DENiM

Deliverable D3.2
Digital Maturity and Skills Assessment Methodology and Toolkit

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D3.2 - Digital Maturity and Skills Assessment Methodology and Toolkit

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Executive Summary

In 2017, the industry sector was responsible for almost the 40% of the total global energy use, causing a relevant impact on the planet from multiple perspectives. Consequently, the Energy efficiency is increasingly considered a crucial theme and ever more considered at all stages of the manufacturing process.
In parallel, the digital revolution is affecting the way we work and live: companies that have invested in digital innovation in the last 5 years are now in the need for an alignment of their internal competencies to maximize the return on investments.

Moreover, the primary characteristic of Industry 4.0 is the digitisation of manufacturing processes, which offers opportunities for energy saving through the optimisation of or replacement of technologies, the application of new software tools for energy efficiency management or adaptation in the business processes.

However, there still exists a lack of tools able to detect the impact that technology is having on specific jobs and skills focusing on energy efficiency and management. This is mainly because technological change is becoming increasingly challenging to measure, given its rapid (and often unpredictable) consequences on the worldwide economy. (Fareri et al., 2020)

Given the above, work presented in this deliverable will focus on two aspects, firstly the assessment of the digital maturity of selected industry sectors represented by the DENiM pilot sites. This is essential to establish the capabilities of the company to maximise the potential of digital technologies. An industry 4.0 digital assessment tool will be specified by MTU and used to create a maturity index

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that can inform and establish a road map for digitalisation of manufacturing processes with an emphasis on supporting energy efficiency.

Secondly, human competence and capabilities profiling will be utilised to develop the core of the DENiM Worker Profiler, a tool that allows users to perform a skills assessment for the single worker to be used as an input of the Competence Matchmaking Tool that finds the optimal training plan to gain the missing skills. Three steps are foreseen to develop the Worker Profiler. Firstly, the authors will identify both the new archetypes requested by the on-going digital transformation and the updated skills to be integrated in the existing archetypes according to the new technological requirements, focusing on energy efficiency and management. Secondly, a map of the skills mismatching is created via a questionnaire. The questionnaire will be generated automatically using an AI based approach applied on the information extracted in previous step. Finally, reference standards like ESCO and O*NET are used to quantify skill gaps and to create a proper assessment procedure to be integrated into the tool.

Keyword list

Industry 4.0, Digital Assessment, Energy Efficiency, Denim Worker Profiler, Skill Assessment

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Glossary

ESCO	European Skill/Competence Qualification and Occupation
GDPR	General Data Protection Regulation
ICDs	International Competences Databases
KPI	Key Performance Indicator
O*NET	Occupational Information Network

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1 Introduction

The digital revolution is introducing epochal changes and challenges. Companies that have invested in digital innovation in the last 5 years are now in the need for an alignment of their internal competencies to maximize the return on investments; governments are trying to look to the future of sectors that characterize modern economy; universities are reshaping their offer almost every year. Among these, the topic of skills and job profiles is ever more assuming a key role. In fact, the literature highlights not only the necessary integration of existing skills in professional profiles, but also the inevitable creation of new ones (and new job profiles as well) to properly manage the digitalisation trends (Fareri et al., 2017; Fantoni et al., 2018).

In parallel, in 2017 the Industry sector was responsible for almost the 40% of the total global energy use, causing an ever more relevant global impact. Thus, the Energy efficiency is increasingly considered a crucial theme and need to be considered at all stages of the manufacturing process. Moreover, the primary characteristic of Industry 4.0 is the digitisation of manufacturing processes, which offers opportunities for energy saving through the optimisation of or replacement of technologies, the application of new software tools for energy efficiency management or adaptation in the business processes.

Although, the state of the art seems to focus on building models to assess the digital maturity of companies, considering instead the impact on the labour market as a hazy issue. Moreover, the literature tends to offer qualitative approaches to the topic, making the results uncertain, while the quantitative assessment on firms is less treated (Fareri et al., 2020).

Given the above, the goal of the task is to develop replicable tools to measure the digitization gap of companies from two points of view: technological and of human skill.

- From a technological point of view, the output will consist in the definition of a digital maturity index, obtained through the industry 4.0 digital assessment performed by MTU tool. The latter will be functional to the definition of a road map towards the evolution to a Company 4.0.
- From a human skill point of view, the output will consist in the development of the DENIM Worker Profiler, which is a tool capable of detecting the missing skills of workers in relation to designed archetypes 4.0. The latter will be functional to the definition of customized and efficient training plans to gain the skills previously detected (input for Task 7.5).

The structure of the document reflects the two points of view previously represented and described by the two main chapters (Chapter 2 and Chapter 3). Both chapters are developed following the same logical flow:

- the first paragraph describes the methodology with which the assessment is performed;
- the second paragraph describes the instrument with which the measurement is carried out;
- in the third paragraph the results of the experiments conducted on the pilots are reported, aimed at validating and improving the defined tool.

