Ensuring a Skilled Renewable Energy and Energy Efficiency Workforce

International Energy Agency

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Abstract

This report examines employment trends, skills needs, and skills gaps across renewable energy, grids, and energy efficiency. It highlights the increased demand for skilled workers in these sectors and the need to address skilled labour shortages. The report identifies barriers which are currently hindering energy education and training. It also discusses policy measures aimed at attracting more people to the renewable energy and energy efficiency sectors and providing them with the necessary training.

The report includes new IEA analysis on online job postings in renewable energy and energy efficiency, and IEA modelling on energy employment from 2024 as the last full year of data available at the time of publication. The analysis also draws from stakeholder input from two in-person *Future of Energy Skills* workshops co-ordinated by the IEA and the European Commission and the results from three IEA surveys conducted in 2025 with over 700 respondents: the *IEA Industry Employment Survey*, *IEA Labour Employment Survey* and *IEA Educators' Employment Survey*.

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Executive summary

Energy demand has increased significantly over the past decade, accompanied by strong growth in investment in renewable energy and energy efficiency. While renewable energy generation and scaling up energy efficiency are driven by investment and technology deployment, they require a workforce equipped with the appropriate skills. In this context, the availability of skilled workers is emerging as a critical factor in ensuring secure, affordable and sustainable energy systems.

In many regions, the energy sector is evolving rapidly, requiring workers to have new skills and putting increasing pressures on education and training systems to respond. To help policymakers, industry, educators and workers representatives address these changing workforce needs, additional information is needed about recent trends in workforce shortages and skills gaps, as well as on the policies to help training and educational systems adapt to evolving contexts.

This report combines new IEA analysis of online job postings with IEA employment modelling and evidence from relevant stakeholders. It examines how workforce needs and skills requirements are evolving across key energy subsectors, including solar PV, wind and energy efficiency. The main findings of the report are:

- Demand for occupations, qualifications and skills is evolving. Using new analysis of online job postings, the *IEA Employment Surveys* and other data sources, the report offers insights into the characteristics of labour demand. The analysis highlights how skill requirements are changing by looking at the balance between transferable and sector-specific competencies and identifying emerging skills across subsectors. Additionally, it identifies the occupations most in demand and examines how these trends differ across subsectors and regions.

- Addressing workforce shortages and skills gaps is inherently a multi-stakeholder challenge. Building on insights from two workshops co-organised by the IEA and the European Commission, the report presents many good practice examples of how multi-stakeholder approaches can be effective in addressing these complex emerging policy needs.

- Finally, the report highlights that low attractiveness of energy careers, limited availability and accessibility of training, and misalignment between energy policy and workforce planning are key barriers to developing a sufficiently large and skilled workforce. The report assesses policy approaches to address these barriers to ensure that workforce development keeps pace with the evolving needs of the clean energy transition.

Chapter 1. Employment trends in renewable energy, grids and energy efficiency

Employment opportunities are growing in renewable energy, grids and energy efficiency

The energy sector has become a driver of employment growth. In 2024, global energy employment grew 2.2% year-on-year, underpinned by energy infrastructure investments, nearly double the economy-wide rate of 1.3%. Since 2019, the energy sector added on average more than 1 million jobs annually, which marks a shift compared to the period between 2015 and 2019, when the sector created around 300 000 jobs per year on average.

Electricity is playing an increasingly central role in energy spending and employment. Power generation investments increased by 70% between 2015 and 2024, and employment in the sector grew 27%, driven by solar photovoltaics (PV) and wind. This shift reflects that the energy sector has entered the Age of Electricity, where electricity is increasingly central to modern economies due to rising consumption driven by industry, electric vehicles, air conditioning and data centres among other factors.

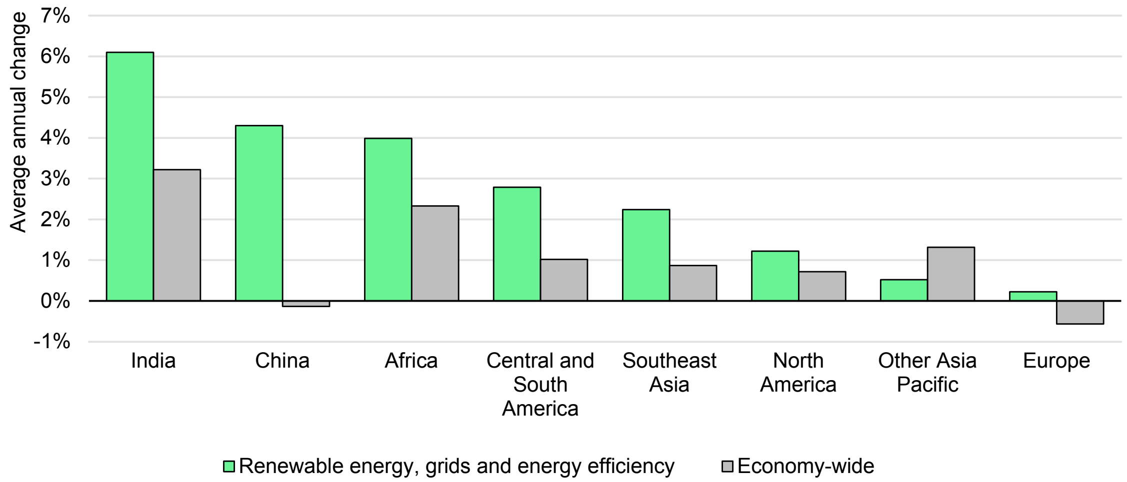
Grid systems need to develop in tandem as electricity systems continue to expand. Annual investments in power networks increased by 30% between 2013 and 2024. This growth also created a need for skilled workers, highlighting the important link between energy policy and workforce planning. However, the grids sector faces not only a skilled labour shortage, but also an ageing workforce. This requires additional skilled workers to replace those approaching retirement and increases the need to attract and train more workers to the sector.

Energy efficiency measures can curb energy consumption growth by reducing the amount of energy required to fuel and grow economies. Energy efficiency interventions deliver multiple benefits, such as improvements in energy security, cutting energy bills and reducing the environmental impact of energy use.

In the States Policies Scenario (STEPS)[1] of the World Energy Outlook (WEO) 2025, labour demand in renewable energy, grids and energy efficiency reaches 35 million workers by 2035. However, the *IEA Industry Employment Survey 2025* found that 66% of companies in these subsectors were already experiencing labour and skills shortages highlighting that efforts are required urgently to attract and train more workers in these sectors now.

This report will focus on four important energy subsectors: solar PV, wind, grids and energy efficiency. Additional clean energy subsectors for example hydropower, low-emissions hydrogen, modern bioenergy, and electric vehicle production are not included in the scope of this report.

Average annual change in renewable energy, grids and energy efficiency workforce and economy-wide workforce by region, 2019-2024



Notes: 'Renewable energy, grids and energy efficiency' includes jobs in solar PV, wind, grids and efficiency. 'Efficiency' includes industrial efficiency, building retrofits, efficient appliances and lighting and other efficient and renewable HVAC equipment, such as heat pumps, bioenergy or solar thermal sources. 'Grids' include battery storage, distribution and transmission. 'Solar PV' includes residential solar PV and utility-scale solar PV. 'Wind' includes offshore wind and onshore wind.
Source: IEA analysis of economy-wide employment based on data from the International Labour Organization (ILO).

The power sector is driving employment growth in the energy sector

In 2024, the power sector became the largest energy sector employer with 22.6 million workers, which includes generation (fossil, renewable and nuclear)

[1] For further information on modelling, scenarios and employment please see the IEA's Global Energy and Climate (GEC) Model. Unless otherwise states, all scenarios refer to Stated Policies Scenario (STEPS), which takes into account policy intentions that have been formally proposed but not codified into current laws and regulations. The STEPS considers targets and pledges only insofar as they are backed by detailed policies and does not assume that aspirational goals are met.

and grids (transmission, distribution and storage). Power generation employment specifically, which in our definition excludes grids, grew at an annual average growth rate of 5.1% between 2019 and 2024, and reached 14.2 million workers, while grid employment grew by 1.9% on average, and reached 8.5 million workers.

Employment in renewable energy, grids and energy efficiency grew at a steady pace between 2019 and 2024, averaging 2.8% per annum, apart from 2020 when the Covid-19 pandemic disrupted markets and slowed activity. In 2024, almost 40% of energy workers were employed in these areas.

Solar PV

The fastest-growing segment of the overall energy workforce in 2024 was power generation led by solar PV. Employment in the sector rose to 5 million in 2024, with 309 000 jobs added year-on-year, as capacity additions reached 540 GW. With the growing rollout of additional generation capacities, around 46% of workers are involved in deployment activities. This segment relies extensively on construction-related workers, such as solar panel installers, electricians and welders. Around 21% are employed in the manufacturing segment, producing for instance polysilicon, modules and inverters. In 2024, People's Republic of China (hereafter, "China") accounted for 60% of the global solar PV workforce, while Europe and India each represented around 10%. Two-thirds of the workforce was employed in distributed solar (e.g. rooftop and small-scale installations) and the rest in utility-scale projects.

Wind

Employment in the wind sector increased by 3% year-on-year, reaching 1.7 million jobs in 2024. Employment growth was lower than in previous years partly due to setbacks in offshore wind, including reduced government support in some countries, project delays and cancellations, with job losses announced in Europe among other places. A quarter of wind workers were employed in the manufacturing of components such as nacelles and turbines, and a third were employed in the construction of wind farms. The rest of the wind workforce was employed in operation and maintenance and other supporting roles, such as grid management and logistics.

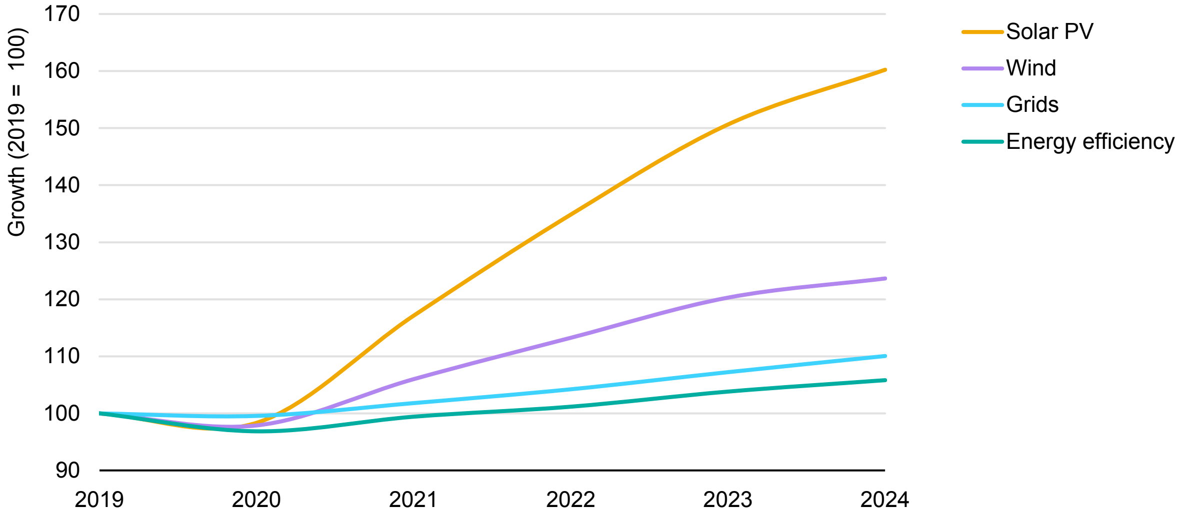
Grids

Investment in grids reached USD 390 billion globally in 2024. Following this trend, global employment in grids (transmission, distribution and storage) grew by 2.6% year-on-year, reaching nearly 8.5 million in 2024. In 2024, 58% of grid workers were employed in professional or utilities roles, while 27% of the workforce were in the construction and expansion of transmission and distribution infrastructure. Nearly 9% were engaged in wholesale and transport and 6% in the manufacturing of grid components.

Energy efficiency

Energy efficiency employment grew moderately, at 1.9% year-on-year, reaching around 14.3 million jobs in 2024. This includes efficient lighting and appliances (6 million), heat pumps and other efficient and renewables-based HVAC systems (3.8 million), industrial efficiency (3.6 million), and retrofits (850 000). Most workers are located in China, the European Union and North America, but year-on-year job growth was fastest in EMDE like India (9%), Africa (4%) and other Asia Pacific countries (4%), all outpacing the global average.

Global energy workforce growth in renewable energy, grids and energy efficiency, 2019-2024



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Notes 'Renewable energy, grids and energy efficiency' includes jobs in solar PV, wind, grids and efficiency. 'Efficiency' includes industrial efficiency, building retrofits, efficient appliances and lighting and other efficient and renewable HVAC equipment, such as heat pumps, bioenergy or solar thermal sources. 'Grids' include battery storage, distribution and transmission. 'Solar PV' includes residential solar PV and utility-scale solar PV. 'Wind' includes offshore wind and onshore wind.

Emerging and developing economies saw the strongest employment growth

Global energy employment in renewable energy, grids and energy efficiency increased by 3% in 2024 (year-on-year) with the strongest growth in EMDE. Employment growth has varied from region to region, with some countries seeing job creation linked to national energy initiatives and dedicated investment, while others have experienced job losses or employment stagnation linked to a number of constraints such as high production costs and the high cost of capital. As countries change their national energy mixes, energy transitions will impact employment needs in different energy subsectors.

Africa

In Africa, renewable energy, grids and energy efficiency employment grew by nearly 4% between 2023 and 2024. While accounting for a smaller overall share of the global renewable, grids and energy efficiency workforce, employment opportunities in the region grew 22% between 2019 and 2024, 1.5 times faster than the global rate of 15%. This expansion was largely supported by strong growth in the power sector, despite stagnation in grid-related employment. New residential solar PV projects have generated employment in the sector which grew around 12% between 2023 and 2024. Additional investments in wind energy, including in Morocco, Egypt and South Africa, could increase local employment opportunities as has been seen at Kenya's Lake Turkana Wind Power Station, where 80% of direct employees are from local communities.

Central and South America

In Central and South America, renewable energy, grids and energy efficiency employment grew by 15% between 2019 and 2024. However, a recent drop in employment in solar PV between 2023 and 2024 has resulted in a more moderate growth in employment. The high cost of capital in the region continues to be a barrier; the IEA's Cost of Capital Observatory found that financing costs for renewable power and battery storage projects in Brazil can be up to three times higher than those in advanced economies. Investment announcements such as for Brazil's grid infrastructure, and renewable target-setting in national tenders such as in Honduras may increase job opportunities in the future.

Spotlight: Renewable energy, grids and energy efficiency employment opportunities in Southeast Asia

With a fast-growing population and expanding industrialisation and urbanisation, energy demand in Southeast Asia[2] is growing rapidly and will represent 20% of the world's global energy demand growth in the next decade. Renewable energy supply in Southeast Asia has almost tripled since 2000 reaching around 20% of the overall energy mix in 2024. In the STEPS, clean energy meets over 40% of incremental demand growth by 2035. This will in turn impact energy employment in renewable energy, grids and energy efficiency, where the region currently accounts for 5% of the global workforce. Workforce mapping and skills planning are necessary to ensure an adequately skilled labour force to meet this new demand.

[2] Southeast Asia: Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Timor-Leste, Thailand and Viet Nam.

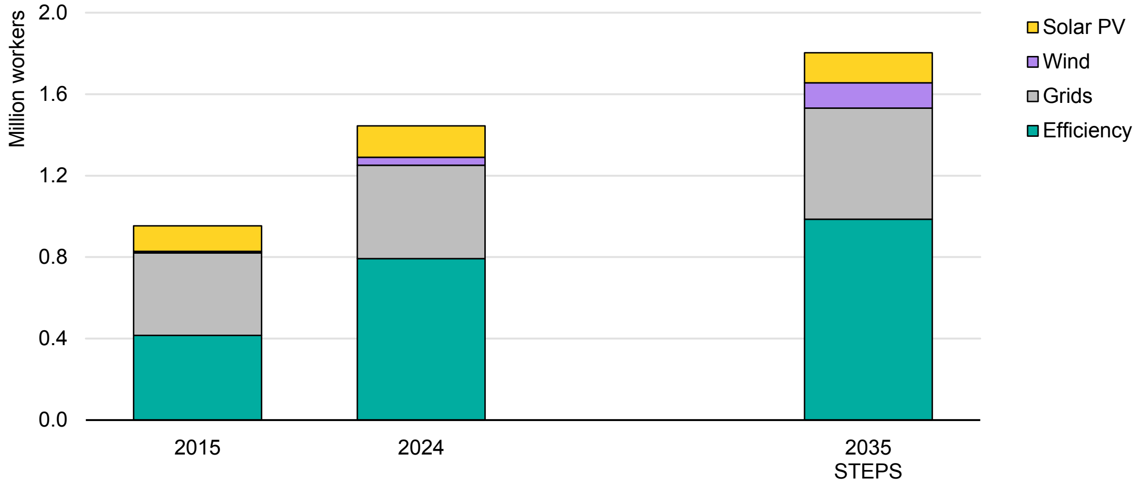
Employment in renewable energy, grids and energy efficiency in Southeast Asia grew at an annual average growth rate of 2% between 2019 and 2024. Growth was the highest in energy efficiency, rising 13% in 2024 year-on-year, as policies and investments supporting deployment of efficient lighting and improvement of industrial energy performance have generated jobs across installation, manufacturing and related services. National energy efficiency strategies could generate additional employment opportunities, such as Cambodia's Accelerating Energy Efficiency in Cambodia's Building Sector Programme and Malaysia's Energy Efficiency and Conservation Act.

