

A Synthesis on the Demand for VET Skills in Transforming Labour Markets – Cross-Country and Regional Insights from Qualitative and Quantitative Analyses

Skills2Capabilities Working Paper, December 2025

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ABSTRACT

The deliverable at hand synthesises findings from work package 4 of the Horizon Europe project *Skills2Capabilities*, in which the demand for vocational education and training (VET) skills in the context of Europe's labour-market transformations were analysed. Drawing on four national studies, the synthesis combines quantitative labour market data from online job advertisements from Germany and the Netherlands with qualitative, regionally grounded analyses of transition processes in fossil-fuel-dependent regions in Estonia and Bulgaria. Across all four case studies, technological change, ecological transition and demographic shifts are transforming the structure of work and the skills and capabilities required in intermediate-level occupations. Quantitative evidence reveals rising demand for skill profiles, combining technical, digital and green competences, particularly in manufacturing, energy and logistics in well-off regions. Moreover, positive correlations between skills supply and demand across occupation are observed. Qualitative findings highlight barriers such as outdated curricula, low participation in (re)training and weak coordination between education providers and employers. In line with the project's overall mission, the synthesis report identifies the *common thread* across the four case studies: We argue that the ability of VET systems to anticipate skill needs determines the success of regional and sectoral transformations. Evidence from diverse methodological and contextual perspectives suggests that regions and countries that integrate evidence-driven monitoring with inclusive, flexible training provision are better positioned to adapt sustainably and successfully to transformations.

Skills2Capabilities, a Horizon Europe study, is about understanding how skills systems need to develop if they are to assist people to make labour market transitions – i.e. between jobs, employers or sectors – and thereby reduce the level of skill mismatch which might otherwise arise.

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1. Introduction

Europe is undergoing a transformation driven by intertwined processes of ecological, technological and demographic change. The European Green Deal, the Digital Decade Policy Programme and the pursuit of climate neutrality by 2050 are reshaping not only production systems and energy use, but also the structure and demands of labour markets (Caldarola et al., 2023; European Commission, 2023; Haas, Niebuhr, Vetterer, 2024). These shifts affect all economic sectors and skill levels, but they are particularly significant for vocational education and training (VET) occupations, because the latter provide the intermediate-level technical expertise behind the green and digital transitions (Kuczera, 2025).

The green transition aims to decarbonise industry and stimulate energy efficiency. These environmental objectives intersect with the digital transformation, which is automating routine tasks, introducing artificial intelligence into production processes, thereby changing the organisation of work. Taken together these transformations redefine occupational profiles and create new professional demands.

While these transformations are often discussed and perceived as global or at least national in scope, it is frequently overlooked that their implementation takes place at the regional level. Persistent, and in some cases widening, regional disparities are a defining feature of European societies (e.g. East vs. West in Germany, North vs. South in Italy, or central vs. peripheral regions in France). The pronounced regional differences in how ecological, digital and demographic transformations unfold, underline the need for a strongly regionalised perspective (Weßling et al., 2025).

Regions historically dependent on fossil fuels or heavy industry – such as Ida-Virumaa in Estonia or Pernik in Bulgaria, which represent one focus of this deliverable – face both the challenge of economic restructuring and social adaptation. At the same time, advanced industrial economies like Germany and the Netherlands – the second focus of the deliverable – are reconfiguring their VET systems to meet emerging demands for more complex skill profiles that combine technical, digital and green competences. In particular, the larger European countries deal simultaneously with pronounced regional inequalities – most notably between urban centres and rural regions, and in Germany also still historically between East and West. Moreover, current transformations that affect the demand for skills are not only driven by technological advances or the shift towards a green economy, but they also profoundly touch upon social and institutional dimensions. Social changes such as demographic ageing, out-migration and shrinking regions confront many countries and regions with additional adaptation pressures (Nicolini & Roig, 2024).

The capacity of individuals and regions to adapt depends not least on the responsiveness of qualification in VET systems. The inclusiveness of training opportunities and the effectiveness of coordination among governments, employers and educational institutions plays a crucial role in the implementation of transformation and change. In this context, VET systems act as one of the key mediators between macro-level policy ambitions and micro-level realities of learners, workers and employers.

This deliverable synthesises the findings from work package 4 of the Horizon Europe project Skills2Capabilities. The work package forms the core of the project's demand-side perspective by examining how labour-market transformations reshape the skills and capabilities required in intermediate-level occupations, complementing the work packages that focus on supply-side dynamics, institutional frameworks and policy interventions. The work package 4 brings together four country studies that differ in methodology and scale but converge on a shared analytical purpose: to understand how technological change, green transition and demographic restructuring translate into concrete demands for skills and occupations.

The four case studies were selected to juxtapose two countries (Bulgaria, Estonia) undergoing fundamental transitions, where the conditions necessary for work-based training are still emerging, with two more economically developed countries (Germany, the Netherlands) that are already at a more advanced stage in implementing these green and digital transitions. Within these different contexts the four studies demonstrate which challenges arise are when transition processes are at the beginning and when they are at a more advanced stage.

- The Bulgarian case focuses on the carbon-intensive region of Pernik in Western Bulgaria and provides qualitative analyses of ongoing transition processes. The semi-structured interviews targeted stakeholders such as policymakers and regional actors.
- The case study from Estonia pursues a similar objective to the Bulgarian one, as both qualitative sub-studies are designed as comparative analyses. The focus here is on the Ida-Virumaa region, where a total of 12 interviews with a similar target group were conducted.
- The German case uses large language models to quantitatively analyse online job advertisement (OJA) data. The analysis concentrates on two occupations that play a crucial role in the green and digital transition: warehouse logistics workers and ventilation technicians. Regional variation in labour demand and its relationship to regional characteristics is examined.
- Like the German case, the Dutch case applies quantitative methods, analysing large-scale OJA datasets to track labour demand. Here, the focus lies on comparing labour demand with the skills supply, specifically, what apprentices learn according to their curriculum. Here the full set of occupations is analysed.

The diversity of approaches is a major strength of this report. The quantitative analyses reveal macro-level trends and emerging demand patterns across economies as well as an in-depth focus on specific occupation. Whereas the qualitative regional cases expose holistic patterns concerning the social, cultural and institutional conditions that determine how transitions unfold and impact labour demand. Together, they illustrate the dynamic interplay between structure and agency.

