOURCES

Data for this exercise was collected from a wide variety of sources, some of which were as follows:

NATIONAL DATABASES

A few countries maintain national databases of off-grid energy projects and plants (e.g. Nepal, Bangladesh, Madagascar). Others, such as India, present aggregated information in their annual reports. Several countries also provide off-grid data directly to IRENA for the completion of IRENA questionnaires (e.g. some small islands and a few countries in Africa). All of this data was included in the database.

INTERNATIONAL DATABASES

Several organisations helped by sharing their data about off-grid power plants that they maintain for analysis or project monitoring. Some of the more significant datasets that were shared included:

- Global Off-Grid Lighting Association (GOGLA) data on sales of solar lights and solar home systems (SHS);
- SNV Netherlands Development Organisation (SNV) data on biogas plant construction;
- International Hydropower Association (IHA) data on small hydropower plants;
- Global Data small hydropower plant list;
- ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) off-grid power plant list;
- WE CARE Solar data on the distribution of solar suitcases; and
- REN21 data on distributed renewable energy plants collected for their "Global Status" Reports.

IRENA gratefully acknowledges the assistance provided by these organisations, as well as the project and plant lists that were provided by commercial companies and project developers in response to requests for information sent to members of the Alliance for Rural Electrification (ARE) and IRENA Coalition for Action.

OTHER ONLINE DATA SOURCES

In addition to the above, data was collected from many different online sources, such as websites, project reports, press releases and news articles. These sources provided much of the data about stand-alone solar PV plants and solar mini-grids, although they often had to be checked carefully to ensure that that these plants were not at a development stage and were currently operating.[3]

AVOIDING DOUBLE COUNTING

During the process of compiling the data, care was taken to check that plants were not double counted. This was particularly important for donor-funded projects, where it is not unusual for the donor, implementing agency, project developer and technology supplier all to report the commissioning of the same new off-grid power plant. In most cases, multiple reports of individual plants could be identified and deleted by cross-checking the name and location of the plant, commissioning year and capacity.[4]

For the two main aggregated datasets (GOGLA sales data and SNV biogas plant data), other reports of solar lights, SHS or biogas developments were not included in the countries and years where GOGLA and SNV reported capacity increases, unless it was very clear that these reports were referring to plants and products not already covered by the GOGLA and SNV data.

PEER REVIEW

As a final step, the data was reviewed as part of the REN21 Global Status Report peer review process in the first quarter of 2018, which led to some revisions to the data.

[3] It is quite common for construction of a plant to be announced with a planned commissioning date, but then to hear nothing more. Such announcements are noted but not included in any IRENA datasets unless there has also been an announcement (e.g. press release, news article) that the plant has been commissioned.

[4] A much larger problem existed in situations where a national energy agency presented aggregated data for off-grid power plants, but other projects in the same country also presented their achievements. In several cases, it was not clear whether the national data included the results of those projects or only the results of projects funded by the government (i.e. it was not known whether the results of non-governmental projects could be added to the database or were already included in the national statistics).

4. DATA PROCESSING

In addition to data collection, the second major task was to convert all the raw data into comparable measurement units that meet the terms, definitions and units used in international energy statistics. The four main measures required for each observation were: the year of commissioning; plant capacity; annual generation or production; and the number of beneficiaries.[5] Additional useful information was also collected where possible (a complete list of the variables stored for each record is given in Annex 1).

Most of the raw data collected at the individual plant level included information about the year of commissioning and at least one of the other three measures. However, some of the more aggregated data sources provided much less precise information. For example, development projects often report achievements simply as the number of plants installed over the duration of a project. The conversion of this information about numbers of plants into more useful measures required further investigation or estimation and the procedures used are described in the following sections.

ELECTRICITY CAPACITY

Electricity capacity is recorded in each record as a total capacity (in kW), an average unit size (in Watts) and number of units commissioned. So, for example, a record of 4,000 sales of solar lights, with a power rating of 3 Watts, is recorded as 4,000 (units) with an average unit size of 3 (Watts) and total capacity of 12 (kW), while a small hydropower plant of 35 kW, is recorded as 1 (unit) with an average size of 35,000 (Watts) and total capacity of 35 (kW).

Although electricity statistics usually only record total capacity, the inclusion of the other two variables in each record was useful for validating or estimating the number of people connected to each plant.

The procedures used to measure or estimate capacity for each technology were as follows:

Off-grid hydropower

Most of the off-grid hydropower capacity records contain data for individual plants and capacity. However, there were some countries where aggregated time-series data were collected (i.e. total off-grid capacity and number of plants, by year). In such cases, the total capacity and number of plants commissioned each year were calculated as the differences between adjacent years and an average unit size was calculated as capacity divided by number of plants commissioned in each year.[6]

Solar lights and solar home systems (SHS)

For these devices, every record in the database represents a batch of units (lights or SHS) sold in a country and year. All the data sources reported the total number of units sold or distributed and most also reported either the total capacity of those devices or the average unit size. With a total number of units and one of the latter two measures, the missing measure could then be calculated.

A significant share of the solar light and SHS data came from GOGLA's biannual surveys of the sales of such devices (80% of the number of units in the database, or 30% of the total estimated capacity). The GOGLA data is disaggregated at two levels, first by country and secondly by country and unit size (in seven size classes). The second dataset was converted into the three technologies used here (by aggregating some of the size classes) and put into the database.

Because of the need for confidentiality, some of the detailed data by size classes was reported at the regional rather than country level in some years (e.g. as "other Africa"). In such cases, those regional sales were reallocated back to the individual countries where data appeared to have been suppressed, so that the sum of the disaggregated data matched the total sales reported for those countries and the size distribution followed roughly the same pattern of sales by size in previous years. Fortunately, due to the rapid growth in sales, fewer observations were suppressed for confidentiality reasons in the most recent years and the need to make these adjustments has diminished.

Many other data sources also reported the number of solar lights or SHS distributed in a year and either average unit sizes or total capacities. However, some simply reported the numbers of units sold or distributed. In these cases, it was sometimes possible to derive an average unit size from

[5] Beneficiaries are defined here as people directly consuming the energy produced by a plant (i.e. the number of people in households connected to electricity and/or biogas plants). Any people benefitting indirectly from off-grid power (e.g. farmers using solar water pumps or children in schools with solar power) were recorded separately as "other beneficiaries" if such information was available.

[6] This calculation assumes that off-grid data reported as a time series is compiled by adding figures for newly commissioned plants to the previous year's total without any adjustments for decommissioning. This appeared to be the case in almost all the sources presenting time-series data.

technical specifications on tender and procurement documents or from information about the range of unit sizes used in a country. In the absence of any other information, it was assumed that solar lights have an average power rating (capacity) of 3 Watts and SHS have a rating of 25 Watts.

Solar mini-grids

Most reports of mini-grids either reported capacity for an individual plant or capacity for a portfolio of plants (i.e. including both total capacity and number of mini-grids), so the total and average capacity and number of units could be calculated in almost all cases. In the few cases where this information was not available, capacity was estimated from the reported area or number of solar panels installed in the plant, or sometimes from photographs of the plants. Many solar mini-grids are implemented as hybrid plants with diesel generators or a combination of wind, solar and diesel. In such cases, only the capacity of the solar component was recorded as solar capacity.

Solar pumps

Most reports of solar powered water pumps reported capacity for an individual or group of plants or, in some cases, this information could be derived from project photographs or information about the power requirements of the pumps. In a few cases, projects did not report capacity but reported the number people served by solar water pumping facilities. In such cases, the capacity was estimated from the results of similar projects (usually about 1 kW of solar PV panels are used for every 2,000 people served). A few examples of solar pumps used in agriculture were also reported without any capacity data and, in such cases, the capacity was assumed to be 3 kW.

Other off-grid solar PV plants

Other off-grid solar PV plants provide power for a wide variety of end-uses such as: industrial facilities; street lighting; solar fridges; communication towers; electrification of schools and clinics; and private commercial developments in the retail and tourism sectors.

Most of the sources for commercial and industrial developments reported an installed capacity and some of the reports of rural electrification programmes also gave the number and sizes of plants installed (e.g. in schools and clinics). However, quite a lot of data sources simply reported the number of plants that had been installed to meet a certain need. In such cases, average unit sizes were derived from the data for similar plants or other technical information.

Based on typical technical specifications, the three most common estimates used were for the average capacity of solar PV plants used with solar direct-drive fridges (325 W each), solar PV plants used for telecommunication masts (4 kW each) and solar street lights (usually panels of 100-200 Watts each, depending on where the lights are used).[7]

Biogas power plants

Almost all reports of biogas power plants included information about generating capacity. However, in a few cases, this was either estimated from the stated biogas digester capacity and/or production level or a capacity utilisation factor was used.

For all technologies, if only the number of plants was reported and this had to be converted into a capacity estimate, figures towards the lower end of the plausible range of unit sizes was used to avoid over-estimation.

BIOGAS DIGESTER CAPACITY

Biogas digester capacity is stored in the database as the total volume of the digester in cubic metres. Most of the biogas digester data came from either reports of individual plants or the aggregated annual results of biogas programmes in countries.

Most of the records for individual plants were collected from reports of commercial or agricultural plants or biogas electricity plants. Digester capacity was reported in almost all cases, except for some plants used for electricity generation. In those cases, the digester capacity was estimated from the expected level of electricity generation.

The results of household biogas programmes sometimes included data for both the total capacity and number of plants built in a year, but many just reported the number of plants. However, most biogas programmes only build biogas digesters in a limited number of standard sizes and this information was usually available along with an indication of the most common digester size used in the country. If no further information was available, a size at the lower end of the range of available sizes was usually chosen as an estimate of average size, because the data showed that relatively small plants are most commonly used in countries.

[7] It should also be noted that solar street lighting projects sometimes report the power of the lights installed on the project rather than the capacity of solar panels used to provide power. Where this was the case, the reported figures were multiplied by three, as a literature search suggested that the solar PV capacity is usually about three times the power rating of the lights used in solar street lights.

ENERGY PRODUCTION

Annual generation is recorded in the database in MWh. Generation statistics were available for some of the off-grid power plants (e.g. where they are operated by national electricity companies) and this data is usually captured as part of IRENA's annual data collection cycle. However, very little information was available for most of the off-grid power plants, so various assumptions and estimates were used. The main procedures used to collect or estimate generation were as follows:

Off-grid hydropower

Where annual statistics were available, the average level of generation for the last three years (2014-16) was used as an estimate of average generation for each plant. If this was not known, the expected level of annual generation (based on initial design studies) was sometimes available and recorded in the database. However, in most cases, no generation data was available, so an average capacity utilisation factor was used to calculate an estimate of annual generation. These capacity utilisation factors were based on the on-grid hydropower capacity and generation figures for each country in 2014-16 and were mostly between 30-50%.[8]

Solar PV

As with hydropower, annual generation was available for a small number of solar mini-grids (e.g. where these are operated by a utility company) but, for almost all observations, the expected level of solar power generation had to be estimated. Estimates of solar PV generation were calculated using capacity factors from the Global Solar Atlas (http://globalsolaratlas.info), using the figure reported for the capital city in each country.

Biogas

Detailed biogas and biogas electricity production statistics were available for China and Cuba and estimates were available for quite a lot of the national biogas programmes and individual biogas plants. However, information about biogas and biogas electricity production was incomplete in some cases and it was necessary to make estimates.

Household biogas production was estimated from digester capacity, with a default assumption that daily gas production is about one-third of digester volume (for fixed dome plants) or one-quarter of volume (for other types of plants).

For industrial biogas plants, the ratio of daily gas production to plant capacity can vary considerably from as little as 10-15% for covered lagoons to 150% or more for stirred tanks and plug flow digesters. Where estimates of gas production were not available, it was usually possible to identify the type of digester and likely feedstock and estimate daily gas production based on the plant volume and productivity of similar plants of that type in that region.

For biogas electricity, generation was estimated from the expected level of biogas production, using the assumption that one cubic metre of biogas will generate two kWh.[9]

In a few cases, only the electricity capacity was reported for a plant and it was necessary to estimate generation and then work back from this figure to derive estimates of biogas production and digester capacity (using the assumptions described above). In such cases, electricity generation was estimated using a capacity utilisation factor derived from the reported capacities and production levels of similar types of plant.[10]

As noted above, estimates of energy production were used quite frequently to fill gaps in the off-grid dataset. However, solar radiation data and capacity utilisation factors derived from other similar plants provide a reasonable basis for estimating generation if this is not recorded (which is frequently the case for off-grid electricity supply). It should also be noted that these generation figures were only used in this analysis to calculate the level of electricity access provided by plants serving households, so some imprecision does not have a major impact on those results.

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8 This calculation to estimate generation is: generation = capacity x capacity utilization factor (%) x 24 x 365. For solar PV, online tools often present this as an estimate of annual generation (in kWh) per kW of capacity.

9 This assumes a methane content of the biogas of around 65% and a generation efficiency of about 33%.

10 For example, biogas plants for mini-grids might be expected to run at a higher capacity utilisation factor than agricultural plants where electricity is only needed part of the time. Although the estimation of three variables from one measurement may lead to a lot of uncertainty, the main aim of these calculations was to ensure that the estimates of plant capacity and production were internally consistent if most of the information was unavailable.

ENERGY ACCESS

The main measure of energy access recorded in the database is the number of people (beneficiaries) connected to the electricity plants or biogas digesters included in each record. For electricity, the level of electricity supply is also calculated and recorded as an electricity access "tier", where:

Tier 0	≤ 4.5 kWh/household/year
Tier 1	= 4.5-73 kWh/household/year
Tier 2 or more	≥ 73 kWh/household/year

As electricity access is usually measured and recorded in terms of household electricity supply (see Box 2), the number of connected households was also recorded for every record. Most data sources reporting number of beneficiaries gave only one of these two measures (i.e. number of people or households), so the alternative measure was calculated in each case using the most recent national figure for average rural household size (or national average household size if the rural figure was not available).

The number of beneficiaries for each off-grid energy plant was calculated differently for small solar devices and other types of power plant. For small solar devices (solar lights and SHS), it was assumed that the number of households using SHS was the same as the reported number of units distributed in each record. For solar lights, GOGLA research has suggested that about 10% of solar lights are sold to households that already own one or more solar lights, so the estimated number of households using solar lights was estimated as 90% of the products distributed in a year.[11]

Box 2: Electricity access tiers, types of power supply and number of beneficiaries

The level of electricity access provided to a household is often described as the energy services or end-uses that can be supported by the power supply and the number of hours of availability. A minimal level of service will support uses such as task lighting or general lighting within a household and mobile phone charging. A slightly higher service level can provide power for small electrical items such as a radio, television, computer or fan. Beyond this, higher levels of supply can power mechanical loads (e.g. a refrigerator) or heating elements (e.g. a kettle, rice cooker, hair dryer, etc.) and at the highest levels of supply, electricity is available all day and is sufficient to power multiple devices at the same time.

To simplify measurement, the level of energy service provision can be recorded as the amount of electricity provided to a household (in kWh/year), as shown by the tiers indicated opposite. Broadly speaking, Tier 1 indicates a level of service that is adequate to support lighting and mobile phone charging for a whole household. Tier 2 is sufficient to power lighting plus entertainment devices and/or a fan and higher tiers can support the use of multiple devices and larger electrical loads.