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2 Digital Maturity Assessment Tool

The focus of this task is to develop an intuitive web based tool that allows industry practitioners to assess, quantify and represent the digital maturity of their organisation. This can then be utilised to support organisations in understanding their readiness to leverage advanced digital tools (such as those developed within DENiM) to optimise existing business processes. In addition, the outcome of the assessment tool can be utilised to define a pathway for an organisation to further progress on the digital transformation journey. From the perspective of DENiM this assessment will be grounded in the ability to identify the needs in order for an organisation to maximise the potential of advanced digital tools to support energy efficient management of processes or products. In addition, this tool and framework can be leveraged to assess the increase in digital maturity of organisations that leverage the DENiM solution and services.

The digital maturity of an organisation will be evaluated based on direct interactions with relevant stakeholders and a set of questionnaires that engage industry partners (and DENiM supported organisations) on how they are performing regarding the following categories: Smart Readiness (covering digitisation, connectivity, Industry 4.0), Digital Maturity (covering digitalisation, automation, flexibility and intelligence) and Sustainability Maturity (covering energy auditing, awareness, sustainable practices and standards).

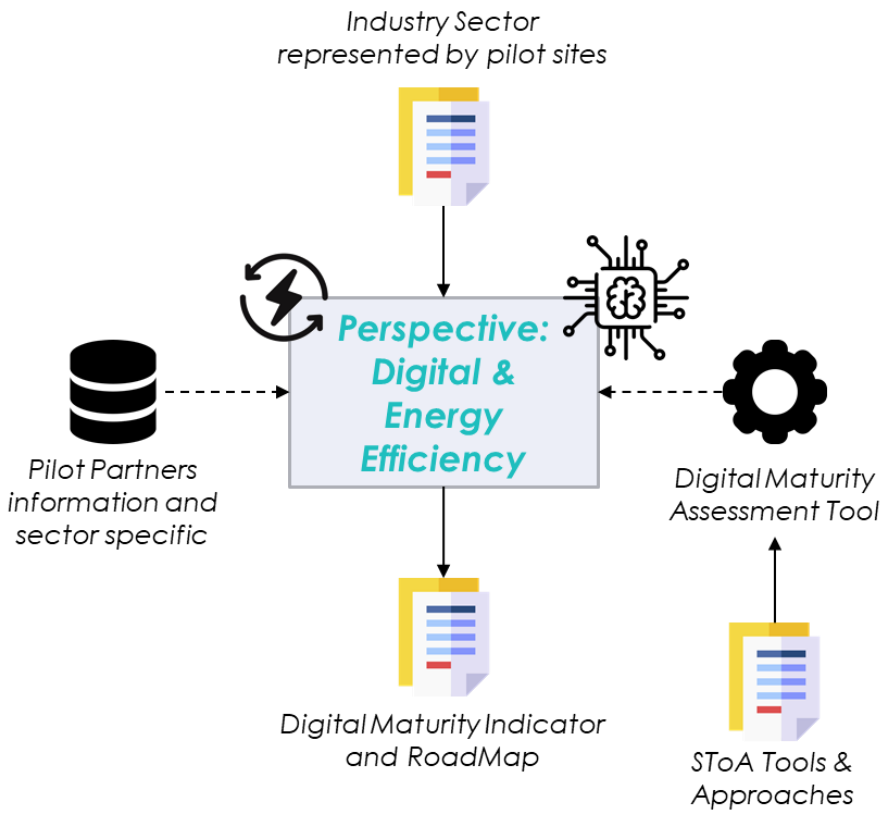

Figure 1: Digital Maturity Assessment Tool considerations

Figure 1 provides an overview of the considerations for the design and implementation of the DENiM digital maturity assessment tool offering perspectives on digital and energy efficiency maturity. Key to being able to recognize opportunities for digital transformation is an understanding of the industry sectors represented by the pilot sites and their specific needs, ambition from a strategic and

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operational viewpoint. Additional inputs to the assessment tool include state-of-the-art approaches used to represent maturity, as captured in DENiM deliverable *D3.1 Current Best Practices, Stakeholder Analysis and Pilot Scenarios for Energy Efficient Manufacturing Systems*. The outcome of the tool will be an easy to understand representation of the maturity and recommendation to define a roadmap to progress further in digitization from an operational stand point.

2.1 Methodology

The approach taken by DENiM involves three distinct phases that when combined form a toolkit to support assessment. Each phase aligns with a set of clearly defined outcomes that can be exploited by the participating organisation to maximise the value digital tools can bring to existing operational processes, supporting agility, flexibility and scalability through data-driven approaches. Figure 2 shows the components and approach for toolkit development, firstly to establish the current status quo of an organisation, contextual inquiry will be utilised combined with engaging workshops and informal engagement with key stakeholders within the organisation. A key objective of this step is to identify a company "digital champion" this will be a key individual to drive the uptake of DENiM tools and services. Supporting tools such as Miro[1] online white boarding and visual collaboration platform will be leveraged for joint workshops at this phase of the process when physical interaction is not possible.