Employment in Solar PV in Southeast Asia remained stagnant between 2021 and 2024. However, the introduction of recent initiatives suggest that employment is likely to increase in the short-term, such as the MTerra Solar Project in the Philippines and the Solar-Plus-BESS project in Indonesia in addition to the commitment by the President for 100 GW of additional solar capacity before 2030. The region has also become a major centre for solar PV manufacturing, accounting for around 40% the manufacturing workforce outside China. Employment in wind has increased at an annual average growth rate of 5% between 2019 and 2024 and new large-scale projects could create additional employment for example in Malaysia which will soon have its first ever commercial large-scale onshore wind power project.

Increased electricity demand also requires the expansion of the grid subsector, where employment increased by 10% between 2019 and 2024. Employment in this subsector may further grow, as energy programmes increasingly prioritise grid development. Thailand's Smart Grid Action Plan, Viet Nam's announcement to invest USD 18 billion in grid infrastructure, the Philippines' strategy to increase island connections and Indonesia's Electricity Supply Business Plan (RUPTL) 2025-2034 are all examples of national plans which require an increase in skilled workers.

In the STEPS, employment in renewable energy, grids and energy efficiency in Southeast Asia rises to 1.8 million workers by 2035. Workforce expansion is supported by policy measures, such as the ASEAN Plan of Action for Energy Cooperation (APAEC) 2026-2030, aiming to reach a 45% share of renewables in the electricity mix by 2030, as well as national strategies with renewable energy and energy efficiency targets in Indonesia, the Philippines and Malaysia.

Southeast Asia's renewable energy, grids and energy efficiency workforce by sector in the STEPS, 2024-2035



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Employment remained stable or decreased in advanced economies

Employment in renewable energy, grids and energy efficiency in advanced economies remained stable or decreased in 2024. Looking at overall job gains and job losses in advanced economies in 2024, around 125 000 power sector jobs were created and around 50 000 fossil fuel supply jobs were lost. Efforts to create new local jobs, provide upskilling and reskilling opportunities, assist with job-to-job transitions and provide for social protection can help ensure a just transition for impacted workers and their communities. A slowdown in energy efficiency employment in advanced economies saw a decrease in energy efficiency employment of 1.5% in 2024.

Europe

Europe saw a 1.5% overall decline in renewable energy, grids and energy efficiency employment, with the largest drop in energy efficiency jobs (2.7%). National strategies such as France's new Multi-Year Energy Programme and the country's goal to produce one million heat pumps could create additional energy efficiency jobs in the future. In 2025, all EU countries were required to submit their National Building Renovation Plans, which may lead to the creation of additional energy efficiency jobs in the region.

Wind employment in Europe saw a 1% decline in 2024, in part related to setbacks due to increased project costs. However, in 2025 Europe built 19.1GW of new wind power capacity, with the largest gains in Germany (5.7 GW), followed by Türkiye (2.1 GW), Sweden (1.8 GW) and Spain (1.6 GW).

Solar PV experienced a 1% employment growth in 2024. In 2025, the EU's solar PV capacity reached around 406 GW, more than the target set by the EU Solar Energy strategy. In 2025, solar PV became the most competitive source of electricity in the European Union and accounted for almost a quarter of EU electricity consumption generated by renewables. The growing solar PV capacity plus initiatives aimed at re-developing Europe's solar PV manufacturing capacity could increase employment in the solar panel supply chain in Europe.

Employment growth in the grid sector was moderate in 2024 (1%). The new European Grids Package which aims to strengthen Europe's energy infrastructure follows the European Grid Action Plan and may create additional job opportunities in the future. Trade unions representing European energy workers have called for increased public investment and local content requirements to modernise the current grid infrastructure and create additional jobs while stressing current labour shortages.

North America

North America experienced an overall increase in renewable energy, grids and energy efficiency employment between 2019 and 2024 (4%). The largest employment growth was in grids (6%), driven by distribution line expansion. Employment in grids may increase with new national strategies, for example the United States introduced its Grid Modernisation Strategy in 2024 and Canada plans to double the capacity of its electricity grids by 2050.

Employment grew in energy efficiency by 3% year-on-year, especially in building equipment. Policies promoting energy efficiency interventions contributed to this growth. These include the Energy Efficiency and Conservation Block Grant Program and the Home Energy Rebates Programme in the United States, the Canadian Greener Homes Initiative and Mexico's Efficient Stoves for Wellness Programme.

In the United States, solar PV employment grew at a faster year-on-year rate than the average across advanced economies, driven partly by a surge in activity as developers accelerated project timelines to meet tax credit eligibility deadlines. Wind employment across North America increased by 2% year-on-year, below the average annual growth rate of 3% between 2019 and 2024.

Spotlight: China accounts for 34% of the renewable energy, grids and energy efficiency workforce

China's renewable energy, grids and energy efficiency sectors saw sustained job growth between 2019 and 2024, averaging over 4% per year, far outpacing economy-wide employment growth which fell to just below zero over the same period. China accounts for 34% of the global renewable energy, grids and energy efficiency workforce, and in the sector, it employed about 10 million people in 2024. China also remains the dominant global solar PV sector employer, employing 60% of the global workforce. However, jobs in the energy efficiency sector have declined in recent years, partly due to the slowdown in the construction and real-estate sectors.

Wind and solar PV

The 14th Five-Year Renewable Energy Development Plan, published in 2021, set clear targets for increased renewable capacity, including the installation of 1 200 GW of wind and solar PV by 2030, which it achieved six years early in 2024. These targets have contributed to the workforce expansion of China's solar PV and wind subsectors, which saw an average annual growth rate of 13% and 4%, respectively, between 2021 and 2024.

The largest spike in employment in both solar PV and wind occurred in 2021, as a post-pandemic rebound, with year-on-year increases of 32% and 11%, respectively. This followed a government announcement in January of 2021 that the preferential feed-in tariffs afforded to new renewable generation capacity subsidised by the central government would be extended only until August of that year. Additionally, in 2021 China launched a country-wide pilot programme designed to expand distributed rooftop solar. This type of programme is particularly labour-intensive and contributed to the sharp increase in solar PV sector jobs in the period.

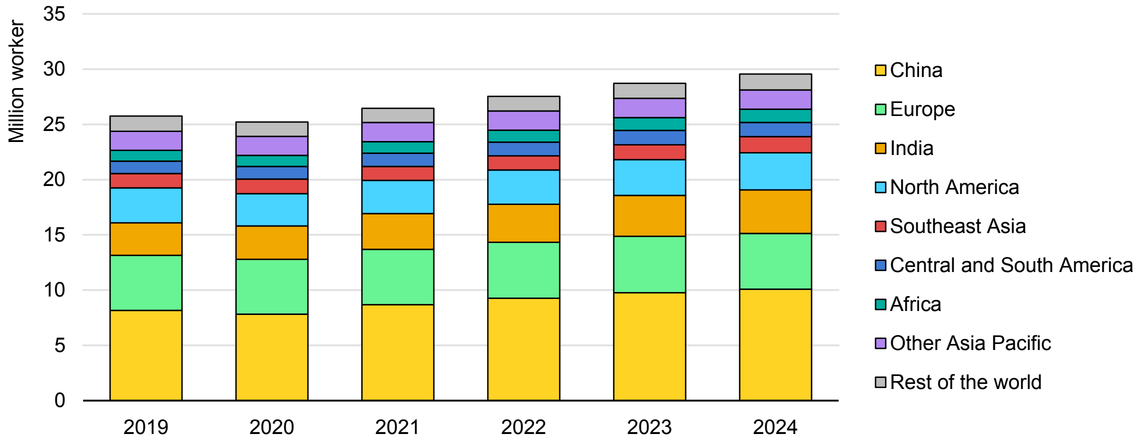
Grids

The development of electricity grids is crucial to clean energy transitions, but China faces several major challenges. First is the pressure that the rapid deployment of solar PV and wind generation has placed on distribution and transmission networks. Grid infrastructure and demand-side flexibility cannot always match the intermittent and variable renewable supply, causing high curtailment rates. A second challenge is geography: China's renewable rich regions are concentrated in the west of the country, while demand is concentrated in the eastern coastal provinces. To address these challenges, the government has put in place several policy measures that have driven sustained employment in the grid sector. Since 2021, 19 new ultra-high voltage (UHV) transmission projects were commenced and the length of China's UHV DC transmission lines increased from 28 000 kilometres to more than 40 000 kilometres. This marked increase in grid infrastructure contributed to consistent job growth in the sector. Employment in the grid sector in China increased at an annual average growth rate of 4% between 2021 and 2024, reaching 2.4 million workers by 2024.

Energy efficiency

China has the largest energy efficiency workforce globally, with 3.8 million workers in 2024. After expanding rapidly from 2015 to 2018, employment fell sharply during the Covid-19 pandemic and has since stabilised at roughly its 2019 level. The stagnation in employment in the energy efficiency sector is partly related to a broader slowdown in economy-wide energy intensity improvements and the slowdown of building construction between 2020 and 2024. However, in recent years China has released several policies that address energy efficiency, including the Heat Pump Action Plan and high-level communiques on energy conservation.

Global renewable energy, grids and energy efficiency workforce by region, 2019 to 2024



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Employment in renewable energy, grids and energy efficiency rises by 5.6 million jobs by 2035 in the STEPS

In the STEPS new energy employment opportunities grow through 2035 with jobs in renewable energy, grids and energy efficiency growing roughly three times faster than overall energy sector employment. As a result, renewable energy, grids and energy efficiency employment rises from around 30 million jobs in 2024 to approximately 35 million by 2035 requiring efforts to attract more people to the energy sector and to train them. Around four in ten energy workers by 2035 are employed in renewable energy, grids and energy efficiency making these sectors a major energy employment creator.

Solar PV

Expanding solar generation capacity continues to increase solar PV employment. In the STEPS, solar PV employment grows by 14% by 2035, mainly in residential installations requiring an increase in roofers and installers as well as workers in manufacturing, sales and aftercare. Policies are contributing to this increase. For example, China has set a target to expand the installed capacity of wind and solar PV to six times the 2020 level. The PM-Surya Ghar: Muft Bijli Yojana programme in India aims to provide solar power to 10 million households by 2027, while the Mission 300 project plans to provide electricity to millions of people across Africa with mini-grids and standalone solar technologies.

Wind

Wind employment increases by an average 2% annual growth rate through 2035 under STEPS, supported by national initiatives. For instance, The UK's onshore wind strategy which aims to unlock 27 to 29 GW of onshore wind by 2030 across the country, could create 45 000 direct and indirect jobs. Brazil's first offshore wind law published in 2025 to expand the use of wind power could generate 500 000 jobs in the subsector by 2050. Morocco's announcement of its first offshore wind farm project with a capacity of 1 GW is aligned with the country's strategy to increase the share of renewables in its energy mix to 52% by 2030, and in so doing could generate thousands of indirect and direct jobs.

Grids

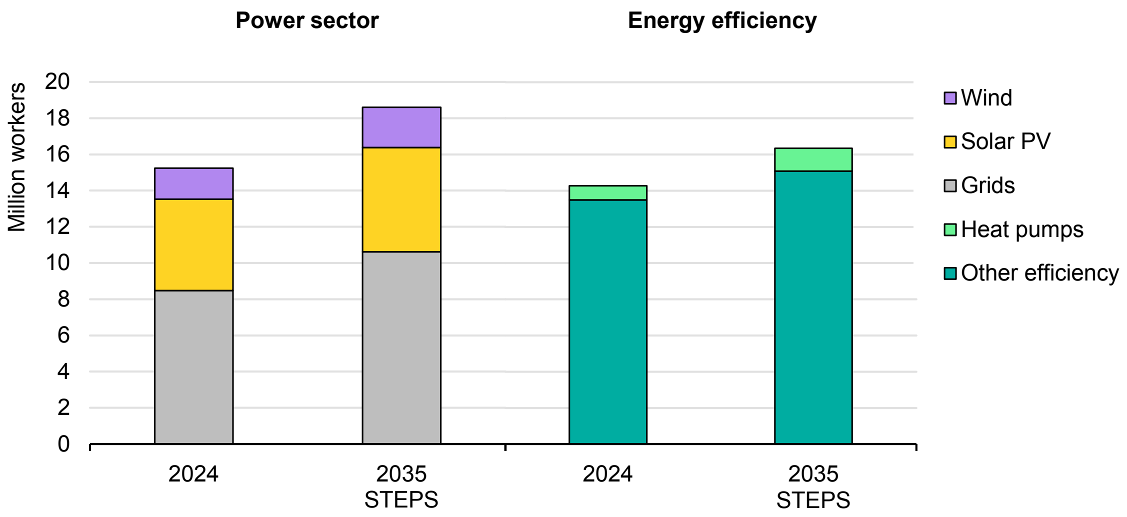
As countries extend and modernise electricity networks to accommodate higher shares of electricity in the energy mix, employment in grids increases by 25% by 2035 in the STEPS, mainly in distribution. The rapid expansion of variable renewables and electrification will also mean higher demand for storage solutions. The new European Grids Package aims to modernise and expand the grid infrastructure with the potential to create over 2 million jobs if the infrastructure matches demand. Chile's plan to build the country's longest transmission line, India's announcement to invest USD 110 billion in transmission infrastructure between 2024 and 2032, and the ASEAN Power Grid Financing Initiative will all require additional job creation.

Energy efficiency

Energy efficiency employment growth is underpinned by primary energy intensity improvements. In the STEPS, energy efficiency progress accelerates to around 2% per year to 2035, up from the 1% improvement seen in 2024. The faster pace of progress increases energy efficiency employment by 15% through 2035. However, not all regions will experience the same growth; most job creation will occur in EMDE. National initiatives that are likely to stimulate job creation include Indonesia's National Roadmap for Green Building Implementation. Some national strategies have included job creation projections and the need to support skills development in the energy efficiency sector, for example, Tanzania's Energy Efficiency Action Plan and Chile's updated National Energy Efficiency Plan.

There are also some specific energy efficiency strategies in advanced economies which have highlighted job creation opportunities. For example, the European Union's Energy Performance of Buildings Directive requires additional workers in construction, energy services and clean-tech supply chains, and the new UK Warm Homes Plan which aims to upgrade up to 5 million homes, estimates that it will create 180 000 additional jobs in energy efficiency and clean heating by 2030.

Global renewable energy, grids and energy efficiency energy workforce by sector in the STEPS, 2024-2035



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Chapter 2. Skills needs in renewable energy and energy efficiency

Technicians and trade workers account for 4 out of 10 online job postings pertaining to renewable energy and energy efficiency

This section provides new analysis of online job postings[3] (OJPs) in the renewable energy and energy efficiency subsectors of selected economies[4] across Europe, North and South America and Southeast Asia. The grid workforce spans a complex mix of occupations, and job-posting terminology varies considerably across countries, which limits the comparability of the available data. Grid workers are therefore not included in this analysis. Owing to the central role of grids in the energy system, a closer analysis of the workforce will be needed to provide an overview of hiring dynamics in the subsector.OJPs provide a real-time overview of labour demand at a granular level, which can help firms, policymakers, trade unions and educational institutions track the most demanded occupations and skills. The analysis finds that online job postings across the energy subsectors assessed rose more than fivefold between 2019 and 2024, twice as fast as the economy-wide average, pointing to a marked increase in labour demand. OJPs have some limitations, as they exclude jobs advertised through offline channels, such as newspapers or job fairs from the data. While the use of online platforms as the main means for job advertisements increased during and after the Covid-19 pandemic, their usage still varies across countries and job profiles. As a result, some technical and elementary occupations might be underrepresented in the analysis.