The classification of small solar devices used here is designed to match these electricity access tiers, so solar lights (<11W capacity) are insufficient to provide Tier 1 access to a whole household and are classified as Tier 0. Small solar home systems (11-50W) will provide Tier 1 access to a household and larger solar home systems (>50W) will provide Tier 2 access or more.

It should also be noted that although solar lights may not provide Tier 1 access to a whole household, they can provide that level of electricity access to one or more individuals within the household. Thus, assuming an average household size of five, the number of people using solar lights reported later (measured at the household level) can be divided by five to give an approximate estimate of the number of people with Tier 1 electricity access from solar lights.

For mini-grids powered by solar, hydro or biogas energy, the level of energy services provided is generally quite high (at the high end of the range for Tier 1 or Tier 2 and above). This is because the cost of investing in distribution infrastructure cannot be justified at lower levels of electricity supply per household. Thus, almost all mini-grids reported a level of production and number of connections that equated to a household supply of Tier 2 or more. An expectation of at least Tier 2 supply was also used to check the reported number of beneficiaries of mini-grid projects and to derive estimates where such information was not available.

[11] Note: the distribution of solar lights and SHS was also calculated as 97% of the sales in a year, because GOGLA research suggested that about 3% of units shipped are lost in the distribution chain or during installation.

Box 3: Number of beneficiaries of mini-grid projects

The reporting of unrealistic numbers of mini-grid beneficiaries (by counting an entire village population rather than number of connections) was a problem in some mini-grid data sources, especially for projects funded by donors or other public funding sources. So, for example, a project might report that a village of 250 households has been electrified with a mini-grid of 4 kW, but this level of capacity equates to an average power supply of only 16 Watts per household, which is usually too low to justify investment in a distribution network. A similar issue arose where companies and projects reported numbers of beneficiaries that included both customers for their mini-grid projects and others that have bought solar lights or SHS from the company.

Statements of generating capacity and numbers of consumers were compared on a case-by-case basis, but if it seemed likely that the number of mini-grid connections had been over-stated, then the reported number was discarded and a minimal estimate was recorded in the database.

For mini-grids (including those powered by hydro or biogas energy) the number of beneficiaries was either reported in the data sources or was estimated.

Where the number of beneficiaries was reported, care was taken to check that the number of beneficiaries was the number of households connected to the mini-grid and not the total population of the town or village where the grid was located. This was usually checked by looking at the planned service levels compared to total generation or by checking whether the level of supply per household seemed reasonable (see Box 3).

To estimate the number of households connected to a mini-grid, the total capacity of a plant was divided by an average level of household power supply. This average level of supply could sometimes be estimated from descriptions of the benefits of the project (i.e. qualitative statements about the level of energy services provided). However, in many cases, this information was not available, so it was usually assumed that a mini-grid would supply 100 W per household. This assumption of 100 W per household was derived from the projects where information about both capacity and number of connections was available.[12]

One other source of uncertainty in the measurement of beneficiaries is due to the use of renewables in hybrid plants (often solar PV combined with diesel generators). For hybrid plants commissioned in previously unelectrified areas, the number of beneficiaries was adjusted to reflect the proportion of renewables in the total capacity of the plant. Similarly, if the addition of a renewable energy plant was expected to increase the number of connections to an existing mini-grid, then that marginal increase in connections was counted as the number of beneficiaries of the renewable energy plant.

However, where renewables were added to an existing diesel mini-grid, it was often unclear whether the number of beneficiaries would increase, the level of power supply per household would increase, or whether the diesel generator would simply be decommissioned or used for back-up power. Again, in such cases, the number of beneficiaries was adjusted to reflect the share of renewables in the total electricity supply, but it should be noted that the number of beneficiaries of hybrid plants does not necessarily represent an increase in electricity access and may simply reflect a switch in the source of electricity used by those people.

COMMISSIONING DATE

In most of the data sources, the commissioning dates of power plants were clearly identified or, for sales of solar devices, the sales were recorded by year. However, in some cases, multiple plants were built over the course of a project and the achievements of the project were only reported at the end of the project. This was not a major source of inaccuracy for projects of only a few years, but was more of a problem for some major projects that were implemented over a long time period.

In such cases, it was sometimes possible to identify when different components were completed by looking at progress reports and news articles. If this was not possible, then it was assumed that an equal number of plants were commissioned over the duration of the project (i.e. by dividing the total number of plants by the length of the project and using the result as the number of plants commissioned each year).

Commissioning dates were only estimated in this way in a few cases (e.g. a major World Bank funded project that supported the construction of 173 micro-hydro plants in Sri Lanka from 2003-12). A

[12] This calculation also needs to account for any non-residential electricity users. So, in cases where a simple estimate of 100 W per household was used, it should be noted that this really means a slightly lower level of supply per household (assuming that some of the capacity will probably be used to supply non-household electricity users).

similar procedure was also used in a few countries where reports of developments in off-grid renewable energy were infrequent and increases in the number of reported plants had to be converted into estimates of annual increments.

END-USES

The end-use of the energy generated by each plant was recorded as one of the following:

- Industry
- Commercial and public services
- Residential
- Other (agriculture, forestry and fisheries or not specified)

These categories match the end-uses of energy consumption used in most energy balances, so they can be used to allocate off-grid energy consumption into the correct end-uses in those balances.

In addition to the above, secondary end-uses (providing more detail) were also recorded where known. So, for example, the end-uses of most solar water pumps were either reported as other (with agriculture as the more detailed secondary end-use) or commercial and public services (with a secondary end-use of public water supply).

Additional detail about the end-uses of other PV plants was particularly useful to split the commercial and public services end-use into: education; health; tourism; public lighting; and communications towers (e.g. mobile phone masts).

These details can be used to examine how renewable energy is supporting the achievement of other Sustainable Development Goals by improving the availability of electricity for facilities such as rural schools and health centres (see Box 4).

It should also be noted that some plants with household connections (beneficiaries) were not recorded as a residential end-use. This occurred, for example, where a plant supplying power to an agricultural enterprise also provided power to neighbouring villages or employees' homes.

Box 4: Secondary beneficiaries

Where more detail about end-uses was available, this sometimes included figures for the numbers of people using these services. This was quite common for reports of solar pumps used for public water supply and solar panels used in schools and clinics. If this information was available, it was also recorded in the database.

While much of this information was presented in a variety of different ways, some of the data was comparable and can be used to give a rough indication of the numbers of people benefiting from improved services through the electrification of facilities. The reported numbers of people using health facilities connected to solar PV plants was the main secondary use where such information was reported in the most consistent way.

5. DATA AGGREGATION

The final stage in the production of IRENA's off-grid statistics was the aggregation of the individual observations (records) and conversion of those figures into a time series for each technology in each country.

To create these time series, the annual figures for each technology were accumulated over time and adjusted to account for the expected lifetime of different types of energy plant (see Box 5). The calculations for each of the main technologies are described below.

Hydropower

The figures for capacity and number of beneficiaries of off-grid hydropower plants were simply aggregated over time in each country. This assumes that all of the hydropower plants included in the database are still working (which was checked and confirmed as far as possible).

However, it should also be noted that any plants currently not operating were also completely excluded from the database and any known changes in the capacity of a specific plant since 2000 were recorded as separate observations of those marginal changes in the years that they occurred.[13]

Solar lights and solar home systems (SHS)

To convert the annual data for these devices to an estimate of total capacity, the amounts sold or distributed each year were accumulated for a limited number of years. In most cases, the total capacity of solar lights was assumed to be the sum of sales over the last three years and for SHS the capacity was calculated as the sum of the last five years. These time periods were based on estimates of average product life provided by GOGLA.[14] The volume of sales each year was also reduced by 3% to account for losses throughout the distribution chain and, for the estimation of numbers of households using solar lights, a further reduction of 10% was applied to each record to account for households purchasing more than one light.

The above calculations were used for all sales and distribution of solar lights and SHS (including from sources other than GOGLA members), unless the SHS were provided by organisations that would provide long-term servicing and maintenance of the units. An example of the latter was Fiji, where the national SHS Project has provided long-term support for the maintenance of the systems installed there. In such cases, the data for the numbers of plants commissioned each year were simply accumulated over time.

Box 5: Adjustments to off-grid statistics (time-series) reported by countries

Several countries report data for the number of off-grid power plants or biogas digesters that have been built under various support programmes. The data is usually presented as an annual achievement and a running total of all plants that have ever been built under these programmes. These annual statistics measure gross increases in capacity each year, but they cannot simply be aggregated over time to produce a reliable time series for total capacity because they do not account for any plant retirement or decommissioning.

The need to adjust reports of annual achievements to produce a reliable time series can be explained using biogas plants in India as an example. India has been supporting the construction of household biogas plants since the 1980s and has now reached a total of almost 5 million plants supported by various government programmes over the years. However, biogas plants have a limited lifespan (usually, about 10-20 years, depending on plant type) and there is also evidence that some households simply stop using them before they reach their end of life. Thus, the number of biogas plants currently operating in India will be much less than 5 million, because most of those plants built more than 20 years ago will no longer be in use.

Where detailed databases of off-grid power plants were available, these data sources were used as a basis for the calculations described here. However, it should be noted that the final estimates calculated by IRENA will not match those figures in many cases (particularly for small solar devices and biogas plants), due to the adjustments made to take into account plant retirement and decommissioning.

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[13] The one exception to the calculation described here was for the estimation of off-grid pico hydro plants in Viet Nam. Several data sources for Viet Nam reported that about 100,000 very small hydro generators (100 Watts) have been sold in the country from 2005-15, which suggests that about 10,000 of these devices are usually sold each year. These cheap, small generators do not last for more than about 3 years, so it was estimated that 30,000 of them have been operating every year since 2005 (with a total capacity of 3 MW).

[14] Based on their internal research, GOGLA suggest that the average life of these products is approximately 1.5 times the guarantee period, which roughly equates to three years for solar lights and five years for SHS.

Other off-grid power plants

The figures for other off-grid power plants (solar mini-grids, solar pumps, other PV plants and biogas power plants) were also simply accumulated over time in each country.

Most PV plants recorded in these categories are using full sized solar panels (which are expected to last 20-25 years) and many of the plants are providing electricity for sale or for public or commercial activities where some level of maintenance might be expected.

The assumption here of little or no degradation in these facilities (over time) may result in some over-estimation of total capacity, but there was very little data available about the long-term use of solar panels in off-grid power plants. In addition, as with hydropower, any plants currently not operating were completely excluded from the dataset and any known changes in capacity were included as separate records.[15]

Biogas digesters

For industrial biogas digesters and those used for power supply, the annual data was treated in the same way as hydropower, biogas power and non-household PV: capacities and generation were simply accumulated over time to create a time series, but any currently non-functional plants were excluded from the dataset.

For household biogas digesters, capacity and gas production were also accumulated over time, but with reductions in the number of plants assumed to be still in use, depending on their age. The baseline assumptions for these reductions were as follows:

Plants 1-5 years old:	95% in use
Plants 6-10 years old:	80% in use
Plants 11-15 years old:	50% in use
Plants 16-20 years old:	25% in use
Plants over 20 years old:	10% in use

These assumptions were based on a review of various studies about the long-term use of biogas digesters and the results of various biogas monitoring exercises. They were also adjusted for countries where monitoring information was available (which also, in many cases, suggested that a higher survival rate is possible if a local capacity for maintenance and repair is developed).

The other two exceptions to the above were China and Cuba, where household biogas capacity and generation are monitored every year and their published data account for plant decommissioning (i.e. the difference between years is a net rather than gross capacity addition and can be negative). In these cases, the annual figures were calculated as differences between adjacent years and these figures were accumulated over time without any adjustment.

[15] For example, the Government of Kenya operated 18 solar PV mini-grids in 2012, with a total capacity of 700 kW, but the capacity was reduced to 569 kW in 2015. Thus, the first record for this shows 700 kW commissioned in 2012 and a second record shows a capacity of -131 kW (de)commissioned in 2015. The records for biogas digesters in China and Cuba also include some years with negative capacity and production, because the original source data was a time series that accounted for plant decommissioning and the total capacity reported in some years was lower than in the previous year.

6. SUMMARY BY TECHNOLOGY

A short summary of the contents of the database (at 30 June 2018) is given below. The figures include all of the raw data in the database. They do not include the adjustments for plant decommissioning (described previously) and they also include some data for 2017. Thus, they do not match the figures for 2016 shown in the annex tables.

HYDROPOWER

The database for hydropower holds 702 records, covering 38,644 plants with a total installed capacity of 331 MW. Most of the records are for individual plants (603 records), with another 99 records covering groups of plants commissioned in a country and year (including the record for the 30,000 pico hydro plants in Viet Nam). Almost all the plants recorded in the database have a capacity of 100 kW or less (38,076 units, with a total capacity of 173 MW).

In most of the data sources, the hydropower plants were reported as supplying electricity to general, non-specific end-uses through local village mini-grids. Thus, about 240 MW of the total capacity (70%) is recorded with an end-use of "other" (meaning "not-specified" in this case). About 60 MW of capacity was clearly identified as serving residential end-uses and the other 30 MW of capacity was divided roughly equally between agricultural uses and public or commercial end-uses.

Although only a small proportion of plants were classified as serving residential end-uses, almost all the hydropower data sources reported some supply of electricity to households, usually with a Tier 2 level of supply or above.

The commissioning dates recorded in the database showed that roughly 400 off-grid hydropower plants have been commissioned each year since 2010. Before that, the number of plants commissioned each year was much lower (usually about 100-150 plants per year).

SOLAR POWER

Solar lights and SHS

The database for small solar devices contains 667 records, covering the distribution of almost 51 million units, with a total capacity of 460 MW.

Most observations came from the results of recent GOGLA surveys. Other data sources included solar light import data, national statistics and the results of off-grid electrification projects in countries that use locally-made lights and SHS.[16]

In addition to the above, there is also a significant market for generic products in many countries and it is thought that the figures captured here could account for only half (or less) of the real number of these devices that have been used in countries.

All solar lights and SHS were classified as having a residential end-use. Some data sources reported the installation of small solar PV systems for other uses (e.g. the provision of lighting in schools and clinics). While these devices could be classified as SHS, they were used for non-residential end-uses, so they were recorded separately as part of the dataset for other solar PV applications.

The average power capacity of solar lights recorded in the dataset was 2.7 Watts each. The average capacity of small SHS (11-50 W) was 34 Watts and for large SHS (>50 W), the average capacity was 117 Watts.

Almost all the recorded information about solar lights came from GOGLA, but national off-grid electrification projects and programmes accounted for a much larger share of the observations for SHS. This is mostly due to the length of time that locally manufactured SHS have been used in some of these programmes (i.e. very little solar light data was available for years before 2011, but several countries recorded the use of SHS back to 2000).

Solar mini-grids

The database contains 314 records of solar mini-grids, with 8,234 recorded plants and a total installed capacity of 328 MW. Three-quarters of the records contained information about individual mini-grids (238 plants), which accounted for about 20% of the total solar mini-grid capacity (65 MW).

Most solar mini-grids in the database were under 10 kW capacity, but these accounted for a very small proportion of total capacity (7,100 plants with a capacity of 14 MW). This part of the dataset included a few countries where large numbers of very small grids (<1 kW) have been installed to provide basic electricity services to small groups of households.

