



Apprenticeships for greener economies and societies



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Foreword

In November 2021, the 26th United Nations Climate Change conference (COP26) set the global agenda on climate change for the next decade. A few weeks earlier, on 21 and 22 October 2021, the second Cedefop-OECD symposium focused on apprenticeships for greener economies and societies. The symposium took place at a time when countries are increasingly putting the green transition on the policy agenda in their efforts to achieve a just recovery from the COVID-19 crisis.

The momentum of the green recovery makes the subject of the symposium, and this collection of research papers, all the more important. The green transition, with its pace and depth will not succeed without developing and using the right skills. Vocational education and training (VET) can play a key role in that respect, by equipping young people with the skills they need in a greener economy and society and providing opportunities for adults to adapt to a greener reality. As such, VET can contribute to ensuring that the green transition is a just transition, which does not lead to further disparities but offers new opportunities to all.

Apprenticeships in particular are well placed to develop the skills for the green transition, as they are at the intersection of the education system and the labour market. Strong social partner involvement in apprenticeships is needed to ensure that the green transition's impact on workplaces and the labour market more broadly is reflected in the design and delivery of apprenticeship programmes. At the same time, the anchoring of apprenticeships in the formal education system contributes to ensuring that apprentices receive a well-rounded, forward-looking training that also includes transversal skills and attitudes that are indispensable to make economies and societies greener. By their design, apprenticeships allow for knowledge exchange and cooperation between apprentices, social partners and education and training providers. Such collaborative mutual learning is of crucial importance when it comes to the green transition, with new developments happening at a fast pace. As such, apprenticeships do not only allow individuals to adapt to a greener reality, but also contribute to innovation. In that regard, apprenticeships enable change, and apprentices become change agents.

The research papers in this collection explore how skill needs are changing due to the green transition, how this impacts apprenticeships systems and how apprenticeships can support and promote the transition. Drawing on practices and insights from scholars from different countries and disciplines, we are convinced that their insights will be of use to all those contributing to a green recovery that leaves no one behind.

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The publication originates from the second joint Cedefop/OECD symposium on apprenticeships for greener economies and societies that was held virtually on 21 and 22 October 2021. We would like to thank all the authors of the papers included in this publication, who presented their work at the symposium. We would also like to acknowledge the contribution of the keynote speakers: Stefano Scarpetta, Director for Employment, Labour and Social Affairs at the OECD; Jürgen Siebel, Executive Director at Cedefop; and Philipp Gonon, Professor Emeritus at the University of Zurich.

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Executive summary

The COVID-19 crisis challenges governments to ensure that the recovery and stimulus measures contribute to, and do not adversely affect, environmental sustainability and well-being. Ultimately, the recovery is an opportunity to ‘build back better’, combining an emphasis on restoring growth and creating jobs with the achievement of environmental goals and objectives. The [2021 OECD Ministerial Council Statement](#) highlights the priority placed by OECD countries on building a green, inclusive, and resilient recovery for all. Countries committed to taking ambitious and effective action to align their recovery plans with the goals of the Paris Agreement to cope with the threat posed by climate change to their economies and societies. At the EU level, since 2019, the [European Green Deal](#) (EGD) has set the blueprint for a transformational change encapsulated in the intention to make Europe the first climate-neutral continent. This change includes protecting human life, animals and plants by cutting down pollution; helping companies become leaders in using or developing clean products, processes and technologies; and helping ensure a just and inclusive transition.

The green transition will likely have a significant impact on labour markets around the world. [Recent OECD estimates](#) of the consequences of a policy-driven transition towards a more resource-efficient and circular economy showed that such transition proves very effective in fulfilling its environmental objectives, along with marginal but positive employment impacts for most countries. Cedefop’s [skills forecast scenario](#) (2021) similarly finds that implementing the EGD has a positive net employment impact, and that employment effects appear to be concentrated in sectors directly targeted, such as extraction industries, construction and waste management. As a spillover effect, employment increase is forecast in service sectors such as engineering and administration, while in most other sectors, a possible redirection of employment towards cleaner production

rather than an employment change is forecast. While various ‘green’ sectors and activities offer significant prospects for job creation and the overall positive impact on employment is likely to be positive, thousands of fossil-fuel workers may need to find new jobs. There are considerable [regional disparities in job creation](#) in some of these sectors, with job gains in some parts of the world outpacing losses in others. In addition, some population groups do not benefit from job creation to the same extent as others.

To achieve the potential of the green transition and ensure that no one is left behind, investment in skills is crucial. The transition to a greener economy requires different skills, both for newly emerging jobs and for existing jobs that are evolving. Without a suitably trained workforce, the transition will be impossible. [Skill gaps and shortages are already recognised as a major bottleneck](#) in a number of sectors, such as renewable energy, energy and resource efficiency, renovation of buildings, construction, environmental services and manufacturing.

Vocational education and training (VET) can play a key role in equipping young people and adults with the skills needed to make the most of the green transition. Well-designed VET systems facilitate school-to-work transitions for the young, provide relevant and flexible upskilling and reskilling opportunities for workers and jobseekers, and ensure that employers find the skills they are looking for. By working closely with social partners, VET curricula can be updated to allow learners to develop transversal and technical skills that are in-demand in a greener labour market.

Apprenticeships can play a particular role in that respect ⁽¹⁾. The governance structures of apprenticeships are usually more open to labour market actors than other forms of VET. Learners alternate between different learning venues (typically a VET provider and a company) and the double ‘identity’ of the apprentice (learner and employee) means that learners can effectively

⁽¹⁾ See Cedefop (2022). An ally in the green transition. [Cedefop briefing note, March 2022](#).

develop a broader range of skills while acquiring work experience. Within apprenticeship systems, VET teachers and in-company trainers regularly work together, facilitating mutual learning. The design of apprenticeships, with their large share of work-based learning, also makes them suitable for the upskilling and reskilling of workers. Hence, the close interaction between the education system and the world of work makes apprenticeships well-placed to respond effectively to changing skill needs, including those related to the green transition. Current or anticipated changes in job profiles or in production technologies can be reflected in apprenticeship curricula much quicker than in the curricula of any other line of education and training, making apprenticeship an enabler of the transition, rather than merely being its repair shop.

The joint *Cedefop-OECD symposium Apprenticeships for greener economies and societies* organised on 21–22 October 2021 provided an opportunity to learn more about how apprenticeships can effectively support the green transition, the challenges in doing so and the conditions and support needed to overcome possible obstacles. This publication brings together the research papers that were presented at the symposium, bringing new insights into the link between apprenticeships and the green transition.

The introduction, based on the symposium keynote speech, discusses the role of apprenticeship, and of apprentices as enablers of change, in a landscape of renewed emphasis on greenification and sustainability. The first three research papers take a general look at changing skill needs due to the green transition and what this means for apprenticeship; the remaining three papers focus on particular sectors or apprenticeship programmes. Their analysis leads to some key messages regarding the adaptations needed for apprenticeships in the context of the green transition, and the role that apprenticeship can assume to be a facilitating factor in that direction.

Key messages

Modular approach to support short-term adaptation

In the short term, to contribute to the green transition, apprenticeships can benefit from relatively easier to develop, targeted, ‘surgical’ initiatives that are based on a modular approach. Short but focused courses and experiences for apprentices can increase their familiarity with concepts and practices relevant to the green transition in their respective field of study (be it subject-specific or general skills relevant for the transition). Such an approach can then pave the way for extensive updating of apprenticeship (or overarching VET) programmes or curricula. Offering apprentices a first-level induction on the challenges and opportunities of the green transition is a valuable first step to support apprenticeships in the short term.

In Chapter 6, Sodermans et al. give an example of how a training centre involved in apprenticeship training greened a training module for chemical process operators. Introducing gamification in the learning units on the use of chemical equipment motivates apprentices to look for the most energy-efficient way to operate their equipment. Apprentices can explore different operation modes, provided they do not exceed the set CO₂ emission limits.

In Chapter 5, Szuppa, Ofstad and Hees describe how Siemens piloted a ‘quick win’ project to promote sustainability and circular economy that can be flexibly adjusted to in-company training and can be applied in apprenticeship training within the organisation. The project improves learners’ knowledge and awareness of the topics, and creates an understanding of one’s own contribution and possible role in the green transition, motivating apprentices to reflect on such issues in their daily work.

Green elements across subjects, occupations and geographic areas

For Cedefop^(?) and the OECD, skills for the green transition comprise sustainable thinking and acting and relate to all economic sectors and occupations, not just ‘green’ ones. As a result, adaptation

(?) See the definition in Cedefop (2014), *Terminology of European education and training policy: a selection of 130 key terms. Second edition*. Luxembourg: Publications Office.

of apprenticeships cannot be limited to specific sectors, occupations or geographic areas ⁽³⁾. Apprenticeship programmes and curricula may also need horizontal transformations in the medium to long term to adjust fully to the new skill needs. This is first to help apprentices develop a full set of skills for the green transition: technical theory and practice is complemented with general/soft skills but also attitudes and new ways of thinking. Then, in many countries, the emphasis is on integrating transversal sustainability-related skills and updating curricula across all apprenticeship qualifications, on top of (or rather than) developing new qualifications specifically to address the challenges and opportunities arising from the green transition ⁽⁴⁾.

In Chapter 3, Zaussinger et al. argue that apprenticeship design requires a granular understanding of the impact of the green transition on labour demand and supply, accounting for different needs across sectors, occupations and geographic areas.

In Chapter 4, Steinberg and Klatt argue that quality apprenticeships, based on comprehensive learning outcomes and the balance between technical and generic competences, can offer a suitable response to the need for transversal skills development and the design of completely new occupational profiles for existing or emerging sectors. The paper presents a project, implemented in Greece, which recognises the importance of interdisciplinary competences in greening occupations and curricula, and therefore complements training on innovative technical competences with developing entrepreneurial skills to further empower young apprentices.

Sodermans et al. present a competence framework for the green transition comprising knowledge, technical and soft skills, but also arguing that this framework needs to be complemented with 'green' attitude/awareness.

According to Szuppa, Ofstad and Hees, basic understanding, self-reflection, and reflection of business functions regarding the ultimate targets of climate protection and sustainable development goals, are

the common competences every apprentice should be educated with, regardless of their specific role and business unit.

Comprehensive approach to skills development for lasting, profound change

The more apprenticeships are adapted in a systematic and comprehensive way to respond to the needs of greener economies and societies, the better they produce a deeper, long-lasting impact. Such approaches are comprehensive first in considering broader needs at occupational level, and second in terms of making use of needs and contributions from a wider set of relevant actors. In this context, apprenticeships provide an opportunity for learners to become fully prepared to practice their profession, with a view not only to immediate transition to the labour market, but also to longer-term employability underpinned by the development of a wider set of knowledge, skills and competences (technical theory, technical practice, personal and interpersonal) for current and future needs. A better informed and more 'complete' adaptation can increase the greening contribution of apprenticeships for learners, economies and societies.

In Chapter 7, Clarke and Winch discuss the benefits of a 'high road' to adaptation of apprenticeship curricula, as with the one followed in Belgium and Germany, where multi-stakeholder approaches support the updating of occupational profiles, curricula and exam regulations for apprenticeship training in low-energy construction. The high road approach develops apprenticeship standards that combine a broad theoretical knowledge (e.g. of building physics and materials) with an overview of the sector, and integrates communication, coordination and teamwork skills, fostering a holistic understanding of the construction process and energy efficiency. Steinberg and Klatt argue that apprenticeships represent an interaction system where the needs of various stakeholders meet. When its unique quality

⁽³⁾ See also Cedefop (2021). *The green employment and skills transformation: insights from a European Green Deal skills forecast scenario*. Luxembourg: Publications Office.

⁽⁴⁾ A similar message came out from Cedefop's analysis of six EU Member States as part of the 2019 research on skills for green jobs. See Cedefop (2019). *Skills for green jobs: 2018 update. European synthesis report*. Luxembourg: Publications Office. Cedefop reference series; No 109.

features are put in motion (e.g. the balance between subject-specific and interdisciplinary competences, the interplay between theoretical and practical training, and the inclusion of different social functional systems in the planning and organisation of the apprenticeship), the transformative power of apprenticeships can be profound for learners, companies and societies.

Learning venue spillover and multiplier effect on VET systems and local communities

The advantageous position of apprenticeships in fully qualifying future workforces is also linked to the collaboration of the two learning venues (school and company). The dual role of apprentices and the frequent collaboration among them, their teachers and in-company trainers allow for cross-fertilisation in supporting the green transition. In apprenticeships, this collaboration is usually more structured (and ideally of greater duration) compared to other VET options. In this context, the level of readiness of teaching (school) and training (company) staff in relation to the green transition is critical. Spillovers can appear through, for example, timely expression of actual company needs in relation to the green transition when apprenticeship curricula are updated, or through sharing new green technologies across venues, or outcomes of smaller-scale green initiatives from one learning venue to the other. Such relationships are prerequisites, but also facilitators of a swift(er), effective and relevant adaptation of apprenticeships for the green transition, so that they can produce outcomes that are relevant for learners, companies and societies.

Sodermans et al. show that the approach that trainers follow to encourage learners to reflect on current procedures and come up with innovative, eco-friendly proposals has, in turn, positively reflected back on the training centre's staff and organisation culture. Steinberg and Klatt present an approach for innovative, joint 'green' teacher and in-company trainer training, while Szuppa, Ofstad and Hees, and Clarke and Winch also focus on the adequacy of skills of apprentices' colleagues and see their training as a condition, and an enabler, for apprentice skills development too.

In Chapter 2, Weber and Wittig discuss how different apprenticeship learning venues can enable the development of skills for the green transition, and point out the need for multiple actors and stakeholders to be involved in the design of learning venues, so that the topic of sustainability, and particularly of sustainability-oriented apprenticeship, can address the needs of both the company and society.

Steinberg and Klatt understand the concept of apprenticeship at the interface of theory and practice as a guiding system for the ecological transformations of society as a whole. They show how innovation processes initiated in apprenticeships in Greece, can positively affect the entire VET system and then the related labour market and social systems. Based on joint creative approaches to which a great variety of stakeholders actively contributed, these processes can affect how apprenticeships (and the overall VET system) can become more open, responsive and also supportive to companies, local labour markets, learners and the local communities.

Apprenticeship as a key element in company skill strategies

The more integrated apprenticeships are in company strategies to tackle the challenges of the green transition, the better the solutions they can provide at company and also at system/society level. This notion points towards complementing one-off, short-term, peripheral responses that can alleviate immediate company needs, with a more structured, forward-looking approach where apprenticeship also serves medium- and long-term needs and is applied in a key, systemic way. High-quality and updated green skills intelligence can support apprenticeship stakeholders

in making informed decisions when adapting or expanding apprenticeship programmes and systems accordingly.

Sodermans et al. point out that apprenticeships can be an effective training method for sustainability if companies are really adopting ecological awareness, though this still remains a challenge rather than a reality. They also recommend skills forecasting as a means first to raise awareness among companies of the skills required, and then to inform apprenticeship training adaptation.

Weber and Wittig argue that the design of sustainability-oriented learning venues in apprenticeship requires a holistic organisational development process that encompasses all levels of a company, from the strategic level of the meta-learning venue to the design of learning and working environments, to teaching and learning situations. They suggest that companies participating in apprenticeships may undergo a wide set of transformations to promote sustainability, including renewing staff and management values and knowledge, adapting working and learning practices and pursuing suitable partnerships and presence in the local environment.

Szuppa, Ofstad and Hees show how apprenticeships are integrated into the overall analyses and discussions of external trends and internal needs, which feed into a learning pyramid that sets out the competences required for sustainability. In this way, the competences planned to be taught to apprentices at various levels and in business units across the company are meticulously and organically linked to business needs and an overarching competence framework.

Zaussinger et al. show that, while apprenticeships may be a suitable learning environment for acquiring skills for the green transition in both initial vocational education and training and retraining, more granular data at regional, sectoral and even skill level would facilitate adjusting apprenticeships to the needs of workers and regions most affected by the transition.

This publication presents practices, research and analyses in an area where relatively little evidence and policy information is yet available. It is a first step towards filling an important knowledge gap and stimulating further research on this topic. Cedefop and the OECD will keep exploring the repercussions of the green transition for apprenticeships, and the role that apprenticeships can play for greener economies and societies.

Introduction

Apprenticeships for greener economies and societies: state of the art and the potential of apprentices

© Philipp Gonon ⁽⁵⁾ ⁽⁶⁾

1.1. Greenwashing, greenification and sustainability

As individuals we have many opportunities (and often get nudged) to act 'green' ⁽⁷⁾. However, to act greener in this way does not guarantee that we (or humankind) will be successful, not knowing how much time and opportunities allow us to turn the wheel and really get a picture of the risks we are facing (Ord, 2020). It seems very likely that consumers and citizens do not modify preferences immediately and a single act cannot solve the problem of climate change or long-term sustainability: the economy still pays too little attention to social needs and nature.

This section, therefore, starts with a critical appraisal: the shift towards incentives and market-based instruments to encourage individuals, the economy and society to act greener seems positive at first glance; but it also serves to avoid important systemic, profound structural reform to our way of producing and living that are actually needed to promote sustainability.

Greenification and, even more, greenwashing are terms which are used not just to approve green issues. They also to hint that many measures promoted as for the environment are actually quite ambivalent in terms of making our world greener, i.e. of value also to the lives of future generations of humankind.

The market economy is counting on elements

which are the core of the system (prices, competition and incentives) rather than prohibition and constraints. Further, there is often a focus on consumers rather than producers, although it is more difficult to modify millions of consumer decisions, instead of improving production i.e. by making production less harmful for the environment.

In this context, greenification based on distracting the central role of producers is prone to pass the buck to others, especially to consumers (Ringger, 2020, p. 142). The general aim to turn green and for humans to act sustainably seems complementary and increasingly consensual. But the question 'what is greenification for' remains debatable, due to the fact that it has to be clarified what the most important measures are.

The discourse and the wording started changing in the 1970s. Today, executive board members, managers and owners of big firms, e.g. like Novartis or Nestle ⁽⁸⁾ seem to suggest that 'something' has happened in recent years, at least the compulsion to justify what has been done and the acknowledgement of a 'green' responsibility. There is a gradual recognition and critique that we still have a spirit of 19th century capitalism and industrialism, trying to make money out of natural resources and leaving a devastated landscape. Many measures, like producing dirty and offering a green tree afterwards, are, in this respect, greenwashing. Green acts and greenwashing as nominal support is not backed up by structural decisions; it equals doing something good for having done

⁽⁵⁾ Professor emeritus of vocational education and training, University of Zurich.

⁽⁶⁾ This paper is based on the keynote speech delivered by the author during the 2021 Cedefop-OECD symposium on apprenticeships for greener economies and societies.

⁽⁷⁾ For example, in a hotel we may be asked not to put towels in the wash prematurely, in order to 'save the planet'.

⁽⁸⁾ See Hoffmann (2021) and Schneider (2021).

something bad. Other views in favour of consuming more ‘healthy food’ products, as opposed to past nutrition lifestyles (e.g. consuming meat), are also potentially greenwashing, admitting that 60% of those products are not really healthy. This is especially true if, at the same moment, companies defend selling luxury products as a right of the people who want to enjoy them, disregarding their production conditions.

All in all, is greenification sufficient? Do we have enough time? ‘Our house is on fire’: if this is true, the Greta-question and her urge ‘I want you to act, I want you to panic’ (Thunberg, 2019) is more than understandable. If we consider the whole range of urgencies, we have to admit that is difficult to act consequently green. Most developments like pollution and overuse of resources still are bound to a growing population and a growing economy ⁽⁹⁾. Some expect progress in handling CO₂-emissions, but technological miracles are not in the agenda. Regarding climate change, the Agenda 2030 is criticised as being unrealistic and based on a compromise, while the Climate Action Plan (CAP) aims at measurable results: zero emissions by 2030. But these are aims for nations and policy and not primarily a question of education.

So, the critical appraisal of this ‘green wave’ is expanded to how it is affecting VET. Many firms and also education policy try to be, and to appear, greener. The question is whether VET is helpful in ‘saving’ the planet or at least if ‘sustainability’, as an education aim, gives us a possibility to modify our behaviour in the long run. But is sustainability really learnable? And what is sustainability? ⁽¹⁰⁾. The following critically discusses the role of apprenticeship, and VET in general, in this landscape and the potential role of apprentices as enablers of change.

1.2. Do ‘green’ VET or ‘green’ apprenticeship exist?

Green issues have also affected VET, and have become more present in conferences, public discourses, and websites of firms or associations related to VET. Some activities labelled as ‘green’ already take place in VET or apprenticeships. VET can benefit from and be part of the transformation towards greening economies and societies.

1.2.1. Greening to make VET more attractive

Greening is important for the (new) prestige of VET and apprenticeships. To appear green attracts attention and learners: in this way, greening is a selling factor. Thus ‘green’ is an incentive and an opportunity for repositioning VET, and defining skills and attitudes for the green transition, and identifying green skill gaps, becomes part of reforming VET.

Greening is also a possible strategy to redefine professions and make them attractive (again). For example, in the rural sector, the food production and all professions around agriculture can be seen as part of an old and new green economy ⁽¹¹⁾. For several sectors, greenification is a marketing strategy for the related professions and a tool to attract apprentices for them, as other examples show ⁽¹²⁾.

Cooperation schemes between VET schools and businesses, typically strong in apprenticeships, present several chances to develop green elements and, in turn, make apprenticeships attractive to some young people.

⁽⁹⁾ The trajectory of the so-called anthropocene is showing that most indicators in recent years (from the 1950s on) beside climate issues, show a dramatic increase in all aspects like pollution, acidification of water and sea, and urbanisation: tropical forest loss has taken place (Steffen et al., 2015). So, the urgency to get ‘greener’ is broadly recognised. It is difficult to say whether it is really too late. Some people said that in the 1980 it had been already too late to save the planet. As it turned out, it was not and perhaps new innovations and a ‘new’ behaviour of mankind help at least to stabilise this fragile situation.

⁽¹⁰⁾ The classical definitions hint to the same meaning: development that ‘meets the needs of the present without compromising the ability of future generations to meet their own needs’ (Brundtland Commission, 1987), ‘while safeguarding Earth’s systems, on which the welfare of current and future generations depend’ (Griggs et al., 2013). There are since two long-standing positions related to sustainability: one believes in a process of education and accommodation, the other seems to trust in technological solutions (Mann, 2018). It is necessary to say that critical appraisals of sustainability also imply a certain bias. The discussion about sustainable development follows the perspective of the global north: insofar as it seems to be a western construct, a floating signifier, but with a global reach. Sustainability includes a mix of economic, rights-based and environmentalist discourse on the one hand, and a gap between policy intentions and what is going on, on the other (Tikly, 2019).

⁽¹¹⁾ See, for example, [rural sector representation in the green apprenticeships advisory panel in the UK](#).

⁽¹²⁾ (Digital) apprenticeship in construction features [lessons](#) identifying the latest sustainable materials, avoiding waste, plus aims such as how to comply with energy efficiency or constructing zero-carbon-buildings.

1.2.2. Greening VET and apprenticeships to address skill needs

Putting VET attractiveness aside, there is an actual demand for new or adapted skills to be developed in VET, including apprenticeships, to contribute to the realisation of the sustainability goals. Sustainability also has a technical side, therefore developing and practising ⁽¹³⁾ green skills and attitudes may be helpful. The overall consensus in the available literature is that skills for the green transition have to be furthered. While recent developments made a decisive contribution to the debate (particularly the GreenComp Framework and the ESCO classification of green skills, Box 1), it is still not easy to determine what skills, competences and attitudes for the green transition include and do not include.

Box 1. International sources about greening skills

- The ILO published a synthesis report based on 21 country studies in order to promote a green transformation, which needs new skills (ILO, 2011). The turn towards a greening economy is described but quite open: changing skills is dependent on environmental changes, regulations, green technology and market and consumer habits (*ibid.*, p. 161). Existing skills are seen to be changed and new skills have to be upgraded to new occupations.
- Upskilling and reskilling in order to ease employment and career transitions in the context of the European Green Deal is also seen in a recent Cedefop publication as the way forward (Cedefop, 2021, p. 9). Greenification depends upon a transition to green economy and the workforce has to be adopted. That is why greening also needs to update teachers, students and apprentices in order to be prepared for this transition. Greening industry requires the knowledge and forecast

of what kind of skills will be in demand in the coming years (Aktor, 2020).

- Greening industry and production, therefore, also means to greenify VET. Many publications have resulted, often with such a specific focus: technical VET (TVET) and reforming teacher education for competences in sustainable development as one element (Maclean et al., 2018), for greening of economies in Asia, as well as offering resource books with a green focus for teaching and learning in Africa (Ramsarmup and Ward 2017).
- An appealing approach of responding to the perceived needs of green skills, competences and attitudes is provided by the Joint Research Centre, European Commission, Policy report GreenComp framework on sustainability, where 12 competences, including valuing sustainability, critical and exploratory thinking and collective action, are identified (Bianchi et al., 2022).
- A recently published technical report from the European Commission tries to identify and label existing skills and new affordances in the context of a green transition for a broad range of professions and activities in the workplace (European Commission, 2022).

Source: Author.

The focus on skills for the green transition is helpful but it has not yet been clarified what this really implies. Some identify skill gaps derived from environmental regulations and suggest an analytical and technical set of skills which have to be acquired (Vona et al., 2015). The focus should be to develop more skills for the green transition, which could be job-specific or much more oriented towards a general approach to VET ⁽¹⁴⁾. Skills for the green transition are based on new occupations and occupational specialisations ⁽¹⁵⁾ but greening of existing skills is also needed ⁽¹⁶⁾, including digital skills.

⁽¹³⁾ Skills for the green transition are acted rather than learned; this is why cooperation with small and medium-sized enterprises is seen as important (European Commission, 2020).

⁽¹⁴⁾ Greening economies and the redefinition of jobs need generic green skills for the green transition, which are based – as one specialist on issues in green VET is putting it – on a ‘weak anthropocentrism’, nevertheless including the personal development of learners (Pavlova, 2012).

⁽¹⁵⁾ For example, domain-specific sustainability skills in certain branches, like in food craft and food industry occupations have to be developed (Fernandez et al., 2020).

⁽¹⁶⁾ A literature review done by Sern et al. (2018) reveals that there is a broad list of skills which seems necessary in order to achieve greenification: starting with design skills, leadership skill, management skill and communication skills the range also includes waste management skills and financial skills (Sern et al., 2018).

Sustainability is a cross-sectional task, including environmental, economic and social aspects. For VET this includes how (school) teachers and (in-company) trainers as key actors shape the implementation of the modernised standard vocational training topic of ‘environmental protection and sustainability’ (BIBB, 2021). Reforming VET today means to open up possibilities, to act in a sustainable way. Along with the sustainability perspective, this includes a long-term perspective taking into consideration future consequences. VET and education policy now see the need and the opportunity, and try to follow a more systematic approach besides (important) grass root politics.

1.2.3. Greening: develop a full set of competences, address society’s needs

Education can be a pivotal element in greening economies and societies. Even within VET, small aspects of a cluttered green agenda are selected with a view to making a contribution towards more sustainability. Promoting green competences through VET seems to help make the future better, while polishing the image of a firm and of VET generally.

However, evaluations of what has been done so far show that education for sustainable development often does not reach a balance between economic, ecological and social interests; at the end of the day, economic concerns come first (e.g. Vollmers et al. 2014). It seems that small-scale, incremental updates of VET and apprenticeship curricula do not suffice. Transversal topics should be included in teaching and learning (Niebert, 2021, p. 16) and education should try to reach a concept of *Bildung*, which links self-development with the broader society, and therefore provides a better basis to not exceed the planetary load limits.

The field of ecological pedagogy offers surprisingly broad skills and competences labelled as green:, 12 main competences are required for sustainable development, among them the attitude of forward-looking, gaining interdisciplinary knowledge, assessing risks and dangers, to plan and act together with others and acting upon the basis of justice, as de Haan programmatically stated (de Haan, 2010). Similar competences, skills and attitudes are also identified by the Green-

Comp Framework (see Bianchi et al., 2022). In this context, promotion of green competences can help a broad development of future workers and citizens with a deeply rooted understanding of their role and responsibility for greener economies and societies.

Box 2. Reforms and greening VET on a national level

- The drive or drift towards a greener economy is very much based on regional or national problem sets. The contradiction between saving jobs in an economy based on carbon-emission and pollution, i.e. reducing greenhouse gas emissions, and providing social inclusion and justice, requires a broad set of competences, but is also hampering quick changes (Fien and Guevara, 2018, p. 264).
- Transition to a green economy requires the ‘right’ skills, as a UK country report is suggesting. This includes not only skills in the low carbons and environmental sector, but also in all businesses in order to use natural resources efficiently (HM Government, 2011, p. 3).
- A report for Germany identified as prior targets for greening VET the following sectors: renewable energy, installation, repair and maintenance of environmental plants, the solar sector and energy saving (Economix, 2010, p. 71).
- There are country-specific foci in presenting policy recommendations for greening industry and society through VET: for Australia, the coal mining and agriculture industries are focused (Rafferty and Yu, 2010).

Source: Author.

1.3. Greening apprenticeships and apprentices as greeners

The identified aspects of greenification and sustainability suggest different levels of (potential) reforms. But what happens today? Among the many initiatives that countries have been taking to ‘greenify’ their VET systems and apprenticeships in recent years, a few that deserve attention

come from German-speaking countries (Austria, Germany and Switzerland) with a strong tradition in dual VET/apprenticeship.

The examples presented below show some activity on a meso-level, i.e. in terms of regulations, syllabi and restandardisation with a green focus.

In Germany, in spring 2020, minimum standards were updated for all vocational training occupations (standard vocational training positions). In the future, competences in digitisation and sustainability will be taught in all vocational training courses, which are typically offered as apprenticeships. Several projects were launched in this direction, including the BIBB-project *Green competences for all apprentices* (BMBF, 2020). Whether the establishment of such sustainability standards is sufficient and relevant in VET is, however, very much dependent on the will of the teachers and trainers in adapting these concepts in everyday practice (Kaiser and Schwarz, 2022).

