IRENA
International Renewable Energy Agency

# Renewable Energy and Jobs
## Annual Review 2020


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## ABOUT IRENA

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

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# MESSAGE FROM THE IRENA DIRECTOR-GENERAL

**Francesco La Camera**

*Director-General*

*International Renewable Energy Agency*

As the world grapples with the coronavirus (COVID-19) pandemic, the close connections between the natural environment, our economies and human well-being have taken centre stage. A clean, reliable energy supply and durable, healthy, low-carbon job creation are essential components to the transformative decarbonisation of our societies.

Renewable energy, now predominant in new electric power capacity, has proven especially flexible, cost-effective, and resilient in the face of the 2020 health and economic crisis. Even better, renewables create numerous and diverse jobs. Last year, jobs in the sector worldwide reached an estimated 11.5 million, continuing a long-term growth trend.

If countries now focus on supercharging the energy transition, many more such benefits are attainable. The post-COVID agenda put forward by the International Renewable Energy Agency (IRENA) would create some 5.5 million transition-related jobs over the next three years, bring renewables jobs to nearly 30 million globally by 2030 and pave the way for longer-term resilience, development and equality.

Already, renewable energy employment reflects the emergence of innovative technologies. Solar photovoltaics (PV) – a segment that looked almost avant-garde just a decade ago – accounts today for some 3.8 million jobs, or nearly a third of the sector total. Growing shares of those jobs are off-grid, supporting productive use in farming, food processing and healthcare in previously remote, isolated, energy-poor communities. In parallel, rural areas benefit from the feedstock production that underpins bioenergy and which accounts for the bulk of about 3.6 million jobs in that segment.

Wind power now employs 1.2 million people, over one fifth of them women. Sector-wide, renewables show a better gender balance (32% women) than fossil fuels (22%), although much remains to be done to even the playing field for women and tap into their talents and ideas.

The transition to carbon neutrality by mid-century calls for an expanded skills base, requiring more vocational training, stronger curricula, dedicated teacher training and enhanced technology use for remote learning focused on forward-looking energy systems. An ambitious package of policies and investments centred on renewables can create new jobs, leverage existing domestic industries, soften the blow of today's economic turbulence and where needed open new opportunities for workers losing jobs in conventional energy. Building up local value chains will widen the benefits further.

More broadly, governments must continue to build strong policy frameworks to enhance the positive impact of the whole energy transition technology mix.

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## KEY NUMBERS

**11.5** million renewable energy jobs in 2019

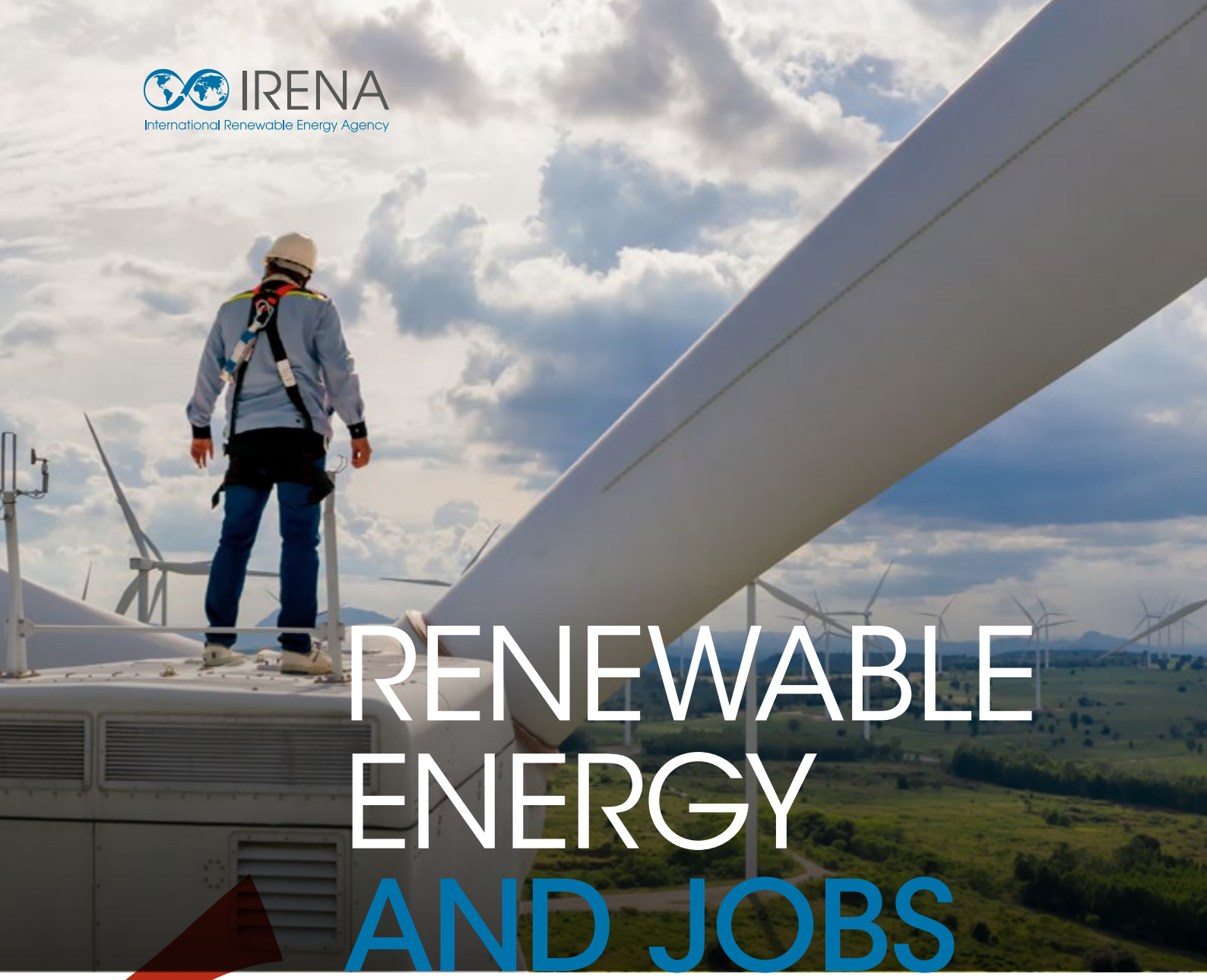
**38%** in China

**3.8** million in the solar PV industry

# KEY FACTS

## Annual Review 2020

- Employment in renewable energy worldwide was estimated at 11.5 million in 2019, up from 11 million in 2018. Women hold 32% of these jobs.
- Most jobs have been created in a small number of countries, but employment benefits are showing up more widely, especially through the deployment of solar photovoltaic (PV) technologies. Asia accounted for 63% of total jobs in renewables globally.
- Although precise estimates remain scarce, off-grid decentralised renewables are creating a growing number of jobs, while also propelling employment in productive uses ranging from agro-processing and health care to communications and commerce in local communities.
- The solar PV industry retains the top spot, with 33% of the total renewable energy workforce. In 2019, 87% of global PV employment was concentrated in the ten countries that lead in worldwide deployment and in the production of equipment.
- Driven by output growth of 2% for ethanol and 13% for biodiesel in 2019, biofuels jobs worldwide expanded to 2.5 million. Production expanded robustly in Brazil, Colombia, Malaysia, the Philippines and Thailand all of which have labour-intensive supply chains, whereas output in the United States and the European Union fell.
- Employment in wind power supports 1.2 million jobs, 21% of which are held by women. Onshore projects continue to predominate, but the number of countries with offshore farms now stands at 18, up from 10 a decade ago. Supply chains are expanding.
- Hydropower has the largest installed capacity of all renewables, but its growth is slowing. The sector employs close to 2 million people directly, many in operations and maintenance.
- Building the skills base necessary to support the ongoing global energy transition from fossil fuels to renewables requires more vocational training, stronger curricula, more teacher training and expanded use of information and communications technology for remote learning.
- The COVID-19 pandemic reinforced the importance of strong policy frameworks for renewables to achieve social, economic and environmental objectives.



# RENEWABLE ENERGY AND JOBS

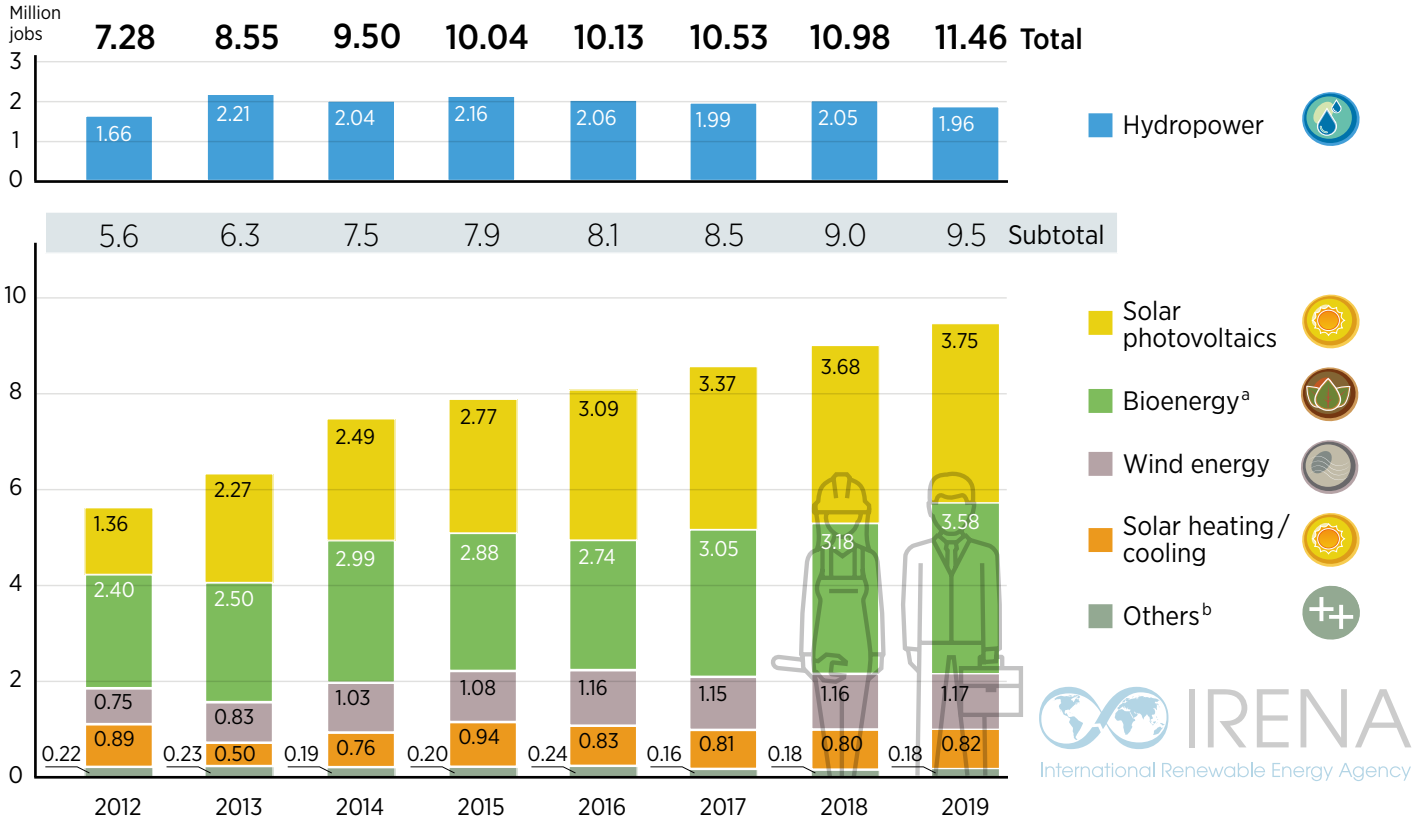
## Annual Review 2020

The renewable energy sector employed at least 11.5 million people, directly and indirectly, in 2019.[1] Renewable energy employment has continued to grow worldwide since 2012, when the International Renewable Energy Agency (IRENA) began to assess it on an annual basis. The solar photovoltaic (PV), bioenergy, hydropower and wind power industries have been the biggest employers. The bulk of global jobs relate to modern energy use, but the 2019 estimate includes jobs tied to the use of decentralised solar PV to expand energy access in parts of Sub-Saharan Africa and in South Asia. Figure 1 shows the evolution of IRENA's renewable energy employment estimates since 2012.[2] The majority of these jobs are still held by men. The share of women in the renewable energy workforce is about 32%, compared to 22% in the energy sector overall (IRENA, 2019a).

*1 Data are principally for 2018-19, with dates varying by country and technology, including some instances where only earlier information is available. The data for hydropower include direct employment only; the data for other technologies include both direct and indirect employment where possible.*

*2 IRENA does not revise previous years' job estimates in light of improved or additional information that becomes available following the publication of a particular edition.*

FIGURE 1: **GLOBAL RENEWABLE ENERGY EMPLOYMENT BY TECHNOLOGY, 2012-2019**




*Source: IRENA jobs database.*

*Note: Except for hydropower, where a revised methodology led to revisions of job estimates, numbers shown in this figure reflect those reported in past editions of the Annual Review.*

*a. Includes liquid biofuels, solid biomass and biogas.*

*b. "Others" includes geothermal energy, concentrated solar power, heat pumps (ground based), municipal and industrial waste, and ocean energy.*

This year's edition of the Annual Review series (see Box 1) highlights the latest employment trends by technology, including jobs in decentralised applications of renewable energy for improved energy access. The report then offers insights for selected regions and countries. It also includes a feature highlighting the importance of education and training policies to avoid skills shortages as renewable energy continues to expand. The report concludes with observations on the impacts of the crisis triggered by the outbreak of COVID-19 and a sketch of the way forward to ensure a successful energy transition.

## BOX 1. IRENA'S ANNUAL REVIEW OF EMPLOYMENT IN RENEWABLES

This seventh edition of *Renewable Energy and Jobs – Annual Review* provides the latest available estimates of renewable energy employment and continues to refine and improve data and methodologies. Global numbers are based on a wide range of studies. Those studies apply varying methodologies to information of varying detail and quality.

The *Annual Review* series is part of IRENA's effort to assess the socio-economic impacts of the energy transition worldwide. Over the past decade, the agency has published an expanding set of reports analysing opportunities for localising value creation, measuring the socio-economic footprint of the transition and assessing the state of gender equity in renewable energy (see Figure 2). Jobs and livelihoods are vitally important in this context, for individuals and families as much as for communities and entire societies.

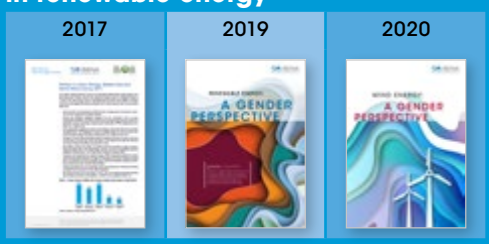
This is being highlighted in dramatic fashion by the response to the COVID-19 crisis, with lockdown orders and other restrictions bringing much economic activity to a halt and causing widespread losses of jobs and income.