The introduction of new green technologies, sustainable production methods and digital systems has begun to reshape the skills landscape. The demand for electricians, mechanics and technicians familiar with renewable energy systems is rising, while automation and smart technologies require workers capable of operating and maintaining complex, data-driven equipment. At the same time, transversal competences like communication, teamwork, adaptability and problem-solving are increasingly critical to navigate rapid change.

The Dutch OJA analyses show that significant mismatches persist between training provision and labour market demand because many VET curricula lag behind emerging requirements for green and digital competences. The qualitative studies reveal that retraining efforts can be hampered by linguistic barriers, low trust in institutions and insufficient coordination between education providers and industry. Without addressing these systemic challenges, the risk of regional polarisation increases: dynamic areas advance towards sustainable, high-value employment, while peripheral industrial regions struggle with unemployment and depopulation.

By integrating the diverse empirical materials and country contexts, this deliverable identifies a *common thread* running through all four cases. From this shared pattern, we conclude that VET systems must be better aligned with transformative labour-market demands, while ensuring that these transitions remain both socially just and regionally inclusive.

The report proceeds as follows: In the next sections, we outline and summarise the four studies' methodological design and present the country-specific findings. Next, we synthesise cross-cutting insights across the four countries focusing on transformation and evolving skill demand. The report concludes with recommendations for strengthening VET responsiveness, promoting lifelong learning and supporting regions in transition across the European Union.

2. The case studies

To explore these dynamics in depth, the following section presents four case studies that highlight regional differences in VET skill demand and the interplay of technological, green, and demographic transformations.

2.1 The green turn in Pernik, Bulgaria

2.1.1 Initial conditions

Bulgaria faces some of the most complex challenges in the European Union's transition toward a climate-neutral economy. These difficulties are due to structural characteristics of the national economy, including a comparatively high share of hydrocarbon energy sources, high energy intensity, widespread energy poverty, low energy efficiency of the building stock, as well as exceptionally low adult participation in education and training (Eurostat, 2025). Within this broader landscape, three Bulgarian regions have been identified as particularly vulnerable to the green transition in the Integrated National Energy and Climate Plan for 2021–2030 (INECP). These regions host concentrated clusters of coal mining, coal-based energy production, and industries embedded in carbon-intensive production models (INCEP, 2024). One of these territories is the region of *Pernik*, an industrial district. The region's development, demography and socioeconomic are characterised for decades by the coal mining industry and heavy manufacturing.

Pernik is situated in Southwestern Bulgaria, adjacent to the capital city of Sofia. While geographically well positioned, the region embodies many of the socioeconomic vulnerabilities associated with carbon-dependent industrial districts. According to the National Statistical Institute (NSI), Pernik has a population of approximately 111,032 residents, representing 1.7% of

Bulgaria's total population, with nearly half of them being older than age 50 (NSI, 2024). This demographic profile reflects long-term patterns of labour migration and an aging workforce that remains heavily tied to traditional industrial occupations.

Coal mining has played a defining role in the economic history of Pernik. Approximately 12% of all mineral extracting territories in Bulgaria are located within the Pernik district (WWF, 2021, p. 19). The region is one of the country's primary industrial centres, historically specializing in ferrous metallurgy, electricity and heat production, mechanical engineering, and metalworking. Although the light industry (notably tailoring), trade, and services have gradually expanded, industrial production continues to form the backbone of the regional economy. According to the data cited in Territorial Just Transition Plan – Pernik, in 2019, the industrial sector generated around one-third of the district's gross value added, with 11% of the population employed in industry and related enterprises (Ministry of Energy, 2024, p. 7). Recent years, however, have seen a deterioration in labour market outcomes. Since 2019, employment has declined, while unemployment has risen significantly (NSI, 2025a). These trends reflect both cyclical economic pressures and structural vulnerabilities associated with decarbonisation requirements that threaten the viability of coal-dependent industries.

The Territorial Just Transition Plan (TJTP) for Pernik forecasts profound labour market consequences from the green transition. It anticipates an 8–10% annual decrease in direct and indirect jobs linked to coal and carbon-intensive sectors through 2030, with additional reductions expected by 2038, the year projected for the full phase-out of mining and coal-fired power generation (Ministry of Energy, 2024). These projections underscore the urgency of reskilling, economic diversification and a strong need for institutional coordination in the region.

Educational attainment in Pernik paints a mixed picture. The district has a higher share of residents aged 25–64 with secondary education (65.7%) compared with the national average of 54%, yet only 17.1% hold higher education degrees, while 17.2% have primary or lower education (NSI, 2023). The district hosts ten secondary schools, of which 7 vocational education and training (VET) institutions (NSI, 2025b), which play a key role in shaping the future workforce. Despite this, Pernik's education and training systems face challenges in responding to evolving labour market demands, particularly in the context of technological upgrading and industrial transformation.

Recognising these structural needs, the Just Transition Fund has allocated €92 million to Pernik, targeting three domains:

- (1) the development of sustainable energy solutions industries,
- (2) support of social and employment development and
- (3) the diversification of the local economy (Ministry of Energy, 2024, p. 11).

The success of these investments in reducing the vulnerabilities and risks facing the region will depend on how effectively national, and especially regional, institutions coordinate interventions across education, labour markets and industrial policy. In this context, we examine the prerequisites for such coordination in the Pernik region, based on a qualitative research design, which is discussed in the following section.

2.1.2 Methodological Approach

The methodological approach for the Bulgarian and Estonian cases is aligned, with a comparative focus on the selected regions in the two countries being the core topic of another paper. The analysis is based on a qualitative research design and grounded in an *ecosystemic perspective*, examining how economic structures, institutional capacities, education systems, demographic trends and local governance interact to shape transition pathways.

The Bulgarian case study relies on semi-structured interviews with regional stakeholders, including employers, municipal representatives, education and training providers, labour office staff and civil society actors. The core topics of the interviews are:

- stakeholder perceptions of the green transition;
- expected impacts on employment and skills demand;
- institutional challenges and capacities;
- coordination between education, industry and policy actors;
- concerns rooted in historical experiences of economic transition;
- expectations for the region's future.

