IRENA
International Renewable Energy Agency

Renewable Energy and Jobs

Annual Review 2015

2015

KEY FACTS

- Renewable energy jobs reached an estimated **7.7 million** in 2014, excluding large hydropower.
- Jobs in the sector increased **18%** from the estimate reported last year and the **regional shifts towards Asia** continued, especially in manufacturing.
- The 10 countries with the largest renewable energy employment were **China, Brazil,** the **United States, India, Germany, Indonesia, Japan, France, Bangladesh** and **Colombia**.
- In 2014, the solar PV sector accounted for **2.5 million** jobs, of which **two-thirds** were in **China**. Solar PV jobs also grew in **Japan**, while decreasing in the **European Union**.
- **Biofuels (1.8 million)**, **biomass (822,000)** and **biogas (381,000)** are also major employers, with jobs concentrated in the feedstock supply. While **Brazil** and the **United States** continued to dominate, **Southeast Asia** saw growth in biofuel jobs, reflecting measures to support production.
- Wind employment crossed the **1 million** mark, with **China** accounting for **half** of these jobs. The **United States**, **Brazil** and the **European Union** also saw gains.
- Solar water heating and cooling employed **764,000** people, more than **three-quarters** of them in **China**. Other significant markets are **India**, **Brazil** and the **European Union**.
- Small hydropower employed about **209,000** people, more than half in **China**, followed by the **European Union**, **Brazil** and **India**.
- Large hydropower was estimated to support another **1.5 million** direct jobs, mostly in **China** and largely in **construction and installation**.
- An array of **industrial and trade policies** continues to shape employment, with **stable and predictable policies** favouring job creation.

Renewable Energy and Jobs

Annual Review 2015

IRENA estimates that renewable energy employed 7.7 million people, directly or indirectly, around the world in 2014[1] (excluding large hydropower). This is an 18% increase from the number reported last year. In addition, IRENA conducted the first-ever global estimate of large hydropower employment, showing approximately 1.5 million direct jobs in the sector[2].

This second edition of the *Renewable Energy and Jobs - Annual Review* presents the status of renewable energy employment, both by technology (Figure 1) and in selected countries (Figure 4). The table at the end of this report summarises the findings across major markets.

Like last year, falling prices for solar photovoltaic (PV) and wind equipment globally posed a challenge for manufacturers in some markets, thus affecting jobs. Yet, accelerated solar PV installation and expanded operations and maintenance spurred job growth.

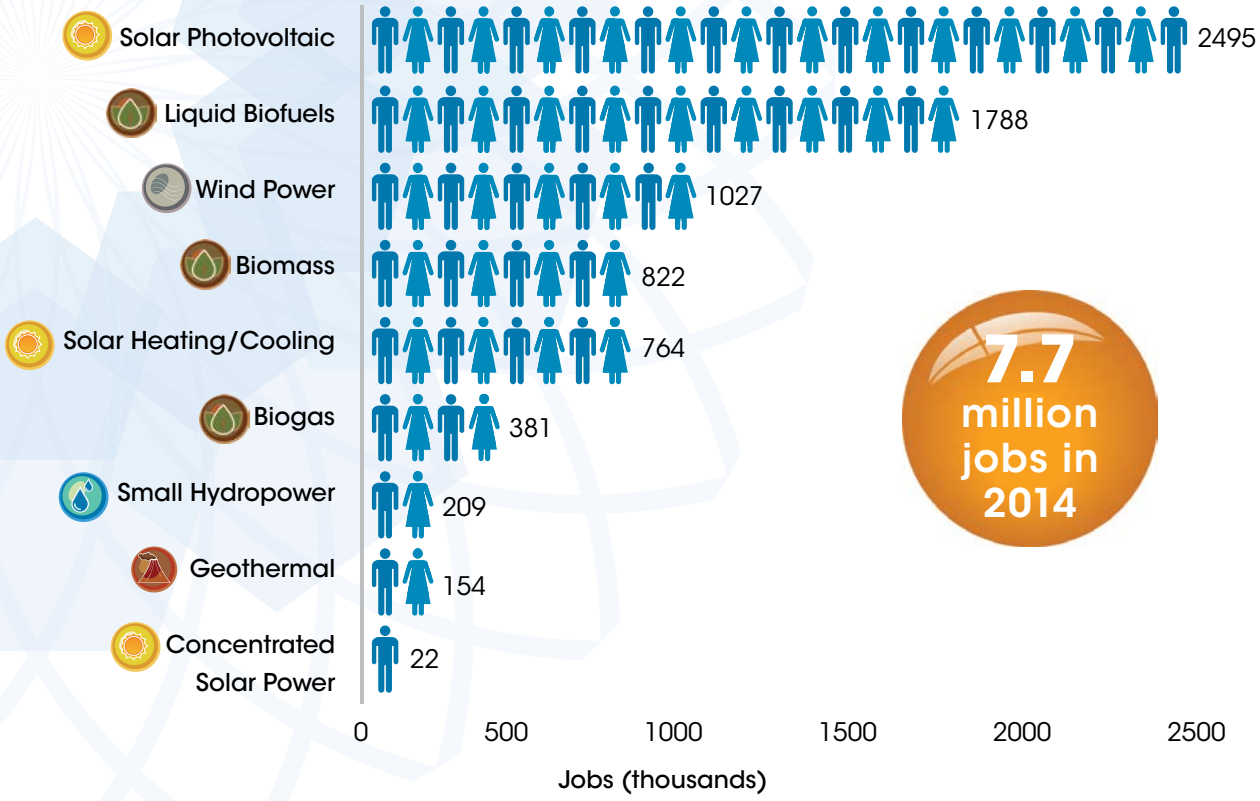
Manufacturing of solar PV panels moved decisively from Europe and North America to Asia, where shifts continue between countries. On the installation side, China and Japan were major markets. Wind power jobs have increased steadily following a market revival in 2014 led by China, Germany and the United States (GWEC, 2015; Navigant, 2015). Employment in biofuels continued growing in the United States and Brazil, and in emerging labour-intensive Asian markets where biofuel production witnessed accelerated expansion.

