World Energy Employment

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Abstract

The inaugural edition of the *World Energy Employment Report* is – to the best of our knowledge – the first comprehensive inventory of the global energy workforce.

The report presents new estimates of the size and distribution of the labour force, across regions and technologies, and increases the granularity on the number of workers along the entire energy value chain. This includes fossil fuel and bioenergy production; power sector generation, transmission, distribution and storage; and end uses, including vehicles and energy efficiency for buildings and industry. It also details segments of the value chain where these jobs are located, including raw materials, manufacturing, construction, utilities, and wholesale, as well as how many are employed for building new projects versus operating existing energy facilities, which includes those working in operating and maintenance of plants. It also provides estimates for emerging segments for energy, including clean energy innovation.

This mapping can serve as a much-needed foundation for global energy decision makers, and provides important insights about the potential opportunities and impacts to labour markets under different drivers, particularly the transitions to clean energy, as well as shifting or development of supply chain capacities. How these labour markets evolve will be explored in depth by scenarios presented in our *World Energy Outlook* series.

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Foreword

The current energy crisis brought on by Russia's invasion of Ukraine is prompting countries and companies to accelerate their clean energy transitions and urgently shift and secure their energy supply chains. The success of these efforts will rest on the shoulders of the 65 million workers currently employed in the energy sector and the ability of the energy sector to attract and train new workers. As presented in the IEA's Global Roadmap to Net Zero Emissions by 2050, realising this pivot requires many more workers than today, and while some jobs will be lost, many more will be created. The new jobs will not always be in the places where jobs are lost, but they may suit the workers and skill sets from industries that are downsizing.

With strategic foresight and commitment to achieving just and people-centred transitions, policy makers and industry decision makers can provide the support workers need to transition out of declining industries and maximise opportunities for additional good quality jobs across different regions. This can be done by capitalising on existing strengths, infrastructure and skill sets; promoting innovation; and identifying opportunities in new and emerging areas.

This is why I convened the Global Commission on People-Centred Clean Energy Transitions to develop actionable recommendations for governments, companies and civil society to maximise the benefits of the transition for people and workers. Building public support for clean energy transitions is more essential than ever if we are to make consistent, enduring progress on fulfilling the world's energy and climate commitments. Creating well-paid, quality jobs is a core pillar of this. It is why the IEA's Clean Energy Labour Council brings together energy leaders and labour union representatives from around the world to understand the challenges the energy sector faces and find ways to address them while improving conditions for workers and attracting a more skilled and diverse workforce.

The most immediate recommendation from the Commission and Council was to develop a comprehensive baseline of global energy employment by region and by technology. This inaugural edition of the *World Energy Employment Report* does just that by providing a first-of-its-kind picture of global energy employment. This work is just a starting point for the IEA and will be updated annually, diving deeper into different sectors and regions each year. The IEA's World Energy Outlook series will also deepen its examination of energy sector labour needs and how they shift under different scenarios.

The transition to a secure and sustainable energy future for all requires unprecedented shifts in the global energy sector. Its success will depend a great deal on the actions governments, industry, labour representatives and educators take to prepare the energy workforce of tomorrow. Above all, it will depend on the capable workers responsible for designing, building, operating and overseeing the new energy economy.

Dr. Fatih Birol
Executive Director
International Energy Agency

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Executive summary

Energy employment is set to shift rapidly as countries and companies accelerate efforts to decarbonise and meet net zero emissions pledges. To date, there is no global benchmark dataset for employment across the energy sector. This report aims to provide this baseline by sector, region, and value chain segment. These estimates were calibrated against more than 15 000 data points on employment and wages gathered from national labour accounts, company reports, in-country experts, international databases and academic literature. The end product is a first-of-its-kind assessment of global energy employment, which can serve as a foundation for policy makers and companies to understand the labour-related opportunities and challenges of an evolving global energy sector.

The energy sector employed over 65 million people in 2019, equivalent to around 2% of global employment. These jobs are roughly equally distributed across fuel supply (21 million), in the power sector (20 million), and in end uses (24 million) such as energy efficiency and vehicle manufacturing.

Energy sector employment has recovered strongly, after a turbulent few years in global labour markets. At the onset of the Covid-19 pandemic, layoffs were common across geographies, especially in oil and gas supply. Yet, energy employment exceeds pre-pandemic levels today thanks to resilient growth in clean energy. Fossil fuel employment, however, is only set to return to pre-pandemic levels this year. Hiring gaps and tight labour markets have contributed to supply chain disruptions and project delays in many parts of the energy sector, notably offshore wind, oil and gas, and energy efficiency retrofits. Today's global energy crisis could prompt governments and industry to rethink their global supply chain exposures especially vis-à-vis dependence on Russia's fossil fuels. This may portend another few years of larger-than-normal shifts in energy employment.

Clean energy employs over 50% of total energy workers, owing to the substantial growth of new projects coming online. Most regions have surpassed this threshold already, though the Middle East and Russia are notable exceptions. Many clean energy segments rival the workforce in conventional energy segments. Low-carbon power generation, mainly solar and wind, employs 7.8 million, on par with oil supply. Vehicle manufacturing employment, which stands at 13.6 million globally, already employs 10% of its workforce in the manufacture of EVs, their components and batteries.

Over half of energy employment is in the Asia Pacific region. Rapid energy infrastructure expansion in Asia Pacific is outpacing other regions, and lower-cost labour is enabling the emergence of significant clean energy manufacturing hubs that supply projects worldwide, notably for solar, electric and hybrid vehicles, and batteries. China alone accounts for almost 30% of the global energy workforce. However, established energy companies in North America and Europe maintain global market strength and anchor a sizeable employment base working on domestic and overseas projects, as is the case in oil and gas, wind, and vehicle engineering.

The construction of new projects, including the manufacture of their components, is the largest driver of energy employment across the value chain. Over 60% of the workforce is employed to develop new projects, including building power plants, bringing oil wells online and laying pipelines, manufacturing cars, carrying out efficiency retrofits and installing high-efficiency electric heat pumps.

The energy sector requires higher-skilled workers than other industries. Around 45% of energy workers today are in high-skilled occupations, compared to only one-quarter across the economy. This share is even higher for jobs in research and development for new energy innovations, many of which are set to grow rapidly to 2030. Strategic planning can ensure that scaling is not hampered by a shortage of skilled workers. Establishing market strength in these segments relies on new training and certification, and can be a focus for industry along with ministries of energy, labour, and education.

Workers in coal and other fossil fuels have many of the skills needed to fill positions in growing clean energy sectors. Fossil fuels employ almost 32 million globally today. Some companies are transferring their workers to low-carbon segments internally to retain talent, and allow for flexibility to shift workers between different business segments as needs arise. However, this is not an option everywhere, and ensuring a just transition for affected workers is a growing focus for policy makers in many regions, especially for coal, which has already seen consistent declines since 2015.

There is tremendous growth for energy employment on the horizon, driven primarily by new investments to decarbonise. In all IEA scenarios, energy employment is set to grow, outweighing declines in fossil fuel jobs. In the IEA's Net Zero Emissions by 2050 Scenario, we estimate that 14 million new clean energy jobs are created by 2030, while another 16 million workers shift to new roles related to clean energy. Around 60% of these new jobs require some degree of post-secondary training.

Making growth in employment people-centred is key to global energy transitions. Maximising job quality helps to attract workers, including those moving from other parts of the energy sector. Energy sector wages typically see a premium over economy-wide average wages, though this premium ranges substantially from 10% to 50% across advanced economies alone. Established industries such as nuclear, oil and gas typically offer the highest wages. Newer segments, such as solar, do not have the same labour protections and union representation as established fossil fuel industries, especially in emerging market and developing economies. The percentage of women in the energy workforce is also consistently low when compared to economy-wide averages, with less than 15% in senior management positions.

Energy employment is central to the IEA's work on accelerating clean energy transitions globally. We will continue to analyse and model global energy employment, including with an increased focus on skills, worker demographics, and best practices for ensuring a secure and just transition. However, all countries have a role in improving energy labour force data. Better data is essential to ground conversations on energy policy and to support workers, governments, labour unions, and companies as they prepare to seize the opportunities of the new energy economy.

Overview

Introduction

Clean energy transitions and efforts to decarbonise energy are the prevailing trend reshaping global energy employment. Countries representing over 70% of global emissions today have committed to net zero emissions targets by mid-century, which will create millions of new clean energy jobs around the world. A paradigm shift in the energy workforce will require strategic foresight to train up the requisite workforce for deploying clean energy at scale as well as just transition policies that provide for employees negatively affected by these changes. The IEA's seminal report, Net Zero by 2050: A Roadmap for the Global Energy Sector (NZE Scenario), projects that the energy transition will create 14 million new jobs related to clean energy technologies and require the shift of around 5 million workers away from fossil fuel sectors. In addition to these new roles, 16 million workers will require shift to work in clean energy segments, requiring additional skills and training.

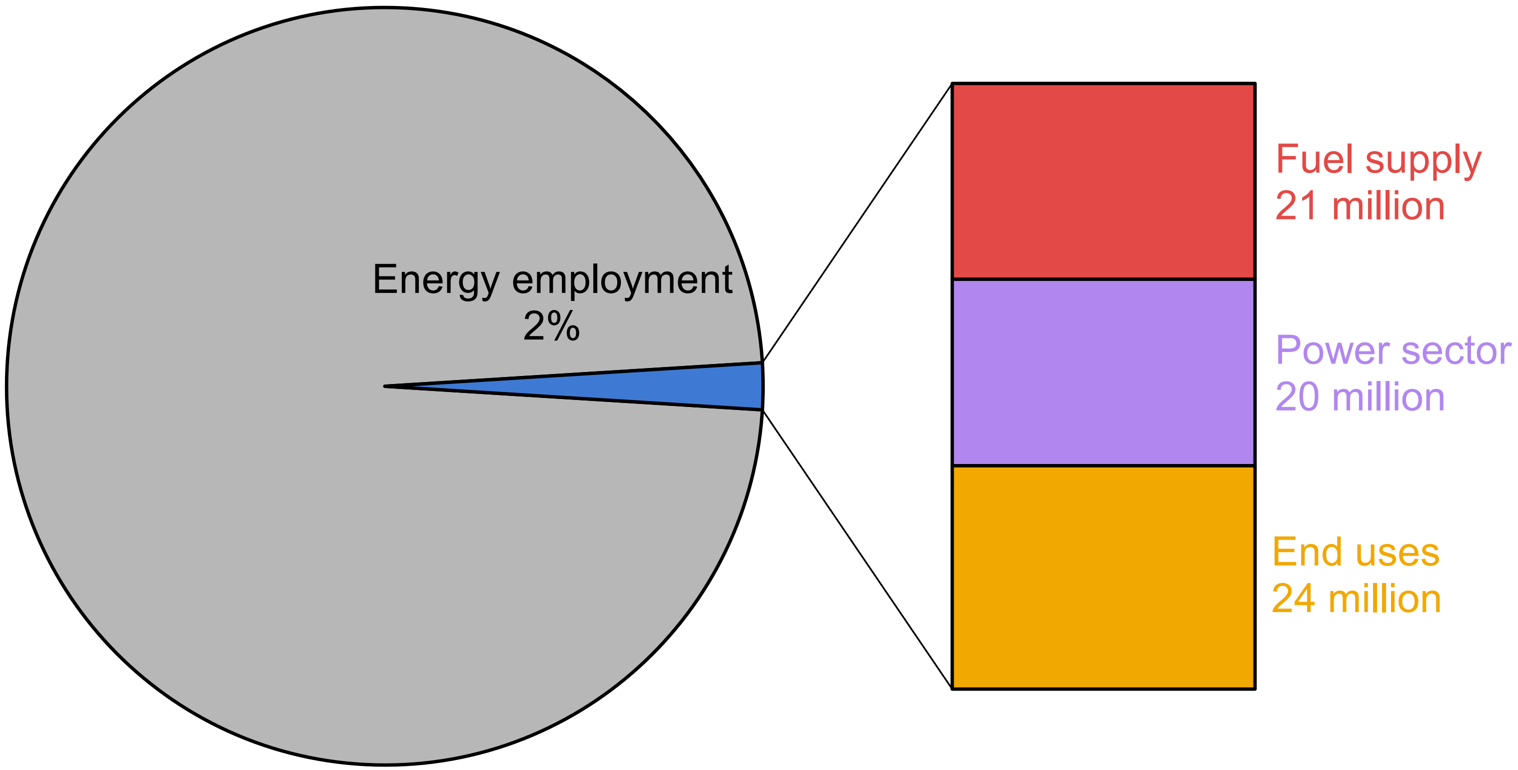
However, this report also comes out amidst an energy crisis incurred by Russia's invasion of Ukraine. This creates urgent imperatives for the energy sector, some of which are accelerating the switch off fossil fuels, and others which are focused on shoring up security of supply. Governments are working with the private sector to localise production and address global supply chain weaknesses, both within fossil fuels and key clean energy segments, including the minerals critical to their manufacture. This builds on the unprecedented USD 710 billion governments made available to clean energy in the wake of the Covid-19 pandemic in the name of sustainable recoveries.

Companies cannot respond to these market and policy signals without the skilled workforce needed to deliver these projects in the regions they are being developed. Shortages of skilled labour across energy supply chains are already translating into project delays and impacting investment decisions in some sectors, such as oil, gas, and offshore wind. While worldwide labour markets remain in flux since the start of the Covid-19 pandemic, energy has been among the fastest evolving industries globally in the last five years.

To navigate the evolutions in the workforce on the horizon, decision makers require better visibility into energy employment today. The *World Energy Employment Report* aims to deliver the most comprehensive assessment of the global energy labour market to date, and provide a foundational resource for policy makers, industry, jobseekers and students. Our analysis focuses on establishing a 2019 baseline, given the tumultuous last few years within the global labour market, but gives 2021 estimates where possible. It also provides an indication of how these labour demands may evolve in 2022. It covers all parts of the energy value chain, from fossil fuels to clean energy and key end-use sectors, and enumerates employment by subsector, by region, and by economic sector. The industry is facing a period of unparalleled change, but has numerous opportunities to expand economic growth, improve labour conditions, continue to cultivate a highly-skilled, inclusive workforce, and ensure people are at the centre of the clean energy transition.

Energy employs 65 million people worldwide and accounts for 2% of global employment, relatively evenly distributed across fuel supply, power sector, and end uses

Energy employment as a share of global employment, and by energy sector, 2019



Note: End uses refers to industry, buildings and transport energy-related jobs.

The energy sector employed around 41 million workers in 2019, with an additional 24 million working in energy end uses including vehicle manufacturing and efficiency

Over 65 million people were employed in the energy and related sectors in 2019, accounting for almost 2% of formal employment worldwide. Half of the energy workforce is employed in clean energy technologies.

Energy sector employment in 2019 is divided approximately into thirds among fuel supply (coal, oil, gas and bioenergy), the power sector (generation, transmission and distribution), and energy end uses (vehicles manufacturing and energy efficiency for buildings and industry).

In fuel supply, oil has the largest labour force, totalling almost 8 million. This is followed by 6.3 million in coal supply and 3.9 million in gas supply. In the power sector, generation employs around 11.3 million while transmission, distribution and storage combined account for approximately 8.5 million. In end uses, 13.6 million are employed in vehicle manufacturing, while another 10.9 million are employed in energy efficiency.

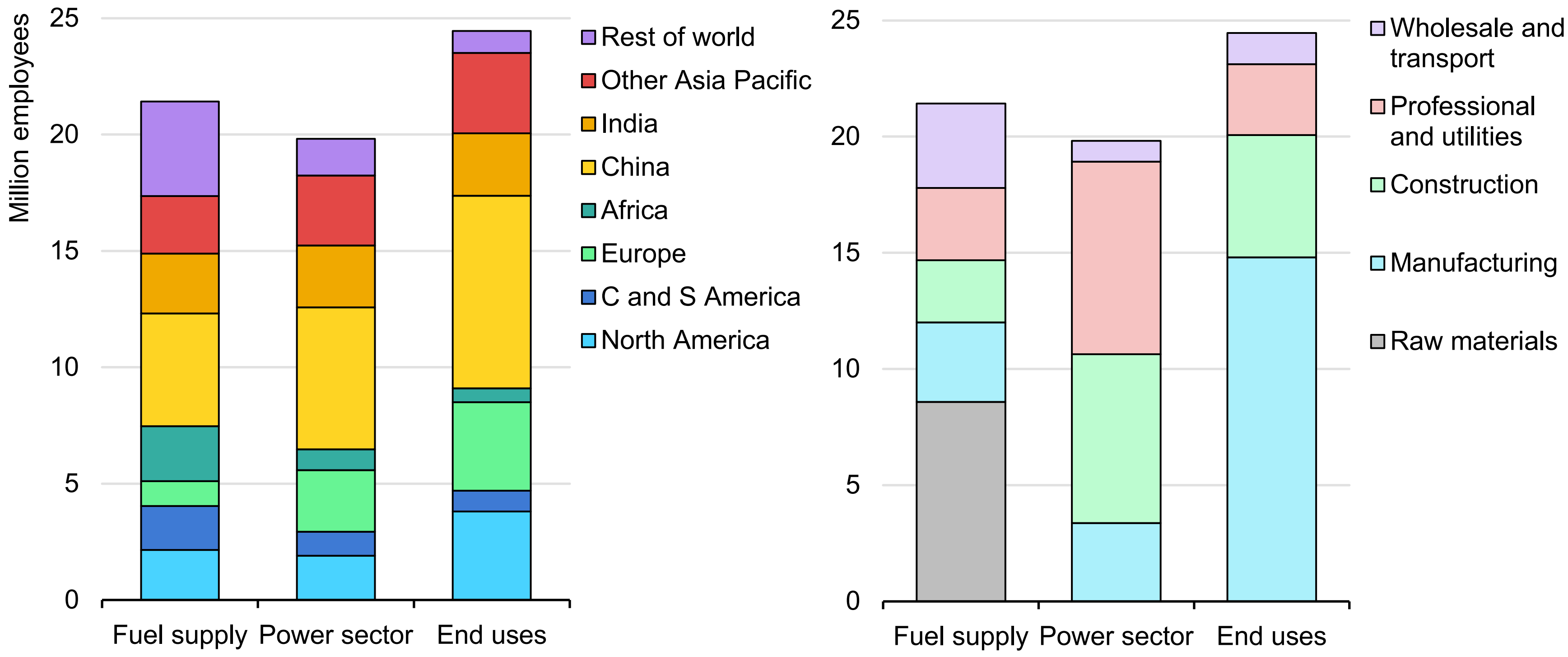
Roughly 65% of the energy sector workforce is connected to developing new energy infrastructure, while 35% are involved in operating and maintaining existing energy assets. Clean energy employment is rapidly growing alongside efforts to decarbonise energy systems—these sectors account for 50% of the global energy labour force today, and represent the highest employment creation potential.