In addition to job postings data, this chapter draws on the IEA *Industry Employment Survey*, which gathered responses from more than 170 renewable energy companies in 2025, and on the O*NET database, from which the skill requirements of the most sought-after occupations are derived.

[3] OJPs for each sector are identified using text searches in job titles, and by searching relevant occupational classifications. OJP databases differ from employment statistics, which measure the stock of workers employed in an economy.
[4] Austria, Brazil, Canada, France, Germany, Italy, Indonesia, Ireland, Mexico, Spain and the United Kingdom.

The occupational definitions used in this analysis are derived from the International Labour Organisation's (ILO) International Standard Classification of Occupations (ISCO-08), with each occupation associated with typical educational requirements, as detailed in the table below.

Occupational groups, their corresponding educational backgrounds and examples

Occupational category	Education required	Job function examples
Managers	Tertiary-level education, university degrees	*Project manager in utility-scale solar*
Professionals		*Wind energy engineer*
Technicians and skilled trade workers	Upper secondary education and training and/or (advanced) vocational qualifications	*Wind turbine technician, electrician*
Plant and machine operators		*Manufacturing assemblers*
Administrative workers	Upper secondary education and training and/or vocational education	*Inventory clerk*
Service and sales workers		*Sales representative*
Elementary occupations	Primary or lower secondary education	*Construction support worker*

The expansion of renewable energy and energy efficiency infrastructure is driving up demand for construction-related workers across these subsectors. OJPs reflect this trend, as around 41% of renewable energy and energy efficiency advertisements in the countries analysed were seeking to recruit technicians and trade workers in 2024. This occupational group includes roles such as building electricians, roofers and solar PV installers. While these workers are essential for the deployment of projects, as installed capacity increases, demand for operation and maintenance roles, such as wind turbine technicians grows as well. These workers typically require formal vocational training or advanced vocational qualifications, which translate into longer lead times to bring new skilled workers into the labour market.

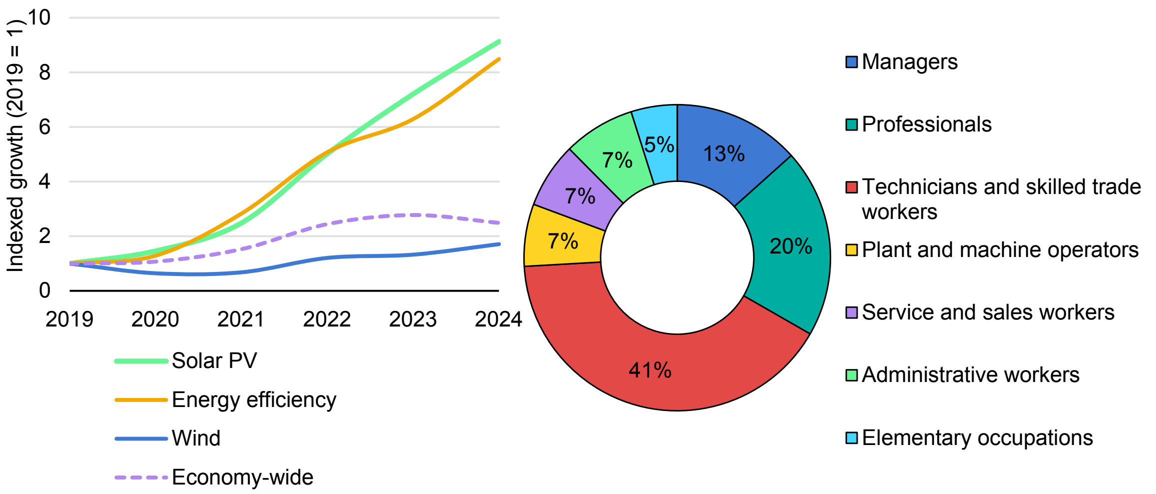
Professionals, which include workers such as engineers and software developers, accounted for 20% of all OJPs in 2024. The majority of these advertisements were posted by utility, manufacturing and professional services, for instance to design solar and wind energy projects and their connection to the grid, and to perform energy audits to recommend energy efficiency measures for end-users. These workers acquire their skills through tertiary education.

Plant and machine operators made up 7% of all OJPs in 2024. This occupational group includes workers such as electrical equipment assemblers and manufacturing machine operators. Demand for these roles is underpinned by investments in clean tech manufacturing, which has been scaling up in Europe, largely driven by efforts to diversify supply chains.

The expansion of renewable energy and energy efficiency creates considerable non-technical roles, as the remaining one-third of OJPs are made up of managers, service and sales workers, administrative workers and elementary occupations. Managers (e.g. solar project managers) supervise staff and ensure that projects are delivered on time and within budgets. Service and sales workers (e.g. sales representatives) maintain relations with customers, administrative workers (e.g. accounting clerks) support the daily running of organisations, for instance through the maintenance of records, and not needed - elementary occupations (e.g. construction labourers) perform routine and physical tasks, such as carrying materials.

Growth was led by solar, where the number of advertisements grew ninefold. This increase is linked to the accelerated installation of solar PV projects, with annual capacity additions rising from 119 GW in 2019 to 553 GW in 2024. Energy efficiency labour demand also experienced a similar growth rate, albeit from a lower base. Growth in the wind sector was the slowest, at an annual rate of 11%, due to rising costs from supply chain bottlenecks and cancellations of offshore wind projects across Europe and Asia.

Indexed growth across renewable energy and energy efficiency labour demand between 2019 and 2024 (left), and the share of occupational groups in 2024 (right).

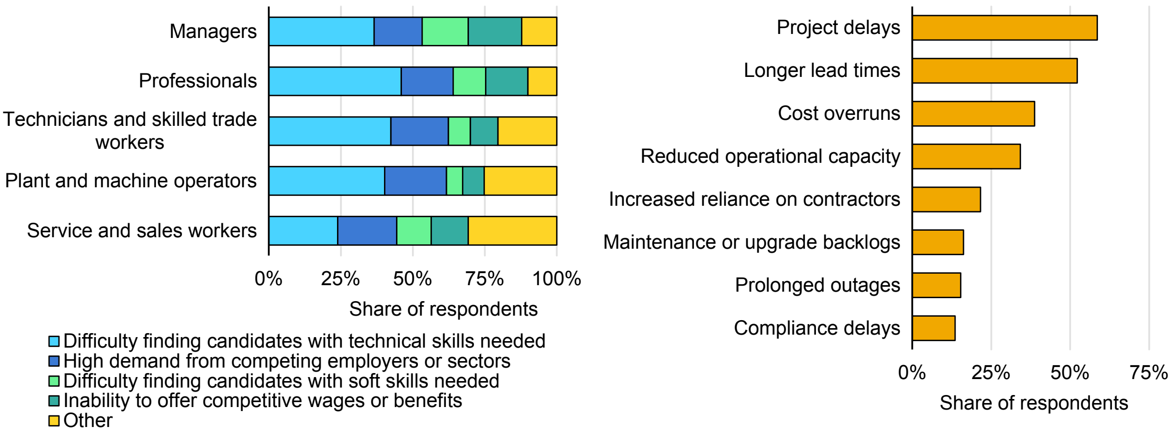


Notes: Countries covered include Austria, Brazil, Canada, France, Germany, Italy, Indonesia, Ireland, Mexico, Spain and the United Kingdom. 'Managers' include the International Standard Classification of Occupations (ISCO)-08 occupational group managers (e.g. project managers). 'Professionals' include the ISCO-08 occupational group professionals (e.g. wind energy engineers). 'Technicians and skilled trade workers' include the ISCO-08 occupational groups technicians and associate professionals (e.g. wind turbine technicians) and craft and trades workers (e.g. electricians). 'Plant and machine operators' include ISCO-08 occupational group plant and machine operators (e.g. power plant operators). 'Service and sales workers' include the ISCO-08 occupational group service and sales workers (e.g. sales representatives). 'Administrative workers' include the ISCO-08 occupational group administrative workers (e.g. inventory clerk). 'Elementary occupations' include the ISCO-08 occupational group elementary occupations (e.g. construction support workers).
Source: IEA analysis based on data from Lightcast.

Project development is increasingly held back by skills shortages. Around 70% of the renewable energy and energy efficiency firms participating in the *2025 Industry Employment Survey* reported hiring difficulties among technicians and skilled trade workers, particularly due to insufficient technical skills among candidates. Construction-related technical roles, such as electricians, welders and pipefitters are in high demand across the broader economy, and with the expansion of the energy sector and the rise of [data centres](), companies face even stronger competition for these roles. To address these challenges, companies must adjust their hiring strategies, for instance by increasing their reliance on contractors, and increasing on-the-job training for new hires.

The shortage of available skilled energy workers is already having significant impacts on project delivery and costs. Over 40% of firms surveyed reported that hiring difficulties have led to operational bottlenecks, such as project delays, longer development timelines and cost overruns, among other issues. For instance, in [Latin America](), analysis shows that shortages of technical staff increase the duration of some phases of grid infrastructure projects by up to three times, which delays the connection of new power generators to the system.

Reasons for hiring difficulties in selected occupation groups among renewable energy and energy efficiency firms surveyed by the IEA, and operational bottlenecks experienced due to hiring difficulties



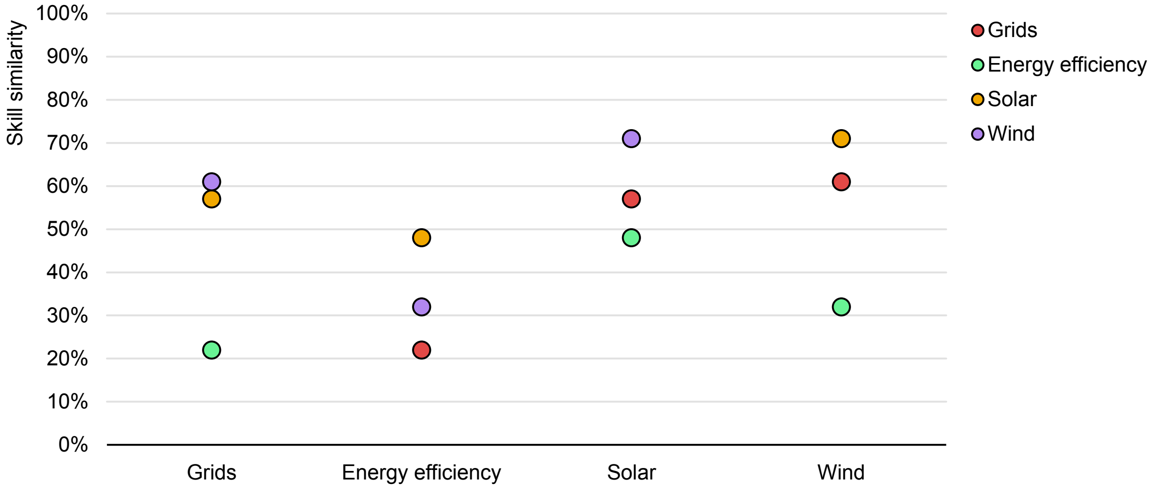
Notes: This analysis is based on a survey of over 170 renewable energy and energy efficiency firms. Other reasons reported for difficulties in hiring include long hiring timelines due to internal, security or regulatory processes, negative perceptions of working conditions in the industry, limited interest in energy sector careers, and geographic or relocation barriers.
Source: IEA Industry Employment Survey, 2025.

Many of the skills sought by firms are common across energy subsectors, reflecting the potential transferability of capabilities. Among technicians and trade workers, cross-sectoral skills include the ability to diagnose faults in power generation systems and machinery, as well as familiarity with components used across renewables technologies, such as inverters. For engineers, key competencies include expertise in integrating renewable energy sources into the grid and skills related to product design and development. In addition to technical skills, a range of soft skills are in demand across subsectors, including effective communication, teamwork and proficiency in digital tools.

Non-transferable skills tend to be closely linked to technologies and their deployment models. The solar PV and energy efficiency subsectors typically involve greater interaction with end users, resulting in higher demand for service orientation among technicians than in sectors such as wind. In subsectors with modular and labour-intensive installation processes, including solar PV, workers require strong skills in assembling and connecting electrical systems. By contrast, in the wind subsector, skill requirements are more concentrated in the operations and maintenance phase, where technicians are needed to diagnose faults and troubleshoot components.

To support a more resilient and adaptable workforce, vocational education and training systems could place greater emphasis on cross-sectoral skills, embedding them across curricula to ensure greater transferability across industrial sectors. Baseline trainings could be complemented with modular trainings targeting sector-specific technical, digital and soft skills, as the skills of the most demanded occupations tend to be specific to their subsectors. The following sections present the minimum proficiency levels required for selected skills across key occupations in solar, wind and energy efficiency, helping stakeholders identify transferable and sector-specific skills and assess opportunities for workforce mobility.

Skill similarity across renewable energy, grids and energy efficiency subsectors in the United Kingdom, 2024



Notes: Similarity scores can range from 0% (perfectly dissimilar) to 100% (perfectly similar) and they exclude common skills.
Source: IEA based on data from the United Kingdom Department for Energy Security and Net Zero. License: Open Government Licence v3.0.

International mobility among the renewable energy workforce

Shortages of skilled labour and an ageing workforce in advanced economies have intensified the role of migration in workforce strategies, alongside domestic training and reskilling initiatives. Several countries have made international arrangements with countries with labour surpluses to alleviate these shortages. For instance, the United Kingdom and Germany signed cooperation agreements with India, while the alignment of vocational qualifications is currently underway in ASEAN countries. In Spain, around 9% of the renewable energy workforce was hired from abroad in 2022, while in Australia and Canada, this share in 2021 stood at 26% and 24%, respectively, though in all three countries these shares are higher among engineering and installation activities. However, a strong reliance on foreign workers in advanced economies may contribute to skilled labour shortages in workers' countries of origin. For instance, around 40% of engineering graduates in Indonesia pursue careers abroad, which exacerbates labour shortages in their home country's renewable energy subsectors such as solar and wind. This trend may also reduce firms' willingness to provide in-house training, reflecting concerns that newly trained workers could be recruited by employers in higher-income countries.

To address the challenges associated with the outflow of skilled workers, several countries have introduced programmes aimed at developing expertise abroad while creating pathways for workers to return to their countries of origin. For instance, the Philippines has introduced the Balik Scientist programme, which provides benefits and incentives to Filipino workers to return home, with renewable energy being one of the targeted areas of the programme. Morocco and Spain have jointly developed the Move Green initiative, which enables Moroccan youth to participate in renewable energy-related vocational training in Spain and receive support to reintegrate into the Moroccan labour market afterwards.

Solar PV: Installation and maintenance are the most sought-after skills in the sector

With over 85 000 job postings in 2024, solar PV, including residential and utility-scale solar, accounted for the largest share of OJPs among renewable energy and energy efficiency. While investments in solar PVs have been declining due to the falling prices of PV modules, capacity additions reached 540 GW in 2024, a 30% year-on-year increase. Following this trend, labour demand increased as well, with OJPs increasing almost ninefold between 2019 and 2024.

In 2024, almost half of all OJPs were concentrated among technicians and skilled trade workers. This occupational group includes workers such as solar PV installers, who constitute the single largest occupation with 13% of all OJPs between 2019 and 2024, as well as electricians and other workers with technical backgrounds. In some regions, such as the European Union, 86% of the solar PV workforce is concentrated in the deployment of additional generation capacity. This reflects the labour-intensive nature of rooftop installations, which on average, create three times more jobs per megawatt installed than utility-scale solar, as they require permitting and installation designs specific to the site.