FIGURE 2. IRENA'S KNOWLEDGE BASE ON RENEWABLE ENERGY EMPLOYMENT... AND MORE

**Annual reviews of employment in renewables**


**Analyses of local capacities**


**Assessing gender equity in renewable energy**

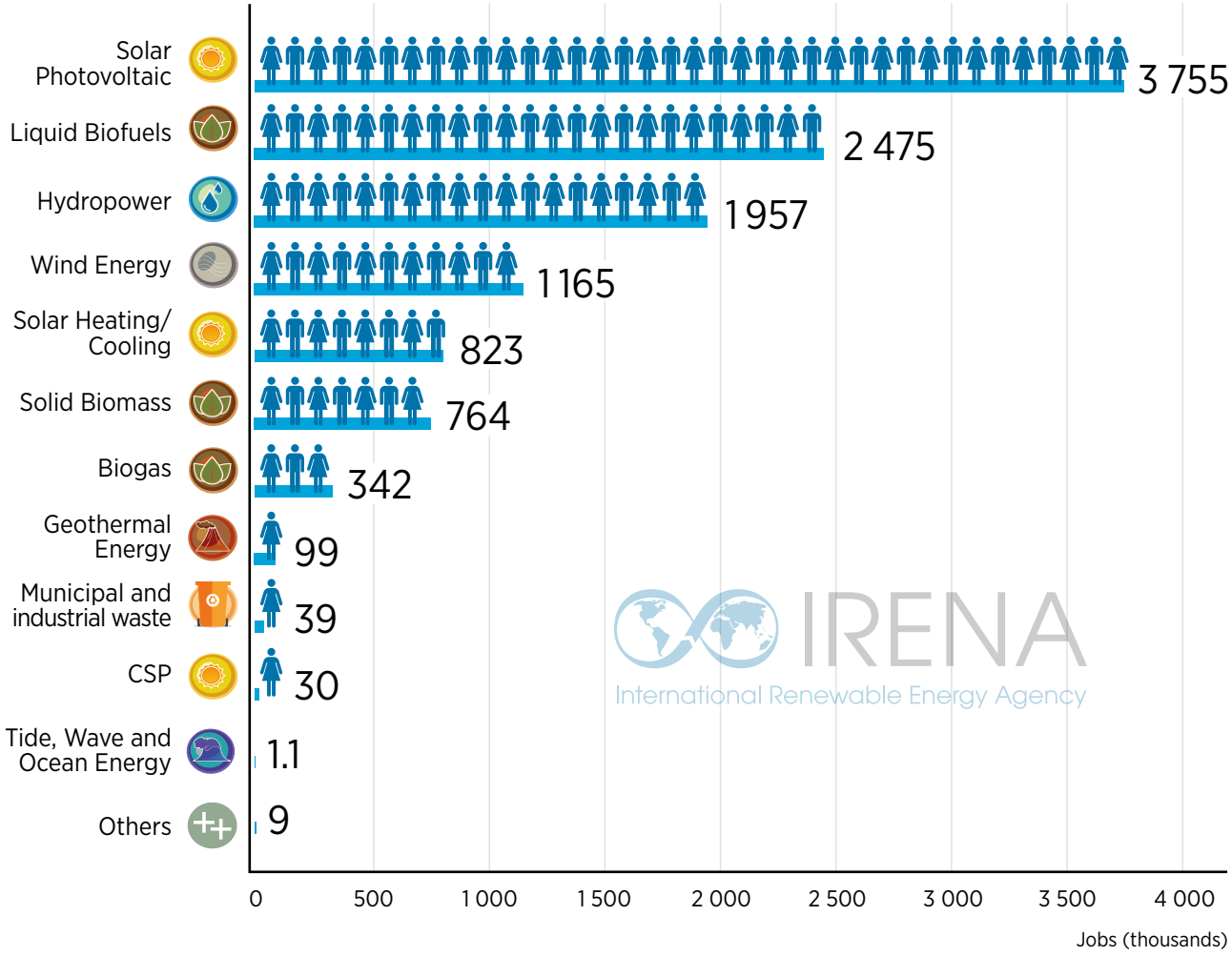



**Measuring the socio-economic impact of renewables**

# RENEWABLE ENERGY EMPLOYMENT BY TECHNOLOGY

This section presents estimates for employment in solar PV, liquid biofuels, wind, solar heating and cooling, and hydropower. Less information is available for other technologies such as biogas, geothermal energy and ground-based heat pumps, concentrated solar power (CSP), waste-to-energy and ocean or wave energy. These other technologies also employ fewer people (see Figure 3).

FIGURE 3: **RENEWABLE ENERGY EMPLOYMENT BY TECHNOLOGY**




*Note: Others include jobs not broken down by individual renewable energy technologies.*

*Source: IRENA jobs database.*

## SOLAR PHOTOVOLTAIC

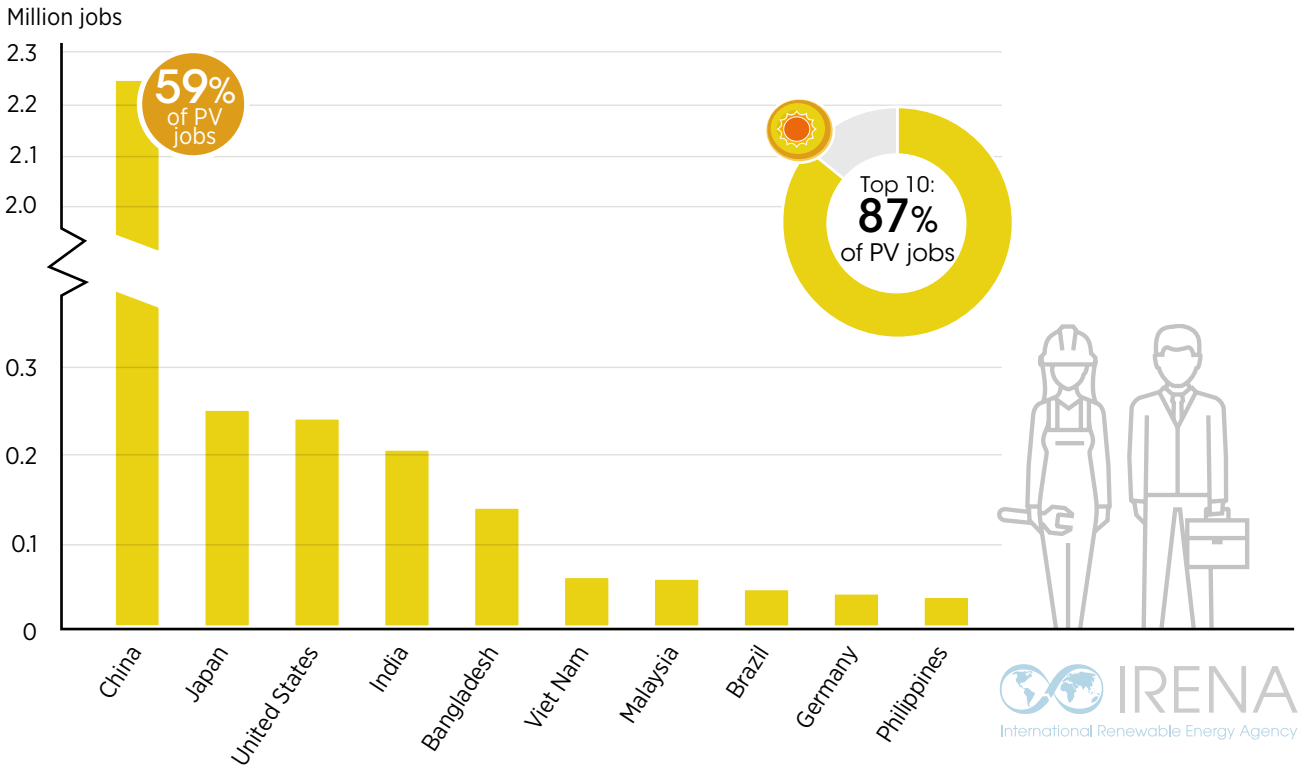
Globally, the solar PV industry installed 97 gigawatts (GW) of capacity during 2019, slightly less than the 100 GW installed in 2018. More than half, some 55 GW, was added in Asian countries (principally China, India, Japan and Viet Nam); Europe installed 19 GW, the United States another 9 GW and Australia close to 6 GW (IRENA, 2020a).

IRENA estimates that global solar PV employment increased by 4% to reach 3.8 million jobs in 2019.[3] Of the leading ten countries shown in Figure 4, seven are Asian. Overall, almost 3.1 million of the solar PV jobs (83% of the global total) were in Asia, followed by North America's 6.5% share, Europe's 4.4% and Africa's 3.7%.

Together, the ten leading countries are home to around 87% of the world's solar PV workforce, which indicates that deployment and manufacturing continue to be concentrated in a handful of countries. The global total includes an estimate of 372 000 off-grid jobs for South Asia and parts of Africa.

China, the leading producer of PV equipment and the world's largest installation market, accounted for more than half of PV employment worldwide, or some 2.2 million jobs (CNREC, 2020). Japan's solar PV industry continues to face difficulties, and capacity additions in 2019 were almost half the volume of the year before. IRENA estimates that jobs fell to 241 000 in 2019. The United States had a similar number of jobs, some 240 000.[4] India's on-grid solar employment is estimated at 109 000 jobs, with another 95 000 off-grid, for a total of 204 000 jobs. Most of the 137 000 solar PV workers in Bangladesh are employed in the installation of solar home systems. PV employment in the European Union rose significantly to 127 300 jobs in 2018, up from 95 600 (EurObserv'ER, 2020).

FIGURE 4: **SOLAR PV EMPLOYMENT: TOP 10 COUNTRIES**




*Source: IRENA jobs database.*

*Note: The figure for India includes an estimated 95 000 jobs in off-grid solar PV. Bangladesh's figure principally represents jobs related to off-grid deployments.*

*3 The countries for which IRENA's database contains solar PV employment estimates represent 574 GW of cumulative installations in 2019, or 99% of the global total. They represent 98.7% of new installations in 2019.*

*4 The Solar Foundation (2020) estimates employment in all solar technologies (PV, solar heating and cooling, and CSP) at 250 000 jobs, but provides no breakdown. Most of the activity is in PV; IRENA assumes 240 000 jobs in PV, and 5 000 jobs each in the other solar technologies.*

## LIQUID BIOFUELS

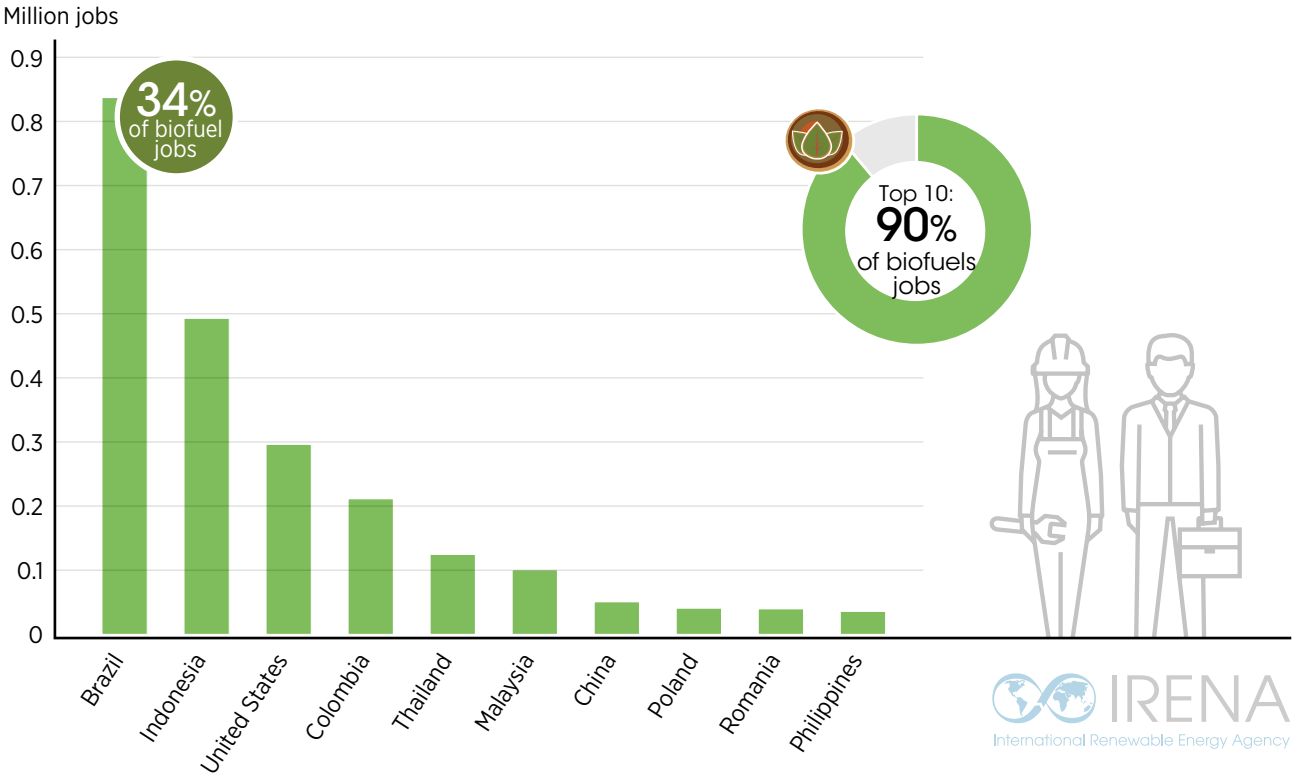
Global biofuels production increased 5% in 2019, principally driven by a 13% expansion of biodiesel (with Indonesia overtaking the United States and Brazil to become the largest national producer), while ethanol production inched up by 2% (REN21, 2020).

Worldwide employment in biofuels was estimated at 2.5 million in 2019.[5] The bulk of these jobs were in the agriculture sector, planting and then harvesting feedstock of various types. Processing the feedstock into fuels requires far fewer people than supplying the feedstock, but processing jobs generally require higher technical skills and offer better pay.

Biofuels employment estimates need to be interpreted carefully. Feedstock such as oil palm, soybeans or corn are also used for a number of non-energy purposes, whether as food, animal feed or ingredients of various commercial products. As the mix of products based on these commodities changes, rising or falling numbers of biofuels jobs do not necessarily equate to net job gains or losses in the economy. Casual and seasonal arrangements – with limited income security – are prevalent in many countries.

The regional profile of biofuels employment differs considerably from that of the solar PV sector. Labour-intensive feedstock supply lines mean that Latin America accounts for 43% of all biofuels jobs worldwide and Asia (principally Southeast Asia) for 34%. The more mechanised agricultural sectors of North America and Europe translate into smaller employment shares of 13% and 10%, respectively. Figure 5 shows the top ten countries, which together account for about 90% of global estimated employment.

FIGURE 5: **LIQUID BIOFUELS EMPLOYMENT: TOP 10 COUNTRIES**




*Source: IRENA jobs database.*

*5 The figure of 2.5 million jobs cannot be directly compared to the 2.1 million in 2018, as published in the 2019 edition of the Annual Review. This is because the estimates of biofuels production were substantially revised upward in the interim, affecting IRENA's employment factor calculations.*

With close to 839 000 jobs, Brazil has the world's largest liquid biofuels workforce. The United States is the leading biofuels producer, but its lower labour intensity translates to about 297 000 jobs. Biofuels employment in the European Union was estimated at about 239 000 jobs in 2018, the most recent year for which data are available (EurObserv'ER, 2020).