The study was approved by the Ethics Committee at the Bulgarian Sociological Association. The interviews took place between spring and summer 2025 and lasted between 40 minutes and two hours. In Pernik ten interviews were realised. Interview participants were recruited by combining publicly available contact information and the snowball method through researchers' existing networks. In most cases, initial contact was made via email, in some cases via phone. Table 1 presents an overview of the realised interviews in Bulgaria and Estonia and the specific stakeholders that were interviewed.

Table 1. Overview of interviews in Bulgaria and Estonia.		
Category	Estonia (EE)	Bulgaria (BG)
Policymakers (Estonia: 2, Bulgaria: 2)	EE_01, EE_02	BG_01, BG_02
Educators (Estonia: 3, Bulgaria: 2)	EE_03, EE_04, EE_05	BG_06, BG_08
Regional Actors (Estonia: 3, Bulgaria: 3)	EE_06, EE_07, EE_08	BG_03, BG_04, BG_09
Regional Employers (Estonia: 3, Bulgaria: 2)	EE_09, EE_10, EE_11	BG_07, BG_10
Trade Union Representatives (Estonia: 1, Bulgaria: 1)	EE_12	BG_05
Interviews by country	12	10
Total interviews		22

The overall response rates and general willingness of interviewees differed markedly between the two countries. While participants in Estonia were generally open and cooperative, in Bulgaria notable reluctance and refusals were encountered.

Secondary data and policy documents, including the Integrated National Energy and Climate Plan, NSI statistics, the Territorial Just Transition Plan, Eurostat data and analyses by civil society organizations such as WWF provide contextual and triangulating evidence (see NSI, 2024; Ministry of Energy, 2024; Eurostat, 2025; WWF, 2021). This combination of data sources supports a robust narrative of regional drivers and constraints shaping the green transition in Pernik

2.1.3 Evidence from Pernik: Transformation Pressures, Skills Challenges and Institutional Constraints

The following section summarises the key topics, challenges and perspectives raised by different stakeholders during the semi-structured interviews.

Transformation of Industrial Production and Supply Chain Dynamics. Regional stakeholders consistently reported throughout the interviews that the green transition is already placing measurable pressures on firms in the region. Companies acknowledge the increasing expectation to reduce carbon footprints across their supply chains and comply with sustainability and environmental standards imposed from above. These pressures stem not only from EU regulatory requirements but also from market dynamics and partner firms that increasingly demand green compliance throughout production processes.

For many enterprises, technological upgrading is viewed as the only viable route to remain competitive. However, employers emphasized in the interviews that successful adoption of new technologies requires long-term strategic planning rather than abrupt restructuring. Rapid, shock-type transformations evoke negative memories of the 1990s post-socialist transition, which was associated with mass layoffs, economic instability, and profound social dislocation. As a result, firms fear that poorly managed or overly rapid decarbonisations might replicate the failures from the past.

Skills Gaps and Systematic Weaknesses in Education and Training. A central theme in the interviews was the mismatch between existing workforce skills and the skills needed for a green-technology sector. Although the region benefits from a technically experienced workforce, many employees lack the specialised qualifications required for renewable energy production, digitalised manufacturing or energy-efficiency technologies. The TJTP highlights that workers will need training in areas such as photovoltaic panel installation, electrical equipment, inverters aluminum structures, and other renewable energy components (Ministry of Energy, 2024).

The interviewees stressed that Pernik's education and training system is poorly prepared to support large-scale reskilling. They particularly identified the following systemic weaknesses:

- Declining quality of vocational education since the 1990s.
- Insufficient practical training in VET schools, with outdated equipment and curricula misaligned with green sectors.
- Lack of teachers trained in emerging technological fields, leading to shortages in specialized instruction.
- Weak coordination between education providers and local industry, limiting opportunities for dual training or apprenticeships.

- Inadequate public awareness of training opportunities, compounded by low adult motivation to engage in learning.
- A prevailing cultural view that education is something “completed at school,” rather than an ongoing process.

The challenges are amplified by Bulgaria’s extremely low rate of adult participation in life-long learning programmes of less than 2%, compared to an EU average of 13.5% (Eurostat, 2024). This constrains the region’s ability to retrain workers at the scale required for a successful green transition.

Labor Market and Demographic Constraints. Pernik’s demographic composition poses additional barriers to transformation. The region has an aging population combined with sustained out-migration, particularly among younger and higher-skilled workers seeking opportunities in Sofia or abroad. This reduces the pool of workers available for retraining. At the same time, the current regional labour market provides limited incentives for workers to pursue green-transition skills. Data provided by a representative of the local Labor Office indicate that blue-collar occupations account for 55% of vacancies, followed by unskilled jobs at 37%, and specialist positions at only 8%. In such a context, workers may consider retraining as risky or unattractive, reinforcing patterns of low participation in lifelong learning.

Governance, Transparency and Trust Deficits. Stakeholders express strong concerns about transparency and public communication in the implementation of the green transition. Many fear that funds from the Just Transition Mechanism could be misallocated or mismanaged. These fears are rooted in persistent distrust toward state institutions, stemming from experiences during earlier periods of economic restructuring. These fears are rooted in persistent distrust toward state institutions, stemming from experiences during earlier periods of economic restructuring.

The interviewees highlighted specifically the following governance challenges:

- Fragmentation between national, regional and municipal authorities.
- Limited communication with businesses and the public on transition risks and opportunities.
- Bureaucratic obstacles to accessing transition funds.
- Insufficient coordination among education providers, businesses and public institutions.
- Poor dissemination of information about training, support programs, or new sectoral opportunities.

2.1.4 Policy Implications

The Pernik case illustrates that the green transition is not solely a technological or economic process but a social one, embedded in demographic trends, institutional capacities and historical trajectories.

Modernise Vocational Education and Align Programs With Green Sector Needs. The region needs to modernise its VET provision by updating curricula to include renewable energy and sustainability competencies, while also investing in modern laboratories, equipment and practical training facilities. Strengthening dual-training models in cooperation with local industry and

expanding teacher training in emerging technological fields are equally essential to ensure a future-oriented skills base.

