IRENA
International Renewable Energy Agency

Renewable Energy and Jobs

Annual Review 2016



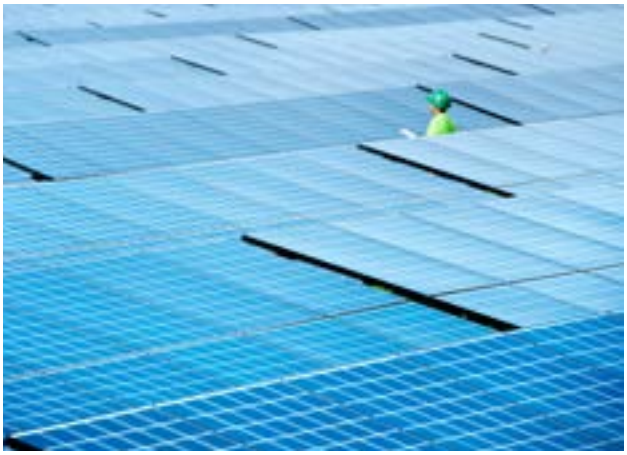
Key Facts

Annual Review 2016

- IRENA estimates that global renewable energy employment increased by 5% in 2015 to reach 8.1 million. An additional 1.3 million people are employed in large hydropower.
- While the growth in jobs slowed down compared to previous years, the total number of jobs in renewables worldwide continued to rise, in stark contrast with depressed labour markets in the broader energy sector.
- Countries with the highest number of renewable energy jobs were China, Brazil, the United States, India, Japan and Germany. Jobs continued to shift towards Asia and the share of the continent in global employment increased to 60%.
- Solar PV was the largest renewable energy employer with 2.8 million jobs worldwide, an 11% increase over 2014. Solar PV employment grew in Japan and the United States, stabilised in China, and continued decreasing in the European Union.

IRENA
International Renewable Energy Agency

- Wind power witnessed a record growth year. Strong installation rates in China, the United States and Germany resulted in a 5% increase in global employment, to reach 1.1 million jobs.
- Bioenergy is a key employer, with liquid biofuels accounting for 1.7 million, biomass 822,000 and biogas 382,000 jobs. Biofuel employment declined by 6% due to mechanisation in some countries and low biofuel production in others.
- Jobs in solar water heating and cooling declined to reach 940,000, as markets in China, Brazil and the European Union contracted.
- Direct jobs in large hydropower fell to 1.3 million due to a drop in new installations. Most of the jobs were in operation and maintenance, and China, Brazil and India were key employers.
- IRENA's early research indicates that the renewable energy features more gender parity than the broader energy sector.



Renewable Energy and Jobs

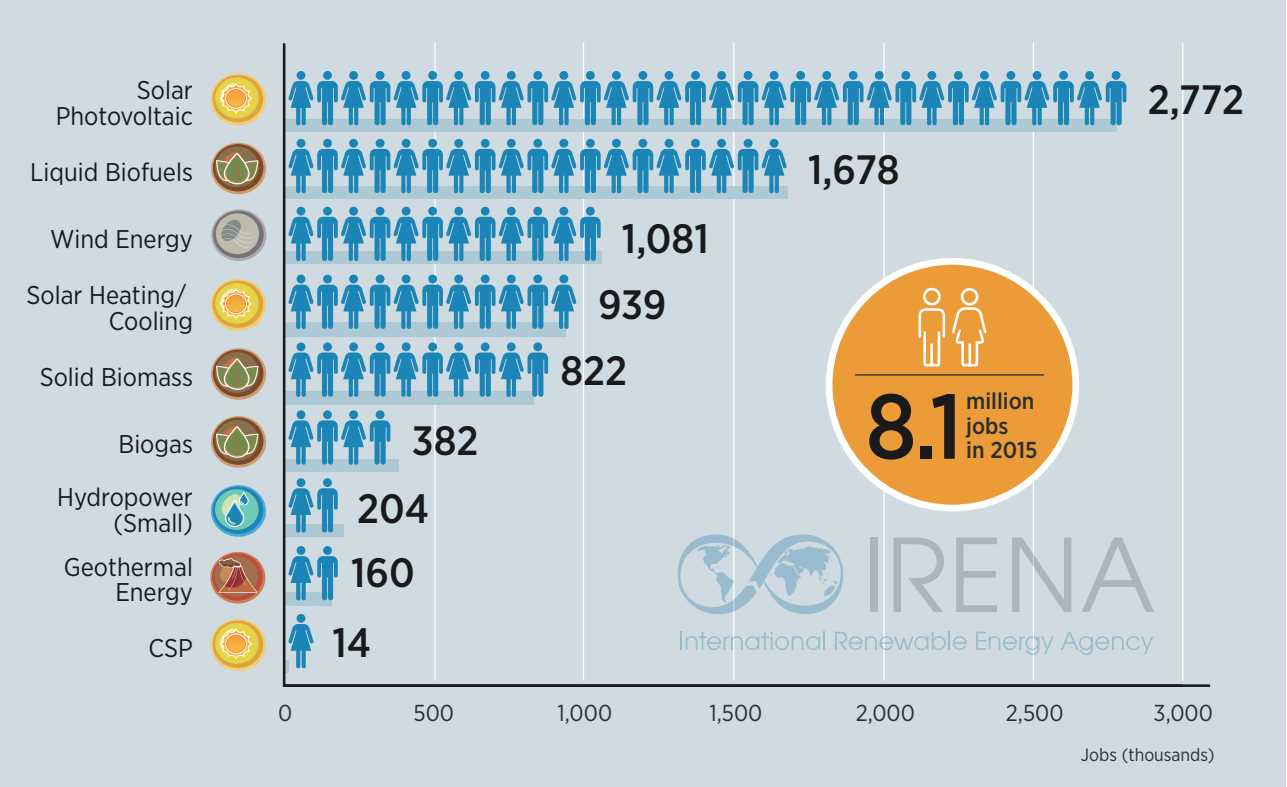
Annual Review 2016

The renewable energy sector employed 8.1 million people, directly or indirectly, in 2015. In addition, large hydropower accounted for another 1.3 million direct jobs in 2015[1]. Renewable energy markets and employment continued to be shaped by favourable policy frameworks in several countries, regional shifts in deployment and increased labour productivity.

Enabling policy frameworks remained, indeed, a key driver of employment. In India, for example, national and state level auctions put ambitious solar targets into action and created jobs. Wind energy auctions in Brazil, coupled with financing rules to encourage local content, created job opportunities throughout the value chain. In the United States, federal investment tax credits, working

[1] Data are principally for 2014–2015, with dates varying by country and technology, including some instances where only earlier information is available. Large hydropower employment has not been included in the total given significant year-on-year fluctuations in investments in the sector which are then reflected in job creation. If included, analysis of renewable energy employment trends is difficult.

FIGURE 1: **RENEWABLE ENERGY EMPLOYMENT BY TECHNOLOGY**



in tandem with state level net metering and renewable portfolio standards, helped sustain the growth of jobs in the solar industry.

Driven by favourable policies and declining technology costs, rising deployment of renewables in Asian markets kept driving the regional shifts in job numbers from Europe. Increased demand in Asian markets created employment opportunities in the installation segment of the value chain, and fostered domestic equipment manufacturing in some countries. Production of solar PV equipment, in particular, continued to be concentrated in manufacturing hubs such as China and Japan, mainly as a response to rising demand.

Increasing labour productivity and production overcapacities continued to influence job creation in 2015. Mechanisation in biofuel feedstock production, for instance, further decreased labour requirements in Brazil. Similarly, Chinese solar PV and wind manufacturers introduced greater automation. Leftover stocks of PV panels from 2014 exacerbated the job-loss trend.

While growth in employment slowed compared to previous years, the total number of jobs in renewables worldwide continued to rise, in stark contrast with depressed labour markets in the broader energy sector. In the United States, for example, renewable energy jobs increased by around 6%, while employment in oil and gas extraction (and support activities) contracted by 18% (Saha and Muro, 2016). In China, renewable energy employed around 3.5 million people, exceeding the 2.6 million employed in the country's oil and gas sector (CNREC, 2016).

