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GRIT

Identification of Skills Shortages and Opportunities for Youth Engagement Programs & VET Learning Materials

Havencentrum · vitant (Provinciaal Centrum voor Volwassenenonderwijs) · Provincie Antwerpen · Alfa-college · provincie groningen · ma-co · Port of Hamburg Marketing

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ROBUST & SMART ECONOMIES

Introduction

The transition to a greener economy is a crucial component of the European Union's strategy to address the pressing challenges posed by climate change. Central to this transition is the **European Green Deal** (EGD), which sets ambitious targets for reducing greenhouse gas emissions, achieving economic growth without depleting natural resources, and ensuring that no one or no region is left behind. The EGD's implications are far-reaching, impacting not only environmental policy but also economic structures, labour markets, and (therefore) (vocational) education and training (VET).

This report, developed as part of the **GRIT project** aims to identify (inter-)regional developments, skills shortages, education and training supply, as well as opportunities in youth engagement programs and VET learning materials that are essential for supporting the green industrial transition. The GRIT project, co-funded by the European Union, focuses on enhancing the capacity of regions in the North Sea area, particularly the provinces Groningen and Antwerp, and the city of Hamburg, to meet the demands of the green industrial transition.

The report is based on a comprehensive **desk study and stakeholder consultation**, of which the latter involved 28 companies, sectoral, and educational institutions across these regions. It provides analysis of major developments affecting the labour market due to the green industrial transition, with a specific focus on the energy sector and energy-intensive industries. Furthermore, it highlights the crucial role that VET plays in equipping both current and future workers with the competencies needed to navigate and contribute to a greener economy.

A common thread throughout this report is the **crucial role of green hydrogen[1] in the industrial transition** in Belgium, the Netherlands, and Germany. Green hydrogen offers a sustainable alternative to fossil fuels, enabling significant reductions in carbon emissions, particularly for hard-to-electrify sectors like energy-intensive industry such as steel and the chemical sector, as well as heavy duty transportation such as shipping and trucking. Seaports play a pivotal role in this transition as they serve as hubs for importing, producing, and distributing green hydrogen. Seaports allow for efficient integration of renewable energy resources, storage, and distribution infrastructure, facilitating cross-border collaboration across the North Sea Region and boosting the regional green hydrogen economy.

As the report delves into the sectoral trends, it emphasizes the dynamic developments within the energy transition and their significant **implications for the labour market and vocational education and training**. These developments are intertwined with broader structural trends such as globalization, digitalization, and automation, all of which are reshaping the demand for skills. The findings presented in this report are intended to inform policymakers, educators, and industry stakeholders about the critical areas where investments in (vocational) education and training are necessary to ensure a successful and socially just green transition. This report therefore serves as a base for the development of youth engagement programs and VET learning materials within the wider GRIT project.

[1] For readability purposes other molecules storing energy are also considered when using hydrogen or the acronym H2.

Desk study & stakeholder consultation

The European Green Deal and impact on the labour market

Among the challenges facing the European Union, climate change is one of the most urgent. In its State of the Union of 2020, the European Commission ambitiously aimed to become the first climate-neutral continent by 2050. To achieve this, the Commission introduced a new growth strategy – the **European Green Deal** (EGD) – which aims to (1) reduce net greenhouse gas emissions to zero by 2050, (2) deliver economic growth without depleting resources, and (3) ensure no individual or region is left behind. [2]

During the **Dutch-Flemish summit** in January 2023, government leaders discussed joint challenges posed by the shifting geopolitical context, the energy crises and the European Green Deal regarding energy supply security and industrial policies. Given its cross-border nature, it was affirmed to safeguard common interests together, especially concerning the energy-intensive industry facing ongoing high energy prices. Both the Dutch and Flemish regional government decided to further accelerate the energy transition at the EU level. Through a combination of measures, the Netherlands and Flanders aim to expedite industrial sustainability while maintaining strong industrial competitiveness. Therefore, they will intensify policy dialogue on industrial transition by exchanging best practices, identifying potential policy synergies, and advocating joint interests at the European level. To achieve (European) climate and energy objectives, the Netherlands and Flanders assign an essential (transitional) role to low-carbon hydrogen. Furthermore, collaboration in innovation in the chemical sector will be deepened, and facilitating the cross-border transport of hydrogen, CO2, and residual gases was reaffirmed. [3]

To contribute to the goals defined by the EGD, **Germany aims** at C02 neutrality by 2045 and to become a leading supplier of hydrogen technology. The German Federal Government (2020) wants to give the best-possible support to the various stakeholders in the hydrogen industry and therefore has created the National Hydrogen Strategy[4] including ambitious energy and climate targets. To achieve these goals Germany sets up prior steps such as to decarbonize its energy and raw material supply, which still heavily relies on fossil fuels. Hydrogen will play a key role in this transformation. The National Hydrogen strategy targets to use climate-friendly hydrogen technologies. According to the roadmap on expected hydrogen off-take, the German Federal Government estimates that total hydrogen demand will be 95 to 130 TWh in 2030[5]. The National Hydrogen Strategy promotes its rapid market rollout and the establishment of the necessary value chains. It contains plans to build industrial-scale Hydrogen production plants with total capacity of up to 5 Gigawatts (Gw) by 2030 which corresponds to 14 terawatt-hour of green Hydrogen Production and will require 20 TWh of additional renewals-based electricity.[6]

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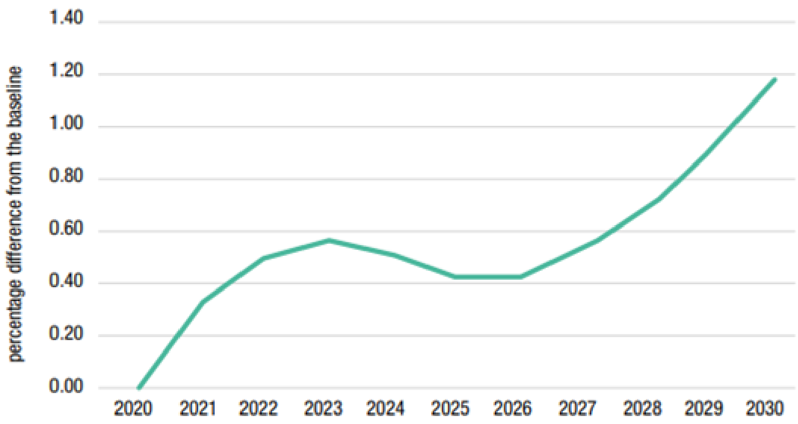
[2] European Commission. (2020). State of the Union 2020.
[3] Nederlands-Vlaamse Top. (2023). Slotverklaring "Door grenzen heen verbonden".
[4] The National Hydrogen Strategy (2024) https://www.bmwk.de/Navigation/EN/hydrogen/national-hydrogen-strategy.html
[5] Federal Ministry of Economic Affairs and Climate Action. Roadmap on expected hydrogen off-take in Germany..
[6] Stiftung Wissenschaft und Politik. (2020). The International Dimensions of Germany's Hydrogen Policy.

The green transition requires the implementation of numerous transformative measures to reduce greenhouse gas emissions. Such profound changes have significant **implications for the economy, employment, education, and training**. The profound changes generate various effects on the labour market, such as creating new jobs, transforming existing jobs, and phasing out obsolete jobs. Certain groups of workers are more vulnerable to these developments. To ensure a socially just transition, it is essential to protect the most vulnerable workers by ensuring they have access to decent jobs, particularly through education, retraining, and reskilling programs. [7]

Scenarios for assessing the impact of the green transition on the labour market reveal a complex picture of demand and supply channels that affect employment in various ways and with different intensities. The analysis is not always straightforward, particularly because there is no established definition of **'green jobs'**. Existing analyses often build upon the 'Green Jobs Framework', initially introduced in the US but applicable to the European labour market with some adjustments. This framework categorises jobs into four groups: [8]

- New jobs created by the emergence of new types of economic activities;
- Existing jobs, but with a significant portion of tasks changing due to green activities;
- Unchanged jobs with an increasing demand due to green activities in the economy;
- Jobs unaffected by the transition ('non-green' jobs).

Figure 1. **Forecast employment impact of the EGD (% difference between EGD skills forecast scenario and baseline), EU-27**



Source: Cedefop skills forecast, 2020 baseline and EGD scenario estimates.

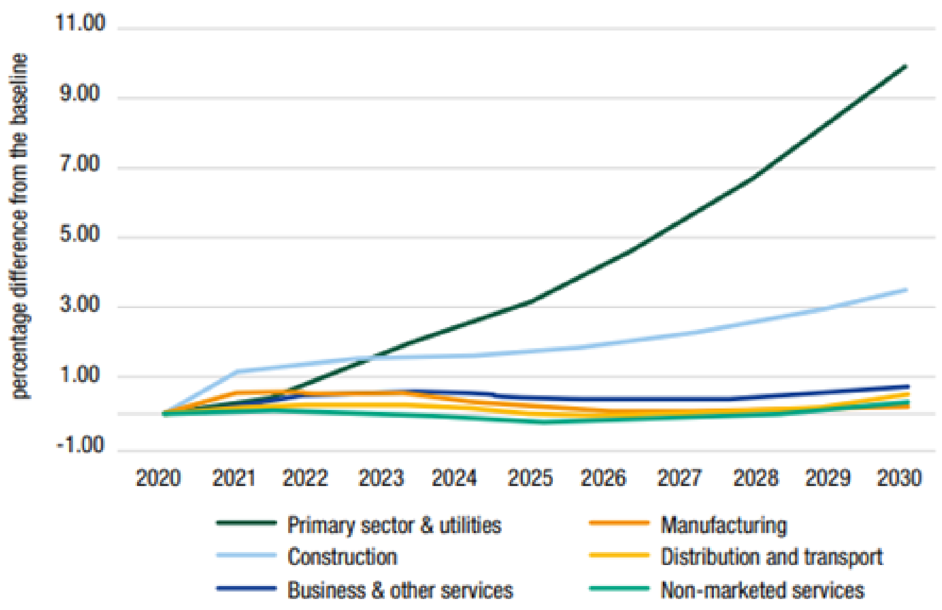
A Cedefop forecast from 2020 (pre-COVID) predicted a 3.7% increase in employment in the EU-27 by 2030. A new scenario considering the implementation of measures from the EGD forecasts further employment growth by 2030. The figure above illustrates that throughout the entire forecast period, employment with the implementation of the EGD is higher.

