JOBS FOR THE GREEN TRANSITION

Definitions, classifications and emerging trends

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SUMMARY

In recent years, the concept of green jobs has been the focus of increasing attention from both policy and research circles. At the EU policy level, the green transition is seen as an opportunity to create jobs in existing and emerging economic sectors. The need for re- and upskilling workers to ensure a socially just green and digital transition is also increasingly being highlighted in the policy debate.

Despite this renewed surge in interest, partly propelled by the necessity to mitigate the impacts of the climate crisis as well as external shocks such as the Covid-19 pandemic and the Russian invasion of Ukraine, the notion of green jobs is not a recent one. A large number of different approaches to how green jobs can be defined and classified have been put forward in the past few decades. While these definitions and taxonomies display certain overlaps, often in terms of a focus on jobs in the Environmental Goods and Services Sector, key analytical differences compromise the comparability of assessments.

These differences along with gaps identified in existing definitions and frameworks have exposed the need to create a novel taxonomy for green jobs. Combining various elements of these approaches in a quantifiable, and thus practically applicable, manner, this report develops an integrated taxonomy based on four pillars: inputs, outputs, processes, and job quality. The use of different indicators to operationalise these pillars aims to enable more accurate assessments and comparison of case studies, to support policymaking in this area.

A number of different strategies and policies that incorporate green jobs elements have been launched, at the EU level as well as by Member States and internationally, in the past couple of years. In line with other recent policy developments, most of these initiatives focus on developing skills for the green transition. In addition, many strategies incorporate a social dimension to green jobs, aiming to ensure that vulnerable groups are protected in the green transition. Tackling the creation and retention of green jobs while phasing out brown jobs may profit from a more integrated approach that goes beyond skills, while also taking into account the greenness of work processes, outputs and supply chain inputs, as put forward by this report.

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1. INTRODUCTION

The structural changes emanating from the green transition are expected to have an important effect on labour markets, creating opportunities but also challenges for adapting skills in different sectors (OECD, 2017; Bowen et al., 2018). At the EU policy level, the green transition is considered to be an engine not only for environmental sustainability, but also for job creation in new and existing economic sectors (European Commission, 2019). The recent Covid-19 crisis and the war in Ukraine have highlighted the vulnerabilities of global supply chains, and the risks associated with the EU's dependencies on critical raw materials. These events and the ensuing policy focus on accelerating deployment of green technologies and increasing domestic sourcing of raw materials emphasised the need to ensure that there is a workforce in Europe with the combination of skills at all levels required for the transition (European Commission, 2023a).

Even though the need to develop green jobs and the skills required for the green transition has been the focus of increasing attention from both policy and research circles, the topic is not new and has been the subject of extensive qualitative and quantitative research over the years[1] (Stanef-Puică et al., 2022; Bowen et al., 2018). Among the topics studied are the job creation potential of the transition (see Cambridge Econometrics et al., 2018; Unay-Gailhard & Bojnec, 2019; Wijkman & Skånberg, 2015), the differences between green and non-green jobs in terms of skill characteristics (see Bowen et al., 2018; Consoli et al., 2016), the required set of skills in the new economies emerging from the transition (see Burger et al., 2019) and the degree to which employment is sustainable (see Bohnenberger, 2022a). While the literature on green jobs has undergone growth and evolution over the years, there is a large heterogeneity in the research approaches adopted and the empirical results (Consoli et al., 2016; Stanef-Puică et al., 2022; Rizos et al., 2017).

An important reason for this heterogeneity relates to the varied interpretations of what constitutes green employment and where the boundaries can be drawn in terms of sectors, tasks and processes that can fit into the scope of green employment (Stanef-Puică et al., 2022; Janta et al., 2023). The principles of green jobs and green employment are grounded in a variety of evolving concepts such as green economy, green growth, sustainable development and circular economy which are multi-dimensional and their understanding evolves in both academic and political contexts (Merino-Saum et al., 2020; Stanef-Puică et al., 2022; Alcalde-Calonge et al., 2022). As such, the profile of green employment has been progressing from activities and tasks related to environmental protection to the broader aspect of job activities that can support the green transition. The social aspects of jobs and the quality of work-lifestyles are also increasingly becoming part of the debate around green jobs. Emerging from these developments is a complex landscape of different green job definitions and classification frameworks which can make it difficult to compare trends across the EU (Janta et al., 2023).

This report synthesises emerging trends in the literature with regard to green jobs and classification frameworks. Based on an analysis of some of the most commonly used

[1] Bowen et al. (2018) argue that research has so far focused more on green job aspects rather than on skills.

frameworks, it proposes a new integrated taxonomy for green jobs and provides examples of indicators that can be used for different aspects of the taxonomy. It also explores trends and approaches with regard to green jobs in a number of countries that have adopted relevant strategies. The report has been produced in the context of the TransEuroWorkS EU-funded project[2] that provides an analysis of the structural labour market transformations across the EU and social implications.

Section 2 provides an overview of green jobs definitions and classifications as they appear in the academic literature and reports by international organisations. Section 3 then presents a new integrated taxonomy for green jobs inspired by existing classification frameworks and policy developments. It also provides examples of the quantitative application of the taxonomy. A presentation of country examples with strategies including green job elements then follows in Section 4. Section 5 concludes by presenting several key messages.

2. GREEN JOBS: DEFINITIONS AND CLASSIFICATIONS

Despite its increased importance in the context of recent policy developments, the concept of green jobs is not a new one. Over the years, the debates about the green economy and green transition have been ultimately intertwined with the questions about how to make jobs 'greener' and manage the associated employment impacts (Bowen et al., 2018). To conceptualise what a 'greening' of jobs could entail, different definitions and classification frameworks of green jobs and related concepts have been suggested in the literature. Some of the most widely used approaches are explored in this section.

2.1. DEFINITIONS AND THEORETICAL CONCEPTS

While the concept of green jobs is increasingly used in both policy and academic contexts, no uniform definition of what constitutes a 'green job' has been established in the growing literature (Stanef-Puică et al., 2022; Deschenes, 2013; Elliott & Lindle, 2014). Its associated meanings vary in academic, political, and national statistical institutions and evolve over time, resulting in a plurality of definitions (Bohnenberger, 2022a; Janta et al., 2023; Stanef-Puică et al., 2022). While many studies classify green jobs broadly as jobs in 'green' sectors, or jobs producing 'green' products, this understanding is often contested. The resulting absence of a clear, common definition creates several issues (Janta et al., 2023). For example, it is difficult to gather and compare data on the number, trends, or needs of green jobs, and to assess the potential impacts of green transitions on occupations.

Many studies follow the approach of the Green Jobs Initiative, established in 2008 by the United Nations Environment Programme (UNEP) and other organisations[3] (Stanef-Puică et al., 2022).

[2] For more info about the project see: https://transeuroworks.eu/.

[3] Launched by UNEP in 2008, the Green Jobs Initiative has been described as the first encompassing research programme on green jobs (Bohnenberger, 2022). The initiative aimed to assess potential synergies between greening the economy and promoting decent jobs. In addition to UNEP, this partnership of organisations involved the International Trade Union Confederation (ITUC), the International Organization of Employers (IOE) and the International Labour Organization (ILO).

In an early report published in the context of this initiative, UNEP defines green jobs as 'those that contribute appreciably to maintaining or restoring environmental quality and avoiding future damage to the Earth's ecosystems' (UNEP et al., 2008, p. 35). For example, green jobs reduce the consumption of materials and energy, support decarbonisation processes, reduce waste and pollution, or restore biodiversity. In addition, the initiative highlights that green jobs need to create just and decent employment, alongside reduced environmental impacts (UNEP et al., 2008). This emphasis on fair working conditions, i.e. adequate wages, safe working conditions, social protection and worker rights, among others, is a key feature of the initiative's conceptualisation of green jobs, distinguishing it from other definitions.

The existing literature on green jobs can be grouped into several definitional (at times overlapping) approaches: output, process and systemic approaches.

2.1.1. Output approach

According to the output approach, jobs can be defined as green when they produce goods or services which are beneficial to the environment or conserve natural resources (Vona et al., 2015; BLS, 2013). This is the most common approach in the existing literature (Janser, 2018; Bohnenberger, 2022b). Most statistical publications rely on this definition, identifying and measuring green jobs via goods and services produced[4], or by aggregating these on a sectoral level, the Environmental Goods and Services Sector (EGSS). Eurostat defines the EGSS as consisting of producers of technologies, goods and services that '[m]easure, control, restore, prevent, treat, minimise, research and sensitise environmental damages to air, water and soil as well as problems related to waste, noise, biodiversity and landscapes' and '[m]easure, control, restore, prevent, minimise, research and sensitise resource depletion' (Eurostat, 2009, p. 29). This definition's focus is on 'cleaner' and resource-efficient technologies, goods and services minimising pollution and resource use.

UNEP and the International Labour Organization (ILO) define 'green-collar' workers based on their employment in the EGSS (UNEP et al., 2008). Employees in the environmental sector are defined as 'persons who, during a set reference period, were employed […] in the production of environmental goods and services' (ILO, 2013a, p. 18). Therefore, green jobs are categorised as jobs in several sectors (agriculture, manufacturing, construction, installation, maintenance, and scientific and technical, administrative, and service-related activities) that '[…] contribute substantially to preserving or restoring environmental quality' (UNEP, 2008, p. 36). This includes but is not limited to improving energy and material efficiency, limiting greenhouse gas emissions, minimising waste generation and pollution, restoring ecosystems or adapting to climate change (ILO, 2016).

Many research papers apply output-oriented definitions as well (Janser, 2018). However, such a sectoral approach risks omitting potentially 'green' jobs in other sectors that do not typically

[4] As emphasised by ILO (2013a), when attempting to assess the green employment figures of a company, it is important to distinguish the core operations of the company that produce environmental goods and services, and other operations that may not be linked to these outputs, or whose output is not 100 % environmentally sustainable. If a company has combined activities, then the jobs that are clearly linked to environmental outputs should be identified, though it is recognised that such a distinction can be challenging in practice.

fall within the EGSS, such as education, healthcare and retail (Bohnenberger, 2022b). Moreover, focusing solely on outcomes has limitations as it does not take into account whether the process by which the output is produced is environmentally friendly or not. For example, a solar panel or an electric vehicle can be produced through advanced and environmentally friendly technologies or through technologies with a high environmental footprint. To overcome this issue, organisations like the US Bureau of Labor Statistics (BLS) and the ILO have included process considerations in their definition.

2.1.2. Process approach

The process approach considers jobs as green when work-related activities contribute to rendering the organisation's production processes more environmentally sustainable or use fewer resources (BLS, 2013). Thus, process-based definitions emphasise environmental protection integrated within a firm's practices. This implies that green jobs can also be found in traditional sectors that are not producing environmental outputs or are considered to be polluting (e.g., energy-intensive industries), as long as they adopt new organisational practices or cleaner production technologies to improve their energy and resource efficiency (Janser, 2018; ILO, 2013a). For example, the ILO definition of employees in the environmental sector includes, next to the EGSS, 'workers whose duties involve making their establishment's production processes more environmentally friendly or more efficient in their use of natural resources' (ILO, 2013a, p. 18).

By differentiating between an output and a process dimension, the ILO taxonomy of green jobs is similar to the approach of the US Bureau of Labor Statistics. The BLS (2013) defines green jobs as '[j]obs in businesses that produce goods or provide services that benefit the environment or conserve natural resources' (i.e., output approach), or as '[j]obs in which workers' duties involve making their establishment's production processes more environmentally friendly or use fewer natural resources' (i.e., process approach). A key distinction between the BLS and the ILO definition is the decent jobs dimension, which is absent from the BLS approach. According to the ILO (2013a;2013b;2016), the jobs falling in either the environmental outputs or the environmental processes category need to integrate social elements to be considered as green. More specifically, they need to meet 'the requirements of decent work – adequate wages, safe conditions, workers' rights, social dialogue and social protection' (ILO, 2013b, p.4).