The third edition of Renewable Energy and Jobs – Annual Review discusses the trends in employment and provides the latest update on job numbers, both by technology (Figure 1) and in selected countries (Figure 3). The table at the end of this review summarises the findings across major markets.

RENEWABLE ENERGY EMPLOYMENT BY TECHNOLOGY

SOLAR PHOTOVOLTAICS

Further cost decreases in solar PV have been driving deployment both at the utility and distributed levels, enhancing job creation. Globally, solar PV installations in 2015 were 20% larger than in the previous year, with China, Japan, and the United States in the lead. Consequently, solar PV was again the largest renewable energy employer with 2.8 million jobs in 2015, an 11% increase over the previous year.

China was the dominant solar PV employer, with 1.7 million jobs in 2015, due to its undisputed lead in both manufacturing and installations. Japan's solar PV employment surged 28% to reach 377,100 jobs in 2014, the most recent year available, partly as a consequence of attractive feed-in tariffs (JPEA, 2016). In the United States, high rates of deployment brought job creation to record levels. In contrast, solar PV employment in the European Union (EU) has fallen by 13% in 2014[2], mainly due to a decrease in manufacturing (EY, 2015).

Several Asian countries, other than China and Japan, have also taken promising strides in solar PV employment. India, for instance, emerged as a major market at both large and small-scale. The region witnessed job growth in solar PV manufacturing in Malaysia and the Republic of Korea, and in solar PV installation in Pakistan.

While supportive deployment policies had a significant impact on solar PV jobs, trade policies continued to affect manufacturing employment in different countries. India, for instance, supported its local solar PV manufacturing industry through local content requirements, which should increase employment in the coming years. The United States and the EU have both levied duties on panel imports from China. The Chinese module suppliers have reacted by locating their new facilities in a number of other countries such as Malaysia, Thailand, the Republic of Korea, India, Brazil and the United States (Osborne, 2015). Overall, employment in solar PV manufacturing continued to shift to Asian countries.

Distributed solar PV increasingly offers a promising solution for energy access. Different parts of the value chain (*e.g.*, assembly, distribution, after sales service) can easily be localised to create jobs as illustrated by countries like Bangladesh, India and Kenya (see Box 1).

LIQUID BIOFUELS

Employment in liquid biofuels declined by 6% in 2015 to reach 1.7 million. This was mainly due to continued mechanisation in countries such as the United States and Brazil and falling production in others like Indonesia. Jobs increased in the EU, Malaysia and Thailand.

With 821,000 jobs, Brazil continues to have the largest liquid biofuel workforce by far. Reductions of about 45,000 jobs in the country's ethanol industry (due to the ongoing mechanisation of sugarcane harvesting, even as production rose) were only partially offset by job growth in biodiesel. Other important biofuel job markets in Latin America include Colombia and Argentina. Similarly, employment declined in the United States by 2% despite an increase in the production of ethanol and biodiesel. Biofuel employment in the EU increased by 8% in 2014 as production rose. Continued growth in production in 2015 most probably resulted in further job creation.

Indonesia's palm oil-based biofuel industry grew dramatically since 2006, until exports collapsed in 2015. Biodiesel production dropped by more than half and the utilisation rate of biorefinery capacity fell to

[2] *The most recent year for which data are available.*

BOX 1: EMPLOYMENT OPPORTUNITIES IN OFF-GRID SOLAR PV

Jobs in off-grid solar PV can result from different applications, ranging from stand-alone installations (*e.g.* solar lanterns and solar home systems) to mini-grids. In general, stand-alone applications create more local jobs in installation and equipment distribution, while mini-grids require more employees in operations and maintenance (*e.g.* to collect tariffs). Given limited information for employment in solar PV based mini-girds, this box focuses on jobs in stand-alone applications.

Countries such as Bangladesh, India and Kenya, used stand-alone solar PV systems to provide electricity access and create jobs. In 2015, Bangladesh, added an estimated 700,000 solar home systems (SHS), raising the total cumulative installations in the country to 4.5 million (Shahan, 2016). IRENA estimates that the workforce in the stand-alone solar PV sector in the country has increased by 13% to reach 127,000 jobs, a quarter of which are in manufacturing, with the remaining spread across distribution, installation and after-sales services. India has also been successful in creating employment opportunities along the off-grid solar PV value chain, which accounts for 73,000 jobs according to the last available estimates (MNRE and CII, 2010). Companies that build, install and maintain stand-alone systems are rapidly scaling up operations and creating jobs along the value chain. D.Light, which manufactures and retails solar lanterns and SHSs, has sold over 10 million solar products, employing over 400 staff (D.Light, 2016). MKOPA has sold over 300,000 SHSs in Kenya, Uganda, and the United Republic of Tanzania and created more than 700 full-time jobs along with 1,500 sales representatives. Similarly, several other companies (see Table 1) are serving vast populations and creating jobs in Sub-Saharan Africa and South East Asia.

TABLE 1: EMPLOYMENT IN SELECTED OFF-GRID SOLAR COMPANIES - MID-2015

Company Name	Full-time Employees	Countries / Regions of Operation	Number of Customers (Last 12 months / Cumulative)
Azuri Technologies	480	United Republic of Tanzania, Kenya, Uganda, Rwanda, Sierra Leone, Zambia	N.A. / 75,000
BBOXX	168	Rwanda, Kenya, Uganda	23,105 / 250,000
D. Light	>400	Uganda, Kenya, China, India	N.A./10 million
Fenix International	120	Uganda, Kenya	115,000 / 165,000
Foundation Rural Energy Services	342	Mali, South Africa, Burkina Faso, Uganda, Guinea Bissau	30,000 / 330,000
Grameen Shakti	6,550	Bangladesh	52,000 / 1.7 million
Mera Gao Power	125	India	8,000 / 22,000
M-KOPA	>700	Kenya, Uganda, United Republic of Tanzania	1.1 million / 3.75 million
Mobisol	>500	United Republic of Tanzania, Rwanda	70,000 / 110,000
Off Grid Electric	>800	United Republic of Tanzania, Rwanda	10,000 per month / N.A.
Renewable Energy Foundation	>400	Sub Saharan Africa	N.A. / >93,000
Simpa Networks	300	India	55,000 / 75,350
Solaraid	130	Kenya, Malawi, United Republic of Tanzania, Uganda, Zambia	519,212 / 10 million
Solar Kiosk	70	Ethiopia, Kenya, United Republic of Tanzania, Rwanda, Botswana, Ghana, Vietnam	802,500 / 1 million
Solar Now	194	Uganda	3,114 /8,476
Solar Sister	58	Nigeria, United Republic of Tanzania, Uganda	152,000 / 281,000
Sunlabob	42	Lao People's Democratic Republic, Cambodia, Uganda, Afghanistan, Sierra Leone, Mozambique and Liberia	N.A. / > 25,000
Tessa Power	300	Niger, Nigeria, Mali	2,000 / 5,000

Sources: Azuri (n.d.); D.Light (2016); Energy Access Practitioner Network (2015); Grameen Shakti (2016); IRENA (2012); Kent (2015); M-KOPA Solar (2015, 2016); Mobisol (2015); Nijland (2015); Sunlabob (2016); Wesoff (2015)

24% (USDA-FAS, 2015a). IRENA estimates Indonesia's biofuel employment in 2015 at 94,800 jobs, down from 223,000 the previous year[3]. Elsewhere in South East Asia, jobs in biofuel continued to increase. Biofuel employment in Thailand, Malaysia and the Philippines reached 76,900, 31,800 and 9,700 jobs, respectively.

WIND

Wind witnessed a record year with strong installations growth in China, the United States and Germany, resulting in 5% increase in global employment, to reach 1.1 million. China leads the way with close to half the jobs. Germany, where offshore wind is also picking up, and the United States are also top players, followed by Brazil and India.