[16] Solar panel trade data is not included in this dataset at all, as one objective of this exercise was to see how much of any estimated capacity could be confirmed from other sources as genuinely existing. However, some import data for solar lights was included in the dataset for the few countries where they are recorded in their detailed import statistics (at the 8 or 10-digit trade code level). As noted previously, such data was only included in countries where it was very clear that these would not be double-counted in the GOGLA dataset.

Medium-sized mini-grids (10-100 kW) accounted for about 10% of the total recorded capacity (35 MW in 775 mini-grids) and the remaining 280 MW of capacity was in mini grids larger than 100 kW (360 mini-grids in total, including 32 larger than 1 MW).

Most solar mini-grids have been commissioned since 2014, although a few countries have operated such grids for more than a decade.

Over half of the recorded solar mini-grids provide electricity to residential customers at a level of Tier 2 or above (4,570 plants with a total capacity of 318 MW). However, a significant number provide only a Tier 1 level of supply (2,820 plants with a total capacity of 6 MW) and a few mini-grids have been commissioned to supply electricity for a variety of end-uses, but without any residential connections (850 plants with a total capacity of 4.4 MW).

All plants recorded as solar mini-grids in the database were power plants distributing electricity to several different end-uses. Therefore, they were all classified as having a non-specified (i.e. "other") end-use. Some of the solar PV plants installed in public and private facilities could technically be described as mini-grids (especially the larger plants), but if a specific end-use for a plant could be identified, then it was recorded in the database as one of the "other solar PV" plants.

Solar pumps

The database contains 558 records of solar pumps, with a total of 199 MW capacity in 108,254 plants. Most of this data came from India, where 101,258 solar pumps had been installed by the end of 2016, with a total capacity of 169 MW.

About 5,000 solar pumps (10 MW) are used for drinking water supply, while almost all of the other pumps in the database are used for agriculture.

About 90% of the solar pumps are 1-2 kW in size (104,600 pumps with a total capacity of 174 MW), although the range of plant sizes is very large and includes a few solar power plants of over 1 MW supplying large irrigation schemes.

Other off-grid solar PV plants

The last category of off-grid solar power plants contains plants that provide electricity for a variety of end-uses, which did not fit into any of the other categories.

This part of the database contains 578 records, covering 176,756 plants with a total capacity of 475 MW. About half of the records were for individual plants (275 plants, with a total capacity of 44 MW), while most of the other records came from reports of various public and commercial electrification projects that covered the installation of multiple off-grid solar PV plants.

Almost all these plants were less than 5 kW in size (176,200 plants with a total capacity of 419 MW), but the range of plant sizes was quite large and included 15 power plants of 1 MW or more. About 95% of these plants provide electricity for commercial or public service end-uses, with the secondary use data showing that the most common end-uses were for communication towers, schools, clinics and public lighting (solar street lights).

Some of these records also included figures for the numbers of people receiving electricity from these plants. This included a small number of records of residential installations that were relatively large (several kW in size), where it can be assumed that these systems will last for more than five years.[17]

It also included quite a few solar charging stations, where solar power is used to recharge batteries that people then take away to provide electricity in their homes (which could be counted as another type of electricity access).

In total, about 15,000 people were recorded as using large residential PV systems and about 35,000 use the services of solar charging stations and kiosks.

BIOGAS

Household biogas digesters

The database contains 353 records of household biogas digesters, with a total of 41.8 million digesters built over the last four decades and a total capacity of 152 million cubic metres of digester volume.

All records for household plants came from aggregated data sources that recorded the total number of plants built in a country each year. The three main sources of data were: national biogas project monitoring reports; a project monitoring spreadsheet provided by SNV; and other miscellaneous reports from national agencies, donors, non-governmental organisations and technical studies.

The two countries with the greatest number of household digesters are China and India and both countries keep detailed statistics of the plants that have been built. The China National Renewable Energy Centre (CNREC) provided a detailed spreadsheet showing the results of their biogas

[17] These plants were classified as other PV plants so that the conversion of the data into time series would not remove these plants from the time series after five years, as would be the usual assumption for SHS.

monitoring programme, which records the number of biogas plants at the start and end of each year, total digester capacity, gas production (for both electricity generation and household supply), numbers of households supplied and biogas electricity capacity and production. This data already accounts for plant decommissioning, so it was used to produce time series of capacity, production and numbers of beneficiaries without further adjustment.[18]

India, Nepal and Bangladesh produce national statistics about the commissioning of new plants (numbers of plants), along with information about digester sizes that can be used to calculate capacity. SNV also provided a spreadsheet recording the numbers of plants built under programmes that they have supported in another 20 countries. These sources provided most of the other household biogas data, to which was added a small number of records for another 10 countries.

None of these other data sources took into account plant decommissioning, so the data had to be adjusted to account for this when converting these figures into time series of total capacity, production and numbers of beneficiaries. However, several of these programmes have produced monitoring studies showing how the use of biogas plants declines over time and this information was used to develop the assumptions about plant lifetime described earlier.

Commercial biogas digesters

The database contains 73 records of biogas digesters used for non-residential heat production, covering 411 plants with a total capacity of 1.8 million cubic metres.

Most of these records were for individual plants, but 28 records covered multiple plants commissioned in a single year, usually to provide cooking gas for public buildings (e.g. schools, prisons, hospitals).

Roughly half of all these plants were used to produce heat for commercial and public services and half were used in agriculture. However, the average sizes of these plants were very different with an average size of 200 m^3 for the public and commercial plants and 8,650 m^3 for biogas plants used in agriculture.

Off-grid biogas electricity production

Each off-grid biogas electricity plant was recorded as a biogas generator and a biogas digester (with two records for the latter if it was a combined heat and power plant, to separate the two uses of the biogas).

The database contained 88 records of biogas generators, covering 486 power plants with a total capacity of 29 MW and a corresponding biogas digester capacity of 240,000 m^3.

Sixty-eight of the records were for individual power plants (mostly in the agricultural and food processing sectors) and 20 records were for multiple plants (mostly used for residential electricity supply through mini-grids or for commercial and public service end-uses).

Most of the biogas electricity capacity was located on farms (16 MW) or in food processing factories (5 MW). The remaining 8 MW of capacity was divided almost equally between residential mini-grids and commercial and public facilities.

[18] Cuba was the one other country that had similarly complete data that could be used without any adjustments. It should also be noted that both China and Cuba reported household biogas production from both household plants and communal biogas digesters and there were a few other countries that also reported communal biogas production for residential use.

7. FURTHER WORK TO IMPROVE OFF-GRID DATA

This exercise to collect off-grid renewable energy data has shown that a significant amount of information does exist in countries and that it is possible to convert much of this into standard energy units that can be used in a country's energy statistics. However, it has also revealed a number of current practices that could be improved to make this process easier. Based on the experiences gained from the collection of this data, recommendations for further work are presented below.

FURTHER WORK AT IRENA

Integration into IRENA's database

IRENA's current off-grid statistics report about 6.4 GW of off-grid renewable electricity capacity at the end of 2016. The table below compares these figures with the data reported here and presents preliminary estimates of what might be reported when these two different datasets are combined.

At present, most of IRENA's off-grid hydropower capacity data covers large-scale isolated systems operated by national utilities or large enterprises. Some of the data reported here overlaps with the existing dataset, but it is estimated that about 200 MW has not been reported previously.

Similarly, most of the current figures for bioenergy only cover electricity produced from solid biomass (usually in large-scale agro-processing facilities), so almost all of the biogas electricity data collected here can be added to the existing database.

In addition, a small number of previously unknown off-grid wind and biomass power plants were found and can be added to the database.

Most of the data for non-electricity uses of biogas was also previously unrecorded and can be added to the energy balances of the countries where this is produced.

For off-grid solar PV capacity, it's more difficult to compare this new dataset with IRENA's existing database due to the complexity of the different sources used.

The existing database reports 2,240 MW of off-grid PV capacity in 2016, with 1,060 MW of capacity coming from questionnaires and official sources and 1,180 MW from other sources (including 310 MW estimated from trade data).

The off-grid solar PV capacity in this new dataset amounts to 1,116 MW (at the end of 2016).[19] In addition to this, another 780 MW in the existing database is identified as off-grid PV from questionnaires and official sources (this is the 1,060 MW above, less what is double-counted in this dataset).

The remaining 330 MW of off-grid PV capacity in IRENA's database comprises 230 MW of capacity estimated from trade data plus 100 MW taken from other unofficial sources. The 230 MW mentioned above is 10% of the currently reported off-grid PV capacity and is the amount that remains uncertain in terms of its quantification, end-uses and grid connection status.

IRENA will use the data collected here to revise the current figures for off-grid electricity capacity and production. In the case of solar PV, IRENA will also target future data collection efforts to reduce the uncertainty associated with the estimation of off-grid capacities from trade data.

Table 1: Off-grid electricity capacity at the end of 2016 (in MW)

Technology	Currently reported figures	Data reported here	Revised figures
Hydropower	613	323	813
Solar PV	2,238	1,116	2,238
Bioenergy	3,094	27	3,121
Other (wind and geothermal)	494	0	494
Total	6,439	1,466	6,666

[19] Most of the data collected here overlaps with figures already collected or estimated in IRENA's main database, so it is not expected that the total off-grid PV capacity reported in IRENA statistics will increase by much as a result of this exercise, except in the few countries where nothing is currently reported.

Statistical capacity building

In this exercise, various estimation methodologies, measurement conventions and validation procedures were tested and developed, as well as a general framework for the collection and management of off-grid electricity data. Contact with other organisations also highlighted the many different ways that off-grid data is collected and disseminated by countries and organisations.

The experiences and lessons learned from this exercise will be included in the training courses and training materials that are used when IRENA supports statistical capacity building in countries.

Cross-sectoral linkages

Many off-grid energy investments are funded by organisations working outside the energy sector. These sources often report other benefits from the provision of off-grid electricity and these were recorded if available. In particular, quantitative information was often presented for the following types of projects:

- Electrification of rural schools (number of children in the affected schools)
- Electrification of clinics and health centres (population served)
- Solar water pumps for drinking water supply (population served)
- Solar water pumps for agriculture (number of farmers served and/or area irrigated)
- Replacement of diesel generators by off-grid renewables (fuel and emissions reductions)

In addition to the above, many studies also reported other social, economic and environmental benefits from the use of renewables, such as income and employment generation, improved waste management, reduced wood fuel use, improved safety and increased opportunities for female employment.

One of the main challenges to interpreting this information is to convert the data presented in the different reports into common and comparable measurement units. However, considering that this could be very useful for showing how renewable energy can contribute to the achievement of other Sustainable Development Goals, these figures may be analysed in more detail in the future.

Technical issues

Due to the way that off-grid electricity data is usually reported, it is often necessary to make assumptions about the lifetime and durability of off-grid energy plants. The assumptions used here for small solar devices and household biogas plants have been based on what little information is currently available. However, a major issue that will have to be addressed soon is the long-term durability of full-sized solar panels.

Fortunately, most of the increase in off-grid solar PV capacity has occurred in the last decade, but it will soon be necessary to start thinking about how the accumulation of gross annual increments in solar PV capacity should be adjusted to account for plant retirement or decommissioning. Thus, further research on the expected lifetime of solar panels used in off-grid applications may be required.

A second issue is the classification and description of different types of off-grid energy plant. The categories used here have been chosen so that the data is organised in a way that can be easily converted into energy and electricity access statistics. However, there is no consensus on the definition of many off-grid energy terms, such as mini-grid or solar home system and there are a lot of other plant descriptions that are not well defined or understood (e.g. solar powerpack).

Further work would useful to clarify some of the terminology used in off-grid energy research, so that comparable information can be collected and shared.

ADDITIONAL RECOMMENDATIONS

Several other improvements could be made to the way that renewable energy data is collected and presented by organisations and agencies active in this area.

Reporting of project achievements

As noted at the start of this document, a few simple measures are particularly important for the collection and reporting of energy and electricity access data.

At a minimum, these include the capacity and expected level of production of renewable energy plants, the dates of commissioning and the numbers of people connected to such plants.

Most projects implemented by energy agencies report this information, but this is often not the case for energy projects implemented in other sectors. Reporting more than simply the number of renewable energy plants installed or distributed by a project would be a good step in this direction.

Mini-grid energy data

The data collected here shows that mini-grid capacity has expanded significantly in just the last few years and rapid expansion of these types of off-grid electricity plants is expected to continue in the future.

If mini-grids expand to account for larger shares of the electricity market in many countries, it will be important for countries to collect reliable data about their capacities, generation, end-uses and numbers of customers to monitor developments in the energy sector and accurately report the production of renewable energy and numbers of people with different levels of electricity access.

These two measures are both indicators for monitoring progress towards the Sustainable Development Goal for energy, so this should be a priority in countries where mini-grids are expected to have a major impact on the energy sector.

Additional information about electricity supply (e.g. reliability, quality of supply, affordability, etc.) would also be useful to examine other dimensions of energy access.

Plant decommissioning and retirement

Several countries have made great efforts to keep records of off-grid energy plants that they have supported and it appears that many more are gradually starting to record such data.

This information is a very useful first step towards monitoring developments in the off-grid energy sector, but the accumulation of these gross additions in capacity will lead to the presentation of misleading trends if these figures are not adjusted for plant lifetime.

Periodic surveys of a sample of plants should provide information that can be used to adjust the data and calculate more accurate trends.

Some countries have already started to produce biogas monitoring studies, but there seems to be little information available about the status of off-grid hydropower and solar PV plants. As these types of plant usually account for a much larger share of off-grid renewables, they should receive more attention in the future.

8. BIBLIOGRAPHY

The following websites and publications provide further information about off-grid developments and some of the data sources used here.

INTERNATIONAL ORGANISATIONS

IRENA

The latest renewable energy statistics published by IRENA are available at: www.irena.org/statistics. Renewable capacity statistics are published at the end of March each year and a more comprehensive set of renewable energy statistics are published at the end of June.

A global and regional analysis of trends in off-grid renewable energy was also presented at the United Nations High-level Political Forum on Sustainable Development in July 2018, a copy of which can be found here: http://irena.org/publications/2018/Jul/Off-grid-Renewable-Energy-Solutions.

An earlier analysis of some of the challenges with measuring off-grid renewables is also provided in this document: www.irena.org/publications/2015/Feb/Off-grid-renewable-energy-systems-Status-and-methodological-issues.

GOGLA

Every six months, GOGLA and The World Bank Group's Lighting Global program publish the Global Off-Grid Solar Market Report. The market intelligence series is based on sales data collected from GOGLA members and Lighting Global associates.

GOGLA also produce other publications about off-grid solar power developments and these can all be downloaded from: www.gogla.org/publications.

SNV

SNV support the development of sustainable energy markets including biodigester programmes across a number of developing countries. To date they have facilitated the installation of over 700,000 bio-digesters to bring clean energy solutions to low-income families and businesses. Further details about SNV biogas activities can be found at: http://www.snv.org/sector/energy/topic/biogas.

REN21

REN21 Global Status Reports provide a comprehensive annual overview of the state of renewable energy, including a chapter on distributed renewables for energy access. REN21 and IRENA collaborate in several areas, including the collection and peer review of the off-grid data presented here. REN21 Global Status Reports can be downloaded at: http://www.ren21.net/gsr.

