EUROPEAN
YEAR OF
SKILLS

Skills in transition
The way to 2035

CEDEFOP

Skills in transition

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Foreword

Europe is at a turning point. The unfolding climate emergency, the digital revolution, geo-political tensions, and the energy and cost-of-living crises fundamentally challenge the economic and social fabric of countries, economic sectors and communities. We see change and megatrends accelerating and their mutually reinforcing features making change exponential. While it is becoming more difficult to foresee what changes lie ahead, it is increasingly obvious that the policy implementation choices we make this decade will determine what the future will look like.

Cedefop has for many years acknowledged and championed the role VET and skills play in shaping and adapting to change. Before policies fully embraced the notion that the twin transition is a skills transition, we leveraged our potential as European VET and skills knowledge and expertise hub to understand how the worlds of work and education are changing. Cedefop 'invented' skills intelligence and has been expanding it ever since. Alongside skills forecasts, we now systematically use skills surveys, foresight and big data to understand skill needs and trends; to reflect at how jobs and work are changing around us, and to foresee the changes in store for Europe's labour markets.

Labour and skills shortages are currently in the spotlight, and rightly so. Many employers face them and in sectors such as construction, care and IT, they are an increasingly pressing challenge. Not all shortages, however, emerge because skills are lacking. There are also marked 'shortages' of quality jobs, decent working conditions and opportunities for skills use. While these may translate into recruitment difficulties, we cannot blame missing skills or education and training for them. In our research and analysis, therefore, we take a nuanced approach to shortages, recognising that they can be the result of supply bottlenecks, demand-side factors, or a combination of the two.

The 2023 European Year of Skills presents a unique opportunity to champion people and their skills. Developing and making good use of the skills of young people and adults motivates them to be the best they can, gives them a springboard to a successful career, and has a positive bottom-line impact for organisations. But while there is enormous up- and reskilling potential, and VET systems are changing and becoming more inclusive to different types of learners in response to trends and challenges, participation in training and

adult learning remains far too low.

To unleash an inclusive skills revolution, alongside the right policies and resources, we need skills intelligence that points us in the right direction and tells us where we should focus our efforts when investing in skills and in skills matching. This report uses Cedefop's entire skills intelligence resource to grasp what has changed in EU labour markets in the past decade and to identify future trends up to 2035. It blends different types of evidence to foster better understanding of the labour market and skills impacts of the green and digital transitions and reflects on labour markets tensions, current and future. We trust the report findings will enrich debates and stimulate critical reflection about how we best tackle the skills and skills matching challenges Europe needs to address.

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Executive summary

Labour shortages have been a key concern for EU and national policy-makers for some time, and rightly so. The labour market continues to be tight, and in the period between 2019-21 there were more people looking for employment than job openings. Digitalisation and technological change are increasing labour market tightness for science, technology, engineering and mathematics (STEM) and IT occupations. With demand for people with a university or higher VET qualification increasing after the pandemic, the hiring challenges employers face have become even more intense.

Cedefop's 2023 skills forecast suggests that, while labour market tightness at the higher end may be here to stay, there are no indications that it will get dramatically worse. In the years up to 2035, despite modest economic growth, the demand for highly qualified people remains dominant across sectors and occupations in the EU. The established job polarisation trend will give way to jobs upgrading, driven by twin transition and the mainstreaming of the knowledge-economy approach. With the educational composition of the future labour force also veering in that direction, labour supply is adjusting: the highly skilled labour force is rapidly expanding, the medium-skilled one remains relatively stable, and the low-skilled labour force is declining.

Megatrends continue shaping labour markets up to 2035

Jobs upgrading is mirrored in projected employment shifting away from sectors such as agriculture, basic manufacturing, distribution and retail towards service sectors. At the same time, the twin – digital and green – transition is driving employment trends up to 2035. Reaching European Green Deal (EGD) targets and delivering on energy security and autonomy ambitions will lead to job destruction in primary industries (particularly coal, oil and gas). Employment in high-end manufacturing is likely to benefit from EU regulations and support mechanisms, such as the European Chips Act, the Critical Raw Materials Act and the EU Sovereignty Fund. Becoming greener translates into significant employment growth in waste management, construction and electricity, sectors that are pivotal in the recently adopted Green Deal industrial plan. Spill-over employment effects are expected for sectors in their supply

chain, such as architectural and engineering services and R&D.

Cedefop projects job openings will be highest for high-skilled non-manual occupations such as business and administration professionals, legal, social and cultural professionals, and science and engineering professionals. At the lower end of the labour market, occupations such as clerks, service workers and shop and market sales workers, craft and related trades workers, and skilled agricultural and fishery workers, are expected to lose market share. This is not only because the skills they embody become less relevant, but also because technology makes it possible to incorporate them in the tasks of higher skilled workers. Significant job losses are projected for manual occupations, often in manufacturing, and for less skilled non-manual occupations such as numerical and material recording clerks.

The demographic challenge the EU faces is the third major transition affecting labour markets. The ageing population and workforce means that, in the run up to 2035, job growth and most job openings will emerge because of replacement demand. Ageing will reduce labour market participation rates, particularly among males. Delaying labour market entry, educational expansion reduces the participation of younger age cohorts. These structural pressures on supply call for targeted action to raise participation among the medium-skilled, particularly females, and other groups with activation potential.

The green transition is a skills transition

The green transition calls for an inclusive skilling revolution involving all workers, across qualification and seniority levels, sectors and occupations. Training needs to help workers in declining sectors and regions transition, and supply skills for 'key green transition occupations' such as electrical vehicle technicians. The relatively small group of professionals driving 'greennovation' need to be fortified with the necessary skill sets to fulfil their critical role. Those holding such 'thyroid occupations', as Cedefop coined them, are not only the highly skilled R&D scientists inventing green solutions, but also the technicians supporting their implementation.

Identifying the skills needed for the green transition is less straightforward than other skills sets, such as digital. Cedefop's sectoral skill foresight shows such skills range from technical and job-specific to soft and transversal. In the circular economy, 'systems thinking' is a foundation skill, while empathy plays a crucial role in ensuring process and product design and business models contribute to the fairness of the green transition (Cedefop, 2023b). Commu-

nication skills build consumer and citizen awareness and engagement to act, live, and work 'green', for example by reducing waste or repairing goods. The twin transition also boosts skill demand for digital and data analysis skills. Fuelling the green transition, such skills must be embedded across the board in 'green' education and training programmes and curricula.

Digital revolution makes more jobs high-tech

Alongside fostering a more sustainable EU economic paradigm, technological innovation, particularly via digitalisation, automation, connectivity, and block-chain and artificial intelligence (AI), transforms jobs and skill needs. Demand for professionals in the computer programming sector is expected to grow, particularly for highly skilled profiles such as IT software and application developers and analysts. In 2022, jobs as database and network specialists and information and communications technology operations and user support technicians represented the lion's share of online jobs advertisements posted by employers in the administrative and support service activities sector. Most online advertisements for electronics engineering technicians, electrotechnology engineers and electronics and telecommunications installers and repairers were for jobs in manufacturing.

Automation, robotisation and other forms of digitalisation transform skill needs in all types of occupations and at all qualification levels. Digital transformation will shift upwards the level of digital skills employers ask for; even in low-skilled occupations, where no special training was needed in the past (such as agriculture), the demand for medium- and high-level digital skills (e.g. using sensors-based technology) will grow.

In high-tech sectors and occupations, which drive change through high R&D expenditure and value-added, technological innovation has always been part and parcel of all aspects of work. About 3 in every 5 jobs in the high-tech sector are in manufacturing companies, many in the electronics and automotive sectors. 'Technology intensive' occupations encompass a mix of professional and technician profiles, such as science and engineering professionals and technicians, information technology professionals, and IT technicians. Sectors at the core of the EGD and the Green deal industrial plan – ICT services, energy supply services, water supply, and waste treatment and manufacturing – have the highest shares of high-tech jobs.

Demand for these workers (for example, petroleum and gas refining plant operators) has been boosted since 2020 by the energy crunch and digitalisa-

tion. Cedefop's skills forecast anticipates strong job growth for highly skilled tech workers, such as ICT professionals, up to 2035. The employment shares of technicians are expected to decline, because of automation, labour market tightness leading to outsourcing, and because the population becoming better digitally skilled supresses the need for service provision to support advanced technologies.

The distinction between high- and medium- or low-tech jobs is blurring. Technological innovation resulting from the introduction of robots, biotechnologies or advanced software is becoming increasingly common in sectors not typically considered 'high-tech', such as agriculture and education, signalling that they are likely to develop in that direction over time.

Shortages in the spotlight, but not just through lack of skills

Labour market pressures induced by the pandemic may have eased in 2023, but skill shortages remain at the top of policy agendas. The share of employees in shortage occupations is highest in human health and social work activities, construction, electricity, gas, steam and air conditioning supply, ICT, waste management, accommodation and food services, and manufacturing. Shortages are a key skills challenge, but not everywhere or to a similar extent. A minority (26%) of EU establishments face a large degree of difficulty in finding employees with the right skills; current labour market tensions are much more pronounced in the areas of ICT, health care and STEM at medium- and at high-skill level than in other labour market segments.

Alongside lacking skills, the 'great resignation', workforce ageing and companies adopting new digital work and learning practices also underpin recruitment bottlenecks. Crucially, analysis using the Eurofound-Cedefop European company survey (ECS) (Cedefop and Eurofound, 2020) shows that recruitment difficulties and shortages vary between types of firms (larger firms experience less pressures than smaller ones) and type of jobs. Shortages of ICT professionals have a clear link to the fact that such jobs are inherently more complex in terms of analytical skills. Shortages of health professionals and associates are often driven by poor working conditions. In some labour market segments, shortages are not primarily caused by insufficient skill supply; the policy mix to address them should include improving HRM practices and making jobs more attractive, challenging and rewarding.

Part of the recruitment difficulties European employers face appear to be driven by their expectation of finding workers with high non-cognitive skills

for roles not demanding (very) high proficiency in cognitive and other skills. Jobs in occupations facing shortages are more likely to demand lower literacy, numeracy, interpersonal and digital skills compared to jobs in occupations that do not and depend more on physical/manual tasks. The finding that jobs of workers in shortage occupations give them more discretion in organising and planning their work, learning, and adapting to unexpected situations or varying tasks, suggests that the lack of such skills may explain why hiring difficulties occur.

As employment shifts away from low and medium qualification levels towards higher ones, hiring difficulties for medium and low-level occupations are projected to exceed those for higher occupations, as the required upgrading in their qualification mix is greater than for higher occupations. Nevertheless, keeping an eye on labour market tensions affecting high-skilled occupations will remain crucial, as the average trend obscures variations in hiring difficulties among them. Recruitment difficulties could be substantial when, among the growing group of highly qualified young people, not enough have the specific job requirements (qualifications or experience) occupations require. Bottlenecks for high-skilled occupations will likely continue and intensify for occupations playing a major role in the twin transition. Population and workforce ageing will continue to be a challenge to providing sufficient supply of personal care workers, making it likely that shortages will persist.

Cedefop's Future Shortage Index (FSI) shows that labour shortages will be mostly driven by employment growth, followed by replacement needs, with mismatches in education composition playing an important role for manual occupations. Sectors with strong EGD implementation-driven employment demand, such as electricity, gas, steam and air conditioning supply, will not experience significant pressures because of future imbalances. The FSI is lowest for mining and quarrying, a sector where replacement demand is low and employment will decline as the energy transition gets up to speed.

A long view needed to manage skills in transition

The challenges and opportunities facing the EU are powerful enough to reshape the future irreversibly. This gives leverage for veering away from myopic policy responses to immediate skills challenges, towards holistic approaches that aim to achieve a more technologically advanced, greener and fairer future. The strong links between the digital and the green transitions call for more alignment between education and training and labour market policies

and their implementation. In the decade ahead, global forces and trends will increasingly require responses that consider sectoral needs and local realities. Skills governance arrangements that bring all stakeholders on board, such as those championed by the European Commission's Pact for Skills, need to be encouraged and upscaled. Silo-thinking needs to give way to trust-based partnership to create the right conditions for delivering VET and skills in line with multiple policy objectives. Among these conditions are strengthening resilience to external shocks, considering of the needs of the low-skilled and other vulnerable groups, and leveraging the benefits of better coordination between skills policy and other policy areas, such as economic growth, innovation, social equity and migration.

Cedefop evidence puts in the spotlight the importance of promoting STEM education and occupations and digital training provision at all levels to make the twin transition work for EU economies, societies, sectors and regions. Participation policies and labour market activation measures to integrate the more medium-skilled (particularly females), not only contribute to the fairness of the green transition, but also cushion labour market consequences of population and workforce ageing.

Accelerating and pervasive change alongside unforeseen shocks, such as the pandemic and the Ukraine war, can strike fear of job and task destruction. While it is evident that some jobs will disappear, and that the people affected need support in making transitions, it is time to change the tone in policy discussions. Rather than considering them as threats to employment, automation and digitalisation should be seen as tools to tackle current and future workforce shortages. VET has a major role to play, because its close connection to the world of work makes it possible to offer the right mix of technical and soft skills, while fostering innovation and project- and team-based learning. Though crucial, up- and reskilling are not a panacea. Making and shaping transitions via skills also requires expanding opportunities for skills utilisation at work and investing in job quality and people-centred human resource practices, allowing workers to contribute their full potential and take ownership in responding to the challenges that lie ahead.

Skills in transition: the way to 2035

1.1.   How did we get here?

The EU economy experienced several major shocks in the past 15 years. In 2008 the financial crisis led to recession across Europe. In the years that followed the economy recovered, but was thrown off course again, first by COVID-19, and then by the supply chain disruptions caused by lockdowns. In December 2019, with the European Green Deal (EGD), greening of the economy became the Union's growth strategy. Alongside digital transformation, the transition to a more circular and renewable energy powered economy took centre stage. Reorientation towards, and concentration on, the twin transition helped to shape a more focused EU policy framework.

The invasion of Ukraine exacerbated supply chain bottlenecks and led to an energy crisis not seen since the 1970s (Bobasu and De Santis, 2022; Eurofound 2022). Spikes in gas prices triggered electricity price hikes which left no sector unaffected and rapidly accelerated inflation across the EU. Increased energy costs will pose a continuous threat to employment, particularly in energy-intensive sectors. The invasion also set in motion policy actions bolstering the EU's energy autonomy, triggering changes in skills and jobs in the short and the long-term.

Understanding the labour market and skill demand implications of these shocks is important. While they have not radically impacted the volume of employment, which remained remarkably intact considering the scale of the shocks the EU economy faced, change in the worlds of work and skills has progressed. Changing labour and skill demand also reflects the rapid pace of digitalisation affecting almost all walks of life and technological change more generally – structural megatrends that have been a concern for experts and policy-makers for decades.

Mapping the sectoral and occupational changes in demand since the financial crisis in 2008 is important from a skills perspective. Such analysis helps assess whether long-term expectations about, for instance, the impact of automation on different jobs, have slowed down or accelerated as a result

of having to respond to crisis and adverse events. This is important for vocational education and training (VET). VET policy-makers and providers need a long-term perspective to shape and set skills content of their programmes and curricula in the years ahead.

From a long-term perspective, employment demand is shifting away from extractive industries and manufacturing sectors towards service sector related activities (Figure 1). Several manufacturing sectors that experienced shrinking employment after the economic crisis have continued to decline in terms of jobs ever since. Several other sectors, including ICT, have experienced continued growth. Some manufacturing sectors had a more uneven trajectory. They struggled in the immediate aftermath of the financial crisis but later displayed relatively strong employment growth.

Massive job loss leading to high and persistent levels of unemployment was feared but did not materialise following either the financial crisis or COVID-19. That said, it is known that people working in certain jobs and industries have fared less well than others (Pouliakas and Branka, 2020). Remote working opportunities and low automation risk act as shields against lob losses (Livanos and Ravanos, 2020). With COVID-19, employment fell substantially in the hospitality sector, wholesale and retail, and the arts, sports, and recreation sector. At the same time, alongside the increase in demand for healthcare workers, the shift to remote work has triggered increased employment in ICT and, for the same reasons, demand for online delivery services. There has undoubtedly been a bounce back from the employment losses, but the jobs re-emerging after the pandemic were often different from the ones that were cut earlier. COVID-19 has also set in motion longer-term trends impacting the sectoral and occupational structure of employment, which reflect the speed with which business and consumers moved to conducting activities online.

The EU economy bouncing back in the aftermath of COVID-19 led to an increase in labour demand (Cedefop, 2022d). The vacancy rate based on Job vacancy statistics reported by Eurostat in 2022Q2 stood at 2.9%, up from 2.2% a year earlier (2021Q3), and 2% in 2019Q3. There was also an increase in the share of residence permits granted for employment-related reasons [1].

Comparing the jobs of recent job starters in the first quarters of 2019 and 2022, shows a marked increase in the manufacturing sector (reflecting the rise in output observed over the first half of 2022) (Eurostat, 2022a). The share of

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[1] According to Eurostat data, 45% of the total first residence permits issued in 2021 were for employment reasons, which is the largest such figure since the time series commenced.
Eurostat. Job vacancy statistics.

Figure 1. **Employment change (%) in 2008-21 and share in total employment in 2021 (%), by sector**
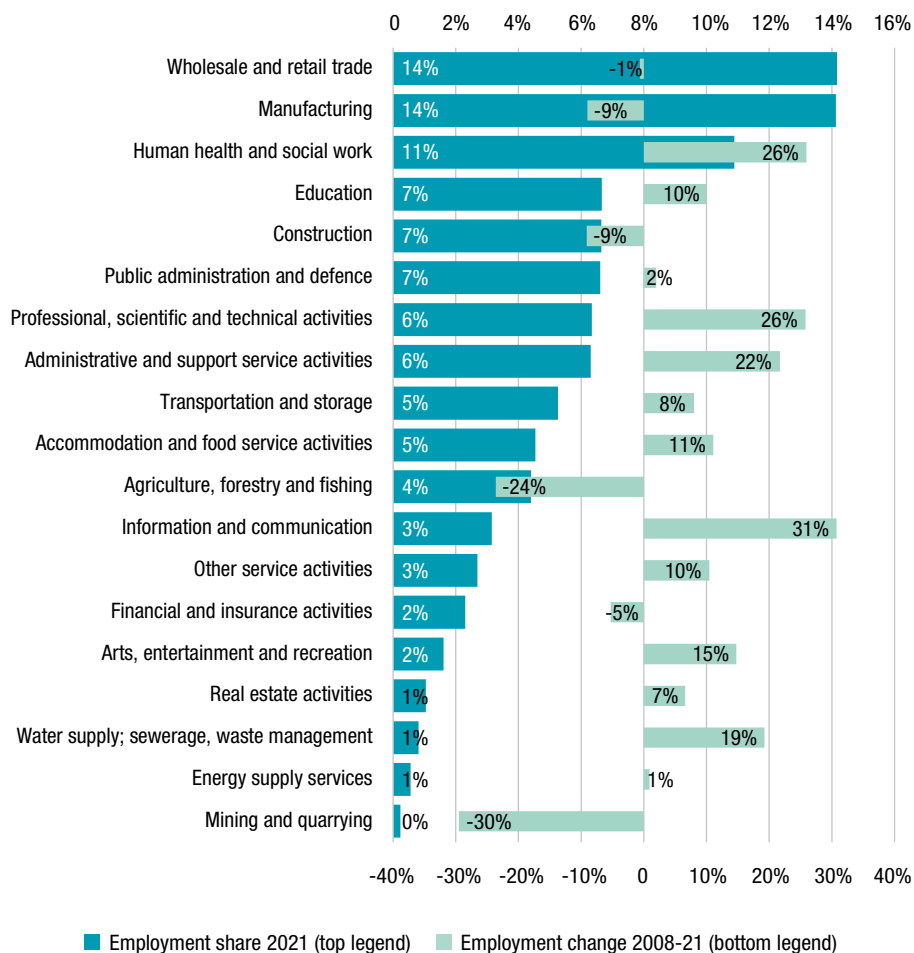
NB: Excludes activities of households as employers; undifferentiated goods- and services-producing activities of households for own use and activities of extraterritorial organisations and bodies.
Source: Eurostat [nama_10_a64_e].

recently hired ICT and health-related workers was substantially greater in early 2022 compared with 2019. This indicates the importance of these sectors during and after the pandemic and underlines the role of ICT as a resilience reinforcing factor (Eurofound, 2021; European Investment Bank, 2022).

Professional and associate professional occupations drove employment change

The direction of occupational change (Figure 2) points towards employment growth in professional and associate professional jobs, such as in ICT, finance and construction (e.g. architects) roles. Such occupational change reflects the wider megatrends impacting the European economy: growing digitalisation, increasing focus on green transition, aging (medical and care jobs growth), but also increasing emphasis on learning (teachers and trainers). Significant job creation also took place in sports and arts. The devastating impact of COVID-19 is particularly visible in the large decline in hospitality jobs in hotels and restaurants.

Figure 2. **Employment change (%) in 2008-21 and share in total employment in 2021 (%), by occupation**
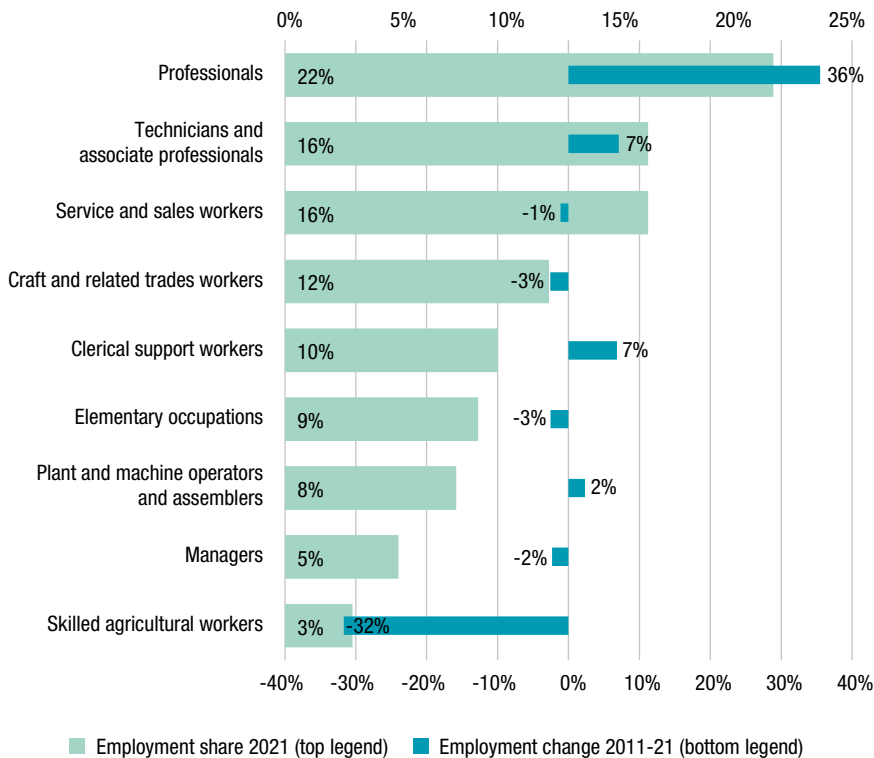
Source: Eurostat labour force survey [LFSA_EGAIS].

