



Green Skills and Knowledge Concepts: Labelling the ESCO classification

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1. The context

The European Union (EU) is pursuing the ambitious goal of achieving climate neutrality by 2050. To transform the economy for a sustainable future, Member States plan to stimulate the creation of green jobs and continue cutting greenhouse emissions.

With the release of the European Green Deal in 2019, the EU has planned an initial roadmap of policies and measures to drive investments and efforts towards a just and inclusive transition. Such policies are aimed at deeply transforming the economy across production and consumption. This includes: the decarbonisation of the energy system, the mobilisation of industry for a climate neutral and circular economy, the engagement in a resource-efficient investments in construction, the preservation of ecosystems and biodiversity, and the creation of a toxic-free environment. As the transition is bringing fundamental transformations in the European economic model, new jobs are created, while some jobs are replaced, and others are redefined. The Directorate-General for Employment, Social Affairs & Inclusion's response is described in the European Skills Agenda, a five-year plan to strengthen sustainable competitiveness, ensure social fairness and build resilience. The target is to invest in skills that support the effort to minimise the environmental footprint of activities. In this context, one specific action (Action 6: Skills to support the twin transitions) requests the definition of a taxonomy of skills for the green transition. The taxonomy should allow the statistical monitoring of the greening of professions.

The European Classification of Occupations, Skills and Competences (ESCO) responded to this call to action. ESCO skills and knowledge concepts needed to live in, develop and support a society which reduces the impact of human activity on the environment (Cedefop, 2012) are now labelled as *green*. This report provides information concerning the labelling process, and guides ESCO implementers in

their use of ESCO green concepts. The following section is an introduction to ESCO labels in the context of the green transition. Section 3 presents the methodology designed for this activity, while Section 4 gives an overview on the results obtained. To ease the use of green concepts, Section 5 shows different use cases for a range of ESCO implementers. Section 6 concludes the report by explaining how to access green labels and listing other useful sources available.

2. The ESCO approach to support the green transition

Monitoring the economy and ensuring adequate occupational mobility facilitates the transition to meet labour market needs for an environmentally sustainable society. The transition to a green, low carbon and resource-efficient economy is a challenge and an opportunity for the European labour market to be tackled at the level of skills. Skills policies aim in fact at bridging skill gaps and better forecasting skill needs across sectors and industries.

To successfully support the re-skilling path, an advanced set-up to anticipate and provide training on both technical and transferable skills is needed. The ESCO classification is already playing a central role as the European taxonomy of skills and occupations. Not only it offers a common language on occupations and skills, but it also provides relationships between them, specifying which skills are essential or optional for a specific occupation. With the release of the updated version of the classification (ESCO v1.1), one further step is taken to support the green transition of the labour market.

As workers need a skill set that can respond to the need of reducing emissions in working practices, the Skills/Competences pillar has been enriched with the additional information at skill level to distinguish **green skills and knowledge concepts**. This means that within the whole dataset of ESCO skills, some can now be filtered as green. ESCO also provides information such as their reusability type and are linked with occupations. All the concepts are translated in 28 languages and are available free of charge in different formats.

3. Methodology

The labelling of skills and knowledge concepts as green follows a methodology based on a 3-step process, which combines human labelling and validation, and the use of Machine Learning (ML) algorithms.

Labelling Green ESCO Concepts



First, skills and knowledge concepts are manually labelled based on the definition of green skills suggested by the European Centre for the Development of Vocational Training (Cedefop):

the knowledge, abilities, values and attitudes needed to live in, develop and support a society which reduces the impact of human activity on the environment (Cedefop, 2012).

When running the manual labelling activity, each concept is analysed based on its preferred term, non-preferred terms, and description. The labelling consists in verifying whether an ESCO skill concept should or should not be considered as green.

For the second step, a ML classifier is developed to extract green skills from all the ESCO skills. To build the classifier, the Commission created a training dataset composed of text of green and non-green activities, mainly sentences and short definitions, collected from European and International sources. These definitions must be categorised in three groups: *brown skills*, which are defined as knowledge and skills that increase the impact of human activity on the environment, *white skills*, which do not increase nor reduce the impact of human activity on the environment, and *green skills*, which reduce the impact of human activity on the environment. Given the preferred term and description of a skill or knowledge, the classifier assigns the brown, white, or green label for the concept. More details concerning this second step are available in Annex I, while Annex II presents the list of sources employed to build the training data.