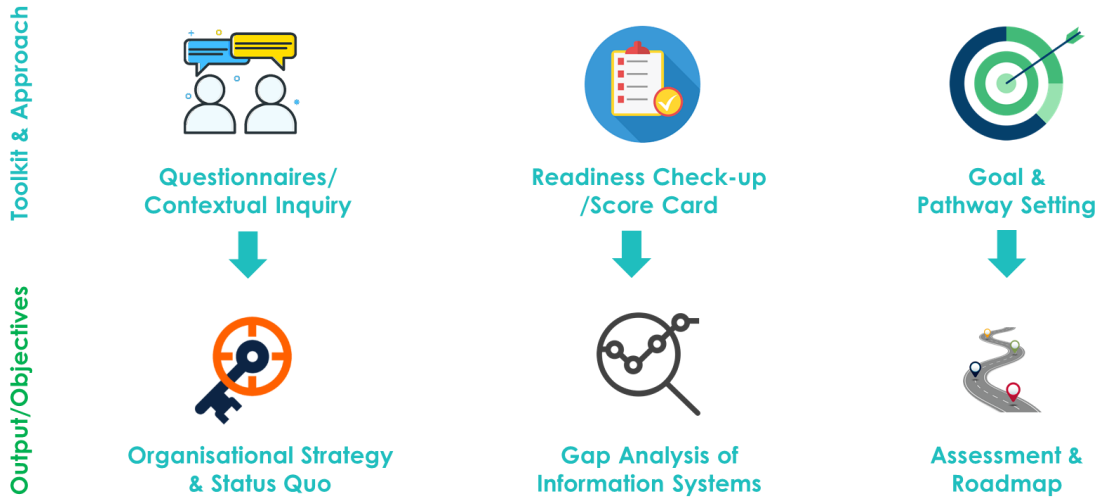

Figure 2: Digital Maturity Assessment Methodology & Approach

The second step is the use of an online tool that integrates a set of questionnaires that capture the different of dimensions relating to the digital maturity of an organisation. An initial set of questions garnered from existing approaches (as defined in Deliverable D3.1) will be set out within this report. These will be developed further based on evaluation and engagement with pilot partners. The use of the questionnaire approach will allow the user of the tool to carry out a guided self-assessment and identify potential gaps from an organisational and technical perspective. The final phase is to utilise the gap analysis to define a maturity index or score to represent the outcome of the readiness check-up. Based on this it can be used to support pathway and goal setting in conjunction with the pilot partners to ensure the benefits of deploying and utilising DENiM tools are fully realised.

In addition, the approach taken by DENiM to establish a digital maturity index will consider the tools envisaged for European Digital Innovation Hubs (EDIHs)[2]. A key point is the definition of KPIs to

[1] https://miro.com/
[2] https://digital-strategy.ec.europa.eu/en/events/digital-maturity-tool-and-innovation-radar

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evaluate the increase in digital maturity of organisations that have used the services of the EDIH network. Similarly the DENiM digital maturity index can be utilised to assess the value and impact the use of the DENiM platform has on advancing the digital maturity of an organisation (e.g. increase in the number of digital services deployed). As such the design of the digital maturity tool will take into account frameworks and methodologies being proposed for EDiH. This alignment will also enable an organisation to advance beyond the DENiM project and support assessments associated with market maturity and innovation potential, as defined in the JRC's Innovation Radar methodology. As such the project will keep abreast of the developments with regards the establishment of a EU digital assessment tool and methodology.

2.2 Digital Assessment Tool Design

This section will describe the approach to be taken to implement the online tool for guided self-assessment of digital maturity. Three dimensions that been identified as the initial focus of the tool as captured in Figure 3. As the emphasis of DENiM is the interconnection and use of data-driven tools to support energy efficiency the assessment tool will focus on Smart Readiness, i.e. ability to support connectivity and willingness to embrace digital tools, Digital Maturity, i.e. the current status and capacity to increase automation facilitated by DENiM digital platform and finally Sustainability Maturity, i.e. capture the degree and potential for digital technologies to support optimisation, efficiencies and sustainability of current products and processes.

