International Labour Organization

Workforce 2030

Skills for thriving in the green and digital transitions

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International Labour Organization • Geneva

ISBN: 9789220430859 (print); 9789220430866 (web PDF)
DOI: https://doi.org/10.54394/XXZW7148

Printed in Switzerland.

Acknowledgements

This report was prepared by a team led by Olga Strietska-Ilina (ILO), who also undertook the final editing. Overall supervision was provided by Mr. Srinivas Reddy, Chief, Skills and Employability Branch, Employment Policy Department, ILO. The initial draft was prepared by Andrew McCoshan and Simon Broek under the guidance and overall project coordination of Hae Kyeung Chun (ILO).

Cornelia-Madalina Suta, Ann M. Furbush, Eva Alexandri and Freya Gompertz of Cambridge Econometrics worked in close collaboration with the ILO and provided the macroeconometric modelling and projections used in the report. Takaaki Kizu (ILO) contributed data analysis and additional inputs. Alice Vozza and Juan Ivan Martin Lataix (ILO) provided valuable comments and suggestions.

The publication was prepared under the oversight of Jenni Jostock (ILO), while Maurizio Costanza was responsible for its design and layout.

▶ Foreword

The world of work is shaped today by deep structural changes that continue to redefine the labour market. Climate change and digitalization, along with other profound transformations, are reshaping jobs and demand for skills in the labour market at an unprecedented pace and scale. The green and digital transitions present a historic opportunity to create more inclusive and sustainable economies and societies. Yet, they also carry significant risks of widening inequalities, skill shortages, labour market disruptions, and uneven access to new opportunities.

This report, titled *Workforce 2030: Skills for Thriving in the Green and Digital Transitions,* responds to these challenges with clarity and insight. It offers new employment projections by occupation, produced jointly by the ILO and Cambridge Econometrics, paired with an in-depth review of global evidence to illuminate how the transitions to clean energy, greater digital connectivity, and the interplay between the two will affect occupations, skills needs, and labour markets across regions and income groups.

The findings underscore a core message: skills development is foundational to a just transition. The green and digital transformations will create millions of new jobs by 2030, particularly when pursued together, but only if countries invest ambitiously and coherently in skills systems. These systems should be able to anticipate change, adapt curricula, strengthen vocational pathways, and reach all learners: young people, adults, women, and informal and disadvantaged workers most exposed to labour market shifts.

At the same time, the report highlights persistent challenges. Women remain underrepresented in many green and digital occupations. Low-income countries, despite substantial potential gains, face limited access to infrastructure, training systems, and finance. Workers in sectors undergoing decarbonization or automation need targeted support to reskill and upskill. Without deliberate action, the coming transitions may reproduce or even deepen existing inequalities.

The ILO's mandate to promote decent work and advance social justice demands that these transformations be approached with a commitment to fairness, inclusion, and social dialogue. Skills development must therefore be placed at the centre of policy frameworks for climate action and digitalization. This requires coordination across ministries, engagement with employers' and workers' organizations, and strong partnerships with training providers, investors, and communities.

The evidence and recommendations presented in this publication will help governments and social partners design skills strategies that fully harness the potential of the green and digital transitions while ensuring that no worker is left behind. Building the workforce of 2030 is not simply a skills development challenge, it is an investment in a more sustainable, more equitable, and more resilient future of work.

Srinivas Reddy
Chief, Skills and Employability Branch
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▶ Abstract

This report analyses the employment impacts of the green and digital transitions, the associated implications for occupational and skills needs, and how to respond more effectively to the challenges arising. The study explores the key drivers influencing labour markets, occupational requirements and employment projections under three scenarios: an Energy Transition Scenario, a Near-Universal Broadband Access Scenario and a Combined Green and Digital Transitions Scenario. It identifies critical occupational and skills needs and evaluates policy and training measures to facilitate workforce readiness. Key findings highlight the need for an accelerated shift in training and education to meet emerging industry demands. The report underscores the necessity of integrating green and digital skills development strategies to foster sustainable and inclusive economic growth. It concludes with recommendations for policymakers, social partners, education and training institutions and other stakeholders.

Executive summary

This report analyses the employment and skills needs arising from the **green and digital transitions** and how to respond more effectively to the challenges they present. At its core is a set of employment and skills scenarios, jointly produced by the ILO and Cambridge Econometrics, which estimate the potential impacts of the transition to climate neutrality in energy production and to near-universal broadband coverage, along with the combined effects of the two transitions. These projections are contextualized with an in-depth review of relevant literature.

The **green transition** is characterized by global efforts to address climate change, particularly driven by commitments to net-zero emissions, which have accelerated investments in, for example, renewable energy and more sustainable manufacturing. Policies such as carbon pricing and regulatory frameworks on energy efficiency play a key role in driving growth in markets for green products and services and stimulating demand for green jobs across multiple sectors, as do green technologies and innovation. Labour demand in a range of occupations (for example, for engineers, technicians and project managers in green infrastructure projects) is already rising and will continue to do so. The Energy Transition Scenario used in this report considers the employment and skills effects of achieving climate neutrality in large part by 2050 and completely by 2060, and focuses on the period up to 2030 (see Annex A). Under the scenario, global employment growth would rise by 1 per cent between 2024 and 2030 compared with the baseline scenario, equivalent to an extra 37.2 million jobs. Significant variations across occupations and geographical regions are anticipated. Job creation is expected in clean energy sectors, with net employment gains offsetting losses in fossil-fuel-dependent industries. The concentration of job growth in construction and manufacturing means that men would benefit disproportionately from the scenario, since they dominate employment in these sectors. The transformation of industries to meet carbon reduction targets will require extensive investment in workforce training, with a particular emphasis on equipping existing workers with new skills and preparing young people for emerging opportunities.

The **digital transition** is reshaping economies through rapid technological advances such as artificial intelligence (AI), automation and big data analytics, which, in turn, are reshaping workforce requirements across multiple industries. Digital transformation means that digital literacy and adaptability to new technological tools are becoming essential across all occupations, while demand for proficiency in specialist technical skills in data analytics, cybersecurity, software development and cloud computing is also rising. The digital transition is projected to create significant employment opportunities, particularly in information and communication technology (ICT) sectors, digital marketing and remote work solutions. However, automation may displace certain roles, necessitating targeted reskilling efforts to mitigate job losses. Demand for advanced IT skills and digital literacy will not be limited to the technology sector, as an increasing number of traditional industries incorporate digital solutions into their operations. Businesses must also invest in training their employees to use AI-driven systems effectively, ensuring that productivity gains from digitalization translate into sustainable employment growth rather than workforce reductions. The Near-Universal Broadband Access Scenario presupposes that access to broadband internet for at least 90 per cent of the population will be achieved by 2030, which would lead to an increase in global employment of approximately 0.7 per cent, or more than 23 million jobs, by 2030 compared with the baseline. Again, there would be substantial spatial and occupational variations in the scenario's impact, and most new jobs would go to men.

The report also considers the employment and skills effects of the **green and digital transitions** combined, since green technology and innovation are key drivers of the green transition, helping in both the mitigation of and adaptation to climate change, for example through smart grids, sustainable AI applications and energy-efficient digital technologies. This intersection presents opportunities for job creation but also challenges in skills development and workforce readiness. At the interface of the transitions, all workers need basic skills in both greening and digital technologies, enabling the use of technologies such as smart meters, as well as core skills in problem-solving and critical thinking. More specialist technical skills are also needed where high-level digital skills are applied to green products and services, and new occupations are emerging, such as digital specialists working in precision agriculture and waste management optimization. Under the Combined Scenario, the assumptions of both the foregoing scenarios are used, aiming to capture the synergies and trade-offs happening concurrently. As a result, the scenario forecasts that global employment growth would be 1.6 per cent higher than the baseline in 2030, or 58 million more jobs. All occupations would show growth, while craft and related trades occupations would be the locus of significant gains. Most gains would take place in occupations requiring medium skill levels.

Analysis of the literature on **skills development responses** to the green and digital transitions reveals a wide range of measures that encompass the entire gamut of technical and vocational education and training (TVET) policy and practice. For the green and digital transitions individually, high-level strategies and policies have been put in place, skills anticipation mechanisms have been developed and utilized, qualifications and programmes have been revised or new ones introduced, and steps taken to adapt programmes for the professional development of teachers and trainers. At the same time, there are far fewer examples of policies and practices that address both transitions simultaneously. Challenges encountered in skills development responses across the transitions include disparities in access to training, particularly in low-income regions, and the slow adaptation of education systems to evolving industry needs. Additionally, gender disparities in science, technology, engineering and mathematics (STEM) and green occupations still need to be addressed to ensure inclusive workforce participation: women remain underrepresented in both digital and green industries, particularly in technical roles, which can limit the overall effectiveness of workforce transition strategies. Encouraging greater female participation in these sectors through targeted outreach, scholarships and workplace policies will be crucial for ensuring that the employment gains from the twin transitions are widely shared.

Both transitions – individually and combined – have the potential to generate significant employment opportunities, provided steps are taken to enable an effective response by skills development systems. The report's **recommendations** include a range of measures to help ensure this happens, including: making skills development central to all strategies, plans and funding commitments related to the green and digital transitions; forging strong relationships across government ministries and engaging all relevant stakeholders in determining the goals for the transitions and the actions required to achieve them; improving education and training provision to enable faster and more effective responses to emerging skills needs; equipping everyone with basic green and digital skills and generic competencies so that all can benefit from the transitions; including gender equality at every stage and level of skills development to ensure a fair gender distribution of employment benefits; and tackling the uneven spatial distribution of likely employment gains, in particular as regards African and low-income countries, which currently stand to benefit least from the transitions.

The report underscores the urgency of aligning workforce development with the green and digital transitions to achieve a sustainable and digitally inclusive future. By addressing skills gaps and implementing targeted policies, economies can harness the full potential of the green and digital revolutions for long-term social, environmental and economic benefits. The success of these transitions will ultimately depend on coordinated efforts among governments, businesses and education providers to build a workforce that is prepared for the challenges and opportunities of a rapidly evolving labour market. Policymakers must prioritize investment in skills, ensuring that workers are not left behind as industries undergo structural changes. With the right support and policies in place, the green and digital transitions can serve as drivers of economic growth, job creation and social equity in the coming decades.

1

Introduction

1.1. Why this report is needed

There is mounting evidence that **human-induced climate and other environmental challenges** pose unprecedented threats to humanity and continue apace, with global and regional temperature and weather records being broken every year (Intergovernmental Panel on Climate Change 2023). There are growing concerns that the Earth may be approaching critical tipping points – such as a sudden loss of permafrost or the collapse of the North Atlantic Gulf Stream – that could trigger irreversible shifts in climate and weather (Lindwall 2022), with massive implications for human activity, including the skills and jobs needed to mitigate and adapt to climate change. Evidence suggests that climate action can drive net job creation in renewable energies, nature-based solutions and circular economies (ILO 2019a; ILO, UNEP and IUCN 2024), but these must be weighed against the risk of job losses in fossil fuel sectors. Beyond the numbers, ensuring decent work, fair working conditions and adequate wages remains a concern.

We are also seeing the **increasing digitalization** of our world. Digitalization has been a feature of working and living for over four decades, with previous waves of digital technologies bringing new forms of automation, and the COVID-19 pandemic accelerating the use of digital tools for work, education and training and in the home, where it has shaped consumer digital behaviour. We now stand on the brink of a new wave of technology with the advent of readily available AI tools and heightened attention to the exposure of jobs to the risk of automation, the opportunities for productivity enhancement and the risk of digital and AI divides (UN and ILO 2024).

Both the green and digital transitions [1] are having and will continue to have important consequences for employment and skills, in terms of both the **creation and destruction of jobs and skill needs and how equally or unequally such effects may be distributed across the population.** It is important to examine these phenomena both individually and together so that the likely interactions between them can be better understood and appropriate steps can be taken in policy and practice. It is with this aim in mind that this report has been prepared.

1.2. Critical infrastructures

Globally, it will be vital to put in place **critical infrastructures** if climate goals are to be achieved and the benefits of digitalization and greening are to be delivered and equally shared. [2] More than that, as this report shows, the interactions between green and digital mean that such infrastructures will be central to realizing the potential synergies between the two transitions to the benefit of humanity at large. For example, as we shall see, digital technologies have the potential to play a vital role in the green transition, providing the

1 Owing to the focus of this report on employment and skills, the 'green transition' is used to describe the changes that are or will take place in the economy resulting from actions to fight human-induced climate change and to cope with other environmental challenges such as the loss of bio-diversity and general pollution control. It is thus the process of transforming economic processes so that they become more environmentally sustainable. It is related to but not synonymous with the concept of the 'just transition' (discussed in section 2.1). The 'green transition' encompasses the 'green economy' and 'green jobs', definitions of which are provided in section 2.1. The digital transition is the process of integrating digital technologies into work and life.

2 See, for example, "Why the AI revolution is leaving Africa behind", *The Economist*, 27 July 2024.

connectivity and access to new green technologies that can be used by citizens and businesses alike, while renewable energy is vital for powering the digital transition with its increasing energy needs. At the same time, the demand for critical raw materials, minerals and technology metals is set to almost triple by 2030 as the world expands its digital infrastructure and transitions from fossil fuels to renewable energy in order to reduce global carbon dioxide emissions to net zero by 2050.

Unfortunately, to date **the implementation of solutions to the threats posed by climate and environmental change has lagged behind our need to apply them.** As Professor Jeffrey Sachs has put it:

> …very tough problems like human-induced climate change have solutions, quite practical, albeit complex solutions of energy sector decarbonization, changes of land use, changes of agricultural practices and so… The solutions exist. But we're not applying them and certainly not applying them at scale. [3]

It is becoming **increasingly imperative to put in place critical infrastructures if climate targets and Sustainable Development Goals are not to be missed.** Achieving the 1.5°C Paris Agreement target by 2060 requires a wholesale shift away from fossil fuels and the achievement of a net-zero global energy system by 2050 through the construction of new infrastructures based on renewable sources such as wind and solar, as well as a wide range of policies and regulations to promote renewable energy generation and energy efficiency (IEA 2021). In relation to digitalization, Sustainable Development Goal 9 (Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation) [4] requires the achievement of near-universal broadband coverage of at least 90 per cent of the population by 2030.

Both of these developments will have positive and negative impacts on employment and skills needs, and it is important to understand what the impacts may be if skills development systems are to play a supportive – rather than a constraining – role in the green and digital transitions. As will become apparent in this report, to date skills development has lagged behind the needs of the transitions, inevitably limiting what can be achieved. It is therefore critical that steps are taken to ensure that skills systems are developed and improved, in line with the changing needs of industry, to mitigate the effects of such lags in the coming years.

1.3. Understanding the possible employment and skills effects

Investments in critical energy and digital infrastructure will affect employment and skills needs. To examine these effects, this report provides a set of **employment projections** produced by Cambridge Econometrics in collaboration with the ILO. These projections use two scenarios to model the possible employment impacts, compared to a baseline scenario, of (a) digital broadband installation to near-universal levels (the Near-Universal Broadband Scenario) and (b) implementation of carbon and energy policies to support the transition to clean energy and energy efficiency and the achievement of net-zero

3 Professor Jeffrey Sachs, Director of the Center for Sustainable Development, Columbia University; President of the UN Sustainable Development Solutions Network; SDG Advocate for the United Nations Secretary-General on the Sustainable Development Goals, "Jeffrey Sachs Interviews - Facing Reality", 28 September 2024.

4 United Nations, "9 - Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation".

carbon emissions by 2060 [5] (the Energy Transition Scenario), as well as their combined impacts.

It is important to contextualize and frame these projections through a **deeper exploration of the employment and skills effects of greening and digitalization** more generally and to build our understanding of the interactions between these transitions. Despite some anecdotal support for the promotion of the green and digital transitions, there is currently little evidence on the complementary – or potentially conflicting – nature of these transitions in terms of employment impacts at the level of occupations. The new projections and related analyses in this report aim to fill this gap in the knowledge base and facilitate policy discussions on how best to support the green and digital transitions through skilling, reskilling and upskilling.

1.4. Structure of the report

With these goals in mind, the report is structured as follows.

Chapters 2, 3 and 4 examine, respectively, **the green transition, the digital transition and the two transitions combined**. Each of these chapters follows a similar structure. First, they examine recent developments driving the transitions in terms of employment and skills needs. They then reveal the key shifts that can be observed in occupational and skill needs. Finally, they present the employment projections for each of the scenarios. As noted, less is known about the combined effects of the green and digital transitions; Chapter 4 therefore seeks to add to our understanding by drawing on both the limited literature that deals with both transitions and the material presented in Chapters 2 and 3 to generate a synthesized examination of trends and developments. It looks at the potential synergies between the transitions, including how far employment and skills trends might reinforce or counteract one another.

Chapter 5 examines **skills development responses** in terms of policies and practices in education and training. It looks at skills development for the green and digital transitions separately, as well as in combination, in relation to a range of dimensions such as skills anticipation, programme and qualification development, initial training for young people, upskilling and reskilling for adults, professional development for teachers and trainers, and activities related to inclusion, especially in relation to gender-related interventions. The chapter closes with a consideration of the critical challenges standing in the way of improving our skills development systems so that they can play a full role in the green and digital transitions.

Chapter 6 provides a set of **conclusions and recommendations**, drawing on the findings presented across the report. It summarizes the gains that could be realized from the transitions in terms of employment and occupations and the obstacles that could inhibit delivering them through skills development systems. Recommendations for policy and practice focus on how to tackle the obstacles faced.

5 The broad emissions reduction, energy efficiency savings and investment and carbon prices contained in the Energy Transition Scenario are aligned with IEA (2021). An assumption of the model is that a combination of climate and energy policies would achieve climate neutrality by 2050 in 124 countries, and by 2060 for the remaining countries (in support of reaching the 1.5°C Paris Agreement target, except China, which would reach climate-neutrality).

2

Greening the economy

2.1. Introduction

This chapter uses qualitative and quantitative information and insights from the literature to examine recent developments driving employment and skills needs around greening as well as the associated impacts on employment, occupations and skills. This provides an in-depth review of these topics before turning, in the final subsection, to the examination of projections of the potential employment effects of climate policies and investments under an Energy Transition Scenario.

The concepts of a "green economy" and "green jobs" are defined in different ways in the literature. For example, some of the literature categorises jobs as green, depending on their sector/industry (for example, the renewable energy sector), others seek to define the degree of "green-ness" of an occupation according to the incidence of "green tasks" and hence the skills for green jobs can potentially be found in any sector/occupation (OECD 2023c). The ILO has recently published a review of definitions to help guide countries and organizations as they develop and implement policies and actions aimed at creating environmentally sustainable economies and societies (ILO 2023c). Here, the following definitions are used:

A green economy is defined as low carbon, resource efficient and socially inclusive. In a green economy, growth in employment and income is driven by public and private investment into such economic activities, infrastructure and assets that allow reduced carbon emissions and pollution, enhanced energy and resource efficiency, and prevention of the loss of biodiversity and ecosystem services (UNEP 2018).

Green jobs are decent jobs that contribute to preserving or restoring the environment, be they in traditional sectors such as manufacturing and construction, or in new, emerging green sectors such as renewable energy and energy efficiency. Green jobs help to improve efficiency in the use of energy and raw materials, limit greenhouse gas emissions, minimize waste and pollution, protect and restore ecosystems, and support adaptation to the effects of climate change (ILO 2016a).

Over the years, the ILO has been increasingly referring to a just transition to environmentally sustainable economies and societies, as described in the 2015 ILO Guidelines and in the Preamble of the Paris Agreement, and the 2023 ILC Resolution which reiterates the principles of just transition, described as a process that "involves maximizing the social and economic opportunities of climate and environmental action, including an enabling environment for sustainable enterprises, while minimizing and carefully managing challenges. It should be based on effective social dialogue, respect for fundamental principles and rights at work, and be in accordance with international labour standards" (ILO 2023e).

2.2. Recent developments driving employment and skills needs: Opportunities, challenges and policy trends

A range of drivers are shaping the employment and skill needs related to the green transition. Many of these have influenced developments for many years, with some evolving or becoming more prominent as the green transition has gathered pace (such as the heightened demand for critical minerals for the energy transition and electric vehicles). Other trends are new drivers which would have been difficult to predict in advance, for example, the spike in energy prices caused by the Russian Federation's aggression against Ukraine, which has cast domestic renewable energy in a new light as a means of reducing reliance on fossil fuel imports.

Looking across the drivers, several important features should be highlighted. One is the **reliance on government policies and investment plans** for stimulating the development of innovations, technologies and markets. This is especially the case regarding the energy transition, which requires large-scale investment as well as policy decisions to decommission oil, coal and gas fields and to transition emissions-intensive sectors towards low-carbon technologies, improved energy efficiency, and the integration of renewable energy. For example, the decommissioning of traditional internal combustion engine (ICE) automotive production can be supported by policies and investment that promote the shift towards low-carbon and energy-efficient alternatives like New Energy Vehicles (NEVs) that run on electricity or hydrogen. A further key feature of the green transition is its **non-linearity and uncertainty over time** due to fluctuations in governments' commitments to green goals and its **variability in space** owing to different localities, regions and countries facing different economic, social and environmental challenges and propensities to minimize the costs and maximize the benefits of greening.

In the following sections, drivers are discussed under the headings used by the ILO (2019a), since they remain relevant and provide a way of highlighting the latest developments.

Changing environment

The pre-eminent driver of the green transition is, of course, the environment itself. Recent years have seen adverse climate trends continue, consistent with human-induced climate change (Intergovernmental Panel on Climate Change 2023). They have also brought a range of other environmental challenges, including plastic pollution, the destruction of habitats and loss of biodiversity, such as through the replacement of rainforests with monocultural palm-oil production. Globally, February 2023 to January 2024 saw the hottest 12-months ever recorded. At regional and local levels, the incidence of unusual, extreme weather events is increasing. In Europe for example, the summer of 2023 saw the largest wildfire and the highest number of days with extreme heat stress ever recorded (Copernicus Climate Change Service 2023). Environmental challenges are continuing to intensify and the "*window of opportunity to secure a liveable and sustainable future for all" is "rapidly closing"* (Intergovernmental Panel on Climate Change 2023). The challenge is especially acute for countries with high dependence on natural resources, most of which are developing economies. It is also severe for countries vulnerable to sea level rise and storm intensification, such as small island states in the Pacific. These countries bear a significant share of the climate change burden, yet they have benefited very little from the use of coal, oil and gas which has fuelled socio-economic progress in high-income countries. Heat stress will also impact jobs and productivity. It is estimated that by 2030, 2.2 per cent of total working hours worldwide will be lost due to high temperatures and heat stress – a productivity loss equivalent to 80 million full-time jobs (ILO 2019b; ILO 2024a).

Policy and regulation

Government policies and regulations play a central role in reducing or preventing damage to the environment and in promoting more sustainable consumption, business processes, products and services. Intergovernmental action through the COP process and the UN Sustainable Development Goals (SDGs) has strongly influenced national policies (ILO 2019a). This is reflected in Nationally Determined Contributions (NDCs), National Adaptation Plans (NAPs) and Long-Term Low Emission Development Strategies (LT-LEDS). It is also evident in Just Energy Transition Partnerships (JETPs), which provide cooperation and financing arrangements between developed and emerging economies to help developing countries transition away from fossil fuels.

Analysis of the NDCs by the ILO (2024b) shows that globally just over half of them address skills development to equip current and future workers with skills for green jobs and evolving industries. However, there are important variations: whilst 84 per cent and 77 per cent of low-income and lower-middle-income countries respectively include skills development policies, only 23 per cent of high-income countries do. Only 6 per cent of NDCs mention TVET, compared to 19 per cent that mention primary and secondary education and 17 per cent that mention higher education. Mention should also be made of the role of regional organizations in policy and regulation. Perhaps most prominent amongst these to date has been the EU, which has a major role in setting common environmental targets and standards for EU Member States. Other regional bodies also have the potential to play an important role, including, in Africa, the African Continental Free Trade Area (AfCFTA), the African Union and the Southern African Development Community (see the example on the Kafue regional skills training in section 5.4).

Policies and regulations tend to be a mix of stimuli and incentives on the one hand and prohibitions to environmentally deleterious practices on the other. In 2024, for example, Brazil launched its National Energy Transition Policy, which aims to attract an estimated BRL 2 trillion in investments towards the green economy over ten years. [6] More generally, the employment gains from the green transition have been identified as a ray of light in difficult economic circumstances post-COVID-19 (as in the promotion, for instance, of the European Green Deal), and this may have started to address the issue that green employment and skills policies have in the past been somewhat detached from "mainstream" green policies.

A growing number of countries are now enacting legislation and policy measures to anchor their net-zero commitments. [7] Recent years have also seen the emergence of policies aimed at securing commitments and reparations from wider stakeholders involved in carbon-intensive industries. For example, South Africa launched a carbon tax in 2019 based on the "polluter pays" principle, which provides that those that cause harm to the environment must pay for the damage caused and which incentivizes firms to adopt cleaner technologies. [8] Other actions in South Africa include the Just Energy Transition Partnership and associated implementation plan (Presidency of the Republic of South Africa 2023). In the Philippines, a Climate Accountability (CLIMA) Bill is being debated, which includes mechanisms for reparations and accountability for losses and damage caused by climate change. [9]

Nonetheless, recent years have also seen some political parties and governments, backing away from the green agenda, responding to fears of the

6 Government of Brazil, "President Lula launches National Energy Transition Policy, expected to bring BRL 2 trillion in investment", 27 August 2024.

7 Tiffanie Chan and Catherine Higham, "Evolving regulation of companies in climate change framework laws", *London School of Economics*, 21 February 2023.