Colombia's biofuels output rose to a new peak of close to 1.2 billion litres in 2019 (USDA-FAS, 2019d). Based on IRENA estimates, the number of people involved in the country's biofuels supply chain in 2019 could be as high as 212 000, though these may not all be full-time equivalents.[6]

Southeast Asian biodiesel producers all increased their output in 2019, in some cases substantially so. Further, for Indonesia and Malaysia, recent years' estimates have been revised upward considerably in light of improved information (USDA-FAS, 2019a and 2019b). This change carries over into IRENA's job estimates, which rely on a calculation based on labour requirements. Reflecting a jump in production from 5.6 billion litres in 2018 to an estimated 8 billion litres in 2019, IRENA estimates Indonesia's biodiesel employment at 494 400 people.[7] Production in Malaysia, the Philippines and Thailand rose to 5.6 billion litres, and IRENA estimates a combined workforce for these three countries of some 261 600 people.[8]

## WIND

Most wind installations continue to be on land, but the offshore market is gaining traction. The 54 GW of onshore capacity added in 2019 brought total installed capacity to 594 GW while installed offshore capacity increased by 4.7 GW reaching a total of 28 GW (IRENA, 2020a).

Worldwide, close to 23 000 wind turbines were installed in 2019. The Chinese market is served almost exclusively by domestic companies, while markets everywhere else in the world are supplied principally by European firms. Eight Chinese turbine manufactures were among the world's top 15 suppliers in 2019. But the top spots were still held by two European companies (Vestas and Siemens Gamesa) accounting for one-third of global wind turbine production, followed by General Electric (GE) of the United States. Market consolidation continues, as the top six vendors increased their market share from 70% in 2018 to 72% in 2019, while the total number of major manufacturers declined from 37 to 33 (Pek, 2020).

China remained the leading country for new installations in 2019, adding 26 GW, of which 1.3 GW is offshore (IRENA, 2020a). The country's wind-related employment was estimated to hold steady at around 518 000 jobs (CNREC, 2020), followed by Germany (121 700 jobs) and the United States (120 000 jobs) (AWEA, 2020).

The total employment in onshore and offshore wind remained steady at 1.17 million people worldwide in 2019.[9] Women represent an estimated 21% of the industry's workforce (see Box 2) (IRENA, 2020b). Most wind jobs are found in a small number of countries. China alone accounts for 44% of the global total; the top five countries represent 74%. Still, the regional picture is more balanced than in the solar PV industry. Asia's 648 000 wind jobs make up about 56% of the total, while Europe accounts for 27% and North America for 11%. Of the top 10 countries shown in Figure 6, four are European, three are Asian, two are from South America and one is from North America.

*6 The 212 000 estimate breaks down into 111 676 jobs in ethanol and 100 195 jobs in biodiesel.*

*7 The calculation relies on revisions of an employment factor initially developed by APEC (2010). This factor is applied as a constant each year for smallholder production, which accounts for 45% of volume (WWF, 2012) and is more labour-intensive than large-scale plantations. For plantations, IRENA applies an assumed "decline" factor of 3% per year as a proxy for rising labour productivity.*

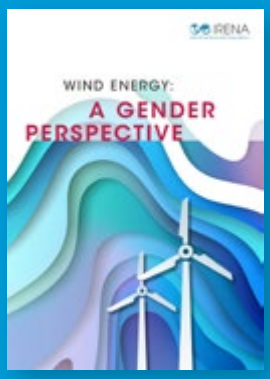
*8 In Thailand, IRENA estimates 124 600 jobs. Smallholders have a 73% production share, an average of the values reported by Termmahawong (2014) and by RSPO (2015). In Malaysia, smallholders account for roughly 35% of production (WWF, 2012). IRENA estimates 100 900 jobs in Malaysia and 36 100 in the Philippines. Focusing only on the construction and operations of biofuels processing facilities, the Philippine government estimates direct employment at 2 426 jobs.*

*9 The countries for which IRENA's database has estimates of wind power employment represent 99.7% of global capacity and cover 99.6% of new installations in 2019.*

## BOX 2. GENDER DIVERSITY IN THE WIND ENERGY SECTOR

Based on a survey of over 1 000 individuals and organisations, IRENA's *Wind Energy: A Gender Perspective* (IRENA, 2020d carried out in collaboration with the Global Wind Energy Council (GWEC) and the Global Women's Network for the Energy Transition (GWNET)) shows that the wind energy sector is male dominated, with women representing just 21% of the workforce (substantially lower than the 32% share of women in the renewable industry globally [IRENA, 2019a]). While respondents perceived that women possess the required skills and knowledge, they highlighted perceptions of gender roles and cultural-social norms as major barriers to gender equality in the sector.

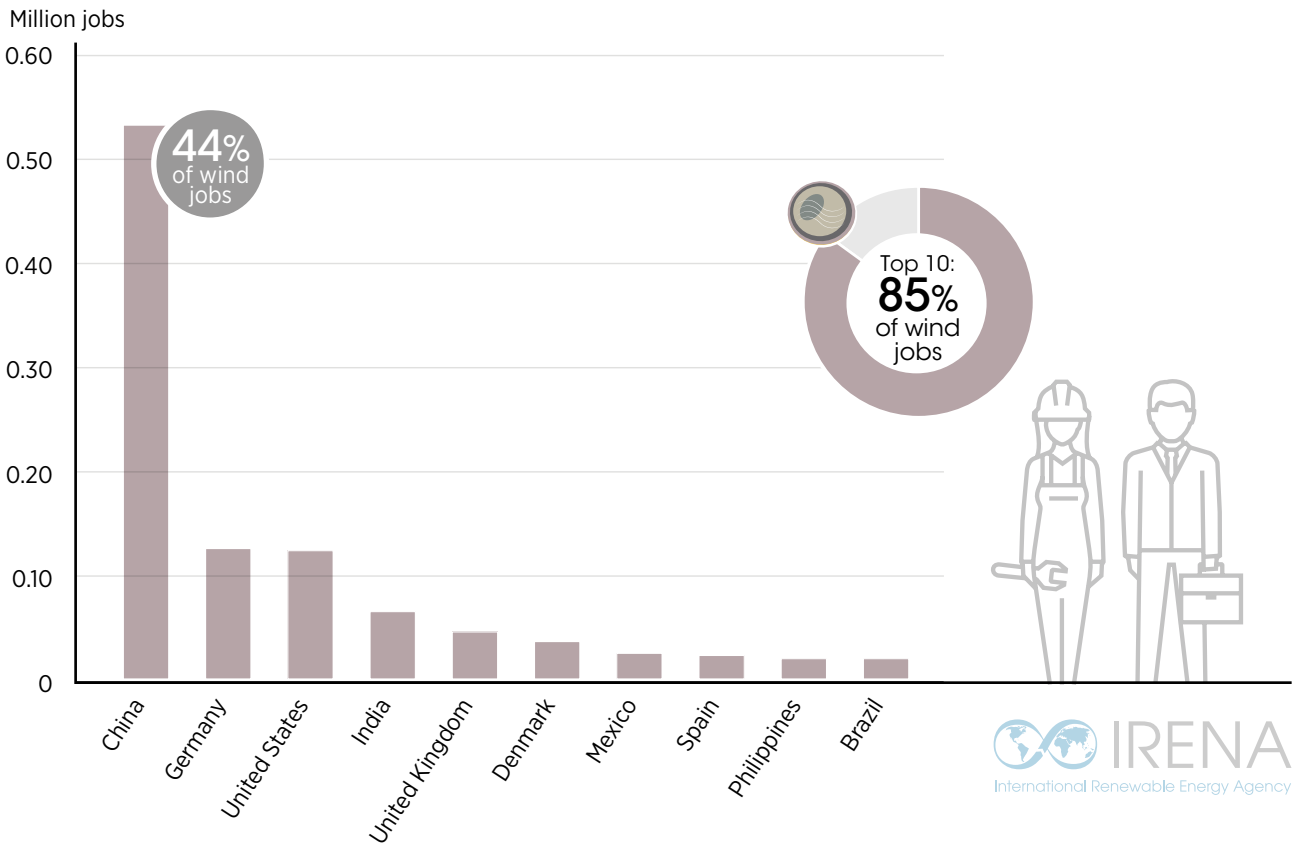
The under-representation of women in the science, technology, engineering and mathematics workforce (at just a 14% share) means that the wind industry is failing to tap a rich pool of talent that could add valuable perspectives and open new pathways for innovation.




To address the persistent gender imbalance, the wind sector needs to diminish ingrained stereotypes, facilitate inclusion and more diverse perspectives, and replicate best practices. Some initiatives already recognise women as agents of change. For instance, Vestas became the first wind-energy supplier to announce ambitious targets to achieve pay equity, support inclusion and address other gender disparities (Vestas, 2020).

GWEC, in partnership with GWNET, launched the Women in Wind Global Leadership Program, designed to accelerate women's careers, support their pathway to leadership positions, and foster a global network of mentorship, knowledge-sharing and empowerment.

FIGURE 6: **WIND EMPLOYMENT: TOP 10 COUNTRIES**




*Source: IRENA jobs database.*

The Global Wind Energy Council (GWEC) estimates that in the years 2020 to 2024, taking into account the impact of COVID-19, some 344 GW of new onshore and offshore wind power capacity may be installed around the world. These new wind power installations could create an additional 2.4 million job-years, rising from 395 200 job-years created in 2020 to 542 900 job-years created in 2024.[10]

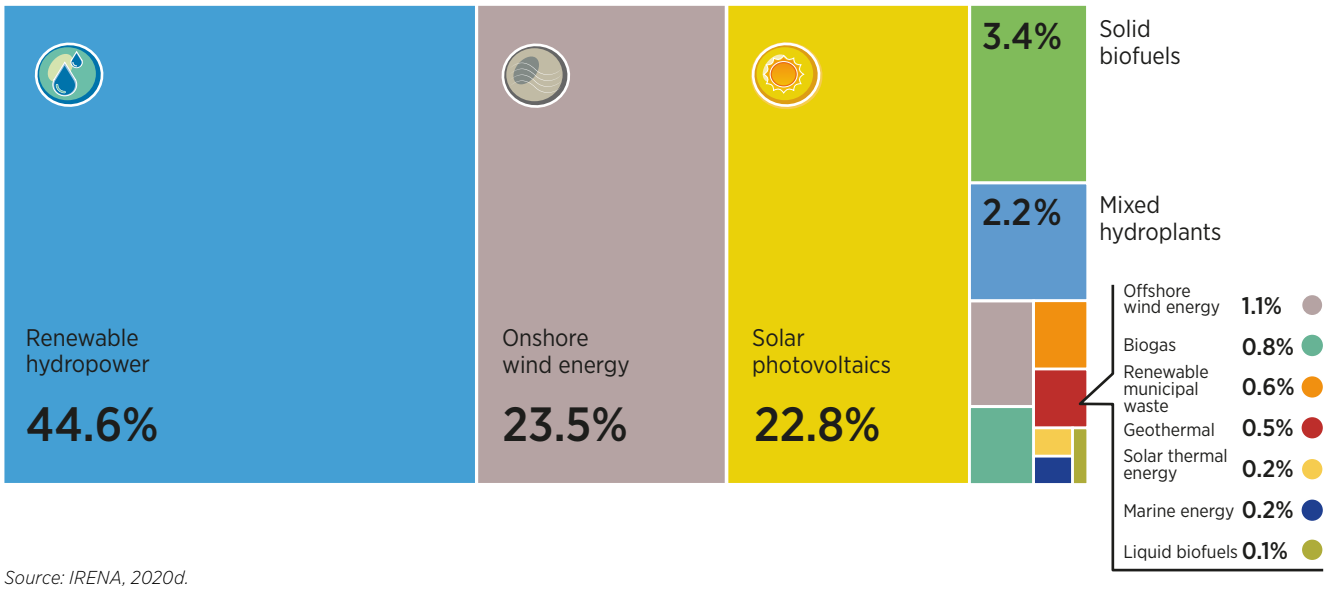
*10 This global calculation does not account for market-based learning rates, productivity improvements, technology evolution or other factors which may affect the labour required to deliver and maintain a project. Computations of jobs in operations and maintenance assume a 25-year project lifetime.*

## HYDROPOWER

Given its deployment over many decades, hydropower is still the largest source of renewable electricity in the world, accounting for 44.6% of the total installed renewable energy capacity in 2019 (see Figure 7).

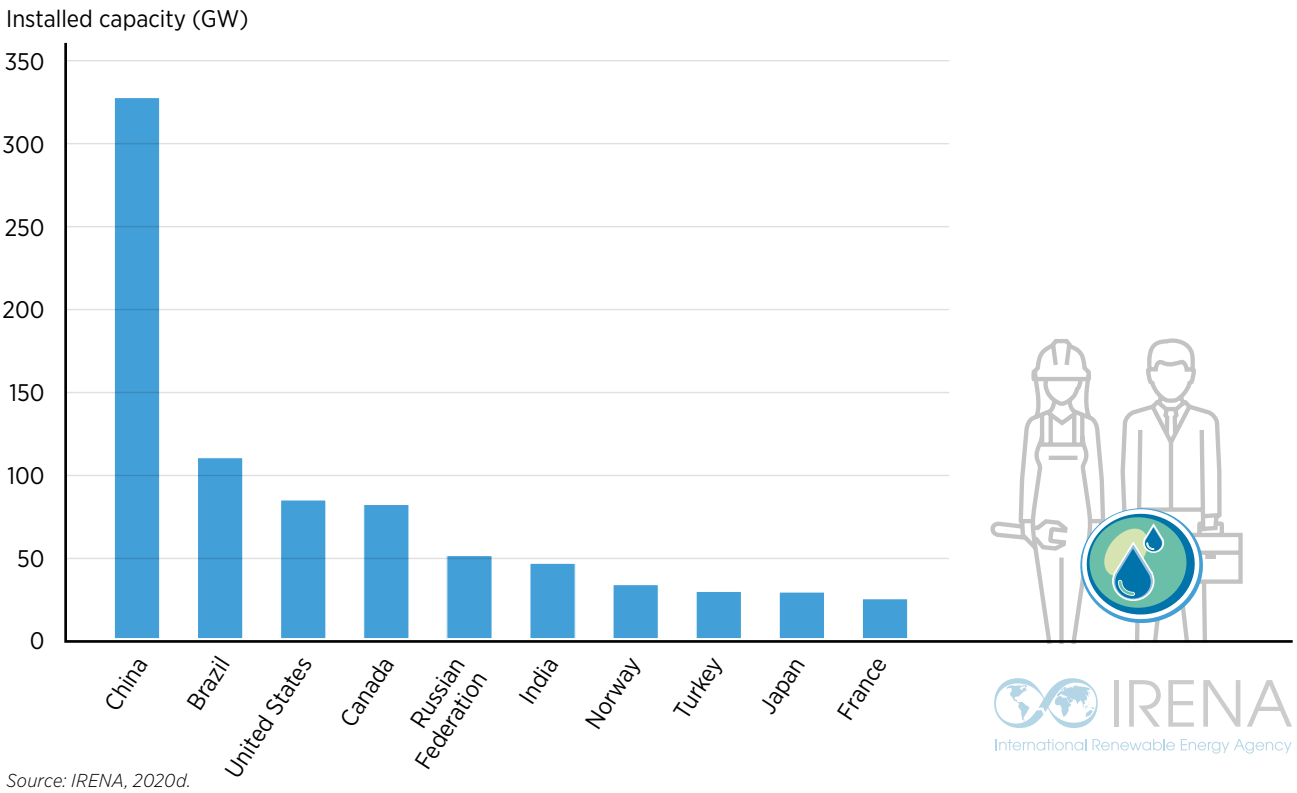
China, Brazil, the United States and Canada were the top countries that year (see Figure 8). However, global net additions of capacity in 2019 were the lowest in the last 17 years and 43% below the value in 2018 (IRENA, 2020a).