Develop a Regional Lifelong Learning System. To address the low participation in adult training, Pernik would benefit from establishing regional VET and LLL centres closely connected to industry and offering modular, flexible and online formats suitable for employed adults. Additionally, employer incentives for workforce development and early-orientation programmes in schools that promote pathways into green professions would help strengthen long-term skills supply.

Strengthen Governance and Communication. Effective transition requires transparent implementation of Just Transition Fund initiatives and clear, consistent public communication about forthcoming changes. It also depends on creating meaningful participation mechanisms for workers, employers, unions, municipalities and civil society, as well as strengthening coordination between national and local authorities. All efforts must be coordinated between national ministries, regional authorities and local employers to ensure alignment with labour market needs.

Support Economic Diversification and Attract New Industries. Pernik should better leverage its industrial legacy and proximity to Sofia by attracting firms in renewable energy, engineering and digital manufacturing, while also supporting start-ups and SMEs in sustainable sectors.

Demographic Challenges. Long-term success requires strategies to retain and attract young workers, supported by housing and mobility incentives (again the close distance to Sofia should be considered) as well as improvements in urban infrastructure and amenities.

Taken together and combined with efforts to reduce distrust and reluctance towards transformation in general, these measures can strengthen the region's attractiveness and resilience.

2.2 Estonia's green transition in Ida-Virumaa

2.2.1 Initial conditions

Estonia's green transition must be understood considering its historical energy system, shaped for decades by the extraction and processing of oil shale, its long-standing integration into the Russian energy infrastructure, and the concentration of a predominantly Russian-speaking workforce in the oil shale mining, chemical processing and energy generation industries of the Northeast. While Estonia has committed to the European Green Deal's objective of reaching climate neutrality by 2050 (European Commission, 2019), it also seeks to maintain low dependence on energy imports, in particular secure energy independence from Russia and generally strengthen the resilience of its critical energy infrastructure. Based on these goals, the country aims to achieve at least 65% renewable energy in gross final energy consumption by 2030. Research, development and innovation in green hydrogen, biomethane and smart energy solutions are central to the National Energy and Climate Plan's (Ministry of Climate, 2024) strategic approach to achieving this transition.

Within this broader national strategy, the region of *Ida-Virumaa* holds a unique position. It is the only Estonian region receiving support under the EU's Just Transition Fund (JTF). *Ida-Virumaa*'s economy remains heavily dependent on oil shale extraction and processing. Historically, it was Estonia's engine having provided the majority of the country's electricity. This shaped the region's industrial identity. Approximately 70% of regional production is tied to oil shale-related industries, reflecting a low level of economic diversification and creating significant vulnerabilities in the face of decarbonisation and the green transition. The region is further constrained by geopolitical instability, strained economic relations with Russia, high energy prices and infrastructural shortcomings (Anger-Kraavi, et al. 2024).

Comparable with Pernik, *Ida-Virumaa* faces pronounced demographic challenges. Its population has steadily declined since the 1990s, falling from 221,807 inhabitants to 132,286 in 2024 (Statistics Estonia, 2025a). This is among the steepest regional population declines in the EU. Projections indicate a further 22% reduction by 2035 (Statistics Estonia, 2025b). This is in stark contrast to the modest 2% Estonian average decline, which is expected over the same period.

Beyond that, the region experiences a high socioeconomic vulnerability. In 2023, the at-risk-of-poverty rate in *Ida-Virumaa* reached 35%, compared with the national average of 21%, and has been increasing over the last decade (Statistics Estonia, 2025c). The population is predominantly Russian-speaking (around 70%), with strong intergenerational traditions of employment in heavy industry (Kesküla, 2014). This linguistic and cultural profile poses particular challenges considering Estonia's ongoing shift toward mandatory Estonian-language instruction across all levels of education, including vocational schooling.

The transformation of *Ida-Virumaa* will have significant implications for its labour market. Approximately half of the current oil shale workforce, which is about 2,800 workers, will require retraining and upskilling (Michelson et al, 2020). The remaining half is expected to have more transferable skills but will nonetheless need support to transition into alternative employment. Against this backdrop, the Estonian Just Transition Territorial Plan (Ministry of Finance, 2022) emphasises the continued importance of heavy industry in the region, arguing that local workers' technical skills, industrial experience and workplace cultures should form the basis for restructuring. It envisions attracting new industrial firms aligned with Estonia's ambitions for smart, ecological production, alongside the support and modernisation of existing industries such as chemicals, plastics, metalworking, electrical equipment, textiles, mining, and related manufacturing.

A second strategic pillar for the region is strengthening the ICT sector, especially in connection with automation and digitalisation processes, and the development of micro-entrepreneurship, healthcare, sustainable tourism and creative industries. With regard to training and skills development, the JTTP stresses the expansion of vocational, higher and adult education, including work-based learning; enhanced provision of Estonian-language instruction; and the development of curricula focusing on digital competence, entrepreneurial thinking and green skills. These

measures aim not only to improve the employability of displaced oil shale workers but also to widen the region's skills base.

Overall, Ida-Virumaa embodies the complex intersection of linguistic, industrial, demographic and geopolitical transitions that shape Estonia's conversion into a climate-neutral economy. The following section briefly outlines the research design for the Estonian case study, followed by an analysis of the empirical insights gained from interviews conducted in the region.

2.2.2 Methodological Approach

The methodological design mirrors that of the Bulgarian case, drawing on a qualitative and ecosystemic analytical framework. The Estonian case also relies on semi-structured interviews with a broad range of regional stakeholders, including policymakers, employers, educators, labour market intermediaries and civil society organisations (see also Table 1). In Ida-Virumaa, twelve interviews were conducted. In contrast to Bulgaria, interview partners were more forthcoming, interested and cooperative, facilitating rich and detailed conversations on the region's transition challenges.