8 IEA (International Energy Agency), "Carbon Tax Act (Act No. 15/2019)", 3 June 2024.

9 Manila Observatory, "The Urgent Need for a Climate Accountability Act Prospects and Challenges of Climate Accountability in the Philippines".

short-term costs of transition and local resistance to the building of wind and solar farms (Not in My Backyard (NIMBYism)). This has manifested itself in, for example, the controversies around opening new coalfields and oil shale fields in Europe and North America, which might bring short-term employment gains in local economies but jeopardize the achievement of limiting global average temperature rises to 1.5C above pre-industrial levels. [10] In other countries, efforts to accelerate the green transition have met with resistance, such as in the EU where legislation passed in 2023 to prohibit the sale of CO_2-emitting new cars and vans by 2035 was amended to include low emission-fuels, which are less sustainable than battery-powered vehicles. [11]

There can also be problems with implementation in some countries (ILO 2019a). For example, the government of Uganda recently banned charcoal production due to its role in widespread deforestation. However, since charcoal remains a primary energy source in low-income communities, enforcement of the ban has been problematic. [12] In Kenya, the implementation of laws to reduce the use of plastics has been undermined by factors such as illegal importation of some types of plastic and other enforcement challenges. [13] Experiences such as these highlight the need for comprehensive packages of policy measures to ensure the costs and benefits of the green transition are balanced.

Green technology and innovation

The intersection between digital technologies and the green transition is examined in Chapter 4, but several key points of a broader nature about this relationship should be made here. Green technology is the application of knowledge, devices and mechanisms, design and skills to generate products or activities that have a less environmentally degrading effect or can be used to improve environmental conditions (ILO 2019a). The development of these technologies requires high-skilled inputs, while bringing them to market requires strong entrepreneurship competencies.

Their application in industry also creates new skill needs – for example, when construction workers need to retrofit new insulation materials to old buildings – or even generates entirely new occupations, such as electricity smart-meter installers. Although hi-tech digital solutions play a role and require high skill levels (for example, “smart city” initiatives in Mauritius (ILO 2022a)), low-tech innovations such as biogas digesters also contribute to employment and skills development. Technologies and innovations continue to develop and emerge. For example, in the electric vehicle market, efforts continue to make batteries deliver greater distances on single charges and to speed up the charging process to make EVs more attractive to consumers. At the same time, investments in research and development (R&D) are prone to cyclical swings: they tend to contract during economic downturns, such as those triggered by the COVID-19 pandemic and the Russian Federation’s aggression against Ukraine. In addition, structural factors also play a role, particularly in low-income countries where limited R&D capacity further constrains the development of locally driven climate solutions.

Green markets and enterprise development

Markets and enterprise development have important roles to play in the green transition. They reflect the complex interplay of supply and demand factors, including the emergence of green(er) products and services in response to government subsidies and incentives, or technological developments. Some markets, for EVs, for example, rely on growing consumer demand, whilst others, as in the general energy market, reflect more complex forces involving national energy supply policies where government policy and regulation play a central role. Trade and global supply chains – as a feature of the modern, globalized economy – have a role to play in the development and exchange of green products and services. They are already leading to important shifts in the competitive advantage of nations, exemplified by China’s rise as a major global manufacturer of electric vehicles.

10 Greg Muttitt, “No New Fossil Fuel Projects: The logical first step in a transition to clean energy”, *IISD*.
11 IEA (International Energy Agency), “Low Emission Fuels”.
12 John Okot, ““Why do they punish us?” Uganda charcoal ban ignites transition debate”, *African Arguments*.
13 Caroline Kimeu, “After a plastic bag ban, Kenya takes another shot at its pollution problem”, *The Guardian*, 30 May 2023.

Markets are, of course, subject to cyclical ebbs and flows as well as structural issues. A challenge in consumer-oriented markets like that for EVs is to find ways to grow the market. Overcoming classic market growth problems will be essential, including the shift from "early adopters" to mass-market uptake and the achievement of economies of scale. Additional issues also need attention, such as overcoming infrastructural constraints around charging points [14] and ensuring that supply chains can meet the rising demand for critical minerals and green hydrogen. Government action can be key in such areas to open markets and support companies in their initial phases to help cover the higher costs of green alternatives compared to established and less sustainable products and services, as well as equipping people with the skills for green jobs and the entrepreneurship skills they need.

The underlying strength of the business environment can vary substantially from country to country, which influences the potential for green market development (ILO 2023a). Green markets have tended to grow fastest and reach the largest scale in developed countries, although developing economies have been narrowing this gap (ILO 2019a). There is potential for developing economies to build competitive green industries. For example, Namibia is seeking to position itself as an international exporter of green hydrogen, drawing on its abundant solar and wind resources. [15] Nonetheless, private capital for green developments is still in short supply in developing countries: whilst 81 per cent of "green investments" in developed economies are funded privately, the figure is only 14 per cent in emerging and developing countries (Kupar 2023).

2.3. Main occupational and skill needs

In light of the drivers described above, what are the main consequences of the greening of economies for employment and skills? Addressing this question – in terms of not only making forecasts but also simply estimating the current situation – faces a number of challenges. Definitions of "green jobs" vary (as noted in Section 2.1) and data availability varies enormously between countries.

In terms of the **prevalence of green jobs in the economy**, estimates vary widely depending on the assumptions made - from 2 per cent to 40 per cent according to one overview (OECD 2023b). ILO, UNEP and IUCN have measured that 78 million people currently work in nature-based solutions (ILO, IUCN and UNEP 2024). A total of 16.2 million people worked in renewable energies in 2023 – a rise by nearly 3 million since the previous year, pointing to possible job transitions from the fossil fuel industry (IRENA and ILO 2024). The recent global baseline assessment of the circular economy employment estimated 121 to 142 million workers, representing 5 to 5.8 per cent of the total employed workforce (Circle Economy et al. 2025). However, even as climate change gains attention, and green jobs are growing in numbers, existing occupations seem to attain green tasks gradually: the share of green tasks in jobs grew only slightly in the decade preceding 2021 (OECD 2023b). Analysis of online job advertisements suggests that in Europe the prevalence of green skills in "high climate impact" occupations rose from 3 per cent to 5 per cent between 2019 and 2022 (Cedefop 2024b). This trend, however, significantly differs across sectors: green skills were mentioned in only 2 per cent of job adverts in the wholesale and retail sector and in 17 per cent in the energy sector (Cedefop 2024b). Available data seem to suggest, therefore, that there is still much scope for stepping up the green transition in employment and skills.

Looking forward, forecasts range from those that look at the possible effects of specific policy measures to more general estimates of greening effects. For instance, it has been estimated that implementation of the European Green Deal will mean an additional 1.2 per cent employment growth to 2030, or an extra 2.5 million jobs in the EU (Cedefop 2021b), whilst implementation of the EU's "Fit for 55" package of measures intended to adjust climate, energy, land use, transport and taxation policies to achieve a 55 per cent emissions reduction target by 2030, might lead

14 Euromonitor International, "Top Three Electric Vehicle Industry Predictions for 2024", 12 April 2023.
15 Green Hydrogen Organisation, "Namibia".

to an additional 204,000 jobs (Eurofound 2023b). Overall, net employment gains from the green transition in the EU are typically expected to be small but significant (Eurofound 2023b); and with some spatial and sectoral variation/concentration (more important in some localities and sectors than others) which is discussed further below. The ILO has estimated that net employment gains through investments in renewable energy and circular economy may bring close to 25 million new jobs globally by 2030 (ILO 2019a).

Regarding the **types of occupations and skills required for the green transition**, a wide variety of approaches has been adopted in the literature. However, a common theme is that individual occupations cannot simply be classified as "green" or "not green" (Cedefop 2023b). Evidently, some sectors and occupations, such as those in waste management or environmental services, are clearly focused on the environment. However, all sectors and occupations fall across a continuum of green-ness when we consider two factors: the actual skills required for the green transition, and the need for all workplaces, all employers and all workers to engage with the green transition to some degree. Thus several types of skill needed for the green transition can be identified:

- **foundational skills**: numeracy, literacy, digital literacy and climate/environmental literacy;
- **core (soft) skills**: communication, problem solving, teamwork, collaboration, creativity;
- **semi-technical skills**: customer handling, project management, research, sales and marketing; and
- **technical skills**: skills needed to build biogas digesters, solar and wind systems, and others (ILO 2019a).

Renewable energy, construction and transport have pivotal roles in delivering new products and services needed to meet green targets. These sectors have already seen the emergence of new occupations – such as wind turbine operators, solar panel installers and energy auditors – with more to come (ILO 2019a). Equally, the green transition will also demand robust systems to measure, monitor, report, and manage environmental impacts, which may, in due course, create a whole ecosystem of new roles in fields like sustainability auditing, carbon accounting, environmental compliance, etc.

Within the overall picture presented above, there are important spatial, sectoral and gender differences which reflect the patchiness of the effects of drivers on policies, technologies and markets. Significantly, the **spatial and sectoral differences** intersect across geographical scales. A country's, region's or locality's ability to benefit from the green transition depends on the composition of its business base and skills base, as well as government policy. Much also hinges on the degree of reliance on carbon-intensive industries on the one hand, and the capacity to take advantage of greening opportunities on the other. This capacity is shaped by factors such as natural endowments of renewable energy sources (sun and wind), the condition of existing energy infrastructure and the ability to manufacture renewable energy equipment (Eurofound 2023b). For example, it has been shown that two-thirds of online job advertisements for power plant operators in Germany were for onshore wind farm technicians compared to one third in Italy (Cedefop 2024b).

Spatial and sectoral effects are particularly visible in old industrial regions, such as in Poland and Romania (Eurofound 2023a), where carbon-intensive extractive and heavily polluting industries have declined. These changes have highlighted the challenges of helping redundant workers move into new green jobs. Evidence from 30 OECD countries suggests that jobs with a high share of green tasks have so far tended to require tertiary levels of education; in contrast, "brown jobs" in declining polluting industries [16] have been concentrated in low- and medium-skilled occupations (OECD 2023b). However, it has also been shown that in most brown occupations, workers have the transferable skills to transition to green jobs (OECD 2023a). And much also depends on how active governments might have been with respect to the green transition. Notable in this regard is the success of Chinese companies in securing a significant position in the global electric vehicles market, overtaking traditional carmakers.

16 It has been estimated that in OECD countries employment in sectors such as mining coal and lignite is expected to fall by as much as 90% between 2019 and 2030 (OECD 2023c).

Regarding **inclusion**, disadvantage affects an individual's capacity to learn, and this shapes the acquisition of skills for green jobs. For example, it has been noted that **disadvantaged youths** are less likely to master environmental sustainability, to be aware of and care about the environment, and to engage in pro-environmental activities (OECD 2023c). **Women** have been, on the whole, under-represented in green jobs; conversely, men have been most affected by the loss of polluting "brown jobs". These patterns reflect the overall structuring of employment along gender lines wherein women are over-represented in service industries like hospitality and health (which are less radically affected by greening) and men are over-represented in manufacturing, construction and utilities, which are more heavily affected by the green transition (Causa, Nguyen, and Soldani 2024). They also reflect the fact that women are less likely to transition from education or training into green jobs, partly because they are less likely to study STEM subjects (Causa, Nguyen, and Soldani 2024).

At the same time, in certain green jobs, such as those in the photovoltaic (PV) solar and broader renewable energy (RE) sectors, women are better represented compared to the traditional energy sector (IRENA and ILO 2023). This indicates the opportunity provided by the green transition to address the long-standing and culturally rooted male domination of certain sectors and occupations. Nonetheless, important issues remain to be addressed. For example, NDCs need to have a better understanding of the differentiated gender impacts of climate change and a stronger commitment to opening up more opportunities for women (ILO 2024b).

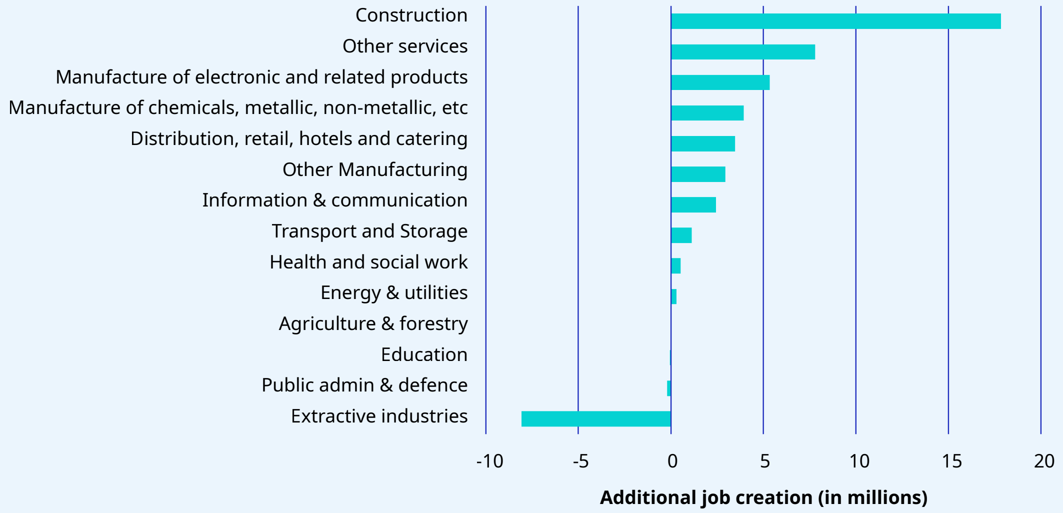
2.4. Employment projections: Energy Transition Scenario

This section considers the employment and skills effects of an Energy Transition Scenario that models a path to achieving near climate neutrality by 2050 and full neutrality by 2060, with a particular focus on the period to 2030. The model incorporates assumptions that include: a shift out of fossil fuels into power generation; improvements in energy efficiency in the built environment (through renovation and retrofit); enhancements in fuel efficiency and adoption of alternative-fuel vehicles (electricity, bioenergy, hydrogen) in the transport sector (mainly road transport); and other effects throughout the economy that stem from the use of carbon pricing.

Overall, under the scenario, **global employment growth** would be 1 per cent between 2024 and 2030 compared to the baseline scenario, equivalent to an extra 37.2 million jobs. Most gains would take place after 2027, with little growth between 2024 and 2027.

In terms of **sectors,** around two-thirds of the gains would be in construction and manufacturing, with substantial gains also in "other services". There would be losses in "extractive industries" as the transition takes place away from fossil fuels (see figure 2.1.).

▶ Figure 2.1. Energy Transition Scenario – Change in employment relative to baseline by 2030 by economic sector (in millions)



Source: ILO, based on E3ME model of Cambridge Econometrics.

Regarding **occupations**, the most significant gains would be in "blue-collar" occupations, amongst labourers in mining, construction, manufacturing and transport, building and related trades workers (excluding electricians) and metal, machinery and related trades workers. Such workers would be important for tasks such as building renewable energy infrastructure, retrofitting buildings to improve energy efficiency and manufacturing associated components. There would also be gains amongst professionals and associate professionals in business and administration as well as science and engineering professionals, who will have important roles in developing and adopting more sustainable business and production processes. There would also be employment gains in a range of industries, including food processing and garment production and handicraft workers, linked to the use of sustainable materials. Compared to the baseline scenario, the Energy Transition Scenario for achieving net-zero carbon emissions would offset some of the forecast decline in elementary occupations globally. Most job gains would be in medium-skilled occupations (see table 2.1.).

▶ Table 2.1. Energy Transition Scenario - Top 10 occupations accounting for 22.4 million jobs, or 60 per cent of total employment gain, 2030

#	ISCO-08 two-digit	Occupation	Employment growth (thousands)	Percentage change relative to baseline (%)
1	93	Labourers in Mining, Construction, Manufacturing & Transport	6 026	4.3
2	71	Building & Related Trades Workers (excluding Electricians)	5 484	4.0
3	72	Metal, Machinery & Related Trades Workers	2 335	2.0
4	74	Electrical & Electronic Trades Workers	1 644	1.9
5	75	Food Processing, Woodworking, Garment & Other Craft & Related Trades Workers	1 409	1.3
6	73	Handicraft & Printing Workers	1 169	1.7
7	24	Business & Administration Professionals	1 125	1.1
8	33	Business & Administration Associate Professionals	1 087	1.0
9	21	Science & Engineering Professionals	1 083	1.3
10	12	Administrative & Commercial Managers	1 023	1.0
All occupations			**37 249**	**1.0**

Note: ISCO-08 two-digit codes based on ISCO-08, ILO, Geneva, 2012. Available at https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_172572.pdf.
Source: ILO, based on E3ME model of Cambridge Econometrics.

Looking across the **regions**, there are important variations in employment effects, reflecting what has been said above. Most employment growth would be accounted for by the Asia and Pacific region – 26 million additional jobs, not only due to the region's high share of world population, but also thanks to steadily growing public investments into renewable energy capacity over recent decades (IRENA 2025). In terms of income level, middle-income countries, lower-middle-income countries in particular, stand to gain the most, accounting for 29 million additional jobs by 2030. In Africa and low-income countries, the scenario would make only a small marginal difference to employment, relatively speaking. The greatest gains relative to their baseline would be in the Arab States thanks to growing investments in renewable energy capacities (IRENA 2025), although employment gains are delayed due to the region's overreliance on cheap fossil fuels (see table 2.2.).

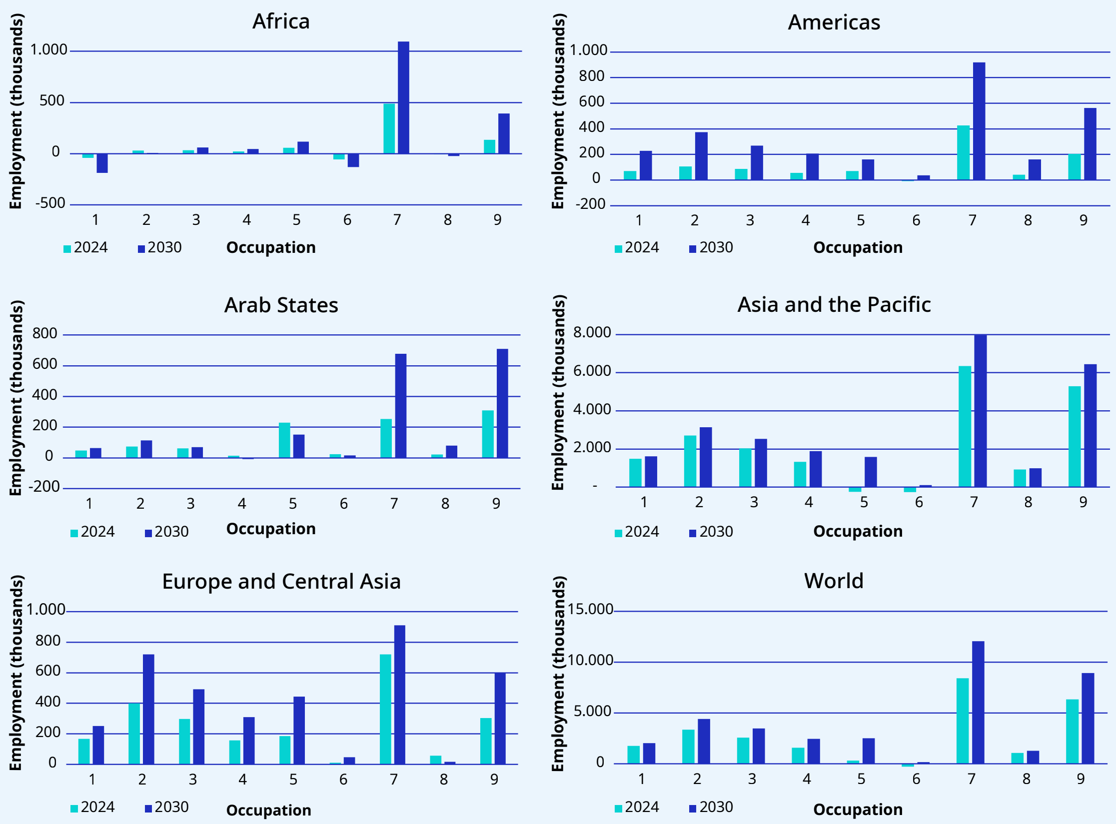
▶ Table 2.2. Energy Transition Scenario – change in employment relative to baseline by 2030

	Change relative to baseline in millions	Change relative to baseline in %
ILO Region		
Africa	1.4	0.3
Americas	2.9	0.6
Arab States	1.9	3.2
Asia and the Pacific	26.3	1.5
Europe and Central Asia	3.8	1.0
Income Level		
High income	5.9	1.1
Upper-middle income	12.0	0.9
Lower-middle income	17.4	1.5
Low income	0.8	0.4
World	**37.2**	**1.1**

Source: E3ME model, Cambridge Econometrics.

Comparing the regions in terms of occupations (see figure 2.2.), it is notable that, of all the regions, the Americas show employment gains between 2024 and 2030 (in relative terms) distributed across all occupations. Europe and Central Asia stand out for the fact that: (i) the forecast gains in professional occupations are substantial and exceed gains in elementary occupations; and (ii) employment gains are spread across a wider range of occupational categories, similarly to the Americas. In contrast, in Africa the employment gains outside the crafts and related trades and, to a lesser extent, elementary occupations would be slender, suggesting that the continent's existing economic and skills composition makes it relatively poorly positioned to take advantage of the potential gains from the green transition, except for the crafts and related trades workers and elementary occupations that would indeed see significant employment gains.

▶ **Figure 2.2. Energy Transition Scenario – Employment change relative to baseline by broad occupation and ILO region, 2024-30**

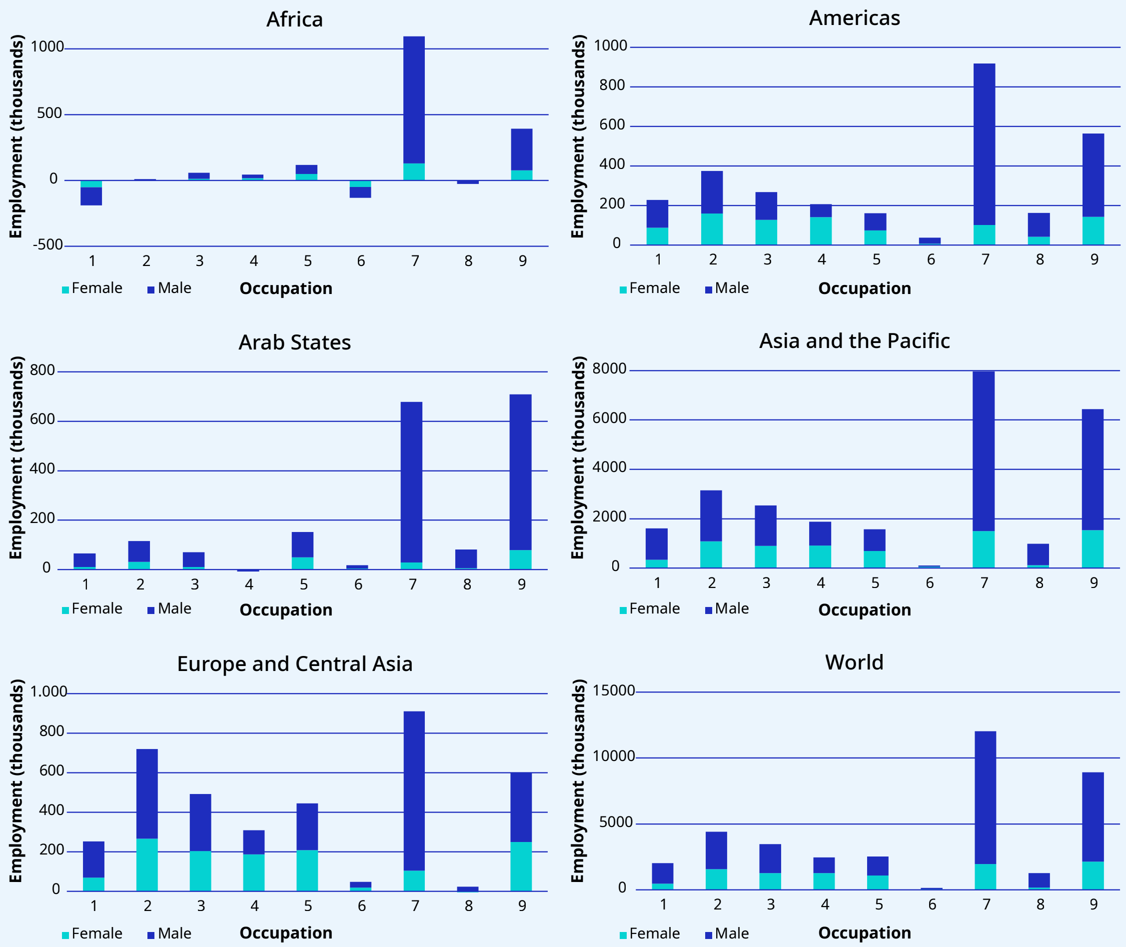


Note: Broad occupations by ISCO-08 one-digit level: 1 - managers, 2 - professionals, 3- technicians and associate professionals, 4 - clerical support workers, 5 - service and sales workers, 6 - skilled agricultural, forestry, and fishery workers, 7 - craft and related trades workers, 8 - plant and machine operators and assemblers, 9 - elementary occupations (ISCO-08, ILO, Geneva, 2012). Available at: https:// www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/ wcms_172572.pdf.

Source: E3ME model of Cambridge Econometrics, based on ILO data on employment.

Regarding **gender**, the concentration of jobs growth in construction and manufacturing means that men would benefit disproportionately from the scenario, since they dominate employment in these sectors. Overall, 73 per cent of employment gains would be filled by male workers, and women would gain around 17 million fewer jobs than men. Within occupations, male job gains will be particularly high in the crafts and related trades, and elementary occupations, where 84 per cent and 76 per cent respectively of the global employment gains will go to men. Regionally, women would benefit more in the Americas and in Europe and Central Asia, since more of the employment gains would be spread across more occupations, including those where women are generally better represented, for example, in professional occupations and amongst technicians and associate professionals, as well as clerical support workers and service and sales workers (see figure 2.3.).