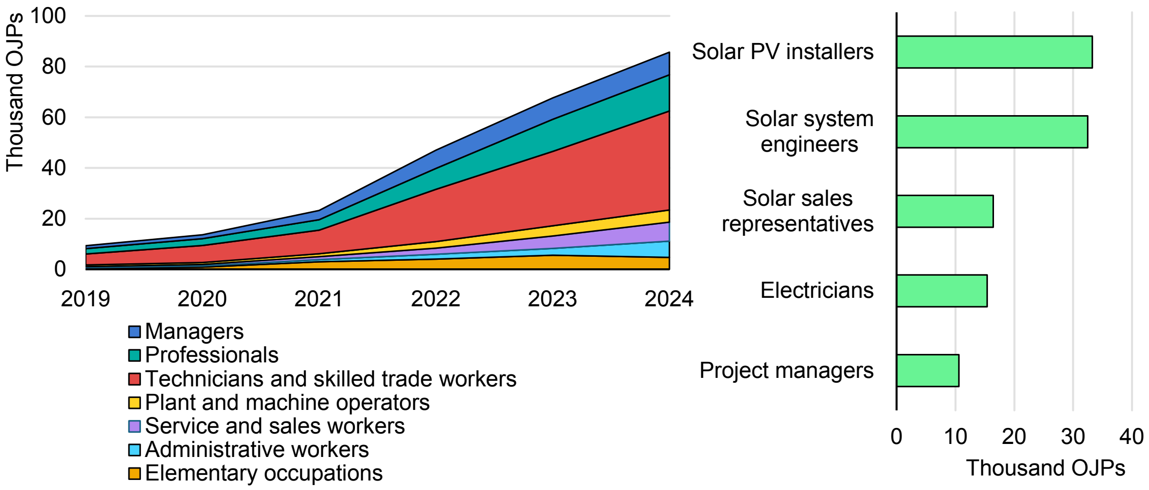
Professionals, such as solar engineers, financial consultants and data analysts account for 17% of all OJPs in 2024. These workers support the rollout of utility-scale projects, and their tasks include project design assessment, and other corporate functions. Labour demand for these workers might vary across regions in the future. Several utility-scale solar PV projects in Latin America have been cancelled due to grid connection queues, slowing demand for workers involved in project design. In the EU, demand for these roles could be supported by growth in corporate power purchase agreements and competitive actions.

Solar PV projects also generate substantial workforce needs for managers, sales and administrative workers. Managers made up 10% of all OJPs in 2024. These roles include project managers for large-scale projects, who manage contractors and monitor activities on sites. Service and sales workers account for around 9% of all OJPs. These workers include sales representatives managing customer relationships and preparing quotes for potential customers, as well as offering logistical services.

With 6% of all OJPs in the solar PV subsector, plant and machine operators are mostly concentrated in the manufacturing segment of the supply chain. The number of OJPs in manufacturing declined by 7% between 2023 and 2024. This trend reflects a slowdown in global PV module manufacturing, as production capacity has expanded to around twice the level of annual PV system deployments, triggering a slowdown in supply chain expansions.

Based on current investment and policy settings, the increase in solar PV capacity could more than double up to 2030. However, developers report skills shortages across regions in both mature and emerging solar PV markets, creating bottlenecks in project deployment. In Germany, job quality concerns, such as career stability regarding trade professions and the lack of awareness about trade careers are deterring young people from entering the sector. In Brazil, solar PV projects are typically undertaken by small and medium-sized enterprises, which often face constraints in offering competitive wages and long-term job security. In Indonesia, where the government targets 100 GW of installed solar PV capacity by 2030, educational pipelines and training capacity are not keeping pace with planned deployment.

Trends in solar energy OJPs (2019-2024) and the cumulative number of OJPs for leading occupations (2019-2024).



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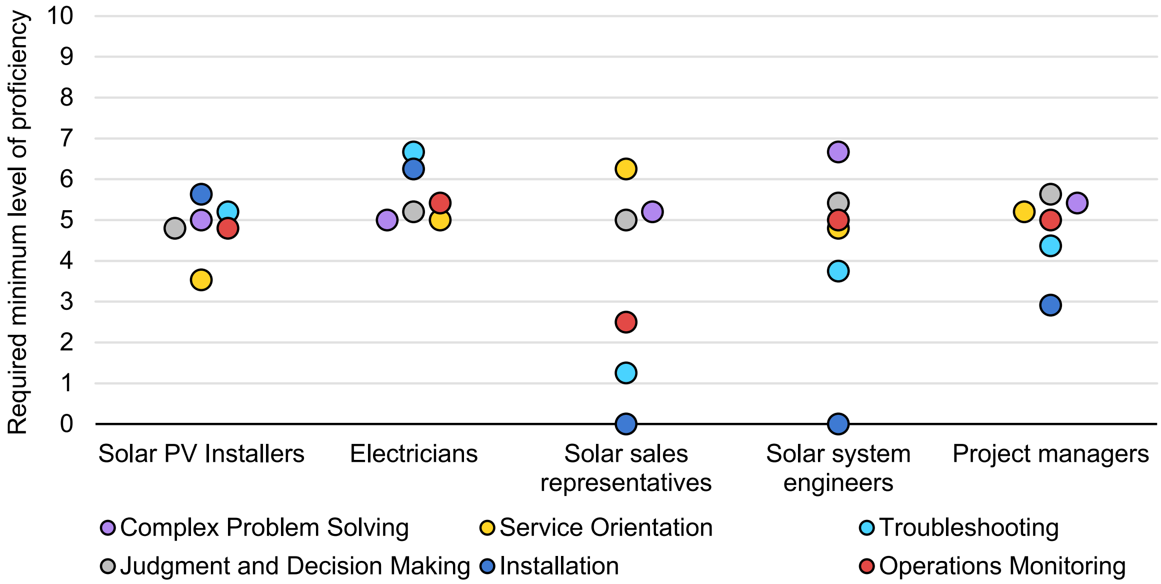
Source: IEA analysis based on data from Lightcast.

As solar PV deployment expands, the sector relies mainly on skills such as installation, operations monitoring and troubleshooting. The specific skill content, however, varies across countries with different levels of energy system maturity and grid development. In parts of Nigeria where grid access remains limited, technical skills must be adapted to off-grid systems. In the European Union, the increasing deployment of smart meters requires programming knowledge among solar PV installers.

There is a growing demand for engineers and technicians with not only solar-specific technical skills but also an understanding of broader energy systems, as solar PVs are becoming integrated into infrastructural systems. In Brazil, the growing adoption of agrivoltaics, where land is used simultaneously for agricultural production and electricity generation, requires installers to have knowledge of agronomy to ensure that solar installations do not compromise agricultural activity. In the European Union, Asia Pacific and North America, the rising demand for building-integrated photovoltaics, such as solar roof tiles, is increasing the need for expertise combining engineering and architecture, as well as problem solving skills.

As the solar PV sector is more client facing than other energy subsectors, communication and service orientation are crucial. Solar PV installers must be able to explain the technical details of equipment to users. In the context of utility-scale solar projects, 35% of project developers reported poor communication between field and office teams as a primary challenge in job site documentation, leading to additional site visits and other inefficiencies.

Minimum required level of proficiency in selected skills among the most demanded occupations in the solar PV sector



Note: Minimum required proficiency refers to the level of competency needed to perform the tasks associated with a given occupation. These estimates are based on the "Level" scores published in the O*NET database and normalised to a 0–10 scale. A score of 0 indicates that the occupation does not require the specified skill, while a score of 10 indicates a high level of proficiency is required to perform relevant tasks.

Source: IEA analysis based on data from O*NET (accessed May 2026).

Gaps in these skills are emerging as challenges for firms. This trend can be observed in both Southeast Asian and European contexts. In Viet Nam, around 40% of young entrants lack the technical competencies required by employers and face difficulties adapting to new technologies and specialised equipment, such as high-capacity inverters and solar radiation meters. Employers also report unpreparedness for working conditions in solar installations, including tasks performed in high-radiation environments at solar power plants. In the Philippines, around 25% of solar PV workers report a mismatch between their skills and job requirements. Employers in the region highlight shortcomings in solar PV-specific technical competencies, as well as in digital and soft skills such as communication and teamwork. In the United Kingdom, firms highlighted that current programmes mostly target residential installations, and graduates lack experience with utility-scale installation projects. These gaps point to a need for stronger alignment between training curricula and industry requirements.

Wind: The demand for workers combining technical skills and safety awareness grows as installed capacity increases

OJPs in the wind sector, including onshore and offshore wind, reached 21 000 in 2024, a 70% increase since 2019. More than one-third of OJPs were recruiting technicians and skilled trade workers, such as wind turbines technicians, which made up of 15% of all OJPs in the sector between 2019 and 2024. These workers repair electrical, mechanical and hydraulic malfunctions on wind turbines. The growing demand for wind technicians is reflected in the expansion of training centres. Since 2021, more than 200 training centres were certified globally by the Global Wind Organisation to train wind turbine technicians according to industry-wide safety and technical standards.

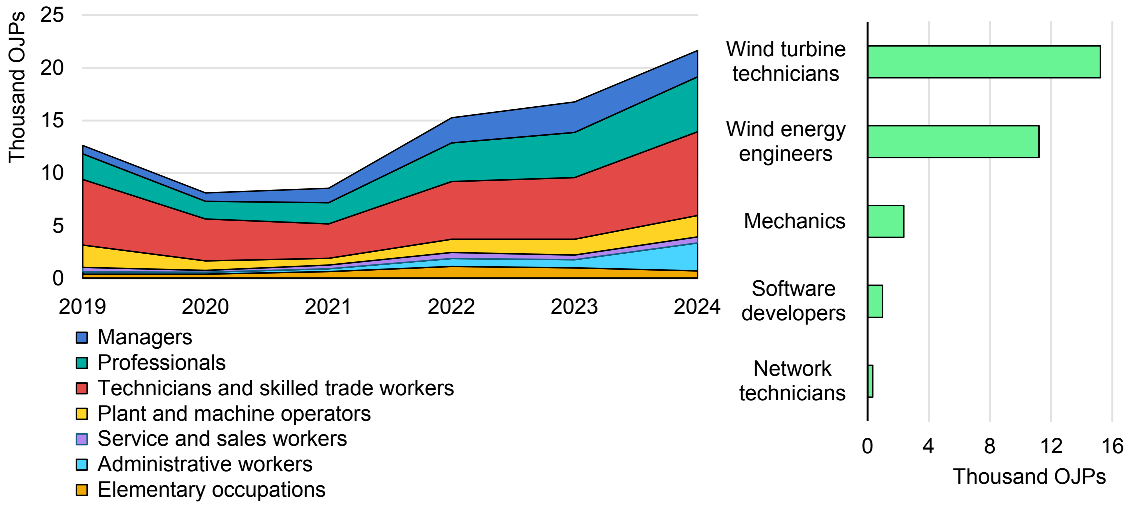
Professionals make up around one-quarter of all OJPs. This occupational group includes wind energy engineers and civil engineers, who design the layout and estimate the energy production levels of wind farms, and product engineers, who design wind turbine components, such as blades, transformers and generators. Job postings for this occupational group saw a 32% decline between 2019 and 2020 due to supply chain bottlenecks and restricted international mobility among workers during the Covid-19 pandemic but saw a rebound with a 33% average annual growth rate since then.

Around 10% of OJPs were hiring for plant and machine operators in 2024, largely concentrated in the manufacturing sector. As demand for turbines and components has been falling due to delays and cancellations in project development in the offshore wind sector, the number of job postings hiring for these workers decreased by 5% between 2019 and 2024. The remaining 25% of OJPs in the sector are concentrated among non-technical roles, such as administrative workers, sales workers and managers. These workers include accounting clerks, human resources administrators and other non-technical roles.

Employers across regions report persistent hiring difficulties in filling roles that require specialised skills. In Europe, which had 291 GW of installed wind generation capacity in 2025, technician shortages are linked to training pipelines that do not keep up with industry needs, as well as diverging training and certification regimes across Member States. In regions with a recently emerging wind sector, developers need to compete for a limited talent pool of trained technicians or rely on overseas labour. In Argentina, where installed wind generation capacity could surpass 5.5 GW by 2030, firms compete with the oil and gas industry where wages and long-term career prospects tend to be perceived as more attractive. In the Philippines, which aims to have installed 5 GW of wind generation capacity by 2030, the lack of local wind-specific trainings often requires project developers to rely on foreign workers, thus limiting local job creation opportunities. High voltage engineers are in short supply worldwide, with wind power plant developers reporting critical shortages of these roles in India and Scotland.

The sector expects labour demand to continue to grow, as installed wind capacity may double to 2 000 GW globally up to 2030. To accommodate this growth, according to the Global Wind Energy Council, the sector needs around 628 000 wind technicians globally by 2030, up from 461 000 in 2024.

Trends in wind energy OJPs (2019-2024) and the cumulative number of OJPs for leading wind occupations (2019-2024).



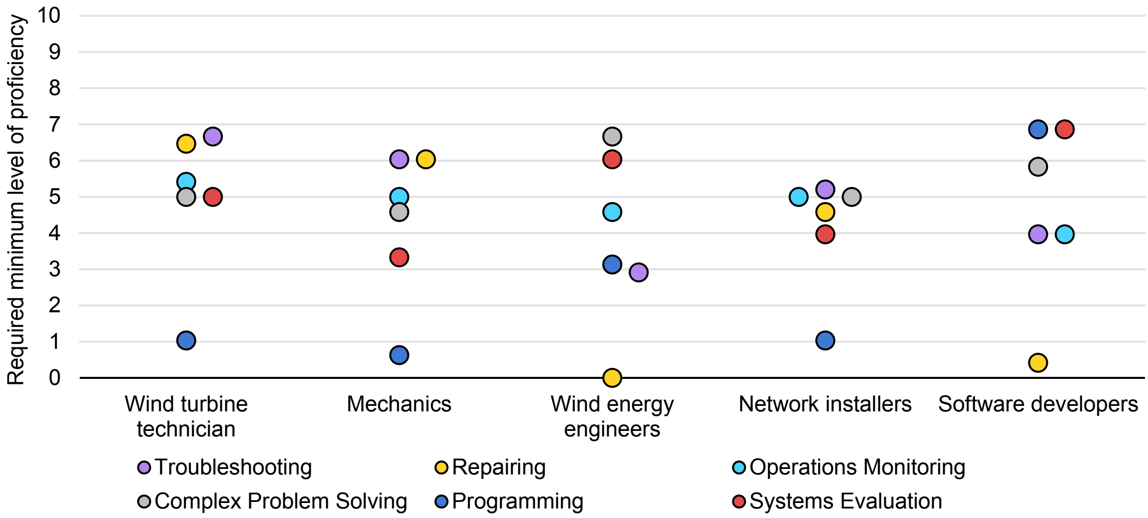
Notes: Countries covered include Austria, Brazil, Canada, France, Germany, Italy, Indonesia, Ireland, Mexico, Spain and the United Kingdom. 'Managers' include the International Standard Classification of Occupations (ISCO)-08 occupational group managers (e.g. project managers). 'Professionals' include the ISCO-08 occupational group professionals (e.g. wind energy engineers). 'Technicians and skilled trade workers' include the ISCO-08 occupational groups technicians and associate professionals (e.g. wind turbine technicians) and craft and trades workers (e.g. electricians). 'Plant and machine operators' include ISCO-08 occupational group plant and machine operators (e.g. power plant operators). 'Service and sales workers' include the ISCO-08 occupational group service and sales workers (e.g. sales representatives). 'Administrative workers' include the ISCO-08 occupational group administrative workers (e.g. inventory clerk). 'Elementary occupations' include the ISCO-08 occupational group elementary occupations (e.g. construction support workers).
Source: IEA analysis based on data from Lightcast.

As demand for operation and maintenance roles grows, skills related to the compliance and performance of fleets are emerging as key requirements in the sector. Among technicians, these skills include troubleshooting and repairing wind turbine gearboxes and hydraulic systems. Digital technologies are becoming more widely used in windfarm maintenance, requiring technicians to adopt digital skills to support remote inspections, operate digital twin systems and navigate drones for inspections. Wind energy engineers need to be able to evaluate wind farm system performance, solve problems that limit output levels and ensure that project plans comply with technical standards, including noise regulations. Programming skills are increasingly important among engineers to automatically detect faults in turbine performance and schedule predictive maintenance.

As technicians in the wind sector can be exposed to safety risks, learning skills that enable adaptability and critical thinking are an essential requirement. For example, they need to assess weather conditions before starting tasks and be able to perform rescue operations in cases of emergency, especially in offshore wind farms. Additionally, workers need to be mentally able to work at heights and be physically able to use rope access techniques.

Arising from these safety needs, soft skills are increasingly demanded across occupational groups. Workers need to be able to work in a team, solve problems and follow instructions. For example, a study among European wind power plant developers found that some firms prioritise these skills during recruitment, as technical skill gaps can be filled more easily with on-the-job training.

Minimum required level of proficiency in selected skills among most the demanded occupations in the wind energy sector



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Source: IEA analysis based on data from O*NET (accessed May 2026).