In Switzerland, the Swisscleantech association formulated recommendations to include in all curricula and all 230 vocational training regulations topics like renewable materials and energies, efficiency and storage of energy, efficiency of water management and eliminating waste (see Heinemann et al., 2012). The association was founded in 2011, including 500 members of different industrial branches, aiming at climate-neutral production and focused on technical occupations.

In Austria, in 2013, the initiative *Green skills for green jobs* launched a qualification barometer for eight branches. It analysed 172 VET and further education programmes in order to define greening elements (Wegscheider, 2015).

To date, there seems to be less activity in terms of comprehensive transformations. Even in the Swiss VET 2030 strategy (which involved many actors relative to the future of VET), sustainability and skills for the green transition have hardly been mentioned until now.

Nevertheless, researchers and specific branch interest groups are collaborating on developing specific models for greenification in specific occupations, as with commercial VET for implementing and evaluating new skill programmes (Casper et al., 2017).

1.3.1. Apprentices and learners in greening: pilot projects in Germany

For many young people, green issues are part of their everyday life. For example, critical opinions related to economic growth and post-materialist values are discussed in private and public lives. Also within the company context, apprentices would like to follow a regulative idea of sustainable development, as was revealed by a small German study of apprentices in commerce (Slopinski et al., 2020).

The *NAZUBI* project (*Nachhaltigkeitsaudits mit Auszubildenden 2015-19*) took further the active role of apprentices in relation to green issues (Zinn et al., 2018). The initial objective of the pilot project was to transform the participating companies into sustainable learning environments with educational training structures, which offer access to sustainability topics ensuring learn effectiveness; then to design and implement audits in the context of sustainability which are education- and training-related. A consortium of two universities, five companies, three vocational schools in Hesse and North Rhine-Westphalia, the German Federation of Trade Unions and the Chamber of Industry and Commerce and participating trainees developed sustainability audits and tested them in practice. The task of the companies was to identify company-specific audit events and prepare and accompany the apprentices in the further course of the auditing, so that sustainability can be identified, and measures and skills can be experienced.

Another project relying on the active role of apprentices comes from a region in the north of Germany. As in the other 49 VET schools in Lower Saxony, in Oldenburg an apprentices' union was founded and named *Kauflust* (shopping pleasure). The union, active in a VET school, organises a weekly event with seven firms, aiming at sustainability and a cooperative business-model in order to transform the local economy and learn more about resource conserving handling (Fairdays) (Jünke, 2020).

These projects focus first on domain-specific knowledge and then on integrating the two learning sites (companies and schools), as both play an important role. What is to the fore, however, is that the learners themselves have an important role, as agenda setters as well as auditors, who assess

the change which has been triggered.

The will to involve apprentices and to stress the participatory aspect of their roles in firms and schools opens up a new perspective in greening, which should be continued more systematically.

1.3.2. Coordinated and liberal market economies: what VET could do better

It is not clear if dual apprenticeship countries are really performing better related to green issues. One study is stressing the fact that these countries fail to innovate, or are not as flexible, with regard to new developing economic sectors like green energy (Steedman, 2011, p. 103).

Nevertheless, the green skills agendas and greening of occupations as an EU policy aim seem to work better in coordinated market economies (CME) with often typically higher apprenticeship-shares than in liberal market economies (LME) which emphasise school-based and higher education programmes.

The dual apprenticeship-countries Austria, Germany and Switzerland, with a high share of apprenticeships, are not per se better at innovation than other countries. But the deeper and more established tradition to cooperate between State, local authorities and interest groups, and especially schools and firms, helps to develop projects.

A comparative study is suggesting that, in the steelwork industry, greening seems to be more advanced in CME (Evans and Stroud, 2016). However, this identified better starting position depends very much on individual initiatives.

The following points of strength of dual apprenticeship countries, compared to others with predominantly school-based VET, could support the argument that promoting green transition seems to work better in CME than in uncoordinated education systems:

- (a) combination of vocational and general competences, which are linked with workplace learning, allows a combination and transfer of different and specific skills for greening;
- (b) two (or more) learning sites (workplace and school) as the basis of dual apprenticeships are often demanding for education policy and the learners themselves but are also incentives for learning from each other;
- (c) strong partnerships with social partners are

one of the core affordances of a dual apprenticeship which really works. Again, cooperation and coordination are indispensable;

- (d) didactical and pedagogical advantage of the orientation towards a broad professional profile is the result of a corporatist approach on VET;
- (e) support of the public is another important element which allows apprenticeship systems to develop VET further and adapt the system to new challenges.

It is the combination of these five elements which is the outstanding feature of dual apprenticeship systems and opens new opportunities for greening.

Other VET systems in liberal market economies with limited apprenticeship tradition could operate with the help of strategic alliances of different interest groups that promote green issues and set aims for them. This kind of alliance could also serve in solving some coordination problems in more liberal economies. The coordinating role of the State in CMEs can be substituted by a coalition of stakeholders.

1.4. Conclusion

Dual apprenticeship countries like Austria, Germany and Switzerland are not per se better at innovation related to green skills than other countries with a school-based vocational system. However, the combination of different learning sites is an advantage in promoting sustainability, and the potential is there, as long as firms are flexible and open for such challenges. A further advantage is an initiative like the pilot projects (as model testing) in Germany for greening VET (apprenticeships).

Pilot projects in Germany have shown that apprentice views on green processes bring a new perspective to firms; apprentices become the pioneers of greenification in industries, also, to some extent, bringing democracy in the workplace. There is a real potential here: apprentices must have opportunities to share their ideas, ask questions about how things are done in the business. This will help greenify firms and the economy as a whole.

In many cases, they are taught about greenification issues and processes at VET schools and

carry such knowledge on to the workplace too. Admittedly, often apprentices do not master green processes but have adopted green practices or are confronted with green issues at schools or in other fields of their personal lives, so they ask valuable and relevant questions. The firm culture is crucial for opening up spaces for greening to which apprentices may contribute.

But the role of VET schools is also important. Revising curricula and introducing green elements provides the basis for informed and active knowledge and skills. While working in firms, apprentices familiarise themselves with other questions and issues that businesses have to deal with, and

that knowledge also gets channelled back into VET schools. It is a two-way process, which helps to greenify education and work.

The paradox around greenification of the economy and skills for the green transition in VET and dual apprenticeships lies in the fact that we do not know exactly the future – whether we have enough time and possibilities – but, at the same time, we have to prepare for it. In such a situation, the concept of education for sustainability open to the future, counting on the continuing learning processes of the learners themselves, offers itself a perspective.

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Learning venues in apprenticeship as a key to sustainable development

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2.1. Introduction

This paper discusses the design of learning venues in apprenticeship programmes with a view to the development of sustainability-oriented professional competence. This term is used as an umbrella term for the knowledge and skills that are needed in the world of work to enable an environmentally sustainable way of life. Like any other aspect of professional competence, sustainability-oriented competence needs to be developed, including over the course of VET programmes such as apprenticeship. This raises the question of how the relevant learning venues, especially at the training enterprise, should be organised to facilitate the acquisition of the skills in question. The aim is that learners are able to think and act responsibly in the sense of sustainability, which also requires appropriate scope for action. The problem of designing sustainability-oriented learning venues is expressed by the following questions:

- (a) how can learners be enabled to act, in their professional working environment, with a sense of sustainability and economic, environmental and social responsibility?
- (b) what are the starting points for the development of learning venues for sustainability?
- (c) what are the characteristics of a sustainable learning venue?

In the following sections we present the findings of recent research on the sustainability-oriented design of learning venues in Germany against the backdrop of the European and international discourse on education and training for the green economy. The paper is based on the results and findings from the pilot projects and scientific monitoring on *Vocational education and training for sustainable development* (BBNE) which were

supported by the Federal Institute for Vocational Education and Training (BIBB) with funding of the Federal Ministry of Education and Research (BMBF). The results on sustainable learning venues, including a proposal for indicators for the description and design of the latter, are based on the work of the scientific monitoring by the Research Institute for Vocational Education and Training (f-bb). Section 2.2, which sets out the conceptual framework of the paper, summarises the current discussion on key competences for sustainability, and introduces a structural model for the design of learning venues. Section 2.3 describes the methodology and discusses some options for designing learning venues in accordance with the concept of sustainability-oriented competence development. Some concluding remarks are made in Section 2.4.

2.2. Apprenticeship and sustainability-oriented professional competence

2.2.1. Sustainability and skills for the green transition

Sustainability and the ecological transformation of European economies are among the top priorities of policy initiatives at the EU level, assigning new tasks to education and training. The European Commission's work programme for the transition towards a digital and green economy, the European Green Deal (cf. European Commission, 2019), includes a number of proposals for activating education and training in order to support the transition. First, the Commission sets out to draft a European competence framework on sustaina-

⁽¹⁷⁾ Research Institute for Vocational Education and Training (f-bb).

bility and climate change. Second, the infrastructure of schools and training institutions is to be made more sustainable with the help of targeted financial support from the Commission and the Member States. Third, the upskilling and reskilling of individuals will be supported by the new ESF+ instrument with a view to assisting employees in the transfer from declining occupational sectors to those with increasing demand (European Commission, 2019, p. 19).

The idea of safeguarding employability for the green economy is taken further in the new European Skills Agenda of 30 June 2020. Action 6 of the agenda is dedicated to skills to support the ‘twin’ transition and reiterates the goal of developing a ‘European competence framework on education for climate change, environmental issues and sustainable development’ (European Commission, 2020, p. 12). It also announces the development of a taxonomy of skills for the green transition with a view to supporting the statistical monitoring of the ‘greening’ of professions. These skills are also supposed to be reflected in the ongoing revision of the ESCO (European skills, competences, qualifications and occupations) classification.

The definition and development of sustainability-related skills thus figures prominently in European education and training policy. This raises the question of what specific skills are relevant for the green transition and what a competence framework for sustainability might look like. In the context of the Commission’s preparatory work on the competence framework, the Joint Research Centre (JRC) has carried out an extensive literature review and suggested a preliminary conceptual approach (Bianchi, 2020), which is adapted in this paper in order to describe the main objectives of sustainability-oriented competence development.

The purpose of a competence framework for sustainability is to articulate the knowledge, skills, attitudes and values that are essential for building a more resilient and sustainable Europe, and for the realisation of the so-called twin transition towards a green and digital economy. Sustainability-related competences may be defined as ‘interlinked set of knowledge, skills, attitudes and values that enable effective, embodied action in the world with respect to real-world sustainability problems, challenges, and opportunities, accord-

ing to the context’ (Bianchi, 2020, p. 9). Based on three particularly influential conceptions in the current literature (Wiek et al., 2011 and 2016; Brundiers et al., 2021; Redman and Wiek, 2021), which show a remarkable degree of convergence, a catalogue of eight key competence areas can be identified. This preliminary framework of key competences for sustainability is depicted in the table below.

Table 1. **Key competences for sustainability**

Competence	Description
Systems-thinking competence	Ability collectively to analyse complex systems across different domains (society, environment, economy etc.) and across different scales (local to global), considering cascading effects, inertia, feedback loops and other systemic features related to sustainability issues and sustainability problem-solving frameworks
Anticipatory or futures thinking competence	Ability collectively to analyse, evaluate and craft rich ‘pictures’ of the future related to sustainability issues and sustainability problem-solving frameworks
Normative or values thinking competence	Ability collectively to map, specify, apply, reconcile, and negotiate sustainability values, principles, goals and targets
Strategic competence	Ability to recognise the historical roots and embedded resilience of deliberate and unintended unsustainability and the barriers to change; ability creatively to plan innovative experiments to test strategies
Interpersonal competence	Ability to apply the concepts and methods of each competence not merely as ‘technical skills’, but in ways that truly engage and motivate diverse stakeholders, and to work emphatically with collaborators’ and citizens’ different ways of knowing and communication
Integrated problem-solving competence	Ability to combine and integrate steps of the sustainability problem-solving process or competences, while drawing on pertinent disciplinary, interdisciplinary, transdisciplinary and other ways of knowing

Competence	Description
Implementation competence	Collective ability to realise a planned solution toward a sustainability-informed vision, to monitor and evaluate the realisation process, and to address emerging challenges (adjustments), realising that sustainability problem-solving is a long-term, iterative process between planning, realisation and evaluation
Intra-personal competence	Ability to be aware of one's own emotions, desires, thoughts, behaviours, and personality, as well as to regulate, motivate and continually improve oneself drawing on competences related to emotional intelligence and social and emotional learning

Source: Bianchi, 2020, pp. 14-15 (adapted).

Originally, these key competences have been defined with a specific focus on academic or higher education (Bianchi, 2020, p. 14), but, in principle, the generic descriptions of the competences also seem to make them applicable in a vocational context. There is also a discussion on sets of knowledge, skills, abilities etc. specifically related to the due consideration of sustainability in the world of work. These are typically referred to as ‘green skills’ or ‘skills for green jobs’ (Bianchi, 2020, p. 32) rather than competences for sustainability. Such skills are not necessarily completely separate from the above-mentioned key competences for sustainability. Instead, they have to be considered as specific skills that are needed for ‘green jobs’ in the circular economy. The underpinning knowledge, attitudes and values are the same in principle as in the case of the key competences for sustainability, which are supplemented and specified through work-related abilities with a focus on the operation of green technologies. Examples of such ‘green skills’ or skills for the circular economy are (Bianchi, 2020, pp. 42-49):

- (a) eco-efficiency and eco-effectiveness (e.g. supply chain and purchasing, energy, waste);
- (b) sustainability systems (standards and certification, metrics, reporting);
- (c) green attitude;
- (d) ability to apply technologies for Industry 4.0;
- (e) flexibility and adaptation;
- (f) resource management skills.

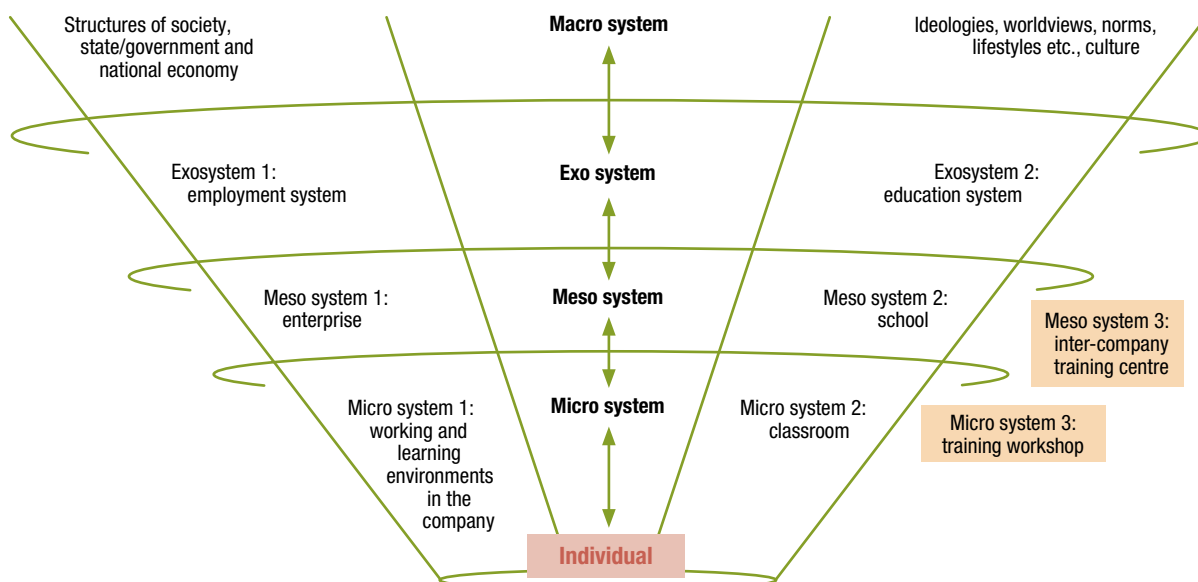
The remainder of this paper uses the term ‘sus-

tainability-oriented professional competence’ to refer to the combination of skills for green jobs and competences for sustainability. The development of sustainability-oriented professional competence, which needs to be associated with organisational development towards a sustainable learning environment, is a challenge for vocational education and training. At this point, the unique capacity of dual VET/ apprenticeship systems to utilise the workplace as a learning venue backed by (and aligned with) systematic theoretical instruction in the classroom comes into play. The issue is how learning venues can be organised to support the imparting of sustainability-oriented professional competence in the course of an apprenticeship programme. More specifically, the options for the various stakeholders in the learning process for shaping the learning venues need to be explored. In order to show how apprenticeship may function as a pathway towards sustainability-oriented professional competence, the role and organisation of learning venues in apprenticeship needs to be illustrated with the help of a basic structural model.

2.2.2. The role of learning venues in apprenticeship

In the following, we describe the function of learning venues as part of the ‘ecosystem’ of dual vocational education and training as it evolved in Germany. Dual VET, according to the Vocational Training Act (*Berufsbildungsgesetz*), which is the mainstream of vocational education and training in Germany, is based on a training contract between the learner (apprentice) and the training enterprise. The enterprise is the dominant learning venue in the sense that the largest part of the training time is spent there in relation to the time spent at a vocational school. Accordingly, the terms ‘apprenticeship’ and ‘dual VET’ may be used interchangeably when applied to the German context. The ecosystem of dual VET or apprenticeship can be depicted as a structure of concentric circles as shown in the following figure (Kell, 1995, p. 375).

Figure 1. The ecosystem of dual VET



Source: Authors (based on Kell, 1995, p. 375).

The ecosystem can be differentiated into four different system levels (Figure 1). The macro-⁽¹⁸⁾, exo- and meso- system levels function as a set of conditions for pedagogical action, expressed within the micro system level in working and learning situations. Consequently, different actors at different levels are jointly responsible for the development of sustainable learning venues and the anchoring of VET for sustainable development. They have an influence on learning and teaching in the places of VET learning through the design of environmental and conditional factors (for further details, see the concept of didactic action by Flechsig and Haller, 1975; Mertineit, 2017, p. 3).

In the exosystem, the employment system and the education system face each other. It is often assumed that the employment system is determined solely by production technologies and business profit calculations. The education system, in contrast, is exclusively concerned with satisfying human needs without being oriented towards socio-economic requirements (Heid, 1999, p. 241). In practice, however, this clear separation is rare. Education institutions are also subject to financial constraints; at the same time, entrepreneurial de-

isions are also influenced by value attitudes such as corporate social responsibility (CSR).

Within the meso system, the environmental system is generally represented by two different VET institutions: company and vocational school. These are to work together in a learning location cooperation against the backdrop of the common objective of promoting the vocational competence of learners. In many training occupations of the dual system, particularly in the area of skilled crafts, the training programmes also include supplementary units in inter-company training centres. In these cases, the VET system must be described as a trial or plural, rather than a dual system.

At the micro system, Kell (2006, p. 462) makes a fundamental distinction between the workplace and the learning place. They represent two differently structured systems in which individuals can develop. In vocational education and training, many microsystems have been reorganised and restructured in recent decades. The result has been new learning environments, pedagogically designed teaching/learning arrangements including learning organisational procedures and methods that can no longer be attributed exclusively to

⁽¹⁸⁾ The macro level, which concerns the structures and processes of the society and the political system as a whole, will not be discussed further since the relevant policy initiatives such as the European Green Deal have already been described at the beginning of this section.

one learning venue (Kell, 2006, p. 463).

This multi-level perspective already shows that multiple actors and stakeholders need to be involved when it comes to the sustainability-oriented design of learning venues in apprenticeship. Shaping learning venues is a process of organisational developments that affects more than one organisational level. It also needs to be taken into consideration that ‘learning venue’ itself is a multidimensional concept.

First, learning venues can be defined from an institutional point of view, i.e. in terms of their formal organisation and status. This is the perspective adopted, for instance, by the Vocational Training Act in Germany, which draws a distinction between training enterprises, vocational schools and learning venues other than enterprises and schools.

Second, there is a pedagogical dimension, according to which learning venues are not just different institutions but also fulfil different functions. In concrete terms, this means that both vocational schools and companies have several ‘places’ where learning takes place. In the company, for example, this is the workplace in the sense of ‘learning in the process of work’, the training room or the learning island. In the vocational school it is the classroom or the workshop. All places in which learners are pedagogically stimulated, be it in formal or informal learning processes, may count as learning venues in this sense (Siebert, 2006, p. 20).

Third, at the micro level, learning venues can be conceptualised as social situations. Central to the social situation in the company is the work activity of the learners. The action situation derived from the work activity has a pedagogical potential that transforms components of the action into components of the learning process (Wittwer and Diettrich, 2015, p. 17). From this perspective, the learning venue is constituted by the action and communication of individuals rather than being a specific location (Wittwer and Rose, 2015).

2.3. Designing sustainability-oriented learning venues in companies: a framework

2.3.1. Methodology and analytical approach

In the context of the priority programme *Vocational education and training for sustainable development 2015-19* of the Federal Institute for Vocational Education and Training (BIBB) in Germany, several pilot projects were funded by the German Federal Ministry of Education and Research (BMBF) to design sustainable in-company learning venues. To provide suggestions for their design, the scientific support of funding line II – the Research Institute for Vocational Education and Training (f-bb) – has developed an orientation framework with indicators. The following descriptions are based on this research ⁽¹⁹⁾.

Box 1. Pilot projects for sustainable in-company learning venues, evaluated by f-bb

The mission of f-bb in its capacity as scientific advisor was to evaluate the implementation of the funding programme and to provide technical assistance for the following six pilot projects:

- ANLIN (*Ausbildung fördert nachhaltige Lernorte in der Industrie*, training to support sustainable learning venues in the industry): two training centres and several enterprises in the chemical industry developed training concepts to integrate sustainable organisational development and VET;
- InnoNE (*Innovationsprojekte und Innovationskompetenz für nachhaltige Entwicklung*, innovation projects and competence for sustainable development): development of sustainability-oriented training units for small and medium-sized enterprises in retail trade;
- KoProNa (*Konzepte zur Professionalisierung des Ausbildungspersonals für eine nachhaltige berufliche Entwicklung*, strengthening professionalism of training practitioners with a view to sustainable development): development of tools for in-company trainers to design sustainability-oriented

⁽¹⁹⁾ Detailed explanations can be found in the original contributions by Feichtenbeiner et al. (2020), Feichtenbeiner et al. (2021) and Hantsch et al. (2021).

learning settings;

- *NAUZUBI (Nachhaltigkeits-Audits mit Azubis, sustainability audits with trainees)*: the concept of auditing is adapted as a learning method to increase awareness of sustainability issues;
- *NL-G (Nachhaltige Lernorte im Gastgewerbe, sustainable learning venues in hospitality)*: analysis of business processes and work routines of apprentices and employees in hospitality with a view to developing guidelines for sustainability-oriented learning settings;
- *Q_EN_POLIS (Qualitätsindikatoren für die Organisationsentwicklung einer überbetrieblichen Ausbildungsstätte im Ausbaugewerbe des Handwerks)*: organisational development for an inter-company training centre in the construction sector with the aim of improving the consideration of sustainability issues in the training centre's structures and processes.

Source: Authors.

The work programme for the evaluation involved a document analysis of relevant sources such as project reports, telephone and face-to-face interviews with project stakeholders, and a series of focus group meetings. The interviews were conducted in four waves between January 2017 and June 2019, covering the different phases of the pilot project life cycles.

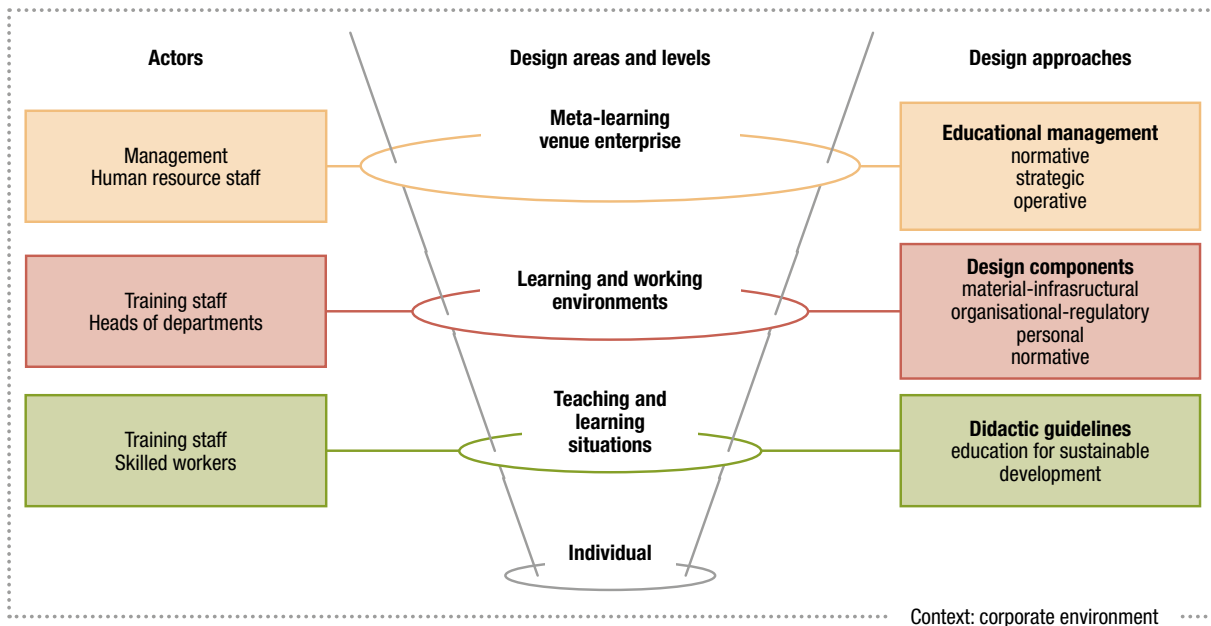
To be able to map the diverse design approaches, findings and experiences of the pilot projects, the scientific support developed an orientation framework in the form of a structural model to show suggestions for the design of company framework conditions to promote VET for sustainable development. The framework focuses on the workplace as a learning venue. With this in mind, the term learning venue is differentiated into three levels: First, the meta-learning venue is understood as the training enterprise, as an institution where learning takes place. Other meta-learning venues can be vocational schools or inter-company vocational training centres. Second, within different meta-learning venues, several learning venues can be identified, which are referred to as learning environments. The third level is the teaching/learning situation, which ultimately focuses on learning itself. In addition to these three levels,

the context or environment in which the company operates must be also taken into consideration as an area of design. The resulting model is depicted in Figure 2.

Arranged around the individual are the teaching/learning situations, which are expressed in informal and formal learning settings and are oriented towards operational action situations. This is followed by the learning environments, which are defined by physical and non-physical components and enable individual as well as collaborative learning. Finally, at the highest level, the meta-learning location is mapped as a normative-strategic enabling framework for learning in the company, including aspects such as culture, strategy and structures.

Using the German sustainability code (*Deutscher Nachhaltigkeitskodex, DNK*) as point of departure, four areas of design activities were described on the basis of the above model (Figure 2). For each of these design areas, indicators for education for sustainable development (ESD) were formulated in accordance with the DNK. These indicators, which describe the characteristics of sustainable learning venues, concern the organisation of work processes and training activities in enterprises, which means that the indicators are relevant predominantly for apprenticeship. The measures to promote the development of sustainability-oriented learning venues at the four levels are described in the following section.

Figure 2. Framework for designing sustainability-oriented learning venues in enterprises



Source: Authors.

2.3.2. Design areas and levels

2.3.2.1. The corporate environment

Design activities at the context level relate to education and training activities that either take place in the company’s external environment or are stimulated by the latter. What all activities have in common is that they can play an important role for education for sustainable development at the workplace from both a business and a social perspective. As sustainable learning venues, companies also have an impact beyond their own horizons, i.e. beyond training their own future (apprentices) or current staff. With their company locations, they are integrated into their region: they participate in the vocational training system within the framework of training or work with partners within the framework of global supply chains.

This level includes the three fields of action: raising awareness of legal framework conditions; promoting cooperation among learning venues and innovation partnerships; and extra-company involvement in the region. Examples would be engagement in regional examination boards of the competent bodies for apprenticeship training (e.g. chambers of commerce and industry), or cooperation with civil society organisations to inform

apprentice training in terms of sustainability.

Following the process described in Section 2.3.1, indicators for education for sustainable development (ESD) were formulated for this level (Box 2).

Box 2. Selected ESD indicators for the corporate environment

Raising awareness of legal framework conditions:

Our company organises regular briefings on work safety and health protection.

Our company informs the employees about compliance with human rights in general and in the company in particular.

Cooperation of learning venues, innovation partnerships:

Our company works with external partners (e.g. schools, non-governmental organisations, research institutions) on topics related to sustainability.

Extra-company involvement in the region:

Our company participates in vocational orientation for students in the region.

Our company supports regional projects for social, environmental and cultural education.

Source: Authors.

2.3.2.2. *The enterprise as a ‘meta-learning venue’*

At this level, the focus is on the organisation of the enterprise as a whole. This includes its strategies, processes, structures and culture. By shaping these elements, a framework is defined that has a significant influence on the learning culture, on corporate learning and on the participation of apprentices (as with all other employees) in the process of sustainable development. By defining guiding principles, strategic measures and short-, medium- and long-term goals, the structural framework for ESD in the company is set. The aim should be to link apprenticeship with sustainable development.

This level of design includes three fields of action: development of a concept of sustainable learning venues; derivation of strategies and goals for ESD; and planning of corresponding ESD measures. An example would be the development of a sustainability-oriented mission statement, in which the apprentices are also involved, e.g. through photo projects, and participate in the clarification of business goals. Some of the ESD indicators that were formulated for this level are listed in Box 3.

Box 3. **Selected ESD indicators for the enterprise**

Concept of sustainable learning venues:

Our company has a mission statement that includes sustainability aspects.

Our company has defined criteria for high-quality initial and continuing vocational education and training.

Strategies and goals for ESD:

Our company involves employees in developing the strategy and sustainability goals for the enterprise.

Planning of ESD measures:

The need for continuing professional development related to sustainable development is systematically monitored.

Our company has defined curricula for sustainability-oriented training units.

2.3.2.3. *Learning and working environments*

The third area comprises the working and learning environments within the enterprise. This refers to ‘spaces’ in which learning is enabled and stimulated through pedagogical action. These can be used for teaching and dealing with sustainability issues. The selection and design of learning and working environments is an important lever to promote the engagement of apprentices and employees with the sustainable development of the company. This is because they also learn informally by talking to each other or by dealing with sustainability issues on their own. Learning and working environments can support or inhibit these informal, self-directed forms of learning; they should therefore be analysed with a view to their potential for sustainable corporate development and designed accordingly.