The world's leading countries for renewable energy employment remain the same as in previous years: China, Brazil, the United States, India, and some members of the European Union, notably Germany. In addition, new markets have emerged including Indonesia, Japan and Bangladesh. In Latin America, Brazil remains the dominant player, followed by Colombia, Argentina and Mexico. Renewable energy-related employment remains low in Africa except in a few countries, like Kenya, Morocco and South Africa, where deployment growth is creating domestic value and jobs. Globally, renewable energy employment continues to be shaped by an array of supportive industrial and trade policies.

[1] *Unless otherwise noted, all employment data refer to direct and indirect jobs (see Box 5 for definitions). IRENA's 2013 estimate of 6.5 million jobs (excluding large hydropower) has been updated to 6.9 million following a revision by the China National Renewable Energy Centre (CNREC) for solar water heating employment. The employment data include information for the latest available year. Overall, most of the numbers are from 2013 and 2014.*

[2] *This is a first time estimate and IRENA will further refine the methodology before including it in the total number of jobs for renewable energy.*

FIGURE 1. RENEWABLE ENERGY EMPLOYMENT BY TECHNOLOGY



RENEWABLE ENERGY EMPLOYMENT BY TECHNOLOGY

SOLAR PHOTOVOLTAICS

Solar PV is the largest renewable energy employer, accounting for 2.5 million jobs. The global production of solar panels keeps increasing and further concentrating in a number of Asian countries. Lower costs are driving accelerated growth in installations, particularly in China and Japan.

China remains the top solar energy job market, retaining its undisputed lead in manufacturing while also expanding its domestic market. Jobs in Japan increased to 210,000 in 2013, thanks to a rapidly growing domestic market. Manufacturing jobs are on the rise in Malaysia, the Republic of Korea and other regional industrial hubs, but those markets are presently too limited to support considerable employment in the installation segment of the solar PV supply chain.

In the United States, installations continue growing, driving job creation linked to solar PV and other solar technologies. In contrast, solar PV employment in the European Union has decreased by 35% to about 165,000 jobs in 2013.

Solar PV is the largest renewable energy employer, accounting for nearly 2.5 million jobs.

Distributed solar PV increasingly offers a feasible and affordable way to address energy poverty. In this case parts of the value chain (*e.g.*, assembly, distribution, after sales service) are easy to localise, ensuring job creation, as seen with the deployment of solar home systems (SHS) in Bangladesh (Box 1).

Box 1

ENERGY ACCESS AND SOLAR EMPLOYMENT IN BANGLADESH

The experience of Bangladesh underlines the tremendous potential for value creation in the expansion of electricity access in rural areas not served by power grids.

Under the aegis of the state-run Infrastructure Development Company (IDCOL), installations of SHS have grown rapidly in the last decade, to 3.6 million units (as of March 2015) (Figure 2). Together with systems installed by non-IDCOL projects, the number rises to at least 3.8 million units, benefiting over 20 million people (Barua, 2015). The 2016 target is 6 million units (Haque, 2014).

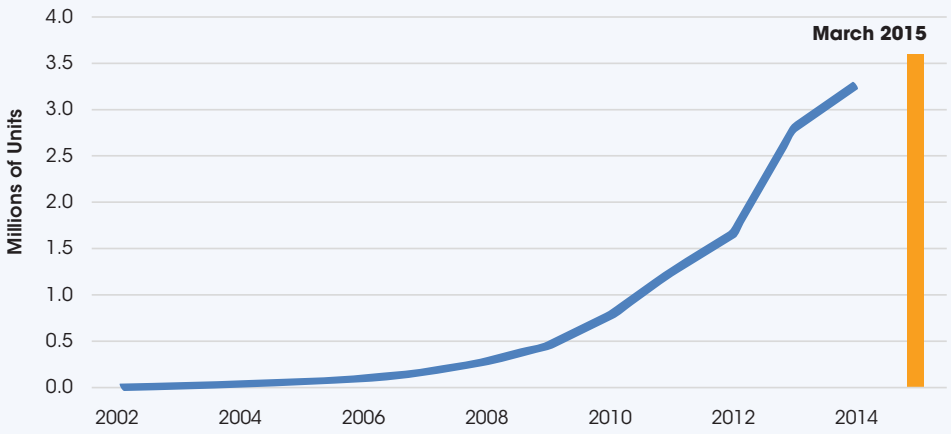
Related employment has expanded accordingly, reaching at least 115,000 jobs in 2014. IDCOL's 48 implementation partners employ an estimated 70,000 people[3], while those not linked to IDCOL employ another 15,000. Solar PV manufacturing and assembly support more than 30,000 jobs (Barua, 2015).

In addition, 50,000 jobs are induced in downstream businesses thanks to the availability of solar electricity in rural areas.

SHS involve sales, installation, maintenance and loan-payment collection. Vocational training has been an important factor, particularly benefiting women, who provide after-sales services in rural areas (IRENA, 2015). In fact, under the IDCOL programme, relevant technical and management training has been delivered to 410,000 individuals ranging from local technicians to customers (IRENA, 2013).

Other IDCOL programmes that promote biogas, improved cookstoves and other renewable energy technologies supported 4,000 jobs in the sector in 2014 (Haque, 2015).

