



Developing a Global Energy Efficiency Workforce in the Buildings Sector

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Abstract

At COP28, all countries committed to work together to collectively double the global average annual rate of energy efficiency improvements. They also recognised the role of energy efficiency as the “first fuel” in the clean energy transition. Implementing this global target, will require a skilled workforce. In the Net Zero Emissions by 2050 Scenario, the growth of the energy efficiency workforce will be led by the building sector, which will create 1.3 million jobs over the next six years. Yet many countries face labour shortages for key energy efficiency occupations. This practical guide pilots an approach to help policymakers identify the key energy efficiency jobs and skills in the buildings sector. IEA analysis finds that training workers for occupations addressing building insulation, the installation and repair of efficient cooling, heating, ventilation and refrigeration devices (HVAC/R) and windows can address the largest drivers of building energy demand across climates. Those occupations are insulation workers, building and construction inspectors (energy auditors), HVAC/R mechanics and installers and glaziers. Training a range of professionals including construction workers, electricians and workers who will design buildings with improved energy efficiency from the outset will also be vital to achieve global energy efficiency targets. These workers will require different types and lengths of training. Involving policymakers, employers, trade unions and other stakeholders is vital to coordinate the alignment between those training requirements and the jobs and skills that will be relevant and provide energy efficiency workers with decent jobs and wages through formal and inclusive pathways.

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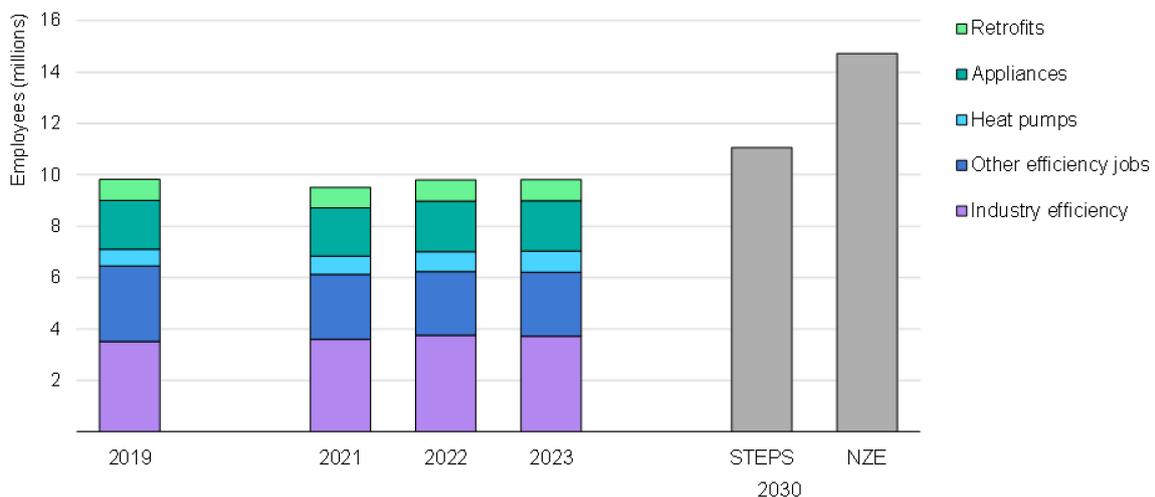
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Introduction

Building operation accounts for 30% of global final energy consumption and 26% of carbon emissions globally, making increasing the energy efficiency of buildings a vital step in combatting climate change (IEA, 2024a). The significant role of building efficiency in reducing global carbon emissions will be a major driver of job growth in the coming years. In the IEA Net Zero Emissions by 2050 scenario, global annual retrofit rates double and energy intensity progress quadruples between 2022 and 2030 (IEA, 2023b). In this scenario, building retrofits alone are responsible for the creation of an additional 1.3 million jobs by the end of the decade – leading growth amongst all other energy efficiency occupations (IEA, 2024d). As demand grows across energy efficiency occupations, a trained workforce will be necessary to take on these jobs. Responding to this labour demand requires investment and planning to ensure there are adequate training programmes that meet job demand within countries’ energy efficiency sectors. For governments, job creation in buildings is an opportunity to provide millions of workers with decent jobs. Creation of decent jobs in turn provides the conditions necessary to reliably attract, retain, grow and sustain a sufficiently skilled and productive workforce and industry.

Employment in end-use efficiency by sub-sector and scenario, 2019-2030



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Notes: End-use efficiency employment includes manufacturing. STEPS = Stated Policies Scenario, NZE = Net Zero Emissions by 2050 Scenario.

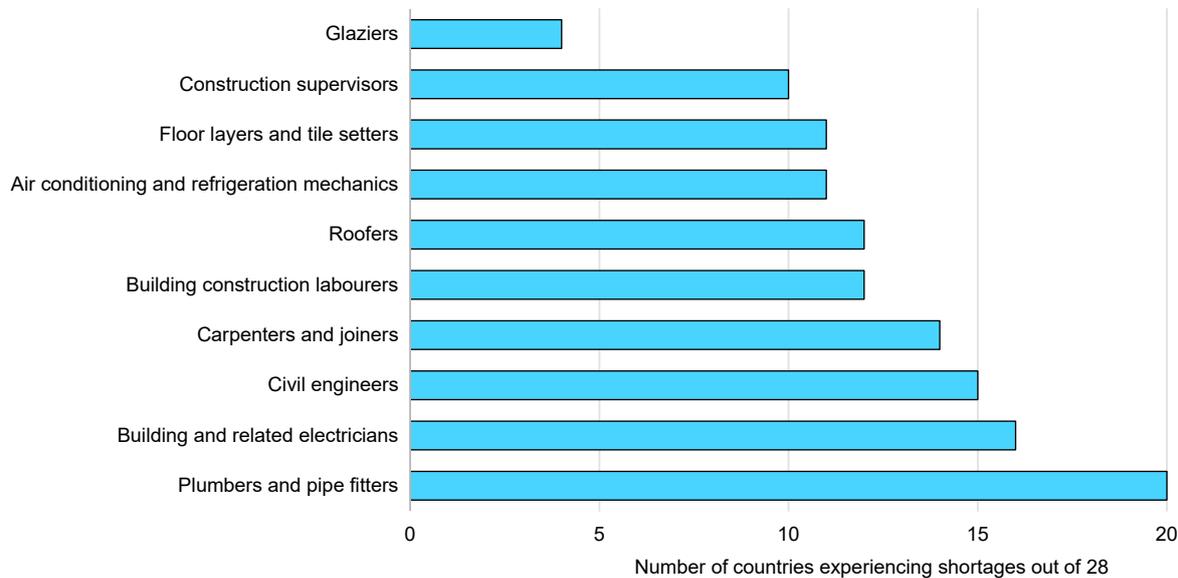
Source: IEA analysis based on IEA (2024) World Energy Employment 2024, (forthcoming).