Energy employment is spread globally, with a greater concentration in manufacturing hubs and producer economies. The People's Republic of China (hereafter 'China') has the largest number of energy workers, near 20 million, which represents around 2.5% of the employed in China. In the Middle East and Eurasia, the energy workforce makes up a relatively high share of economy-wide employment, averaging 3.6%. North America has 7.9 million workers in energy, equivalent to 3.4% of total employment; Europe has 7.5 million workers in energy, or 2.4% of total employment.

These jobs span the energy value chain and are captured in different economic activities. Those working in the production of raw materials, which includes mining and extractive sectors for fuels and agriculture for the production of bioenergy, total over 8.5 million. In the mining sector in particular, energy workers make up 15% of global employment. Over 21 million energy sector employees work in manufacturing and approximately 15 million are in construction, making up 5-6% of their respective sectors. An estimated 14 million work in utilities and other professional services. Other types of jobs, such as wholesale traders and energy transport, make up the balance.

Energy employment spans many economic sectors, with manufacturing and construction of new projects dominating today’s energy workforce

Energy employment by region and economic sector, 2019



Notes: C and S America = Central and South America. Please see the Annex for definitions of regional groupings and economic sectors.

Fuel supply, power and end use sectors are key sources of employment across every region

Employment by region and energy sector in thousands of employees, 2019

	North America	Central and South America	Europe	Africa	China	India	Other Asia Pacific	Rest of world	Global
Supply: coal	100	<50	100	200	3 400	1 400	800	300	**6 300**
Supply: oil and gas	1 900	1 100	600	1 600	1 100	700	1 100	3 800	**11 800**
Supply: bioenergy	100	800	300	600	300	500	600	<50	**3 300**
Power: generation	1 000	600	1 400	400	3 800	1 200	1 800	1 000	**11 300**
Power: grids	900	400	1 200	500	2 300	1 500	1 200	600	**8 500**
End uses: vehicle	1 800	600	2 700	200	4 500	1 200	2 100	600	**13 600**
End uses: efficiency	2 000	300	1 100	400	3 800	1 500	1 400	400	**10 900**
All energy	**7 900**	**3 800**	**7 500**	**3 800**	**19 200**	**7 900**	**8 900**	**6 600**	**65 700**

Notes: Grids includes transmission, distribution, and storage. Vehicles includes the manufacturing of all road vehicles (two- and three-wheelers, passenger vehicles, light-duty commercial vehicles, buses, and trucks) and batteries for electric vehicles. Efficiency refers to energy efficiency in buildings (covering retrofits, heating, ventilation and air conditioning equipment, as well as appliances); and in industry. Values may not sum due to rounding.

Understanding the scope and drivers of global energy employment

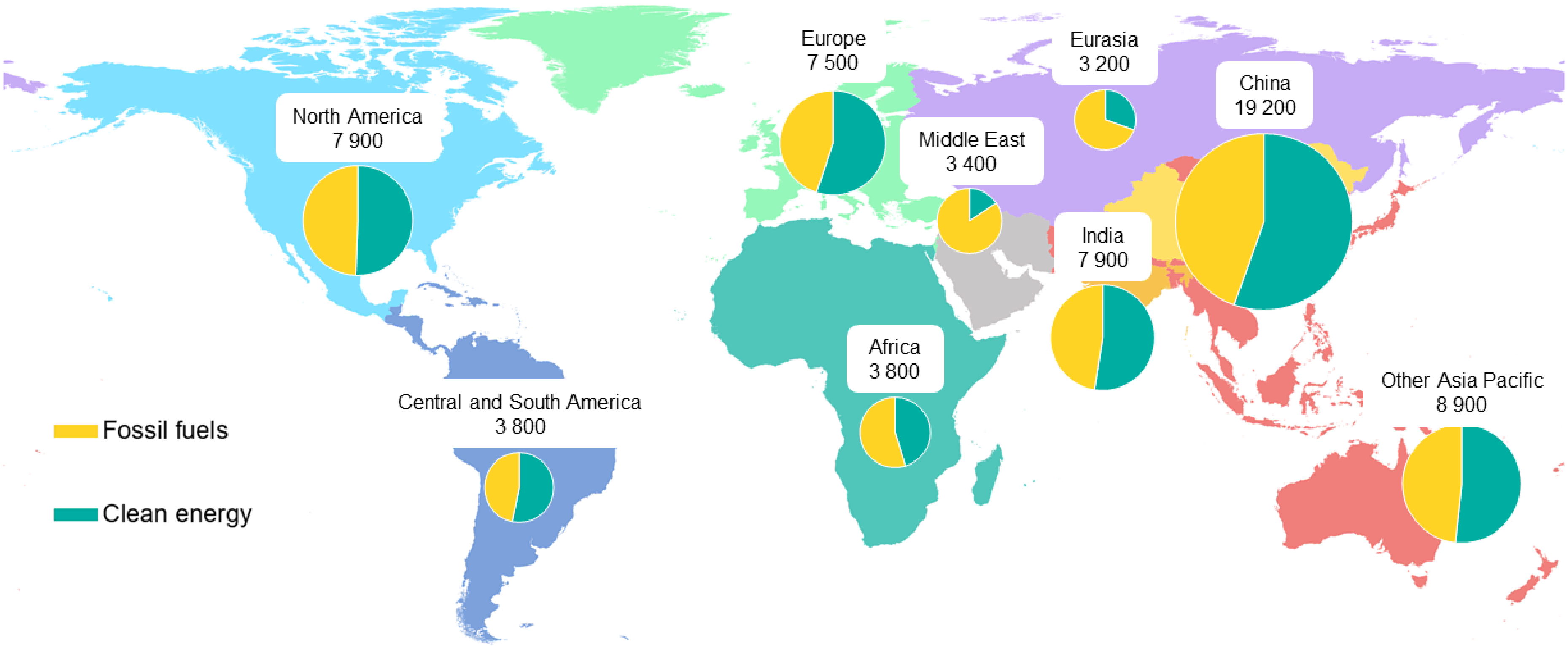
The energy sector is a capital-intensive industry, geared to meet, as efficiently as possible, the world's expanding energy needs. Given this, a large portion of its workforce is focused on new and expanding projects—building energy efficient power plants, expanding and upgrading grids, and tapping into additional deposits of fossil fuels. Accordingly, developing an estimate of global energy employment needs depends heavily on planned energy investments in the coming years, as well as current and new capacity and production. Our employment estimates are developed using the IEA's comprehensive data on global investments, energy production and demand. Our assessments are also calibrated to data from national labour statistics, corporate filings, company interviews, international organisations' databases and academic literature.

Numbers in this report are shown for 2019, the latest year of comprehensive historic data, to establish a pre-pandemic baseline, accompanied by high-level estimates for 2021 and 2022. In this report's accounting, energy employment encompasses all jobs directly related to the operation of energy facilities and their construction, as well as indirect jobs in manufacturing of direct inputs specific to the energy industry. Indirect jobs associated with production of general goods such as cement are not counted, nor are induced jobs. Jobs are normalised to full-time equivalent (FTE) employment for consistent accounting. Numbers include informal workers in order to better reflect the impacts of energy policy on the labour force. The Annex shows further detail on the methodology.

The regional distribution of energy jobs depends on multiple factors. First, jobs are concentrated where energy facilities are being built more than where they currently exist. Given the labour intensity of building new facilities, fast-growing markets tend to dominate the workforce. Second, today's global supply chains for some upstream components are concentrated in certain countries. Notably, manufacturing of solar PV is centred in China. The production of fossil fuels spans the globe among resource-rich economies, but know-how on areas such as exploration, development, production and services are concentrated in regions like Houston, Texas in the United States, with companies based there providing expertise for projects worldwide. Third, worker compensation differs widely across countries, by a factor of up to 20. Differences in labour costs beyond earnings, such as benefits and pensions, add a secondary layer of country variations. Where compensation is low, like in India, the construction of the same project may employ many-fold the workers as they do in advanced economies. Finally, the prevalence of part-time, temporary, and informal work creates wide disparities in how many people work in a sector, even when normalising to FTEs, as we do in this report. Short-term projects, such as the installation of rooftop solar PV, often rely on part-time workers. In emerging markets and developing economies (EMDEs), informal work is common. Deployment or decommissioning of a project can create jobs only for a few weeks but wages earned can represent an important share of workers' annual income, even if they work in farming or other jobs for most of the year.

Asia is home to energy's largest and fastest-growing workforce, driven by rapidly expanding energy infrastructure and a significant share of global clean energy manufacturing capacity

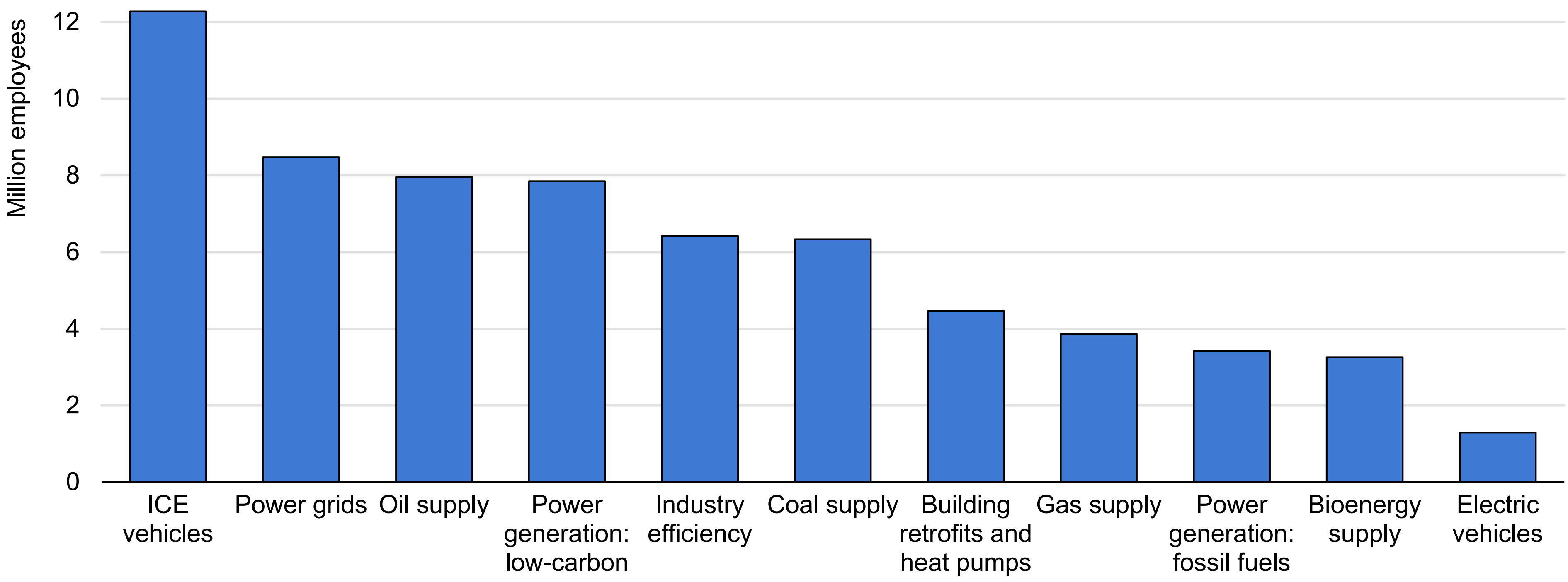
Energy employment in fossil fuel and clean energy sectors by region, 2019



Notes: This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area. Please see the Annex for definitions of regional groupings.

Employment in new sectors already rivals levels in conventional energy sectors

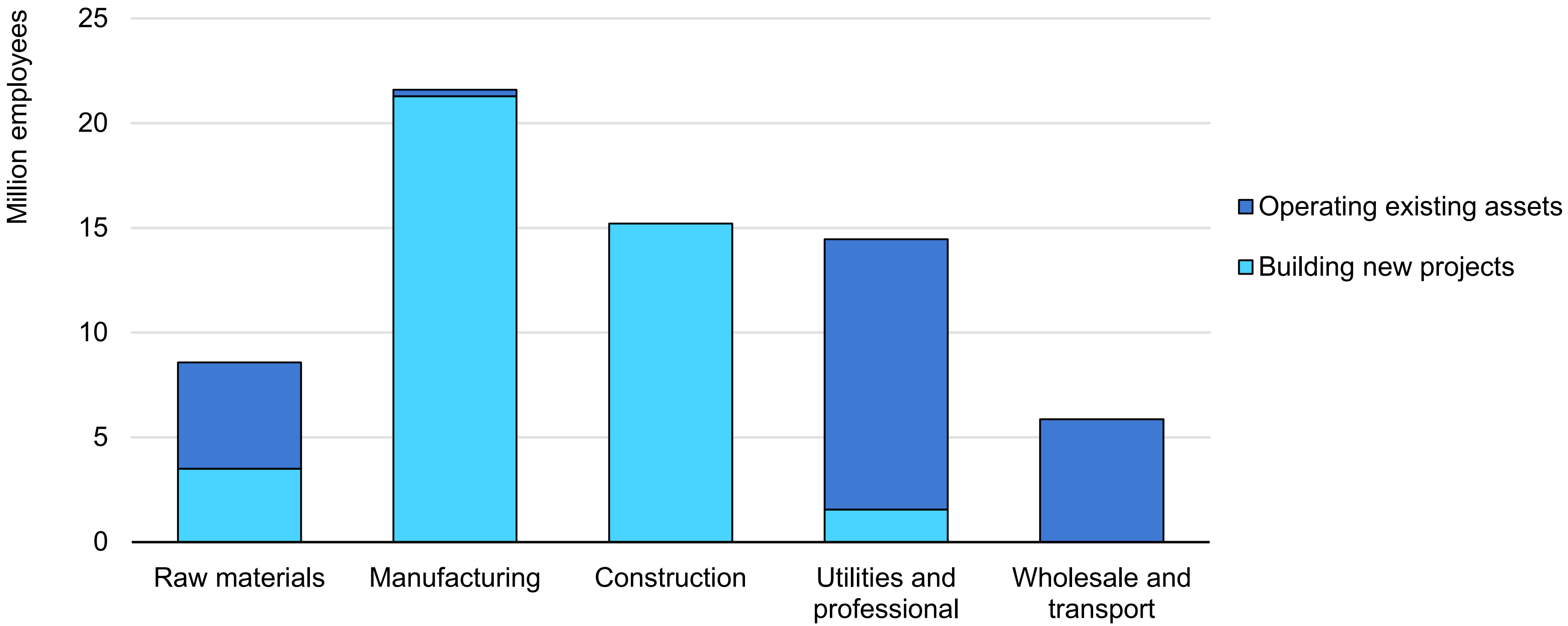
Employment in selected energy subsectors, 2019



Notes: ICE vehicles = internal combustion engine vehicles. Power grids includes transmission, distribution and storage. Low-carbon power generation includes nuclear and renewables. Electric vehicles includes the manufacturing of batteries.

New energy projects are the major driver of employment, with around 65% of energy workers employed to build and deploy new solar plants, wellheads, heat pumps, cars, and more

Energy employment by economic sector, 2019



Notes: Jobs labelled "building new projects" include those construction of new power plants, building new well heads in existing or new oil and gas fields, manufacturing upstream components for these new projects (including IT systems and software), implementing new energy efficiency retrofits in buildings or upgrades to industrial processes, manufacturing new vehicles, and others. "Operating existing assets" includes jobs in operations and maintenance, administration at energy firms, energy traders, transport and shipping of fuels, and in wholesale trade. These jobs are commonly at electricity and gas utilities, power plants, refineries and other fuel processing facilities, at trading decks and offices and ports, etc. Please see the Methodology section and the Annex for definitions of economic sectors.

Energy employment rebounded in 2021 and is set to rise further in 2022, but tight labour markets remain a cross-cutting barrier

All drivers of energy employment are set to rise in 2022, but the turbulence afoot in global markets is reshaping which regions are seeing investment and how much of the increased economic activity flows to workers. Energy investment is set to pick up by 8% in 2022, reaching USD 2.4 trillion, but almost half of the increase in capital spending is linked to higher costs. Total energy demand also climbed higher than pre-pandemic levels in 2021, with increased production driving a greater need for workers.