ECREEE

The ECOWAS Observatory for Renewable Energy and Energy Efficiency (ECOWREX) was developed in 2012 to provide targeted, timely and statistical information and data about the energy sector (especially in the fields of renewables and energy efficiency). A variety of statistics about renewable energy in the region can be found at: http://www.ecowrex.org.

ESMAP

The World Bank's Energy Sector Management Assistance Program (ESMAP) led the development of the multi-tier framework to monitor and evaluate energy access, which is used here to differentiate between different levels of electricity access provided by off-grid renewables. More details about this measurement framework can be found at: www.esmap.org/node/55526.

NATIONAL DATA SOURCES

The national data sources used for compiling this dataset are too numerous to list here, but some comprehensive national data sources are as follows:

Bangladesh

Sustainable & Renewable Energy Development Authority (SREDA) Renewable Energy Master Database: http://www.sreda.gov.bd/index.php/site/re_present_status.

Guinea

Système d'Information Energétique (SIE): www.sieguinee-dne.org.

India

Ministry of New and Renewable Energy Annual Reports: www.mnre.gov.in/annual-report.

Madagascar

Office de Régulation de l'Electricité (ORE) Synoptique des parcs de production en Electricité: http://www.ore.mg/DonneesTechniques/ParcsDeProductions.html.

Nepal

Alternative Energy Promotion Centre (AEPC) Statistics: https://www.aepc.gov.np/statistic/solar-home-system.

ANNEX 1: OFF-GRID DATABASE RECORD METADATA

Variable	Description
ISO	ISO 3-alpha country code.
Sort	Sort order (used to sort countries and areas for printing tables).
Country label	IRENA short name of country or area (in English).
Region	IRENA region.
Plant/project name	Name of plant, project or data source.
Type	Renewable energy plant type (i.e. hydropower, solar lights, small SHS, large SHS, solar pumps, solar PV mini-grid, other solar PV plant, biogas digester, biogas power plant).
Source	Data source (e.g. organisation, database, report, webpage, etc.).
Year	Year of plant commissioning (or year of sale or distribution of solar devices).
Capacity	Total capacity of power plants included in the record (in kW) or total capacity of biogas digesters included in the record (in m^3).
Annual generation	Total annual generation of power plants included in the record (in MWh) or total annual biogas production of biogas digesters included in the record (in m^3).
Number of units	Number of power plants or biogas digesters included in the record. *Note: For solar devices, each device is counted as a small individual power plant.*
Unit size	Average capacity of each power plant included in the record (in W) or of each biogas digester included in the record (in m^3).
End-use	Main end-use of the electricity produced by the electricity plants included in the record (i.e. industry, commercial and public services, residential, or other). For biogas, the same end-uses are recorded or the end-use can be recorded as electricity in the case of biogas plants used for electricity generation. *Note: Plants with unknown end-uses are recorded as other end-use. Plants with household connections may be recorded as one of the non-residential end-uses if meeting that demand appears to be the main purpose of the plant. All biogas digesters used for electricity generation have a matching record for the associated biogas electricity plant. Biogas digesters used for combined heat and power (CHP) production are also recorded as two records, one showing the share of the plant capacity and production used for electricity generation and the other showing the share used for the end-use of the heat.*
People	Number of people in the households connected to the electricity plants or biogas digesters included in the record (where applicable).
HH	Number of households connected to the electricity plants or biogas digesters included in the record (where applicable).
kWh/HH/yr	Household electricity supply provided by the electricity plants included in the record (where applicable). The supply is converted into an "electricity access tier", where Tier 0 is an average electricity supply of up to 4.5 kWh/HH/yr, Tier 1 is a supply of 4.5 - 75 kWh/HH/yr and Tier 2+ is a supply of more than 75 kWh/HH/yr. *Note: In most cases, this figure is calculated by dividing annual generation by the number of households in the record, after reducing the generation value to reflect any non-household electricity consumption, where applicable (often assumed to be 50%).*
Secondary use (optional)	A secondary use or a more narrowly defined end-use of the electricity or biogas reported in the record (e.g. dividing plants used for commercial and public services into plants used in sectors such as: health; education; public lighting; retail; tourism; or telecommunications).
Oppl (optional)	Number of people benefitting indirectly from the off-grid electrification of economic activities or public services (used mostly for plants serving the health and education sectors).
OHH (optional)	Number of households benefitting indirectly from the off-grid electrification of economic activities or public services (used mostly for plants serving the health and education sectors).
Other information	Any additional information collected from the data source about employment, investment costs, electricity prices, etc., where available.
Notes	Other notes about any assumptions, additional data sources, conversion factors or other calculations made to convert from figures reported in the data source to values expressed in the standardised units used in the database (e.g. most commonly, an assumption about average plant size used to estimate capacity and generation from information about numbers of plants/units commissioned or sold in a country in a year).

Annex 2: Off-grid capacity

Annexe 2: Capacité hors réseau

Anexo 2: Capacidad fuera de la red

Hydropower
Hydroélectricité
Hidroeléctrica

MW	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total	198.293	207.122	224.737	242.061	259.473	275.261	286.576	297.721	315.494	322.525
Africa	25.302	26.437	26.722	28.349	28.892	29.651	30.351	31.165	37.049	37.720
Cent Afr Rep	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
Eswatini	1.690	1.690	1.690	1.690	1.690	1.690	1.690	1.690	1.690	1.690
Ethiopia	1.150	1.150	1.150	1.157	1.279	1.279	1.279	1.279	1.279	1.279
Guinea	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220
Kenya	3.411	3.415	3.495	5.115	5.115	5.115	5.115	5.755	5.755	6.115
Lesotho	0.190	0.190	0.190	0.190	0.190	0.190	0.190	0.190	0.190	0.190
Liberia	4.800	4.800	4.800	4.800	4.800	4.800	4.800	4.860	4.860	4.860
Madagascar								0.018	0.018	0.018
Malawi	1.340	1.340	1.340	1.340	1.400	1.400	1.400	1.400	1.400	1.700
Mali		0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Mozambique		0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.549	0.549
Nigeria									0.400	0.400
Rwanda	0.440	0.440	0.640	0.640	0.640	1.040	1.740	1.740	1.740	1.751
Sierra Leone						0.250	0.250	0.250	0.250	0.250
South Africa	6.693	6.756	6.761	6.761	7.091	7.096	7.096	7.192	7.192	7.192
Tanzania	2.830	2.830	2.830	2.830	2.860	2.860	2.860	2.860	7.860	7.860
Uganda	0.000	0.300	0.301	0.301	0.302	0.406	0.406	0.406	0.406	0.406
Zambia		0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700
Zimbabwe	0.338	0.338	0.338	0.338	0.338	0.338	0.338	0.338	0.338	0.338
Asia	166.433	174.092	190.689	206.348	223.134	238.028	248.362	258.406	270.019	276.243
Afghanistan	4.957	5.201	10.401	13.850	17.299	20.748	24.197	27.646	31.095	34.544
Bhutan	1.140	1.140	1.240	1.240	1.240	1.240	1.240	1.240	1.240	1.240
India	65.830	66.892	70.633	74.150	78.568	79.237	82.169	83.377	84.079	84.675
Indonesia	5.320	5.664	6.384	7.145	8.402	9.087	9.636	10.136	10.636	11.066
Malaysia	0.018	0.060	0.060	0.110	0.110	0.110	0.110	0.450	0.450	0.450
Myanmar	2.740	2.815	2.828	2.834	2.949	2.949	2.974	3.165	6.890	6.890
Nepal	29.408	31.499	33.023	34.961	39.345	44.645	46.718	50.764	53.056	54.275
Pakistan	0.590	1.625	5.750	10.820	11.596	15.104	15.554	15.619	15.619	15.619
Philippines	1.092	1.749	2.699	2.936	2.936	3.053	3.078	3.078	3.078	3.078
Sri Lanka	4.173	4.339	4.505	4.671	4.837	5.003	5.248	5.493	5.738	6.068
Tajikistan	7.586	9.528	9.586	10.051	12.272	13.272	13.858	13.858	14.358	14.558
Thailand	0.255	0.255	0.255	0.255	0.255	0.255	0.255	0.255	0.455	0.455
Timor Leste	0.325	0.325	0.325	0.325	0.325	0.325	0.325	0.325	0.325	0.325
Viet Nam	43.000	43.000	43.000	43.000	43.000	43.000	43.000	43.000	43.000	43.000
C America + Carib	3.104	3.140	3.272	3.290	3.373	3.508	3.789	4.076	4.352	4.483
Dominican Rep	0.034	0.052	0.184	0.202	0.285	0.362	0.514	0.801	1.077	1.208
El Salvador	0.064	0.082	0.082	0.082	0.082	0.140	0.140	0.140	0.140	0.140
Haiti	2.170	2.170	2.170	2.170	2.170	2.170	2.170	2.170	2.170	2.170
Honduras							0.129	0.129	0.129	0.129
Nicaragua	0.836	0.836	0.836	0.836	0.836	0.836	0.836	0.836	0.836	0.836
Oceania	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Fiji	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
S America	2.454	2.454	3.054	3.074	3.074	3.074	3.074	3.074	3.074	3.079
Argentina	2.445	2.445	2.445	2.445	2.445	2.445	2.445	2.445	2.445	2.445
Brazil				0.020	0.020	0.020	0.020	0.020	0.020	0.020
Colombia										0.005
Peru	0.009	0.009	0.609	0.609	0.609	0.609	0.609	0.609	0.609	0.609

Solar lights and solar home systems (SHS)
Lampes solaires et systèmes solaires domestiques (SDD)
Lámparas solares y sistemas solares domésticos (SSD)

MW	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total	23.557	31.388	43.048	59.166	78.489	112.226	164.288	212.562	250.257	273.128
Africa	5.131	5.808	5.893	5.899	7.327	11.467	23.571	40.539	61.519	83.617
Benin									0.064	0.246
Burkina Faso					0.013	0.049	0.209	0.380	0.596	0.603
Burundi							0.010	0.023	0.029	0.019
Cameroon										0.089
Congo DR					0.022	0.086	0.284	0.503	0.567	0.445
Cote d Ivoire									0.055	0.141
Egypt										4.889
Ethiopia					0.256	0.975	3.171	5.604	6.332	5.381
Gambia										0.002
Ghana							0.144	0.146	0.199	0.386
Guinea Bissau							0.051	0.102	0.152	0.203
Kenya					0.408	1.556	5.060	9.007	11.256	11.974
Lesotho						0.097	0.097	0.097	0.097	0.097
Liberia									0.024	0.052
Madagascar										0.041
Malawi					0.051	0.081	0.144	0.222	0.568	0.581
Mali							0.188	0.272	0.493	0.576
Mauritius					0.049	0.087	0.126	0.107	0.134	0.230
Morocco	4.001	4.578	4.583	4.583	4.583	4.583	4.583	4.583	15.857	15.857
Mozambique							0.010	0.031	0.031	0.084
Namibia										0.010
Niger								0.015	0.015	0.015
Nigeria					0.022	0.086	0.748	1.431	2.258	3.212
Rwanda					0.056	0.212	0.692	1.235	1.815	6.959
Senegal							0.049	0.097	0.303	0.434
Sierra Leone									0.129	0.177
Somalia										0.023
South Africa							0.265	0.52962	0.852	1.136
Sudan								0.000	0.000	0.000
Tanzania					0.272	1.031	3.354	10.724	12.160	17.438
Togo										0.002
Tunisia	1.130	1.230	1.310	1.316	1.350	1.450	1.450	1.450	1.450	1.800
Uganda					0.074	0.283	1.023	1.905	4.014	8.873
Zambia									0.208	0.294
Zimbabwe					0.172	0.890	1.916	2.076	1.861	1.349
Asia	18.221	25.375	36.950	53.057	70.903	100.047	138.848	169.512	185.375	185.576
Afghanistan							0.470	0.941	1.509	1.637
Bangladesh	6.596	11.097	18.304	32.186	42.524	65.911	93.769	118.097	128.106	126.074
Bhutan					0.023	0.023	0.023			
Cambodia							0.541	0.735	1.238	1.892
India	6.216	7.615	10.754	11.515	17.401	21.043	29.873	33.584	38.727	40.694
Indonesia	1.360	1.360	1.621	1.636	1.660	1.726	1.926	2.195	2.179	2.031
Mongolia	2.100	2.385	2.669	2.954	3.239	3.524	3.524	3.524	3.524	3.524
Myanmar					0.011	0.041	0.133	0.257	0.289	0.254
Nepal	1.950	2.918	3.602	4.767	5.953	7.585	8.325	9.856	9.236	8.906
Pakistan					0.007	0.026	0.085	0.166	0.264	0.235
Philippines								0.033	0.178	0.183
Sri Lanka	4.898	5.576	6.255	6.934	7.698	7.780	7.791	7.723	7.724	7.744
Timor Leste								0.013	0.013	0.013
C America + Carib				0.004	0.016	0.174	0.178	0.357	0.376	0.458
Bahamas					0.011	0.020	0.025	0.126	0.147	0.172
Cuba										
Dominica										
Guatemala								0.005	0.005	0.005
Haiti						0.002	0.002	0.002		0.017
Honduras						0.146	0.146	0.198	0.198	0.239
Nicaragua				0.004	0.005	0.006	0.005	0.005	0.005	0.002
Panama								0.021	0.021	0.023
Puerto Rico										

Solar lights and solar home systems (SHS)
Lampes solaires et systèmes solaires domestiques (SDD)
Lámparas solares y sistemas solares domésticos (SSD)

MW	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Middle East					0.027	0.056	0.122	0.214	0.526	0.536
Jordan					0.027	0.056	0.122	0.214	0.526	0.536
Oceania	0.136	0.130	0.152	0.143	0.127	0.424	0.666	0.939	1.220	1.588
Fiji	0.141	0.174	0.197	0.261	0.261	0.540	0.737	0.929	0.929	0.929
Papua N Guin					0.010	0.037	0.119	0.229	0.572	0.894
Vanuatu										0.046
S America	0.207	0.207	0.205	0.629	0.628	0.868	1.872	2.134	1.889	3.335
Argentina				0.423	0.423	0.423	0.423	0.423		
Bolivia				0.000	0.000	0.000	0.349	0.352	0.355	0.307
Brazil	0.002	0.002								0.159
Chile										
Colombia										0.876
Peru	0.205	0.205	0.205	0.206	0.205	0.444	1.100	1.359	1.533	1.993

Solar lights (<11 W)
Lampes solaires (<11 W)
Lámparas solares (<11 W)