Tasks- and skills-based approaches

A segment of the process-oriented literature has investigated green jobs in terms of the tasks and skills[5] they encompass, in order to shed light on the specific transitions at the worker level (Vona et al., 2015; Bowen et al., 2018). Such a granular approach also allows for assessing the 'greenness' of jobs on a continuous scale rather than within a simple binary of 'green' versus 'non-green'.

[5] As argued later, however, skills can be seen as owned by workers and entering the production process as an *input*, rather than simply being part of the process – unlike tasks, which are integral sub-units of production processes aimed to generate output.

In a report by the Joint Research Centre (JRC), Rodrigues et al. (2021) define tasks as the smallest unit of work activity producing economic output, whereas skills refer to an individual's ability to perform a task well. Skills and tasks are subject to change and may be reallocated over time (Janser, 2018). Vona et al. (2015) therefore argue that the main advantage of a task-based model is its ability to account for changes in workforce skills induced by new technology, such as the emergence of new tasks and changed task requirements.

Many studies investigating green tasks or skills use the US Department of Labor's database O*NET (Occupational Information Network). O*NET contains information on tasks and skills involved in occupations, including a list of green tasks unique to green occupations. Occupations are defined as groupings of work roles or jobs that are found at more than one organisation, but share common sets of requirements, such as tasks, duties and skills (Dierdorff et al., 2009). Taking into account the different degrees to which green economy activities impact occupations, Dierdorff et al. (2009) define the 'greening of occupations' as 'the extent to which green economy activities and technologies increase the demand for existing occupations, shape the work and worker requirements needed for occupational performance, or generate unique work and worker requirements' (Dierdorff et al., 2009, p. 11). From this definition, several categories of green economy impacts on occupational performance are derived, which are further elaborated in the next section of this report.

Several authors use O*NET to create measures of 'greenness'. Vona et al. (2015) develop four categories of green skills: engineering and technical, science, operation management, and monitoring. Bowen et al. (2018) find that while transitioning to indirectly green jobs[6] is easier than to directly green jobs, these jobs differ only in a few skill-specific aspects. Strategic management of job transitions could support retraining on the job and, thus, transition to directly green jobs (Bowen et al., 2018). The O*NET approach is largely being used by the European Centre for the Development of Vocational Training (Cedefop) (Janser, 2018).

2.1.3. Systemic approaches

In assessing the potential greenness of jobs, the definitions above place a strong emphasis on technological solutions, circular economy and bioeconomy approaches, although in some cases a social dimension is also taken into account. Criticising the implicit reliance on consumerism and economic growth, an emerging strand within the literature conceptualises green work beyond current economic paradigms (see Bohnenberger, 2022a).

For example, labour environmentalism critically examines the relationship between profit-oriented systems of production and environmental impacts. Labour environmentalists argue that capitalist production leads to the exploitation and destruction of nature, and frame workers as active agents of change with the potential to induce a just transition to a sustainable economy (Stevis et al., 2018). The role of workers' representative organisations, such as trade unions, and on intersections of environmental protection with social justice and equity is particularly emphasised.

[6] Indirectly green jobs refer to jobs that support green economic activity but do not entail any green tasks themselves. In contrast, directly green jobs must entail green tasks (Vona et al., 2015).

Whereas labour environmentalism still focuses only on formal, paid employment, post-work literature highlights the need to overcome the focus on employment, while examining the social necessity of jobs (see Bohnenberger, 2022a). Post-work does not approach interactions between labour and the environment through the lens of 'green jobs'. Instead, it investigates work as a cause of ecological harm and societal unsustainability (Hoffmann & Paulsen, 2020). Post-work calls into question the social usefulness or potential redundancy of certain kinds of (paid) work, particularly when actively harming the environment (Hoffman & Paulsen, 2020). At the same time, this strand of the literature emphasises that there are many unpaid activities that are not considered as 'work' despite being socially relevant – many of them performed by women, such as unpaid caring activities (Himmelweit, 1995).

Drawing on these approaches, Gerold et al. (2022, p.4) argue that 'paid work is not necessarily productive: in a considerable number of cases, it is unproductive and of no value to society. Moreover, due to its biophysical basis, it involves and legitimises destructive behaviour.' In addition, the authors highlight linkages between paid work, long working hours and mass consumption – which is related to resource use and environmental impacts (Gerold et al., 2022). Bohnenberger (2022a;2022b) builds on this literature, but still uses the concept of 'green jobs'. While not providing an explicit definition of green jobs herself, Bohnenberger combines these different considerations into a more systemic approach. The author considers jobs as green when they produce outputs that serve human needs without transgressing environmental limits, while being based on green workplace activities, allowing for sustainable lifestyles beyond work and exhibiting less environmental pressures than a job with a comparable output[7].

2.1.4. Definitions and interpretations at the EU level

While there is no legal definition of green jobs at the EU level, there have been different definitions and interpretations of green jobs in reports by EU agencies with a focus on green skills (e.g., European Commission, 2023b). For example, according to Cedefop (2022a, p. 1), green skills are defined as 'the knowledge, abilities, values and attitudes needed to live, work and act in economies and societies seeking to reduce the impact of human activity on the environment'. A very similar attempt to provide a common definition of green skills was put forward in 2022, by the Inter-Agency Working Group on Work Based Learning[8]. The group defines skills for the green transition as 'skills and competences but also knowledge, abilities, values and attitudes needed to live, work and act in resource-efficient and sustainable economies and societies' (Cedefop, 2022b, p. 5). Such skills include occupation-specific or cross-sectoral technical skills 'required to adapt or implement standards, processes, services and technologies to protect ecosystems and biodiversity, and to reduce resource energy, materials and water consumption', and transversal skills 'linked to sustainable thinking and acting, relevant to work (in all economic sectors and occupations) and life' (Cedefop, 2022b, p.

[7] Bohnenberger's approach is elaborated in more detail in the next section.

[8] The group has existed since 2015 and consists of the European Commission, the European Training Foundation (ETF), Cedefop, OECD, ILO and UNESCO. Its objective is to share knowledge about work-based learning, identify knowledge gaps and develop joint actions (Cedefop, 2022b).

5). The European Commission, too, has adopted this definition. Using the Classification of Occupation, Skills and Competences (ESCO) database, the Commission further differentiates brown, white and green skills (European Commission, 2022). Specifically, brown skills, such as electricity production by coal, increase negative environmental impacts of human activity, white skills neither increase nor reduce this impact, and green skills reduce negative impacts, such as power generation from geothermal energy (European Commission, 2022).

2.2. CLASSIFICATION FRAMEWORKS AND TAXONOMIES

Based on the definitions described above, there have been several attempts to formalise requirements for what constitutes a green job. A number of classification frameworks and taxonomies of green jobs have been put forward by different organisations. This section presents in more detail five different classification frameworks emerging from the literature. For each framework, we present the main principles, key taxonomy pillars and form of operationalisation.

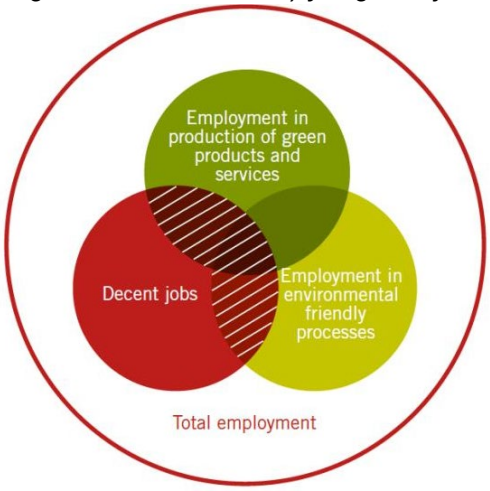
2.2.1. ILO taxonomy for green jobs

While the Green Job Initiative's definition of green jobs is widely used in the literature, the definition itself offers no quantification or clear delineation of how to account for green jobs in practice. Therefore, based on the definition by UNEP et al. (2008), the ILO developed a framework to support countries in creating statistical standards and methods for measuring green employment (see ILO, 2013a). The statistical guidelines define employees in the environmental sector both through an output and a process perspective, as discussed in the previous section.

Taxonomy pillars

Using this (employment) concretisation of the original definition by UNEP et al. (2008) as a starting point, the ILO developed three pillars to evaluate whether jobs can be classified as green: employment in the production of green products and services, employment in environmentally friendly processes, and decent jobs (ILO, 2013a, see Figure 1).

Figure 1. ILO taxonomy for green jobs



Source: ILO, 2016.

The first dimension, e*mployment in production of environmental goods and services* is a sectoral approach, focusing on outputs of green jobs. This category assesses whether a job produces goods or provides services that benefit the environment, in line with the definition by UNEP et al. (2008). Examples of such environmental outputs include green buildings or clean transportation (ILO, 2016). However, green outputs are not necessarily produced in an environmentally friendly manner, which is incorporated into the second dimension of the framework.

Employment in environmental-friendly processes acknowledges that production processes themselves can contribute to an alleviation of the environmental impacts of employment. This pillar thus includes jobs in traditionally polluting industries, such as mining, that employ environmentally friendly technologies in their production processes (ILO, 2013a). By minimising waste generation or water consumption, for example, employment in green processes can contribute to minimising environmental impacts (ILO, 2016).

The classification of a job as 'green' requires that either of the above pillars intersect with the third pillar, *decent work*. This concept was first introduced by the ILO in 1999[9] and stressed as a dimension in the original Green Jobs Initiative report by UNEP et al. (2008). Decent work refers to work '[…] in conditions of freedom, equity, security and human dignity' (ILO, 1999). It covers different labour concerns, such as wages, career prospects, job security, worker rights, and occupational health and safety (UNEP et al., 2008).

For a job to be categorised as green within this taxonomy, it has to benefit the environment (i.e., reduce resource consumption, minimise emissions, waste and pollution or restore and protect ecosystems) while meeting the criteria for decent jobs. Therefore, green jobs lie at the intersection of either employment in environmental outputs *or* employment in environmental processes *and* decent work (the dashed area in Figure 1). For example, a job in waste management would be considered 'green' when social protection measures are accessible, and health and safety at work are ensured (van der Ree, 2019).

Operationalisation

The statistical guidelines suggest a range of quantitative operationalisation options for the different dimensions of green jobs.

For the *output dimension*, the environmental sector is defined as comprising '[…] those establishments where all or at least some of the goods or services produced belong to the environmental goods and services domain and are designated for consumption outside the establishment.' (ILO, 2013a, p. 21) However, since in most occupations, the production of environmental outputs is not the only activity of an establishment, employment cannot be measured directly. Therefore, the ILO suggests approximating this type of employment by using data on the value of environmental goods and services produced as a share of the company's total value of production (ILO, 2013a).

[9] ILO, 1999, *Report of the Director-General: Decent Work*, International Labour Conference, 87th Session, Geneva, June 1999. Available at: https://www.ilo.org/public/english/standards/relm/ilc/ilc87/rep-i.htm

The *process pillar* relies on data on '[…] job-related characteristics such as occupation, the specific tasks and duties undertaken in the jobs and the kind of processes or technologies used.' (ILO, 2013a, p. 22) However, most workers' activities comprise both environmental and non-environmental tasks, and many of them are involved in the production of environmental goods and services to be consumed both within (i.e., for processes) and outside the firm (corresponding to the output dimension). As a result, the ILO proposes to split the hours spent on each component, distinguishing between workers spending more and those spending less than half of their working time on environmental processes. Still, the authors argue that employment in environmental processes is more challenging to measure, as it also involves data that are often not collected in economic censuses and surveys (ILO, 2013a).