Rebound to high-tech knowledge services, electricity, and gas

After the pandemic, job vacancy rates increased, implying that more employment openings became available for jobseekers (Box 1 and Figure 3). The job vacancy rates are highest in high-technology knowledge services (Figure 4) and in energy sectors, which suggests that employers in these sectors faced substantial difficulties in finding suitable candidates for the jobs they offer.

Box 1. **Understanding employment trends via online job advertisements**

Contraction or expansion of the EU economy in terms of employment can be measured by looking at developments in the number of job openings. In the EU there are two sources of information: the Job vacancy statistics, collected as part of the EU statistical system, and online job advertisement data collected jointly by Eurostat and Cedefop in the context of the Web Intelligence Hub project (WIH-OJA) (Eurostat and Cedefop, 2020). Tracking online job advertisements makes it possible to analyse labour market change almost in real-time.

Cedefop's project on building skills intelligence based on content of online advertisements in 2020 became a joint endeavour with Eurostat, which, via its Web Intelligence Hub, aims at developing smart statistics. The WIH-OJA database follows the same methodology for all Member States, allowing for comparative analysis at granular level. Information is collected almost in real time and published quarterly at ISCO 4-digit occupation levels. The European multilingual classification of skills, competences and occupations (ESCO) is used to classify skills [2].

Interpreting job vacancies based on online job advertisements is not straightforward, but is statistically feasible when accounting for the differences in the statistical units and coverage (Beresewicz and Pater, 2021). In some cases, the quality of analysis based on job vacancy surveys is questionable due to low response rates from companies or low reliability of information reported back to statistical offices (Beresewicz, et al., 2023). The variation in methodologies used by countries also constrains the potential of using vacancy surveys for comparative analysis; for example, in some countries small companies or certain sectors are out of survey scope. Therefore, job vacancy statistics derived from online job advertisements [3] or based on a combination of the two sources (e.g. supplementing online job advertisement data with vacancy survey data for sectors with low coverage in OJAs) may provide better information on unmet EU labour demand than relying solely on vacancy surveys.

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[2] For more information: Cedefop project: *Skills in online job advertisements,* or European Commission: *Trusted smart statistics: web intelligence hub.*

[3] The job vacancy rate measures the proportion of total job advertisements that are online at the last day of each referenced quarter divided by the sum of the number of job advertisements and occupied posts in the respective sector.

Figure 3. **Job vacancy rates in selected sectors (Q1 2020 – Q3 2022) (⁴)**
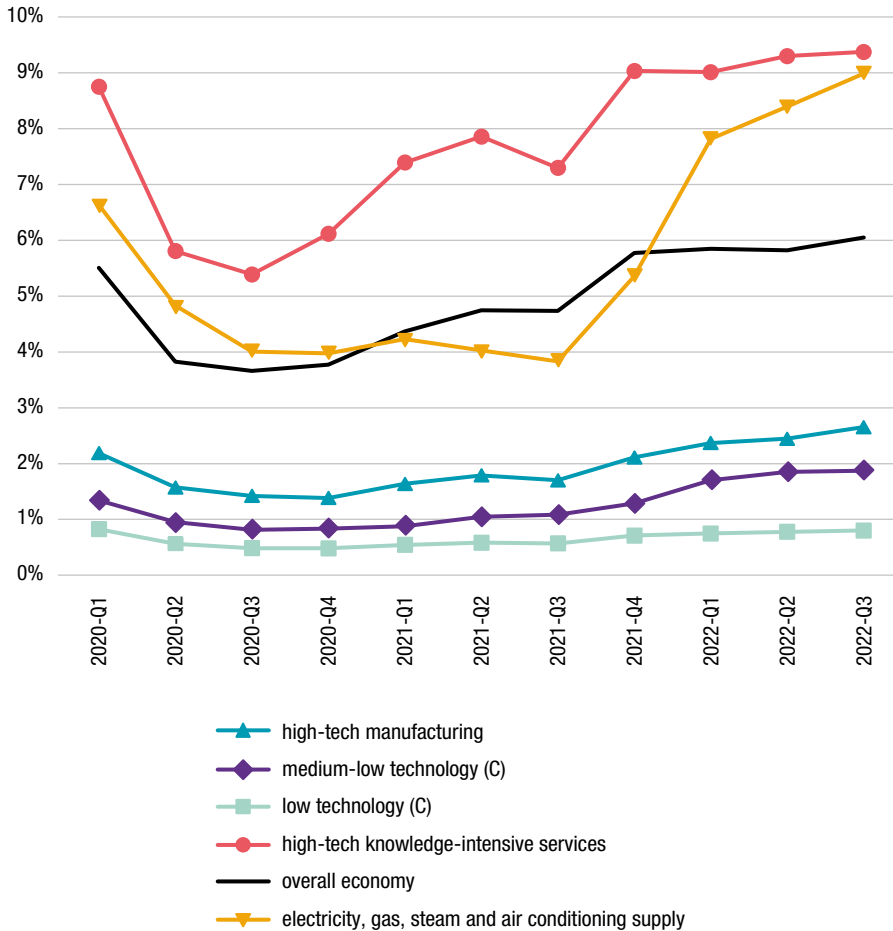
NB: For better visualisation, sectors that followed the same trends as the overall economy are not included.
Source: WIH-OJA data, Eurostat LFS LFSQ_EISN2.

(⁴) High-tech manufacturing includes the 'high-technology' (Manufacture of basic pharmaceutical products and pharmaceutical preparations, and Manufacture of computer, electronic and optical products) and 'medium-high technology sectors' (Manufacture of chemicals and chemical products; Manufacture of electrical equipment; Manufacture of machinery and equipment not elsewhere classified; Manufacture of motor vehicles, trailers, and semi-trailers; Manufacture of other transport equipment). High-tech knowledge-intensive services include: Motion picture, video and television programme production, sound recording, and music publishing activities; Programming and broadcasting activities; Telecommunications; Computer programming, consultancy, and related activities; Information service activities; and Scientific research and development.

It is important to understand the underlying causes of the increase in vacancy rates and the potential impact on the EU economy, as this may suggest structural or aggravating mismatches between jobseeker skills and employer requirements. The required level of skills requested matters to vacancy rates: these were higher for high and low-skilled workers than the average rate for all skill groups combined (Figure 4). This strongly suggests potential shortages for low- and high-skilled workers (Chapter 6).

Figure 4. **Job vacancy rates by skill level requested (Q1 2020 – Q4 2022)**
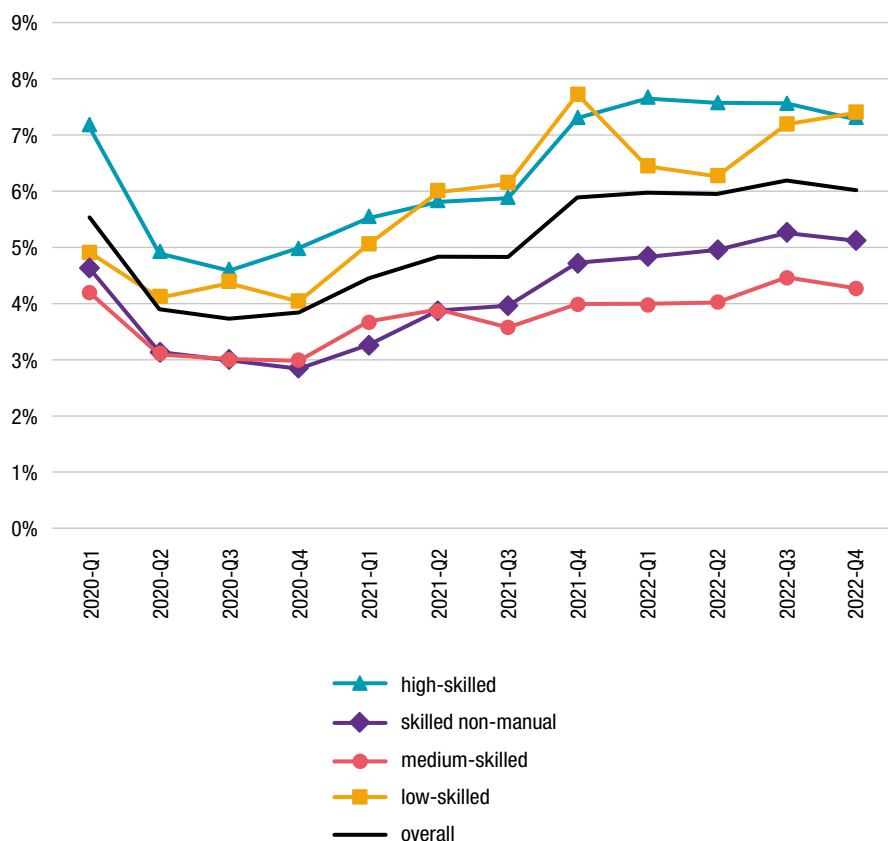
NB: Skill level is defined based on ISCO codes as follows: high-skilled non-manual (ISCO 1 and 2), skilled non-manual occupations (ISCO 4 and 5), skilled manual occupations (ISCO 6, 7 and 8), and elementary occupations (ISCO 9).
Source: WIH-OJA data, Eurostat LFS LFSQ_EGAIS.

1.2. Tighter labour market, especially for the high-skilled

Labour market tightness refers to the degree to which demand for labour exceeds the available supply (Box 2). While tightness in the EU labour market has been trending upwards after the Covid-19 pandemic, the tightness indicator is still below one, which suggests that – on average and seen from the perspective of the EU labour market as a whole – there are more people looking for employment than job openings.

Box 2. **Measuring labour market tightness**

A tight labour market is defined as one 'in which demand for labour is at least as strong as supply' (Eurofound, 2020). One of the ways to measure labour market tightness is to calculate the ratio of the number of vacancies offered by firms seeking to fill open positions relative to the number of would-be workers looking for jobs, proxied by the number of unemployed actively searching for work. A tightness ratio above one indicates that the economy is close to full employment and employers need to compete for workers. A ratio below one indicates that there are more people searching for employment than possible job openings.

This average measure of tightness, however, obscures what is the reality in labour market segments, with tensions between workers' qualifications, skills and other characteristics and the profiles employers are looking for. Tightness measures that consider the required level of education show where labour market mismatch is on the rise. After the pandemic, the labour market for workers with tertiary education became much tighter; at the higher end of the labour market, tightness increased faster than overall labour market tightness (Figure 5).

Figure 5. **Trends in labour market tightness in the EU-27
(Q1 2019 = 100)**
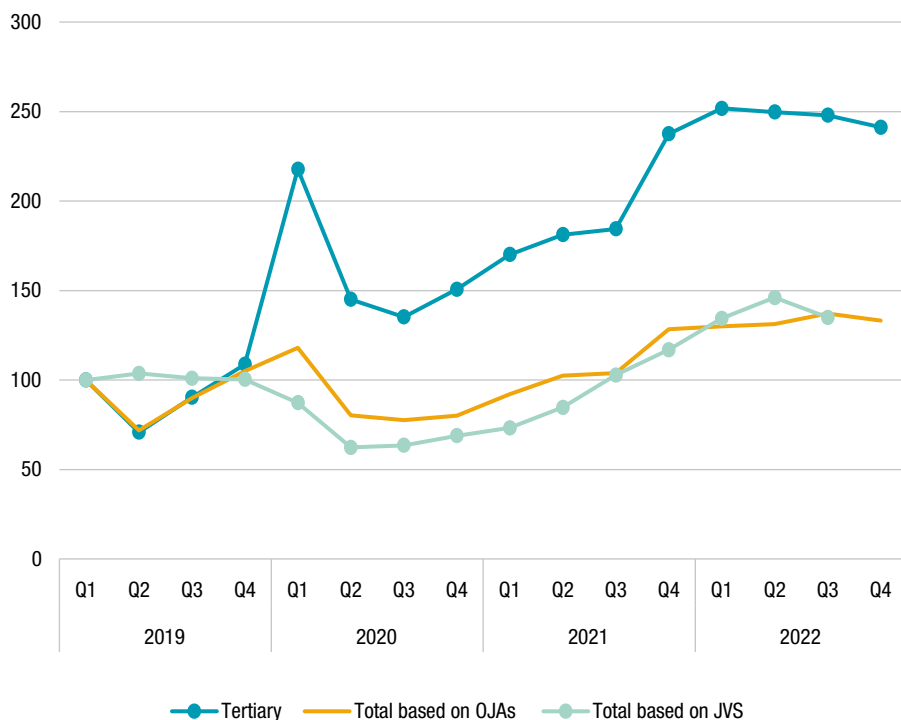
NB: Calculation of tightness based on JVS data does not include information from DK, FR and IT. Vacancies
    requiring tertiary education were derived based on occupation group, including ISCO groups 1,2 and 3. The
    tightness for 2022 was calculated based on values for unemployment for year 2021.
Source: Cedefop calculations based on EU-LFS, JVS and WIH-OJA database.

Analysis of tightness in regional labour markets in the EU in the last quarter of 2022 suggests employers faced challenges to recruit workers in most regions in Belgium, Germany, France and the Netherlands and in some Italian, Polish and Swedish regions (Figure 6). In some regions where the overall labour market tightness indicator was below one (e.g. in Italy, Poland, Romania and Sweden), demand for highly skilled workers exceeded supply of available unemployed people with tertiary education.

Figure 6. **Overall labour market tightness (left) and tightness for
tertiary educated workers (right) in EU regions (Q4 2022)**

10.00
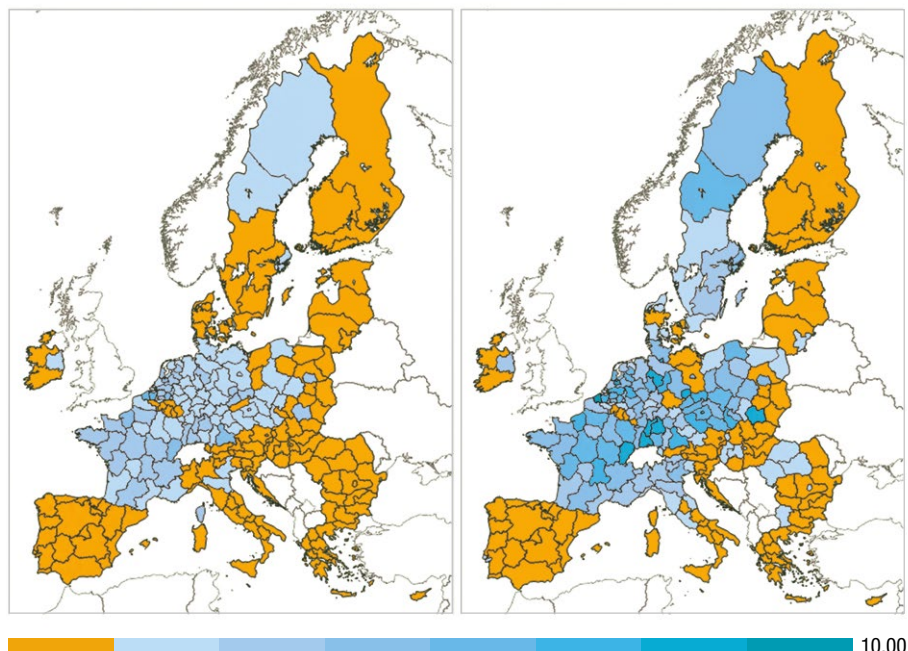
NB: The tightness for Q4 2022 was calculated based on the values of regional numbers of unemployed for 2021.
Scale from 0-10, with values below 1 marked in orange.
The granularity of online job advertisement data allows for analysis at more disaggregated levels, but the information about characteristics of unemployed people is not sufficient for comparative analysis. At this moment only census data could allow for more in-depth analysis of mismatches by type of education in the EU-27.
Source: Own calculations based on LFS and WIH-OJA database.

In STEM and IT occupations labour market tightness is quite pressing in several countries. At the end of 2021, in the Netherlands there were more than seven vacancies for a high-skilled STEM job for every highly educated unemployed person. Also in Belgium, Germany, France, Italy, Ireland, Luxembourg and Sweden there were more vacancies for STEM jobs than unemployed people with a STEM background. The comparison of vacancies for IT occupations and unemployed people with an IT degree confirms that finding staff for such occupations is particularly difficult. Czechia, with 25 IT vacancies for every unemployed person with an IT background is a case in point (Figure 7). Labour market tightness for IT occupations, which can often be performed remotely using English as a working language, can be addressed

by recruiting workers abroad. For example, IT workers from Greece, Spain, Croatia, Slovenia and Finland, where demand for their skills and qualification is lower than the numbers of unemployed with an IT profile, can telework for employers located in countries with higher demand for such profiles.

Figure 7. **Labour market tightness for IT and STEM occupations in EU countries, 2021**
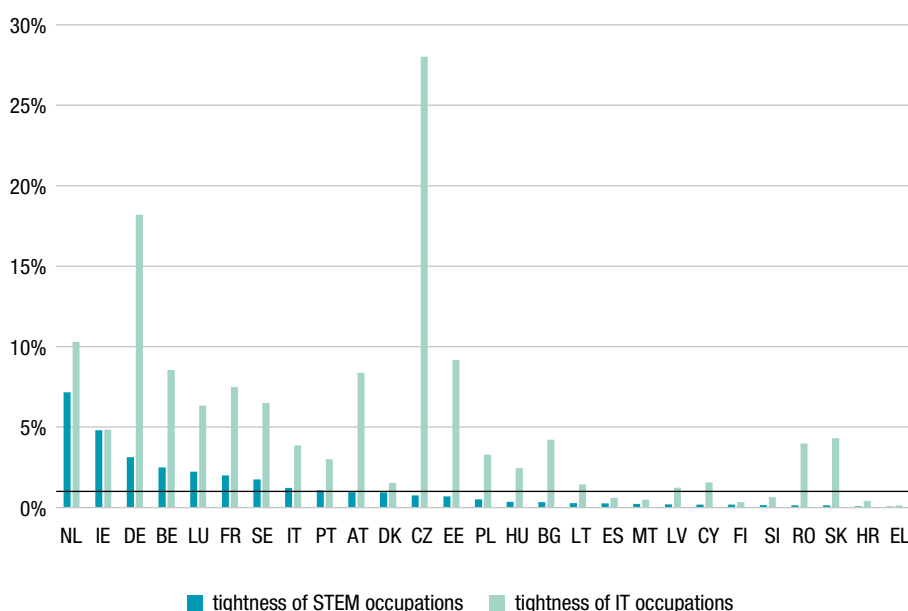
NB: Q4 2021 stock data and stem unemployed identified based on Hatfield variable.
Source: WIH-OJA database, EU-LFS.

1.3. Summing up

The available evidence on job market trends and labour market tightness reflects a complex interplay of economic and sectoral and occupational employment developments since the economic crisis. As most data, evidence and research show, the joint impact of shocks and progressing megatrends makes it challenging to disentangle permanent and temporary change. In the immediate aftermath of COVID-19, the demand for labour and skills was buoyant, as the economy bounced back from the lockdowns and pent-up

demand drove growth in many sectors. But the pandemic also changed economies and labour markets more fundamentally: digitalisation accelerated and much of its impact on the worlds of work, learning and business is likely to become permanent.

At the end of 2022, stronger signs emerged that the EU economy is slowing, because of soaring energy prices and cost-of-living increases following the Russian invasion of Ukraine. These trends have had, and will likely continue to have, an impact on employment, particularly in energy-intensive sectors. Again, while some of the impact of soaring energy prices may be temporary and not as adverse as initially feared, the energy-crisis is also likely to have lasting effects. The crisis can become a catalyst for faster green transition, and the process of moving towards energy independence that it set in motion will not be without longer-term economic and labour market impacts.

Tracking, and correctly interpreting trends in sectors and occupations, and developing an understanding about what changes are permanent or temporary, is vital for well-functioning VET systems and skills formation and matching more broadly. Next generation skills intelligence incorporates capacity, tools, and methods that help distinguish long-term trends from short-term interruptions. Where such skills intelligence is not available, labour market signals can easily be misinterpreted or misjudged in terms of magnitude. Sending the wrong signals to VET and skills policy-makers and providers can result in increasing skill mismatch; this has a proven cost for societies, companies and citizens (Cedefop, 2010).

In the immediate post-pandemic period, labour shortages rather than surpluses dominate policy discussions. This report builds on all Cedefop skills intelligence to identify future employment and skill trends up to 2035. More specifically, Chapter 2 sets the scene for future EU labour markets, building on the 2023 Cedefop skills forecast results; it also discusses the direction and intensity of change in sectors, occupations and qualification levels. Chapter 3 elaborates on Cedefop's work on skills and jobs for the green transition and reflects on expected developments and their implications for VET. An analysis of the impact of the digital transition, and particularly the identified and expected developments in digital skill demand, is presented in Chapter 4. Acknowledging the importance of high-tech sectors and services for the EU's ability to innovate and compete globally, Chapter 5 offers evidence that can be leveraged to strengthen high-tech sectors and occupations. Chapter 6 uses next generation skills intelligence to reflect on labour and skills shortages and what drives them. Chapter 7 concludes with the key take-aways for policy.

CHAPTER 2

Future outlook: the road to 2035

In a dynamic, fluid and competitive global environment, where the only constant is change itself, EU, national, regional, and sectoral policies need to respond in a timely manner to emerging and future labour market and skill needs. In labour markets where supply is constrained by the ever more visible demographic challenge, policy-makers must react to change, but also anticipate it and innovate to shape a more digital and greener future. Skills intelligence, based on sound anticipation methods, helps them do just that. With labour market change accelerating, the value of skills intelligence as a strategic tool for understanding trends in sectors and occupations is increasingly appreciated. The insights it provides into future labour market demand, skills trends, and labour market imbalances and pressures do not only serve economic purposes. Such information is also increasingly relevant for social policy and its Implementation. It is obvious that Europe cannot achieve a just twin transition without doing more to support the employability and the sustainable labour market inclusion of the low-skilled and other vulnerable groups.

This chapter presents a skills intelligence-driven and forward-looking perspective to labour market change. It uses the 2023 edition of Cedefop's skills forecast ([5]) to explore and interpret trends in the EU labour market up to 2035. Showing the direction and extent of change in sectors, occupations, jobs and skills, the information in this chapter gives broad insights that support the EU policy agenda for VET and skills and its implementation.

2.1. Employment outlook

In the first months of 2023, the future looked uncertain because it is difficult to assess how and to what extent geopolitical and macroeconomic developments will affect the EU economy. As in all previous Cedefop skills forecasts,

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([5]) Cedefop, Skills forecast. Provides detailed results for all EU Member States, Norway, Iceland, Switzerland, North Macedonia and Türkiye.

expert-validated assumptions were made to establish a 'best-estimate' baseline (Box 3).

While it is unlikely that the COVID-19 pandemic will cause further major disruption, with a forecast average rate of just above 1% per annum, economic growth in the EU economy is expected to remain modest ([6]). Recession remains a real possibility because of high inflation, the energy crisis, and critical bottlenecks in commodity markets and value chains.

Thanks to the 2022 economic rebound from the severe shock caused by the COVID-19 pandemic, the EU economy will continue growing moderately in terms of employment in 2023. In 2024, employment growth is expected to slow, but average annual employment growth in the years up to 2035 should remain positive.