There are five fields of action at this level: utilising the potential for sustainability in learning and working environments; learning-supportive design; trainers and superiors; exchange and collaborative learning; and creative leeway. For example, company explorations can contribute to opening up company learning spaces and occasions in which apprentices participate and contribute. Similarly, the formation of cross-departmental teams promotes joint learning from and with each other and allows apprentices to be acquainted with sustainability-related technologies and practices used in other departments. Another example related to apprenticeship is that company staff acting as in-company trainers (mentors/tutors) are trained on topics related to sustainability and therefore have increased capacity to pass on such knowledge and values to apprentices. Examples of the corresponding ESD indicators are given in Box 4.

Box 4. Selected ESD indicators for learning and working environments

Utilising the potential for sustainability:

Our company uses learning and working environments in the enterprise and beyond (external, virtual) to reflect on ecological, economic and/or social aspects of sustainability.

Our company identifies conditions that support or inhibit learning.

Learning-supportive design:

The routine operations in our company include opportunities for staff members to experience sustainability-friendly behaviour.

Trainers and superiors:

Our company regularly briefs trainers and managers on ecological, economic and/or social aspects of sustainability.

Exchange and collaborative learning:

Employees and apprentices are given insight into other departments of the enterprise.

Our company supports informal communication between employees on matters related to sustainable development.

Creative leeway:

Employees are given the opportunity to participate in sustainability projects.

Source: Authors.

2.3.2.4. Teaching and learning situations

The fourth area is dedicated to the design of teaching/learning situations that are evident in the communication and behaviour of learners and teachers in everyday business life. VET for sustainable development does not require a completely new didactic orientation. Rather, it is based on recognised vocational pedagogical principles of in-company training and contemporary vocational school teaching, and supplements these with sustainability perspectives (Schütt-Sayed; Vollmer and Casper, 2021, p. 56). The didactic principles for ESD developed for this purpose give indications on how teaching/learning situations can be designed in terms of sustainability (Schütt-Sayed; Vollmer and Casper, 2021). The aim is to initiate holistic learning processes in which, in addition to imparting knowledge, action-motivating, perception-enhancing and value-oriented aspects are

also relevant. To this end, it is essential to enable living learning, i.e. to include own experiences and personal experience (Schütt-Sayed; Vollmer and Casper, 2021, p. 57).

This level includes two fields of action that deal with the learning content of sustainability (sustainability as a topic) and sustainable action in the learning process. One example would be that apprenticeship training is adapted to include sustainability-oriented training content that is identified by the company in relation to its needs, structure and culture. Other examples include providing apprentices with opportunities to familiarise with and practise on sustainability-related topics: sustainability-related learning tasks and planning games with design thinking methods; the use of learning apps, so-called ‘serious games’ and learning diaries; and the integration of sustainability into everyday work and training through so-called ‘5-minute conversations’. Box 5 presents some of the ESD indicators that were formulated in the process described in Section 2.3.1.

Box 5. Selected ESD indicators for teaching and learning situations

Sustainability as a topic for teaching and learning:

Our company identifies opportunities for education for sustainable development within the units of IVET and CVET curricula.

Our company utilises aspects of ecological sustainability as learning contents for initial and continuing vocational education and training (e.g. product life cycle, circular economy and waste management, mobility, nutrition, energy, water and emission).

Sustainable action in the learning process:

Our company gives learners the opportunity to direct their own learning process.

Our company uses examples of best practice to motivate learners to take part in the collaborative shaping of sustainable development.

Source: Authors.

2.4. Conclusion

The complexity of the framework described above shows that there can be no single, one-size-fits-all approach to the design of learning venues with a view to supporting the development of sustainability-oriented professional competence for apprentices. This makes it clear that a holistic foundation of a sustainable learning venue requires the interplay of different design levels. In addition to the further training of trainers, it is also about the implementation of guiding principles and strategies, the introduction of sustainable procedures and technologies in working and learning processes, and the development of sustainability-oriented teaching/learning situations.

A sustainable learning venue must be also considered in the context of social developments. Policy frameworks such as the 2030 Agenda for sustainable development (United Nations, 2015) or the European Green Deal have formulated concepts and benchmarks at the macrosystem level. The idea is to develop common solutions for global challenges in the triad between economic progress, social justice and within the ecological limits of the earth. Sustainable learning places should take up these concepts within the possibilities of the respective company or institution or organisation.

The cornerstone for structural consolidation of apprenticeship for sustainable development is

within the learning venue itself, be it in the training company, the vocational school, the inter-company training centre or at a training provider. The topic of sustainability, particularly general and sustainability-oriented apprenticeship, should be based on the needs of the company and society, the challenges of the company, and the specific work and business processes. It is important to realise that training for sustainable development should not be an additional learning content 'on top', but an integral part of a profession and an apprenticeship programme. Topics such as innovative production or sales strategies, the quality of on-site training, the attractiveness as an employer on the job market, the compatibility of family and work, the promotion of health and job satisfaction of employees, come into question as anchors and connecting points for sustainability projects.

The design of sustainability-oriented learning venues in apprenticeship requires a holistic organisational development process that encompasses all levels of a company, from the strategic level of the meta-learning venue to the design of learning and working environments, to teaching and learning situations. The design approach presented here, with its different levels and the associated indicators, can give companies an orientation on which direction they can choose in the design of sustainable learning venues.

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Labour market impacts of the green transition: the need for more granular data

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3.1. Introduction

Mitigating dangerous levels of anthropogenic climate change requires a global green transition. In the European Union (EU), the European Green Deal (EGD) serves as the overarching framework for the policy-driven transition to a carbon-neutral economy by 2050 (European Commission, 2019). The implementation of the EGD will drive job growth in low carbon-emission ('green') sectors ⁽²⁶⁾, while jobs in high-carbon emission ('brown') sectors will decline (Nesta, 2020). Consequently, the green transition will lead to an increase in the 'demand for knowledge, abilities, values and attitudes needed to live in, develop and support a society which reduces the impact of human activity on the environment' (Cedefop and ILO, 2012, p. 20).

While there is overwhelming evidence that the green transition results in net job creation (Wei et al., 2010; Pai et al., 2021; Cedefop, 2021b), the shift away from fossil fuels also creates geographically, sectorally and socially concentrated losses (Vona et al., 2019), potentially resulting in political backlash against climate policy (Egli et al., 2020; Lewin, 2019; Vona et al., 2019) and losses of long-term earnings and tax revenues (Gathmann and Schönberg, 2010; Nedelkoska et al., 2015; World Economic Forum, 2018).

On these grounds, EU policy-makers have recognised the imperative of supporting workers to transition from declining ('brown') into growing ('green') sectors through reskilling and upskilling (European Commission, 2019). The EGD itself explicitly recognises the significance of skills ⁽²⁷⁾ for the green transition (European Commission, 2019) and includes a EUR 40 billion **Just transition fund** for retraining and labour market inclusion in regions and sectors that depend on high-emission economic activities (Sabato and Fronteddu, 2020).

Given the availability of dedicated funds, different formalised learning environments are available for re- and upskilling workers adversely affected by the green transition. These include full-time school-based vocational education, standalone on-the-job training, labour market programmes and apprenticeship. The particular institutional context of apprenticeship – involving continuous coordination between employer, employee and government representatives – has been identified as a crucial driver of the 'greening' of the German vocational education and training (VET) system (Evans and Stroud, 2014). However, open questions remain regarding the design of 'green apprenticeships' (those that facilitate the development of skills for the green transition) and the targeting of such schemes at workers in adversely affected occupations.

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⁽²⁴⁾ Ibid.

⁽²⁵⁾ Ibid.

⁽²⁶⁾ Note that the terms 'sector', 'industrial sector' and 'industry' are used interchangeably to refer to segments of the economy across various levels of disaggregation.

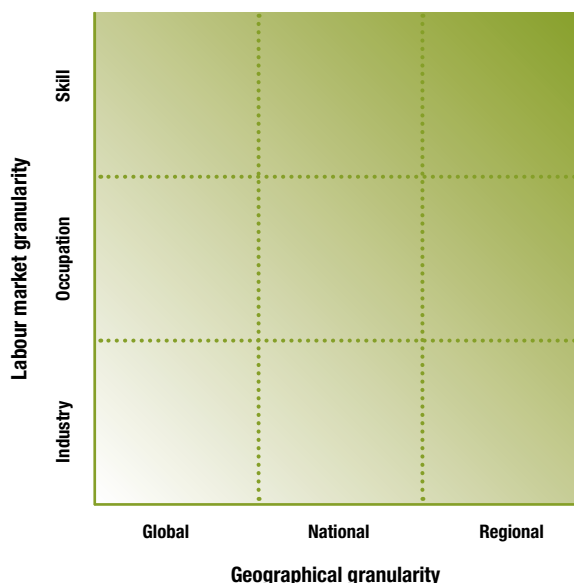
⁽²⁷⁾ The European Pillar on social rights, the Porto declaration, the EU Skills Agenda and the Osnabrück declaration have all placed increased investment in vocational education and training, lifelong learning, upskilling and reskilling at the centre of the EU agenda.

A granular understanding of the impact of the green transition on labour demand and supply at the level of industries, occupations and skills can inform the evidence-based design and targeting of green apprenticeships. For example, knowledge about changes in skill demand can inform the prioritisation of learning outcomes while gauging demand changes at industry – and occupation – level can help target apprenticeship offerings. However, few studies provide granular empirical estimates of the impacts of a green transition on labour markets at the level of industrial sectors (ILO, 2018; Cedefop, 2021a; Cedefop, 2021b) or at the level of occupations (ILO, 2019; Cedefop, 2021b). There is some evidence on the skills relevant for a green economy, but it remains high-level ⁽²⁸⁾.

The green transition is also likely to be geographically disparate in its impacts. Net employment change at the global (Wei et al., 2010; Pai et al., 2021) and EU levels (Cedefop, 2021b) is estimated to be positive, but this level of aggregation does not reflect net employment losses occurring at national and regional levels due to the specific industrial composition and related skill supply. While this is especially evident when comparing countries rich and poor in fossil fuel resources (Pai et al., 2021), even within countries job losses tend to cluster around extractive industries (e.g. coal mining) and are closely linked to the economic decline of a region (Campbell and Coenen, 2017; Oei et al., 2020). These regional disparities suggest that one-size-fits-all approaches to retraining at-risk workers may be insufficient, and that both the design and targeting of apprenticeship offerings can benefit from regional customisation.

Figure 1 shows a stylised granularity space along labour market and geographic granularity, the two key dimensions outlined above. Along labour market granularity (y-axis), it distinguishes between industries, occupations and skills; along geographic granularity (x-axis) it distinguishes between global, national and regional scopes. The darker the shading, the more granular the data and thus the resulting insights. Building on this space, this paper describes and reflects on the data granularity currently available for the EU and makes suggestions to improve it

Figure 1. Granularity space



Source: Authors.

The remainder of this paper is structured as follows. Section 3.2 introduces a framework for conceptualising the sequential nature of the labour market impacts of the green transition and suggests three empirical approaches to estimating these impacts. On this basis, Section 3.3 analyses the level of insight that these empirical approaches provide along the two dimensions of the granularity space. Section 3.4 makes suggestions to improve granularity and Section 3.5 concludes with key insights.

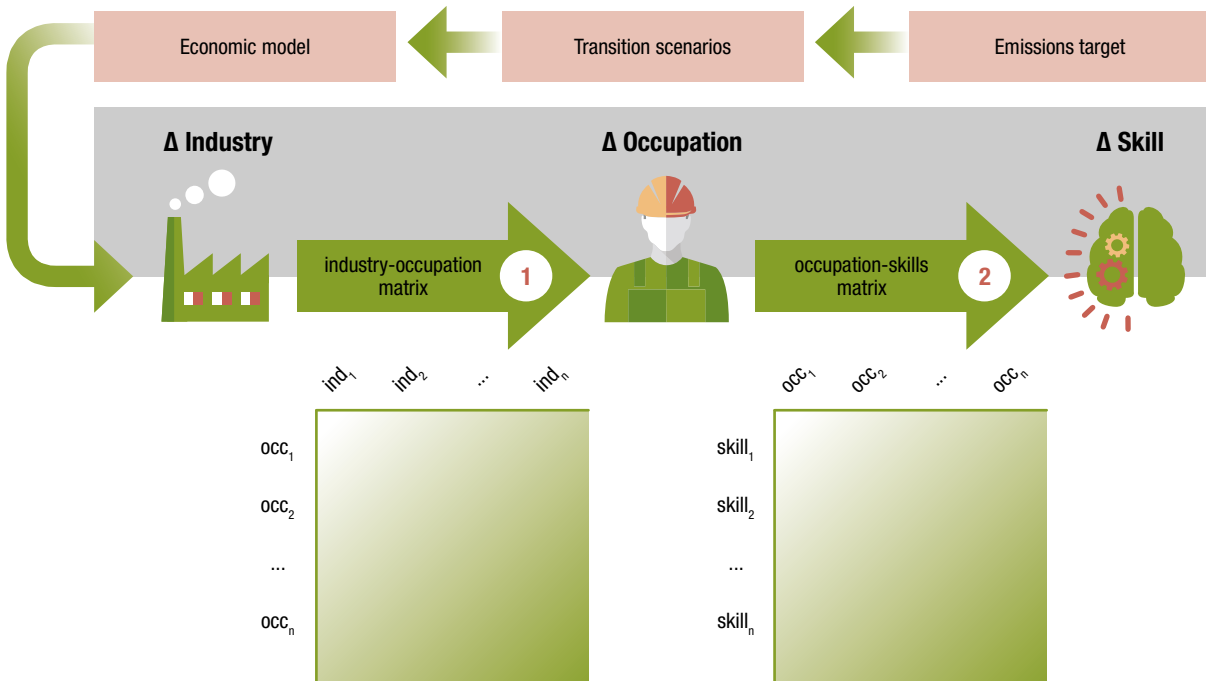
3.2. Quantifying green transition impacts on labour markets

3.2.1. Skills delta framework

The Skills delta framework (Figure 2) conceptualises the sequential nature of the green transition impacts on skills. On the basis of a high-level emissions target and the formulation of transition scenarios, economic models (input-output, computable general equilibrium or analytical models; see Cameron and Van Der Zwaan (2015)) are used to estimate the resulting demand changes at the

⁽²⁸⁾ For instance, Vona et al. (2018) find that engineering and management skills are more intensively used in green occupations compared to the rest.

Figure 2. Skills delta framework



Source: Authors.

level of industrial sectors (ILO, 2018; Cedefop, 2021; Cedefop, 2021b). Given detailed knowledge of the occupational structure across sectors – parametrised by an industry-occupation matrix – this ‘industry delta’ can be propagated to the level of occupations, yielding an ‘occupation delta’⁽²⁹⁾ (International Labour Office, 2019a; Cedefop, 2021b). This step requires detailed labour market statistics such as the European Union labour force survey (EU-LFS), a harmonised database that contains key labour market variables from nationally representative surveys for all EU Member States (Eurostat, 2020).

The framework moves beyond the existing literature by proposing to estimate demand changes at the level of individual skills (‘skills delta’). The European skills, competences, qualifications and occupations (ESCO) taxonomy, for example, allows for expressing each occupation through a set of skills (European Commission, 2017). Spe-

cifically, ESCO maps 3 008 occupations to 13 890 skills, allowing for parametrising a detailed occupation-skills matrix. For illustration, each occupation consists of 39 different skills on average, which can be either essential or optional⁽³⁰⁾.

Industries, occupations and skills for which demand increases in a green transition (positive delta) can be thought of as green; those for which demand decreases are ‘brown’ (negative delta)⁽³¹⁾. The framework provides an empirical basis for informing the design of apprenticeships by identifying skills for the green transition, and the targeting of apprenticeships by identifying adversely affected industries and occupations.

⁽²⁹⁾ Calculating the occupation delta requires assuming (i) that employment changes within a sector are homogeneously distributed across all occupations in this sector, and (ii) that workers in an occupation have an identical skillset. The former assumption is likely problematic as sectors contain a variety of occupations, which may be affected differently. The latter assumption is likely a fair representation as occupations in ESCO are granular.

⁽³⁰⁾ A new ESCO release (v.1.1) was published on 28 January, 2022 [accessed 7.3.2022]. Our calculation is based on data from the major ESCO version (v.1.0) which consisted of 2 942 occupations and 13 485 skills.

⁽³¹⁾ A negative delta also encompasses an estimate of the skill supply made available (‘released’) due to a fall in demand for the industry, occupation, or skill in question.

3.2.2. Empirical approaches

Rooted in the Skills delta framework, we present three empirical approaches⁽³²⁾ for quantifying the industry, occupation, and skills deltas resulting from a green transition (Table 1). The first two approaches, called ‘ILO scenario’ and ‘IEA scenario’ hereafter, build on modelling work⁽³³⁾ by the International Labour Organization (ILO) and the International Energy Agency (IEA). The third approach, hereafter referred to as ‘green/brown classification’, builds on a task-based measure of occupational greenness and a classification of brown occupations constructed by Vona et al. (2018).

Table 1. **Empirical approaches**

Approach	Specification	References
ILO scenario	Multi-regional input-output model; energy sustainability and circular economy scenarios; IEA energy technology perspectives scenario	IEA, 2015; ILO, 2018; Montt et al., 2018; Wiebe et al., 2019; ILO, 2019
IEA scenario	IEA World energy outlook and energy technology perspectives models; net-zero emissions scenario	IEA, 2021
Green/brown classification	Task-based quantification of the greenness of occupations. Binary identification of brown occupations based on industry pollution intensity	Dierdorff et al., 2009; O*NET, 2010; Vona et al., 2018

Source: Authors.

The ILO scenario is based on existing projections of industry-level employment changes in an energy sustainability and a circular economy scenario up to the year 2030 (Montt et al., 2018; ILO, 2018; Wiebe et al., 2019; ILO, 2019). These projections⁽³⁴⁾ are based on country-specific decarbonisation pathways developed by the IEA that limit end-of-century global warming to 2°C above pre-industrial levels, compared to a somewhat outdated business-as-usual scenario of 6°C (International Energy Agency, 2014; International Labour Office, 2019a). The first link of the Skills delta framework, from industry to occupations, was previously established by the ILO (2019). For the second link from occupation to skills we use the occupation-skills mapping provided by ESCO, allowing propagation of the modelled demand changes from the industry level down to the skill level.

The IEA scenario builds on the recently published Net Zero by 2050 report, which outlines a pathway to a global net-zero carbon economy (IEA, 2021). We can link the scenario for global total energy supply up to 2050 – disaggregated in detail by several renewable and non-renewable energy carriers⁽³⁵⁾ – to the Skills delta framework by semantically matching ESCO occupations related to energy supply industries to the relevant IEA energy carriers⁽³⁶⁾. It is thereby assumed that occupations will experience an increase in demand if they are associated with increasingly demanding energy carriers and vice versa. We can then translate occupation demand changes to skill demand changes via the occupation-skills matrix based on the ESCO framework.

The green/brown classification builds on an existing task-based measure of occupational greenness (reflecting the percentage of working hours spent on green tasks) and a binary classification

⁽³²⁾ At the time of writing, these three approaches were identified as the state-of-the-art. Recently published analysis by Cedefop (2021b) and ESCO v.1.1 (see Footnote 30) classification of green skills and knowledge concepts (European Commission, 2022) are not accounted for in detail.

⁽³³⁾ A related analysis was published by the OECD (2018) using the computable general equilibrium model ENV-Linkages to explore the distributional impacts of a carbon tax on labour markets. While the effects on aggregate employment are small yet positive, there are substantial differences between sectors and worker skill levels, with workers in energy supply sectors and low skill workers affected most negatively.

⁽³⁴⁾ The environmentally extended multi-regional input-output model EE-MRIO EXIOBASE v.3 (Stadler et al., 2018) was used.

⁽³⁵⁾ The scenario includes seven types of renewable energy technologies (solar, wind, hydro, modern solid bioenergy, modern liquid bioenergy, modern gaseous bioenergy, other renewables), traditional biomass, nuclear, unabated natural gas, natural gas with carbon capture, use and storage (CCUS), oil, unabated coal and coal with CCUS.

⁽³⁶⁾ For example, the occupation ‘solar energy engineer’ was matched to the energy vector ‘solar’, while the occupation ‘oil and gas production manager’ was matched to the vectors ‘oil’, ‘unabated natural gas’ and ‘natural gas with CCUS’.

of brown occupations (reflecting the pollution intensity of associated industries) constructed by Vona et al. (2018). As these data are only available within the U.S. standard occupational classification adopted by the Occupational Information Network (O*NET), we use an established crosswalk between the American and European occupational frameworks (Kanders et al., 2020) to map them to ESCO occupations. Although the use of crosswalks is subject to certain limitations, translating O*NET data to the EU context is a viable approach, especially given the data constraints at the European level (Vona, 2021). This allows us to group ESCO occupations into the three categories ‘green’⁽³⁷⁾, ‘brown’ and ‘neutral’ (the remainder), which provides a discrete proxy for the labour demand changes in a green transition. Specifically, green occupations are expected to face increasing demand, brown occupations decreasing demand and neutral occupations are assumed to be unaffected by the green transition. Using the ESCO occupation-skills matrix, we can map these occupational changes to skills. An important caveat of the green/brown classification is the categorisation of occupations into discrete categories. As argued by Vona (2021), it is paramount to move beyond a binary view of green and brown occupations and towards a continuous measure of greenness and/or brownness that respects the fact that few jobs are entirely green or brown.

3.3. Levels of granularity

Understanding the impact of the green transition at a high level of labour market and geographic granularity is crucial for the evidence-based targeting and design of green apprenticeship schemes. However, currently available data – as illustrated through the three empirical approaches outlined above – suffer from a variety of shortcomings that are discussed along the axes of the granularity space.

3.3.1. Labour market granularity

3.3.1.1. Industry

At the industry level, standardised classifications cannot disaggregate key sectors of a green economy at a sufficient level. A robust quantification of the Skills delta requires a detailed account of supply and demand changes (industry delta) for the industries expected to be most impacted by the green transition. For example, the EE-MRIO model used in the ILO scenario satisfies this requirement by distinguishing between 12 extractive sectors (e.g. mining of coal/lignite and extraction of oil/gas versus metal ores) and 11 power production sectors (e.g. renewable versus non-renewable). To move from industries to occupations (and eventually to skills) in the Skills delta framework, the industry and occupation deltas are connected via a sectoral employment matrix. Sectoral employment is typically reported according to standardised industry classifications such as the International standard industrial classification of all economic activities (ISIC) and the Statistical classification of economic activities in the European Community (NACE). However, the comprehensive representation of power production and extractive sectors by the EE-MRIO model used in the ILO scenario cannot be captured by ISIC or NACE. Therefore, the industry delta estimated by the EE-MRIO model (163 sectors) needs to be aggregated to match ISIC or NACE at a much coarser level⁽³⁸⁾ (88 sectors) (ILO, 2019). As a consequence, the resulting occupation delta only captures changes in aggregate employment of the electricity production sector, instead of reflecting differential employment changes in occupations related to renewable and non-renewable electricity production⁽³⁹⁾.

3.3.1.2. Occupation

At the occupation level, standardised classifications, such as the International standard classification of occupations (ISCO-08), do not differentiate between low and high-carbon emission activities, which impairs the granularity of the occupation delta. In many cases, the tasks performed by

⁽³⁷⁾ Lacking *a priori* information, an occupation is labelled as ‘green’ if its greenness score is above zero.

⁽³⁸⁾ For example, the employment levels of 11 electricity production sectors need to be summed up in NACE Rev. 4 class 35.11 Production of electricity.

⁽³⁹⁾ Note that in the IEA Scenario, ESCO occupations are semantically matched to relevant energy vectors, which partly circumvents this problem.

workers within the same occupation can be related to both low- and high-carbon emission activities. This especially applies to mining occupations. While some workers may work on lignite extraction for coal-fired power production, others may work on lithium extraction for battery manufacturing; yet both are mapped to a single ISCO-08 occupation. Even ESCO, which disaggregates ISCO occupations into narrower occupations, does not provide for sufficient granularity to allow such differentiation. Consequently, in the semantic mapping between occupations and energy carriers in the IEA scenario, all mining-related occupations are currently mapped to fossil fuel energy carriers. The specific skills needed to perform the required tasks may also differ, which is currently not taken into account in ESCO. In sum, low- and high-carbon emission activities are not sufficiently differentiated to quantify accurately the occupation delta.

As a further caveat, available estimates of the green transition impacts on labour demand across occupations are not granular enough. The only modelling study that estimates employment changes of green transition scenarios for standardised occupational categories – the ILO scenario – does so for the 42 occupations at the ISCO-08 2-digit level (ILO 2019). The IEA scenario gives estimates for 89 ESCO occupations related to electricity production and transmission but does not provide information for other sectors. In contrast, the discrete green/brown classification allows assigning a directional demand change to every ESCO occupation (increased, decreased and unchanged demand), but its quantification remains unattainable in terms of absolute or relative employment changes. Evidence-based targeting of apprenticeships requires a granular and quantified understanding of the occupation delta consistent with a standardised occupational framework. As exemplified above, this is difficult given current data availability.

3.3.1.3. Skill

The empirical identification of skills for the green transition would be valuable for informing the definition of learning outcomes in apprenticeship schemes. However, the lack of granularity on industries and occupation levels leads to substantial uncertainty in the quantification of skill demand

changes. Moreover, the skills needed for certain occupations are continuously evolving. Increasing the granularity of industry and occupation classifications is necessary, but capturing the skills content of an occupation – especially in emerging and changing occupations – remains a challenge. The process for updating expert-led taxonomy (such as ESCO), is inherently demanding and intensive, as it is based on input, discussion and consensus among specialised experts for each occupation (and a likelihood of sampling errors). Ideally, more up-to-date and granular skills intelligence should also be available to update VET curricula, including apprenticeships.

While the scenarios considered use proxy variables to infer changes in skill demand, surveys can provide deeper insight. Corbella and Mane (2015) suggest that measuring the skills used in an occupation would imply collecting data from workers on the different dimensions of the skills they employ, such as by using surveys. While traditional approaches to skill surveys can be work-intensive, time-consuming and expensive, surveys remain useful for determining the skill content of occupations that are likely to be in more and less demand and capturing the skill delta at a granular level. Such data would substantially reduce the number of assumptions required for moving from occupations to skills in the Skills delta framework, especially when combined with a more granular, differentiated view of occupations.

To capture skill needs and trends stemming from emerging and new technologies, skill taxonomies and databases should be updated continuously with new and emerging skills. Supplementing skill surveys with real-time labour market data from, for example, online job advertisements (OJAs), taking into consideration challenges regarding the representativeness of this data, could be considered. With skill surveys as a potential tool to better define the skill requirements and content for granular occupations, labour market data coming from OJAs can complement skills anticipation of emerging and yet-to-be-defined occupations and changes in the skillsets of existing occupations.

3.3.2. Geographic granularity

3.3.2.1. Global

Data from top-down modelling of the impact of the green transition is often only available at the global level. For example, the IEA scenario takes as a starting point global supply projections of different energy carriers. However, the mapping between energy carriers and occupations critically depends on the geographic context. While mining occupations in fossil-fuel-rich countries and regions may be exclusively tied to the extraction of coal, oil and gas, the extraction of metals crucial for the energy transition such as lithium may dominate in others. The green/brown classification – although based on US data – can be mapped to the occupational frameworks of other world areas, such as the European ESCO. However, mapping it to occupational frameworks of countries with vastly different economic structures than the US demands caution. In such cases, there may be large differences between the tasks performed by workers of the same occupation (and hence their greenness) and between the pollution intensities of the industries they are employed in (and hence the identification of brown occupations).

3.3.2.2. National

Few models can directly estimate industry-level green transition impacts (industry delta) by country. The model employed in the ILO scenario (EEMRIO) covers the economic transactions of 200 products across 163 industries in 44 countries. However, because industries are composed differently across national economies, accurately linking the industry delta to the occupation delta hinges on the availability, quality and granularity of national employment statistics. To this end, along the lines of Vona (2021), certain limitations may be seen in the official source of EU-wide labour market statistics, EU-LFS microdata.

Eurostat, the statistical office of the EU, sets out minimum granularity standards for the national statistical institutes (NSIs) providing the data (Eurostat 2020). These require the industry sector and

occupation to be coded at two digits in NACE Rev. 2 (e.g. '05 Mining of coal and lignite') and three digits in ISCO-08 (e.g. '811 Mining and mineral processing plant operators') respectively. However, while some countries report more granular data, others do not meet the minimum requirements, resulting in a heterogeneous data granularity.

The collection of such statistical data at national level is bound to legislative rules (such as terms of anonymisation), and their aggregation by Eurostat abides by quality criteria for collecting and analysing statistical data. Granularity is therefore limited and distinction, for example, between green and brown industries is not feasible at this level. Although anonymity and available sample sizes are to be borne in mind, identifying ways to allow for more granular data by the NSIs (possibly with the facilitation of Eurostat for harmonised access) would significantly support evidence-based policy-making.

3.3.2.3. Regional

The impact of the green transition will also be regionally disparate. In principle, labour force surveys such as those provided by the EU-LFS allow estimating regional demand changes across all levels of labour market granularity based on any of the three empirical approaches⁽⁴⁰⁾. However, while the underlying surveys are statistically representative at the national level, their representativeness at the regional level is limited, thus leading to potential sampling errors.

For some occupations, even if granularly defined, assuming a constant skill composition can prevent capturing regional differences. Taking the example of a mining assistant, the skill supply in regions where surface mining is common may be significantly different from that in a region with underground mining. While possible, it is unlikely that occupational classifications can capture these differences in all circumstances. Similarly, demand changes may vary by region. While this issue can occur at the national level too, it is more likely at the regional level, where affected populations are smaller and more concentrated⁽⁴¹⁾.

⁽⁴⁰⁾ Regional variables in the EU-LFS are generally reported at the Nomenclature of territorial units for statistics (NUTS) level 2, thus providing a granular lens for analysing green transition impacts.