[7] FOD Volksgezondheid. (2023). Implications of the climate transition on employment, skills, and training in Belgium.

[8] European Commission. (2023). Employment and Social Developments in Europe. Addressing labour shortages and skills gaps in the EU.

Through a sectoral lens, we can assert that on average at the EU level, by 2030, no broad sector would experience adverse effects on employment due to the European Green Deal (EGD) (see Figure 2 below). However, some sectors benefit more than others. Employment in the primary sector shows the most notable increase. Utilities drive the increase in the broader (primary) sector. This is attributed to employment generated by increasing recycling and in **electricity provision**.[9]

Figure 2. **Forecast employment impact of the EGD (% difference between EGD skills forecast scenario and baseline) by broad sector, EU-27**



Source: Cedefop skills forecast, 2020 baseline and EGD scenario estimates.

At the level of specific **occupational groups**, there will be clearer 'winners' and 'losers' as a result of the EGD. Some occupations (e.g., coal mining) will experience a decline in employment, while others (e.g., green energy production) will see growth. Nevertheless, when considering educational levels, the employment benefits of the EGD appear to spread across almost all occupational categories. From a socio-economic policy perspective, this is a positive finding. It shows that the greening of the European economy will not solely rely on highly skilled workers, and the implementation of the EGD seems to **temper job polarization rather than reinforce it**. The mitigating effect of the EGD on polarization is evident in employment trends across qualification levels in the figure below. The positive effects of the EGD are visible across all technical skill levels. Although creativity and innovation from higher-skilled workers are essential for breakthroughs in climate technology, employment in middle-skilled manual and elementary occupations is expected to grow faster than in higher-skilled occupations. [10]

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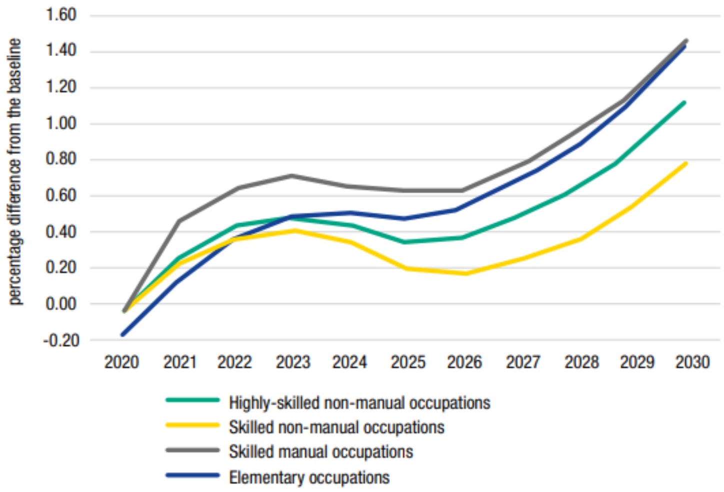
[9] Cedefop. (2021). The green employment and skills transformation.
[10] Cedefop. (2021). The green employment and skills transformation.

Figure 5. **Forecast employment impact of the EGD (% difference between EGD skills forecast scenario and baseline) by skills level, EU-27**



Source: Cedefop skills forecast, 2020 baseline and EGD scenario estimates.

The proportion of employees in the EU with higher education qualifications has increased in most transformation sectors in recent years, but not more so than in other sectors. Employees with intermediate qualification levels currently form the largest group in all transformation sectors. However, despite increasing demand for new specific competencies in existing occupations, sectors crucial for the green transition report lower **participation in lifelong learning**. Approximately 60% of employers in these sectors indicate that the lack of appropriate competencies is a barrier to investing in more green economic activities.

The expected employment growth resulting from the green transition in the EU also involves jobs in sectors and occupations already facing **persistent labour shortages**. The predicted expansion needs, the underrepresentation of women, and an increasing demand for middle- and high-skilled workers with qualifications essential for the green transition, combined with high replacement needs of older workers, will exacerbate existing shortages. [11] [12]

An analysis and roadmap was made for **Flanders** for the main energy-intensive sectors, namely chemicals, primary metals, rubber, plastics, and petrochemicals. The largest employment is currently in the chemical sector, which is mainly concentrated in the chemical cluster around the Port of Antwerp. According to a Flemish skills roadmap for climate transition in energy-intensive sectors, the transition will require approximately 15,500 additional workers in the chemical sector by 2035. There will also be a growing need to adopt innovative low-carbon and energy-efficient technologies such as hydrogen and carbon capture. This technology, in turn, requires new competencies for the (future) workforce. [13] In the next chapter on 'skills shortages' we dive deeper in specific skills shortages that are related with the green industrial transition.

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[11] European Commission. (2023). Employment and Social Developments in Europe.
[12] VNO-NCW & MKB Nederland (2022). Arbeidsmarktkrapte analyse en oplossingsrichtingen.
[13] Departement WSE & Roland Berger. (2021). Skills roadmap voor de Vlaamse klimaattransitie.

In **Germany**, companies are adapting, but a shortage of skilled workers is hindering these efforts. By 2045, Germany aims to be CO2-neutral, requiring a workforce with new skills. A survey shows nearly half of companies expect employees to need additional skills due to ecological changes by 2025, but the shortage of qualified workers poses a significant challenge.[14] According to the OECD, over 21% of jobs in Germany are linked to "green activities," while less than 5% are in emission-intensive industries. Men and older workers are more likely to work in both green and emission-intensive jobs. As emission-intensive jobs decline due to the push for climate neutrality, policies are needed to support income and job transitions. Germany faces a shortage of at least 300,000 skilled workers by 2030 in the renewable energy sector, particularly in solar and wind power.[15]

The dynamic developments within the energy transition have significant implications for the labour market.[16] These labour market challenges are strongly intertwined with other structural trends affecting the entire economy such as globalization, digitalization, and robotization. Techniek Nederland[17], for instance, identified the green transition as central societal challenges with the greatest impact on the broader technical sector in the **Netherlands** by 2030. To address these challenges, digital competencies among adults and investments in human capital were also highlighted as crucial for future-proof operations within the technical sector. For the labour market in the sector, Techniek Nederland identifies lifelong learning and development as important trends. An organization actively investing in competence development can thus become more attractive as an employer in a labour market characterized by shortages.

The crucial role of Vocational Education and Training

As emphasized above, the impact of the green transition on the labour market requires additional investments in (re-)training to familiarize (future) workers with new green economic activities and technologies and to help them acquire competencies to potentially transition to another sector or profession. The trends and developments within and between sectors will **shape the provision of vocational education and training (VET)**, both for initial vocational education and for re- and upskilling.

An important focus in European policy initiatives to strengthen competencies is the **linkage between the digital and green transition**. It is argued that it is neither possible nor desirable to analyse both megatrends and their employment and competency implications in isolation. Competencies to design and implement digital technologies that indirectly contribute to 'greening' must be considered symbiotic with 'green' competencies. Regarding VET, this requires a holistic approach to adjusting programs, curricula, and methods. [18][19][20][21] [22]

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[14] IWD. (2023). Green Jobs: Skilled Labor Shortage Slows Down Energy Transition.
[15] OECD. (2024). OECD Employment Outlook 2024 - Country Notes: Germany.
[16] SER. (2018). Energietransitie en Werkgelegenheid. Kansen voor een duurzame toekomst.
[17] Techniek Nederland. (2023). Connect2030: Het belang van toekomstbehendigheid en de technieksector.
[18] Cedefop. (2021). The green employment and skills transformation.
[19] Agoria, VBO & Deloitte. (2023). The future of work: Strategieën voor de digitale transitie.
[20] Vlaamse Regering. (2021). STEM-Agenda 2030.
[21] SER. (2018). Energietransitie en Werkgelegenheid. Kansen voor een duurzame toekomst.
[22] Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). (2022). Skills for a Just Transition to a Green Future.

A joint report from leading international organizations such as Cedefop, OECD, and UNESCO[23] states that **education and training systems should support the green transition**: (1) by equipping students during initial education with the competencies to navigate a greener economy and society; (2) by giving adults the opportunity to adapt to – and preferably anticipate – changes arising from the transition. VET plays a key role in this. Quality VET prepares students for the labour market and must therefore ensure that the developed competencies correspond to a greener economy. VET is also vital in providing opportunities for reskilling and upskilling of adults.