The statistical measurement of both dimensions requires the use of different methods. Therefore, the authors emphasise that separate statistics are needed for each dimension, which cannot be aggregated as this would lead to double counting of workers who produce environmental outputs (consumption from outside the company) and who are also involved in environmental processes (for consumption within the company).

Suggested data sources for the assessment of these dimensions include surveys and censuses. The authors also propose the use of inventories of establishments that produce environmental goods and services to account for the sectoral approach (ILO, 2013a). Moreover, when data are incomplete, statistical modelling, such as input-output models or social accounting matrices may be necessary (ILO, 2013a). Additionally, the ILO (Gregg et al., 2015) suggests using the International Standard Classification of Occupations (ISCO) to quantify green jobs. It provides information about occupations on different levels of aggregation, from the broad one-digit level to the highly specific four-digit level. According to the ILO (Gregg et al., 2015), valid assumptions about the sustainability of an occupation can be made from the third-digit level on.

For the *dimension of decent work*, the taxonomy developed in the 2013 statistical guidelines does not offer a concrete measurement approach. However, the authors suggest the use of decent work indicators as developed by the ILO in a manual on decent work indicators (ILO, 2013c). These statistical and legal framework indicators were created to support countries in monitoring decent work and in identifying decent work deficits in a given economy (ILO, 2013c).

2.2.2. Bohnenberger taxonomy of sustainable employment

In an effort to develop a more integrative framework for determining whether employment is green, brown, or mixed, Bohnenberger (2022a) combines different theoretical conceptualisations and definitions of green jobs. The author develops a classification framework that builds on output, process, task-based and systemic approaches that exist in the literature[10]. As discussed in the previous Section, Bohnenberger's taxonomy is developed from theories of needs and need satisfiers (Brand-Correa et al., 2020) to assess whether an occupation is sustainable.

[10] See, for example, UNEP et al. (2008), Vona et al. (2015) and Hoffmann and Paulsen (2020).

By integrating different conceptualisations, Bohnenberger clusters sustainable employment on two scales, the organisational level of analysis (differentiating between the macro and micro level) and the immediacy of environmental effects (differentiating between direct and indirect effects, see Figure 2). The macro level encompasses employment effects that are applicable to plants, businesses and sectors, whereas the micro level assesses the (un-)sustainability of tasks and activities of individual workers. Direct effects are defined as environmental effects resulting from the workplace itself; indirect effects stem from the interplay of workplaces and overall socio-economic structures.

Taxonomy pillars

Based on these two scales, Bohnenberger identifies four dimensions of sustainable employment: output type, occupation, work-lifestyles and outcome efficiency.

Figure 2. Bohnenberger taxonomy of sustainable employment

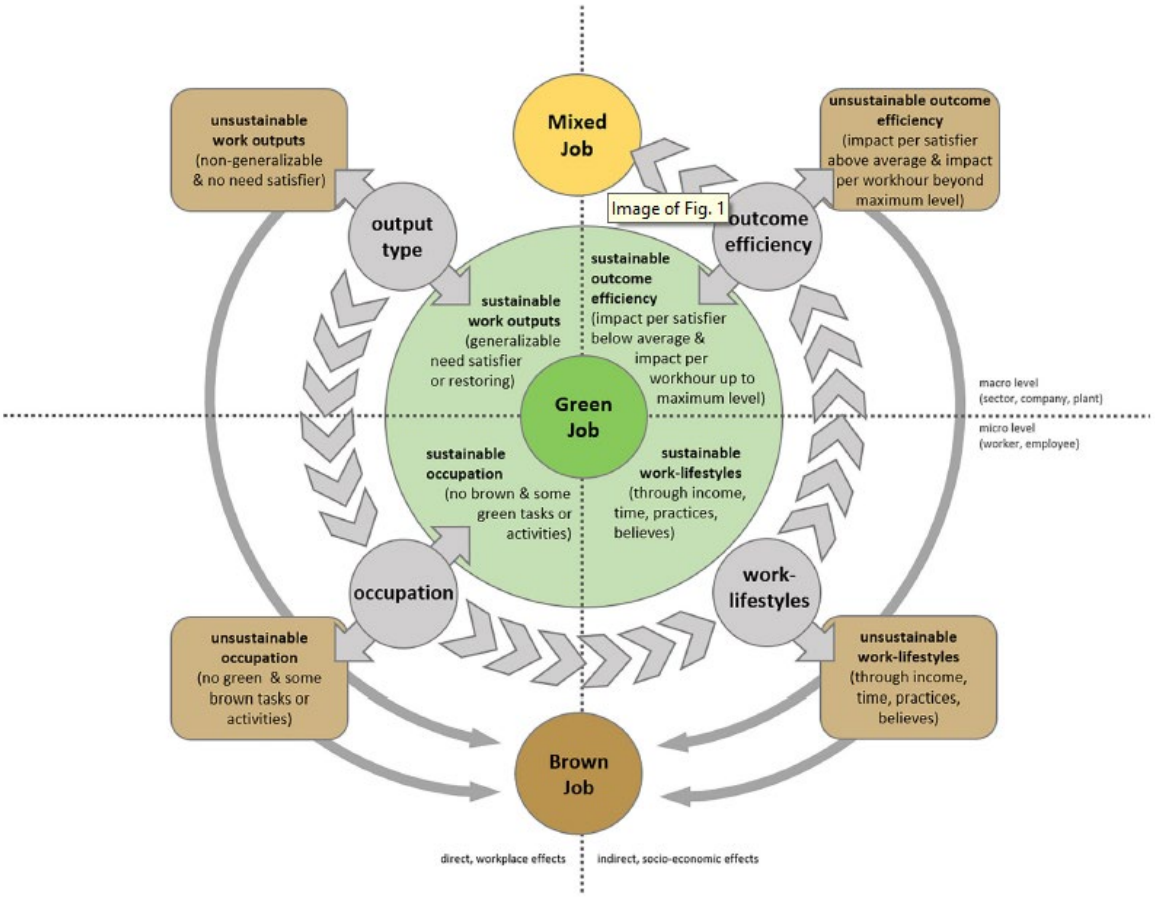


Fig. 1. Taxonomy of Sustainable Employment with decision system to classify jobs as brown, mixed, green.

Source: Bohnenberger, 2022a.

Output type refers to the direct (workplace) effects of a company or sector (macro level). This pillar evaluates whether work outputs serve human needs, comforts or wants, and whether they do so within planetary boundaries when generalised (i.e., used to satisfy everyone's needs). Bohnenberger argues that need satisfiers have become more unsustainable (i.e.,

resource-intensive and environmentally harmful) in recent decades. At the same time, some goods and services actively contribute to restoring the environment, serving as enablers to ensure that human needs are met within planetary boundaries. Therefore, work outputs are defined as sustainable when they benefit the environment or constitute 'ecologically generalisable need satisfiers', such as the conversion of former industrial sites to municipal parks, composting food waste or organic horticulture.

Occupation classifies direct (workplace) effects of workers' tasks and activities (micro level). This dimension evaluates the share of green and brown tasks and activities involved in an occupation. In this context, tasks and activities are categorised as green when they improve, restore or protect the environment, while brown tasks and activities impede environmental protection and encourage unsustainable solutions. Analysed activities not only include the tasks directly required for participation in the occupation, but also indirect activities beyond work hours, such as means of commuting to work or other work-preparing activities. Moreover, the occupation pillar accounts for environmental effects that emerge through side activities at work, such as their recycling practices, transport modes like business flights, or the choice of nutrition in the canteen. Based on this differentiation, occupations are sustainable when they involve no brown and at least some green tasks and activities. Unsustainable occupations, in contrast, encompass no green and some brown tasks and activities.

Work-lifestyles assesses the indirect (socio-economic) effects of working conditions on workers' individual sustainable work-lifestyles (micro level). Bohnenberger argues that working conditions significantly impact lifestyles, particularly when employment is the only source of income to enable or prevent a sustainable way of life. The author differentiates four levers through which an occupation can impede a sustainable lifestyle: income (which can be too low or too high for responsible consumption), working time, everyday work practices (which can translate into unsustainable private life behaviour), and political and moral identity. Work-lifestyles are defined as sustainable when the occupation does not prevent a worker's sustainable way of life, through the levers mentioned above, and vice versa.

Finally, *outcome efficiency* evaluates the indirect (socio-economic) effects of a company or sector in meeting societal goals (macro level). This category incorporates a process perspective. The environmental impacts of production processes are assessed through the societal functions of production processes, i.e., satisfying social needs and providing employment. An occupation has a sustainable outcome efficiency when the environmental harm caused per production of satisfier (i.e., goods and services produced to satisfy needs) is lower than for a similar satisfier. In addition, the environmental harm per employment volume (i.e., work hour) provided in the process must be below a justifiable impact-hour-ratio. As an example, a shift from sectors with high resource consumption per work hour (such as manufacturing) to ones with lower environmental impacts (such as services) could contribute to greening the economy (Bohnenberger, 2022a).

Based on these four dimensions, Bohnenberger develops a taxonomy of sustainable employment (see Figure 2). The taxonomy serves as a decision system, differentiating green, brown and mixed jobs. Within the taxonomy, a job is classified as green only when it fulfils all of these four dimensions. If a job is assessed to be unsustainable in any of the four dimensions,

the job is classified as brown. If the dimensions are neither sustainable nor unsustainable, a job is classified as 'mixed'.

Operationalisation

Contrary to other taxonomies, Bohnenberger does not provide a quantitative operationalisation of the four dimensions. The author highlights that '[f]urther research is required on how to translate the taxonomy into regionally specific indicators that take into account the local temporal and physical infrastructures, the remaining time scales to combat environmental crises, and the multidimensional nature of environmental problems.' (Bohnenberger, 2022a, p. 7) Bohnenberger emphasises that supply chain data should be included in quantifying environmental impacts, to derive accurate footprints of occupations. However, quantification of micro-level impacts might be challenging, as data on workplace activities and time-use effects are scarce (Bohnenberger, 2022a). Thus, while providing a critique and expansion of existing approaches, the operationalisation of Bohnenberger's taxonomy remains an open question.

*2.2.3. O*NET taxonomy for green occupations*

The O*NET classification[11] (see Section 2.1.2) was expanded in 2009 to include green tasks unique to green occupations. To account for impacts of green economy activities on occupational requirements and O*NET occupations, the National Center for O*NET Development developed a framework for green occupations (Dierdorff et al., 2009), referred to in this report as the O*NET taxonomy for green occupations. This taxonomy assigns different types of green occupations to analytical codes that are easily comparable through survey data. It includes job-related requirements such as tasks, skills and objectives (Dierdorff et al., 2009). As such, it extends previous approaches rather focused on broader industry-level output and products and applies a process approach to green jobs. Various authors have used this taxonomy for quantitative assessments (see, for instance, Consoli et al.,2016; Popp et al., 2020; and Rutzer et al., 2020; OECD, 2023).

Taxonomy pillars

Dierdorff et al. (2009) explicitly state the importance of assessing the impact of greening the labour market and the economy. As such, in their taxonomy, they try to capture the dynamic processes in the labour market, including a shift to different technologies, new work requirements and occupational performance. Three categories of how occupations are affected by such processes are pointed out: green increased demand occupations, green enhanced skills occupations, and new and emerging green occupations.