Higher levels of capital spending and energy demand are not necessarily correlating to increases in labour. Multiple supply chain pressures and higher energy prices are driving up the costs of construction inputs like steel and cement, meaning more project costs are going to materials. Key components for energy projects are also seeing cost inflation for services and operations, notably in oil and gas, transmission and distribution, wind and solar. Tight markets for specialised and highly skilled labour have led to increased worker turnover in response to more competition and escalating wages, hindering hiring.

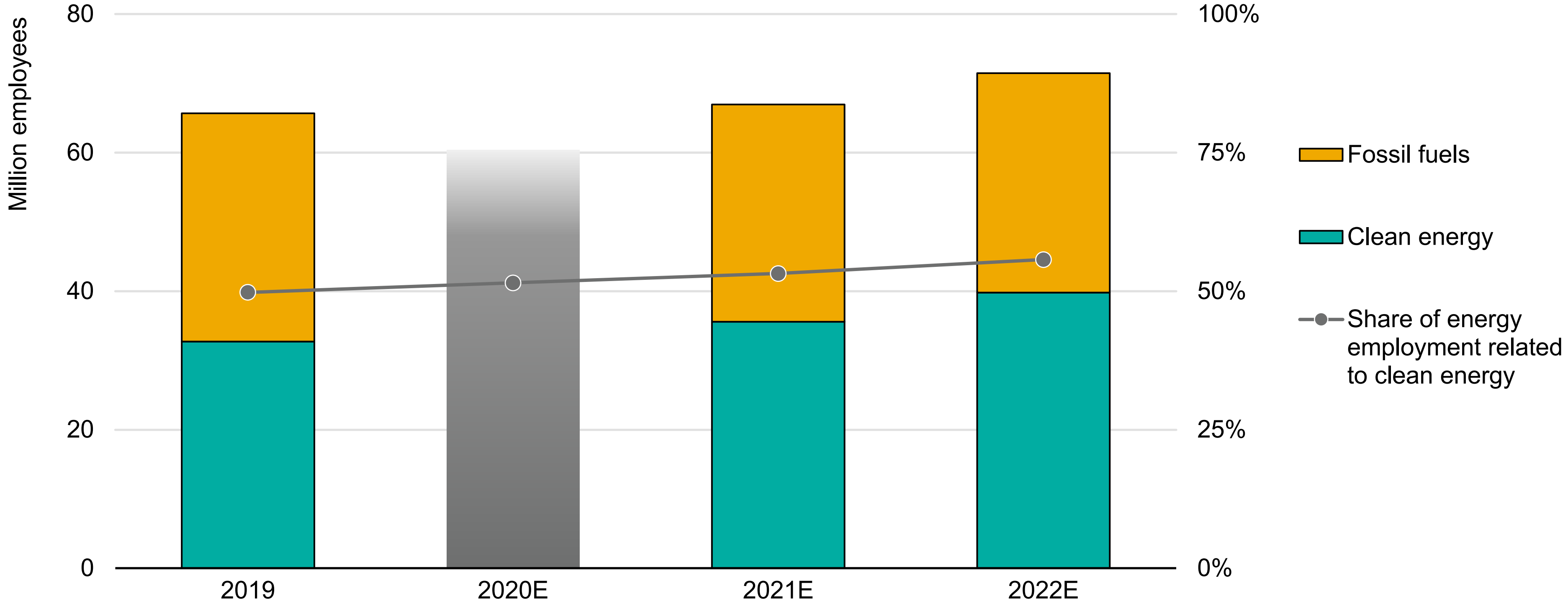
We estimate that total energy employment in 2021 was up around 1.3 million from 2019, and could increase by another 6 percentage points by 2022. Clean energy accounts for virtually all of the growth in energy employment. Major new manufacturing facilities have come online since 2019, most notably for solar and EVs. These facilities are larger and increasingly automated, improving labour efficiency, especially in EMDEs. Advanced economies provided the largest increases in investment in 2021 and, along with China, are set to drive nearly 60% of the growth in 2022. Employment constructing new projects has grown strongly in these regions, whereas EMDEs have struggled to find the investment resources needed. In particular, energy efficiency programmes have been allocated an extra USD 165 billion in the wake of the pandemic. New programmes, notably the European Union's REPowerEU, put increasing emphasis on energy efficiency targets, driving up demand for workers to retrofit buildings and to administer these projects.

Employment in fuel production has recovered somewhat amidst the scramble to secure energy supply, but remains below pre-pandemic levels. Employment growth is concentrated in natural gas, with the build out of new LNG facilities and expanding production. The coal mining workforce – which had been decreasing rapidly with increased mechanisation – saw this trend let up with coal mining on the rise in China after shortages in 2021, and could climb in India with mounting concerns for energy security in 2022.

However, several risks could derail this momentum in expanding energy employment. Concerns about cost inflation are acting as a brake on the willingness of companies to increase spending, despite the strong price signals. Ongoing labour shortages and increased worker turnover are creating challenges for hiring and recruitment.

In recent years, the share of energy employment related to clean energy technologies has grown steadily and has proven more resilient through the Covid-19 pandemic

Energy employment in fossil fuel and clean energy sectors, 2019-2022



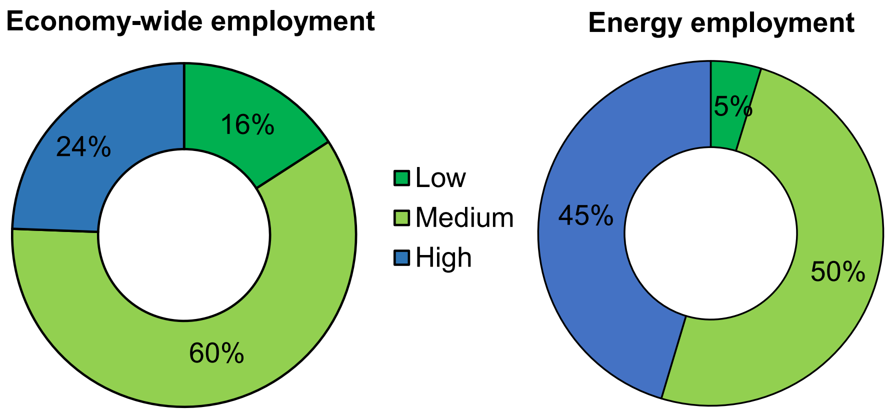
Notes: Clean energy employment includes workers in bioenergy supply, nuclear and renewables for power generation, grids and storage, electric vehicles manufacturing, and energy efficiency. Estimates are modelled for 2020 to 2022 based on latest IEA energy balances and investment data, under the assumption that labour intensity and the job creation potential of new investment remain constant across years. Labour market disruptions associated with the Covid-19 pandemic made 2020 employment difficult to assess. Accordingly, 2020 estimates are indicative.

The energy sector has a large share of high-skilled labour and offers higher than average wages

The energy sector demands more high-skilled workers than other industries, with 45% of the workforce requiring some degree of tertiary education, from university degrees to vocational certifications. Less than 10% of energy employment is in low-skilled labour, and is concentrated in EMDEs, although may be missing many informal workers in those regions.

Variations are larger between geographies than across sectors, with EMDEs employing more low-skilled or informal workers in manual tasks, whereas in advanced economies, many labour-intensive parts of the energy business have been mechanised or automated.

Global employment by skill level, 2019



This high degree of skilling fetches higher wages on average. Energy sector wages typically see a premium over economy-wide average wages, though this premium ranges substantially from 10% to 50% across advanced economies alone. These premiums remain true across all regions, but the differences between wages in advanced economies and EMDEs remain pronounced, with the range of wages between geographies being larger than the range of jobs within the energy sector within the same region.

Established industries such as nuclear, oil and gas typically offer the highest wages. Industries with a high share of workers in construction, such as installing solar panels or carrying out energy efficiency retrofits, typically have lower wage premiums. Newer energy sector sectors, such as solar, also have less union representation than established fossil fuel industries, especially in EMDEs. Labour representation has led to higher wages in parts of the energy sector. For example, coal jobs in India receive compensation around three to four times the national average.

In all IEA scenarios, energy employment is set to grow, creating a growing demand for workers with energy-sector specific skill sets. Meeting a growing need for skills is a concern raised in interviews we conducted with companies,[1] well as in dialogues held in IEA's

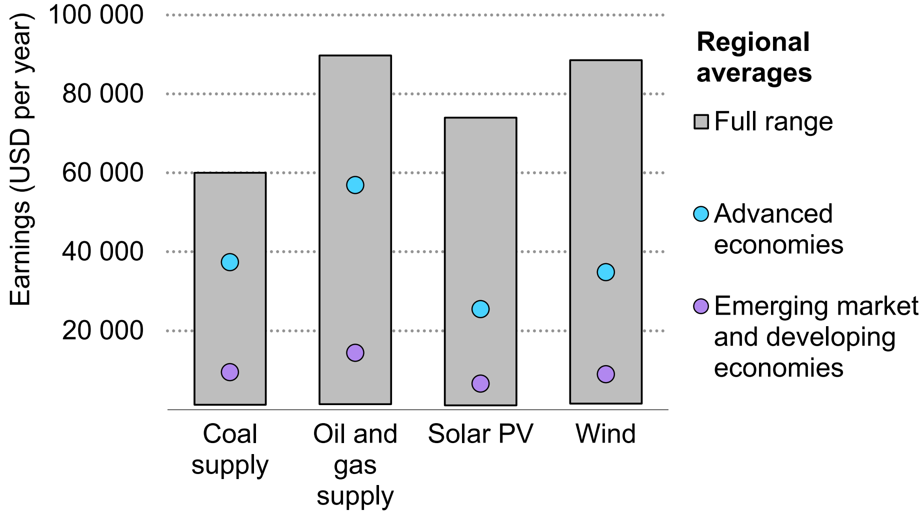
[1] This employment includes passenger cars, commercial vehicles, buses, and trucks. Employment in other forms of transportation such as rail, aviation, and shipping is not included. Jobs in the retail and maintenance of vehicles are not included.

Clean Energy Labour Council between governments and labour leaders. Many of the skills needed exist in adjacent industries. For instance, project managers in residential construction have some of the same skills needed to manage the construction of solar farms. Companies also indicate an intention to transition existing employees from carbon-intensive activities to other parts of their portfolio, instead of exclusively pursuing new hires or dismissing any workers. This is particularly true in the electricity and other clean energy sectors, where all firms interviewed saw either rising employment or were reallocating their workforce internally rather than dismissing any workers. To support this, companies have created internal upskilling and reskilling programmes in partnership with universities.

Many firms interviewed said they faced a very competitive environment for hiring candidates with the requisite skill sets. This was particularly true for positions in fields for science, technology, engineering, and mathematics (STEM), followed by project managers and other technical roles. Companies also expressed concern about the high turnover of workers with the most in-demand competences, which has increased throughout the Covid-19 pandemic.

Strong links between employers and universities or vocational training programmes can fill talent pipelines, as can research grants for PhDs, internships and apprenticeships. New graduate rotation programmes were cited as ways to cultivate, attract and retain key talent. Companies highlighted a growing need to revamp teaching curricula of degrees with the highest demand, namely engineering, followed by economics and information technology. Surveyed companies also welcome opportunities to work with universities to shape new curricula.

Average annual earnings per employee by energy sector, 2019



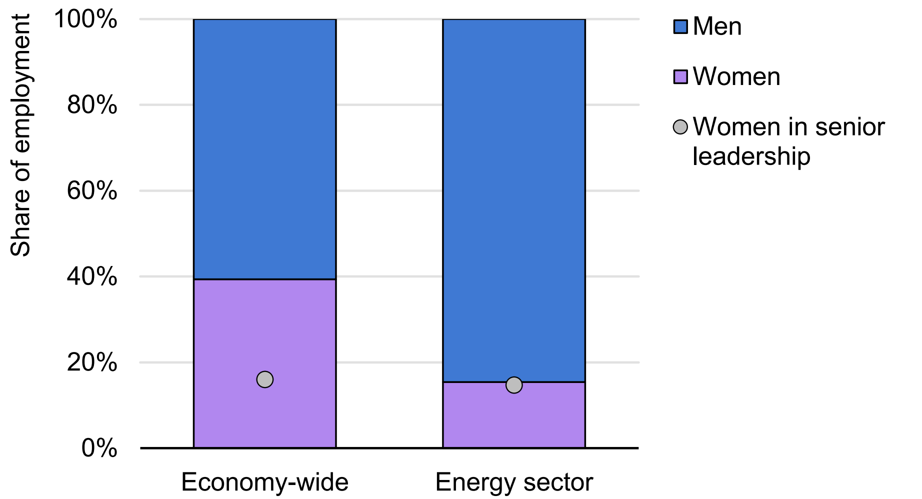
The IEA intends to deepen our analysis on growing skilling needs in energy, as well as the transferability of skills from energy sectors in decline and from adjacent industries.

Female representation in energy is far below economy-wide averages

Women are strongly under-represented in the energy sector. Despite making up 39% of global employment, women account for only 16% of traditional energy sectors captured in dedicated labour classifications. As in economy-wide employment, women make up a very small share of senior management in energy, just under 14% on average. However, there is substantial variation among energy sectors, with the percentage shares in nuclear and coal the lowest at 8% and 9%, respectively, whereas electric utilities are among the highest with nearly 20%. This compares with 16% of women in senior management economy-wide. While ratios are better in regions with policy frameworks and strong private sector efforts to improve gender balance, all geographies show the energy sector lags behind the economy-wide average when it comes women's participation in senior management roles in the sector.

There are no major differences in the share of female employment between fossil fuels and clean energy globally. However, clean energy start-ups show signs of change, with a greater share of women founders and inventors in clean energy, even if still far short of parity. This marks an opportunity for these growing segments to help increase female representation. However, further steps must be taken in all energy sectors if women's roles in energy companies is to improve. In the IEA's NZE Scenario, as many as 14 million new jobs in clean energy are created by 2030. Introducing new public sector policy frameworks supporting diverse hiring practices, as well as private sector initiatives, could make the energy employment growth this decade an opportunity to achieve a better gender balance, with special focus needed particularly in management. Numerous studies show that improved diversity enhances firm performance, long-term competitiveness and greater innovation, all of which contribute to the energy sector advances needed to meet global change goals.

Employment by gender, 2019



Notes: Employment shares are from the International Labour Organization (ILO) covering 48 countries for the energy sector. Senior management shares are IEA global calculations based on the Refinitiv PermID database.

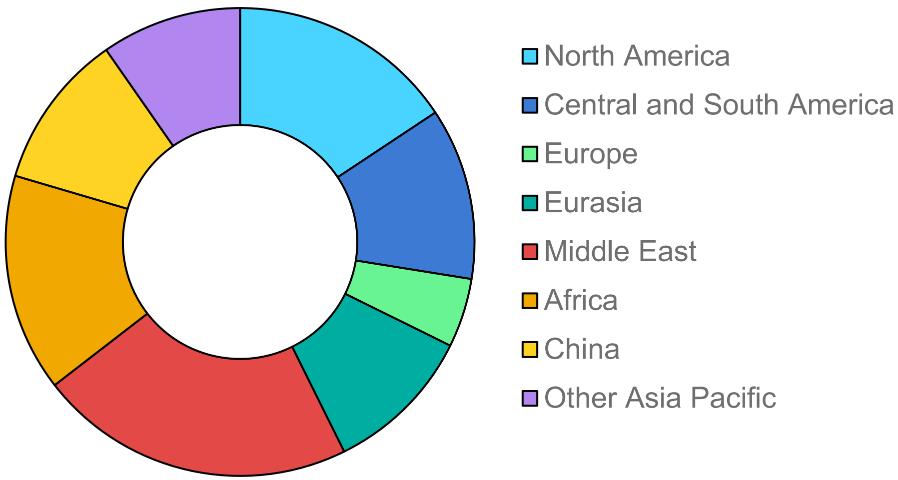
The IEA's Gender Diversity Initiative has been developing further indicators on the topic of gender and energy, including energy employment, recently published in a dedicated data explorer.

Fuel supply

Oil supply employs almost 8 million, but companies face challenges hiring and retaining staff

Around 95 million barrels per day (mb/d) of crude oil were produced in 2019, with the Middle East and North America making up over half of global production. Oil supply has increased by an annual average of around 1.6% from 2010 to 2019, though global investment declined over the same period, before rebounding to USD 440 billion in 2021.

Employment in oil supply by region, 2019.



Oil supply has the highest employment among fossil fuels, at almost 8 million workers in 2019, of which 5 million work in extraction and production, and around 1.4 million each in transport and refineries. Nearly 20% of the jobs are in the Middle East, followed by almost 15% each in North America and Africa. Refining employs 1.4 million, concentrated in the Asia Pacific region.