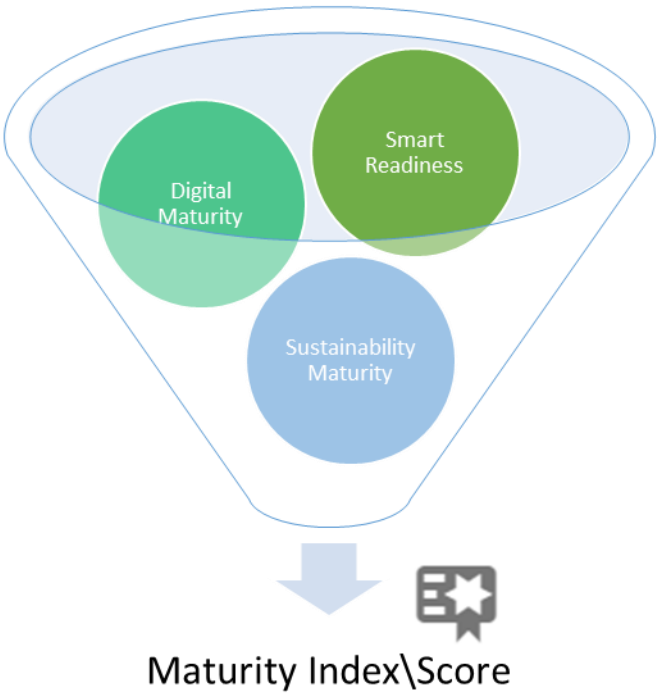

Figure 3: DENiM Digital Maturity Assessment Dimensions

2.2.1 Guiding questionnaires for self-assessment of maturity dimensions

Figure 4 provides a high level view of the modules that constitute forms/questionnaires within the online tool. General company information will be used to capture details relating the industrial sector, company size, country, region etc. In addition, general information regarding target areas for the organisation is solicited (e.g. which value stream or process is aimed for improvement). Reponses to

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these are generally based on a scaling factor (e.g. strongly disagree, disagree, unsure, agree, strongly agree) with some support for free text for additional information. The following are example questions that will be incorporated as part of this module:

- Does your organisation have a clear strategy for digitalisation?
- Do management see digitalisation as a key strategic objective for the company?
- What are the business areas where digital technologies can provide added value?
- The organisations digital strategy is communicated at all levels and business functions?
- The organisation already has the necessary skills to successfully execute the digital strategy?
- What timeframe is expected to implement and execute the digital strategy?
- What are the current barriers you see in realising digital transformation?

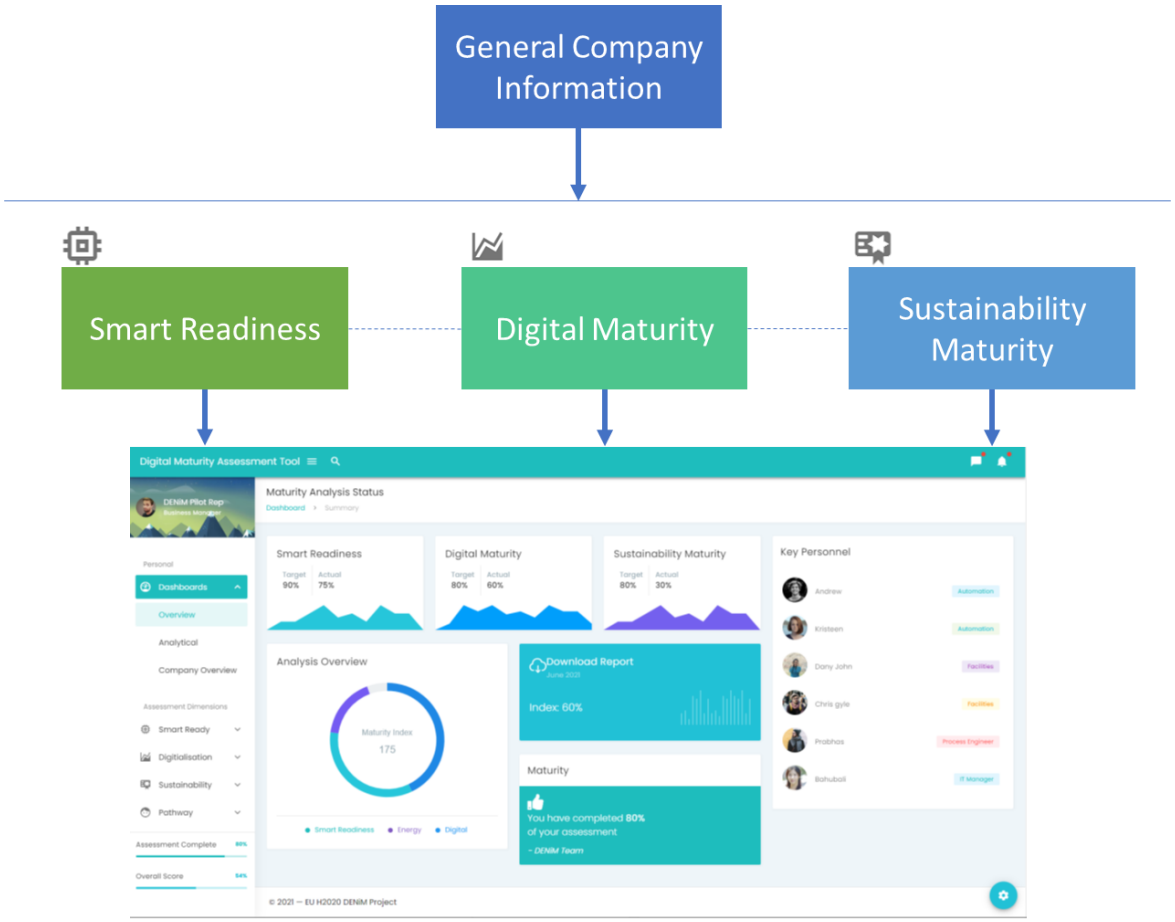

Figure 4: Tool Structure and Modules

The Smart Readiness module is a questionnaire to assess the status of the company in its progress towards the use of smart industry technologies (e.g. Industry 4.0 & IoT). Example questions such as the following will be incorporated (with a range as a response):

- How digitally mature do you consider your organisation to be currently?
- How far away from full maturity do you consider your company to be?
- To what extent does your organisation have a digital strategy?
- What is the expectation based on the objective to increase digital maturity?
- What digital tools do you use for day to day business?