Strengthening competencies for the green transition requires the definition of green competencies. The above-mentioned report refers to technical and transversal competencies. "Green competencies encompass skills, knowledge, and attitudes necessary to live, work, and act in green economies and societies". They include:

- **Technical competencies**: necessary to adapt or implement standards, processes, services, products, and technologies to protect ecosystems and biodiversity and reduce energy, material, and water consumption. Technical competencies can be intersectoral or occupation-specific.
- **Transversal competencies**: related to sustainable thinking and action, relevant for work (in all economic sectors and professions) and life. Also referred to elsewhere as 'sustainability competencies', 'soft skills', or 'key competencies'.

(Inter-)regional developments in the green (hydrogen) industrial transition

Renewable energy constitutes a labour-intensive sector with a high level of investment in research and development. The energy crisis resulting from the Russian invasion of Ukraine further intensified the pressure on the energy sector. In response, the European policy level introduced the **REPowerEU plan** aimed at accelerating the green energy transition. It is expected that wind energy, green hydrogen and biogas will benefit the most from this European policy initiative.

To maximize the use of the produced renewable energy, new technologies are being researched for **energy efficiency, transport, grid balancing, storage, and system integration**. This is necessary to ensure the long-term stability of the electricity grid and to optimize connections with other countries around the North Sea. Examples include batteries and the conversion of offshore energy into (green) hydrogen. The latter energy technology is of particular interest for the regions involved in the GRIT project, as is further discussed below.

Due to the global climate warming combined with the current energy crisis, the interest in and need for (green) hydrogen solutions has accelerated. There is significant interest in hydrogen for industrial applications, where hydrogen is used not only as a **chemical feedstock but also as an energy carrier**. This evolution is also reflected in European and national policy ambitions. These ambitions have translated into the signing of international agreements and the announcement of large-scale investment projects.

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[23] European Commission, European Training Foundation, Cedefop, OECD, International Labour Organisation and UNESCO. (2022). Work-based learning and the green transition.

Next to energy production, storage and distribution, important trends and developments are visible in **energy-intensive industries** as a response to the necessity of decarbonization. Industries need to embrace sustainable energy techniques to limit their carbon footprint. The green industrial transition generally only stimulates limited growth in employment. However, significant shifts occur through intra-sectoral job-to-job mobility, requiring reskilling or upskilling.[24] In the following subsections we give more in-depth regional insights into the developments in the North Sea regions involved in the GRIT project.

Antwerp, Belgium

Belgium announced in its **post-COVID recovery plan** that, like the Netherlands and Germany, it aims to become a hydrogen economy. This plan includes significant investments in offshore wind energy generation and the development of the hydrogen value chain, among other general investments in renewable energy. Through electrolysis of water using renewable electricity, the production of green hydrogen is entirely carbon-neutral. However, ensuring an adequate supply of renewable energy is a significant challenge for Belgium. Belgium currently faces a structural shortage of renewable electricity, which also limits large-scale investments in electrolysers. Therefore, in addition to **green** hydrogen, the production of **blue** and **pink hydrogen** is also considered. The construction of CO2 pipelines connecting industrial zones can help transport captured CO2 emissions, including those from the production process of blue hydrogen. Another policy option for hydrogen production involves producing so-called pink hydrogen using nuclear energy.

Significant quantities of low-carbon hydrogen are needed to make **Belgium's energy-intensive sectors** such as the steel industry, chemicals, or heavy transport carbon-neutral. Furthermore, the industry requires a stable energy supply, which cannot be provided by Belgian offshore wind farms. Therefore, the import of green hydrogen from countries with abundant solar and wind resources is on the policy agenda. However, this is only possible in the longer term as Belgian partner countries such as Oman or Namibia need time to build up the necessary capacity. During this transition period, pink and blue hydrogen may provide a solution. [25]

In combination with the existing hydrogen network and new **hydrogen pipelines, Belgium** can also become a significant hydrogen supplier for Europe, particularly for the German Ruhr area. This also applies to the dense gas pipeline network. This hydrogen "backbone" of pipelines will also connect the Flemish industrial clusters. In the Port of Antwerp(-Bruges), the second-largest petrochemical cluster in the world, grey hydrogen will be replaced by green hydrogen. Belgian seaports thus play a significant role in large-scale industrial projects. [26] In contrast to the production of green hydrogen, Belgium is well positioned to play a central logistical role in energy distribution for a global hydrogen economy. By importing hydrogen from countries with a greater potential for renewable energy, green hydrogen becomes cheaper. In this transport, there may be less focus on hydrogen molecules and more on ammonia. Ammonia has a higher energy density and is thus more effectively shipped in liquid form. [27]

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[24] Cedefop. (2021). The green employment and skills transformation.
[25] Agoria. (2022). Heeft waterstof een rooskleurige toekomst in België?
[26] Cleantech Vlaanderen. (2023). Cleantech Rapport 2023.
[27] Voor meer info: https://www.fluxys.com/nl/about-us/energy-transition#/

Hamburg, Germany

The **German national hydrogen strategy** has been working across sectors to work on solutions to well-known challenges surrounding the green transition and the role of green hydrogen. These opportunities and challenges can be divided in 8 areas[28]:

1. **Hydrogen Production**: The development of a hydrogen economy hinges on the reliable and sustainable production of hydrogen at competitive costs compared to conventional energy sources. To reduce production costs, industrial-scale electrolysis must produce green hydrogen, which requires the expansion of renewable energy sources to supply the necessary green electricity. For investments to be profitable, there must be sufficient demand, particularly in sectors where hydrogen use is economically viable and in industries without alternatives for decarbonization, e.g. steel and chemical sectors.
2. **Transport:** Hydrogen plays a crucial role in sustainable and climate-friendly mobility, particularly for large and heavy vehicles like those in trucks, aviation, and maritime transport. It can be used in fuel cells or as a feedstock for renewable fuels, offering an alternative where battery-electric drives are not suitable. Key initiatives include promoting green hydrogen for fuel production, especially in aviation, and in hydrogen-powered vehicles across various transport modes.
3. **Industrial Sector**: The Federal Government is focused on transitioning the industrial sector, particularly the steel and chemical industries, from fossil technologies to low or C02-neutral processes. To support this shift, the government is offering investment grants and funding mechanisms to help make climate-friendly processes economically viable. "Carbon contracts for difference" will also be introduced to offset the higher costs of these sustainable methods, encouraging early adoption of climate projects.
4. **Heat:** The Federal Government has been supporting the purchase of efficient fuel cell heating appliances in buildings. This grant program is set to run until the end of 2022, with a possible extension depending on an evaluation later this year. Future support for fuel cell technology within technology funding will depend on this evaluation, and any continuation of the grant will require clear cost reductions in its provisions.
5. **Infrastructure/supply**: A secure and efficient hydrogen supply is crucial for a hydrogen economy. Efforts are focused on repurposing existing infrastructure, like natural gas pipelines. Funding is also being directed towards developing supply structures, including expanding hydrogen refueling stations for road, rail, and waterway transport.
6. **Research, education and innovation:** Technological innovation is crucially driven by new scientific discoveries. To support this, the Federal Government has launched research funding initiatives that will pave the way for future market success across the hydrogen value chain and speed up the integration of innovations into industry. Additionally, the 'Hydrogen Technologies 2030' campaign strategically coordinates research efforts on essential hydrogen technologies, including smaller applied energy research projects.

[28] German Federal Government. (2024). Hydrogen Strategy Action Plan.

7. **Need for action at European level**: Germany is committed to advancing hydrogen technologies at the EU level, aligning with the European Green Deal. This initiative supports flagship projects covering the entire hydrogen value chain. Additionally, developing uniform sustainability and certification standards across Europe is crucial for creating a common internal market. These standards must also align with international norms to facilitate global hydrogen trade, including proof of origin for renewable energy.
8. **International hydrogen market and external economic partnerships:** The development of hydrogen technologies requires integration into a global market, as domestic production alone cannot meet the demand needed for decarbonization. To secure sufficient hydrogen supplies, Germany must rely on imports, making international cooperation crucial. Strengthening existing energy partnerships is essential to meet import needs, enhance export opportunities for German hydrogen technology, and support sustainable energy development in partner countries.

The National Hydrogen Strategy[29] of Germany outlines a comprehensive plan for developing a **German national hydrogen network** that includes the following key points:

1. Initial Core Network: A hydrogen core network is planned, with the first phase set to be implemented by 2032. This network will connect relevant regions across Germany, focusing on both supply and application sides. This will include an initial network of more than 1,800 km of pipelines, a mix of repurposed and newly built infrastructure.
2. Expansion and Integration: By 2032, the network will expand further to link major production, import, and storage centers with consumers. The expansion will be aligned with the broader European Hydrogen Backbone.
3. European Hydrogen Backbone: Germany's network will integrate into a European-wide network. This backbone will include 4,500 km of pipelines across Europe, with connections to potential production centers in Scandinavia, Southern and Eastern Europe, and import hubs in Western Europe.
4. Storage and Reserves: The network will include hydrogen storage facilities, and a national hydrogen reserve might be established to mitigate risks related to production or import failures.

Even before the National Hydrogen Strategy of 2020, the Ministries of Economic Affairs and Transport of the Northern German coastal federal states Bremen, Hamburg, Mecklenbug-Western Pomerania, Lower Saxony and Schleswig-Holstein agreed on a **Northern German Hydrogen Strategy** in November 2019. It is the result of intensive cross-state cooperation and the extensive and constructive involvement of active players from industry, science and administration. The aim is a green hydrogen economy already in 2035 to enable almost complete supply to all customers interested in green hydrogen.[30]

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[29] The German Federal Government. (2023). National Hydrogen Strategy Update.