Green Increased Demand Occupations classify occupations for which the greening of the economy leads to a significantly higher employment demand without forcing changes in the

[11] The O*NET classification is a project developed under the sponsorship of the US Department of Labor/Employment and Training Administration. It is used as a primary source of occupational information in the US, classifying occupations to 8-digit O*NET-SOC codes. For more information see https://www.onetcenter.org/overview.html.

skill pattern of the occupation type. Green increased demand occupations are existing occupations that do not require any significant changes in tasks and work requirements. These jobs do not involve green tasks, but indirectly support green economic activity. Examples of such jobs include occupations related to energy-efficiency facility and infrastructure upgrades (e.g., electrical power line installers and repairers), green construction (e.g., carpenters and electricians) or research and development (e.g., geoscientists and engineering managers), among many others.

Green Enhanced Skills Occupations experience a shift in specific job-related requirements of already existing occupations due to the greening of economic processes. This significant impact occurs irrespective of whether there is an increase in employment demand for the occupation. For example, architects are now required to significantly increase their knowledge in energy efficient construction and material usage.

New and Emerging (N&E) Green Occupations are new occupations created through the process of greening the economy. Thus, the greening of economic activities can lead to the generation of entirely new working requirements. Dierdorff et al. (2009) highlight the example of solar system technicians who are required to assess the most efficient usage of a technology at a specific site besides accomplishing its installation.

*Figure 3. The O*NET Green Occupations database*

	A	B	C
1	**O*NET-SOC Code**	**Title**	**Green Occupational Category**
2	11-1011.03	Chief Sustainability Officers	Green New & Emerging
3	11-1021.00	General and Operations Managers	Green Enhanced Skills
4	11-2011.01	Green Marketers	Green New & Emerging
5	11-2021.00	Marketing Managers	Green Enhanced Skills
6	11-3051.00	Industrial Production Managers	Green Increased Demand
7	11-3051.02	Geothermal Production Managers	Green New & Emerging
8	11-3051.03	Biofuels Production Managers	Green New & Emerging
9	11-3051.04	Biomass Power Plant Managers	Green New & Emerging
10	11-3051.05	Methane/Landfill Gas Collection System Operators	Green New & Emerging
11	11-3051.06	Hydroelectric Production Managers	Green New & Emerging
12	11-3071.01	Transportation Managers	Green Enhanced Skills
13	11-3071.02	Storage and Distribution Managers	Green Enhanced Skills
14	11-3071.03	Logistics Managers	Green New & Emerging
15	11-9013.02	Farm and Ranch Managers	Green Enhanced Skills
16	11-9021.00	Construction Managers	Green Enhanced Skills
17	11-9041.00	Architectural and Engineering Managers	Green Enhanced Skills
18	11-9041.01	Biofuels/Biodiesel Technology and Product Development Managers	Green New & Emerging
19	11-9121.00	Natural Sciences Managers	Green Increased Demand

Source: O*NET (2023). Note: Example occupations based on the O*NET taxonomy for green occupations. The analytical codes for the occupation is found in the left column, the occupation name in the middle and the occupational category in the right column.

Operationalisation

Rather than suggesting how to operationalise the O*NET Green Economy taxonomy, Dierdorff et al. (2009), collect different types of green occupations within a database. To identify green occupations and include them in the database, the authors followed a systematic process. Following a literature review, they compiled a list of job titles. The job titles were then reviewed and sorted into five broad groups. Within these groups, the authors then clustered similar job titles and identified relevant occupational titles. These titles are then assigned to a scheme of 12 sectors[12] that feature green jobs. As a next step, they determine the overlaps with previously existing O*NET occupations and identify potential N&E green occupations. Finally, to include the N&E green occupations into the O*NET green occupations database, its potential and relevance is assessed using further evidence. Overall, the O*NET Green Economy taxonomy labels 204 occupations as green, of which 62 fall within the category of green enhanced skills occupations, 64 within green increased demand occupations, and 78 within green economy N&E occupations[13]. As depicted using some examples in Figure 3, the occupations are accessible through a database and can be sorted via their analytical codes and the different categories of green occupations.

In addition to other taxonomies, the O*NET Green Economy occupational classification provides an analytical base that has been used in several quantitative studies. To provide a picture of how taxonomies on green jobs and skills could be put into practice, some examples are presented below.

Consoli et al. (2016) use the O*NET classification[14] to investigate how green jobs differ from non-green jobs in terms of human capital levels and task profiles. Combining occupational information from the O*NET database with industry-level data, they additionally provide evidence on the effect of executing a green enhanced skills occupation, a green N&E occupation, or a non-green occupation on a bundle of skill measures. Effectively, they conclude that both the above two categories of green occupations are significantly more linked to higher average human capital indicators like years of formal education, work experience or on-the-job training. Moreover, green occupations require significantly fewer routine tasks compared with non-green occupations. Nevertheless, the empirical analysis by Consoli et al. (2016) is likely to be biased by the potential self-selection of individuals with higher average human capital levels in green occupations. Rutzer et al. (2020) tackle this shortcoming by evaluating the potential of selecting into green occupations with different worker skill sets. They summarise that technical skills are crucial for the selection into green occupations whereas a large fraction of the composition of the US labour market has a low probability of selecting into green occupations.

Another notable example of using this occupational classification has been made by Popp et al. (2020). They estimate the effect of a green fiscal stimulus in the US on the share of employment in green occupations based on the O*NET classification. While the authors find no significant

[12] The sectors are highlighted in Table 1.

[13] See O*NET, Green Jobs (database), www.onetcenter.org.

[14] Notably, in their work they not only use the 204 occupations that are classified as green but also distinguish between green and non-green occupations based on the 905 total occupations in the O*NET-SOC database.

evidence that the green fiscal stimulus boosts overall employment, there is a weak shift towards green occupations. Moreover, areas that were already in favour of having a higher share of green occupations based on their skill composition, benefit above average from the fiscal stimulus.

*2.2.4. Bowen and Hancké taxonomy based on O*NET*

Bowen and Hancké (2019) extend the described O*NET taxonomy for the European Commission and develop a more distinguished and European approach to assess the impact of greening the economy on occupations.

Taxonomy pillars

Bowen and Hancké (2019) extend the taxonomy by Dierdorff et al. (2009) by adding two pillars that contrast green occupations with non-green occupations, namely *Green Rival Jobs* and *Other Non-Green Jobs*. In their approach, they frame the different categories as job categories, since the approach taken by Dierdorff et al. (2009) assessing occupations is considered to be too granular. Apart from the two additional categories, the authors adapt the occupational categories based on the O*NET taxonomy as *Green Increased Demand Jobs, Green Enhanced Skills Jobs*, and *Green New and Emerging Jobs*.

Green Rival Jobs are jobs that require similar tasks and skills as green jobs without carrying out green activities. Therefore, they explicitly compete with green jobs on the labour market and the cost of a transition between a Green Rival Job and a Green Job is significantly low. Typical sectors entailing Green Rival Jobs are 'Agriculture, forestry and fishing', 'Mining and quarrying', 'Wholesale and retail trade and repair of motor vehicles and motorcycles' (Bowen & Hancké, 2019).

In contrast, other Non-Green Jobs require different tasks and skills than most green jobs. Thus, it is unlikely that they are affected by the greening of economic activities. Typically, this includes medical occupations such as pharmacists and doctors (Janta et al., 2023).

The authors complement the occupational categories introduced by Dierdorff et al. (2009) with the additional categories to obtain a holistic perspective on the employment dynamics between green and non-green sectors (Janta et al., 2023). Accordingly, Bowen and Hancké (2019) aim to enhance analyses based on the EGSS sector to a broader range of industries that are affected by a transition towards a green economy.

Table 1. Sectors containing green occupations

O*NET Green Economy	Bowen and Hancké (2019) (NACE rev2 sectors)
1. Renewable Energy Generation	1. Agriculture, forestry, and fishing
2. Energy Efficiency	2. Mining and quarrying
3. Energy Trading	3. Manufacturing
4. Research, Design and Consulting	4. Electricity, gas, steam and air conditioning supply; Water supply; Sewerage, waste management and remediation activities
5. Agriculture and Forestry	5. Construction
6. Recycling and Waste Reduction	6. Wholesale and retail trade; Repair of motor vehicles and motorcycles
7. Transportation	7. Accommodation and food service activities, Transportation and storage; Information and communication
8. Green Construction	8. Financial and insurance activities
9. Energy and Carbon Capture	9. Real estate activities; Professional, scientific, and technical activities; Administrative support service activities
10. Environmental Protection	10. Public administration and defence; Compulsory social security
11. Manufacturing	11. Education
12. Governmental and Regulatory	12. Human health and social work activities
	13. Arts, entertainment and recreation; Other service activities
	14. Activities of households as employers; Goods and service producing activities of households for own use
	15. Activities of extraterritorial organisations and bodies

Operationalisation

To identify green sectors in the EU, green occupations from the O*NET classification were matched with the standard classification ISCO-08 or ISCO-88. Consequently, green occupations can be pointed out from the EU Labour Force Survey (LFS), in which occupational information is available at the four-digit ISCO-08 level. For the inclusion of a broader set of sectors, compared to O*NET, involved in the green transition, every ISCO-08 three-digit sector that includes at least one green four-digit sector is labelled as green[15].

Since the O*NET classification offers more granular insights about the tasks performed in the different sectors, Bown and Hancké (2019) are able to point out descriptive evidence on the importance of green occupations in total and in sectoral employment for the EU.

Comparing employment shares in the year 2016 with those in 2006, the share of green occupations in total employment increased from 35.5 % to 40 %. Distinguishing between the different categories of green occupations, Green Increased Demand occupations account for the largest share of green occupations in total employment (22.5 % in 2006 and in 2016) while Green N&E occupations represent the smallest. However, the share of Green N&E occupations in total employment increased significantly from 10.8 % in 2006 to 17.4 % in 2016 (Bowen & Hancké, 2019).

Differentiating between the 15 sectors highlighted in Table 1, construction (73.32 % in 2016) and transportation and storage; Information and communication (60.7 % in 2016) contain the highest share of green occupations.In contrast, financial and insurance activities (53.13 % in 2016) and agriculture, forestry and fishing (50.63 % in 2016) are the sectors with the highest shares of Green Rival occupations (Bowen & Hancké, 2019).

Lastly, Bowen and Hancké (2019) confirm the evidence of Consoli et al. (2016) that green occupations are correlated with higher levels of educational attainment. Green N&E occupations in particular are linked with higher average educational attainment levels, from which the educational sector and the financial and insurance activities sector benefit the most.

2.2.5. European Standard Classification of Occupations (ESCO) taxonomy for green skills and knowledge concepts

Within the EU, the ESCO database serves as a common tool to classify jobs. ESCO is the European Commission's taxonomy of skills, competences, and occupations. It classifies jobs and skills which are relevant to the EU's labour market and education and training. By establishing relationships between these concepts, it provides descriptions of skills linked to occupations. Using a common reference terminology, ESCO aims to support the integration of the European (digital) labour market. In particular, ESCO concepts and descriptions aim to support education and training providers, as well as employers and job seekers in addressing existing skills gaps in the face of increasing occupational mobility[16].

To facilitate the transition to a green economy and statistically monitor the greening of jobs, ESCO has added an additional layer to its classification. Based on the Cedefop (2012) definition of green skills, i.e. knowledge and abilities required for the reduction of environmental impacts from human activities (see Definitions section), ESCO has labelled certain skills and knowledge concepts as green. Arguing that a taxonomy of skills for a green transition is crucial to support necessary investments in the skills of people, ESCO thus takes a skills-based approach to green jobs (European Commission, 2022).

[16] See https://esco.ec.europa.eu/en/about-esco/what-esco.

Taxonomy pillars

The ESCO taxonomy consists of three pillars: occupations, skills/competences, and qualifications.