FIGURE 2: SHS INSTALLATIONS IN BANGLADESH, 2002-MARCH 2015



Sources: Haque, 2012; IDCOL, n.d.

LIQUID BIOFUELS

Liquid biofuels remain a large employer, accounting for nearly 1.8 million jobs worldwide. Brazil has the largest workforce, with 845,000 employed. Job losses in the ethanol industry (due to the increasing mechanisation of sugarcane harvesting) were more than offset by job growth in biodiesel, mainly supported by incentives such as increased blending requirements[4]. Other major biofuel job markets in Latin American include Colombia and Argentina, with workforces of 97,600[5] and 30,000, respectively.

[3] *This includes 39,000 direct and 31,000 indirect jobs in IDCOL partner organisations (Haque, 2015).*

[4] *Biodiesel blending mandates in Brazil were increased from 5% to 7% in November 2014.*

[5] *Estimation based on information from Pabón Restrepo (2015).*

Liquid biofuels are the second largest employer with nearly 1.8 million jobs.

The United States, France and Germany are key biofuel producers, though mechanised harvesting and processing limit employment compared to countries with more labour-intensive operations.

Supportive policy frameworks and attractive market conditions spurred job growth in liquid biofuels in several Far Eastern countries, including China, Indonesia and Thailand. Indonesia's labour-intensive palm oil-based biodiesel industry, for instance, supports 223,000 jobs.

WIND

Global wind employment crossed 1 million jobs in 2014, up from 834,000 the year before, primarily fuelled by deployment in China, Germany, the United States and Brazil. In China, wind jobs surged from 356,000 in 2013 to 502,400 in 2014. The United States recovered in 2014 from a policy-induced slump in new installations as wind jobs rose by 43% to 73,000. Brazil saw encouraging gains, with an estimated 35,800 wind jobs in 2014, up 12% from the previous year.

Wind employment increased by 23% to more than 1 million jobs.

The European Union has seen moderate additions with wind employment increasing by 5.6% to reach 319,600 in 2013[6]. Germany accounted for nearly half of these jobs, followed by the United Kingdom, Italy and Denmark. In 2014, the growing offshore segment employed 75,000 in Europe.

SOLAR HEATING AND COOLING

A complete and reliable employment picture remains difficult for solar heating and cooling. Available reports are sparse, with limited information about methodologies and unclear segmentation of the value chain.

A review of the literature supports a rough estimate of 764,000 for total employment in the sector, a 16% decline over the previous year[7]. This is primarily caused by a slowdown in the Chinese solar water heating market, which is home to 80% of global installed capacity.

Despite this decline, China remains by far the dominant market for solar water heaters, with 600,000 jobs in manufacturing alone. Other available estimates include India with 75,000 jobs (Epp, 2011), Brazil with 41,000 (Alencar, 2015), and the European Union with 37,600. For the United States, IRENA estimates more than 5,000 jobs in the sector[8].

SMALL HYDROPOWER

Employment in small hydropower is difficult to estimate, as operators may be employed under informal arrangements and certain segments of the supply chain are shared with large hydropower.

The global employment is estimated at 209,000 jobs. China, with close to half of global deployment, has 126,000 jobs in the sector. The European Union supports around 20% of the total jobs. India, Brazil and the United States are also significant employers.

LARGE HYDROPOWER

The available information on large hydropower jobs is insufficient for a comprehensive picture. To fill this data gap, IRENA has conducted the first-ever[9] global estimation of employment in the sector. This shows approximately 1.5 million direct jobs in 2013, up 6% from 2012 (Box 2).

[6] *The most recent year available.*

[7] *The global estimate for 2013 has been updated from 503,000 to 913,000 following a major revision of Chinese solar water heating employment estimates.*

[8] *A conservative estimate based on SEIA (2013).*

[9] *Energy [R]evolution by Greenpeace provides a global estimate for 2010 for all hydropower.*

Box 2

EMPLOYMENT IN LARGE HYDROPOWER

The estimation of jobs in large hydropower is based on an employment-factor approach, which allows us to examine direct jobs in different segments of the value chain. Given the rapid pace of capacity additions in 2013 and the significant pipeline of upcoming projects, the construction and installation segment accounts for 805,000 jobs (54% of the total).

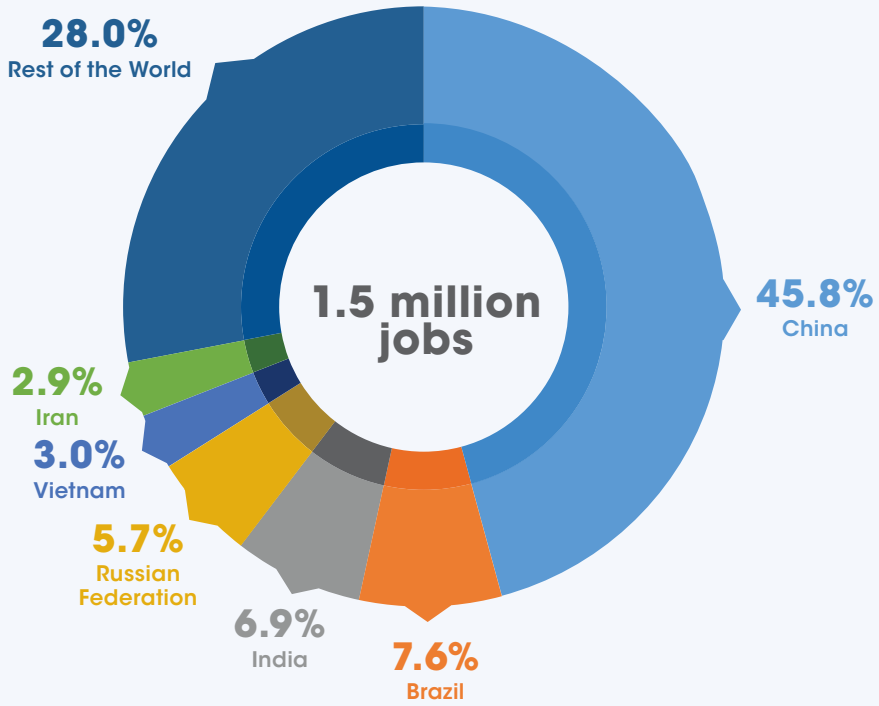
Operation and maintenance employs more than 571,000 people catering to the requirements of around 900 GW of installed capacity worldwide. The manufacturing segment remains a distant third because of lower labour intensity.