⁽⁴¹⁾ This concern becomes even more pressing when trying to advise individual workers in a rapidly evolving labour market. An aggregate view of skills, relying on top-down classifications, may not capture an individual worker's full skill set and the worker's capability of acquiring new skills. Individually transferable and useful skills are more nuanced and depend on previous experience,

3.3.3. Granularity of insight

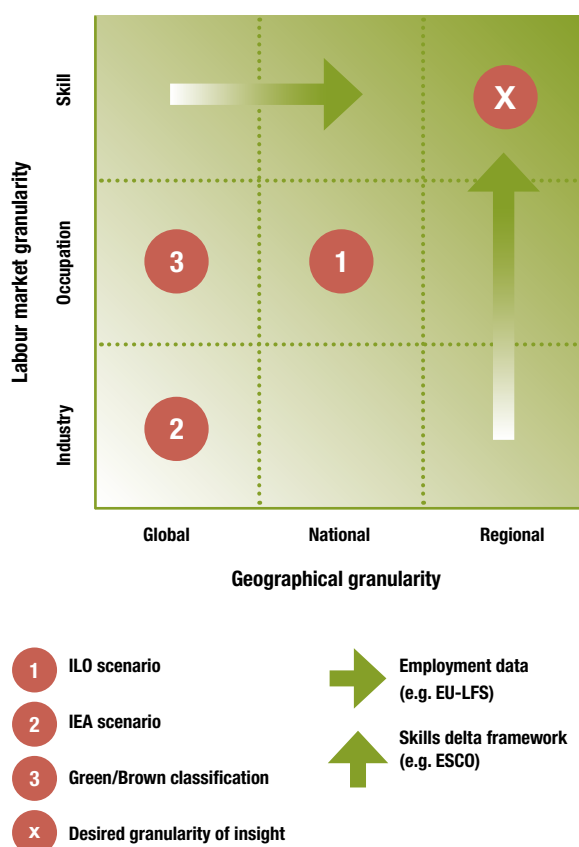
Figure 3 summarises the degree of granularity that is currently achievable by situating the empirical approaches outlined in Section 3.2.1 in the granularity space⁽⁴²⁾. All three approaches can be used to provide insights into the impacts of a green transition at the skill-level, albeit via different avenues. The ILO Scenario establishes a data-driven link between industries and occupations based on a sectoral employment matrix parameterised by labour force survey data. In contrast, the IEA scenario relies on manual mapping of occupations to energy carriers and the green/brown classification only starts at the occupation-level, effectively skipping the link to the industry-level.

The link to the skill-level is a shared element of all three approaches and is established through an occupation-skills matrix based on ESCO⁽⁴³⁾. Along the dimension of geographic granularity, the empirical approaches have global to national coverage. Owing to the underlying modelling exercise, the IEA provides a global proxy. The green/brown classification is likely applicable globally (although caution should be exercised in countries with an economic structure not comparable to the US, as argued above) and the geographic granularity of the ILO scenario is defined by the underlying EE-MRIO, which models economic interactions at the country-level.

However, to provide policy-relevant insights into the design and targeting of green apprenticeships, it is necessary to understand the impact of the green transition, both at the skill-level and within their regional context, i.e. to move towards the upper right corner of the granularity space. Hence, along the labour market granularity dimension, we propose to move towards the skill level by following the sequenced steps of the Skills delta framework⁽⁴⁴⁾. Moving along the geographic granularity dimension is equally possible given the

availability of granular employment data. For all three empirical approaches, the respective industry and occupation deltas can be further disaggregated by leveraging harmonised labour force surveys such as the EU-LFS, national surveys, micro-censuses or regional skill surveys.

Figure 3. Empirical approaches in the granularity space



Source: Authors.

which may differ substantially between workers in the same occupation. Especially in recognising an individual's prior learning and counselling transitioning workers, an aggregate view of the skills delta and a one-size-fits-all approach may miss possible pathways for individuals and lead to unnecessarily cumbersome learning journeys, skill mismatches and lost potential.

⁽⁴²⁾ The recently published EGD scenario analysis of Cedefop (2021) resolves the industry delta at the NACE 2-digit level and the occupation delta at the ISCO-08 2-digit level. Employment impacts are estimated for the EU-27. Hence, the analysis would be placed between (3) and (1) in Figure 3.

⁽⁴³⁾ While developed with the EU labour market in mind, ESCO has found application beyond the EU. The European Training Foundation relied on ESCO for projects in Tunisia and Ukraine (Vaccarino, 2020). SkillLab has implemented over 20 projects outside of the EU from Latin America through Africa and the Middle East, without significant issues around the applicability of ESCO.

⁽⁴⁴⁾ While the first step of the Skills delta framework – from industries to occupations – requires labour market data arranged in an industry-occupation matrix, the second, novel step we propose is rooted in an occupation-skill matrix parameterised by an occupational taxonomy such as ESCO.

3.4. Improving granularity for better informed apprenticeship

3.4.1. Refining industry and occupation classifications, improving modelling efforts and facilitating data access

- (a) Organisations (such as the UN, ILO, EU) could explore increasing the granularity of standardised industry classifications (ISIC, NACE) in those sectors most likely affected by the green transition (energy supply, extraction, transport) to allow for differentiation between high- and low-carbon emission intensity sectors. Collection of sectoral employment data by European national statistical institutes would enable comparisons between employment in high- and low-emission intensity sectors.
- (b) Organisations, such as Cedefop or the ILO, and researchers concerned with modelling the impact of the green transition on labour markets could explore ways to provide results at more detailed level. While this may not be feasible for global/EU-level analysis, it may be possible for case countries (at ISCO-08 3- to 4-digit level).
- (c) Current data availability constrains the potential for granular, policy-relevant research into the impact of the green transition on the labour market. Researchers and apprenticeship stakeholders would benefit from the availability of more granular, harmonised labour market data and better data access. Greater emphasis by the national statistical institutes on providing more granular data would assist researchers and apprenticeship stakeholders in identifying skill trends and adjusting apprenticeship offers to meet labour market needs.

3.4.2. Complementing data through skill surveys of individuals and novel sources

- (a) Running regular and representative skill surveys of workers in the sectors and occupations that are most affected (positively and negatively) by the green transition would be a powerful (although resource-demanding) tool for all apprenticeship stakeholders. Collecting data from individuals would support flexible aggregation

and disaggregation to analyse green transition impacts across different levels of granularity. Such data could be further used from career guidance practitioners for providing individual guidance to workers.

- (b) The collection and combination of data sources such as online job advertisement boards, public employment service records, including EURES, the European Employment Services, would aid identification of trends in demand for occupations and, specifically, for green occupations.
- (c) Analysing vocational training and education content and could allow cataloguing the skills they provide to students. A skill-based understanding of the education landscape allows for a better analysis of the current support from institutions for a green transition as well as for the identification of gaps in the curricula.
- (d) Combining the data on skill content of occupations from skill surveys with insights into the demand for certain occupations could enable the identification of some skills in increasing/decreasing demand due to the green transition.
- (e) In line with the deployment of skill surveys (supply), the collection and analysis of online job advertisement data (demand) should keep up with a dynamically evolving labour market. If resources are made available to collect skill survey data at the level of the individual worker, and demand data rely on geographically specific job postings, data regarding occupation and skill demand can be aggregated and disaggregated at global, national and regional levels.

3.5. Conclusions

While the transition to a green economy will likely result in net employment gains, its economic effects will vary across sectors, occupations and regions. The EGD recognises the importance of supporting adversely affected workers to transition to occupations in increasing demand; it also foresees dedicated funds for retraining. People joining the workforce may also need adapted training to be able to work in occupations in increasing demand.

Apprenticeships may be a suitable learning environment for acquiring skills for the green transi-

tion, in both initial training and retraining. However, the current evidence for prioritising apprenticeship offers towards the most affected workers or regions is thin. This paper has argued that an evidence-based design and targeting of green apprenticeships requires a granular understanding of the impact of the green transition along two key dimensions: labour market and geographic granularity. A comparative analysis of three empirical approaches to map the labour market impacts of the green transition revealed limitations of the current data landscape.

A main takeaway for concerned EU actors (Eurostat, European Commission) and international organisations (UN, ILO) could be that the development of industry and occupation classifications needs to consider the differences between high and low carbon emission activities. The recently published ESCO taxonomy of green skills goes in this direction (European Commission, 2022). As a complementary approach to support actors providing and using labour market information,

skill surveys and job advertisements data are suggested as promising sources to improve the understanding of skills for a green transition (especially if resources are available for such exercises). In sum, improved classification systems combined with novel data sources could help differentiation of labour market information on a regional as well as a skill level.

Forward-looking design and delivery of apprenticeships (reflecting the needs across all VET) must be driven by an understanding of skill-deltas and requirements of emerging green occupations. Building on granular data (also with the collaboration of research institutes and specialised service providers) would help providers and other apprenticeship stakeholders in developing or updating curricula. A comprehensive approach to skill governance is required for appropriate skills anticipation methods that proactively anticipate changing requirements in occupations as the labour market impacts of the green transition are evolving.

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Apprenticeship as a systemic change-agent for green and social transitions

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4.1. Introduction

In the 21st century, societies are having to re-define their way of life and values, in line with ecological change. Only economies that respect ecological limits and socially just living conditions can offer societies the opportunity to develop and to prosper. They must emerge in new framework conditions that are characterised by holistic, deep economic, social, technical and cultural transformations ⁽⁴⁶⁾, to be carried by civil society as well as by politics and science, institutions, organisations and individuals (Schneidewind, 2018, p.23 ff.).

Education systems, including vocational training systems and apprenticeships, play a key role in societal transformations (e.g. Friederichs and Sanders, 2002). They are interaction systems and the interface to different social systems for the dissemination of new, practice-relevant knowledge; they bring the implementation of this knowledge to the 'centre' – i.e. to the structure – of society. They create the conditions for transformative action and the emergence of new values, not only semantically but also sociostructurally ⁽⁴⁷⁾. Vocational training systems are social subsystems that implement transformations and initiate transformation impulses to the overall social system. They bear part of the responsibility for the success of the necessary transformation of European societies.

The need for green transformation of education programmes has arrived in European VET discourses. Greening is important for the prestige of modern VET and an important selling point. In all European countries, and increasingly in countries with a strong tradition of VET, institutions are facing the challenge of adapting their offers to the requirements of climate protection. Mostly,

this focuses only on technical innovations. A real cultural, economic and social transformation of VET systems and related social systems is a long, difficult process.

In this paper we consider apprenticeships as interaction systems and as a mirror for the vocational training culture of a country. They anchor innovative ideas, new knowledge and advanced technologies, (often, but not exclusively) at the middle level of society, among the prospective craftsmen and employees of industry and service providers. As heterogeneous stakeholders are involved in the planning, organisation and implementation of apprenticeships, the transformative impulse of apprenticeships in their social systems is multiplied.

Our objective is to analyse, based on the in-depth case study of the GRÆEDUCATION Greek-German cooperation project, how VET and apprenticeship can contribute to transform existing (scientific) knowledge about the climate crisis into practical transformation literacy and action of crafts, industry and services. This would enhance professional competences and promote instrumental action for supporting the transformation of (local) economies and labour markets and, beyond that, cultural, social, economic and political transformation.

4.2. Apprenticeship as social interaction system and change agent

Ecological challenges support the need for the collaboration among different systems, with system-immanent transformative relevance. Eco-

⁽⁴⁵⁾ Institute for innovative and preventive job design (FIAP e.V.)

⁽⁴⁶⁾ Maja Göpel describes these framework conditions vividly. See Göpel (2016).

⁽⁴⁷⁾ For the distinction between semantics and social structure see Stichweh (2006).

logical changes – such as catastrophic severe weather events – emerge as social facts that cause socio-cultural changes independent of our communicated environmental perceptions, which are no longer questioned. The policy framework of green transition (e.g. the European Green Deal) also creates realities that neither individuals nor organisations can escape. These new realities call for reforms and changes that ensure our survival ⁽⁴⁸⁾.

Apprenticeships are perceived here as interaction system because heterogeneous stakeholders have to collaborate in planning, organising and implementing apprenticeships. The representatives of two or three learning venues have to communicate among each other and with the students in implementing apprenticeships. Even if the system of dual education is not implemented in the same way in different countries, the need for collaboration between social partners, education institutions and enterprises is obvious. This is why apprenticeships offer ideal research conditions but also a high potential for transformational impact.

The hypothesis we propose is that a society can make use of apprenticeship to transform existing (scientific) knowledge about the climate crisis into practical transformation competence and action of crafts, industry and services. This brings vocational and practical action competence for a change of (local) economies and labour markets and, beyond that, for cultural, social, economic and political changes.

This hypothesis can be illustrated in the following process model (Figure 1), which places apprenticeship and vocational education at the centre of ecological transformation.

Here, we understand vocational education as a kind of social experimental field for ecological practice transformation; this approach differs from those that locate the ‘starting point’ for change more in the realm of science, law, or politics. This is not trivial because the previous ordering schemes tended to concentrate and focus societal resources in these fields, rather than in the field of (vocational) education.

In contrast, our design-oriented research in the

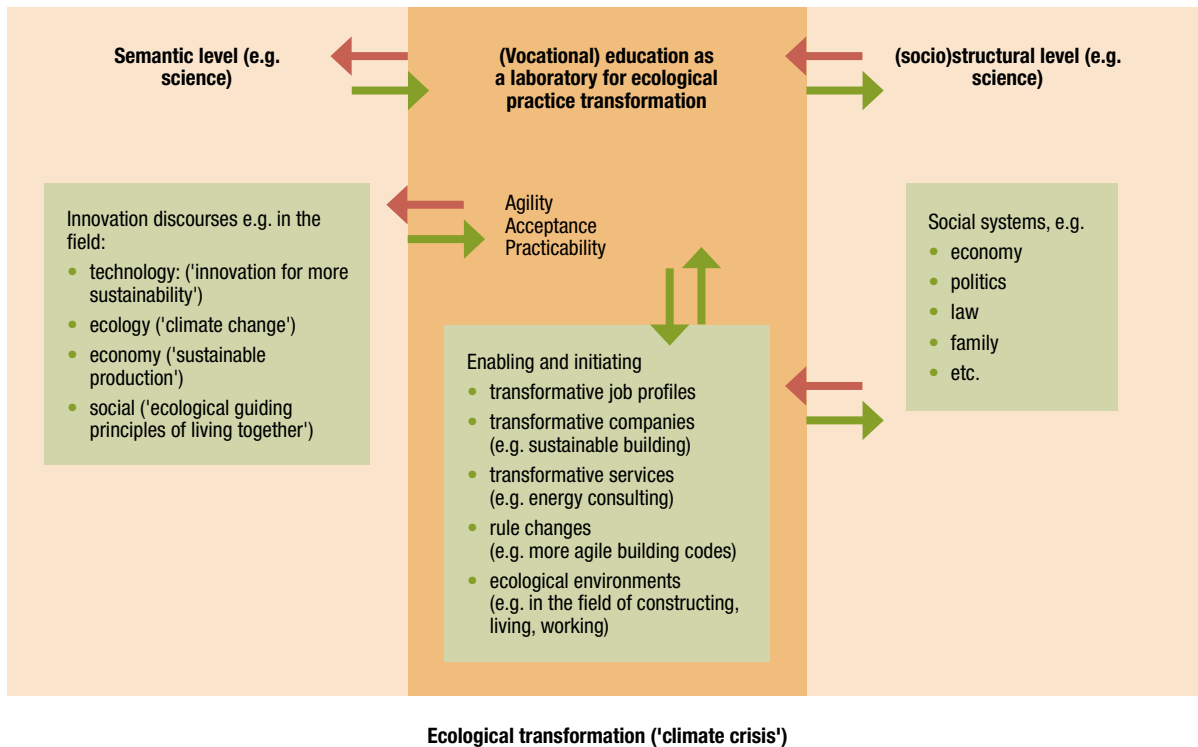
field of international VET cooperation suggests cautiously that crucial impulses for the ecological transformation of social structure and semantics might emerge at the interface of VET reform and shape or change from there.

The development of qualifications and training for professional work in the field of energy transition, climate protection and generally in the ‘green economy’ offers huge opportunities for transformative developments, initially within the vocational training system, because they do not move in well-worn tracks of the previous vocational training logic. In many respects, they are entering uncharted territory. Even more so in apprenticeships, it is about technical and practical competences for the implementation of innovative, green technologies in crafts, production and services. The dual learning characteristics of apprenticeship (in contrast to school-based forms of VET) allow the involvement of the different social actors through the different places of learning. The practice- and workplace-oriented learning offers space for new adapted forms of learning. The case study highlights this potential of apprenticeship.

But beyond that, new services, business models and occupational profiles must be developed and implemented in cooperation with consumers, which have a significant impact on local labour markets, companies and organisations. Green qualifications will trigger transversal skills development that define new, sustainable, social, cultural and economic values and goals. Technical and social innovations in green vocational training expand the scope for action that stimulates social innovation and transformation at different levels. For example, through technically competent, creative and responsible apprentices (who will become future employees or entrepreneurs), innovative companies and agile apprenticeship systems adapt to the new challenges. In apprenticeships, this transformation engine then ideally meets interfaces with other social functional systems (politics, economy, family) and, under specific conditions, takes the transformation movement into these systems: rules and regulations, for crafts and industry, are changed, new

⁽⁴⁸⁾ From a theoretical point of view (Theory of social systems), ecological realities are disruptive factors (limits of the overall system of society) that challenge and modify our communications, i.e. what constitutes society from a systems-theoretical point of view (cf. on this: Metzner, 1993).

Figure 1. **FIAP Process Model: Innovation driver ‘green apprenticeship’**



Source: Authors.

green companies emerge, and greener models of everyday life develop.

4.3. Methodological approach

The methodology of this paper recurs to the research approach of the Research Institute for Innovative and Preventive Job Design (FIAP) in the field of service and social cultural research. This approach has developed on the basis of the Theory of social systems (Luhmann, 1984) incorporating action research (Lewin 1948; Cherry 1999) and productively adopts approaches from network research (Castells 1996) and the interactive value creation model (Reichwald and Piller 2009). With Böhle (2011), this approach stimulates a discussion of boundary drawing and the relationship between subject and object (at least) in the human sciences.

The methodology of the research carried out for this paper is based on a hermeneutical analysis of a case study, that of the Greek-German coopera-

tion project called GRÆDUCATION and its related activities. The case study includes interviews, workshop and seminar protocols and the results of innovation workshops, which bring participants together in a creative process and focus on joint creation and development. Quantitative surveys were also conducted in companies and VET institutions in cooperation with the German-Greek Chamber of Industry and Commerce.

For this study, we paid special attention to the different (communication) cultures among the stakeholders planning, organising and implementing apprenticeship: for example, a trainer in an enterprise speaks a completely different ‘language’ from a teacher in a VET school⁽⁴⁹⁾. We went one step further and applied this openness productively by modelling general guidelines and ‘rules’ of cooperation and communication that aim at not ‘clogging’ this openness too quickly with own convictions. With these new cooperation and communication rules, German and Greek experts developed new curricula for apprenticeship and

⁽⁴⁹⁾ By avoiding pre-determinations or dominance gestures and by orienting the dialogue towards freedom from hierarchy (in the VET systems and on a transnational level) and agreement-oriented action, we took into account the constitutive openness and uncertainty of the communication process in VET discourses.

qualification services for teachers. So, in the case-study we tried to avoid lock-in effects. Learning direction, learning object, learning methods and also their embedding in institutional structures are open from our perspective, also for innovative and surprising moments. Who learns, what and how it is learned in the interaction systems of apprenticeship is relatively open in this approach of systemic service development.

Transformation research describes seven priority turnarounds⁽⁵⁰⁾ of ecological change, all of which are driven by the empowerment⁽⁵¹⁾ of people, organisations and institutions, as they require new potentials and competences in their implementation. The GRÆDUCATION project presented in Section 4.4 focuses on the energy and resource turnaround.

4.4. Case study: Greek-German cooperation for vocational training

4.4.1. Green economy eco-system: framework conditions in Greece

The GRÆDUCATION project introduced a bottom-up approach which already enabled important transformations to be initiated in 2017 and 2018, especially with the 2020 VET reform. The project gained further relevance with the European Green Deal, more so due to the goals of the Greek government⁽⁵²⁾ to reduce greenhouse gases, increase the share of renewable energies, complete decarbonisation and strengthen energy efficiency and sufficiency. In November 2019, the Greek government presented the second and final National plan for energy and climate⁽⁵³⁾ ⁽⁵⁴⁾. The Greek government expects that by 2030, assuming that the targets

for the use of renewable energies and increased energy efficiency in buildings are met, around 60 000 jobs, some existing but also newly created, will be safeguarded. Employee wages are expected to increase by EUR 8.2 billion, and gross domestic product will increase by about EUR 20.7 billion. Taking into account the recommendations of the EU Commission and the UN targets, the national energy plan is to serve as an instrument for implementing the *Long-term strategy 2050*. Greece must change course in the short term in order to achieve its climate targets. This requires a major innovation and investment programme, which, starting from technological and economic solution modules, is supported in its implementation primarily by technical competences in companies and also by cultural acceptance. These plans are creating great pressure to act and are triggering intensive structural change in some regions of Greece, which offers challenges but also potential⁽⁵⁵⁾.

Greece is therefore currently undergoing intensive structural change, which is also having an impact on the vocational training system. A first step for VET, and apprenticeship in particular, in managing the transformation is to adapt the existing offer to build up sufficient technical competence in dealing with new technical requirements. Skills for the green transition, which are fundamental for companies in the energy and resource transition, must be anchored in vocational education and training offerings.

Fundamentally, the Greek VET system faces specific transformation requirements, particularly in apprenticeship, which were directly addressed in the project. For apprenticeship, the lack of connection to the market and its needs should be mentioned here, as well as insufficient cooperation with the companies involved in training (especially with regard to the EPAS apprenticeship schools)

⁽⁵⁰⁾ Consumption turnaround, energy turnaround, resource turnaround, mobility turnaround, food turnaround, urban turnaround, industrial turnaround (Schneidewind, 2018, p.172 ff.).

⁽⁵¹⁾ 'Empowerment' in this article refers to strategies and measures that support individuals and communities in their autonomy, self-determination and self-representation of their interests.

⁽⁵²⁾ See Greek Ministry for the Environment and Energy – Open consultation process and the presentation of the [National Energy Plan: investing EUR 43.8 billion by 2030, Naftemporiki, 29.11.2018](#).

⁽⁵³⁾ See Greek Ministry for the Environment and Energy – Open consultation process and the presentation of the [National Energy Plan: investing EUR 43.8 billion by 2030, Naftemporiki, 29.11.2018](#).

⁽⁵⁴⁾ Approximately EUR 43.8 billion will be made available for implementation by 2030. The plan has eight elements: climate change, greenhouse gas emissions and absorption; renewable energies; improving energy efficiency; energy security; energy procurement; research, innovation and competitiveness in the energy sector; agricultural sector, shipping and tourism; and Government implementation strategies.

⁽⁵⁵⁾ For the regions of Peloponnese and Western Macedonia, this is excellently illustrated in a [WWF study](#).

but invest too little in practical training, poor appreciation of vocational education and training, and the weak permeability or the lack of progression opportunities that are offered to apprentices (Cedefop, 2018). Apprenticeship suffers from low demand in Greece and still counts as ‘marginal’ in the education system (Ioannidou, 2019 p.52). Despite strong reform efforts by governments, vocational education remains a stopgap solution for many students and parents who favour academic education ⁽⁵⁶⁾.

The case study shows how the particular framework of the green economy eco-system has created transformational opportunities, which have reached national stakeholder discourse and are being systematically implemented through the new reform.

4.4.2. Case study GRÆEDUCATION: joint creative design options for change management

The GRÆEDUCATION project was approved in 2017 and has since been accompanying developments in vocational training in green employment in Greece and in Germany. The project was mainly focused on apprenticeships in Greece, covering the EPAL scheme (offered by the Ministry of Education at EQF level 5) and the EPAS scheme (traditional apprenticeship scheme by the OAED, the Greek PES, offered at upper-secondary level).

Project partners included German experts in greening (Chamber of Craft in Münster) and career orientation (*Wissenschaftspark Gelsenkirchen*), the German-Hellenic Chamber for Industry and Commerce, and the FIAP as coordinator, developer and evaluator. On the Greek side the partners were from the Ministry of Education and Religious Affairs, from OAED and IEP (Institute for Education Policies), as well as different associations, representatives of social partners and enterprises. The cooperation of the Greek and German actors has been structured and accompanied by the research institute FIAP e.V ⁽⁵⁷⁾.

As described in Section 4.4.1. Greece has ambitious climate goals and immense pressure to

cope with structural change in the regions, but also ideal conditions for successful structural change due to its wealth of resources. Germany has a historical pioneering role in the energy transition and has a head start in terms of experience, as the structural change began earlier. In Germany there is much technical and social know-how, because of that development, which can be adapted, optimised and support other countries in structural change. (Steinberg, Klatt, 2019).

Building on the methodological principles presented in Section 4.3, the interdisciplinary Greek-German team (consisting of social partners, government representatives, experts and teachers and trainers from both countries and apprentices from Greece) has generated shared creative ⁽⁵⁸⁾ modernisation impulses for vocational training systems in Greece and (retroreflective) Germany in the context of the green transition. Existing technical professions and apprenticeships have been expanded with skills for the green transition and interdisciplinary training elements, with regard to sustainability and modern professionalism, adapted to the new sustainable markets and the special needs in Greece. The focus on apprenticeships also resulted from the fact that the shared creative approach of the project could be implemented particularly well due to the characteristics of apprenticeship described above.

⁽⁵⁶⁾ A total of 97 452 students started vocational education in the 2017/18 school year. Of these, 62 922 were young men and 34 530 were young women. Source: [Hellenic Statistical Office](#).

⁽⁵⁷⁾ The framework for this collaboration is the Phase model for customer-integrative development of transcultural educational services, which was developed by FIAP in the China care project and has been further modelled in numerous projects (Steinberg, 2016).

⁽⁵⁸⁾ Shared creation relies on the heterogeneity of the collaboration partners, allowing different knowledge and perspectives to flow together in the development.

Box 1. The participatory, shared creative approach followed

Apprenticeship teachers (EPAL/EPAS s.b.) have been empowered to design and implement new training programmes. Both vocational school teachers and those responsible for training in companies have been jointly addressed. Apprentices have been involved in special feedback rounds and workshops. In working groups, Greek and German actors have been pushing innovation and transformation processes forward, with the aim of closing innovation gaps that exist in vocational training in both countries (e.g. with regard to digitalisation and technology, but also in social innovation). New innovation requirements have appeared on all sides during the project (e.g. the coronavirus pandemic digitalisation push that is impacting vocational education), for which solutions have been found together. They were negotiated or determined in a dialogical process between equal partners. The exchange of roles between apprentices and teachers has been explicitly encouraged on both sides.

Source: Authors.

Three areas for innovation for greening VET/apprenticeships were tested in the first phase of the project, evaluated ⁽⁵⁹⁾ and adapted by all stakeholders. They are now the basis for the collaboration. First, through a moderated collaboration process of German and Greek apprenticeship teachers, in-company-trainers and technical experts, the curriculum for training electricians at EPAS apprenticeship schools of OAED was restructured and expanded. Technical competences in the areas of photovoltaics, network technology and KNX/smart ⁽⁶⁰⁾ home have been added. The focus of the training is now on renewable energies and energy-efficient, sustainable construction. The cooperation has resulted in a completely new curriculum, which does not exist in this form in Germany. Within the framework of the coordinated workshops, technical discourse has been initiated that also covers general topics of vocational training and in which joint efforts are being made

to master the challenges. For example, the lack of innovative infrastructure in schools was discussed and solutions from Germany have been implemented (sponsored by enterprises). Three further curricula (technician for thermal and hydraulic installation, mechatronics technician for refrigeration, and technician for renewable energy systems for the post-secondary IEK scheme) have been redesigned and modified with green and interdisciplinary training modules using the same procedural model, which is now used by the Greek teachers to work on more curricula.

The second area focuses on innovative ‘green’ teacher training. In cooperation with the Technical University of Athens and the German expert partner involved in the project (HBZ), teachers from vocational lyceums EPAL (apprenticeship teachers and school-based programmes), EPAS schools and in-company trainers were trained on solar cooling, cooling, ventilation and air conditioning technology and heat pumps with the aim of integrating modern green standards and new technologies into teaching/training. The topics were previously identified in a quantitative survey of Greek teachers and qualitative interviews with Greek companies. Companies were also involved in order to improve training opportunities in-house, to stimulate dialogue between learning locations and jointly to find solutions on how to make innovative green technologies available for teaching. The dialogue with companies, which have to comply with European and international regulations and requirements on climate protection in their work processes, made the market relevance of the new teaching modules clear to all stakeholders. The pressure to act, built up by the climate protection regulations, leads to remarkable changes within the culturally shaped vocational training tradition. Given the sometimes costly, innovative technologies that are lacking in the training facilities, a concept has been developed for how certain companies can provide this infrastructure in alliances and how funds can be jointly acquired to build innovative inter-company learning sites that are used by different schools. Such a centre for green skills is currently being established by

⁽⁵⁹⁾ For this purpose, a participatory evaluation model was developed and agreed, which is intended to assess the impact of the measures in terms of successful change management in the long term.

⁽⁶⁰⁾ KNX systems replace conventional switches and support the energy efficiency of buildings through smart energy savings.

OAED in cooperation with the project in Kozani (Western Macedonia), a former lignite-production region affected by severe structural change.

The third area for greening Greek curricula and teaching practice builds on the second approach. In the cooperation with teachers and companies, it became clear that many new services are required in the green occupation fields in order to lower the barriers in the use and handling of new technologies for the user as well. Here, many interdisciplinary employee competences are required in companies; they can be summarised under the term soft skills. So far, this aspect of interdisciplinary competence development has received too little attention in vocational training programmes in Greece and, to some extent, also in Germany. As part of the project, a train-the-trainer seminar was designed and implemented in cooperation with apprenticeship teachers and in-company trainers from Greece and Germany, which, in addition to innovative technical competences, aims at empowering young people in the areas of entrepreneurship and employability. In our view, this is the area with the greatest transformation potential for teaching practice, as well as for local labour markets and sociocultural developments in society.