FIGURE 7: **HYDROPOWER'S SHARE OF TOTAL INSTALLED RENEWABLE ENERGY CAPACITY, 2019**




*Source: IRENA, 2020d.*

FIGURE 8: **HYDROPOWER CAPACITY, TOP 10 COUNTRIES, 2019**



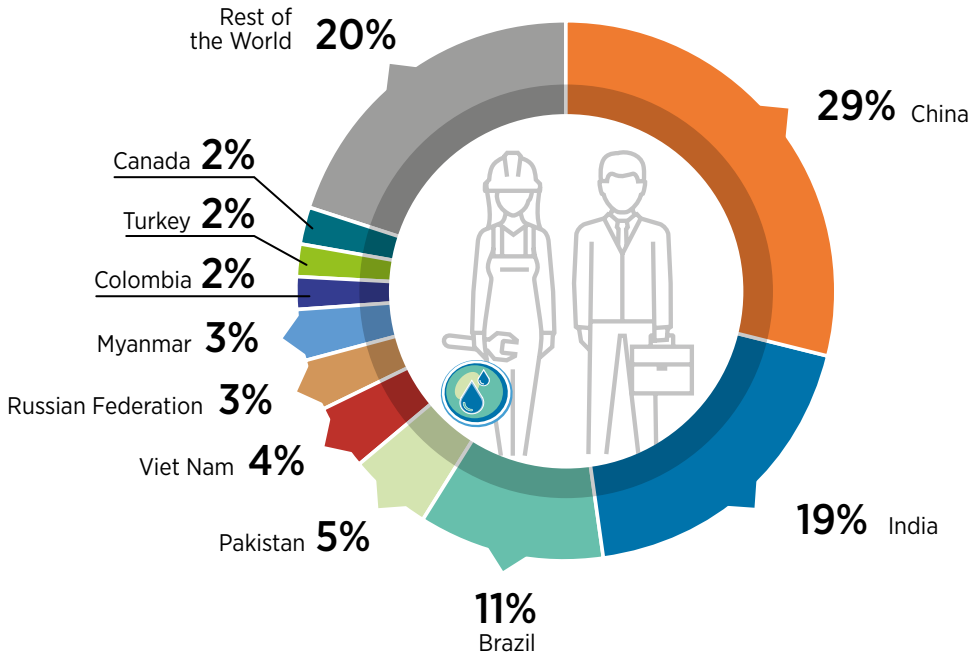

*Source: IRENA, 2020d.*

IRENA estimates jobs in the hydropower sector based on an employment-factor approach, which allows the revision of previous estimates and an examination of direct jobs in the main segments of the value chain: manufacturing, construction and installation, and operations and maintenance (O&M). The results reveal that approximately 1.93 million people worldwide worked in the sector in 2019. China, India and Brazil are the largest employers, followed by Pakistan, Viet Nam, the Russian Federation and Myanmar (see Figure 9).

Employment in 2019 was slightly lower (-6%) than in the previous year, as projects in the pipeline faced delays in several countries. The employment figure is likely to decrease further in 2020, given the delays in construction during the COVID-19 lockdown, which caused staff shortages due to travel bans.

Hydropower still presents huge untapped potential. It is expected to remain the world's largest source of renewable electricity generation in the medium term. Therefore, skills, training and educational requirements need to be understood well so that policy makers can anticipate hydropower's future workforce needs and design support policies accordingly.

FIGURE 9: **HYDROPOWER EMPLOYMENT BY COUNTRY, 2019**




*Source: IRENA jobs database.*

## SOLAR HEATING AND COOLING

The global solar heating and cooling market was led by China – followed by Turkey, India, Brazil and the United States. While installations declined in China and the United States, markets in India and Brazil saw growth in 2019 (Epp, 2020a).

IRENA's estimates indicate that global employment in the sector stood at 823 300 jobs. The top five countries account for 93% of all jobs. Of the top ten, four (China, India, Turkey and Jordan) are from Asia and three (the United Kingdom, Germany and Spain) from Europe. Asia accounts for 88% of the world total, some 727 000 jobs. With more than 70% of global installed capacity and a strong position in export markets, China remains the dominant employer in solar heating and cooling. Estimates for the country suggest that the workforce held steady at 670 000 in 2019 (CNREC, 2020).

After declining for three straight years, Brazil's solar heating market grew by 6% in 2019. Employment in the country's solar heating industry is estimated at 43 900 jobs.[11]

According to EurObserv'ER (2020), some 25 300 people worked in the EU solar thermal sector in 2018, the latest year for which data are available.[12] In the United States, IRENA estimated employment at 10 000 jobs in 2019, including both solar heating and cooling and CSP.

For India, which had the sixth-largest installed capacity worldwide in 2017, IRENA calculations suggest that the country may have employed some 23 800 people in 2018, when annual collector additions reached a new peak of almost 1.8 million square metres. However, since imports of Chinese-manufactured equipment have captured a growing share of the market, this calculation may over-estimate domestic jobs (Malaviya, 2019).


*11 IRENA uses an employment factor of one full-time job per 87 square metres ($m^2$) installed, as suggested by IEA SHCP (2016).*

*12 EurObserv'ER combines solar heating and cooling and CSP. Adjusting the EurObserv'ER figure with national-level reports suggests a higher figure of 36 300 for 2018. For Spain, APPA (2019) puts employment at 6 100, of which 900 jobs for solar heating and cooling and 5 200 for CSP. For the United Kingdom, REA (2018) offers a much higher figure (9 500 jobs) than the 200 published by EurObserv'ER.*

# DECENTRALISED RENEWABLE ENERGY EMPLOYMENT

Extraordinary growth potential exists for decentralised applications of renewable energy, especially in the least-developed countries, where only 52% of the overall population had access to electricity in 2018. In some countries, rural access rates are well below 10%. At the same time, even before the COVID-19 crisis unemployment rates in these rural communities were high and rising, with women and youth the most affected.

Decentralised renewable energy (DRE) solutions – solar for home and business, green mini-grids and stand-alone machinery for productive use (such as solar-powered irrigation pumps) – are generating significant economic opportunity, including employment. Emerging economies, by mainstreaming DRE, can not only meet the goal of universal electrification by 2030, but can also provide more decent work.

New country-specific data from India, Kenya and Nigeria covering 2017-18 show that DRE companies operating locally are already a large contributor to direct and indirect employment. Companies directly employed 95 000 workers in India, as many as the traditional utility-scale power sector, and that number was expected to double by 2022-23. Similarly, in Kenya, DRE companies accounted for 10 000 jobs, compared with 11 000 from the national utility KPLC, and employment was forecast to increase 70% by 2022-23. Direct employment in Nigeria was expected to increase tenfold during the same period to 52 000. Informal employment was almost double the size of the direct, formal workforce: 210 000 jobs in India, 15 000 in Kenya and 9 000 in Nigeria (see Figure 10).

Additional research is required to understand the full scope of employment in non-electricity DRE, such as clean cooking solutions. Initial data on employment in Kenya from clean cooking showed that direct, formal jobs are currently dominated by liquefied petroleum gas suppliers, representing 17 000 jobs, while electric cooking, bioethanol and biogas account for just 1 700 jobs (Lee *et al.*, forthcoming 2020).

DRE solutions have the potential to create up to five times more jobs in local communities than direct, formal DRE employment, through their application in so-called productive uses in agro-processing, communications, commerce, education and other fields. Early and rough analysis of the productive use of new or improved electricity access in 2017-18 indicates that 470 000 jobs were created in India, 65 000 in Kenya and 15 000 in Nigeria. In economies still dominated by agriculture, this is an important linkage, especially as food insecurity is increasing with the disruption of supply chains caused by global events.

In addition to their growing volume, DRE jobs also offer quality. Companies delivering access to electricity create skilled jobs that largely fall within the middle-income range for their respective countries. Employee retention is also better than for utility-scale power – more than two-thirds of jobs are full time and long term. A similar percentage of the workforce is skilled, compared with 50% for the global utility-scale solar sector workforce.

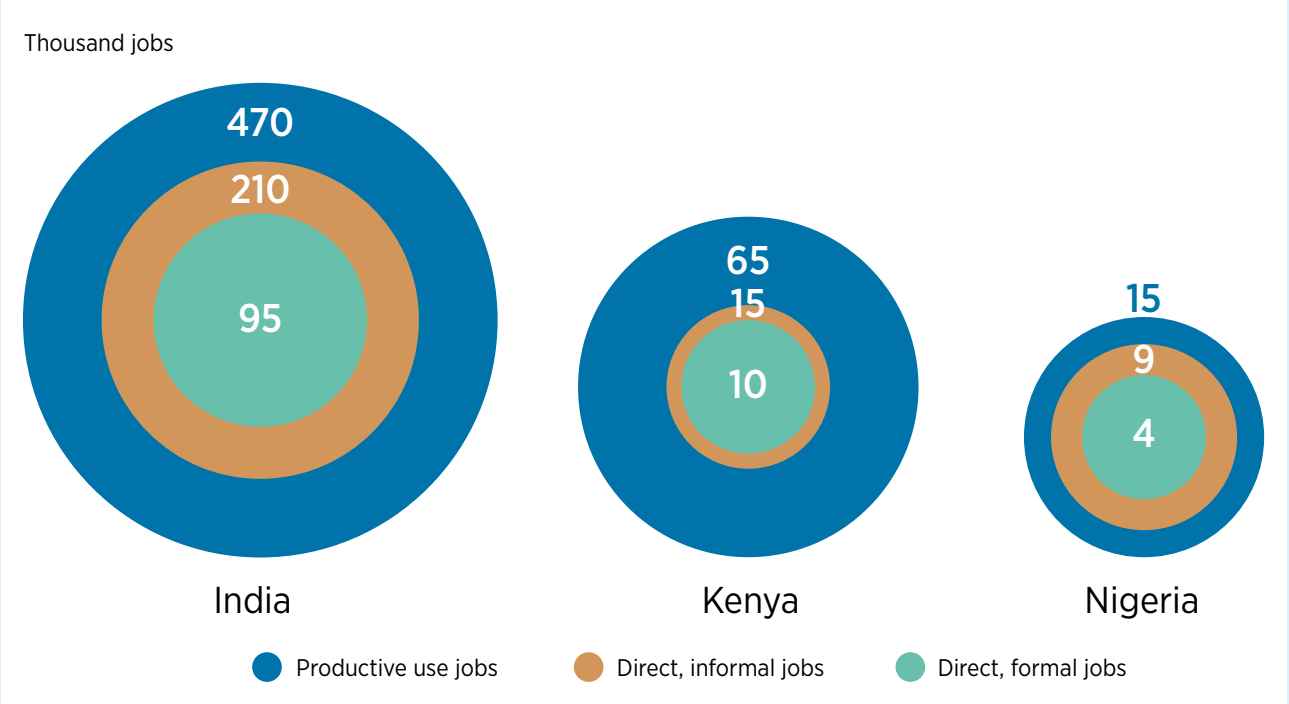
Another opportunity to generate both social and economic impact is by further engaging women in the DRE industry. Women currently make up about 25% of DRE employment in India, Kenya and Nigeria. While this is better than 22% in the overall energy industry, it lags behind the 32% estimated for the broader renewable energy industry (IRENA, 2019a). Lower participation of women in the DRE sector is related to broader sociocultural challenges involving gender stereotypes, recruitment biases, discriminatory business cultures, perceptions of gender roles and women's representation in STEM education (IRENA, 2019a).

Aside from presenting a strong opportunity to promote further gender equality, the DRE sector creates decent work for youth, who currently fill 40% of all DRE jobs. This is an important response to the growing challenge of youth unemployment in emerging economies. In Africa, for example, the youth population is projected to double by 2050 to 840 million, and 100 million youth could go without work by 2030 without urgent action. These projections were made even before the COVID-19 crisis added a new layer of complexity.

Despite its vital role in achieving universal electrification and generating employment, the DRE sector is experiencing significant skill gaps. There is a growing shortage of job-ready talent to finance, develop, install, operate and market energy solutions in the sector. Management skills, in particular, are a critical gap that must be filled to unlock further sectoral growth.

*Source: Data cited are primarily drawn from Power for All (2019).*

FIGURE 10: **ESTIMATED FORMAL, INFORMAL AND PRODUCTIVE USE EMPLOYMENT, 2017–18**



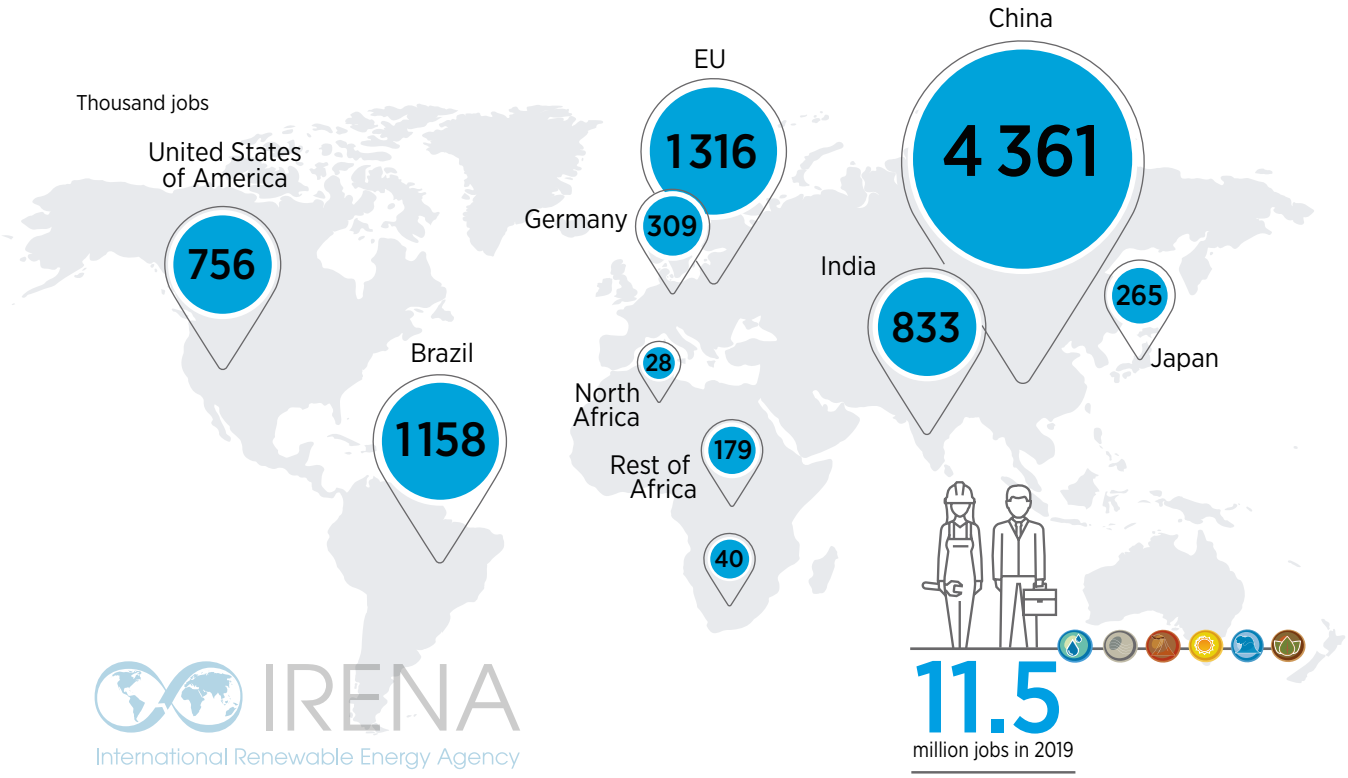

*Source: Power for All, 2019.*

*Note: "Productive use jobs" refers to jobs resulting from the application of renewable energy in agro-processing, communications, commerce, education and other fields.*

# RENEWABLE ENERGY EMPLOYMENT IN SELECTED COUNTRIES

This section presents key country-level trends and observations. It first discusses a number of leading countries – China, Brazil, the United States, India and members of the European Union (see Figure 11 and Table 1) – and then presents information on additional countries by region. Overall, the bulk of renewable energy employment is in Asian countries, which accounted for 63% of jobs in 2019.