Energy efficiency employment spans a large range of occupations, including in the buildings sector. Today, around 10 million workers are employed in energy

efficiency occupations including in industry efficiency, building retrofits, appliances and heat pumps (IEA, 2024d). Like the energy efficiency sector more broadly, the buildings sector relies on both energy efficiency specialised workers such as heating, ventilation, air conditioning and refrigeration (HVAC/R) installers and mechanics and more generally trained workers including construction workers and electricians. Given the broad scope of occupations needed across the building efficiency value chain, workforce training will need to encompass a range of skills and sub-sectors. In some countries, training for these skilled trades is supported by longstanding union, industry, or joint training and apprenticeship infrastructure that can play a key role in meeting training needs and creating more inclusive access to energy efficiency jobs.

Energy efficiency jobs in the buildings sector are experiencing significant shortages, especially for installation and repair workers. This includes workers in construction, electricians, plumbers and HVAC/R technicians, especially those with energy efficiency training. In the United States, although this share has gone down nearly 10% from the previous year, 83% of energy efficiency employers report at least some hiring difficulty in 2023 ([United States Department of Energy](#), 2024). While countries experience different levels of shortages for different workers, a 2023 IEA survey of over 160 companies finds that installation and repair workers are the most challenging segment to hire across sectors due to a lack of industry-specific knowledge. The skills gap in the clean energy sector is directly affecting business, like in Brazil where it is reported to constrain labour productivity and firm growth ([The World Bank](#), 2015; [The World Bank](#), 2023). In the European Union, most countries report shortages in key occupations related to energy efficiency in the buildings sector including plumbers and pipe fitters, electricians, construction workers and more specialised occupations such as roofers, HVAC/R mechanics and glaziers ([EUROpean Employment Services](#), 2023). Although occupations related to the design of new builds are briefly mentioned, this paper focuses on the jobs that can directly support the renovation of existing buildings. It therefore also excludes jobs related to the manufacture of building parts and equipment.

Number of countries experiencing shortages for key energy efficiency occupations in the European Union, 2023



IEA. CC BY 4.0.

Source: European Commission (2024), [Labour shortages and surplus in Europe](#) (accessed September 2024).

Identifying where the demand for jobs will be and what skills will be required is fundamental to respond to labour shortages and develop a skilled energy efficiency workforce. Wages, working conditions, and job security must also be sufficient to retain appropriately skilled workers. As energy efficiency spans a large range of occupations, understanding where to start can be a challenge. This paper pilots an approach to help governments prioritise workforce training investments by looking at key energy efficiency occupations across climate zones. Governments can accelerate energy efficiency progress by identifying key energy efficiency occupations based on climate, understanding the training and wage implications of these interventions, building or expanding educational and training pathways to support careers in these occupations, and formalising and diversifying the building efficiency sector. In this paper, the strategic considerations include:

- 1. Identifying the key occupations and skills needed for each occupation within climate zones.** The climate zone in which a building is located is a significant factor in determining the amount of energy needed to heat or cool it. The measures that will most effectively reduce building energy use in a given climate zone can be associated with the specific occupations needed to implement them. Identifying these occupations helps direct investments in workforce development programmes to target the most relevant skills to quickly achieve energy efficiency gains.
- 2. Planning to ensure education and training opportunities are in place.** Providing quality primary education and opportunities for vocational education

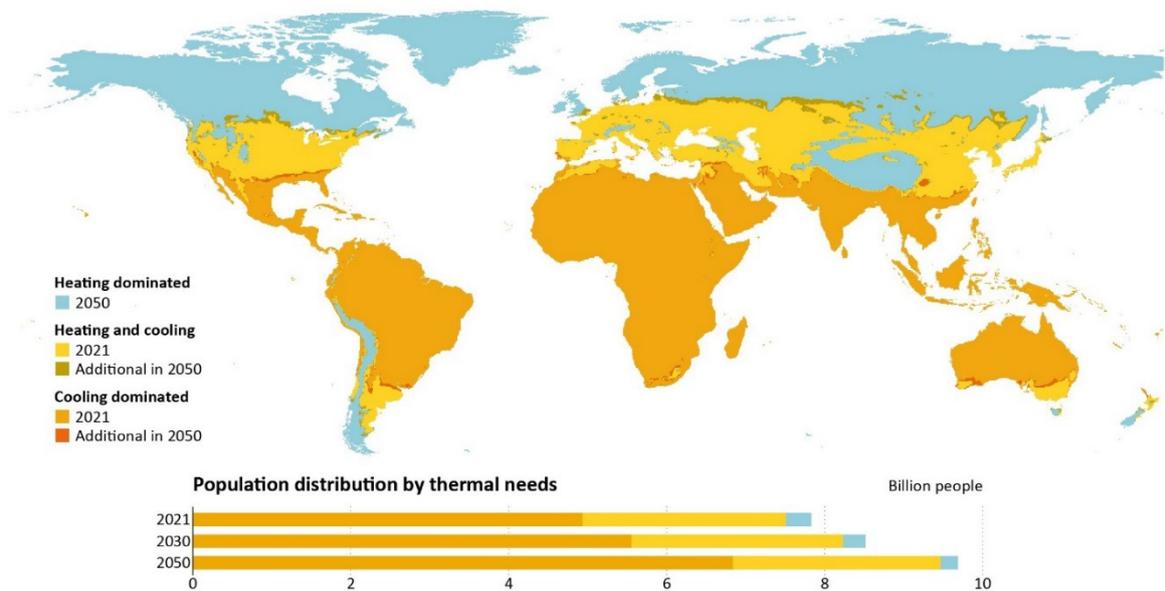
and training (VET) and lifelong learning and training opportunities are key to equipping the energy efficiency workforce with the necessary skills and foster career mobility across sectors and geographies. Working directly with employers and labour unions carrying out energy efficiency activities and training to revise and supplement curricula can ensure that training includes in-demand skills and the specific knowledge needed to install and maintain energy efficient technologies. It can also deliver mechanisms for ongoing upskilling, and a focus on transferable skills that allow workers to build long-term careers and continue to support the industry as technology changes.