The *occupations* pillar organises hierarchical relationships between occupations according to the International Standard Classification of Occupations (ISCO) classification system. Occupations include a description and definition of the occupational profile, and a list of relevant knowledge, skills and competences[17].

The *skills* pillar describes skills and knowledge concepts according to their skill type. These concepts are structured in a hierarchy of sub-classifications: knowledge, skills, attitudes and values, and language skills and knowledge[18].

Lastly, the *qualifications* pillar structures information on formal qualifications, i.e. outcomes of assessments of individual learning outcomes by competent bodies according to given standards[19].

To identify green skills, the Commission has added information to the second pillar of *skills*. It differentiates between green, white and brown skills. Green skills reduce the environmental impact of human activities, white skills neither reduce nor increase the environmental impact of human activities, while brown skills increase the environmental impact of human activities (European Commission, 2022). To bridge skills gaps across industries and sectors in the transition to a green economy, the European Commission argues that both technical and transferable skills need to be anticipated and included in education and training. ESCO specifies which skills are crucial or optional for which specific occupation.

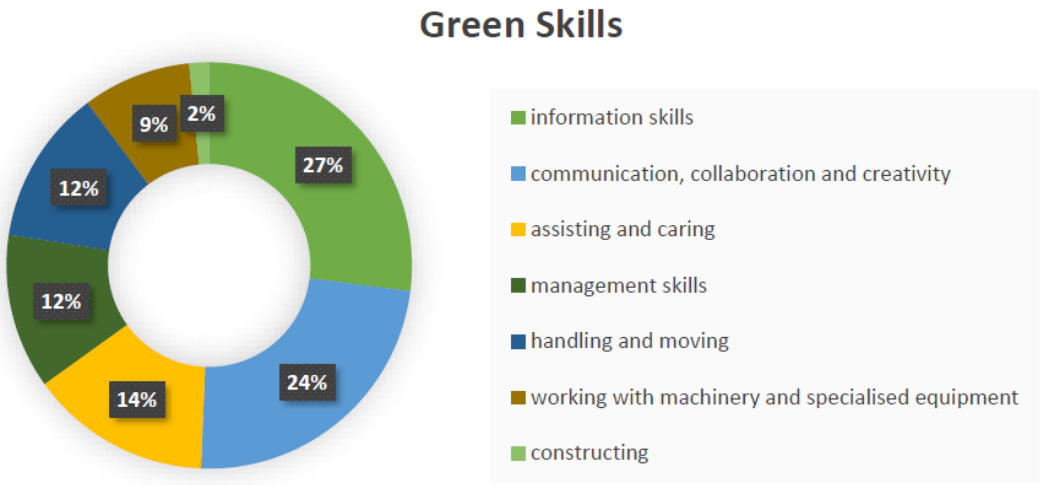
The outcome of this additional layer in the taxonomy is a list of green concepts in different economic sectors, aimed at covering the activities of the European labour market. These skills range from energy production to auditing and education (European Commission, 2022). Around half of the identified green skills are either information skills (e.g., monitoring radiation levels or measuring the sustainability of tourism activities, see Figure 4) or communication, collaboration and creativity skills (e.g., designing heat pump installations or educating on hazardous waste, see Figure 5). Relevant knowledge concepts for these green skills are mainly related to engineering, manufacturing and construction, as well as natural sciences, mathematics and statistics (European Commission, 2022).

[17] See https://esco.ec.europa.eu/en/classification/occupation_main.

[18] See https://esco.ec.europa.eu/en/classification/skill_main.

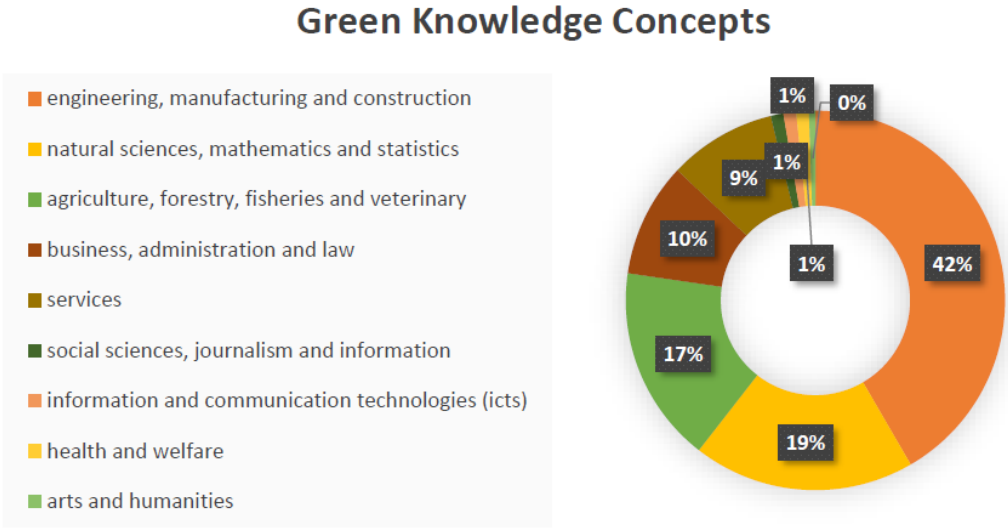
[19] See https://esco.ec.europa.eu/en/classification/qualifications.

Figure 4. Green skills in ESCO



Source: European Commission, 2022.

Figure 5. Green knowledge concepts in ESCO



Source: European Commission, 2022.

Operationalisation

Whereas other taxonomies provide a conceptual framework to classify green jobs, the operationalisation of the ESCO taxonomy is an operationalised output in itself – a list of green skills and knowledge concepts. To label ESCO-categorised occupations and skills as sustainable, the European Commission (2022) applies a machine learning approach. While previous approaches have mainly relied on expert panels, surveys and other labour-intensive mixed methods, machine learning, especially natural language processing, is becoming a popular and effective technique to group jobs and skills (Chiarello, et al., 2021). To classify ESCO occupations, the European Commission (2022) applies the natural language processing algorithm BERT, together with manual labelling and validation. The algorithm uses the definitions of green, white and brown skills as specified above. In total, the algorithm is trained

with 4 800 strings that classify ESCO occupations and skills as either green, white or brown. Effectively, 571 out of 13 890[20] ESCO skills and knowledge concepts are identified as green. These are accessible in the ESCO database on skills using the 'green labels' filter (European Commission, 2022).

2.2.6. Overlaps between the taxonomies

Outputs

Almost all of the described taxonomies include considerations on outputs of green jobs and in this sense overlap with each other. However, the way they approach output aspects differs between the taxonomies. Most classifications (ILO, 2013a; Dierdorff et al., 2009; Bowen & Hancké, 2019) apply a sectoral approach to outputs. For example, the ILO classification, the O*NET taxonomy, as well as its extension developed by Bowen and Hancké (2019), build upon employment in the Environmental Goods and Services Sector (EGSS), reporting output that has been produced for the purpose of reducing environmental harm (Eurostat, 2009).

The framework developed by Bohnenberger (2022a) considers outputs in a different manner. On the one hand, Bohnenberger's *output type* pillar is based on existing output approaches. As such, it shares common aspects with the other taxonomies (for example, the ILO (2013a) dimension of *Employment in production of green products and services*). However, to overcome shortcomings of existing sectoral approaches (such as the inclusion of greenwashed products), Bohnenberger focuses on the satisfaction of needs, thus diverging from existing output approaches (Bohnenberger, 2022a).

Processes

A focus on green processes is common to all the reviewed taxonomies. While the ILO taxonomy initially does not focus on specific tasks in its process pillar, the operationalisation of this dimension is linked to job-related characteristics such as tasks (ILO, 2013a). Therefore, this framework overlaps with the ones developed by Dierdorff et al. (2009) and Bowen and Hancké (2019). All of these explicitly classify green jobs according to the tasks they involve, thus applying a process perspective.

While these three frameworks are fundamentally built on a process perspective, the Bohnenberger taxonomy includes process considerations as well. Its dimension of *occupation* focuses on tasks and activities, thus overlapping with tasks-based taxonomies. However, differences between the described classifications arise from the question of whether or not green processes are contrasted with brown and white ones. Bohnenberger (2022a) and Bowen and Hancké (2019) also include brown tasks, as it is vital for the environment to end damaging activities in addition to creating beneficial ones (Bohnenberger, 2022a). Furthermore, Bohnenberger (2022a) expands the process pillar by including not only employees' tasks that are directly related to executing a profession, but also environmentally relevant activities such as transport and nutrition at the workplace in her *occupation* pillar.

[20] Source: https://esco.ec.europa.eu/en/about-esco/what-esco accessed on 08/06/2023.

Beyond this, Bohnenberger's dimension of *outcome efficiency* relates to process-based approaches, such as the pillar of *Employment in environmental-friendly processes* in the ILO (2013a) taxonomy, which raised the importance of resource use efficiency of production processes. In contrast to previous approaches, Bohnenberger's taxonomy does not define outcome efficiency in terms of relative improvement, but through absolute limits of environmental harm, and desired employment volume.

Inputs

Many of the analysed taxonomies also consider inputs relevant for an establishment's production processes. Since skills can be considered inputs of workers, the ESCO and O*NET frameworks as well as the O*NET expansion by Bowen and Hancké (2019) can all be said to apply an input lens to green jobs. Moreover, the statistical definition of the ILO taxonomy acknowledges skills as well (ILO, 2013a). In contrast, Bohnenberger (2022a) does not technically consider inputs to green jobs in her taxonomy. However, the author emphasises that looking at value chains is crucial for preventing greenwashing jobs that are based on environmental harm that was outsourced to upstream supply chain partners. Thus, Bohnenberger highlights supply chain inputs (such as resource consumption) as a relevant consideration for classifying green jobs.

Job quality

Only two of the reviewed taxonomies consider working conditions and job quality a vital part of green jobs – the ILO (2013a) taxonomy and the framework developed by Bohnenberger (2022a). By including job quality and wages in the analysis, Bohnenberger's pillar of *work-lifestyles* exhibits overlaps with the *decent work* pillar emphasised by ILO (2013a). However, Bohnenberger proposes an explicit analysis of how working conditions impact the sustainability of workers' private lifestyles, thereby connecting employment with (un-)sustainable consumption patterns. As such, Bohnenberger's taxonomy goes beyond the ILO's classification of decent work.

Operationalisation

Different approaches to the practical application of the taxonomies have been put forward in the literature. While the ILO (2013a) provides a detailed description of the potential quantification of its taxonomy pillars, Bohnenberger (2022a) has a higher focus on qualitative aspects and in many regards does not elaborate on the quantification aspects of her framework. Another key difference between the operationalisation of these two taxonomies is the question of additionality or exclusivity of the taxonomy pillars. Whereas the ILO taxonomy considers a job as green if it fits in either of the two dimensions of employment in the environmental sector, Bohnenberger's framework adopts a stricter approach where all dimensions need to be sustainable in order for a job to count as 'green'. The tasks- and skills-based taxonomies (O*NET and ESCO) do not provide a conceptual basis for classifying green jobs, as these taxonomies themselves are already operationalised in the form of databases for green tasks, skills and concepts. In addition, the O*NET taxonomy was further extended by Bowen and Hancké (2019) and put into practice by calculating the share of green occupations in specific sectors.