Finally, the list of concepts manually labelled as green (first step), and the concepts classified as green by the ML algorithm (second step) are compared. The final round of validation follows the following rules:

- If a concept is labelled as green by the two methods, it is automatically accepted as green
- If a concept is labelled as non-green by the two methods, it is automatically accepted as non-green
- If a concept is labelled as green by only one of the two methods, it is revised and then labelled either as green or non-green.

4. Result

A total of 591 ESCO skills and knowledge concepts are labelled as green. This includes: 386 skills and 205 knowledge concepts. Among the 386 green skills, 5 of them are transversal. The full list of green concepts is available in the ESCO portal (see Section 6).

Additional to the preferred term, description, and non-preferred terms for each concept, ESCO provides information such as the essential and optional relationship with occupations, the skill reusability type, and the allocation in the respective hierarchies. Concepts are translated in the 28 ESCO languages.

The green concepts aim to cover the activities of the European labour market. As such, skills range within different economic sectors, from energy production and distribution to manufacturing processes, from waste management and pollution standards to auditing and impact assessment, from research to education.

Charts 1, 2, and 3 show the distribution of the green concepts in the skills, knowledge, and transversal skills hierarchies. As for the skills hierarchy, about half of the skills are part of the skill groups S2 and S1:

- S2 – Information skills. Examples include: [monitor radiation levels](#), [conduct energy audit](#), [measure sustainability of tourism activities](#)
- S1 – Communication, collaboration and creativity. Examples include: [train staff on recycling programs](#), [design heat pump installations](#), [educate on hazardous waste](#)

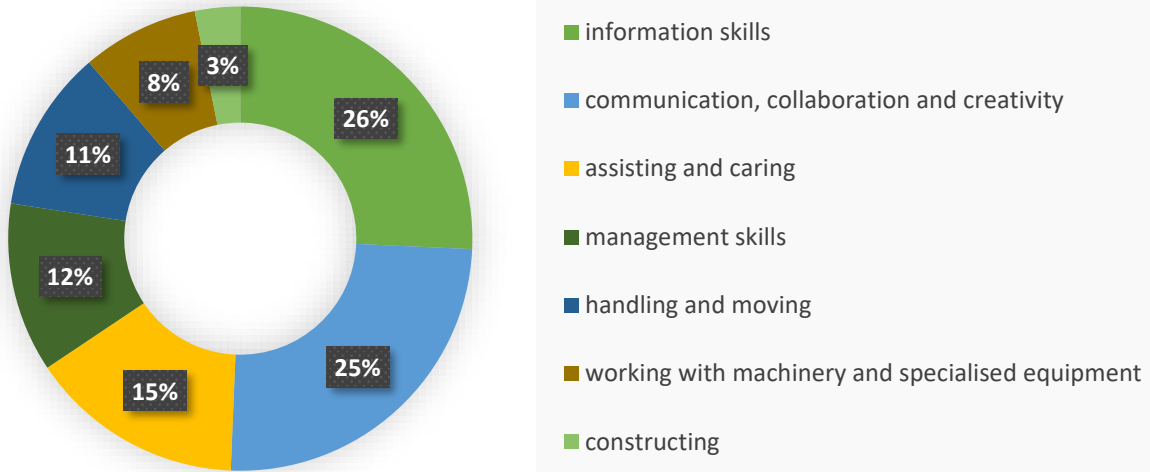
Within the knowledge hierarchy, which is based on the International Standards Classification of Education (ISCED-F), most of the skills labelled as green are part of the following groups:

- Engineering, manufacturing and construction. Examples include: [types of wind turbines](#), [sustainable installation materials](#), [emission standards](#).
- Natural sciences, mathematics and statistics. Examples include: [ecological principles](#), [biomass conversion](#), [oceanography](#).