China's position as a leading employer is underlined by the strong showing of Chinese wind companies. Goldwind, for example, now ranks as the world's largest wind energy company in terms of new capacity commissioned, ahead of Denmark's Vestas and GE of the United States, the two closest rivals. Five out of the top 10 wind companies in terms of new commissioned capacity in 2015 are Chinese (BNEF, 2016).

Wind employment in the United States rose by 20% to 88,000 jobs, as new capacity additions grew by two-thirds over 2014 (AWEA, 2016). Brazil saw strong gains, with an estimated 41,000 wind jobs in 2015, up 14%. The EU added about 10,000 wind jobs during 2014 (up about 4%).

SOLAR HEATING AND COOLING

China kept the lead in solar heating but suffered job losses for the second year running, due to a slowing housing market and the removal of subsidies in 2013. India, Brazil, Turkey and the United States are other major employers.

A review of the literature suggests a rough global employment figure of 940,000 jobs. The Chinese solar water heating market accounts for the vast majority (80%) of global installations and employment, but employment fell to 743,000 jobs in 2015[4]. The EU accounts for 6.5% of global installed capacity and 36,000 jobs. Other available estimates include India (75,000 jobs[5]), Brazil (41,000 jobs), and the United States (10,400 jobs). Turkey, an emerging solar heating market, has 90 manufacturers, 700-800 retailers, and more than 3,000 system installers, who all together provide 20,000 direct and indirect jobs (IEA-SHC, 2015). Tunisia, through the PROSOL programme, has generated more than 1,500 jobs in the solar water heating sector (ANME, 2016).

HYDROPOWER

Estimating small hydropower employment is challenging since certain activities of the supply chain are shared with large hydropower and a significant share of the jobs are informal. IRENA finds that employment in this technology has decreased by 13% to reach 200,000 in 2015. This is largely due to job losses in China, where installed capacity has recently fallen by around 10%. China accounts for half of the estimated jobs in small hydropower, followed by India, Germany and Brazil. Large hydropower employed more than 1.3 million people, with the majority in the operation and maintenance segment of the value chain (Box 2).

OTHER TECHNOLOGIES

There is considerably less information available for other renewable energy technologies, such as biogas, biomass, geothermal and ocean energy, which can potentially lead to an underestimation of global employment. Country-level employment information is especially scarce in applications that address the demand for cooking and motive power in rural areas. However, anecdotal evidence from the literature suggests significant potential for job creation (Box 3).

[3] *The calculation relies on an employment factor initially developed for an APEC study in 2010 (APEC, 2010). IRENA then applies an assumed "decline" factor of 3% per year to reflect rising labor productivity.*

[4] *The 2014 estimates for employment in Chinese solar heating and cooling industry were revised to include an estimated 220,000 installation jobs, thus increasing the total to 820,000 jobs*

[5] *Estimate dating back to 2011 - the most recent year available.*

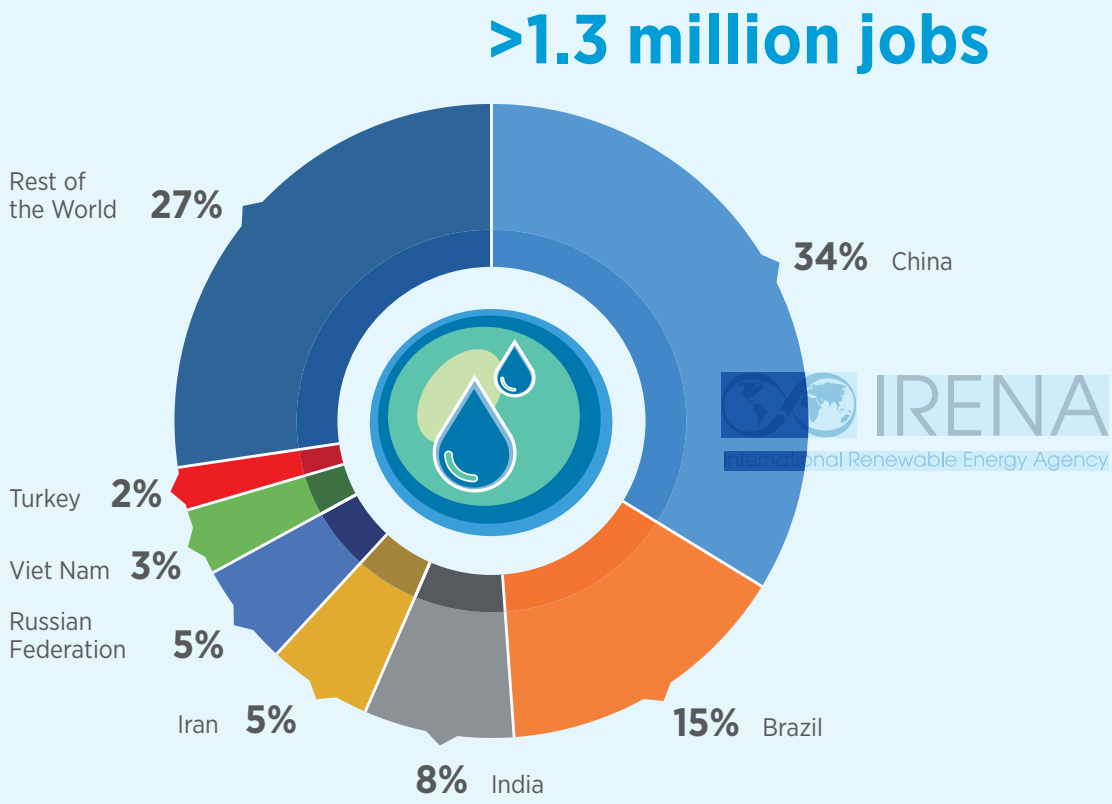
BOX 2: **LARGE HYDROPOWER**

The available information on employment for this technology is especially sparse. For the second year running, IRENA has conducted the global employment factor-based estimation to fill the data gap. The results reveal approximately 1.3 million direct jobs in 2015, down 13% from last year.

The estimates allow for a better understanding of the dynamics along the segments of the value chain. In 2013, several new projects were coming online and the construction and installation segment was the largest employer, with 52% of the jobs. In 2015, new capacity additions have declined by around 40% and jobs in the construction and installation segment have decreased to 43% of the total. The operations and maintenance segment is now the largest, with 51% of the jobs.

The results show that China's dominance of large hydropower employment has somewhat declined from 42% in 2013 to 34% in 2015, primarily due to a slowdown in new installations and a leaner project pipeline. Brazil is the second largest employer with 15% of the total large hydropower jobs, followed by India, Iran, the Russian Federation and Viet Nam (Figure 2). Other relevant employers are Turkey, Canada, the United States and Paraguay.

FIGURE 2: **EMPLOYMENT IN LARGE HYDROPOWER BY COUNTRY**



BOX 3: OFF-GRID RENEWABLES FOR COOKING AND MOTIVE POWER

Several renewable energy sources can be used to provide heat for cooking (mainly biomass and biogas) or motive power for agro-processing or other uses (mainly small watermills) in rural areas.

Traditional biomass dominates with around 9% of global final energy consumption. It supports the livelihoods of around 3 billion people and creates millions of jobs. The Food and Agriculture Organization of the United Nations (FAO) estimates that 41 million people work worldwide in commercial fuelwood and charcoal production, including 19 million in Africa, 11 million in Asia and 11 million in the Americas, mostly South America (FAO, 2014).

Improved cookstoves, which constitute a crucial upgrade for sustainable bioenergy use, are also source of employment. The partners of the Global Alliance for Clean Cookstoves, for instance, manufactured almost 10 million cookstoves, employing 76,000 people in 2012, of which 54% were women. In addition to the job opportunities, women benefited from reduced exposure to smoke and time saved in fuelwood collection (Global Alliance for Clean Cookstoves, 2013).