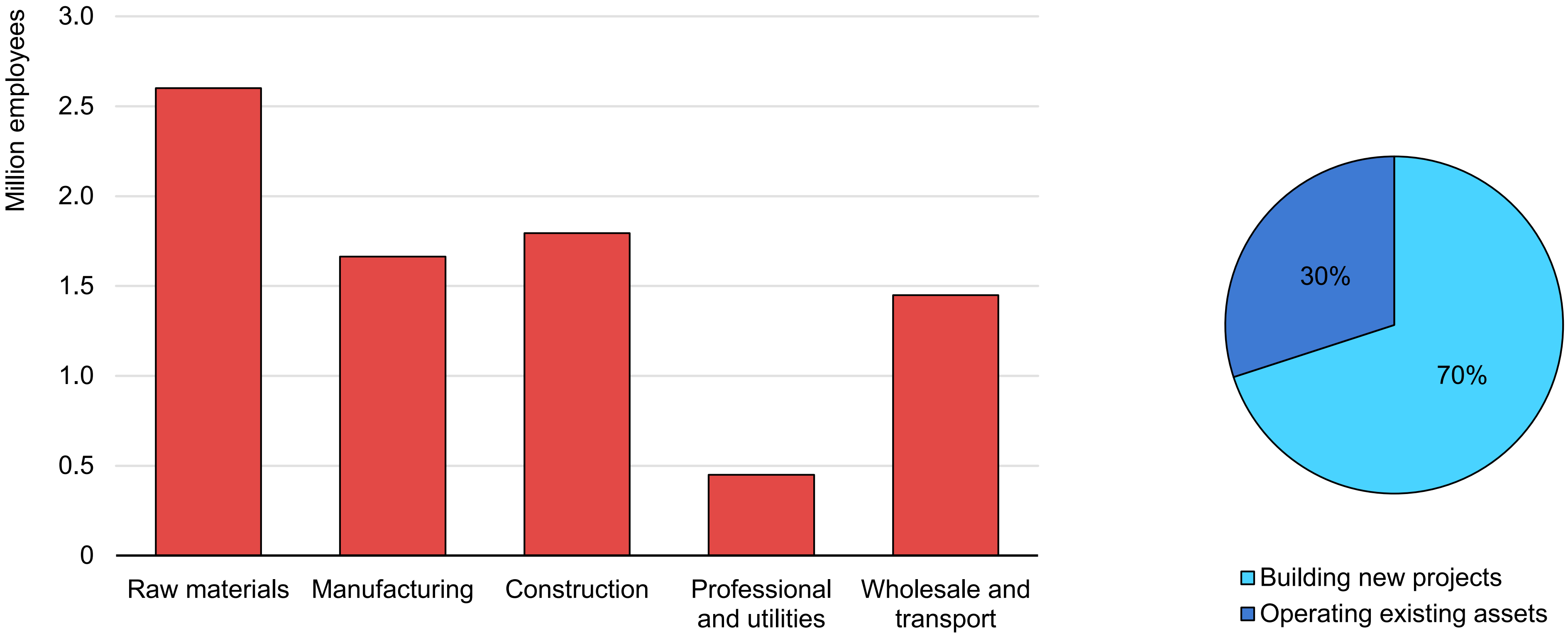
The historic plunge in oil prices at the start of the Covid-19 pandemic in 2020 led to a sharp decline in oil industry employment as layoffs forced workers flee to other industries. A strong rebound in oil demand has not led to a commensurate increase in investment or staffing levels, with employment falling to 7.1 million in 2021 and is only recovering slightly in 2022.

Oil and gas companies see significant challenges in hiring new staff, and face an ageing workforce. A growing number of oil and gas workers indicate interest in shifting their careers to clean energy. Companies have been increasing wages to attract talent. Some have also published just transition strategies to upskill and retain existing staff in an effort to address employees' worries about declining career development opportunities.

Many skills of oil and gas workers are in strong demand by other energy sectors. For example, petroleum and gas engineering skills are highly applicable to geothermal, including seismic interpretation, drilling and completions, reservoir mapping or flow assurance. Chemical engineers in refineries can apply their knowledge of common raw materials and equipment towards the production of green fuels and hydrogen. Skilled workers can transfer to deep water offshore wind, carbon capture and storage, or midstream hydrogen pipeline infrastructure, among many other job disciplines.

Drilling new wells and developing infrastructure occupies most oil supply workers, though operating existing platforms and refineries provide a sizeable share of employment as well

Employment in oil supply by economic sector and asset life stage, 2019

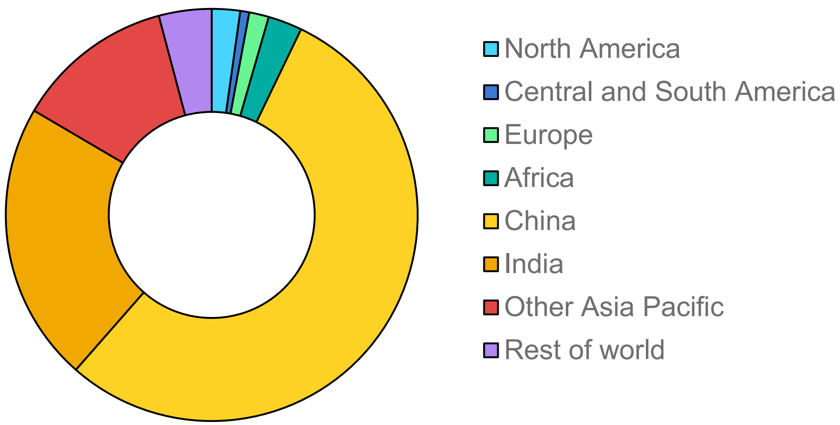


Notes: These figures include employment in oil production, transportation, and refining. Our estimates do not contain employees who work at retail fuelling stations, as many of these jobs are connected to service and retail, and are not linked exclusively to oil with different fuelling sources (biofuels, CNG, electric charging, etc.).

Coal supply employs 6.3 million workers, but the industry is focused on the coming transition

Global coal production totalled 5.7 billion tonnes in 2021, following a decade at similar levels. Production has shifted towards Asia Pacific countries since 2010, where 77% of global coal is now mined, while output in Europe and North America continues to fall. Investment in coal supply has declined by 4% per year from 2010, to USD 95 billion in 2021, with further contractions projected in every IEA scenario.

Employment in coal supply by region, 2019



In 2019, around 6.3 million employees worked in coal supply—3.4 million in China, 1.4 million in India, and another 790 000 in other Asia Pacific countries. These jobs are predominately in mining, and also cover the transport, washing, and processing of coal, as well as the manufacturing of specialised mining and conveying equipment. Coal mining is labour-intensive, despite significant improvements in productivity thanks to automation, including a near-halving of workers per tonne produced in China over the last decade. As such, mining jobs make up 60% of employment in coal supply, followed by 20% of jobs in wholesale and transport. With global coal demand flat over the last decade, most workers are engaged in existing operations.

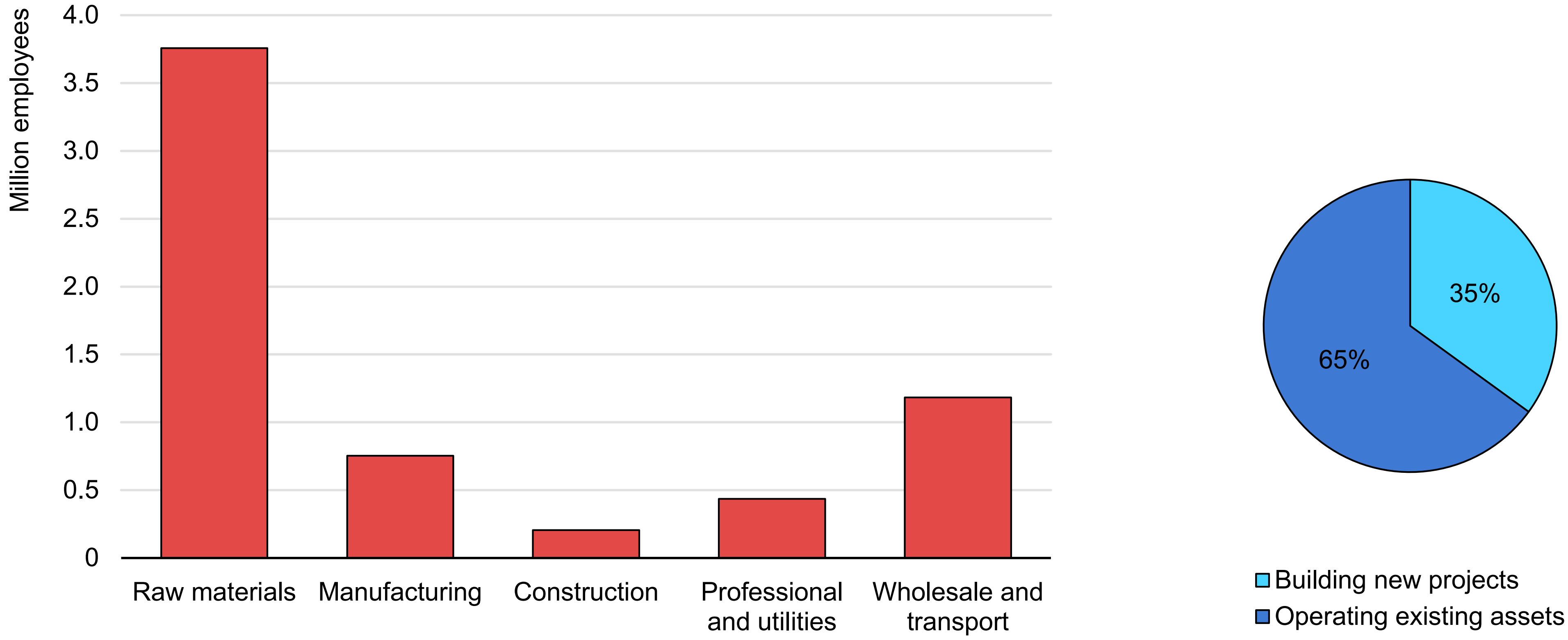
Coal supply jobs often provide more benefits and worker protection than competing industries. In the United States, coal workers see a wage premium over average jobs of about 50%. In India, coal is the only sector with its own pension scheme covering both permanent and contract workers. These benefits have been established to compensate for the health and safety hazards of mining.

Coal supply jobs tend to be concentrated in remote areas, with local communities highly dependent on coal for income and employment. Regions such as Mpumalanga in South Africa, Cesar in Colombia, and East and South Kalimantan in Indonesia have up to 10% of their employment and 35% of their GDP directly predicated on coal.

Given the emissions intensity of coal, both direct and indirect jobs in coal-dependent communities are among the most at risk in energy transitions. Low-skilled and informal coal supply workers, particularly in EMDEs, will require retraining as well as productive inclusion programmes. Several countries where historic transitions from coal have taken place provided policy and financial support for miners to assume new employment. In the United States, former miners have been upskilled to work on wind turbines and rooftop solar installation, and in IT. Coal miners can also transfer to jobs in the growing critical minerals industry if the geographies of resources are compatible.

Most coal supply employees are miners, whose jobs are highly geographically concentrated, making these workers particularly vulnerable in the energy transition

Employment in coal supply by economic sector and asset life stage, 2019



Note: This figure includes coal production and transportation, but excludes coal transformation for blast furnaces and coke ovens.

The quality of energy jobs is an important factor, especially when transitioning workers

When assessing the just transition, the quality of clean energy jobs is as important as their quantity. Key criteria determining job quality include wages, medical insurance, retirement and other benefits, job security, terms of employment, occupational safety standards, union membership, and overall scope of labour rights.

Globally, energy jobs pay more than the median national wage, however there are disparities between segments. Workers in less-established clean energy industries typically earn less than jobs in the fossil fuel or nuclear industries. For instance, in the United States, the median hourly wage premium above the national median for workers in wind and solar is 36% and 28%, respectively, compared to 39% in oil, 58% in natural gas, and over 100% in nuclear. This is in part due to the higher skill requirements for many of these jobs, as well as strong and longer-standing union representation, whereas clean energy jobs tend to offer more opportunities to workers with lower levels of post-secondary education and formal qualifications. Clean energy jobs are relatively safer than other sectors, especially compared to mining jobs, and as such there is less compensation for occupational hazards. Clean energy employment, especially solar, also has a larger share of part-time or contract work, and often require workers to travel to work sites far from their homes. They have a higher union membership than the national private sector workforce average, but they remain far less unionised than fossil fuel jobs in most geographies with data.

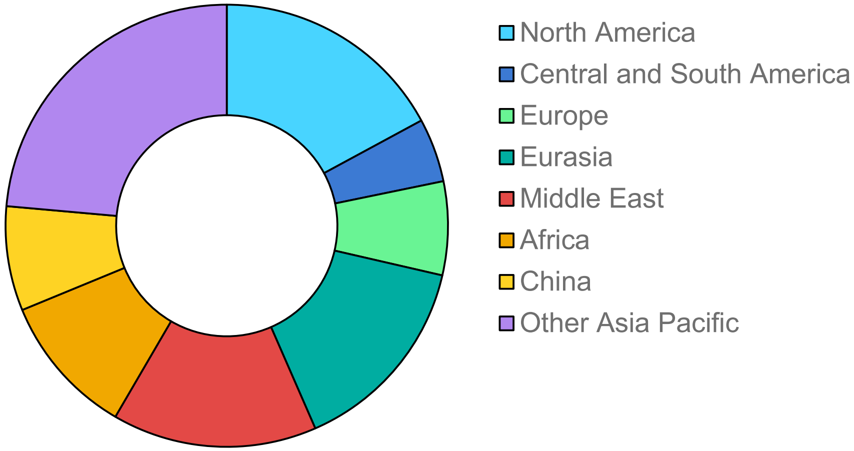
These dynamics are not always consistent in EMDEs. Energy jobs remain on average better paid, however, many are temporary and informal. This includes a wide-range of work, from coal and critical minerals mining, construction, harvesting crops for biofuels or making charcoal, and temporary work at energy facilities, like cleaning coal power plants during annual maintenance. This work may only represent a small portion of their total labour hours in a year, but can be a sizeable portion of their formal income. Many countries have clean energy poverty alleviation programmes in rural areas, such as in China. Programmes for clean cooking and electricity access solutions often provide training for local workers, and offer more secure employment and a stepping stone into the formal economy.

In EMDEs, clean energy sectors also have lower rates of union representation. In India, for example, the clean energy sector is predominantly private and lacks labour unions, which stands in stark contrast to the heavily unionised coal sector where wages and benefits are negotiated within committees formally established through the government. Sectors that rely heavily on contract or part-time staff often do not offer these workers the same labour protections as permanent employees. This is common in construction for efficiency retrofits, rooftop solar installations, bioenergy harvesting, and coal mining, especially in EMDEs.

Natural gas supply employs 3.9 million workers, with growth in LNG driving hiring

Global natural gas production has grown steadily since 2010, and in 2019 exceeded 4 100 billion cubic metres (bcm). Following a dip in 2020, production rebounded in 2021, while investment almost recovered. North America, Eurasia, and the Middle East remain the regions with the largest shares of production.

Employment in gas supply by region, 2019



Gas supply employment was 3.9 million in 2019, with large shares in the Asia Pacific (31%), North America (17%), Eurasia (15%) and the Middle East (15%). National oil and gas companies in countries such as Nigeria, Iraq, and Saudi Arabia contribute to a disproportionately high share of natural gas employment, because relatively high rates of public sector employment are associated with lower levels of labour productivity. However, many upstream operations are still outsourced to companies in North America and Europe.

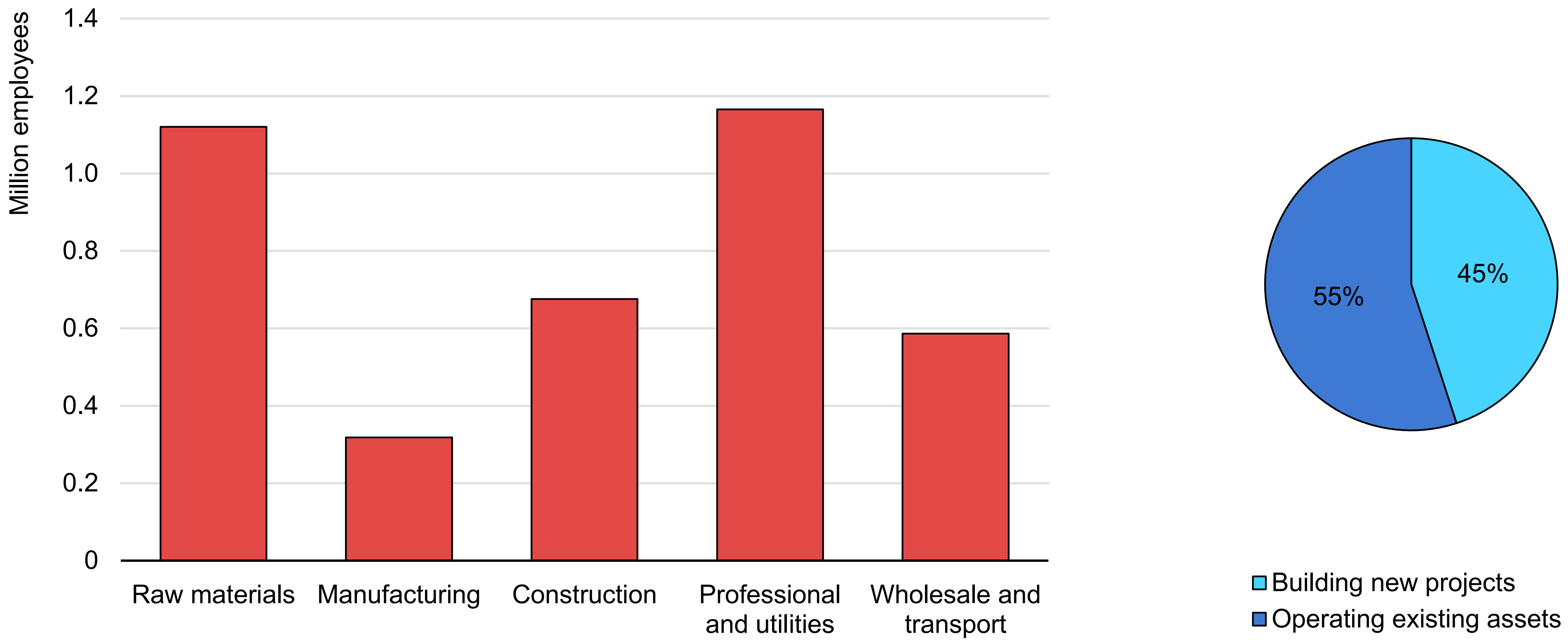
With the rebound of production following the pandemic, global natural gas employment is estimated at 4.5 million in 2021, up 600 000 over 2019 levels. The industry is bracing for the prospects of radically shifting global trade dynamics in the coming years, taking stock of their ability to ramp up production with flexibility. This is likely to drive up the prevalence of contract-based employment via consultancies and services companies.