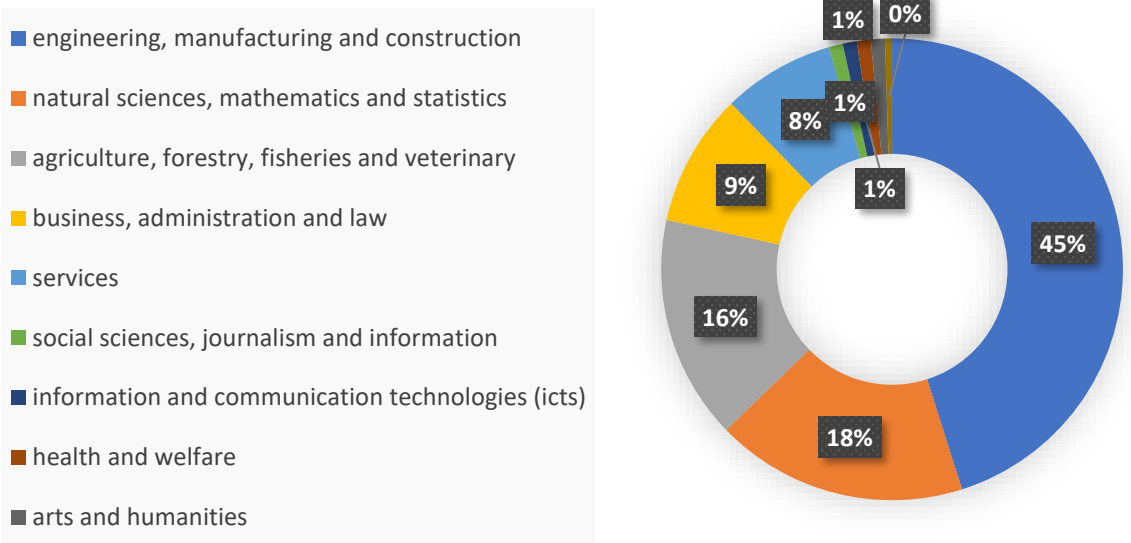
Within the transversal skills hierarchy, the five green transversal skills belong to the same transversal skill group:

- T6 – Life skills and competences. Examples include: [evaluate environmental impact of personal behaviour](#), [adopt ways to foster biodiversity and animal welfare](#), [adopt ways to reduce negative impact of consumption](#).

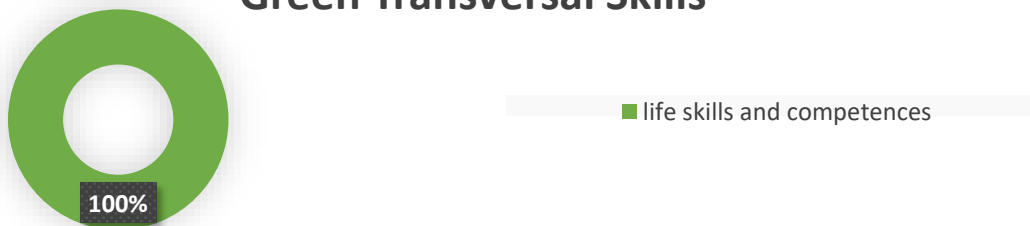
Green Skills



Green Knowledge Concepts



Green Transversal Skills



Charts 1, 2, 3

5. Use cases

The results of labelling green ESCO skills and knowledge concepts can be employed for different purposes. Based on the needs of some of ESCO implementers, we propose here options to guide them towards a successful use of green labels.



5.1 Public Employment Services

Public Employment Services (PES) inform, advice and guide job seekers on green jobs and activities. Following the introduction of European and national policies driving the transition to an environmentally sustainable economy, PES are expected to include the green skills and employment agenda within their standard services (European Commission, 2013). Thanks to the introduction of green labels for skills, ESCO can support PES to achieve this goal. Examples are:

1. **Compare vacancies and resumes with an eye on the green transition.** PES can use ESCO green skills as a web-based system to analyse job vacancies and curriculum vitae in their databases and automatically detect matches and mismatches. This would help balancing the supply and demand in the local labour market, while focussing on the green transition.
2. **Suggest greener career pathways.** Looking at changes in the requirements demanded for some occupations, PES can use ESCO green skills to build pathways into greener careers for job seekers to ensure they can successfully take part to the transition.