Biogas, often used for cooking and heating applications in rural settings, also support jobs. The SNV Biogas programme in Viet Nam, for instance, has installed over 150,000 digesters since 2003, creating around 4 jobs per installation during the construction phase (IRENA, 2016 forthcoming).

Small watermills can be used to produce electricity or harness motive power for agricultural or industrial processes. An improved watermills programme in Nepal, for example, created an estimated 8,500 jobs in operation and maintenance alone, feeding electricity into mini-grids to supply almost 900 households while also providing motive power for agro-processing (IRENA, 2016 forthcoming).

Overall, renewable energy offers a key solution for the provision of universal access to modern energy sources, in line with the United Nation's Sustainable Development Goal 7. In addition to the development benefits, providing access represents a vast potential market for job creation. The market for renewable applications for cooking and motive power has been picking up in rural areas in several countries, but further policy action is needed to accelerate deployment and to maximise the socio-economic benefits.

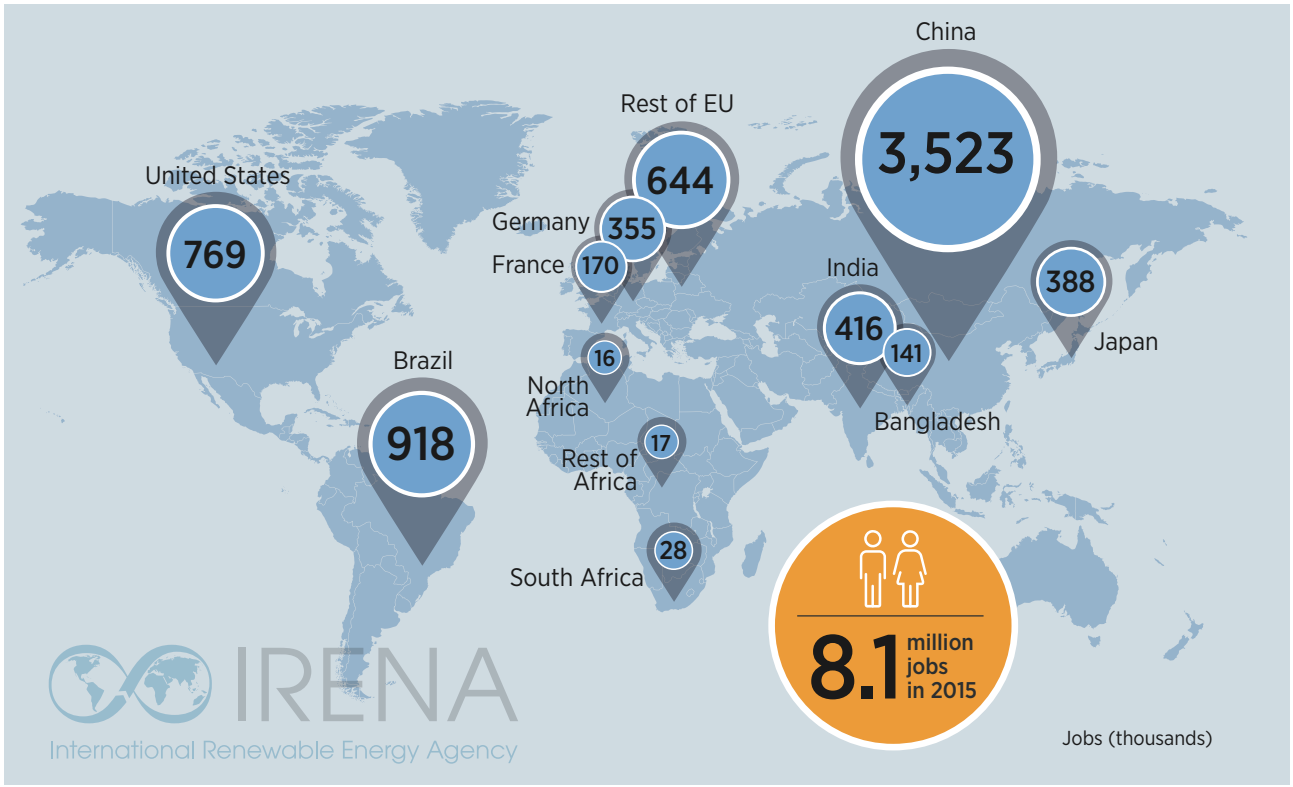
RENEWABLE ENERGY EMPLOYMENT IN SELECTED COUNTRIES

For the second year in a row, the global top-ten in job creation includes four countries in Asia. The continent's share of total renewable energy employment reached 60% in 2015, up from 51% in 2013. African countries also witnessed an increase, with a conservative estimate of 61,000[7] jobs in 2015 as new projects came online. The leading employers are[8] in China, Brazil, the United States, India, Japan and Germany (Figure 3).

With more than a third of the global renewable energy capacity additions in 2015, **China** led employment with 3.5 million jobs, a minor reduction of 2% over previous year. Gains in solar PV and wind were offset by losses in the solar heating and cooling and small hydropower sectors.

Even though annual solar PV installations increased to a record 15 GW (up from 9.5 GW in 2014), employment edged up by just 1%, to 1.65 million jobs. The slow growth can be attributed to: 1) automation in the solar PV manufacturing sector; 2) use of leftover stocks of solar PV panels from 2014; and 3) consolidation of market shares in favour of large suppliers/manufacturers,

FIGURE 3: **RENEWABLE ENERGY EMPLOYMENT IN SELECTED COUNTRIES AND REGIONS**



[7] *This does not include the jobs in improved cookstoves, charcoal and fuelwood (see Box 1).*
[8] *This section analyses the job estimations excluding large hydropower.*

resulting in economies of scale. Of the total, 1.3 million jobs were in manufacturing, 330,000 in installations, and a comparatively small 22,000 in operations and maintenance. Similarly, wind employment in China grew marginally (1%) to reach 507,000 jobs in 2015. Despite strong growth in deployment, factors such as overproduction in 2014 and market consolidation played a key role in decelerating growth in jobs (CNREC, 2016).

For the second year in a row, employment in the Chinese solar water heating industry fell (by 9%) as sales declined (down 17%) due to a slowdown in the real estate market and removal of subsidies back in 2013. Employment in small hydropower facilities declined by 26,000 jobs, reflecting a reduced pace of new installations.

In **Brazil**, most renewables employment is found in bioenergy and large hydropower. Jobs in the wind sector are growing, as a result of increasing deployment and local manufacturing.

Employment in biofuels declined (by 3%) as jobs in bioethanol dropped by 46,000 due to growing mechanisation[9]. Brazil's biodiesel production, mainly soy-based, rose to a record 3.9 billion litres in 2015 (ABIOVE, 2015). IRENA estimates that biodiesel employment increased by 15% to reach 162,600 jobs in 2015[10].

Wind industry grew rapidly in 2015 with 2.8 GW of new installations primarily driven by wind energy auctions. In tandem, financing rules to encourage local content resulted in the strengthening of the Brazilian wind equipment manufacturing and service industry. Correspondingly, Brazil's wind employment increased to 41,000, up from 35,800 in 2014. While jobs in the installation segment remain dominant, manufacturing jobs also increased with the opening of a number of factories along the entire supply chain (ABEEolica, 2016) (GWEC, 2016b&c).

New installations in Brazil's solar heating market declined by 3% in 2015 due to delays in implementation of the social housing programme Minha Casa Minha Vida as well as an overall reduction in purchasing power and investments. Total employment in 2015 is estimated at about 41,000 jobs, including 30,000 in manufacturing and the rest in installation[11] (Alencar, 2013) (Epp, 2016). To date, Brazil has manufactured and installed PV equipment only on a small-scale. Employment in solar PV is estimated at 4,000 jobs, but is expected to rise with greater deployment in the future. Indeed, several manufacturers have indicated interest in setting up solar PV manufacturing facilities.