Box 3. **2023 Cedefop skills forecast assumptions**

The 2023 skills forecast baseline scenario assumes that geopolitical tensions remain high and related sanctions against Russia, because of the war in Ukraine, remain in place in 2023. The baseline scenario assumes that the cumulative net inflow of Ukrainians to the EU will reach 6 million and stabilise at that level ([7]). The assumptions to reflect the implementation of the European Green Deal include higher use of renewable energy, energy efficiency and carbon prices ([8]).

Source: 2023 Skills forecast technical report.

Even though COVID-19, with its social distancing and economic restrictions, negatively affected employment in 2020, the employment impact was not as severe as the effects on economic activity and working hours, because unprecedented government support and short-time work schemes were quickly made available in many European countries. The employment impact of COVID-19 was, therefore, not as dramatic as earlier skill forecast estimates suggested (figure 8, red line). The economic impact of the current uncertainties, however, puts a brake on employment. Estimated employment in 2030, according to Cedefop's 2023 skills forecast, is one million (jobs) lower compared to the 2020 forecast. The implementation of the EGD (green line) may partly offset the negative employment impact of geopolitical tensions

[6]   Cedefop. 2023 skills forecast.
[7]   No assumptions are made about the number of people fleeing Ukraine beyond 2023.
[8]   See the Technical report for the full set of assumptions adopted in the 2023 Skills forecast.

because greening is a driver of employment growth. Forecast employment in 2030 is highest when the EGD is fully implemented ([9]).

If food prices continue to be high, and/or – as in 2022 – energy prices increase again, the resulting economic slowdown will negatively impact employment ([10]). Dependence on fossil fuels makes consumers vulnerable to high energy prices. Lower purchasing power means less consumer expenditure, and this will have a negative impact on employment. All sectors are vulnerable to high prices, as they all lose jobs because of them, compared to the baseline. Agriculture, basic manufacturing, and distribution and retail would lose out most in terms of employment, because of lower demand from consumers. Extraction industries are also expected to be impacted, particularly in the short term, but the jobs impact of high energy prices is likely to be smaller because employment in the sector is already declining as EGD-driven policies are being implemented.

Figure 8. **Employment levels in Cedefop skills forecast scenarios (millions), EU-27**
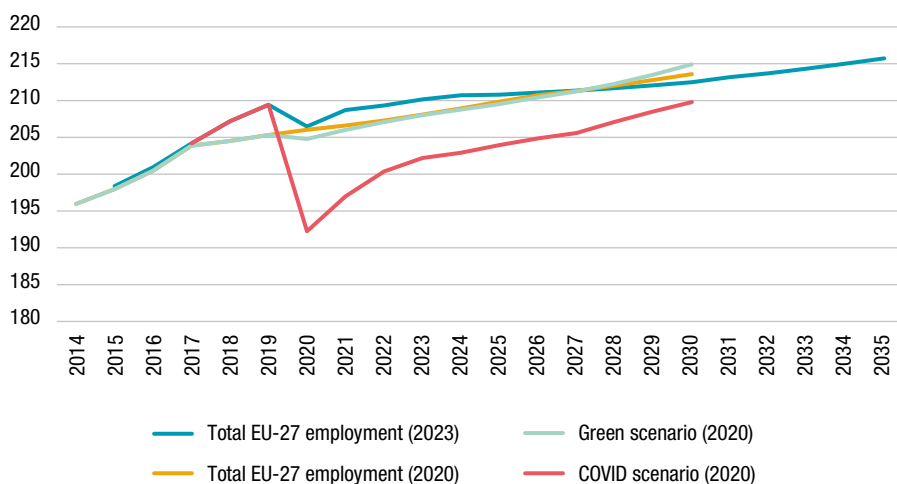
Source: Various Cedefop skills forecast scenarios. 2023 release (blue line). 2020 skills forecast (orange line) completed just before the pandemic; COVID scenario (Cedefop, 2021a) (red) and Green Deal scenario (Cedefop, 2021b) (green).

([9]) Elaborated in 2020, Cedefop Green Deal scenario does not consider impacts of COVID, the war in Ukraine or the energy crisis.

([10]) This is based on sensitivity analysis (of Cedefop's skills forecast 2023 baseline) utilising updated energy prices from the World Bank Commodity Markets Outlook for October 2022 (compared to April 2022 in the baseline).

2.2. Twin transition driving labour market change

On the road to 2035, the transition to a more knowledge- and skills-intensive EU economy coincides with further expansion of service sectors. These trends will suppress employment in agriculture, which is expected to shrink further in the longer term (Figure 9). The substantial forecast employment decline may not completely materialise, because Cedefop's skills forecast methodology may not capture the full complexity of the Farm to Fork Strategy, one of the flagship EGD initiatives. This strategy may boost employment in agriculture because of the shift in protein production (from animal-based to plant-based sources) which is central to the emerging production and consumption paradigm it stands for (Cedefop, 2023a).

The twin digital and green transition shapes employment trends in the years up to 2035. Employment losses are likely in primary industries (particularly coal, oil and gas), because demand for their products will decline as other sectors and countries take action to implement the EGD and reach its emission reduction targets. The lion's share of the employment decline in these sectors will materialise in the coming years, because of the EU's 55% CO_2 emission reduction target (compared to 1990) set for 2030. There is some uncertainty about short-term employment trends, with energy security and independence having become a key challenge and ambition in many Member States since the war in Ukraine started.

Targeted initiatives to secure supply chain resilience and action to anticipate possible future disruption have helped the EU emphasise the importance of local sourcing for vital industries such as semiconductors, rare earth metals, and medical supplies. This may boost employment in manufacturing. The European Chips Act announced early 2023 promises investments in Europe to increase its global capacity share from 9% to 20%. The Critical Raw Materials Act facilitates the roll-out of raw materials projects in the EU and a new EU regulation to help establish a complete value chain for battery production in the EU (European Commission, 2022). The EU Sovereignty Fund will involve measures to transfer critical industry production back to the EU and strengthen resilience, with direct implications for employment and skill demand in the most targeted sectors.

Figure 9. **Employment growth by broad industry (% pa), EU-27**

Legend: ■ 2015-20 ■ 2020-22 ■ 2022-30 ■ 2030-35
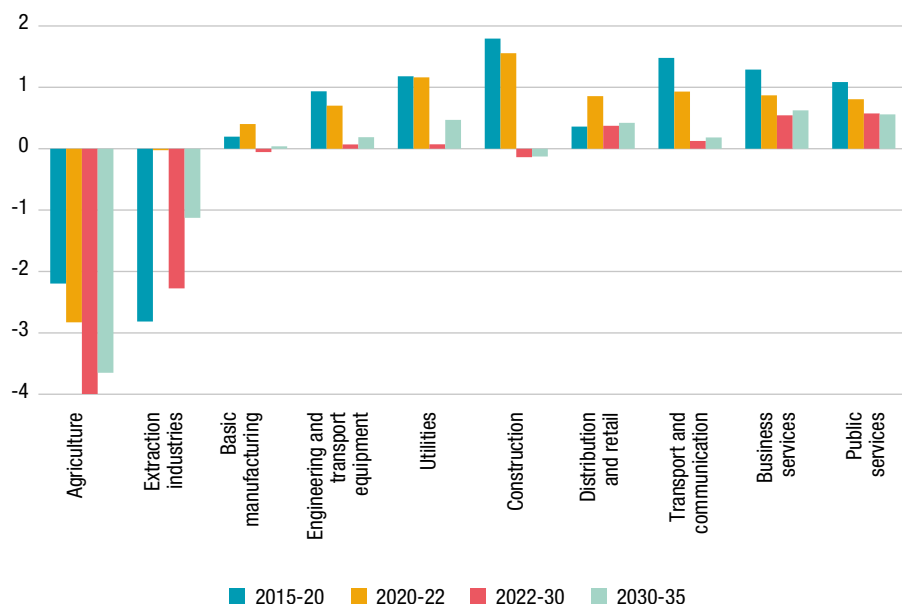
Source: Cedefop skills forecast 2023.

2.3. More skills-intensive employment dominates labour market trends

For several decades, the EU and many Member States and regions have sought to expand the knowledge base in their economies. Moving towards knowledge-based economies means leveraging human capital, information, and high skill levels to strengthen economic performance. Although it is not new, the knowledge economy concept remains relevant, because it captures the progressively skill and knowledge-intensive character of economic activities, supported by learning opportunities and an ICT infrastructure that aids information sharing (Lundvall, 2016; Bonoli and Emmnegger, 2022). Highly skilled and specialised employment, often linked to ICT and high productivity service sectors, powers knowledge economies. Nevertheless, spill-over effects impacting related sectors and other labour market segments also need to be considered, because of their effect on upskilling needs (Lundvall and Lorenz, 2012).

The shift towards services and emerging and future skill needs linked to the twin transition expand high-skilled employment in the years up to 2035. The long-standing job polarisation trend in EU labour markets is giving way to jobs upgrading. With most forecast job openings requiring a high-level qualification, the demand at the higher end of the labour market is expected to grow fast. Openings for jobs requiring a low or medium qualification level reflect replacement demand, as employment at these qualification levels is declining. Shrinking employment in many medium- and low-skill occupations is expected in most EU Member States, except for some customer service occupations. Employment in elementary occupations is expected to increase, albeit marginally.

Jobs upgrading is mirrored in the educational composition of the future labour force (Figure 10). With the numbers of the highly skilled labour force rapidly expanding, the group of medium-qualified remaining relatively stable, and the low-skilled labour force declining, skills upgrading is clearly visible.

Figure 10. **Skills upgrading in the EU labour force (millions), 2015-35**
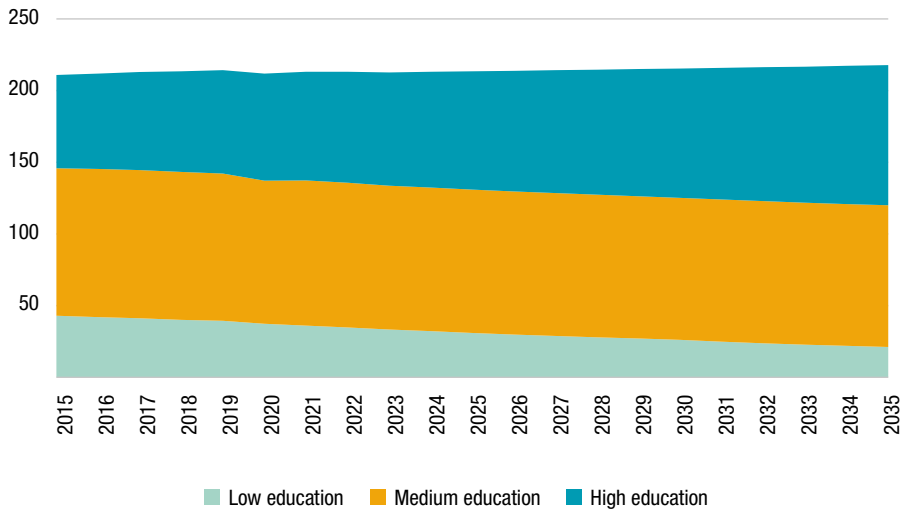
Source: 2023 Cedefop skills forecast.

In the period up to 2035, employment in almost all occupations in EU-27 is expected to either increase or remain stable. Only employment for skilled agricultural and fishery workers is expected to decline (Figure 11).

The lion's share of job opportunities emerging up to 2035 will be for highly

skilled occupations, which jointly amount to about 56% of total job openings (the combination of new/lost jobs and replacement needs). 26% of job openings are for professionals; technicians and associate professionals and service workers will also be in high demand. Job openings are highest for high-skilled non-manual occupations such as business and administration professionals, legal, social and cultural professionals and science and engineering professionals. Many will likely be triggered by the implementation of the European Green Deal: developing 'greentech' requires a technical and/or engineering profile; dealing with new regulation boosts demand for roles with legal background; and managing the green transition will require organisations to employ people that can act as greening promoters and ambassadors ([11]).

Figure 11. **Job openings by broad occupational group (millions), 2021-35**
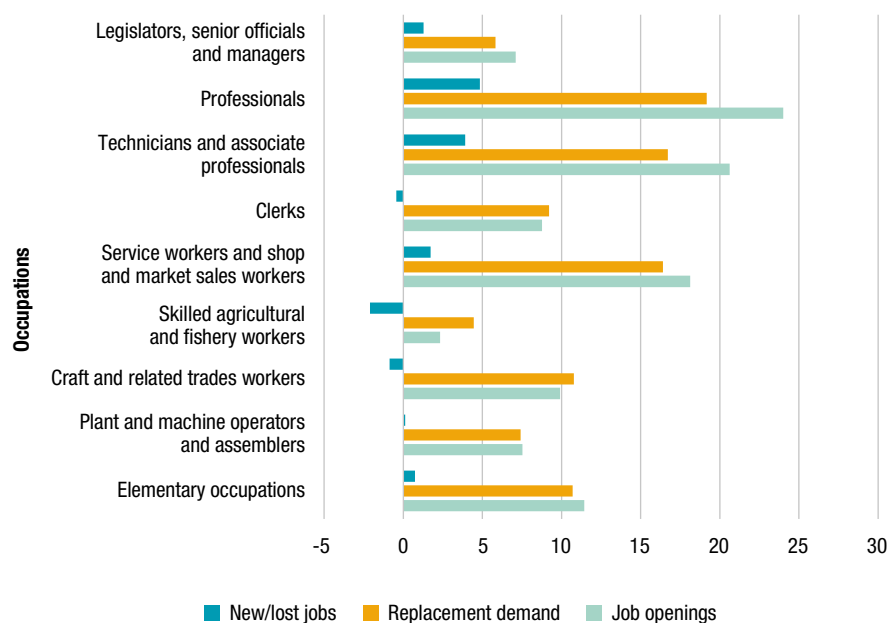
Source: Cedefop 2023 skills forecast.

([11]) For more information on job roles important for the green transition, see Cedefop, 2022, 2023a, 2023b, 2023c.

Services, retail and related sectors will provide many job openings for skilled and semi-skilled non-manual occupations, such as personal service workers and sales workers. Most occupations with expected employment decline are manual ones, often in manufacturing. These include skilled metal, machinery and related trades workers and less skilled workers such as plant and machine operators and assemblers. Significant job losses are also projected for less skilled non-manual occupations such as numerical and material recording clerks.

Increased specialisation, upgrading of existing tasks and a more demanding work environment benefit employment levels for high-skilled workers in professional and associate professional occupations. Other occupations, such as clerks, service workers and shop and market sales workers, craft and related trades workers, and skilled agricultural and fishery workers, lose market share because part of their skills become less relevant and can be incorporated in the tasks of higher skilled workers. To a lesser extent, high-skilled occupations such as legislators, senior officials and managers may also be affected by such shifts as some of their current tasks become less labour-intensive and are taken over by cutting edge technology.

In 2021-35, employment growth will be concentrated in occupations belonging to the categories of legislators, senior officials and managers, professionals, and technicians and associate professionals. Among those, professional occupations will likely experience the most rapid growth: science and engineering, business and administration, information and communication and legal, social and cultural professionals will increase, because they play major roles in designing and implementing technological and process innovation, and in reflecting regulatory change driven by the green transition and other trends into new ways of working and producing goods and services.

In around half of the EU Member States, employment in occupations that can be characterised as elementary is expected to grow, although the relative change in some occupations is small. Occupations categorised as clerks are expected to see employment decline in most Member States, likely as a result of task automation.

2.4. Expanding labour market participation of an ageing labour force

After having grown slightly (+3%) in the 15 years leading up to 2020, the EU-27 population is forecast ([12]) to remain constant between 2021 and 2035. At the same time, the composition of the population changes as ageing progresses. Between 2005 and 2020, the total number of children (18 years of age or below) had already fallen by 3% and a further decline of 10% is projected for 2020-35. The population over 65 grew by 27% between 2005 and 2020 and is expected to grow further by 26% in the following 15 years. In 2035, the population share of people over 65 will reach 26%, up from 17% in 2005. The mass of the working population slowly moves upwards in the age distribution, and only the age cohort of people over 60 is expected to grow between 2020 and 2035.

The importance of health occupations was accentuated during the COVID-19 pandemic. With an aging population, employment for health professionals will grow rapidly in the coming years in almost all Member States ([13]). The demographic challenge amplifies the demand for health professionals, personal service workers and personal care workers. Employment in these occupations will increase in more than half of the Member States ([14]).

As a result of demographic trends, the core or prime-aged workforce, (mainly those aged between 20 and 50) will eventually shrink by 2035 while the older workforce (60+) will grow. Activity rates ([15]) will increase by 2035 thanks to policies aimed at extending working life and promoting labour market integration and participation of particular groups. For example, female participation rates have consistently increased in recent decades, echoing societal trends (European Commission, 2021). The male participation rate will decline slightly over time, mainly because ageing increases the share of older workers in the male workforce. As older male workers have lower participation rates than younger male age cohorts, this trend pushes down the average male participation rate.

On the lower side of the age distribution, educational expansion is a factor driving down participation. On average, people with higher levels of edu-

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([12]) The baseline population projections (see Eurostat, 2020a) assume a convergence between Member States' socioeconomic composition, i.e. fertility and mortality converge to that of the best-performing Member States.

([13]) 2023 Cedefop skills forecast results.

([14]) 2023 Cedefop skills forecast results.

([15]) Eurostat definition of activity rate: 'The percentage of active persons in relation to the comparable total population' (Eurostat, 2020b).

cational attainment have higher participation rates, but more young people spending time in education programmes lowers their labour market participation because it delays labour market entry. There is room to increase the activity rates of particular groups: medium-skilled people, in particular females, have significantly lower participation rates than those with higher level qualifications. Targeted participation policies and activation measures aimed at labour market integration and providing the support this requires can partly offset the negative impacts of ageing. At the same time, groups with low or medium-level qualifications can be up- or reskilled, to expand the pool of skills and their participation rates, avoid future imbalances expected at the middle level, and counteract the trend of medium skilled jobs being filled by higher educated people. Forward-looking labour market activation policies can contribute substantially to easing imbalances by focusing on medium- and low- educated women aged 25-54, older people of working age (particularly women) and, to a lesser extent, young people (European Commission, 2021).

2.5. Most job openings are replacement demand-driven

For several decades a significant part of the demand for skills in Europe has represented replacement needs, which emerge because people leave the labour market to retire or for another reason or because they transition between jobs ([16]). The growing share of replacement demand in job openings mirrors the ageing population and workforce, which is viewed as an acute challenge in several Member States. Towards 2035, replacement demand is expected to provide the bulk of job opening ([17]) across sectors (Figure 12). Job openings are also positive in agriculture and mining and quarrying – sectors where employment is expected to shrink – because replacement demand more than compensates for the forecast employment decline in these sectors.

([16]) Replacement demand arises when workers leave their job, temporarily or permanently. The main cause of permanent separations is retirement, but there are also other causes: emigration, sickness and, especially for women, family formation. Movements of workers from one occupation to another also create replacement demand, because they create vacancies for the jobs workers leave. More details on replacement demand can be found in Cedefop, Eurofound (2018). *Skills forecast: trends and challenges to 2030*. The methodology is explained in Cedefop, 2012.

([17]) The number of job openings indicates the number of jobs that are required to be filled due to lost/newly created jobs and those that need replacement workers.

Figure 12. **Replacement demand versus employment change in selected sectors, 2021-35, EU-27**

Legend: Replacement demand 2021-35 ■ Employment change 2021-35
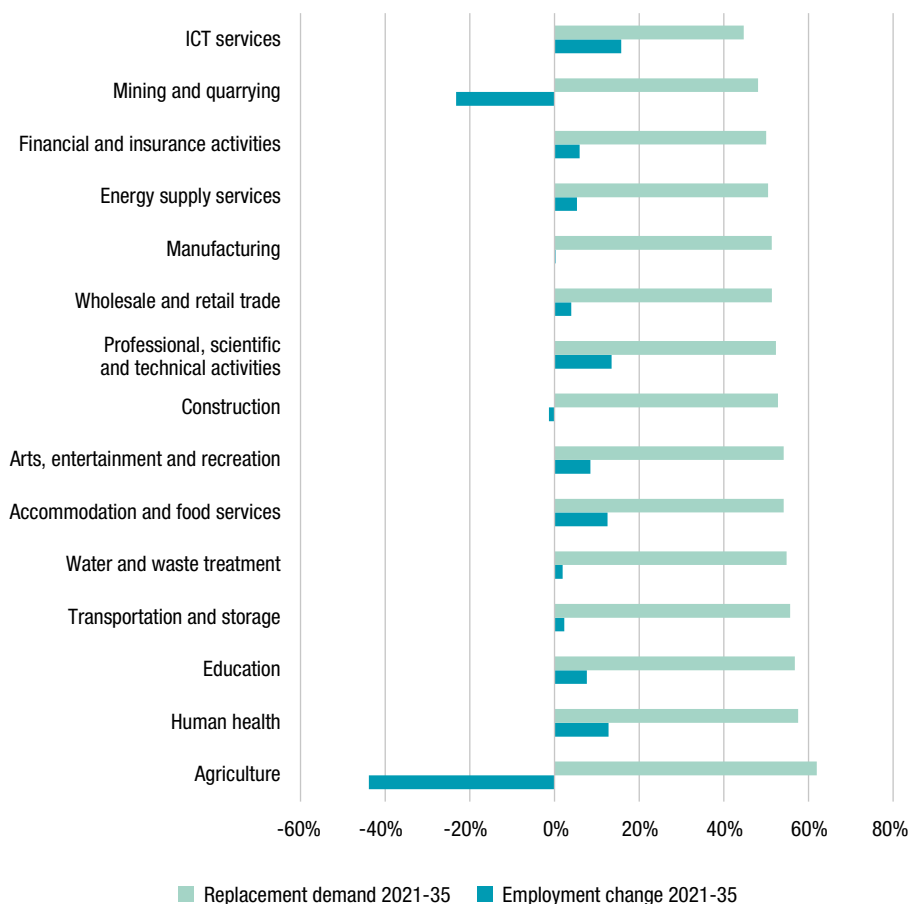
Source: Cedefop 2023 skills forecast.

As replacement demand does not only reflect vacancies emerging because ageing employees leave the labour market, measures aimed at meeting it should also consider other reasons driving it. For example, the green transition is expected to become a driver of occupational, and in some cases sectoral, transitions for energy workers (Cedefop, 2021). Regional and sectoral-level analysis of current and expected shifts of that sort will help shape targeted policy implementation approaches, which go beyond training provision.

Going stronger, going green(er): skills for EU's green growth strategy

With the agreement on the European Green Deal (EGD), the EU has put sustainability at the heart of its growth strategy. Implementing the EGD and the strategies it brings together (e.g. the Renovation Wave, the Farm to Fork strategy) calls for fair, cost-effective and competitive transformational change in all sectors of the EU economy. Interdependencies between sectors are accentuated to maximise progress towards green objectives. A clear example is the link between more sustainable transport and renewable energy production: electric vehicles are only 'green' when the electricity fuelling them is generated by renewable energy sources and not fossil fuels.

A dedicated EGD skills forecast scenario undertaken in 2020 (Cedefop, 2021) already showed that fully implementing the EGD will have significant employment benefits. Depending upon the extent to which organisations introduce new production technologies, develop new products and services, and restructure how work is undertaken in response to climate change, there could be substantial implications for the skill content of jobs. This might take the form of existing jobs being reconfigured (where the combination of existing skills changes), the emergence of new skills to be incorporated within existing jobs or leading to the creation of, as yet, unspecified new jobs.