5.2 Private Companies and Human Resource Services

The position taken by public institutions and international organisations towards the green transition is an important driver of changes in demand of services and products, and standards to be followed. To maximise the positive impact of the transition to a greener economy, companies must develop and integrate into their businesses the skills, knowledge and competences required by resource-efficient processes and technologies (Cedefop, 2019).

1. **Forecast the impact of green investments on the skills needed by the company.** As companies are called to reduce greenhouse gas emissions and minimise the use of resources,

businesses need to ensure their workforce can follow the changes in processes, machines, rules, and possess new knowledge. Using ESCO, human resource officers can focus on the ESCO occupations of interest for one specific company and estimate whether there are skill shortages for the transition.

2. **Invest in the development of green transversal skills.** Transversal skills are highly demanded by companies, and different studies demonstrated that they could improve the outcomes of workers. The ESCO transversal skills hierarchy provides a set of green skills related to the impact of the individual and collective behaviour on the environment that can be used by companies to educate the workforce to adopt a more sustainable workstyle.

5.3 Research bodies

Policy makers, businesses, education providers, among others, necessitate a clear understanding of the consequences of the economic change for the green transition. For this reason, research bodies are seeking to quantify the impact of green policies on the labour market. When designing their research activities, researchers can benefit from the use of the ESCO classification to create surveys or to use ESCO as a web-based service to include in their applications, or to use directly as a tool to read and classify information available online. We report here two possible uses.

1. **Automatise the process to collect information on green skills from online sources.** Today, most of the information concerning vacancies are available online. As ESCO offers access to the classification through Application Program Interface (API) software components, it is designed to support machine-to-machine interaction over the World Wide Web. This enables researchers to design long-term, customised analyses on specific topics, such as green skills. For those who prefer not to use the API, the same approach can be taken simply downloading the ESCO data files.
2. **Detect green skill gaps between similar occupations.** One of the main strengths of ESCO is the fact that for each concept the classification provides more than descriptions and terms. Using the skill groups where green skills are mapped, or the occupations linked to such skills, researchers can extend their investigation beyond skills, for example comparing the occupations linked to such skills and analyse differences and similarities. To better use the skill hierarchy, or to use groups of occupations instead of individual ESCO occupations, implementers can also benefit of the use of the [matrices](#) available in the ESCO portal.

5.4 Education and Training providers

To ensure a positive labour market integration of students, education and training providers should ensure that their subjects include sustainable practices. Learners and students can play a crucial role in the green transition of the economy, as they specialise in industries that are significantly impacted by carbon emission standards, pollution regulation and the circular economy. The ESCO classification can help education and training providers to:

1. **Assess the inclusion of sustainable practices in learning material and training activities.** Using the ESCO green skills, education and training providers can focus on a group of skill of interest (for example, ESCO skill group *S7.1 Building and repairing structures* or *S3.5 Preparing and serving food and drinks*) and check whether green skills mapped in those groups are included in their learning curricula.

2. **Describe and automatically translate green learning outcomes in a fast manner.** All the ESCO skills can be used to describe and translate learning outcomes, but this practice is further eased now for green skills. In fact, learning providers can choose to filter only green skills, and use terms, descriptions and the other information when building curricula. This can then be translated in the 28 ESCO languages.

6. Supporting material

ESCO green skills and knowledge concepts can be accessed via different channels.

As of January 2022, a document (.xlsx format) listing all the green concepts can be downloaded in the [Download Section](#). Here, each skill presents the Uniform Resource Identifier (URI), preferred term, non-preferred terms, description, and other data. Information is provided for every of the ESCO languages. To ease the download of the green concepts, the box below showcases how to download the list in English.

