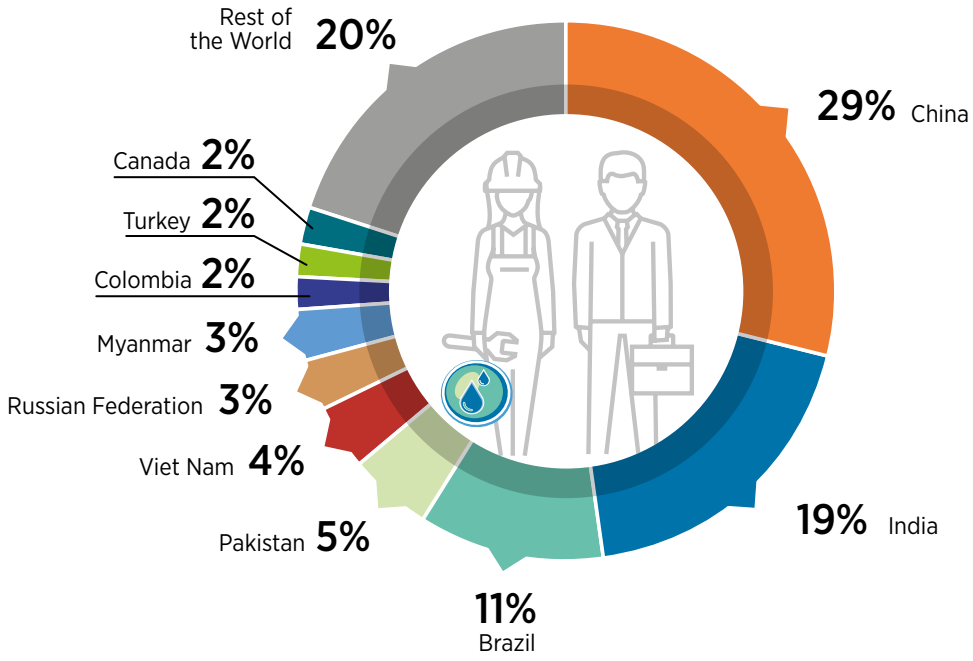
IRENA estimates jobs in the hydropower sector based on an employment-factor approach, which allows the revision of previous estimates and an examination of direct jobs in the main segments of the value chain: manufacturing, construction and installation, and operations and maintenance (O&M). The results 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.

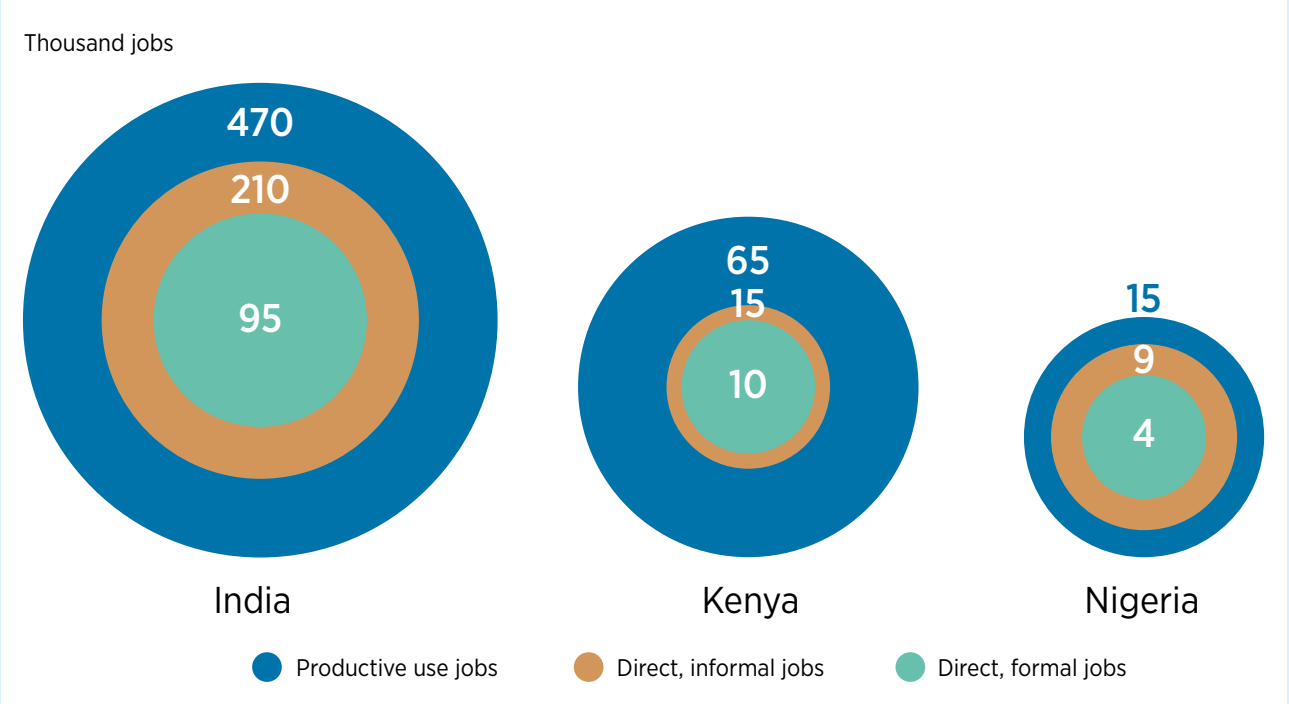
Another opportunity to generate both social and economic impact is by further engaging women in the DRE industry. Women currently make up about 25% of DRE employment in India, Kenya and Nigeria. While this is better than 22% in the overall energy industry, it lags behind the 32% estimated for the broader 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**