2.2.3 Evidence from Ida-Virumaa: Updating Curricular, Shrinking region and language barriers

Transformation of Training Systems and Curricula. A central component of Ida-Virumaa's transition strategy concerns the expansion and modification of educational offerings, particularly in VET and higher education. Higher education institutions have begun integrating themes related to sustainability, green technologies and circular economy into their programmes. Virumaa College, part of Tallinn University of Technology, has long been a centre of technical and oil shale-related research but has diversified its offering to include ICT and chemistry programmes. With JTF support, it has introduced applied bachelor's and master's programmes in Sustainable Entrepreneurship, Circular Economy, Sustainable Chemical Technologies, Sustainable Industry, and Green Energy Technologies. Narva College of the University of Tartu has launched a master's programme in Robotics and Data Science Applications, directly linked to regional industrial needs.

In VET, the Ida-Virumaa Vocational Education Centre is investing in new laboratories, updated learning bases and modernised curricula. Examples include new programmes for solar panel installation and plans for additional programmes in building automation and mechatronics. The school aims to prepare for "future jobs", such as software development and UX design, while also integrating soft skills to attract learners. Admissions to these new programmes have so far been positive, though educators expressed concern that enrolment may decline due to the requirement to study in Estonian.

Retraining and Adult Learning Opportunities. Beyond formal VET and higher education, JTF support enables a range of short training courses delivered by vocational centres, private training institutions. Also, external providers offer "pop-up" training in the region. Courses include digital skills, Estonian and English language instruction, business skills, chemical and environmental technologies, customer service, and construction-related skills such as welding and CNC operation. Many are free of charge and are offered in both Estonian and Russian (the latter with

Estonian technical terminology modules). In addition, the Unemployment Insurance Fund plays an important role in procuring training, offering career counselling and supporting employers in workforce development. Estonian-language training remains a key priority, reflecting national language policy.

Persistent Language Barriers and Skills Mismatches. Interviewees identified language proficiency as one of the most significant structural obstacles to retraining. The transition toward Estonian-language instruction in VET is particularly challenging in a region where most residents speak Russian as their first language and lack sufficient Estonian skills to understand technical subjects. Many adult learners also struggle to access retraining programmes offered mainly in Estonian. At the same time, the linguistic demands of local workplaces remain inconsistent: while many industrial jobs operate in Russian, international firms often require English, creating a multilayered linguistic landscape that complicates training strategies. Employers expressed dissatisfaction with the alignment between educational programmes and industry needs. Some firms must train workers entirely in-house, including cases of large-scale foreign investment, because suitable VET programmes do not exist nationally. Specialist skills required for areas like magnet production are not taught anywhere in Estonia, necessitating recruitment from abroad.

Motivational and Practical Barriers to Training. Several interviewees stressed the reluctance of both employers and employees to engage in retraining. Employers often refrain from releasing workers for training during work hours. They also fear that once employees acquire new qualifications and language skills, they may leave for better-paid jobs elsewhere. Among workers, especially those formerly employed in high-paying oil shale positions, motivation to retrain is low. Ambivalence stems from lingering uncertainty about the finality of the sector's decline, given past political decisions to postpone closures, and from concerns that new jobs will not match previous wage levels. Older workers, particularly those without Estonian language or digital skills, are considered especially vulnerable. Interviewees frequently highlighted late-middle-aged, non-Estonian-speaking women and older men from the oil shale sector as facing the greatest labour market difficulties.

Systemic Gaps, Public Skepticism and the Legacy of Past Transitions. Stakeholders reported broader systemic barriers linked to public communication, information gaps and mistrust. Residents lack clear information about the types of new jobs being created, making it difficult to make informed decisions about (re)training. The concepts of “green skills” and “green transition” are often perceived as vague or politically motivated, contributing to skepticism. The application procedures for JTF support were described as bureaucratic and insufficiently flexible, particularly regarding funding for modern equipment essential for VET institutions.

The legacy of earlier transitions plays a major role in shaping local attitudes: Previous restructuring periods generated profound social and economic instability, leaving many residents skeptical of centrally driven reforms. Ida-Virumaa is also known for strong Eurosceptic tendencies and a sense of political marginalisation, intensifying distrust toward national and EU institutions. As several respondents noted, the green transition has triggered emotional stress and uncertainty among workers. Some stakeholders questioned the long-term viability of new industries and the relevance of retraining programmes.

Demographic and Labour Market Constraints. Demographic decline exacerbates the problems on the labour and training market. The region suffers from a shrinking working-age population, an ageing population structure and a poor dependency ratio. The most available local labour supply are low-skilled, Russian-speaking and often long-term unemployed workers. This does not align with the growing demand for digitally proficient, multilingual specialists and engineers. Companies increasingly rely on international recruitment to fill these specialist roles. Meanwhile, the unattractive living environment, marked by outdated Soviet-era housing and limited amenities, discourages incoming specialists from settling in the region.

2.2.4 Policy Implications

The transformation of Ida-Virumaa illustrates how the green transition intersects with linguistic, demographic and institutional factors, presenting challenges that extend beyond technological innovation. Since the challenges are similar, also the policy recommendations are often comparable those identified for Pernik, Bulgaria:

Strengthen VET and Higher Education for Green Transition. Curricula should be continuously aligned with industry demands, particularly in the areas of renewable energy, digitalisation and sustainable manufacturing. Investments in modern laboratories, updated equipment and specialised teacher training are essential to ensure that learners acquire the practical and technological skills required for new industrial activities.

Develop Regional Adult Learning Ecosystem. Given the linguistic and motivational barriers identified, adult learning must be made more accessible through flexible, modular, bilingual and workplace-based formats. Expanding Estonian-language instruction that is context-specific and technically oriented is crucial. Employer incentives to support worker participation in training should be strengthened, particularly in companies operating shift-based production.

Improve Governance, Transparency and Public Communication. Clear, accessible information on newly created jobs, training opportunities and transition timelines would help counter public skepticism. Coordination between regional and national authorities should be enhanced to ensure coherent implementation of JTF measures, while easing bureaucratic burdens for companies and training providers.

Support Economic Diversification and Improve the Living Environment. To attract high-skilled specialists and retain younger workers, Ida-Virumaa must invest in urban renewal, modern housing and public amenities. At the same time, targeted strategies for industrial diversification will be crucial for long-term regional resilience.

Address Social Vulnerabilities and Mitigate Inequalities. Retraining efforts should prioritise vulnerable groups, particularly older non-Estonian-speaking workers and long-term unemployed women. Tailored programmes combining language skills, digital skills, basic technical training and social support services can help bridge multiple labour market barriers.