[30] Wirtschafts- und Verkehrsministerien der norddeutschen Küstenländer. (2019). The Northern German Hydrogen Strategy.

Groningen, The Netherlands

In the **Netherlands**, industry requires over 500 petajoules of heat annually. Currently, this heat comes almost entirely from fossil fuels. Three routes can achieve a move away from fossil fuels: process efficiency, reuse and upgrading of waste heat, and a more sustainable heat supply. Regarding the latter, there is significant activity surrounding hydrogen. In early 2020, the first Innovation Agenda 'Hydrogen for the Energy Transition' was published. By mid-2021, the work plan for the National Hydrogen Program (NWP) was developed. The Electrochemical Conversion & Materials (ECCM) platform published its Second National Agenda at the end of 2021, which specifically links hydrogen to the chemical industry. Additionally, in 2021 and 2022, two applications from the GroenvermogenNL program were granted funding from the National Growth Fund with a work budget of €838 million.[31]

To replace fossil (grey) hydrogen with cleaner alternatives. As part of the climate agreement process, the **potential demand for hydrogen in the Netherlands** has been mapped out. This indicates that by 2030, there is already a significant potential demand for hydrogen for industrial applications along the coast (appr. 125-213 PJ). Additionally, there may be an additional demand for hydrogen for electricity production along the coast. The actual demand in 2030 depends on the development of incentives for industries to decarbonize and incentives for sustainable and CO2-free electricity production.

A portion of the **hydrogen produced by the Netherlands** will be produced offshore in the future. In the National Leadership scenario, by 2050, there will be 20 GW of electrical power converted on platforms or islands. The 14 GW produced via electrolysis must be brought ashore via pipelines. In addition to this hydrogen from dedicated electrolysis, hydrogen will also be produced from hybrid-connected wind farms - with both electricity and hydrogen landing. The development of offshore hydrogen production will begin around 2030.

Traditionally, the **northern provinces of the Netherlands** (e.g. Groningen) have a strong knowledge position on gas extraction and handling that is highly applicable to the development of hydrogen chains. The knowledge position of the Dutch industry and knowledge institutions offer excellent opportunities for innovations focused on electrolysers, the application of hydrogen in the process industry and heavy transport, and around the transport and storage of hydrogen. The Integrated Infrastructure Exploration 2030-2050 describes that a hydrogen network will largely be expanded within the current routes of the natural gas network. In all scenarios, more transport capacity is needed, especially parallel pipelines on routes of the national hydrogen network.

Due to the combination of the energy transition with the **cessation of gas extraction in Groningen** a transformation of the socio-economic structure in the region of Groningen is necessary. Gas extraction and industry based on fossil raw materials played a dominant role in the socio-economic structure of Groningen. The cessation of gas extraction means that an important pillar will disappear. Regional employment are under pressure. The JRC report 'The socio-economic impacts of the closure of the Groningen gas field' (JRC 2020) states that more than 20,000 jobs are affected, distributed across the various parts of the chain.

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[31] TNO. (2022). Ambities Nederland voor waterstof en groene chemie komen in versnelling.

Seaports

Seaports thus play a crucial role in the energy transition, particularly in the hydrogen economy. To secure energy supply, especially for industry, we will need sources other than fossil fuels. This role can be taken on by hydrogen and its derivatives, which will become more and more important in the future. The seaports play an important role in strengthening sustainable technologies and energy sources.

In the **Antwerp-Rotterdam-Rhine-Ruhr (ARRRA)** region, a large part of the energy-intensive industry is already directly connected to seaports. This means that port authorities play an important role in the energy transition as operators, regulators, and community managers. As operators, the focus is primarily on reducing the carbon emissions of their own activities, such as tugboats/pilot boats.

German ports are also vital to the energy transition, particularly for importing hydrogen and its derivatives. The ports are expected to handle a significant portion of Germany's hydrogen imports, which will account for 50-70% of the projected demand of 90 to 135 TWh by 2030. The **German National Ports Strategy**[32] aims to develop ports into sustainable energy hubs. This involves conducting a needs analysis to determine the most suitable ports for hydrogen import and ensuring that these ports have the necessary infrastructure to handle various hydrogen forms (e.g., ammonia, methanol, LH2). Ports need to develop flexible infrastructure capable of handling different hydrogen import methods. The infrastructure must align with the hydrogen core network and downstream distribution grids to ensure efficient transport and processing. The strategy currently lacks specific targets and clear funding plans. The National Hydrogen Council emphasizes that without clear goals and financing, the transformation of ports might be jeopardized. They advocate for a federal-state cost-sharing model and new funding approaches to support the necessary infrastructure upgrades.

In the **Port of Hamburg**, authorities, institutions and companies will spend the next years creating and developing a sustainable energy hub. In this way, the port is ensuring Germany's supply readiness and further expanding its importance. With the 'Sustainable Energy Hub Hamburg', the Hamburg Port Authority (HPA) has launched a powerful initiative to bring all players closer together. Hydrogen will thus play an important role as an energy source:

- The Port of Hamburg is positioning itself as a key player in the energy transition by also becoming a **major hub for importing hydrogen and its derivatives**. The port plans to develop flexible infrastructure for hydrogen imports and integrate with the Hyperlink hydrogen pipeline network. Additionally, projects like the green energy import terminal and the Moorburg electrolysis plant, with potential capacities up to 800 MW, are central to Hamburg's strategy to support Germany's decarbonization goals[33]
- Through the Clean Port & Logistics Cluster (CPL), Hamburger Hafen und Logistik AG (HHLA) collaborates with around 50 participating companies, driving the practical application of hydrogen technology to enhance its market readiness. The initiative involves testing **hydrogen-powered equipment in port logistics**. For this purpose, the

[32] The National Hydrogen Council. (2024). A look at Germany's National Ports Strategy.
[33] Hafen Hamburg. (2023). Energy transition offers great opportunities for Port of Hamburg.

CPL unites container and port logistics firms, vehicle and handling equipment manufacturers, hydrogen producers, universities, and research institutes. They engage in practical research and testing to explore how hydrogen can reliably fuel port technology and logistics.

- The "**Sustainable Energy Hub Hamburg" initiative** aims to transform parts of the port into a key hub for sustainable energy, especially hydrogen. The project focuses on enhancing collaboration among companies, developing infrastructure for handling and processing energy sources, and positioning the port as a pivotal player in Germany's energy transition. The initiative will be concentrated in specific port districts, like Neuhof and Moorburg, to support large-scale industrial activities.[34]

In Groningen, Gasunie subsidiary EemsEnergyTerminal has developed a new floating LNG terminal in the **Eemshaven port area**. This terminal will make it possible to transport liquefied natural gas by sea to Eemshaven, where the plant will return the liquefied natural gas to a gaseous state. After conversion, the gas is ready to be transported inland via Gasunie's gas pipeline network. In the future, EemsEnergyTerminal can be used for green hydrogen imports. EemsEnergyTerminal is thus working on a sustainable, permanent terminal with both a short-term and a long-term purpose.

Building on the desk study, the GRIT partners approached regional stakeholders to consult them about their insights on the main trends and developments with regard to the green industrial transition and its impact on the regional labour market. The following subsection first summarises the findings.

Stakeholder consultation

In what follows we highlight the main findings from the stakeholder consultation held during the spring of 2024. In total 28 companies, sectoral and educational organisations across the 3 regions involved in the GRIT project (*i.e.* Groningen, Antwerp and Hamburg) were consulted on the main sectoral trends and developments regarding the green industrial transition.

As highlighted in the desk study, seaports play a major role in the green industrial (hydrogen) transition. As Antwerp and Hamburg each host a major European seaport, the stakeholder consultation in these regions added – to insights with regard to the energy sector and energy-intensive industry – special focus to the impact on port activities such as maritime and logistical applications of green (hydrogen) technology.

Production, storage & distribution

- Hydrogen (H2) widely available across the Antwerp port area due to the chemical cluster, however, infrastructure needs adaptation in terms of scale and safety;
- H2 infrastructure requires more safety precautions in piping, insulation, coating, …
- Alternative molecules (ammonia/methanol) are considered more promising for import of green energy than H2 because of being better transportable by shipping.

[34] Hafen Hamburg. (2023). Sustainable Energy Hub Hamburg" initiative.

- Current H2 in Antwerp Port area is still mostly grey and blue, most green H2 will need to be imported because of lack of regional green energy production opportunities;
    - H2 mostly produced via steam methane reforming (SMR), capturing CO2.
- The "BioH2Log - Biogenic Hydrogen Production with Innovative Distribution Logistics" project, launched in January 2023, supports Germany's national hydrogen strategy by developing dynamic models, or digital twins, for the production, storage, and distribution. The green hydrogen is produced by steam reforming of biogas. [35]
- In the port of Hamburg, renewable energies are on the rise, and not just because of legal requirements. The Ukraine war (energy shortage) is creating more pressure than climate change.
- Groningen Seaports strongly advocates scaling up the production of green hydrogen. Dozens of hydrogen projects are already under development in the northwest of the Netherlands, many of which are planned in the port of Delfzijl and Eemshaven.
    - Examples include the construction of electrolysers and hydrogen plants, the creation of specific port facilities, the development of a pipe system ('backbone'), but also the use of hydrogen in public transport and the development of hydrogen filling stations.