Driven by growth in wind and solar, renewable energy employment in the **United States** increased by 6% in 2015 to reach 769,000 jobs. Solar employment continued its rapid expansion – growing by almost 22% to reach 209,000 in 2015. Jobs in the solar industry grew 12 times as fast as overall job creation in the U.S. economy, and surpassed those in oil and gas extraction (187,200) or coal mining (67,929). Most solar jobs (194,200) are in solar PV, with relatively few in solar heating/cooling (10,400) and CSP (4,200). The installation sector accounts for 57% of these jobs, with manufacturing representing less than 15%. Almost two thirds of all solar jobs in 2015 were in the residential market, 22% in the utility-scale segment, and 15% in commercial installations. Given the U.S. Congress' extension of the federal Investment Tax Credit through 2021, continued fast growth is expected[12]. Much of it is likely to occur in the utility-scale market, which is less labour intensive[13] than rooftop (Solar Foundation, 2016).

Noteworthy in the U.S. solar market is the growing share of women in the workforce. They accounted for 24% of the total 209,000 jobs, up from 19% in 2013 (Solar Foundation, 2016). This is more than in the conventional energy industry, but still well below the 47% share in the economy as a whole. The share of women in the U.S. solar workforce is comparable to Germany and Spain, with 24% and 26%, respectively (see Box 4).

Employment in the United States wind industry registered a 21% gain to reach 88,000 jobs, as annual installations rose by 77% to reach 8.6 GW in 2015. The growth was driven by the Production Tax Credit (PTC)

[9] In 2015, Brazil had around 268,000 workers in sugar cane cultivation, 190,000 workers in ethanol processing and another 200,000 indirect jobs in equipment manufacturing (MTE/RAIS, 2016).

[10] Based on employment factors (Da Cunha et al., 2014) and on the shares of different feedstock raw materials (USDA-FAS, 2015b)

[11] IRENA calculation of installation jobs is based on Brazilian market data (DASOL, 2015) and a solar heating and cooling employment factor (Mauthner, 2014). The estimate for manufacturing jobs is provided by Alencar (2013).

[12] Economic modeling before the ITC extension suggested that as many as 100,000 direct and indirect jobs could be lost in 2017 in the absence of extension. Between 2016 and 2022, solar employment was projected to be 32% larger with an ITC extension than without it (SEIA, 2015).

[13] Residential-scale installations require 40 labor hours per 5 kW of capacity: commercial-scale requires 36 hours, and utility-scale just 25 hours.

BOX 4: WOMEN IN MODERN RENEWABLE ENERGY JOBS

Gender-disaggregated data in the renewable energy sector is scarce. As a first step to close this gap, IRENA conducted an online survey among private companies working in the sector. Nearly 90 companies from more than 40 countries participated, representing the entire value chain of the sector (including, manufacturing, installation, operations and maintenance, consulting and policy making).

Among the companies that responded, women represent an average 35% of the workforce. This is a significant finding, considering women only account for 20 - 25% of the workforce in the overall energy industry. (Stevens *et al.*, 2009). This may reflect greater interest among women in sustainability-related fields. Yet the percentage remains lower than women's economy-wide share in employment, which is 40 - 50% for most OECD countries (World Bank, 2016).

35%

Average share of women working at 90 renewable energy companies surveyed

The survey results are generally in line with numbers submitted in the annual reports of large companies. At Trina Solar and REC Group, for example, women represent 42% and 35% of the workforce, respectively (REC Solar ASA, 2015, Trina Solar, 2014)[14].

The survey also provides insight on the roles women fulfill in the sector. On average, women represent 46% of the administrative workforce, 28% of the technical workforce, and 32% of management roles. The latter is a marked increase from the estimated 25% of senior-level management positions held by women in Fortune 500 companies in 2015. Indeed, as a new and fast-growing sector, renewables could give women opportunities to gain commensurate representation in higher management.

While the survey provides some company-level insights, it does not yet reveal the evolution of gender roles within the sector. Country-specific literature points to a positive trend of greater participation of women. The solar industry in the United States, for example, reports an increase in women's employment from 19% in 2013 to 24% in 2015.

The entry of more women into the renewable energy job market could enrich the fast-growing sector with a wider pool of skills. IRENA will continue to gather primary data from the different actors in the sector to monitor women's evolving participation in the renewable energy workforce.

[14] *IRENA itself strives to set an example for gender equality by employing 50% women.*

as developers sought to ensure project completion by the end of 2016 - the expected end of the qualification period (BNEF and BCSE, 2016). The subsequent extension of the PTC until January 2020 should ensure continued growth of the wind energy industry in the next 5 years. Manufacturing factories employed 21,000 people; construction, project development and transportation accounted for 38,000 jobs, and operation and maintenance for 29,000 jobs (AWEA, 2016; Cusick, 2015).

Following a high yield of corn crops and falling feedstock prices, ethanol production in the United States rose 3.7% to a record of 56 billion litres in 2015 (Peterka, 2015). Despite the growth in output, ethanol employment declined by 2% to reach 227,600 due to decreasing labour intensity (Urbanchuk, 2016). Meanwhile, biodiesel production (4.8 billion litres; EIA, 2016) and employment (49,500 jobs) remained virtually unchanged in 2015 from the previous year.

In 2014, for the fourth year in a row, member states of the **European Union** witnessed a decline in renewable energy employment. As in previous years, economic crises and adverse policy conditions led to reduced investments. The total number of jobs fell by 3% to reach 1.17 million in 2014[15]. The wind industry accounted for most of these jobs, led by Germany, the United Kingdom, Denmark, Sweden, Greece and Austria, while a few other countries saw some progress. The United Kingdom, Germany, and Denmark were the global leaders in offshore wind employment. A third of Denmark's 30,000 wind jobs, for instance, depend on offshore projects (Jepsen, 2015) (O'Sullivan *et al.*, 2015)[16].

Employment in the European solar PV industry is now just one third of its 2011 peak, largely due to a reduction in manufacturing (EY, 2015). The United Kingdom became the continent's largest PV installation market (2.6 GW in 2014), and the second-largest employer with 35,000 people. However, cuts in feed-in tariffs for residential rooftop in the United Kingdom could result in a loss of 4,500 to 8,700 solar jobs (DECC, 2015).

For the biofuels sector, conservative estimates indicate 105,000 jobs across the EU in 2014[17] (an 8% increase). Employment in the next largest sectors, biogas and geothermal energy (including heat pumps), stayed unchanged. Small hydropower and solar thermal technologies saw small reductions.

[15] *This total, along with the other European Union figures, is based on EurObserv'ER (2015), but is adjusted with national data from APPA (2015) for Spain; from REA (2015) for the UK; and from BMFLUW (2015) for Austria.*

[16] *Denmark is also home to a strong wind turbine manufacturing industry.*

[17] *European Biodiesel Board estimates biodiesel alone to employ 220,000 people. The ethanol supply chain may employ another 70,000 according to ePure.*

Despite a 4% decline in employment in 2014, **Germany** remains the European country with the highest number of jobs by far – almost as much as France, the United Kingdom, and Italy combined (O'Sullivan *et al.*, 2015). The decrease in employment mirrors trends in investments in new renewable energy projects - down almost a third from their peak in 2010. The drop in domestic consumption was partly compensated by increasing exports, which support about a quarter of all German renewables jobs. The German wind equipment manufacturing industry, which holds a 20% share of the global market, exported two-thirds of its production in 2015 (GWEC, 2016a).

Onshore wind registered job gains of about 10% in 2014. Even though job estimates for 2015 are not available yet, Germany installed more new wind capacity last year than in 2014[18]. However, changes from binding expansion targets to annually-variable auctioned quantities in 2016 may introduce uncertainties (O'Sullivan *et al.*, 2015; GWEC, 2016a&b; EWEA, 2016).

Germany's solar PV industry fared poorly, suffering a 38% decline in sales in 2014. Employment decreased by 32%, reaching 38,300 jobs[19], reflecting the third consecutive decrease in domestic installations and a reduction in manufacturing amid an ongoing shift to Asia. The German CSP sector was marked by insolvencies and companies exiting the market (O'Sullivan *et al.*, 2015).