▶ **Figure 2.3. Energy Transition Scenario – Employment change relative to baseline by broad occupation and sex, 2030**



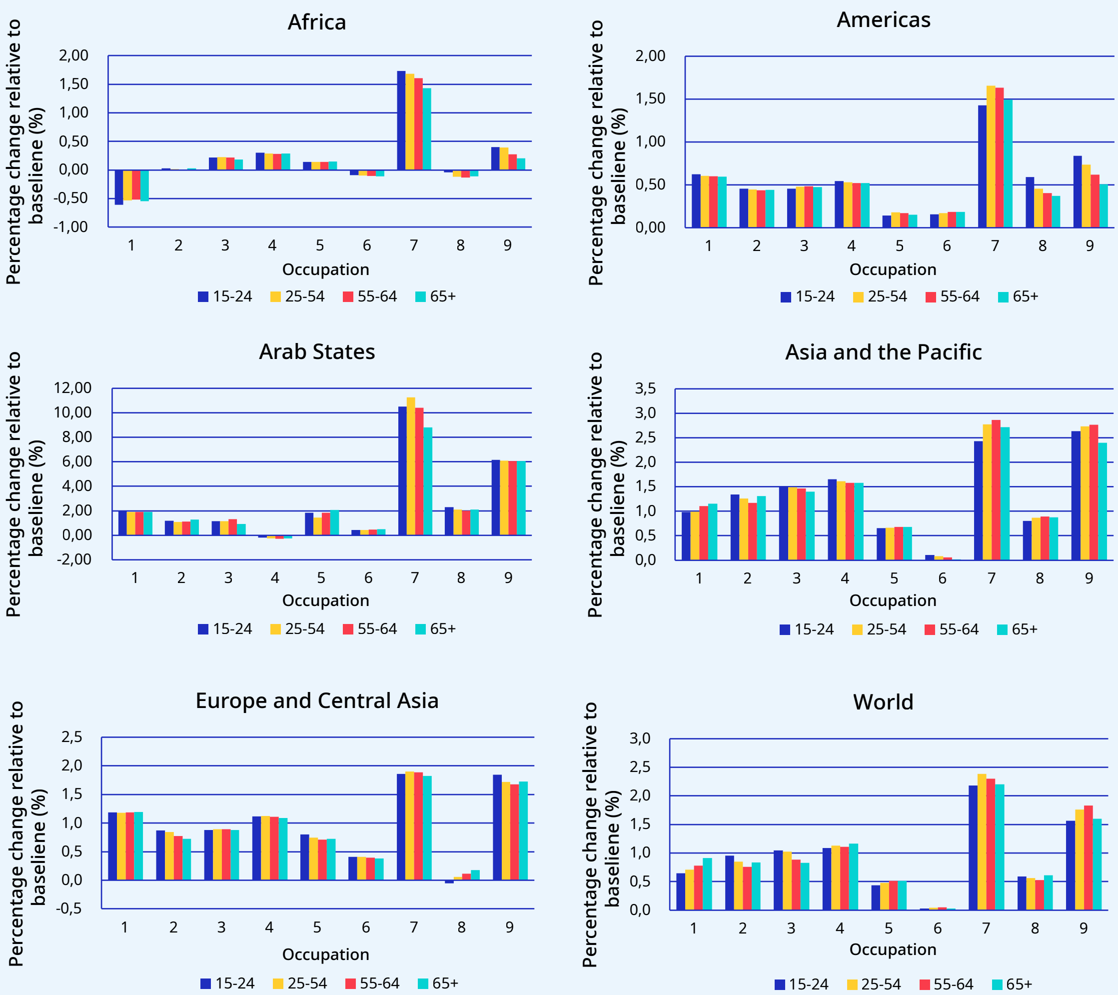
Note: A fixed-shares approach is used to disaggregate employment by sex. As a result, the share of employment by sex is identical throughout the projection period.

Broad occupations by ISCO-08 one-digit level: 1 - managers, 2 - professionals, 3- technicians and associate professionals, 4 - clerical support workers, 5 - service and sales workers, 6 - skilled agricultural, forestry, and fishery workers, 7 - craft and related trades workers, 8 - plant and machine operators and assemblers, 9 - elementary occupations (ISCO-08, ILO, Geneva, 2012). Available at: https:// www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_172572.pdf.

Source: E3ME model of Cambridge Econometrics, based on ILO data on employment.

In relation to age, **young people** (aged 15-24) will significantly gain from the transition to renewable energy in all broad occupational categories, while young professionals and associate professional and technicians will gain relatively more compared to other age groups in the same categories. The relatively better prospects for higher-skilled young people can be seen in Asia and the Pacific, the Americas and Europe and Central Asia. Young people in Africa will particularly benefit from job growth in craft and related trades, and elementary occupations, while losses are expected for young managers. This reflects the fact that not enough good quality jobs are created in Africa, where economies are largely informal. Youth will also benefit relatively more than other age groups from employment growth in elementary occupations in Europe and Central Asia and in the Americas, whereas in the latter youth will also benefit from job growth among plant and machine operators. Young people are relatively prominent in agricultural occupations (especially in Africa), and employment in these occupations is forecast to decline in the baseline scenario (which does not include any effects from the energy transition) and hence the energy transition could potentially offset these losses, although naturally this will vary from place to place. However, this would require effective policies and measures to enable this transition to take place, not least to ensure jobs are created in the locations suffering agricultural employment loss and with effective reskilling measures. **Ageing workers** will also relatively benefit from the energy transition scenario, especially higher-skilled older workers in Aisa and the Pacific, and in Europe and Central Asia (see figure 2.4.).

▶ Figure 2.4. Energy Transition Scenario - Employment change relative to baseline by broad occupation and age group, 2030



Notes: A fixed shares approach is used to disaggregate employment by age group. As a result, the share of employment by age group is identical throughout the projection period.

Broad occupations by ISCO-08 one-digit level: 1 - managers, 2 - professionals, 3- technicians and associate professionals, 4 - clerical support workers, 5 - service and sales workers, 6 - skilled agricultural, forestry, and fishery workers, 7 - craft and related trades workers, 8 - plant and machine operators and assemblers, 9 - elementary occupations (ISCO-08, ILO, Geneva, 2012). Available at: https:// www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_172572.pdf.

Source: E3ME model of Cambridge Econometrics, based on ILO data on employment.

3

Digitalizing the economy

3.1. Introduction

This chapter explores the digital landscape, outlining current trends and developments in occupational and skills needs. It examines the employment implications of expanding digital economies, highlighting variations across gender, skill levels, occupations, age, regions, and income groups. It also sets the stage for discussing skills responses in Chapter 5.

A distinction is made between “digital skills” and “skills for the digital economy” (ILO 2021a). Digital skills are a subset of broader skills needed for the digital economy, including foundational and complementary skills such as analytical thinking, creativity, and problem-solving, which were important even before the digital era. While digital skills help digitalize the economy, broader skills enable individuals to thrive in it. Digitalization encompasses a wide range of technologies, including AI, big data, extended reality, 3D printing and blockchain (ECB 2021). Defining the digital economy is challenging due to the pervasive nature of digital technology, but it generally refers to all economic activities reliant on digital inputs, such as infrastructure, services, and data (OECD 2020). While some digital technologies can support the green transition, for example by reducing the need to travel, others, such as blockchain mining or Generative AI, increase energy consumption and environmental footprint. This highlights that the digital and green transitions do not always move in the same direction.

The digital economy has evolved in waves,[17] from the 1990s focus on efficiency, to the 2000s rise of digital services, and the 2010s transformation of business models. The current wave, driven by generative AI, promises to further disrupt industries, particularly in sectors like banking, technology and life sciences, but also in healthcare, manufacturing, retail and logistics (ILO 2021a). While AI could boost productivity and augment workforce capabilities, it requires substantial investment in retraining to mitigate potential negative impacts (UN and ILO 2024). As digitalization accelerates, issues like misinformation (OECD 2024), inequality, uneven adoption across countries (UN and ILO 2024), and the risk of job displacement must be addressed. However, the ongoing shift suggests adaptation rather than apocalypse, requiring policies to manage transitions and ensure equitable outcomes (ILO 2023b).

While the role of digital technologies is widespread in the economy and society, 2.6 billion people, approximately a third of the world’s population, remain offline. Universal connectivity remains a distant prospect (ITU 2024). When looking at more advanced digital technologies, such as the use of AI, the group of people not having access is even larger, as its usage requires resources and infrastructure (broadband, devices, GPUs, etc.) and relevant skills.

3.2. Recent developments driving employment and skills needs: Opportunities, challenges and policy trends

The digital transformation of the economy, driven by emerging technologies like generative AI, has profound implications for employment and skills needs. These shifts are intertwined with global

17 See for a discussion on waves of digitalization of the economy: Dmytro V. Maliar et al., “Four waves of digitalization of the economic system in the EU countries and Ukraine”. *Studies of Applied Economics*, 39(6), 2021. https://doi.org/10.25115/eea.v39i6.5244. See as well: SIDGS, “Three Waves of Digital Transformation: What You Need to Know to Stay Ahead”.

developments in technology, society, geopolitics, and the environment. This section explores four key developments shaping the digital economy and their impact on the workforce: the rise of generative AI, the structural changes brought by the COVID-19 pandemic, increasing demand for minerals and energy to support digital growth, and societal challenges linked to digitalization. Each of these trends reflects a different dimension of digital transformation, from technological innovation to global health crises and geopolitical tensions. Together, they highlight the opportunities and challenges for policymakers in addressing the changing demands of the labour market and ensuring workers are equipped with the necessary skills. Understanding these developments is essential to formulating effective strategies for navigating the future of work.

Generative AI: Technological development having widespread implications

Generative AI represents a transformative, disruptive, technological development with far-reaching implications for the labour market (NATO 2020). As AI advances, it is poised to significantly disrupt industries by automating tasks across various sectors, from healthcare and transport to education and agriculture. By 2040, generative AI could automate up to a quarter of current jobs, potentially affecting 300 million full-time positions globally (Hatzius et al. 2023). While AI is expected to improve productivity, historical trends suggest that job displacement may be balanced by the creation of new roles, fostering long-term employment growth (Hatzius et al. 2023).

Generative AI, when combined with robotics, has the unique capacity to affect not only routine, low-skilled jobs but also high-skilled positions, especially in advanced economies, where up to 60 per cent of jobs may experience some level of AI-driven change (IMF 2024). While AI may enhance productivity in half of these roles, the other half could face reduced demand, leading to job losses and lower wages. Emerging markets and lower-income countries, with less AI exposure, may see fewer immediate impacts. However, they risk falling behind without the necessary infrastructure and skilled workforce to leverage AI's potential, exacerbating global inequality (IMF 2024).

The rise of generative AI highlights urgent challenges in workforce development, particularly the need for new skills and regulations to protect workers. Policymakers must prioritize strategies that mitigate job displacement while maximizing the technology's productivity benefits (ILO 2023b). This requires collaboration between governments, AI developers, and researchers to address the risks and knowledge gaps associated with rapid technological advancements (OECD, 2024). At the organizational level, companies, particularly in advanced economies, should adopt proactive strategies to manage AI-driven changes (Morandini et al. 2023). Identifying skills gaps, offering targeted training, and supporting workers in developing AI-related competencies are essential steps in ensuring adaptability. These efforts will be crucial in preparing the workforce for the ongoing digital transformation, enabling workers to thrive in an evolving labour market.

The COVID-19 pandemic and the impact on work structure and practices

The COVID-19 pandemic significantly accelerated digitalization, reshaping work structures and practices across sectors. Remote working became widespread, particularly for higher-skilled, white-collar workers, while lower-skilled, blue-collar workers faced greater job losses, as their roles were less adaptable to remote conditions (OECD 2021). This shift deepened existing inequalities, with vulnerable groups such as those in low-paid jobs, younger workers, and those with lower education levels experiencing higher unemployment and reduced hours (OECD 2021).

Inequalities have risen within countries, but also between countries, influenced by labour market structures and infrastructure. Countries with robust digital infrastructure and skilled workforces were better able to adapt, turning the crisis into an opportunity for further digital transformation. However, the pandemic also exposed a growing digital divide, especially in rural areas and developing regions, where access to necessary technology and training remains limited (ILO 2021a), exacerbating inequality. This disparity highlights the need for policies that promote equitable access to digital infrastructure.

The COVID-19 pandemic has increased the demand for digital literacy and advanced skills in IT, cloud computing, and data analysis. This shift requires education systems to prioritise key digital competences and adapt upskilling and reskilling programmes to meet the needs of a more automated workplace. In response, governments and international organizations are promoting policies that ensure equitable access to digital infrastructure and support lifelong learning. The rise in digital work underscores the importance of inclusive policies to help all workers participate in and benefit from the digital economy.

Geopolitical tensions: Rising demand for minerals, and energy sources to fuel the digital economy

The rapid digitalization of the global economy has intensified geopolitical tensions as nations compete to secure essential minerals and energy sources needed to fuel emerging technologies like AI, 5G, and advanced manufacturing. This demand has led to political friction, [18] with countries seeking to protect strategic industries and assert control over critical resources. The digital economy depends heavily on physical infrastructure, requiring significant energy and specialized minerals for hardware production. As a result, the demand for a skilled workforce in energy supply, infrastructure development, and mineral extraction and beneficiation is growing, presenting both opportunities and challenges for the labour market.

Countries with strong digital and energy infrastructures are better positioned to capitalize on tech-driven industries. In contrast, those lacking digital and manufacturing infrastructure, and the ability to upskill their workforce, risk failing to capitalize on the opportunities presented by mineral processing and beneficiation, job displacement and widening inequality. Securing access to key resources and technologies, as well as the national capacity to capture the value addition generated through the rising digital economies, remains a central issue in the global race for digital dominance, further escalating geopolitical tensions. It also comes with environmental challenges (UNCTAD 2024).

Societal issues related to the digital transformation

Technological progress certainly generates increases in living standards, but this is unequally distributed (ECB 2023). At societal level, automation and AI are widening the digital divide. Those with limited access to technology or lacking digital skills are increasingly marginalized, particularly women, the elderly, and disadvantaged communities. Even if technological change benefits society, the labour market vulnerabilities it creates tend to be concentrated among certain social groups, potentially leading to significant economic and political disruption. [19] These effects are substantial and demand appropriate policy responses (Bürgisser 2023).

Platform work continues to expand, offering new income opportunities, but also deepening labour market vulnerabilities. These include temporary, part-time, and gig economy jobs, where workers are hired for specific tasks and paid per assignment. Key decent-work deficits in the platform economy relate to unclear employment status, algorithmic management practices, gaps in social protection and labour rights, and the limited availability of reskilling and upskilling opportunities, which are often borne entirely by workers.

Additionally, digitalization raises issues of data privacy, with many citizens accepting some

18 See for a discussion: Centre of European Reform, *Helping Europe's digital economy take off: An agenda for the next Commission*, 2024. European Parliament briefing, *The geopolitics of technology: Charting the EU's path in a competitive world*, 2024.

19 See for instance Im, Zhen et al., "The 'Losers of Automation': A Reservoir of Votes for the Radical Right?" *Research & Politics* 6, No. 1 (2019): 1–9.
Carles Boix, *Democratic Capitalism at the Crossroads: Technological Change and the Future of Politics* (Princeton: Princeton University Press, 2019).
Thomas Kurer, "The Declining Middle: Occupational Change, Social Status, and the Populist Right," *Comparative Political Studies* 53, Nos. 10–11 (2020): 1798–1835.
Aina Gallego and Thomas Kurer, "Automation, Digitalization, and Artificial Intelligence in the Workplace: Implications for Political Behavior," *Annual Review of Political Science* (2022), Online First.

loss of privacy as inevitable, while a number of countries are dealing with the issue of digital sovereignty as a matter of national security, thus heightening geopolitical tensions. This coincides with a rising proportion of the population who think that technical progress is destroying our lives (IPSOS 2023). The latter is also linked with the negative societal impact of AI, deepfakes and social media spreading misinformation, misleading and manipulating people's perception, beliefs and behaviour (PEW Research Center 2022). Overall, effective governance is essential to mitigate risks and ensure that the benefits of digital transformation are equitably shared across society, demanding policy responses that focus on upskilling, reskilling, and developing digital infrastructure.

▶ 3.3. Main occupational and skill needs

In this section, the occupational and skill needs that emerge as a result of digital transformation are further examined. For this, several projections, forecasts and future-oriented studies are explored.

The **global employment landscape** is undergoing significant changes due to digital transformation, with varying impacts across sectors and regions. Advances in technologies such as artificial intelligence (AI), robotics, and automation are reshaping job markets, creating opportunities while displacing routine and low-skill jobs. Routine manual and clerical roles are particularly vulnerable, with sectors like manufacturing and services facing significant risks of job loss due to automation (ILO 2021a). This is evident in regions such as ASEAN, where countries like Indonesia, Philippines and Thailand are expected to experience substantial job displacement in industries like electronics and textiles (ILO 2016).

Conversely, digital transformation is driving job creation, particularly in high-tech fields. In Europe, there is a projected increase of 900,000 jobs in AI and ICT by 2035 (Cedefop 2024a; Eurofound 2023a) and the digital skills needs transcend traditional IT occupations. Several sectors are rapidly becoming more digital (Cedefop 2023d). Sectors such as electricity, gas, steam, and air conditioning supply, construction, and professional, scientific, and technical activities have a high demand for IT skills, with nearly half of online job ads for non-IT roles requiring digital competencies. In contrast, sectors like education, water supply, and waste management, while also being highly affected by digitalization, have lower digital skills requirements, compared to the earlier-mentioned sectors, with only about one third of job ads mentioning digital skills. However, the trend is shifting, as the accommodation and food services sector has seen a dramatic increase in demand for digital skills, driven by advancements in AI and robotics, and the expansion of e-commerce and warehouse automation (Blöcher and Alt 2021). Overall, in developed economies (for instance in Europe), surveys show that 87 per cent of workers used a computer device (a desktop computer, laptop or notebook, tablet or smartphone) for their work and, therefore, required at least basic digital skills (Cedefop 2022a). Despite such increases in IT-related jobs, the overall net effect of AI in Europe is expected to be negative, with an estimated loss of 300,000 jobs due to increased labour productivity and the high cost of upskilling (Cedefop 2024a).

Regionally, the impact of digital transformation varies significantly. In developed economies with advanced digital infrastructures, job displacement may be mitigated by higher digital skill levels and more adaptive labour markets (OECD 2019). However, in developing countries where digital adoption is slower and informal employment prevails, the transition may be more gradual. These regions might face delayed or less severe disruptions, though they are not immune to the effects of global technological shifts (ILO 2021a).

The digital transformation is reshaping the global labour market, leading to **the emergence of new occupations** while rendering others obsolete. Technologies such as AI, robotics, and the Internet of Things (IoT) are transforming the nature of work across various sectors. Information and communication technology (ICT) roles are experiencing significant growth, with over 65,000 new jobs anticipated in Europe by 2035 (Cedefop 2024a). These roles require not only technical proficiency but also the ability to utilize emerging technologies like AI and cloud computing.

While some roles are being enhanced by automation, others, particularly low-skilled and routine manual jobs, are at risk of displacement. This concerns for instance clerical and administrative jobs with tasks such as document drafting and information analysis showing high potential for automation – jobs that are traditionally filled by women (ILO 2023b). Furthermore, sectors such as agriculture (Cedefop 2023c) and manufacturing are seeing the adoption of robots and AI, reducing the need for human labour. Many traditional roles in industries like metallurgy, food processing, and clerical work are being replaced by machines, driving the need for new skills in advanced manufacturing technologies (Cedefop 2024a) and digital literacy. Jobs that primarily involve physical tasks, such as cleaners and helpers, including roles like painters, paper hangers, and plasterers, are considered to be among the least affected by AI advancements (Guaracio, Reljic, and Stöllinger 2023). All in all, the digital transformation works out differently per sector, and the skills dynamics require different response strategies (ILO 2021a).

The rise of hybrid roles, which blend technical and human-centric skills (ILO 2021a), highlights the importance of lifelong learning and reskilling. Skills in computer-human interaction, creative thinking, data analysis and external communication are becoming increasingly essential (OECD 2023c), especially in sectors like sales, where AI automates routine tasks (Cedefop 2024a). The demand for digital skills is not limited to IT professionals, as non-technical fields like marketing and journalism now require data analysis and digital communication abilities (ILO 2023b). What becomes clear from existing research is that basic digital skills are not enough. To thrive in the digital economy, a combination of technical skills and human-centric abilities is essential (ILO 2021a).

Despite the growing need for digital skills, gender disparities persist (ILO 2021a), particularly in ICT roles. Women are significantly underrepresented in high-demand digital fields across the globe, but especially in developing countries, such as India, Indonesia, and Thailand. Closing this gender gap requires targeted efforts to encourage women to enter ICT education and careers.

As the digital transformation continues, constant reskilling and upskilling will be crucial to adapting to automation and evolving technologies. The AI impact quadrant provides a framework to navigate the skills required, distinguishing between reskilling, upskilling, and cross-skilling, [20] which are essential for managing the impacts of AI and automation on the workforce. This model differentiates between reskilling, upskilling and cross-skilling, all serving a purpose in sectors that are differently exposed to AI impact: reskilling is more related to job replacement and automation, while upskilling and cross-skilling are more related to job augmentation and hybridization. Here, workers expand their skills to work alongside AI, enhancing their roles rather than losing their jobs (UN and ILO 2024).

Regarding matters of **inclusion**, the digital transition has deepened inequalities in opportunities, particularly due to disparities in digital skills and access to training. The "Matthew principle", where the advantaged benefit more while the disadvantaged fall further behind, is evident in this context. Workers in low-wage or temporary positions often lack access to digital training, exacerbating the divide between those able to use digital advancements and those who cannot. Eurofound notes that younger, higher-skilled employees on permanent contracts are more likely to receive employer-funded training, while older and temporary workers are left behind (Eurofound 2023a). Globally, many people lack basic digital literacy (OECD 2023c), further limiting their ability to engage with digital tools and navigate vast amounts of information, including misinformation.

This digital skills gap, combined with unequal access to resources, leaves marginalised groups at greater risk of exclusion from the digital economy. African leaders see a clear need for additional action to make the digital transformation of Africa an inclusive one, bridging the digital divide and inequalities. [21] Cedefop highlights that disparities in digital skills are influenced by factors such as age, education, and socioeconomic status (Cedefop 2023d). To address these inequalities, targeted reskilling programmes and equitable access to digital training are urgently needed. Additionally, the integration of AI and digitalization into workplaces can impact job quality, sometimes reducing worker autonomy and satisfaction (Eurofound 2023a), emphasising the importance of worker involvement in technological change. In countries

20 Workers expand their capabilities to work alongside AI, enhancing roles rather than losing them (UN and ILO 2024).

21 African Union, "African ministers rally more action to bridge the digital divide and inequalities", 2023.

with strong workplace consultation practices, such as those in the Nordic region and Germany, workers generally experience more positive outcomes from technological changes (UN and ILO 2024).

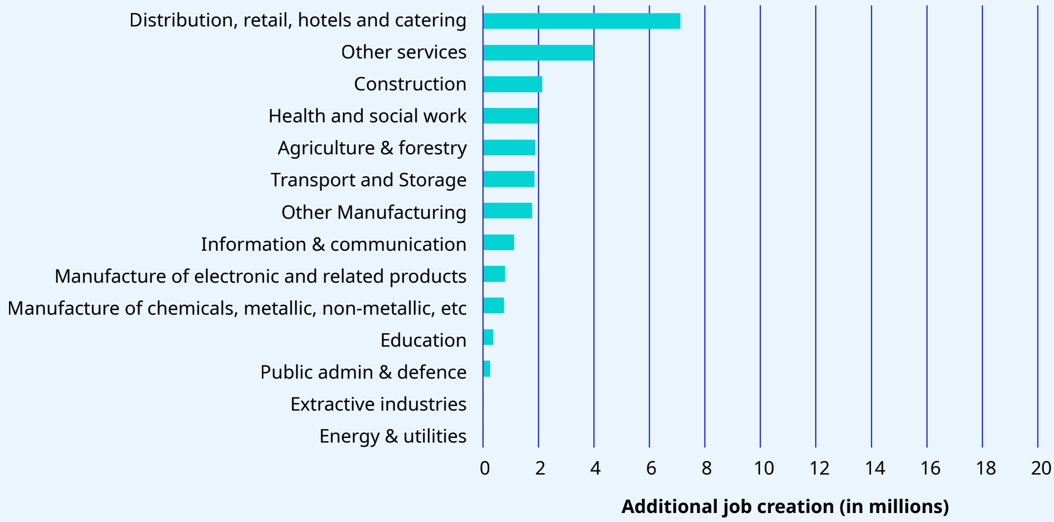
3.4. Employment projections: Near-Universal Broadband Scenario

The digital transition scenario (further referred a Near-Universal Broadband Scenario) presented below analyses the impacts of investment to reach universal broadband Internet coverage (defined as covering at least 90 per cent of the population) across regions and sectors in 2030. The scenario assumptions are based on the ITU (2020) modelled estimates of the impact of the universal broadband coverage, both fixed and mobile on the economy (see Annex A). It therefore does not capture the employment effects of AI discussed in earlier sections based on the literature review. In contrast to the mixed or potentially negative impacts associated with AI, expanding broadband connectivity is expected to have a positive effect on employment, particularly in regions that are currently poorly connected. For some regions, such as Africa, and for low-income countries, this would require a major increase in coverage and therefore investment in infrastructure. Internet use in these areas remains very low, at only about 27 per cent among low-income countries, and 38 per cent in Africa (ITU 2024). Accordingly, the Near-Universal Broadband Scenario cannot be assumed by default and constitutes a substantial challenge for policy and implementation.

The scenario predicts that by 2030, universal broadband is expected to enhance digitalization, boosting productivity through increased use of digital technologies by firms and greater demand for digital services. This rise in productivity will positively impact domestic economies by lowering prices and enhancing trade competitiveness, although it may reduce wages due to decreased demand for labour. However, increased output is anticipated to drive employment and real incomes, leading to higher consumption. Productivity gains will vary by sector and region, with the size of the productivity boost depending on the existing gap in broadband coverage. Sectors with low digital intensity will experience smaller productivity improvements. Internet access will also shift consumer spending towards digital services, particularly in regions with lower current coverage, such as Africa, where spending on financial and communication services could increase by up to 50 per cent. Other impacts include reduced administrative costs for firms and increased investment in infrastructure, with significant funds allocated to construction and technology sectors. The expansion of broadband infrastructure will be funded by private firms, with costs passed on to consumers or absorbed through reduced profits, depending on sector-specific factors. The scenario does not consider the increasing evidence that digitalization and AI have a more significant impact on employment in advanced economies, where the adoption of these technologies is more straightforward.