The limited availability of specialised training programmes is emerging as a constraint in several regions, particularly in countries seeking to rapidly expand wind power capacity. In Brazil, where there are plans to install 22 GW of generation capacity between 2025 and 2030, the absence of dedicated wind energy safety trainings requires maintenance technicians to complete multiple training programmes to collect all certificates required by the industry. In Namibia which plans to install 99 MW of generation capacity by 2030, technicians are offered general technical and safety programmes but lack access to training that is specific to wind turbine installation and maintenance. These gaps limit opportunities for workers to gain experience on equipment used in operational settings, which can carry potential risks for worker safety and project quality. As a result, firms increasingly rely on international training arrangements. For instance, in Argentina and Canada, some developers train their recent hires in Spain and the Netherlands, which have more mature wind markets, in order to gain experience in wind projects.

In regions where wind energy programmes have already been established, they are not always fully aligned with industry requirements. In the European Union, companies noted a lack of specialised programmes focusing on marine operations preparing vocational education and training (VET) graduates for offshore wind projects. Similarly, in Uruguay, around 60% of wind project developers report difficulties in finding workers with renewable energy expertise, and approximately 80% have introduced in-house training programmes to fill knowledge gaps.

Energy efficiency: energy savings and performance regulations drive demand for energy efficiency workers

Job advertisements in energy efficiency, covering industrial and building energy efficiency grew at an annual average growth rate of 53% between 2019 and 2024. High energy prices and regulatory measures mandating efficiency improvements were among the contributing factors to these efficiency gains and the corresponding labour demand growth. Analysis indicates that energy efficiency investments generate more jobs per unit of investment than any other energy subsector, with many of these jobs created within small and medium enterprises (SMEs).

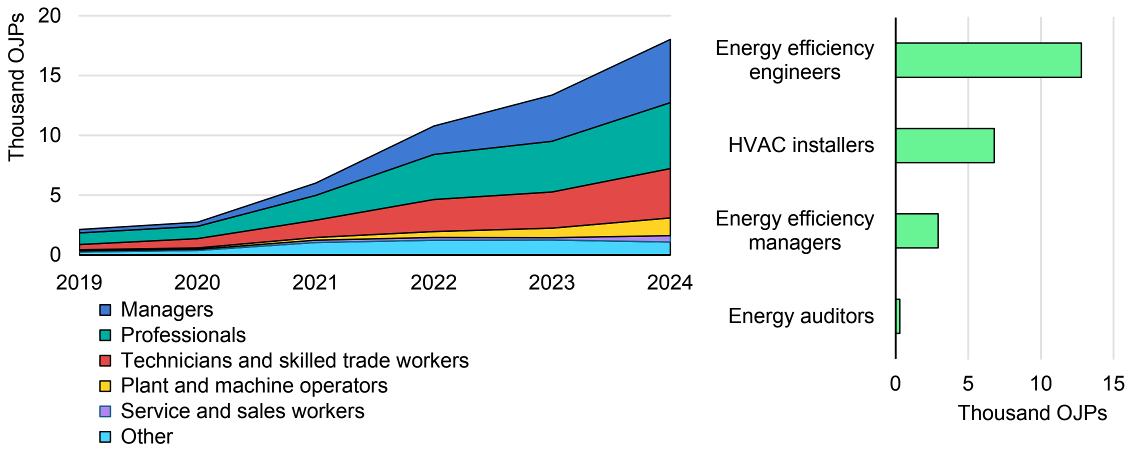
Almost one-third of OJPs in 2024 were concentrated among managers, such as energy efficiency project managers. These roles are responsible for proposing and leading strategies reducing the energy intensity of industrial equipment and buildings, for instance through the introduction of energy management systems.

Professionals accounted for 30% of OJPs in 2024. This occupational group includes energy efficiency engineers, who design energy efficiency systems by for instance, selecting the right materials and components to optimise energy performance. Professionals also include energy auditors, who identify energy saving measures and analyse their impacts by collecting data through devices such as psychrometers and thermometers. Demand for energy auditors has been growing due to increasing cost saving measures and policies requiring energy performance certificates for buildings before the occupancy or sale of buildings. Such certificates have been introduced in many countries, for instance in the European Union, the United Kingdom, Chile and Malaysia.

Technicians and skilled trade workers made up around a quarter of OJPs in the energy efficiency subsector in 2024. These workers include occupations such as heating, ventilation and air conditioning (HVAC) installers, who install or adjust heat pumps, thermostats, humidistats or timers, and test components for proper functioning, and weatherisation installers, who seal air leaks and replace windows and doors to help control temperature, thus improving energy efficiency.

Meeting labour demand in energy efficiency is constrained because of increasing skills shortages. According to the Association of Energy Engineers, more than 40% of energy firms consider the shortage of skilled workers as the most significant challenge to increasing energy efficiency. The energy sector is characterised by an ageing workforce, which is the case of the HVAC installer workforce as well. In the European Union, around 80% of HVAC installers are above the age of 30, while in the United Kingdom, more than two-thirds of them are above the age of 45.

Trends in energy efficiency OJPs (2019-2024) and the cumulative number of OJPs for leading energy efficiency occupations (2019-2024).



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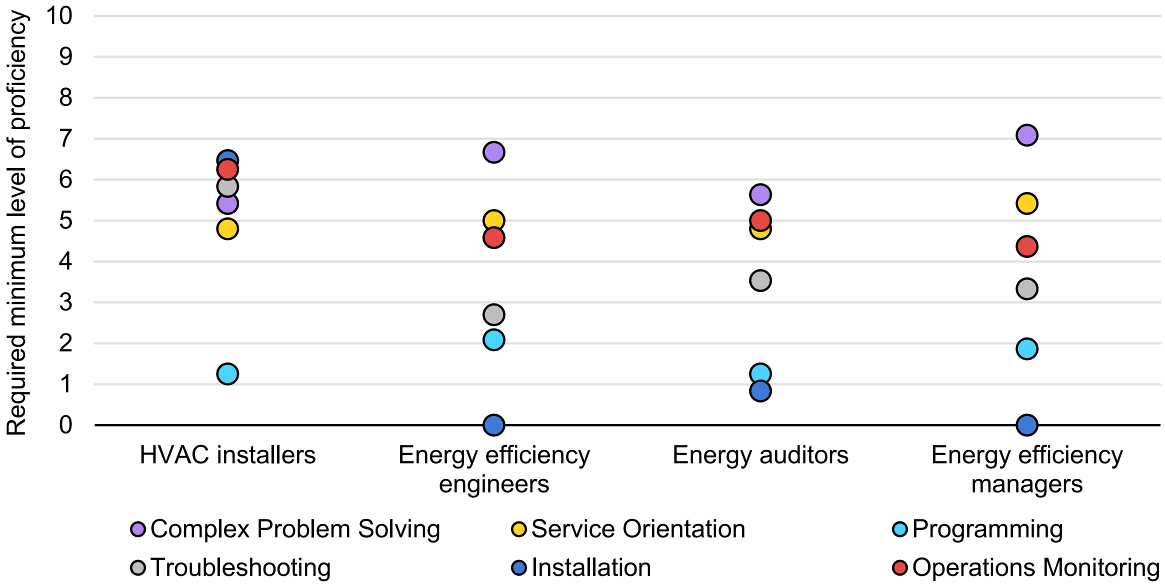
Source: IEA analysis based on data from Lightcast.

The penetration of new technologies, practices and materials in buildings and industrial processes requires the adoption of new skillsets among technicians. Gas boiler installers need additional trainings to be able to install energy efficient HVAC appliances, such as heat pumps. This includes learning how to work with the electronic controls and wiring that regulate systems, and how to properly size units so they match the needs of buildings. Additional training is also needed for systems that provide both heating and cooling with gas systems. Demand for these new skills underscores the importance of expanding HVAC trainings. However, some successful programmes are beginning to emerge, especially in regions such as Southeast Asia. The National Cooling Action Plan of Viet Nam seeks to certify at least 8 000 HVAC technicians in the next ten years, while Indonesia has certified more than 9 000 since 2020.

With the increasing adoption of energy performance targets across industry and buildings, engineers need the skills to more systematically integrate energy efficiency considerations into design processes. These include gaining a deeper understanding of emerging technologies in building envelopes and of retrofit opportunities for legacy systems, as well as the integration of renewables into buildings. Engineers also need to be able to use software for these purposes, for instance multi-dimensional modelling tools, to estimate the costs and benefits of efficiency measures over the life cycle of projects.

Required minimum level of proficiency in selected skills among most the demanded occupations in the energy efficiency sector



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Source: IEA analysis based on data from O*NET (accessed May 2026).

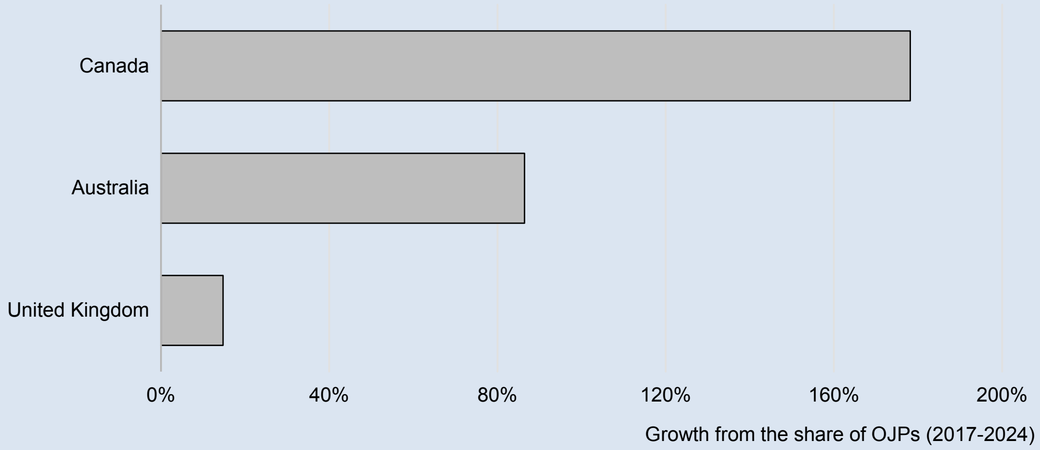
Energy efficiency also requires workers to engage with end-users closely, underpinning the importance of service orientation and teamwork which are not typically taught in technical programmes. Engineers are increasingly interacting with industrial and residential end-users to help them make decisions about energy efficiency interventions and need to work more closely with contractors during the early stages of projects to ensure that construction, electrical and mechanical workers consider building energy performance. The retrofits of legacy systems require planners to interpret incomplete information and solve complex problems. During the maintenance phase, technicians need to adopt a systems-based approach, ensuring that reparations of specific pieces of equipment do not compromise overall building performance.

Spotlight on lineworkers

As electricity production increases, existing power networks need to be modernised to accommodate variability in output, driving demand for lineworkers. These workers are involved in the installation of transmission and distribution assets, including cables, substations and metering systems. Australia, the United Kingdom, the European Union and Canada have increased efforts in recent years to modernise their grid infrastructure. The share of lineworkers from all OJPs in the United Kingdom grew by 15% between 2017 and 2024, while in Australia and Canada it doubled and almost tripled respectively. In the European Union, 16 Member States reported shortages of lineworkers in 2024, up from 8 in 2022.

As project pipelines continue to expand, constraints in the availability of adequately trained personnel are emerging as a key obstacle to grid development. According to the *2025 IEA Industry Employment Survey*, more than 40% of grid companies experience high competition for skilled labour owing to the limited pool of qualified applicants. Labour shortages are further exacerbated by the ageing grid workforce. IEA analysis indicates that for every young person joining, 1.4 workers are aged 55 years or above, a ratio much higher than the economy-wide average.

Growth of the share of lineworkers in all OJPs in Australia, the United Kingdom and Canada, 2017-2024.



Notes: Lineworkers refer to Canada NOC code 72203 (electrical power line and cable workers), ANZSCO code 3422 (electrical distribution trades) and UK SOC code 5249 (Electrical and electronic trades not elsewhere classified).

Source: IEA analysis based on data from UK Office for National Statistics, Statistics Canada and Jobs and Skills Australia (acessed May 2026).

The workforce challenges faced by the sector reflect the complex set of skills that lineworkers must learn. Constructing grid infrastructure requires skills to install the structures used in the transmission and distribution of electricity, such as poles, conductors and high voltage cables, and test the equipment to ensure compliance with regulations. They also need to be physically able to climb tall structures, lift heavy objects and follow safety protocols to avoid injuries.

Emerging skills in the renewable energy and energy efficiency workforce

Emerging technologies, such as artificial intelligence (AI), data analytics, digital design software and energy management systems, are increasingly regarded as necessary tools to enhance operational effectiveness among firms. These tools can be used to speed up administrative efficiency, improve system performance and increase worker safety.

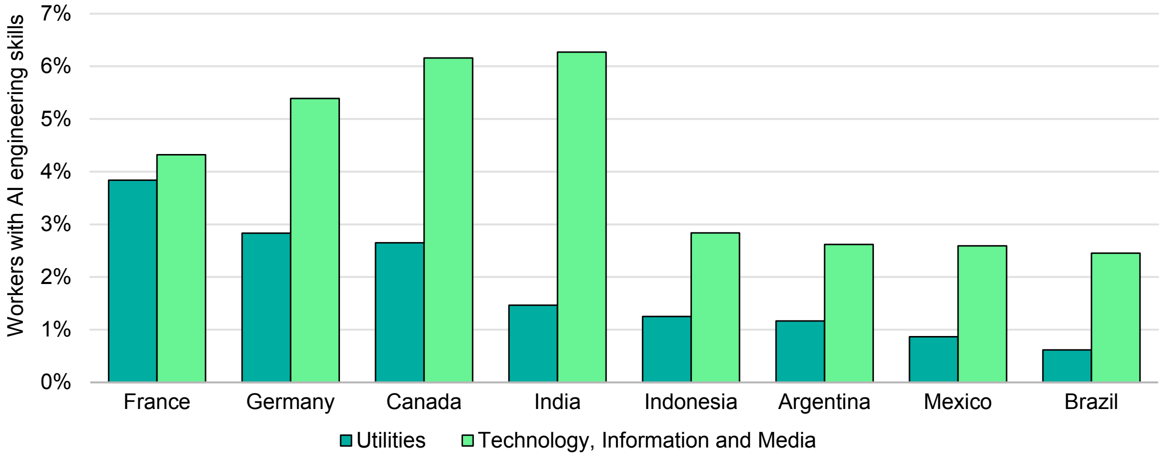
The rapid growth of AI presents challenges for the power sector, such as higher electricity demand, but also opportunities. BCG analysis shows that AI adoption can help renewable energy firms improve operational efficiency by up to 25%. AI can provide accurate weather forecasting for power generators, reducing the need to procure electricity on the intraday market. AI-equipped sensors can help system operators determine maintenance requirements on high and low voltage lines, which are increasingly deployed by companies such as Enedis, the UK National Grid and TNB Malaysia. To introduce AI systems, firms need workers with AI engineering skills, who can develop and train algorithms and machine learning models. This requires competencies in programming, data management and software development. Once introduced, the usage of these systems requires workers across occupation groups to develop AI literacy skills. These include the ability to critically assess AI-generated information, understand the limitations of AI tools, identify effective use cases and comply with relevant data protection requirements.

Expertise in specialised software is increasingly sought after in renewable energy and energy efficiency projects. Computer-aided design programmes (CAD) have become widespread among energy engineers to design accurate site layouts by identifying optimal positions for solar irradiation or wind speed. HVAC installers increasingly use 3D modelling to improve the energy efficiency of heat pump systems. These models can help design systems with fewer parts and with smoother transitions from one pipe size to another, resulting in the minimisation of energy losses such as pressure drops. Supervisory Control and Data Acquisition (SCADA) systems enable the real-time monitoring of energy infrastructure through sensors and controllers. This software is increasingly used by solar and wind power plant operators to monitor production levels and detect turbine faults, as well as by grid operators, who use this tool to prevent grid failures by regulating voltage and frequency levels through this system.

The rollout of renewable energy technologies and smart meters creates large amounts of data that utilities and electricity producers can leverage. Analysis of consumption and production patterns enables utilities to anticipate demand spikes and make informed decisions about network investment that could help curb congestion issues. Power generators rely on data analysis to model production levels and inform pricing and trading strategies. Capturing these opportunities requires workers with the skills to statistically analyse datasets covering electricity prices, weather patterns and geospatial information, and to visualise these insights. Demand is also rising for workers with coding capabilities (e.g. Python, R and MATLAB) to manage increasingly complex databases.