Box 2. The value of international cooperation for greening VET/apprenticeships

The experiences in the GR/EDUCATION project reflect the fact that international, sustainability-oriented VET cooperation, such as the one which formed the basis for this project:

- (a) leads to more agility in the vocational training/apprenticeship system;
- (b) triggers creativity and social responsibility as a focus of training and qualification;
- (c) generates innovation impulses at different social system levels and has an impact on political, economic and socio-cultural conditions.

Source: Authors.

4.5. Transformation impact from greening apprenticeships in Greece

Various sustainability-oriented transformation activities encompassing a broad network have emerged from the project, sending reform and innovation impulses to other social systems far beyond the project. This supports our perception of apprenticeship as an interaction system with broader transformative potential and that ecological communication as a ‘disruptive factor’ within the system creates free spaces for transformations that radiate throughout society.

The case study shows transformation on three levels:

- (a) innovation and reform movements are set in motion within vocational training systems including regulations for apprenticeship at system level (national reform of VET);
- (b) local labour markets are changed, thereby supporting structural change (and improving economic performance);
- (c) on a cross-sectional level, for us the most important aspect, the transformation paradigm of sustainability in apprenticeship ‘sends’ reform impulses to the (political) system level of vocational education and training, but also to other societal functional systems and sociocultural developments in society.

The ‘system-level’ (VET system) impact of sustainability-oriented VET cooperation is especially clear in apprenticeships because of the characteristics we described.

In all three areas, the project work has tried to consider the different types of public schools within the Greek VET system. Due to the reforms in the Greek VET system since 2018, apprenticeship has been expanded from the EPAS (EQF3) apprenticeship scheme to a new, post-secondary EPAL apprenticeship scheme (apprenticeship class/year upon completion of school-based VET, EQF4/5) and even to IEK (post-secondary) that only foresaw internships in the past. Today all three offer apprenticeships and therefore the EFQEA criteria, especially at the pilot schools where the Greek government wants to implement innovation for the green transition.

Comparison of these options shows that the

degree of dualisation decisively influences the implementation of the EFQEA criteria to support transformation for the green transition: the long-term dualised EPAS apprenticeship schools already offer an optimal environment to train comprehensive transformation movements and to send impulses to other systems. Combining teaching and practice, VET institution and market, creates an agile entity that can adapt to modern forms of knowledge organisation and transfer. With regard to the other two types of schools (where apprenticeship can be offered too), the higher qualification framework is a favourable aspect with regard to complex, holistic transformation.

4.5.1. Transformation impact of greening within the VET system

The case study has shown that the integration of new technical skills in the context of the green transition, including digital skills, and the goal of using vocational training to motivate young people to behave in a responsible, creative and self-determined manner, breaks the traditional walls of vocational training.

First, the roles and interaction of the actors in apprenticeship, and all VET, are redefined, as the new, emerging knowledge in science and green technologies requires that the content of vocational qualifications and programmes is also becoming more agile and must be continually tested for its degree of innovation. Knowledge is no longer monopolistically linked to the role of the teacher or the institution. It is generated in communications in which the actors act with almost equal preconditions. The ‘teacher’ no longer acts on the background of a fixed knowledge inventory but is ideally a moderator in the production of the teaching content, which takes place through mutual communication. This process also involves experts from academia, institutional representatives as representatives of binding regulations, companies as representatives of the market, and also, motivated by the relevance of the topic, the students.

In the case-study, the innovation for greening apprenticeships (and other VET offers) led to changes in the self-image of the different actors and their relationship to each other, especially learners (apprentices) and teachers. A low-threshold example is the traditional teacher-student

relationship: green technologies are innovation-intensive and digitisation-oriented: younger students often have a lower inhibition threshold in dealing with these technologies and using them more naturally. In the piloted apprenticeships it was often the student who provided the teacher with technological support. An agile, productive approach to classroom content requires enthusiasm for technological innovations and also a commitment to sustainability. Here, too, the teacher is not automatically ‘superior’ to the student. We saw that collaboration took place at eye level; teachers and students defined projects in which they worked together. In terms of the soft skills to be integrated, the teachers were considered as coaches and supporters. They had to train themselves to satisfy student needs. A new self-image of teachers and students emerged, leading to new formats in the vocational training system (including apprenticeships). Students were motivated to develop ideas independently in the context of sustainability (which offers a lot of room for innovation) and to implement them together with their teachers. Digital learning formats were used because they offer the opportunity to explore innovative, technical solutions without being limited to the existing infrastructures of education institutions or companies. The project introduced event days where students could try out new technologies. This resulted in working groups and projects, the results of which were presented by the students as their products at joint events with local companies, which had a decisive influence on the student motivation. The companies are interested in young talent, especially in the area of green skills, so the events function as a kind of trade fair where trainees and companies find each other, which is a new format, at least in Greece.

As a second example, the adaptations in apprenticeship (and other VET forms) in the context of the case study, based on direct cooperation with companies, paved the way for transformation regarding the possible role of companies and social partners in VET in Greece. In the areas related to the energy and resource transition, the needs of the market are not fixed, as they involve entirely new processes and technologies. The companies themselves sometimes have difficulty defining their needs and providing clear feedback. We

saw that, for example, regarding technologies which are relevant for training and examinations depending on international and European regulations, national requirements and the conditions in the companies. The new curricula developed in the case study required intensive dialogue and shared responsibility among all stakeholders involved in the process. The involvement of the social partners in the design of vocational training programmes and structures is partly a matter of course in Germany. In Greece, however, this is relatively new and institutional structures need to be established to ensure this participation. In the green professions in the field of energy and resource transition, this is an obvious necessity for all partners, as the level of interdependence is much higher. This area thus offers laboratory conditions for the development of new structures in the VET system, which were used in the project. Here, too, the climate-related pressure to act and the associated structural change in many regions of Europe are important drivers.

4.5.2. Transformation of local labour markets

As a second level of the transformative role of apprenticeships in the context of the green transition, reforms within apprenticeship (and other VET forms) as part of the GRÆDUCATION project triggered positive effects on local labour markets. Besides, combating the high youth unemployment rate through measures in green skills is one of the project central starting points.

First, apprenticeships were highlighted as an attractive and innovative option to start a socially and economically secure career. High-quality, future-oriented apprenticeships are considered a preventive instrument in the fight against youth unemployment (Bohlinger and Wolf, 2016) and the market highlights their need for apprentices, especially in the green sector. For this reason, concepts for green vocational orientation and preparation were developed in the project together with Greek

schools and key actors, which motivate young people to take up apprenticeships in the field of energy transition and in the green sector. The participation of companies was essential here.

In cooperation with OAED, the project has addressed two target groups for the new apprenticeships: young people in schools with an interest in technical studies, and unqualified and unemployed young people (NEETs).

The project set as a specific objective for apprenticeships the empowerment of apprentices to assume responsibility for their learning and their career. The predominantly small-business-based structure of the Greek economy (rated as problematic (Ioannidou, 2019 p.56)) leads to a low willingness of companies to train and to a weak responsibility of companies towards training ⁽⁶¹⁾. This responsibility is largely shifted to the State and learners: for young Greeks, this means much greater personal responsibility for personal skills development, employability and professional development.

This shift included promoting entrepreneurship in apprenticeships. The new aspects of apprenticeships have not only focused on new technical skills but also on interdisciplinary qualifications. The topic of entrepreneurship is particularly relevant in Greece. However, specific competences needed for such self-responsible or even entrepreneurial action, are not sufficiently taken into account in existing apprenticeships programmes in Greece (and also in Germany) (PISA, 2018) ⁽⁶²⁾. Especially in societal change movements they become indispensable competences with which individuals can carry and shape transformation ⁽⁶³⁾. Depending on the target group, it is about a portfolio of skills, knowledge and key qualifications that should help individuals to plan, shape and align their professional and private lives in a self-determined way, as well as to react resiliently to crises. In the context of sustainability-oriented apprenticeships, the training of social and ecological responsibility is to be emphasised.

The new green apprenticeships motivate ap-

⁽⁶¹⁾ The companies cooperating with the project recognise the danger of a shortage of skilled workers and are very much interested in training their junior staff. However, this is much easier for medium-sized companies. The project has succeeded in firmly integrating companies into a dialogue on the topic of sustainability and motivating them to become involved in the training of professions related to the energy transition and sustainability orientation.

⁽⁶²⁾ PISA 2018 Global Competence.

⁽⁶³⁾ These competences include independent learning, the ability to work in a team, problem-solving skills, planning thinking, analytical thinking, flexibility, communication skills and taking responsibility.

prentices to develop new business areas and services, in cooperation with companies where they are trained, and ideas for new companies, which both simplify the use of green, sustainable technology and improve the economic performance. They are trained to support existing companies in service development and to initiate new job profiles in their activities themselves, which has the potential to further develop work and corporate culture in Greece, ultimately exerting an invigorating stimulus on the local economies.

4.5.3. Socio-cultural transformations

The overarching, cross-sectional impact level to be highlighted is the potential of green apprenticeship for broader socio-cultural transformation. For us, this is the most relevant level. In Greece, many of the students who enrol in an apprenticeship after the first year at general education or vocational lyceums do not make a conscious decision to pursue specific education. Especially for the students who do not make it to the lyceum, the goal is to get an apprenticeship just to benefit from receiving a wage, set at 75% of the national minimum wage.

Despite this lack of clear motivation to become an apprentice, the project showed that apprenticeships have a role to play in addressing modern learner interests. Particularly in the technical professions, there is great potential in the students' enthusiasm for new, sustainable technologies. For this reason, the project, in cooperation with OAED, placed a strong focus on vocational preparation in EPAS schools. EPAS students experimented with environmental technologies in student laboratories during their apprenticeship, which they then studied in more detail in compulsory and elective modules in their second year. This type of vocational preparation offers a lot of room for a general ecological sensitisation, to which young people have become increasingly receptive in recent years, also due to the media appeal of the **Friday for future** movement⁽⁶⁴⁾. Responsible vocational education can lay the foundation for anchoring the idea of sustainability in the communications within a society, in its values and in its behaviour

patterns. This potential of green vocational education is conceptualised by the German and Greek vocational educators involved in the project. The dual character of apprenticeships and the involvement of different learning places is used to link the learning outcomes to real life and to show the students the environment-oriented impact of their new knowledge. The apprentice can contribute her/his knowledge directly to the company and support the processes in the company.

A second dimension of cultural sustainability in green vocational education and training programmes specifically concerns the Greek understanding of education and contributes to an upgrading of vocational education and training in Greece. One of the reasons why this understanding of vocational education is critical is that the purely functional teaching of (technical) skills for use in the labour market is not perceived as education in a holistic sense. We have seen that green vocational education addresses all other dimensions of sustainability besides the environmental. It is not only about skills in the field of new technologies, but in the course of a transformation of labour markets and cultures, of forms of business and employment biographies, it is also about a supra-disciplinary empowerment that strengthens key qualifications, innovative spirit and creativity. Through the required interdisciplinary opening of green apprenticeships, the holistic demands in the Greek understanding of education are fulfilled. Instead of mere qualification, it is about the empowerment of young people, which increases their opportunities to participate in society.

4.6. Unlocking the greening potential of apprenticeship as an interaction system

The potential of the apprenticeship as an interaction system can only be used if the suitable design conditions for apprenticeship within national VET systems are in place. The European framework for quality and effective apprenticeship (EFQEA)

⁽⁶⁴⁾ In the project, we tried to motivate young people by enabling them to recognise what they contribute to climate protection with their knowledge and professional actions. For example, measurements were made of the CO₂ emissions of certain types of energy. The apprentices designed advisory modules to help public buildings save energy and became ambassadors for environmental protection in peer groups.

criteria ⁽⁶⁵⁾, which the European Council sets for the member countries to ensure the quality of apprenticeship, can be also used to evaluate whether the transformative potential of apprenticeship can be realised. This applies to EFQEA criteria linked to the learning outcomes and the balance between subject-specific and interdisciplinary competences, the interplay between theoretical and practical training, and the inclusion of different social functional systems in the planning and organisation of the apprenticeship. The implementation of the quality criteria is a major challenge for many Member States (Cedefop, 2021 a), because it requires a cultural change within national VET systems.

The initial thesis of this paper (based on the experiences of the GRÆDUCATION project) is that this culture change is more likely to succeed in the innovative field of green employment than in sectors and fields that are less affected by the need to adapt to innovative technological developments and new knowledge contexts. This thesis implies, from a rotated perspective, that it is precisely the apprenticeship interaction system (the planning, organisation, and implementation of such a form of training) that offers itself to sending innovation and transformational impulses to adjacent societal systems in order to advance the green transition of European societies, which is the *leitmotiv* (Cedefop, 2021) of our present. The required cultural change within vocational education systems radiates to the adjacent systems due to the holistic nature of education. This will be exemplified below by some of the EFQEA criteria below.

First, the desired partnership and transparent dialogue between the social partners and vocational training stakeholders and institutions is a central feature of apprenticeships (criterion 9 of the EFQEA) that can facilitate the transformations needed for the green transition. Progressive green employment is about new sectors and new competence requirements within these sectors. For the players in the vocational training system, this also involves new content and new organisational forms of training. Completely new professional profiles need to be designed for emerging sectors. To design training regulations and curricula that meet the requirements in the new sectors, cooperation with market players and companies

is necessary, as there is no content that already exists. The new technologies also require costly technical infrastructure in training, which is often lacking in vocational schools. Here, too, cooperation with companies, as well as opening up to a third learning location, inter-company training, is a solution growing in use. This means that there must be a change not only in the content but also in the structure and organisation of training: how training content is designed and delivered, and who is involved in this process. As well as companies and associations, trade unions offer themselves as dialogue partners in the design of new training courses in such a way that they comply with European regulations and standards at all levels, which is a fundamental prerequisite in a globalised, or at least European, market. Apprenticeship is an interaction system that offers a suitable platform for partnerships and transparent dialogue between the social partners and vocational training stakeholders and institutions.

The apprenticeship focus on comprehensive learning outcomes and the balance between technical and generic competences (criterion 2 of the EFQEA), offers an excellent environment for the development of skills for the green transition. Many of the new occupations in green technologies are service-intensive: the user/customer has to learn to use these technologies. This requires a whole set of soft skills to make customer dialogues successful. The green economy is an emerging sector. New companies and innovative business organisation are needed to implement new regulations socially through new technologies. Entrepreneurial skills are required in green employment, which is coming into view in training courses and changing curricula. Corporate cultures also need to change, employees need to be able to act under their own responsibility and develop solutions creatively, as this new economic sector has to deal with many uncertainties of its employees. Apprenticeships offer the opportunity for broad development of technical and general skills or overall attitudes and values.

From these few examples it is clear that in the environment of planning, organising and implementing green apprenticeship, many fields of action are emerging that require change management within vocational training/apprenticeship

⁽⁶⁵⁾ See Cedefop (2021).

systems, at the policy level (new regulations and laws), and also at the cultural level within the system and in adjacent systems. The fact that this change requires constant dialogue, sometimes even collaboration, between the different actors, and that new knowledge and structures have to be created together, favours the acceptance and sustainability of the transformation. This was demonstrated in Sections 4.4 and 4.5 on the basis of the GRÆDUCATION project.

4.7. Conclusion: innovation driver green apprenticeship

The aim of this paper was to raise awareness of the ‘disruptive power’ of ecology in societal functional systems and, in contrast to what has been done so far, to understand the concept of apprenticeship at the interface of theory and practice as a guiding system for the ecological transformations of society as a whole. If social subsystems are designed according to criteria that allow for openness with regard to innovation and transformation, they can become innovation drivers for other social systems. This is especially true for the concept of apprenticeship, because it is a system of interaction that brings heterogeneous actors together. In our case-study, green apprenticeship creates the conditions for transformative action and the emergence of new values not only semantically but also in terms of social structure.

In the case study of GRÆDUCATION, it became clear how the transformation of apprenticeship correlates with changes in the overall VET system, in local labour markets, economic structures and corporate cultures and can contribute to more sustainability-oriented practices, social participation and equity. We have shown that, especially regarding the interaction system, apprenticeship offers ideal transformation conditions because of its dual character, when these characteristics are designed close to the EFQEA criteria.

The crucial challenge is to facilitate the agility, acceptance and practicality of ecological innovation discourses in technology, ecology, economics and in the sociocultural sphere. This agility has to be developed on a cultural level inside the systems, but it has to be supported by regulations and reforms.

Guiding principles that emerge here must ‘arrive’ in the normality of the craft enterprise through education and training, for example, and are deconstructed in the education system for this purpose. In our view, vocational training has such an important role in ecological transformation because it is here that the processes of exchange with nature are (can be) controlled across the board and in the middle of society. In this respect, only this reformulation of new (science-based) guiding principles, driven by vocational education, can enable and initiate transformative occupational profiles, (craft) enterprises and industries and services, as well as new sets of standards and regulations.

An agile, reform-oriented and fluid vocational education and training system that fulfils this laboratory function, and engages in dialogue in communication with stakeholders from science, politics and economics, is an important prerequisite and driving force for an ecologically transformed society.

The relevance and success of apprenticeships is based on their ability to adapt to the changing ecological, technological, economic, social and political framework conditions. For this sustainability, the shared creative collaboration among the different stakeholders is crucial.

International cooperation in vocational education and training must not be underestimated for many reasons. It accelerates and deepens the process of innovation in vocational education and training through the adaptation of good practice; this is represented, for example, by the needs-based (with regard to different vocational training systems) dualisation of vocational education and training, through knowledge and technology transfer, and through the merging of (labour) markets. Ecological transformation processes are thus initiated and enabled worldwide.

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New skills for apprentices and students to master green transformation at Siemens

© Dr Stephan Szuppa, Barbara Ofstad and Christina Hees ⁽⁶⁶⁾

5.1. Introduction

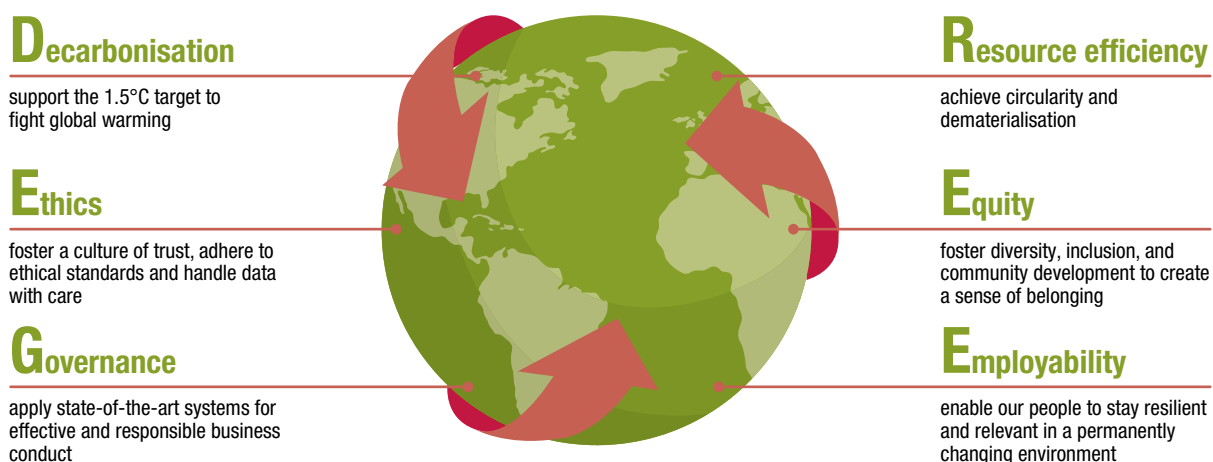
5.1.1. Importance and definition of sustainability for Siemens

A multinational enterprise (MNE) like Siemens, with a history over 170 years, is based on values as well as core competences in electrification, automation, and digitalisation. Providing value to customers and society is what Siemens calls 'purpose'. The broad understanding of sustainability at Siemens is based on its core values: to be responsible, excellent, and innovative. In alignment with the UN's 2030 Agenda for sustainable development, Siemens strives to balance people, profit, and the environment ⁽⁶⁷⁾.

Based on a strong track record, Siemens is accelerating its sustainability approach:

- (a) sustainability is embedded in all business activities; it is part of the portfolio, of operations and governance, its DNA and the engine that drives it;
- (b) technology and innovations at Siemens create opportunities and help customers achieve their sustainability goals for a better future;
- (c) Siemens is committing to – and will report on its progress toward – clear ESG priorities and ambitions in keeping with its DEGREE framework (Figure 1). With skills for both the green transition and innovation Siemens will create opportunities for growth and help customers achieve their sustainability goals for a better future.

Figure 1. Siemens DEGREE framework for sustainability



Source: Siemens AG (2021). *Sustainability report 2021*, p.12.

⁽⁶⁶⁾ Siemens AG.

⁽⁶⁷⁾ Siemens Sustainability report 2021.

The comprehensive new sustainability framework of Siemens, DEGREE, (Figure 1) puts focus on decarbonisation, ethics, governance, resource efficiency, equity and employability, with relevant KPIs in each of these six levers ⁽⁶⁸⁾.

These commitments at company level are operationalised, among many other initiatives, in apprenticeship activities, curricula and mindset, in order to meet today's and tomorrow's strategic goals through a pipeline of skilled young talents. For vocational education and training (VET) it means not only greener apprenticeships, but also an agenda induced by the DEGREE framework which sets clear priorities:

- (a) in the narrow sense, to the green technologies for decarbonisation and resource efficiency;
- (b) in a broader sense, to ensure employability not only at the beginning of one's professional career but also for re- and upskilling programmes for the entire existing workforce.

Hence, helping our employees stay resilient and relevant has become one of the central goals of the People and governance department when it comes to sustainability of Siemens today (Figure 1). Siemens Professional Education (SPE), above and beyond its apprenticeship activities, has become a strong partner for re-/upskilling within the Siemens ecosystem and strives to provide solutions that enable the company's people to acquire the skills of the future. As provider of training, curator of training contents and consultant for Siemens businesses, Siemens Professional Education helps ensure that the skills of workers in the areas of electrification, automation and digitalisation topics, notably for mechatronics/electronics and IT, but also for select commercial content, are up to date ⁽⁶⁹⁾.

5.1.2. Objective and structure of the paper

The purpose of this paper is to illustrate how Siemens integrates sustainability into its vocational education and training apprenticeship provision.

Section 5.1 defines what sustainability means for Siemens and its customers. As sustainability, like digital transformation, is a central element of company strategy it has a major impact on all em-

ployees: starting with apprentices, dual students and including blue collar and white-collar staff via training, reskilling and upskilling measures.

Section 5.2 introduces the company's vocational education and training department called Siemens Professional Education (SPE). It illustrates the importance of a business-oriented and agile innovation process in VET. Via the important trend of 'sustainability and circularity' it describes how the core competences required for apprentices have been defined and what extraordinary role industrial use cases play in the development of new education modules.

Section 5.3 describes the quick and agile integration of the new sustainability and circularity education module into the existing occupations in apprenticeship and dual student portfolios.

Section 5.4 sums up the findings for a conclusion.

5.2. Siemens Professional Education and its role in sustainable innovation

5.2.1. Apprenticeship as a core of Siemens professional education

As part of the People and Organisation (formerly known as HR) department, Siemens Professional Education (SPE) is responsible for global dual vocational education and training (VET) operations for all Siemens AG operating businesses. Siemens is one of the largest companies offering apprenticeship in Germany in the technical field, with 3 682 apprentices enrolled (all numbers as of 30 September 2021) and another 1 029 apprentices that are trained by Siemens Professional Education for third party companies. In addition, the company manages international dual VET activities for approximately 2 000 apprentices enrolled in other countries (Figure 2).

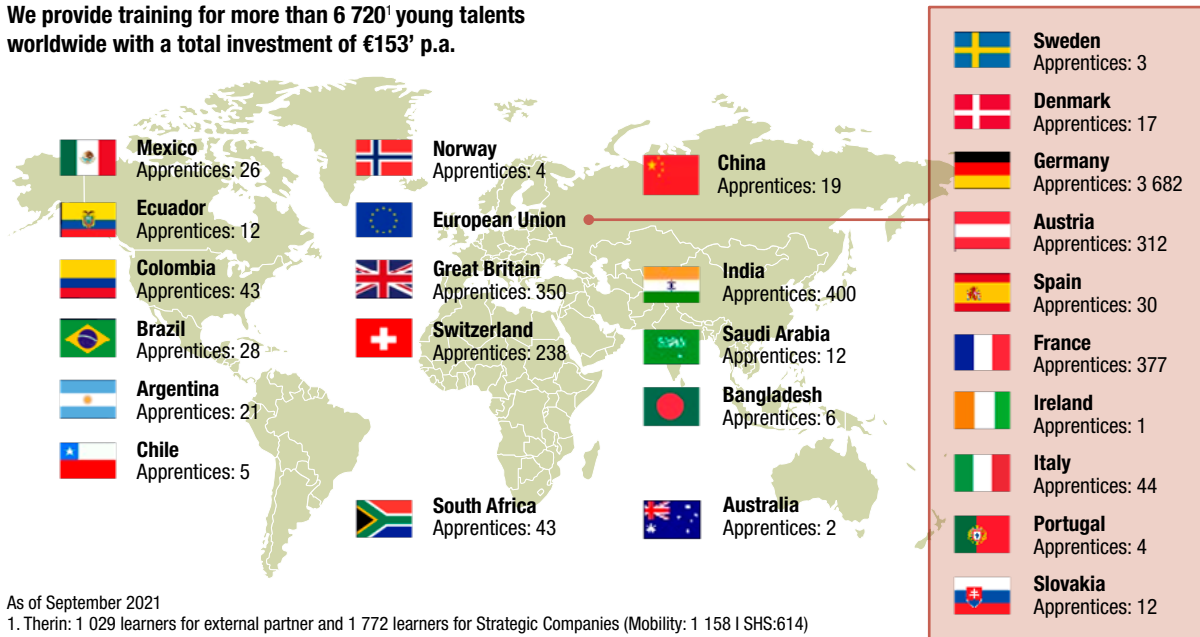
Dual VET for Siemens in Germany includes not only what is traditionally understood as apprenticeship in the German context (i.e. dual VET at upper secondary level), but also dual study pro-

⁽⁶⁸⁾ Launched in the recent Capital markets day of Siemens on June 24, 2021, which dedicated a separate chapter to sustainability topics.

⁽⁶⁹⁾ Hollatz and Ofstad (2021).

Figure 2. **Worldwide Dual VET operations of Siemens Professional Education**

We provide training for more than 6 720¹ young talents worldwide with a total investment of €153¹ p.a.



As of September 2021
1. Therin: 1 029 learners for external partner and 1 772 learners for Strategic Companies (Mobility: 1 158 | SHS:614)

Source: Siemens AG, internal.

grammes at a higher level (aka degree apprenticeships in the UK or *apprentissage dans l'éducation supérieure* in France). This higher dual VET option is an apprenticeship-like education combined with academic studies at university level. In many such cases, higher dual VET graduates obtain an academic diploma in addition to the certificate issued by the Chamber of Commerce and Industry.

Vocational training costs amount to about EUR 121 million p.a. (as per 30 September 2021). When considering the pipeline of young talents (25 years or younger) hired each year by Siemens in Germany, up to 80% are apprenticeship graduates from the Siemens Professional Education pool ⁽⁷⁰⁾. This means that Siemens Professional Education contributes to young talent acquisition through apprenticeship (and higher-level dual VET) in a substantial manner.

A central team within the VET team is responsible for the global strategies and processes regarding apprenticeships, bringing together IT infrastructure, governance and reporting as well as strategy and product lifecycle management (PLM); products in this case are occupations with curricula and different education modules and that are offered to the Siemens business units.

Siemens Professional Education acts as a service unit, not only for all Siemens divisions (smart infrastructure, digital industry, or mobility) but also offers apprenticeships for third-party apprentices. It has a global impact when designing new common training modules suitable for all occupations and skill levels in Germany and Austria, because these modules are then offered to other countries. Therefore, a well-designed engineering process is of relevance for a sustainability and green competence framework.

5.2.2. SPE and its innovation process

Adaptation of apprenticeship training offered by SPE in relation to sustainability includes the assessment of relevant external trends, the understanding of relevant competence needs and the identification of existing or development of new training offers. This adaptation is based on the overall innovation screening process followed internally.

The VET PLM team is responsible for the innovation screening process. Innovation trends, including those that are relevant for sustainability, are regularly monitored and evaluated as to their relevance for VET content via a trend radar. This

⁽⁷⁰⁾ Similar to the national average, as in general, approximately 80% of the German apprentices are hired at the end of their apprenticeship.

task is performed via a variety of internal and external sources, among which are customer panels, interviews with internal and external thought leaders, desk research, international conferences and central technology department input.

Once a trend has been proven to be relevant, it is evaluated as to its strategic scope and time-to-realisation, then further explored by the VET innovation management team according to the following process steps:

- (a) SPE trend radar provides an overview of the most relevant technology and business trends;
- (b) internal customer (aka business units) needs are analysed in detail, as the VET department is responsible for education of apprentices of these business units. Tangible use cases ⁽⁷¹⁾ of Siemens business units help apply knowhow in the specific business context;
- (c) Siemens business experts are involved in order to translate the most relevant technological and business needs into the right competences (Section 5.2.3);
- (d) for fast implementation, existing training offers available on the market are analysed, and necessary new training formats are developed and piloted with apprentices and higher-level dual students ⁽⁷²⁾;
- (e) general rollout follows afterwards, with a strong focus on train-the-trainer activities aiming at bringing all VET trainers up to speed. Suitable methods include classroom teaching, self-learning units via virtual learning nuggets, learning-from-colleagues and learning-by-doing (a project).

In the case of sustainability, the VET innovation process was applied as follows. Initially, 'environmental protection' had been identified as a trend since 2017 when the internal innovation radar first picked it up. It was predicted to become a topic of relevance with a 3-year horizon to develop into a mainstream topic for VET curricula. Upon the innovation radar reassessment 2 years later, in 2019, 'sustainability and circular economy' conquered its own trend card with a 3-to-4-year horizon concerning VET curricula realisation. Since then, it has again picked up speed. Fuelled by the green agenda set by national politics, interest

groups, the public, the European Union and the United Nations, it has become a topic of focus for Siemens and hence, for Siemens Professional Education in its VET operations.