Given this scenario, **global employment is projected to rise by approximately 0.7 per cent by 2030** or over 23 million jobs compared to the baseline. Employment dynamics under the Near-Universal Broadband Scenario exhibit significant variation across skills levels, occupations, age groups, regions, and income levels. Concerning **skills levels and occupations**, the scenario predicts notable employment gains in service and sales workers, craft and related trades workers, and elementary occupations. By 2030, service and sales occupations will see substantial growth, particularly in the wholesale and retail trade sectors, which will add over 4 million jobs. Craft and related trades will benefit significantly from growth in the manufacturing sector, contributing more than 3 million new jobs. Elementary occupations will experience widespread growth across various sectors, with significant increases in construction and administrative support services. More specifically in the service sector, job creation will be relatively strong in distribution, retail, hotels and catering, community, social and personal services, health and social work, and transport and storage, with notable gains also in construction and agriculture and some parts of manufacturing (see figure 3.1.).

▶ Figure 3.1. Near-Universal Broadband Scenario – Employment change relative to baseline by economic sector (in millions)



Source: ILO, based on E3ME model of Cambridge Econometrics.

The Near-Universal Broadband Scenario predicts job growth in **occupations** related to the development and maintenance of the digital infrastructure, and also the expansion of e-commerce and online services, notably amongst sales and personal service workers as well as drivers, plant operatives, builders and related trades workers (see table 3.1.).

▶ Table 3.1. Near-Universal Broadband Scenario - Top 10 occupations accounting for 11 million jobs, or 46.3 per cent of total employment growth

#	ISCO-08 2 Digit	Occupation	Employment growth (Thousands)	Percentage change relative to baseline (%)
1	52	Sales Workers	2 041	0.9
2	51	Personal Service Workers	1 423	1.0
3	83	Drivers & Mobile Plant Operators	1 137	0.9
4	71	Building & Related Trades Workers (excluding Electricians)	1 095	0.8
5	93	Labourers in Mining, Construction, Manufacturing & Transport	986	0.7
6	54	Protective Services Workers	983	1.1
7	91	Cleaners & Helpers	907	0.9
8	72	Metal, Machinery & Related Trades Workers	796	0.7
9	12	Administrative & Commercial Managers	780	0.8
10	61	Market-oriented Skilled Agricultural Workers	765	0.4
All occupations			**23 548**	**0.7**

Note: ISCO-08 two-digit based on ISCO-08, ILO, Geneva, 2012. Available at: https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/ wcms_172572.pdf.

Source: ILO, based on E3ME model of Cambridge Econometrics.

Globally, universal broadband internet coverage is expected to create 23.5 million jobs. While all **regions** are predicted to gain jobs, Asia and the Pacific (8.2 million jobs), Africa (6.3 million) and the Americas (6.2 million) will gain most of jobs. Africa and the Americas will also enjoy a high rate of job growth in the scenario, while relatively modest job gains in the Middle East in absolute terms may be compensated over time as the rate of job creation will be the highest in the region. Conversely, Europe and Central Asia, where internet access is already widespread, will see modest growth. Middle-income countries will gain over 17 million or 75 per cent of the employment gain in this scenario. Low-income countries, however, will benefit from the highest rate of job gain among income groups (see table 3.2.).

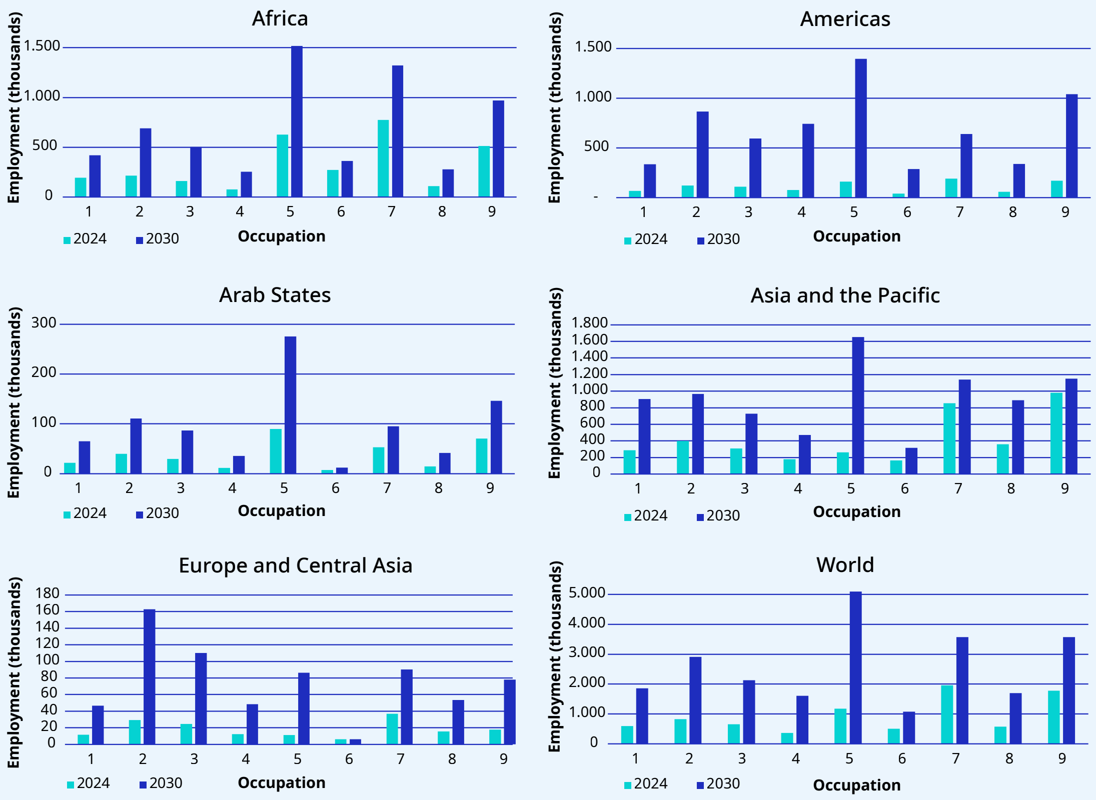
▶ Table 3.2. Near-Universal Broadband Scenario – Change in employment relative to baseline by 2030

	Change relative to baseline in millions	Change relative to baseline in %
ILO Region		
Africa	6.3	1.2
Americas	6.2	1.2
Arab States	0.9	1.5
Asia and the Pacific	8.2	0.5
Europe and Central Asia	0.7	0.2
Income Level		
High income	2.0	0.4
Upper-middle income	8.7	0.7
Lower-middle income	8.9	0.8
Low income	2.7	1.4
World	**23.5**	**0.7**

Source: E3ME model of Cambridge Econometrics.

The net employment gains by occupation are expected to have strong variation across regions. Service and sales workers consistently show the largest increases, especially in Africa, Asia and the Pacific, and the Americas, where digital services and online commerce are expanding rapidly. Elementary occupations and craft and related trades workers are also projected to grow notably in these regions, driven by rising demand for basic services and digitally enabled trades. In contrast, in Europe and Central Asia and the Arab States, the more modest employment gains are spread more evenly across occupations, with higher-skill groups (managers, professionals and technicians) expected to experience the most positive impacts (see figure 3.2.).

Figure 3.2. Near-Universal Broadband Scenario – Employment change by broad occupation and ILO region, 2024-30

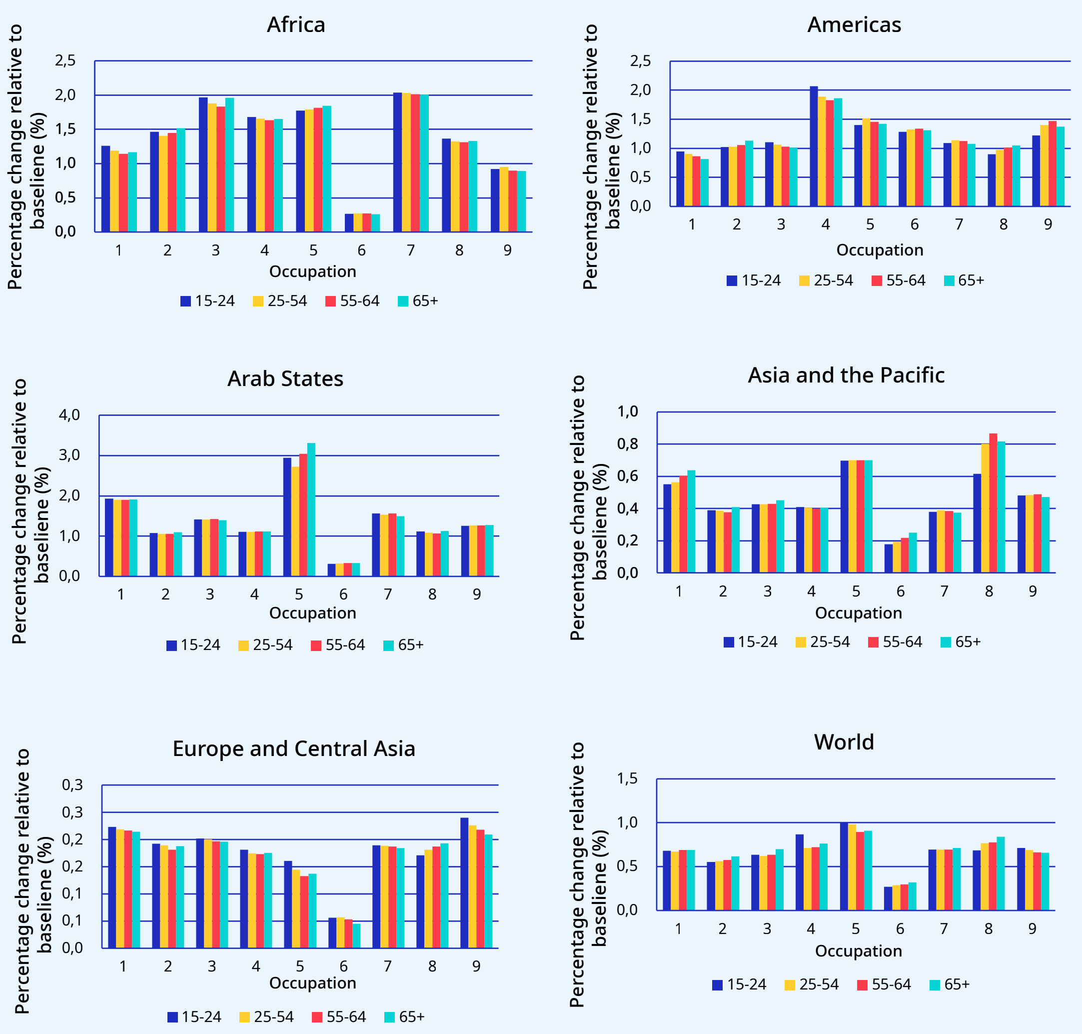


Note: Broad occupations by ISCO-08 one-digit level: 1 - managers, 2 - professionals, 3 - technicians and associate professionals, 4 - clerical support workers, 5 - service and sales workers, 6 - skilled agricultural, forestry, and fishery workers, 7 - craft and related trades workers, 8 - plant and machine operators and assemblers, 9 - elementary occupations (ISCO-08, ILO, Geneva, 2012). Available at: https:// www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_172572.pdf.

Source: E3ME model of Cambridge Econometrics, based on ILO data on employment by occupation and sector.

Considering age groups, **young people** (ages 15–24) are projected to benefit significantly from digitalization under the Near-Universal Broadband Scenario, particularly in middle-skill occupations (see figure 3.3.). In Africa, however, high-skilled youth are expected to have the strongest labour market prospects. Despite its young population, Africa will also continue to rely on high-skilled **older workers**. Older workers are expected to remain active across all occupations and regions, underscoring both the value and necessity of their continued labour market participation and signalling the need for digital upskilling measures to help them maintain their relevance.

▶ Figure 3.3. Near-Universal Broadband Scenario – Employment difference from baseline by broad occupation and age group, 2030



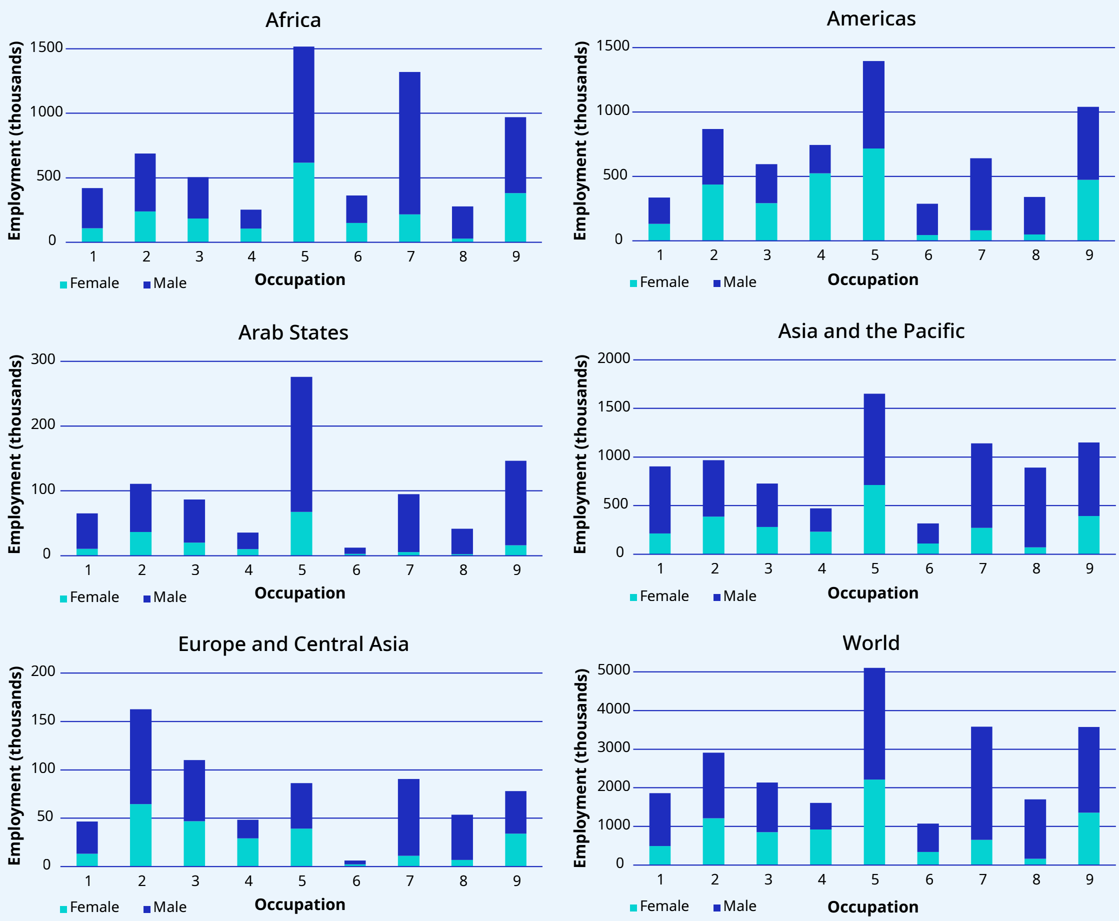
Notes: A fixed shares approach is used to disaggregate employment by age group. As a result, the share of employment by age group is identical throughout the projection period.

Broad occupations by ISCO-08 one-digit level: 1 - managers, 2 - professionals, 3- technicians and associate professionals, 4 - clerical support workers, 5 - service and sales workers, 6 - skilled agricultural, forestry, and fishery workers, 7 - craft and related trades workers, 8 - plant and machine operators and assemblers, 9 - elementary occupations (ISCO-08, ILO, Geneva, 2012). Available at: https:// www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_172572.pdf.

Source: E3ME model of Cambridge Econometrics, based on ILO data on employment by occupation, sector and age.

Regarding **gender** aspects, employment gains from digitalization are expected to be uneven globally, extending current occupational inequalities into the future. By 2030, 65 per cent of the new jobs created under the Near-Universal Broadband Scenario are projected to go to men, with regional disparities even more pronounced. For example, around 80 per cent of employment gains in the Arab States are expected to benefit male workers, compared with about 56 per cent in the Americas (see figure 3.4.). Although women have better prospects in services and sales – occupations that are among the fastest-growing in most regions – craft and related trades, technical professional roles and technician occupations remain predominantly male, indicating a significant gender imbalance in employment growth. Addressing these disparities will require targeted global gender equity initiatives alongside investments in digital infrastructure.

Figure 3.4. Near-Universal Broadband Scenario – Employment difference from baseline by broad occupation and age group, 2024-30

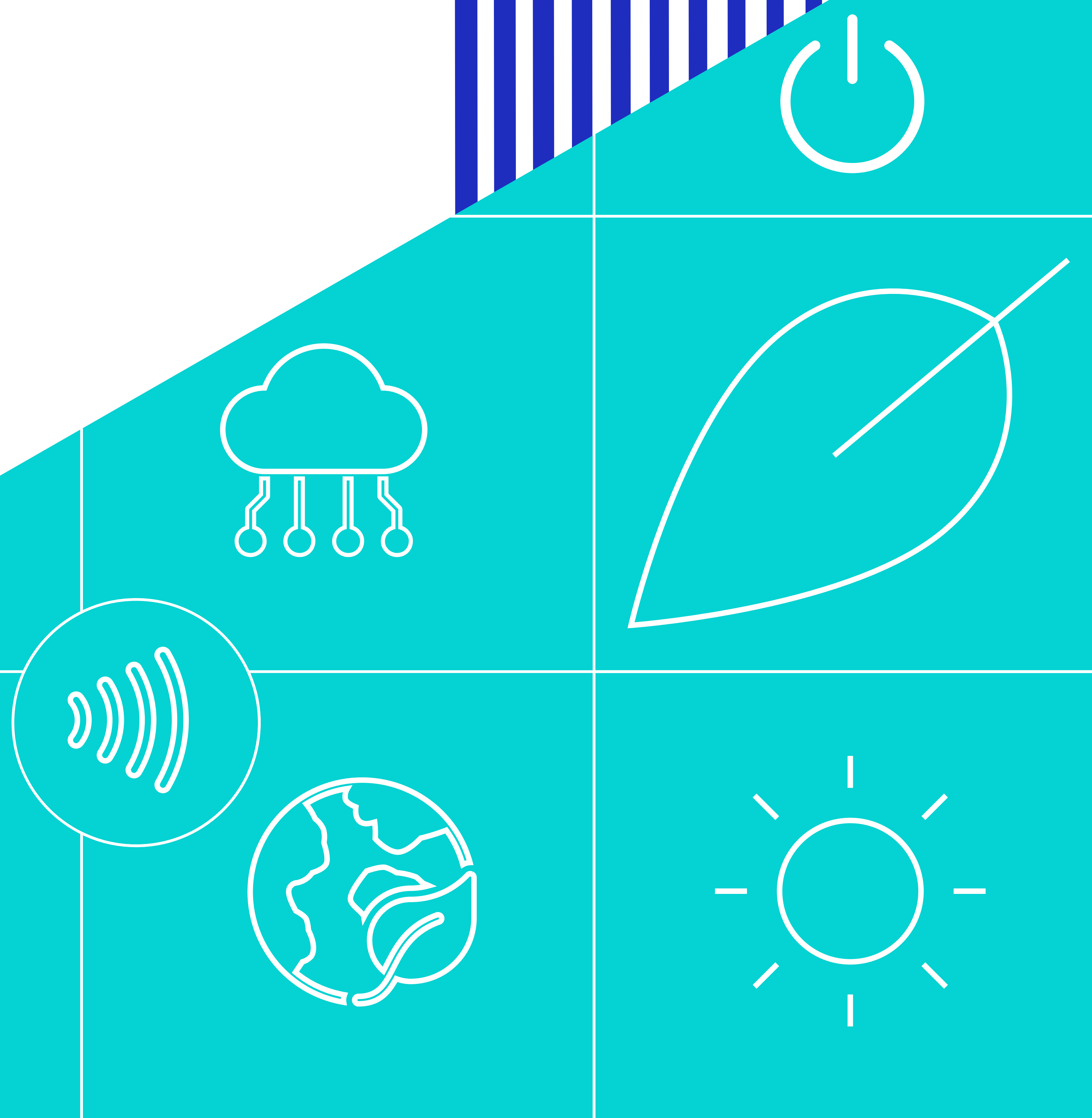


Notes: A fixed shares approach is used to disaggregate employment by sex. As a result, the share of employment by sex is identical throughout the projection period.

Broad occupations by ISCO-08 one-digit level: 1 - managers, 2 - professionals, 3 - technicians and associate professionals, 4 - clerical support workers, 5 - service and sales workers, 6 - skilled agricultural, forestry, and fishery workers, 7 - craft and related trades workers, 8 - plant and machine operators and assemblers, 9 - elementary occupations (ISCO-08, ILO, Geneva, 2012). Available at: https:// www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_172572.pdf.

Source: E3ME model of Cambridge Econometrics, based on ILO data on employment by occupation, sector and sex.

▶ 4



Tackling the green and digital transitions together

4.1. Introduction

This chapter examines the intersection between the green and digital transitions. Most of the literature tends to deal with one or the other transition in isolation. [22] Drawing on both the comparatively limited literature available and the analyses presented in Chapters 2 and 3, this chapter provides an integrated examination of recent developments and related labour market and skills trends. It considers the potential for synergies between green and digital transitions, including the extent to which employment and skills changes may offset or reinforce one another.

4.2. Recent developments: opportunities, challenges and policy trends

As noted in Chapter 2, **green technology and innovation are key drivers of the green transition, and vice versa**. Technological developments are central to the production of renewable energy, for example, through wind turbines and photovoltaic (solar) power systems and to the continual improvemen of these technologiest. Innovations continue to open up new opportunities such as tidal energy and the use of hydrogen for e-fuels. Technological developments have similarly been vital to the use of renewable energy in, for example, electric vehicles and to the creation of new products to improve the energy efficiency of buildings. Technology thus has an important catalytic role in the green transition. Conversely, developing new technologies to meet climate needs and global commitments means that the green transition can also catalyse new technological advances. Electric vehicles would likely still be in their early stages of development if the climate emergency had not begun.

Specifically digital technologies can help in both the **mitigation of and adaptation to climate change** (GeSI 2020) as well as helping to address other environmental challenges such as air pollution, waste management and the protection of biodiversity. Regarding mitigation, smart grids and smart buildings can increase energy efficiency and improve the management of renewable energy, and entire intelligent transport systems and "smart cities" are being developed on this basis (Cedefop 2022b). Digital systems can also be used to measure energy usage at the local level and to manage demand and supply. They are key to improving manufacturing efficiency through Industry 4.0 (ILO 2022b) and to supporting precision agriculture. It has been estimated that measures such as these could support significant carbon abatement. [23] In relation to adaptation, technologies such as remote sensors, satellites, geographic information systems (GIS), AI and big data analytics can help with monitoring extreme weather events, disaster management and resource management. Table 4.1. provides examples of how green technologies may affect different sectors.

22 Even reports that mention both transitions in their titles often treat them individually (OECD, 2023c; Cedefop 2022c).
23 GeSI (2020) estimated the potential carbon abatement for four sectors in seven countries and found that, depending on the scenario, it could range from 1.1Gt to 2.1Gt of CO2e (CO2 equivalent) against a 2014 baseline of 13.2Gt, which was projected to reach 21.8Gt by 2030 under 'business as usual' conditions. Highest abatement potential was found to be in the power sector.

An important characteristic of such examples is the **central role played by connectivity, data and data analytics** (see table 4.1.).
Hence universal broadband coverage, which is the focus of the projections related to the digital transition presented in this report, will be central to achieving the goals of the green transition and realizing the potential benefits of digitalization.

▶ Table 4.1. Examples of impacts of green technologies on selected sectors

Sector	Green technology impacts
Agriculture	Better systems management can increase agricultural productivity at the same time as supporting climate-resilient farming methods through more accurate applications of feed, water, energy, fertilizers, and pesticides, e.g. through equipment based on global positioning systems.
Buildings and construction	Smart building technologies and the Internet of Things devices can be used to monitor energy usage and optimize resource consumption.
Energy	Digital information and smart grid technologies facilitate communication between stakeholders and technical elements in an increasingly complex energy system.
Manufacturing (Industry 4.0)	Monitoring and tracking through smart sensors provides real-time information on the parts and materials used in products to enable better maintenance, increased recycling, and reuse.
Mobility and transport	Simulation and forecasting can help optimise traffic flows to limit congestion and pollution.

Source: Adapted from Muench et al. (2022).

At the same time, **digital technologies themselves have a carbon footprint** and impose new demands on the Earth's resources, for example for lithium used in batteries in electric vehicles. Estimating the carbon footprint of the ICT industry is challenging and has produced wide-ranging results (GeSI 2020). Nonetheless, the energy demands of the latest wave of digital technologies that support, for example, 5G networks, advanced manufacturing and data centres that can handle AI are high. In themselves they should act as a spur to further rapid and concerted action on the transition to renewable energy. On the positive side, many applications that can support climate mitigation or adaptation activities have a relatively small carbon footprint (GeSI 2020). However, awareness of the potential for negative – as well as positive – feedback loops between the green and digital transitions is important if a more sustainable future is to be achieved.

Regarding the **factors influencing** the intersection of the green and digital transitions, Chapters 2 and 3 show that consideration should be given both to "which specific drivers operate at their intersection" and to "how the drivers of each transition influence one another". These intertwined drivers can operate in ways that either support or hinder positive synergies between the two transitions. Analysis along these two dimensions highlights the following key issues:

First, it is important to recognize the contrasting situations of the two transitions in relation to **government policies, markets and technological innovation**. Although consumer behaviour and demand for greener products and services have been gaining importance, the green transition has so far depended largely on public policies and regulations to create the enabling environment for the development of green technologies and green markets. This is not the case for the digital transition, which largely evolves endogenously under market forces with regulatory intervention mainly around issues such as data privacy and monopolistic behaviour by large technology companies, even though many foundational technologies—such as the internet and satellite navigation—originated from public spending through defence contracts.