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- What is needed to enable digitalisation of existing products or processes?
- We actively seek new technologies that can support our digital development
- We involve operators in process improvement projects?

Within the Digital Maturity module an emphasis is placed on the ability to connect, integrate, extract, monitor and analyse process data. A focus will be placed on understanding connectivity and the convergence of IT & OT operations across the process value stream. The following provides example questions used in this module:

- What level of connectivity is in place across the value-chain?
- What degree of automation is implemented on the specific process?
- What are the expected improvements through digitisation?
- Are communication networks integrated across the organisation?
- Is there direct connectivity between process data and enterprise applications?
- Process data is collected in a structured manner within the organisation?
- Data is used to optimise and increase performance of our organisation?
- We have the correct tools and competencies to analyse process data for decision making.
- We use digital technologies to connect & gather data across the different technologies, platforms, business functions.
- Data analytics models are part of the decision making process within our organisation?

To assess the Sustainability Maturity, the final module will include questions around energy and resource efficiency and ability to optimise processes from a sustainability standpoint. These should be supported and facilitated through the use of digital tools. Example questions are as follows:

- Do you follow any formal standard for energy management within the organisation?
- How is energy usage considered as part of process planning and scheduling?
- What is the approach to asset management
- Do you capture material consumption at machine, process and factory level?
- To what degree do you tackle energy consumption at machine, process and plant levels?
- At what level do you proactively deal with the waste flows at machine, process and factory level?
- Do you measure the environmental impact of your manufacturing processes?
- What digital technologies do you use to support facilitates management?
- To what level does digital technologies support sustainability of your processes?
- Do you have KPIs defined that target sustainability at process, plant and organisation level?
- Do you have a strategy and targets to reduce energy consumption?

2.2.2 Calculation of Maturity Score

The approach to capture user response will be based on a ranking or multiple choice, some instances will enable the user to include additional relevant information that can be reviewed subsequently. The Smart Industry Readiness Index (SIRI) Self-Assessment Tool[3] provides a good example to quickly capture user input, this can be generalised as shown in Figure 5, as an alternative a range slider (Figure 6) provides a nice visual representation of each range that can be customised depending on the inputs and question being asked to the user.

[3] https://www.siri.gov.sg/self-assessment

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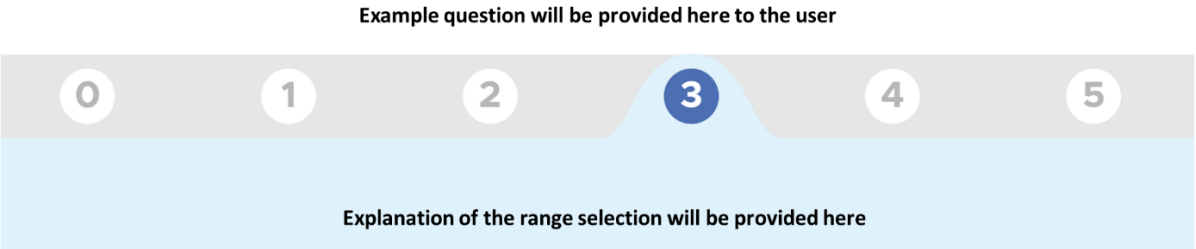

Figure 5: User input to capture ratings and score

Figure 6: Slider range selection

the response of each question will be aggregated together to provide a score (represented as a percentage of the maximum score achievable) for each dimension. Table 1 provides an example of how the maturity score can be represented to the user, it outlines the score achieved based on the questionnaire responses as well as an explanation of what this score represents for the company. This can be expanded further in terms of key actions that can be taken to move up the scale as well as an indication of how DENiM activities, tools and services can be used to support this progression.

Table 1: Example Digital Maturity Representation for Company

Maturity Level	1 (0-25%)	2 (25 - 50%)	3 (50% - 75%)	4 (75% - 100%)
Status Explanation	Some digitisation but unplanned & incidental	Making purposeful strides towards digitalisation	Integrating digital tools to support decision making	Streamlined, coordinated and automated
Actions	Define Strategy	Develop Data Integration Platform	Derive Insights	Optimise & Sustain
DENiM Role	Digital Roadmap	Data Architecture and Platform	Performance Modelling	DENiM Digital Intelligence Decision Support Tools

This will form the basis of the current status of this dimension. Drawing on synergies with the approach taken in Canetta et al. (2018), the score from each dimension will be equated as a weighted sum of all three dimensions to provide a composite score or overall index that is representative of the digital maturity. This will be presented to the user as the overall maturity index that can be explored further under each dimension. The weights can be used to prioritise the various dimensions depending on the goals of the particular organisation and help highlight the appropriate steps to increase the maturity across all dimensions. The definition and effectiveness of the weighted approach will be explored further as part of the tool evaluation.