- 3. Enhancing the workforce through formal and inclusive training and career pathways to deliver fair outcomes.** Ensuring that all segments of the population have access to training opportunities is the next essential step to build a robust and qualified workforce. Formal and inclusive training pathways and employment opportunities are central to building a diverse, equitable and cohesive workforce.

Identifying key building energy efficiency occupations

The heating and cooling needs of buildings and the associated energy demand varies based on climate. This suggests that some energy efficiency interventions and technologies will generate quicker and more prominent gains than others depending on the respective climates. This section lays out four key energy efficiency occupations that are needed across different climate regions, identifying how specific climates impact the skills needed, and therefore the training, within each occupation.

Heating and cooling needs by region in the STEPS, 2021 and 2050



IEA. CC BY 4.0.

Notes: Heating and cooling refer to areas where HDDs calculated with base temperature 18 °C HDD (18 °C) are greater or equal than 1 000 (°C days) and cooling degree days (CDDs) calculated with base temperature 10 °C CDD (10 °C) are greater or equal than 1 000 (°C days). For further information on the indicator see IEA (2020a) and for further information on HDDs and CDDs see IEA (2022b). STEPS = Stated Policies Scenario.

Source: IEA (2022), [The Future of Heat Pumps](#).

Key energy efficiency interventions are broadly similar across climates. The types of skills needed to implement these measures can also be quite similar, but the technologies themselves and their composition may vary depending on the climate. Prioritising workforce training for occupations that provide significant

improvement in building energy performance in respective climate zones, can help governments target their investments and accelerate the impact of their energy efficiency workforce.

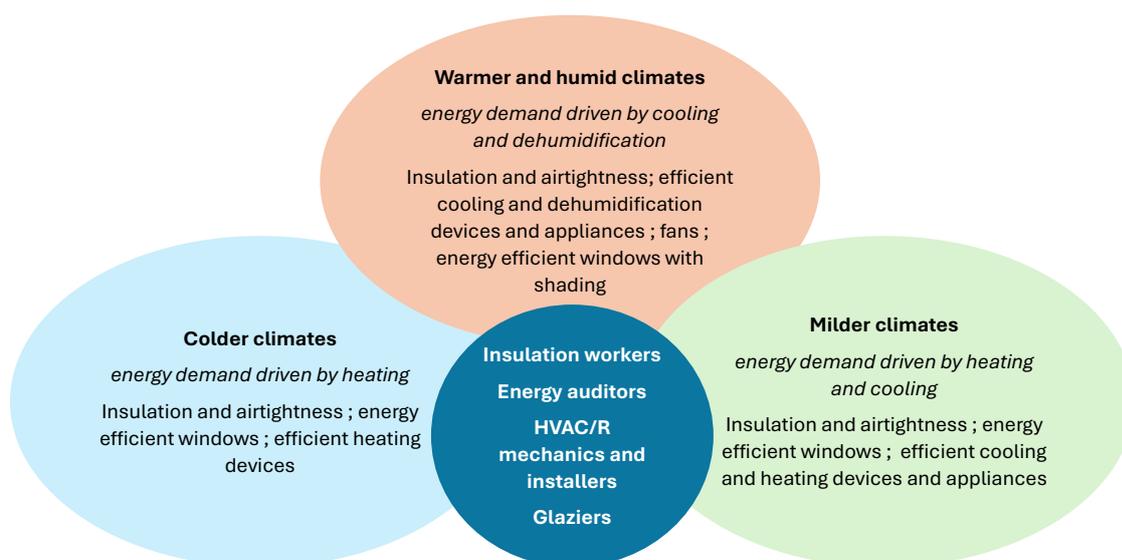
In colder climates where building energy demand is largely driven by heating needs, buildings that are well insulated, airtight and equipped with efficient heating devices and energy efficient windows are key to limit energy demand. This means that training workers, including insulation workers and construction and building inspectors (energy auditors), who can spot infiltration points in homes and correctly insulate those spaces are most important. In addition, glaziers install new double or triple-glazed windows to keep the heat in, help to insulate windows and improve air sealing to reduce building heat loss. HVAC/R mechanics and installers are also important in these climates as they will be needed to install efficient heating systems, such as heat pumps.

In warmer climates where energy demand is driven by cooling needs, buildings that are well insulated, improve dehumidification and are equipped with efficient cooling devices and energy efficient windows with shading can reduce energy demand. In these climates, glaziers who can install energy efficient windows to keep the heat out and improve air sealing and HVAC/R workers installing efficient cooling can address the main drivers of energy demand. Installing efficient HVAC/R equipment and other appliances will also be key to reducing energy demand that results from indoor heat gains by refrigerators, cookstoves and ovens.

In milder climates where energy demand is driven both by the need to cool and heat buildings, insulation, energy efficient equipment and energy efficient windows will all be key to reduce building energy demand. HVAC/R mechanics and installers, glaziers and insulation workers are all required to perform a mix of tasks and duties to address these issues in both the colder and warmer climates.

Across different climates, HVAC/R installers and mechanics, insulation workers, glaziers and construction and building inspectors are top priority occupations. The activities carried out by these workers will have to be complemented by support from the broader energy efficiency workforce.

Key energy efficiency measures and occupations across climate zones



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Although a given occupation will require a similar skill base across geographies, workers may need to perform specific tasks depending on the climate zone where they are based. Workers will need regionally specific knowledge as well as awareness about local building codes or safety requirements, handling practices for refrigerant, and other locally specific factors. This locally specific expertise highlights the important role that existing employers and industry associations can play in developing and supporting locally specific training programmes.