3.1. Key Green Deal industrial plan sectors drive employment trends

The 2023 Cedefop skills forecast was released as the Green Deal industrial plan took shape. Although there are employment effects of the EGD in all sectors, the impact on most of the sectors the industrial plan designates as more relevant to green transition will be more pronounced. Such sectors (electricity, steam gas and air-conditioning, manufacturing, construction,

transport, and waste management), are already strongly impacted by EGD strategies and regulation.

In, for example, electronics, electrical equipment, and machinery equipment manufacturing, this comes from the growing demand for efficient appliances and equipment for renewable technologies (e.g. wind turbines). For motor vehicles the picture is mixed: the switch to electric vehicles (eVs) implies that part of manufacturing would switch to other sectors (e.g. combustion engines are manufactured in the motor vehicles sector, while the electrical equipment sector produces batteries). Employment in transport will also benefit from local level initiatives, as the smart green city model turns mainstream and becomes a platform for implementing new mobility paradigms (see Cedefop, 2022a).

Electricity supply is expected to see employment increase, because operating and maintaining renewable energy technology is more labour-intensive and demand for electricity will increase as more producers electrify their processes. Employment in construction, the sector driving the Renovation Wave, is expected to decrease by around 1% between 2021 and 2035, but retirement and other reasons for people leaving construction jobs will lead to at least 7 million job openings. Strongly impacted by the move towards circularity in sectors such as construction and manufacturing, waste management is expected to attract workers of all skill-levels: these will be mostly refuse and other elementary workers, but also drivers and mobile plant operators and science and engineering associate professionals.

Sectors in the supply chain of the core EGD sectors, such as architectural and engineering services and R&D, are also likely to see employment boosts. Over the period 2021-35, all EU Member States except Luxembourg will see strong employment growth in R&D, highlighting Europe's crucial role in the sector. The development of new technologies critical to achieving increased energy efficiency explains why R&D employment is booming. EU policy and support measures provide strong incentives for industries to contribute to the 2030 and 2050 targets by innovating and boosting demand. As in the R&D sector, employment in architectural and engineering services will grow in most Member States.

In most of these sectors employment will trend towards higher qualifications: for example, in manufacturing, more high-qualified workers are expected in 2035 compared to 2015, while employment at medium-level qualifications levels will remain the same and employment for low-qualified workers is expected to shrink. Across these sectors, high qualifications do not always mean employment as a professional. In some cases, such qualifications end up in jobs as technicians and even elementary occupations. Construction is a

notable example, where crafts and related trades workers, the most populous occupation in the sector, is expected to need more highly qualified workers in 2035 compared to two decades ago.

The employment impact of the EGD on 'brown' sectors is also considerable. EGD implementation will suppress employment in primary industries (coal, oil, gas), with the largest decline to take place up to 2030, when the EU 55% emission reduction target is to be reached. Short-term uncertainty exists around the employment prospects in the extraction industries because energy security and independence has become a key concern in many Member States since the Ukraine war broke out. If energy prices increase again, sectoral and occupational impacts on employment are likely to be amplified in the short- and the medium-term, as energy crisis accelerates the shift to alternative energy sources. The rapid rise in energy prices seen in 2022 has already been a catalyst for the development of renewable energy across the EU.

Simultaneously, subsectors in mining and quarrying may be boosted by the green transition, because metals and rare earth materials are critical for producing wind turbines, solar panels, batteries, and electric vehicles. This will affect metal ore mining, which accounts for around 14% of employment in the sector and has been growing, by more than 20% between 2018-20 (Eurostat, 2023a). Employment in coke and refined petroleum and in the gas supply sectors will decline because of high energy prices (reducing demand) and electrification of production processes.

Rising energy prices following the invasion of Ukraine have interrupted the trend of decline in coal mining, as several EU countries (among them Germany, Greece, France, Italy, Italy, the Netherlands, and Austria) have either announced their plans to reopen coal powered electricity plants or have done so already. Although this has not yet translated into increases in coal production, it is expected that employment in coal mining will increase in the short-term, granted that there is enough supply of workers to meet demand. The energy crisis has also led to a renewed interest in nuclear power, although this is not a short-term solution as building new nuclear power stations typically takes at least 5 years (World Nuclear Association, 2022). Further efforts to diversify the EU's energy mix will require investment in infrastructure, such as pipelines and liquid natural gas terminals (European Council and Council of the EU, 2022 and European Parliament, 2023) to support new energy trade patterns in the medium term.

Box 4. **What are the skills for the green transition?**

'Skills for the green transition' include skills and competences, but also knowledge, abilities, values and attitudes needed to live, work and act in resource-efficient and sustainable economies and societies. These are:
- technical: required to adapt or implement standards, processes, services, products and technologies to protect ecosystems and biodiversity, and to reduce energy, materials and water consumption. Technical skills can be occupation-specific or cross- sectoral; and
- transversal: linked to sustainable thinking and acting, relevant to work (in all economic sectors and occupations) and life. They are alternatively referred to as 'sustainability competences', 'life skills', 'soft skills' or 'core skills'.

Source: Cedefop et al., 2022.

3.2. Green transition is also a skills transition

Apart from shifting employment towards sectors that drive greening and green jobs, the shift towards sustainable production and consumption will have impacts that affect all occupations and sectors and bring about changes in skill needs. Alongside technical skills linked to the green transition, transversal skills must also be reflected in education and training provision at all qualification levels. Vocational education and training (VET) will be crucial to providing skill sets that evolve flexibly and reflect the dynamic nature of the new green paradigm. Therefore, understanding the skill implications of greening for occupations and sectors is vital (Box 4).

Cedefop's EGD scenario (Cedefop, 2021) pointed towards significant additional employment growth for science and engineering (associate) professionals, business and administration professionals, chief executives, senior officials and legislators, administrative and commercial managers, and information and communications technology professionals in the years up to 2030. Among medium-skill occupations, the highest impact is expected for refuse workers, building and related trades workers, electrical and electronic trades workers and drivers. Cedefop's 2023 skills forecast, which looks at labour market developments until 2035, confirms most of these trends.

Although almost all occupational categories are expected to benefit from the implementation of the EGD, identifying the occupations that are most critical to the green transition can help in setting priorities for education and

training policies ([18]). Online job advertisements can be used to expand understanding of how 'green' different occupations are and of trends in greening. They have a clear advantage over other data sources, because they provide granular and up-to-date information on skills, which – using a suitable skills taxonomy – can be classified.

Analysis using Cedefop SkillsOVATE ([19]) shows that only a small share of occupations across sectors can be considered 'high-green intensive', which is defined as having a share of green transition skills of 6% or higher. Only in a few occupations (e.g. environmental protection professionals, forestry workers) do green transition skills add up to more than half those required. On average, the share of green transition skills in the skills profile required in ESCO occupations ([20]) is 5%. About 1 in 3 occupations (143 out of 426) does not require any green transition skills.

Occupations with high and medium green transition skills intensity accounted on average for 40% of the total stock of online job ads (14% and 26% respectively) posted between Q1 2020 and Q4 2022 (Figure 13). 17% required some green transition skills and 43% did not require any. There are no differences in growth in job ads between these groups, meaning that the stock of vacancies for occupations with different degrees of 'greenness' grew at the same pace.

([18]) The EU response to the energy crisis resulting from the war in Ukraine already affects policy decisions at national and regional levels and hence labour markets, particularly regarding investments and jobs in the energy sector and energy-intensive sectors.

([19]) Using the ESCO classification, which provides information about the relationship between occupations and skills and allows distinguishing between green transition skills and knowledge concepts necessary to perform the job, it is possible to group occupations by share of required green transition skills.

([20]) At 4-digit occupational level.

Figure 13. **Online job advertisements by greenness and required skill level (averages for Q1 2020 – Q4 2022)**
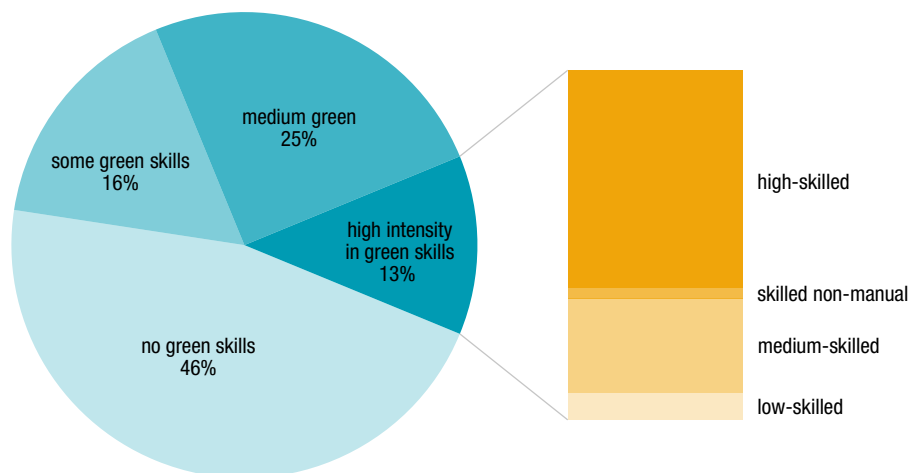
NB: Occupations were grouped into quartiles according to their level of green skills intensity. No green skills: the ratio between green skills and other required skills is below 1%; some green skills: the share of green skills is between 1%-2%; medium green skills: share of green skills between 2-6%; and high green intensive >6%.

Source: WIH-OJA database.

More than half of the online job ads for occupations with high green transition skills intensity posted between Q1 2020 and Q4 2022 required high-skilled workers. While this confirms the importance of such profiles for the green transition, the significant – albeit lower – share of medium-skilled workers shows they are also pivotal in driving change. Such workers are often responsible for implementing green transition technologies, processes and transversal greening measures.

Earlier Cedefop research confirms that demand for workers for high-skilled occupations, particularly in some sectors, is expected to grow, but the transition will not solely rely on them. Medium- and low-skilled occupations will benefit from EGD-driven employment gains. Examples include crafts and related trade workers (+1.7%), plant and machine operators and assemblers (+1.6%) and elementary occupations (+1.4%). Such workers will be engaged in new recycling factories, in waste management facilities, and in the construction of electric vehicle charging stations (Cedefop, 2021). The rapidly expanding waste management sector translates into employment increases for refuse workers in 3 out of 4 Member States.

3.3. Greening employment and 'greennovation' go together

Water and waste management, energy and construction gain most employment as a result of implementing the EGD (Cedefop, 2021). These sectors drive and absorb significant impact from action aimed at attaining the EGD goals. People with a technical profile, such as construction workers, but also managers (e.g. quality assurance and strategic waste managers; Cedefop, 2022c), who can use circular and inclusive ways of working to carry out new and changed tasks, are essential.

Alongside direct job creation, spill-over effects must also be considered. For example, construction is an important contributor to job creation – or destruction in case of crisis – in sectors like steel, glass, furniture, plastics, textiles, electrical equipment, and so on. In the US context, the multiplier effect has been estimated to be more than 2. Assuming that this multiplier is of the same order of magnitude in Europe, this would mean that at least 27 million additional jobs depend on the performance of construction sector (Bivens, 2019).

Apart from shifts in employment, veering towards a more sustainable EU economy also relies on technological innovation, particularly via digitalisation, automation, connectivity, and blockchain and artificial intelligence (AI). Cedefop's 2020 European Green Deal skills forecast scenario uncovered the intricate links between the digital and the green transitions. It forecast an employment boost in the computer programming sector, 86% of which concerns jobs for highly skilled workers (Cedefop, 2021).

Several occupations which typically require jobholders to have a technical or research-oriented qualification support green technology development, implementation, and infrastructure upscaling. Occupations, such as scientists, R&D researchers, specialised engineers and associate professionals supporting them do not have a large or rapidly expanding labour market share in the green economy. As they are nonetheless critical for making and shaping the green transition, Cedefop has coined such occupations (predominantly in R&D or engineering), as 'thyroid' (Cedefop, 2022c).

While many 'thyroid' occupations, such as alternative fuel engineers and researchers, require highly skilled workers, this is not always the case. Middle-skilled occupations with technical profiles, such as offshore renewable energy plant operators and biogas technicians, are equally essential. Some thyroid occupations are still being defined, as the implications of emerging technologies (e.g. hydrogen) for skills progressively find their way into pro-

fessional practice, and others may emerge.

The green transition is also a megatrend, with geographic and governance implications. Agriculture will change substantially as a result of implementing Farm to Fork and other EGD strategies. Governance at sub-national levels, which is where much of the change needs to take place, will become more important: regions, and especially cities, should become hubs of circularity to ensure that regulations and policy goals from overarching administrative levels are adopted and implemented. As a result, occupations such as urban space specialists, transport and mobility specialists, and citizen engagement specialists will be indispensable in helping European cities become smart(er) and green(er) (Cedefop, 2022b).

3.4. EU funding boosts to greening

Achieving the EGD goals will trigger large-scale green investment in the EU in the coming years. Although the main aim of Recovery and Resilience Facility (RRF) is to support resilience of EU Member States after the pandemic and mitigate the impact of global energy market disruptions caused by the war in Ukraine, sustainability and speeding up the transition towards climate neutrality by 2050 were important requirements to receive funding. Investment will have spill-over effects and promote economic growth and job creation beyond the sectors in which investments will be made.

Most expenditures planned by Member States classified as related to green transition relate to transportation and storage. Examples of financially supported projects include development of more sustainable local transportation, experimentation with hydrogen fuel for road transport, and developing electric charging stations for electronic vehicles (Darvas et al., 2023). The sector with the second highest RRF investment is electricity, gas, steam and air conditioning supply. Projects in this sector typically finance the replacement of oil and gas heating systems, the modernisation of heat distribution, and increasing the share of renewables in energy production. Construction (e.g. projects financing restoration of buildings, energy retrofitting of public buildings, public cycling infrastructure) ranks third in terms of planned investment.

Figure 14. **Investment in planned RRF green transition projects by sector (in bn EUR)**

Sector	Value
Transportation and storage	~74
Electricity, gas, steam and air conditioning supply	~52
Construction	~34
Agriculture, forestry and fishing	~11
Water supply; sewerage, waste management and remediation activities	~11
Public administration and defence; compulsory social security	~6
Manufacturing	~4
Professional, scientific and technical activities	~3
Arts, entertainment and recreation	~1
Real estate activities	~0
Financial and insurance activities	~0
Other service activities	~0
Mining and quarrying	~0
Administrative and support service activities	~0
Education	~0
Activities of extraterritorial organisations and bodies	~0

Source: Darvas et al., 2023.

EU Member State Recovery and Resilience Facility plans, which jointly represent an investment of 23 billion EUR in renewable energy sources (wind, solar, alternative fuels and others) has stimulated the demand for renewable energy professionals. The growth in the share of professional level online job ads seeking renewable energy professionals (which include hydropower engineer, biochemical engineer, renewable energy engineer, wind, solar, energy systems engineers and renewable energy consultants) exceeds the growth of the corresponding share for technicians, associate professionals, and craft and related trades workers (Figure 15).

Figure 15. **Growth in online job ads for renewable energy occupations by ISCO 1-digit level (Q1 2020 = 100)**
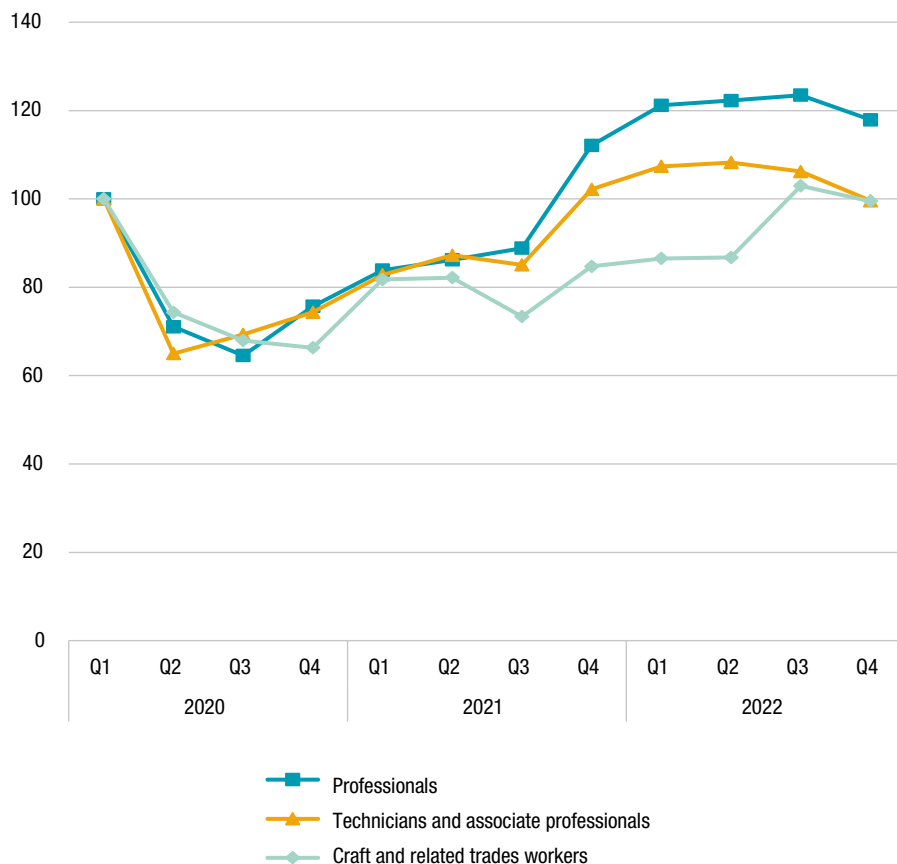
Source: WIH-OJA database.

3.5. Green transition skills implications beyond job-specific expertise

Education and training need to prioritise the development of technical job-specific skills for occupations critical for the green transition. Without such skills it is not possible to implement and mainstream the 'green' technologies and processes that are at the core of these occupations. But shifting to a new 'green' paradigm is more than just that. A wide range of technical, transversal

and soft skills in sectors driving the transition to greener societies (Table 1), and attitudes, behaviour and civic skills facilitate it.

Soft skills, such as communication and persuasion, are becoming more important in profiles across sectors and demonstrate the proliferation of service-oriented activities (for example, in waste management. Cedefop, 2022c). Such skills help communicate and educate producers and consumers about the merits of adopting green solutions or practices and contribute to establishing green visions or mindsets among the population, workers, and organisations. The digitalisation and 'greening' of processes also affects work organisation in sectors such as waste management (Cedefop, 2022b). Soft skills that facilitate working collaboratively across functions within organisations and with an expanding range of stakeholders are becoming more important. The overarching EGD goal of ensuring a just transition means that acting with empathy and taking a human centred approach to management and process design are essential.

Table 1. **Emerging skill needs in waste management, circular economy, agri-food sectors and smart and green cities (expert assessment)**

	Technical skills	Soft skills
Waste management	ICT / engineering skills related to the adoption of new technologies for processing waste	Collaboration skills Persuasion skills to work with organisations to persuade them to reduce waste levels including product design consistent with the circular economy
Circular economy	Skills linked to design and repair (some may be traditional manual ones currently in decline)	Marketing / communication skills Persuasion skills (e.g. to support change in consumer behaviour)
Agri-food	Skills linked to adoption of advanced agricultural production (e.g. precision farming). Skills linked to more sustainable foodstuff production. ICT / data analysis skills	Communication and persuasion skills (to engage with producers and the public)
Smart green cities	ICT and data analysis skills (at the heart of smart, green cities) Awareness of the potential of analysing data generated by sensors (municipal planning).	Communication and persuasion skills to encourage the general public to make use of the services / functions made possible by smart, green technologies (e.g. e-government). Collaboration skills (to engage with different types of organisations in cities)

Source: Cedefop skill foresights undertaken in 2021-23.

The specific skills required in occupations and sectors, and the extent and level of mastery required, depend on the speed and direction of change brought about by regulation, technology, changing consumer preferences, emerging partnerships between stakeholders and their features, and other trends. In rapidly changing contexts, technical skills facilitating the green transition are symbiotic with soft ones, as the latter amplify the impact of innovation via consumer and citizen engagement. Digital and data analysis skills need to be embedded across the board in 'green' curricula and programmes, because the twin transition boosts demand for such skills in all sectors. In some jobs, digital skills will increasingly be considered transversal rather than purely technical.

Greening trends challenge education and training systems fundamentally. It is not just a matter of providing the skills needed to implement 'greennovation' at scale. The scope and scale of change also require a silo-free approach in programme and curriculum design and provision (e.g. more blended and work-based learning) and expanding teacher and trainer professional development opportunities.

Shifting gears in the digital transition

Digitalisation is a long-standing megatrend that has already had a transformative labour market impact. In recent decades, the IT sector has expanded and become increasingly strategically important; digital skills and the capacity to work with digital tools have become transversal requirements in almost all types of jobs. The digital transition will continue to impact employment across sectors, with demand in the telecommunications and the computer programming sectors expected to grow in most Member States.

Emerging digital skill needs transcend sectors, occupations and qualification levels. With industry 4.0, the knowledge-based economy concept has become more strongly connected to digitalisation. The expanding capacity and application of digital technologies have set the EU on course for more fundamental transformation. Going beyond driving product, process and service innovation, currently available digital technology (e.g. cloud-based solutions, sensor-enabled data collection and analysis, and machine learning) is game-changing because it also enables better and more informed decision-making.

Digitalisation has long been viewed as an integral part of skills-biased technological change. About a decade ago, the view that automation leads to destruction of jobs which involve mainly routine and predictable tasks by machines became quite prominent (Acemoglu and Autor, 2011). Since then, insights into the impact of digital technology have evolved and the tone in policy debates has changed. Experts and policy-makers increasingly acknowledge the potential of digitalisation to create new types of jobs in the technology-driven knowledge economy (see Acemoglu and Restrepo, 2018). Early research findings, which led to dramatic speculations in the press that up to half of the workforce might be substituted by robots, have made way for a much more nuanced view. Contemporary analysis suggests that only a minority of the workforce (8 to 14%) is at risk of being fully replaced by technology (Pouliakas, 2019). While this is still substantial, affecting up to 27 million EU workers, for many more digitalisation means job enrichment and task expansion, which requires substantial digital and other up- and reskilling.

The COVID-19 pandemic and policy action taken in response to it accelerated digitalisation trends, augmented the value of digital skills, and expanded demand for them. Compared to the situation before the pandemic, close to 4 in 10 adult workers more often used digital technology to perform some of their job tasks or engaged in more online job-related learning (Cedefop, 2022e). Apart from understanding employment and skills trends in core ICT occupations, such as software developer or system administrator, it is increasingly vital to map emerging and future digital skill needs in non-IT occupations, and to use such information for education and training policy, policy implementation and programme provision.

Digitalisation and innovation policy and funding will contribute substantially to the digital transformation in the EU. The European Commission's Digital Decade policy programme aims at a secure and sustainable transformation by 2030. It sets ambitious targets to be achieved by then: 20 million ICT specialists, 80% or more of the population having basic digital skills, and 3 in 4 EU companies using cloud/AI/big data. Policy development and implementation aimed at reaching these targets will likely significantly boost employment in occupations where high-level digital skills are required.