Employment in production and extraction (denoted as raw materials), followed by utilities, dominate the natural gas value chain, with over a million in each. Around 767 000 people work in liquefied natural gas (LNG) globally, which is expected to grow, driven by new facilities.

Focus on seaborne trade of LNG has increased since the Russia Federation (hereafter “Russia”)’s invasion of Ukraine, with 8 bcm of new projects fast-tracked in 2022. In Canada, where around 0.7% of workers are employed in oil and gas – and over 5% of workers in the province of Alberta – government career services emphasise jobs in LNG to attract oi and gas workers towards a growing industry short on needed skills in operational management.

A large share of jobs in natural gas supply are in extracting and producing gas, although LNG is driving growth in new asset construction

Employment in gas supply by economic sector and asset life stage, 2019



Note: This figure includes employment in natural gas production, transportation, and liquefaction (LNG).

Bioenergy supply employs roughly 3.3 million, with a large share working in agricultural roles

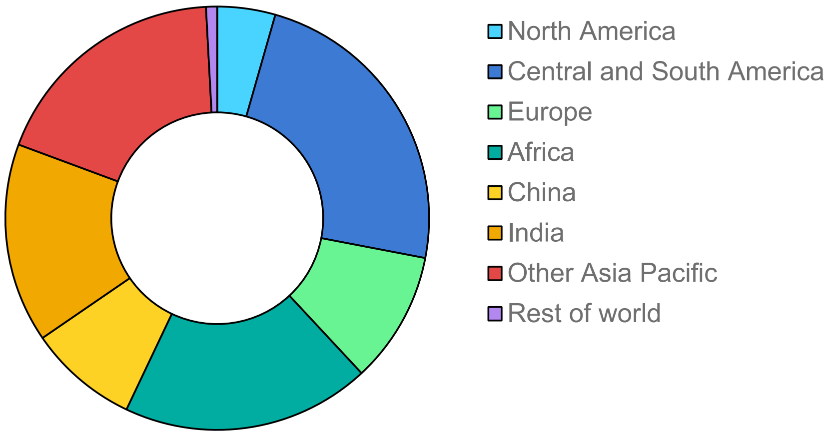
Global biofuel energy supply was 2 million barrels of oil equivalent per day (mboe/d) in 2019, and combined biogas and biomethane supply were 2 exajoules (EJ), with a stable pipeline of new production facilities coming online in the next few years. Modern solid biomass supply, which includes charcoal, pellets, crop residues and waste, reached 31 EJ in 2019.

Around 3.3 million people globally worked in bioenergy supply in 2019. The production of commercial biofuels is a major driver for employment in agriculture, especially in countries like Brazil, Indonesia, and the United States. Biogas and bioenergy for power and heat play a larger role in Europe. The collection of firewood and other agricultural residues plays an important role in EMDEs for the traditional use of bioenergy in cooking, which we are not able to fully capture in our employment estimates.

Almost one-third of workers are dedicated to producing and collecting agricultural feedstock and another one-third are in the development and operations of processing facilities. Employment in feedstock processing varies by regions and often features seasonal labour. In EMDEs these activities are considerably more labour-intensive than in advanced economies, where these tasks are more mechanised.

Three-quarters of bioenergy jobs are connected to operating existing supply chains, with the construction of new facilities driving less than a quarter of new jobs. The Covid-19 pandemic impacted feedstock harvest and biofuels shipping globally, with Malaysia losing up to a quarter of its palm oil yield due to a labour force shortfall worsened by travel restrictions for migrant workers. The ongoing global price spikes brought on by Russia's invasion of Ukraine are reinforcing political support for bioenergy production, as is the case in Brazil and Indonesia, although global food security concerns are creating countervailing pressures as well.

Employment in bioenergy supply by region, 2019



The majority of bioenergy employment is in rural areas, and relies on workers skilled with operating agricultural machinery, as well as manual labour for the processing of feedstocks. The production of liquid biofuels is often coincident with existing refinery operations, and draws heavily upon existing petrochemical industry expertise and employment base. The same applies to biomethane production, of which a large share is integrated with existing gas businesses.

Power sector

Power generation employs 11.3 million worldwide, of which 6.8 million are in renewables

Global power capacity neared 7 500 GW in 2019, spanning 30 000 power plants and a multitude of distributed generation sources. Capacity has grown at an average of 4% per year over the past decade, with new additions shifting quickly toward renewables.

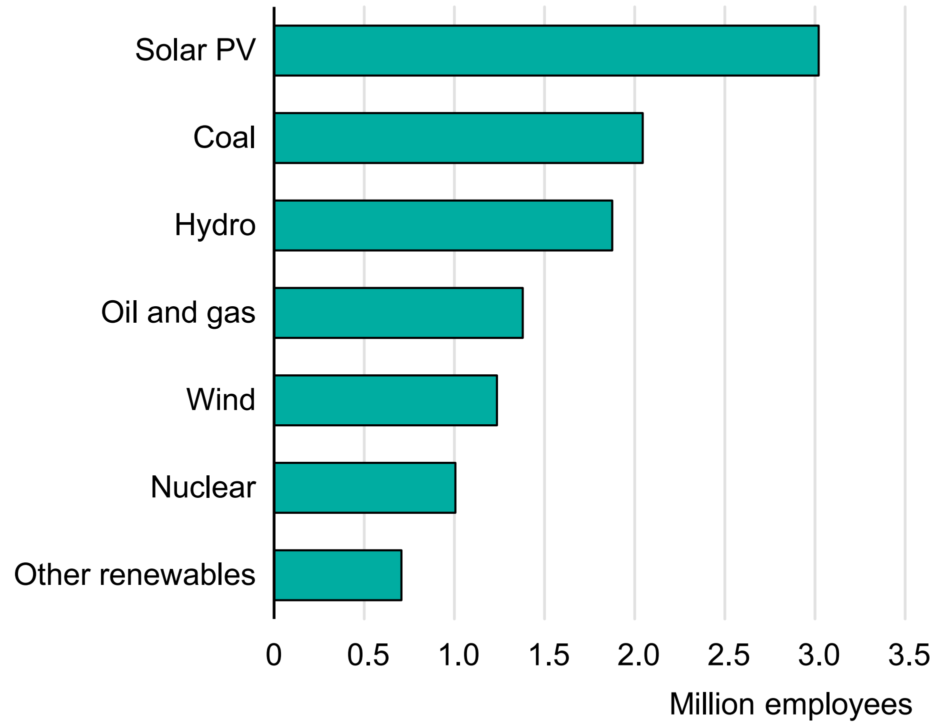
The power sector has the potential to reshape global energy demand and supply through the electrification of end uses combined with the ongoing transition towards low-emissions sources of electricity. The realisation of this transformation will depend on having the requisite workforce to deploy new capacity and retrofit existing capacity, and on training workers adequately when shifting between different power sectors.

Power generation employment totalled 11.2 million in 2019, comprised of 3 million in solar PV, 2 million in coal power, and 1.9 million in hydro. Wind power, including onshore and offshore, employed 1.2 million and nuclear power 1 million. Employment in other renewables totalled some 710 000 employees. Over 60% of workers are employed in the deployment of capacity additions, while the other almost 40% work in the operations and maintenance of existing facilities.

About two-fifths of power sector employment is for the operations and maintenance (O&M) of existing capacity, across the utilities, professional, wholesale and transport economic sectors. Coal and hydro power have the highest numbers of O&M employees, while nuclear is among the most labour-intensive in terms of staff working in O&M per GW installed.

Overall, power generation employment includes 2.6 million workers in manufacturing transformers, turbines, compressors, and solar panels; 4.0 million construction workers building power plants, dams, mounting systems; and 3.8 million in utilities and in professional roles such as project finance and procurement.

Employment in power generation by technology, 2019



Solar PV has 3 million employees, with manufacturing jobs highly concentrated in China

Solar PV capacity worldwide stood at 740 GW in 2019, comprising 425 GW of utility-scale solar PV installations and 315 GW of building panels. Global investment in solar PV reached USD 215 billion in 2021, having seen over 5% annual average growth over the previous decade. This burgeoning sector is expected to see continued growth in annual capacity installations globally in every IEA scenario.

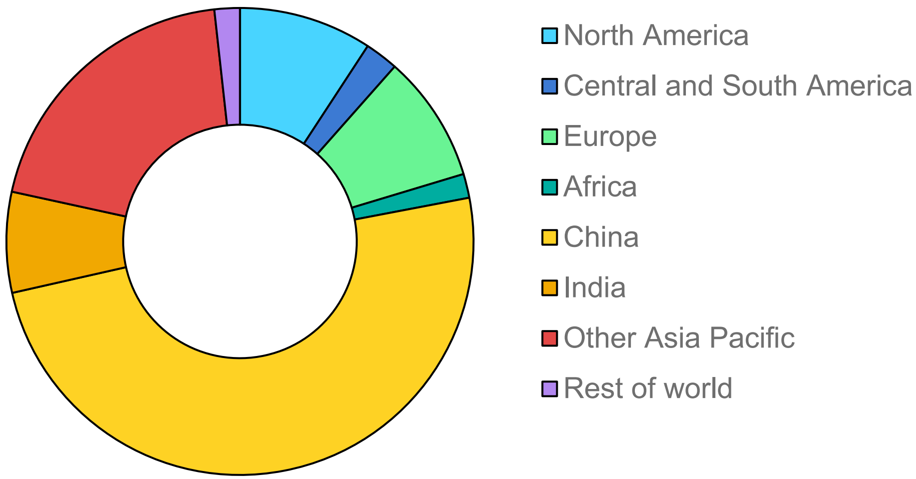
As of 2019, there were over 3 million employed in solar PV value chains, and increased to an estimated 3.4 million in 2021. Almost half were employed in China. North America had almost 280 000 solar PV workers, and Europe had more than 260 000. Africa had around 50 000 working in solar PV, and this number has high potential for growth as both on- and off-grid solar solutions proliferate to provide electricity access.

Correspondingly, a large majority of employees in solar PV are engaged in the manufacturing and installation of new capacity. The new investments are expected to create jobs split between manufacturing and construction. Manufacturing jobs are strongly concentrated in just a few countries, with China in the lead with 260 000 workers in the production of polysilicon, wafers, cells, and modules alone. Research and innovation are powering the latest-generation PV panel factories across other countries.

The employment impacts of installing building-scale versus utility-scale solar PV differ. The installation of building-scale solar PV is about four times more labour-intensive than utility-scale solar PV.

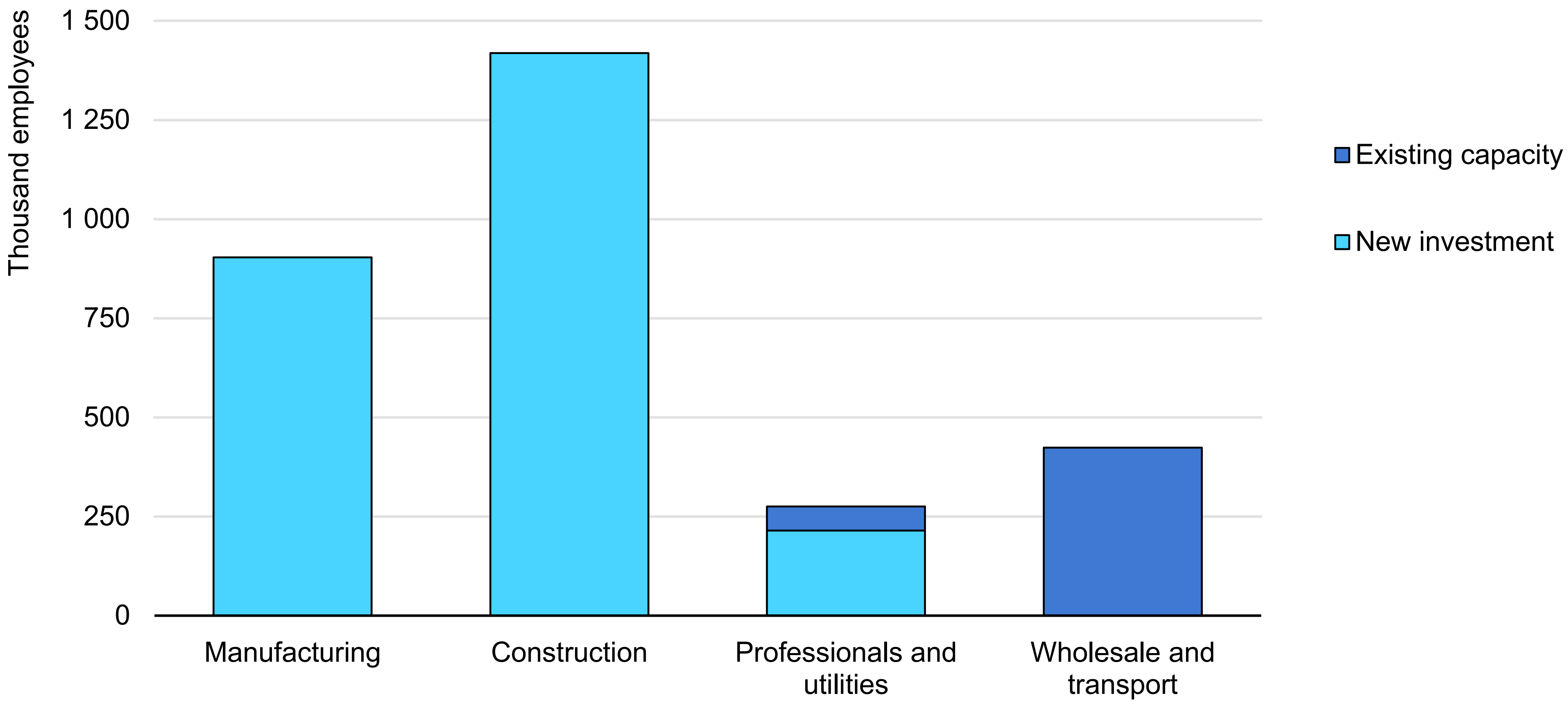
Residential solar panels are often installed by construction workers and electricians who also work on other projects, such that many solar PV jobs are not full-time, and it can be difficult to count employees accurately. For example, the United States Energy and Employment Report (USEER) reported 28% of solar PV workers spent less than half of their time on solar PV-related work. The shortage of a skilled labour force is prevalent in this industry as well, for instance hindering the development of large-scale solar in Australia.

Employment in solar PV by region, 2019



Solar PV employees are primarily engaged in building and installing new capacity, in line with the sector's steady growth

Employment in solar PV by economic sector and asset life stage, 2019



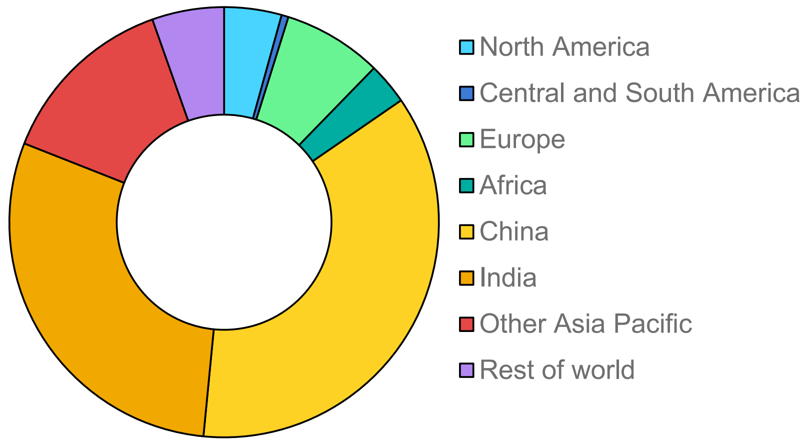
Coal power employs 2 million globally, largely concentrated in emerging market and developing economies in Asia, including a high share of informal workers

Coal capacity worldwide stands at 2 100 GW in 2021, of which three-quarters is located in the Asia Pacific region. Coal meets around half of the electricity demand in EMDEs. Capacity additions that are currently planned correspond to projected investment averaging USD 40 billion per year to 2025.

Global coal power employment totalled 2 million in 2019 and was largely concentrated in Asian EMDEs. An estimated 740 000 were employed in China and another 600 000 in India, where around one in four are informal workers, not included in company records but contributing as plant operators and in elementary occupations. Despite the decrease in coal-fired power generation in Europe, 150 000 were still employed as of 2019.

With an unprecedented number of countries committing to phase out unabated coal-fired power at COP26, 750 plants around the world (550 GW) now have effective close-by dates. China, Japan, and Korea have all pledged to end public support for new unabated coal plants overseas. As such, we estimate that almost 20% of jobs in coal power O&M are at risk globally in the clean energy transition. However, a significant share of integrated utilities or power generation companies are looking to redeploy their current staff working at coal-fired power plants elsewhere in their businesses, with many possessing transferable skills for operating other power plant facilities, or able to be upskilled as needed. Manufacturers of coal power equipment can also find new opportunities in other parts of the power generation value chain, such as turbine manufacturing and engineering, including redesigning power plant equipment for co-firing or running with carbon capture, utilisation and storage (CCUS), which are being pursued at pilot scale in certain regions.