HVAC/R mechanics and installers

Occupation and Description	Detailed work and energy efficiency tasks	Climate specific tasks
<p>Heating, Air Conditioning, and Refrigeration (HVAC/R) mechanics and installers install or repair heating, central air conditioning or refrigeration systems, including oil burners, hot-air furnaces, and heating stoves.</p> <p>Specific work activities for HVAC/R mechanics and installers include testing electrical circuits, determining operation compliance, interpreting blueprints, conferring with customers and installation of equipment.</p>	<p>Install HVAC equipment and connect heating or air conditioning equipment to fuel, water, or refrigerant source to form complete circuit.</p> <p>Install or repair self-contained ground source heat pumps or hybrid ground or air source heat pumps to minimise carbon-based energy consumption and reduce carbon emissions.</p> <p>Adjust equipment to ensure optimal performance. Install, connect, or adjust thermostats, humidistats, or timers.</p> <p>Test electrical circuits or components for proper functioning.</p> <p>Service HVAC systems or components and repair worn, damaged, or defective mechanical parts. Braze or solder parts to repair defective joints and leaks.</p> <p>Determine operational compliance with regulations or standards.</p> <p><i>Additional tasks include performing mechanical overhauls and working with flammable or environmentally hazardous refrigerants and retrieving used refrigerant in a safe and leak-free manner upon decommissioning of systems; inspecting systems to determine if they are operating properly; conferring with customers or users to assess problems; interpreting blueprints, specifications, or diagrams to inform installation, development or operation activities and advising on installation, repairs and equipment design.</i></p>	<p>In all climates, HVAC/R workers will install air or ground source heat pumps that can heat buildings efficiently. HVAC/R mechanics and installers will have to know how to appropriately calculate cooling load and size heat pump systems accordingly to ensure maximum comfort among building inhabitants.</p> <p>In warmer climates with high levels of humidity, HVAC/R mechanics and installers also ensure that efficient cooling can take place and external air cannot infiltrate gaps, walls, and ducts. In places where HVAC/R workers are required to replace gas and oil boilers with heat pumps, they will have to understand the specifics behind how heat pumps work which mobilises skills traditionally associated with air conditioning devices. Workers will have to know how to appropriately size heat pumps with the volume of space that needs to be cooled, and how to address high levels of humidity.</p>

Insulation workers

Occupation and Description	Detailed work and energy efficiency tasks	Climate specific tasks
<p>Insulation workers apply insulating materials to walls and other building structures, pipes or ductwork, or other mechanical systems to help control and maintain temperature.</p> <p>Specific work activities for insulation workers include cutting materials like carpet or vinyl, measurement of materials for installation, and installation of insulation in equipment or structures.</p>	<p>Select appropriate insulation, such as fibreglass, styrofoam, or cork, based on the heat retaining or excluding characteristics of the material. Select construction materials considering properties such as insulating performance, environmental impact and flammability.</p> <p>Measure materials or objects for installation or assembly. Measure and cut insulation for covering surfaces, using tape measures, handsaws, power saws, knives, or scissors. Cut carpet, vinyl or other flexible materials.</p> <p>Prepare surfaces for insulation application by brushing or spreading on adhesives, cement, or asphalt, or by attaching metal pins to surfaces.</p> <p>Remove worn, damaged or outdated materials and install insulation in equipment or structures.</p> <p>Apply sealants or other protective coatings. Apply adhesives to construction materials.</p> <p>Prepare surfaces for finishing. Cover, seal, or finish insulated surfaces or access holes with plastic covers, canvas strips, sealants, tape, cement, or asphalt mastic.</p> <p><i>Additional tasks include reviewing blueprints or specifications to determine work requirements; loading materials into construction equipment; distributing insulating materials evenly into small spaces within floors, ceilings, or walls, using blowers and hose attachments or cement mortar.</i></p>	<p>In colder climates, insulation workers are primarily responsible for addressing infiltration and heat loss through walls, windows, and ducts, which is a main driver of heat loss.</p> <p>In warmer climates, insulation workers will address heat entry points through ducts, infiltration, and walls. Where humidity levels are high, insulation workers will also have to utilise insulation suited to higher moisture levels.</p> <p>In milder climates, insulation workers will be needed to prevent direct air flow into buildings and insulate walls.</p>

Glaziers

Occupation and Description	Detailed work and energy efficiency tasks	Climate specific tasks
<p>Glaziers install glass in windows, skylights, store fronts, display cases, and on surfaces, such as building fronts, interior walls, ceilings, and tabletops</p> <p>Glaziers are also important for installing windows that prevent conduction and heat loss. For glaziers, activities include reviewing blueprints and specification to determine work requirements, aligning structures, and installation of metal and wooden components like doors or windows</p>	<p>Read and interpret blueprints or specifications to determine size, shape, colour, type, or thickness of glass, location of framing, installation procedures, or staging or scaffolding materials required.</p> <p>Select the type or colour of glass or mirror according to specifications.</p> <p>Fabricate parts or components. Cut glass.</p> <p>Determine plumb of walls or ceilings, using plumb lines and levels. Verify alignment of structures or equipment.</p> <p>Measure, cut, fit, and press anti-glare adhesive film to glass or spray glass with tinting solution to prevent light glare.</p> <p>Install metal structural components, wooden structural components, doors or windows.</p> <p><i>Additional tasks include reviewing blueprints or specifications to determine work requirements; driving trucks or truck-mounted equipment; loading or unloading materials used in construction or extraction; operating cranes or hoists with suction cups to lift large, heavy pieces of glass or other moving or lifting equipment.</i></p>	<p>In colder climates, glaziers examine windows and window frames to minimise conduction of windows and prevent heat from leaving buildings.</p> <p>In warmer climates, glaziers are needed to install solar-blocking windows with UV protection and shading to keep the heat out. Where humidity levels are high, installing windows that can block both solar radiation from heating buildings and conduction from cooling buildings is important. Glaziers need to know the range of solar radiation blocking materials available to building owners in the form of new windows as well as additive films or other products that can be attached to existing windows.</p> <p>In milder climates, glaziers will remedy windows and window frames that fail to retain heat within the building.</p>

Construction and building inspectors (energy auditors)