Therefore, the innovation initiative 'sustainability and circular economy' started in 2020 to develop skills for the green transition, as well as content, and a suitable format for apprentices, particularly higher-level dual students (Figure 3).

As part of this innovation process, use cases describe a concrete practical application within industrial application fields. They help identify the skills required and provide a basis for adapting apprenticeship programmes such that apprentices can develop new competences in a practical and customer-driven context. This is what distinguishes apprenticeship curricula from pure knowledge transfer and from generic training offers.

Table 1 illustrates the use cases regarding sustainability and circular economy that have been collected within the Siemens internal and external network of application and education experts.

Table 1. Use cases from different business units on sustainability and circular economy

Use case no	Use case
1	Energy efficiency building technology
2	Decarbonisation of energy systems/ distributed energy systems
3	Engineering tools lifecycle cost analyses (LCA) calculation report
4	Energy consumption & CO2 emission in radiology
5	Reduction resource consumption in use phase moving products
6	Evaluation of sales projects according to sustainability criteria letters of authority (LOA)
7	E- Highway

Source: Siemens AG, internal.

⁽⁷¹⁾ Use cases describe a concrete practical application within industrial application fields.

⁽⁷²⁾ Pillkahn (2008).

Figure 3. Innovation Initiative ‘sustainability and circular economy’

Sustainability and circular economy

High prior trend card at SPE Trend Radar 2019

The starting point for green skills training development



Related trends

Education environment Generalist and flexible multiple specialisation	Business Predictive maintenance
Business Customer value co-creation	Business Reprofit and shortage of resources
Technology business Distributed Energy Systems	Work Environment Interdisciplinary collaboration and external networks
Work environment Understanding of complex systems	

Trend details

Description Sustainability and circular economy/solutions is a highly prioritised trend mentioned by the majority of external and internal interviewees in all branches in 2019	Strategic relevance • Customer ask for sustainable (CO ₂ consumption free) solutions • High on the agenda of international regulation
Examples • Energy: power to gas to power incl. use of renewables to power electrolyser • Communication industry: Re-use of rare raw materials to save supply cost	Key facts • High availability risk for >100 raw materials (VDMA, 2019) • Increase of international waste is rising by 70% until 2050 (VDMA, 2019) • Need for reduction of CO ₂ consumption (Paris climate agreement, 2015)

Source: Siemens AG, internal.

To compare and discuss the use cases among application and education experts, a common unified description methodology has been developed, containing:

- (a) challenge/request/problem to be solved;
- (b) solution/methods;
- (c) who is the user;
- (d) what are the benefits;
- (e) self-describing graphical scheme.

Figure 4 presents an example of how a use case related to the challenges of climate change, global warming, environment protection and resource saving is translated into benefits for the organisation and its business units.

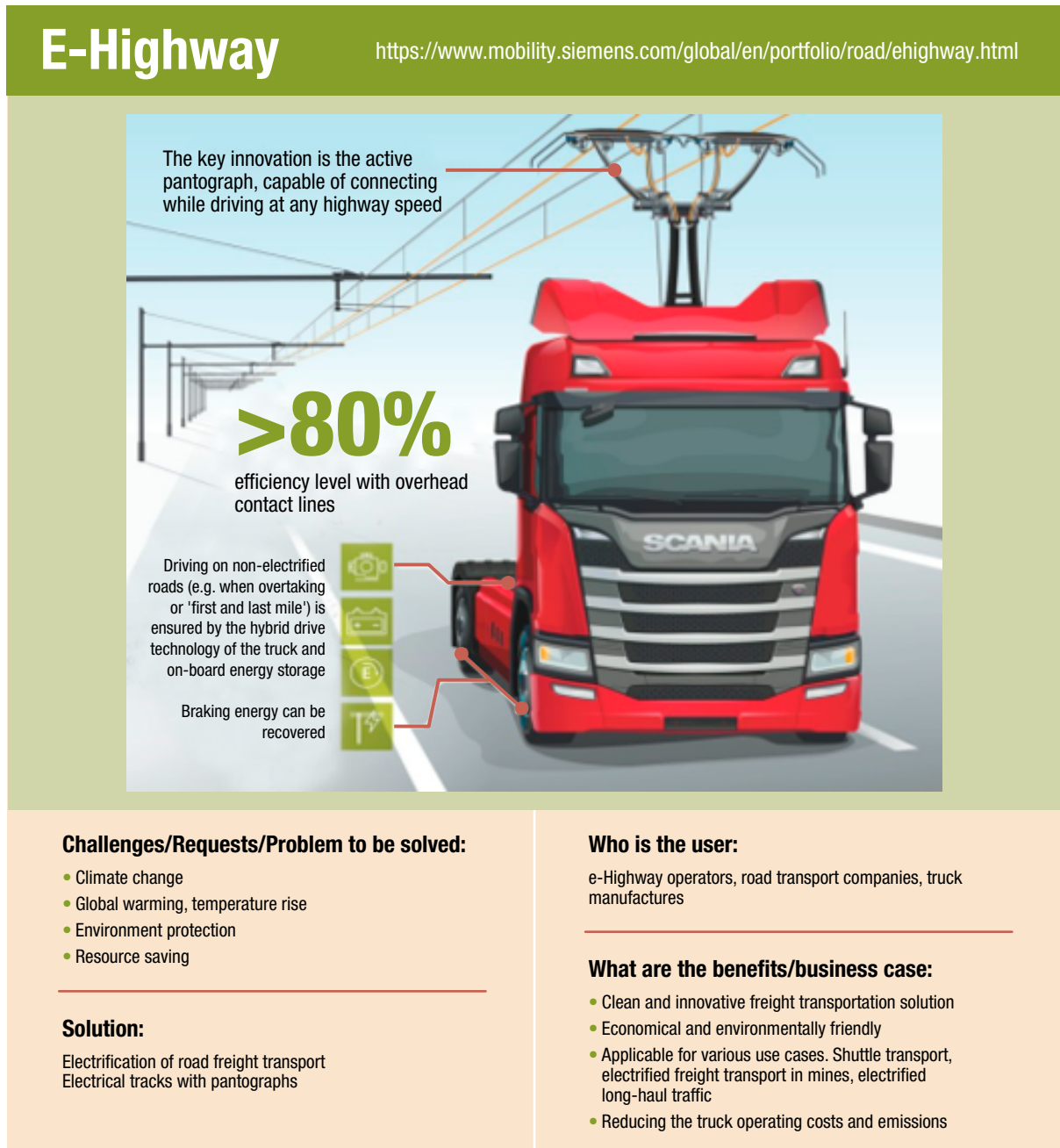
In summary, analysis and integration of use cases have the following advantages for developing skills for the green transition for apprentices:

- (a) identification of overall skills required;
- (b) transparency of use case specific skills to be applied in specific businesses;
- (c) the involvement and valuable feedback of experts and business.

5.2.3. Developing green competence framework with stakeholders

In the case of the VET innovation process for sustainability, SPE set an innovation initiative with a so-called core team, based on the trend radar priorities, as well as internal and external stakeholder discussions and use case collection (Section 5.2.2). This core team consisted of SPE PLM, and Siemens Technology experts plus select external members from academia or employers’ associations, to drive this initiative with the aim to

Figure 4. Exemplary unified use case description

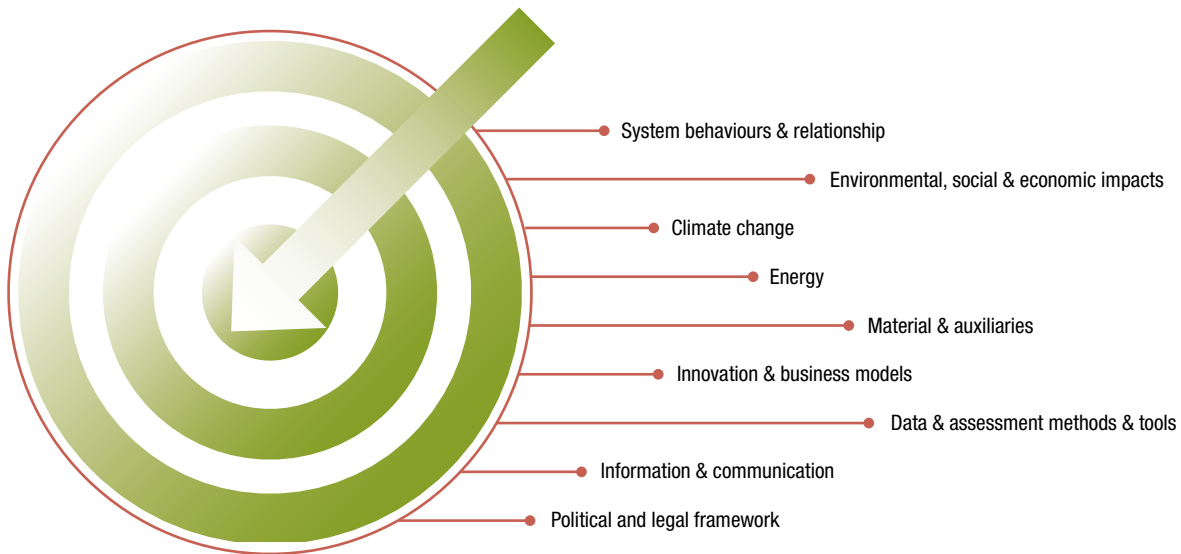


Source: Siemens AG, internal.

define further the correspondent skill requirements of all occupations in which Siemens Professional Education trains apprentices or higher-level dual students. This was done via a workshop and via individual interviews with business experts. Typically, these business experts were involved in the above-mentioned use cases in their departments. The interviews were carried out by the workshop participants.

The workshop had the goal to define common competences and hence, learning targets, for sustainability and circularity. In the workshop, the team started with the general definition of sustainability and circularity and an initial collection of already known learning targets (Figure 5), to ensure a common understanding and establish common targets among the participants.

Figure 5. Initial cluster of learning targets



Source: Siemens AG, internal.

The initial clusters of learning targets (Figure 5) served as input for the definition of specific learning targets that were collected and detailed during the workshop sessions.

The 22 workshop participants represented many different business functions (e.g. engineering, sales, supply chain, control, manufacturing and service) and were therefore able to cover a

broad range of use cases and applications. The team was complemented by education and sustainability experts. Some had been interviewed before and were then invited to join.

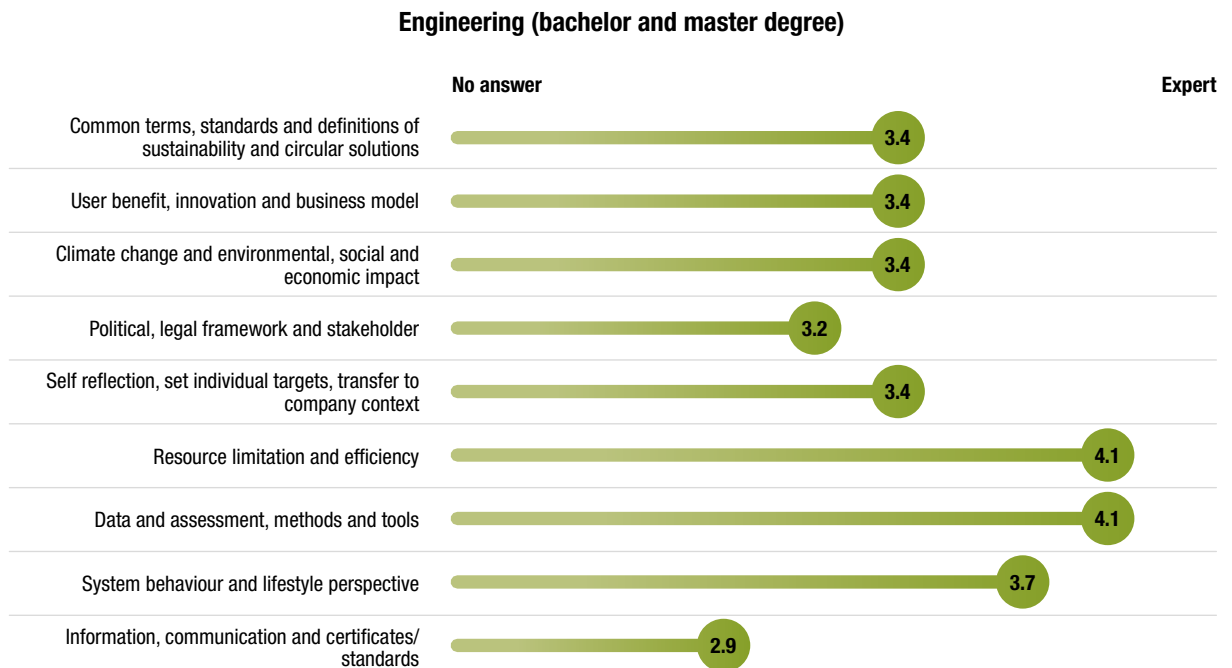
Based on the experience and expertise of the participants, typical sustainability and circularity skillsets and learning targets were defined as illustrated in Figure 6.

Figure 6. Refined sustainability and circularity learning topics and targets

<p>User benefit, innovation and business models</p> <ul style="list-style-type: none"> • Understand customer value • Know relationship • Derive actions 	<p>Resource limitation and efficiency</p> <ul style="list-style-type: none"> • Understand root cause • Quantity and assess • Derive actions 	<p>Climate change and environmental, social and economic impacts</p> <ul style="list-style-type: none"> • Understand boundaries • Derive consequences • Derive actions 	<p>Data and assessment methods and tools</p> <ul style="list-style-type: none"> • Share own conviction • Derive consequences • Derive actions for business
<p>Political, legal framework and stakeholder</p> <ul style="list-style-type: none"> • Measure performance • Calculate indicators • Improve/optimize 	<p>Self reflection set individual targets transfer to company context</p> <ul style="list-style-type: none"> • Measure performance • Calculate indicators • Improve/optimize 	<p>System behaviour, and lifecycle perspective</p> <ul style="list-style-type: none"> • Collect data • Analyse performance • Improve/optimize 	<p>Information, communication and certificates/standards</p> <ul style="list-style-type: none"> • Collect data • Analyse performance • Improve/optimize

Source: Siemens AG, internal.

Figure 7. **Exemplary survey at expert workshop; required green competences level for engineering**



Source: Siemens AG, internal.

By mapping the use cases defined in Table 1 to the initial learning targets (Figure 5), the completeness of competences required was cross-checked against the need to solve business tasks according to the respective professional role. Missing competences were added by the workshop participants and gaps were closed.

Workshop participants then rated the required competence levels for apprentices, skilled workers, engineering bachelor and master holders. Figure 7 shows exemplary competences for en-

gineering bachelor and master levels.

This was later translated into four general training levels: beginners, basic, advanced and expert (Figure 8). A learning pyramid and overall green skills competence framework (Figure 9) was mapped onto these four training levels.

Further on, the pyramid and framework were applied to all types of occupations offered by Siemens, both apprenticeships and dual study programmes. On a schematic roadmap, the meta-topics to be developed were identified as:

Figure 8. **Skill level for competences**



Source: Siemens AG, internal.

Figure 9. Learning pyramid and overall green competence framework

Technology and business competency assignment to green skills in multi-level hierarchy allow for a differentiated VET portfolio

Description	Level	Common terms standards and definitions	User benefit, innovation and business	Climate change	Political and legal framework	Self-reflection (exercise)	Resource limitation and efficiency	Data assessment, methods and tools	System behaviour and life cycle perspective	Information and communication
Transfer to Reality	EXPERT	Planetary boundaries	Assess customer's portfolio and derive innovation potentials	Negative emissions	Derive development and design implications	CE business models and their perception	Closed/open loop	Find trade-offs for decision-making	CE risks and opportunities	Integrated materials management
		Screening methods		Energy system transformation			Substitution			
		Criticality		Decarbonisation or carbon neutrality			Circularity metrics			
		GHG emissions and CO2-equiv								
Experiences in application	ADVANCED	Basic understanding of LCA methodology	Perform value stream mapping for a better circularity	GHG mitigation potential of Siemens portfolio	EU Green Deal and UNEP SDG's	Reflexing on customer's behaviour	Improvement in resource efficiency and rebound effect	Perform system modelling	Identify hot and cold spots for improvements	PLM and how to work with digital twins
		IPCC Reports on climate change	Influencing factors and levers	Basics of carbon footprint (products)	Identified opportunities and risks	Discussion on potential contributions to sustainability and CE	Recycled content in materials	Criticality impact categories	Approach of life cycle thinking	Track and trace solutions for products
		CSR Reporting of corporations	Future challenges in customer's business	GHG emissions & accounting and tracing	Stakeholders and their requirements					
		Basic requirements from EU CE action plan	Derive actions to deliver CE value to customers	Drivers of environmental and societal impacts	Products and solutions with implications from legal framework	Awareness of SDG's importance	Systems performance versus efficiency	Tools and method for material flow analysis (MFA)	Influencing behavior to complex system actions	Importance of transparency
Facts, knowledge	BASIC	17 UNEP sustainability development goals	Products and solutions in Siemens portfolio	Know fundamental mechanisms of climate change	Fundamental knowledge of regulations and guidelines	Reflexing on individual private and professional impact	Definition of resource efficiency	Extraction of decision-related info	Transfer basic idea to different types of systems	Stakeholder requirement engineering
		Understanding of sustainable business activities	Understanding of stakeholder value perception				Know different types of resources and their limitations	Gathering data for life cycle inventories	Understanding of components and their interaction in systems	Identify customers USP's to communicate benefits & savings
Motivation	BEGINNER									

Source: Siemens AG, internal.

- (a) sustainability and circularity (fiscal year 2021);
- (b) decentralised and alternative energy and storage (fiscal year 2022);
- (c) retrofit and shortage of resources, disassembly (fiscal year 2023).

It was concluded that basic understanding, self-reflection, and reflection of business functions regarding the ultimate targets of climate protection and sustainable development goals, were the common competences every employee, and therefore also every apprentice, should be edu-

cated with, regardless of their specific role and business unit.

In summary, the additional review of existing internal and external learning programmes and the matching with the learning targets proved a good baseline to develop the missing pieces and connections between theory and practice in-house.

5.3. Sustainability and circularity approach for apprentices

5.3.1. Applying the learning pyramid to apprenticeships

Based on the taxonomy of the learning pyramid and the overall green competence framework (Figure 9), all occupations were assigned specific contents at specific levels.

As identified in Section 5.2.3, the basics – basic understanding, self-reflection, and reflection of business functions regarding the ultimate targets of climate protection as well as sustainable development goals – consisted of common competences every apprentice should be educated in, regardless of their specific role and business unit. This led to a common development for all apprenticeship types, i.e. a quick win for all sides. This helped speed up development, implementation and rollout.

It is suggested to embed these basics into the first weeks of all new apprentices and higher-level dual students. In contrast, the in-depth and occupation-specific elements of sustainability and circularity were integrated into the ‘competences of the future’ section, which typically takes place during the third-year curriculum. Competences of the future is a term used to describe the digitalisation topics which were recently introduced into the German STEM apprenticeship curricula. Mostly, the use-case-based learnings are set up in the form of project learning and can be easily combined with other learning targets. For instance, an automation project can focus on improving the ecological footprint of a machine or measuring emissions, sending data to the cloud and reading it out.

This meets with federal and sectoral qualifications for apprenticeships, especially since digital competences have recently been added to all apprenticeship curricula in the metal and electronic fields ⁽⁷³⁾. Our projects show how skills for the green transition and digitalisation act synergistically.

As an example of an application of the learning pyramid for mechatronics/electronics and IT apprentices, a project could focus on measuring

energy efficiency directly at field level, e.g. due to power or voltage anomalies or deviations in a drive motor with an automation peripheral component. With the integrated and consistent energy suite (e.g. SIMATIC), the data are processed at the production level, and at the same time monitored and operated via human-machine-interface blocks, e.g. energy-efficiency templates.

For a holistic plant or company-wide energy analysis, the collected and monitored data are uploaded to the industrial internet of things (IoT) as a service cloud solution MindSphere. The App SIMATIC energy manager provides simple, out-of-the-box analytics with flexible KPI definition and user-specific dashboards (value, chart, pie, gauge, sankey, heat map widgets) for energy consumption, costs, and CO² observation. The consistent and integrated E2E-approach fulfils the standard ISO50001 for operational energy management.

In summary, skills for the green transition and sustainability are addressed via suitable project topics and practical examples identified earlier on in the use cases, rather than producing theoretical learning nuggets around this topic.

5.3.2. Developing and piloting sustainability basic content for apprenticeship

Based on the findings of the innovation initiative and the relevant content from the learning pyramid, it was decided by SPE management to pursue a common development for all apprenticeship types, offering a quick win for all sides.

Common development means that the project content aims to address all apprentices (and higher-level dual students), no matter which faculty or year they belong to: both those at upper secondary (traditional apprenticeship) and those at higher-level, apprenticeship-like dual study programmes. (For an illustration of ‘basic level’, please refer to Figures 8 and 9). This way, a broad range of young talents can be reached with the following targets:

- (a) for learners to know the inter-relatedness between greenhouse gas emissions, climate change and energy and resource efficiency;
- (b) to create awareness of the dimensions of sustainability and how these are lived and addressed at Siemens;

⁽⁷³⁾ Bundesinstitut für Berufsbildung (2018).

- (c) to create an understanding of one’s own contribution and possibilities for exerting influence in relation to sustainability;
 - (d) to motivate apprentices (and potentially later, other learners within Siemens) to reflect and advance the topics in their daily work and with the customer in relation to sustainability.
- Using various tools and methods, learners first work interactively and individually, then in small

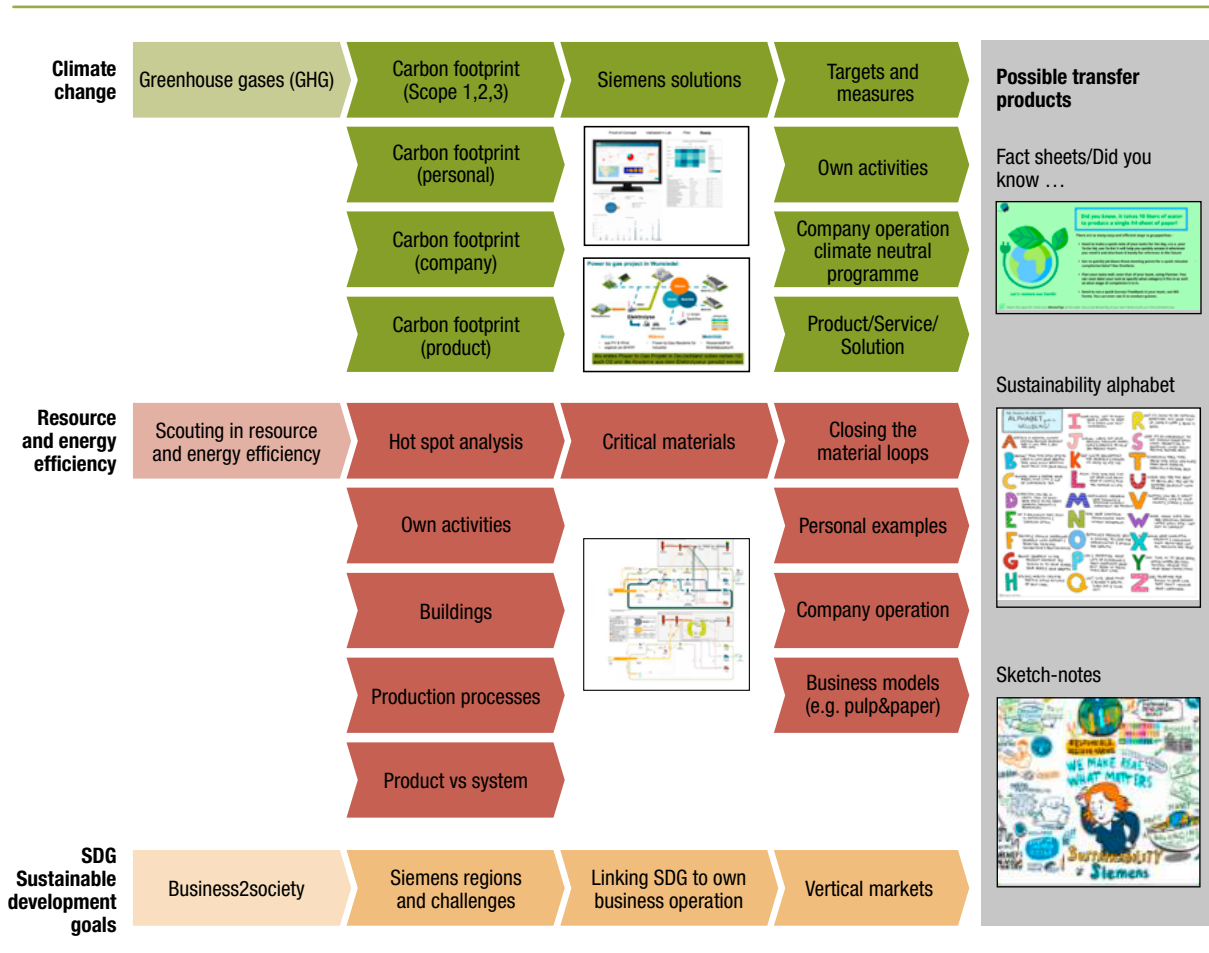
groups, and finally, in the plenum, on three topics: climate change, resource and energy efficiency, and sustainable development goals (Figure10). Then they leverage their learnings in a summary using formats like fact sheets, videos or sketch notes or any other type of suitable presentation.

Depending on the time available, the content of these basics is deployable flexibly. A total duration of 2 to 3 days is envisaged, depending on how

Figure 10. **Project regarding sustainability and circular economy for apprentices, students and employees reskilling and upskilling**

Project sustainability and circular economy

Innovative formats including project design, gamification and interactive elements to motivate apprentices, thereby contributing to enhanced mindset of participants



Planned VET activities

- Pilot run with a learning group in Regensburg, Austria and Switzerland in June 2021
- Subsequent improvements and finalisation of the learning concept
- Rollout of the learning as basis project (2–3 days) for all SPE learning groups starting in September 2021 for all occupations

Further implementation options

Adaptation and adjustment for other learning groups: e.g. blue-collar learners

Source: Siemens AG, internal.

many topics are worked on and selected. It can be shortened or extended, carried out in one piece or spread over time. The training can be conducted in presence using (hybrid) digital tools, or fully virtually. It is recommended to pursue this basics unit on sustainability on skills for the green transition as early as possible during the apprenticeship in order to stimulate a green mindset, such that it can be deployed in all subsequent projects.

The learning nuggets on sustainability and skills for the green transition basics were initially tested in the timeframe of June/July 2021 by two pilot groups of apprentices. Not all the trainers were subject matter experts at that time. Instructions before the pilots in a short ‘train the trainer’ format ensured that all professional trainers were well equipped to teach sustainability and circularity competence as an integrated part of daily work.

One pilot took place in Regensburg, present on-site with an apprentice group of electronics technicians (training year 1). The other pilot was conducted virtually in a cross-country approach with a mixed group of apprentices from Austria and Switzerland from different occupations and experience levels.

Initial feedback looked very promising, as trainers and participants appreciated both the interactive format and the depth of the content. A mixture of tasks combining personal life examples and professional use cases helped start discussions among participants.

After only 3 days, the interaction among participants improved, opening their minds to interconnecting the challenges and opportunities in the three workstreams ‘climate change’, ‘resource and energy efficiency’ and ‘SDG’ (sustainable development goals (Figure 10). They were increasingly able to relate their learnings to their own individual tasks and occupations.

By autumn 2021, the learning concept was subsequently revised and finalised such that roll-out for all learners (apprentices and dual students at higher levels) was able to take place. Beyond Germany, international use of this training is planned in Austria, Switzerland and other countries as part of the formal apprenticeship curriculum.

Siemens Professional Education sees the project as a starting point for motivating apprentices (and dual students at higher levels) to reflect on

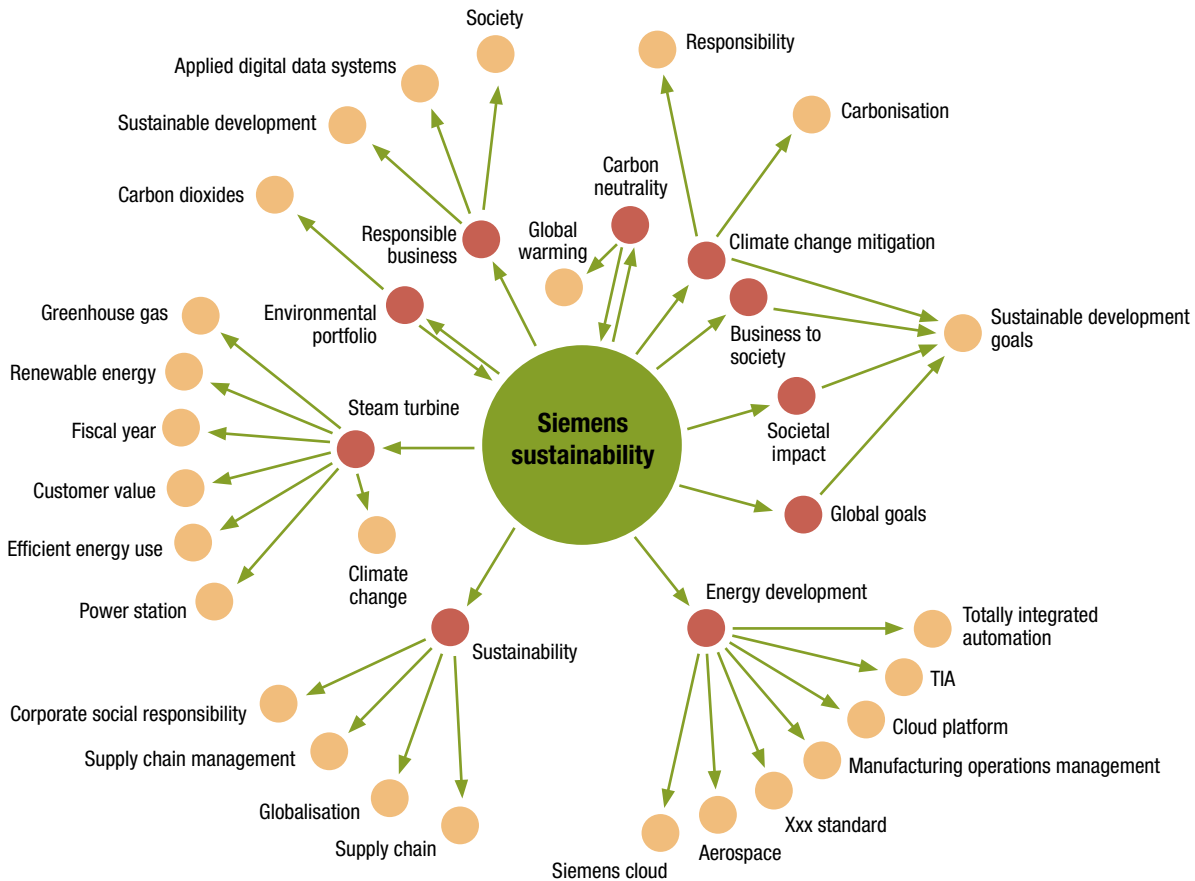
their professional and personal activities, strive for improvements, foster collaboration, and ownership. In parallel, Siemens wants to use this format to learn more about their young talents, their thinking and wishes regarding a prospective future. Sharing open questions, ideas, and the various results in its own internal communities will be one more step towards sustainability.