While both regions, Pernik in Bulgaria and Ida-Virumaa in Estonia face structural vulnerabilities, the empirical material suggests that certain components of the green transition, particularly stakeholder engagement, educational modernisation and governance coherence, are progressing more smoothly in Ida-Virumaa than in Pernik. This relative advantage appears linked to Estonia's longer-standing investments in digitalisation and innovation, stronger institutional coordination,

and more responsive education providers. However, at the same time, the region faces specific challenges such as severe demographic decline and linguistic barriers.

2.3 Mapping regional skill demand in Germany

2.3.1 Initial conditions

Germany stands out in Europe for its strong industrial base, its highly standardised VET system, and its pronounced regional disparities that continue to shape labour-market dynamics (Jung et al., 2023). While the country is a leading actor in the green and digital transitions, these transformations unfold unevenly across regions. Southern Länder such as Bavaria remain economically strong, whereas parts of North Rhine-Westphalia and Eastern German (in particular rural) regions struggle with structural weaknesses, demographic ageing and out-migration. These established differences have consequences for employers' recruitment strategies and shape the degree to which firms can adapt to emerging labour and skill demands.

On the one hand, the *green transition* is particularly visible in building technology and heating systems, where *ventilation technicians* play a key role. Their tasks include integrating renewable technologies such as heat pumps or solar thermal systems, ensuring compliance with safety and energy-efficiency standards, and configuring increasingly digitalised control systems (Bundesagentur für Arbeit, 2025a). Access to this occupation is tightly regulated through standardised VET, legal provisions under the Handwerksordnung and technical norms that restrict installation work to certified professionals. These strong institutional boundaries reduce regional variation in job requirements and limit employers' flexibility in hiring.

On the other hand, the *digital transition* is reshaping logistics and supply chains, where *warehouse logistics operators* take on expanded responsibilities in digitally supported material management, tracking systems and automated warehouse processes (Bundesagentur für Arbeit, 2025b). This occupation is far less standardised: a large share of workers hold no formal qualification, and employers have greater discretion in defining skill and qualification requirements. As a result, regional labour-market conditions play a more significant role in shaping hiring practices in logistics than in building technology.

Labour-market tightness remains a common challenge across regions: 64% of German firms report difficulties filling skilled positions (Hohendanner et al., 2025). However, these shortages manifest differently across the country. They are more severely in rural, ageing and structurally weak regions, particularly in the East (Buch et al., 2024). The literature suggests that, in response to hiring difficulties, employers may adjust qualification requirements, broaden their applicant pools, or rely more on recruitment agencies. (Brenzel & Müller, 2015). Yet, little is known about the extent to which regional differences in employers' recruitment strategies are reflected in online job advertisements (OJAs).

Unlike the cases of Pernik and Ida-Virumaa, which focus on single regions undergoing profound transformations, the German case examines two occupations, namely ventilation technicians and

warehouse logistics operators, across the entire country. As a result, the German findings reflect differences in regional labour-market patterns rather than region-specific transition dynamics. Thus, while the former two provide an in-depth picture of regions in transition, the German case explicitly illustrates how labour-demand patterns and the green and digital transformation are implemented differently across regions, even within nationally regulated occupations.

2.3.2 Methodological Approach

The German case adopts a quantitative design and analyses all online job advertisements (OJAs) published in 2024 for two occupations: ventilation technicians (ISCO 7126) and warehouse logistics operators (ISCO 4321) (Textkernel, 2024). The data were collected from commercial job platforms and from the German Federal Employment Agency. Several filtering steps excluded apprenticeships, degree-requiring roles, non-German posts and OJAs without geocoded workplace data. Recruitment-agency postings were removed from regional analyses, because the metadata typically refer to the agency's location rather than the actual workplace.

The analysis uses Natural Language Processing (NLP) to extract skills and qualifications. Sentences were preprocessed, manually annotated and used to fine-tune the JobBERT-de model (Gnehm et al., 2022) to distinguish requirement-relevant sentences from contextual information. Occupation-specific skills were matched using BERUFENET dictionaries, whereas transversal skills were mapped to the ESCO taxonomy. Multi-label classification using logistic regression, SMOTE oversampling and hard negative sampling ensured reliable assignment across skill categories (Chawla et al., 2002; Clavié & Soulié, 2023; Robinson et al., 2021).

The analysis combines:

- **Skill complexity:** number of occupation-specific skills noted in an OJA
- **Transversal skills**
- **Specificity of formal qualifications:** measured through an ordinal scoring model reflecting how narrowly employers define required credentials
- **Regional indicators:** urbanisation, economic strength, attractiveness, labour-market tightness, and structural transformation (BBSR, 2025; BMWK, 2024; KOFA, 2025), skill importance indices (Fabo et al., 2017) quantify how frequently each skill appears in a region.

In contrast to the interview-based designs in Bulgaria and Estonia, the German case relies exclusively on large-scale text analytics, enabling systematic measurement of regional variation but offering less insight into local perceptions or governance processes.

2.3.3 Evidence on Skill Demand Across German Regions

Limited Regional Variation in Highly Standardised Occupations. Ventilation technicians show remarkably little regional variation in skill requirements across region. Correlations between regional indicators and skill or qualification specificity remain below .10, underscoring the dominance of regulatory standardisation. This aligns with strong legal and institutional boundaries

in this occupation, where safety rules and manufacturer warranty requirements limit flexibility that are reflected in OJA data (DVGW G 600; DIN EN 806-4).

Greater Variation in Low-Standardised Occupations. For warehouse logistics operators, OJAs display greater heterogeneity. The data suggests that urban and economically strong regions list more occupation-specific skills. Moreover, employers more often specify narrower formal qualifications in urban areas. The picture is less clear concerning transversal skills, which vary only slightly across regions. Overall, the findings suggest a small but consistent urban specialisation effect for warehouse logistics but no differences across regions for ventilation technicians. This is somewhat in line with previous research (Kok, 2014; Rouwendal & Koster, 2025).