Secondly, both transitions involve **costs** borne by businesses and individuals, such as those associated with recycling schemes, the automation of tasks through digital solutions, or the decline of carbon-based extractive industries and consequential job losses. These can lead to resistance to change. While this has led some governments to retreat from green policies, no comparable retreat can be observed in relation to digitalization, which has unfolded over several decades in successive waves, despite recent concerns about the potential employment impacts of AI, ethical questions over algorithmic management and the negative effects of social media on young people among many other issues.[24]

Finally, drawing on the analysis of Chapters 2 and 3 and the limited literature that deals with the green and digital transitions in an integrated manner (GeSI 2020), it is possible to synthesise a range of **political, economic, social and technological (PEST) factors** shaping the green and digital transitions (see table 4.2.). There are strong mutual interactions among all these factors. In particular, the strong role of governments in setting the conditions through which green goals will be achieved means that they also have a strong role in the development of green technologies, their roll-out through markets and enterprise development, their uptake and use by businesses and citizens and the development of skills to enable all these processes to take place. In short, governments must navigate a broad and complex set of economic, social and technological factors to achieve green and digital goals, including the development of the critical infrastructure that underpins the employment projections presented in this report.

For example, governments need to offset the high initial costs of green technologies; attract the required investment; facilitate the reallocation of jobs between growing and declining sectors and occupations through career guidance, and workforce reskilling and upskilling; provide a regulatory environment that enables the growth of green technology markets; ensure fairness in the distribution of costs and benefits across the population; facilitate dialogue between the public and private sectors, including with employers and workers potentially affected by the changes, and encourage behavioural shifts towards sustainability through climate and digital literacy. The agenda for governments is indeed wide and deep.

▶ Table 4.2. PEST analysis of key factors shaping the green and digital transitions

Factors	
Political	- Political commitment and stability – long-term or affected by short-term policy "flip-flops"? - Collaboration across government ministries – open sharing or "silo" mentalities? - Policy and regulatory framework – favourable to or restrictive of research, innovation and market creation? - Social dialogue and related institutional mechanisms - functional or underdeveloped? - Stakeholder buy-in and ownership – high or low? - Skills development – embedded in policies or on the sidelines/ad hoc?
Economic	- High initial costs of green technologies – left to the market or reduced through government intervention? - Role of big tech companies – encouraging or stifling innovation? - Start-up ecosystem – accelerating or constraining job creation and innovation? - Nature of skills supply – inhibiting or enabling ability to take advantage of new market opportunities?
Social	- Opinions andperceptions of the effects of the green and digital transitions on work and well-being, including employment opportunities, and data security/privacy - positive or negative? - Actual socio-economic impacts of the transitions combined on communities' and individuals' life chances – positive or negative? - Fairness in the distribution of costs and benefits – positive or negative? - Labour market institutions – effective or underdeveloped?
Technological	- Possibilities for synergistic digital-green developments (green technologies) – high or low? - Degree of interoperability between technologies and willingness to share data – high or low - Availability of high-quality digital infrastructure to support latest and future developments (including AI etc.) – limited or ubiquitous? - Collaboration between technological firms (green and digital) and universities and training centres – high or low? - Technology transfer mechanisms – available or scarce?

Source: Authors, based on a range of sources.

24 Latterly there have also been attempts to reduce the damaging consequences of digitalization on learning in which some governments have reversed policies in this area, halting the roll out of digital learning tools in the absence of much evidence about their benefits and announcing bans on mobile phones in schools (e.g. in England).
See: Associated Press in Stockholm, "Switching off: Sweden says back-to-basics schooling works on paper", *The Guardian*. 11 September 2023.
Government of the United Kingdom, "Government launches crackdown on mobile phones in schools", 19 February 2024.

4.3. Effects of the green and digital transitions on occupations, skills and employment

In terms of the effects of the green and digital transitions on occupations, skills and employment, there are two main questions to consider: (i) what skills and occupations are required at the interface of the transitions and (ii) what the employment interactions between the two might be – in other words, whether losses in one could be offset by gains in the other?

Regarding **occupational and skill needs**, Chapters 2 and 3 showed that three broad types of skills are needed in both the green and the digital transitions. What sorts of skills might be required at the interface of the two transitions?

First, all jobs require some form of **basic skills**. On the one hand, these include skills related to awareness of the need for more sustainable living and working and how to achieve this, for example through recycling. On the other hand, they include basic digital skills, such as how to make optimal use of laptops and smartphones. Evidently, there are areas of potential overlap between these types of skills. For example, "green computing skills" that raise awareness of the need to use more energy-efficient hardware and to recycle information technology (IT) equipment responsibly can reduce the environmental impact of technology (Cedefop 2024b). At the same time, while there is a dearth of evidence in this area, it appears that such overlaps and synergies have not been prominent in policy and practice on skills development to date, as discussed further in Chapter 5.

Secondly, all workers stand to benefit from a range of **core skills** such as systems thinking, problem-solving and communication – also referred to as soft skills, social and emotional skills, and cognitive and metacognitive skills (ILO 2021b). In the green transition, such skills are key to dealing with the complex challenges posed by climate change and environmental degradation. In the digital transition, these skills have become increasingly important for IT workers, as employers now seek people with broader capabilities beyond technical expertise, such as the ability to collaborate effectively in teams to address clients' complex networking problems (ILO 2022b). More generally, they are seen as important in future-proofing people against the potential employment impacts of AI by highlighting the importance of "human-centric abilities" in the workplace (ILO 2021a). The OECD projects that demand will grow most for skills related to interacting with computers, creative thinking, data analysis and information management, and communication with external clients or partners; yet many people worldwide still lack the basic proficiency needed to meet this rising demand (OECD 2023c).

Thirdly, both transitions require different types of **technical skills**, whether they are the skills required by energy auditors or by machine learning engineers. At the intersection of the transitions, we are seeing the application of high-level technical digital skills to the development of green products and services. This may not require entirely new skills or occupations tailored to the needs of the green economy per se, though it may stimulate the creation of new jobs through the usual forces of demand and supply. At the same time, new types of occupations have been identified that combine green and digital technical skills – for example, green technology specialists such as energy experts and circular economy plant designers; digital specialists working in precision agriculture and waste management optimization; and green management occupations that require a well-developed understanding of digital applications, such as smart city managers and renewable energy managers (Cedefop 2022b, 2023a, 2023b, 2023c).

In terms of the **employment** interactions between the green and digital transitions, patterns of job creation and destruction are complex (see Chapters 2 and 3). The green transition entails closing down production and associated "brown jobs" in industries based on fossil fuels, while creating jobs to build and operate new energy infrastructure and to improve energy efficiency in homes and workplaces. It also generates wider effects not directly linked to climate change, such as increased demand for construction workers, plumbers and electricians. Overall, forecasts tend to indicate net gains from such processes. In contrast, the employment effects of the digital transition are more challenging to predict owing to uncertainties regarding the potential for the latest technological wave based on AI to create and destroy employment, especially in occupations with a higher degree of cognitive work, which have so far been relatively unaffected by digitalization. Job quality is also an important and complicating factor, as it remains unclear whether the new jobs generated through greening efforts or the expansion of platform work offer better pay and working conditions than the jobs they replace.

As to **whether the green transition might help to offset losses from the digital transition**, this will depend on their respective effects on occupations and skills and on how these play out at detailed geographical scales. One detailed analysis (OECD 2023a) suggests that workers in most "brown" occupations have the skills needed to move into green jobs, but that workers in most of the occupations at greatest risk of automation lack the skills to make such a transition. This illustrates the complexity of the challenge involved in ensuring that any job losses resulting from digitalization can be offset through action on the green transition in terms of upskilling and reskilling. A key question, however, is where job creation and destruction take place. In the green transition, "brown jobs" have been and continue to be lost in areas that may not be well positioned to take advantage of new job creation, either because they are disadvantaged in terms of renewable energy sources, such as solar and wind resources, or because of their business composition. When the digital transition is added to this mix, it becomes necessary to consider whether the areas worst affected by job losses caused by digitalization are, or are not, well placed to take advantage of greening.

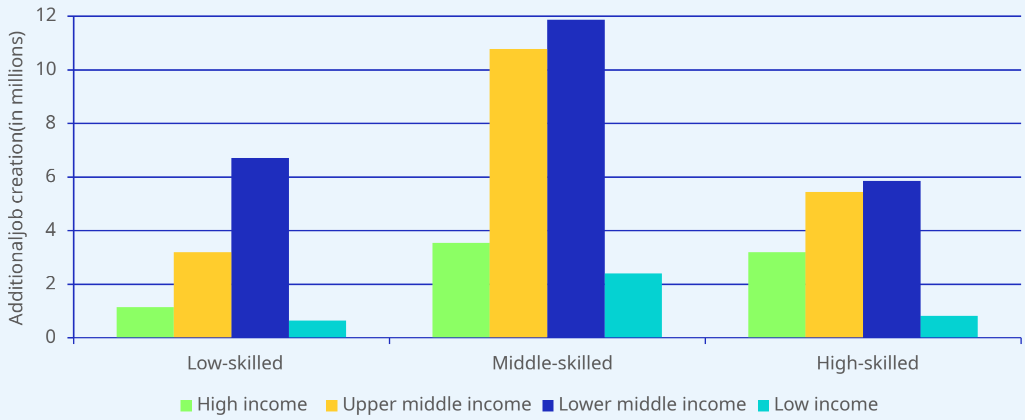
As has been shown in previous chapters, this raises a **critical question of equity**: who is affected by employment changes, and to what extent the benefits of the transitions are fairly distributed across the population in terms of gender, age and income level. In both cases, there is a risk that, without some form of intervention, employment gains will be unevenly distributed across the population.

4.4. Employment projections: Combined Scenario

This section examines a scenario that combines the Energy Transition and Near-Universal Broadband Scenarios already considered. This Combined Scenario incorporates the assumptions of both individual scenarios, capturing the synergies and trade-offs that arise when they occur simultaneously. No further adjustments or reinterpretations are applied.

The result of combining the scenarios is that **global employment growth** would be 1.6 per cent above the baseline in 2030, or 58 million more jobs. This is about 2.7 million fewer jobs than the sum of the two transition scenarios. This difference is explained by the fact that, in the model, combining the two individual scenarios may increase productivity owing to higher investment: the higher investment expenditure may lead to stronger efficiency gains than in each individual scenario, as a result of economies of scale. It may also increase pressure on wages, since both scenarios together raise demand for labour and have a stronger influence on wage rates than when considered separately. The Energy Transition Scenario has the greater effect, accounting for 37.2 million extra jobs, compared to 23.5 million under the Near-Universal Broadband Scenario. In all scenarios, most gains would take place in occupations requiring medium skill levels in all income groups, particularly in middle-income countries (see figure 4.1.).

▶ **Figure 4.1. Job creation relative to baseline by skill levels and country income group by 2030, Combined Scenario (in millions)**

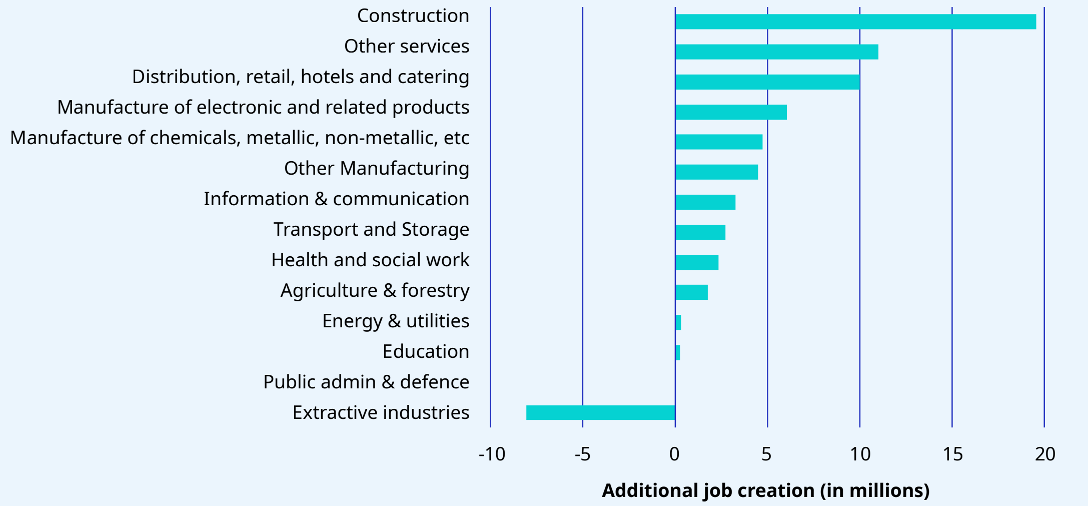


Source: ILO, based on E3ME model of Cambridge Econometrics.

The Energy Transition and Near-Universal Broadband Scenarios have both similarities and differences in their **occupational profiles**. Broadly, employment gains under the Near-Universal Broadband Scenario are spread across a wider range of occupations, but both scenarios will lead to important employment gains in craft and related trades, elementary occupations, and jobs in construction and manufacturing. The Near-Universal Broadband Scenario, on the other hand, will also lead to important gains for service and sales workers, professionals, technicians and associate professionals, and managers. As a result, under the Combined Scenario all occupations would show growth (even in agriculture, to some extent, where employment is forecast to be in general decline globally), and craft and related trades and elementary occupations would be the locus of significant gains, accounting for 47 per cent of all employment gains, followed by service and sales workers (12 per cent) and professional occupations (12 per cent).

At sectoral level, job creation would be especially notable in construction, wide range of services and the manufacturing of electronic and related products. Losses would be concentrated in extractive industries (see figure 4.2.).

Figure 4.2. Combined Scenario by 2030 – Employment change relative to baseline by economic sector (in millions)



Source: ILO, based on E3ME model of Cambridge Econometrics.

Looking at occupations in more detail reveals that job growth would be spread across a wide range of occupations with notable gains among labourers, builders, metal, machinery, electrical and electronics trades and related occupations. There would also be gains in service jobs, including sales workers and personal service workers. Job growth for professionals and associate professionals would also appear in the "top 10" occupations by job growth (see table 4.3.).

Table 4.3. Combined Scenario by 2030 - Top 10 occupations accounting for 30 million jobs, or 52 per cent of total jobs gains

#	ISCO-08 two-digit	Occupational title	Additional job creation (thousands)	Percentage change relative to baseline (%)
1	93	Labourers in mining, construction, manufacturing & transport	6 811	4.8
2	71	Building and related trades workers (excluding electricians)	6 409	4.7
3	72	Metal, machinery and related trades Workers	3 032	2.6
4	52	Sales workers	2 764	1.2
5	74	Electrical and electronics trades workers	2 076	2.4
6	51	Personal service workers	2 036	1.5
7	75	Food processing, woodworking, garment and other craft and related trades workers	2 007	1.8
8	83	Drivers and mobile plant operators	1 661	1.4
9	24	Business and administration professionals	1 636	1.7
10	33	Business and administration associate professionals	1 574	1.5
All occupations			**57 645**	**1.6**

Note: ISCO-08 two-digit codes based on ISCO-08 (ILO, Geneva, 2012). Available at: https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/ wcms_172572.pdf.

Source: ILO, based on E3ME model of Cambridge Econometrics.

In terms of **regions**, the bulk of employment gains from the Combined Scenario would benefit the Asia and the Pacific region, with an impressive 32.8 million additional jobs. Africa and the Americas would also enjoy substantial job gains, each adding close to 8 million jobs. The Arab States would experience the highest rate of job growth under the Combined Scenario. Gains from the Combined Scenario are somewhat more evenly distributed across regions than in each scenario on its own. The Energy Transition Scenario has a clear front-runner – Asia and the Pacific – with very limited job gains for Africa and low-income countries, while the Near-Universal Broadband Scenario shows very few gains for high-income countries, especially Europe and Central Asia, since they already have substantial broadband coverage. Low-income countries would benefit more under the Near-Universal Broadband Scenario than under the Energy Transition Scenario. As a result of these differences there tends to be a "**levelling up**" in the Combined Scenario compared to the scenarios separately, so that although employment growth varies by region and income level, it is never less than 1.1 per cent. The main beneficiaries are middle-income countries in terms of their share of total global employment gains (see table 4.4.).

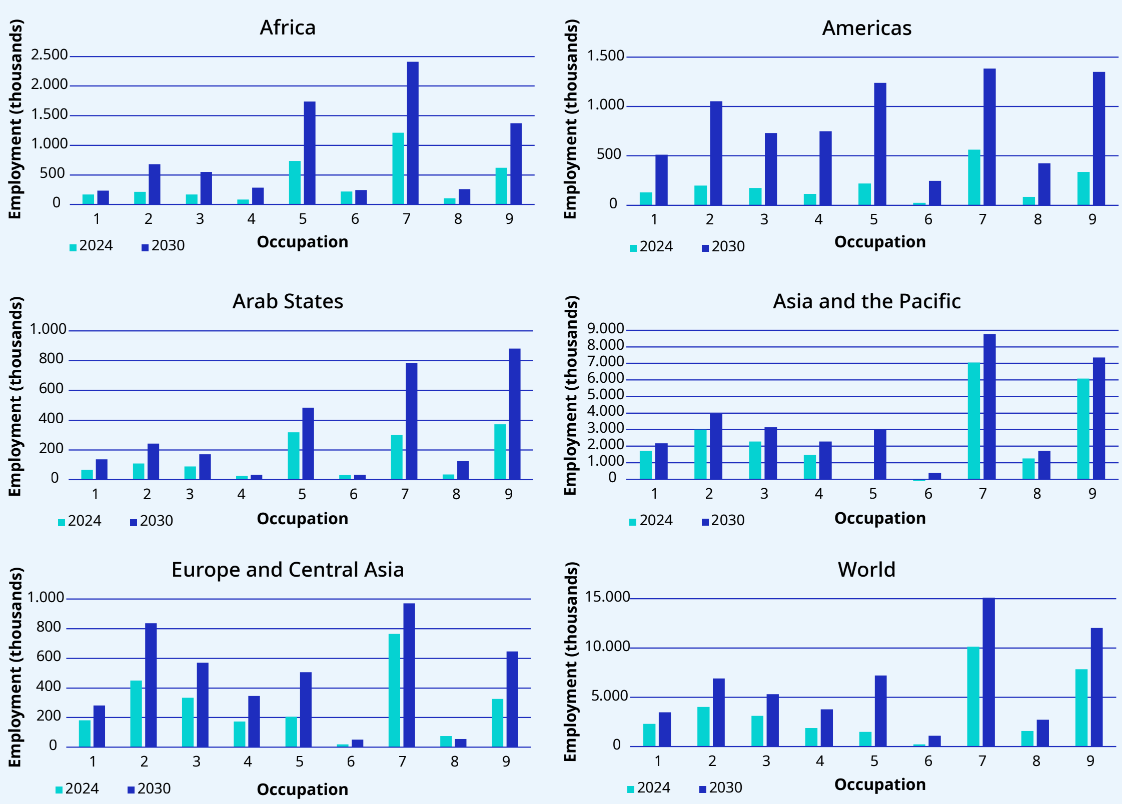
▶ **Table 4.4. Combined Scenario - Employment change from baseline by 2030 (in millions)**

	Change relative to baseline (millions)	Change relative to baseline (%)
ILO Region		
Africa	7.8	1.5
Americas	7.7	1.5
Arab States	2.9	4.9
Asia and the Pacific	32.8	1.9
Europe and Central Asia	4.3	1.1
Income Level		
High income	7.8	1.4
Upper-middle income	19.4	1.5
Lower-middle income	24.4	2.1
Low income	3.8	1.9
World	**57.6**	**1.6**

Source: E3ME model of Cambridge Econometrics.

The more even distribution of employment gains under the Combined Scenario also applies to occupations. However, there are substantial differences by region: while craft and related trades workers, service and sales workers, and elementary occupations would enjoy substantial growth in all regions, high-skill occupations would be in particularly high demand in the Americas and in Europe and Central Asia (see figure 4.3.).

▶ Figure 4.3. Combined Scenario – Employment change from baseline by broad occupation and ILO region, 2024-30

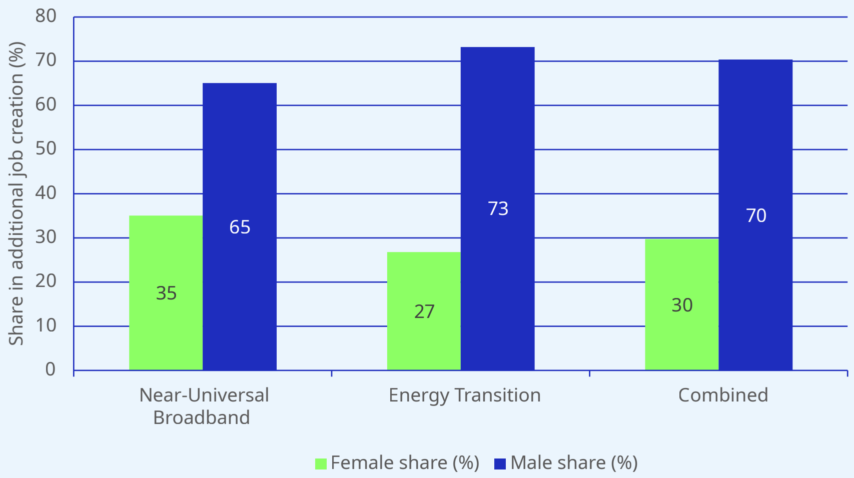


Note: Broad occupations by ISCO-08 one-digit level: 1 - managers; 2 - professionals; 3- technicians and associate professionals; 4 - clerical support workers; 5 - service and sales workers; 6 - skilled agricultural, forestry, and fishery workers; 7 - craft and related trades workers; 8 - plant and machine operators and assemblers; 9 - elementary occupations (ISCO-08, ILO, Geneva, 2012). Available at: https:// www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_172572. pdf).

Source: E3ME model of Cambridge Econometrics, based on ILO data on employment by occupation and sector.

With regard to gender, gender equality is not an automatic outcome of the Near-Universal Broadband, Energy Transition and Combined Scenarios. The gender distribution of the additional job creation is markedly unequal: women gain a smaller share of additional jobs than men by 30 percentage points in the Near-Universal Broadband Scenario, 46 percentage points in the Energy Transition Scenario and 40 percentage points in the Combined Scenario (see figure 4.4.).

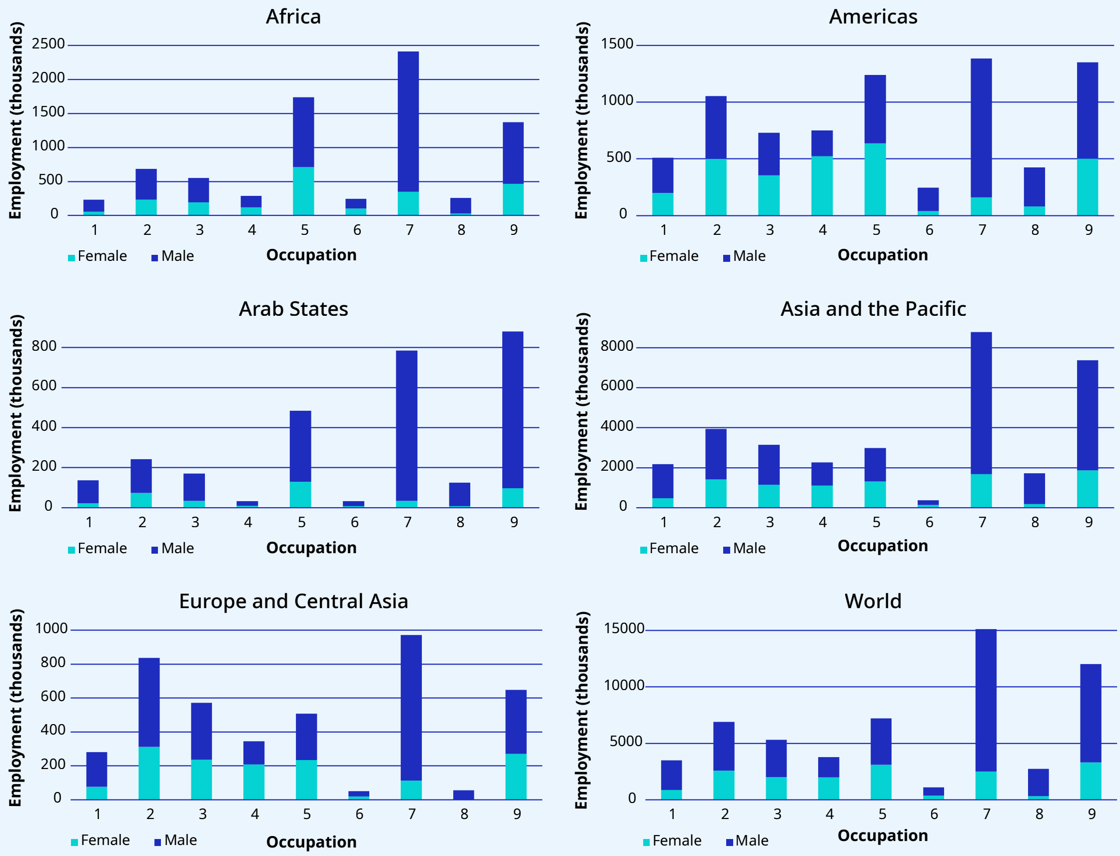
▶ Figure 4.4. Gender gap in employment opportunities by scenario (percentage)



Source: ILO, based on E3ME model of Cambridge Econometrics.

Under the Near-Universal Broadband Scenario, the spread of employment gains across a wider range of occupations means that, while men would still be the main beneficiaries, gains for women are greater than under the Energy Transition Scenario. This is because significant job growth is forecast in occupations such as services and sales and clerical support, where women are generally better represented than in, for example, crafts and related trades. Hence, in the Combined Scenario, men would take 70 per cent of the new jobs – and an even higher percentage in the Arab States and Africa (88 and 86 per cent, respectively). One region stands out for its potential to achieve more equity in employment gains among women in high-skill and medium-skill occupations – the Americas (see figure 4.5.).