5.3.3. Apprentices accessing corporate learning platforms for sustainability

Beyond these contents specifically developed for the target group, apprentices, as with all Siemens employees, can use My learning world, the corporate digital learning platform (DLP), for their individualised learning. Sustainability skills for the green transition are addressed in many such voluntary learning modules, as sustainability is a collaborative effort of functions, business, and countries. Sustainability in IT, supply chain, and environmental health and safety has already been addressed in various learning nuggets. Figure 11 shows the overall concept graph of the DLP of Siemens with all facets of learning nuggets around sustainability and skills for the green transition.

Apprentices have access to the DLP and can access topics, including on skills for the green transition. In some cases, apprentices are trained on such topics or projects side-by-side with regular staff upskilling. Though the methods for adult education and training may vary in comparison to those used for young apprentices (and higher-level dual students), synergies are possible for both target groups. Further, apprentices should get acquainted with the platform to prepare themselves for future learning.

Figure 11. Overall sustainability concept graph within digital learning platform for Siemens



Source: Siemens AG, internal

5.4. Summary and conclusion

Companies that want to introduce or update their own apprenticeship (or upskilling) curricula on skills for the green transition may want to learn from success factors, identified by Siemens Professional Education:

- (a) dynamic and fast trend scouting, with an up-to-date innovation radar and short access to strategy adjustment is a way to guarantee non-obsolescence of topics on skills for the green transition;
- (b) an innovation initiative, where the right business experts bring their customer and use case knowledge together, ensures unbiased assessment of learning topics with deep grounding in business relevance;
- (c) an education expert team to identify the right occupations, modules, and formats of new

learning content and training in the curricula of apprentices, students and employee reskilling and upskilling, guarantees operationalisation of technology topics in the format required by VET;

- (d) innovative training formats and ‘quick-win’ projects with agile design and interactive elements will motivate apprentices, contributing to a real mind shift among participants.

Such updates for apprenticeships may also lead to innovative changes, e.g. in the national curricula for occupations. As SPE innovation process is driven in the open innovation mode, interested education experts from other companies are invited to share their experiences with the authors of this paper.

From an industry perspective, sustainability, circularity and green transformation of businesses, education and – consequently – apprenticeships

will be a long-term trend, with high impact and world-wide validity.

In parallel, energy technologies, IoT and digitalisation are developing fast within the 4th industrial revolution, also known as digital transformation. Therefore, development of respective apprentice training in the perspective of sustainability and circularity will not be finalised but will have to be continuously monitored and updated.

As an outlook, this green transition will not start nor stop at VET. It is a comprehensive upskilling

and reskilling initiative throughout the different companies and industries which will touch all employees and stakeholders involved.

Siemens, as a big player in automation and digitalisation, will use its experience and vision regarding sustainability and skills for the green transition to help ensure operationalisation of these topics via employer associations, federal institutes of vocational training, and national and European initiatives.

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How apprenticeships can lead to a greener labour market: policy lessons from the ‘greenification’ of a chemical sector training module

© An Katrien Sodermans ⁽⁷⁴⁾, Helena Van Langenhove ⁽⁷⁵⁾, Frederick Van Gysegem ⁽⁷⁶⁾, Sarah Pascal ⁽⁷⁷⁾

6.1. Introduction

Policies to mitigate climate change will have a profound impact on the way we produce and consume, and will therefore also affect future jobs and skills and the labour market as a whole. The transition to a low-carbon, resource efficient and green economy can only be made by developing the right skills, knowledge and competences. Both the Paris Agreement and the European Green Deal recognise that the development of skills for the green transition ⁽⁷⁸⁾ will play an indispensable role in achieving the transition to a sustainable society.

Initial education is an important in equipping students with the necessary knowledge, skills and attitudes to contribute to the green transition. However, this influx of skills will not be sufficient, especially in the context of an already tight labour market. For a successful transition, it will also be essential to upskill and reskill the current workforce, to equip workers with the skills they will need to perform their job in the future and/or to support employee mobility across jobs and sectors.

This paper looks at how apprenticeships can play a major role in both helping young people to acquire skills for the green transition through initial training/education and in upskilling and reskilling workers and unemployed people in green themes. A case study on the greenification of a 7-day train-

ing module for both students and employees in the chemical sector, combined with several interviews, is used to identify the barriers and critical success factors for acquiring these skills through training and education.

6.1.1. Skills outlook for the energy-intensive industry in Flanders

The paper builds on a recent study Skills roadmap for the Flemish climate transition, conducted by Roland Berger on behalf of the Flemish government Department of Work and Social Economy. That study identified, for the first time, the concrete skills challenges facing the traditional energy-intensive industries (chemicals, petrochemicals, primary metals and rubber and plastics) in Flanders for the period 2020-35. The research team built on an extensive literature review, quantitative analysis of several skill forecasting studies, and interviews with more than 50 industry experts (Roland Berger, 2021).

First, major changes that can be expected in the workplace in the coming years as a result of the green transition were identified. Typical examples include smart metering, augmented operators and environmental impact monitoring. In addition, main technological changes by 2035 were also considered, such as carbon capture and electrolysis for hydrogen production (Deloitte, 2020). This analysis demonstrates that the green and digital

⁽⁷⁴⁾ Department of Work and Social Economy.

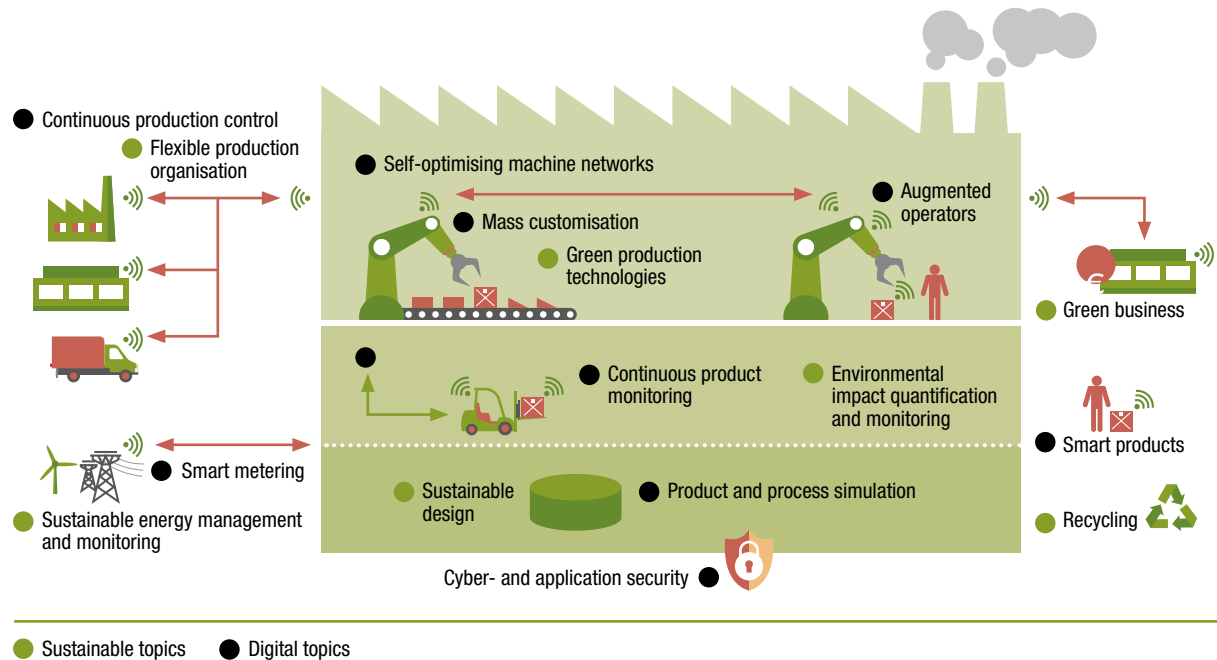
⁽⁷⁵⁾ Department of Work and Social Economy.

⁽⁷⁶⁾ Roland Berger.

⁽⁷⁷⁾ Acta vzw.

⁽⁷⁸⁾ Such skills are generally referred to also as ‘green skills’, that is the total set of skills required to make the transition to a greener economy. The paper will refer to such skills as ‘skills for the green transition’.

Figure 1. In the factory of the future the green and digital transition go hand-in-hand



Source: Roland Berger (2021).

transitions will go hand-in-hand at the workplace (the so called 'twin transition') (Figure 1).

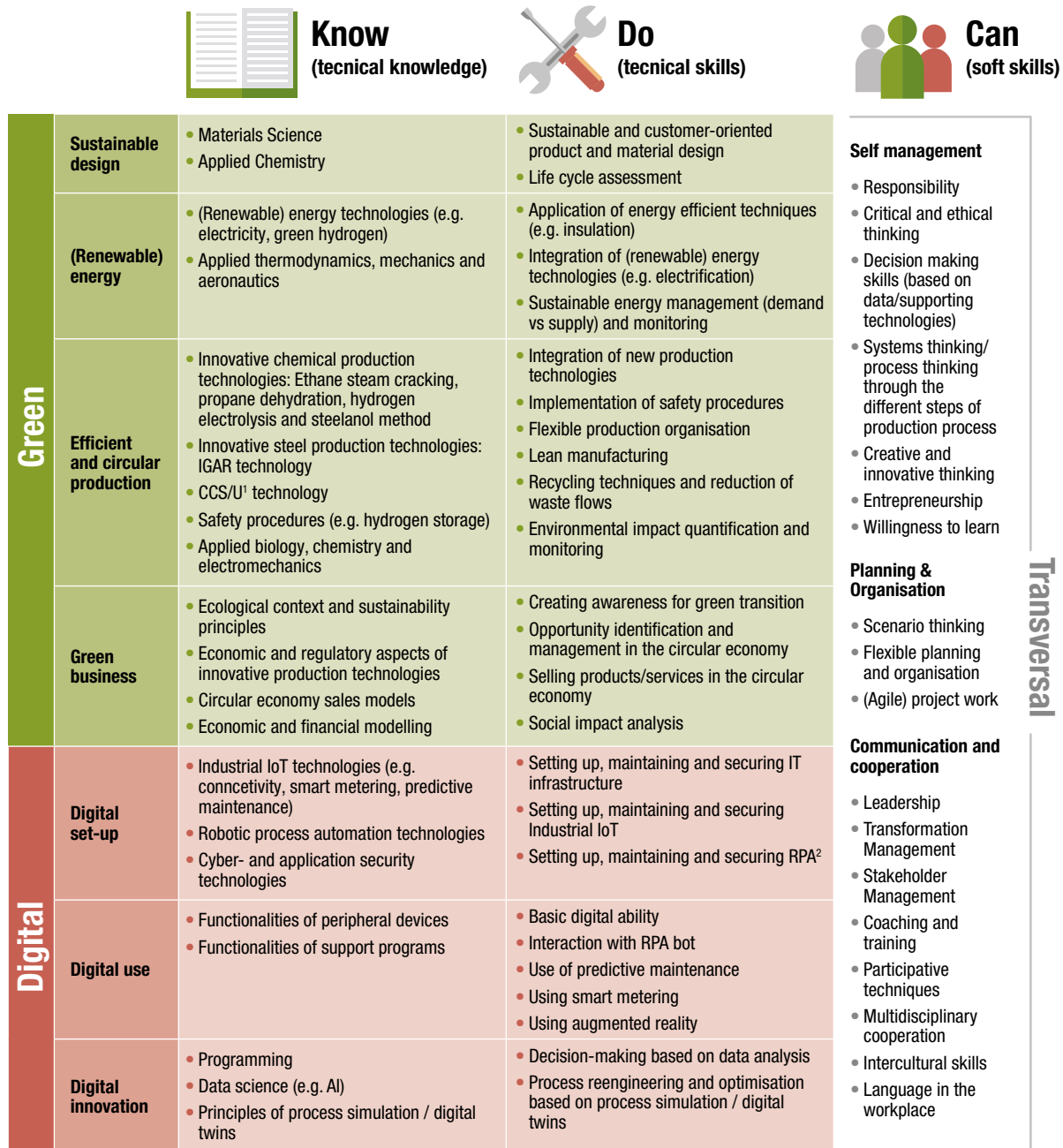
In a next step, these changes were translated into competences to acquire, resulting in a new competence framework. The overarching framework consists of three elements: technical knowledge, covering the subjects in which knowledge needs to be built; technical skills, covering the measurable and objective abilities that will gain importance; and soft skills covering the subjective and non-tangible abilities that are becoming increasingly important. The total set of future skills required to make the transition towards a greener economy are referred to as skills for the green transition.

The expected changes were analysed both qualitatively (type of skills) and also quantitatively (number of workers impacted). The research demonstrated that, for the chemical sector, the demand for workers in Flanders is expected to remain stable at circa 34 000 until 2035. Combined with an expected retirement outflow of 2.9% per annum, this leads to an important need to find circa 16 000 new workers until 2035. These 16 000 new workers are either individuals who are already in the labour market (and hence need to be reskilled/upskilled) or future labour market entrants (who need to get such training as part

of their initial education, including through VET/apprenticeship). The study also demonstrates that the ratio between different profiles will change (e.g. higher share of engineers, electricians, IT specialists), impacting also the incumbent workers in the chemical sector. Hence, a significant effort needs to be made to train new or existing workers on specific topics in response to the green transition within the sector. Starting from the new skills framework, the study shows that, between now and 2030:

- more than 26 000 workers (around 75% of the current workforce) need to be trained in 'efficient and circular production' topics (across all profiles);
- more than 24 000 workers (around 70% of the current workforce) need to be trained in 'use of digital technologies' topics (mainly operators, technicians, production workers/ drivers);
- approximately 22 000 workers (around 65% of the current workforce) need to be trained in 'renewable energy' topics (mainly engineers, operators and electricians);
- approximately 12 000 workers (around 35% of the current workforce) need to be trained in 'digital innovation' topics (mainly technicians and engineers).

Figure 2. A new competence framework for the energy-intensive industry



1) Carbon capture and storage / usage; 2) Robotic process automation

Source: Roland Berger (2021).

6.1.2. Apprenticeships as an effective way of developing new skills for both students and workers

The above analysis has identified which jobs and skills will be necessary to make the transition towards a greener economy; the next step is to develop ways and strategies to train people in these future skills, both through initial education

and training as well as via upskilling and reskilling the existing workforce.

As is shown in previous research, apprenticeship training offers several benefits for both apprentices and companies. Apprenticeships provide learners with real-life work experiences and so offer a good learning environment for teaching specific professional skills, through presence of more

state-of-the-art tools, as well as soft skills (OECD, 2010). For companies, there are certain short-term benefits, like the productive contribution of apprentices during their period of apprenticeship. Moreover, when an employer can upskill/reskill employees through workplace learning, there is no indirect training cost of unworked paid hours in comparison with training for employees outside the workplace. However, there are additional long-term benefits for companies, like the recruitment of the most productive apprentices as valued employees after the end of the apprenticeship. Also, employers offering apprenticeships enhance their reputation as they may be seen as contributing to the common good. This may indirectly increase profits if companies seen as socially responsible are more likely to sell their products and services (though these benefits are difficult to measure) (Kuczera, 2017).

Despite these generally acknowledged benefits, in Flanders, apprenticeships ⁽⁷⁹⁾ are not very widespread. A reform in legislation of 2019 aims to improve the quality of the dual learning scheme at upper secondary level (initial education) ⁽⁸⁰⁾. Also, for jobseekers and the unemployed there are some possibilities to get trained on the job, offered by VDAB, the public unemployment agency ⁽⁸¹⁾. For workers who want to reskill or upskill, however, the options of engaging in apprenticeship training are rather scarce. This paper presents evidence on the advantages of apprenticeships in training young students and workers on new skills, in particular those linked to the green transition.

6.2. Greenification of an apprenticeship training module for chemical operators

6.2.1. The ACTA case

This section analyses the assumption about the advantages of apprenticeship training for the green

transition by means of a Flemish case study, hereafter referred to as the 'ACTA case'. In an effort to prepare learners better for the green transition, ACTA, a centre for technical training in the chemical sector, adapted one of its training modules by aligning it to the competence framework discussed above (Section 6.1).

The training module in question is part of the 'chemical process techniques' (CPT) training offered to apprentices in upper secondary education (initial education) ⁽⁸²⁾ and covers 7 non-consecutive days of technical training. CPT is an education programme consisting of three parts: theoretical training provided by a secondary school; work-based learning at a chemical company; and a technical training module offered by ACTA, partially in a simulated production plant.

Box 1. ACTA and the Chemical process techniques (CPT) programme

About ACTA

ACTA is a technical training centre situated in the Flemish-Dutch delta region, with a main office located in Brasschaat, near the port of Antwerp. It has experience providing experience-based learning since 1991. The organisation was founded as collaborative initiative between the Flemish sector of the chemical industry and the education sector. ACTA provides multiple learning platforms for innovation-driven knowledge transfer between industry experts, scholars and technology partners. ACTA's target groups include employees, teachers, students and the unemployed.

All training offers are facilitated by a chemical plant (400 m²) equipped to simulate training environments. The conditions are the same as in a real plant and observation of trainees is possible. ACTA staff consists over 30 people, including expert teachers and seconded industry experts in chemical process techniques, electro measuring and control technology, safety, and transportation. ACTA trainers have extensive experience over many years. Over 14 000

⁽⁷⁹⁾ This paper refers to the apprenticeship scheme Dual learning (upper secondary level). In 2019/20, 1 567 learners were enrolled in this scheme, which accounts for less than 10% of VET learners. See [Cedefop European database on apprenticeship schemes](#).

⁽⁸⁰⁾ See [Cedefop European database on apprenticeship schemes](#).

⁽⁸¹⁾ See information on the relevant [VDAB web page](#).

⁽⁸²⁾ Although the ACTA case comprises a training module in initial education, ACTA has plans to extend the lessons to other training modules and to other target groups, e.g. employees and jobseekers needing upskilling or reskilling.

workdays of training are provided yearly in real-life simulated working environments: 9 000 workdays for upskilling and reskilling of employees in the chemical industry and 5 000 workdays for training young people in initial education tracks. A few years ago, ACTA started investing in digital training modules, including e-learning offers and augmented reality (AR) and virtual reality (VR) training simulations.

Chemical process techniques (CPT) programme

After finishing their 6 years of secondary education, Flemish students are able to opt for an extra seventh year to acquire additional technical/vocational skills for a specific job. 'Chemical process techniques' is one of those trainings and prepares young people in 1 year to become a process operator in the chemical industry. Some students take up this training right after graduating from secondary school, while others have already worked or studied for some years and decided to give training a turn. This results in a very diverse target population which forms an ambitious challenge for both the students and their teachers, trainers and mentors. The education side and the chemical industry work closely together and reinforce each other in organising this course. The secondary schools take care of the theoretical part of the training, while students undertake an apprenticeship in a chemical company to acquire practical skills. On top of the training at school and the company, ACTA delivers a part of the training. The students come to the ACTA training facilities for a module of 7 non-consecutive days where they are trained in subjects such as distillation, flow, pressure or temperature and where they learn to work with equipment such as pumps, measuring devices and steam generators. ACTA trains around 200 students in the chemical process techniques programme on a yearly base.

Source: Authors.

The training module in question had existed for more than 20 years and was developed together with schools and the chemical industry. As circumstances for operators are changing rapidly, due to digital and environmental challenges, ACTA decided to renew their training module and adapt it to the challenges lying ahead. The Skills roadmap for

the Flemish climate transition study was an ideal starting point for doing this. The study forecast that the following competences would be in high demand in 2035 for chemical operators.

Table 1. Important skills for chemical operators in 2035

Skills type	Important skills for chemical operators in 2035
Green skills	Applying energy-efficiency techniques
	Implementation of security procedures
Digital skills	Basic digital skills
	Use of smart metering
	Use of augmented reality
Soft skills	Flexible planning and organisation
	Decisiveness (based on data/assistive technologies)
	System thinking/process thinking through the different steps of the production process

Source: Roland Berger, 2021.

In response to the forecast changing skill needs, ACTA renewed the training module by including skills for the green transition in the learning objectives and by inserting a higher awareness of climate impact throughout the entire training module. Examples of the modifications are given below.

- (a) One part of the training module comprises the starting up and handling of a distillation column, an essential item used in the distillation of liquid mixtures to separate the mixture into its component parts, or fractions, based on the differences in volatilities. A distillation column is controlled by turning on a wheel, which might have a huge climate impact without operators always being aware of it. It was the intention of ACTA to raise the awareness among (future) operators of the ecological impact of their handling of the distillation column and to ensure that searching for the least polluting or most energy-efficient way to operate their equipment become an automatic reflex. In order to achieve this goal, ACTA created a game at the distillation column. For a certain amount of time, the learner has to keep certain values within specific limits by manipulating a combination of buttons. A digital display gives instant feed-

back about how their performance influences CO₂ emission and thus about their ecological impact. ACTA hopes to increase awareness and make ecological impact visible in this way.

(b) Another activity to create green awareness among the future chemical operators, is a quest in virtual reality to search for 'green crimes'. Students need to report spills or leakages.

(c) ACTA trainers continuously encourage the learners to have critical reflections about current procedures, and stimulate them to formulate new, innovative proposals on how things could be managed in a more sustainable way.

ACTA wants to increase the general knowledge of their learners about current problems, challenges and innovative solutions regarding the sustainability debate in the chemical industry. Therefore, the course books were supplemented with recent and relevant news articles.

6.2.2. Methodology

Different stakeholders involved in the CPT training course were interviewed and asked their opinion about skills for the green transition, the plans of ACTA to redesign their training module, and possible barriers to overall greenification of education and training modules. The interviews were conducted and analysed in June and July 2021 by two policy workers of the Department of Work and Social Economy and an employee of ACTA, and analysed by the authors of the current paper.

Box 2. Respondents and interview questions

The following respondents were interviewed:

- The head of Co-Valent, the joint (parity) sectoral training fund in the chemistry, plastics and life sciences sector
- An education and labour market specialist at Essensscia, the Belgian sector federation of the chemical industry and life sciences
- An HR representative at BASF, a multinational chemical company, training apprentices in the CPT course
- A chemistry teacher at a secondary school
- A production manager at BASF
- An apprentice supervisor at a secondary school
- A consultant at the Regional Technological Centre Antwerp (RTC) which contributes to qualitative

education at the interface between education and the labour market by various actions.

- Two process operators at BASF, who were former apprentices at BASF

Interview questions were, among others:

- Is there currently sufficient awareness of green themes in the existing training for the sector?
- How can we make progress in this area?
- Are there any obstacles?
- In what way can training providers get started with competence frameworks such as in the Roland Berger study?
- Are there specific points for attention regarding green skills in apprenticeship training?
- Which partners/stakeholders should be involved in make training modules greener?
- What is the role of companies?
- What is the role of training providers?
- What is the role of other actors?
- How can the ACTA case be a lever for introducing green skills into other courses as well?
- What do you think is needed from the policy to put the green theme on the (training) map?

Source: Authors.

6.3. Case study results

Trends and patterns that could be observed throughout the interviews, were identified and turned into several main findings.

6.3.1. Skills for the green transition cover knowledge and skills, plus attitude/awareness

The interviewees indicated that skills for the green transition are difficult to grasp, but that the competence exercise made in the roadmap study (Section 6.1) makes the concept for the chemical sector more concrete. The competence framework shows that skills for the green transition are a combination of knowledge, technical skills and soft skills, but interviewees added to this framework that skills lay also in a green attitude/awareness that needs to be formed. Hence, there is an important lever in embedding a 'green reflex' in the way

of executing tasks (see example of the distillation column game of ACTA).

6.3.2. It is difficult to teach skills for the green transition in a school context only; the company context is essential

As skills for the green transition are also a matter of attitudes, the interviewees indicated that the workplace context is better suited for acquiring these skills than the school context. An awareness or reflex can be best taught at the workplace, during repetitive handling and exposure, which makes apprenticeship training very effective in training green attitudes/awareness.

6.3.3. Short-term economic return still takes precedence over ecological thinking

A business context lends itself better to making skills for the green transition applicable and concrete compared to learning in the classroom. However, for this to be successful, companies should already focus on green transition priorities. Nowadays, most companies are still not always eager to work in a more ecological and sustainable way if this would mean a loss in profit in the short term, according to our interviewees. When companies are acting on green transition, this is often limited to the management and the research and development department. Hence, apprenticeships are only an effective training method for skills for the green transition when companies are really adopting ecological awareness.

6.3.4. Green themes are included in curricula and education objectives, but there is a lack of coordination and concrete course material

Most schools and teachers involved in the CPT programme are aware of the importance of green themes. There are often green policies at school, such as a ban on single-use plastic, and teachers include this in their courses. The new secondary education plans of the Flemish community also include transversal skills on 'sustainability'.

Nevertheless, there are also barriers and problems. First, there seems to be a lack of coordination on the topic and the attention to green themes is greatly dependent on single actions and initiatives of teachers or school leaders.

Another issue is the lack of concrete course material on the green transition. Including green themes into the curriculum and learning objectives is one thing; knowing how to teach them is another. Teachers involved in the CPT track expressed their concerns over whether sufficient material will be available to teach these competences.

Education professionals involved in the CPT are also worried about the inclusion of skills for the green transition in the curricula, especially regarding the content that will be lost at the expense of these new elements. The CPT training is a 1-year programme and is quite onerous, according to both teachers and students in the programme. Because of this, there is little room left during the lessons at school to focus on skills for the green transition. Perhaps this is not true for other education providers as green elements do not necessarily take up space from other subjects; ideally, they are integrated in other subjects.

Apprenticeships offer a good solution for the problems and issues mentioned. By acquiring skills for the green transition, mostly during workplace training, time is saved at school to focus on other skills and topics.

6.3.5. Teachers are not sufficiently trained to teach skills for the green transition and not well aware of what is going on in companies

Teachers and trainers are not always sufficiently trained to teach skills for the green transition. Although schools find the topic important, there is little interest in investing in training courses or train-the-trainer modules for their teachers on green themes, at least for the chemical sector. Resources are scarce and guiding teachers in getting started with these skills is not always a priority for schools. Secondary education teachers, especially, are often distanced from the world of work and are not always aware of the major competence changes that the transformation to a carbon neutral society will bring. Apprenticeships might offer a good solution in bridging the gap between education and industry.

There are good practices, such as that of BASF, a company involved in the interviews that wants to play an exemplary role in the cross-fertilisation between education and the labour market. In the

case of apprenticeships (or longer internships), BASF requires school teachers to visit the production plant and offers additional opportunities for them to get to know the production environment. For instance, teachers visit the company with a number of students to give classes on site. BASF also offers teachers the opportunity to do internships in the company (varying from 2 hours to 2 weeks). This kind of activity provides insight into each other's living environment, with cross-fertilisation in both directions. BASF also brings mentors to the classroom, such as to experience lab activities together with their apprentice.

The ACTA case shows how the awareness of skills for the green transition in a training centre can raise awareness in general. The adaptation of the CPT training module created a wider green awareness among ACTA staff members, as a task force was created, and enthusiasts had some joined-up thinking. ACTA mentioned that teaching green awareness to students only becomes credible if the entire organisation lives by this philosophy and if other ACTA training modules for other target groups are adapted as well.

Besides adaptation to the training course, trainers and other staff members need to be informed and retrained. ACTA trainers need to become ambassadors of sustainability. Only if they truly live by these attitudes will they really influence their students.

6.3.6. Greenification of a training module requires close collaboration between companies, schools and private training providers

The strength of the current case is based on the good cooperation between the different stakeholders involved. Because apprenticeship programmes like CPT are composed of different parts (school-based training, company-based training and technical training at a simulated industry plant at ACTA) it is important that all those actors work closely together when greenifying the curriculum. ACTA took the lead in this case study by adapting their training module based on the competence framework described above (see Section 6.2). The schools were immediately involved and supported these plans. Also, BASF and the sectoral organisation were enthusiastic and stimulated this project.

In BASF, focusing on sustainability is important. To improve the quality of the apprenticeship training, they took various initiatives to reach out to the schools and were also prepared to include the green theme in their mentor training. The role of players at the regional level was equally important: the Regional Technological Centre Antwerp has the task of establishing connections between companies and schools and making them work together. They know all actors within the region well and are able to establish contacts in the field.

6.4. Policy lessons and recommendations

Four specific policy recommendations to stimulate the teaching of skills for the green transition through apprenticeships are offered.

Recommendation 1: Create awareness by investing in skills forecasts

Before skills for the green transition can be included in curricula and apprenticeships programmes, it must be clear which skills are desired. Skills assessments and anticipation/forecasting exercises give policy-makers, companies and training providers information on current and future skill needs. In employment and education policy, this type of information is necessary to update (re-)skilling programmes and curricula. While overall, comprehensive skills forecasting is needed to steer policy-making, specific additional skills forecasting for the green transition at sectoral or regional level is useful to create awareness around such skills. The study on skills for the green transition in the energy-intensive industry made these skills more concrete for stakeholders (sectoral actors, training providers and policy-makers) and demonstrated the urgency of taking action in this field. The ACTA case showed that a skill forecast study, as carried out for the energy-intensive sectors in Flanders, can be a good start to thinking about adapting training modules to skill needs for the green transition.