Results indicate that China, with the largest installed capacity in the world, accounts for around 46% of global employment in 2013, followed by Brazil (8%), India (7%) and the Russian Federation (6%) (Figure 3).

The employment estimates in the manufacturing sector benefit from an analysis of equipment trade. The international market for large hydropower turbines is dominated by China with 24% of the market share, followed by Germany at 10%, and Austria, Italy and France each at about 7%. The market is relatively concentrated with these 5 countries holding a market share of close to 60%.

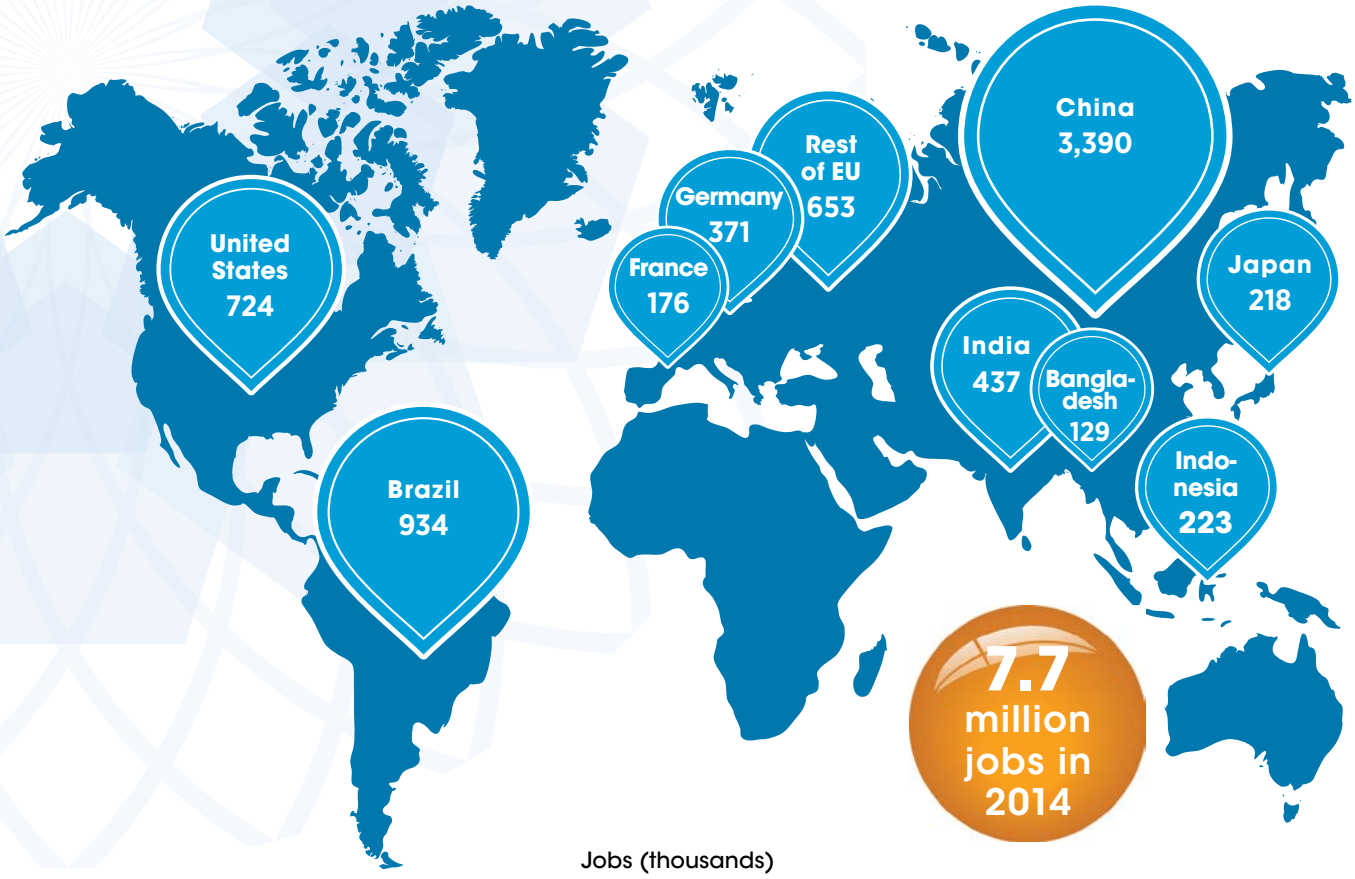
Finally, it should be noted that the addition of indirect jobs can potentially double the estimates for employment in construction and installation as well as the manufacturing segment of the value chain. Construction and installation require significant intermediate goods, such as cement, sand, bricks and cables. Manufacturing needs machinery and raw materials and thus creates additional demand and jobs in the respective sectors. The addition of indirect jobs in the operation and maintenance segment could result in an increase of up to 50%.

FIGURE 3. EMPLOYMENT IN LARGE HYDROPOWER BY COUNTRY



Source: Lehr and Nieters (2015).