Labour-Market Tightness: No Clear Adjustment in OJA Requirements. Despite expectations from labour-shortage research (Brenzel & Müller, 2015; Linckh et al., 2024), no evidence was found that companies in tight labour markets reduce qualification requirements. A plausible explanation is that adaptations occur later in the recruitment process, not at the level of job advertisements.

Recruitment Agencies as Regional Actors. The results reveal distinct spatial patterns in the use of recruitment agencies as intermediaries. For warehouse logistics operators, recruitment agencies publish more OJAs than employers themselves, and their involvement is widespread, showing no systematic regional pattern. However, for ventilation technicians the use of recruitment agencies is strongly concentrated in structurally weak, low-income and economically transforming regions in Eastern Germany. Agency involvement is negatively correlated with GDP per capita and positively associated with unemployment levels and GRW transformation funding, indicating that intermediaries play a particularly prominent role where labour-market conditions are weaker and structural change is more pronounced. This supports the idea that in regions facing structural weaknesses, intermediaries compensate for limited local applicant pools.

Skill Importance Patterns. Most transversal skills (e.g., teamwork, reliability, efficient working) are highly standardised across both occupations, suggesting that employers rely on conventional templates rather than tailoring soft skills to local labour

2.3.4 Policy Implications

The German findings demonstrate that the green and digital transitions interact with the institutional structure of the VET system and with persistent regional disparities. Several policy implications emerge:

Enhance Responsiveness of VET in High-Demand Occupations. Even though –or particularly because – ventilation technicians show minimal variation in requirements across regions, the evidence suggests that their flexibility and adaptability need to be better aligned with local conditions in order to respond effectively to on-site demands and to play a central role in an efficient green transition.

Support Structurally Weak Regions Through Recruitment and Training Incentives. Since recruitment agencies play a compensatory role in Eastern and structurally weak areas, targeted regional training subsidies, mobility assistance and employer incentives for local skill development could help reduce reliance on intermediary hiring channels.

Improve OJA Transparency in Anticipation of Pay Transparency Directive. The EU Pay Transparency Directive (Directive (EU) 2023/970, 2023) may generate new regional dynamics by revealing salary differences, thereby strengthening negotiation power in less attractive regions, enabling analysis of wage–skill relationships, and reducing uncertainty among applicants.

Expand Research on Employer Flexibility in Requirements. Germany’s OJAs reveal little downward adjustment of formal requirements despite labour shortages. Future analyses should focus on: the degree of requirement flexibility (e.g., “preferred” vs. “required”), wage offers (once available) and additional benefits (mobility support, training opportunities) to understand how employers compensate for local recruitment difficulties.

While the Pernik and Ida-Virumaa cases reveal deep institutional and demographic constraints that limit the capacity for reskilling, the German case shows fewer skill-mismatch issues but highlights segmentation between highly and less standardised occupations. This suggests that policy interventions should not only respond to regional needs but also consider the specific characteristics of different occupations and their regional embeddedness. Targeted strategies (e.g. occupation-specific training programs, flexible upskilling pathways and employer engagement) could help improve adaptability and efficiency in the green and digital transitions.

2.4 Dynamics of skill demand in the Dutch Labour Market

2.4.1 Initial conditions

Like other European countries, the Netherlands is undergoing rapid change, driven by digitalisation, the growing complexity of production systems and the transition toward a climate-neutral economy (OECD, 2023). These developments reshape the content of work, increase the demand for digital, technical and socio-emotional skills, and heighten the importance of well-functioning VET pathways (Autor et al., 2003; Acemoglu & Autor, 2011; Deming, 2017).

With roughly 40% of 15–19-year-olds enrolled in VET programs, the system is a central pathway for occupational qualification in the Netherlands (OECD, 2023). A nationally standardised curriculum framework (CREBO), which is regularly updated ensures that program content and assessment procedures are uniform across schools. This standardisation provides a unique opportunity to systematically compare educational skill supply with employer skill demand.

Dutch employers face persistent labour shortages, particularly in technical, digital and care-related occupations (OECD, 2023). Against this backdrop, the alignment of VET curricula with labour-market requirements has become a key policy concern. OJA data provide real-time information on employer needs, while Dutch VET curricula represent a stable institutional benchmark for what students learn. Linking these data makes it possible to examine how quickly the education system adapts to the evolving skill landscape.

Similar to the German case, and unlike Pernik and Ida-Virumaa, the Dutch case operates at the national level and focuses on the alignment between national VET curricula and the nationwide

demand for skills, rather than on regional restructuring dynamics. However, like the first two cases, it is concerned with the mismatch between the skills acquired and those required by employers.

2.4.2 Methodological Approach

The Dutch case combines three large-scale data sources:

- **JobDigger vacancy data:** a dataset of around 14 million OJA postings (2021–2023), scraped from roughly 1,700 websites. After restricting to vacancies requiring an MBO-level (VET) qualification and no prior experience, 7 million postings remain, representing early-career labour demand.
- **Standardised VET curricula:** nationally uniform MBO programs obtained from SBB (*Samenwerkingsorganisatie Beroepsonderwijs Bedrijfsleven*; Cooperation Organisation for Vocational Education, Training and the Labour Market), containing detailed descriptions of competences and learning objectives (2016–2021).
- **Graduate survey data:** a nationally representative survey of VET graduates 1.5 years after graduation, including self-reported mismatch and wage outcomes (N = 45,784).

Skills from both curricula and OJA are mapped onto six competency domains following the O*NET taxonomy (basic, social, technical, systems, complex problem-solving, and resource-management skills). Skill mismatch is operationalised as the Euclidean distance between curriculum-based and vacancy-based skill vectors for individuals working in occupations matched to their field of study.

The empirical analysis proceeds in three steps: First, identifying temporal and structural patterns in employer skill demand; second, assessing alignment between VET curricula and occupational skill requirements; third, estimating the association between measured mismatch and labour-market outcomes using fixed-effects models.

2.4.3 Evidence on Skill Demand and Mismatches in the Dutch labour market

Dynamics of Employer Skill Demand. Vacancy trends between 2021 and 2023 show strong seasonal fluctuations, which peaked mid-year and fell during winter, but the composition of required skills remains highly stable over time. The demand for technical and complex problem-solving skills has increased slightly, consistent with technological upgrading (Acemoglu & Restrepo, 2018; Hershbein & Kahn, 2018). Sectoral patterns confirm the plausibility of the skill classification: social-intensive sectors such as education and care prioritise interpersonal skills, while construction and industry emphasise technical skills.