Example: How to download the list of green skills and knowledge concepts in English using ESCO v1.1, in csv format

Path:

ESCO Portal > Use ESCO > Download

Selection:

Version: v1.1.0

Content: classification

File type: csv

Language: English

Document:

Green Skills Collection: *greenSkillsCollection*

For those who are interested in the full list of ESCO skills and knowledge concepts, this can be downloaded in the [Download Section](#). We recommend using the latest version of the classification. Based on the file type, green concepts can be filtered in the following ways:

- Using the CSV (*Skills/competences*, ≈ 9MB), green concepts can be filtered at the column *inScheme*, the concept type can be filtered at the column *skillType*
- Using the TTL (*ESCO v1.1.0 classification*, Full RDF, ≈ 688MB), green concepts can be filtered via the SKOS property *skos: inScheme*.

The [ESCO portal](#) allows the functionality to filter only green concepts in the Skills/competences pillar by clicking on *Show filters* and then choosing the *Label*.

7. Annex

7.1 Annex I: Classifier for green skills

Building a classifier for green skills and knowledge concepts labelling represents an effective approach to assist in the maintenance of a large dataset such as the ESCO classification. The main goal of the model is to categorise text (i.e. ESCO skill or knowledge concept) into one of the predefined groups (i.e. green, white, brown).

The classifier is built using the Python programming language thereby using different pre-trained models. After comparing the results of different models, the Bidirectional Encoder Representations from Transformers (BERT) model was selected. BERT is a pre-trained ML technique for natural language processing developed by Google (Devlin J. & Chang M, 2018).

The training data is composed of about 4,800 strings of text that describe activities considered as environmentally sustainable, polluting, or none of the two by official classifications, job vacancies, European or national legislation, and reports. The definitions are selected based on the source reliability and their similarity to the structure of the preferred term and description of ESCO skills. Strings are then distinguished as *brown* (400 elements), *white* (2,100 elements), and *green* (2,300 elements). The table below describes the differences between these three groups.

Group colour	Definition – developed by the ESCO team	Example of string for training data (<i>source</i>)
Brown	knowledge and skills which increase the negative impact of human activity on the environment	Production of electricity by coal (<i>International Labour Organization, Skills for a Greener Future</i>)
White	knowledge and skills which do not increase nor reduce the negative impact of human activity on the environment	Test computer or software performance (<i>Australian Skills Classification</i>)
Green	knowledge and skills which reduce the negative impact of human activity on the environment.	Cogeneration of heat/cool and power from geothermal energy (<i>EU Taxonomy for Sustainable Activities</i>)

BERT was fine-tuned with a linear layer appended at the end. The ESCO preferred terms with the descriptions are fed to BERT for encoding. From the BERT outputs we use the pooled output as the input for the linear layer, resulting in a representation for the entire input phrase. This pooled output is the final hidden vector for the CLS token that is passed through a linear layer and a tanh activation function.

7.1.1 False positives and False negatives

The choice to not limit the training dataset to green and brown concepts only is based on the role of white skills to ease the filtering of green skills from the full classification.