Despite growing demand for digital competencies, the energy sector lags in attracting workers with the desired skillsets. IEA analysis of LinkedIn data indicates that across many economies, the share of utility-sector workers with AI engineering skills is around half that observed in the technology sector. The IEA's *2025 Industry Energy Employment Survey* shows that the inability to match the salary expectations of qualified candidates set by other high-paying industries, such as the tech industry, is the largest barrier to hire or retain employees with AI and digital skills. Analysis shows that tech companies hired 30% more workers with energy skills since 2022, with efforts to secure energy supply for data centres contributing to this increase. The growing demand for energy expertise across other sectors, together with the emergence of new technologies within the energy sector, is increasing pressure on education systems to expand and broaden training curricula.

Share of utility and technology workers with AI engineering skills, 2024.



Source: IEA analysis based on data from LinkedIn.

Chapter 3. Policy enablers for a skilled renewable energy, grids and energy efficiency workforce

Well-designed policy and supportive measures can help attract, train and retain workers

Through research, surveys and interviews with key stakeholders, and two in-person workshops, the IEA has identified polices and initiatives that governments and key stakeholders, including energy companies, educators and workers' representatives can implement to help address skilled labour shortages. In 2025, the *IEA Labour Employment Survey* found that energy workers and their representatives identified well-paying jobs, training leading to nationally recognised certification, and free training as the top three solutions for attracting more workers to the energy sector. These findings were mirrored in the 2025 *IEA Industry Employment Survey*, which found that employers had increased wages and enhanced internal training programmes to address hiring difficulties.

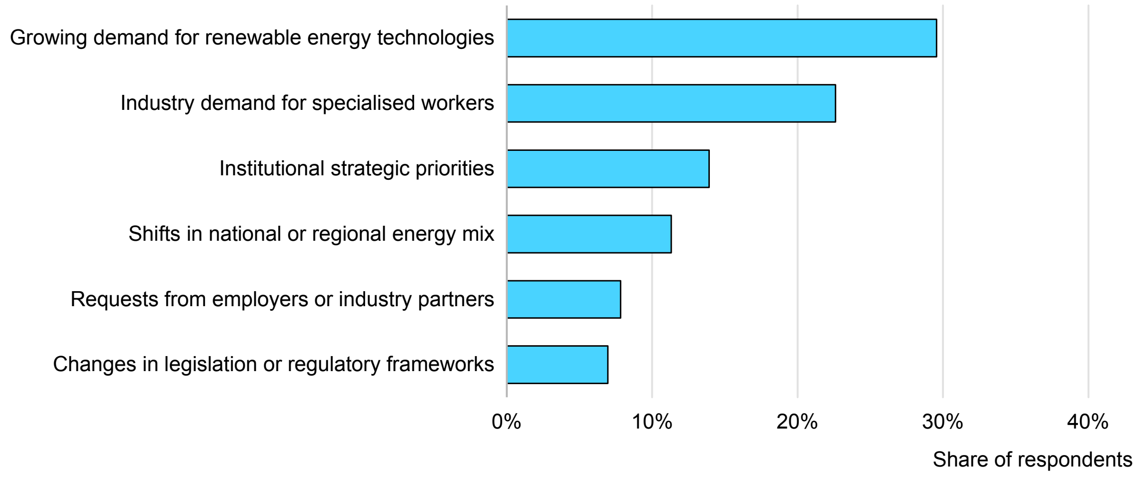
These findings illustrate some of the policy issues explored in this chapter. It examines how policies can improve access to education and training pathways, strengthen job attractiveness through financial and other measures, and better link energy policies with workforce development, including workforce mapping and skills planning, through a multi-stakeholder approach.

Ensuring adequate, accessible and well-designed energy education and training

Education and training: supply and demand

Energy educators surveyed by the IEA in 2025 reported that a growing demand for renewable or alternative energy technologies and industry demand for upskilled or specialised workers were the top drivers behind decisions to offer or expand energy-related training programmes. However, the survey also found that over half of energy educators reported not being fully confident that their existing training capacity could meet growing demand over the next five years. This reflects the need for many countries and education centres to invest in clean energy education and training, including increasing the number of qualified trainers and educators, classroom and equipment spaces and number of courses offered.

Share of respondents reporting the main drivers behind the offering or expanding of renewable energy, grids or energy efficiency programmes, 2025



Notes: includes those delivering education and training in wind, solar, energy efficiency and grids.
Source: IEA, Educators' Employment Survey, 2025.

A range of education and training pathways exist for energy occupations

The energy sector requires a large number of workers in a range of occupations with different skill levels. Compared to the economy-wide average, the energy sector employs a higher share of medium-to-high skilled technical workers. Applied technical workers make up over 50% of the overall energy workforce compared to around 25% of the wider labour force. This includes occupations such as electricians, grid line workers and HVAC installers.

Education pathways differ depending on the skill level and learning outcome that is required by industry standards for specific occupations - for example whether a degree, certification or licence is needed. Some occupations such as wind turbine technicians, battery or renewable systems engineer, require formal education such as a university degree or a vocational qualification obtained through attending a vocational or technical school. In some circumstances, companies offer paid apprenticeships which provide a hands-on approach to learning, certification and potentially swift transition to employment with these companies following completion. In addition, short training courses, top-up trainings and on-the-job training can equip workers with specific certifications or licences which are often recognised by an industry body and may be a legal requirement for some professions (e.g. electricians) in some countries.

Types of qualifications: Degrees, certificates, certifications and licenses

Credential Type	Definition	Purpose	Typical Duration	Example	Training Modality
Degree	Academic qualification awarded upon completion of a tertiary educational programme	In-depth knowledge and theoretical understanding in a field	Several years	Master's degree in Electrical Engineering	University
Vocational qualification	Qualification awarded upon completion of a vocational educational programme	Knowledge, skills and competencies specific to a particular occupation, trade, or class of occupations or trades	Several years	NVQ Level 3 Electrical Installation / Maintenance	Vocational or technical school
Certificate	Proof of completing a specific course or programme	Verifies education or training in a specific area	A few days to several months	Solar Energy International Certificate	Short course
Certification	Awarded after passing an exam and meeting criteria (e.g. work experience); usually from a non-governmental/ industry body	Validates skills and competency in a professional area	Varies	NABCEP Certified Solar Installer	Varies – can involve short course, or self-directed learning
Licence	Government/regulatory approval to legally practice a profession	Legally authorises someone to work in regulated professions	Varies (includes training plus exam)	Electrician Licence	Apprenticeship, technical school, on-the-job training

For some roles, such as solar or wind energy engineers, academic training is required. However, for occupations such as wind turbine technicians either academic training, vocational education and training, or apprenticeships can be completed to obtain the necessary knowledge, experience and qualifications. Solar panel technicians tend to complete either vocational education and training or apprenticeship training, or have undertaken skills-based certification or on-the-job training, especially if they have some pre-existing training or experience. Heat pump installers usually qualify through VET pathways or apprenticeship routes, with shorter skills-based certification pathways used to provide targeted upskilling and on-the-job training which is often embedded within apprenticeship schemes.

Training pathways by occupation based on selected OECD countries

	Basic training options						Additional training options	
	Academic training		VET		Apprenticeship training		Skills-based certification	On-the-job training
Solar panel installer	N/A*	OR	6 – 24 months	OR	24 – 36 months	AND	< 1 month ** Industry standard	< 6 months **
Wind turbine technician	24 – 48 months	OR	12 – 24 months	OR	24 – 36 months	AND	< 1 month Industry standard	6 – 12 months
(High voltage) line worker	N/A*	OR	12 – 36 months	OR	36 – 48 months	AND	3 – 6 months Industry standard	N/A
Electrician	24 – 48 months	OR	24 – 48 months	OR	36 – 60 months	AND	< 1 month ** Technology specific	6 – 12 months Technology specific
Welder	N/A*	OR	6 – 24 months	OR	36 – 48 months	AND	1 – 6 months Industry standard	3 – 6 months Technology specific
Heat pump installer	N/A	OR	21 – 28 months	OR	48 – 60 months	AND	7 – 12 months Industry standard	3 – 6 months N/A

*Possible pathway but rarely pursued or very limited offer; ** Voluntary training.

Notes: VET = vocational training and education. OECD countries included in the sample were Canada, Germany, New Zealand, the United Kingdom and the United States.

Graduation rates are not keeping up with the pace of worker demand

In the energy sector as a whole, graduates with energy-relevant training are not keeping pace with the rising demand and vocational education in fields relevant to energy has stagnated in many countries over the past 10 years. Specifically, when looking at energy-related certifications in advanced economies, in fields such as engineering, manufacturing and construction[5], the number of graduates has been gradually falling. While vocational and tertiary graduate rates are growing faster in EMDE than in advanced economies, a significantly lower overall number of people are completing VET in EMDE.

Spending on technical training will need to increase substantially to ensure an equipped workforce. To meet the rising demand for energy-related professions under STEPS, expenditure on energy-related vocational programmes would need to rise by 21%. This represents an increase of 50% relative to current levels for EMDE and 14% for advanced economies. This will require substantial investment into skills development including official development assistance (ODA) and other international public finance which have historically been key funders for EMDE. Overall, the number of VET graduates entering the energy sector would need to increase 43% by 2030 to meet worker demand. Under a more ambitious scenario (net zero emissions in the energy sector by 2050), this would be even higher.

[5] ISCED-F field code 07 and qualifications in trades such as electricians and welders.

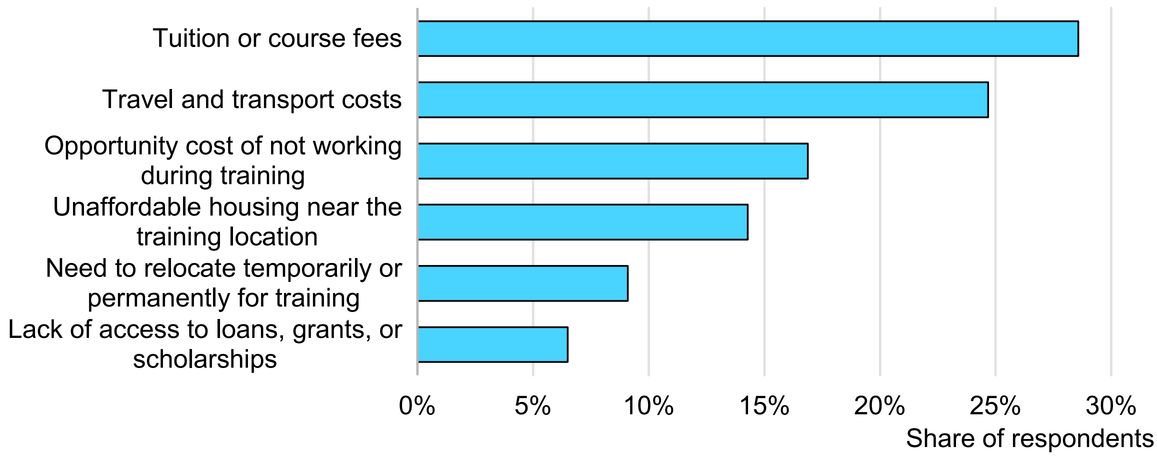
Identifying and addressing barriers to entering energy education and training

Various challenges exist to workers increasing uptake to energy education and training. Findings from IEA surveys of energy educators, workers and their representatives, show that many people face barriers to enrol in education and training. At the same time, energy educators and training providers are encountering difficulties in increasing their capacity to meet the growing demand and keep up with technological change. Keeping pace with the rapidly evolving requirements of the sector is especially important for educators, to ensure that the programmes they offer are perceived as not only relevant by potential applicants but can ensure a swift entry into the energy workforce.

High cost of training can be a major barrier to training uptake

Educators in renewable energy, grids and energy efficiency surveyed by the IEA identified high tuition or course fees, lost wages during training and lack of access to loans and grants as the main financial barriers to training uptake. These were followed by travel and transport costs, unaffordable housing near the training location, and the need to relocate for training highlighting the geographical importance of training institutions for in-person courses especially for those in rural communities.

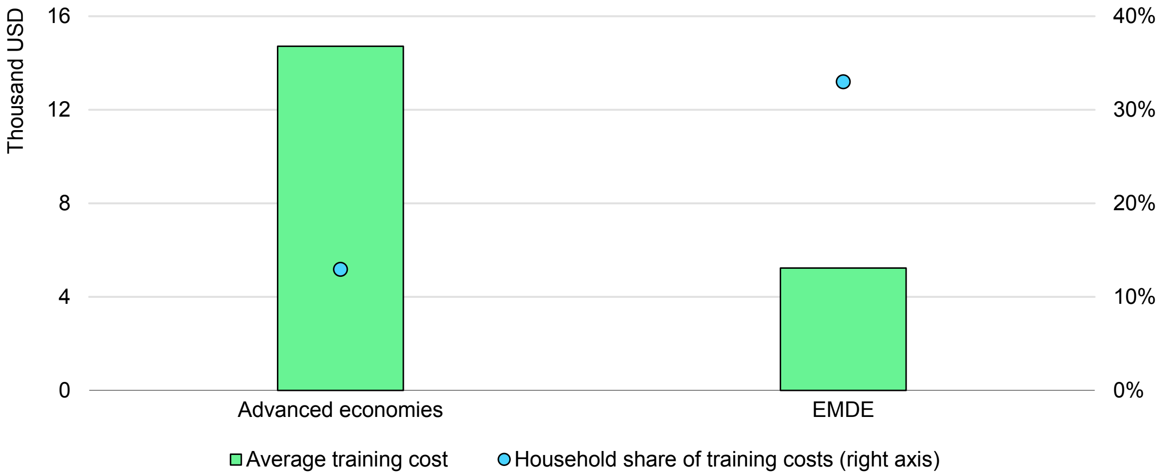
Share of training and education providers reporting on financial barriers affecting training uptake, 2025



Notes: includes those delivering education and training in wind, solar, girds and energy efficiency.
Source: IEA Educators' Employment Survey, 2025.

Who pays for energy education and training is dependent on the type of training and the institution delivering the training. For example, whether the training is delivered by a public education institution, in-house by an energy company with internal resources, or by a private training provider. The *IEA Educators' Employment Survey 2025* found that almost half of energy education and training was covered through public funding with the other half paid for by industry or by individuals enrolled in the programme. The cost borne by the individual undertaking the training varies between regions. IEA analysis estimates that the total vocational training costs and share of these costs borne by individuals are substantially higher in EMDE than in advanced economies which may form an additional barrier for people to undertake formal training in EMDE.

Comparison of vocational training costs and share of these costs borne by households in advanced economies versus EMDE, 2024



Note: EMDE = emerging and developing economies.
Source: IEA analysis based on OECD (2024) and World Bank (2024) data.

Potential energy education and training applicants also face non-financial barriers. Almost half (44%) of the surveyed educators delivering training in renewable energy, grids or energy efficiency reported the lack of awareness about energy training opportunities as the biggest issue, greater than any financial barrier. This was followed by a perceived lack of relevance (17%) and resistance to change (12%), for example potential resistance to upskilling or reskilling due to a preference for familiar working methods. Addressing these barriers, for example through industry-education collaboration and encouraging early interest may help.

Policy solutions exist to lower training costs and enhance flexibility

Different policy tools can help ensure that energy education and training are financially accessible. One approach is the provision of public funding for training providers that results in free or low-cost training programmes such as Canada's Sustainable Jobs Training Fund. The goal of this programme is to allocate approximately USD 50 million between 2024 and 2028 to support training programmes for jobs including in wind, solar and energy efficiency. Similarly, the UK's new Warm Home Skills Programme builds on previous public funding for training providers and will support training delivery in solar panel installation and other energy efficiency roles. It will allot over USD 10 million to provide subsidised training opportunities for up to 9 000 installers and retrofit professionals, including those installing insulation and solar panels.

In addition, providing direct individual financial support, for example through scholarship schemes, can encourage students to continue their studies. In the United States, the Get Into Energy Scholarship Fund provides financial support for individuals for a range of energy-related education and training courses including registered apprenticeships, and two- and four- year degrees with specific scholarships for those in urban communities. SSE Renewables offers scholarship funding for individuals located near their wind farms in the United Kingdom and Ireland for science, technology, engineering and mathematic courses as well as for advanced degrees in wind energy. MENALINKS offers fully funded individual scholarships for professionals from Egypt, Jordan, Morocco, Tunisia and Türkiye on renewable power integration.

Ensuring that individuals can continue to earn an income while undertaking education and training can help encourage those currently active in the labour market to upskill or reskill into the renewable energy, grids and energy efficiency sectors. Denmark's wage compensation scheme provides support in the form of a basic salary and coverage of travel costs during reskilling or upskilling with the aim to ensure a qualified workforce, notably for vocational trained workers.