Energy-intensive industry

- Electrification is a main driver in green industrial transition, in which H2 is also projected to help balance the system, next to battery systems;
- H2 is currently mostly used as a molecule in chemical processes, not yet widely as energy source (for heating) replacing fossil fuels;
- H2 is, however, projected as a future green energy source (replacing natural gas) for (heating) processes where electrification is not possible;

Maritime & port logistics

- H2 considered as a potential shipping fuel, both maritime as for inland vessels;
- H2 has potential for heavy duty onshore equipment and long-distance trucking;
- Mostly dual/multi-fuel engines, using fuel cells, some are exploring and implementing technologies for H2 combustion engines.
- Flemish H2 pioneers, e.g. CMB Tech and ABC motors for H2 combustion (both develop applications in e.g. shipping, trucking, heavy duty vehicles).
- Converting vehicles to H2: technology, driving, maintenance and refueling expertise needs to be taken care of.
- Port handling: with increasing volumes of containers with hydrogen, employees' hazardous goods expertise must be expanded.
- The large-scale import of hydrogen will create new job profiles, e.g. combinations of logistics and engineering. These employees are not yet available on the market.

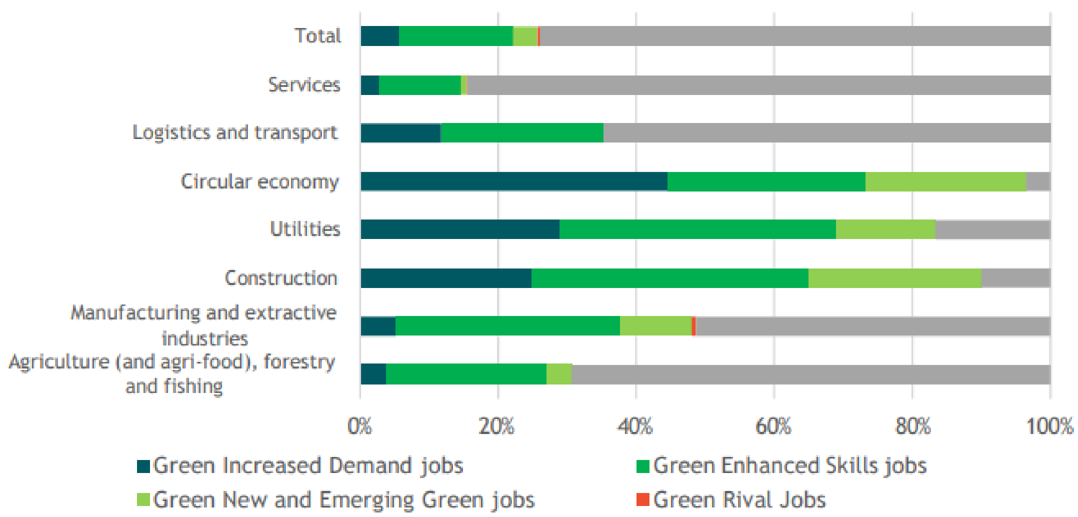
[35] BioH2Log. Biogenic Hydrogen Production with Innovative Distribution Logistics. Institute of Plant and Process Technology.

Overall, technical, financial and legal challenges slow down H2 scaling:

- Import of (green) H2 is still rather expensive;
- H2 needs to be very clean for fuel cell technology;
- Regulations and certification are still being developed for some applications.
- Groningen Seaports are seeing a pressing need for new applications in the hydrogen ecosystem. Groningen Seaports is therefore fully committed to innovation and offers space and facilities for test centers, start-ups, scale-ups, pilot and demo plants.
- In Germany, the funding backdrop is under pressure, financing hydrogen projects and investments are therefore not easy.

Skills shortages

Achieving the European Green Deal, the objectives of the Fit for 55 package and the RePowerEU plan requires a significant acceleration of the energy transition in the EU. To scale up the production of green energy technologies (e.g., wind, solar, batteries, heat pumps, electrolysers), the European Commission has proposed the Net Zero Industry Act (NZIA). This policy initiative aims to increase investments in physical infrastructure, as well as additional qualified labour for their production. By 2030, depending on the European market share in the production of these technologies, the **investment need for re- and upskilling** for the production of strategic carbon-neutral technologies in the EU is estimated to be between €1.7 billion and €4.1 billion. Additionally, there will be a need for additional qualified labour for the increased installation and implementation of these technologies. While various assumptions lead to different estimates, it is clear that the energy transition will require a significant increase in the number of qualified technicians in various sectors. Persistent labour shortages in the EU may therefore lead to delays in the energy transition. [36]



[36] European Commission. (2023). Employment and Social Developments in Europe.

In Flanders, it is generally expected that about 26% of jobs will be significantly affected by the green transition, requiring enhanced skills (16%), new and emerging skills (4%), or leading to increased demand for jobs with existing green skills (6%). The figure below from the Green Skills Roadmap for Flanders shows that the **sectoral distribution of green jobs** is heavily concentrated in the circular economy, utilities (mainly energy), and the construction sector, and to a lesser extent in industry. Given that the circularity of resources and construction is beyond the scope of this project, the impact of the energy transition in utilities, manufacturing and extractive industries is particularly interesting.

As described in the first chapter, green competence needs **encompass both (job-specific) technical and transversal competencies**. [37] Despite on technical competencies in sector-specific skills forecasts, it is important not to neglect transversal competences. Relevant transversal competences for the green transition include leadership skills, innovative abilities, as well as communication skills. In the following sections, we will specifically address skills gaps resulting from the energy transition at the level of a sector or professional group. Both transversal and more (job-specific) technical competencies will be covered below.

Central to the energy transition is, of course, the **energy sector** itself, particularly the production, storage, and distribution of energy, both in terms of heat and power. The sector, in Flanders for instance, accounts for only 1% of employment and is thus not significant in terms of the numbers, but it is undergoing a major transition in skills gaps. On average, it is assumed that the energy sector based on renewable energy creates more employment than one relying on fossil fuels. The additional jobs are primarily concentrated in the installation and manufacturing of renewable energy sources. [38]

Overall, changing competence needs relate to the necessity of increased ecological awareness and systems thinking to apply green practices in all parts of the value chain of the energy sector. Below are the main competency needs for some **relevant occupational groups**:

- Installation and maintenance technicians: new technical competencies related to renewables, e.g. installation and maintenance of smart meters, electrolysers, etc.
- ICT specialists: programming and ICT skills, management of networks, social skills.
- Engineers: specific technical skills for (renewable) energy technologies, communicative and broader social competencies such as teamwork.

Economic activities related to renewable energy increasingly require highly **qualified workers, ranging from technicians to engineers**. However, this does not mean that jobs for shorter and mid-qualified workers will disappear; on the contrary, jobs in the installation of additional demand for renewable energy sources are expected to remain and even grow.

In addition to specific technical skills, work in the new energy sector **also requires transversal competencies**, such as digital skills. For example, Information exchange about measuring and reading projects, recording work execution, planning and coordinating work among different

[37] The Green Skills Roadmap for Flanders identifies professional skills that are relevant to the entire labour market but are not job-specific. However, professional skills are considered more specific than transversal competencies.
[38] Departement Werk & Sociale Economie. (2022). Green Skills Roadmap Flanders: Final Report on Green Skills Need in Flanders.

professionals, is increasingly done electronically. It is important that education includes teaching the use of ICT tools as planning systems. Furthermore, some activities also require social skills, such as good communication skills and flexibility. Often, intensive collaboration occurs in small teams of specialists performing partially overlapping – but sometimes complementary – tasks, which increases the importance of multidisciplinary collaboration.[39]

An important energy technology for the transition to green energy is the production, storage, and distribution of (green) hydrogen. The **labour market developments in the field of green hydrogen** are evolving rapidly. The demand for personnel is sharply increasing and is expected to reach approximately 31,000 temporary and 7,000 permanent jobs in the Netherlands. There is significant competition to recruit this scarce technical talent from other activities in the energy transition (such as grid reinforcement, the built environment and offshore wind). This leads, at least in the short term, to shortages and thus a constraint on the growth of the sector. It is expected that this scarcity will persist at least until 2035. Re- and up-skilling for these evolving occupations are seen as significant challenges in the energy sector. Specifically in the field of the green hydrogen transition, GroenvermogenNL is focusing explicitly on this with an ambitious Human Capital Agenda.

In **Germany** as well, hydrogen is receiving a lot of attention. National hydrogen strategies have mainly focused on investments in infrastructure, research, and development. However, in Germany, a project has recently been launched that focuses on the impact of hydrogen on the required competencies to be/remain active as an employee. Strong attention was paid to the impact on middle- and high-skilled technicians because they are indispensable for realizing the ambitious hydrogen plans in reality. Tasks and responsibilities in these technically skilled professions include planning and development, production, operation and monitoring, as well as repair and maintenance of products, machinery, and processes. Therefore, the project investigates how tasks and qualification requirements change as a result of the use of hydrogen technology.[40]

This **competency forecast by the German Federal Institute for Vocational Education and Training (BiBB)**[41] summarized that for hydrogen production, at least in Germany, no specific hydrogen training needs to be established as a full-fledged VET study because existing training programs are suitable, albeit with the addition of specific safety-related competencies. The relevant existing occupational competencies are often interdisciplinary and come from technical professions in the industry such as electro- and (chemical) process technicians. The additional safety regulations concern installations and equipment for the production, storage, and transport of green hydrogen. These safety regulations need to be closely monitored according to authorized occupational safety regulations due to pressure and explosion hazards, especially because hydrogen systems are expected to become part of a country's critical infrastructure in the near future.