Occupation and Description	Detailed work and energy efficiency tasks	Climate specific tasks
<p>Construction and building inspectors inspect structures using engineering skills to determine structural soundness and compliance with specifications, building codes, and other regulations.</p> <p>Inspections may be general in nature or limited to a specific area, such as electrical systems or plumbing.</p>	<p>Conduct energy audits to examine primary points of building energy loss.</p> <p>Evaluate construction projects to determine compliance with external standards or regulations and technical specifications.</p> <p>Review blueprints or specifications to determine work requirements and review and interpret plans, blueprints, site layouts, specifications, or construction methods to ensure compliance to legal requirements and safety regulations.</p> <p>Monitor construction operations including installation of plumbing, wiring, equipment, or appliances to ensure that installation is performed properly and in compliance with applicable regulations. Inspect completed work.</p> <p>Conduct inspections, using survey instruments, metering devices, measures, or test equipment. Inspect plumbing systems or fixtures and test electrical equipment or systems to ensure proper functioning.</p> <p>Inspect work sites to identify potential environmental or safety hazards.</p> <p><i>Additional tasks include recording operational or environmental data; authorising construction activities; estimating cost of necessary renovations or upgrades.</i></p>	<p>In colder climates, construction and building inspectors are workers who conduct energy audits and can identify places within homes where air infiltration, conduction, or other energy losses are occurring.</p> <p>In warmer climates, construction and building inspectors examine buildings for windows failing to block solar radiation and ducts, gaps, and walls that allow for entry of outside air. Where humidity levels are high, these workers will examine buildings for moisture control as well as heat gains through windows, ducts, infiltration, and walls.</p> <p>In milder climates, construction and building inspectors will analyse buildings for points of entry for outside air and moisture.</p>

In addition to workers with energy efficiency specific occupations, workers with broad skills in construction, electrical works and plumbing will be essential to support the implementation of energy efficiency measures. This includes workers who can support construction and installation work; work with electrical wiring (particularly for higher voltage systems) and install and maintain efficient water heating and steam-involved systems. These workers will also require some to medium levels of training and are currently experiencing significant shortages globally.

The occupations related to the design and renovation of buildings and energy efficient appliances, including architects and engineers, will also be key to limit new and existing buildings’ emissions reduce energy use and long-term operational costs. These professions tend to require considerable to extensive levels of training. In advanced economies such as in the European Union, these occupations will be key to achieve ambitious net zero plans to decarbonise the building stock by 2050 and exclusively allow the construction of new buildings that are net zero from 2030 ([European Council](#), 2024). In emerging and developing economies – where the floor area is set to grow by 80% between 2023 and 2030 – whether professionals in charge of designing new builds are equipped with energy efficiency training will have significant implications for the energy intensity of the buildings sector globally ([IEA](#), b, 2023).

Key components of the energy efficiency workforce by training requirement in the buildings sector

Some preparation (At least several months to 1 year of training)	Medium preparation (At least 1 to 2 years of training)	Considerable to extensive preparation (At least 2 years of training)
<ul style="list-style-type: none"> Construction workers and carpenters Glaziers Insulation workers Roofers 	<ul style="list-style-type: none"> Construction and building inspectors (incl. Energy auditors) Electricians Facilities managers HVAC/R mechanics and installers Plumbers, pipefitters and steamfitters Administrative workers 	<ul style="list-style-type: none"> Construction managers Engineers (electrical, civil, industrial etc.) Architects Managers (incl. general and operations managers and others)

Note: The ‘some preparation’ category refers to occupations requiring a high school diploma, and at least a few months to a year of related experience. The ‘medium preparation’ category refers to occupations requiring vocational education training, on the job experience or an undergraduate degree. Generally, these occupations require one or two years of formal on the job training and informal training with experienced workers. The ‘considerable to extensive occupations’ category refers to occupations that generally require a bachelor’s, master’s and/or doctoral degree. The occupations generally require several years of experience and vocational training.

Job definitions and families may vary by context. For example, weatherisation professionals may conduct a range of activities including energy audits or installing HVAC/R devices, which are separated into distinct occupations in the table. Although these distinctions may change, the activities carried out by professionals to improve energy efficiency in buildings remain relatively similar in substance. They are related to the insulation of buildings, installation and maintenance of efficient equipment and window glazing.

Source: O*Net online, [Job zones](#) (accessed September 2024).

Certifications and training for a skilled workforce

A knowledgeable and well-trained energy efficiency workforce is essential to ensure that a nation’s decarbonisation goals can be met. This section examines the general training and workforce systems relevant to energy efficiency activities in countries across the world and highlights good practices for supporting an energy efficiency workforce.

Certifications and training are key to harmonise standards and knowledge requirements within and across countries. Ensuring that energy efficiency workers are equipped with the right tools and knowledge is essential for the success of installations and service provisions. Examples from the United States, the European Union, Brazil and Indonesia show that although the type of training for a given occupation can be similar, certification processes vary by context.

Certification and education requirements by occupation in the United States, the European Union, Brazil and Indonesia

Occupation Title	Country / Region	Certifications and Education*
Electrician	US	In the United States, a job seeker typically attends a federally registered apprenticeship programme provided by unions, community colleges, technical colleges, private or non-profit training or adult education institutions. completing the approved number of hours, which can take two and a half to four years, a trainee can sit for the State Certification Exam if the state has one. Upon passing this exam, an individual is a licensed electrician.
	EU	Most European Union countries require apprenticeship training that results in a certificate of completion. Completed secondary education is preferred, but not necessarily required.
	Brazil	In Brazil, after training in electrical engineering or a related field through vocational education and training, a job seeker may seek a certification through the regional office of the Federal Council of Engineering and Agronomy (Conselho Federal de Engenharia e Agronomia, CONFEA).
	Indonesia	In Indonesia, after completing an electrical engineering VET or related programme, a job seeker may request a competence certification from the Indonesian Professional Certification Authority (Badan Nasional Sertifikasi Profesi) in electrical work.