4.1. Digitalisation accelerating knowledge economy transition

STEM (science, technology, engineering and mathematics) jobs are at the heart of the knowledge-based economy. Employment trends in engineering and ICT jobs give insight into the speed at which Europe is moving towards it. Aggregate analysis in previous chapters has shown the increasing importance of ICT and engineering jobs, particularly in the context of supporting the green transition. Between 2011-20, employment in ICT-related occupations increased in all sectors (Eurostat, 2022b). It increased most in the construction sector, where it has almost doubled within a decade. The employment boost in construction is linked to the expansion of new digital technology such as cloud computing for information storage and distribution, the use of sensors, and building information modelling (BIM) technology. These technologies transform the way construction sites are managed and require massive up-skilling of the workforce (Cedefop, 2023c).

After the first signs of recovery appeared about a decade ago, following the financial crisis, European countries started investing in ICT to push forward digitalisation of their economies. ICT employment growth accelerated

between 2015 and 2019 and the pandemic had, up to 2020, merely slowed
its growth rate.

Figure 16. **Investment in planned RRF digital transition projects by
sector (in bn EUR)**
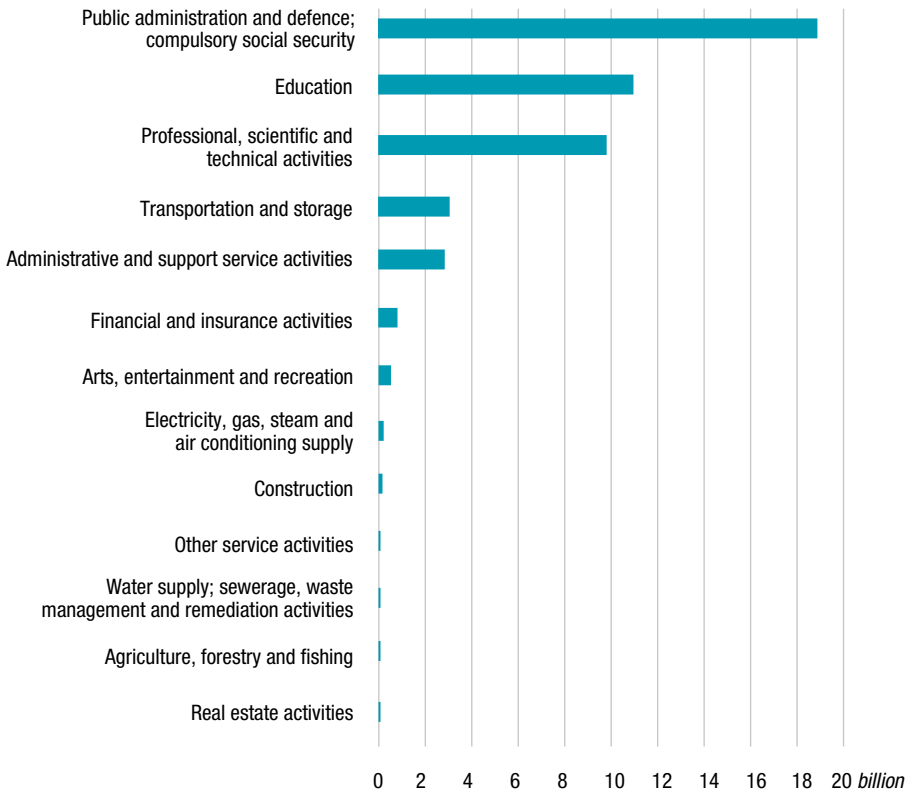
Source: Darvas et al., 2023.

EU Member State recovery and resilience plans, with 96 billion EUR of
investment, aim at supporting countries in digitalising their economies. RRP
projects finance the digitisation of processes and the scaling-up of data cloud
capacities, and help improve the efficiency of public administration. The largest
share of funding (25% of the amount for projects supporting digital transition)
will directly benefit the IT sector. Such projects often finance broadband ex-
pansion or investment in high-speed networks. One fifth of the RRP funding
for digital investment is for public administration. These funds are typically

used for cybersecurity projects, public sector modernisation, and developing or improving digital public administration systems. Education will also benefit from significant funding, because of projects promoting population digital literacy and more targeted digital skill development projects. The planned investment is expected to translate into higher demand for IT professionals across sectors in the EU economy.

Figure 17. **Demand for IT occupations by sector (2022)**

- information and communications technology service managers (133)
- database and network professionals (252)
- electronics engineering technicians (215)
- electronics engineering technicians (311)
- graphic and multimedia designers (216)
- information and communications technology operations and user support technicians (351)
- other teaching professionals (235)
- telecommunications and broadcasting technicians (352)
- sales, marketing and public relations professionals (243)
- electronics and telecommunications installers and repairers (742)
- software, application developers (251)

Source: WIH-OJA database.

Software and application developers and analysts are currently most in demand in the EU IT labour market. In 2022, online job advertisements for

such roles represented the lion's share of demand ([21]) for IT professionals in all sectors (Figure 17). The shares of online job ads for database and network specialists and information and communications technology operations and user support technicians were highest in the administrative and support service activities sector. The manufacturing sector stands out because it has the highest share of advertisements for job opportunities for electronics engineering technicians, electrotechnology engineers and electronics and telecommunications installers and repairers.

4.2. Digital skills intensity is expanding fast in lower-level occupations

Alongside expanding demand for key IT occupations, automation, robotisation and AI raise digital skill requirements transversally. This trend affects all occupations and qualification levels. Using big data, it is possible to assess the digital skills intensity of occupations (Box 5)

Box 5. **Digital skills intensity in occupations**

The ESCO classification provides information about the relationship between occupations and skills. It allows to distinguish between digital skills and digital knowledge concepts necessary to perform the job. Cedefop used the WIH-OJA database to group occupations according to the share of digital skills they require (digital intensity) as follows:
- no or marginally digitally intensive occupations: the ratio between digital skills and other required skills is below 1%;
- low digitally intensive occupations: the share of digital skills is between 1%-3%;
- medium digitally intensive occupations: the share of digital skills is between 3-5%;
- high digitally intensive occupations: the share of digital skills is more than 5%.

Between 2020-22, growth in the number of vacancies for high digitally intensive occupations was highest at the lowest skill level. Examples of such occupations include manufacturing labourers and crane operators. It can be expected that the demand for medium and high-digital skills in jobs traditionally occupied by low-skilled workers will grow, even in occupations where no special training was needed in the past. Digital transformation in agriculture, for example, will boost the demand for skills needed to work with sensor-based technology and other advanced digital skills (Cedefop 2023a).

([21]) Based on analysis of online job advertisements of the WIH-OJA database.

Such trends showcase the importance of targeted digital skills training at the lower end of the labour market.

Figure 18. **Growth in online job advertisements for highly digitally intensive occupations by skill level of occupation (Q1 2020 = 100)**
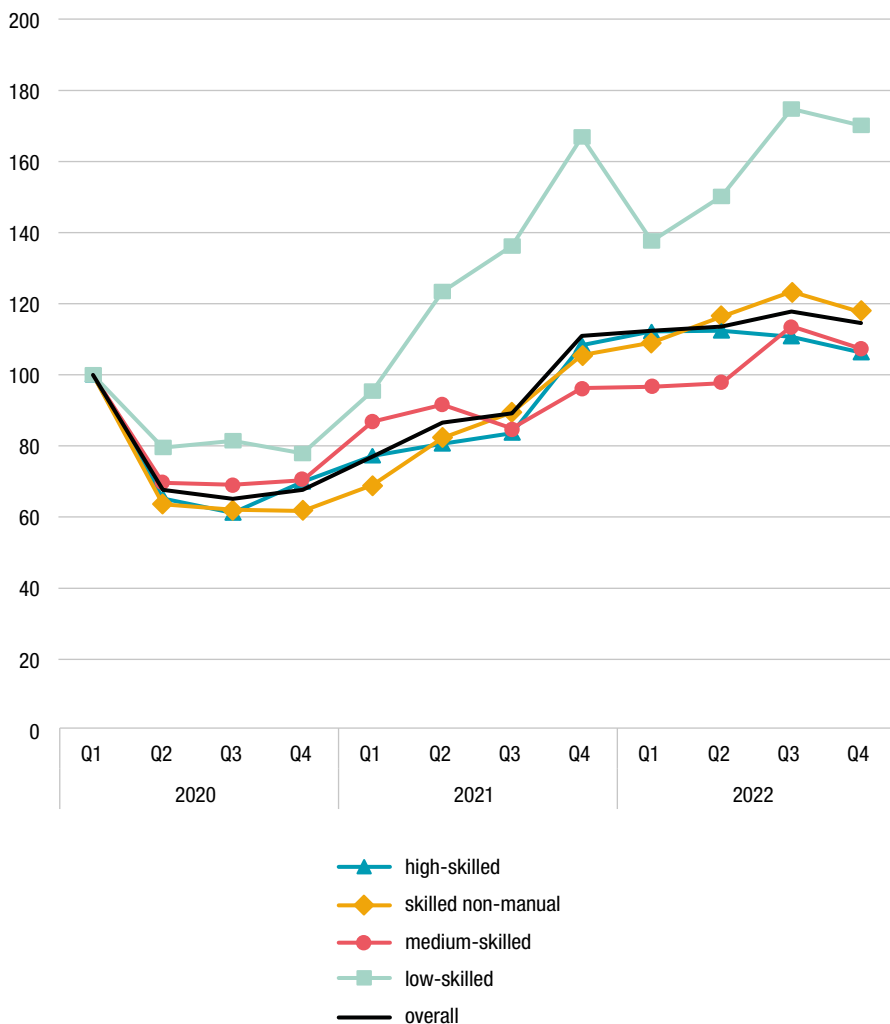
This does not mean that providing digital skilling opportunities for those in high-skilled occupations is not equally important; this also goes beyond doing so for people in IT jobs. Most online job advertisements targeting non-IT professionals demand advanced digital skills and more than half of job ads for (non-IT) technicians and associated professionals expect candidates to have high- or medium-level digital skills ([22]). Only for (non-IT) legislators, senior officials and managers, do basic digital skills suffice in most cases.

Figure 19. **Online job advertisements for high-skilled non-IT occupations (ISCO 1 digit) by requested level of digital skills (millions, 2022)**
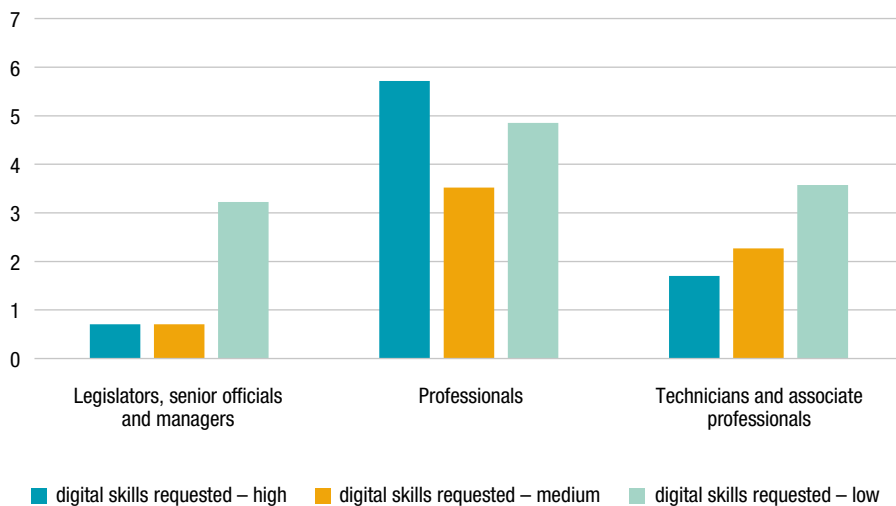
Source: WIH-OJA database.

([22]) Digital skills level was approximated by allocating digital skills extracted from online job advertisements using the ESCO classification to skill levels based on the classification developed for Cedefop's second European skills and jobs survey (ESJS2). This classification of digital skills used at work divides occupations into three groups (high/medium/low) according to the level of digital skills required. Low digital skills include internet browsing, use of email and social media, writing or editing text or use of spreadsheet at work. Medium digital skills include skills to use specialised software, prepare presentations and advanced use of spreadsheets. High digital skills include managing or merging databases, programming and coding skills, and the design of IT systems, and hard- and software.

CHAPTER 5

Technology as a twin transition enabler

Technology-intensive sectors and occupations drive change and – because dynamics translate into new skill needs – shape the up- and reskilling potential that economies need to address. Technology powers the twin transition but it can also be used to mitigate the impact of other socioeconomic challenges, such demographic change. Taken together, technology-intensive or 'high-tech' sectors (Box 6) represent a wide range of activities linked to creating and adopting new technologies; these typically require well-educated and trained workers with advanced STEM skills.

Box 6. **High-tech sectors defined**

'High tech' sectors include manufacturing and service activities with a high technology intensity, a concept measured by their R&D expenditure and value added. Eurostat's high-tech aggregation by NACE Rev. 2 is used for the analysis of technological trends in this chapter.
- 'high-tech manufacturing' includes the 'high-technology' (manufacture of basic pharmaceutical products and pharmaceutical preparations and manufacture of computer, electronic and optical products) and 'medium-high technology sectors' (manufacture of chemicals and chemical products; manufacture of electrical equipment; manufacture of machinery and equipment not elsewhere classified; manufacture of motor vehicles, trailers, and semi-trailers; manufacture of other transport equipment).
- 'high-tech services' encompass 'high-tech knowledge-intensive services' (motion picture, video and television programme production, sound recording, and music publishing activities; programming and broadcasting activities; telecommunications; computer programming, consultancy, and related activities; Information service activities; scientific research and development).

5.1. High-tech employment is expanding, especially in services

Jointly, high-tech sectors represented 8.3% of EU employment in 2022 (Cedefop 2023 Skills Forecast), up from 7.5% in 2009 (Figure 20). About 3 in every 5 jobs in the high-tech sector are in manufacturing companies, and the electronics and automotive sectors have traditionally been high-tech employment powerhouses. High-tech sectors have been in transition: employment in the manufacturing part stagnates, while job growth in high-tech services accelerates and reinforces the long-term trend towards an increasingly service-oriented EU economy. The Cedefop skills forecast projects an employment share of 9% for high-tech sectors. While high-tech manufacturing and services are expected to grow, new job creation foreseen in high-tech services is likely to be more than three times higher than in high-tech manufacturing.

Figure 20. **High-tech manufacturing and services (% of EU employment, 2011-35)**
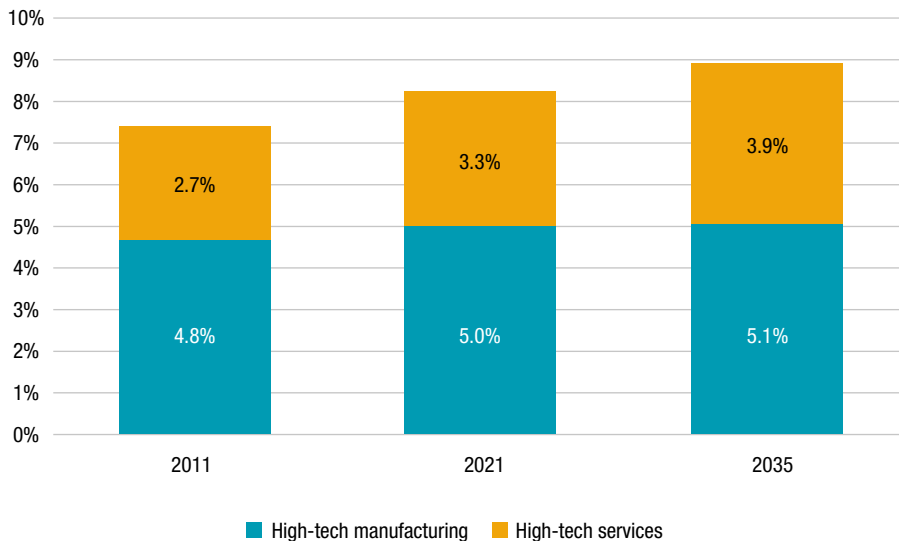
Source: 2023 Cedefop skills forecast database. Own calculations.

Growing employment in the high-tech sectors reflects the success stories of many EU Member States joining the Union in or after 2004, particularly countries that were part of the former communist bloc. They joined the Union as their economies were going through challenging transformations, often

lacking access to capital and state-of-the-art technologies. Following lengthy periods of adjustment, today four of them – Czechia, Hungary, Slovenia, and Slovakia – have the highest employment shares in high-tech sectors in the EU, together with Germany.

High-tech manufacturing has contributed greatly to the strong position of eastern EU countries today. Strong VET systems ([23]), an abundant skilled workforce and lower labour costs made it possible to become hubs for large-scale production outsourcing and to establish assembly factories for multi-national companies from more developed countries. At the start, many such companies kept close control of strategic and high value-added activities, such as research and development and design, and most jobs associated with them did not move to other locations. Although such choices are still visible today in the occupational structure of employment in east European economies, the skill level of jobs in high-tech sectors has been rising across the EU. In high-tech services, such as software development, Estonia now has the highest employment share. Cedefop's Skills Forecast projects future job growth in the high-tech sector to be strongest in eastern Europe, with Estonia, Romania and Slovenia among the top five countries.

5.2. High-tech employment shift from technical to professional jobs

Aggregating jobs across high-tech sectors does not equate to mapping employment in technology-intensive activities; such an approach does not consider the different types of jobs in these sectors. Even in industries widely viewed as at the core of the high-tech economy, such as ICT manufacturing, many jobs can be low-skilled, when they primarily involve simply assembling imported components. In contrast, sectors such as agriculture, education, or retail, which are typically not considered 'high-tech', may develop in that direction over time. The expansion of jobs for workers who pursue and implement technological innovation, for example by using robots, biotechnologies, or advanced software, *de facto* makes these sectors more 'high-tech'.

High-tech occupations include science and engineering professionals, science and engineering technicians and associate professionals, information technology professionals, and information technology technicians and associ-

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([23]) For more information, see Cedefop's Vocational education and training in Europe and National VET systems.

ate professionals ([24]). The employment share of these occupations is highest in northern Europe countries (Finland, Sweden, Denmark, Estonia). In recent decades, the labour market share of high-tech occupations in eastern and southern Europe countries has been lower. Such countries have been quickly catching up, with Portugal, Estonia and Poland leading the ranks. Cedefop's 2023 Skills Forecast suggests that this trend will continue.

By 2035, some of the countries joining the EU after 2004 (Czechia, Estonia, Croatia and Slovenia) will be in the top 10 of EU countries with the highest employment shares of high-tech occupations.

High-tech occupations encompass a mix of professional and technician profiles. Employment of high-tech professionals in jobs that typically require a tertiary degree has grown notably over the years. There are 63% more employed ICT professionals compared to a decade ago and further growth of 33% is expected in the years up until 2035. Science and engineering professionals follow with employment growth rates of 21% and 24% respectively. Employment for technicians will also expand in the 2021-35 period, but the growth rates will decline. Several factors drive the declining importance of technicians. Automation, better product design and higher digital skills among the population reduced the need to provide service support for advanced technologies, for a long time a core part of tasks carried out by high-tech technicians. Labour market tightness also plays a role. The shortage of ICT experts across Europe ([25]) (see also Chapter 6) leads employers increasingly to outsource coding and testing activities to countries outside the EU. Professional level jobs mostly remain, which offer career opportunities for those formerly employed as technicians.

The comparison of past and forecast employment shares, and the current composition of online job advertisements for high-tech occupations confirm the shift from technical to professional high-tech employment (Figure 20). The employment share of professionals in high-tech occupations was 48% in 2011, but job openings for professionals contributed 75% to job growth in the last decade. Currently, 70% of online job advertisements in high-tech occupations are for professionals. For the years up to 2035, it is expected that

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([24]) Cedefop defines 'technology intensive' occupations using the approach described in *Human resources in science and technology* (Eurostat, 2019) and more specifically the definition proposed in *Professionals and technicians employed in science and technology occupations* (Eurostat, 2023d). However, Cedefop's definition does not include medical occupations, as the emphasis is on jobs related to design, development, and maintenance of advanced technologies. Medical professionals are considered users of such technologies.

([25]) See also Chapter 1 on labour market tightness and Cedefop (forthcoming). *Data insights series*. ICT Services Sector.

almost 9 in 10 new high-tech jobs (87%) will be for a professional.

Mechanical engineering technicians and professionals, particularly in manufacturing and construction roles, have traditionally played an important part in high-tech occupations. However, recent job creation has been mostly for software developers, architects, designers ([26]) and ICT technicians. Architects are likely to be in high demand thanks to the EGD's Renovation Wave and activities for and by smart and green cities (Cedefop, 2020a). Database and network professionals, and life science professionals are relatively small, but fast-growing occupations. Technician roles, especially in manufacturing and construction, are on the decline in terms of numbers and market-share.

Figure 21. **Trends in employment and online job advertisements for high-tech occupations**
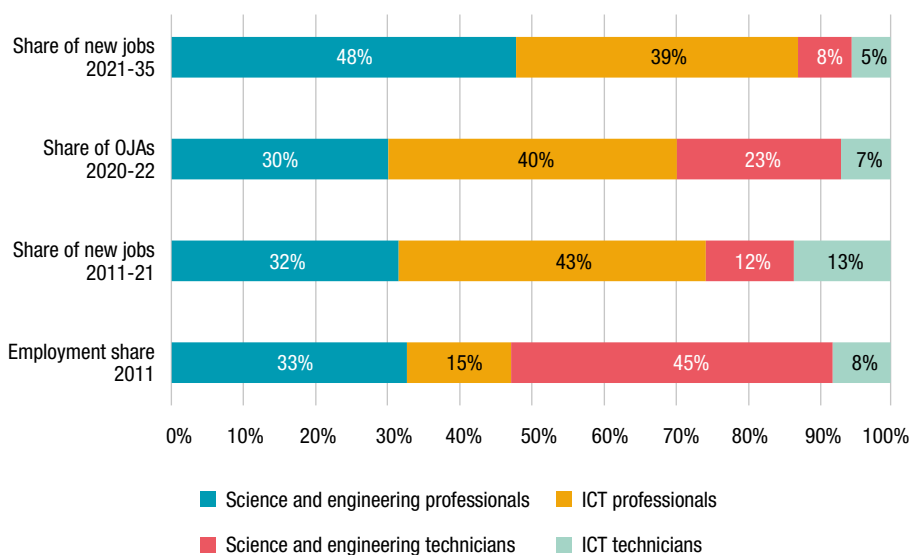
Source: 2023 Cedefop skills forecast and Skills OVATE databases. Own calculations.

The skill level of high-tech jobs is rising (Figure 21); professional level jobs overwhelmingly require tertiary education. With the fast development of ICT roles and the lack of specialised education opportunities in the past, many workers in technician roles still held a mid-level qualification just a decade

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([26]) By ISCO definition they also include some ICT roles, such as computer graphics and multimedia designers.

ago. While in 2021 high-tech technicians with a medium-level qualification still represented a considerable share of employment, the estimated future upgrading of qualification needs is remarkable. Technician roles – in particular in ICT – will approach a level comparable to professional jobs. The rapid expansion of advanced digital technologies poses challenges for workers and employers, because the rising task complexity they imply translates into growing needs for qualifications and training.