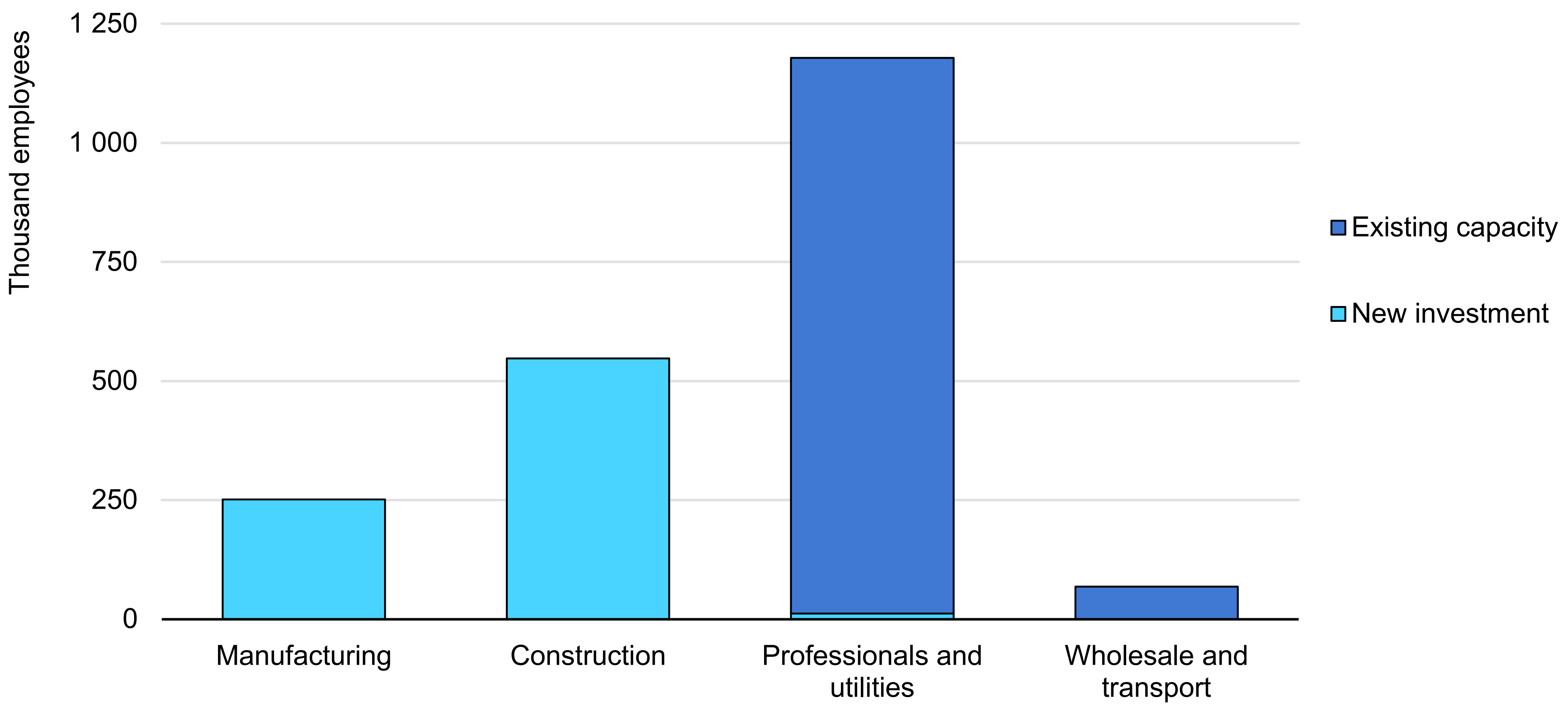
Employment in coal power generation by region, 2019



However, foresight is required to prevent and minimise the negative impacts of potential transition-related layoffs. Many governments are preparing strategies to protect affected coal power workers. For example, Japan is developing ammonia co-firing technology, which will help plants to avoid rapid closure. Similarly, some coal power plants in Romania will be replaced with gas units, although these tend to be less labour-intensive to operate and maintain.

Coal power employment is concentrated in operations, which poses transition risks as coal-fired plants close

Employment in coal power generation by economic sector and asset life stage, 2019



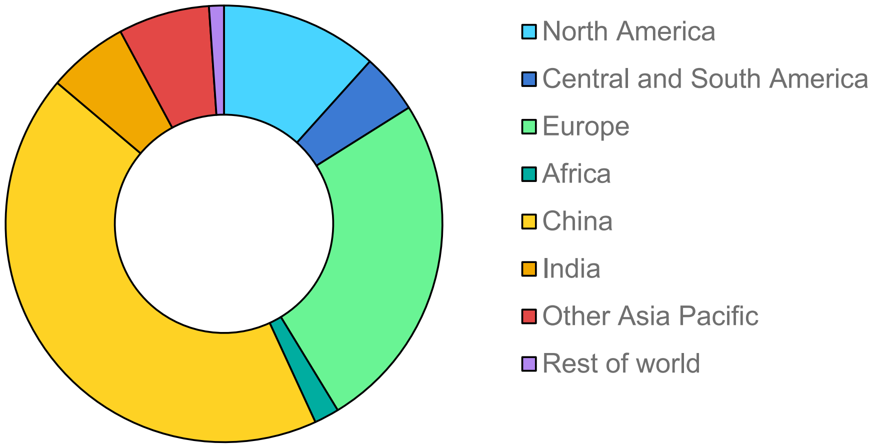
Wind power employs 1.2 million, with supply chains concentrated in Europe and China

Wind capacity worldwide stood at around 625 GW as of 2019, comprising 600 GW onshore and 30 GW offshore. The sector's growth has proven relatively resilient to recent disruptions. Capacity additions grew in 2020 despite the Covid-19 crisis, and reached around 95 GW in 2021, 60% more than in 2019. Global investment in wind totalled USD 145 billion in 2021.

As of 2019, there were 1.2 million employed in wind power—over 500 000 employed in China, 300 000 in Europe, and 144 000 in North America. By 2021, an estimated 1.3 million were employed in wind power. Onshore wind accounts for about four-fifths, corresponding to its higher share of existing capacity as well as greater planned capacity additions. As with solar PV, the most labour-intensive part of the deployment of wind power is the build-out of new assets. Over 80% of those employed in wind power work in the manufacturing and installation of new turbines.

Wind manufacturing capacity worldwide of nacelles, blades, towers, generators, gearboxes and bearings is already closely aligned with expected capacity additions in the coming years, such that wind is less likely to see a large uptick in manufacturing capacity and corresponding employment in the coming years as solar PV. China and Denmark are among the few countries which have the capacity for manufacturing all of the above components, with jobs sustained by exports to other countries.

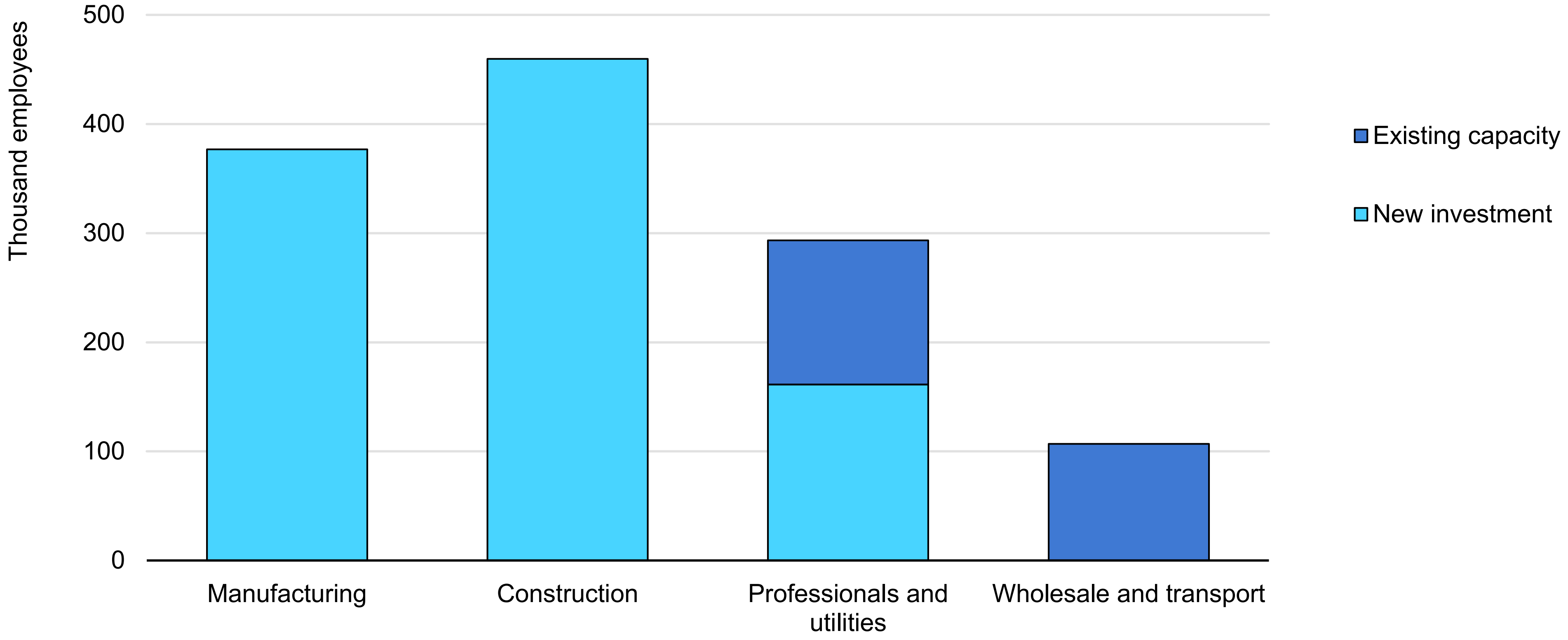
Employment in wind by region, 2019



Employment in offshore wind totals around 210 000 globally, and is mainly concentrated in Europe and in China. Training needs are a particular concern for the offshore wind industry, especially for workers to learn safety protocols relevant to working at heights and survival at sea. The construction of dedicated port and ship infrastructure for offshore wind development is also a driver of new employment, which has received government support under several recovery plans. Oil and gas workers can transfer their skills to offshore wind if properly retrained.

Wind manufacturing employment capacity is largely in line with expected new installations in the coming years, but growth in offshore wind will demand more diverse skill sets

Employment in wind by economic sector and asset life stage, 2019



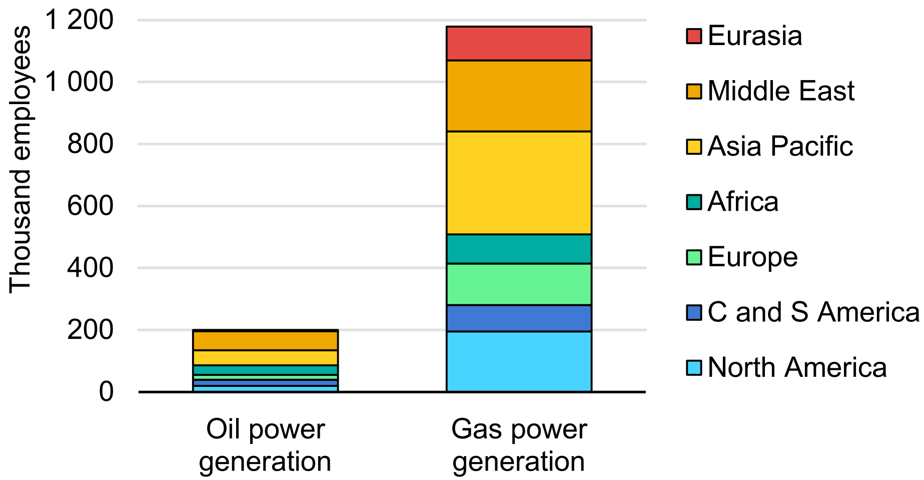
Oil and gas power employment totals 1.4 million, with the most workers in the Middle East, North America, and Asia Pacific

Globally, the total installed capacity of natural gas power plants was 1 790 GW in 2019, whereas oil power generation capacity, comprising both power plants and diesel gensets, stood at 430 GW. Capacity has grown by 75 GW and declined by 20 GW, respectively, since then. Together, they account for almost 30% of global power capacity. North America and the Middle East have over 40% of this capacity, while growth is expected in the Asia Pacific, Middle East, and Africa. Investment for oil and gas power in 2021 was around USD 65 billion, a small share (7%) of total power generation investment, reflective of low upfront costs.

Employment for gas-fired power generation was around 1.2 million worldwide in 2019. Fewer people are needed onsite for natural gas generators, such that employment related to new investment versus operating existing capacity accounts for 44% and 56%, respectively. Upstream manufacturing of generators and specialised pumps and compressors is concentrated in advanced economies.

Oil-fuelled power generation has a smaller labour force of 200 000 employees, with almost one-third located in the Middle East. However, in places where low reliability plagues the grid, such as in Africa, there are a fair number of people informally employed in the resale, maintenance, and operation of diesel gensets.

Employment in oil and gas power generation by technology and region, 2019



During the energy transition, the jobs of oil and gas power plant workers may be at risk, though with a more gradual shift than coal plant workers. Manufacturers of turbines as well as construction workers can likely transfer their skills to the deployment of other power technologies, and towards updating existing turbine designs to use a higher mix of hydrogen and other clean fuels in the future.

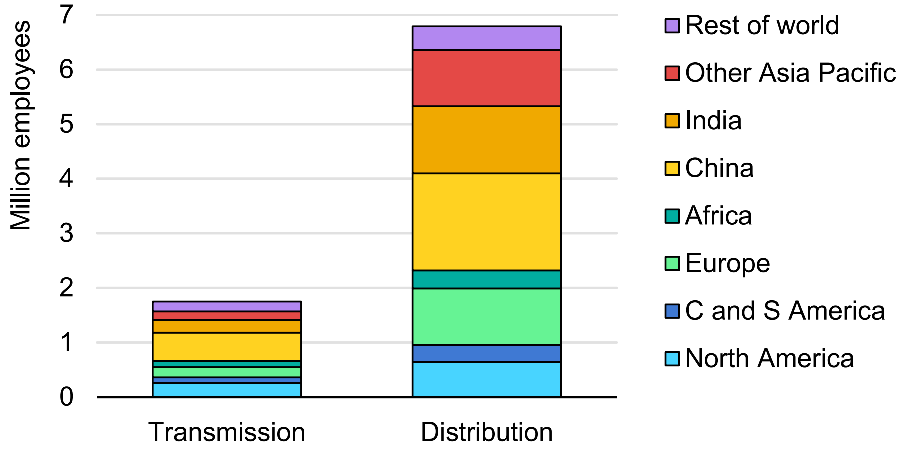
Power transmission, distribution, and storage employ 8.5 million with strong demand for expansion projects expected to drive growth in the labour force

Grid operators currently manage around 80 million km of electricity networks globally. In 2021, USD 310 billion of investment went into expanding and upgrading existing networks. Investment in electricity networks declined from 2016 to 2020, but recovery plans after Covid-19 are sharply driving up demand for new grid expansion projects, especially in China, Europe, and the United States.

Around 8.5 million are employed in the power transmission and distribution (T&D) sector, excluding storage. Over half of these jobs are in the utilities sector, which is the dominant economic activity in all regions except China, where continued expansion of new T&D networks resulted in slightly more workers in construction. Globally, around 40% of T&D jobs are in the construction of new grids. Over a quarter of all T&D workers are employed in China. However, the operation of existing grids means that total employment is spread relatively evenly across regions, somewhat proportionate to their size. In Africa, power sector employment is also driven by objectives to achieve universal access to electricity, making the production and distribution of mini- or off-grid solutions major drivers of employment.

The bulk of grid-related employment is focused on the operation of distribution systems, which involves maintaining power lines and customer support for meter reading and billing. The uptick in smart metering and other grid digitalisation is reducing the labour intensity of operating and maintaining grids while increasing the need for IT skills. Regions with low levels of smart grid deployment see three-times higher labour intensity than regions with higher levels.

Employment in power grids by technology and region, 2019



Notes: C and S America = Central and South America. Distribution in this figure includes employment for battery storage.

Utility-scale battery storage installations reached almost 10 GW worldwide in 2020, and are expected to expand in the coming years. Electricity storage employed around 65 000 people in 2019, with over 40% located in China. Jobs in manufacturing battery cells and components are geographically concentrated in China, as is the processing of upstream materials, although critical minerals reserves, particularly of lithium, are more geographically diverse.

Providing universal access to electricity and clean cooking is a major driver of energy employment in developing regions, especially in Africa

Approximately 770 million people in the world still lack access to electricity and 2.5 billion do not have access to clean cooking as of 2021. Reaching universal access by 2030 is a goal canonised in the Sustainable Development Goals, and working toward this creates sizeable employment opportunities in EMDEs. Access-related jobs can often provide an important stepping stone into formalised employment for those without formal job training.

Three in every four people without access to electricity live in Africa. The pursuit of universal access by 2030 in this region would create around 1.8 million full-time equivalent jobs between 2021 and 2030, as presented in the IEA's Sustainable Africa Scenario. These jobs include electricians and construction workers extending grid infrastructure (including putting up poles which can be done by untrained workers), wiring houses for grid connections, and installing new generation facilities. However, over 60% of those jobs are related to the distribution, sale, assembly, and installation of distributed access solutions, especially solar home systems which have grown at similar paces as solar PV over the 2015-2019 period and are expected to play a major role in providing distributed access in Africa.

Improving clean cooking solutions can significantly reduce health and environmental damages, while creating a significant number of jobs, and thus promoting community development. Clean cooking jobs include manufacturing and sale of modern cookstoves, in fuel distribution and retailing, and also in upstream fuel delivery supply chains, whether that be for terminals and filling stations for liquified petroleum gases (LPG) or charcoal production. Biogas digester manufacturing, installation, and maintenance are also a growing area of interest in the clean cooking space.