Figure 4. Renewable energy employment in selected countries



RENEWABLE ENERGY EMPLOYMENT IN SELECTED COUNTRIES

The geographical shift in renewable energy employment continued in 2014. In fact, the combined share of the European Union and the United States in global employment declined from 31% in 2012 to around 25% in 2014. The global top 10 countries now feature five in Asia, as opposed to just three in the previous year. The leading countries are China, Brazil, the United States, India, Germany, Indonesia, Japan, France, Bangladesh and Colombia.

China has firmed up its position as the leading renewable energy job market with 3.4 million employed. Sustained domestic deployment and rising global solar PV demand ensured that jobs in the solar PV sector grew by 4%, to 1.6 million. The country produced around 34 GW of solar PV modules in 2014 (70% of world's production) (Bradsher, 2014). The manufacturing segment employs close to 80% of China's solar PV workforce, followed by installation and operation and maintenance (CNREC, 2015). It is also home to the world's largest SWH industry, catering to domestic demand as well as exports of SWH equipment.

Demand for domestic SWH installations fell considerably in 2014. As a result, despite the 2% increase in exports, manufacturing employment declined 20% to 600,000 jobs[10]. As many as 2.2 million people may be employed in sales, installation and after-sales service of SWHs. However, these jobs are likely to be part-time and often associated with businesses also involved in solar PV. To avoid potential double-counting, they are not included in the aggregate numbers.

Bolstered by a strong domestic market, with 20 GW installed in 2014 and 77 GW under construction (Reuters, 2015), Chinese wind employment is growing. The Chinese Wind Energy Association estimates 2014 employment at 502,400 jobs, up from a 2013 figure

[10] *CNREC has updated the 2013 SWH estimate to 760,000 jobs in the manufacturing sector.*

of 356,000 put forward by the Energy Research Institute of NDRC. More than 70% of the jobs are in manufacturing.

Bioenergy in China employed 521,000 people in 2014, with biomass and biogas supporting the majority of those jobs (241,000 and 209,000, respectively). Employment in biofuels is likely to increase as incentives such as blending mandates are enforced.

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China remains a clear leader in hydropower. The country added around 30 GW of large hydropower in 2013 and planned another 75 GW of new projects in the 2014-2017 period. Construction and installation accounted for more than 70% of the country's large hydropower employment in 2013. With close to half of global installed capacity, small hydropower accounts for more than 126,000 jobs in China.

Renewable energy employment declined in 2013 in the **European Union**, reflecting a sharp decrease in overall investment as well as adverse policy conditions (EurObserv'ER, 2014). The 2013 total of 1.2 million jobs in the 28 member states of the European Union was down from 1.25 million the year before[11].

Germany remains the European country with the highest renewables employment by far (371,400 jobs in 2013). This is more than double the number in France (176,200), which itself remains far ahead of the United Kingdom, Italy and Spain[12]. These five countries account for about 70% of the total European Union renewable energy employment. In the United Kingdom, ambitious offshore wind plans will likely translate into further job expansion in the next few years.

The solar PV industry suffered job losses (down 87,000), due to lower manufacturing competitiveness and a weaker installation market in many countries in the European Union. Only a handful of them – the United Kingdom, Greece, Romania and the Netherlands – gained solar PV jobs in 2013. Other renewable energy technologies experienced weak growth and were unable to compensate for the loss in solar PV jobs.

Solid biomass added 37,900 jobs in 2013, wind, another 12,600, and geothermal 7,300 jobs. Interestingly, the biomass sector, at 342,100 jobs, now tops wind energy's 319,600 jobs. Both are far ahead of solar PV (165,000), geothermal heat and power (104,600) and biofuels (97,200). Biogas, small hydropower and solar thermal heat and power contribute smaller shares to overall employment.

Germany suffered minor job losses in 2013, following a decade of strong employment expansion. Yet it remains a major manufacturer and installer of renewable energy technologies.

German solar PV manufacturers are struggling to stay competitive, with many shifting operations to the Far East. For 2014, the solar industry association (BSW-Solar, 2015a) offers a preliminary estimate of 45,000-50,000 jobs, compared to 56,000 in 2013 (O'Sullivan *et al.*, 2014) and a peak of almost 111,000 in 2011. Jobs in installation are also suffering as the domestic market has weakened[13].

German solar heating and cooling employment likely decreased in 2014. New installations of collectors, on the decline since 2008, fell from 1.02 million square meters in 2013 to 0.9 million square meters in 2014 (BSW-Solar, 2015b).

The wind industry employment is likely to have increased as capacity expanded by 5.3 GW in 2014 – the second-highest addition after China (GWEC, 2015). Offshore installations accounted for about 32% of the total capacity additions (Deutsche Windguard, 2015). The level of offshore wind employment (about 19,000 jobs) was roughly sustained in 2014 (BWE, 2015).

Renewable energy employment in **France** fell by 4%, from 184,000 in 2012 to 176,200 in 2013, the most

[11] *This total, along with the other European Union figures, is based on EurObserv'ER (2014), but relies on APPA (2014) for Spanish employment figures, on Deloitte and APREN (2014) for Portugal, on BMFLUW (2014) for Austria, and includes an IRENA estimate of 3,210 jobs in the United Kingdom's ocean energy sector based on renewableUK (2013), but excludes waste energy jobs. 2012 figures did not include data for Croatia, which is thought to have 3,550 jobs.*

[12] *EurObserv'ER (2014) puts Spain's employment at 60,250, much lower than the estimate of 94,800 put forward by APPA (2014).*

[13] *New installations of 1.9 GW in 2014 fell short of the government's 2.6 GW cap, and were down from 3.3 GW in 2013 and 7.6 GW in 2012 (BSW-Solar, 2015a).*

recent year for which EurObserv'ER offers data. This is entirely due to a loss of 14,100 jobs in the solar industry (primarily the solar PV sector, where new installations declined by 45%), mirroring difficulties experienced across Europe. Employment in all other renewable energy technologies remained essentially unchanged. Biomass heat and power is by far France's largest employer with 52,500 jobs, followed by ground source heat pumps and biofuels. In these industries, France is ahead of Germany and leads the continent. Solar PV and wind together employ fewer people than the biomass sector in France. All other technologies account for just 8% of the total.