France remained the second largest renewable energy employer in the EU, but employment fell by 4%, to reach 170,000 people in 2014. The country lost jobs in solar PV, biomass, geothermal heat pumps and solar thermal. Biofuels, geothermal energy and small hydropower added jobs.

Spain, once a leader in renewable energy, continues to fade, with exports being the only lifeline. Employment in 2014 declined to 76,300 jobs[20], about half the peak in 2008. Adverse policies in the electricity sector continue to drive the decline in wind, solar and biomass power (APPA, 2015).

In **India**, the solar and wind markets have seen substantial activity, as the ambitious renewable energy targets are translated into concrete policy frameworks. Central and state auctions for solar PV, for instance, have resulted in the installation of 1.9 GW in 2015 and an impressive pipeline of 23 GW. Solar PV employs an estimated 103,000 people in grid-connected (31,000 jobs) and off-grid applications (72,000 jobs)[21].

The Indian government's push for 100 GW of cumulative PV installations by 2022 is generating momentum (Puri, 2015). With increasing domestic demand, local companies are utilizing their production capabilities and several foreign companies are interested in investing. Irrespective of further developments in manufacturing, reaching the government's goal of 100 GW PV by 2022 could generate 1.1 million jobs in construction, project commissioning and design, business development, and operations and maintenance. However, meeting skills requirements (30% of these jobs would be highly-skilled) requires stepping up training and educational initiatives (CEEW and NRDC, 2016).

The Indian wind energy industry has also had a fruitful year with the installation of more than 2.5 GW. Employment has remained steady at 48,000 jobs.

[18] *6 GW installed – the third-largest capacity worldwide after China and the United States*

[19] *The German solar industry association, however, reported a range of 45,000 to 50,000 jobs for 2014 (BSW-Solar, 2015).*

[20] *EurObserv'ER (2015) reports an even lower figure of 60,450 jobs.*

[21] *The estimates for grid-connected employment are based on employment factors developed by Bridge to India for rooftop and utility-scale installations. Jobs in off-grid solar PV are based on a dated estimate by MNRE and CII (2010)*

Japan experienced impressive gains in solar PV in recent years, resulting in a 28% increase in employment in 2014. A strong domestic market in 2015 likely supported further job growth in both construction and manufacturing, especially since 60% of panels were supplied by domestic companies (JPEA, 2016) (Clover, 2016 a&b).

However, latest policy developments, specifically with feed-in-tariffs, may change the trend. The tariffs were cut twice during 2015, with analysts warning that new installations may decline starting in 2017. Challenges pertaining to grid connection, available land and financing may further limit installations and thus dampen employment prospects (Clover, 2016 a&b).

Several other **Asian countries** are also showing signs of progress in solar PV. **Malaysia** was home to 19,000 direct solar PV jobs in 2015. Given the limited number of domestic installations, around 60% of these jobs are in solar PV manufacturing plants that have been set up to cater to foreign markets. The **Republic of Korea** supports more than 8,200 jobs in solar PV manufacturing and distribution. **Pakistan** created jobs primarily through small-scale installations in residential and commercial sectors. The solar industry in the country imported and installed an estimated 800 MW of PV modules in 2015, creating jobs for around 20,000 people.

Africa has a significant untapped potential for renewable energy deployment, and has witnessed a number of interesting developments, leading to job creation. In North Africa, Egypt and Morocco are not only deploying wind farms, but also a manufacturing base.

In northeastern **Egypt**, Siemens has announced plans to set up a rotor blade factory in 2017, creating 1,000 jobs (Weston, 2015). Egypt also has a budding PV sector that currently employs an estimated 3,000 people, but is expected to add many more jobs in 2016 (NREA, 2016).

Morocco's 160 MW Noor I CSP plant started operations in early 2016. It created 1,800 jobs during construction along with 250 permanent operations jobs (Zawya, 2015). For Noor II, AFDB projects 2,000 to 2,500 construction jobs and 400 to 500 operations jobs (AFDB, 2014). Following construction, which employed 700 people, Morocco's

300 MW Tarfaya wind farm became fully operational in late 2014, with about 50 operations jobs (Al Arabiya, 2014). As part of a winning consortium under a 850 MW government tender (Dodd, 2016), a Siemens factory in Tangier is scheduled to start producing blades for the domestic and export markets in the spring of 2017, with a workforce of up to 700 (Siemens, 2016).

In **Kenya**, wind development is generating jobs in construction, and operation and maintenance. Construction for the 310 MW Lake Turkana wind farm, Sub-Saharan Africa's largest, began in late 2014, due to be completed in April 2017 (LTWP, 2015) The project may create 2,500 jobs spread over the course of the construction period and up to 200 full time jobs during its operation (Makenzi, 2015).

Since 2011, **South Africa** has carried out four bidding rounds under its Renewable Energy Independent Power Producer Procurement Programme (REIPPPP), with a fifth to be unveiled in 2016. Estimates indicate that close to 20,000 jobs have been created in the solar industry alone (Warner, 2014).

As distributed solar PV becomes more affordable, it offers opportunities for alleviating energy poverty, reducing reliance on polluting fuels and creating jobs. Several parts of the solar PV value chain (*e.g.,* distribution, sales, operations, and after sales service) are easy to localize. As discussed earlier in Box 1, a number of companies and initiatives are beginning to scale up in several Sub-Saharan African countries.

THE WAY FORWARD

As the ongoing energy transition accelerates, renewable energy employment will remain strong. While growth is likely to slow down with a maturing industry and rising labour productivity, IRENA's estimates that doubling the share of renewables in the global energy mix would result in more than 24 million jobs worldwide by 2030 (IRENA, 2016). Meeting the increasing labour requirements of the renewable energy sector will require stable and predictable policy frameworks that encourage deployment, stimulate investments in local industries, strengthen firm-level capabilities and promote education and training.

TABLE 2: **ESTIMATED DIRECT AND INDIRECT JOBS IN RENEWABLE ENERGY WORLDWIDE, BY INDUSTRY**

	World	China	Brazil	United States	India	Japan	Bang-ladesh	European Union[i]		
								Germany	France	Rest of EU
Solar Photovoltaic	**2.772**	1.652	4	194	103	377	127	38	21	84
Liquid Biofuels	**1.678**	71	821[c]	277[f]	35	3		23	35	47
Wind Power	**1.081**	507	41	88	48	5	0.1	149	20	162
Solar Heating/ Cooling	**939**	743	41[d]	10	75	0.7		10	6	19
Solid Biomass[a,g]	**822**	241		152[e]	58			49	48	214
Biogas	**382**	209			85		9	48	4	14
Hydropower (Small)[b]	**204**	100	12	8	12		5	12	4	31
Geothermal energy[a]	**160**			35		2		17	31	55
CSP	**14**			4				0.7		5
Total	**8,079[h]**	**3.523**	**918**	**769**	**416**	**388**	**141**	**355[j]**	**170**	**644[k]**

Note: *Figures provided in the table are the result of a comprehensive review of primary (national entities such as ministries, statistical agencies, etc.) and secondary (regional and global studies) data sources and represent an ongoing effort to update and refine available knowledge. Totals may not add up due to rounding.*

[a] Power and heat applications (including heat pumps in the case of the European Union). [b] Although 10 MW is often used as a threshold, definitions are inconsistent across countries. [c] About 268,400 jobs in sugarcane and 190,000 in ethanol processing in 2014; also includes 200,000 indirect jobs in equipment manufacturing, and 162,600 jobs in biodiesel in 2015. [d] Equipment manufacturing and installation jobs. [e] Biomass power direct jobs run only to 15,500. [f] Includes 227,562 jobs for ethanol and 49,486 jobs for biodiesel in 2015. [g] Traditional biomass is not included. [h] The total for 'World' is calculated by adding the individual totals of the technologies, with 3,700 jobs in ocean energy, 11,000 jobs in renewable municipal and industrial waste and 14,000 jobs in others (jobs that cannot be broken down by technology). [i] All EU data are from 2014 and the two major EU job markets are represented individually. [j] Includes 8,300 jobs in publicly funded R&D and administration; not broken down by technology. [k] Includes 8,000 jobs in renewable municipal and industrial waste and 3,700 jobs in ocean energy.