Curriculum–Demand Alignment and Mismatch Patterns. Curricula and employer skill demand are positively correlated, especially for technical and social skills, indicating that Dutch VET programs broadly reflect labour-market needs. Yet the Euclidean distance measure reveals substantial heterogeneity:

- **High mismatch:** sales demonstrators, service managers, medical secretaries.
- **Low mismatch:** construction managers, bus and tram drivers, pharmaceutical technicians.

Occupations with complex, rapidly changing task profiles tend to exhibit larger mismatches, while standardised or stable professions show stronger alignment between training content and job requirements.

Consequences for Labour-Market Outcomes. Skill mismatch has clear economic implications. A one-unit increase in the mismatch index are associated with **19.6** percentage point higher likelihood of self-reported mismatch (attenuating after occupational and industry fixed effects), 30% lower monthly earnings and 22.3% lower hourly wages. These wage penalties persist even after controlling for occupation, industry, year and individual characteristics. The results suggest that mismatches between what VET curricula and employers' demand translate into lower early-career earnings.

2.4.4 Policy Implications

The Dutch findings underline the importance of improving the responsiveness of VET programs to emerging skill needs. Three policy directions follow:

Strengthen Curriculum Updating Mechanisms. While the Dutch VET system already operates regular curriculum revisions, evidence indicates that certain occupations experience faster task shifts than curricula can accommodate. Real-time labour-market intelligence (e.g. vacancy analytics) could serve as an input into SBB's review cycles, especially for digitally intensive or service-oriented occupations where mismatch is highest.

Expand Targeted Upskilling and Transitional Pathways. Given the substantial wage penalties associated with mismatch, targeted interventions, could reduce the adjustment burden for graduates entering dynamic labour markets.

Improve the Integration of Skill Demand Data into VET Governance. Stronger institutional channels between employers, training providers and curriculum developers are needed to ensure that skill shifts (e.g. rising demand for complex problem-solving and technical competencies) are translated into teaching content more rapidly.

Whereas the qualitative analyses of regions in Bulgaria and Estonia highlighted how institutional capacity, demographic constraints, and trust deficits influence the demand for VET skills, the Dutch and German cases reveal pronounced differences across occupations. Moreover, the Dutch analysis bridges to the qualitative studies by placing a strong emphasis on the relationship between skill supply and demand and the associated challenges.

3 Discussion and Conclusion

This deliverable summarises the methodologically, geographically and substantively broad work carried out in Work Package 4 of the Skills2Capabilities project on the demand for VET skills. To analyse skill and capability demand as comprehensively as possible, this work package employed multiple countries, combining both qualitative and quantitative methods and drawing on diverse theoretical approaches. The result is a rich and insightful set of findings that illuminate trends and

challenges in VET demand against the backdrop of profound labour-market transformations. Driven by the green transition, digitalisation and demographic shifts, these transformations are reshaping occupational structures and redefining the competences and capabilities required in intermediate-level jobs.

The report synthesises four case studies that adopt complementary methodological approaches: qualitative, regionally focused analyses in Bulgaria (Pernik) and Estonia (Ida-Virumaa), and large-scale quantitative analyses of online job advertisements (OJAs) in Germany and the Netherlands.

The qualitative case studies highlight the multidimensional pressures facing fossil-fuel-dependent regions. In Pernik, Bulgaria, the coal-intensive economy faces declining employment and structural vulnerabilities, intensified by an ageing population, low participation in lifelong learning and weak coordination and mistrust in and between VET providers, industry and policymakers. Similarly, Ida-Virumaa in Estonia, historically reliant on oil shale extraction, confronts sharp demographic decline as well as linguistic barriers (Russian speaking region in Estonia) and yet again social skepticism toward transition policies. While local VET institutions are expanding curricula in renewable energy and digitalisation mismatches between training provision and labour-market needs persist, especially for non-Estonian-speaking workers and older adults.

The German and Dutch cases illustrate labour-demand patterns across larger, more diversified economies. Germany's analysis reveals that highly standardised occupations, such as ventilation technicians, display minimal regional variation in skill requirements, whereas less standardised occupations, like warehouse logistics operators, show regional heterogeneity influenced by urbanisation and economic strength. The role of recruitment agencies in structurally weaker regions highlights the importance of compensatory mechanisms in addressing local skill shortages. In the Netherlands, comparison between VET curricula and employer demands uncovers substantial skill mismatches in rapidly changing occupations, with measurable wage penalties. Thus, despite a nationally standardised system, curricula struggle to keep pace with technical and problem-solving demands.

Across all four cases, a *common thread* emerges: the ability of VET systems to anticipate, align with and respond to evolving skill demands is central to the success of regional and sectoral transitions. The four studies also show that *responsiveness* itself has multiple dimensions. On the one hand, industries, especially those undergoing rapid technological change require the ability to quickly adapt to new tools, processes and skills. On the other hand, VET schools and (re-)training institutions face structural constraints that limit their ability to rapidly integrate new subjects, equipment or pedagogical approaches. Outdated curricula may persist not only because change is slow, but because past curriculum reforms were only partially effective, illustrating that frequent updates do not automatically lead to more relevant ones. In certain sectors, the underlying nature of occupations is changing so profoundly that incremental curricular adjustments may be insufficient; some mismatches emerge not from slow VET responses but from transformations that outpace what school-based training alone can address.

Taken together, these insights show that key challenges include outdated or insufficiently adaptive curricula, limited capacity for practical and work-based learning, low adult participation in lifelong

learning, weak institutional coordination and demographic constraints. Conversely, regions that integrate evidence-driven monitoring, flexible and inclusive training provision and very importantly strong collaboration between education providers and employers are much better positioned to navigate the green, digital and demographic transformations successfully.

The four case studies highlight that effective policy interventions should be sensitive to regional, occupational and individual contexts. By proactively aligning VET provision with the evolving nature of work and by recognising the structural constraints faced by schools and training providers, regions and countries can reduce skill mismatches and foster socially inclusive and economically resilient transitions within European labour markets.

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