In the **United States**, the latest National Solar Job Census (Solar Foundation, 2015)[14] indicates that total solar employment surged from 142,700 to 173,800 jobs in 2014, an increase of 22%. As in the last several years, installations (adding 1.4 GW during 2014) were the main engine of job growth, accounting for 97,000 jobs. Manufacturing gained as well, adding about 2,600 jobs and continuing an upward trend after the difficulties experienced in 2012. The United States Department of Energy's "SunShot Initiative", launched in 2011, supports innovation in manufacturing, helping attract new facilities.

The 2013 edition of the Solar Census was the first to include gender information. The 2014 edition provides an update, reporting a rise in solar jobs held by women from 26,700 to 37,500. Relative to the total solar workforce, this represented an increase from 18.7% to 21.6%.

Employment in the United States wind industry recovered from the sharp downturn suffered in 2013 due to uncertainties surrounding the Production Tax Credit. Wind energy employment in 2014 was estimated at 73,000, up from 50,500 the previous year. Construction, project development and transportation accounted for 26,700 jobs, while equipment manufacturing supported 19,200. Operation and maintenance and other activities accounted for the remainder (AWEA, 2015).

Still, difficulties persist. The number of component manufacturing facilities dropped from 550 to 500 in 2013-2014, several companies closed plants, announced lay-offs, or left the United States wind market entirely (AWEA, 2015). The consolidation of the industry left GE, Vestas and Siemens as the three dominant companies, with about 90% of the United States market (Davidson, 2014).

Employment in the United States increased by 16% to reach 724,000 jobs.

Ethanol production increased an estimated 7.4% to 54 billion litres. This was driven by sharply lower feedstock prices and a record 2014 corn yield, 36% of which was used to produce ethanol (Urbanchuk, 2015). In line with this development, the United States ethanol employment is estimated to have expanded by 34% to 232,600 in 2014 (Urbanchuk, 2015), including jobs created in the construction of 380 million liters of new ethanol processing capacity. Biodiesel production declined by 6.6% to 4.8 billion litres in 2014 (EIA, 2015). The use of an employment factor developed by the National Biodiesel Board (NBB, 2012) yields an estimate of around 49,500 jobs.

Brazil's renewable energy employment remains dominated by liquid biofuels, given the large labour needs to cultivate feedstock for ethanol and biodiesel. Even though production increased, rising mechanisation trimmed the agricultural workforce in the sugarcane-ethanol sector by about 25,000 to 304,350 in 2013 (MTE/RAIS, 2015). Although formalisation of employment has made forward strides, there are still significant numbers of informal and part-time harvest workers not included in the government RAIS database. Employment in ethanol manufacturing declined slightly to 199,590 jobs, reflecting a consolidation of refineries from 430 in 2010 to 390 in 2014 (USDA-FAS, 2014). Brazil's biodiesel production, mainly soy-based, has more than doubled since 2009 (ABIOVE, 2015). IRENA's calculation, based on employment factors (Da Cunha *et al.*, 2014) estimates 141,200 jobs in 2014. The biodiesel feedstock supply employs more than 83,700 small farmers and their number is expected

[14] *The Census is an extensive employer survey. A "solar worker" is defined as an employee who spends at least 50% of work time supporting solar-related activities. Findings are that 91% or more of those who meet this definition actually spent their entire work hours on solar projects.*

to reach 105,000 in 2015 with the increase in blending requirements to 7% and the expected improvement in rainfall patterns (Ministry of External Relations, 2015).

Brazil's wind industry is growing rapidly. Power capacity has expanded from under 1 GW in 2010 to nearly 6 GW in 2014 and could reach 16.5 GW in 2019 (Fonseca, 2015). The number of wind power equipment manufacturers operating in Brazil has risen from just one in 2007 to ten. In a sign of the growing maturity of the supply chain, not only is the number of plants producing blades and towers increasing, but the number of service providers as well (Simas and Pacca, 2013; Larive International, 2014). As a result, Brazil's wind employment stood at 35,800[15] for 2014. About 21,800 of those jobs are in construction and operation and maintenance, with the rest in manufacturing[16].

Liquid biofuels support the majority of Brazil's 934,000 renewable energy jobs and the share of wind employment is increasing.

Brazil's solar heating market has expanded strongly in the past decade. The social housing program "*Minha Casa, Minha Vida (My House, My Life)*", initiated in 2009, has become a key market driver. In 2013, it was estimated to account for 17% of the newly installed collector area (Epp, 2013). Total employment in 2013 is estimated at about 41,000 jobs, including 30,000 in manufacturing (Alencar, 2013) and the rest in installation[17].

Up-to-date information for **India** is limited, making the extent and recent trends of renewable energy employment hard to determine. Solar PV employs 125,000 people in grid-connected and off-grid applications. The latter supports 72,000 jobs, according to an estimate by MNRE and CII (2010). For grid-connected applications, IRENA and CEEW estimate[18] that direct employment increased by 28% to reach 53,000 in 2014, with 29,000 jobs in installation and operation and maintenance and the remainder in manufacturing. India's solar PV manufacturers have struggled to compete with suppliers from China, the United States, Japan and Germany. In 2014, only 28% of India's module production capacity and 20% of its cell manufacturing capacity were being utilised (Chadha, 2014; Climate Connect, 2014).