Note: *Data are principally for 2014–2015, with dates varying by country and technology, including some instances where only earlier information is available.*

REFERENCES

ABIOVE (Brazilian Association of Vegetable Oil Industries) (2015), "*Biodiesel: Production and Delivery - December, 2015*," www.abiove.com.br/site/index.php?page=statistics&area=MTAtMi0x.

AfDB (African Development Bank) (undated), "*Largest concentrated solar plant in Africa reducing Morocco's dependency on external power*," http://www.afdb.org/en/projects-and-operations/selected-projects/largest-concentrated-solar-plant-in-africa-reducing-morocco's-dependency-on-external-power/.

AfDB (2014), "*Ouarzazate Solar Power Station Project II. Summary Environmental and Social Impact Assessment*," www.afdb.org/fileadmin/uploads/afdb/Documents/Environmental-and-Social-Assessments/Morocco_-_Ouarzazate_Solar_Power_Station_Project_II_-_ESIA_Summary.pdf.

AfDB and CIF (2015), "*NOORo: the largest concentrated solar power complex in Africa increases the share of renewable energy in electricity generation in Morocco*," www.afdb.org/fileadmin/uploads/afdb/Documents/Generic-Documents/NOORo_Press_Kit_Eng.pdf.

Al Arabiya (2014), "*Morocco wind farm, Africa's biggest, starts generating power*," 25 April, http://english.alarabiya.net/en/business/2014/04/25/Morocco-win-farm-Africa-s-biggest-starts-generating-power-.html.

Alencar, C. A. (2013), "*Solar Heating & Cooling Market in Brazil*," presentation at Intersolar, September, available at http://solarthermalworld.org/sites/gstec/files/news/file/2013-11-06/ dasol_presentation_at_intersolar_2013.pdf.

ANME (National Agency of Energy Conservation, Tunisia) (2016), Communication with experts, March 2016.

APEC (Asia-Pacific Economic Cooperation) (2008), "A Study of Employment Opportunities from Biofuel Production in APEC Economies".

APPA (Asociación de Productores de Energía Renovables) (2015), *Study of the Macroeconomic Impact of Renewable Energies in Spain*. Year 2014, Madrid.

AWEA (American Wind Energy Association) (2016), *U.S. Wind Industry Annual Market Report Year Ending 2015,* Washington, DC.

Azuri (n.d.), "*What We Do*," www.azuri-technologies.com/what-we-do#how-it-works

BMFLUW (Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Austria) (2015), *Erneuerbare Energie in Zahlen. Die Entwicklung erneuerbarer Energie in Österreich im Jahr 2014.* Vienna, December.

BNEF (Bloomberg New Energy Finance) (2015), "*How Extending the Investment Tax Credit Would Affect US Solar Build*," 15 September.

BNEF (2016), "*In a First, Chinese Firm Tops Annual Ranking of Wind Turbine Makers*," press release, London and New York, 22 February,

BNEF and BCSE (Business Council for Sustainable Energy) (2016), *2016 Sustainable Energy in America Factbook*.

Bridge to India (2015), *India Solar Map 2015 Edition*, 23 September.

BSW-Solar (Bundesverband Solarwirtschaft) (2015), "*Statistische Zahlen der deutschen Solarstrombranche (Photovoltaik)*," February, www.solarwirtschaft.de/fileadmin/media/pdf/2015_2_BSW_ Solar_Faktenblatt_Photovoltaik.pdf.

CEEW (Council on Energy, Environment and Water) and NRDC (Natural Resources Defense Council) (2016), *Filling the Skill Gap in India's Clean Energy Market: Solar Energy Focus*, New Delhi and New York, January.

Clover, I. (2016a), "Japan to hit solar peak of 14.3 GW this year, finds BNEF," *PV Magazine*, 18 February, www.pv-magazine.com/news/details/beitrag/japan-to-hit-solar-peak-of-143-gw-this-year--finds-bnef_100023281/#axzz40sn26VSJ.

Clover, I. (2016b), "Japan proposes 11% FIT cut as domestic solar demand falls," *PV Magazine*, 23 February, www.pv-magazine.com/news/details/beitrag/japan-proposes-11-fit-cut-as-domestic-solar-demand-falls_100023330/.

CNREC (China National Renewable Energy Centre) (2016), Communication with experts, March 2016.

Cusick, D. (2015), "Renewables Boom Expected Thanks to Tax Credit," *Scientific American*, 21 December, www.scientificamerican.com/article/renewables-boom-expected-thanks-to-tax-credit/.

D.Light (2016), Company website, www.dlight.com

Da Cunha, M.P., Guilhoto, J. J.M., and Da Silva Walter, A.C. (2014), "*Socioeconomic and environmental assessment of biodiesel production in Brazil*," The 22nd International Input-Output Conference 14 - 18 July, Lisbon, Portugal. Available at: https://www.iioa.org/conferences/22nd/papers/files/1771_20140512071_Paper_Cunha_Guilhoto_Walter.pdf.

DASOL (Departamento Nacional de Aquecimento Solar) [Brazil] (2015), "*Relatório de Pesquisa. Produção de Coletores Solares para Aquecimento de Água e Reservatórios Térmicos no Brasil. Ano de 2014*," May.

DECC (Department of Energy and Climate Change) [UK] (2015), *Periodic Review of FITs 2015*, London, 17 December, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/486084/IA_-_FITs_consultation_response_with_Annexes_-_FINAL_SIGNED.pdf.

Dodd, J. (2016), "Morocco confirms 850MW tender results," *Wind Power Monthly*, 14 March, www.windpowermonthly.com/article/1387236/morocco-confirms-850mw-tender-results.

EIA (U.S. Energy Information Administration) (2016), "*U.S. Biodiesel production capacity and production*," www.eia.gov/biofuels/biodiesel/production/table1.pdf.

Energy Access Practitioner Network (2015), *Investing for Energy Access. 2015 Directory of Investment and Funding Opportunities*, Washington, DC: United Nations Foundation.

EurObserv'ER (2015), *The State of Renewable Energies in Europe, 2015 edition*, December.

EWEA (European Wind Energy Association) (2016), *Wind in Power. 2015 European Statistics*, Brussels, February.

EY (2015), "*Solar Photovoltaics Jobs & Value Added in Europe*", www.solarpowereurope.org/fileadmin/user_upload/documents/Media/Jobs___Growth.pdf

FAO (2014), "*State of the World's Forests 2014. Enhancing the socio-economic benefits from forests*", www.fao.org/forestry/sofo/en/

Global Alliance for Clean Cookstoves (2013), "*2012 Results report*". Global Alliance for Clean Cookstoves, Washington DC.

Grameen Shakti (2016), "*Programs at A Glance*", www.gshakti.org/index.php?option=com_content&view=category&layout=blog&id=54&Itemid=78

GWEC (Global Wind Energy Council) (2016a), "*Germany adds 3.5 GW onshore wind, bringing the total new installations to over 5.8 GW in 2015*," press release, www.gwec.net/germany-adds-3-5-gw-in-2015/.

GWEC (2016b), *Global Wind Statistics 2015*, Brussels, 10 February. www.gwec.net/wp-content/uploads/vip/GWEC-PRstats-2015_LR.pdf

GWEC (2016c), *Global Wind Report 2015*, Brussels,

IEA-SHC (International Energy Agency Solar Heating and Cooling Programme) (2015), "*Country Report – Turkey. Status of Solar Heating/Cooling and Solar Buildings – 2015*," www.iea-shc.org/country-report-turkey.

IRENA (2012), "*Renewable Energy Jobs & Access: A Series of Case studies*". IRENA, Abu Dhabi.

IRENA (2016), 'Renewable Energy Benefits: Measuring The Economics'. IRENA, Abu Dhabi.