Figure 22. **Share of people employed in high-tech occupations with a tertiary qualification (2011 and 2021) and estimated share of future job openings in high-tech occupation requiring a tertiary qualification (2021-35)**
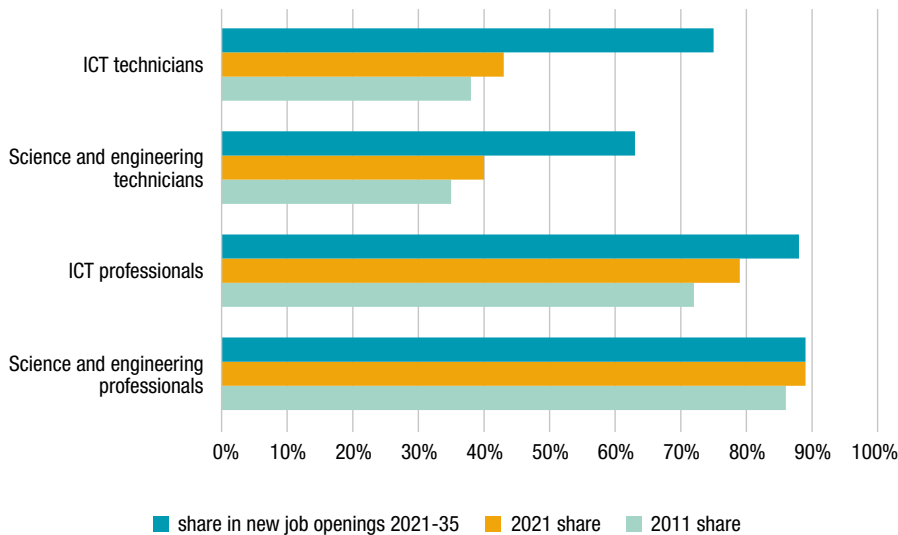
Source: 2023 Cedefop skills forecast database. Own calculations.

Future job openings (expansion and replacement demand) will be highest for science and engineering professionals, amounting to 77% of 2021 employment in the years up to 2035. For ICT specialists this is 72%. A large share of the workforce holding science and engineering occupations is ageing, making meeting replacement demand a daunting challenge, particularly in the energy sector (European Commission, Joint Research Centre and Czako, 2020). The aging challenge is slightly less pressing for ICT roles as, on average, more jobs are taken by younger workers. Satisfying high expansion demand will be central to matching labour market needs.

Overcoming the persistent gender gap in high-tech employment and STEM education is a precondition for matching demand to supply in the coming years. On average in high-tech occupations, the share of females in employment is just 22%, and progress has been slow in the last decade (Figure 23). While the gender gap is narrowing in engineering professions, in ICT it remains large (ESSA, 2022). Attracting more female talent to high-tech occupations should therefore remain an overarching priority in skills and activation policies.

Figure 23. **Female employment in high-tech occupations**
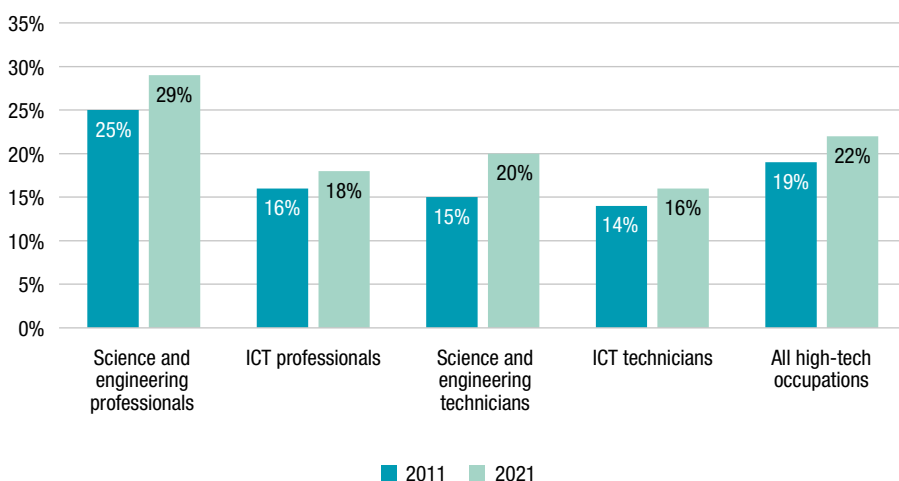
Source: European labour force survey. Own calculations.

5.3. Energy crunch and digitalisation accelerate demand for high-tech workers

Between 2020 and 2022, the fastest growing occupation was petroleum and gas refining plant operator (Figure 24) ([27]). This is clearly linked to the energy crunch that has been transforming the EU economy since the beginning of 2022 and the fast construction of new fuel processing facilities to address the impacts of Russian gas and oil import restrictions. Growth in demand for

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([27]) See Skills OVATE, Cedefop's platform which looks at skills and job demand in online job advertisements (OJA).

environmental engineers, a 'thyroid' occupation ([28]), was second highest. It is plausible the energy crunch also contributed here, as environmental engineers are often tasked with improving energy efficiency. Jobs commonly categorised as environmental engineers ([29]) include circular economy specialists, energy efficiency auditors, air pollution control engineers and wastewater process engineers.

Figure 24. **Online job advertisements for occupations (ISCO 4-digit level) growing faster than high-tech occupations on average (growth in %, 2020-22)**
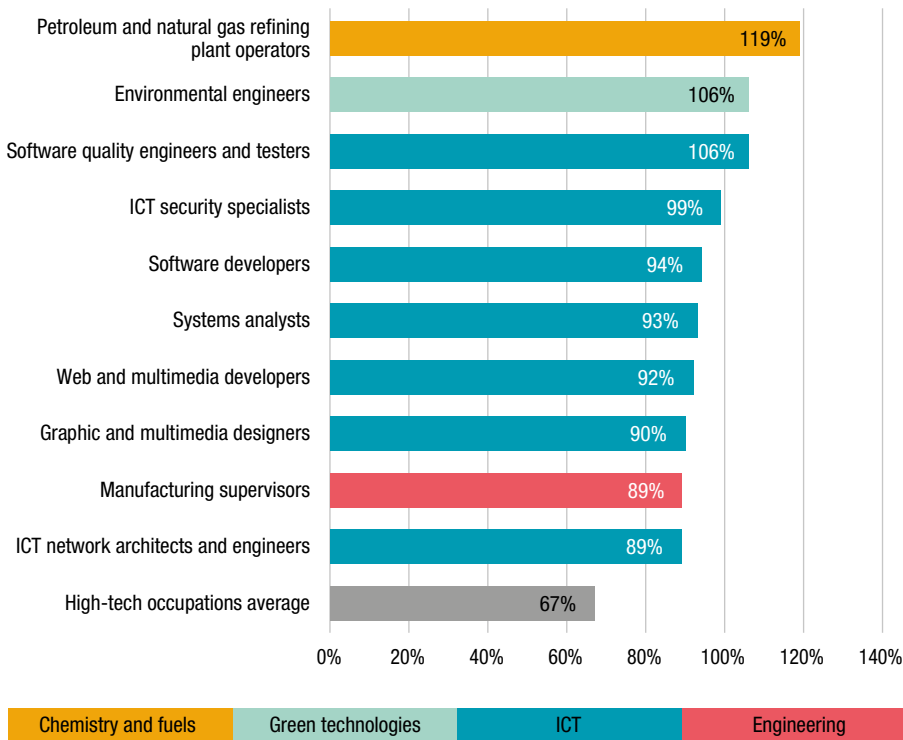
NB: Colour coding indicates occupations in different job areas.
Source: Cedefop skills forecast and Skills OVATE databases. Own calculations.

([28]) Cedefop defines 'thyroid occupations' as 'profiles which are small in terms of employment share, but indispensable for developing green technologies and reaching EGD targets; see Chapter 3 for the role of 'thyroids' in the green transition and Cedefop (2022c). *An ally in the green transition. Cedefop briefing note, March 2022.*

([29]) Based on *Cedefop's analysis on thyroid occupations and ESCO description for ISCO 2143.*

High-tech job opportunities for ICT workers are expanding. Online job ads for software quality specialists and testers, and ICT security specialists are growing fastest in demand; software developers and systems analysts rank second and third. While COVID-19 and rapidly expanding e-commerce accelerated the demand for web and multimedia developers, the fast-growing gaming industry is likely to have boosted demand for graphic and multimedia designers.

5.4. ICT, energy and waste treatment are high-tech powerhouses

The share of high-tech occupations in sectoral employment is a proxy for technology intensity and STEM skill needs. Upward trends in this share signal where digitalisation and automation are progressing fastest. With over half of its employment in high-tech occupations, the ICT services sector leads the ranks (Figure 25). With one high-tech job for every two that are not-high tech, energy supply services comes second. In professional services, water supply, and waste treatment around 1 in 4 jobs is high tech.

In almost all sectors, the high-tech employment share has grown substantially over time. Professional services, where employment of high-tech occupations grew, but not as fast as total employment, and administrative services are notable exceptions.

Figure 25. **Employment share of high-tech occupations in sectors (2011 and 2021)**
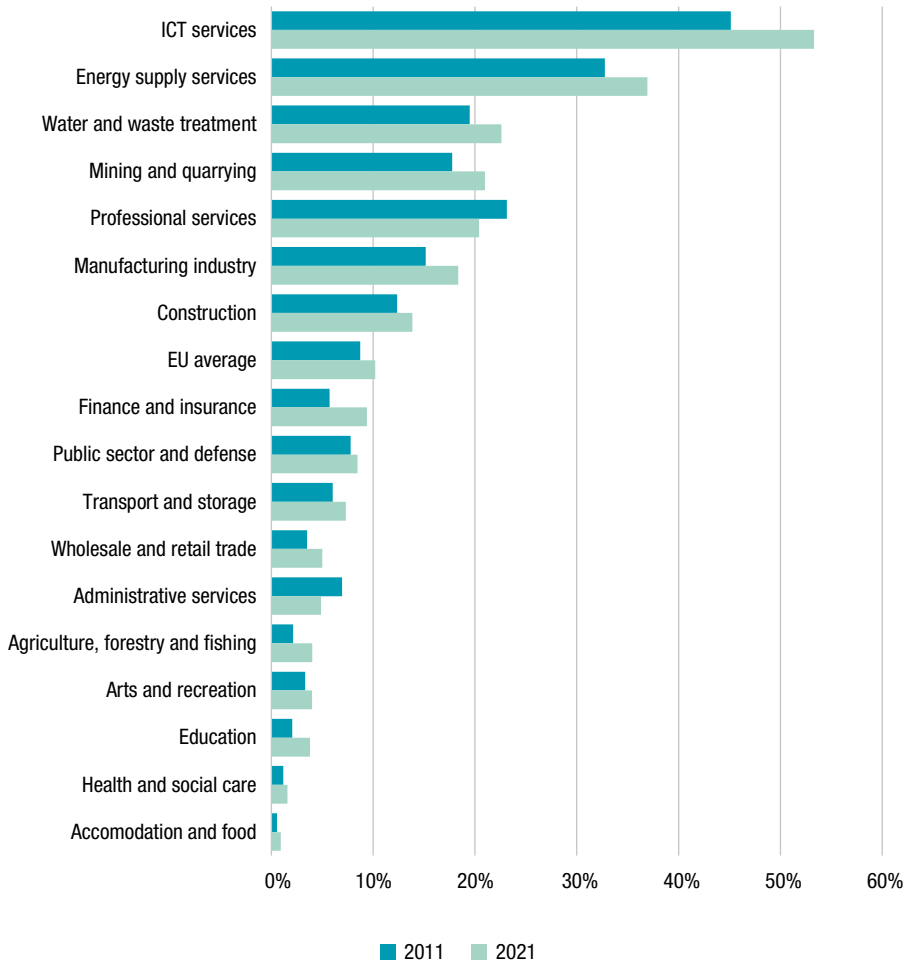
Source: Cedefop skills forecast database. Own calculations.

5.5.   Technology and skill needs will transform manufacturing

Manufacturing is, and will remain, a key sector for high-tech occupations. In 2021, 26% of employment in EU manufacturing was in high-tech occupations. The European Green Deal industrial plan places manufacturing at the heart of the green transition. Insight into employment trends of high-tech occupations supports the formulation and implementation of twin transition, employment, and skill policies. Automation and digitalisation have already radically changed the face of manufacturing in recent decades. Contrary to what was often feared, the impact of technology from a longer-term perspective has frequently been positive: alongside jobs and task destruction, it has also augmented the share of high-tech jobs over time and boosted demand for high-tech services. A clear example is the automotive industry (see DRIVES, 2021), which leads the ranks when it comes to the deployment of industrial robots and the expansion of high-tech employment (Figure 26).

Change is likely to accelerate soon. Data on new robot installations (see Müller, 2022) point towards rising automation in the manufacturing of electrical equipment and in the metals and metal products industry. Digitalisation and deployment of new design and process management ICT technology are on the rise in most manufacturing sectors. Cedefop's 2023 skills forecast suggests most new high-tech jobs in 2021-35 will be created in the food, drinks and tobacco industry. Forecast new high-tech job creation is also substantial in the automotive, metal products and electrical equipment industries. While they jointly represented just 41% of manufacturing employment in 2021, these four sectors are expected to take the lion's share (55%) of high-tech job openings until 2035.

Figure 26. **Employment share of high-tech occupations in manufacturing industries (in %)**
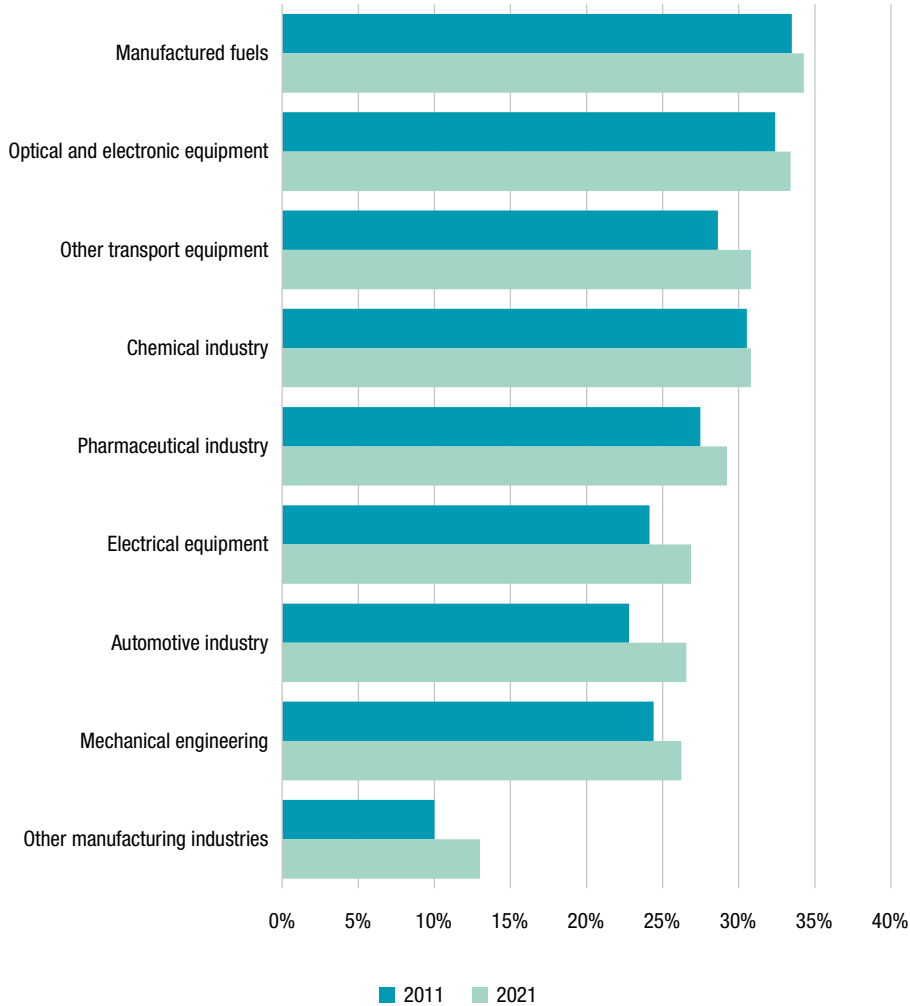
Source: 2023 Cedefop skills forecast database. Own calculations.

With skill needs rising, high-tech jobs are also likely to become more important in sectors currently still considered 'low-tech' manufacturing. Many may no longer be designated as such in the future, because the share of high-tech jobs is set to increase. This trend is particularly visible in the food, drinks, and tobacco sector, metal industries, and in wood and paper processing. At the

same time, employment in medium- to low-skilled manual occupations (ISCO 7, 8 and 9) in manufacturing will continue declining. Ageing and shrinking populations, especially in the east European countries, together with rising tertiary educational attainment, will also shrink workforce supply for skilled manual and elementary occupations.

The impacts on employment in manufacturing of automation, digitalisation and aging and demographic decline in the medium to longer term could well match one another. Instead of fearing their job and task destruction potential, policy and its implementation should acknowledge automation and digitalisation as an approach to dealing with the workforce shortages Europe is experiencing, and will increasingly feel, in the next decade.

Shortages in the spotlight

Since 2020, with the COVID-19 pandemic, the Ukraine war, increasing energy and food prices and continued economic and social turmoil, European economies and firms experienced severe disruptions in supply chains and have been confronted with considerable economic and job market uncertainty. Labour market pressures eased during the early stages of the pandemic in some sectors and occupations, particularly in those where remote work was not feasible and social distancing measures became the norm. As economies recovered, difficulties finding people with the right skills reported by firms swiftly returned to pre-pandemic levels. The finding that almost three quarters of EU firms continue to encounter recruitment bottlenecks in the post-COVID-19 period has become a frequently used headline statistic. The growing tension between rising job vacancy and falling unemployment rates (European Commission, DG Employment, Social Affairs and Inclusion, 2023) is often interpreted as evidence of primarily supply-driven shortages.

Increasing recruitment difficulties have coincided with slashed training investments by firms, raising concerns that current skills matching challenges may become persistent in the medium term (Pouliakas and Wruuck, 2022). Increasing labour market turnover resulting from shifting work attitudes and expectations among workers (e.g. the 'great resignation') and workforce ageing also underpins recruitment bottlenecks. Digitalisation and companies adopting new digital work and learning practices may have further accentuated the gap between hiring requirements and the skills of job applicants. Cedefop's European skills and jobs survey (ESJS2) captures the pervasiveness of change: compared to before the pandemic, close to 4 in 10 adult workers more often used digital technology to perform some of their job tasks or engage in more online activity for job-learning purposes (Cedefop, 2022e).

Understanding the reason(s) underpinning a regional/industrial or occupational skill shortage is crucial, given that it provides insight into the type of policy intervention that can or should be pursued to mitigate the phenomenon. This is easier said than done. Identifying whether labour market imbalances constitute 'skill shortages' *strictu sensu* is a challenging endeavour. It is difficult to define the phenomenon accurately and measure it reliably (Cedefop, 2015, 2018). There is confusion in the literature and among policy-makers about

the underlying drivers and appropriate policy remedies. It is often not easy to determine what measures (e.g. vocational education and training, activation policies, migration, career guidance, improvement of HRM practices) should be priorities to confront what is described by companies as 'hard-to-fill vacancies' or 'recruitment bottlenecks'. Most of the research literature on the topic struggles to identify clearly whether reported occupational shortages are linked to the demand for particular skills exceeding supply or to low job quality or inferior working conditions. The lack of surveys and direct measures of skill needs in labour markets and job quality indicators at detailed occupational level, complicates and, at times, confuses analysis.

6.1. Company recruitment difficulties and shortages go beyond lack of supply ([30])

Discussions about skill shortages in almost all sectors have started dominating the policy debate. They became fiercer after the EU economy started rebounding after the COVID-19 slowdown. Lack of sufficient skills in the labour market is often viewed as the key matching challenge in heated exchanges between employers and other actors: better alignment between labour market needs and provision of education and training is often put forward as a suitable response to address the issue. Cedefop evidence suggests only exploring such supply-side oriented approaches may not always be the right solution.

A first important finding is that, while recruitment difficulties are real, not all employers equally struggle to find talent. Evidence from the Eurofound-Cedefop European company survey (ECS) shows that only 26% of EU establishments faced a large degree of difficulty in finding employees with the right skills ([31]); 51% of them faced some difficulties and 23% experienced little or no difficulties. The conclusion is that many recruitment bottlenecks reported by European firms are moderate. ECS-based analysis also shows that:

(a) companies' overall difficulties in finding people with the right skills are closely linked to the inability to retain workers and less to a lack of skills among job applicants;

(b) there is an institutional dimension to firms' recruitment difficulties, as the presence of a recognised employee representation body is associated

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([30]) This is a summary of Cedefop's contribution to the *2023 ESDE report*.
([31]) The *European company survey 2019 (ECS 2019)* is an EU-wide establishment survey commissioned by Eurofound and Cedefop. The questionnaire and additional information are available.

with a reduced chance of experiencing difficulties;

(c) recruitment difficulties are less likely in larger firms, which are better able to recruit from a larger available talent pool (both externally and internally) and are also more likely to have an employee representation body (ESDE, 2023).

Apart from type of firm, the type of job also matters for recruitment difficulties and shortages. Deepening understanding of shortages is possible by looking beyond occupations. Cedefop leveraged current evidence on skills shortages to establish a comprehensive list of 33 (4-digit) shortage occupations ([32]) and used Cedefop's second European skills and jobs survey (ESJS2) to see whether skills shortage occupations are different from non-shortage ones (ESDE, 2023). This analysis shows that EU labour market tensions prevail in the areas of ICT, health care and STEM at medium- and at high-skill level. The share of employees in shortage occupations is higher in human health and social work activities, construction, electricity, gas, steam and air conditioning supply, ICT, waste management, accommodation and food services, and manufacturing.

Shortage occupations are more likely to be jobs with lower skill demand compared to those without marked hiring difficulties. People working in shortage occupations are more likely to need lower literacy, numeracy, interpersonal and digital skills and to be in jobs depending more on physical/manual tasks. But, despite lower skill needs on average, employees in shortage occupations are expected to exercise greater discretion in organising and planning their work and to learn and adapt to unexpected situations or varying tasks. This suggests that occupational shortages in the European economy are also driven by firms' expectations to find workers with high non-cognitive skills. They also reflect some upskilling needs, albeit at a relatively low skill level.

This means that the features underlying shortages differ according to occupation. For example, shortages of ICT professionals are linked to the fact that their jobs are inherently more complex in terms of analytical skills. Shortages of health professionals and associates, in contrast, can be primarily viewed as outcome of poor working conditions.

The available evidence suggests that occupations with persistent labour shortages tend to be characterised by lower skill demand. Linked to that, employers' recruitment difficulties seem mostly to be an outcome of poor

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[32] For this analysis, Cedefop used both a relatively broad list of occupational skill shortages at 3-digit ISCO level, as identified by European Commission, DG Employment, 2022, as well as the detailed list of 4-digit occupations in shortage as identified by the 2021 report on labour shortages and surpluses of the European Labour Authority (McGrath, 2021). More information on the methodology is available in the Annex.