MW	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total	1.346	1.710	1.910	1.358	4.775	11.676	29.232	46.395	55.607	58.056
Africa					1.253	4.799	14.442	24.058	28.759	27.435
Benin									0.064	0.246
Burkina Faso					0.013	0.049	0.162	0.287	0.456	0.417
Burundi							0.010	0.023	0.029	0.019
Cameroon										0.089
Congo DR					0.022	0.086	0.284	0.503	0.567	0.445
Cote d Ivoire									0.055	0.141
Ethiopia					0.256	0.975	3.171	5.597	6.324	5.356
Gambia										0.002
Ghana							0.016	0.018	0.071	0.257
Kenya					0.359	1.366	4.441	7.830	9.411	9.314
Liberia									0.024	0.052
Madagascar										0.041
Malawi					0.051	0.081	0.144	0.222	0.568	0.581
Mali									0.116	0.200
Mauritius					0.049	0.087	0.126	0.107	0.134	0.230
Mozambique							0.010	0.031	0.031	0.058
Namibia										0.010
Niger								0.015	0.015	0.015
Nigeria					0.022	0.086	0.282	0.500	0.861	1.204
Rwanda					0.048	0.180	0.589	1.039	1.013	1.224
Senegal							0.049	0.097	0.303	0.434
Sierra Leone									0.129	0.177
Somalia										0.023
South Africa									0.057	0.077
Sudan								0.000	0.000	0.000
Tanzania					0.238	0.904	2.941	5.187	5.534	3.790
Togo										0.002
Uganda					0.024	0.093	0.303	0.528	0.926	1.596
Zambia									0.208	0.294
Zimbabwe					0.172	0.890	1.916	2.076	1.861	1.142
Asia	1.346	1.710	1.910	1.354	3.469	6.755	14.456	21.686	25.512	29.088
Afghanistan							0.342	0.683	1.025	1.025
Bangladesh									0.184	0.236
Bhutan					0.023	0.023	0.023			
Cambodia									0.055	0.103
India	1.346	1.710	1.910	1.354	3.318	6.407	13.404	19.863	22.908	26.510
Indonesia					0.024	0.090	0.290	0.560	0.543	0.395
Myanmar					0.011	0.041	0.133	0.257	0.289	0.254
Nepal									0.014	0.075
Pakistan					0.007	0.026	0.085	0.166	0.264	0.235
Philippines								0.033	0.106	0.111
Sri Lanka					0.085	0.168	0.178	0.111	0.112	0.132
Timor Leste								0.013	0.013	0.013
C America + Carib				0.004	0.016	0.029	0.033	0.136	0.156	0.196
Bahamas					0.011	0.020	0.025	0.126	0.147	0.172
Dominica										
Haiti						0.002	0.002	0.002		0.017
Honduras								0.003	0.003	0.003
Nicaragua				0.004	0.005	0.006	0.005	0.005	0.005	0.002
Panama										0.002
Puerto Rico										
Middle East					0.027	0.056	0.122	0.214	0.526	0.536
Jordan					0.027	0.056	0.122	0.214	0.526	0.536
Oceania					0.010	0.037	0.119	0.229	0.572	0.762
Papua N Guin					0.010	0.037	0.119	0.229	0.572	0.717
Vanuatu										0.046

Solar lights (<11 W)
Lampes solaires (<11 W)
Lámparas solares (<11 W)

MW	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
S America				0.000	0.001	0.001	0.060	0.072	0.082	0.038
Bolivia				0.000	0.000	0.000	0.056	0.059	0.062	0.014
Colombia										0.003
Peru					0.000	0.001	0.004	0.014	0.020	0.022

Solar home systems (SHS 11-50 W)
Systèmes solaires domestiques (SSD 11-50 W)
Sistemas solares domésticos (SSD 11-50 W)

MW	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total	13.620	20.125	30.955	47.319	62.906	89.261	122.587	147.868	162.500	162.872
Africa					0.142	0.539	1.884	3.472	5.971	9.410
Ethiopia								0.007	0.007	0.024
Ghana							0.128	0.128	0.128	0.128
Kenya					0.049	0.190	0.620	1.178	1.755	2.571
Mozambique										0.026
Nigeria										0.146
Rwanda					0.009	0.032	0.103	0.196	0.292	0.423
Tanzania					0.034	0.127	0.413	0.785	1.169	1.284
Uganda					0.049	0.190	0.620	1.178	2.620	4.600
Zimbabwe										0.208
Asia	13.415	19.920	30.750	47.113	62.560	88.132	119.167	142.537	154.501	151.061
Afghanistan							0.064	0.128	0.289	0.353
Bangladesh	6.596	11.097	18.304	32.186	42.524	65.911	93.769	118.097	127.922	125.838
Cambodia							0.541	0.735	1.183	1.789
India	4.869	5.905	8.844	10.161	14.082	14.636	16.469	13.722	15.820	14.184
Myanmar										
Nepal	1.950	2.918	3.602	4.767	5.953	7.585	8.325	9.856	9.222	8.831
Philippines									0.065	0.065
C America + Carib						0.146	0.146	0.221	0.221	0.262
Guatemala								0.005	0.005	0.005
Honduras						0.146	0.146	0.195	0.195	0.236
Panama								0.021	0.021	0.021
Oceania										0.178
Papua N Guin										0.178
S America	0.205	0.205	0.205	0.206	0.205	0.444	1.390	1.639	1.806	1.962
Bolivia							0.293	0.293	0.293	0.293
Chile										
Peru	0.205	0.205	0.205	0.206	0.205	0.444	1.096	1.345	1.513	1.668

Solar home systems (SHS >50 W)
Systèmes solaires domestiques (SSD >50 W)
Sistemas solares domésticos (SSD >50 W)

MW	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total	8.591	9.553	10.183	10.489	10.807	11.289	12.470	18.299	32.151	52.200
Africa	5.131	5.808	5.893	5.899	5.933	6.129	7.246	13.010	26.789	46.773
Burkina Faso							0.047	0.093	0.140	0.186
Egypt										4.889
Guinea Bissau							0.051	0.102	0.152	0.203
Kenya									0.090	0.090
Lesotho						0.097	0.097	0.097	0.097	0.097
Mali							0.188	0.272	0.376	0.376
Morocco	4.001	4.578	4.583	4.583	4.583	4.583	4.583	4.583	15.857	15.857
Nigeria							0.466	0.931	1.397	1.862
Rwanda									0.510	5.312
South Africa							0.265	0.530	0.794	1.059
Tanzania								4.753	5.457	12.364
Tunisia	1.130	1.230	1.310	1.316	1.350	1.450	1.450	1.450	1.450	1.800
Uganda							0.100	0.200	0.468	2.678
Asia	3.460	3.745	4.290	4.590	4.875	5.160	5.224	5.289	5.362	5.427
Afghanistan							0.065	0.130	0.195	0.259
Indonesia	1.360	1.360	1.621	1.636	1.636	1.636	1.636	1.636	1.636	1.636
Mongolia	2.100	2.385	2.669	2.954	3.239	3.524	3.524	3.524	3.524	3.524
Philippines									0.008	0.008
Sri Lanka	4.898	5.576	6.255	6.934	7.613	7.613	7.613	7.613	7.613	7.613
Oceania	0.136	0.130	0.152	0.143	0.117	0.387	0.546	0.711	0.648	0.648
Fiji	0.141	0.174	0.197	0.261	0.261	0.540	0.737	0.929	0.929	0.929
S America	0.002	0.002		0.423	0.423	0.423	0.423	0.423		1.335
Argentina				0.423	0.423	0.423	0.423	0.423		
Brazil	0.002	0.002								0.159
Colombia										0.873
Peru										0.303

Solar mini-grids
Mini-réseaux solaires
Mini-redes solares

MW	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total	6.397	10.519	15.694	18.705	22.123	31.552	38.676	48.779	122.619	295.877
Africa	0.454	0.526	0.906	1.291	1.911	3.672	6.920	7.908	68.255	240.214
Algeria	0.454	0.454	0.454	0.454	0.454	0.454	0.454	0.454	49.100	219.100
Benin										0.595
Burkina Faso										0.086
Cabo Verde						0.027	0.027	0.040	0.149	0.149
Cameroon			0.010	0.010	0.010	0.010	0.010	0.010	0.082	0.154
Chad									0.122	0.122
Cote d Ivoire									0.218	0.218
Egypt									10.000	10.000
Eritrea										0.350
Gambia									0.060	0.060
Ghana								0.012	0.012	0.222
Guinea Bissau										0.312
Kenya						0.714	0.754	0.804	0.769	0.848
Liberia										
Madagascar				0.003	0.003	0.003	0.003	0.003	0.148	0.148
Mali		0.072	0.072	0.454	0.870	1.172	3.050	3.380	4.222	4.266
Mauritania								0.135	0.135	0.135
Mozambique							1.324	1.331	1.331	1.331
Namibia					0.202	0.202	0.202	0.494	0.494	0.494
Niger								0.028	0.028	0.028
Nigeria								0.045	0.045	0.045
Rwanda									0.046	0.046
Senegal			0.370	0.370	0.370	1.089	1.089	1.089	1.089	1.099
Sierra Leone							0.005	0.005	0.005	0.005
South Africa					0.001	0.001	0.001	0.001	0.001	0.001
Tanzania								0.074	0.108	0.210
Togo										
Uganda								0.005	0.092	0.092
Zambia									0.001	0.001
Zimbabwe										0.099
Asia	5.941	9.991	14.162	16.022	18.097	25.614	29.491	38.602	46.466	47.171
Afghanistan				0.100	0.100	0.100	0.344	1.394	1.394	1.797
Bangladesh				0.100	0.100	0.100	0.100	0.540	1.921	1.921
India	2.180	3.030	3.700	4.420	4.720	5.030	5.340	6.410	6.900	7.020
Indonesia	3.761	6.961	10.462	11.402	13.177	20.384	23.707	28.530	33.557	33.607
Malaysia								1.525	2.412	2.412
Maldives								0.204	0.204	0.204
Myanmar									0.079	0.211
C America + Carib					0.253	0.346	0.346	0.346	0.546	0.549
El Salvador					0.044	0.044	0.044	0.044	0.044	0.044
Guatemala					0.108	0.108	0.108	0.108	0.108	0.108
Haiti						0.093	0.093	0.093	0.293	0.296
Honduras					0.063	0.063	0.063	0.063	0.063	0.063
Nicaragua					0.039	0.039	0.039	0.039	0.039	0.039
Puerto Rico										
Middle East			0.012	0.012	0.012	0.017	0.017	0.017	3.767	3.767
Palestine			0.012	0.012	0.012	0.017	0.017	0.017	0.017	0.017
United Arab Em									3.750	3.750
Oceania									0.555	0.555
Fiji									0.555	0.555
S America	0.002	0.002	0.614	1.379	1.850	1.903	1.903	1.907	3.030	3.622
Bolivia					0.119	0.119	0.119	0.119	0.119	0.119

Solar mini-grids
Mini-réseaux solaires
Mini-redes solares

MW	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Brazil						0.040	0.040	0.040	0.040	0.040
Colombia								0.004	0.004	0.596
Ecuador					0.084	0.096	0.096	0.096	0.096	0.096
Paraguay					0.079	0.079	0.079	0.079	0.079	0.079
Peru	0.002	0.002	0.002	0.002	0.192	0.192	0.192	0.192	0.192	0.192
Uruguay									0.052	0.052
Venezuela			0.612	1.377	1.377	1.377	1.377	1.377	2.448	2.448

Solar pumps
Pompes solaires
Bombas solares

MW	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total	13.001	13.146	13.778	14.876	16.153	19.659	26.190	59.348	119.345	193.426
Africa	1.175	1.183	1.205	1.542	2.684	3.334	4.382	5.359	7.079	8.821
Algeria	0.050	0.050	0.050	0.050	0.051	0.056	0.057	0.073	0.076	0.076
Angola					0.000	0.010	0.016	0.016	0.016	0.016
Botswana						0.003	0.003	0.003	0.003	0.025
Burkina Faso					0.004	0.009	0.016	0.017	0.417	0.417
Burundi										0.002
Cameroon						0.002	0.006	0.006	0.007	0.007
Chad				0.003	0.003	0.003	0.008	0.008	0.008	0.008
Congo DR							0.001	0.001	0.001	0.005
Congo Rep						0.003	0.015	0.019	0.020	0.032
Cote d Ivoire								0.000	0.000	0.000
Djibouti				0.009	0.013	0.013	0.013	0.013	0.013	0.013
Egypt			0.002	0.043	0.043	0.097	0.325	0.607	1.117	1.350
Eritrea	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Ethiopia	0.001	0.001	0.001	0.002	0.002	0.015	0.015	0.025	0.041	0.046
Gabon					0.020	0.020	0.020	0.020	0.020	0.020
Gambia	0.048	0.050	0.052	0.163	0.163	0.163	0.223	0.249	0.249	0.554
Ghana									0.016	0.016
Guinea									0.002	0.002
Guinea Bissau			0.001	0.005	0.014	0.016	0.018	0.018	0.031	0.031
Kenya	0.009	0.014	0.020	0.025	0.027	0.069	0.111	0.220	0.298	0.349
Libya							0.004	0.004	0.004	0.004
Madagascar								0.011	0.011	0.011
Malawi						0.045	0.091	0.137	0.182	0.497
Mali	0.013	0.014	0.015	0.095	0.112	0.125	0.138	0.138	0.138	0.152
Mauritania					0.014	0.014	0.014	0.030	0.045	0.045
Morocco	0.046	0.047	0.047	0.058	0.086	0.318	0.634	0.800	1.014	1.298
Mozambique						0.001	0.001	0.008	0.011	0.021
Namibia	0.916	0.916	0.916	0.952	0.952	0.952	0.952	0.952	0.952	0.953
Niger			0.006	0.006	0.006	0.008	0.008	0.011	0.026	0.031
Nigeria	0.001	0.001	0.005	0.005	0.959	0.959	0.959	0.959	0.984	0.984
Rwanda										
Senegal					0.010	0.030	0.089	0.136	0.164	0.261
Sierra Leone					0.002	0.002	0.002	0.002	0.002	0.002
Somalia								0.075	0.108	0.108
South Africa				0.012	0.016	0.076	0.076	0.087	0.090	0.100
South Sudan							0.015	0.015	0.015	0.030
Sudan	0.002	0.002	0.002	0.002	0.002	0.007	0.020	0.020	0.022	0.022
Tanzania				0.008	0.008	0.076	0.209	0.279	0.345	0.409
Tunisia	0.086	0.086	0.086	0.086	0.096	0.105	0.105	0.113	0.260	0.260
Uganda				0.020	0.077	0.122	0.167	0.212	0.260	0.515
Zambia										
Zimbabwe	0.002	0.002	0.002	0.002	0.005	0.015	0.053	0.075	0.112	0.149
Asia	11.818	11.953	12.281	12.681	12.794	15.534	20.750	52.404	110.209	182.130
Afghanistan			0.002	0.002	0.002	0.004	0.011	0.011	0.011	0.074
Bangladesh			0.012	0.023	0.023	0.373	0.703	2.043	4.583	11.473
Cambodia			0.003	0.007	0.007	0.007	0.007	0.007	0.007	0.034
India	11.804	11.937	12.248	12.517	12.517	14.739	19.415	49.547	104.273	168.880
Indonesia	0.013	0.013	0.013	0.013	0.031	0.064	0.116	0.179	0.317	0.401
Korea DPR										0.004
Lao PDR		0.001	0.001	0.002	0.003	0.003	0.003	0.003	0.003	0.003
Malaysia				0.004	0.004	0.004	0.004	0.004	0.004	0.006
Myanmar				0.005	0.024	0.028	0.030	0.037	0.037	0.071
Nepal	0.002	0.002	0.002	0.077	0.152	0.227	0.302	0.377	0.578	0.694
Pakistan				0.025	0.025	0.079	0.125	0.153	0.199	0.221
Philippines							0.006	0.007	0.130	0.138
Sri Lanka	0.000	0.000	0.000	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Thailand				0.005	0.005	0.005	0.010	0.012	0.043	0.106
Timor Leste							0.017	0.023	0.023	0.023
C America + Carib	0.003	0.003	0.003	0.003	0.004	0.070	0.141	0.204	0.280	0.398