FIGURE 11: **RENEWABLE ENERGY EMPLOYMENT IN SELECTED COUNTRIES**




*Source: IRENA jobs database.*

TABLE 1. **ESTIMATED DIRECT AND INDIRECT JOBS IN RENEWABLE ENERGY WORLDWIDE, BY INDUSTRY, 2018–19**

| Thousand jobs | World | China | Brazil | India | United States | European Union[m] |
|---|---|---|---|---|---|---|
| **Solar photovoltaic** | **3 755**[e] | 2 214 | 43 | 204[h] | 240 | 127 |
| **Liquid biofuels** | **2 475** | 51 | 839[g] | 35 | 297[i] | 239 |
| **Hydropower**[a] | **1 957** | 561 | 213 | 367 | 22[j] | 78 |
| **Wind energy** | **1 165** | 518 | 19 | 63 | 120 | 292 |
| **Solar heating/ cooling** | **823** | 670 | 44 | 23.8 | 5 | 36[n] |
| **Solid biomass**[b,c] | **764** | 188 | | 58 | 51[k] | 392 |
| **Biogas** | **342** | 145 | | 85 | 7 | 75 |
| **Geothermal energy**[b,d] | **99.4** | 3 | | | 9[l] | 40.6[d] |
| **CSP** | **29.5** | 11 | | | 5 | |
| **Total** | **11 459**[f] | **4 361** | **1 158** | **824** | **756** | **1 317**[f] |

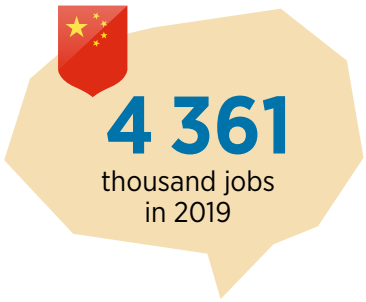


*Source: IRENA jobs database.*

*Note: Figures provided in the table are the result of a comprehensive review of primary national entities, such as ministries and statistical agencies, and secondary data sources, such as regional and global studies. This is an on-going effort to update and refine available knowledge. Totals may not add up due to rounding. Previous editions in this series distinguished small from large hydropower. Given changes in the available industry capacity data, this edition offers a single estimate for all hydropower facilities.*

*a. Direct jobs only.*
*b. Power and heat applications.*
*c. Traditional biomass is not included.*
*d. Includes 8 700 jobs related to ground-based heat pumps for EU countries.*
*e. Includes an estimate by GOGLA of 372 000 jobs in off-grid solar PV in South Asia and in East, West and Central Africa. South Asia accounts for 262 000 of these jobs. IRENA estimates Bangladesh's solar PV employment at 137 000 jobs (almost all off-grid), India's off-grid solar PV employment at 95 000, and the rest of South Asia at 30 000.*
*f. Includes 39 000 jobs in waste-to-energy and 1 100 jobs in ocean energy (reflecting available employment estimates in the European Union) as well as 9 000 jobs that are not broken down by individual renewable energy technologies.*
*g. About 216 100 jobs are in sugarcane cultivation and 158 600 in ethanol processing in 2018, the most recent year available. Figure also includes a rough estimate of 200 000 indirect jobs in equipment manufacturing, and 264 100 jobs in biodiesel in 2019.*
*h. 109 000 in grid-connected and 95 000 in off-grid solar PV. Also see note e.*
*i. Includes 229 600 jobs for ethanol and about 67 300 jobs for biodiesel in 2019.*
*j. IRENA employment-factor calculation. NASEO and EFI (2020) report a higher estimate of 67 700 jobs.*
*k. Biomass fuels and power, and biomass combined heat and power.*
*l. Direct geothermal power employment.*
*m. Almost all European Union data are for 2018. Hydropower data for several EU countries are from 2019.*

## LEADING MARKETS




**China** remains the clear leader in renewable energy employment worldwide, with a share of 38% of the world's total. The country's job number held steady at 4.4 million (CNREC, 2020).

China's solar PV workforce remained at 2.2 million, but the composition of jobs related to domestic and export markets changed dramatically. Employment in the construction and installation segment declined because of the slowdown in the domestic market, whereas jobs in the O&M and manufacturing segments increased (CNREC, 2020).

Solar PV installations in China declined for the second year in a row in 2019 and were estimated at 30 GW, down from 45 GW the previous year and 53 GW in 2017 (IRENA, 2020a). The drop can be attributed to the uncertainty surrounding the delayed release of auction rules, which left only limited time for project completion in 2019 (Wang and Tao, 2020; CNREC, 2019).

As the pace of installations slowed at home, manufacturers had considerable success in finding overseas markets for their modules. Exports of solar modules during the first three quarters of 2019 reached 58 GW, almost 40% higher than the export volume in all of 2018 (Xu and Stanway, 2019). In 2018, China accounted for 93% of global wafer production, and close to three-quarters of the world's cell and module production (Foehringer Merchant, 2020).

Employment in the Chinese solar water heating industry is thought to have held steady at 670 000 jobs. New installations declined by 8% in 2019, which contributed to a reduction in employment in the installation segment. However, as was the case with solar PV, exports of solar heating equipment rose, leading to an increase in the manufacturing workforce (Epp, 2020b).

While new domestic installations in solar PV and solar heating declined, wind had a good year. Capacity additions ran to almost 26 GW in 2019, driven by feed-in tariffs (IRENA, 2020a). Wind employment remained steady at around 518 000 jobs. China added about 24.5 GW of onshore wind capacity (up from 18.5 GW the previous year), and another 1.3 GW in the offshore segment (compared with 1.8 GW in 2018) (IRENA, 2020a).

Domestic companies have commanded a share of more than 90% of onshore installations over the past decade. This will likely also be the case as the offshore segment expands. Western firms provide advanced technology, but typically do not offer the type of lowwind-speed turbines well suited to China's offshore wind conditions. China's own firms, meanwhile, are not yet able to rely on a mature supply chain for the needed turbines (Li, 2019a).

Coastal provinces are now working to establish local chains, however, bringing together turbine manufacturers and key component suppliers. Manufacturers that build their facilities at local industrial parks are given preference in procurement. Localisation has progressed the most in Jiangsu Province, north of Shanghai. Other coastal provinces with ambitious installation plans, such as Guangdong and Fujian, have not yet been able to establish strong offshore turbine production capabilities (Li, 2019b).

**1 158**
thousand jobs
in 2019

**Brazil** has an estimated 1.2 million renewable energy jobs. As in previous years, the country remains the world's largest employer in biofuels. Output of fuel ethanol is driven by tax incentives and a mandate of 27% ethanol content in gasoline. Feedstock production set new records in 2018 and 2019, with 30.3 billion litres and 31.4 billion litres of sugarcane, respectively (USDA-FAS, 2019c). The most recent available employment estimate for bioethanol is for 2018, when employment held steady from the previous year at close to 575 000.[13] Biodiesel production reached a new peak of 5.9 billion litres in 2019 (ABIOVE, 2020a), and IRENA estimates employment rose to 264 100 jobs in 2019.[14]

Wind energy is today the second-largest power source in Brazil, following hydropower. But new additions to Brazil's wind power generating capacity ran to just 745 MW in 2019, a significantly lower amount than during the five previous years, bringing cumulative capacity to 15.4 GW. About 80% of this capacity is located in the country's northeast, which has the best wind conditions (ABEEólica, 2020).

IRENA estimates the country's wind workforce at about 18 750 people, down from close to 34 000 the previous year.[15] Prior to the onset of COVID-19, employment was expected to climb again during 2020, in view of planned installations. Local content requirements and subsidised loans for project developers have brought about a strong domestic supply chain for tower production, though less so in turbine manufacturing (Ferreira, 2017). Overall, domestic content in Brazil's wind sector is estimated at about 80% (Yamamoto, 2020).

New installations in Brazil's solar heating market increased by 6% in 2018 (ABRASOL, 2020), and employment is estimated to have increased to 43 900 jobs.[16] Brazil's solar PV installations have been rising rapidly since 2017. With new additions of about 2 GW in 2019, total capacity was close to 4.5 GW (ABSOLAR, 2020). IRENA estimates employment at about 43 200 jobs in 2019.[17] The distributed solar PV segment, which includes systems up to 5 MW under Brazil's net-metering scheme, is estimated to account for around two-thirds of capacity additions and 85% of solar PV jobs in 2019.

More than half of all PV installations, and therefore many PV jobs, are concentrated in four of Brazil's states (Minas Gerais, Rio Grande do Sul, São Paulo and Paraná) (ABSOLAR, 2020). Brazil is expanding its PV manufacturing capacity, with several Chinese companies setting up plants. Solar farms that use local components can access financing from BNDES, the national development bank, and from the regional Banco do Nordeste (Molina, 2020).

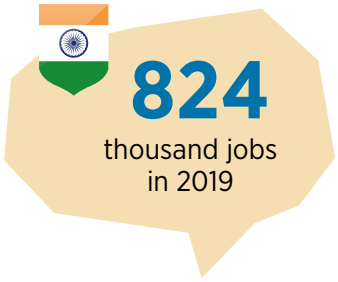
*13 In 2018, around 216 100 workers were engaged in sugarcane cultivation in Brazil, and almost 159 000 in ethanol processing (MTE/RAIS, 2020). IRENA's employment estimate for the country includes 200 000 indirect jobs in equipment manufacturing, though this figure is rough and dated.*

*14 The calculation is based on employment factors for different feedstocks (Da Cunha, Guilhoto and DaSilva Walter, 2014). The shares of feedstock raw materials, principally soybean oil and animal fat (beef tallow), are derived from ABIOVE (2020b).*

*15 This calculation is based on employment factors published by Simas and Pacca (2014).*

*16 This IRENA calculation of installation-related jobs is based on Brazilian market data and a solar heating and cooling employment factor. The estimate for manufacturing jobs is derived from an original 2013 estimate by Alencar (2013).*

*17 IRENA calculation uses a jobs-per-megawatt employment calculation that distinguishes between labour requirements for centralised and decentralised deployments.*




**India** added 7.7 GW of solar PV capacity in 2019, 16% less than in the previous year. After eight years of continued growth, the labour-intensive rooftop solar market also contracted by 7%, reaching 1.5 GW in 2019 (IRENA, 2020a). The drop in solar PV installation can be attributed to several factors, including policy uncertainties, reduced project developer participation in auctions (due to low tariff caps, land and transmission bottlenecks, payment delays by distribution companies, and steps by some state governments to renegotiate power purchase agreements), and an increase in module prices traceable to import duties and currency devaluation (IRENA, 2019b; Gupta, 2019; Mohanty, 2020).

IRENA's employment-factors-based estimates suggest that India's jobs in grid-connected solar PV declined by 14% to settle at 109 000 in 2019. Jobs in off-grid solar applications were believed to number some 95 000 (Power for All, 2019).

Today, Indian solar manufacturers continue to struggle with costs, though the gap between imported and local modules has narrowed gradually to less than USD 0.015 per watt. Exports of cells and modules increased by around 137% in 2019. The United States accounted for 76% of these shipments, followed by Viet Nam, Belgium and Turkey (Ranjan, 2020).


India's imports of solar cells and modules declined in 2019 owing to duties imposed and a decrease in installations. Despite falling volumes, Chinese suppliers still account for around 78% of total module imports, followed by Viet Nam, Singapore and Thailand. The proposed introduction of a 20% import duty on solar inverters in August 2020 could help local suppliers seize a larger share of the market (Chatterjee, 2020; Stoker, 2020).

Attempts to set up a domestic solar manufacturing industry better able to compete with cheap imports have run into problems in recent years. Yet, according to a KPMG study, by 2030 domestic manufacturing could save India USD 42 billion in equipment imports and create as many as 50 000 direct and 125 000 indirect jobs over a five-year period (Dewan, 2019).

Based on consultations with industry representatives, India's Energy and Resources Institute (TERI, 2019) proposed a three-stage industrial policy strategy for the expansion of solar manufacturing in India. A first step would create 15 GW of cell and module production capacity at manufacturing hubs over two to three years. State governments would assist with the acquisition of land and infrastructure. A second step would focus on the production of silicon ingots and wafers; the third on the production of associated machinery to complete the value chain.

Measured by total capacity, India is the world's fourth-largest wind market. But annual installations have waned; the 2.2 GW added in 2019 was only slightly more than half of the 4.1 GW installed in 2017 (IRENA, 2020a). IRENA estimates jobs in the country's wind sector at 62 800.

India's wind manufacturing industry produces close to 75% of the equipment used in domestic installations. The plans and policies in place have led to reduced installations, hurting the supply chain. Many component manufacturers that had been expecting increased deployment had aimed to scale up production. However, the slowing pace of new installations resulted in extensive competition and an over-supply of equipment. The number of wind turbine makers has dropped from fourteen to four or five, with attendant job losses (Arora, 2019).

**756**
thousand jobs in 2019

The **United States** has an estimated 755 600 renewable energy jobs. The expected reduction of federal tax credits at the end of 2019 prompted a rush to initiate wind and solar projects before the cut-off point, contributing to a combined 20 GW of capacity installed in the two sectors during the year. Ultimately, the US Congress decided to extend the production tax credit for wind by another year, but not the investment tax credit supporting solar (BNEF and BCSE, 2020).