HRM practices (e.g. poor retention) and unattractive jobs (e.g. poor working conditions, including high job strain), rather than skill supply inadequacy that fails to meet high skill needs. However, there are significant differences across occupations: it is obvious that supply bottlenecks play a major role in shortages for ICT professionals. Also, things may change, given that several new future labour shortages are concentrated in higher-skilled occupations (European Commission. DG Employment, 2022).

6.2. Hiring difficulties until 2035 more pressing at the lower end of the labour market

Hiring difficulties can be characterised by the number of jobs they concern and their severity. For some occupations, it may be very difficult to find staff for a limited number of jobs. For others, the number of jobs up for hire is high, while hiring difficulties are moderate. The 'degree of hiring required' encompasses the additional hiring linked to the growth of occupations and the upgrading in the qualification structure. The 'difficulty of hiring' approximates supply shortages by qualifications and their impact on occupations, reflecting the difficulties in fulfilling demand given the available supply of qualifications (Figure 27).

Between 2021 and 2035, the shift from low and medium level qualifications to higher level ones in the workforce is a megatrend. Higher-level occupations (professionals, technicians and associate professionals) are expected to grow; this will happen as employers hire high-qualified personnel. Because of the steadily growing supply of people with a higher qualification in many countries, only moderate hiring difficulties are expected on average for higher-level occupations. However, for some high-level occupations, hiring difficulties could be substantial when they require specific qualifications (fields of study) or experience which many in the growing group of young people with a higher qualification may not have.

For medium and lower-level occupations the level of required hiring is expected to be intermediate. While they grow more slowly, the required upgrading in the qualification mix is greater than for higher occupations, as employment shifts away from low and medium qualification levels toward higher ones. As a result, hiring difficulties are projected to be greater than in higher-level occupations.

Figure 27. **Required future hiring and hiring difficulties, 2021-35**
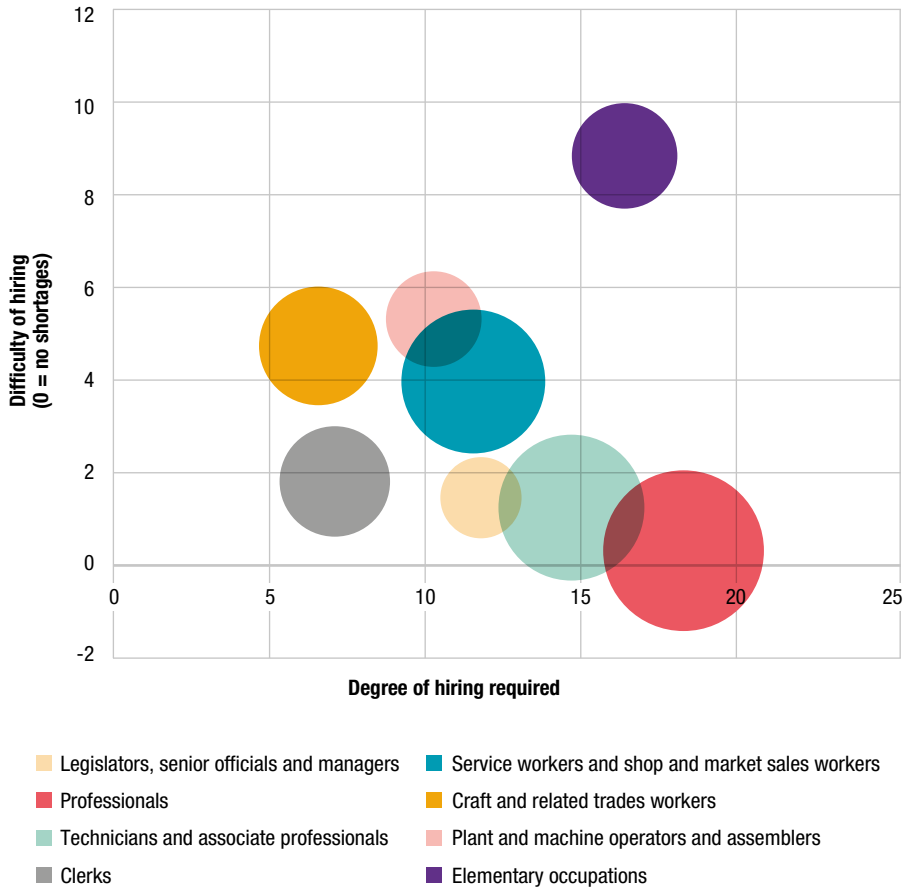
NB: Difficulty of hiring indicates the difficulties in fulfilling demand given the available supply of qualifications utilised in the occupation. The degree of hiring measures, for each qualification level, the amount of net hiring (stemming from net demand, i.e. job growth not accounting for replacement needs) needed to reach the estimated level of employment. Details on methodology are available.
Source: Cedefop skills forecast.

Service workers and shop and market sales workers, skilled agricultural and fishery workers, craft and related trades workers, and plant and machine operators and assemblers typically require a specific medium-level qualification, often acquired via vocational education or training. The skill sets they have cannot always be substituted by digitisation and organisational change, which means that simply hiring higher-qualified workers will often not be a feasible

course of action. The moderate to high hiring difficulties expected in these occupations can put a brake on innovation in sectors such as construction and agriculture, which play a crucial role in the green transition.

The expected degree of hiring is high and foreseen hiring difficulties are highest for elementary occupations. The implications of these hiring difficulties are likely to be less severe, as many elementary occupations require only a limited skill set that can be taught or acquired via work experience relatively quickly. The high degree of hiring simply reflects the change towards inter-mediate-level qualifications driven by the change in supply.

6.3.   Cedefop's Future Shortage Index: how shortages are likely to evolve until 2035

Cedefop's Future Shortage Index (FSI) uses core metrics of Cedefop's skills forecast to provide insight into future labour shortages by occupation (Figure 28) and by sector ([33]). The index shows that labour shortages will be mostly driven by growth of overall employment, followed by replacement needs, with mismatches in education composition also playing an important role for manual occupations.

In the group of highly skilled occupations, labour market pressures are expected to be most pronounced for legal, social, cultural and related associate professionals, production and specialised services managers and business and administration associate professionals. Employment in these occupations is expected to expand alongside high replacement needs. Among skilled non-manual occupations, labour market pressures are likely to be greatest for sales workers and personal care workers. At the lower end of the labour market, among manual and elementary jobs, the shortages will likely be highest for skilled agricultural workers and cleaners and helpers, primarily because of strong replacement needs.

For highly skilled non-manual occupations, expansion demand is most likely to create shortages. This is linked to the general trend of expansion of skills-intensive employment and possibly also an outcome of the twin tran-sition: expansion demand is highest for science and engineering, business, information and communication and legal professionals.

([33]) FSI calculates possible occupational shortages and does not provide information at the level of fields of study, which plays a crucial role in explaining shortages. For more information on the methodology, please see Annex.

Figure 28. **Cedefop Future Shortage Index by occupation – ISCO**

Legend: Expansion, Replacement, Imbalance, Future shortage indicator

Skilled non-manual occupations

41. General and keyboard clerks
42. Customer services clerks
43. Numerical and material recording clerks
44. Other clerical support workers
51. Personal service workers
52. Sales workers
53. Personal care workers
54. Protective services workers

Skilled manual occupations

61. Market-oriented skilled agricultural workers
62. Market-oriented skilled forestry, fishery and hunting workers
63. Subsistence farmers, fishers, hunters and gatherers
71. Building and related trades workers, excluding electricians
72. Metal, machinery and related trades workers
73. Handicraft and printing workers
74. Electrical and electronic trades workers
75. Food processing, wood working, garment and other craft and related trades
81. Stationary plant and machine operators
82. Assemblers
83. Drivers and mobile plant operators

0   0.5   1   1.5   2   2.5   3   3.5   4   4.5

■ Expansion   ■ Replacement   ■ Imbalance   ■ Future shortage indicator

NB: The imbalance indicator estimated for occupations has been used to construct the index for sectors. It has been calculated as the arithmetic average of the dominant occupations (defined as occupations that add to at least 50% of employment within the sector and typically have an individual share of 8% or more), assuming equal weights. The 2035 replacement demand rates were used to assess the degree of shortage stemming from replacement demand.

Source: Based on Cedefop skills forecast, see methodological note in annex.

Replacement demand will create relatively strong pressures for chief executives and health professionals, which may be challenging to manage because both profiles require particular qualifications and experience. However, for these high skilled occupations the shortage appears to be less linked to imbalances, as future supply is relatively well-aligned with demand. Imbalances will be stronger for associate professional occupations. Overqualification may rise because it is likely that such occupations will absorb some higher educated people.

Critical imbalance-driven shortages, for example for sales workers and personal care workers, need to be addressed. The skill sets needed for carrying out the activities such occupations entail may not be easily substituted by people with an academic or other type of high-level qualification. Shortages will be least pronounced for numerical and material recording clerks and other clerical support workers. Such profiles are good examples of occupations that can easily be supported by technology and digitalisation, allowing people with diverse backgrounds to enter them.

Shortages for most skilled manual occupations will predominantly reflect future replacement demand and, to some extent, imbalances. Building and related trades workers, and drivers and mobile plant operators will be the ones

facing the most prominent shortages. Such occupations require specialisation and practical knowledge that typically cannot be acquired via education at a higher level.

With high future imbalances, street and related sales and service workers are likely to become the elementary occupations with the highest shortages. Shortages of cleaners and helpers are driven by strong replacement needs.

The FSI calculated for sectors (Figure 29) demonstrates the impact of digital and particularly green transition even more strongly. Even though the implementation of the Green Deal will bring about strong demand for employment in certain sectors, such as electricity, gas, stream and air conditioning supply, future imbalances are not expected to exert significant pressures. The future shortages indicator is lowest for mining and quarrying, a sector with low replacement demand and declining employment because of green transition policies.

Figure 29. **Cedefop Future Shortage Index: 17 sectors – NACE 1 digit**

Expansion   Replacement   Imbalance   Future shortage indicator
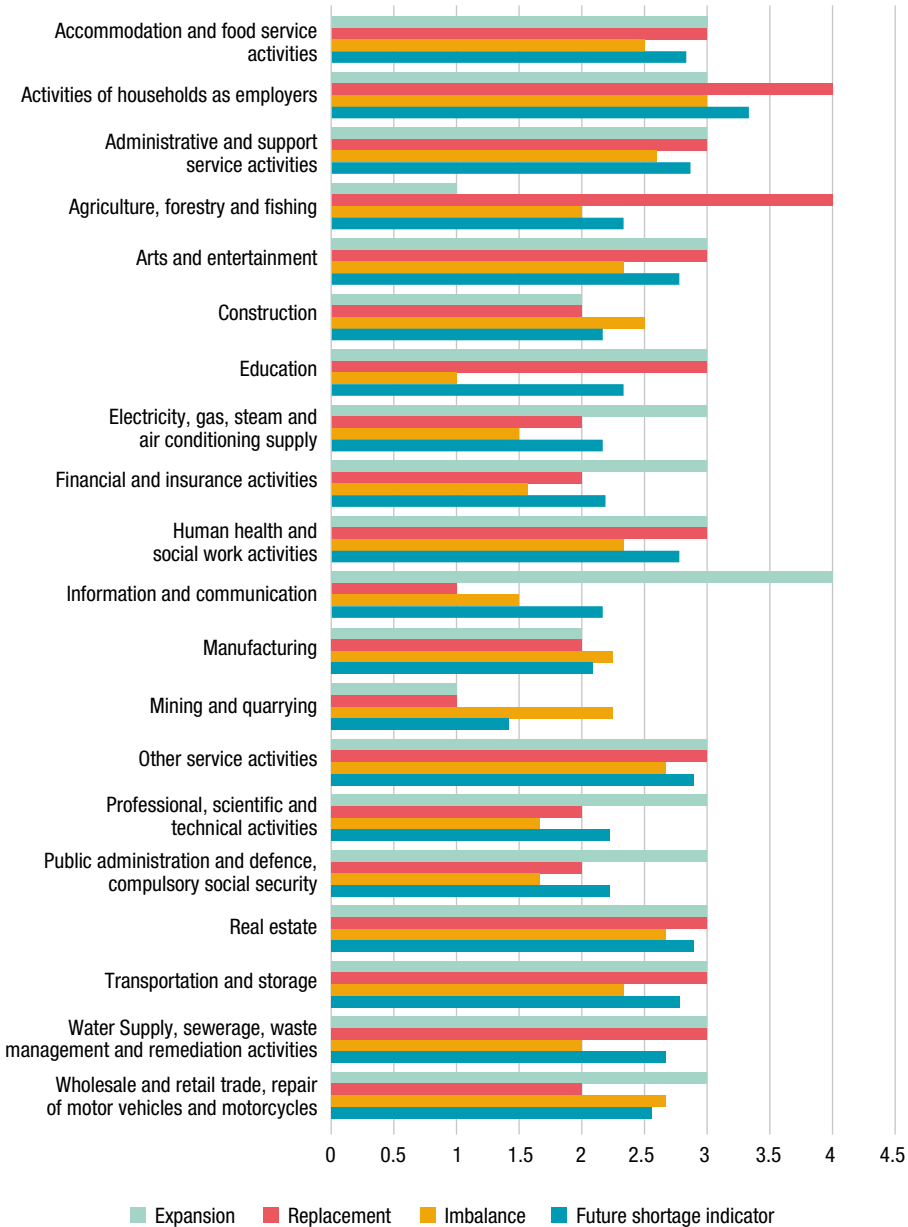
Source: Cedefop own calculations, based on 2023 Cedefop skills forecast.

The FSI for manufacturing should be treated with caution, as aggregating quite different sectors into a single measure prevents developing conclusions that apply generally: employment in electronics, electrical equipment, and machinery equipment will grow thanks to the green transition and contribute to shortages in manufacturing sector. The opposite is likely to be the case in manufacturing sectors facing employment decline, such as manufactured fuels (-39%) and textiles, clothing and leather (-13%). In construction, future shortages are expected to remain limited, given the moderate construction activity in EU and the impact the war in Ukraine is having on building costs. Among the sectors viewed as most important for the green transition in the Green Deal Implementation Plan launched in 2023, transportation and storage, water supply, sewerage and waste management are expected to face the strongest shortages. In these sectors, employment will rapidly expand, replacement needs will be high, and there will be pronounced imbalances.

The ageing workforce in human health and social work activities will translate into increasing replacement demand, while population ageing more generally will lead to future employment growth. Given that ageing societies strongly rely on health professionals and health associate professionals, the future shortages may turn out to be more persistent than the FSI suggests, as the training and specialisation of such professionals takes time. Policy-makers should not forget lessons learned during the COVID-19 pandemic, which highlighted the importance of health workers and helped make a case for a strong and well-maintained health sector. It will be important to keep a focus on addressing the structural problems the pandemic helped reveal and on avoiding future recruitment bottlenecks in the sector [34].

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[34] Cedefop (forthcoming). Care sector data insight.

6.4. Analysing online job advertisements broadens understanding of shortages

Online job advertisements (OJA) provide fast and detailed information about labour market and skills trends. They do not give the insight into future labour market imbalances and shortages that forecasts offer but make it possible to reflect on shortages in the context of current labour market trends (Box 7). Monitoring absolute change in the volume of OJA posted for occupations or in sectors alone is not sufficient for developing sound assessments of shortages. Looking at relative changes in demand is a more viable option, but also has its limitations. An increase in OJA posting intensity can be driven by shortages, but it can also be the result of changes in employment structure, changes in recruitment strategies, and workplace innovation. What complicates OJA-based analysis of shortages is that comparable information about the profile of people searching for jobs, and about whether or not the post was filled in the end, is lacking [35].

Box 7. **Leveraging the power of big data to reflect on skills shortages**

The use of online job advertisements (OJA) for talent search has accelerated in recent years. Improving access to high-speed internet and rising digital skills in the population made OJAs an increasingly effective job and talent search method. With high employment rates across the EU contributing to the scarcity of talent, employers increasingly use OJAs to search for suitable candidates, even for occupations where more traditional recruitment channels were more common not long ago. The trend towards more online job search and recruitment has been accentuated by the COVID-19 pandemic. During lockdowns employers could not effectively use other recruitment methods such as physical postings and job fairs.

Cedefop's Skills OVATE platform demonstrates how using OJA for talent search became much more common. A few years ago, OJAs were mainly to recruit staff into 'high level occupations', but recent trends show that online job postings for lower and medium level occupations rapidly accelerated. The number of OJA for a skilled non-manual job more than doubled (+103%) between 2020 and 2022, and OJAs for elementary jobs grew by 91%. With increasing coverage of the labour market, over time the representativeness of OJA data and analysis improved.

Calculating the demand intensity of occupations is the most appropriate approach to gaining insights into possible shortages using OJA. The indicator combines the percentage change in the volume of OJAs over time and the

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[35] For strengths and weaknesses of OJA data use for labour market analysis see Cedefop; European Commission; ETF et al. (2021). *Perspectives on policy and practice: tapping into the potential of big data for skills policy.*

changes in the shares of 2-digit ISCO occupations in broad occupational groups: highly skilled, skilled manual, skilled non-manual, and elementary as defined in Cedefop's skills forecast ([36]). The shortage assessment for ICT professionals, for example, considers the percentage change in the number of OJAs posted by employers in time, and interprets this by comparing it to the respective change in OJAs for its 'parent' group, highly skilled occupations. Occupations with high demand intensity have experienced more dynamic growth compared to other occupations at the same skill level. The indicator shows in which occupations demand grew fastest, indicating possible shortages.

OJAs aimed at recruiting business and administration professionals, hospitality, retail and other services managers, and administrative and commercial managers grew faster than those targeting professionals for other highly skilled occupations. In the group of skilled non-manual occupations, numerical and customer services clerks are the occupations in greatest demand. The same holds in the group of skilled manual occupations for drivers and mobile plant operators, assemblers and stationary plant and machine operators, which are considered to have high demand intensity. Food preparation assistants were assessed as a high demand occupation among elementary occupations, while for cleaners and helpers and labourers in construction, manufacturing, and transport the demand intensity can be characterised as medium. The findings resemble those based on the Cedefop future shortage indicator (FSI), which also found evidence pointing in the direction of shortages for business and administration professionals and drivers.

Seeing the two types of analysis together (Figure 30) makes it possible to reflect on whether current labour market tensions are likely to persist. The principle of empirically assessing whether shortages based on recent data should be viewed as a threat in the long-run or as only as a short term 'blip' can be used to design early warning systems. The analysis shows that ([37]):

(a) for high-skilled occupations, short-term tensions will likely remain, and bottlenecks can increase, particularly for occupations strongly linked to the green and the digital transition. Examples include legal, social and cultural professionals and associate professionals, who are often in charge of designing and applying legislation and regulations and science and engineering professionals, the 'thyroid' occupations (Chapter 3);

(b) among skilled non-manual occupations, the recent spike in demand for

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([36]) These four groups were chosen based on the assumption that employers are competing for 'similar type of talent' or qualification level.

([37]) For elementary occupations no trends can be identified because of lack of data.

customer services clerks and numerical recording clerks appears temporary; Personal care workers are much more likely to be in short supply also in the longer term, reflecting the rapidly growing need for care services in ageing societies;

(c) among skilled manual occupations, shortages are likely to affect construction workers and metal and machinery trade workers, but there are no indications these are acute.

Figure 30. **Short- and long-term skill shortage indicators by occupation skill level**

HIGH-SKILLED

SKILLED MANUAL

OC11: Chief executives, senior officials and legislators
OC12: Administrative and commercial managers
OC13: Production and specialised services managers
OC14: Hospitality, retail and other services managers
OC21: Science and engineering professionals
OC22: Health professionals
OC23: Teaching professionals
OC24: Business and administration professionals
OC25: Information and communications technology professionals
OC26: Legal, social and cultural professionals
OC31: Science and engineering associate professionals
OC32: Health associate professionals
OC33: Business and administration associate professionals
OC34: Legal, social, cultural and related associate professionals
OC35: Information and communications technicians

OC61: Market-oriented skilled agricultural workers
OC62: Market-oriented skilled forestry, fishery and hunting workers
OC63: Subsistence farmers, fishers, hunters and gatherers
OC71: Building and related trades workers, excluding electricians
OC72: Metal, machinery and related trades workers
OC73: Handicraft and printing workers
OC74: Electrical and electronic trades workers
OC75: Food processing, wood working, garment and other craft and related trades
OC81: Stationary plant and machine operators;
OC82: Assemblers
OC83: Drivers and mobile plant operators.

—— Future shortage indicator   —— OJA indicator

SKILLED NON-MANUAL

OC41: General and keyboard clerks
OC42: Customer services clerks
OC43: Numerical and material recording clerks
OC44: Other clerical support workers
OC51: Personal service workers
OC52: Sales workers
OC53: Personal care workers
OC54: Protective services workers

ELEMENTARY
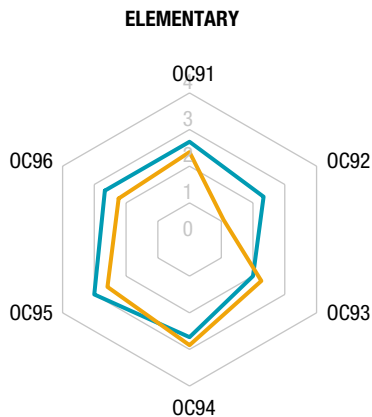
OC91: Cleaners and helpers
OC92: Agricultural, forestry and fishery labourers
OC93: Labourers in mining, construction, manufacturing and transport
OC94: Food preparation assistants;
OC95: Street and related sales and service workers
OC96: Refuse workers and other elementary workers

——— Future shortage indicator   ——— OJA indicator

Source: Cedefop FSI and Demand intensity indicator (based on OJA); own calculations.

CHAPTER 7

Key take-aways

The challenges and opportunities the EU faces are powerful enough to reshape the future irreversibly. This gives leverage for veering away from primarily short-term focused policy responses to immediate skills challenges, and moving towards holistic approaches that aim to achieve a more technological advanced, greener and fairer future. The evidence presented and discussed in this report points to the following recommendations for policy and its implementation:

(a) **Investing in STEM and digital skills.** To make the twin transition work for EU economies, societies, and citizens, more must be done to promote STEM education and occupations and greatly expand digital skills training at all levels. A focus on twin transition skills can reinforce policies to drive up participation and labour market activation measures aimed at integrating medium-skilled people (particularly females) and other groups with low participation rates. This will help fortify labour supply and alleviate the tensions affecting occupations and skill profiles in high demand. Activation contributes to the fairness of the green transition and workforce diversity, paves the way to a more technologically and socially inclusive future, and helps offset some of the labour market impact of population and workforce ageing.

(b) **Championing VET as an agent of change.** The green transition and the shift to carbon neutrality and circularity requires recalibrating VET systems, so that new programmes can be developed, and existing ones updated. VET and other skills ecosystem players need to promote and market such programmes to avoid negative stereotypes about jobs or sectors among learners constraining green progress. Upscaling green VET will boost skills for the green transition – digital and others – and expand 'green' mindsets. Understanding which labour or skill shortages are temporary and which are more structural helps decision-makers set priorities for the 'sprint' and 'marathon' approaches VET needs to pursue (Cedefop briefing note, March 2022). Pressing short-term shortages must be addressed quickly, for example via short courses leading to microcredentials. Where persistent shortages are anticipated, a 'long-haul' approach, which links skill development to new business models and building green and circular

mindsets, may be more appropriate.