Recently, the Indian government has announced ambitious plans to expand installed solar and wind power capacity. These along with the government's "Make in India" initiative should encourage local and foreign manufacturers to establish a strong domestic industry. For instance, Sun Edison announced in early 2015 that it would build a 7.5 GW production plant, creating about 20,000 construction jobs over three years (Doom, 2015).

If the government reaches its goal of installing 100 GW of solar PV by 2022, CEEW and NRDC (2015) project that India could create 1.08 million jobs. Under the mix of projects proposed by MNRE, three-quarters would be short-term jobs (construction, etc.). Prioritising rooftop projects over mega-scale solar parks would raise the country's total solar PV employment potential to 1.31 million[19].

India is the world's fifth-largest solar heating and cooling market, where employment has increased from 41,000 jobs in 2009 to 75,000 in 2011[20], according to available estimates (MNRE and CII, 2010; Epp, 2011). However, India's SWH manufacturing industry presently faces strong competition from Chinese imports. Withdrawal of subsidies by the Indian government in 2014 and an extension of Chinese export incentives have rendered local models more expensive, forcing local manufacturers to become distributors of Chinese products to stay profitable (Mishra and Damor, 2015).

Employment in the wind power sector is estimated at 38,000 to 40,000 jobs. The CEEW and NRDC study (2015) projects that if the government's goal of installing 60 GW is reached, India could create up to 183,500 wind power jobs (excluding manufacturing) by 2022. Most of these (81%) would be in temporary occupations like construction. About 16% of the jobs would be skilled, 59% semi-skilled and the remaining unskilled.

[15] IRENA estimate based on employment factors from Simas and Pacca (2013).

[16] Brazil requires that a rising portion of wind projects be sourced domestically, but the precise breakdown between domestic and imported equipment is unavailable. For sake of simplicity 100% local manufacturing is assumed.

[17] IRENA calculation based on Brazilian market data (Paukowski Moreno, 2013) and a solar heating and cooling employment factor (Mauthner, 2014).

[18] Building on the employment factors estimation of Ganesan et al. (2014).

[19] For PV, the extent and nature of employment that could be created in the process will depend strongly on the particular mix. A joint study by Bridge to India and Tata Solar Power (2014) suggested that small residential and commercial rooftop assemblies would generate a far larger number of jobs (39.3 and 26.5 per megawatt, respectively) than utility-scale (9.4) or "ultra mega-scale" projects (5.7).

[20] It should be noted that differences in the methodologies of the two reports may limit the comparability of the 2009 and 2011 figures.

Along with China, other Asian countries are also prominent producers of solar panels. Of these, only **Japan** has so far developed a major domestic solar PV market. Based on the strength of local installations under the feed-in tariff programme, direct and indirect employment increased from 60,000 in 2012 to 210,000 jobs in 2013 (JPEA, 2015)[21]. IEA-PVPS (2013a) indicated that more than three-quarters of all solar jobs in 2012 were in distribution, installations and services, compared with 17% in manufacturing.

With a conducive investment environment, **Malaysia** has succeeded in attracting a range of solar PV equipment producers from Asia, Europe and the United States, including First Solar, Panasonic, SunEdison, SunPower, Hanwha Q Cells and JinkoSolar. The country has become the world's third-largest solar PV producer, well behind China but ahead of Japan (Bradsher, 2014). The most recent employment estimate shows 18,000 solar jobs in 2014 (SEDA, 2015), up from 10,700 in 2013 (IEA PVPS, 2014a).

The **Republic of Korea** was the fifth largest PV panel producer in 2014, with PV jobs estimated at about 13,500 in 2012 (IEA PVPS, 2013b). Manufacturing accounted for an estimated 56% of these jobs (Yu, 2014).

THE WAY FORWARD

Worldwide employment related to renewable energy continues to grow significantly, reaching 7.7 million in 2014, up 18% from the number reported in the *Renewable Energy and Jobs – Annual Review 2014*.

As last year, China, Brazil, the United States, India and Germany are the key employers. However, emerging renewable energy markets such as Japan, Bangladesh and Indonesia are gaining prominence.

Manufacturing jobs, especially those for wind turbines and solar panels, are increasingly concentrated in a few Asian markets. Other segments of the renewable energy value chain (namely operation and maintenance and construrction and installation) offer the bulk of employment opportunities for most countries.

In the coming years, renewable energy employment growth will depend on the return to a strong investment trajectory, as well as on continued technological development and cost reductions. Stable and predictable policies will be essential to support job creation. Finally, in a year when negotiators in Paris aim to carve out a global climate agreement, the broader policy framework for energy investments will also move to the forefront.

Box 3

METHODOLOGY: CONTINUOUS IMPROVEMENT IN COVERAGE AND DATA QUALITY

IRENA's estimates are the result of data collection from a mix of primary and secondary data sources. Primary data come from government entities (*e.g.*, ministries, statistical agencies), industry representatives or are estimated in collaboration with national experts. Secondary data are drawn from a wide range of regional and global studies. The figure for large hydropower jobs is based on the employment-factor approach (IRENA, 2013), which provides the first-ever global estimate for employment in this sector.

Because of the cross-cutting nature of the renewable energy industry, information on employment is seldom captured in national statistics. IRENA's *Renewable Energy and Jobs – Annual Review* series aims to expand and continually refine the knowledge available. This edition, for example, broadens the geographic scope of the employment database, adding 11 countries.