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2.2.3 User Interface Modes and Features

The tool will provide two distinct user modes, the first view will be a simplified version of the assessment methodology, this will provide a rapid check-up and assessment of maturity. The user will be able to run through this process without providing any details on the company, the outcome will be the visualisation of the assessment score, this will be a once off process (but can be repeated multiple times) and no data will be stored for later analysis.

Alternatively the user can opt to register their details for a more in-depth assessment, the user will be provided with credentials to allow them to access the DENiM tools and have a continuous view on the status of the assessment (example login screen shown in Figure 7). They will also be provided with more features to allow them to track particular projects and initiatives that directly align with the maturity roadmap and can be used to enhance the current maturity score.

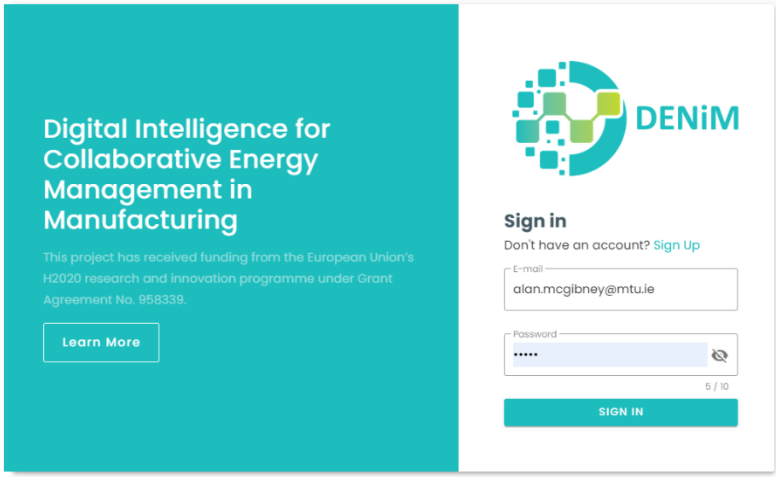

Figure 7: DENiM Digital Maturity Assessment Tool User Authentication

Considering the outcomes of the digital maturity a number of additional services will be provided that includes the ability to record and track project progress relating to energy efficiency and enhancing digital maturity. Broadly speaking the developed tools objective is to support DENiM pilot partners advance in the areas outlined in

Table 2 through the use of DENiM solutions and tools. Key to this is to ensure the industry sectors are ready and able to build on this opportunity to add-value to current business processes.

Table 2: Digital Maturity Objective

Consideration	Objective
IT Infrastructure	Secure integration of relevant IT systems (MES, PLM) and OT systems to support flexibility and interoperability and collaboration across business roles
Data Collection	Continuous collection and aggregation of high-quality data from manufacturing processes, enterprise and products
Data Analytics	The application of data analytic services for pattern recognition, model building and predictive capabilities
Smart KPIs	Supporting KPI-based decision making through utilisation of KPIs that reflect resource efficiency, flexibility and energy optimisation
Asset Management	Use of innovative mechanisms to proactively manage assets (production and auxiliary assets) from an energy efficiency perspectives.

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Digital Score Card	Track the success and impact of digital initiatives, tools and services.

The outcomes of the assessment will be used to work in conjunction with pilot partners to define a clear pathway and trajectory to achieve their maturity objectives.

2.3 Tool Implementation & Evaluation Plan

The assessment tool will be built using JavaScript framework known as VueJS for the front-end. This will be a web-based platform that provides the mechanism for interacting and supporting users, (depending on their roles and permissions) to access, visualize and analyze related assessment data. Data will be cached locally or reside on the application server using secure data storage (e.g. JSON based or SQL database). The frontend will be modular and customizable depending on the needs of the users, currently the web-app consists of a number of different views that together cover the assessment dimensions and dashboarding of results.

The frontend platform is built using the VueJS framework, Vuex for state management and Vuetify as the template for defining and customizing the website styles. In addition to this, custom features such as charts, widgets and forms will be incorporated through the use of open source third-party libraries (e.g. auto form builder to customize forms).

A high-level representation of the frontend components is shown in Figure 8**Error! Reference source not found.** and is the basis for the web application that uses a Vue based master template. From an abstract point of view, the web app follows the traditional and popular VueJS development architecture MVVM (Modal View View-Modal). This provides a modular approach and provides flexibility in cases where applications have a well-defined data structure as input to the visual components. For interaction with other potential services a promise-based HTTP client known as Axios will be utilized to retrieve and loads data to the client side Vuex store for further processing. Further the template will be extended to incorporate data analysis and visualization of assessment scores for interrogation and comparison. A report engine will be developed to capture the results of the assessments in a format that can be distributed within the organization or external as appropriate.