3. TOWARDS AN INTEGRATED TAXONOMY FOR GREEN JOBS

3.1. A TAXONOMY FOR GREEN JOBS

The taxonomies described in the previous section provide key insights on how to define and measure green jobs. Most taxonomies rely on a production approach to green jobs, as they focus on the process[21] and the output of production to identify green sectors, and ultimately green jobs. On the other hand, the variety of dimensions used (e.g. tasks, skills, output) also reveals the complexity and multidimensional nature behind the concept of green jobs. An important conclusion drawn from the literature review (Section 2), is that different approaches need to be integrated in order to capture this complexity. This point is exemplified by the ILO (2013a) taxonomy, which merges the output and processes approaches in order to fine-tune the measure of green jobs. Moreover, it is important to note that the taxonomies, which are operationalised to quantify the number of green jobs, tend to do so at the sectoral level. Whereas the use of very granular information (often three- or four-digit NACE/NAICS/ISCO/SOC codes) constitutes an advantage, focusing on sectors or occupations separately can limit the relevance of each approach, given that all occupations within a green output/process sector are not necessarily green (as per their tasks/skills). Conversely, a non-green sector could include green occupations.

Therefore, a key conclusion is that green jobs should be identified at the sectoral and occupational level (i.e., determine whether occupation *i* in sector *j* can be defined as green). Furthermore, the approach should be able to account for the evolving nature of green jobs. For instance, New and Emerging occupations and Green Enhanced Skills Occupations (Dierdorff et al., 2009) imply that the development of green jobs should affect the occupational composition of employment (i.e., through the creation of new jobs) and the skill requirements of certain occupations. The latter impact suggests that some occupations could become green(er) as the required skills change[22]. Another important consideration relates to the production process, which can evolve through time as firms in specific sectors adopt more efficient technologies reducing the environmental impact of their production[23]. In such cases, jobs in these specific sectors could also become green(er) with time.

In order to account for these observations, we develop an analytical framework that can support assessing the greenness of occupation *i* in sector *j*. For the development of this framework, we are inspired by existing work in the field of composite indicators (or indices). Composite measures can be a useful tool to synthetise multidimensional concepts into one single indicator, while allowing for the tracking of trends and cross-country comparisons. As emphasised by Nardo et al. (2008), an important step to develop such an indicator is the

[21] As noted by ILO (2013a), occupation tasks are linked to the production process. See Section 2.2.1.

[22] Occupations are taken as an example to illustrate the evolving nature of green jobs. In practice, occupational classifications are updated at a rather low frequency (e.g., once or twice per decade for the Standard Occupational Classification of the Bureau of Labor Statistics), and new jobs are added to the classification when such updates take place.

[23] Policies supporting and incentivising the green transition are also likely to contribute to such improvements in production processes.

development of a theoretical framework that defines and structures what is measured and 'provides the basis for the selection and combination of single indicators into a meaningful index' (Nardo et al., 2008, p. 15). This step is also relevant for the development of our taxonomy and could then serve as the basis for the development of an index at a later stage of the project.

3.2. ANALYTICAL FRAMEWORK

In order to clarify the presentation and ensure that the multidimensionality of green jobs is accounted for, it can be useful to break down the framework into dimensions, sub-dimensions and indicators (EIGE, 2017). To identify the main dimensions, we rely on System Theory (or General System Theory, von Bertalanffy, 1950), which has been applied in various branches of science; for instance, in social sciences to study organisation systems and management or industrial relations (Kim et al., 2015). System Theory proposes to conceptualise the subject (or object) of interest in terms of input, process and output. These three stages of a system seem particularly well-suited to develop our taxonomy of green jobs, as they encompass aspects already captured in existing analytical frameworks (e.g., the process and output dimensions in the ILO (2013a) taxonomy). Furthermore, we follow ILO (2013a) and include a fourth dimension related to job quality.

These four main dimensions are further split into eight sub-dimensions to which sets of indicators are assigned. Figure 6 displays the complete theoretical framework that could support assessments of which occupations and sectors are defined as green. The figure underlines how our approach builds on existing taxonomies, and its main contribution is in integrating all these into one single framework. Each of the four dimensions with its associated sub-dimensions and indicators are discussed in more detail in the following sections.

3.2.1. Input

The inputs to the production system are the components entering production, which are transformed at the process stage to generate output. Therefore, sub-dimensions can be identified from the usual inputs entering a production function. We consider labour, capital/other goods, and natural resources.

Labour

The labour input in production is linked to workers who apply their skills to tasks to create output. Therefore, an indicator of the greenness of the labour input is the use of green skills. The ESCO classification can be utilised to construct such indicator, e.g., a measure constructed as the share of green skills required for each occupation available in the classification. The ESCO provides information on ISCO occupations, which are used as well in the EU Labour Force Survey (EU-LFS) at the three-digit level. This indicator is kept at the occupational level and not aggregated in terms of sectors as in Dierdorff et al. (2009).

Goods/Capital

Capital is the second common input in production. However, it is not straightforward to obtain indicators on the greenness of capital. An interesting indirect measure could be obtained from an Environmentally-Extended Input-Output (EEIO) analysis (Kitzes, 2013). EEIO analysis can provide information on the embodied environmental impact associated with the production of

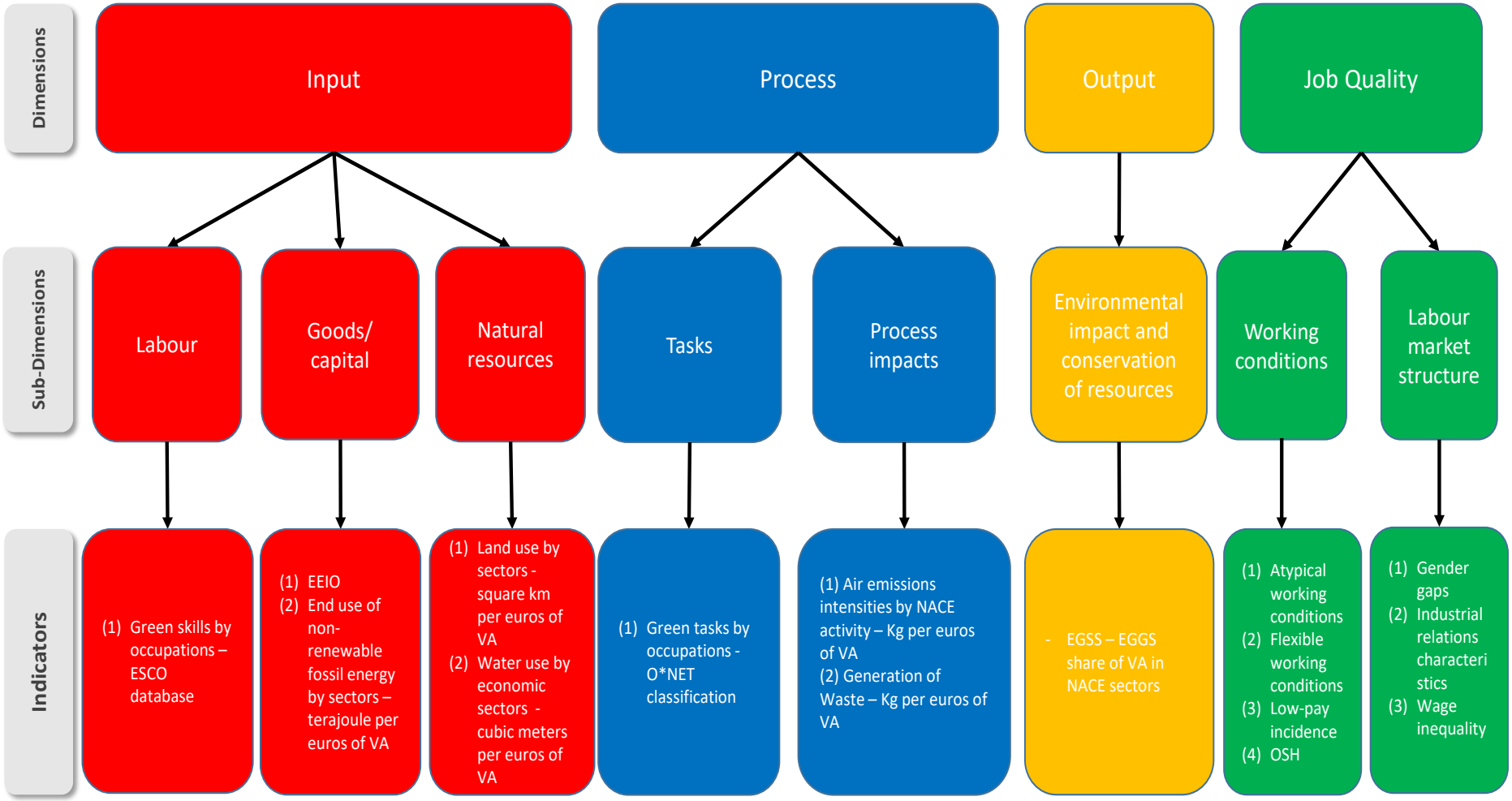
goods. As such, the results from the analysis could be employed to measure the greenness of (intermediate) inputs in production[24]. However, this exercise is demanding, and it is unclear at this stage whether relevant results can be produced and used.

As an alternative, indicators on the use of non-renewable energy by NACE sectors could provide relevant insights into the greenness of inputs used in the production system. Eurostat publishes data by sector and for each MS on 'end use' of energy[25]. This information is expressed in terajoule and available for more than 30 energy products (nuclear fuel, solar, wind renewable, coal, etc.) classified into renewable and non-renewable. The indicators can be normalised by sectoral value added (VA) to obtain the quantity of energy in the terajoule required to produce one euro of value added.

[24] This would not provide information on capital but on goods and services used to generate output.

[25] End use refers to use for energy purposes and for non-energy purposes. See Eurostat [ENV_PEFA] metadata for more information.

Figure 6. Analytical framework for the computation of a composite measure of the greenness of jobs



Notes: EEIO stands for Environmentally-Extended Input-Output analysis, KG for kilograms, VA for value added and OSH for Occupational Safety and Health.

Natural resources

Production functions are often extended to include additional inputs such as land. Given that the restoration and conservation of the environment are important aspects of the green job definition (Section 2.1), it is relevant to include the utilisation of natural resources as a sub-dimension. Indicators on the use of natural resources can be extracted from Eurostat.

A first indicator can be constructed based on the square kilometres of land use by activity[26]. Furthermore, Eurostat provides information on the water usage by NACE sectors expressed in millions of cubic metres broken down between sources from public and self/other. Both indicators can be normalised by sectoral VA to obtain the km^2 of land and the millions of m^3 of water used to generate one euro of value added.

3.2.2. Process

The process dimension refers to the stage in which inputs are transformed to generate output. The relevance of this dimension to measure green jobs is already acknowledged in the literature on green jobs (Section 2.1.2). The process dimension is split between tasks and process impacts.

Tasks

The use of tasks to measure the greenness of the production process has been proposed by the ILO (2013a) (see Section 2.2.1). Information on green tasks can be retrieved from the O*NET database and an indicator at occupational level can be computed in a similar manner to Vona et al. (2015) as the share of green tasks per occupation.

Process impacts

The process impacts sub-dimensions are meant to capture the environmental impacts resulting from the production process. As noted by ILO (2013a), information related to waste management can be used to measure this sub-dimension. Data on the generation of waste is published by Eurostat[27], broken down into categories and sources of waste generation. There are 51 waste categories classified into hazardous and non-hazardous waste. Of particular interest is the fact that the generation of waste is attributed to production activities identified by NACE sectors. An indicator of the kilograms of waste generated to produce one euro of VA can be computed.

In addition, information on air emissions by sector can also be used to measure the environmental impact of the production process. Eurostat publishes air emission accounts[28], constructed in a similar way to national accounts, which provide data on the release of 12

[26] See [LAN_USE_OVW] and https://ec.europa.eu/eurostat/lan_esms. Activities include, e.g. agriculture, fishing, industry and manufacturing, and are constructed from NACE codes. A category 'Land use with heavy environmental impact' exists but it is unclear at this stage how this indicator is constructed.