Multi-stakeholder initiatives to support skills development can help pool both financial resources as well as technical knowhow. The European Solar Academy, supported by public funding through the European Union, aims to develop specialised education and training programmes to reskill and upskill 65 000 solar workers in two years with support from the solar industry. The Asia Low Carbon Buildings Transition (ALCBT) Programme aims to train 19 000 workers with support from international partners and industry. In South Africa, Ethekwini Municipality aims to significantly reduce training costs for energy transition jobs, with the goal of assisting over 10 000 workers annually over the next 25 years. Through the Just Energy Transition Skills for Employment Programme, they are pooling funding through private-sector contributions, donor climate funding and government resources to maximise financial support.

In addition to ensuring that energy education and training are financially accessible, providing flexible education and training options such as online learning, courses held outside standard working hours, short-term courses and top-up training can increase accessibility. This is especially true for those already in work or for those in rural communities who face transport costs or housing costs if they need to find accommodations closer to the training centres.

Offering online training can provide accessible upskilling courses for those already active in the labour market. For example, Heat Geek offers online heat pump training courses and accreditation in the United Kingdom, Belgium and the Netherlands with over 3 000 installers trained to date. It also offers follow-up support for new graduates while they are developing their new skills. In India, completion of part-time online classes can result in a professional certification in solar, wind and hybrid energy systems from the national Centre for Environmental Health and Safety. A hybrid approach to education and training, offering both online and classroom training, can provide flexibility while ensuring that participants have an opportunity to practice their newly developed skills. OLACDE's 2026 Training Program offers free training through e-learning and blended learning to participants in Latin America and the Caribbean to promote sustainable energy transition in the region. In Kenya, renewable energy training sponsored by Enel includes additional practical training which grants participants the opportunity to boost their hands on experience.

Not all skills or certifications require full-time, year-long courses. Micro-credential training can provide specific certifications to increase an individual's career pathway into the energy sector. For example, in Canada, micro-credentials on targeted topics within the green buildings sector, such as surveying, and measurements and verifications, provide a flexible and hybrid approach to learning. In Africa, micro-credential training and the recognition of prior learning pathways for informal and displaced workers has also been used successfully in Kenya through Canadian and Kenyan co-developed Competency-Based Education and Training (CBET) which has trained 880 young people over five years across three polytechnics. In Uganda the provision of short-term courses developed through industry-education collaboration with support from international development funds in addition to the recognition of prior learning pathways is supporting a number of female, informal and displaced workers in gaining formal qualifications.

Collaboration between industry and educators is key for long-term workforce planning

Verifying that energy curriculum is industry-aligned can ensure that education and training swiftly lead to employment. However, an IEA survey of energy employers found that less than 25% of companies reported any engagement with educators. In addition, only around 40% of industry respondents believed that national certification systems for relevant occupations were aligned with industry needs. However, new initiatives aim to tackle this education/industry needs mismatch.

Acknowledging the importance of this alignment, the European Solar Academy's new European Solar PV Credentials aims to be the first EU-wide training and certification standard backed by both educators and industry. The training is a blend of online, classroom and practical training and the credentials will certify that students have completed either solar PV installer (entry level) or solar PV installation technician (experienced) training aligned with a harmonised European framework. India's Skills Council for Green Jobs (SCGJ) also aims to align education and training standards and qualifications for various fields, including in renewable energy and energy efficiency with direct input from industry. To date, the SCGJ has trained over 650 000 people and has certified over 6 000 trainers.

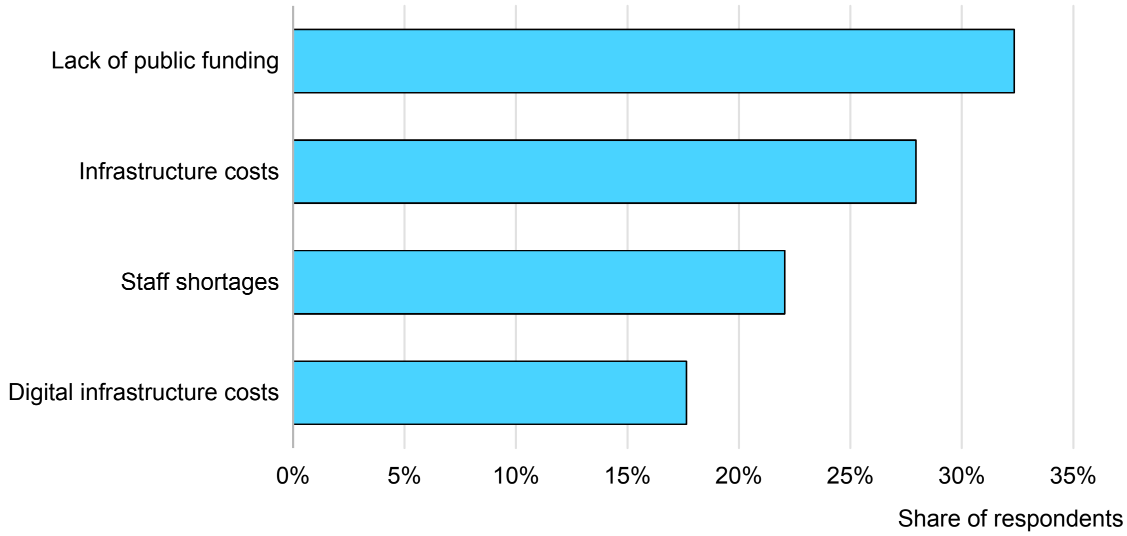
Industry-supported paid apprenticeships can also ensure that education is financially accessible, including for low-income applicants, while also ensuring industry relevance. Engie offers apprenticeships in over 300 roles in over 30 countries, with 83% of apprentices finding employment post training. Orsted offers apprenticeship programmes including in Denmark, the United Kingdom and Taiwan for mechanical engineers as well as critical applied technical roles such as for electricians specialising in wind energy.

Educators and trainers also face specific barriers to expand training capacity

Energy educators and training providers also face specific issues that prevent them from increasing their capacity to educate and train more people. During two workshops on the *Future of Energy Skills* organised by the IEA and the European Commission, energy educators from across the world highlighted challenges such as increased investment in VET to hire additional trainers and provide additional courses, the time needed to train trainers, and costs to acquire new equipment, including for new energy processes and technologies. These findings were in-line with the *IEA Educators' Employment Survey 2025* which identified the key financial barriers for renewable energy and energy efficiency educators and trainers as lack of public funding, infrastructure costs - for example for laboratories, simulators and training facilities - staff shortages, and digital infrastructures costs. Addressing these issues requires not only greater financial resources - through additional public funding or industry-education collaboration, including equipment loans - but also long-term planning, as training or upskilling educators and trainers and revising curricula can take months or even years.

Energy companies and international organisations can assist in curriculum design, development and delivery by providing expertise to train trainers and technical equipment to keep up with technological change. In Viet Nam and Latin America, "train the trainer" schemes are supported by national education ministries and development partners. Companies can also provide support. For example, Schneider Electric has trained 10 000 trainers in climate change and digital transformation and their Electric's Education Solutions supports education providers by providing training equipment. In Poland, GE Verona is supporting a new technical training programme for up to 800 students focused on distributed grids and grid integration and with a fully equipped training lab and additional financial support for low-income applicants.

Share of respondents reporting the main financial barriers faced by training providers, 2025



Notes: includes those delivering education and training in wind, solar, grids and energy efficiency.
Source: IEA Educators' Employment Survey, 2025.

Attracting more people, including underrepresented groups, into the energy workforce

Attracting more young people, as well as workers currently underrepresented in the energy workforce, such as women, can help address current and future skilled labour shortages. This includes building early interest in the energy sector and tackling specific barriers to entry, such as limited access to training or a lack of flexible work arrangements.

Attracting young people into the energy workforce

The overall energy workforce is ageing. This is especially pronounced in advanced economies, where in the grid sector, for example, for every new young recruit under 25 years old, there are 1.4 workers approaching retirement. Overall, fewer young people are entering the energy sector and the share of energy workers over 55 years has been increasing over the past 10 years, with the exception of sub-Saharan Africa. The share of younger entrants has declined in various regions including Europe, Asia Pacific and Central and South America.

Youth organisations have underscored the need to create training opportunities and new jobs as part of energy transitions. A youth survey in Southeast Asia found that 84% of people surveyed believed that there was a lack of industry-relevant skills training for energy transitions. With around 50% of the population in

Southeast Asia projected to be within the 15 to 34-year cohort by 2050, Youth for Energy Southeast Asia has stressed the importance of both the inclusion of youth in energy transitions and the creation of training and mentoring for youth in energy-related fields. Aiming to encourage more young people to the sector, the European Youth Energy Network will launch an Energy Transition Careers Compass, a digital tool to empower youth to discover careers linked to the energy transition.

Participants at the *Future of Energy Skills* workshops highlighted the importance of developing school-age children's interest in energy careers. The Leading Sustainability in School Education Programme, with input from Wind Europe and co-designed with teachers, aims to support educational professionals in integrating sustainability concepts into school curricula. GE Verona's Engineers of Change will be launched in late 2026 with the help of GE engineers and volunteers, to provide training and mentorship to up to 6 000 students between 13 and 18 years old in a range of countries.

Additional efforts may be required to reach vulnerable or disadvantaged youth, including those not currently employed. In South Africa, the Youth for Energy Transition Programme aims to provide 6 000 unemployed graduates of electrical or energy engineering programmes with accredited solar PV installation training. Canada's Science and Technology Internship Programme (STIP)- Green Jobs funds employers to hire, train and mentor youth (aged 15 to 30) in the natural resources sector, including energy and clean technology and is open to those with refugee status. Since 2017, the programme has created more than 6 000 green jobs and skills-training opportunities. In France, Total Energies' Industreet campus provides free training for students from across the country – including those without prior qualifications – with accommodation options to ensure that a lack of finances does not prevent low-income students from applying.

Women remain an underrepresented group in the energy workforce

Women make up only around 20% of the total energy workforce. In some applied technical roles, the share of women is less than 5%. In some regions it is even lower. For example, in Southeast Asia women represent 15% of the total energy workforce, and in Kenya, less than 5% of licensed wiring technicians are women and less than 10% of licensed solar technicians are women. During the *Future of Energy Skills* workshops, many participants raised issues preventing women from enrolling in energy education and training or entering the energy workforce such as safety concerns, lack of female personal protective equipment or sanitary services, and cultural biases around gender roles for some energy occupations. The *IEA Educators' Employment Survey 2025* also found that the lack of flexible working-time arrangements, insufficient childcare policies and limited access to mentoring programmes were the main barriers facing women from entering energy education and training.

Various policies and programmes exist to address some of these barriers such as offering women-only training programmes, for example the electrical programmes offered by Strathmore University in Kenya, Student Energy's African Career Training Programme and Bogotá Energy Group's transmission line training in Colombia. Women are more exposed to informal work than men in most countries. Recognising previously acquired skills and offering top-up training can help more women enter the energy workforce. In Uganda, flexible certification pathways have supported women's ability to join the energy workforce, including the recognition of previously acquired skills.

Across the workshops and surveys the need to support women in their careers was raised including during the gap between completing education and training and entering the energy workforce as well as providing ongoing support for career development including into management roles. The IEA Gender and Energy Data Explorer provides detailed data on gender gaps in the energy sector in employment and wages, entrepreneurship and innovation, and senior management. Women make up 18% of senior management across the energy sector, compared to 25% across the wider economy in 2024. This can vary significantly by subsector, with the share of women in senior management ranging from 11% in the Energy Efficiency sector to higher than 30% in firms related to renewable energy (in IEA member countries).

In Ukraine, a new initiative Power Women 2026, offers free career counselling as well as training for women in renewable energy. Improving workplace conditions and career progression opportunities is also important to retaining and advancing women in the energy workforce. ESMAP's Women's Employment in Energy Sector Utilities Toolkit offers advice and resources on how to bolster women's continued employment in energy utilities. The Women in Wind Global Partnership Programme aims to accelerate careers in the sector through a global network of support and mentorship. Her Power Viet Nam brings together a range of stakeholders to position more women leaders in renewable energy including through professional development trainings.

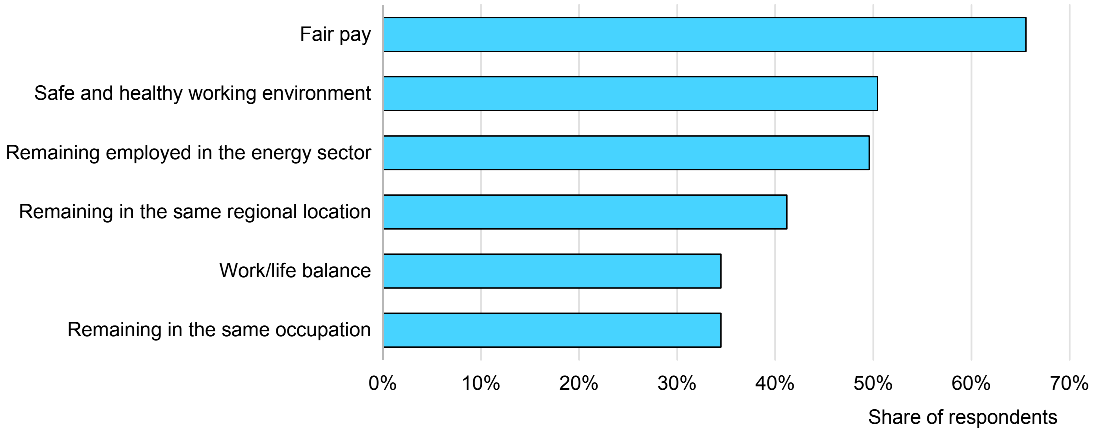
High level campaigns have been promoting inclusivity and encouraging more women to the energy sector. The Clean Energy Ministerial (CEM) Equal by 30 Campaign is a commitment by public and private sector organisations to work towards equal pay, equal leadership and equal opportunities for women in the sector by 2030 and currently has 230 signatories. The CEM Equality in Energy Transitions Initiative undertakes awareness-raising, education and empowerment of women in the energy sector while also collecting and exchanging quantitative and qualitative data on gender equality.

Reskilling and upskilling workers to address skilled labour shortages and ensure people-centred energy transitions

Many countries are increasing the share of renewable energy in their energy mix and improving energy efficiency. Providing reskilling or upskilling for impacted energy workers can help retain sectoral and technical knowledge and experience in the energy sector to help address the current and future skills shortages, while also ensuring fair transitions for impacted workers.

To better understand workers' perspectives, the *IEA Labour Employment Survey 2025* asked about the priorities of fossil fuel workers for transitioning to a job in the clean energy sector. Fair pay (66%), a safe and healthy working environment (50%) and remaining employed in the energy sector (50%) were the top three answers. This response indicates that to be attractive for workers in more traditional energy sectors, the clean energy sector should provide good wages and a safe working environment. While reskilling opportunities exist only 32% of survey respondents reported that active training programmes were available in their home regions to support fossil fuel workers moving into the clean energy sector, suggesting that reskilling opportunities remain limited or unevenly distributed.

Fossil fuel workers' identification of priorities when it comes to transitioning to a job in the clean energy sector, 2025



Source: IEA Labour Employment Survey, 2025.

Reskilling workers requires planning and financial support. The UK's Energy Skills Passport is a digital platform to help energy professionals move between sectors. It focuses on helping people currently working in oil and gas to transition to offshore energy. Additional support is available through funding such as the Oil and Gas

Transition Fund for those working in Scotland's oil and gas sector. The province of Alberta in Canada offers financial support and education towards re-employment for those impacted by the coal phase-out for the end of 2029 through a Coal and Electricity Transition Tuition (CETT) Voucher. Some impacted workers may be more vulnerable than others, including those not on permanent contracts. In order to expand reskilling opportunities to more workers, India's new labour codes have introduced access to reskilling funds for both permanent and fixed-term employees.

A multi-stakeholder approach to reskilling workers can have positive impacts. In Europe, the RES-SKILL project brings together educators and regional agencies, with support from the European Commission, to identify skills transferability between coal and the renewable energy sectors. In Chile, employers, educators, government representatives and international development agencies are working together to assist ex-coal workers in learning how to work on high-voltage lines. In Western Australia following input from local stakeholders, the Collie Transition Package aims to support the creation of new local sustainable jobs with reskilling opportunities through support from the Collie Industrial Transition Fund.