IRENA (2016 forthcoming), "*Renewable Energy Benefits: Decentralised Solutions in Agriculture*". IRENA, Abu Dhabi.

Jepsen, S. (2015), "*Expanding offshore wind industry provides job opportunities*," 30 November, https://www.linkedin.com/pulse/expanding-offshore-wind-industry-provides-job-steen-jepsen-.

JPEA (Japan Photovoltaic Energy Association) (2016), Communication with experts, March 2016.

Kent, A. (2015), "*The Employment Revolution: Part 1. How BBOXX is Fighting Africa's Youth Unemployment Crisis*," 12 January, www.bboxx.co.uk/the-employment-revolution-part-1

LTWP (Lake Turkana Wind Power Project) (2015), "*The Lake Turkana Wind Power Project – Fact Shee*t," June. www.ltwp.co.ke/the-project/overview.

Makenzi, L. (2015), "Kenya leaping forward with Lake Turkana Wind Project," *Clean Leap*, 31 May, http://cleanleap.com/kenya-leaping-forward-lake-turkana-wind-project.

Mauthner, F. (2014), e-mail communication, 8 April.

MNRE and CII (Ministry of New and Renewable Energy [India] and Confederation of Indian Industry) (2010), Human Resource Development Strategies for Indian Renewable Energy Sector.

M-KOPA Solar (2015), "Affordable, clean energy: a pathway to new consumer choices." *Lessons from M-KOPA's first three years of innovative energy service*, October.

M-KOPA Solar (2016), "*300,000 East African Homes Now on M-KOPA*," 13 January, www.m-kopa.com/press-release/asante-sana-300000-east-african-homes-now-on-m-kopa

Mobisol (2015), "*Mobisol installs 3MW PV on 30,000 African households*," 2 November, www.plugintheworld.com/mobisol/2015/11/02/mobisol-installs-3mw-pv-on-30000-african-households

MTE/RAIS (Ministério do Trabalho Emprego (Ministry of Labor and Employment) / Relação Anual de Informações Sociais (Annual Report of Social Information) [Brazil] (2016), *Annual List of Social Information.* Database including active and inactive employments for sugarcane cultivation and alcohol manufacture, accessed March 2016.

Nijland, C. (2015), "*Financing Clean Energy Rural Electrification Projects*," www.ruralelec.org/fileadmin/DATA/Documents/07_Events/SAIREC_2015/20150904_Financing_RE_Projects_def.pdf

NREA (New & Renewable Energy Authority, Egypt) (2016), Communication with experts

O'Sullivan, M., Lehr, U., and Edler, D. (2015), "Bruttobeschäftigung durch Erneuerbare Energien in Deutschland und verringerte fossile Brennstoffimporte durch Erneuerbare Energien und Energieeffizienz. *Zulieferung für den Monitoringbericht 2015*", Berlin, Bundesministerium für Wirtschaft und Energie, September.

Osborne, M. (2015), "Seismic shift: No new solar PV manufacturing expansion plans announced for China in 1H 2015", www.pv-tech.org/news/seismic_shift_no_new_solar_pv_manufacturing_expansion_plans_announced_for_c

Peterka, A. (2015), "Biofuels: U.S. Now No. 1 Exporter – USDA," *Greenwire*, 3 September, www.eenews.net/greenwire/2015/09/03/stories/1060024252.

Puri, A. (2015), *F.I.T.T. for Investors. Make Way for the Sun*, Deutsche Bank Markets Research, 19 July.

REA (Renewable Energy Association) (2015), *REview 2015, Renewable Energy View*, 8 May, www.r-e-a.net/resources/rea-publications.

Saha, D., and Muro, M. (2016), "Rigged: Declining U.S. oil and gas *rigs forecast job pain*", www.brookings.edu/blogs/the-avenue/posts/2016/03/16-declining-us-oil-gas-rigs-saha-muro

SEIA (Solar Energy Industries Association) (2015), "*Solar ITC Impact Analysis*," www.seia.org.

Siemens (2016), "Siemens to Build Rotor Blade Factory for Wind Turbines in Morocco," *press release*, 10 March, www.siemens.com/press/pool/de/pressemitteilungen/2016/windpower-renewables/PR2016030214WPEN.pdf.

Shahan, Z. (2016), "25 Million People Benefit From Home Solar In Bangladesh (Video)", http://cleantechnica.com/2016/04/06/25-million-people-benefit-from-home-solar-in-bangladesh/

Solar Foundation (2016), *National Solar Jobs Census 2015. A Review of the U.S. Solar Workforce*, Washington, DC, January.

Sunlabob (2016), "About Us", www.sunlabob.com/about-us.html#our-achievements

Epp, B. (2016), "*Big Ups and Downs on Global Market*", www.solarthermalworld.org/content/big-ups-and-downs-global-market

Urbanchuk, J.M. (2016), *Contribution of the Ethanol industry to the Economy of the United States in 2015*, ABF Economics, Doylestown, PA, February 5.

USDA-FAS (U.S. Department of Agriculture, Foreign Agricultural Service) (2015a), "*Indonesia Biofuels Annual Report 2015*", 31 July 2015. Available at: http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Biofuels%20Annual_Jakarta_Indonesia_7-31-2015.pdf

USDA-FAS (2015b), "*Brazil Biofuels Annual*", 10 August 2015. Available at: http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Biofuels%20Annual_Sao%20Paulo%20ATO_Brazil_8-4-2015.pdf

Warner, G. (2014), "*Solar energy in South Africa – Challenges and opportunities*," www.solarcentury.com/za/media-centre/solar-energy-south-africa-challenges-opportunities

Wesoff, E. (2015), "*Off Grid Electric Raises $45M in Debt for African Micro-Solar Leasing Platform*," www.greentechmedia.com/articles/read/Off-Grid-Electric-Raises-45M-in-Debt-For-African-Micro-Solar-Leasing-Platf

Weston, D. (2015), "Siemens Secures 2GW Turbine Deal in Egypt," *Wind Power Monthly*, 4 June, www.windpowermonthly.com/article/1350015/siemens-secures-2gw-turbine-deal-egypt

Young, D. (2016), "EU Roots Out China Solar Cheats in Malaysia, Taiwan," *Renewable Energy World*, 15 February, www.renewableenergyworld.com/ugc/blogs/2016/02/eu_roots_out_chinas.html?cmpid=renewablesolar02162016

Zawya (2015), ACWA Power Consortium Named Preferred Bidder of Noor II and Noor III projects in Morocco, www.zawya.com/story/ACWA_Power_Consortium_Named_Preferred_Bidder_of_Noor_II_and_Noor_III_projects_in_Morocco-ZAWYA20150115044758/

Photo credits

page 10 Women moulding clay stoves in Burkina Faso, GIZ

SNV/Biogas programme for the animal husbandry sector of Vietnam

Water-powered mill in Nepal, ICIMOD Kathmandu, Flickr

page 13 Adapted from Candice Nyando/Black Rock Solar, Flickr page Black Rock Solar at Pyramid Lake High School

page 14 PV Pilot, International Water Management Institute (IWMI)

All other photos are from www.shutterstock.com

IRENA
International Renewable Energy Agency

IRENA Headquarters

Masdar City
P.O. Box 236, Abu Dhabi
United Arab Emirates

www.irena.org

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

ACKNOWLEDGEMENTS

Authors: Rabia Ferroukhi, Arslan Khalid (IRENA), Michael Renner (Worldwatch Institute) and Álvaro López-Peña (IRENA)

Contributors: Divyam Nagpal (IRENA), Ulrike Lehr and Helena Walter (GWS)

Reviewers: Henning Wuester and Neil MacDonald (IRENA)

For further information or for provision of feedback, please contact Rabia Ferroukhi, IRENA, Knowledge, Policy and Finance Centre (KPFC), Email: RFerroukhi@irena.org

IRENA
International Renewable Energy Agency

Renewable Energy and Jobs

Annual Review 2016