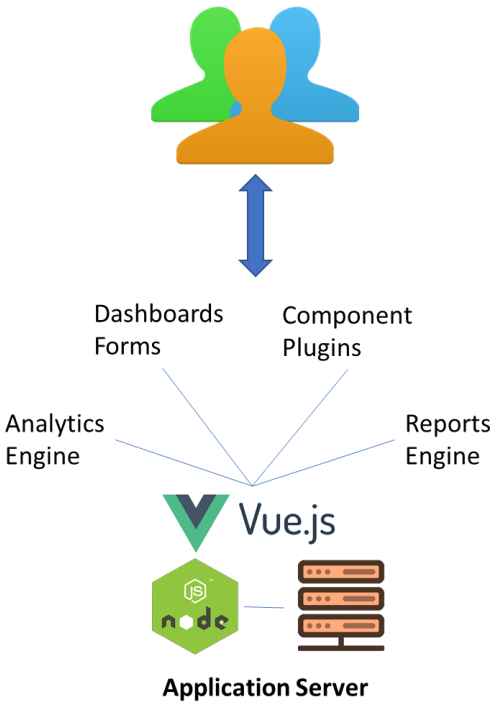

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Figure 8: Assessment tool implementation components

The validation of the tool will be conducted in close collaboration with the pilot partners as part of DENiM WP8, the following process is envisaged:

1. Workshops to engage on the general design and usability of the tools
2. The use of the tool across the different industry sectors
3. Review and assessment of the advantages and disadvantages of the tool, both from a usability and effectiveness perspective.
4. Based on usability-testing the tools will be enhanced and re-designed as appropriate.
5. A number of rounds of assessment are envisaged to support the evaluation of the tools to support continuous tracking of digital maturity.

In addition as part of the Community of Practice established within WP9, workshops will be setup to allow pilot partners to share learnings and experience regarding firstly the use of the tools and secondly the outcomes (success and failures) of implementing recommendations from the assessment tool. This will allow partners across sectors to share knowledge regarding the use of digital tools to support their specific needs in establishing energy efficient manufacturing processes.

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3 DENIM Worker Profiler

The Worker Profiler is a semi-automatic developed questionnaire able to measure the difference between the skills that a worker is currently owning and the ones that he/she needs to acquire to embody an ideal archetype (i.e. professional profile). The Worker Profiler is built starting from the detection of the existing and new archetypes for Energy management sector. The archetypes are designed through The Technimetro®, a set of Natural Language Processing algorithms, analysing International Competences Databases (ICDs).

The ICDs are dictionaries that classify occupations and skills in different countries. The primary sources of occupational information are ESCO[4] (European Skill/Competence Qualification and Occupation) for Europe and O*NET [5] (Occupational Information Network) for America. ESCO is a multilingual system that classifies jobs, capabilities, competences, and qualifications relevant to the labour market in Europe. The aim of this framework is to provide an overview of the relationship among skills, profiles, and qualifications in order to fill the gap between academia and industry in Europe. The occupation classification corresponds to ISCO-O8, which is the International Standard Classification of Occupations (International Labor Organization, 2008). O*NET, the American equivalent of ESCO developed for the U.S. Department of Labor, comprises occupations from the Standard Occupational Classification (SOC) system and their corresponding skills, knowledge, and abilities. Each job profile has quantitative information about the level and importance for every owned skill described above.

The ICD's, The Technimetro®, and the state-of-art retrievable from Deliverable T3.1, represent the main inputs of our analysis, while the Worker profiler will be the central output. The previous key elements are summarized in figure 9.

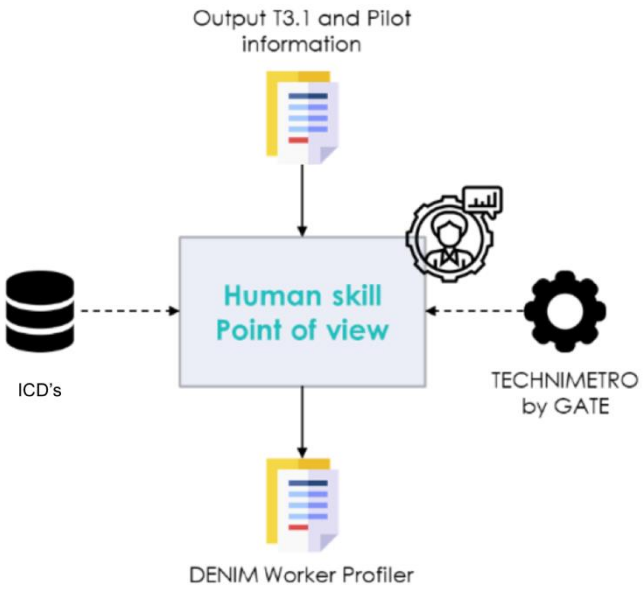

Figure 9: Main Inputs and Outputs for the development of the Worker Profiler

The process will start with the collection of ESCO job titles & skills and O*NET soft skills & Hot Technologies, namely the tools which are ever more required by the Labor market. Thus, the