[27] Waste is defined as 'any substance or object which the holder discards or intends or is required to discard' See [ENV_WASGEN].

[28] See [ENV_AC_AINAH_R2] and the associated metadata: https://ec.europa.eu/eurostat/env_ac_ainah_r2_sims.htm

pollutants (e.g., carbon dioxide, methane, etc.) associated with the production of NACE activities. These data are also available in terms of 'intensities' corresponding to the normalisation of emissions by VA.

3.2.3. Output

As noted in Section 2.2.6, the output dimension features in most taxonomies of green jobs, and as such, this dimension does not warrant a lengthy presentation. An indicator can be computed from the Environmental Goods and Services Sector (EGGS) identified by Eurostat (2009) as discussed in Section 2.1.1. As explained by Eurostat[29], the EGGS spans many NACE[30] sections, divisions, and groups which are then aggregated at the one-digit level. As a result, an indicator can be computed as the output share of the EGGS among the total output by one-digit NACE sectors.

3.2.4. Job quality[31]

The last dimension follows from the ILO (2013a) taxonomy, which includes an aspect related to decent work. This dimension suggests that a green job is also one offering good working conditions in terms of wages, occupational safety and health (OSH) or other working conditions, such as access to flexible working time or atypical working conditions (e.g., evening, week-end work). The decent work dimension is closely related to indicators of job quality that have been used to construct the industrial relations index of Eurofound (2018), for example. Hence, a number of indicators already exist to measure job quality[32]. However, given our interest in occupations interacting with sectors, indicators computed directly from micro-data should be utilised, as much as possible, to construct the index[33].

Furthermore, structural aspects of the labour market, related to social dialogue / industrial relations, gender equality or wage inequality are also important to characterise the (labour market) framework in which jobs take place. Such indicators are not always available at the sectoral and/or occupational level, in particular for social dialogue[34], but measures of the gender pay gap or wage inequalities could be computed from the Structure of Earnings Survey once the data set becomes available.

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[29] See https://ec.europa.eu/eurostat/metadata/env_egs_esms.htm.

[30] See https://ec.europa.eu/eurostat/web/metadata/classifications.

[31] This dimension could be included as a sub-dimension of the process dimension given that it relates to labour conditions during production.

[32] See Piasna (2023) or www.eurofound.europa.eu/job-quality for examples.

[33] Micro-data from the EU-LFS and the Structure of Earnings Survey (SES) will be used to construct these indicators. The data is not yet available which makes it difficult to provide a precise list of meaningful indicators that can be created at the sectoral and occupational level.

[34] For industrial relations, usual indicators include collective bargaining coverage, trade union density, or the existence of a minimum wage and its setting. The OECD-AIAS database can be used to retrieve these indicators (see www.oecd.org/employment/ictwss-database). Alternatively, some composite index (Garnero, 2021; Ounnas, 2022) could also be used.

4. POLICY EXAMPLES

As explained in earlier sections, the concept of green jobs is being increasingly taken up at the policy level, with many countries putting forward dedicated strategies on green jobs that are often part of larger green transition strategies. This section presents examples of three countries with such strategies in place and analyses how the concept of green jobs has been integrated and operationalised in these strategies.

4.1. IRELAND: GREEN SKILLS ACTION PROGRAMME

4.1.1. Description and objectives

In Ireland, policy awareness for the transition towards more sustainable jobs and skills profiles has been reaffirmed in recent years. An Expert Group on Future Skills Needs was already set up in 1997 to advise the government on future skills requirements and related labour market issues. A 2010 study by the Expert Group found that 60 % of companies in Ireland experienced a gap between the actually employed skills and those needed to ensure a competitive low-carbon economy (Bennet et al., 2010). The study identified six sub-sectors of particular importance to sustainable development: Green ICT, Renewable Energies, Efficient Energy Use & Management, Waste and Wastewater Treatment, Waste Management Recovery & Recycling, as well as Environmental Consultancy Services. These sub-sectors are expected to contribute to the production of innovative and high-value products and services. Therefore, the Expert Group study suggests that it would require approximately EUR 25–30 million annually to equip enterprises in these sub-sectors with necessary skills (Bennet et al., 2010).

To address such skills gaps, the Future Jobs Ireland initiative was launched by the Government of Ireland in 2019. It is connected to several other government initiatives (e.g., Project Ireland 2040, Global Ireland 2025 and the national Climate Action Plan) aimed at anticipating challenges and opportunities of the future economy (Government of Ireland, 2019). At its core, the Future Jobs Ireland initiative focuses on ensuring resilient quality jobs and increased labour market participation in the face of current and emerging transitions. The initiative is the first to reemphasise that targeting the low-carbon economy is crucial for imminent challenges in the country's labour market (Government of Ireland, 2019a). It points out that decarbonising the country's economy could leverage opportunities for job creation in the expansion of the renewable energy sector, the circular economy, and the bioeconomy. Therefore, further education and training (FET) is identified as an important tool to strengthen the economy's resilience in the green and digital transition. FET is intended to bridge knowledge and skills in clusters with small and medium-sized enterprises (SMEs) and multinational enterprises (MNEs) and to enhance productivity within them.

The FET sector is at the core of the recent Green Skills Action Programme, established in 2021 by the government agency SOLAS of the Department of Further and Higher Education, Research, Innovation and Science. The Green Skills Action Programme is part of the SOLAS Recovery Skills Response Programme (Government of Ireland, 2021b), and is mainly funded through the National Recovery and Resilience Plan, devoting EUR 225 million to FET

(Government of Ireland, 2021a). Acting as an overarching framework for green skills policies in Ireland (SOLAS, 2022), the Green Skills Action Programme's task is to fund, coordinate and monitor the FET sector in Ireland. The programme identifies climate justice, sustainable development, and the bioeconomy as the main challenges for the Irish and the global economy. Accordingly, it suggests cultural and technological adaptations accomplished by a well-prepared FET sector. It consists of three main pillars: green skills for life, green skills for construction and green skills for carriers.

G*reen skills for life* addresses the importance of creating awareness for the above-mentioned challenges, enabling access to FET courses for all and promoting the FET sector as such. *Green skills for construction* introduces pathways to decarbonise the construction sector, including an emphasis on green skills in apprenticeships, FET programmes suited to emerging technologies and the creation of centres of excellence. *Green skills for careers* aims to enhance career opportunities in the green economy. This includes an expansion of non-construction apprenticeships focused on green skills, flexible upskilling and reskilling of workers and unemployed persons, as well as a support framework for a just transition for vulnerable employees and employers (SOLAS, 2022).

Overall, the Green Skills Action Programme aims to achieve Ireland's climate targets to increase energy efficiency by 50 % and reduce GHG emissions by 30 % by 2030 compared to 2005 levels. Additionally, the programme should support the transition towards achieving 70 % renewable energy capacity, the installation of 400,000 heat pumps and 950,500 electric vehicles on the road by 2030 (Government of Ireland, 2019b).

4.1.2. Approach to Green Jobs

To put the Green Skills Action Programme into practice, SOLAS (2022) uses the Cedefop definition of green skills, i.e. 'the abilities needed to live in, develop and support a society which aims to reduce the negative impact of human activity on the environment' (Cedefop, 2022a, p. 1). Moreover, green skills are specified as generic skills that assist in raising awareness or implementing resource-efficient activities, thus going beyond traditional skills in environmental goods and services. Skills are also considered necessary to protect ecosystems and biodiversity, with respect to the implementation of standards and processes, as well as the reduction of energy and material use and water consumption. Lastly, SOLAS (2022) emphasises that highly specialised green skills are crucial for developing and implementing green technologies in renewable energies and recycling.

The Irish approach to green jobs can be allocated to distinct pillars in the taxonomy developed in the present report (see Section 3.1). Given the Green Skills Action Programme's structure around education and training activities, the focus of the programme is on equipping the labour force with green skills. This emphasis on reskilling and upskilling workers to adapt to challenges related to climate change corresponds to the *input* dimension, which evaluates workers' skills as a crucial input into production processes. Moreover, the programme's intention is to shift the tasks in specific sectors towards the application of green skills and the use of low-carbon technology. Shifting tasks is part of the *process* pillar, which evaluates the greenness of tasks employed in an establishment's production processes. Finally, as a basis for achieving the Irish

climate goals, the Green Skills Action Programme implies an effect on the production of environmentally sustainable goods and services. Thus, the programme additionally covers the *output* pillar of the taxonomy depicted in this report.

4.2. CANADA: SUSTAINABLE JOBS PLAN

4.2.1. Description and objectives

In recent years, there has been an increasing impetus in Canada to exploit the employment creation opportunities arising from the transition to a green economy. This is also due to the recognition that the fossil fuel industry – which plays an important role for the Canadian economy[35] – is concentrated in a few Canadian regions, namely Alberta, Newfoundland and Labrador, and Saskatchewan. Moreover, although the contribution of the fossil fuel industry to these regions' GDP is relatively large[36], the sector is characterised by a relatively low labour intensity (Mertins-Kirkwood, 2017). While there is an acknowledgement of the benefits of the green transition, concerns have also been raised about the impacts on vulnerable regions and worker groups (Commissioner of the Environment and Sustainable Development, 2022).

Different studies have assessed the job creation potential in Canada arising from the move towards low-carbon technologies. For instance, it has been estimated that Canada has the potential to create up to 250 000 jobs in the electric vehicle (eV) sector by 2030, given that it builds the right policy framework and uses its know-how in eV assembly. These jobs would be created across the full eV supply chain including the mining sector where Canada has the know-how and workforce available (Clean Energy Canada, 2022). Moreover, Canada has significant potential in shifting its workforce towards the supply of renewable energy. Assessing Canada's capacity to produce electricity from wind, solar, geothermal, tidal and wave, hydroelectric, and nuclear sources, 1 048 900 jobs could be generated in infrastructure construction by 2050. In total, adding jobs in the creation of smart communities and in the transportation sector, 3 313 400 direct jobs in the green economy could potentially be created by 2050. Considering indirect occupations in supply chains and through spillover effects, the green economy could include 17 million new jobs (Columbia Institute, 2017).

Aiming to support green job creation in every region of the country and equipping workers with the skills required in the economy of the future, the Canadian government launched the Sustainable Jobs Plan (SJP) in February 2023. The plan intends to provide a framework for a just transition of the Canadian workforce towards reaching the target of net-zero carbon emissions by 2050. The SJP closely follows the governing Liberal Party of Canada's (2019) plan 'Forward' for promoting improved employment opportunities for the middle class and strengthening social security for vulnerable groups in Canadian society.

[35] In 2016, the relative contribution of the fossil fuel extraction to the country's GDP amounted to 7.9 % (Mertins-Kirkwood, 2017).

[36] The fossil fuel sector accounts for 31.7 % of the regional GDP in Alberta, 23.8 % in Newfoundland and Labrador, 18.7 % in Saskatchewan in 2016 (Mertins-Kirkwood, 2017). In addition, The shares of total employment in the fossil fuel industry amount to 5.1% in Alberta, 3.0 % in Saskatchewan, 3.5 % in Newfoundland and Labrador (Statistics Canada, 2023).

Among the key priorities of the SJP is the inclusion of each province and region, as well as of indigenous people and other marginalised groups. Its ambition is to promote the inclusion of indigenous communities, to achieve higher gender equality, diversity, and inclusion. The SJP was first launched as an interim solution, valid until 2025. From then onwards, a new Sustainable Jobs Action Plan should be implemented every five years, after consultations with all relevant stakeholders. The action points that are highlighted in the interim SJP focus on institutional capacity building and financing the creation of sustainable employment.