▶ Figure 4.5. Combined Scenario – Employment change from baseline by broad occupation and sex, 2030

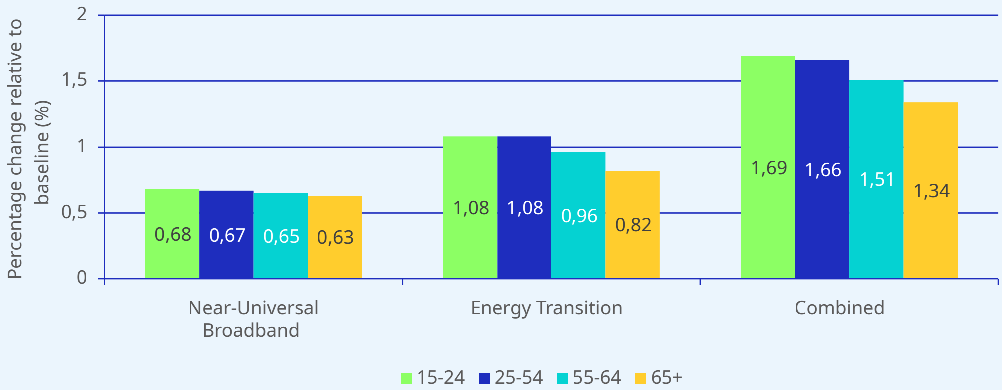


Notes: A fixed-shares approach is used to disaggregate employment by sex. As a result, the share of employment by sex is identical throughout the projection period. Broad occupations by ISCO-08 one-digit level: 1 – managers; 2 – professionals; 3 – technicians and associate professionals; 4 – clerical support workers; 5 – service and sales workers; 6 – skilled agricultural, forestry and fishery workers; 7 – craft and related trades workers; 8 – plant and machine operators and assemblers; 9 – elementary occupations (ISCO-08, ILO, Geneva, 2012). Available at: https:// www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/ wcms_172572.pdf.

Source: E3ME model of Cambridge Econometrics, based on ILO data on employment by occupation, sector and sex.

In relation to **age**, employment opportunities are expected to increase across all age groups, but with stronger relative gains for youth (15–24 years old) and consistently smaller relative gains for older workers, especially in the Energy Transition and Combined Scenarios (see figure 4.6.).

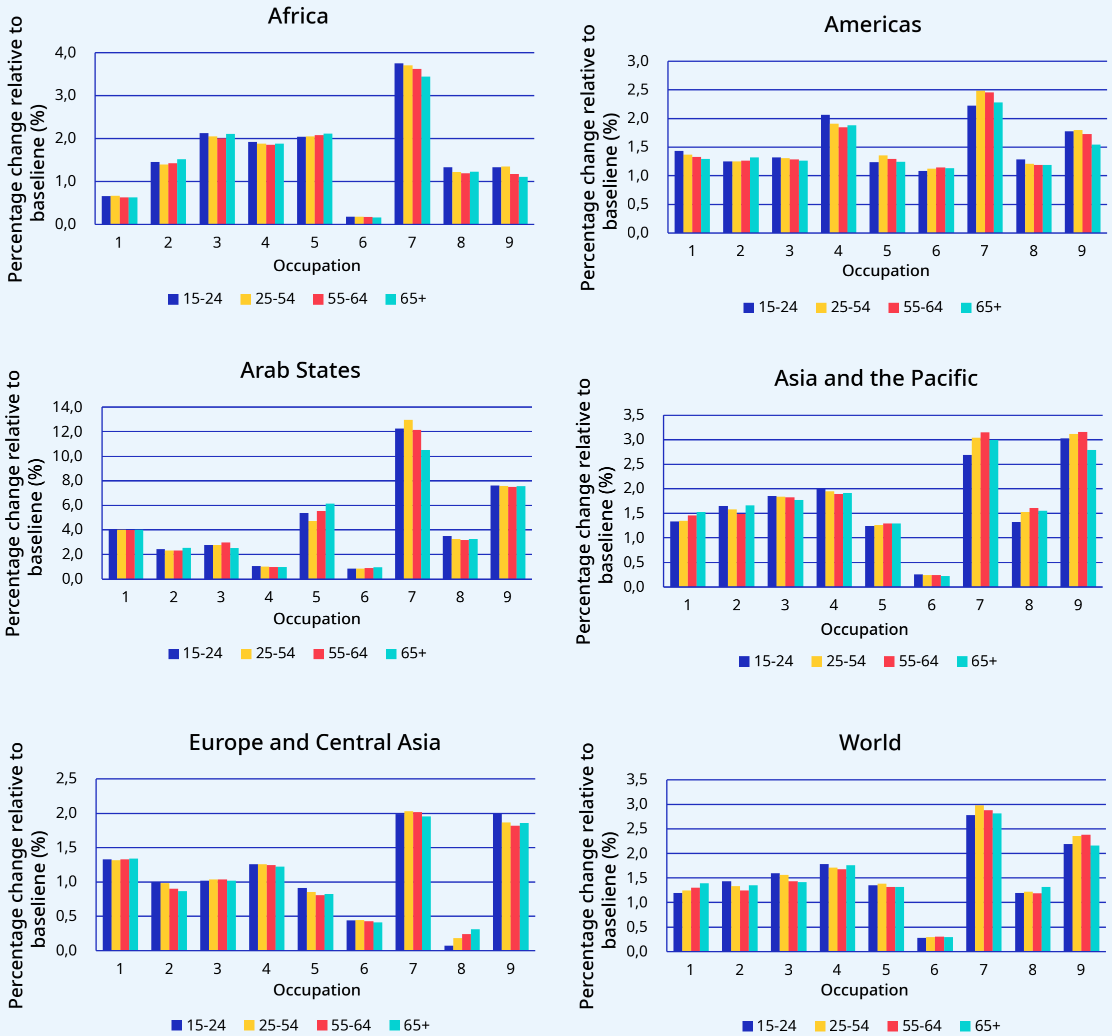
▶ Figure 4.6. Additional job creation by age group (percentage change relative to baseline)



Source: ILO, based on E3ME model of Cambridge Econometrics.

Since both scenarios show relatively high gains in craft and related trades and in elementary occupations, where young people are generally well represented, and since the Near-Universal Broadband Scenario also shows gains in service and sales workers, which are also key for young people, almost 9 million youth jobs would be supported by the Combined Scenario. Five million of these jobs would be in craft and related trades and elementary occupations. Africa is expected to register robust job growth for youth across all occupational categories, while the Americas are expected to see particularly high demand for high-skilled young workers (see figure 4.7.).

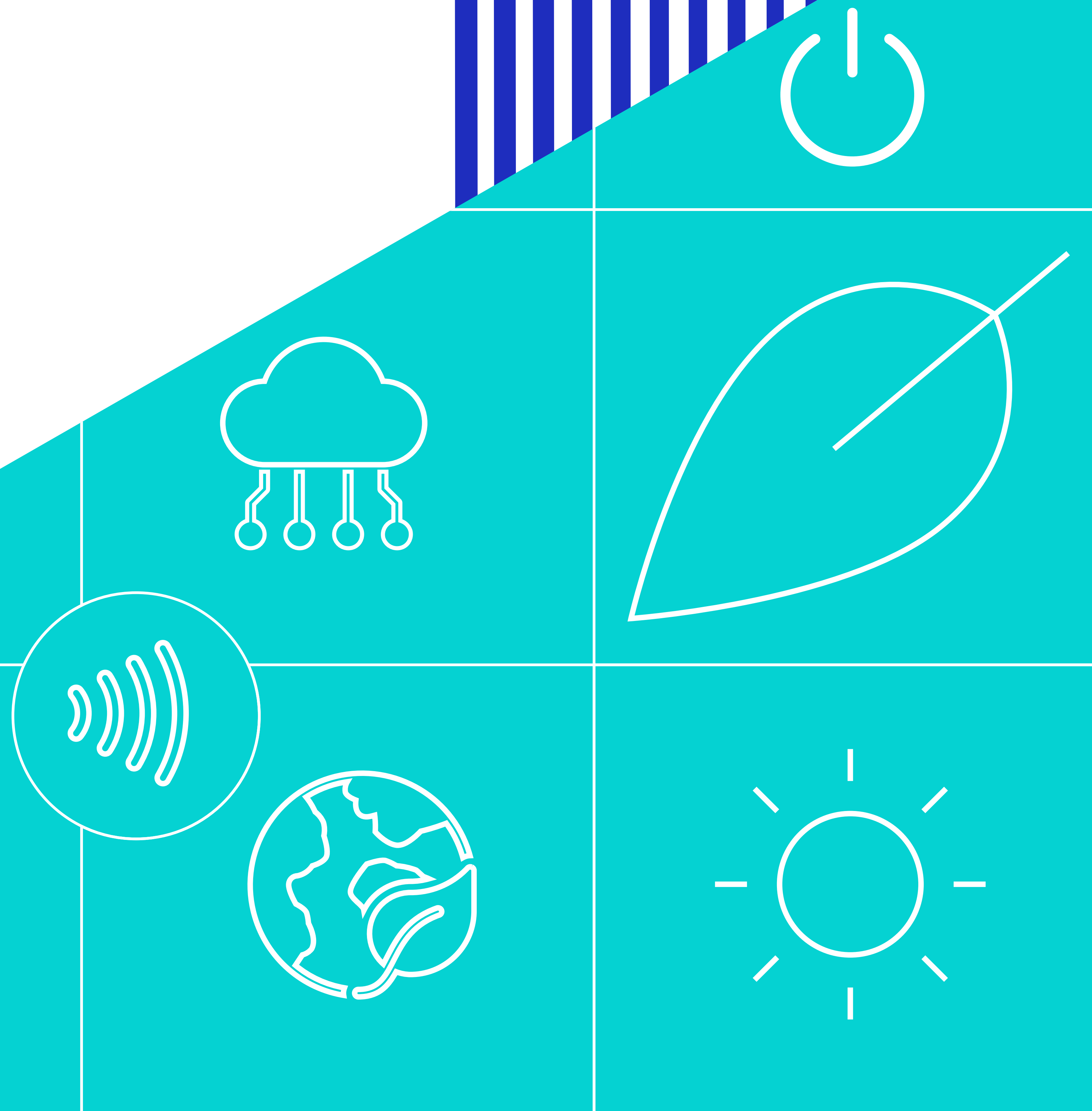
▶ Figure 4.7. Combined Scenario – Employment change from baseline by broad occupation and age group, 2030



Notes: A fixed-shares approach is used to disaggregate employment by age group. As a result, the share of employment by age group is identical throughout the projection period. Broad occupations by ISCO-08 one-digit level: 1 – managers; 2 – professionals; 3 – technicians and associate professionals; 4 – clerical support workers; 5 – service and sales workers; 6 – skilled agricultural, forestry and fishery workers; 7 – craft and related trades workers; 8 – plant and machine operators and assemblers; 9 – elementary occupations (ISCO-08, ILO, Geneva, 2012). Available at: https:// www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/ wcms_172572.pdf.

Sources: E3ME model of Cambridge Econometrics, based on ILO data on employment by occupation, sector and age.

▶ 5



Skills development responses

5.1. Introduction

The preceding chapters examined the green and digital transitions in terms of their drivers and the implications for skills needs. This chapter turns to the issue of skills development and the current responses that can be observed in terms of policies, programmes and initiatives in education and training and related fields such as enterprise development.

It should be clear from the preceding analysis that the green and digital transitions require **wide-ranging and deep changes in skill needs**. This is not only a question of meeting the need for new technical skills and occupations that have emerged and will continue to emerge, but also of ensuring that everyone is equipped with the foundational and core skills they will need to contribute to the transitions. This requires interventions in education and training for both young people and adults. While it is difficult to make an overall assessment of progress to date in this regard, the speed of climate change and recent technological innovation has not been matched by the pace of change in education and skills policies (OECD 2023c). What has been done to date, and what challenges stand in the way of further progress?

Before turning to those questions, it is important to note that the **measures taken will depend on the nature of skills development systems**. Globally, there is enormous variation in the state of development of these systems. High-income countries tend to have relatively well-developed systems both for labour market entry and for reskilling and upskilling through adult learning, with collaboration between governments and social partners (employers' and workers' organizations) and significant investments by both the public and private sectors. In contrast, low-income countries tend to have poorly developed systems, with low levels of public sector investment, limited availability, quality and relevance of training, and low levels of involvement and investment by the private sector. In high-income countries, initial training tends to be free to individuals, whereas in low-income countries individuals often have to finance it themselves. Such variations considerably influence the ability of countries to respond to the challenges of the green and digital transitions. Although high-income countries still suffer from skills gaps and shortages, their skills development systems place them in a relatively advantageous position compared to low-income countries. The position of low-income countries is especially problematic given that they are most likely to suffer some of the worst effects of global warming but lack the skills development infrastructures to respond effectively.

5.2. Skills interventions for the green transition

A wide range of measures is found in the literature. **Policies and strategies** on skills for the green economy, aligned with other relevant policies in the environmental and industrial policy domains, are important for providing a coherent framework for action to tackle the need for skills for the green economy because "governments have considerable control of the levers that stimulate demand during the transition" (OECD 2023b). However, such strategies can sometimes be a missing link because of poor communication between government departments (ILO 2019a), or they may have been produced only for sectors most affected by greening (Cedefop 2019). In Europe, most countries address skills for the green economy as part of other national strategies and plans rather than through a dedicated document

(European Commission 2023). Regions and cities may also need their own dedicated strategies given the spatial variation in the impact of greening (OECD 2023b). In the years up to 2019, much effort was focused on strategy development, but many countries experienced implementation challenges (ILO 2019a). Some higher-income countries have now moved beyond a focus on strategy formulation to implementation (European Commission 2024).

Skills anticipation mechanisms are a foundation stone for understanding the skill needs of the green economy and can involve:

- integrating skills for green jobs systematically into existing mechanisms, such as in Costa Rica's National Institute of Apprenticeship (ILO 2019a);
- taking one-off initiatives through specific studies or expert groups, often focused on specific sectors or as part of activities of sectoral skills bodies, such as in Zambia or Ghana;
- creating specific structures and processes, such as in France's National Observatory for Jobs and Occupations of the Green Economy and India's Skill Council for Green Jobs (European Commission 2023).

Close involvement of the business community is an important ingredient for successfully identifying skills needs, as in South Africa where Business Unity South Africa (BUSA) has partnered with the National Business Initiative (NBI) and the Boston Consulting Group (BCG) to undertake joint research into the skills development needs of the country's transition to renewable energy to achieve a net zero economy by 2050 (BCG 2022). This collaborative effort found that job creation in the renewable energy sector will not automatically absorb workers displaced from the fossil fuel industry because of potential skills mismatches and advocated appropriate reskilling.

Higher- and upper-middle-income countries tend to have well-developed skills anticipation systems, which can be used for forecasting skills for the green economy (see Box 5.1. for a case study from Brazil), whereas lower-income countries have tended to rely on more ad hoc mechanisms and targeted stakeholder collaboration (ILO 2019a). Despite the spread of skills anticipation mechanisms, such activities often do not reflect the impact of environmental policies on the labour market (OECD 2023b), and there is a need for more fine-grained data at the level of skills, occupations, regions and local labour markets (OECD 2023c).

Box 5.1. Identifying skills for the green economy through a system-wide approach

In Brazil, the "TVET project" (supported by the German aid agency GIZ 25) which began in 2021 and runs until 2025, addresses skills development for the green economy in a coherent way across relevant sectors (energy, bioeconomy and circular economy). Rather than sectoral projects working individually, the project applies a system-wide approach, advising relevant ministries (for example the ministries of education and labour, the National Service for Industrial Training and the Federal Network of TVET) on developing needs-based education and training, and targeting companies and vocational schools with the aim of anchoring a skills development agenda for green jobs in the TVET system. The project:

- identifies the demand for skills in selected sectors
- develops occupational standards for relevant green occupations
- designs curricula
- mainstreams skills for green jobs in the training of TVET personnel.

A special emphasis is placed on encouraging women and girls to enter the energy sector as well as creating training opportunities for vulnerable groups. Digitalization is a cross-cutting theme. The project is closely linked to regulatory frameworks and market development in the sectors with greening potential, and thus is able to link its interventions with the demand side of the labour market.

Sources:
GIZ, "Advancing vocational skills to drive Brazil's green economy".
GIZ, *Skills for a Just Transition to a Green Future*, 2022.

25 Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH

The **greening of skills development programmes** is now widespread and involves inserting both foundational and core skills for the green economy and technical occupation-specific skills into qualifications and training programmes. This may involve anything from fully reviewing existing courses to creating new modular components and introducing micro-credentials that complement or form part of current qualifications (as in Ireland, where a suite of micro-credentials was developed for Near Zero Energy Buildings). Updating or designing new training programmes can be challenging, especially in lower-income countries with less developed skills systems, which may benefit from support for capacity-building and coaching, such as that provided by the ILO in the framework of implementing the Greening TVET Toolkit (ILO 2022a).

Work-based learning (WBL) and apprenticeships can play an important role in supporting skills development for the green and digital transitions by combining theoretical learning with hands-on experience tailored to the latest industry needs, both for new labour market entrants and to upskill and reskill the current workforce (ILO 2022d). With innovations related to the green economy taking place rapidly, WBL and apprenticeships enable young people and adults to gain the most up-to-date experience within companies. Indeed, apprenticeships can be a systemic change agent for the green transition (Cedefop and OECD 2022). In Germany, trade unions, employers, training institutions and government bodies have collaborated in the development of comprehensive apprenticeship programmes to equip workers with the technical and safety skills required for wind turbine manufacturing, installation and maintenance. Apprenticeships can also be used as a tool to promote inclusivity, as highlighted in the Quality Apprenticeships Recommendation, 2023 (No. 208) (ILO 2023d): for example, Barefoot College International, using mainly WBL and/or informal apprenticeship, has trained some 3,500 rural women (most of whom have only low levels of literacy) across 93 countries as solar engineers, leading to the installation of solar lighting systems for over 2.5 million people. [26] See also Box 5.2. for a case study from Estonia.

Box 5.2. Tailoring training to new demands in the construction sector

Estonia has introduced a new internship system in vocational training programmes related to construction, with a project focused on energy-efficient building and smart home solutions. These fields are characterized by skills shortages, as identified by the national skills forecasting system, and by insufficient TVET provision. Consequently, learners often struggle to secure company internships where they can acquire the specialized technical skills required.

Through the project, construction teachers at schools and partner companies are improving how internships are organized, and top industry practitioners play a greater role in training. Ten leading specialists from companies within the Estonian Association of Construction Entrepreneurs provide lectures or supervise practical training in schools for at least four hours.

Partners include three TVET schools, the Estonian Employers' Confederation and the Estonian Association of Construction Entrepreneurs, whose participation is seen as a major asset.

Source:
Annika Poldre, "Suur samm kutsehariduses ettevõtetega parema koostöö poole", 19 March 2021.

Some countries have already embedded **generic and foundational green skills** across all TVET programmes. In Germany, for instance, a nationwide standard on environmental protection and sustainability has applied to all dual-system apprentices since 2021. Developed by federal and state authorities together with social partners, this binding standard must be integrated throughout training and assessment. It sets out six core competences for the green transition, including pollution prevention, sustainable use of materials and energy, compliance with environmental

26 Barefoot College, "Solar".

protection regulations, waste reduction and recycling, developing proposals for actions to support sustainability in their own work area and complying with company sustainability regulations (European Commission 2023). Yet even in higher-income countries with advanced skills systems, such comprehensive approaches are not fully standardized and are either still being developed or not applied to all programmes (European Commission 2023). This could slow the green transition, since greening programmes with generic green competences is particularly important for young people: initial education can build the labour force resilience needed for changing labour markets (OECD 2023b).

When it comes to **technical skills** and meeting the needs of **new and emerging occupations**, an increasing number of new education and training programmes are being created and existing programmes are being adapted (see Box 5.3. for a case study from Brazil). For example, in the Flanders region of Belgium new training profiles have been created for occupations such as Renewable Energy Technology Technician (European Commission 2023), and in Ireland a coordinated approach has been adopted to developing skills for Nearly Zero Energy Buildings, developing a suite of modules for new and existing construction workers.

Box 5.3. Developing training modules for solar energy workers

In Brazil, the Central Única dos Trabalhadores (CUT) has taken proactive steps to address skills gaps in the solar energy sector. Working with local universities and technical schools, CUT has developed training modules that cover a broad spectrum of competencies – from basic installation to advanced system design and maintenance. The programmes also place strong emphasis on occupational health and safety, given the demanding conditions involved in solar panel installation and maintenance. Through these initiatives, CUT not only enhances workers' employability but also helps ensure that the rapidly expanding solar sector has access to a skilled and well-prepared workforce.

Sources:
Rosely Rocha, "CUT 40 anos: formando novas gerações para o futuro do movimento sindical", 1 September 2023.
INEEP and CUT, Changes in the energy sector in Northeastern Brazil and heir impacts on the world of work, 2022.

Upskilling and reskilling programmes related to green jobs are widespread both for those in work and those who are unemployed (see Box 5.4. for a case study from the Philippines). Skills for the green economy are widely perceived as a means of reskilling unemployed people into shortage occupations – as in Sweden's 2020 Green Jobs Initiative (European Commission 2023). Reskilling and upskilling can also be spatially targeted, notably in areas of decline due to the withdrawal from fossil fuels and associated job losses where training is often part of a wider package of measures including careers counselling. For instance, in Alberta, Canada, the provincial government's Coal Workforce Transition Program includes career advice in every affected workplace plus help with CV writing and interview preparation, financial assistance and a Coal and Electricity Transition Tuition voucher, which can be used to access appropriate publicly funded reskilling programmes (OECD 2023b). In many cases, however, the employment issues raised by the green transition have revealed weaknesses in adult learning systems around the quality of provision and the lack of schemes to deliver training to those most in need of it, especially the low-skilled, older workers, the self-employed and part-time and temporary workers (OECD 2023a). Adult learning systems are not sufficiently adapted to learning needs, practices and methods suitable for adults in many countries around the world, especially in low-income countries.

Box 5.4. Becoming a regional hub for renewable energy skills

In the Philippines, the Department of Energy is spearheading a programme to reskill and upskill workers for renewable energy, specifically in offshore wind and PV/solar. Linked to the national goal of increasing the share of renewable energy to a minimum of 35 per cent by 2030 and 50 per cent by 2040, the programme seeks to position the country as an Asian training hub and accelerate offshore wind development in the region, establishing an international certification system for the labour force, which will also allow Filipino workers to support energy transition workforce requirements globally. Supporters of the programme include the Energy Secure Philippines (ESP) project of USAID, which provides skills research support and capacity-building activities and targeted skills enhancement for the prospective workforce, and the Government of Denmark, which has committed to support the reskilling and upskilling of at least 50,000 technical workers in the renewable energy sector and to advocate international support for the certification system. The Department of Energy also coordinates alignment with other government agencies' development projects, such as TESDA's ADB Skills Development Project and the DOLE's Sectoral Green Jobs HRD Plan for the Renewable Sector supported by the ILO. The private sector also recognizes the crucial role of skills development, as noted in the recent Philippine Power Industry HR Forum, where discussions revolved around retaining workers, investing in their skills, ensuring talent mobility opportunities and giving them a sense of purpose.

Sources:
Meg J. Adonis, "Upskilling of Workers for Wind Energy Dev't Pushed", *Inquirer*, 2 May 2023.
Myrna M. Velasco, "USAID Extends Development Assistance on 'Right Skilling' of Filipino Offshore Wind Workers", *Manila Bulletin*, 22 November 2023.
Myrna M. Velasco, "PH Explores Global Certifications for Workers in Renewable Energy Sector", *Manila Bulletin*, 7 October 2023.

Updating the **skills of teachers and trainers** is vital in this domain, not just to teach the new technical skills required but also to teach the basic skills and generic competences required (ILO 2022a). Teaching skills and competences such as problem-solving and critical thinking requires approaches to teaching and learning that are learner-centred and enable learners to be actively engaged in their learning, for example through project-based learning. For many teachers this is an innovative step forward, and their initial and continuing teacher training needs to incorporate these new approaches, as in Nigeria, where the Department of Vocational Teacher Education of the Centre for Technical and Vocational Education, Training and Research has reviewed and revised its teacher education curricula to include two mandatory green courses in its postgraduate programme (ILO 2022a). Teachers and trainers also need to be provided with opportunities for networking and sharing good practices with peers (European Commission 2023). For example, Zimbabwe's Green enterPRIZE programme includes building a network of VET institutions (ILO 2022a), and Germany's BilRess network supports the development and exchange of educational materials (European Commission 2023). Ideally, professional development for teachers and trainers should be included in measures to design and redesign training programmes.

Skills development responses are also often incorporated into **enterprise development schemes** as part of a package of support measures to help people to set up and run green businesses (see Box 5.5. for a case study from India). Such schemes are especially relevant for low- and middle-income countries, which frequently face the greatest environmental challenges (ILO 2022a). For example, Zambia's Green Jobs Programme includes a Start and Improve Your Green Construction Business (SIYGCB) programme to target emerging and established entrepreneurs in developing environmentally sustainable construction businesses, including a training package (ILO 2022a).

Box 5.5. Supporting green enterprise development in India

The Confederation of Indian Industry (CII) has a Renewable Energy Council, which is involved in many renewable energy activities. It also has a network of Centres of Excellence, including the Green Business Centre, focused on renewable energy and energy efficiency, and the Centre of Excellence for Sustainable Development, which provide training and consultancy services and develop knowledge products for businesses:

- The Green Business Centre was set up as CII's developmental institute on green practices and businesses, aimed at offering world-class advisory services on the conservation of natural resources. Through its services in energy management, green buildings, green companies, renewable energy, green product certification, waste management and cleaner production processes, it aims to support India in becoming a world leader in green businesses. Since 2004 the Centre has registered 13,720+ green building projects, certified 8,200+ products under its GreenPro eco-label, conducted 2,100+ energy audits across the globe, registered 1,150+ manufacturing facilities under its sustainability evaluation tool, GreenCo, and has over 30 cleantech start-up cohort members.
- The Centre of Excellence for Sustainable Development is a not-for-profit, industry-led institution that helps businesses become sustainable organizations and to be "future ready", with improved ecological footprints. It works with a wide range of partners across a broad range of intervention areas, including the circular economy and building resilient businesses, for example providing management training to help companies to develop and monitor Environmental, Social and Governance frameworks. It has produced many publications, for example on topics such as greenhouse gas mitigation across the value chain in the cement industry.

Sources:
Confederation of Indian Industry, "About Us".
Confederation of Indian Industry, "History".