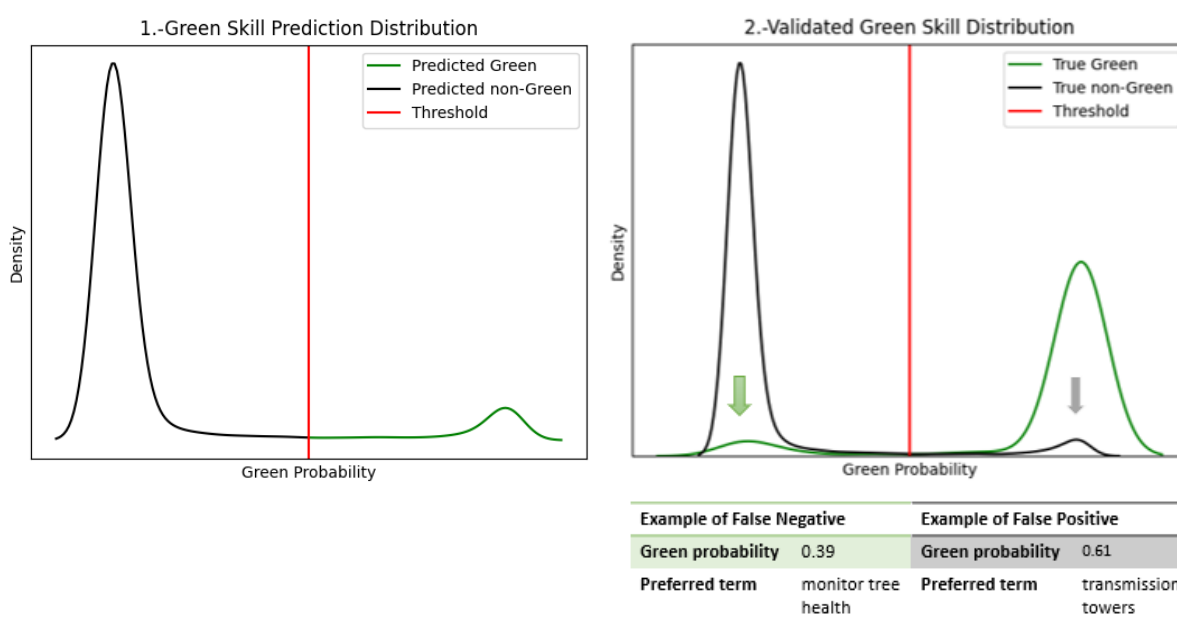
When distinguishing between green and non-green concepts, the model is able to identify ESCO skills that are carbon-intensive or polluting. Brown skills can be clustered more easily because they cover a small range of activities in comparison to the whole economy, and they are usually described with a limited set of words – in particular, terms referring to non-renewable energy extraction and use, as

well as some activities in manufacturing processes, act as keywords that ease the work performed by the classifier. This does not apply only in few cases, when the model fails and wrongly classifies green skills as non-green. We call these skills *false negatives*.

However, for this labelling activity, all ESCO skills and knowledge concepts need to be considered. This includes a broad range of activities which do not use carbon intensively, but which also do not promote sustainability, such as caring or recruiting skills. Due to the lack of a clear distinction, these skills are more challenging to classify, and would pollute the result of the classifier. This creates the issue of *false positives*, meaning non-green skills that are classified as green by the model.

Labelling and including white skills in the training data results in a more continuous spectrum for the classifier to label skills that fall in between brown and green skills. This significantly reduces the likelihood of encountering false positives. Figure 1 shows the density estimation for green and non-green (combining white and brown) skills based on the green probability assigned to ESCO skills by the model.

Figure 2 shows the density estimation *after* the comparison with the manually validated skills and the final round of validation (see Section 3). On the left side, the green distribution shows green skills that scored a low green probability (below the threshold), and were wrongly labelled as non-green (false negatives). On the right side, there are non-green skills wrongly labelled as green (false positives).



7.2 Annex II: Sources employed to build the training dataset used by the classifier

Source Type	Source Provider	Source Name	Brown	Green	White
Classification	ARPA Lombardia	Inventario Emissioni Aria (INEMAR)	X		
Classification	European Commission	EU taxonomy for sustainable activities	X	X	
Classification	Eurostat (European Commission)	Statistical Classification of Economic Activities in the European Community, Rev. 2 (2008) (NACE Rev. 2)	X		X
Classification	Ministère de la Transition écologique - France	Observatoire national des emplois et des métiers de l'économie verte (ONEMEV)		X	
Classification	National Skills Commission - Australia	Australian Skills Classification		X	X
Classification	Office for National Statistics - United Kingdom	Low Carbon and Renewable Energy Economy (LCREE) Survey		X	
Classification	Office for National Statistics - United Kingdom	UK environmental goods and services sector (EGSS)		X	
Classification	U.S. Department of Labor/ Employment and Training Administration	Occupational Information Network (O*NET)	X	X	X
International Standards	United States Environmental Protection Agency (EPA)	Inventory of U.S. Greenhouse Gas Emissions and Sinks	X	X	X
Online Job Board	ECO Canada	ECO Canada		X	
Online Job Board	GoodWork.ca	GoodWork.ca		X	
Online Job Board	Indeed	Indeed		X	
Other	Open source	Wikipedia	X	X	
Project	European Commission	BUILD UP - The European Portal For Energy Efficiency in Buildings		X	