The roles created are diverse, requiring both skilled and unskilled labour. However, at all levels technical and managerial skills are required. Safety training is particularly pertinent given the risks associated with many of these fields, such as the transport and filling of LPG canisters, and electrical wiring. Training for these roles can help improve access to gainful employment for people in rural areas, particularly women and youth. Many of Africa's and developing Asia's most prominent access-oriented companies are run by female entrepreneurs, who often better understand the challenges faced when working with households first gaining access to electricity and clean cooking solutions.

Energy end use and efficiency

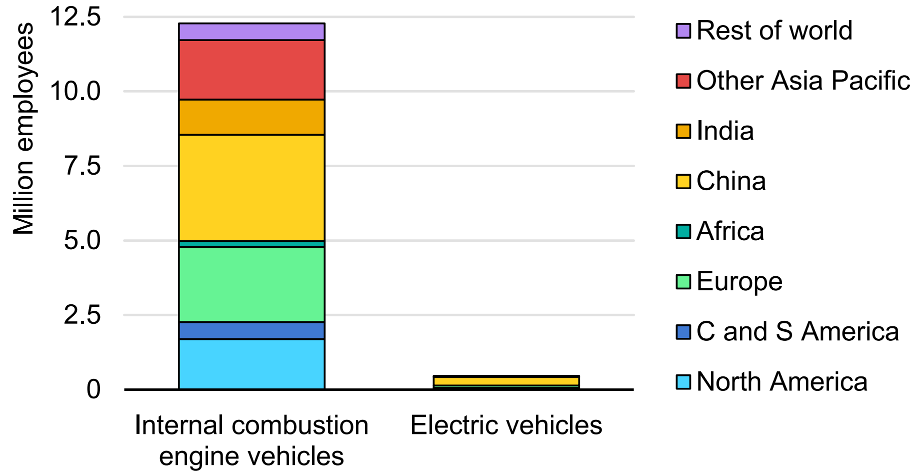
Around 2.5% of manufacturing workers worldwide are employed to produce road vehicles, with EVs powering growth in employment

Global road vehicle sales totalled around 175 million in 2021. Of these sales, almost 110 million were in the Asia Pacific, and over 20 million each in North America and Europe. Following a dip during the pandemic, sales of electric vehicles (EVs), which include battery electric and plug-in hybrids, have also rebounded exponentially, reaching a new record of 18 million—10% of total vehicle sales in 2021. Despite strains along global supply chains, sales continued to rise strongly into 2022. Manufacturing of EVs and battery chargers is expected to be one of the largest areas of employment growth for the energy sector in the coming years.

Around 12.7 million were employed in road vehicle manufacturing in 2019,[1] constituting around 2.5% of total manufacturing employment worldwide. Beyond direct employees, up to five times more are indirectly employed in related manufacturing and service provision such as vehicle maintenance, which is outside the scope of this report. Including those manufacturing batteries for electric vehicles, employment totals almost 13.6 million.

Prior to the pandemic, global vehicles manufacturing employment increased steadily year-on-year, with the growth in Asia Pacific. Currently, around one-third of vehicle manufacturing jobs are in China, with another 16% in the rest of Asia Pacific. Europe follows with 20%. Following the dip during the pandemic, 2021 global employment in vehicle manufacturing is estimated to have rebounded to 12 million.

Employment in vehicle manufacturing by region, 2019



Notes: C and S America = Central and South America.

Of the 12.7 million workers in the vehicles sector in 2019, around 460 000 were employed in EVs manufacturing, which is highly regionally concentrated, with over 60% in China. Decisions across

[1] This employment includes passenger cars, commercial vehicles, buses, and trucks. Employment in other forms of transportation such as rail, aviation, and shipping is not included. Jobs in the retail and maintenance of vehicles are not included.

countries about whether or not to increase domestic manufacturing capacity of EVs and their batteries will determine how employment by region shifts in the coming years, as exponentially more EVs are deployed.

As EVs have fewer components and are simpler to assemble, the labour intensity for manufacturing them may be lower than that of vehicles with internal combustion engines. However, when accounting for the manufacture of the requisite batteries and related charging infrastructure, EVs could be roughly as labour-intensive across the entire value chain. We estimate around 850 000 jobs are in the EV batteries value chains. Beyond direct manufacturing, automakers are increasingly focusing their R&D and design teams toward new lines dominated by EVs, with many announcing expanded EV line-ups in the coming years. Accounting for these workers means that the EV workforce is disproportionate to their total sales today. On top of this, the development of EV charging networks requires jobs in manufacturing, installation, and upkeep. Electric utilities and fuelling stations are increasingly playing a role in this segment, as are EV automobile manufacturers like Tesla.

Based on projected EV sales for 2022, EV and battery manufacturing are set to be one of the largest areas of employment growth for energy in the coming years. Major EV battery manufacturers are reporting a shortfall in the skilled labour force to staff their facilities, highlighting an important gap in the growing sector, and prompting companies to improve their employment packages to attract talent. This is also driving further automation in vehicle manufacturing as well as an increase in the use of temporary workers to achieve flexibility in the labour force. This may lead to decreased job security, but can improve job quality for workers, for example via the adoption of exoskeletons (robotic suits that reduce the physical strain caused by repetitive tasks). Automobile labour unions are calling for increased support to retrain workers on manufacturing EVs, and demanding higher wages and worker protections during the transition.

Efficiency in buildings and industry employs 10.9 million with China accounting for one-third

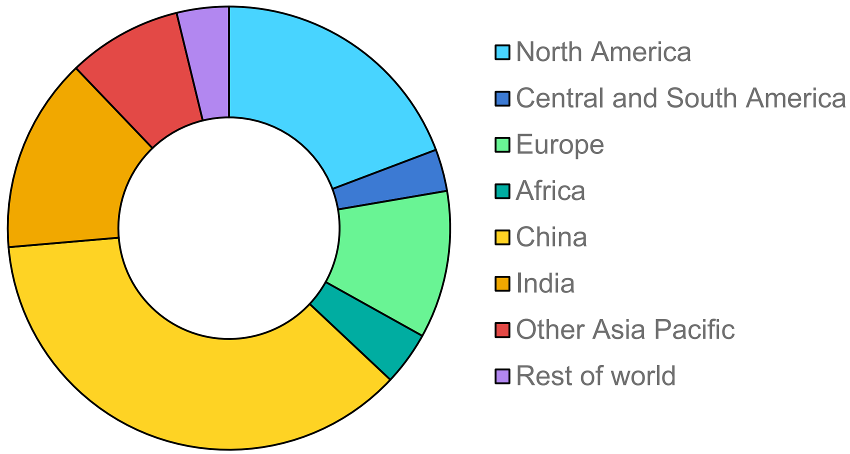
Global investment in building retrofits and efficient new construction, as well as for more energy-efficient appliances, vehicles and industrial equipment, neared USD 330 million in 2021, a rise of around 14% from 2019 levels. Most energy efficiency measures, in particular in the buildings sector, are highly labour-intensive. In this report, we assess the job creation from building retrofits, construction of energy efficient new buildings (the incremental employment compared to standard practice), heat pumps, industrial efficiency retrofits, energy management systems and the manufacture of efficient building materials. While difficult to disentangle data, we try to isolate the jobs that require energy efficiency skill sets and knowledge to be completed.

Worldwide, around 10.9 million people worked in energy efficiency in buildings and industry in 2019, with China accounting for just over one-third of these jobs followed by around 2 million in North America. Nearly half of all efficiency jobs worldwide are in the construction sector.

The Covid-19 pandemic initially reduced those working in energy efficiency as social distancing requirements prevented contractors from gaining access to residential properties to perform retrofits, leading to notable declines in efficiency employment in the United States and elsewhere. However, energy efficiency has featured prominently in economic recovery packages targeting both public and private residential buildings over the last two years, totalling more than USD 72 billion worldwide as of March 2022.

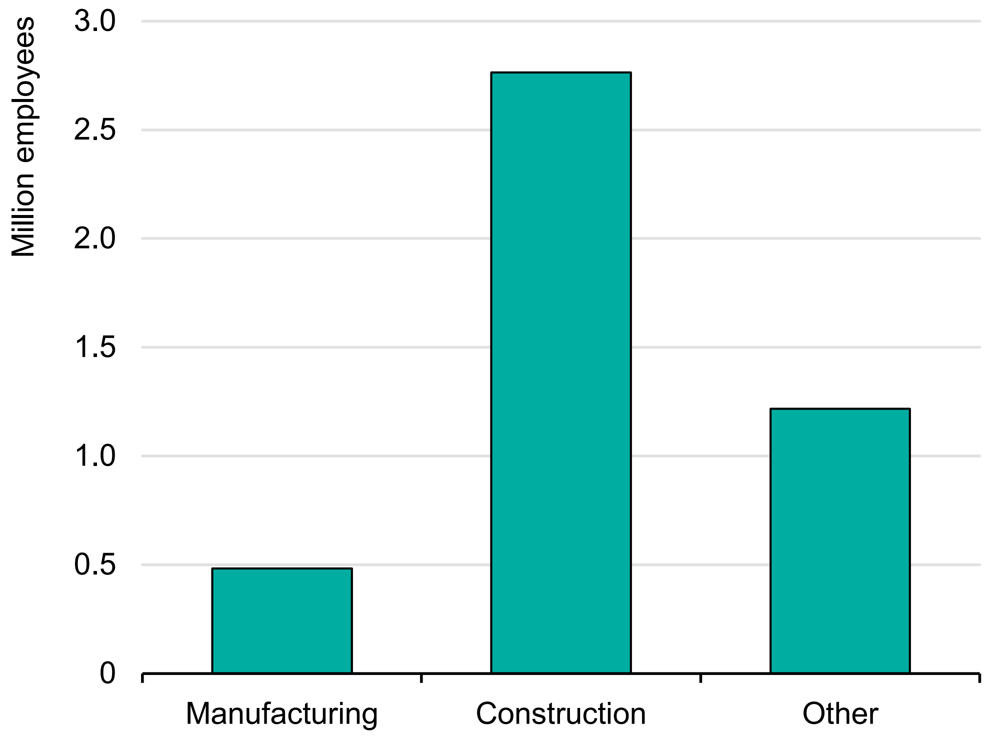
Many efficiency jobs rely heavily on local supply chains, such as contractors and local programme administrators. The lack of trained personnel can be detrimental to the quality of installations or retrofits and negatively affect the energy saving potential of an intervention. This makes training and vetting vendors a major challenge, and there is a growing focus for many efficiency programmes to provide the appropriate skilling and certifications. Technical and vocational education and training can be helpful for workforce preparation.

Employment in energy efficiency by region, 2019

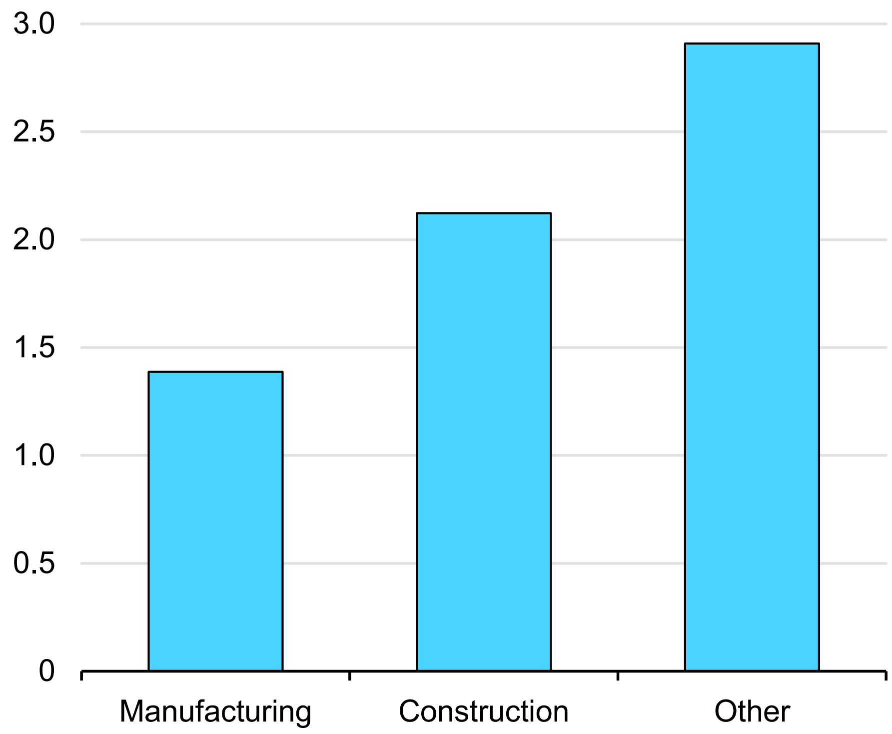


Energy efficiency measures are typically very labour-intensive in construction

Employment in buildings energy efficiency, 2019



Employment in industry energy efficiency, 2019



Notes: HVAC = Heating, ventilation, and air conditioning. Other includes employment in utilities, professional, wholesale, and transport sectors.

Looking forward

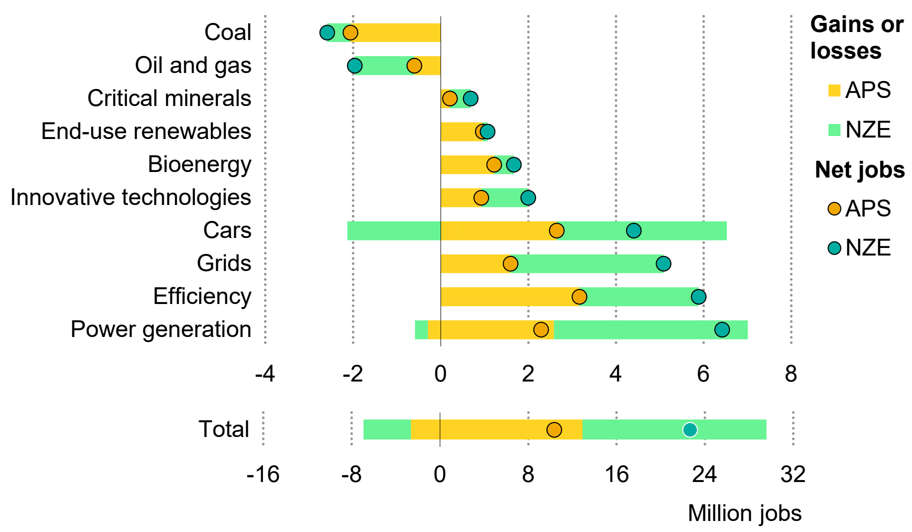
Employment will grow as the world decarbonises the energy sector in line with global targets

Employment in clean energy is set to grow in all IEA scenarios. In the [World Energy Outlook 2021](), employment impacts were evaluated in two scenarios: the Announced Pledges Scenario (APS) where all announced climate pledges were met in time and in full, and the Net Zero Emissions by 2050 Scenario, which is consistent with limiting global surface temperature warming to 1.5 °C by 2100.

In both scenarios, job growth more than offsets a decline in traditional fossil fuel supply sectors. We estimate that an additional 13 million workers are employed in clean energy and related sectors by 2030 in the APS, and this figure doubles in the NZE. Many of the jobs lost are not necessarily where new jobs are created. Skill sets are also not automatically transferable, and new skills are needed. This is true both within countries and internationally.

Quantifying the employment effects of energy transitions facilitates proper planning of support measures including training and education programmes. Countries are designing programmes that seek to take advantage of existing strengths in fossil fuel sectors to support emerging areas such as offshore wind, CCUS, geothermal and hydrogen. The United Kingdom's North Sea Transition Deal is one such example. Other countries, including South Africa, have instituted broad social dialogue on just and inclusive transitions, encompassing companies, trade unions, regional and local governments, civil society and the financial sector.

Employment by scenario and by subsector, 2019-2030



As transitions gain pace, there will be increased competition for clean energy supply chains and related jobs. Most clean energy jobs are created in the same location of a project, whether it is a solar farm construction or energy-efficiency retrofits. However, clean energy supply chains extend around the globe. Some governments are looking to localise these supply chains, and are making strategic investments in low-carbon technologies such as advanced batteries and low-carbon fuels. Favouring domestic manufacturing capacity can lead to more secure supply chains, but can also drive up clean energy technology costs if it poses barriers to trade and reduces economies of scale.

Governments and companies are looking to better equip their workers and industries for energy transitions

The IEA's Global Commission on People-Centred Clean Energy Transitions brought together global leaders to enumerate key principles for maximising the benefits of clean energy transitions for people. Their recommendations related to energy sector employment include: 1) maximising the creation of decent jobs, 2) developing tailored government support for communities and workers as well as opportunities for reskilling and training, and 3) using robust stakeholder engagement, social dialogue, and policy co-ordination across ministries of energy, employment, and education to deliver better outcomes. Policies embodying these principles differ across regions, but best practices are beginning to emerge.

Worker training—an omnipresent need—intensifies with clean energy transitions. Well-crafted training programmes are a first response to equip employees with an energy transition-ready knowledge base, leveraging their existing competencies. In the IEA's Net Zero Emissions by 2050 Scenario, 60% of energy employment growth to 2030 requires at least two years of post-secondary education. Reskilling through programmes offering certifications and on-the-job training is a key alternative to formal education for experienced energy workers considering a career switch. Developing effective training necessitates tighter co-ordination between public institutions, private sector, and academia to keep curriculum up to date. Expanding worker training programmes and designing new curriculum, in particular for so-called "green jobs", requires a better understanding of the skills held by energy sector workers today and the skills needed in the fastest growing clean energy segments.