Solar pumps
Pompes solaires
Bombas solares

MW	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Barbados							0.001	0.001	0.001	0.001
Cayman Is							0.000	0.000	0.000	0.000
Costa Rica						0.002	0.002	0.002	0.002	0.020
Cuba										0.000
Dominican Rep	0.001	0.001	0.001	0.001	0.001	0.004	0.007	0.007	0.007	0.019
El Salvador										
Guatemala								0.001	0.011	0.025
Haiti						0.021	0.042	0.063	0.084	0.105
Honduras						0.039	0.078	0.117	0.156	0.195
Jamaica							0.006	0.008	0.013	0.013
Martinique						0.002	0.002	0.002	0.002	0.002
Nicaragua	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.012
Panama				0.000	0.000	0.000	0.000	0.000	0.000	0.005
St Kitts Nevis								0.001	0.001	0.001
Middle East	0.005	0.006	0.008	0.012	0.020	0.027	0.145	0.577	0.910	1.077
Iran IR	0.005	0.005	0.005	0.007	0.007	0.014	0.014	0.014	0.014	0.014
Iraq			0.002	0.004	0.004	0.004	0.009	0.039	0.039	0.039
Lebanon		0.002	0.002	0.002	0.002	0.002	0.032	0.269	0.269	0.269
Oman										0.011
Syrian AR					0.008	0.008	0.018	0.018	0.018	0.024
United Arab Em							0.002	0.002	0.017	0.017
Yemen							0.070	0.235	0.552	0.704
Oceania								0.001	0.001	0.027
Papua N Guin								0.001	0.001	0.001
Tonga										0.026
S America	0.000	0.001	0.282	0.637	0.650	0.694	0.772	0.803	0.866	0.972
Argentina				0.001	0.002	0.006	0.035	0.037	0.037	0.064
Bolivia							0.001	0.002	0.025	0.054
Brazil			0.001	0.001	0.001	0.001	0.001	0.001	0.010	0.012
Chile				0.002	0.006	0.035	0.037	0.042	0.052	0.071
Colombia				0.003	0.009	0.012	0.023	0.032	0.038	0.042
Ecuador				0.001	0.001	0.001	0.001	0.001	0.001	0.001
Guyana	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Paraguay		0.001	0.001	0.002	0.004	0.012	0.027	0.033	0.046	0.052
Peru				0.000	0.000	0.000	0.018	0.023	0.023	0.030

Solar pumps (agriculture)
Pompes solaires (agriculture)
Bombas solares (agricultura)

MW	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total	12.753	12.896	13.239	13.858	13.977	16.998	22.951	54.738	111.913	184.986
Africa	0.947	0.955	0.974	1.286	1.366	1.762	2.530	3.213	4.179	5.373
Algeria					0.001	0.006	0.008	0.023	0.026	0.026
Angola					0.000	0.000	0.000	0.000	0.000	0.000
Botswana						0.003	0.003	0.003	0.003	0.014
Cameroon								0.000	0.001	0.001
Congo DR							0.001	0.001	0.001	0.001
Congo Rep						0.003	0.015	0.019	0.020	0.023
Cote d Ivoire								0.000	0.000	0.000
Djibouti				0.009	0.013	0.013	0.013	0.013	0.013	0.013
Egypt			0.002	0.043	0.043	0.097	0.325	0.607	1.117	1.318
Eritrea	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Ethiopia								0.010	0.010	0.010
Gabon					0.020	0.020	0.020	0.020	0.020	0.020
Gambia	0.048	0.050	0.052	0.163	0.163	0.163	0.223	0.249	0.249	0.554
Ghana									0.016	0.016
Kenya	0.009	0.014	0.020	0.025	0.027	0.027	0.027	0.051	0.087	0.087
Madagascar								0.011	0.011	0.011
Malawi							0.001	0.002	0.002	0.272
Mali				0.080	0.080	0.093	0.106	0.106	0.106	0.106
Mauritania					0.000	0.000	0.000	0.016	0.016	0.016
Morocco		0.001	0.001	0.012	0.040	0.272	0.588	0.754	0.965	1.230
Mozambique						0.001	0.001	0.008	0.008	0.018
Namibia	0.803	0.803	0.803	0.839	0.839	0.839	0.839	0.839	0.839	0.840
Niger			0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.010
Nigeria			0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Rwanda										
Senegal					0.006	0.006	0.036	0.073	0.089	0.169
Somalia								0.032	0.032	0.032
South Africa				0.012	0.016	0.076	0.076	0.087	0.090	0.099
Sudan						0.005	0.018	0.018	0.020	0.020
Tanzania				0.008	0.008	0.008	0.063	0.073	0.079	0.079
Tunisia	0.086	0.086	0.086	0.086	0.096	0.105	0.105	0.113	0.235	0.235
Uganda									0.004	0.004
Zambia										
Zimbabwe					0.003	0.013	0.051	0.073	0.110	0.143
Asia	11.804	11.937	12.261	12.561	12.578	15.154	20.218	51.063	106.957	178.604
Afghanistan										0.046
Bangladesh			0.012	0.023	0.023	0.373	0.703	1.343	3.183	9.923
Cambodia										0.025
India	11.804	11.937	12.248	12.517	12.517	14.739	19.415	49.547	103.293	167.900
Indonesia					0.018	0.018	0.018	0.054	0.165	0.200
Lao PDR			0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Malaysia									0.000	0.002
Myanmar								0.000	0.000	0.005
Nepal									0.117	0.233
Pakistan				0.013	0.013	0.016	0.062	0.090	0.137	0.157
Philippines							0.006	0.007	0.010	0.018
Sri Lanka	0.000	0.000	0.000	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Thailand				0.005	0.005	0.005	0.010	0.012	0.043	0.086
Timor Leste								0.006	0.006	0.006
C America + Carib	0.002	0.002	0.002	0.002	0.003	0.009	0.014	0.015	0.026	0.083
Barbados							0.001	0.001	0.001	0.001
Cayman Is							0.000	0.000	0.000	0.000
Costa Rica						0.002	0.002	0.002	0.002	0.020
Dominican Rep					0.001	0.003	0.006	0.006	0.006	0.018
Guatemala									0.011	0.023
Jamaica							0.000	0.002	0.002	0.002
Martinique						0.002	0.002	0.002	0.002	0.002
Nicaragua	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.012

Solar pumps (agriculture)
Pompes solaires (agriculture)
Bombas solares (agricultura)

MW	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Panama				0.000	0.000	0.000	0.000	0.000	0.000	0.005
Middle East		0.002	0.002	0.002	0.009	0.009	0.051	0.276	0.544	0.619
Iraq										
Lebanon		0.002	0.002	0.002	0.002	0.002	0.032	0.178	0.178	0.178
Oman										0.011
Syrian AR					0.008	0.008	0.008	0.008	0.008	0.008
United Arab Em							0.002	0.002	0.017	0.017
Yemen							0.010	0.089	0.342	0.406
Oceania								0.001	0.001	0.001
Papua N Guin								0.001	0.001	0.001
S America		0.001	0.001	0.008	0.020	0.064	0.139	0.170	0.206	0.306
Argentina				0.001	0.002	0.006	0.035	0.037	0.037	0.062
Bolivia							0.001	0.002	0.007	0.033
Brazil										0.002
Chile				0.002	0.006	0.035	0.037	0.042	0.052	0.071
Colombia				0.003	0.008	0.011	0.023	0.031	0.037	0.042
Paraguay		0.001	0.001	0.002	0.004	0.012	0.027	0.033	0.046	0.052
Peru				0.000	0.000	0.000	0.015	0.020	0.021	0.028
Uruguay							0.001	0.005	0.006	0.017

Solar pumps (public water supply)
Pompes solaires (alimentation en eau publique)
Bombas solares (suministro público de agua)

MW	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total	0.248	0.250	0.539	1.018	2.176	2.661	3.239	4.610	7.432	8.440
Africa	0.228	0.229	0.230	0.257	1.318	1.572	1.853	2.146	2.900	3.448
Algeria	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
Angola						0.009	0.015	0.015	0.015	0.015
Botswana										0.012
Burkina Faso					0.004	0.009	0.016	0.017	0.417	0.417
Burundi										0.002
Cameroon						0.002	0.006	0.006	0.006	0.006
Chad				0.003	0.003	0.003	0.008	0.008	0.008	0.008
Congo DR										0.004
Congo Rep										0.009
Egypt										0.032
Ethiopia	0.001	0.001	0.001	0.002	0.002	0.015	0.015	0.015	0.031	0.036
Guinea									0.002	0.002
Guinea Bissau			0.001	0.005	0.014	0.016	0.018	0.018	0.031	0.031
Kenya						0.042	0.084	0.169	0.211	0.262
Libya							0.004	0.004	0.004	0.004
Madagascar										
Malawi						0.045	0.090	0.135	0.180	0.225
Mali	0.013	0.014	0.015	0.015	0.032	0.032	0.032	0.032	0.032	0.046
Mauritania					0.014	0.014	0.014	0.014	0.029	0.029
Morocco	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.049	0.068
Mozambique									0.003	0.003
Namibia	0.113	0.113	0.113	0.113	0.113	0.113	0.113	0.113	0.113	0.113
Niger						0.002	0.002	0.006	0.021	0.021
Nigeria	0.001	0.001	0.001	0.001	0.954	0.954	0.954	0.954	0.979	0.979
Senegal					0.004	0.024	0.053	0.063	0.075	0.091
Sierra Leone					0.002	0.002	0.002	0.002	0.002	0.002
Somalia								0.043	0.075	0.075
South Africa										0.001
South Sudan							0.015	0.015	0.015	0.030
Sudan	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Tanzania						0.068	0.146	0.206	0.266	0.330
Tunisia									0.025	0.025
Uganda				0.020	0.077	0.122	0.167	0.212	0.257	0.512
Zimbabwe	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.006
Asia	0.015	0.015	0.020	0.120	0.216	0.380	0.532	1.341	3.252	3.526
Afghanistan			0.002	0.002	0.002	0.004	0.011	0.011	0.011	0.027
Bangladesh								0.700	1.400	1.550
Cambodia			0.003	0.007	0.007	0.007	0.007	0.007	0.007	0.009
India									0.980	0.980
Indonesia	0.013	0.013	0.013	0.013	0.013	0.046	0.098	0.125	0.152	0.201
Korea DPR										0.004
Lao PDR		0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002
Malaysia				0.004	0.004	0.004	0.004	0.004	0.004	0.004
Myanmar				0.005	0.024	0.028	0.030	0.036	0.036	0.066
Nepal	0.002	0.002	0.002	0.077	0.152	0.227	0.302	0.377	0.461	0.461
Pakistan				0.012	0.012	0.062	0.062	0.062	0.062	0.065
Philippines									0.120	0.120
Thailand										0.021
Timor Leste							0.017	0.017	0.017	0.017
C America + Carib	0.001	0.001	0.001	0.001	0.001	0.061	0.127	0.189	0.254	0.315
Costa Rica										
Cuba										0.000
Dominican Rep	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
El Salvador										
Guatemala								0.001	0.001	0.001
Haiti						0.021	0.042	0.063	0.084	0.105
Honduras						0.039	0.078	0.117	0.156	0.195
Jamaica							0.006	0.006	0.012	0.012

Solar pumps (public water supply)
Pompes solaires (alimentation en eau publique)
Bombas solares (suministro público de agua)

MW	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Nicaragua										
St Kitts Nevis								0.001	0.001	0.001
Middle East	0.005	0.005	0.007	0.011	0.011	0.018	0.094	0.301	0.366	0.458
Iran IR	0.005	0.005	0.005	0.007	0.007	0.014	0.014	0.014	0.014	0.014
Iraq			0.002	0.004	0.004	0.004	0.009	0.039	0.039	0.039
Lebanon								0.091	0.091	0.091
Syrian AR							0.011	0.011	0.011	0.016
Yemen							0.060	0.146	0.211	0.298
Oceania										0.026
Tonga										0.026
S America	0.000	0.000	0.281	0.630	0.630	0.630	0.633	0.633	0.659	0.666
Argentina										0.002
Bolivia								0.000	0.018	0.021
Brazil			0.001	0.001	0.001	0.001	0.001	0.001	0.010	0.010
Colombia					0.001	0.001	0.001	0.001	0.001	0.001
Ecuador				0.001	0.001	0.001	0.001	0.001	0.001	0.001
Guyana	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Peru							0.003	0.003	0.003	0.003
Venezuela			0.280	0.628	0.628	0.628	0.628	0.628	0.628	0.628

Other off-grid solar PV
Autre solaire PV hors réseau
Otra solar PV fuera de la red

MW	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total	1.977	2.734	3.131	4.996	18.170	76.161	143.489	215.941	295.645	353.256
Africa	0.687	0.843	1.068	1.131	1.472	1.736	5.521	18.743	45.868	55.008
Algeria	0.685	0.685	0.685	0.685	0.685	0.685	0.685	0.685	0.685	0.685
Angola							0.021	0.320	0.320	0.320
Benin								0.050	0.050	0.050
Burundi									0.023	0.023
Cameroon						0.011	0.011	0.011	0.017	0.023
Chad							0.043	0.043	0.043	0.043
Congo DR					0.001	0.001	0.104	0.104	0.104	1.787
Cote d Ivoire								0.009	0.010	0.010
Eritrea						0.004	0.004	0.314	0.314	0.314
Ethiopia			0.026	0.026	0.028	0.109	0.109	3.453	3.468	8.510
Gambia						0.004	0.007	0.007	0.007	0.007
Ghana								3.200	3.219	3.220
Guinea							3.371	3.371	13.271	13.276
Kenya		0.150	0.165	0.171	0.484	0.550	0.622	5.409	17.150	17.393
Liberia					0.018	0.018	0.018	0.018	0.018	0.018
Malawi						0.003	0.003	0.003	0.003	0.003
Mali	0.002	0.002	0.002	0.002	0.002	0.059	0.088	0.098	0.098	0.237
Mauritania							0.010	0.010	0.010	0.010
Mozambique				0.000	0.000	0.000	0.038	0.124	0.256	0.488
Niger							0.003	0.003	0.003	0.003
Nigeria			0.184	0.190	0.190	0.190	0.190	0.196	5.196	6.846
Rwanda		0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
Senegal						0.000	0.000	0.000	0.004	0.004
Sierra Leone					0.008	0.008	0.024	0.024	0.024	0.130
Somalia					0.000	0.000	0.000	0.060	0.060	0.060
South Africa								0.504	0.504	0.504
South Sudan					0.000	0.007	0.046	0.046	0.055	0.069
Sudan							0.008	0.015	0.015	0.015
Tanzania				0.023	0.023	0.050	0.071	0.071	0.071	0.087
Togo							0.007	0.007	0.007	0.008
Uganda				0.027	0.027	0.032	0.032	0.032	0.032	0.032
Zambia								0.000	0.276	0.276
Zimbabwe							0.001	0.551	0.551	0.551
Asia	0.568	1.170	1.341	1.341	14.172	71.423	120.628	178.240	228.368	274.316
Afghanistan				0.000	0.000	16.000	16.000	16.000	16.000	16.644
Bangladesh								1.180	10.200	15.312
India				0.000	10.564	50.564	98.564	154.564	195.496	235.496
Indonesia	0.568	1.170	1.341	1.341	2.591	3.841	4.993	4.993	5.069	5.115
Korea DPR							0.033	0.033	0.033	0.033
Mongolia					1.008	1.008	1.008	1.008	1.008	1.008
Myanmar				0.000	0.000	0.000	0.000	0.000	0.000	0.146
Nepal					0.008	0.008	0.008	0.008	0.008	0.008
Pakistan							0.000	0.026	0.031	0.031
Philippines							0.021	0.427	0.522	0.522
Thailand				0.000	0.000	0.000	0.000	0.000	0.000	0.000
Timor Leste						0.001	0.001	0.001	0.001	0.001
Viet Nam						0.000	0.000	0.000	0.000	0.000
C America + Carib				0.544	0.545	0.600	14.542	16.043	17.551	18.854
Costa Rica										0.053
Dominican Rep							1.500	3.000	4.500	5.750
El Salvador							12.361	12.361	12.361	12.361
Haiti				0.543	0.543	0.599	0.679	0.679	0.687	0.687
Honduras								0.001	0.001	0.002
Nicaragua				0.000	0.000	0.000	0.000	0.000	0.000	0.000
Panama					0.001	0.001	0.001	0.001	0.001	0.001
Puerto Rico										
US Virgin Is										