Occupation Title	Country / Region	Certifications and Education*
Heating, Air Conditioning, and Refrigeration (HVAC/R) Mechanics and Installers	US	In the United States, common pathways into HVAC/R mechanic and installer roles typically entail enrolment in an apprenticeship or secondary educational programme which takes two to four years to complete.
	EU	Most European Union countries give completion certificates to those who complete training through a school or apprenticeships. On the job training is also a pathway. Many European Union countries also look for experience rather than certifications.
	Brazil	In Brazil, a recent graduate of VET might seek out a certification in HVAC/R through the regional office of the Federal Council of Engineering and Agronomy (Conselho Federal de Engenharia e Agronomia, CONFEA).
	Indonesia	In Indonesia, after completing the relevant training through VET, a job seeker might attain a professional certificate in HVAC/R.
Pipelayers, Plumbers, Pipefitters, and Steamfitters	US	In the United States, an apprenticeship or secondary education is a common entry point, but no formal licence is required by technicians if they are supervised by a licensed contractor.
	EU	In the European Union, apprenticeships or vocational training programmes are needed to become plumber/pipefitters in the European Union. Most countries do not require specific certifications but seek experience. Apprenticeships or vocational training will offer completion certifications. Completed secondary education is preferred, but not necessarily required.
Construction workers	US	Construction workers tend to have informal requirements or pathways in the United States. Job seekers are often hired based on prior job site experience, so vocational or technical schools, pre-apprenticeships, apprenticeships, and potentially even some secondary education can be useful in helping candidates distinguish themselves in the hiring process.
	EU	In the European Union, some countries require specific certificates (France, Sweden, Ireland). Most other European Union countries do not require specific certificates favouring apprenticeships or on the job training and experience. Completed secondary education is preferred, but not necessarily required.
Insulation workers	US	In the United States entry-level insulation workers tend to have informal requirements or pathways. Job seekers are often hired based on prior experience, so vocational or technical schools, pre-apprenticeships, apprenticeships, and potentially even some secondary education can be useful in helping candidates distinguish themselves in the hiring process.
	EU	More extensive training is needed to work on commercial buildings compared to residential in most European Union countries. This training is usually an apprenticeship. There are some required safety certifications in Germany and The Netherlands. Completed secondary education is preferred, but not necessarily required.

Occupation Title	Country / Region	Certifications and Education*
Construction and Building Inspectors	US	Certifications are important for energy auditors in the United States. A selection of Building Performance Institute (BPI) and Residential Energy Service Network (RESNET) certifications are common. Additional certifications--such as Certified Energy Manager, Certified Residential Energy Auditor, and Association of Energy Service Professionals can help individuals advance in their careers.
	EU	In the European Union, after obtaining a bachelor's degree, or completing an apprenticeship or postgrad conversion course, a person will need to complete an assessment of professional competence to become a chartered quantity surveyor.
	Brazil	Brazil is still lacking a specific standard for energy audits. The use of international standards is common for larger energy service companies, but the Brazilian Association of Technical Standards (ABNT) developed a methodology that may see broader use.
Glaziers	US	In the United States, entry-level glaziers tend to have informal requirements or pathways. Job seekers are often hired based on prior experience, so vocational or technical schools, pre-apprenticeships, apprenticeships, and potentially even some secondary education can be useful in helping candidates distinguish themselves in the hiring process.
	EU	Residential glaziers in the European Union largely only require experience to work. This experience is mostly obtained through on the job training. Some safety certifications are needed in Germany and Netherlands. Completed secondary education is preferred, but not necessarily required.

Note: * Please note this is an indicative list of typical certifications and training requirements for these roles, not an exhaustive review.

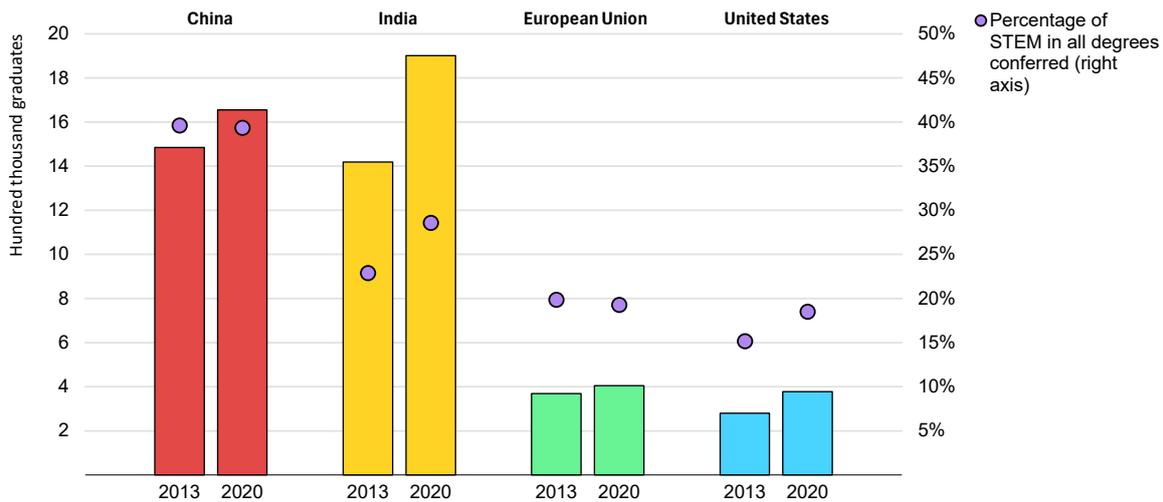
Sources: ILO (2018), [Skills for Green Jobs in Brazil](#); ILO (2019), [Skills for Green Jobs in Indonesia](#); United States Department of Energy (2023), [United States Energy & Employment Report](#); CEDEFOP (2021), [Vocational Education and Training in Europe](#).

Ensuring access to skilling, upskilling and reskilling training opportunities that can provide the workforce with the quickest pathway to a job in the energy efficiency sector is key to achieve the global efficiency improvement targets set over the next six years. This requires both short- and long-term interventions to create clear transition pathways from school to work and enable worker mobility across sectors and geographies ([Cuautle Segovia & Costa Checa](#), 2021).

Bolstering primary education is essential to build the basis of the energy efficiency workforce. The core energy efficiency occupations identified in this white paper are largely trades occupations that require physical labour and the installation or repair of structures or systems, and these workers will need to have foundational reading, writing, and mathematics skills that are established through primary education. Mathematics is particularly important, as being able to calculate electrical loads or convert units is essential for all the primary energy efficiency occupations identified. Higher-paying roles—such as site managers or business owners—can require more advanced mathematics, writing, and reading. Education in science, technology, engineering and mathematics

(STEM) is important to equip workers with solid foundational knowledge that can be built on to adapt to fast-paced innovations and technological changes in the energy field. Over the last decade, the conferral of STEM degrees has been rising in some of the world’s major economies, but the increase is insufficient to keep pace with demand (IEA, 2023c).

Percentage of Science, Technology, Engineering and Mathematics bachelor’s degrees out of all conferred bachelor’s degrees in selected economies



IEA. CC BY 4.0.

Notes: European Union excludes Bulgaria, Croatia, Cyprus, Malta and Romania due to data unavailability. Different data sources may create slight discrepancies in data for the People’s Republic of China.