Utility-scale solar PV additions in 2019 were estimated at 7.3 GW, the second highest after the 10.2 GW peak in 2016. Another 3.9 GW were added in residential and commercial installations (BNEF and BCSE, 2020). The expansion was aided by declining costs, reduced uncertainty over trade tariffs and the tax credit rush among project developers. Solar jobs grew 2.3% to just under 250 000 in 2019, about 10 000 below the 2016 peak.[18] Two-thirds were in installation and project development (Solar Foundation, 2020).

Three-quarters of the solar modules installed in the United States in 2019 were imported, as were half of all inverters, whereas 90% or more of batteries, electronics, wires, cables and mounting structures came from domestic sources (Solar Foundation, 2020). Tariffs enacted in February 2018 have had mixed effects. Under the assumption that tariffs lead to higher prices, the Solar Energy Industries Association (SEIA, 2019) argued that they could reduce installations by 10.5 GW and create 62 000 fewer jobs. However, Chinese module suppliers set up factories in Malaysia and Viet Nam to avoid the tariffs, and these two countries accounted for close to three-quarters of US PV imports in the first eight months of 2019 (Murray, 2020; BNEF and BCSE, 2020). Further, foreign manufacturers set up five new module plants in the United States with a combined 3 GW of capacity (Foehringer Merchant, 2020).

The pace of new US wind installations, 9 GW in 2019, was the quickest since 2012. Just two turbine manufacturers, GE and Denmark-headquartered Vestas, accounted for 82% of US domestic manufacturing capacity in 2018, and for 79% of installations (BNEF and BCSE, 2020). In 2019, US wind employment rose 5% to 120 000 jobs, of which equipment manufacturing accounted for 26 000 distributed across 530 factories.

Wind development mostly benefits rural areas, in states like Texas, Iowa, Illinois, Colorado and Indiana. Projects in 2019 added USD 912 million to state and local tax revenues, and USD 706 million went to landowners in lease payments (AWEA, 2020).

The US offshore wind segment is still in its infancy, but projected capital investments of USD 78 billion in the 2020s will rival planned spending in offshore oil and gas; this will be in sharp contrast to the past decade, when USD 154 billion was spent on offshore oil but zero on offshore wind (Meyer, 2020).

Many components are manufactured in Europe. But a planned 2.6 GW wind farm in the coastal waters off Virginia could spur the emergence of a domestic supply chain (Stromsta, 2020).

US biofuels employment runs to about 297 000 jobs. With biodiesel output dropping 7% to about 6.5 billion litres in 2019 (EIA, 2020), IRENA's estimate suggests that the number of jobs fell to about 67 300. Ethanol production also slipped, to 59.8 billion litres, with employment estimated at 229 600 jobs (Urbanchuk, 2020).

The US energy sector remains less gender-diverse than the overall national workforce, which is nearly half (47%) female. Women account for a minority of energy sector jobs, ranging from 23% to 33%, depending on the specific industry. Renewables fare comparatively well, with women accounting for about 32% of the workforce in hydropower, 31% in wind and 30% in solar PV (NASEO and EFI, 2020).

18 *This figure includes jobs in solar PV, solar heating and cooling, and CSP, but US solar capacity additions since 2016 have been exclusively in the PV sector (BNEF and BCSE, 2020). A solar job is defined as one held by a worker spending at least 50% of his or her time on solar-related work. About 90% of these workers spent all of their time on such work. An additional 94 549 employees spent less than half their time on solar-related work, for a total of 344 532 workers (Solar Foundation, 2020).*

**1 317**
thousand jobs in 2019

In 2018, the most recent year for which data are available, the number of renewable energy jobs in the 28-member **European Union** was estimated at 1.3 million (EurObserv'ER, 2020).[19] This was up from about 1.2 million the previous year. Germany, the United Kingdom, France, Italy, Spain, and Poland led the job rankings.

The bioenergy sector is the largest renewables employer in the European Union. Solid biomass (heat and electricity) leads with approximately 392 400 jobs, followed by biofuels (239 000), and biogas (74 900).

IRENA estimates EU wind power employment at about 292 300 jobs.[20] The continent's cumulative capacity stands at 205 GW, after 12.1 GW were added in 2018 and 15.4 GW in 2019 (Wind Europe, 2020). Germany, Spain and the United Kingdom are the leaders in new and overall installations. The pace of European installation markets slowed in the last two years, but a substantial portion of European jobs is created by companies that also serve export markets, notably Vestas, Siemens Gamesa, Enercon and Nordex (EurObserv'ER, 2020).

Employment in the solar PV industry grew to about 127 300 jobs, reflecting a significant upturn in several European markets. After adding about 6 GW of PV capacity in 2016 and a like amount in 2017, EU member countries installed about 8 GW in 2018 and close to 15 GW in 2019 (IRENA, 2020a).

**Germany's** renewable energy employment continued to decline from a peak of 416 700 jobs in 2011. In 2018 (the most recent year for which estimates are available), the number of jobs was 312 000 (BMWi, 2020; EurObserv'ER, 2020).[21] O&M jobs continued to expand, but manufacturing and installation employment suffered. After losing many jobs between 2011 and 2014, Germany's solar PV industry stabilised and registered a gain of 4 000 jobs in 2018. Most other renewables industries also showed small improvements.

But the wind sector, dominant among renewables, has been shedding jobs since 2016. Employment in the onshore wind segment went from 113 400 in 2017 to 96 600 in 2018, overshadowing smaller gains in the offshore segment (BMWi, 2020). This is due to a precipitous decline in new onshore installations, from 5.5 GW in 2017 to about 2.5 GW in 2018, and further to 958 MW in 2019, the lowest level since 1998 (FA Wind, 2020).

Policy changes, including restrictive rules for the siting of wind farms and a lengthening permitting process, lie behind this development (Diermann, 2019; IRENA, 2019b).[22] Although data for 2019 are not yet available, it is very likely that job losses in onshore wind continued. Manufacturer Senvion declared insolvency in April 2019. Enercon announced in late 2019 that it was laying off some 3 000 workers, affecting northern and eastern parts of the country that are not well diversified economically (Balser and Bauchmüller, 2019).

In **Spain** the enforcement of laws in the context of the EU's Renewable Energy Directive at national, regional and local levels, as well as growing interest from the public and private sectors, have injected a new dynamic into what had been a stagnant sector. According to APPA, the Spanish Association of Renewable Energy, the sector experienced 10.7% growth in real terms in 2018. The same year, a new export record of EUR 4.7 billion was set, and the sector contributed EUR 10.5 billion to GDP, close to 1% of Spain's total (APPA, 2019).

19 *Including the United Kingdom prior to Brexit. The EU total, along with the estimates for individual renewable energy technologies, is based on EurObserv'ER (2020) and adjusted with national data in the cases of Germany (BMWi, 2020), France (FEE and Capgemini Invent, 2019), Spain (APPA, 2019) and the United Kingdom (REA, 2020). Differences in methodologies used by the cited sources generate widely differing employment estimates.*

20 *The data are for the EU-28, including the United Kingdom. The country withdrew from the European Union effective 31 January 2020, after the period of time that serves as the basis for this report.*

21 *The data reported in the 2019 edition of the Annual Review are not directly comparable with the estimates reported here, since they were based on a different source and methodology. This year, an estimate of 7 600 jobs in energy from municipal waste reported by EurObserv'ER (2020) was added to the BMWi figure of 304 400 jobs.*

22 *Boosting wind generating capacity in line with projected demand would require expanding it from 54 GW at present to 97 GW by 2030. This would translate into annual additions similar to those made in 2014-18. The government's 2030 climate policy implies adding 17 GW, or less than 2 GW per year (Diermann, 2019).*

APPA highlights that the sector employed 81 294 people in 2018. The largest employer was biomass (with 32 300 jobs), followed by wind energy and solar PV (22 200 and 13 300, respectively). By technology, wind energy created most of the net new jobs (1 961), followed by solar PV (966) and biofuels (158). The total represents a 3.3% increase in employment, the highest figure since 2013, but still far from the record set in 2008, when the sector employed 144 000 people (APPA, 2019).

In the **United Kingdom**, renewables employment in 2018 is estimated at 114 500 jobs.[23] According to the UK National Grid Net Zero Energy Workforce Report, the country's energy sector workforce employs 144 000 people directly. As is true in other countries, women are under-represented across the energy sector; they account for only 12% of its engineers (National Grid, 2020).

Employing some 44 100 people, the wind industry accounted for 37% of the United Kingdom's renewable energy total. Wind jobs are concentrated in London and the southeast (one-third of employment), northern parts of England (another one-third) and Scotland (10%) (REA, 2020). In northeast England, an offshore wind industry cluster helped Hull (East Yorkshire) cut its unemployment in half (Reed, 2020).

The United Kingdom has Europe's third-largest installed wind capacity after Germany and Spain, with a significant portion of its industrial supply chain located abroad. The turbines for Dogger Bank, set to become the world's largest offshore wind site, are to be supplied by GE Renewable Energy from factories in France. Nacelles will come from Saint-Nazaire (400 employees) and blades from Cherbourg (more than 550 direct jobs and 2 000 indirect) (WEAMEC, n.d.). Locally, the Port of Tyne will serve as the O&M base for Dogger Bank, with more than 200 direct jobs expected (Dogger Bank, 2020).

In **France**, direct and indirect wind jobs were estimated at 18 400 in 2018, a gain of 1 400, or 8% over the previous year. Planning and design jobs have seen the most growth, employing 5 400 people in 2018. This compares with 4 900 in engineering and construction, 4 100 in component manufacturing and 3 700 in O&M. The two northeastern regions of Hauts-de-France and Grand Est are home to half of France's wind capacity and 20% of total wind employment. But it is the capital region, Île-de-France, that has the single-largest number of jobs, at 29%.

The French wind supply chain now comprises more than a thousand companies. In the traditional industrial region of Auvergne–Rhône-Alpes, a competitiveness cluster focused on energy transition innovation, Tenerrdis, brings together some 300 partners from industry, R&D centres and local authorities (FEE and Capgemini Invent, 2019). Another noteworthy cluster is the West Atlantic Marine Energy Community, which groups more than 100 regional companies, engineering schools and research laboratories, and offers training courses relevant to marine-based renewable energy (WEAMEC, 2020).

According to EurObserv'ER (2020), solid biomass was the largest employer in France in 2018 with 31 100 jobs, followed by liquid biofuels (29 100 jobs), wind (15 700 jobs) and solar PV (15 000 jobs).

*23 This figure is principally based on reporting from the Renewable Energy Association (REA, 2020), with some adjustments. REA published a figure of 9 796 jobs in air- and ground-source heat pumps, but IRENA includes only ground-source heat pumps (2 100 jobs). IRENA's estimates indicate 1 900 jobs in hydropower in 2019. The REA estimates energy from waste employment at 8 084 jobs.*

## OTHER COUNTRIES

Several other countries – in Asia, Latin America and the Caribbean, the Middle East and North Africa, and Sub-Saharan Africa – are expanding their presence in renewables. In the process, they are creating jobs in various segments of the value chain. This is particularly true of the solar PV sector, where several **ASIA-PACIFIC** countries are major players.

In **Japan**, cumulative solar PV capacity reached 61.8 GW in 2019, the second-largest after China and just ahead of the United States (IRENA, 2020a). The growth came amid a shift from large-scale to rooftop assemblies, because suitable land is scarce in Japan. IRENA estimates 2019 employment at some 241 000 jobs, a reduction of 10 000 from 2018.[24] The bulk of Japan's solar panels are imported. In the first three quarters of 2019, domestic production accounted for just one-sixth of total shipments (JPEA, 2020), limiting the extent of domestic manufacturing jobs.

The **Republic of Korea** estimates all renewable energy employment at 25 730 in 2018 – the most recent year for which estimates are available (Korea Energy Agency, 2020). In solar PV, the country employs about 13 800 people directly in manufacturing and in construction and installation. Production is heavily export oriented, with about 90% of the modules shipped abroad (IEA PVPS, 2020c). The domestic market received a boost when the capital city, Seoul, announced plans to deploy rooftop PV on a million homes and all public buildings, with the intent to quintuple its total capacity to 1 GW by the end of 2022. The initiative is expected to create up to 4 500 new jobs (Bellini, 2019).

**Malaysia** is a major solar PV manufacturer for export markets; half a dozen leading companies have set up facilities with a module-production capacity of about 5.4 GW (IEA PVPS, 2020a). The Sustainable Energy Development Authority (SEDA, 2020) estimates the number of people working in solar PV in 2019 at 54 900. IRENA's calculation yields an estimate of 100 900 jobs in the agricultural supply chain for biodiesel in 2019. Altogether, IRENA estimates Malaysia's renewable energy workforce at 187 000 in 2019.[25]

In **Thailand**, a total of 15 companies produced PV modules in 2018, with an annual capacity of 4.3 GW. There are also 80 PV inverter suppliers, 20 companies in the storage battery field, and 70 engineering, procurement, and construction companies specialising in both utility-scale and rooftop systems. Direct PV jobs were estimated at 18 710 in 2018, of which 14 000 were in operations and 3 000 in manufacturing (IEA PVPS, 2020b).

Solar PV jobs in the **Philippines** increased from 20 800 in 2018 to 33 700 in 2019. Wind power contributes close to 18 780 jobs, solid biomass more than 11 000 and geothermal power another 11 980 (REMB DOE, 2019). IRENA estimates biofuels employment at 36 100 jobs, including informal jobs in the agricultural supply chain.

**Viet Nam** had already become a notable PV manufacturer in recent years. But in 2019 the country joined the ranks of large installation markets with additions of 5.6 GW (IRENA, 2020a). This was driven by deployment policies (feed-in tariffs and most recently, auctions). Developments have been so rapid that they completely overtook recent projections, such as a 2019 World Bank supply-chain assessment that foresaw 12 GW of solar PV installations and some 45 000 full-time equivalent (FTE) jobs by 2030 (World Bank, 2019). IRENA estimates that, due to the accelerated pace of deployments and large exports, Viet Nam's solar PV workforce already stood at 56 700 jobs in 2019. The manufacturing and construction and installation segments of the value chain each accounted for around 25 000 of these jobs, with the remainder in operations and maintenance.

As noted earlier, **Indonesia** is a large biofuels producer and employer. The government is now working on the Solar Archipelago (Surya Nusantara) plan to install 1 GW each year over the next four to five years, with a focus on serving the poorest households. The initiator of the plan, the Institute for Essential Services Reform, estimates that up to 22 000 jobs could be generated in installations. But because experienced installers are in short supply, stepped-up training is essential to make the plan a reality (Harsono, 2020).

*24 In the absence of direct employment data, this calculation is based on the assumption that employment closely tracks the reduction in demand during 2018.*

*25 Hydropower employment is estimated by the government at 22 000 jobs. IRENA's employment-factor calculation is lower, at 7 000 jobs.*

In **Bangladesh**, IRENA estimates 137 400 jobs are related to the country's 5.8 million decentralised solar home systems that represent about 80% of total installed solar capacity. However, in recent years, grid-connected solar generation installations surpassed those of off-grid solar home systems (SREDA, 2020), some 25 and 18.3 MW in 2019, respectively (Islam, 2020a). Although most Bangladeshi solar jobs are in sales, installation and maintenance, some 10 000 people are also employed in module assembly (Islam, 2020b).