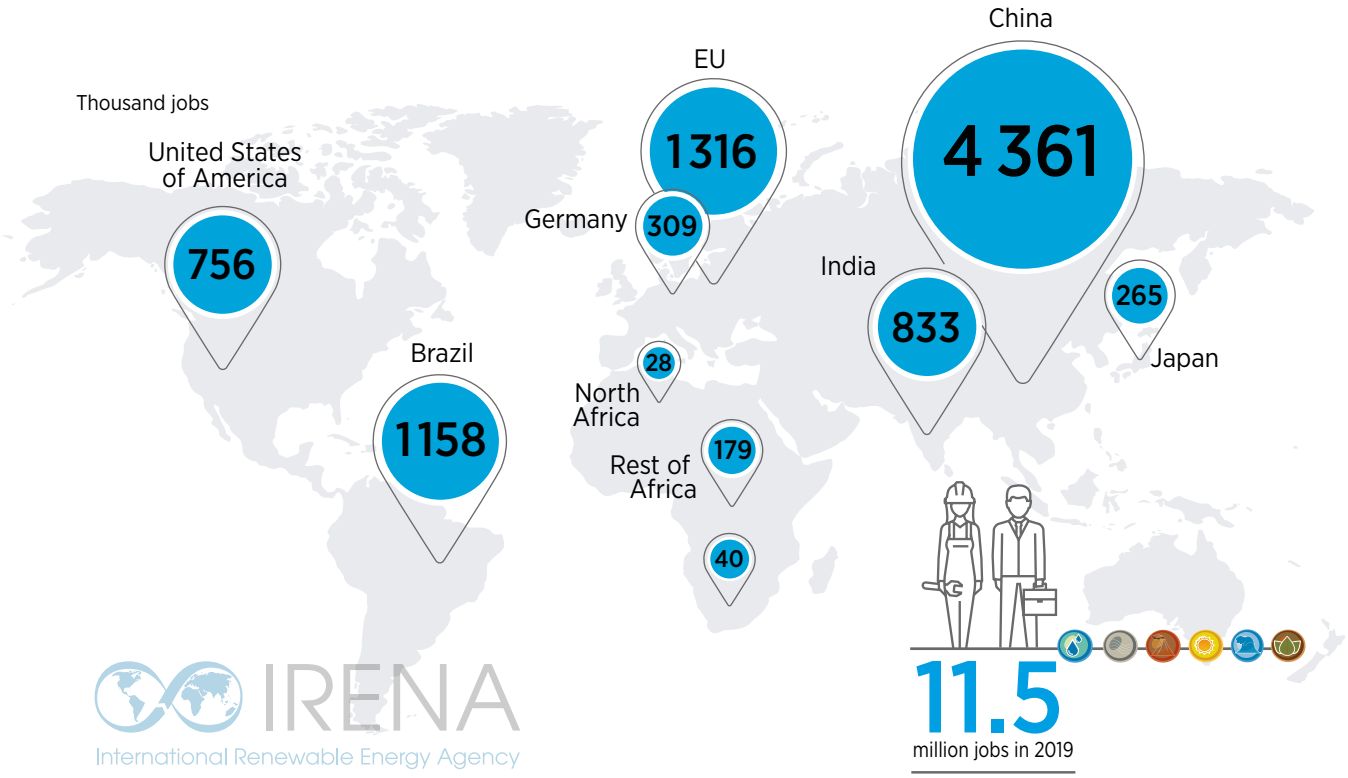
Source: Power for All, 2019.

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.