Source: IEA (2023), [World Energy Employment Report](#).

Other necessary knowledge and skills, which can be acquired through specialised courses, include an understanding of construction sites and building processes; health and safety; familiarity with power tools; ability to carry out physical work and operate within confined spaces; and basic knowledge of electricity and wiring, plumbing, framing, and insulation. Ensuring that vocational and educational training and post-secondary training systems offer adequate and accessible opportunities will be essential for individuals to acquire those foundational skills and the specialised skills related to their specific occupation. Vocational and technical education (VET) is often the entry point for the energy efficiency occupations discussed in this report. Key characteristics of VET include coverage within different levels of education, working in conjunction with academic programming or independently, certification of a formal education level, and inclusion of apprenticeship and workplace learning. Education systems may be school-based, work-based, or a combination. The availability of vocational training opportunities varies by country and energy specialisation.

Lifelong learning and training opportunities are also important, as technological innovations and related shifts may require workers to adapt their skillsets

through time ([ILO](#), 2023b). In a practical example, the knowledge and understanding required of heat pump water heaters and hydronic heat pumps requires a combination of knowledge from two traditionally separate roles; knowledge of heating, ventilation, air conditioning and refrigeration systems (HVAC/R) to understand systems that utilise refrigerants, and experience in plumbing to work with water and piping. The need for flexible learning opportunities also applies for digital skills which are becoming increasingly relevant as digitalisation and automation require workers' familiarity with specialised software that will run calculations ([IEA](#), 2024c).

Policy and stakeholder collaboration plays a critical role in enabling workers to access training that leads to decent jobs. Dialogue with private sector employers, labour unions and other stakeholders improves educational programming, especially apprenticeship curricula, and addresses current labour shortages and skills gaps ([OECD](#), 2022). Public-private partnerships and employer-driven training can respond to changing labour markets and directly train workers for the skills relevant to the jobs they are offering. Without the involvement of employers, there is a risk of workers investing in training without a clear pathway into employment. Targeted policy design is particularly important: policies can help facilitate the match between employers and future employees by assessing gaps in worker availability and skillsets, at the country, regional and city level and can incentivise employers to train workers, contribute to designing educational programmes, or offer more attractive working conditions. In addition, accredited and formal apprenticeships with government, labour unions and private sector participation provides students with hands-on work-based learning and can connect apprentices to careers.

Green Skills & Jobs programme in Portugal

The Green Skills & Jobs programme, part of Portugal's 2030 Energy and Climate Plan, offers a comprehensive approach to vocational training in the energy sector ([Eurofound](#), 2024). The programme provides both short- and medium-term training options to support companies and employees impacted by rising energy costs, and workers at risk of unemployment due to the energy transition. With a budget of EUR 20 million, funded by European Funds and the National Recovery and Resilience Facility, the courses are designed in cooperation with public employment services, trade unions and employers' organisations. They address key areas such as energy efficiency, renewable energy, water efficiency, and sustainable mobility. This initiative helps workers acquire new skills, promotes job retention and creates job opportunities. Notably, the training is available online and in person, ranging from 25 to 350 hours, ensuring flexibility and accessibility. The courses may be complemented with practical training in a work context.

Cohesive coordination across government and other key stakeholders is essential to deliver effective education and training. Providing effective coordination can be particularly challenging in contexts where multiple ministries and local-level governments have their own VET and training initiatives. Some countries have addressed this issue by establishing bodies to coordinate between different institutions that impact education, training and employment.

The National Skill Development Corporation (NSDC) in India

The NSDC, established in 2008 as a non-profit public limited company, operates under the Ministry of Skill Development and Entrepreneurship (MSDE). Its mission is to empower India's youth through skill development (NSDC, 2024). NSDC works to enhance and support private sector participation in vocational training, creating opportunities for skills development across the country. With 49% of its share capital held by the government and 51% by the private sector, NSDC bridges public and private efforts to expand the reach of skill development initiatives. NSDC focuses on facilitating efficient and scalable training models through strategic partnerships with industries, startups, and educational organisations. The NSDC ensures that financial barriers do not limit skills development by providing financial support, including concessional loans and innovative funding products. The organisation also plays a crucial role in setting national skills standards, supporting curriculum development, and ensuring that training initiatives align with industry demands through frameworks like the National Skills Qualification Framework (NSQF). Through these efforts, the NSDC aims to improve the skills of 150 million people, empowering India's workforce to meet current industry needs and anticipate future trends.

Most countries will need to develop and expand training programmes for energy efficiency and clean energy jobs more broadly. However, governments should leverage existing training facilities and resources, as many of the skills needed for clean energy transitions are related to occupations that already exist. Training programmes are part of a broader societal ecosystem that ultimately require an enabling policy environment to lead to better outcomes in the long-term.

Legal Framework for Skills and Training in Green Jobs in the Philippines

In 2016, the Philippines launched the Green Jobs Act, the country's first legislation specifically aimed at generating and incentivising green jobs to foster an environmentally sustainable economy (ILO, 2018b). The legislation explicitly defines green jobs and consolidates various policies to support them. The Act mandates the formulation of a National Green Jobs Human Resource Development Plan by the Department of Labor and Employment, in coordination with other agencies. The plan focuses on building the workforce needed for the green economy, ensuring that training and qualifications align with the competencies required for green jobs. The Technical Education and Skills Development Authority and the Professional Regulation Commission are key actors in developing training regulations and qualification standards, facilitating the certification of skilled workers for green sectors. The Green Jobs Act also tasks various government bodies, such as the Department of Trade and Industry and the Department of Labour and Employment with incorporating green job initiatives into their respective programs. Through this law, the Philippines aims to create a significant number of jobs that protect the environment, reduce waste, and contribute to a sustainable, low-carbon economy.

Key considerations for fair and inclusive workforce planning

Provide formal training and employment opportunities in energy efficiency

Offering formal training and employment pathways into energy efficiency is important to ensure that workers are properly trained and that the full range of efficiency gains can be realised. Haphazard installations may jeopardise any energy savings that energy efficiency measures might intend, while also frustrating building occupants thereby potentially increasing resistance to future energy efficiency measures. This section explores the role of formal employment in the energy efficiency sector both to stay on track with net zero goals and deliver fair and inclusive outcomes for workers in the form of decent jobs and wages.