It is important to note, however, that these markets have a minor impact on total employment figures as they represent less than 1% of global employment and around 8% of the 1.1 million additional jobs recorded in the sector over the preceding year. While the database continues to expand, the quality of existing job data has also improved, reflecting more refined methodologies as well as greater engagement with national experts.

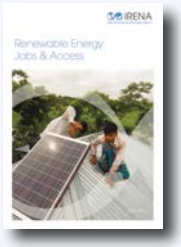
[21] *Direct jobs increased from 41,000 to 90,000 in the same period.*

Box 4

IRENA'S WORK ON THE SOCIO-ECONOMIC BENEFITS OF RENEWABLE ENERGY

2011

» The 2011 policy brief *Renewable Energy Jobs: Status, Prospects & Policies* laid the ground for IRENA's work on employment. The analysis focused on job creation in the large-scale renewable electricity and transport biofuel industries.

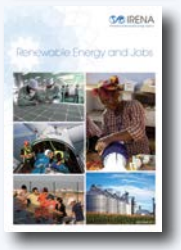


2012

» The 2012 *Renewable Energy Jobs & Access* report analysed the role of renewable energy in creating jobs and improving livelihoods in the context of energy access.

2012

» In 2012, IRENA developed country and project case studies to demonstrate the potential for job creation in rural areas through the deployment of renewable energy-based solutions.

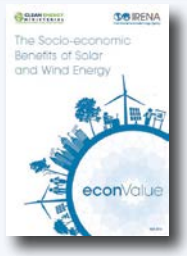


2013

» The 2013 report *Renewable Energy and Jobs* provides the first comprehensive view of the various dimensions of global employment in the sector. It underlines the importance of an enabling policy framework to realise the full potential for job creation.

2014

» In January 2014, the first *International Renewable Energy Jobs Conference*, held in Abu Dhabi, brought together experts, practitioners, academics and policy makers to discuss employment dynamics in the sector.



2014

» The 2014 report *Socioeconomic Benefits of Solar and Wind Energy* highlights the significant potential for value creation along the different segments of the value chain of the two technologies.

2014 and 2015

» *Renewable Energy and Jobs – Annual Review* series provides yearly updates on the state of global renewable energy The first edition was launched in May 2014 and estimated that a total of 6.5 million people worked, directly or indirectly, in the renewable energy sector in 2013.

» In parallel, IRENA has been contributing a sidebar on renewable energy employment to REN21's annual *Global Status Report* since 2012.

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Box 5

KEY DEFINITIONS

Direct employment refers to employment that is generated directly by core activities without taking into account the intermediate inputs necessary to manufacture renewable energy equipment or construct and operate facilities. Direct employment data may be estimated on the basis of an industry survey, or data derived from representative projects and facilities for the industry in question (Bacon and Kojima, 2011), or derived from economic data such as labour input coefficients for selected industries.

Indirect employment includes the employment in upstream industries that supply and support the core activities of renewable energy deployment. Usually, these workers do not consider themselves as working in renewables; they produce steel, plastics or other materials, or they provide financial and other services. These industries are not directly involved in renewable energy activities but produce intermediate inputs along the value chain of each renewable energy technology (RET). A review of employment factors available in the literature indicates that the inclusion of indirect jobs typically increases overall job numbers by anywhere from 50% to 100% (Rutovitz and Harris, 2012).

Induced employment encompasses jobs beyond the renewable energy and its upstream industries, such as jobs in the consumer goods industry. When people who are employed directly or indirectly spend their incomes on a variety of items in the broader economy (such as food, clothing, transportation and entertainment), the expenditure gives rise to induced employment effects. Similarly, changes in consumer electricity tariffs due to higher/lower costs of RETs give rise to induced employment impacts as the disposable income of the consumer changes.

TABLE 1. ESTIMATED DIRECT AND INDIRECT JOBS IN RENEWABLE ENERGY WORLDWIDE, BY INDUSTRY

	World	China	Brazil	United States	India	Japan	Bangladesh	European Union[m]		
								Germany	France	Rest of EU
	Jobs (thousands)									
Biomass[a,h]	822	241		152[e]	58			52	53	238
Liquid biofuels	1,788	71	845[c]	282[f]	35	3		26	30	42
Biogas	381	209			85		9	49	3	14
Geothermal[a]	154			35		2		17	33	54
Small Hydropower[b]	209	126	12	8	12		5	13	4	24
Solar PV	2,495	1,641		174[g]	125	210	115	56	26	82
CSP	22							1		14
Solar Heating/ Cooling	764	600	41[d]		75			11	7	19
Wind Power	1,027	502	36	73	48	3	0.1	138	20	162
TOTAL	7,674[i]	3,390	934	724	437	218	129	371[k]	176	653

[a] Power and heat applications (including heat pumps in the case of European Union). [b] Although 10 MW is often used as a threshold, definitions are inconsistent across countries. [c] About 304,400 jobs in sugarcane and 199,600 in ethanol processing in 2013; also includes 200,000 indirect jobs in equipment manufacturing, and 141,200 jobs in biodiesel in 2014. [d] Equipment manufacturing and installation jobs. [e] Biomass power direct jobs run only to 15,500. [f] Includes 232,633 jobs for ethanol and 49,525 jobs for biodiesel in 2014. [g] All solar technologies combined. [h] Traditional biomass is not included. [i] The total for 'World' is calculated by adding the individual totals of the technologies, with 3,600 jobs in ocean energy and 8,300 jobs in R&D in Germany. [j] All EU data are from 2013 and the two major EU countries are represented individually. [k] Includes 8,300 jobs in publicly funded R&D and administration; not broken down by technology.

Notes: Data are principally for 2013–2014, with dates varying by country and technology, including some instances where only dated information is available. Totals may not add up due to rounding.

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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