Just transition policy making is an increasingly common practice to support workers and communities in fossil fuel industries set for closure as part of efforts to decarbonise. So far, the majority of these plans target coal communities, but long-term support for oil and gas producers to diversify are also becoming more prevalent. Companies who see a declining workforce have worked with labour representation to establish long-term plans, and offer early retirement packages to workers. International support for just energy transitions plans (JETP) is becoming a much-discussed tool, with advanced economies committing climate finance to help producer economies accelerate their transitions away from fossil fuels, as was done in South Africa and as is under discussion in other EMDEs.

Finally**, social dialogue** with unions, employers, civil society and government is a cross-cutting theme for all decision making in this space. This includes robust stakeholder engagement – such as with communities, international organisations, academia and civil society, including youth participation – in the design of labour transition plans, collective bargaining agreements, developing labour standards, and on topics of diversity and inclusion. Large-scale engagement can be time-consuming, but can save time later on, and helps arrive at more durable outcomes for clean energy policy design and worker arrangements within energy employment.

Clean energy innovation demands highly trained workers and could grow immensely this decade

Emerging clean energy industries such as hydrogen and CCUS constitute small portions of the energy workforce today, but they are important areas of growth, demanding highly skilled workers to establish and expand these industries. Clean energy innovation is labour-intensive and is supported by growing investment in research and development (R&D). In 2020, around 750 000 people worked in energy R&D, of whom half were in China, Japan, the United States, France, and Germany. Government support can help innovative start-ups to expand operations, since early-stage R&D requires only a limited number of highly skilled workers and tends to be geographically concentrated around university centres or tech hubs.

Around 35 000 work in hydrogen production today, by estimates based on IEA investment data and energy balances, and other inputs. This sector is also expected to see high growth rates in a net zero world, requiring skills that are potentially compatible with those of oil and gas workers, but requiring specialised safety training. The European HySafe consortium has developed the world's first engineering courses in hydrogen safety. Similar worker training will be important for ensuring the labour supply requisite to scale-up hydrogen production rapidly.

CCUS demonstration projects have created many jobs, particularly during the construction phase of new pilot plants. An average stand-alone CCUS plant can create up to 1 200 jobs for an estimated three-year construction phase and up to 60 jobs during the subsequent decades of operations. Retrofitting plants to use CCUS may also provide continuity of employment for existing plants. For example, developers of the United Kingdom's Net Zero Teesside industrial hub envision that CCUS infrastructure could safeguard between 35% and 70% of existing power plant manufacturing jobs in the region. However, only 12 CCUS projects for gas power plants are currently under development, mostly located in North America.

Among the critical minerals, copper, cobalt, nickel and lithium are vital inputs for batteries, hydrogen electrolysers, grids, solar panels and wind turbines. We estimate around 800 000 people worked in the mining of these four minerals in 2019. Demand for these four minerals is expected to grow between two- and 16-fold from 2020 to 2030 under scenarios consistent with global climate ambitions. Miners face substantial occupational health hazards and risks of human rights violations, especially in artisanal and small-scale operations where regulatory standards are weak and health care or compensation in the event of an accident are often non-existent. Increased commitments to environmental, social, and governance (ESG) standards along the entire value chain can improve safety and labour conditions. Efforts to recycle these materials are also increasing and further mechanisation of mining processes may reduce the need for unskilled miners. Automation can also enable remote mining operations from offices, greatly improving safety, while employing less labour.

Improving energy employment data provides a foundation for better energy and labour policy

Improved energy employment data provides an important basis for estimating how energy policies affect workers and a foundation for assessing both the potential risks of labour shortages as well as the growing needs for education and skilling. National labour statistics are typically structured based on codes consistent with the International Standard Industry Classification (ISIC) system. As shown in the International Recommendations for Energy Statistics, ISIC codes align well with traditional energy industries, but do not map directly onto emerging energy industries such as solar and wind. Furthermore, many jobs impacted upstream by changing dynamics in energy production are not listed within a single code, but rather separately accounted for under general codes like manufacturing or construction.

One way to systematically improve energy employment data is to create new codes specific to emerging energy segments. For instance, in June 2022, the Chinese Ministry of Human Resources and Social Security updated its occupation classification scheme to include new categories for jobs related to the green economy, such as carbon sink assessors and integrated energy service workers.

Codes have also been added in the United States to achieve a holistic and consistent view of energy jobs across emerging technologies. Additionally, the US government administers a survey that cuts across industry classifications. This survey yields the United States Energy and Employment Report (USEER), one of the earliest resources which provides annual national accounting for energy jobs and wages.

These surveys are expensive to administer, but have a track record of securing funding in different countries. For example, there are ongoing efforts in the Australian government to establish a granular energy labour report, to be completed in June 2023. These surveys enable accurate projections necessary for governments and training providers to design adequate workforce development programmes, and to ensure that labour shortages do not hinder clean energy deployment. Survey outcomes are also useful for companies tendering projects as well as local policy makers assessing ex-post how their spending supported job creation in their communities.

Beyond establishing a baseline on employment, data on wages and labour cost, skilling needs, and demographics also help to enhance decision making for key energy stakeholders. This data informs master plans for skilling and education within energy and labour ministries, and helps to assess the impacts of diversity and inclusion initiatives. It also contributes to the good design of just transition plans, including appropriate worker support and compensation.

While this report provides many of the above-mentioned data points, it is not a substitute for better data collection, especially when it comes to subnational data. Enhancing these data foundations can be a near-term priority for policy makers looking to take concrete steps related to advancing people-centred energy transitions.

Next steps

As part of our continued efforts to inform governments and other stakeholders in their design of energy policies and their understanding of the human impact of these policies, the IEA will publish forward-looking projections on energy employment by scenario over the next decade in the *World Energy Outlook 2022*. The projections will show the expected magnitude of changes in energy sector employment as an increasing number of countries commit to net zero emissions targets and as energy value chains shift in response to major disruptions such as the Covid-19 pandemic and Russia's invasion of Ukraine.

Additionally, the IEA aims to update this assessment of energy employment annually to continue to provide a baseline for understanding how global energy employment is shifting over time. As we continue to develop this area of work, we welcome suggestions and collaboration. Please direct inquiries to weo@iea.org.

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Annexes

Methodology

Modelling is based on IEA's energy balances as well as energy investment data, and calibrated based on a rich collection of employment data in the 2010s from the following sources:

- National statistics for all major countries
- International Labour Organization (ILO) employment databases
- United Nations Industrial Development Organization (UNIDO) IndStat and MinStat databases
- Reports by international organisations and industry associations
- Academic literature
- Annual reports of major companies in each sector
- Company interviews

The employment numbers in this report represent our best estimates of employment across the energy sector based on currently available data. They are published to help governments and other stakeholders to understand the magnitude of the impacts of energy policy and investment on workers, but given the uncertainty that exists, they are clearly not the last word. We aim to update our estimates as new and improved data become available.

Where data was missing for certain years, energy subsectors, or countries, employment multipliers were applied based on the corresponding volumes and investment values in IEA energy balances. Regional multipliers were constructed based on wage differences. The steps included:

- **Identifying the cost contribution breakdown** for USD 1 million spent on new projects or products for regions with existing multipliers (e.g. 10% labour, 50% materials, 10% equipment costs). These breakdowns were derived using detailed manufacturer surveys, primarily from the US Annual Survey of Manufacturers data which provide information on the contribution to costs of average wages, labour and materials. Industry evaluation was used to confirm breakdowns or provide more granular detail for specific technology types.
- **Adapting the cost contribution breakdown** to each region, taking specific account of how differences in wages and material costs shift the relative shares of labour and material. Average wages and basic material costs were indexed on the basis of US costs, and these were applied to the labour and material costs for a USD 1 million project or purchase to calculate how much that same purchase would cost to produce in a low-wage economy. We utilised local wages, average cost differential of input materials, share of imports in production and the costs of those imports to arrive at adjusted cost contribution breakdowns for various regions.
- **Finding average wages for relevant jobs** in a region by using national average salary information specific to a subsector. Where information on wages specific to a subsector was not available, average wages from salary reporting websites were used, splitting the labour costs to distinguish between those associated with production and manufacturing and those associated with overheads (e.g. research and development, procurement and marketing).
- **Calculating jobs per million dollars for the expenditure** by dividing the portion spent on salaries by average salaries. The indirect multiplier for advanced economies was used as a basis for

indirect jobs, and the rectification multiplier for each country was applied to calculate indirect jobs.

The final employment multipliers were integrated with the World Energy Model by applying the multipliers to the appropriate sector and regional investments.

Definition and scope of employment

The definitions used in this report are:

- **Direct**: Jobs created to deliver a final project or product. These are counted in this report.
- **Indirect**: Supply chain jobs created to provide inputs to a final project or product. Only inputs that are predominantly demanded by the energy industry are counted in this report.
- **Induced**: Jobs created by wages earned from the energy sector and spent in other parts of the economy, thereby creating additional jobs. These jobs are not counted in this report.

In this report's accounting, employment encompasses all direct jobs and the indirect jobs from suppliers providing immediate inputs to the sector considered. Induced jobs are not included. This sets a clear boundary around the jobs that the upfront investment would pay for to deliver the project.

Jobs are normalised to full-time equivalent (FTE) employment for consistent accounting. An FTE job represents one person's work for one year at regulated norms (e.g. 40 hours a week for 52 weeks a year, excluding holidays). Where data is available for hours worked, we calculate part-time workers with a proportion. Otherwise part-time employment is assumed as 0.5 FTE.

Employment numbers include informal workers, with the hope that our numbers reflect the scope of energy policy impact more completely. In alignment with ILO definitions, informal workers comprise own-account workers and all those employed in informal sector enterprises; contributing family workers; employees holding informal jobs; members of informal producers' cooperatives; and own-account workers engaged in the production of goods exclusively for own final use by their own household. Estimates are based on a literature review of informality rates by region and sector.

This report does not address employment in the following energy sectors, among others, which will be covered in forthcoming reports:

- Coal transformation for blast furnaces and coke ovens
- Fossil fuel downstream distribution, for example workers in petrol stations and workers in gas utilities
- Uranium mining and processing for nuclear power
- End-use renewables such as geothermal or solar heating for buildings or biomass boilers
- Efficiency jobs related to appliances and lighting in buildings
- Manufacturing of non-road vehicles, as well as the servicing and maintenance of vehicles

Economic sectors

Employment in this report is presented not only by energy sectors, but also by economic sectors (as defined by the ISIC Revision 4 classification system), with significant numbers of workers in the following sectors:

- Agriculture (code A), in particular for bioenergy production
- Mining and quarrying (code B)
- Manufacturing (code C)
- Electricity, gas, steam, and air conditioning supply (code D)
- Construction (code F)
- Wholesale and retail trade (code G)
- Transportation and storage (code H)
- Professional, scientific, and technical activities (code M)

Throughout the report, the economic sectors are aggregated to five groupings for simplicity:

- Raw materials (codes A and B)
- Manufacturing (code C)
- Construction (code F)
- Professionals and utilities (code D and M)
- Wholesale and transport (codes G and H)

Sample of ISIC codes referenced in employment modelling[1]

Code	Name
0510	Mining of hard coal
0520	Mining of lignite
0610	Extraction of crude petroleum
0620	Extraction of natural gas
0892	Extraction of peat
0910	Support activities for petroleum and natural gas extraction
1920	Manufacture of refined petroleum products
2710	Manufacture of electric motors, generators, transformers and electricity distribution and control apparatus
2720	Manufacture of batteries and accumulators
2731	Manufacture of fibre optic cables
2732	Manufacture of other electronic and electric wires and cables
2733	Manufacture of wiring devices
2815	Manufacture of ovens, furnaces and furnace burners
2824	Manufacture of machinery for mining, quarrying and construction
2910	Manufacture of motor vehicles
2920	Manufacture of bodies for motor vehicles; manufacture of trailers and semi-trailers
2930	Manufacture of parts and accessories for motor vehicles
3510	Electric power generation, transmission and distribution
4321	Electrical installation
4322	Plumbing, heat and air conditioning installation
4661	Wholesale of solid, liquid and gaseous fuels and related products
4930	Transport via pipeline

[1] While some of the codes listed correspond in scope directly to their respective energy subsectors, others are referenced with the understanding that only a subset of the employees enumerated under these ISIC codes work on energy infrastructure and value chains.

Glossary

Clean energy: In power, clean energy includes generation from renewable sources, nuclear and fossil fuels fitted with CCUS; battery storage; and electricity grids. In efficiency, clean energy includes energy efficiency in buildings, industry and transport, excluding aviation bunkers and domestic navigation. In end-use applications, clean energy includes direct use of renewables; electric vehicles; electrification in buildings, industry and international marine transport; use of hydrogen and hydrogen-based fuels; CCUS in industry and direct air capture. In fuel supply, clean energy includes low emissions fuels liquid biofuels and biogases, low-carbon hydrogen and hydrogen-based fuels.

Fossil fuels: Include coal, natural gas, oil and peat.

Informal employment: Includes all remunerative work (employees, self-employed workers) that is not registered, regulated or protected by existing legal or regulatory frameworks, as well as non-remunerative work undertaken in an income-producing enterprise in accordance with guidelines concerning a statistical definition of informal employment by the 17th International Conference of Labour Statisticians.

Labour force: All individuals who fulfil the requirements for inclusion among the employed or the unemployed. The employed are defined as those who work for pay or profit for at least one hour a week. The unemployed are defined as people without work but actively seeking employment and currently available to start work.

Economic sectors

Construction: Refers to economic activities related to both general construction and specialised construction activities for buildings and civil engineering works; in alignment with ISIC Rev.4 section F. This includes electrical contractors.

Economic sectors: Refers to industry groupings such as mining and quarrying, manufacturing and construction, which are categorised in accordance with Revision 4 of the International Standard Industrial Classification of All Economic Activities (ISIC Rev.4) – the international reference classification of productive activities.

Manufacturing: Economic activities related to the physical or chemical transformation of materials, substances, or components into new products; in alignment with ISIC Rev.4 section C.

Mining: Economic activities related to the extraction of minerals occurring naturally as solids (coal and ores), liquids (petroleum) or gases (natural gas), as well as the supplementary activities aimed at preparing the crude materials for marketing; in alignment with ISIC Rev.4 section B named “Mining and quarrying.”

Professionals: Economic activities related to specialised services including legal and accounting, activities in head offices and management consulting, architecture and engineering, scientific research and development, advertising and market research, etc.; in alignment with ISIC Rev.4 section M titled “Professional, scientific and technical activities.”

Utilities: Economic activities related to the operation of electric and gas utilities, which generate, control and distribute electric power or gas; in alignment with ISIC Rev.4 section D that is named "Electricity, gas, steam and air conditioning supply."

Wholesale: Economic activities related to wholesale and retail sale (i.e. sale without transformation) of any type of goods and the rendering of services incidental to the sale of these goods; in alignment with ISIC Rev.4 section G, named "Wholesale and retail trade; repair of motor vehicles and motorcycles."

Regional groupings

Advanced economies: Australia, Austria, Belgium, Bulgaria, Canada, Chile, Colombia, Costa Rica, Croatia, Cyprus[1,2], Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Malta, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States.

Africa: Algeria, Angola, Benin, Botswana, Cameroon, Côte d'Ivoire, Democratic Republic of the Congo, Egypt, Eritrea, Ethiopia, Gabon, Ghana, Kenya, Libya, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Tunisia, Republic of the Congo (Congo), Senegal, South Africa, South Sudan, Sudan, United Republic of Tanzania (Tanzania), Togo, Zambia, Zimbabwe and other African countries and territories.

Asia Pacific: Australia, Bangladesh, Brunei Darussalam, Cambodia, Chinese Taipei, Democratic People's Republic of Korea (North Korea), India, Indonesia, Japan, Korea, Lao People's Democratic Republic (Lao PDR), Malaysia, Mongolia, Myanmar, Nepal, New Zealand, Pakistan, People's Republic of China (China), Philippines, Singapore, Sri Lanka, Thailand, Viet Nam and other Asia Pacific countries and territories.

Central and South America (C and S America): Argentina, Plurinational State of Bolivia (Bolivia), Brazil, Chile, Colombia, Costa Rica, Cuba, Curaçao, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Jamaica, Nicaragua, Panama, Paraguay, Peru, Suriname, Trinidad and Tobago, Uruguay, Bolivarian Republic of Venezuela (Venezuela), and other Central and South American countries and territories.

China: Includes the (People's Republic of) China and Hong Kong, China.

Emerging market and developing economies (EMDEs): All countries not included in the advanced economies regional grouping.

Eurasia: Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Russian Federation (Russia), Tajikistan, Turkmenistan and Uzbekistan.

Europe: Albania, Austria, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus[1,2], Czech Republic, Denmark, Estonia, Finland, France, Germany, Gibraltar, Greece, Hungary, Iceland, Ireland, Israel, Italy, Kosovo, Latvia, Lithuania, Luxembourg, Malta, Montenegro, Netherlands, North Macedonia, Norway, Poland, Portugal, Romania, Serbia, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Republic of Moldova, Republic of Türkiye (Türkiye), Ukraine and United Kingdom.

North America: Canada, Mexico and United States.

Middle East: Bahrain, Islamic Republic of Iran (Iran), Iraq, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syrian Arab Republic (Syria), United Arab Emirates and Yemen.

[1] Note by Republic of Türkiye: The information in this document with reference to "Cyprus" relates to the southern part of the island. There is no single authority representing both Turkish and Greek Cypriot people on the island. Türkiye recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Türkiye shall preserve its position concerning the "Cyprus issue".

[2] Note by all the European Union Member States of the OECD and the European Union: The Republic of Cyprus is recognised by all members of the United Nations with the exception of Türkiye. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

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