Recommendation 2: Provide financial and other incentives for education and training providers to adapt training programmes to future skill needs

It is important that skills forecasts do not remain a dead letter, but that the information is used by policy-makers, education actors and employers. To (re-) train (future) employees for the green transition, it will be necessary that these topics are covered in (re-)training courses and school curricula. The findings showed that skills for the green transition are not yet a topic high on the agenda in sectors and companies. Therefore, there is no demand stimulus for training providers to develop training courses. The findings in the ACTA case also indicated that it is often not profitable for training providers to offer a sole course on skills for the green transition. To solve this, it is recommended for governments to give financial support to education and training providers to adapt their courses to new developments regarding skills for the green transition. Ideally, these support measures are put in place simultaneously with measures to stimulate skills forecasting in clusters and sectors.

However, it is not enough to include this in objectives and school curricula. It must also be made transparent how teachers can get started developing skills for the green transition and how they can work on them in the classroom. The theme should, therefore, also be addressed in teacher training courses and classroom materials.

Recommendation 3: rely on apprenticeships to teach skills for the green transition

According to the interviewees, skills for the green transition are best taught in a combination of learning at school and at the workplace. The classroom or school, on the one hand, is necessary to gather theoretical knowledge on green technologies and innovations. The workplace, on the other hand, is a good place to develop a 'green attitude' when performing tasks, which complements knowledge of green technologies.

Apprenticeships can provide added value for developing skills for the green transition. Through dual learning, apprentices immediately apply learning content at the workplace. The interview with graduates showed that theoretical knowledge on green innovation and technology learned in the

classroom did not have the same impact on them as learning at the workplace during their apprenticeship at a company.

The cross-fertilisation between education and the labour market that is established through dual learning also depends on how this is implemented in reality (see challenges and best practices, Section 6.3). It is important that in-company trainers gain insight into the learning process of apprentices and learn how to challenge and facilitate them in their thinking. In this way, the pedagogical abilities of the mentors are increased.

Recommendation 4: create a strong partnership between education providers, companies, sectoral and regional players to teach green skills through apprenticeships

It will only be possible to develop skills for the green transition if education and business work together and join forces. Policy-makers should continue promoting and relying on apprenticeships, as this is a perfect way to bring the theme of skills for the green transition inside the education world.

The present case makes it clear that a strong (local) partnership is necessary for apprenticeships to work. The roles and tasks of the various players must be clear. Our case identified the stakeholders who are crucial.

- (a) Educational providers: schools and training providers, such as ACTA in this case study, must first see the urgency and need to make their training programmes future proof and include skills for the green transition in their training programmes. They must actively seek collaboration with companies to integrate the work-based and school-based training into a meaningful apprenticeship programme.
- (b) Companies: as a starting point it is necessary that the green theme is considered important by companies and they make investment in training for this a priority.
- (c) Sectoral players: sector bodies can encourage and support companies in their sector to put the topic high on the agenda. Sector funds, for example, can organise and financially support apprenticeship training for employees within the sector, as well as for in-company trainers. In this way, skills for the green transition can

be taught through apprenticeship training to (re)train future and existing workers.

- (d) Regional players: a real local ecosystem at regional level, in which companies and training providers (schools and ACTA) work together to provide apprenticeships training and programmes, would be an enabling condition.

6.5. Conclusion

In the coming years and decades, companies will have to radically shift the way they produce and do business to meet the ambitious and necessary targets on CO₂ reduction. This transition will require both future employees equipped with the right skills and massive up- and reskilling of the existing workforce. Specific forecasts dedicated to the green transition can raise awareness of this need for future skills and make skills for the green transition more evident for stakeholders. To

(re)train many employees and to provide students with skills for the green transition in a short time, apprenticeships may offer an important lever for companies and sectors.

A skills forecast for the energy intensive industry in Flanders showed that the transition will only be possible by investing in technical knowledge and skills, and soft skills. In the case presented in this paper, students, employees and jobseekers are taught skills for the green transition through a combination of classroom teaching and workplace learning. All stakeholders (education actors, companies, sectoral actors and students) agree that dual learning is an ideal way to develop skills for the green transition. As the demand from companies for training on these skills is still low, policy-makers should raise awareness through skills forecasting and incentivise training and education providers to adapt their training courses and curricula to future skill needs related to the green transition.

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VET for a greener construction sector: low road or high road approaches to apprenticeship

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7.1. Introduction

The built environment is responsible for 40% of energy consumption and 36% of energy-related CO₂ emissions in the European Union (EU). The aim to become zero carbon implies a transformation of the construction industry and, by implication, construction-related vocational education and training (VET) programmes across Europe (Viejo, 2021). The construction industry ⁽⁸⁶⁾ is set to gain more employment than any other from the transition to a green economy, through policies and programmes for nearly zero energy building (NZEB), renewable energy installations and retrofit (ILO, 2018). Zero carbon building and NZEB require the training of millions of construction workers, a different construction process from traditional ones and, consequently, a significant upgrading of existing VET programmes. The imperative of equipping the future and existing construction workforce with the appropriate knowledge, skills and competences is, therefore, an integral part of the EU green transition policy for the built environment. It has important implications for apprenticeship systems for the different construction occupations in the industry, which are deeply rooted and rest on the integration of work-, classroom- and workshop-based elements. The complex technical and social challenges confronting construction VET programmes, above all apprenticeships, throughout Europe, and the constraints involved in addressing these, are the focus of this paper.

As apparent from the European Commission's (EC's) BUILD UP Skills (BUS) initiative (Section

7.3), successful NZEB depends on coordination and overall project awareness, teamwork and the application of theoretical knowledge to particular circumstances (EC, 2014). Our research has shown how comprehensive VET systems (including based on apprenticeship) and broad occupational profiles covering a range of activities, constructed and maintained through consultation and coordination with social partners and based on imparting relevant knowledge, represent the 'high road' to energy efficiency in buildings; these are best placed to respond to the challenges of climate change (Clarke et al., 2019a, 2019b). Such systems successfully embed low-energy construction (LEC) elements by adopting a VET standards-based approach and seeking to overcome occupational boundaries, developing a holistic understanding of the construction process. Classroom and workshop-based elements assume greater significance within apprenticeship programmes and are carefully integrated with work-based elements. In contrast, an approach to VET based only on learning outcomes and targeting specific skills can be too narrow and lacking in depth to allow for the systematic application in the workplace of theoretical knowledge about LEC and the development of work-based NZEB expertise. Theoretically broader, deeper, more technical and inter-disciplinary expertise is needed to meet European performance in buildings directive (EPBD) targets (EPBD, 2018).

The depth and breadth of expertise, and the qualitative transformation of the construction labour process required for an energy literate work-

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force, also need to be expressed by qualification frameworks to support a uniform approach across Europe in conformity with the European qualifications framework (EQF). Despite this, VET for LEC has been largely preoccupied just with developing specific 'skills' and confined to short and task-specific continuing VET (CVET) courses, representing what can be regarded as the 'low road'.

Mainstreaming the knowledge, skills and competences required for NZEB into apprenticeship programmes is rare (Clarke et al., 2020a and 2020b). This paper highlights the strengths and weaknesses of different VET systems in meeting NZEB requirements and presents examples of what can be done to incorporate LEC elements into apprenticeships.

7.2. Adapting construction apprenticeships

7.2.1. Why do construction apprenticeships need to adapt?

VET programmes for construction occupations generally require a combination of three locations: site, workshop and classroom. They can range from employer-based apprenticeships, as in Denmark or Germany, to more school-based programmes, as in Belgium, Poland or Sweden (Brockmann et al., 2010b). Each implies a different learning process, roles of the social partners, the State and the education authorities, responsibility for work-based training, and status of the learner.

With school-based systems, which depend more on the classroom and simulated learning in workshops, the workplace element is overseen by the school or education system and the learner is only a student. Although they may be better able to connect the knowledge, skills and competences attached to a particular occupational qualification, VET provider practice and theory may be at odds with firm practice and learners may subsequently experience difficulties in entering the labour market.

Apprenticeships, in contrast, as in Denmark and Germany, are dependent on employer engagement in providing and monitoring work-based

experience, despite being coordinated market economies (CMEs) with strong social partnership arrangements (Hall and Soskice, 2001). Here, the construction employer may not seek to address carbon emission reduction targets, the apprentice is a worker and there can be a divide or lack of connection between the employer and the school (Grytnes et al., 2018).

As the construction labour process has become more complex and abstract, requiring considerable application of theoretical knowledge, so the classroom and workshop-based elements have assumed greater importance. This is especially so in the first years of initial VET, as exemplified in the 4-year apprenticeship programme of Denmark, where the first year is almost entirely in the vocational school (Grytnes et al., 2018). At the same time, the long-term tendency has been for the construction labour market to become increasingly fragmented through self-employment and extensive subcontracting (EC, 2020). Nearly half the construction workforce across the EU is employed in micro firms and nearly three quarters in small firms, including in Germany; nearly 90% is employed in SMEs (small and medium size enterprises) rising to 95% in Italy (Eurostat, 2021). Small firms constitute 99.4% of all construction firms across the EU, medium-sized firms only 0.5% and large just 0.1%, though the proportion of medium-sized firms is much higher in Belgium at 20% and Germany at 22%. A large proportion of the workforce is self-employed, ranging from 49% in Britain and 43% in Italy to 25% in Belgium and only 11% in Germany (ONS, 2021; Clarke et al., 2019a).

In terms of VET, the problem posed by this fragmentation is that it erodes the work-based training infrastructure; small and micro firms have limited capacity, resources or scope to provide placements and/or work-based learning covering a broad range of activities. In addition, many large firms rely on subcontracting much of their workforce and those who are self-employed are not in a position to train. This means that little substantial work-based training takes place, and a considerable challenge is presented to apprenticeships in the construction sector. Yet this is a sector in need of increasing training provision given forecasts for millions of new and replacement workers

required as a result of the transition to NZEB by 2030, and given the construction skill shortages reported in many European countries (Cedefop, 2020; ILO, 2018).

The difficulties in providing work-based training are less severe in CMEs like Belgium and Germany, which have comprehensive VET systems for construction and higher proportions of medium-size firms. In Belgium, for instance, according to the collective labour agreement classification of salary levels based on workers' professional aptitudes, it is estimated that 37% of the construction workforce have a superior professional competence, 25% have expert knowledge with a minimum of 3 years' experience, 24% hold a construction diploma from full-time education, and only 16% are at the lowest skill level in the collective agreement (Clarke et al., 2019b). Such a highly qualified workforce would have little difficulty in becoming upskilled for NZEB, including through apprenticeships.

However, in Germany, where entry into the VET system remains largely dependent on the employer, a different challenge arises from the decline in the number of construction apprenticeships by over two thirds since the 1990s, from 98 000 to 34 000 in 2017 (Clarke et al., 2019b).

Both the fragmentation of the labour process and the decline in the number of construction apprenticeships pose considerable problems in integrating into apprenticeship programmes the LEC requirements for a high level of expertise, theoretically broader, deeper, more technical and inter-disciplinary than found hitherto (Clarke et al., 2019a). As a direct result of the transition to greener economies and societies, additional pressure to adapt is therefore placed on construction apprenticeship. This was highlighted in the EU's BUS initiative (EC, 2014).

7.2.2. Adapting apprenticeships to changing: low roads or high roads

An occupational qualification in the construction industry, as a social guarantee of the competence of the practitioner who holds it, can only fulfil this role if it is comprehensive. Occupations change

due to technological, economic and social pressures and, to remain a guarantee, qualifications must reflect those changes. The more rapid and profound the changes, the greater and more frequent the need for the revision of qualifications. At the limit, it may be necessary to replace one type of qualification with another or, somewhat less drastically, to revise the design philosophy, for instance whether it is outcome or content led, of an occupation-related qualification. It has been claimed, for example, that a switch to a learning- outcomes-based approach leads to more responsiveness to changes in the labour market (Cedefop, 2017) ⁽⁸⁷⁾. A more common situation is that qualifications and their design philosophy are retained, but the content is altered to ensure continuing relevance. This is often the case with apprenticeships in the construction industry, which have a long tradition in many European countries of qualifying learners for a broad occupation rather than simply introducing young people to the labour market through a relatively narrow training content. Qualifications with a modular design can also 'plug in' and withdraw new and outdated modules respectively, as with 'microcredentials' or part qualifications based on short periods of learning (Gabriel and Schmidt, 2021).

Such practices entail an agreed way of revising and creating qualifications so that they remain relevant to the needs of the occupation and continue to supply society with the necessary guarantee that practitioners are competent ⁽⁸⁸⁾. This is especially important in the case of NZEB, as issues concerned with energy use and climate change have increasingly concerned the broader public as well as the interests traditionally involved in VET. As qualifications are subject to State regulation of varying degrees of rigour, this also circumscribes the possibilities for their revision. The broader the base of social partners involved in qualification construction and revision, the greater the range of interests and concerns that can be taken account of in the revision process.

Two countervailing trends are evident. On the one hand, liberal market economies (LMEs) such as England tend to favour an employer-led

⁽⁸⁷⁾ Within Europe there is also the opposing tendency. To ensure an adequate degree of formal learning, a purely outcomes-based approach has been 'delegitimated' in England in order that knowledge and behaviours are integrated into practice (Ofqual, 2016).

⁽⁸⁸⁾ The German dual system is a good example of a VET approach with an inbuilt review of the continuing relevance of qualifications.

approach to qualification construction and revision, albeit with a strong structural steer from the State. In contrast, in CMEs such as Belgium and Germany a more diverse range of stakeholders is found, including unions and regional governments (Hall and Soskice, 2001). Employer-led systems (in LMEs) are claimed to be agile and responsive to market conditions; however, as employers tend to focus on existing practices, the scope for innovation is limited (Brockmann et al., 2010a). Social partnership systems (in CMEs) are claimed to be responsive, not just to passing market conditions but also to important interests within the society, including workers themselves, for whom the qualifications serve as a guarantee and the possibility of a good working life (Streeck, 1992). There is little evidence that they are less agile since qualifications are kept under constant review.

In many countries, ambitious targets, relating to decarbonisation and the creation of a ‘circular economy’⁽⁶⁹⁾, have led to an increasing interest in the role that VET and associated qualifications can play in equipping the current and future workforce to meet them (Spiridon, 2021). These have, in turn, led to scrutiny of the fitness of existing qualifications and the possibilities for apprenticeships in the construction sector to be more appropriate to the NZEB goal. Here we assess whether, and how far, the construction apprenticeship system is able to respond to the challenges.

7.3. Methodology

This paper draws on a project entitled *Inclusive vocational education and training for low-energy construction*, known as VET4LEC. It was carried out between 2017 and 2019, led by the EU construction sector social partners, the European Construction Industry Federation (FIEC) and the European Federation of Building and Woodworkers (EFBWW), and involving partner organisations from Belgium, Bulgaria, Germany, Ireland, Spain, Italy, Hungary, Poland, Slovenia and Finland (Clarke et al., 2019a and 2019b). Building on the BUILD UP Skills (BUS) initiative, the project included: national status quo analyses for each country; scoping the

extent of VET provision for NZEB; detailing the construction labour market and workforce and the extent of NZEB implementation; and assessing examples of VET for construction occupations, excluding those for building services such as electricians and plumbers. It aimed to identify the core knowledge, skills and competences required. The training evaluated in this project includes examples of both apprenticeships and continuing VET. Site visits and interviews were conducted in seven of the countries (excluding Spain, Hungary and Slovenia) with training providers, social partners, contractors and site personnel. The analysis was aided by a conceptual framework developed to increase the transparency of construction VET across the EU (Clarke et al., 2020a) and provides a basis for evaluating future NZEB related developments in construction apprenticeships.

Box 1. The legacy of the BUILD UP Skills (BUS) programme

The EU’s BUS programme, addressing skills and training provision required for LEC, was conducted with the ultimate aim of supporting the development of training in energy efficiency measures and the installation of renewable energy systems for the existing construction workforce. In Pillar I (2010-12), 30 European countries completed a status quo analysis, establishing quantitative (the number of qualified personnel needed to meet energy efficiency targets) and qualitative (the kind of changes needed in existing VET) skill gaps, and developing road maps for addressing the challenges identified in preparing the workforce for NZEB (EC, 2014). According to the national status quo analyses from Pillar I, across the EU, over three million workers need to be trained to deliver the EU’s energy efficiency targets. The investigation identified significant challenges posed by underfunded and out of date VET infrastructures and showed that, while all EU countries need to upgrade their VET systems for NZEB, there are significant differences between countries in terms of the measures to be taken (EC, 2014). In the subsequent BUS Pillar II (2014-17) programme, 22 Member States developed pilot training programmes to help address the gaps identified (EC, 2018).

⁽⁶⁹⁾ For example, concern about the challenges brought about by climate change and the corresponding need to reduce energy consumption have led to increasingly demanding requirements on the part of the European Commission (EC) and Member States.

BUS Pillar II and subsequent EC Horizon 2020 projects were designed to develop capacity and the infrastructure of future VET and increase the reportedly very low awareness of NZEB and incoming legislation among all construction stakeholders. These projects include: the development of learning materials (Bulgaria, Ireland, Spain), the training of teachers (Bulgaria, Ireland, Spain, Poland), setting up training centres (Bulgaria, Ireland), developing introductory courses for the existing operative workforce (Ireland, Italy), and establishing a register of qualified workers to regulate newly emerging occupations (Hungary) (EC, 2018).

In terms of the 'qualitative skill gap', the BUS overview highlighted the significance of knowledge of energy efficiency, higher technical skills, a holistic approach to the building process, and inter-disciplinary understanding, as well as transversal abilities not addressed in most VET systems such as effective communication, project management, problem-solving and autonomous working (EC, 2014).

Source: Authors.

7.4. National approaches in VET/apprenticeship adaptation

Building on the BUS initiative, the VET4LEC project found that in only a small number of countries, including Belgium, Denmark and Germany, are VET systems adequately equipped to integrate NZEB competences into existing programmes (EC, 2014; Clarke et al., 2019a and 2019b). These countries have already made substantial progress in mainstreaming NZEB competences into existing VET, including apprenticeship programmes, though being also recommended by BUS to strengthen the core competences in curriculum and ensure up-to-date teaching materials and better teacher training. In contrast, many other Member States (such as Bulgaria, Ireland, Spain, Hungary, Slovenia) were recommended major reforms to their existing VET systems: reviewing and aligning national qualification frameworks with the EQF (Poland); restructuring the VET model to rebalance work-based and theoretical learning (Bulgaria,

Spain, Hungary); and strengthening the regulatory framework and governance arrangements (Ireland, Poland, Slovenia) (EC, 2014; Clarke et al., 2019a and 2019b). The VET4LEC project further highlighted the divisions between countries: the small number, such as Belgium, Denmark and Germany, where LEC competences have been integrated or mainstreamed into VET programmes; those where LEC competences are non-existent, including Bulgaria, Hungary and Slovenia; and those, such as Ireland, Spain, Italy and Poland, where LEC competences tend to be incorporated in higher levels of VET for building services occupations (Clarke et al., 2019b).

Training for NZEB for the existing workforce was found in both BUS and VET4LEC investigations to be fragmented in most European countries and provided by a range of private training organisations, technical colleges, further education colleges, public sector training bodies and manufacturers of renewable energy systems (RES). Many courses are standalone, not standardised or monitored, focusing on imparting narrow and specific skills, mostly in the installation of new technologies and renewable energy systems; they are limited in occupation range and geographic reach, and cater to those with some existing training and qualifications, particularly in building services such as electricians and plumbers (EC, 2014). This suggests the need for fuller and more comprehensive LEC training programmes for both adults and apprentices.

7.4.1. NZEB training programmes in Ireland

Ireland was one of the 22 Member States that developed a pilot training programme funded in Phase II of the BUS initiative. Though the Foundation energy skills (FES) programme targeted experienced building workers with or without qualifications, it is also adaptable for apprenticeship programmes (Qualibuild, 2017). While most VET for LEC is in the installation of renewable energy systems and has a narrow, technical skills focus, the FES programme prioritised core climate and energy literacy; it had a substantial emphasis on measures addressing the building process, including airtightness and insulation, rather than building services. It initially ran as a 3-day, standalone introductory module that con-

sists of six units ⁽⁹⁰⁾.

The course is primarily theoretical, suitable for self-study, and aiming to instil an understanding of the reasons for the transition to energy-efficient building construction in the context of the climate crisis. This approach underscores knowledge and understanding of NZEB, its rationale and the precision, coordination and collaboration needed to achieve the standards required. Rather than just imparting specific ‘skills’ (e.g. how to lay insulation), it empowers and equips workers to take ownership of the objective of delivering NZEB. The original pilot training was subsequently developed for accreditation by City and Guilds ⁽⁹¹⁾ as a short but comprehensive and accessible introductory core course, which can then be tailored to specific occupations and to apprenticeship programmes ⁽⁹²⁾. As the course is regulated at the regional level, quality standards can be established and monitored, an aspect missing from one-off short courses from private providers and generally from more fragmented approaches to CVET.

A significant factor in achieving this outcome in Ireland has been the proactive role assumed by the Irish government in the transition to NZEB. The process of developing a standardised VET programme in LEC, out of a BUS pilot, is characterised by collaboration between stakeholders, including employer organisations and trade unions, training bodies, private companies with expertise in energy-efficient construction, and government representatives. This stakeholder support meant that momentum could be maintained in moving from the pilot to a national rollout ⁽⁹³⁾.

7.4.2. VET adaptation to NZEB in Belgium and Germany

In both Belgium and Germany, the knowledge, skills and competences required for VET for LEC are deeply integrated into existing profiles, curricula and exam regulations for each construction occupation. These broad-based construction VET systems emphasise LEC underpinning knowledge,

such as of building physics and materials, and provide apprentices with an overview of the sector, as well as stressing transversal abilities such as communication, coordination and teamwork.

Occupational profiles such as those used in the Belgian construction sector set a standard for what good VET for LEC should look like. Belgian VET is a hybrid of both a dual apprenticeship and a school-based system (Clarke et al. 2019a; Allinckx; Karno and Monico, 2019). It operates within a social partnership context in which the State plays a background role in constructing occupational profiles. The more day-to-day aspect of Belgian construction VET is run through the paritarian organisation, *Constructiv*, which involves the close cooperation of the social partners (employer associations and unions) in together developing occupational profiles. These consist of three closely related elements – knowledge (*savoir*), know-how (*savoir faire*) and attitude (*savoir être*) – and provide a detailed account of what it is to practise an occupation; all recognised qualifications must conform to the respective profile. Construction VET providers then write the curriculum for each occupation, which introduces the attributes needed by workers, the application of knowledge to practice and the appropriate attitudes required.

The development of integrated occupational competences of the kind found in construction VET programmes in Belgium suggests a pedagogy that combines operational practice, simulation and classroom work, resulting in a complete capacity for action or what is termed in German VET programmes *vollständige Handlung* (Brockmann et al. 2011).

In Germany, national curricula for each construction occupation (including building services) incorporate VET for LEC elements and provide detailed syllabi through pedagogic materials, such as textbooks. These cover the nature of climate change, so imparting to the apprentice climate literacy, as well as both practical and theoretical elements of VET for LEC: these can include the

⁽⁹⁰⁾ The units are: Energy and buildings, How energy works, Building fabric 1 (air and wind tightness), Building fabric 2 (insulation, thermal bridging and best practice), Heating and ventilation, and Systems thinking.

⁽⁹¹⁾ City and Guilds is an education institution in the United Kingdom offering training and awards accredited qualifications.

⁽⁹²⁾ The first introductory course was delivered by Wexford and Waterford Education and Training Board in September 2018, and the first trade specific course in January 2019. There has been a steady increase in attendance on the different courses, totalling 582 until March 2020, including for: NZEB fundamentals (457), electrical (18), retrofit (36), plumbing (6), ventilation (60) and carpentry (5).

⁽⁹³⁾ NZEB courses have begun to be delivered by Laois & Offaly Education and Training Board (ETB) and plans are underway for Limerick and Clare, Mayo, Sligo, and Leitrim and Cork ETBs.

purpose of insulation, internal climate control, costs of heating and energy use, environmental protection and thermal bridging (Handwerk and Technik, 2014). Construction VET programmes (which are often provided as apprenticeships) are under constant review and adjusted to take account of technological changes, economics, the legal framework and social conditions. Social partnership structures oversee the apprenticeship curricula and ensure the representation of all relevant perspectives and inclusion of critical elements.

LEC in Belgium and Germany has a long history and both countries were early adopters of NZEB: they have established expertise and knowledge on energy efficiency and renewable energy sources incorporated in VET systems, and their respective governments provide a strong lead and investment in implementation. Both VET systems for construction are resourced and up to date, combining school-based and practical learning through a substantial off-site, workshop-based component and/or work placements.

This broad, standards-based model offers apprenticeships a suitable framework for developing knowledge and understanding of energy efficiency, and opportunities for gaining a holistic view of construction to improve occupational coordination. With its scope for developing transversal abilities, such as communication, collaboration and coordination, VET (including apprenticeship programmes) develops 'occupational capacity'. It implies a broad understanding of agency (Clarke et al., 2013; Winch, 2014), responding to the demands of a LEC labour process where workers operate independently, apply expertise acquired appropriately, problem solve as necessary and take responsibility for meeting specified standards and quality.

7.5. Options for apprenticeship adaptation to NZEB

So far, we have examined requirements on construction apprenticeships and good practice or 'high road' approaches to construction VET, based on the BUS reports and the VET4LEC project, where NZEB is integrated into the curriculum and

pedagogic practice.

The examples of Belgium and Germany relate to social partnership systems, with backup from the public authorities, in which wide-ranging consultation and procedures for continuous incremental updating and improvement are embedded (Clarke et al., 2020a). Such systems are well-adapted to the NZEB challenge and, while the exception rather than the rule in most areas of the EU, provide important lessons for less well-coordinated economies. These include curriculum integration of climate energy issues through teaching materials, such as found in relevant occupations within the German Dual System. Where wide-ranging and sufficient workplace experience is available, including pedagogic and pastoral support, such issues, dealt with theoretically in teaching materials and simulated in practice in workshops, can be exemplified and consolidated in the workplace. Elements of broad agency involving problem-solving and project management can be developed and incorporated in such experience, although this depends on the design of VET.

In LMEs the approach to VET for LEC for both the existing and future workforce represents the 'low road', revolving around such features as skill-based microcredentialling, modular structures, accreditation of prior learning and the use of skill frameworks, together with forecasting tools such as observatories for the anticipation and matching of skill supply and demand (Viejo, 2021).

VET for existing construction workforce is vital for apprentices whose workplace experience requires the support of colleagues acquainted with the latest technological and work practice developments.

In some cases, countries have developed guidelines that work for both groups, for apprentices and the existing workforce. For example, Leeds College of Building in the United Kingdom (UK) has developed indicative guidelines for curriculum inclusion of NZEB topics, organised by theme and with the content differentiated between the roles of designers, managers and construction and building services occupations. Despite their brevity, these guidelines are capable of forming the basis of VET curricula for a range of occupations and can be manipulated according to different categories of worker; for example, the agency of

workers can be increased by moving some at supervisory level to construction occupations (Clarke et al., 2019a, p. 14).

Slovakia, also participating in BUS, adopted a different approach, specifically targeting supervisory and managerial levels and developing fully fledged stand-alone modules for these categories of workers at EQF level 4 and above. Specific NZEB expertise is thereby located in the construction workforce, not at operative level but at various different levels, including site managers, supervisors and technical supervisors.

The approach taken by Ireland, while bearing some similarity to the UK and Slovakian ‘low road’ examples, is also of potential value in being much more detailed in outline and developing a nationally recognised and comprehensive introductory qualification that addresses key dimensions of NZEB expertise (Clarke et al. 2019b). The Quali-Build FES (Section 7.4.1) has a modular structure that can be added to as required and can serve as a component of VET courses. Further courses considering NZEB can be add-ons to the FES course for site managers and professionals as Qualibuild (2017) provides indicative content for modules and it is for providers to develop fully fledged curricula and awards.

7.6. Conclusion

The move to NZEB poses a conundrum for apprenticeships, and VET systems overall. School- and apprenticeship-based construction VET systems, as well as hybrid combinations of both, depend on good coordination between VET provider and workplace for their effectiveness, so that theoretical background and simulatory practice in a non-work context are reinforced and integrated into operational constraints in the workplace (Grytnes et al., 2018). Apprenticeship, with its firm roots in the workplace through the employee status of the apprentice, may be best placed to do this, suggesting that knowledge and practices for VET for NZEB need to be established within the workplace. However, currently, as our VET4LEC research shows, to a large extent they are not.

Unless there is a major effort to develop the

knowledge and ability of the current workforce in order for it to be equipped for NZEB now, the future construction workforce will not receive effective preparation in the workplace. Major VET, including apprenticeship, initiatives and regulation, are required for both the existing and the future workforce to meet the NZEB challenge: in order to be effective, curricula need to follow a higher road. They must be transformed to incorporate new knowledge and ways of working rather than being confined to ‘low road’ ‘skills upgrades’ in microcredential packages. Ireland is a country that has recognised and begun to respond to this challenge; ‘high road’ countries, such as Germany, which already have broad-based apprenticeship programmes, a highly qualified workforce, strong social partnership and a regulated labour market, are well placed to meet it. The application of NZEB knowledge and competences into practice in the workplace presents perhaps the greatest challenge to the European construction sector.

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Apprenticeships for greener economies and societies

As the green transition creates new skill needs across sectors and occupations, implications for preparing, reskilling and upskilling the workforce emerge for vocational education and training. Apprenticeships can help by providing opportunities to young people, as well as adults, to develop appropriate skills; at the same time, apprenticeships will also need to undergo changes in response to the green transition. Cedefop and the OECD decided to explore this two-way relationship.

This publication draws from practices and research and provides insights into how apprenticeships can promote and react to a green economy and society, from small-scale modular curriculum adaptation, to more encompassing sectoral or regional approaches. In this way, apprenticeships demonstrate transformative potential for economies and societies, responding to the opportunities and challenges that may support a green recovery that leaves no one behind.



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