(c) **Moving away from silo-thinking.** Thinking in policy silos is incompatible with the rapid and complex change the digital and the green transition bring about and the need for skills and VET policies and practices to be more inclusive and resilient to external shocks and crises. Traditional boundaries between the worlds of education and training, employment and careers are blurring. Trends and challenges may be national or global, but sectoral needs and local realities define how they can be tackled. Stakeholder partnerships, such as the ones championed by the Pact for Skills, need to be encouraged and upscaled. Centres of vocational excellence enable comprehensive skills governance and widen collaboration opportunities that help tap synergies and foster innovative solutions. It takes skills eco-system thinking, trust-based partnership, and expanding support for learners to create the right conditions for delivering VET and skills in line with multiple policy objectives. Placing such principles centre stage in policy implementation also helps leveraging the benefits of better coordination between skills policy and other policy areas, such as economic growth, innovation, social equity and migration.

(d) **Engaging employers.** Digitalisation, automation, and adopting circularity principles and production modes profoundly change the worlds of work and learning and transform business models. Employers need to be well-informed of change, to understand it and acknowledge the benefits, and must translate shifting paradigms and trends into business practices (for example, by integrating circularity into key performance indicator frameworks and financial reporting). Micro companies and small and medium-sized enterprises (SMEs) need to be active players in skills ecosystems and have access to support. This helps them identify the skills they need to make and shape their own twin transition, to invest in developing them, and to expand opportunities for their use. Practices within companies are equally important. Evidence points to the crucial role HR practices play in skills utilisation and shows that where they are lacking or inferior, labour or skills shortages tend to be more severe.

(e) **Empowering local level players.** The local level crucially matters for realising Europe's digital and green ambitions. Reaching EGD goals and easing labour market tensions cannot happen without local level action and the engagement of local policy-makers, employers, VET providers, social partners and citizens. Transparent collaboration helps develop shared visions, which can become a basis for addressing current and future challenges and benefitting from emerging opportunities. Local companies, particularly

SMEs, can become advocates of change and contribute to the uptake of twin transition driven transformations. Cities and regions that think and act more strategically and interconnect different policy areas will be more successful in developing the new skills and mindsets the twin transition requires. In regions facing shrinking employment due to the green transition, and smaller urban centres that experience bottlenecks in funding and infrastructure or skill shortages, it takes local level thinking to ease labour market and social tensions. In regions where the labour market is tight, up-skilling workers, stimulating mobility within and between EU countries, or looking into the possibilities of recruiting workers from third countries can be viable policy options. Mitigating labour market tightness is also a matter of addressing horizontal mismatch, for example via attractiveness campaigns, incentives, or by prioritising investment in skills the local economy needs.

(f) **Anticipating skill needs for better decision-making.** VET can only be relevant and responsive when strong feedback loops between the education and training system and the labour market are in place. These need to incorporate the needs and aspirations of national, regional and local level stakeholders. European countries with comprehensive skills governance systems tap the potential of different skills anticipation approaches (such as skill forecasts, skill foresights, surveys, big data), combine them to gain profound insight into labour market trends and skill needs, and involve stakeholders in all policy-making layers. Such arrangements underly resilience and the capacity to react to unexpected shocks and to adapt to perma-crisis.

(g) **Understanding and addressing skill shortages.** The evidence presented in this report shows that there is no single approach to measuring shortages and that the available data make it challenging to draw definite conclusions about what drives them. There is no one-size-fits-all explanation for the tightness in different labour market segments and there are no simple policy solutions that can tackle the proliferation of (labour/skill) shortages in European labour markets. The underlying reasons for shortages are diverse: while some shortages are short-term, others are more structural. Policy-makers need to reflect on of the type of response, its intensity, its time-horizon, and need to decide which groups of people and/or employers to target. While high quality training will be the answer in some cases, improving working conditions and human resource management practices may be much more suitable in others.

Acronyms

AI	artificial intelligence
ECS	European company survey
EGD	European Green Deal
ESCO	European multilingual classification of skills, competences and occupations
ESDE	Employment and social developments in Europe
FSI	Future Shortage Index
ICT	information and communication technology
IT	information technology
OJA	online job advertisement
R&D	research and development
RRP	Recovery and resilience plan
STEM	science, technology, engineering and mathematics
VET	vocational education and training
WIH	Web Intelligence Hub

References
[URLs accessed 21.6.2023]

Acemoglu, D. and Autor, D. (2011). Skills, tasks and technologies: implications for employment and earnings. *Handbook of Labor Economics*, Vol. 4.

Acemoglu, D. and Restrepo, P. (2019). Automation and new tasks: how technology displaces and reinstates labor. *Journal of Economic Perspectives,* Vol. 33, No 2, pp. 3-30.

Beręsewicz, M. and Pater, R. *Inferring job vacancies from online job advertisements: 2021 edition*. Luxembourg: Publications Office, 2021.

Beręsewicz. M. et al. (2023). *Improving the quality of the job vacancy survey in Poland using administrative and online data.* Presentation at Conference on New Techniques and Technologies for Official Statistics NTTS 2023, Brussels, 7-9 March 2023.

Bivens, J. (2019). *Updated employment multipliers for the U.S. economy*. Washington, DC: Econonic Policy Institute.

Bobasu, A. and De Santis R.A. (2022). *The impact of the Russian invasion of Ukraine on euro area activity via the uncertainty channel.* ECB Economic Bulletin, No 4, 2022.

Bonoli, G. and Emmenegger, P. (2022) Collective skill formation in a knowledge economy: challenges and dilemmas. In Bonoli, G. and Emmenegger, P. (eds) *Collective Skill Formation in the Knowledge Economy, pp. 1-30.*

Cedefop (2010). *The skill matching challenge. Analysing skill mismatch and policy implications.* Luxembourg: Publications Office.

Cedefop (2012). *Future skills supply and demand in Europe: forecast 2012.* Luxembourg: Publications Office.

Cedefop (2015). *Skill shortages and gaps in European enterprises: striking a balance between vocational education and training and the labour market.* Luxembourg: Publications Office. Cedefop reference series, No 102.

Cedefop (2018). *Insights into skill shortages and skill mismatch: learning from Cedefop's European skills and jobs survey.* Luxembourg: Publications Office. Cedefop reference series, 106.

Cedefop (2021a). *Digital, greener and more resilient: insights from Cedefop's European skills forecast.* Luxembourg: Publications Office.

Cedefop (2021b). *The green employment and skills transformation: insights from a European Green Deal skills forecast scenario.* Luxembourg: Publications Office.

Cedefop (2022a). *Cities in transition: how vocational education and training can help cities become smarter and greener.* Luxembourg: Publications Office. Policy brief.

Cedefop (2022b). *Too good to waste: tapping the potential of vocational education and training in the waste management sector.* Luxembourg: Publications Office. Policy brief.

Cedefop (2022c). *An ally in the green transition.* Cedefop briefing note, March 2022

Cedefop (2022d). *Employment trends during the COVID-19 pandemic: skills intelligence data insight.* Cedefop data insights, April 2022.

Cedefop (2022e). *Challenging digital myths: first findings from Cedefop's second European skills and jobs survey.* Luxembourg: Publications Office. Policy brief.

Cedefop (2023a). *Growing green: how vocational education and training can drive the green transition in agri-food.* Luxembourg: Publications Office. Policy brief.

Cedefop (2023b). *From linear thinking to green growth mindsets: vocational education and training (VET) and skills as springboards for the circular economy.* Luxembourg: Publications Office.

Cedefop (2023c). *The greening of the EU construction sector: skills intelligence data insight.* Cedefop data insights, April 2023.

Cedefop (2023d). *2023 skills forecast technical report: March 2023: unedited proof copy.*

Cedefop (forthcoming). *Care sector.* Cedefop data insights series.

Cedefop (forthcoming). *ICT Services Sector.* Data insights series.

Cedefop and Eurofound (2018). *Skills forecast: trends and challenges to 2030.* Luxembourg: Publications Office. Cedefop reference series, No 108.

Cedefop and Eurofound (2020). *European company survey 2019: workplace practices unlocking employee potential.* Luxembourg: Publications Office.

Cedefop et al. (2022). *Work-based learning and the green transition.* Luxembourg: Publications Office.

Cedefop. *National VET systems*

Cedefop; European Commission; ETF et al. (2021). *Perspectives on policy and practice: tapping into the potential of big data for skills policy.* Luxembourg: Publications Office.

Darvas, Z. et al. (2023). *European Union Countries' recovery and resilience plans.* Bruegel Data sets.

DRIVES (2021). *Automotive skills agenda: strategy & roadmap.* DRIVES Blueprint project. DRIVES development and Research on Innovative Vocational Education Skills.

ESSA (2022). *Micro interview: overcoming gender stereotypes in the ICT sector.* European Sofware Skills Alliance.

Eurofound (2020). *EurWORK industrial relations dictionary: labour market slack.*

Eurofound (2021). *COVID-19 and digitalisation.* Eurofound research digests, 15 December 2021

Eurofound (2022). *First impacts of the Ukrainian crisis on employment in the EU.* Eurofound article, 7 April 2022

Eurofound and Cedefop (2019). *European Company Survey (ECS) 2019.*

European Commission (2020). *ESCO classification.*

European Commission (2021). *The 2021 ageing report: economic and budgetary projections for the EU Member States (2019-2070).* Luxembourg: Publications Office.

European Commission (2022). *2022 State of the Union Address by President von der Leyen.* 14 September 2022.

European Commission (2023). *Environmental engineers.* The ESCO classification: occupations.

European Commission, Joint Research Centre and Czako, V. (2020). *Employment in the energy sector: status report 2020.* Luxembourg: Publications Office.

European Commission. DG Employment, Social Affairs and Inclusion (2023). *Employment and social developments in Europe: addressing labour shortages and skills gaps in the EU: annual review 2023.* Luxembourg: Publications Office.

European Council and Council of the EU (2022). *Infographic: Liquefied natural gas infrastructure in the EU.*

European Investment Bank (2022). *Digitalisation in Europe 2021-2022: evidence from the EIB Investment Survey.*

European Parliament (2023). *EU energy security and the war in Ukraine: from sprint to marathon: briefing.* Brussels: European Parliamentary Research Service.

Eurostat (2019). *Glossary: human resources in science and technology (HRST).* Eurostat statistics explained.

Eurostat (2020a). *EUROPOP2019: population projections (2019-2100).* Eurostat data: statistical themes; population and demography: population projections.

Eurostat (2020b). *Glossary: activity rate.* Eurostat statistics explained.

Eurostat (2022a). *European statistical recovery dashboard: July edition.* European statistical recovery dashboard.

Eurostat (2022b). *EU Labour Force Survey.*

Eurostat (2023a). *Annual detailed enterprise statistics for industry (NACE Rev. 2, B-E).* [SBS_NA_IND_R2]. Eurostat data sets.

Eurostat (2023b). *CROS portal: trusted smart statistics: web intelligence hub (TSS-WIH).* CROS Collaboration in Research and Methodology for Official Statistics

Eurostat (2023c). *National accounts employment data by industry* [nama_10_a64_e]. Eurostat data browser.

Eurostat (2023d). *Professionals and technicians employed in science and technology occupations.* Eurostat statistics explained.

Eurostat and Cedefop (2020). *Towards the European Web Intelligence Hub: European System for Collection and Analysis of Online Job Advertisement Data (WIH-OJA)* carried out during 2020-24.

Livanos, I. and Ravanos, P. (2021). *Job loss and COVID-19: do remote work, automation and tasks at work matter?* Luxembourg: Publications Office. Cedefop working paper, No 4.

Lundvall, B.A. (2016). *The learning economy and economics of hope.* London: Anthem Press.

Lundvall, B.A. and Lorenz, E. (2012). Innovation and competence building in the learning economy: implications for innovation policy. In: Asteim, B.T. et al. (eds.) Interactive Learning for Innovation, pp. 33-71. Berlin: Springer.

McGrath (2021). *Report on labour shortages and surpluses: November 2021.* Bratislava: European Labour Authority (ELA).

Müller, C. (2022). *World robotics 2022: industrial robots: statistics, market analysis, forecasts and case studies.* IFR Statistical Department. Frankfurt: VDMA Services

Pouliakas, K. and Branka, J. (2020). *EU jobs at highest risk of COVID-19 social distancing: Is the pandemic exacerbating the labour market divide?* Luxembourg: Publications Office. Cedefop working paper, No 1.

Pouliakas, K. and Wruuck, P. (2022). *Corporate training and skill gaps: did COVID-19 stem EU convergence in training investments?* Luxembourg: European Investment Bank. EIB Working Paper, No 7, 2022.

WIH-OJA *database*

World Nuclear Association (2022). *Economics of nuclear power: updated August 2022.*

Cedefop online tools

Cedefop Skills intelligence.
Cedefop Skills forecast.
Cedefop Skills OVATE.
Cedefop Vocational education and training in Europe: detailed description of VET systems in Europe.

Skills in transition: methodology

Cedefop future shortage index methodology

The future skills shortage indicator is constructed around three areas of information coming from the Skills forecast. The first is expansion demand, which captures the extent to which the overall level of occupational employment to 2035 will be growing or contracting. This measure purely reflects future demand for employment and could reflect trends in sectoral employment, changes in the occupational structure of employment and the overall trends in the economy. Whether this demand materialises will depend on the available supply of labour ready to take up such employment. However, strong positive expansion growth may create future shortages for the occupation in question and the outcome will depend on the responsiveness of the wage mechanism and the availability of education and training to cover future demand.

The second is replacement demand, which looks at employment needs that will arise as the workforce leaves the occupation due to retirement, career changes, health, or other reasons. Replacement needs, generally, provide more job opportunities than new jobs, meaning that significant job opportunities arise even in occupations declining in size. Agricultural workers are a typical example, as ageing workers employed in the sector will need to be replaced. As in the case with expansion demand, the outcome will depend on other factors: companies and organisations may decide not to replace retiring workers due to budget reasons or they may be substituting labour with technology in highly routinised jobs. However, replacement demand is an important source of information as it will create the most future job openings and neglecting it may lead to misleading estimations.

The third is labour market imbalances, which captures the share of occupational employment that is likely to encounter difficulties in the future because there may not be enough available supply to match the demand in terms of formal education composition. These difficulties could come at any level of education: one occupation in the future may not have enough highly educated

employees to cover needs while, in others, the level of available education may exceed demand. In the former case this may lead to phenomena such as low productivity or employee stress; the latter may cause over-education, low job satisfaction and high turnover, with increased costs for the employer. Therefore, a good understanding of future labour market imbalances can aid prevention by taking the right measures.

In constructing the future skills shortage indicator, the three measurements ([38]) produced by the Cedefop Skills forecast have been transformed into indicators measuring the shortage on a scale 1 to 4, where 1 indicates a weak or no shortage and 4 ([39]) indicates strong shortage. The overall future skills shortage indicator is then constructed by an arithmetic average assuming equal weights.

The future shortage indicator has also been estimated for the 17 NACE, 1-digit, sectors using broadly the same methodology, with a few adjustments. As the imbalance indicator is only estimated for occupations, assumptions were made regarding its construction at the sectoral level. Its value for a sector was set equal to the arithmetic average of the dominant occupations ([40]), assuming equal weights. With regards to replacement demand, which for sectors is calculated in an ad hoc fashion, the 2035 rates were used. This means that the broad level of sectoral aggregation and the assumptions on imbalances place limitations on the approach.

Demand intensity indicator

The indicator is built as a combination of percentage change of the volume of online job advertisements (OJAs) over time and change in the share of individual two-digit ISCO occupations in the broad occupational group (highly skilled, skilled manual, skilled non-manual, elementary as defined in Cedefop Skills Forecast). For example, the shortage assessment for ICT professionals will not only take into account % change of OJAs over time, but also how this

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[38] These are: (a) 2021-35 per annum percentage net occupational employment change; (b) 2021-35 per annum occupational replacement change; and (c) percentage of occupational employment in 2035 likely to encounter education imbalances.

[39] To elaborate, 4 (1) is indicated where e.g. the net employment growth for an occupation is a standard deviation above (below) the average while 2 (3) is indicated where the growth is between the standard deviation above (below) the average and the average itself. In a similar manner, similar indicators have been constructed for all three areas.

[40] Occupations that add to at least 50% of employment within the sector and typically have an individual share of 8% or more are considered dominant.

% change compares to the % change of OJAs for its 'parent' group, highly skilled occupations.

The demand intensity indicator presents current changes in demand that were combined with the long-term indicator based on 2023 Cedefop Skills Forecast results. The comparisons can support early warning system approaches and can assess if the current perception of shortages could be perceived as a threat in the long run or as only a short term 'blip'. The analysis in Cedefop's *Skills in transition* report concerns two level ISCO occupations and focuses on four major occupational groups: high-skilled, skilled manual, skilled non-manual, and elementary occupations. The distinction between these four groups assumes that employers are competing for 'similar type of talent' or qualification level.

Calculations per occupational group are available in the tables below:

Table A1. **Demand assessment for high-skilled occupations (2020-22)**

Occupation	Occupation code	Share of OJAs	Demand intensity
Chief executives, senior officials, and legislators	OC11	1%	2.41
Administrative and commercial managers	OC12	5%	2.61
Production and specialised services managers	OC13	2%	2.28
Hospitality, retail, and other services managers	OC14	1%	2.65
Science and engineering professionals	OC21	6%	2.18
Health professionals	OC22	2%	1.83
Teaching professionals	OC23	2%	2.17
Business and administration professionals	OC24	7%	2.63
ICT technology professionals	OC25	8%	2.38
Legal, social, and cultural professionals	OC26	2%	2.13
Science and engineering associate professionals	OC31	4%	1.95
Health associate professionals	OC32	2%	1.89
Business and administration associate professionals	OC33	9%	2.37
Legal, social, and cultural associate professionals	OC34	3%	2.33
Information and communications technicians	OC35	1%	2.13

Source: Cedefop Skills OVATE. Own calculations.

Table A2. **Shortage assessment for skilled non-manual occupations (2020-22)**

Occupation	Occupation code	Share of OJAs	Demand intensity
General and keyboard clerks	OC41	2%	2.23
Customer services clerks	OC42	3%	3.59
Accounting clerks	OC43	3%	4.00
Other clerical support workers	OC44	2%	1.97
Personal service workers	OC51	3%	3.05
Sales workers	OC52	5%	2.77
Personal care workers	OC53	2%	2.62
Protective services workers	OC54	0%	2.16

Source: Cedefop Skills OVATE. Own calculations.

Table A3. **Demand assessment for skilled manual occupations (2020-22)**

Occupation	Occupation code	Share of OJAs	Demand intensity
Skilled agricultural workers*	OC61	0%	1.87
Skilled forestry, fishery, and hunting workers*	OC62	0%	1.00
Subsistence farmers, fishers, hunters and gatherers	OC63		3.01
Construction workers	OC71	2%	1.95
Metal, machinery, and related trades workers	OC72	3%	2.25
Handicraft and printing workers*	OC73	0%	1.93
Electrical and electronic trades workers	OC74	2%	2.31
Food processing, woodworking, garment workers	OC75	1%	2.21
Stationary plant and machine operators	OC81	3%	2.33
Assemblers	OC82	1%	2.38
Drivers and mobile plant operators	OC83	3%	2.68

Source: Cedefop Skills OVATE. Own calculations. * Occupations with low OJA counts; less reliable data. No data for occupation OC63 – Subsistence farmers, fishers, hunters, and gatherers.

Table A4. **Demand assessment for elementary occupations (2020-22)**

Occupation	Occupation code	Share of OJAs	Demand intensity
Cleaners and helpers	OC91	2%	2.38
Agricultural, forestry and fishery labourers	OC92		1.07
Labourers in construction, manufacturing, and transport	OC93	6%	2.26
Food preparation assistants	OC94	1%	2.89
Street and related sales and service workers	OC95		2.59
Refuse workers and other elementary workers*	OC96	0%	2.23

Source: Cedefop Skills OVATE. Own calculations. * Occupation with low OJA counts; less reliable. No data available for OC92 – Agricultural, forestry and fishery labourers, and OC95 - Street and related sales and service workers.

Underlying factors driving occupational labour shortages in Europe

The investigation into the underlying factors driving occupational labour shortages in Europe (e.g. high skill needs, skill mismatches, turnover and retention, low job quality, mobility), uses two dependent variables: a relatively broad list of 'persistent' occupational skill shortages at 3-digit ISCO level, as identified by the European Commission (ESDE 2023); and a detailed list of 4-digit shortage occupations, as identified by a report on labour shortages and surpluses of the European Labour Authority (ELA) (McGrath, 2021).

The ELA list of occupational skill shortages is compiled by synthesising information provided by the EURES National Coordinating Offices in 25 EU Member States, three autonomous Belgian regions, and Norway and Switzerland. The source of such information mostly comes from public employment services (PES) administrative data, as well as occupational forecasts and other combinations of sources (McGrath, 2021). The most recent list available at the time of the analysis refers to the period covering the latter half of 2020 and first quarter of 2021, incorporating the initial impact of the Covid-19 pandemic shock. From the ELA analysis, a total of 28 4-digit occupations are classified as 'most often' shortages; 19 of these are classified as shortages of 'high magnitude'.

For the Cedefop analysis, we assembled a comprehensive list that compiles

the 28 'most often' shortage occupations with three additional/residual high shortage ones and two elementary groups (cleaners and helpers in offices, hotels or domestic, corresponding to ISCO 3-digit category 911). This final list of 33 4-digit occupations was then merged with data on job-skill requirements and other indicators of job quality from Cedefop's second European skills and jobs survey (ESJS2) at the 4-digit ISCO level.

A probit multivariate estimation was subsequently deployed to detect the association between different sets of variables, **X**, corresponding to different theoretical determinants of occupational labour shortages, and the probability that individuals are employed in a shortage occupation (s) i.e. *P (s=1 | **X**)*. The analysis was first carried out on the whole sample of paid adult EU+ employees. To examine workers in shortage occupations, who are as comparable as possible in terms of their 'skill' level, to those in non-shortage ones, the analysis subsequently implemented the multivariate regression across broad occupations skill groups (skilled, semi-skilled, manual and elementary occupations) or 2-digit occupations.
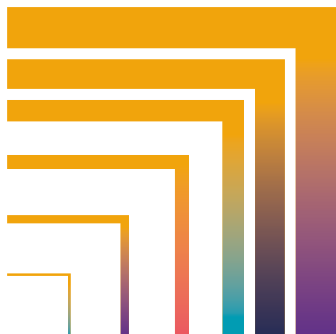
Skills in transition
The way to 2035

To make and shape the green and digital transitions, Europe needs a skills revolution. Sitting alongside the current VET and skills policy framework and expanding funding opportunities, Cedefop EU skills intelligence is a key resource that can help unleash it. Skills intelligence provides sound and trusted evidence on labour market trends and skill needs, which guides policy- and decision-makers in focusing their efforts when investing in skills and in skills matching.

This report is one of Cedefop's key contributions to the 2023 European Year of Skills. It broadens understanding of what has changed in EU labour markets in the past decade and uses Cedefop's 2023 skills forecast, sectoral foresight and big data-powered analysis to track ongoing and future trends. The report blends different types of evidence to foster better understanding of the labour market and skills impacts of the twin transition and current and future labour markets tensions.

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