A focus on **inclusion** is an important part of many interventions. Some countries have embedded the just transition into their strategies, as in Austria where in 2023 the Just Transition Strategy Action Plan for Education and Training of the Federal Ministry for Climate Protection, Environment, Energy, Mobility, Innovation and Technology was published (European Commission 2023). More specific interventions include measures taken to enable people to transition from brown to green jobs, which are important to mitigate the negative employment effects of the transition on communities in specific areas and to "prevent widespread resentment that endangers political support for the green transition" (OECD 2023b). **Gender-based measures** have also increasingly been introduced to counteract the dominance of men in occupations that stand to benefit most from the green transition (Chapter 2). For example, a Women's Entrepreneurship Laboratory has been established in the Canary Islands, Spain, which promotes female self-employment in the design and fashion sector and incorporates circular economy and eco-design concepts; it has also led to the creation of an African Women's Entrepreneurship Hub. **Disability inclusion** is much less prominent in green transition measures, but in Poland the remit of Sectoral Skills Centres includes developing pathways for people with disabilities (European Commission 2023).

Finally, interventions for the green transition also need to make sure that **TVET providers** are equipped with the skills, knowledge and resources they need to deliver the new and updated courses and measures described above (see Box 5.6. for a case study from Bangladesh). Indeed, TVET providers have the potential to become beacons of good practice around the green agenda in their communities, not only meeting the needs of the economy but also adopting green practices so that they can become "working examples" of what it means to live, work and learn sustainably. In this sense, they can help to integrate the interventions described above.

Box 5.6. Covering all the key elements at TVET provider level

In Bangladesh between 2017 and 2024, the Skills 21 – Empowering Citizens for Inclusive and Sustainable Growth project supported two teacher training institutions to become centres for skills excellence and seven Technical and Vocational Education and Training (TVET) institutes to become model TVET institutes for skills training. Overseen by a partnership of the Government of Bangladesh, the Bangladesh Employers' Federation, the National Coordination Council for Workers' Education, and the ILO, and funded by the European Union, the project undertook a range of activities including:

- introducing a range of green initiatives at TVET institutes and training TVET officials on greening TVET
- developing and implementing a green guideline to provide a framework for interventions by the TVET institutes and supporting institutes to develop specific action plans
- identifying employment opportunities for graduates in green enterprises and skills and identifying green elements to be incorporated into revised qualifications
- developing business incubation centres providing services such as green entrepreneurship, and financing, and appointing mentors knowledgeable in green business.

Key results of the project were: 2,242 TVET managers, master trainers, trainers and assessors were trained and certified; 6,791 youth were trained in certificated courses, nearly half of which joined the labour force; 3,498 youth took part in entrepreneurship development training; 3,595 industry workers had their prior learning certified; and 3,474 migrant workers were reintegrated into the labour market, along with skilling of their family members.

Source:
ILO, "Skills 21 – Empowering citizens for inclusive and sustainable growth".

5.3. Skills interventions for the digital transition

Over recent decades, governments have responded in various ways to the waves of digital transformation. These responses generally fall into three categories (Bürgisser 2023). First, compensation policies, such as unemployment benefits and universal basic income, aim to provide financial support for workers displaced by technological advancements. Second, investment policies focus on education, retraining and skills development to equip both new and displaced workers with the competences required in today's labour market. Finally, steering policies, which include industrial strategy, taxation and regulatory measures, seek to influence the pace and direction of technological change, ensuring its alignment with broader socio-economic goals (Bürgisser 2023). Below, we mainly focus on steering and investment policy responses.

Overall, many countries have implemented overarching **digital education policies** to steer the reform of their education and training systems, and wider skills development systems, in response to the digital transformation (WEF 2023). These policies are designed not only to meet basic digital skills needs but also to prepare the workforce for emerging technological challenges such as AI. In this context, merely achieving basic digital skills is insufficient; robust investment in human capability, including AI education and lifelong learning, is essential for long-term employability (Cedefop 2024a). Similarly, digital skills policies need to be well integrated with broader labour market strategies, including demographic, climate and globalization factors (ILO 2021a). At global level, guides have been developed to support the digital transformation of education. UNESCO, for instance, emphasizes connectivity, leadership, capacity, costs and content (UNESCO 2024). Specifically for the digital transformation of TVET, UNESCO-supported frameworks emphasize institutional capacity-building, research and innovation, and industry collaboration and community engagement (Yang and Yang 2024). At continental level, UNESCO and partners in 2021 launched the Pan-African Initiative for Digital Transformation of TVET and Skills Development Systems in Africa [27] to create an ecosystem that will enable the digital transformation of TVET and skills development systems in Africa. At national level, for instance in Ethiopia, specific digitalization plans have also been developed for TVET. The Government of Ethiopia in 2020 launched the Digital Skills Country Action Plan for higher education and TVET institutions to realize its ambition of producing a competent and digitally skilled workforce that can modernize the agriculture, manufacturing, tourism and mining sectors. The plan focuses on developing enabling policies, reforming training programmes, expanding online courses, improving connectivity and building staff capacities (Ministry of Science and Higher Education Ethiopia 2020).

In response to the **digital transformation, new education and training programmes are being developed to meet the growing demand for digital skills and emerging jobs** (see Box 5.7. for a case study from Malaysia). These programmes are not limited to formal TVET; private and non-formal sectors are also capitalizing on opportunities to offer targeted training. A combination of education and training programmes, along with targeted upskilling, reskilling and other learning opportunities, will help learners keep up with the latest trends and technologies in their fields. AI-driven training programmes can significantly improve both the learning experience and outcomes (Cedefop 2024a). There are many initiatives and projects that focus on making TVET provision in developing countries more relevant, also focusing on responding to digital skills needs. One example is UNESCO's Better Education for Africa's Rise project, which in various African countries improves TVET systems from curriculum design and delivery to assessing labour market needs in specific economic sectors such as agriculture and construction. [28] Digitalized apprenticeship programmes are also being developed in Australia, Egypt and Malaysia (Gupta et al. 2023).

Box 5.7. Implementing apprenticeships with digital learning

In Malaysia, the SHRDC is working on digital apprenticeships by launching a two-year master's-level apprenticeship programme that blends digital and hands-on learning. Using technology as part of the process, SHRDC is developing a plug-and-play remote-access curriculum in which students access resources and assessments remotely, enabling flexible learning. With industry mentors, SHRDC emphasizes applied learning and user experience.

Additionally, the SHRDC is currently exploring ways to finance the TVET model by using a "learning blockchain" approach. If TVET stakeholders collaborate by sharing curricula, different companies can come together and put their curricula into a common "bank". Such blockchain learning concepts could help lower costs, cut out unnecessary intermediaries and make programmes more accessible. This innovative approach not only reduces expenses but also fosters industry collaboration, promising a sustainable model for digital apprenticeships in Malaysia.

Source: ILO, *The Digitization of TVET and Skills Systems,* 2020.

In addition, there are skills training opportunities outside the formal TVET system that aim to meet the growing demand for digital skills. Providing students with advanced digital skills can enable graduates to look beyond the local labour market for opportunities in the global digital economy (see Box 5.8. for a case study from Pakistan). In recent years, more emphasis has been placed on the idea that digital education is not without negative consequences. The UNESCO Global Education Monitoring (GEM) 2023 report, based on existing evidence, makes clear that the use of technology in education is not a panacea but comes with negative effects as well. It calls for decisions about

27 See: UNESCO, "Pan African Initiative for Digital Transformation of TVET and Skills Development Systems in Africa".
28 UNESCO, "Better Education for Africa's Rise project".

technology in education to prioritize learner needs after assessment of whether its application would be appropriate, equitable, evidence-based and sustainable (UNESCO 2023).

Box 5.8. Responding to the growing demand for digital skills through international collaboration

Pakistan's Punjab Skills Development Fund (PSDF) has collaborated with Coursera to fund internationally recognized hybrid and online courses from top universities, focusing primarily on digital fields such as graphic design, digital marketing, game development and IT support. An evaluation found that 1,200 students completed the internationally recognized Coursera courses from the PSDF platform, and that their income substantially increased as a result.

Sources:
Coursera, "PSDF Prepares the Next Generation of Digital Entrepreneurs with Coursera", *Coursera for Government.*
Punjab Skills Development Fund (PSDF), "Coursera", *PSDF.*
Punjab Skills Development Fund (PSDF), "Learn PSDF", *PSDF.*
International The News, "Online Courses Increase Employability, Income for Young Pakistanis, Study Finds", 10 November 2023.

The rapid pace of digital transformation necessitates **continuous upskilling and reskilling through lifelong learning systems**. As technologies and job requirements evolve, individuals must regularly update their skills rather than rely on one-time education. People gain or lose proficiency in digital skills depending on how often they use them, while emerging technologies and changing social and environmental conditions continually create demand for new competences (OECD 2023c). In this context, enhancing adult learning programmes, particularly through on-the-job training, financial incentives, and digital integration in educational and training systems is important. Policies that support adult learning, such as online training, standardized certification, and targeted awareness campaigns, are essential to fostering digital literacy and ensuring all populations are equipped to navigate the requirements of the digital era.

Relevant policy examples include Denmark's retraining subsidies, which have been shown to mitigate the negative effects of automation by helping routine workers transition into new roles and improve their employment prospects (Bürgisser 2023). Similarly, in Germany, training and upskilling programmes have helped reduce the negative impact of automation on job satisfaction and workers' sense of identity (Bürgisser 2023). In addition, public programmes are being launched to increase the digital literacy of the population, often influenced by an increasing reliance on digital tools to access public services (for example, paying taxes or making a medical appointment). One example is Aula Mentor in Spain, which offers online courses for adult learners across various fields, including administration, agriculture, graphic design, marketing, electronics, tourism, personal care and media production, focusing on practical skills for career and personal development. [29] Another example is Oefenen.nl in the Netherlands, [30] which offers digital skills training for adults online. [31]

To support education systems during the digital transformation, significant investment is required in both digital infrastructure and the digital competences of teachers and instructors. Schools must become digitally equipped, affecting their infrastructure, operations and the digital readiness of staff, from management to teachers. However, many teachers still lack confidence in using digital technologies, requiring major investments both in initial and continuous teacher training (Cedefop 2022c). Especially in regions such as Africa, significant challenges persist, including inadequate education and training infrastructure, a shortage of digitally proficient teachers, limited localized

29 Ministerio de Educación, Formación Profesional y Deportes, "Aula mentor". Aula mentor, "Course catalogue".
30 Oefenen.nl
31 See: European Commission, "SELFIE for work-based learning".

content and the high cost of devices and internet access. Together, these factors hinder the effective integration of digital education and training (African Union 2022). Policy initiatives can relate to developing comprehensive and integrated learning infrastructures (see Box 5.9. for case studies from Kenya and China). An interesting tool to test the digital readiness of schools and TVET institutions is the European Commission SELFIE self-assessment tool, which looks at a variety of dimensions including infrastructure, teacher and trainer competences and leadership. [32]

Box 5.9. Policy initiatives to develop comprehensive and integrated learning infrastructures

In Kenya, the draft National Policy on Continuous Professional Development for TVET Trainers explicitly mentions the need for digital competencies of TVET trainers and the use of digital infrastructures to have TVET system better equipped for emerging needs. The policy mentions many issues and constraints, such as uneven and limited distribution of digital infrastructure, lack and unreliable power supply, digital literacy challenges among TVET trainers, rapid evolution of digital technologies, and, finally, poor trainers' attitude to the acquisition and use of digital skills. As a policy response, the government shall further ensure the ICT integration in continuous professional development of TVET trainers.

In China, the 2023 government reform paper (*Notice on the Key Tasks of Accelerating the Development and Reform of the Modern TVET System)* outlines plans to establish around 200 national first-class virtual training bases and approximately 1,000 regional model virtual training bases across various provinces and cities by 2025 to support virtually delivered TVET programmes. This initiative aims to foster innovation in practical teaching and training models within the Technical and Vocational Education and Training (TVET) sector.

Sources:
The Government of Kenya, *National Policy on Continuous Professional Development for TVET Trainers (draft II),* 2024.
See: Xinbin Yang and Wenming Yang, *Digital Transformation in Global TVET: Methodology and practices,* UNESCO Chair on Digitalization in TVET, 2024.

A final aspect that can be encountered in countries that are equipping their economy and society to yield the benefits of the digital transition is the need to put **conditions in place to make digital innovation happen and to enable people to use their digital skills** (see Box 5.10.). Setting conditions for digital transformation involves creating a supportive environment that encourages innovation and entrepreneurship in the digital sector. This includes establishing financial and support systems for business start-ups, which are crucial for fostering a dynamic digital economy. Policies aimed at market openness are essential, as digital technologies significantly reshape competition, trade and investment. To promote competitiveness and innovation, governments should reduce barriers to trade and investment, enhance competition law and facilitate access to technology for both firms and citizens. Furthermore, financial and support conditions for business start-ups and entrepreneurship need to be established in the digital domain. In Nigeria, the National Digital Innovation and Entrepreneurship Policy (2021–2023) focused, inter alia, on unlocking access to capital, offering an enabling infrastructure and promoting digital entrepreneurship. [33]

There are specific challenges that still play a key role throughout all the policy initiatives discussed. Persistent **gender gaps** in digital skills and jobs can hinder women's access to quality jobs and working conditions. Examples of policies aimed at closing the gender gap related to digital skills, and more

32 See: European Commission, "SELFIE for work-based learning".
33 Federal Ministry of Communications and Digital Economy, *National Digital Innovation and Entrepreneurship Policy (2021-2023)*, 2021.

broadly in STEM (science, technology, engineering and mathematics), can be found across the world. An interesting bottom-up initiative is the African "Women in Technical Education and Development" project, which has designed a guide to support self-assessment and the planning of actions to increase the participation of women in STEM and in TVET institutions.[34] Furthermore, the integration of generative AI and other digital technologies may impact **job quality, affecting work intensity, working conditions and autonomy** (UN and ILO 2024). Therefore, targeted policy interventions are necessary to address gender-specific needs and invest in skills relevant to growing occupations in digital and green economies. Promoting social dialogue among workers and employers' organizations during the transition to AI integration could also facilitate fair practices in adopting new technologies, ensuring that policies not only focus on re-employment but also enhance job quality (ILO 2023b). The gig economy and similar emerging business models put pressure on the existing social fabric. All in all, the policy initiatives mentioned above are unlikely to fully overcome the digital divide, and additional action may be needed to secure quality jobs and working conditions, including within new business models fuelled by the digital transformation.

Box 5.10. International action to boost digital skills

Launched in 2017, the Digital Skills Campaign is led by the International Telecommunications Union (ITU) and the ILO with the goal of scaling up action and promoting youth employment by equipping young people with digital skills. Through a multi-stakeholder alliance, the campaign addresses digital skills gaps by encouraging partners to make commitments to invest in digital skills training. The Campaign recognizes that such investment is a win-win strategy: it addresses the skills gap by increasing young people's employability, creating quality jobs, and sparking innovation across all sectors of the digital economy. The campaign has secured the commitment of numerous partners including governments, the private sector, development banks, foundations, youth-led organizations and other civil society organizations. Actions undertaken include:

- funding, designing and implementing digital skills development programmes for young people – including programmes that focus on disadvantaged groups, such as young women and young persons with disabilities
- embedding digital skills training in apprenticeship schemes and educational and professional development programmes across sectors and industries and for young entrepreneurs;
- developing and strengthening the capacity of education and training providers, and of teachers and trainers, to deliver digital skills and adapt curricula to young people (for example, through professional development, entrepreneurship activities, on-the-job learning and job placements)

Thanks to such activities over 23 million young people have been equipped with digital skills since 2017 – from basic computing skills to more advanced skills connected to cybersecurity and the green transformation.

Sources:
ILO and ITU, "ILO-ITU Digital Skills Campaign", *ITU Academy*.
ILO and ITU, "Join us to Boost Youth Employment by Equipping 25 Million Young People with Digital Skills", *Decent Jobs for Youth*.

34 See: Commonwealth of Learning, *Practical Guide For Wited Chapters And Individual Champions For Increasing Girls' And Women's Participation In STEM-TVET*, 2021.

5.4. Skills interventions that combine green and digital angles

As discussed earlier in the report, there is very limited literature that considers the green and digital transitions in an integrated manner. Similarly, when it comes to skills responses, there are far fewer examples of policies and practices that deal with both transitions simultaneously. At the same time, many of the observations made above regarding policies and practices are likely to apply when it comes to combining the green and digital transitions. There seems to be a **growing confluence between green and digital skills development**, with education and training systems forging strong links between the two (European Commission 2024). Some limited observations can therefore be made.

First, **strategies and policies** that deal with skills for the green and digital transitions together seem to be the exception rather than the rule. Exceptions include Austria's just transition strategy (mentioned above), which covers green technologies (European Commission 2023), and the Action Plan on Green and Digital Jobs produced by the Government of the Netherlands, which anticipates that shortages in both green and ICT skills could significantly slow down efforts to reach the country's 2030 and 2050 climate goals and which includes roles for national, regional and local stakeholders in the public and private sectors (OECD 2023a).

Secondly, when it comes to the **provision of education and training**, digitalization of production and service delivery processes in the workplace is currently a strong driver of digitalization in TVET (European Commission 2020). As a result, the ubiquity of digital tools in environmental sustainability and hence in green jobs means that digital skills are often taught as a matter of course, since the subject matter involves technologies of one type or another, as in the case of the many courses that already exist or are being launched in smart technologies related to renewable energy and energy efficiency.

Thirdly, combining green and digital can involve the **development of programmes** for new occupations in the green technology domain, but it can also involve the more general use of **digital tools in teaching and learning** about topics related to environmental sustainability. In Europe, it has been noted that "blended learning is often an integral component of many projects related to the green transition in TVET" (European Commission 2023). More ambitiously, it can also involve the creation of digital products and services for the green transition as part of school curricula, for example through project-based learning. In Latvia a vocational horticultural school is creating a "smart garden" that uses a robot to monitor plant health and an intelligent watering system controlled from a local weather station (European Commission 2023). In Luxembourg, a training course enables learners to reflect on the ecological footprint of digital tools and teaches how to reduce it (European Commission 2023).

Fourthly, an important global development is the growing network of **Centres of Vocational Excellence** (CoVEs), which have the potential to bring the green–digital nexus together in new and productive ways by linking skills, research, innovation and business development (see Box 5.11. for a case study from the Southern Africa region). For example, the Smart Energy Systems Campus in the Auvergne-Rhône-Alpes region of France (part of a national CoVE network) brings together over 100 stakeholders from business, research, TVET and higher education, as well as local governments to develop new products, assess skill needs and design relevant education and training (European Commission 2023).

Box 5.11. A regional Centre of Excellence in renewable energy training in Southern Africa

On the border of Zambia and Zimbabwe, the Kafue Gorge Regional Training Centre provides specialized training solutions in hydropower and related fields across sub-Saharan Africa. Controlled by a regional Board of Trustees from Malawi, Eswatini, United Republic of Tanzania, Uganda, Zambia and Zimbabwe, the Centre has been recognized by the Association of Power Utilities in Africa as a centre of excellence. The Centre was a key implementing partner in the Skills for Energy in Southern Africa (SESA) project (2021–2024), a public–private partnership launched by the ILO and the Swedish Government and aimed at supplying the region with power technicians, engineers and managers with enhanced technical skills to apply, manage and promote the latest renewable energy and energy efficiency technologies. The project successfully developed 26 courses covering the wide range of topics needed in the field, including gas turbine technologies (in collaboration with Siemens), grid integration of renewable energy sources, financial modelling, asset management and environmental and social impact assessment of renewable energy projects. Training was provided to over 1,100 participants, including women who received scholarships from the project to encourage female participation. Seventeen partnerships with private enterprises in the energy sector were established, which leveraged US$400,000 in contributions to course development, delivery and related equipment.

Source:
ILO, "Empowering change: SESA Project trains over 1,100 in renewable energy", 19 December 2024.

5.5. Critical challenges

Evidence from the literature indicates that the digital and green transitions present broadly similar challenges for ensuring that education and training systems can meet evolving skills demands. This section therefore explores how these challenges take shape at the intersection of the two transitions, highlighting any significant distinctions between the two.

Perhaps the most important overarching challenge – especially in view of the projections that are foregrounded in this report – is that the **supply of digital skills and skills for the green economy lags demand, leading to major skills bottlenecks**. This is due to a range of interconnected weaknesses in skills development systems.

The first critical challenge to highlight is the **lack of coherence and coordination between different policy domains or communities and between government departments**. Green and digital are cross-cutting issues, and such issues are challenging for vertically organized, hierarchical, siloed structures of government to deal with. This applies to each transition on its own. In many countries, for instance, linkages between environmental policy and labour market or skills policies are limited (ILO 2019a; OECD 2023b). However, combining the green and digital transitions at the policy, strategy and funding levels creates a double challenge, as it requires addressing two cross-cutting issues simultaneously. In the absence of strong alignment, **strategy and funding frameworks risk becoming ad hoc and piecemeal**, despite the effectiveness of sector-specific responses (ILO 2019a). Dealing with this requires a high level of effective coordination within government.

A second critical challenge relates to the **ability of skills systems to be responsive to new demands in the labour market**. Weak responsiveness and limited labour market relevance in skills development systems are long-standing global issues. The skills challenges posed by the transitions throw this into sharp relief, as they introduce new demands that require rapid responses – often within short timeframes and amid significant uncertainty, such as that generated by the emergence of AI. Responding to such challenges means having effective skills anticipation systems to provide a solid empirical basis for understanding skill needs (UNIDO 2022) and the capacity to design new programmes and update existing ones, as well as to deliver them quickly and efficiently. Governments have a particular responsibility in the green transition because they play a role both in creating an enabling environment for green product markets – and therefore demand for labour – and in shaping the supply of that labour (OECD 2023b); they are equally key to ensuring that the green and digital transitions are considered together. Likewise, the new demands of the green and digital transitions in terms of the speed and flexibility required in skills development may mean reconsidering how key stakeholders in the private and public sectors work together, reflecting on how they can better collaborate and their relative roles and responsibilities in designing and delivering TVET. Apprenticeships may be key here in terms of the central role played by industry in determining the content of training and how it is delivered.

A third challenge, which is closely related to the preceding two, is **how to bring in and manage broad groups of stakeholders** (UNIDO 2022). Responsive skills systems depend on the quality of engagement with relevant stakeholders (Cedefop 2021a), especially social partners (European Commission 2024; ILO Human Resources Development Recommendation, 2004 (No. 195)). The digital and green transitions mean widening the circle of such stakeholders to bring in new interests, concerns and insights on skills needs. [35] Effective stakeholder engagement is needed at all levels, from national policy level (for example, India's Skill Council for Green Jobs, whose governing council includes representatives of government ministries and employer bodies as well as individual employers (ILO 2019a)) to regional/sectoral level (for example, France's regional network of employment and training observatories (OECD 2023b)). Stakeholders need to have ownership of skills development processes through genuine collaborations and partnerships.

A notable development has been the emergence of regional partnerships and Centres of Vocational Excellence. Many such centres show a successful track record in meeting sectoral and regional needs and in realizing synergies between the two transitions through integrating research and development, innovation, enterprise and skills development, such as France's network of Centres of Vocational Excellence for the energy transition and eco-industry (European Commission 2023).

A fourth challenge relates to **ensuring that teachers and trainers can deliver the developments required**. As noted above, this is more than just making sure they can teach the subject matter of new curricula – though this can be a challenge; it means changing mindsets so that digital and green programmes can be delivered with new teaching methods. While this is arguably less important for the types of occupations involved in the employment projections, it is nonetheless key to successful green and digital transitions (Cedefop 2022c). Challenges here include: governments often lacking the right levers to intervene in initial teacher education (Cedefop 2024c); the challenge of reskilling and upskilling trainers, whose role is often not professionalized and where qualifications in didactics are not required (Cedefop 2022c); and the nature and pace of change in school systems, which is traditionally slow and heavily dependent on the decisions of individual school leadership teams and teachers (European Commission 2020). Ensuring that teachers and trainers have buy-in and ownership of the green and digital transitions is essential to success, especially as it is at the school and classroom levels where green and digital curricula and pedagogies are enacted and where synergies between the two might be realized.

A fifth critical challenge concerns the **need for infrastructure and equipment within skills development systems to develop the required green and digital skills.** Green and digital skills training often requires new technologies and equipment, as well as reliable internet access to use digital tools effectively. [36] Especially in TVET systems in developing countries, the lack of equipment and

35 Witness, for example, the creation in France in 2014 of the Grenelle de l'environnement (environment round table) in 2007, which linked the public sector with civil society and social partners at national, sectoral and local levels (ILO 2019a).

36 European Commission, "SELFIE for work-based learning".

materials related to the green transition (such as PV solar panels) and poor broadband connectivity hamper efforts to build capabilities for the green and digital economies.

The final critical challenge relates to **how best to tackle issues of inclusion and specifically gender equality**. Often these issues are treated on a rather ad hoc, project basis, which may have the benefit of drawing attention to them but means they are time-limited interventions. This can be true when, for example, fossil-fuel-based activities are brought to an end: long-term effects are not necessarily dealt with effectively or at all, as witnessed in the permanent decline of many coalfield communities around the world, with patterns of enduringly high unemployment and underemployment and persistent high poverty levels due to the recurrence of "sticking plaster" approaches to industrial decline. When it comes to issues of gender, women are underrepresented in digital skills training and in digital jobs, but at the same time they are also overrepresented in occupations that are under higher threat of job losses due to automation, such as clerical occupations (Gmyrek et al. 2025; WEF 2020). Interventions therefore must go beyond creating and funding skills programmes specifically for women; they must also address deep-seated prejudicial attitudes that have masculinized many occupations, requiring sustained, long-term efforts. Issues such as these highlight the importance of having in place coherent and comprehensive strategies with long-term funding commitments to ensure a socially fair distribution of the costs and benefits of the green and digital transitions.

▶ 6

Conclusions and recommendations

This chapter draws on the preceding chapters of the report to synthesize overall conclusions and recommendations.

6.1. Gains from the green and digital transitions

The projections presented in this report suggest that, combined, the major infrastructure developments of the digital and green transitions and associated downstream effects could create an additional 58 million jobs, or 1.6 per cent more, by 2030 compared with a baseline scenario. Digital technologies have already been central to the early stages of the green transition, to the point that one of the world's leading electric vehicle manufacturers has triggered debate over whether it should be considered more of a technology company than a traditional carmaker. [37] Universal broadband coverage will provide the infrastructure needed for digital devices to be used at the local level to monitor and control energy usage and to undertake local adaptations to climate change. Connectivity, data and data analytics will be key not just to a prosperous digital future but to a more sustainable one.