Report	European Environmental Agency (EEA)	EU Emissions Trading System (ETS) data viewer	X		
Report	Fundación Biodiversidad & Observatorio de la Sostenibilidad en España (OSE)	Empleo verde en una economía sostenible		X	
Report	International Labour Organization	Skills for Green Jobs in Bangladesh		X	
Report	International Labour Organization	Anticipating skill needs for green jobs. A practical guide			X
Report	International Labour Organization	Skills for a Greener Future: a Global View		X	
Report	Joint Research Centre (European Commission)	Labour markets and the green transition : a practitioner's guide to the task-based approach	X		
Report	Organisation for Economic Co-Operation and Development (OECD)	Energy prices, environmental policies and investment: Evidence from listed firms	X		
Report	Organisation for Economic Co-Operation and Development (OECD)	Employment Implications of Green Growth: Linking jobs, growth, and green policies	X		
Report	Platform for Accelerating the Circular Economy (PACE)	Circular Economy Action Agenda. Electronics		X	
Report	Platform for Accelerating the Circular Economy (PACE)	Circular Economy Action Agenda. Textiles		X	
Report	Platform for Accelerating the Circular Economy (PACE)	Circular Economy Action Agenda. Plastics		X	
Report	The Intergovernmental Panel on Climate Change (IPCC)	Special Report on Climate Change and Land		X	

Report	United Nations Environment Program (UNEP)	State of Finance for Nature		X	
Report	United Nations Industrial Development Organization (UNIDO)	Green Industrial Skills for a Sustainable Future		X	
Research Paper	Journal of the Association of Environmental and Resource Economists	Environmental Regulation and Green Skills: An Empirical Exploration	X		
Research Paper	University of Wollongong	Towards a green IS taxonomy		X	

8. Glossary

Description: a text field providing a short explanation of the meaning of the concept and how it should be understood. Most importantly, it clarifies its semantic boundaries (*European Skills/Competences, Qualifications and Occupations Classification, ESCO*).

ESCO v1.1: ESCO 1.1 is the next major release of ESCO. The Commission plans to release it end 2021, at the end of the three-year period that Member States have to map or adopt ESCO according to the EURES Regulation.

Green skills and knowledge concepts: the knowledge, abilities, values and attitudes needed to live in, develop and support a society which reduces the impact of human activity on the environment (*European Centre for the Development of Vocational Training, Cedefop*).

Knowledge: the outcome of the assimilation of information through learning. Knowledge is the body of facts, principles, theories and practices that is related to a field of work or study (*European Qualification Framework, EQF*).

Non-preferred term (NPT): can be synonyms (words with similar or same meanings) but can also be spelling variants, declensions, abbreviations, etc. They are regularly used by the target group (jobseekers, employers, education institutions) to refer to concepts that are described in ESCO with the preferred term (*European Skills/Competences, Qualifications and Occupations Classification, ESCO*).

Occupation: a grouping of jobs involving similar tasks and which require a similar skills set (*European Skills/Competences, Qualifications and Occupations Classification, ESCO*).

Preferred term (PT): each concept within ESCO has a designated, unique preferred name per ESCO language. It is called the preferred term and can be a single-word term or a multi-word term. The preferred term is used to represent a concept in ESCO in a specific language. Out of a group of terms with similar meaning, the one that best represents the concept is chosen to be the preferred term (*European Skills/Competences, Qualifications and Occupations Classification, ESCO*).

Skills: ability to apply knowledge and use know-how to complete tasks and solve problems (*European Qualification Framework, EQF*).

Transversal skills: Learned and proven abilities which are commonly seen as necessary or valuable for effective action in virtually any kind of work, learning or life activity. They are “transversal” because they are not exclusively related to any particular context (job, occupation, academic discipline, occupational sector, group of occupational sectors, etc.) (*European Skills/Competences, Qualifications and Occupations Classification, ESCO*).

Uniform Resource Identifier (URI): Each occupation, knowledge, skill and competence in ESCO is identified by a string of characters that follows a specific syntax: the Unique Resource Identifier (URI). Each URI is unique over the web, allows data from different sources to link to it, and is persistent (*European Skills/Competences, Qualifications and Occupations Classification, ESCO*).

9. References

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