Nearly 60% of workers worldwide operate in the informal economy, for many reasons ranging from a lack of economic growth, burdensome government regulations and taxes, and high barriers to entry for the formal economy, to a lack of formal employment and business development policies ([ILO](#), 2024a). Workers in the informal economy can include both wage workers and own-account workers. These workers are often extremely vulnerable because they lack rights and representation and can remain trapped in poverty. Providing current and future workers with formal pathways into the energy efficiency workforce is essential to address this imbalance and ensure fair outcomes for workers who may otherwise be disenfranchised.

Informal workers are largely concentrated in emerging markets and developing economies (EMDE), with more than 80% of workers in Africa employed in the informal economy and between 50% and 60% in Asia Pacific and Central and South America ([ILO](#), 2024c). Ensuring that workers have access to formal training and employment pathways can provide them with a range of benefits including reductions in poverty, unemployment, higher wages, improved working conditions, greater economic mobility, and transferability of skills.

A barrier to offering these formal opportunities, is that the energy efficiency workforce can vary considerably by geography and market dynamics. For example, some parts of the United States do not have any licensing requirements for electricians, while others require an extensive apprenticeship and state-licensing processes which take four to five years to complete.

Furthermore, the commercial energy efficiency sector tends to have more formalised, credentialed, and often unionised workers, while the residential energy efficiency sector tends to rely on field training and experience rather than formal certification. This dynamic often results in significant variation in wages and benefits between workers in the two markets.

Addressing these barriers to build a skilled workforce will be key to reap the benefits energy efficiency can provide. Relying on a qualified workforce to implement energy efficiency measures is key to reduce energy poverty by cutting bills and address growing energy demand. Energy efficiency interventions can also provide a range of benefits to end users including better health, improved air quality and productivity. When workers do not receive adequate training, there is a risk that interventions are realised in haphazard ways and that those benefits are not perceived by users. This can however be the case when formal training opportunities are not accessible, leading many to find work through informal channels and resulting in minimal or inexistent worker protection and low wages. Inclusive workforce development practices can both reduce these risks and strengthen the labour force by capitalising on the knowledge and capabilities of different population groups including women, youth, Indigenous peoples and others. Policies that involve employers, trade unions and other stakeholders in educational programming and that ensure opportunities for clean energy jobs are accessible to all from the start, are key to lower job seekers' likelihood of entering informal positions and contributing to improving equality and fairness in the clean energy workforce.

Improve inclusivity within the energy efficiency workforce

Diversifying the workforce means bringing in different and valuable sets of skills and knowledge. Today fewer than 20% of workers in the energy sector are women compared to more than 40% in the broader economy ([IEA, 2024b](#)). Women also tend to hold fewer than 15% of senior leadership positions and are under-represented in STEM education, which bars many from building careers in the energy industry at the outset ([IEA, 2023](#)). In the field of energy efficiency, there is strong evidence that women can be great assets and contribute to closing existing labour shortages. In Kenya, for example, women only represent 3% of construction professionals while the sector faces a shortage of skilled workers. The BuildHer programme aims to increase this participation rate to 10% in the next five years, paving the way for women to get equal pay and quality jobs in the sector while addressing the labour market shortage ([Buildher, 2024](#)). The programme targets women in marginalised urban communities who tend to have low-paying and unstable jobs and offers them a year-long accredited construction training and employment programme. Of the 169 women it has

trained so far, 80% are now employed in skilled occupations and have improved economic mobility. Collaboration with the National Construction Authority has been key in facilitating three new accredited courses in carpentry and joinery, painting, decorating and tiling, and facilitating connections between trainees and employers. Reducing entry barriers for women, through the provision of childcare support and activities that foster well-being, including sports, was essential for the programme's success. Advocacy sessions with communities have also contributed to foster a bottom-up change in social norms.

Young people can contribute to shape their own future when they participate in the clean energy sector. In 2024, 20% of young people globally (aged 15 to 24) are neither in employment, education or training and half of those who work are in informal employment ([ILO](#), 2024b). In emerging and developing economies, two thirds of young adults have a job that does not match their qualifications. Young people are the workforce of the future and ensuring they are adequately trained and included in clean energy transition planning is critical to achieve net zero. Eliminating barriers by ensuring young people have access to education and training opportunities in the STEM field is key, especially for women. In Jordan, an upskilling programme aims to provide training in artificial intelligence applications relating to renewable energy and energy efficiency for young people, especially women ([ILO](#), 2023a). The programme equips young people with digital skills that will be increasingly necessary in the jobs of the future and fosters employment growth in the construction sector where demand is projected to grow. Over the course of their training, students are provided with theoretical training and internship opportunities to put their knowledge into practice and gain work experience.

Engaging Indigenous and local communities can build local capacity and resilience and unlock access to local knowledge. This is particularly relevant for Indigenous peoples, who have historically suffered discrimination and been excluded from the benefits energy can provide while their lands have often been used for the development of large-scale energy projects. When Indigenous communities become active participants of clean energy transitions and decarbonisation projects, clean energy can become a tool to build their resilience and generate benefits including improved health. In Akwesasne, Canada, the Mohawk Council invested in training community-based contractors to build energy efficient homes and reduced energy bills by more than 60% for residents ([Indigenous Clean Energy](#), 2024). Targeted training was provided to head contractors who then trained others in the community and fostered the development of local skills. This investment in local training equipped workers with knowledge and practical techniques that accelerated construction processes. In addition, the uptake of energy efficient housing by some residents and proven energy savings motivated others to also live in higher energy

efficiency homes. By spreading awareness and educating users on how to operate the new energy systems, the project fostered residents' trust in the new installations.

Targeting training programmes is key to ensure that the energy efficiency workforce offers equal opportunities to all. This entails identifying the groups that are underrepresented in the workforce and reducing barriers they may face. These barriers can include the upfront cost of training for low income or young households, childcare support for women and transport for rural populations. Fostering an inclusive environment, by raising awareness and challenging social norms is also an essential part of the solution.

Annex

List of Abbreviations

ABNT	Brazilian Association of Technical Standards
BPI	Building Performance Institute
CEM	Clean Energy Ministerial
EMDE	emerging markets and developing economies
HVAC	heating, ventilation, air conditioning and refrigeration
IEA	International Energy Agency
ILO	International Labour Organization
RESNET	Residential Energy Service Network
STEM	science, technology, engineering and mathematics
VET	vocational education and training

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