[39] Koning, M. Smit, N. & Van Dril, T. [EIB]. (2016). Effecten van de energietransitie op inzet en kwaliteit van arbeid.
[40] Bundesinstitut für Berufsbildung (BIBB). (2022). H2Pro, VET as a Blind Spot in Discourses about Hydrogen.
[41] Bundesinstitut für Berufsbildung (BIBB). (2022). a future-oriented topic for VET with regard to energy transition.

In Flanders too, the hydrogen economy is in full development, with numerous companies reaping the benefits. However, the technological employer federation Agoria argues that a new technology like hydrogen can only optimize if it goes hand in hand with **investments in necessary competency enhancement**. While companies are currently heavily investing in expanding research and production capacity, the influx of technical profiles and investments in specific training (e.g., on safety) remain limited for now. Agoria emphasizes the importance of expanding and professionalizing the training offer around hydrogen, tailored to the companies. Developing quality training programs requires a mix of theory and practice. [42]

Seaports play a central role in the transition to green hydrogen. Availability of **human capital is crucial for the ports** as well. Shortages of labour at various qualification levels are expected. Working in the port – and the heavy industry in the immediate vicinity of a port – is often considered unattractive. Since the sustainability impact of a company increasingly influences employees when choosing a job, sharing ambitions related to the energy transition can be a positive factor in attracting labour. Additionally, cooperation with regional authorities is necessary to develop a strategy to encourage (future) employees to develop the necessary competencies needed for the energy transition in and with the ports. Inviting cooperation with schools, organizing excursions, etc., can influence the enthusiasm of future employees to want to work on the logistical and industrial green transition in ports. [43]

Many **industrial sectors** in Flanders[44] and the Netherlands[45] are energy-intensive and therefore sensitive to changing recruitment and competency needs resulting from the energy transition. To safeguard the energy transition and employment in these sectors, investment in re- and upskilling is crucial. Energy-intensive sectors such as chemistry, primary metals, rubber and plastics, which already face labour shortages, are identified as vulnerable to the green transition. It is expected that with ongoing innovation in the (chemical) processing industry, driven by increasingly stringent regulations, jobs will shift from fossil fuel-based chemicals to 'greener' processes.

GroenvermogenNL – promoting a green hydrogen economy in the Netherlands - Identifies and prioritizes specific capacity and competency needs will be a result of regional stakeholder exploration, similar to the GRIT stakeholder consultation. We will connect to the GroenvermogenNL initiative, which is also active in the province of Groningen. We are thus keen to align with these and other existing GAP analyses and seek complementarity in developing new educational materials.

A recent study by Roland Berger[46] suggests that reskilling workers in key green themes is necessary for the green transition in energy-intensive sectors. To enable reskilling in these **green competencies, as well as in digital competencies and soft skills**, there is a need for an increase in sector-specific training capacity. Furthermore, it is advisable to pay more attention to these green themes in initial education, as well as by strengthening lifelong learning. The

[42] Agoria. (2022). Waterstofopleiding van start in 2023.
[43] Radboud Universiteit & Bond Beter Leefmilieu. (2023). Towards sustainable port areas.
[44] Departement Werk & Sociale Economie. (2022). Green Skills Roadmap Flanders: Final Report on Green Skills Need .
[45] TNO. (2022). TNO Green Print versnelt de verduurzaming van industrie.
[46] Departement WSE & Roland Berger. (2021). Skills roadmap voor de Vlaamse klimaattransitie. .

report showed the importance of reskilling in certain competencies per occupational group active in the energy-intensive industry. Renewable energy has a moderate impact on operators, technicians, and electricians/electrical technicians, but a more significant impact on managers, scientists, and engineers. The theme of renewable energy is particularly important for energy-intensive sectors. In total, this would involve approximately 34,000 workers in Flanders who require the necessary reskilling.

There is also a significant need for reskilling in **digital skills**, especially effective use of basic digital equipment in the workplace. The most extensive job groups requiring this are operators, technicians, administrative staff, production workers, and managers. Regarding **soft skills**, the study identifies three drivers that increase its importance, i.e. (1) the emergence of new - often digital - ways of working; (2) an increase in the importance of collaboration across value chains and different sectors; and (3) the need for transformation management to realize the green and digital transition.

Stakeholder consultation

In what follows we summarise our findings from the stakeholder consultation on the main skills shortages with regard to the green industrial transition. As for the main trends and developments regarding the technological transformations, we categorise our findings by application in each sector. First, we highlight some general labour market impacts of the green industrial transition:

- There already exists a crucial lack of technicians across different industries, not specifically competent in H2 or even as an impact from the green industrial transition;
- Additional need for skilled labor is expected. In some cases, new employees will be needed for new technologies and existing employees will have to undergo additional training and expand their skills.
- Impact of green transition not only concerns engineers but also concerns ISCED 3-4 level technicians, e.g. maintenance technicians and (process) operators;
- Relevant study profiles at ISCED level 3 - 4 are electromechanics, electrotechnicians, chemical process operators, welders and pipefitters;
- Currently companies feel obligated to invest heavily in training on the job upon arrival due to a lack of alignment between education and industry (~inhouse academies);
- Some specialised skills/work will be outsourced to specialized technical service companies, often the companies developing and producing the green (H2) technology.

Production, storage & distribution

- Higher levels of complexity and safety levels (even for technicians handling H2);
- Electro chemistry is gaining importance as a subject for VET, up- and reskilling, mostly for H2 production through electrolysis;
- New insulation, coating and welding techniques are required to store and distribute explosive molecules such as H2, ammonia, …;
- Dealing with danger and dangerous goods will be central overall. There will be an increased need for safety modules, e.g. how to extinguish an H2 or ammonia fire.

Energy-intensive industry

- There will be new jobs and also slightly to significantly adapted jobs. Industrial employees will have more technical related jobs.
- Classical STEM subjects such as electricity, physics and chemistry are becoming increasingly important;
- Specific subjects that gain importance: electro chemistry and high voltage electricity;
- In chemical process industry specific competences on working with hydrogen and other explosive molecules were already expected;
- Transversal competences gain importance (e.g. digital competences, agility, problem-solving skills, multi-disciplinary cooperation, communication skills, ...).

Maritime & port logistics

- Often (traditional) mechanics, therefore more knowledge of electrotechnology is required, currently outsourced to specialized technical service companies;
- For shipping, mostly trained inhouse and/or by specific nautical colleges.

Education and training supply

In this chapter, we briefly reflect on the existing education and training supply relevant to the green industrial transition. We start by examining education – including secondary, adult, and higher VET – but also consider some accredited supply from other (publicly funded) training providers. We primarily discuss general considerations from existing gap analyses that compare the VET supply against industry competency needs. Various fields of study are relevant for the energy sector, albeit often focused on the disciplines of electricity, chemistry and electromechanics.

In **Flanders** (Belgium), the energy sector does not have its own sectoral training services providing employee training or coordination with VET providers. Nevertheless, sector federations (e.g., Waterstofnet.eu) and the Flemish spearhead clusters Flux50 make competency forecasts that ideally lead to strengthening of the existing training. Examples include courses and training sessions on battery infrastructure and on-/offshore wind turbines. Recent projects such as Energie(k) Onderwijs, AMV Energy Learning Community, T-shore and 'Opleidingen van de Toekomst' – co-funded by EU programs – develop new learning materials. These open-source materials will be taken into account when developing the GRIT VET module, whilst making sure to take on a unique perspective, *i.e.* green hydrogen applications in the energy sector, energy-intensive industry and port activities.

When scanning for existing education and training supply specifically targeting green hydrogen, most training are developed for professionals with **higher education qualification levels** (e.g. engineers). As the technology is often still in a research and development or early adaption phase, training for engineers was the initial focus. In the long term, for operations, technicians must be upskilled. We consider some concrete examples below.

Within the Dutch **GroenvermogenNL** initiative, promoting a strong national innovation ecosystem for hydrogen production and application, a **human capital agenda** is one of its three pillars. Central to this is ensuring that new and necessary competencies are quickly available in both regular education and for the re- and upskilling of professionals.

In Germany, in the **mobility sector**, vehicle manufacturers, fuel cell manufacturers and refuelling stations have dedicated hydrogen-related training programmes. These companies mostly offer their own in-house training concepts. Moreover, an innovation and technology centre '*Hydrogen in Mobility*' is to be established in Hamburg from autumn 2024. This centre will also cover the areas of shipping and aviation. The focus of the centre is currently on technical tests. There will be a multi-fuel bunker system for liquid and gaseous hydrogen, methanol and ammonia.

A concrete example of such training in **Flanders** – also specifically aimed at higher-educated profiles such as managers and engineers – is the recently launched hydrogen training program as a collaboration between Ghent University and the Belgian Technology Federation Agoria. [47] An important aspect in the training is safety and certification to transform processes and applications to hydrogen. It combines theoretical knowledge in various aspects of hydrogen combined with company visits to relevant captains of industry.