In **Australia**, direct FTE renewable energy employment ran to about 26 850 jobs in 2018-19 (ABS, 2020), 27% more than the previous year. Rooftop solar PV leads with 13 070 jobs, ahead of utility-scale PV (4 740 jobs), wind (3 240) and hydro (3 060),[26] with biomass and geothermal weighing in less heavily. Australia's 2020 renewable energy target drove much investment. But now the renewable energy sector is contending with problems of grid connection and transmission infrastructure – and with a lack of continued federal government policy support (Maisch, 2019). Still, Australia's Clean Energy Council (CEC, 2020) projects that renewable jobs could rise to 44 000 by 2025 if ambitious policies and adequate skill training are put in place (CEC, 2020).[27]

In **EASTERN EUROPE**, **Ukraine** had a stellar year for solar PV deployment in 2019. Solar PV capacity tripled, as close to 3.9 GW were added to the grid, encouraged by a combination of feed-in tariffs and net metering. IRENA's estimates put solar PV jobs in the country at close to 24 800, one-third of which are in the labour-intensive rooftop solar segment. Reductions in feed-in tariffs could reduce jobs in the utility-scale segment in 2020, but will not affect rooftop deployment, which is driven by net-metered projects (UNIAN, 2020; Teush, 2020).

In **LATIN AMERICA**, Argentina, Brazil, Chile and Mexico are among the largest actors in the renewables sector, but with each passing year more countries are adopting new policies and increasing the share of renewables in their energy mix.

**Mexico** has the region's largest installed solar PV capacity, ahead of Chile and Brazil. Solar PV grew from 2.5 GW to 4.4 GW in 2019. Utility-scale plants account for more than 80% of this total, with employment estimated at more than 50 000 jobs. Solar rooftop installations are responsible for another 6 000 jobs, according to the Asociación Mexicana de Energía Solar (ASOLMEX) (Zarco, 2019). INEGI (2020) suggests a lower value of direct and indirect solar PV employment, estimated at 23 300 jobs.

In **Argentina**, the successful RenovAr auction programme remains strong; it is oriented toward innovation trends and now provides guarantees to back up contracts and mitigate risks. Domestic technology is being promoted; technology imports are not allowed when local alternatives are available. Projects that source at least 60% of their materials locally can apply for special tax regimes (IRENA, 2019b). This has helped mobilise private sector participation and increased local employment. As of March 2020, Argentina reported that 15 000 people were working directly in renewable energy. The liquid biofuels sector is the main employer with 5 530 jobs, followed by wind energy with around 3 750 jobs (lower than previous years as many projects under construction came to an end) and solar energy, with some 2 720 jobs (Ministerio de Energía, 2020).

Since 2008, **Ecuador's** constitution has included an explicit reference to the need to address climate change mitigation, implying a governmental responsibility for promoting the use of clean energy sources and energy efficiency measures to preserve the environment and maintain food and water security. Since then, Ecuador has increased its renewable energy generation, mostly from hydropower, followed by wind and solar PV, creating ample job opportunities.

As reported in the first quarter of 2020, around 44 000 people were directly employed in solar (PV and CSP), geothermal and wind. Additionally, 67 000 people are directly or indirectly employed in other renewables, notably biofuels, biogas, solid biomass and waste management. The country reports that women and men participate equally in the biogas industry, while women's participation is lower in other renewable energy technologies: accounting for 44% in solid biomass, 38% in wind energy, 33% in all solar technologies and only 22% in the geothermal workforce (IIGE 2020).

*26 The ABS estimate contrasts with an estimate of 12 000 jobs based on IRENA's employment calculation.*

*27 For purposes of comparison, coal mining employs some 40 000 people in Australia.*

**Costa Rica** is already a front-runner in the deployment of renewable energy. Yet the country still has great unexploited potential in various end uses (namely transport and heating and cooling) and in diversifying the power generation mix, which is highly focused on hydropower. Geothermal energy employed over 100 people in 2019 (SEPSE, 2020). The Solar Energy Association of Costa Rica, Acesolar, reports that up to 1 467 people were employed in 2018 (Acuña *et al.*, 2018), supporting the addition of 30 MW of solar capacity between 2014 and 2019 (IRENA, 2020a). As of early 2020, national statistics reported 46 employees in the design and operation of solar PV and CSP plants. With some wind farm construction coming to an end, jobs in that sector decreased to 53 in O&M and environmental management (SEPSE, 2020).

**Colombia** remains a top biofuels producer and employer, as noted previously. The country also reports over 4 900 jobs in solar and wind energy. It is important to mention that, inspired by the success of auctions in other Latin American countries and thanks to a conducive market structure, Colombia has recently awarded contracts for nine projects that will provide 1 374 MW from wind and solar sources. These should bring ample employment opportunities in the coming years. Most of the projects will be located in La Guajira, a region that has been historically marginalised and energy-poor. The inclusiveness and long-term sustainability of the employment opportunities in the region will depend on the presence of a labour force with the requisite education and skills, and social protection policies that will need to be coordinated with industrial and financial ones (IRENA and USAID, forthcoming; IRENA, 2019b).

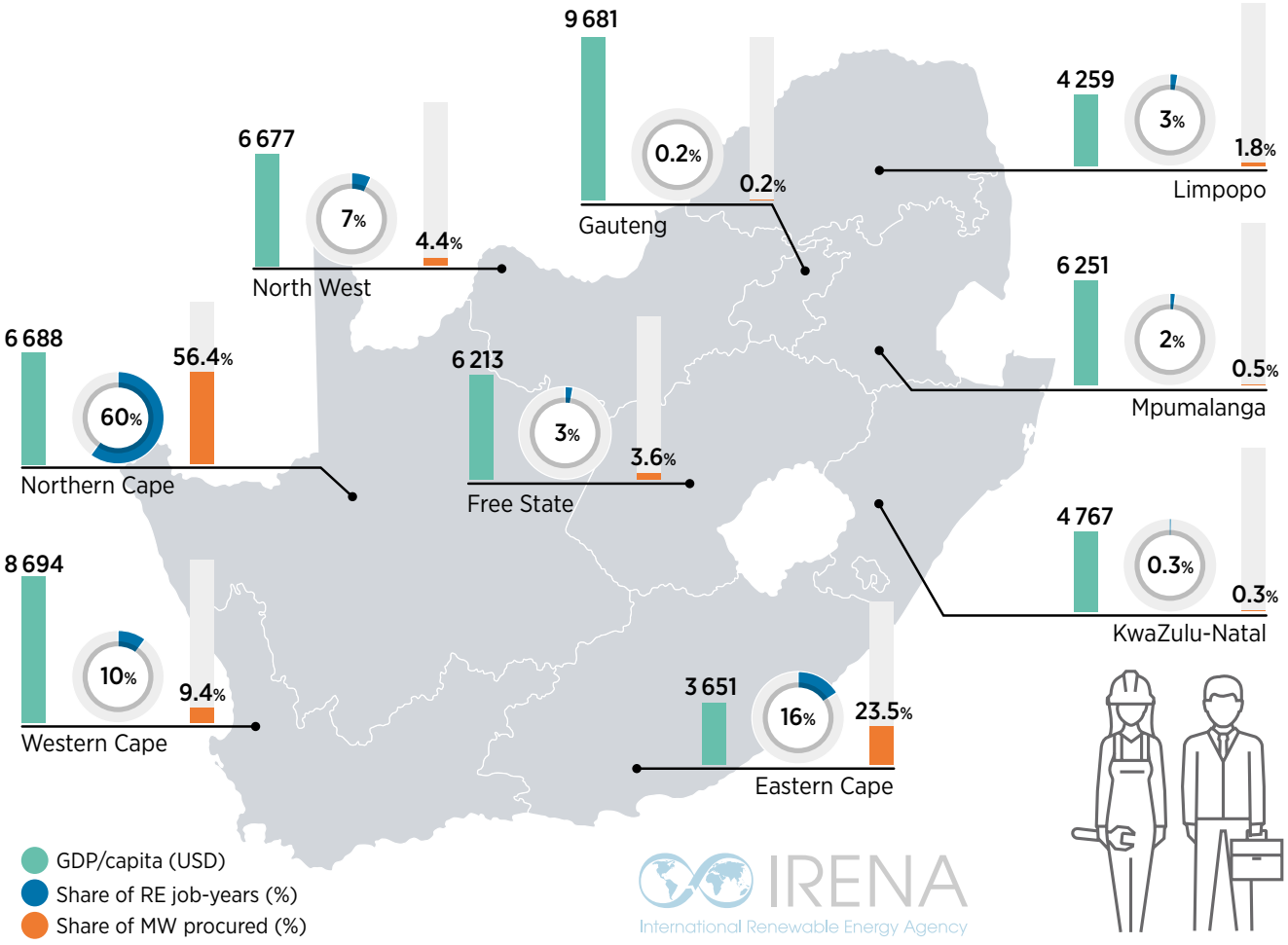
A number of other countries in the region are creating jobs while ensuring better energy access. For example, benefiting from funding provided by the Abu Dhabi Fund for Development through the IRENA/ADFD Project Facility, **Cuba** finished construction of four solar PV parks with a cumulative 10 megawatt peak (MWp) of capacity, employing about 40 people. The project will be expanded by an additional 5 MWp, requiring 50 persons to complete.

In the **MIDDLE EAST AND NORTH AFRICA**, **Egypt** is nearing completion of its Benban solar complex. Employment estimates hovered around 3 000 for installing the site's PV panels, with more in construction and in other activities (Nordrum, 2019).

**Algeria** is slowly expanding its capacity to produce solar PV modules (Bellini, 2020a). SPS, a local firm, is to begin production of panel mounting structures in a joint venture with Dubai-based Qi-energy. Mounting systems could account for up to 12% of a project's balance-of-system costs, and this would help achieve the Algerian government's domestic content objectives. Algeria is also adding to its solar panel manufacturing capacity. By 2024, the government is planning to install 4 GW of PV through five annual tenders. The expectation is that construction of these facilities will create some 56 000 jobs, and operating them could create another 2 000 jobs (Bellini, 2020b, 2020c, and 2020d).

In **SUB-SAHARAN AFRICA**, direct employment in projects under **South Africa's** Renewable Energy Independent Power Producer Procurement Programme rose from 17 800 job-years in 2014 to 45 450 by mid-2019. The bulk – some 82% – came in construction, the remainder in operations (IPPPP, 2020). About 80% of renewable energy capacity procured as of September 2019 is being installed in just two provinces that account for 15% of the country's population and 10% of its GDP (see Figure 12). The Northern Cape, with a per capita GDP figure close to the country's average, has 56% of the capacity and 60% of the job-years (in construction, installation and O&M). The country's poorest province, the Eastern Cape, accounts for 24% and 16%, respectively. By contrast, the third-poorest province, KwaZulu-Natal, has garnered only 0.3% of installations and jobs (IPPPP, 2020).

FIGURE 12. **RENEWABLE ENERGY DEPLOYMENT AND JOB CREATION IN SOUTH AFRICA'S PROVINCES, AS OF SEPTEMBER 2019**




*Source: IPPPP, 2020.*

*Disclaimer: Boundaries and names shown on this map do not imply any endorsement or acceptance by IRENA.*

The deployment of renewables is still relatively limited in most countries of Sub-Saharan Africa. But as noted elsewhere in this report, some countries are making progress in improving energy access. Kenya's DRE sector has created an estimated 10 000 direct formal jobs and 15 000 informal jobs. Formal DRE employment in Nigeria is estimated at about 4 000, with another 9 000 informal ones (Power for All, 2019).

# BEYOND THE NUMBERS

- In our societies, a job is how the vast majority of working people secure an income for themselves and their families. Beyond ensuring an adequate number of jobs, labour representation is often essential to ensuring good jobs that will provide an adequate wage or salary (see Box 3) in a safe and productive workplace.
- Jobs build experience, hone skills and can provide a path to self-fulfilment by way of a worker's pride in performing a task well or in helping a community or country accomplish an important objective, such as creating a clean energy system.
- Jobs in renewable energy are important beyond the energy sector: incomes spent on food or consumer goods and services stimulate many different industries in local, national and global economies.
- Available evidence suggests that renewable energy employs more people than do fossil fuels. An input-output analysis (Garrett-Peltier, 2017) performed to evaluate public and private energy investment found that, on average, spending USD 1 million on renewables creates 7.49 FTE jobs, almost triple the 2.65 FTE jobs in fossil fuels.
- Learning curves, economies of scale and new technologies such as drones and artificial intelligence will shape the labour intensity of renewables in years to come (see Box 4). The dynamics will probably differ somewhat in the agricultural supply chains for bioenergy, where informal employment is often the norm in developing countries.

### BOX 3. WAGES IN CLEAN ENERGY

Information on pay in the renewables sector is fragmented. In part, this is because renewables stretch across agriculture, construction, manufacturing, commerce and many kinds of services. Renewables-related positions are found in the formal and informal economies. Detailed assessments are needed in each country.

A US study (Muro *et al.*, 2019) found that hourly wages in clean energy production, at USD 28.41 in 2016, far surpass average wages of USD 23.86 across the whole economy (energy efficiency jobs averaged USD 25.90). Among the lowest decile of earners, who earn only slightly above USD 9 per hour, the clean energy bonus can run up to USD 7. However, workers in the fossil fuel sector often seem to earn more than those in renewable energy (Saha and Jaeger, 2020).

### BOX 4. SOLAR PV: NEW TECHNOLOGIES, APPROACHES AND LABOUR INTENSITY

While module manufacturers are continuing to automate production processes, new technologies like drones and aerial thermography, automated module washing and robotic vegetation management have implications for employment in operations (Liu and Garcia da Fonseca, 2020). For example, it takes a technician on average about 10 hours to inspect 1 megawatt (MW) of solar modules, but drones could reduce this to an estimated 15-18 minutes/MW, a pace 38 times faster. Thermal imaging and digital technologies may be increasingly used for early detection of equipment faults. (To date, the wind industry is outpacing solar farm operators in adoption of these technologies.)

Other technologies – such as automated washing of modules and robots tending to ground-level vegetation at solar farms – are less common but influence the need for lower-skilled labour. While the promise of cost savings, greater inspection accuracy and enhanced flexibility is a major driver of remote technologies, the COVID-19 pandemic may further prompt greater use to reduce risks to operating and maintenance personnel (Liu and Garcia da Fonseca, 2020).

A low-impact approach known as agrivoltaics embodies a very different cost-benefit rationale. It avoids removing vegetation in favour of growing crops under the shade of solar panels, which can reduce water needs and raise yields, while potentially boosting energy production (ground shading provided by crops or vegetation can cool the solar panels, avoiding the higher temperatures that can reduce the efficiency of PV cells). Such a nexus offers cost savings and added benefits, including job creation not only in energy production but also in agriculture (NREL, 2019).