Policy actions for a skilled workforce

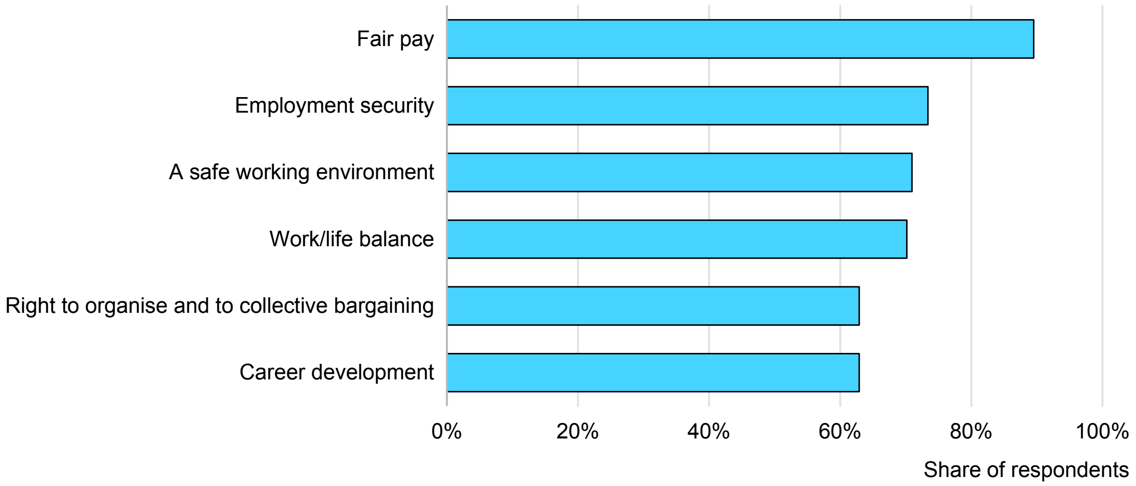
Ensuring decent work to attract more people to the renewable energy, grids and energy efficiency sectors

In a competitive global employment market jobs in renewable energy, grids and energy efficiency need to be attractive to encourage more people to enter these subsectors and overcome current hiring difficulties. OECD analysis has shown that some low-skill occupations in these energy subsectors can often be associated with lower job security and wages due to high flexibility. This can result in lower job quality in comparison with similar low-skill occupations in the fossil fuel sector and other energy intensive industries. This was reflected in the *IEA Labour Employment Survey 2025* which found that only 35% of respondents classified clean energy jobs as quality jobs with both good working conditions and good pay. The importance of job attractiveness in addressing skilled labour shortages, including providing decent wages and working conditions, were also raised by several participants at the *Future of Energy Skills* workshops.

These findings suggest that improving job quality and providing decent work in clean energy sectors, including renewable energy, grids and energy efficiency, may be important to attract and retain workers. Decent work has been described by the ILO as employment that delivers a fair income, with job security and social protection, equal opportunity for men and women, and freedom for workers to express their concerns and organise and participate in the decisions that affect their work. Some of these criteria were highlighted in the *IEA Labour Employment*

Survey which identified fair pay, employment security and a safe working environment as the top three requirements of decent jobs.

Share of energy workers and workers' representatives reporting decent job requirements, 2025



Source: IEA Labour Employment Survey, 2025.

Implementing ILO conventions can help ensure the respect of basic principles and rights at work including eliminating forced labour, ensuring equal treatment and promoting safe workplaces. These conventions include the rights to freedom of association, to organise and to collective bargaining with social dialogue as a tool to reaching collective agreements between employer and workers' representatives.

Social dialogue, whether bipartite (employers' representatives and workers' representatives) or tripartite (also with government representatives) provides a platform to negotiate agreements on important topics such as pay, working hours and other terms relating to working conditions. Members of the IEA Labour Council have identified wage levels as a central issue in attracting workers to clean energy jobs. In particular, they noted that lower wages in some clean energy sectors compared with oil and gas can discourage fossil fuel workers from moving into clean energy roles.

Improved wages and working conditions have been negotiated for energy workers in Italy following national sectoral level social dialogue between social partners, workers' and employers' representatives. At European level, sectoral social dialogue committees supported by the European Commission provide a platform to develop and promote dialogue between social partners. For example, the European Electricity Sectoral Social Dialogue Committee has set out joint recommendations towards developing attractive workplaces and a ensuring a just transition. In addition to national or regional agreements, sectoral agreements can be made at the company level. A new Global Framework Agreement was signed in 2026 between IndustriALL Global Union and the energy company Eni which strengthens the commitment to respecting labour rights, including occupational health and safety, and ensures a just transition for workers.

Informal work remains an issue in the energy sector and the *Future of Energy Skills* workshops included discussions on the need to tackle informal work and promote decent work including through providing formal employment contracts and social protection for workers. Participants at the workshops highlighted that in some EDME, informal work can be the norm not the exception which is supported by ILO analysis which estimates that informal work can reach over 80% in some EMDE, such as India and Indonesia compared with 4% in most advanced economies.

Providing formal employment opportunities in the energy sector can create attractive career options including by offering formal employment contracts with increased job security, fair pay and social protection. It can increase the possibility to collect granular data and conduct detailed workforce planning and skills mapping and help ensure that energy workers have the right qualifications to work safely in the sector. In India, a multi-stakeholder project led to informal female workers receiving industry-approved training in solar installation, repair and maintenance as well as solar pump handling and repairing which led to formal employment for many graduates.

Linking energy policies to skills and workforce needs

Participants in the *Future of Energy Skills* workshops emphasised the need for both anticipation of workforce needs and skills mapping as part of broader energy planning. These require inter-agency collaboration, including among the ministries of energy, education and labour. In many countries, such collaboration does not exist in either a formal or informal manner. Collaboration can also help in the collection and analysis of granular level disaggregated on energy employment which is needed to make appropriate assessments on employment and skills needs.

Investment in training energy ministries to gather the necessary data and maintaining databases could help improve workforce mapping and skills planning. The US Energy & Employment Report (USEER) uses stakeholder surveys to gather additional data on workers' demographics and occupations. In Australia, Powering Skills produces a workforce and training data dashboard with input from multiple stakeholders to conduct workforce mapping and skills planning and develop energy curricula. To help shape policy recommendations, the European Renewable Energy Skills Partnership supports the exchange of best practices and data on skills gaps and needs.

Multi-stakeholder collaboration can provide additional expert input on workforce and skills needs to help inform policies and implementation. The Philippines' National Green Jobs Human Resource Development Plan was developed through a multi-stakeholder process and aims to grow a green jobs-ready and skilled labour force through supporting green VET, expanding scholarships, creating a national database of green jobs and ensuring decent work. India's Skill Council for Green Jobs brings together the Ministry of Skills Development and Entrepreneurship and the Ministry of New and Renewable Energy with energy educators and industry representatives to identify skills needs and design and deliver training including in renewable energy and energy efficiency.

Some energy and climate policies now include references to employment and skills needs. For example, the UK's Warm Homes Plan is accompanied by the Warm Homes Plan Workforce Taskforce, a partnership between government, trade unions, local government, business and civil society which aims to develop a workforce plan to meet the need for key clean energy occupations such as heat pump and solar panel installers. Including workforce and skills needs analysis as well as provisions in energy policies or establishing multi-stakeholder task forces to work on this could help ensure a skilled workforce to implement new energy policies.

Promoting the adoption of emerging skills among the renewable energy, grids and energy efficiency workforce

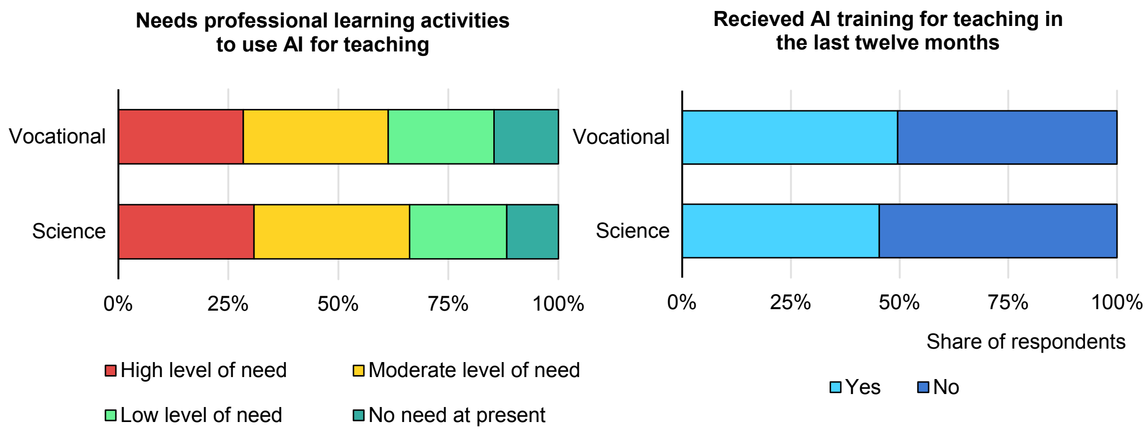
Digitalisation and the adoption of AI technologies are reshaping skills demand in the clean energy labour market. Although these tools have the potential to make certain jobs redundant, in other situations workers can improve their productivity by using generative AI and automation. While there is limited evidence relating to the workforce impacts of AI in the energy sector, participants of the *Future of Energy Skills* workshop highlighted the importance ensuring that all workers are equipped with the skills needed to interact with these systems.

A growing number of countries have adopted national AI upskilling strategies to ensure that societies can harness the benefits of AI, as well as assess AI-generated information. For instance, Lithuania has introduced a digital upskilling programme for workers with high risk of task automation, and Chile's National AI strategy establishes multi-stakeholder forums to develop guidelines limiting the negative impacts of automation. Some countries such as Canada, have rolled out AI upskilling programmes for some 5 000 solar, wind, geothermal and hydrogen workers. In the European Union, more than 200 000 workers from fields including energy will be offered AI-related micro-credentials.

Despite the emergence of policies promoting digital competencies, educational institutions are struggling to keep up with the industry's demand for emerging skills. IEA analysis of the OECD's Teaching and Learning International Survey (TALIS) shows that around only half of vocational and science teachers received

AI upskilling courses in 2024, even though around 85% of them indicated that they need such programmes. As teachers require professional development programmes to be able to effectively deliver digital skills training for students, several countries, such as Malaysia, have adopted train-the-trainers programmes which offer courses on AI and coding to teachers.

Share of vocational skills and science teachers who need AI upskilling (left) and those who received AI training in the past twelve months (right), 2024



Source: IEA analysis based on data from OECD TALIS 2024 (accessed May 2026).

Educational institutions also face financial barriers in procuring the technologies needed to integrate digital skills into training curricula. According to the Digital Education Council's *Global AI Faculty Survey*, the lack of time and resources poses the largest barrier to AI adoption among faculty members. To overcome this challenge, governments have been increasingly offering subsidised equipment procurement programmes for training providers. For instance, the EU's Centres for Vocational Excellence received financial support to use latest technologies, such as virtual reality, to train wind turbine technicians.

Due to the limited capacity of educational systems, a growing number of renewable energy companies are partnering with universities to ensure that prospective workers acquire the emerging digital and AI skills the sector increasingly requires. For example, Siemens has set up a microgrid laboratory at the Humber Polytechnic of Toronto, where prospective engineers can gain real-life experience in integrating renewable energy sources into the grid, while Vestas has partnered with the Canberra Institute of Technology to upskill its wind turbine technicians in cybersecurity. In addition to partnerships targeting entrants to the field, some firms offer in-house trainings to upskill their current workforce. For example, Schneider Electric rolled out an online training programme to expand its workers' knowledge about generative AI, cybersecurity and data analysis. To date, more than 10 000 employees have completed this programme.

Policy overview

Various policy measures aimed at addressing skilled labour shortages can be found in national strategies and initiatives or programmes led by interinstitutional, industry or multi-stakeholder organisations.

Area	Potential policy measure	Examples
Accessible education and training	Financial incentives such as free or low-cost training programmes.	Canada's Sustainable Jobs Training Fund
	Wage compensation to cover participants' lost wages during reskilling and upskilling.	Denmark's Wage Compensation Scheme
	Flexible education and training programmes, such as online learning, evening and weekend courses, short-term courses and top-up training.	Micro credential training in Kenya
Well-designed education and training	Industry-education collaboration in curriculum design and education and training delivery.	Schneider Electric's Education Solutions
	Industry-supported apprenticeship schemes.	Apprenticeships at Orsted
	Industry-approved curricula.	European Solar PV Credentials
Attracting workers	Encouraging early interest in technical and trade careers through outreach programmes.	GE Verona's Engineers of Change
	Programmes to attract underrepresented workers, including hard to reach youth and women.	Women in Wind Global Leadership Programme
Reskilling workers	Platforms which match skills with jobs to assist impacted workers find new roles.	UK's Energy Skills Passport
	Financing support towards reskilling or upskilling programmes for impacted workers.	India's Reskilling Fund
	Local reskilling and upskilling programmes linked to future employment opportunities.	Western Australia's Collie Transition Package
Linking energy policies to workforce needs	Inter-institutional committees to ensure linkages between energy and employment/skills policies.	India's Skill Council for Green Jobs
	Multi-stakeholder groups to provide additional information on workforce and skills needs to help inform policies and implementation.	The Philippines' National Green Jobs Human Resource Development Plan
Workforce mapping and skills planning	National tracking systems to analyse occupation and skill needs and develop forecasting systems.	Australia's Powering Skills workforce and training data dashboard
	Multi-stakeholder committees to work on labour market monitoring and skills mapping, for example through observatories.	UK's Warm Homes Plan Workforce Taskforce
	Additional survey data and stakeholder input to assess needs.	US Energy & Employment Report (USEER)
Ensuring quality jobs	Tripartite social dialogue with energy employers' and workers' representatives.	Sectoral agreement in Italy
	Addressing informal work while increasing formal training and certification.	India's Project Surya

Annexes

CEM Empowering People Initiative

The Clean Energy Ministerial Empowering People Initiative was launched in 2021 to address the socio-economic aspects of the energy transition. It focuses on skills development, inclusivity and workforce preparation to ensure that the transition to clean energy is just and equitable. The initiative convenes dialogues among stakeholders to share best practices and develop solutions that promote diversity and inclusivity in the energy sector.

The Initiative is co-led by the European Commission and Natural Resources Canada, and partners include the IEA, International Labour Organization, SDG7 Youth Constituency and World Bank.

Future of Energy Skills Workshops

The IEA and the European Commission held two in-person workshops on the *Future of Energy Skills* in preparation for this report. Each workshop was attended by participants representing governments, industry, educators, labour, civil society, youth, academia and international organisations.

The first workshop was held at the IEA's headquarters in Paris on 13-14 May 2025 and was attended by over 60 representatives. Through high-level interventions, technical panels and breakout sessions, experts explored pressing methodological and policy questions relating to the future of energy employment and skills development. Participants shared their perspectives on the challenges they face in measuring and addressing workforce needs and planning for the delivery of adequate quality training. With the aim to create a comprehensive research agenda for participants, the workshop drew out priorities on energy employment and skills, with a view to building a community of practice around this topic and providing inputs for upcoming publications on energy employment.

The breakout sessions covered four important areas: EMDE- specific challenges, assessing the implications of skills shortages for energy security, assessing the benefits of a skilled energy workforce, and workforce and education planning. The workshop identified key takeaways including the need for better data collection and sharing for enriched workforce mapping and skills planning. It also recognised the need for improved coordination between policy ambition and implementation capacity with cross institutional and multi-stakeholder engagement playing important roles, increased efforts in attracting underrepresented groups such as women, and the imperative that education and training to be well-designed and accessible. The additional challenges faced by EMDE were also raised.

The second workshop, held on 17-18 March 2026, also took place at the IEA's headquarters in Paris. It was attended by around 45 participants. Co-organised by the IEA and European Commission the aim was to attract practitioners representing employment departments in energy ministries, national skills authorities, industry representatives responsible for skills development, energy educators, labour and youth representatives and international organisations.

This workshop focused on workforce development and challenges across different regions, the benefits of a multi-stakeholder approach, approaches to attracting more young people to the sector, the impact of digitalisation and AI on the energy workforce including upskilling, the opportunities and challenges of reskilling impacted energy workers, and addressing barriers facing women interested in working in the energy sector who remain underrepresented.

Included in this report are perspectives and inputs from workshop participants as well as examples of national programmes, initiatives and strategies.

Abbreviations and acronyms

OJP	Online job posting
ILO	International Labour Organization
HVAC	Heating, ventilation and air conditioning
PV	Photovoltaic
AI	Artificial intelligence

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