For the VET supply aimed at strengthening green competencies in the **energy-intensive industries, a case study in Flanders** [48] indicated the positive role of workplace learning. The study reported policy recommendations based on the 'greening' of the dual education in chemical process technology (CPT). In this dual education program education and the chemical industry work closely together and reinforce each other in organizing the training. Secondary schools provide the theoretical part, while an internship at a chemical company helps to gain practical skills. In addition to the education in school and on the workplace, ACTA[49] provides part of the training. In an effort to better prepare students for the green transition in the chemical cluster in the Antwerp port area, ACTA adapted a training module within the CPT program by aligning it with a recent Flemish competence roadmap on the impact of the green transition in energy-intensive sectors. This 'greened' training module included green competencies in the learning objectives and thereby created a better awareness of climate impact throughout the entire training module. Some highlights of the training module:

- The module aims to increase the overall knowledge level of students about current issues, challenges, and innovative solutions related to the sustainability debate in the chemical industry. Therefore, the **course books** were supplemented with recent and relevant news articles.
- Another learning activity based on **gamification** to create green awareness among (future) chemical operators is a virtual reality search for 'green crimes in the virtual workplace'. Students try to recognize and report discharges or leaks.

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[47] Agoria. (2022). Waterstofopleiding van start in 2023.
[48] Dep. Werk & Sociale Economie, Roland Berger & Acta. (2022). How apprenticeships can lead to a greener labour market.
[49] ACTA is a technical training centre with (chemical) installations (400m²) located near the port of Antwerp. ACTA was established as a collaborative initiative between the chemical industry and training providers. Recently, ACTA invested in innovative digital learning tools, including e-learning and extended reality.

- A **simulation** was developed to increase awareness among (future) operators about the ecological impact of operating a chemical distillation column. The student is challenged to always seek the least polluting or most energy-efficient way to operate the equipment. The distillation column was equipped with a digital display indicating to what extent the student can keep values within specific limits. The display provides immediate feedback on their performance regarding ecological impact. The training module thus aims to increase awareness among (future) chemical operators and make the ecological impact visible through simulation and gamification.
- ACTA trainers also constantly encourage students to think critically about current procedures and stimulate them to formulate innovative proposals on how things can be managed in a more sustainable way.

The wider green industrial transition in the **province of Groningen** requires a workforce that is able to adapt and move with the ever-changing demands placed on employees. In view of the declining labor force (partly due to demographic developments), investments in re- and upskilling are necessary. Initiatives in Groningen are already under way and will be fully committed in the coming years. In collaboration with / between triple helix the following ambitions were established:

- Contributing to the **implementation of (training) activities in the context of lifelong development** and solving shortages in the labor market. Education, training and development must be optimally available for the different target groups (workers, job changers, job seekers, drop-outs, self-employed people) and bottlenecks due to barriers in regulations, target groups and sectors must be solved as much as possible;
- Contribute to the **learning culture of companies**. Investing in staff development must be part of business operations for all employers. To this end, the HRM function within smaller SMEs in Groningen, among other things, are strengthened.
- Contribute to the **(individual) learning culture of workers and job seekers** in the region. Investing in the development of own (changing) skills must be a normal part of the career orientation and planning of employees;
- **VET schools** in the region are transforming their curricula for the energy transition, in which green hydrogen plays a prominent role. Working together with other knowledge centers enhanced the developments. In this effort, GRIT partner Alfa-college is closely working with the university of applied science and the industry. Alfa-college is currently already running hydrogen modules with both students and also workers.
- Alfa-college students are working through **hydrogen projects** such as hydrogen boats and mini racing cars, to stimulate interest in the energy transition and hydrogen.

Stakeholder consultation

As for the main sectoral trends and skills shortages, we questioned our regional stakeholders on the (lack of) regional education and training supply in competences for the green industrial transition, mostly specifically focusing on hydrogen technology. The main findings for the stakeholder consultation in Antwerp, Hamburg and Groningen are outlined below:

As for the stakeholder consultation in Antwerp:

- Most companies invest heavily in in-company training/academies due to lack of availability of specific training modules or correspondence between VET and industry competency needs, both for entry level employees as for up-/reskilling employees.
- Companies and sectors develop their own training materials but are mostly open to working with VET in sharing, co-developing and outsourcing learning materials
    - e.g. an introductory course on hydrogen technologies
- Stakeholders insist on providing innovative and engaging learning methods such as multidisciplinary assignments and project-based learning.
- To integrate innovative technology in secondary education level VET it is fruitful to cooperate with higher education VET.

Findings from the stakeholder consultation in Hamburg:

- Current training programmes do not meet competence requirements. The topic of hydrogen must be taken into account when adapting curricula/training programmes.
- However, it is necessary to define standards. The training programme can then be developed accordingly and will require constant adaptation.
- So far, companies have developed their own training strategies, as there is already some internal expertise and knowledge needs to be passed on. Extensive onboarding of new employees is followed by "learning by doing".
- Identified skills gaps often focus on specific technical aspects (physical and chemical aspects, production technology, plant safety, storage, etc.). However, the entire value chain from production to transport and utilisation must be taught too.
- In principle, all training should be modular in order to support individualised learning.
- The learning programmes must be interactive and practice-oriented. Practical relevance must be established through co-operation with companies. There is a desire to develop XR environments, especially for dealing with hydrogen.
- The further education courses (or training courses) must be approved and certified so that they are attractive and based on general standards
- Middle and VET schools, higher education institutions, companies and industry sectors should work closely together.

Findings from the stakeholder consultation in Groningen:

- Learning on-the-job as much as possible would be beneficial in addressing the skills gaps. With a technical education as a basis, the students have a good starting point.
- Current VET does not always meet the companies' requirements. The curriculum must be further expanded across the entire education chain.
- These are particularly VET students, who are currently scarce and are also attracted by other sectors (healthcare, education, …). Focus should therefore be on secondary education VET level (EQF level 3 and 4.
- The content of the modules must be aligned as much as possible to what the labour market demands.

Conclusions and Recommendations

With the European Green Deal (EGD), the EU has strengthened its commitment to green its economy and society.[50] The results of various skills forecasts help assess labour market effects and can be used to inform policymakers, social partners and education stakeholders about where investments in (re)training should focus. To understand how priorities for (re)training should be set, it is informative to look at sectors strongly affected by developments towards greener economies. Although research indicates that the green transition brings competency and training needs for all sectors, significant employment effects are expected in the energy-intensive industry, energy sector and port activities. [51][52][53] This supports the choice of the GRIT project to prioritize these sectors.

This overview of competency and training needs in light of the energy transition teaches us that labour market shortages pose a significant threat to the success of the European Green Deal. Combating scarcity requires a decisive approach, both to increase the quantity and quality of competent technicians. In the following, we elaborate on the conclusions and link them to recommendations for the co-creation of new learning resources. Below, we present three central strategies and more concrete building blocks. We also indicate where they are translated into the activities of GRIT.

Central strategies and building blocks for the GRIT project

1. Strengthening the influx into relevant education and professions

Educational and professional career guidance play a crucial role in preparing education and the labour market for the green transition. Sensitization campaigns can attract (young) people to promising 'green' jobs and sectors, overcoming negative stereotypes and gender imbalances in traditionally male-dominated technical professions. The GRIT youth engagement program targets to increase awareness of and access to relevant technical and transversal competencies to support the transition to a greener economy. [54]

2. Strengthening initial vocational education and training

The revaluation of strong technical or STEM education plays a crucial role. Investing in initial vocational education and training (VET) is essential from both social and economic perspectives. Targeted investments in the GRIT VET module targets to increase the job prospects of future workers, as well as the productivity and sustainability of companies. A future technician with competencies geared towards professions in the energy transition is more attractive to employers.

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[50] European Commission. (2023). Vocational Education and Training and the Green Transition.
[51] SER. (2018). Energietransitie en Werkgelegenheid. Kansen voor een duurzame toekomst.
[52] Departement Werk & Sociale Economie. (2022). Green Skills Roadmap Flanders: Final Report on Green Skills Need
[53] Although also the built environment is strongly affected by the green (skills) transition, the shared challenges among the regions involved in this Interreg project convinced us to focus on the energy sector and energy-intensive industry.
[54] Cedefop. (2021). The green employment and skills transformation: Insights from a European Green Deal skills forecast.

3. Strengthening opportunities for re- and upskilling for current professionals

The green transition can change work processes and thus the demand for skills and professions, creating displaced workers. By providing targeted opportunities for re- and upskilling to affected workers, this increases retention in their existing profession or enables them to transition more smoothly into a greener economy. The GRIT VET module targets to help minimise potential social and economic costs of the energy transition by tackling skills mismatches among technicians. [55]

In summary, vocational education and training (VET) is a crucial engine of economic and social change in the wake of the energy transition. This desk study and stakeholder consultation report points to several concrete building blocks that can help make the green industrial transition a success by investing in VET.[56][57][58][59] We discuss these **building blocks** and link them with the GRIT project plan:

- **Engaging companies and sectoral partners in updating learning contents** ensures that learned competencies meet current and future labour market demands. Cross-sectoral dialogue can significantly contribute to effectively steering the relevance and practicality of competency development in education and training. In GRIT, we strongly focus on this alignment by starting our work from a stakeholder consultation.
- Aligning with existing collaboration platforms helps **to improve collaboration between the involved sectors and education**, particularly to make strategic choices together for adjustments to education, curricula, and certifications in view of the energy transition. Within GRIT, alignment with existing national and regional advisory bodies and initiatives is sought after. Ideally, learning communities can be formed with experts from education and companies for the development of a youth engagement program and VET module.
- The energy transition requires an **increased influx of technicians**, and so there should be broader efforts from a younger age to excite young people for STEM education. Without a foundation in STEM, they may find it more difficult to specialize in relevant technical disciplines later on. We work on this within the development of the GRIT youth engagement program.
- By **highlighting the importance of VET for the societal challenge of the energy transition**, the attractiveness of VET itself can increase. The energy transition can thus be a stimulus and an opportunity to reposition VET. Defining competencies for the energy transition and identifying shortages of professionals can become an integral part of the economic and societal revaluation of VET. Collaboration with businesses, including through the development and implementation of the GRIT VET module, offers opportunities to develop green STEM competencies and make VET attractive for young people, both young men and women.