Other off-grid solar PV
Autre solaire PV hors réseau
Otra solar PV fuera de la red

MW	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Middle East						0.007	0.034	0.140	0.268	0.485
Jordan							0.000	0.000	0.000	0.000
Lebanon						0.002	0.029	0.122	0.129	0.238
Palestine						0.005	0.005	0.005	0.005	0.005
Saudi Arabia								0.014	0.014	0.014
Syrian AR									0.000	0.000
United Arab Em									0.120	0.228
Yemen									0.000	0.000
Oceania				0.014	0.014	0.017	0.078	0.082	0.894	1.894
Cook Is							0.010	0.010	0.010	0.010
Fiji				0.014	0.014	0.014	0.024	0.028	0.728	1.728
Kiribati							0.010	0.010	0.017	0.017
Micronesia							0.010	0.010	0.010	0.010
Papua N Guin						0.003	0.003	0.003	0.003	0.003
Solomon Is							0.010	0.010	0.010	0.010
Vanuatu							0.010	0.010	0.116	0.116
S America	0.721	0.721	0.722	1.966	1.968	2.379	2.687	2.693	2.696	2.699
Argentina	0.041	0.041	0.041	1.285	1.285	1.285	1.285	1.285	1.285	1.285
Bolivia			0.000	0.001	0.002	0.004	0.009	0.009	0.009	0.009
Brazil	0.680	0.680	0.680	0.680	0.680	0.680	0.680	0.680	0.680	0.680
Chile										
Colombia										
Paraguay										
Peru						0.410	0.712	0.719	0.722	0.725
Venezuela	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Biogas (electricity)
Biogaz (électricité)
Biogás (electricidad)

MW	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total	1.400	1.470	2.156	3.180	4.710	11.712	15.614	18.114	23.115	26.590
Africa				0.004	0.139	0.139	0.156	0.216	1.531	1.551
Gabon									1.200	1.200
Ghana					0.120	0.120	0.120	0.120	0.135	0.135
Kenya				0.004	0.019	0.019	0.019	0.079	0.079	0.079
Mozambique										0.010
Nigeria										0.010
Senegal									0.100	0.100
Uganda							0.017	0.017	0.017	0.017
Asia	1.400	1.400	2.070	2.790	4.027	10.300	12.209	13.555	16.281	19.376
Bangladesh			0.670	1.390	2.060	2.750	3.420	4.120	4.250	4.650
Cambodia									1.500	1.500
India					0.567	1.150	2.389	3.035	4.131	4.826
Myanmar	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400
Philippines						5.000	5.000	5.000	5.000	5.000
Viet Nam										2.000
C America + Carib			0.016	0.316	0.458	1.187	3.163	3.457	4.417	4.677
Costa Rica			0.016	0.316	0.316	0.396	2.216	2.216	2.683	2.683
Dominican Rep					0.142	0.791	0.947	1.227	1.720	1.970
Honduras								0.014	0.014	0.014
Nicaragua										0.010
S America		0.070	0.070	0.070	0.086	0.086	0.086	0.886	0.886	0.986
Argentina										0.100
Bolivia										
Colombia										
Ecuador		0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070
Peru					0.016	0.016	0.016	0.016	0.016	0.016
Uruguay								0.800	0.800	0.800

Annex 3: Biogas production

Annexe 3: Production de biogaz

Anexo 3: Produccion de biogas

Total biogas production
Production totale de biogaz
Producción total de biogás

1,000 m^3	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total	12 068 078	13 644 173	14 799 692	16 061 869	16 885 565	16 849 928	16 852 135	16 529 907	15 850 201	15 874 758
Africa	74	296	881	3 184	8 229	17 982	27 736	38 969	45 001	50 557
Benin				8	15	20	26	39	36	34
Botswana				1	1	1	1	1	1	1
Burkina Faso			0	41	264	737	1 469	1 999	2 482	3 041
Cameroon			10	31	45	68	85	126	143	139
Ethiopia		57	74	498	1 449	2 904	4 720	6 176	7 419	8 748
Gabon									610	610
Ghana	16	110	110	110	292	292	292	4 292	4 302	4 499
Kenya			2	503	1 899	3 933	6 940	8 638	9 725	10 336
Mali							6	76	113	161
Mozambique										15
Nigeria			347	347	353	353	353	298	298	325
Rwanda	59	128	252	615	1 070	4 608	5 128	6 638	7 313	8 647
Senegal				15	249	394	612	900	1 600	2 139
Tanzania		2	61	653	1 490	2 886	5 099	6 424	7 163	7 546
Uganda			25	363	1 102	1 787	3 004	3 305	3 670	3 885
Zambia								35	70	373
Zimbabwe								21	56	56
Asia	12 067 088	13 643 049	14 796 521	16 050 174	16 868 565	16 820 890	16 806 134	16 459 364	15 585 730	15 597 338
Afghanistan										25
Bangladesh	31 231	35 219	40 129	46 457	51 865	57 991	63 591	68 881	71 557	72 713
Bhutan					22	168	455	774	1 376	1 944
Cambodia	838	2 194	3 710	5 880	8 658	11 023	11 526	12 427	16 302	16 680
China	9 883 460	11 388 364	12 548 896	13 740 204	14 487 465	14 349 844	14 304 143	13 962 937	13 103 930	13 103 930
India	1 976 397	2 015 253	1 954 801	1 959 466	1 975 503	1 996 494	1 979 659	1 918 719	1 837 628	1 819 907
Indonesia			54	1 428	4 023	6 951	9 863	12 341	13 696	16 368
Lao PDR	89	242	769	1 580	2 659	4 045	4 021	3 937	3 809	3 639
Myanmar	921	921	948	948	948	1 073	1 073	1 069	1 069	1 069
Nepal	91 778	100 117	110 940	122 894	134 167	143 654	145 842	161 997	177 334	184 274
Pakistan			58	510	1 258	2 053	2 915	4 658	4 839	5 033
Philippines						8 760	8 760	8 760	8 760	8 760
Sri Lanka	4 130	4 194	4 257	4 321	4 296	4 272	4 247	4 222	4 091	3 822
Thailand									490	490
Viet Nam	78 244	96 546	131 958	166 484	197 700	234 564	270 039	298 641	340 848	358 682
C America + Carib	916	646	613	6 793	6 999	7 736	14 950	17 313	17 754	21 024
Costa Rica			4	304	304	505	7 468	7 468	7 774	9 965
Cuba	914	644	606	6 487	6 568	6 536	6 649	8 691	8 102	8 198
Dominican Rep					124	693	830	1 075	1 507	1 726
El Salvador										120
Grenada										2
Honduras								17	17	17
Jamaica	2	2	2	2	2	2	2	2	2	2
Nicaragua							1	61	352	738
Panama										250
St Lucia										8
S America		182	1 678	1 718	1 772	3 319	3 315	14 261	201 716	205 840
Argentina										3 997
Bolivia		36	72	112	148	195	191	187	196	192
Brazil									187 434	187 434
Colombia										18
Ecuador		146	146	146	146	146	146	146	151	264
Peru			1 460	1 460	1 478	1 478	1 478	1 478	1 486	1 486

Production of biogas for cooking
Production de biogaz pour la cuisson
Producción de biogás para cocinar

1,000 m^3	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total	12 067 139	13 642 994	14 796 906	16 052 768	16 875 224	16 826 288	16 819 683	16 480 691	15 606 574	15 622 341
Africa	59	187	771	3 056	7 908	16 201	25 946	32 525	37 093	42 188
Benin				8	15	20	26	39	36	34
Burkina Faso			0	41	264	737	1 469	1 999	2 482	3 041
Cameroon			10	31	45	68	85	126	143	139
Ethiopia		57	74	498	1 449	2 904	4 720	6 176	7 419	8 748
Kenya			2	487	1 877	3 911	6 918	8 386	9 473	10 084
Mali							6	76	113	113
Nigeria			347	347	347	347	347	292	292	294
Rwanda	59	128	252	615	1 070	3 148	3 668	4 754	4 950	6 109
Senegal				15	249	394	612	900	1 235	1 774
Tanzania		2	61	653	1 490	2 886	5 099	6 424	7 163	7 546
Uganda			25	363	1 102	1 787	2 995	3 296	3 661	3 876
Zambia								35	70	373
Zimbabwe								21	56	56
Asia	12 066 167	13 642 128	14 795 458	16 048 957	16 866 445	16 809 212	16 792 752	16 445 084	15 566 680	15 576 938
Afghanistan										25
Bangladesh	31 231	35 219	39 987	46 162	51 427	57 407	62 864	68 005	70 654	71 725
Bhutan					22	168	455	774	1 376	1 944
Cambodia	838	2 194	3 710	5 880	8 658	11 023	11 526	12 427	13 382	13 760
China	9 883 460	11 388 364	12 548 896	13 740 204	14 487 465	14 349 844	14 304 143	13 962 937	13 103 930	13 103 930
India	1 976 397	2 015 253	1 954 801	1 959 466	1 974 741	1 995 081	1 976 685	1 914 996	1 832 583	1 814 065
Indonesia			54	1 428	4 023	6 951	9 863	12 341	13 696	16 368
Lao PDR	89	242	769	1 580	2 659	4 045	4 021	3 937	3 809	3 639
Myanmar			27	27	27	152	152	148	148	148
Nepal	91 778	100 117	110 940	122 894	134 167	143 654	145 842	161 997	177 334	184 274
Pakistan			58	510	1 258	2 053	2 915	4 658	4 839	5 033
Sri Lanka	4 130	4 194	4 257	4 321	4 296	4 272	4 247	4 222	4 080	3 770
Thailand										
Viet Nam	78 244	96 546	131 958	166 484	197 700	234 564	270 039	298 641	340 848	358 257
C America + Carib	914	644	606	647	728	696	810	2 910	2 608	2 913
Cuba	914	644	606	647	728	696	809	2 851	2 262	2 358
Nicaragua							1	59	346	555
S America		36	72	108	144	180	176	172	193	302
Argentina										
Bolivia		36	72	108	144	180	176	172	180	177
Colombia										
Ecuador									5	118
Peru									7	7

Production of biogas for off-grid electricity
Production de biogaz pour l'électricité hors réseau
Producción de biogás para electricidad fuera de la red

1,000 m^3	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total	921	1 067	1 213	1 672	2 788	13 104	17 924	23 031	28 457	30 138
Africa				6	75	75	84	199	618	655
Gabon									305	305
Ghana					64	64	64	64	69	69
Kenya				6	11	11	11	126	126	126
Mozambique										15
Nigeria										22
Senegal									110	110
Uganda							9	9	9	9
Asia	921	921	1 063	1 216	2 120	11 678	13 382	14 279	18 549	19 857
Bangladesh			142	295	438	584	727	876	903	988
Cambodia									2 920	2 920
India					761	1 413	2 974	3 723	5 045	5 843
Myanmar	921	921	921	921	921	921	921	921	921	921
Philippines						8 760	8 760	8 760	8 760	8 760
Viet Nam										425
C America + Carib			4	304	428	1 187	4 294	4 556	5 293	5 520
Costa Rica			4	304	304	494	3 464	3 464	3 770	3 770
Dominican Rep					124	693	830	1 075	1 507	1 726
Honduras								17	17	17
Jamaica										
Nicaragua										8
S America		146	146	146	164	164	164	3 997	3 997	4 106
Argentina										110
Bolivia										
Colombia										
Ecuador		146	146	146	146	146	146	146	146	146
Peru					18	18	18	18	18	18
Uruguay								3 833	3 833	3 833

Production of biogas for industry
Production de biogaz pour l'industrie
Producción de biogás para la industria

1,000 m^3	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total				5 840	5 959	7 459	11 452	15 452	16 012	16 282
Africa					119	119	119	4 119	4 679	4 789
Gabon									305	305
Ghana					119	119	119	4 119	4 119	4 228
Senegal									256	256
C America + Carib				5 840	5 840	5 840	9 833	9 833	9 833	9 993
Costa Rica							3 993	3 993	3 993	3 993
Cuba				5 840	5 840	5 840	5 840	5 840	5 840	5 840
Nicaragua										160
S America						1 500	1 500	1 500	1 500	1 500
Ecuador										
Venezuela						1 500	1 500	1 500	1 500	1 500

Production of biogas for commercial and public services
Production de biogaz pour services commerciaux et publics
Producción de biogás para servicios comerciales y públicos

1,000 m^3	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total	18	112	112	128	135	1 606	1 606	2 029	2 531	5 077
Africa	16	110	110	122	128	1 588	1 588	2 011	2 491	2 803
Botswana				1	1	1	1	1	1	1
Ghana	16	110	110	110	110	110	110	110	110	198
Kenya				11	11	11	11	11	11	11
Mali										49
Nigeria					6	6	6	6	6	6
Rwanda						1 460	1 460	1 883	2 363	2 538
Asia									18	59
Sri Lanka									11	52
Thailand									7	7
C America + Carib	2	2	2	2	2	2	2	2	7	2 201
Costa Rica										2 191
Grenada										2
Jamaica	2	2	2	2	2	2	2	2	2	2
Nicaragua									5	6
S America				4	4	15	15	15	15	15
Bolivia				4	4	15	15	15	15	15

Production of biogas for agriculture
Production de biogaz pour l'agriculture
Producción de biogás para la agricultura