In this context, the Canadian government set up the Sustainable Jobs Secretariat and the Sustainable Jobs Partnership Council to advise and supervise the government on issues related to the creation of sustainable jobs. Additionally, their aim is to engage with workers, unions, industry and Canadians in an inclusive sense. With continuous financial support for Canadian workers and communities, the government intends to provide the necessary reskilling and upskilling to access sustainable jobs. Besides preparing the key economic sectors for a low-carbon transition, funding is being directed towards labour union apprenticeship and training programmes, as well as towards assisting disabled people (Government of Canada, 2023).

4.2.2. Approach to green jobs

To build a framework for their policies, the Government of Canada (2023) defines sustainable employment as any work compatible with the country's target to reach net-zero carbon emissions and strengthen climate resilience. Additionally, a sustainable job is understood as employment that guarantees decent working conditions, is well-paid and is of high quality. Thus, a sustainable job proposes sustained social and economic security for workers and their families.

From the perspective of the integrated taxonomy outlined in Section 3.1, the SJP addresses three pillars, *output*, *job quality*, and *input*. First, promoting the eV and renewable energy sectors demonstrates interest in expanding the production of environmental goods and services, thus targeting green jobs through a sectoral output lens. Second, the creation of supervising institutions and the SJP's emphasis on attractive and inclusive working conditions particularly for vulnerable and marginalised groups reveals a strong focus on improving job quality. Third, significant investments in reskilling and upskilling workers as well as the target of augmented renewable energy use as factor input shows that the SJP does not neglect the input pillar of the integrated taxonomy developed in this paper.

4.3. PORTUGAL: GREEN SKILLS & JOBS PROGRAMME

4.3.1. Description and Objectives

In Portugal, green jobs have received increased attention since the government's adoption of the 'Green Growth Commitment' (GGC), a strategy launched in 2015 in the context of the Coalition for Green Growth (Government of Portugal, 2015). One of the Commitment's key objectives was to create green jobs, raising the number of people employed in a green job from 75 000 in 2013 to 100 400 in 2020 and 151 000 in 2030. The Commitment mainly highlighted

the potential of green jobs to contribute to sustained economic growth (Government of Portugal, 2015).

More recently, the relevance of green jobs was re-emphasised in the context of the Portuguese 2030 National Energy And Climate Plan (NECP) (Government of Portugal, 2019). The NECP acts as a primary energy and climate policy tool for 2021-2030 and is aligned with the EU Member State obligations, underpinned by the EU Governance of the Energy Union and Climate Action. While targeting specific sectors for reduction of GHG emissions, the NECP extends policy objectives to five dimensions, namely decarbonisation, energy efficiency, security of supply, internal energy market and research, innovation and competitiveness[37]. Thus, it aims to support the economy and workers in the green transition through decarbonisation and reskilling. Action Strategy 8.3 of Portugal's NECP emphasises the relevance of capacity building in green job creation for achieving the targets of climate change and altering social behaviours towards low-carbon lifestyles (Government of Portugal, 2019). Action measures include education and training, increased awareness of a low-carbon economy and behaviour, as well as the promotion of sustainable production and consumption.

In this context, Portugal introduced the Green Skills and Jobs Programme ('Programa Trabalhos e Competências Verdes') in 2023, under the umbrella of the NECP. It is aimed at reskilling and upskilling employees of enterprises directly or indirectly affected by increased energy costs, as well as the unemployed. The programme acknowledges the pressing need of job creation and new skills development to accommodate the economic and structural changes associated with the energy transition and climate action. Training courses are based on identified skills gaps and needs, and jointly developed by the Agency for Energy, the Portuguese Renewable Energy Association, and the National Agency for Qualification and Vocational Education and Training. The programme incorporates short- and medium-term courses as well as training activities that fall within the scope of energy and environment. Training groups are intended to prioritise workers in the energy transformation process, including those affected by the energy transition in the fossil fuel industries, and the unemployed.

With an overall funding of EUR 20 million for 2023[38], training courses can address the following themes[39]: energy efficiency, renewable energy, water efficiency, sustainable mobility and circular economy. *Energy efficiency* encompasses training projects and requalification to provide participants with the knowledge and skills they need to contribute to energy independence, decarbonisation, and energy optimisation, specifically through efficient methods for lowering energy consumption in buildings and installations. *Renewable energy* courses are aimed at promoting the transformation of skillsets towards renewable energy sources, by emphasising the role of technologies that effectively produce green electricity from renewable sources. Trainings related to *water efficiency* are intended to address more efficient water usage, reuse, and management systems by utilising renewable energy sources. *Sustainable mobility* aims to reduce the environmental impact of mobility as well as offer

[37] See https://apambiente.pt/clima/plano-nacional-de-energia-e-clima-pnec.

[38] As specified by the *Resolution of Council of Ministries n.º 87/2022 (4 October, 2022).*

[39] See https://www.iefp.pt/programa-trabalhos-competencias-verdes-green-skills-jobs.

solutions-based technologies for decarbonisation. Finally, courses on the topic of *circular economy* aim to contribute to circular economy practices by offering technological solutions for energy efficiency and efficient resource management for activities such as waste reduction and reuse, and material efficiency.

4.3.2. Approach to green jobs

A crucial reference for the Green Skills and Jobs Programme is the Green Paper on the Future of Work, published in 2021 by the Office for Strategy and Planning (GEP) of the Ministry of Labour, Solidarity and Social Security, and the Institute of Employment and Vocational Training (Coelho Moreira et al., 2021). In an attempt to frame green jobs and skills, the Green Paper follows the ILO definition, discussed in Section 2.1. Green jobs are seen as decisive contributors to environmental, economic and social goals, such as inclusion and cohesion (Coelho Moreira et al., 2021). To achieve this potential, the adaptation and adjustment of the workforce to anticipated market restructuring processes are highlighted as a pressing matter.

Therefore, the Green Paper calls for training programmes aimed at reformulating the educational content delivered by universities to address green skills. Additionally, green reskilling should be incorporated in vocational education within the National Qualifications Catalogue (Coelho Moreira et al., 2021). As such, the Green Skills and Jobs Programme addresses green jobs from an *input* perspective, as specified in the taxonomy presented in Section 3.1. Moreover, the training of the workforce for energy optimisation practices, including the creation and enhancement of models for reduced energy consumption, targets the *process* dimension of the integrated taxonomy, aiming to support environmentally friendly production processes in organisations. The *process* pillar is further mirrored in the funding available to turn tasks green, such as generating green electricity, intelligent water management and management of other scarce resources. By targeting low-carbon and 'sustainable' sectors, such as the renewable energy sector, the Portuguese Green Skills and Jobs Programme also emphasises the *output* dimension of the present taxonomy for green jobs. Finally, the focus on a just transition and fostering social inclusion and regional cohesion targets green jobs from a perspective of *job quality*, the fourth pillar of the taxonomy developed in section 3.1.

5. CONCLUSIONS AND REFLECTIONS

The concept of green jobs is not recent. It has been discussed in academic and policy contexts for several decades, to anticipate and shape the labour market response to a shift towards more environmentally sustainable economic activities. In recent years, the Covid-19 crisis and the Russian war in Ukraine have further reinforced attention on green jobs and the need for Europe to have in place the skills and the workforce necessary for the green transition. In this context, the 'greening' of jobs is being viewed as both a means to reduce human impacts on the environment and to increase the resilience of labour markets to structural crises.

DEFINITIONS AND INTERPRETATIONS

To account for the interrelations between employment and sustainability transformations, it is vital to understand which jobs may be impacted by, and which ones may act as enablers or obstacles to 'greening' processes. However, such an understanding requires a clear understanding of which jobs can fit within the concepts of green work and sustainable employment. **A variety of definitions and classification frameworks have been produced by international organisations and academics, with most of them assessing the greenness of jobs either from a firm-level or a worker-level perspective.** These definitions range from assessing environmentally friendly work outputs or processes to individuals' skills and tasks to more systemic questions of how work can be reconceptualised in a more sustainable way.

While many definitions overlap in certain regards, such as in considering the output of a job as an important prerequisite for its sustainability, there are also key differences among the approaches. **These conceptual differences translate into a range of methodological approaches to estimate the prevalence of green jobs, leading to heterogenous results and complicating the comparisons of results across different studies.** Although several studies broadly follow the approach of UNEP et al. (2008), assessments by EU agencies and initiatives usually approach green jobs in terms of the skills they involve.

Integrated frameworks have the potential to capture the different elements of green jobs, both from a firm and a worker perspective, and thus bridge the gaps between existing definitions. **Attempts to create an overarching taxonomy for sustainable employment are scarce in the literature.** Moreover, measurability and instructions for implementation of such an integrative approach, enabling comparisons between different studies to facilitate green policy design, have yet to be put forward.

Measurability has proven to be particularly challenging for social aspects. **While there have been efforts to include a social dimension into some of the existing taxonomies for green jobs, social aspects and the question of how to measure and practically implement them have not been fully incorporated in most approaches.** Moreover, the question of how to account for the greenness of material inputs and associated environmental impacts has not yet been tackled in the literature. **Most of the existing taxonomies and classifications for green jobs do not include material inputs to organisational processes into their approach.** However, it is crucial

to consider these inputs and the associated supply chain environmental impacts to determine the greenness of an occupation.

APPLYING THE 'GREEN JOBS' CONCEPT

As a response to the shortcomings in existing green jobs classifications, the basis for a novel taxonomy, seeking to integrate inputs and intuitions from very different classifications, has been developed in this report. **By combining different (firm- and worker-level) elements of preceding approaches in a quantifiable manner, this taxonomy aims to enable estimates of the interconnections between employment and sustainability transformations in a comparable way.** Furthermore, it is the first taxonomy to explicitly cover material inputs and associated supply chain environmental impacts of jobs.

One key limitation of this framework is that measuring material inputs is often difficult due to limited availability of such data at sectoral level – a prerequisite to aggregating the different indicators. Another challenge is the question of exclusivity versus additionality of the taxonomy pillars, and how open or strict these should be designed. An additional complicating aspect to formulating a framework for 'green' jobs is the fact that labour markets, firms and workers are constantly changing and adapting to structural changes such as the green transition or the development of digital jobs that act as enablers of the green transition. Thus, any encompassing taxonomy must be dynamic in nature to capture developments and evolutions in the labour market. Allowing for such flexibility, however, seems in opposition with the very concept of a classification framework, which is inherently static and depends on simplification and rigidity. Related to this, certain aspects, such as how emerging jobs in the digital arena can act as critical enablers for the green transition in different sectors, require further research to assess how to best incorporate them into our taxonomy.

On a policy level, many initiatives tend to focus on skills aspects for supporting the creation of green jobs and the phasing out of brown ones. At the same time, the examples assessed in this report indicate that there is a tendency in overall strategies that incorporate green job elements to have a sectoral focus. **Re- and upskilling courses are often focused on employees of specific sectors. While sectoral approaches can provide indications of the potential 'green' contribution of selected sectors, an understanding of the impacts of the green transition on jobs overall would require more integrated assessments of direct and indirect effects on jobs in other sectors.** Moreover, although the examples of policies analysed in this report integrate social aspects to varying degrees, there may be room for extending the scope of consideration, to ensure that structural labour market changes induced by the green transition happen in a socially just manner that protects vulnerable groups.

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About the TransEuroWorkS project

TransEuroWorkS is a multi-disciplinary EU-funded research project that conducts analysis and policy recommendations for the future world of European work and social protection. It will provide new, more integrative understandings of how fundamental changes to the labour market and European context can be better and more proactively managed through national and European Union (EU) level social protection policies. At the centre of TransEuroWorkS are three critical structural labour market transformations: green transition and decarbonisation, technological change, and the internationalisation of the workforce. For more information, see https://transeuroworks.eu/.

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