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[55] UNESCO/UNEVOC. (2017). Greening Technical and Vocational Education and Training A practical guide for institutions.
[56] European Commission. (2023). Vocational Education and Training and the Green Transition.
[57] FOD Volksgezondheid. (2023). Implications of the climate transition on employment, skills, and training in Belgium.
[58] Departement Werk & Sociale Economie. (2023). Proposal for an implementation roadmap for the Flemish Green Skills Strategy.
[59] Departement Werk & Sociale Economie. (2023). Green Skills Roadmap Flanders: Best Practices Report.

- The energy transition requires the **development and programming of new VET modules**. Existing programs need to be evaluated for emerging competency needs. While procedures for revising qualifications are inflexible and time-consuming, it is essential to update curricula – and the qualifications underlying them – in a timely manner. In GRIT, existing curricula are evaluated by project partners CVO Vitant, Alfa College and Ma-Co, new content is added via a new module.
- Another important aspect is strengthening **participation in lifelong learning** and, more specifically, developing targeted modules for re- and upskilling. Development of re- and upskilling modules for current employees is worked on by the above-mentioned VET providers within the GRIT project that all have current professionals as part of their target group.
- **A modular approach** to integrating new learning content into existing curricula and qualifications is better suited to a rapidly changing labour market. Short, targeted courses and learning experiences enhance familiarity with relevant concepts and practices for the energy transition in their respective fields. This approach can pave the way for comprehensive adjustments to education or curricula in the (medium to) long term. Offering an introduction to the challenges and opportunities of the energy transition is a valuable first step.
- **Ensuring that teachers are up to date** with new learning contents is crucial. By providing time and training, teachers can be motivated and enabled to focus on the energy transition in their schools. Professional development opportunities through formal training and learning/practice communities will be part of the implementation of the GRIT VET module.
- **Encouraging businesses to engage in competency development** through VET, including offering workplace learning or sharing up-to-date equipment. Close collaboration between learning environments – companies and VET providers – is sought after in GRIT.
- New green competencies often require **new learning methods and environments**. The combination of practical and theoretical learning forms the basis of VET and means VET can provide a fertile ground for new learning methods. It is important, however, to recognize that pedagogical change is not a simple process. A non-threatening approach to teachers is important to effect change, rather than imposing changes. Within GRIT, we work with education managers, teachers, and pedagogical advisors to find suitable learning methods and environments. Examples can include:
    - **Digital and blended learning** is perhaps one of the most prominent areas of innovation found in inspiring educational practices and has the potential to expand the range of authentic and experiential learning opportunities (e.g., through augmented, virtual reality, and gamification).
    - **Project-based learning** has great potential to strengthen green competencies. This form of learning is suitable for strengthening interdisciplinary learning and problem-solving skills, reflecting the increasing complexity of the energy transition.

- **Workplace and hybrid learning** provide students with more access to innovative practices and technology. By purposefully and systematically intertwining school and workplace learning, students gain more realistic learning opportunities. [60]

Below, we formulate more specific conclusions and recommendations for the development of new learning content and resources tailored to the competence and training needs linked to the energy transition in energy sector and energy-intensive industry.

Inspiring practices

Energy, as a sector, has a cross-cutting influence on transportation, buildings, and industry. There is a need to control total energy consumption and improve the efficiency of production, storage and distribution. This naturally has significant implications for workforce competencies. For VET, this means, in addition to increasing quantity of inflow of technicians and engineers, focusing on developing new competencies related to the application of energy efficiency measures and renewable energy technologies. [61] Specifically for the value chains surrounding hydrogen, we highlight recommendations from existing literature and link them to GRIT activities.

According to research by FME - a Dutch entrepreneurs' organization for the technological industry, Dutch manufacturing companies can produce and maintain components and systems in almost the entire hydrogen value chain. To be competitive, human capital is crucial. Specifically, regarding a **Human Capital Agenda, GroenVermogenNL** strengthened cooperation between businesses and education. This collaboration primarily focuses on:

- Mapping the job market for hydrogen: analysing human capital needs at companies, quantified over time, types of jobs, and required knowledge and skills, as well as promoting hydrogen as a field of work among students.
- Establishing regional learning communities around hydrogen (technologies) involving education (VET and higher education) and industry, and developing educational programs focused on hydrogen (technologies) for VET and science education.
- Developing a widely shared narrative about hydrogen within the sector, which should also be translated for the general public.
- Due to extensive digitization and automation, it is necessary to consider the implications of this for the hydrogen system to impact the Human Capital Agenda.

Energy-intensive industries represent important sectors where progress must be made in the fight against climate change. For the GRIT project, we identified metallurgy and chemical industry key sectors for which we want to enhance competences in regard to the energy transition. Therefore, technicians need to be trained in line with greener codes of conduct and with knowledge of changing environmental standards and sector-specific regulations, such as energy-efficient industrial production and the application of greener energy technology. [62]

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[60] European Commission, ETF, Cedefop, OECD, ILO and UNESCO. (2022). Work-based learning and the green transition.
[61] UNESCO/UNEVOC. (2017). Greening Technical and Vocational Education and Training A practical guide for institutions.
[62] UNESCO/UNEVOC. (2017). Greening Technical and Vocational Education and Training A practical guide for institutions.

Building on a **Flemish Green Skills Roadmap** for energy-intensive sectors, specific policy recommendations have been formulated for the chemical sector with a view to greening the training offer. Three **strategies** were identified to strengthen the attractiveness of these sectors for future professionals: [63]

- Increasing the inflow of graduates from STEM study programs: Existing initiatives such as Da's Geniaal, STEM platforms & academies, and Brightlab were highlighted as promising. The aim is to specifically target groups and scale up successful initiatives.
- Improving the value proposition to (future) employees: specifically, strengthening the green image of the professions and economic activities of the sectors involved. Practical examples such as Young Talent Lab and BlueChem are referenced.
- Increasing the capacity for reskilling of job seekers and employees: there is a desire to promote collaboration between education and the labour market. There is also advocacy for more uniform quality recognition of training programs.

A case study of the dual study program chemical process technician (CPT), with attention to the role of the sectoral training centre ACTA[64] recommended that **dual/hybrid apprenticeship programs** are an effective way to develop new (green) competencies for both students and employees. This includes both initial education and training and retraining of the existing workforce. The workplace provides access to advanced tools as well as opportunities for developing transversal competencies. The case study increased not only specific transversal and technical competencies but also emphasized the importance of embedding a green mindset in the way (future) employees perform tasks. The case study shows a practical example of collaboration between education and a chemical company, as well as the sectoral training centre, in the development of a specific CPT training module integrating sustainability goals. Because hybrid/dual learning-work pathway programs like the CPT training consist of different components (school-based learning, workplace-based learning, and learning in a simulated industrial plant), it is important for all stakeholders to collaborate closely in greening the curriculum.[65]

Although the VET module that is targeted by GRIT does not entail a full study program that can be provided as a full-fledged apprenticeship, in the development of the VET module we aim for a strong collaboration between VET and companies and where possible cocreate authentic learning opportunities in (simulated) industry environments.

The case study also revealed that sustainability themes are included in educational objectives and curricula, but there is a **lack of concrete teaching materials**. Furthermore, there is also a lack of coordination on the subject, and the emphasis on sustainability relies too heavily on individual actions and initiatives by teachers or school managers. Additionally, teachers indicated that they are insufficiently trained to teach competencies for the green transition and are not well informed about what is happening in companies regarding this matter.

[63] Departement Werk & Sociale Economie & Roland Berger. (2021). Skills roadmap voor de Vlaamse klimaattransitie. Focus op de energie-intensieve sectoren 2020-2035.
[64] Departement Werk & Sociale Economie, Roland Berger & Acta. (2022). How apprenticeships can lead to a greener labour market.
[65] https://acta-vzw.be/acta-scherpt-groene-bewustzijn-bij-procesoperatoren-aan/

Resources to invest in teaching materials and train-the-trainer programs are scarce and are not always a priority for schools. The GRIT project provides such resources to invest in teaching materials, where possible within a learning community that provides an ecosystem to develop learning materials in cocreation between VET, the industry and research in higher education.

Based on the development and testing of the training module, the following policy lessons were drawn, which could also be valuable for the development and implementation of the GRIT VET module:

- Raising awareness by investing in skills forecasts and a roadmap for adapted trainings.
- Rely on hybrid/dual learning-work environments to teach green competencies.
- Create strong collaboration between educational providers, companies, sectoral, and regional players to teach green competencies.

The authors concluded by indicating that to further promote the development and implementation of competencies for the green transition, a coordinated approach, collaboration, and funding are needed to adapt and develop learning materials and resources. It is precisely this unique opportunity that the GRIT project offers to work on together.