1,000 m^3	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total			1 460	1 460	1 460	1 471	1 471	8 704	196 626	200 919
Africa								115	119	122
Ghana									4	4
Kenya								115	115	115
Nigeria										2
Asia									484	484
Thailand									484	484
C America + Carib						11	11	12	12	398
Costa Rica						11	11	11	11	11
Cuba										
El Salvador										120
Grenada										
Nicaragua								1	1	9
Panama										250
St Lucia										8
S America			1 460	1 460	1 460	1 460	1 460	8 578	196 011	199 916
Argentina										3 887
Brazil									187 434	187 434
Colombia										18
Peru			1 460	1 460	1 460	1 460	1 460	1 460	1 460	1 460
Uruguay								7 118	7 118	7 118

Annex 4: Off-grid energy access

Annexe 4: Accès à l'énergie hors réseau

Anexo 4: Acceso a la energía fuera de la red

Number of people connected to hydropower
Nombre de personnes connectées à l'hydroélectricité
Número de personas conectadas a la hidroelectricidad

Thousands	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total	2 632	2 846	3 529	4 200	4 709	5 220	5 570	5 857	6 194	6 372
Africa	231	240	251	285	295	305	315	316	389	395
Cent Afr Rep										
Eswatini										
Ethiopia	5	5	5	7	10	10	10	10	10	10
Guinea	28	28	28	28	28	28	28	28	28	28
Kenya	59	59	63	96	96	96	96	96	96	96
Lesotho	1	1	1	1	1	1	1	1	1	1
Liberia	62	62	62	62	62	62	62	63	63	63
Madagascar								1	1	1
Malawi	32	32	32	32	37	37	37	37	37	42
Mali		2	2	2	2	2	2	2	2	2
Mozambique		1	1	1	1	1	1	1	8	8
Nigeria									27	27
Rwanda	6	6	12	12	12	17	26	26	26	27
Sierra Leone						4	4	4	4	4
South Africa	0	0	0	0	0	0	0	0	0	0
Tanzania	35	35	35	35	35	35	35	35	74	74
Uganda	0	1	3	3	3	5	5	5	5	5
Zambia		5	5	5	5	5	5	5	5	5
Zimbabwe	2	2	2	2	2	2	2	2	2	2
Asia	2 358	2 562	3 233	3 869	4 368	4 867	5 204	5 485	5 748	5 919
Afghanistan	122	128	286	383	481	578	676	774	871	969
Bhutan	8	8	9	9	9	9	9	9	9	9
India	785	836	1 016	1 184	1 396	1 429	1 569	1 627	1 661	1 690
Indonesia	108	114	123	132	140	150	159	167	176	183
Malaysia	0	0	0	1	1	1	1	1	1	1
Myanmar	37	37	37	38	40	40	41	46	101	101
Nepal	784	840	881	932	1 049	1 191	1 246	1 354	1 415	1 448
Pakistan	35	96	339	638	683	890	917	917	917	917
Philippines	18	28	65	70	70	73	73	73	73	73
Sri Lanka	12	15	17	19	22	24	28	31	35	40
Tajikistan	45	56	56	59	72	78	81	81	84	85
Thailand	19	19	19	19	19	19	19	19	19	19
Timor Leste	5	5	5	5	5	5	5	5	5	5
Viet Nam	380	380	380	380	380	380	380	380	380	380
C America + Carib	39	39	41	41	41	42	47	50	52	53
Dominican Rep	1	1	2	3	3	4	6	9	11	13
El Salvador	0	1	1	1	1	1	1	1	1	1
Haiti	34	34	34	34	34	34	34	34	34	34
Honduras							2	2	2	2
Nicaragua	4	4	4	4	4	4	4	4	4	4
Fiji	3	3	3	3	3	3	3	3	3	3
S America	2	2	2	2	2	2	2	2	2	2
Argentina	2	2	2	2	2	2	2	2	2	2
Brazil				0	0	0	0	0	0	0
Colombia										
Peru	0	0	0	0	0	0	0	0	0	0

Number of people using solar lights (<11 W)
Nombre de personnes utilisant des lampes solaires (<11 W)
Número de personas que usan lámparas solares (<11 W)

Thousands	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total	969	1 231	1 375	977	5 784	15 617	39 997	64 342	88 824	100 395
Africa					1 647	6 405	19 697	33 154	46 665	48 073
Benin									143	950
Burkina Faso					23	89	288	508	990	1 076
Burundi							26	58	74	48
Cameroon										220
Congo DR					37	139	454	801	1 004	1 050
Cote d Ivoire									144	300
Ethiopia					361	1 375	4 471	7 891	10 810	9 811
Gambia										8
Ghana							29	32	98	255
Kenya					452	1 720	5 594	9 864	13 487	14 070
Liberia									55	119
Madagascar										88
Malawi					70	109	195	300	606	673
Mali									277	473
Mauritius										
Mozambique							19	62	62	103
Namibia										9
Niger								39	39	39
Nigeria					31	117	382	674	1 450	2 275
Rwanda					64	245	796	1 403	1 619	1 746
Senegal							190	380	744	923
Sierra Leone									100	228
Somalia										61
South Africa									200	235
Sudan								1	1	1
Tanzania					357	1 357	4 413	7 783	10 249	8 509
Togo										1
Uganda					34	131	426	743	1 405	2 349
Zambia									693	957
Zimbabwe					217	1 123	2 415	2 616	2 417	1 495
Asia	969	1 231	1 375	974	4 067	9 041	19 851	30 366	40 270	50 124
Afghanistan							221	443	664	664
Bangladesh									329	358
Bhutan					10	10	10			
Cambodia									46	148
India	969	1 231	1 375	974	3 902	8 624	18 723	28 353	37 413	46 973
Indonesia					27	104	338	655	665	611
Myanmar					14	54	175	338	421	414
Nepal									59	207
Pakistan					14	54	176	340	403	434
Philippines								80	111	131
Sri Lanka					100	196	209	129	131	154
Timor Leste								28	28	28
C America + Carib				3	4	8	7	9	6	35
Bahamas										
Dominica										
Haiti						3	3	3		27
Honduras								2	2	2
Nicaragua				3	4	5	4	4	4	2
Panama										3
Puerto Rico										
Middle East					50	104	226	398	977	997
Jordan					50	104	226	398	977	997
Oceania					15	58	187	363	836	1 095
Papua N Guin					15	58	187	363	836	1 067
Vanuatu										28

Number of people using solar lights (<11 W)
Nombre de personnes utilisant des lampes solaires (<11 W)
Número de personas que usan lámparas solares (<11 W)

Thousands	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
S America				0	1	2	28	51	69	71
Bolivia				0	1	1	21	27	33	25
Colombia										5
Peru					1	1	8	25	37	40

Number of people using SHS (11-50 W)
Nombre de personnes utilisant des SSD (11-50 W)
Número de personas que usan SSD (11-50 W)

Thousands	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total	2 044	2 920	4 405	6 404	8 564	11 912	15 835	19 170	21 205	21 400
Africa					43	165	571	1 055	1 825	2 470
Ethiopia								1	1	3
Ghana							35	35	35	35
Kenya					14	53	173	330	491	674
Mozambique										3
Nigeria										39
Rwanda					3	10	31	59	88	103
Tanzania					11	42	138	262	390	428
Uganda					16	60	194	369	820	1 127
Zimbabwe										58
Asia	2 027	2 903	4 389	6 388	8 504	11 689	15 119	17 936	19 184	18 681
Afghanistan							6	12	21	27
Bangladesh	726	1 221	2 013	3 540	4 678	7 440	10 291	13 288	14 155	13 929
Cambodia							55	73	115	172
India	935	1 134	1 698	1 951	2 707	2 822	3 202	2 710	3 150	2 882
Myanmar										
Nepal	367	549	677	896	1 119	1 426	1 565	1 853	1 734	1 660
Philippines									10	10
C America + Carib						21	21	34	34	38
Guatemala								2	2	2
Honduras						21	21	27	27	31
Panama								5	5	5
Oceania										34
Papua N Guin										34
S America	16	16	16	16	16	37	124	145	162	177
Bolivia							30	30	30	30
Chile										
Peru	16	16	16	16	16	37	94	115	132	147

Number of people using SHS (>50 W)
Nombre de personnes utilisant des SSD (>50 W)
Número de personas que usan SSD (>50 W)

Thousands	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total	635	715	752	797	828	869	935	1 011	1 272	2 118
Africa	375	424	429	430	431	443	500	566	837	1 607
Burkina Faso							4	8	12	15
Egypt										29
Guinea Bissau							3	6	8	11
Kenya									3	3
Lesotho						7	7	7	7	7
Mali							7	11	15	15
Morocco	313	357	357	357	357	357	357	357	483	483
Nigeria							26	52	79	105
Rwanda									31	249
South Africa							14	27	41	55
Tanzania								13	60	412
Tunisia	62	68	72	72	74	80	80	80	80	99
Uganda							3	6	20	126
Asia	256	285	317	346	375	395	399	403	407	411
Afghanistan							4	8	12	15
Indonesia	11	11	13	13	13	13	13	13	13	13
Mongolia	148	168	188	209	229	249	249	249	249	249
Philippines									0	0
Sri Lanka	97	107	116	125	134	134	134	134	134	134
Oceania	4	5	6	8	8	16	22	27	27	27
Fiji	4	5	6	8	8	16	22	27	27	27
S America	0	0		14	14	14	14	14		72
Argentina				14	14	14	14	14		
Brazil	0	0								1
Colombia										57
Peru										15

Number of people connected to solar mini-grids (Tier 1)
Personnes connectées aux mini-réseaux solaires (N.1)
Número de personas conectadas a mini-redes solares (N.1)

Thousands	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total	0	0	146	216	230	319	374	531	611	708
Africa			1	3	8	97	152	224	270	366
Benin										79
Burkina Faso										3
Cameroon			1	1	1	1	1	1	8	15
Ghana								2	2	2
Kenya						63	63	63	75	77
Liberia										
Madagascar				2	2	2	2	2	2	2
Mali					5	31	84	119	144	150
Mauritania								16	16	16
Mozambique							1	3	3	3
Nigeria								11	11	11
Senegal										1
Sierra Leone										
Tanzania										
Uganda								7	7	7
Zambia									1	1
Asia								85	120	120
Bangladesh									25	25
India								85	85	85
Indonesia										
Myanmar									10	10
S America	0	0	145	213	222	222	222	222	222	222
Peru	0	0	0	0	9	9	9	9	9	9
Venezuela			145	213	213	213	213	213	213	213

Number of people connected to solar mini-grids (Tier 2)
Personnes connectées aux mini-réseaux solaires (N.2)
Número de personas conectadas a mini-redes solares (N.2)

Thousands	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total	134	210	297	341	385	555	676	805	1 122	1 425
Africa	6	9	26	26	36	99	141	153	298	585
Algeria	6	6	6	6	6	6	6	6	91	344
Benin										2
Burkina Faso										1
Cabo Verde						0	0	0	1	1
Cameroon										
Chad									1	1
Cote d Ivoire									4	4
Egypt									25	25
Eritrea										16
Gambia									2	2
Ghana										2
Guinea Bissau										7
Kenya							2	3	5	6
Madagascar									6	6
Mali		3	3	4	13	13	44	49	65	65
Mozambique							11	11	11	11
Namibia					1	1	1	3	3	3
Niger								1	1	1
Rwanda									1	1
Senegal			17	17	17	78	78	78	78	78
Sierra Leone							0	0	0	0
South Africa					0	0	0	0	0	0
Tanzania								2	2	4
Togo										
Uganda									3	3
Zimbabwe										3
Asia	129	201	271	314	348	453	532	650	759	773
Afghanistan				2	2	2	5	14	14	20
Bangladesh				2	2	2	2	12	39	39
India	80	111	135	162	173	184	197	221	238	241
Indonesia	49	90	136	148	171	265	328	398	463	463
Malaysia								1	3	3
Maldives								2	2	2
Myanmar										4
C America + Carib						2	2	2	5	5
Haiti						2	2	2	5	5
Middle East			0	0	0	0	0	0	0	0
Palestine			0	0	0	0	0	0	0	0
United Arab Em										
Oceania									14	14
Fiji									14	14
S America					0	1	1	1	46	48
Bolivia					0	0	0	0	0	0
Brazil						1	1	1	1	1
Colombia								0	0	2
Ecuador						0	0	0	0	0
Paraguay					0	0	0	0	0	0
Peru										
Uruguay									0	0
Venezuela									44	44

Number of people using biogas electricity
Nombre de personnes utilisant l'électricité biogaz
Número de personas que usan electricidad biogás

Thousands	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total	226.5	226.5	226.5	226.5	230.4	232.1	234.3	236.3	271.4	276.8
Africa							0.1	0.1	0.1	0.7
Uganda							0.1	0.1	0.1	0.1
Mozambique										0.6
Asia	226.5	226.5	226.5	226.5	230.2	231.9	234.0	236.0	271.1	275.9
Cambodia									34.3	34.3
India					3.7	5.4	7.5	9.5	10.3	15.1
Myanmar	226.5	226.5	226.5	226.5	226.5	226.5	226.5	226.5	226.5	226.5
S America					0.2	0.2	0.2	0.2	0.2	0.2
Peru					0.2	0.2	0.2	0.2	0.2	0.2

Number of people using biogas for cooking
Nombre de personnes utilisant le biogaz pour la cuisson
Número de personas que usan biogás para cocinar

Thousands	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total	90 720	102 735	115 000	120 028	126 527	128 159	127 628	125 105	125 631	125 746
Africa	0	1	6	24	63	131	213	272	318	371
Benin				0	0	0	0	0	0	0
Burkina Faso			0	0	3	8	16	22	27	33
Cameroon			0	0	0	1	1	1	1	1
Ethiopia		0	1	4	11	22	36	48	57	67
Kenya			0	4	14	30	54	65	74	78
Mali							0	1	2	2
Nigeria			3	3	3	3	3	2	2	2
Rwanda	0	1	2	5	8	23	27	35	37	45
Senegal				0	3	6	11	19	30	45
Tanzania		0	1	5	12	24	42	53	59	62
Uganda			0	3	8	14	23	25	28	30
Zambia								0	1	3
Zimbabwe								0	0	0
Asia	90 714	102 729	114 989	119 999	126 458	128 021	127 407	124 809	125 290	125 350
Afghanistan										0
Bangladesh	129	146	166	194	217	244	269	291	307	314
Bhutan					0	1	4	6	12	16
Cambodia	7	19	32	50	74	94	98	106	114	117
China	78 825	90 455	102 763	107 442	113 523	114 668	113 938	111 355	111 938	111 938
India	10 613	10 822	10 497	10 522	10 604	10 713	10 615	10 283	9 841	9 741
Indonesia			0	6	17	30	42	53	58	70
Lao PDR	0	1	4	8	13	20	20	19	19	18
Myanmar			0	0	0	1	1	1	1	1
Nepal	802	875	970	1 074	1 173	1 256	1 275	1 416	1 550	1 611
Pakistan			1	4	11	18	25	41	42	44
Sri Lanka	18	18	18	18	18	18	18	18	17	16
Thailand										
Viet Nam	319	394	539	680	807	957	1 102	1 219	1 391	1 462
C America + Carib	5	4	4	4	4	4	5	21	20	22
Cuba	5	4	4	4	4	4	5	21	17	18
Nicaragua							0	0	2	4
S America		1	1	2	2	3	3	3	3	4
Argentina										
Bolivia		1	1	2	2	3	3	3	3	3
Colombia										
Ecuador									0	1
Peru									0	0

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