# IN FOCUS: EDUCATION AND TRAINING

As the renewable energy workforce continues to expand, education and training along with reskilling and upskilling rises in importance. Policies and programmes centre on vocational training, curricula, teacher training, information and communications technology (ICT), public-private partnerships, and recruitment of under-represented groups such as women.

## CURRICULA AT ALL EDUCATION LEVELS, AND TEACHER TRAINING

Renewable energy can be better integrated into national curricula – not only in science and technology but also in social studies – for students in primary, secondary and tertiary education and at technical and vocational institutions. Teaching students well at all levels requires that teachers and trainers have a good knowledge of the sector. Industry leaders can play a major role in imparting that knowledge – and thus in educating the workforce of the future.

The chronic shortage of skilled workers in the area of expanding access to modern forms of energy could constitute a major barrier to the deployment of renewables. Installations undertaken by unskilled workers can result in performance issues and a negative perception of renewable technologies. Training initiatives are critical to forestall such outcomes and instead translate potential benefits into reality.

### INITIATIVES: TRAINING

Solar PV companies BBOXX and M-KOPA have created training programmes for their employees (BBOXX, 2014; Maritz Africa, 2015). Schneider Electric's 2025 objective is to impart energy skills to a million people in countries where access to energy is limited. The company has opened training centres in South Africa and other African countries as part of its Access to Energy Solutions programme (Schneider Electric, n.d.).

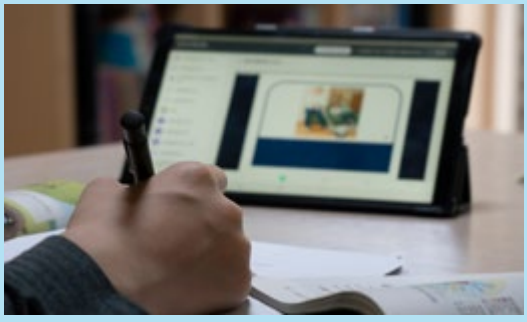
## TECHNOLOGY-ENHANCED LEARNING

Innovations in the use of ICT can play an important role in the delivery of education and training related to renewable energy. Models and simulations can be used to build learners' technical skills, and flexible delivery of online content can improve access for learners. Learning-management systems can be applied to deliver personalised learning content that takes into account the different starting points of learners. ICT can also be used to increase collaboration between industry and technical and vocational education and training (TVET) institutions, thus allowing experts to contribute to the curriculum as well as deliver instruction digitally.

Technology-based learning, however, can result in greater inequality in areas where low-income communities lack access to the requisite equipment and infrastructure.

### INITIATIVES: ONLINE COURSES

The Online Lifelong Education Institute (OLEI) at the Korea University of Technology and Education offers simulated learning in a virtual training environment (Yian and Park, 2018). Funded by the Korean government, OLEI offers over 200 free online courses in a range of fields that include renewable energy technologies. Three types of training are offered: components (using 3D modelling to take apart and assemble equipment), scenarios (following prescribed procedures to learn about operating equipment) and equipment practices (practicing controlling the equipment in different environments).



## PUBLIC-PRIVATE PARTNERSHIPS

Engaging the private sector is crucial for meeting sectoral labour requirements, promoting national skill standards, providing on-the-job training and improving the quality of training overall. Public-private partnerships can play an especially important role in TVET. The private sector can contribute to skill delivery in several ways, including course delivery, work-based learning and apprenticeships, and transfers of knowledge and equipment.

The private sector is playing an increasingly significant role in the financing of TVET programmes. Dunbar (2013) discusses the need to move away from the traditional fragmented model of training markets, which are financed primarily through fees, toward a more integrated market that incorporates a range of funding mechanisms, including payroll-based training levies, tax incentives, scholarships and donations, vouchers and student loans.

### INITIATIVES: SKILLS COUNCILS

India's National Skill Development Corporation (NSDC, 2020) seeks to close the skill gap by providing funding and support services to organisations and enterprises providing skill-based training. To achieve the government's objective of skilling and upskilling 150 million people, NSDC formed 37 sector skill councils bringing together industry, labour and academia.

The Skill Council for Green Jobs and the Power Sector Skill Council, for example, identify sectoral requirements, determine standards and qualifications, and train trainers. The Skill Council for Green Jobs has established over 350 training centres in seven states, training more than 25 000 certified solar PV installers and engineers and 160 installers of improved cookstoves (SCGJ, 2018).

## EDUCATING GIRLS AND WOMEN

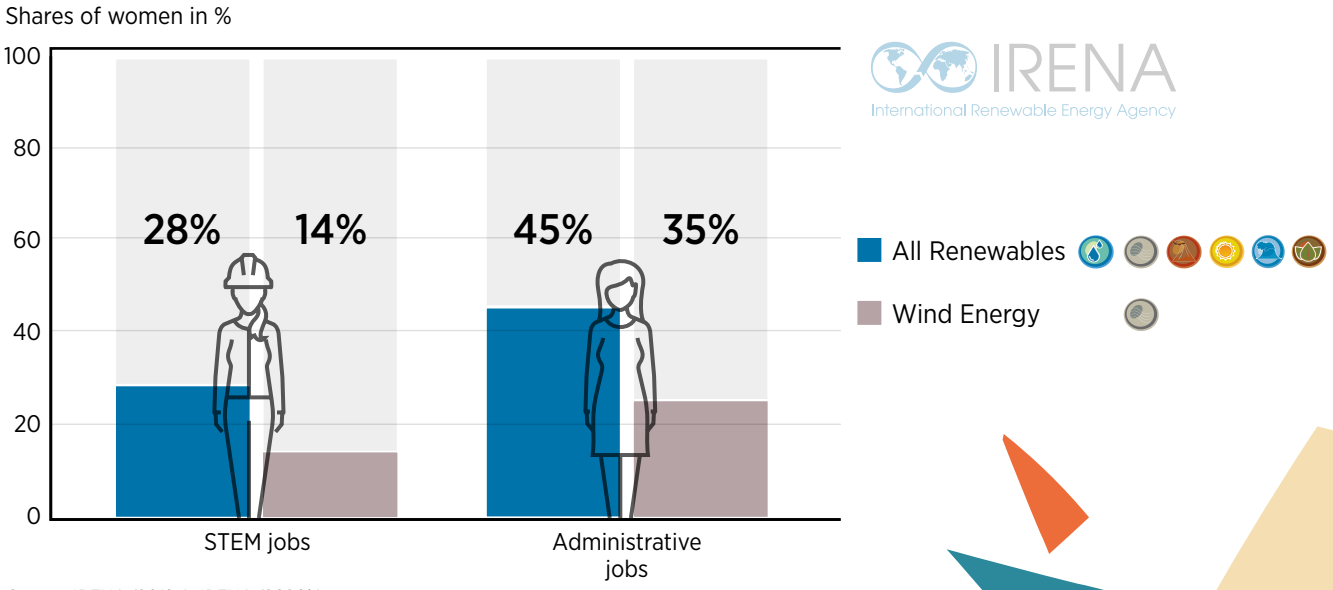
In the renewable energy sector, women's participation in science, technology, engineering and mathematics (STEM) jobs is far lower than in administrative jobs (28% versus 45%) (IRENA, 2019a). The difference is more pronounced in the wind energy sector, where women account for only 14% of the STEM total, compared to 45% in administrative jobs (see Figure 13) (IRENA, 2020d).

Strategies to increase the representation of women in the renewable energy sector often focus on workplace accommodations, mentorship and professional development. These approaches reach only the small number of women who have already made a conscious career path decision. Influencing the choices girls make earlier in life, when aspirations and affinities are still being discovered, can help increase the number of women in the renewable energy sector specifically, as well as in STEM fields more broadly.

Early career choices are often shaped by gendered cultural norms and perceptions (IRENA, 2019a). Even where no direct structural constraints limit career choices, gendered cultural norms have been shown to influence girls' self-understanding and interests – and in turn their future career trajectories. Such norms can result in the categorisation of occupations as masculine and feminine, biased self-assessments of personal abilities, a perception of the engineering profession as a male bastion, unwelcoming classrooms and institutions, and gender segregation of workplace environments.

In the decentralised renewable energy industry, there are plenty of opportunities for women's engagement along multiple segments of the value chain. Yet women also face challenges owing to insufficient skills and training opportunities (IRENA, 2019a).

FIGURE 13: **WOMEN'S SHARE OF STEM AND ADMINISTRATIVE JOBS, ALL RENEWABLES AND WIND POWER**




*Source: IRENA (2019a); IRENA (2020b).*

*STEM = science, technology, engineering and mathematics.*

## INITIATIVES: EMPOWERING YOUNG WOMEN

The Green Girl Project is a social enterprise that has reached over 6 000 young people by empowering young women to become facilitators of sustainable practices that build peaceful and economically viable communities in Africa (Green Girl Project, n.d.). Greenlight for Girls, for example, is an initiative to encourage girls of all ages and backgrounds in science, math, engineering and technology (Greenlight for Girls, n.d.).

To satisfy its growing needs for skills, the renewable energy industry will have to engage and retain more girls from early ages. Initiatives all over the world help boost girls' interest in subjects typically regarded as less "female oriented". But to achieve greater gender equality, it is crucial that education and training scholarships and mentorship opportunities be available to girls.

## RESKILLING AND UPSKILLING

Governments and the private sector can take steps to reskill and upskill parts of the existing energy workforce, allowing fossil fuel workers to take on new roles in renewables (IRENA, 2020c). For instance, this is the purpose of a GBP 12 million (USD 12 million) Transition Training Fund set up by the Scottish government for oil and gas workers at risk of redundancy (Skills Development Scotland, 2019).

Assessing the skills relevant to renewable energy and ascertaining which are transferable from fossil fuel industries allows an estimate of how many workers could, in principle, make a lateral move between the two sectors. IRENA's *Leveraging Local Capacity* series (IRENA, 2017a, 2017b, 2018) assesses the requirements for selected technologies and synergies between industries such as offshore oil and gas and offshore wind.

# THE IMPACTS OF COVID-19 AND THE WAY FORWARD

The onset of the COVID-19 crisis upended economic trends and dynamics around the world, including in the energy sector. To date, renewable energy as a whole has fared better than fossil fuels. Nonetheless, renewables have been affected by temporary disruptions in the supply of equipment, components or raw materials, and more recently by demand-side impacts.

Although the pace of new renewables installations has been slower in 2020 than predicted in pre-COVID forecasts, construction of many large-scale utility projects is proceeding, though with some delays. Jobs appear less affected in the operation of utility-scale wind and solar plants than in solar rooftop installation and off-grid solutions, where social distancing requirements and constrained household budgets have a significant impact (IRENA, 2020c).

An ambitious strategy linking short-term recovery efforts with medium- and long-term strategies to 2030 and 2050 is essential to achieving the Sustainable Development Goals and the Paris Agreement on Climate Change. IRENA's proposed investment and policy package gives the world a chance to accomplish these twin objectives (IRENA, 2020c). Under this approach, annual investment in energy-transition-related technologies[28] would more than double from the 2019 level of USD 824 billion to nearly USD 2 trillion in the 2021-23 recovery phase, before reaching an annual average of USD 4.5 trillion in the decade to 2030.

By 2023, this investment package would create 5.5 million more jobs in energy transition-related technologies than under a business-as-usual approach.


28 *Technologies related to the energy transition include renewable energy, energy efficiency and energy system flexibility.*

This outcome is the result not only of shifting investment priorities within the energy sector, but also of the greater labour intensity of renewables compared with fossil fuels. Gains in energy transition-related fields would far outweigh the loss of about 1 million jobs in fossil fuels (IRENA, 2020c).

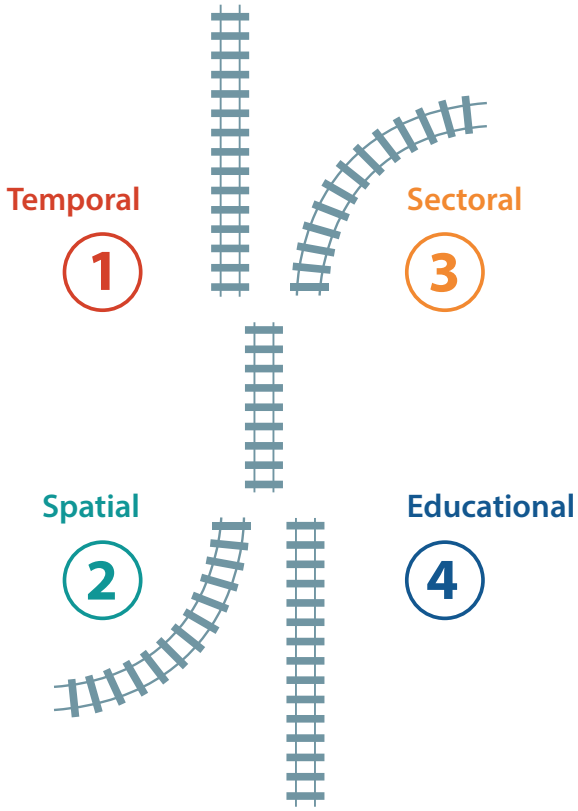
By 2050, IRENA's Transforming Energy Scenario foresees 100 million workers in the energy sector as a whole: 42 million in the renewable energy sector, 21 million in energy efficiency and almost 15 million in power grid and energy flexibility, with the remainder in conventional technologies (IRENA, 2020b). This figure is 62% larger than under the Planned Energy Scenario, which hews to governments' current plans.[29]

To maximise benefits and limit adjustment costs, governments must keep in mind the underlying drivers of the energy transition (investment, trade, fiscal policy, and indirect and induced effects of the transition across the economy) and put in place policies enabling the accelerated deployment of renewables. They must also be alert to potentially significant misalignments between job gains and losses in the transition (IRENA, 2019c). Such misalignments may take any of several forms:

1. **Temporal.** The creation of new jobs does not necessarily take place on the same time scale as the loss of employment.
2. **Spatial.** New jobs are not necessarily being created in the same locations – communities, regions or countries – where losses occur.
3. **Sectoral.** Job gains and losses may affect different sectors of the economy, given different supply-chain structures and diverging sets of inputs between rising and declining industries.
4. **Educational.** The skills associated with vanishing jobs do not always match those required by emerging jobs.

Policies to accelerate the uptake of renewables must go hand in hand with efforts to leverage and enhance local capabilities through industrial policies, building supply chains and developing the available pool of skilled labour, without which the energy transition cannot maximise socio-economic benefits. Therefore, educational and training programmes, labour market measures and social protection policies are essential to match the demand for jobs and skills with supply of the same, to retrain fossil fuel workers and to preserve social equity.

Holistic economic stimulus packages, recovery plans and policy frameworks can drive the wider structural shifts needed in the energy sector, fostering national and regional transition strategies as a decisive step in building more inclusive and resilient economies and thus more just societies.




*29 The Planned Energy Scenario is based on governments' current energy plans and other planned targets and policies, including climate commitments made since 2015 in the Nationally Determined Contributions articulated pursuant to the Paris Agreement on Climate Change. The Transforming Energy Scenario entails a more climate-resilient course, with a large-scale shift to renewable energy, electrification and ramped-up energy efficiency in the period to 2050. In this latter scenario, the share of renewables in the power sector increases from 24% today to 86% in 2050 (IRENA, 2020b).*

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