The projections highlight **additional benefits** of harnessing the green and digital transitions. With respect to digital jobs, gains under the Near-Universal Broadband Scenario are forecast to be fewer than under the Energy Transition Scenario, but job growth would be relatively higher for African and low-income countries – in contrast to energy transition effects, which would be concentrated in Asia and the Pacific and in middle-income countries. However, evidence from the literature also highlights that AI (which is not included in the current projections) could have negative impacts, including job losses, especially among vulnerable populations.

Under the Combined Scenario, **job gains** are possible across all occupational categories (except for workers in fossil-fuel energy generation), including slight growth among skilled agricultural workers, despite the broader global decline in this sector, and across all skill levels. This is encouraging from an equity perspective. However, while medium- and lower-skilled workers can benefit from the integrated energy and broadband connectivity transition, Europe and Central Asia and the Americas will particularly require high-skilled workers.

In fact, both transitions to date have tended to require relatively higher-level skills as compared with the current skill levels in a given country. This is partially due to a focus on researching, developing and innovating new products and services in the early stages of the transitions, but also because the current structure of populations in lower-income countries is characterized by a low starting point in terms of skill levels. Deploying green products and services and expanding connectivity has a multiplier effect on the whole economy, generating many indirect jobs through the value chain and creating additional employment through the reinvestment of profits. Such jobs span production, operation, maintenance and service functions, and require a pipeline of skilled workers in a wide spectrum of occupational groups. The projections indicate that employment growth in the coming years will occur not only among university graduates but also further down the skills hierarchy, **particularly at medium-skill levels** across all income groups of countries. This may potentially contribute to a more equitable distribution of benefits.

37 Schumpeter, "Tesla Faces an Identity Crisis: Carmaker or Tech Firm?", *The Economist*, 24 April 2024.

The employment opportunities generated by the transitions will also benefit **youth** relatively strongly, particularly in crafts and related trades and elementary occupations. In Africa, young workers are expected to gain across all skill levels. By contrast, **ageing workers** will face relatively lower demand compared with other age groups, partly owing to retirement patterns; at the same time, older workers will continue to experience stable employment levels across occupations and regions, especially under the Near-Universal Broadband Scenario. Of particular concern is the persistent **gender gap** in employment opportunities across all scenarios, occupations, regions and income groups, with the Americas being the only region where higher-skilled women may experience greater equity.

6.2. Obstacles to realizing the gains

However, important questions concern the obstacles that might exist in skills development systems that could inhibit the achievement of the full roll-out of renewable energy and broadband connectivity by 2030, as well as a just distribution of the income-generation opportunities. Several areas raise concern.

- First, in the light of experiences to date, the **lag between skills supply and demand** caused by long-standing inefficiencies in skills development systems is a critical issue.
- Second, the last few decades have shown that **the green transition and digitalization are not linear processes** of gradual, incremental roll-out over time; developments can be interrupted, governments can backtrack or change course, while economic crises and recessions can change the balance of costs and benefits, putting a brake on investment.
- Third, as we have seen, a critical equality question is who is affected by these changes and **how far the benefits of the transitions are fairly distributed across the population** in terms of dimensions such as locality, gender, age and income level. As the projections show, there is a risk that employment gains – without some form of intervention – will be unfairly distributed across these dimensions and, if this occurs, there is a risk of pushback on green goals and technological roll-outs. In the context of skills shortages, unequal access to employment and skills development opportunities is not merely an equity issue. When women, youth or older workers cannot participate in the green and digital economies to their full productive capacity, the result is also a lose–lose outcome for economic growth and development.

Regarding skills development overall, there is therefore a critical need to step up the green and digital transitions in employment and skills. Indeed, **the development of skills supply systems should be an urgent priority since failure to do so risks missing global emissions targets and creating even wider digital divides.** The green transition's heavy reliance on technology – both known technologies and future technologies that are yet to be developed – makes it all the more important that digital skills and skills for the green economy are developed in tandem and across the skills spectrum to meet the need for ongoing investments in research and innovation (where high-level skills are needed) and in building, operating and maintaining critical infrastructures (where medium- and lower-level skills are required). Likewise, digitalization, especially the widespread adoption of AI, creates an urgent need to address its environmental impacts. Training at all skill levels offers the most effective means of raising awareness of these impacts and demonstrating practical solutions.

6.3. Tackling the obstacles

The following recommendations are made.

Skills development should be centre stage in all strategies, plans and funding commitments related to the green and digital transitions. This should go beyond considering skill needs alone and lead to concrete action plans for how education and training will be developed to meet the new demands, with clear funding and implementation commitments among stakeholders. As the transitions influence new entrants and the current workforce alike, albeit in different ways for young, prime-age and older workers, **lifelong learning systems** need to provide strong **incentives for continuous learning and skills recognition.**

Essential corollaries of the above are (i) to take steps to ensure that there are **strong relationships across government ministries** in order to realize the potential synergies from the green and digital transitions and (ii) ensuring that **social partners and all other relevant stakeholders, including from the private sector, are engaged** in determining the goals for the transitions and the actions required to achieve them. Early and regular engagement in the formulation and implementation of strategies and plans through **social dialogue** will help to ensure buy-in and ownership.

Attention should be given to **how to improve education and training provision** so that they are more responsive to new skill needs and can respond quickly. This may involve a range of activities depending on the context of individual countries, including: enhancing skills anticipation systems and tackling the question of how to obtain more fine-grained data on skills needs; improving quality procedures related to programmes and their delivery; investigating new forms of provision, such as micro-credentials, and how they may add to the portfolio of training options; and ensuring that teachers and trainers have the initial training and continuing professional development they need to implement new curricula and pedagogies. In all such considerations, the potential for work-based learning and apprenticeships to contribute to a more responsive skills system should be given attention.

Interventions should go beyond technical skills and ensure that all individuals gain **foundational green and digital skills and core competencies**, enabling them to benefit fully from the transitions. A combined green–digital skill set should be embedded in all initial education and training and incorporated into upskilling and reskilling programmes. The roll-out of universal broadband should be accompanied by the development of basic digital skills for all citizens so that they can make use of applications that help to mitigate and adapt to climate change.

Issues of **gender equality should be included at every stage and level of skills development**, from strategic planning, including through NDCs (ILO 2024b), to delivery in the classroom or workplace. Without appropriate interventions, as the projections show, inequalities will magnify as the green and digital transitions roll out. **Women** need comprehensive intervention packages, of which training is just one element; such packages should include promotional activities to change attitudes in schools and workplaces and the development of workplace spaces where women can feel safe and accepted; ongoing help to support the training-to-work transition; targeted active labour market measures; and careers advice and counselling.

Other aspects of inequality also need to be tackled. **Spatial and geographical variability** in the distribution of the benefits and costs of the transitions should be considered in all interventions. Globally, attention should be paid to African and low-income countries, which stand to benefit least, especially from the energy transition, according to the projections. Such a situation stands to compound and continue the injustice whereby these countries already suffer some of the worst consequences of the climate emergency yet have little responsibility for it. International efforts to resolve this ongoing injustice should be intensified.

There are evidently gaps in our knowledge and understanding of the green and digital transitions that require **further research**. These include a need for:

- more granular data about green and digital skill needs at the level of individual occupations to complement the type of projections presented in this report and to develop a more detailed understanding of likely changes, including job losses and possible workers' transitions across occupations;
- a greater understanding of how green and digital skills can be handled together in curricula and pedagogies and whether there are synergies between the two, especially in respect of core competences such as problem-solving, critical and systems thinking, which are typically hard to analyse;
- more comprehensive and regular projections with the inclusion of other policy scenarios, including circular economy, nature-based solutions and AI, and their interaction and combined impact on jobs and skills;
- more research to understand better how emerging business models (related to greening and digitalization) can be sustainable and support quality jobs and working conditions;
- more examination of the relationship between skills development and the nexus of research, innovation and enterprise development to better understand how stakeholders can mutually support one another.

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Appendix

Appendix A. The E3ME model of Cambridge Econometrics and the baseline and policy scenarios

Overview

E3ME is a computer-based model of the world's economic and energy systems and the environment. The description in this appendix provides a short summary of the E3ME model and policy scenario assumptions.[38] For further details of E3ME model, the full technical manual available from https://www.e3me.com/ should be consulted.

Basic structure and data

The structure of E3ME is based on the system of national accounts, with further linkages to energy demand and environmental emissions. The labour market is covered in detail, including both voluntary and involuntary unemployment. In total there are 33 sets of econometrically estimated equations, also including the components of GDP (consumption, investment, international trade), prices, energy demand and materials demand. Each equation set is disaggregated by country and by sector. The E3ME historical database that was used for this report covers the period 1970–2020 and the model gives projections for every year up to 2100. The main data sources for European countries are Eurostat and the International Energy Agency (IEA), supplemented by the OECD's STAN (Structural Analysis) database and other sources where appropriate. For regions outside Europe, additional data sources include the United Nations, the OECD, the World Bank, the International Monetary Fund (IMF), the ILO and national statistics. Gaps in the data are estimated using customized software algorithms.

Main dimensions of the model

The main dimensions of E3ME are:

- 70 global regions, including all G20 and EU Member States explicitly, plus a set of regions to meet global totals;
- 43 economic sectors in each region, with additional detail in Europe; X a time frame covering every year from 1970 to 2050;
- 43 categories of household expenditure;
- 22 different users of 12 different fuel types; and
- 14 types of airborne emission (where data are available), including the six greenhouse gases (GHGs) monitored under the Kyoto Protocol.

Standard outputs from the model

As a general model of the economy, based on the full structure of national accounts, E3ME is capable of producing a broad range of economic indicators. In addition, it features a range of energy and environment indicators. The following list provides a summary of the most common model outputs:

- GDP and the aggregate components of GDP (household expenditure, investment, government expenditure and international trade);
- sectoral output and gross value added, prices, trade and competitiveness effects;
- international trade by sector, origin and destination;

38 It is based on the description given in I2 AM Paris (Integrating Integrated Assessment Modelling in Support of the Paris Agreement), "The E3ME-FTT Model". https://paris-reinforce.epu.ntua.gr/detailed_model_doc/e3me-ftt

- consumer prices and expenditures;
- sectoral employment, unemployment, sectoral wage rates and labour supply;
- energy demand, by sector and by fuel, energy prices;
- CO^2 emissions by sector and by fuel;
- other airborne emissions; and
- materials demand.

This list is by no means exhaustive and the outputs delivered often depend on the requirements of the specific application of the model. In addition to the sectoral dimension mentioned in the list, all indicators are produced at the national and regional level and for every year up to 2100.

Scenario assumptions

Baseline scenario

The baseline scenario represents a business-as-usual case, and seeks to include most regional policies confirmed by 2020. The specific date may vary slightly between regions, depending on the sources of information used.

The Digital Transition: Near-Universal Broadband Scenario

The aim of the digitalization scenario is to estimate the employment impacts of reaching universal broadband coverage (defined as at least 90 per cent of the population) by 2030, in line with SDG Goal 9.[39]

The main assumption is an increase in investment leading to the expansion of broadband Internet coverage within and across countries. It is assumed that the countries implement these investments from 2022 onwards and that the investments are repaid during the period. By 2030, the universal coverage is achieved.

Table A.1. shows the gaps in coverage by region, comparing the current situation to the goal of universal broadband coverage. These gaps in coverage by region determine the required levels of investment in the assumptions and the consequent assumed changes in productivity and consumer spending patterns.

Table A.1. Assumptions on the increase in Internet broadband coverage by region

ILO region	Current coverage	2030 coverage (universal coverage)	Gap in coverage to be closed over the period 2022-30
Africa	10%	90%	80%
North America	90%	90%	0%
Latin America	42%	90%	48%
MENA	33%	90%	57%
South Asia	45%	90%	45%
East Asia and the Pacific	67%	90%	23%
Europe and Central Asia*	70-80%	90%	10-20%

Note: * Western European countries have a higher current coverage than Eastern European and Central Asian countries. The share thus belies wider variation than the other regions listed.

Source: ILO (based on "ITU 2020").

39 Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.

Internet access is expected to increase digitalization through increased use of digital technologies by firms and increased demand for digital services from the population. At firm level, digital technologies lead to an increase in productivity, which in turn leads to an increase in productive capacity. This has a positive impact on the domestic economy through lower domestic prices and a negative impact through lower wages (relative to the baseline). The downward pressure on wages is due to increased capacity that results in lower demand for labour. Other things being equal, lower domestic prices have a positive impact on the trade competitiveness of the economy, increasing demand for domestic output over imports. In turn, higher output drives higher employment, which leads to higher real incomes. Additional indirect effects on output come from increases in consumption driven by those with higher real incomes.

The productivity gains by sector and ILO geographical region [40] are estimated by applying an elasticity that relates broadband coverage to productivity. Firstly, an increase in productivity is estimated by region, based on the extent to which the current gap in mobile phone coverage will be reduced. This overall regional productivity impact is allocated to sectors, based on the relative size of the sectors and their likelihood of benefiting from the extended coverage. The effect is thus related to the size of the gap to be closed by 2030. This information is presented in the last column of table A.1. above. The elasticity is based on ITU (2020) that estimate the relationship between mobile broadband penetration and GDP per capita. The size of this elasticity by sector is in line with the taxonomy of digital-intensive sectors published by the OECD (Calvino et al. 2018), that is the lower the digital intensity of a sector, the smaller the impact of broadband Internet on productivity.

In the Near-Universal Broadband Scenario, changes in consumer spending patterns are expected, with increases in expenditure on Internet-enabled services, such as financial, recreational and communication services. While increased digitalization is expected to also decrease administrative costs at enterprise level, it is difficult to disentangle the reduction in administrative costs (for example, less paperwork, change in the way inventories or production are organized) from other productivity impacts. This aspect is thus not separately considered in the scenario. Instead, it is assumed to be captured by the productivity change.

Investment is allocated to the sectors that build the new infrastructure. The allocation of purchases of investment goods is as follows: 50 per cent to construction, 15 per cent to electronics, 15 per cent to electrical equipment, 10 per cent to communication, and 10 percent to computer services.

The increased broadband Internet penetration is assumed to be financed through private sources (namely the broadband firms pay the costs). Each sector decides if the payment of the investment is passed on to prices or through reduced profits according to econometrically estimated cost pass-through rates.

The Green Transition: The Energy Transition Scenario

For the Energy Transition Scenario, a combination of climate and energy policies are modelled to achieve climate neutrality by 2050 in 124 countries, and by 2060 for the remaining countries (in support to reach the 1.5-degree target, except China, which will reach climate-neutrality).

It is assumed that the countries implement these policies from 2022 onwards. While these policies are long-term in nature, the results in this report are presented up to 2030 only. For this modelling exercise, the broad emissions reduction, energy efficiency savings and investment and carbon prices are aligned with the IEA Net Zero by 2050 Report (2021).

Carbon pricing policy is one of the key drivers of investment in green and energy-efficiency technologies. On the investment side, the increase in carbon prices leads to additional net investment (including the reduction in energy and energy mining sector investment relating to fossil fuels) re-oriented towards technologies that reduce emissions. Low-carbon investment will also lead to increased investment in other parts of the economy, as a spillover effect. On the economic side, the increase in carbon prices does however

40 See list of ILO regions in Appendix B.

lead to an increase in both consumer and industrial prices, impacting differently countries and sectors. Increases in consumer prices in turn lead to lower real disposable incomes, which lead to lower spending on goods and services and demand for industrial output. On the environmental side, an increase in carbon prices will lead to lower demand for high carbon content products which in turn will reduce CO_2 emissions.

Carbon and energy prices by country will be set to match those in the IEA World Energy Outlook 2020.

Power generation is endogenous to the model and the necessary investment will be determined by E3ME.

Coal generation is expected to decrease in the scenario to reach net zero. Additionally, policies are added to speed up the uptake of renewable technologies, in particular solar and wind. The main policy options that can be implemented in E3ME are:

- subsidy support for certain (for example, Renewable Energy Sources (RES)) electricity-generating technologies
- feed-in-tariffs
- regulation that prevents the new construction of certain types of power plant (for example, coal)
- For this scenario, E3ME is be aligned to be consistent with the following information and projections from the World Energy Outlook 2020:
- electricity capacity and generation by country
- investment by country/region in power generation by technology/sector

The scenario also includes assumptions about increased energy efficiency compared to baseline and the cost to achieve such energy savings. These energy savings are assumed to be the result of increased appliance efficiency and improvements in buildings (renovation and retrofit). The scenario also includes assumptions about which sectors are more likely to achieve the energy savings and how these energy savings are financed.

For buildings' energy efficiency, different policy options, such as subsidies or regulation, can be implemented to change the heating technologies used by the building sector to improve energy efficiency and reduce emissions. For this purpose, investment by country/region in energy efficiency by sector and change in final energy demand by product/sector as result of energy efficiency is set to match the World Energy Outlook 2020. Specific focus is given to the road transport sector, which in most countries is the second-largest CO_2-emitting sector. The scenario includes assumptions regarding improved fuel efficiency standards and alternative fuel vehicles (electricity, bioenergy, hydrogen).

For the transport sector, an increase in the deployment of public charging and refuelling points, and in the number of electric vehicles sold is assumed. To reduce emissions, the main policies considered for road transport are:

- subsidies to support electric vehicles
- biofuel mandates (if required)
- various tax options for inefficient vehicles (such as fuel taxes, road taxes or registration taxes)

The policy inputs are adjusted so that the final energy demand for the transport sector will be closely aligned with IEA projections.

The carbon pricing applied to all sectors and regions in the scenario generates revenue. The revenue is used to pay for: energy efficiency investments, power sector subsidies to support low-carbon technologies, early scrappage costs (that is compensation for taking a power plant out of service earlier than its originally intended lifetime), and household heating subsidies. If any revenue is left, then it is used to lower taxes on income, VAT and employers' social security contributions (equally distributed). Conversely, if there is not enough revenue, then taxes are raised to cover the shortfall. On top of that it is assumed that, for the oil-exporting countries, the governments lose royalty revenues and will have to take measures in order steps to limit the size of any additional debt in the scenario. The loss of these revenues is offset in equal measure by a reduction in government spending and increases in taxes (if carbon price revenues are insufficient). The estimated loss of revenue is calculated based on the decrease in oil and gas exports and the change in the price, in proportion to the volume exported and the cost of extraction (for example, it can be more expensive to extract fossil fuel in Canada because it comes from oil sands as opposed to the Middle East where it is extracted by traditional drilling and pumping methods).

The Combined Scenario

The background of the Combined Scenario incorporates the backgrounds of both the Near-Universal Broadband Scenario and the Energy Transition Scenario. It thus aims to capture the synergies and trade-offs of both transformations happening concurrently.

The narrative behind the Combined Scenario is the integration of the digital and green narratives, without any additional themes or assumptions. The assumptions in the Combined Scenario are, thus, a combination of the specific assumptions made under the Near-Universal Broadband and Energy Transition Scenarios, without making any additional adjustments and re-interpretations. The assumptions in the two separate scenarios have been preserved and simply brought together in a single scenario. No changes have been made to timelines, policies and revenue and funding approaches. While the inputs to the Combined Scenario are simply the combination of the exact inputs from the Near-Universal Broadband Scenario and the Energy Transition Scenario, this does not mean that the results from the Combined Scenario will be equal to the sum of the two separate scenario. The results of the Combined Scenario will be broadly of a similar magnitude to the sum of the results of the two separate scenarios (in terms of absolute difference from baseline), but they are not identical to the sum of thew two. The reason behind this is linked to the amplification of certain effects, such as increased productivity because of higher investment (the higher investment expenditure may lead to stronger efficiency gains than in each individual scenario as a result of economies of scale) or increased pressure on wages, as both scenario combined lead to higher demand for labour and stronger influence on wages rates than the two separate scenarios may result in.

Appendix B. Country groupings by region and income level

Africa

North Africa
Algeria
Egypt
Libya
Morocco
Sudan
Tunisia
Western Sahara

Sub-Saharan Africa
Angola
Benin
Botswana
Burkina Faso
Burundi
Cameroon
Cabo Verde
Central African Republic
Chad
Comoros
Congo
Côte d'Ivoire Democratic Republic of the Congo
Djibouti
Equatorial Guinea Eritrea
Eswatini
Ethiopia
Gabon
Gambia
Ghana
Guinea
Guinea-Bissau
Kenya
Lesotho
Liberia
Madagascar
Malawi
Mali
Mauritania
Mauritius
Mozambique
Namibia
Niger
Nigeria
Rwanda
Sao Tome and Principe
Senegal
Sierra Leone
Somalia
South Africa
South Sudan
Togo
Uganda
United Republic of Tanzania
Zambia
Zimbabwe

Americas

Latin America and the Caribbean
Argentina
Bahamas
Barbados
Belize
Bolivia (Plurinational State of)
Brazil
Chile
Colombia
Costa Rica
Cuba
Dominican Republic
Ecuador
El Salvador
Guatemala
Guyana
Haiti
Honduras
Jamaica
Mexico
Nicaragua
Panama
Paraguay
Peru
Puerto Rico
Saint Lucia
Saint Vincent and the Grenadines
Suriname
Trinidad and Tobago United States Virgin Islands
Uruguay
Venezuela (Bolivarian Republic of)

North America
Canada
United States of America

Arab States

Bahrain
Iraq
Jordan
Kuwait
Lebanon
Occupied Palestinian Territory
Oman
Qatar
Saudi Arabia
Syrian Arab Republic United Arab Emirates
Yemen

Asia and the Pacific

East Asia
China
Democratic People's Republic of Korea
Hong Kong, China
Japan
Macao, China
Mongolia
Republic of Korea
Taiwan, China

South-East Asia
Brunei Darussalam
Cambodia
Indonesia
Lao People's Democratic Republic
Malaysia
Myanmar
Philippines
Singapore
Thailand
Timor-Leste
Viet Nam

Pacific Islands
Australia
Fiji
French Polynesia
Guam
New Caledonia
New Zealand
Papua New Guinea
Samoa
Solomon Islands
Tonga
Vanuatu

South Asia
Afghanistan
Bangladesh
Bhutan
India
Iran (Islamic Republic of)
Maldives
Nepal
Pakistan
Sri Lanka

Europe and Central Asia

Northern, Southern and Western Europe
Albania
Austria
Belgium
Bosnia and Herzegovina
Channel Islands
Croatia
Denmark
Estonia
Finland
France
Germany
Greece
Iceland
Ireland
Italy
Latvia
Lithuania
Luxembourg
Malta
Montenegro
Netherlands
North Macedonia
Norway
Portugal
Serbia
Slovenia
Spain
Sweden
Switzerland
United Kingdom

Eastern Europe
Belarus
Bulgaria
Czechia
Hungary
Poland
Republic of Moldova
Romania
Russian Federation
Slovakia
Ukraine

Central and Western Asia
Armenia
Azerbaijan
Cyprus
Georgia
Israel
Kazakhstan
Kyrgyzstan
Tajikistan
Türkiye
Turkmenistan

High-income countries/territories	Upper-middle-income countries/territories	Lower-middle-income countries/territories	Low-income countries/territories
Australia	Albania	Angola	Afghanistan
Austria	Algeria	Bangladesh	Burkina Faso
Bahamas	Argentina	Belize	Burundi
Bahrain	Armenia	Benin	Central African Republic
Barbados	Azerbaijan	Bhutan	Chad
Belgium	Belarus	Bolivia (Plurinational State of)	Democratic People's Republic of Korea
Brunei Darussalam	Bosnia and Herzegovina	Cambodia	Democratic Republic of the Congo
Canada	Botswana	Cameroon	Eritrea
Channel Islands	Brazil	Cabo Verde	Ethiopia
Chile	Bulgaria	Comoros	Gambia
Croatia	China	Congo	Guinea
Cyprus	Colombia	Côte d'Ivoire	Guinea-Bissau
Czechia	Costa Rica	Djibouti	Liberia
Denmark	Cuba	Egypt	Madagascar
Estonia	Dominican Republic	El Salvador	Malawi
Finland	Ecuador	Eswatini	Mali
France	Equatorial Guinea	Ghana	Mozambique
French Polynesia	Fiji	Haiti	Niger
Germany	Gabon	Honduras	Rwanda
Greece	Georgia	India	Sierra Leone
Guam	Guatemala	Indonesia	Somalia
Hong Kong, China	Guyana	Iran (Islamic Republic of)	South Sudan
Hungary	Iraq	Kenya	Sudan
Iceland	Jamaica	Kyrgyzstan	Syrian Arab Republic
Ireland	Jordan	Lao People's Democratic Republic	Togo
Israel	Kazakhstan	Lesotho	Uganda
Italy	Lebanon	Mauritania	Yemen
Japan	Libya	Mongolia	
Kuwait	Malaysia	Morocco	
Latvia	Maldives	Myanmar	
Lithuania	Mauritius	Nepal	
Luxembourg	Mexico	Nicaragua	
Macao, China	Montenegro	Nigeria	
Malta	Namibia	Occupied Palestinian Territory	
Netherlands	North Macedonia	Pakistan	
New Caledonia	Panama	Papua New Guinea	
New Zealand	Paraguay	Philippines	
Norway	Peru	Samoa	
Oman	Republic of Moldova	Sao Tome and Principe	
Poland	Romania	Senegal	
Portugal	Russian Federation	Solomon Islands	
Puerto Rico	Saint Lucia	Tajikistan	
Qatar	Saint Vincent and the Grenadines	Timor-Leste	
Republic of Korea	Serbia	Tunisia	
Saudi Arabia	South Africa	Ukraine	
Singapore	Sri Lanka	United Republic of Tanzania	
Slovakia	Suriname	Uzbekistan	
Slovenia	Thailand	Vanuatu	
Spain	Tonga	Viet Nam	
Sweden	Türkiye	Western Sahara	
Switzerland	Turkmenistan	Zambia	
Taiwan, China	Venezuela (Bolivarian Republic of)	Zimbabwe	
Trinidad and Tobago			
United Arab Emirates United Kingdom			
United States of America			
United States Virgin Islands			
Uruguay			

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