[4] https://ec.europa.eu/esco/portal
[5] *https://www.onetonline.org*

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archetypes will be integrated with the technologies that proved to be relevant during the patent analysis performed in task 3.1; besides, the technologies will be used to identify the new archetypes (i.e. professional profiles that are not currently retrievable from ICDs). Once the database of existing and new professional figure is completed, the questions will be produced automatically. The questionnaire will be based on close-ended questions focusing on proficiency on soft skills, management or use of tools and the tasks usually performed. The output of the Worker Profiler will be the three archetypes the worker embodies the most and the difference between the skills he/she currently owns and the ones that he/she needs to acquire.

The paragraph is structured as follows: first of all, the methodology to define new and existing archetypes is presented in detail; after that, the semi-automatic development of the questionnaire and its structure are proposed; finally, the validation of the tool and the obtained results are shown.

3.1 New Archetypes & Skills

In the present paragraph, the authors propose a workflow to design the new archetypes and the new skills that need to be integrated into the existing ones. The process started with the parsing of the documents provided by task 3.1; they were investigated through text mining algorithms in order to define the boundaries of the overall analysis. After that, the new skills to be integrated and the new archetypes (i.e. clusters of skills and technologies) were computed, analyzing International Competence databases.

3.1.1 Definition of the Environment

All the documents and analyses result of task 3.1 were parsed by GATE algorithms.

Thus, GATE extracted:

- The **Job descriptions and the activity sectors** of pilot cases from Deliverable T3.1 and the declared **tools and software** from "Requirements Gathering: Pilot Specification";

Table 3: Extract of Job descriptions of pilots (collected from Deliverable T3.1)

Actor	Role	Interaction
Energy Manager	Energy Systems Integration Asset Identification (Significant Energy Users) Awareness and Policy implementation Energy Auditing and Performance Verification	Energy Performance Models & Verification of energy savings Decision Support System (Visualisation of Energy flows, performance metrics, reports)
...	...	...

- The **map of technologies** related to energy management (assessment, control and optimisation) for the industrial manufacturing sector, retrieved from patents.

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Table 4: Extract of tools from patent analysis (collected from Deliverable T3.1)

Technologies from patents
Air conditioning
Computer device
Heating device
Switching electrical device
Energy storage device
Communication device
Heat exchanger
...

3.1.2 Identifying existing archetypes and Integrating New Skills

Starting from the job descriptions, the pilot's activity sectors and the tools from the state-of-the-art, a set of existing archetypes was identified analysing International Competence Databases (ICDs), both ESCO and O*NET.

In more detail, the correspondent job profiles on ESCO were obtained:

- Identifying the job profiles that correspond to the job titles reported by pilots;
- Identifying the key job profiles for the activity sectors which have the key tools included in their skills.

The number of existing archetypes is **83**.

Once the existing archetypes were identified, the new skills should be integrated. To achieve the goal, a crosswalk between ESCO and O*NET was performed, allowing the collection of soft skills, tasks, technological skills coming from both the databases. In particular, the importance level for each soft skill and work style was retrieved from O*NET: the latter process guarantees the definition of **integrated** existing job profiles, since the content of O*NET database is different from the one retrievable from ESCO, both in term of detail level and data categories.

3.1.3 Designing New Archetypes

Since patents analysis shows where the innovation is currently focusing, it embodies a predictive overview of the future needs of skills as well. The output of 3.1 additionally defined what problems the technologies contribute to solve and, as explained before, it represents an effective way to cluster the elements.

The new technologies were searched in ICDs to collect the profiles which already owned them. The authors kept trace of the problems the technologies contribute to solve. After that, a ranking of the most impacted job profiles was drafted, and the authors identified the similitudes among the obtained job profiles, measuring the similarity between their skills through BERT.

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First cluster analysis

After that, a cluster analysis between the job profiles was be performed and a set of homogenized groups of jobs was automatically computed by an unsupervised algorithm (Blondel V. et al., 2008; Lambiotte et al., 2009). In this layout, two nodes are represented closely if they share an edge, and the closeness is proportional to edge weight. In this way, nodes that belong to the same communities of nodes (can be grouped into sets so that each set is densely connected internally) but do not share any edge are represented closely. In other words, the visualisations tend to be coherent with the clustering algorithm. The size of the node is proportional to its in-degree, while the colour signifies the cluster to which each node belongs. In the end, we obtained 9 clusters (Fig. 10).

Figure 10: First clustering of ICDs job profiles containing the greatest number of technologies retrieved from patents

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Second cluster analysis

The skills of each cluster were collected, and the duplicated skills deleted. After that, a further process of similarity analysis between the nine groups was performed, in order to avoid redundancy of skills and to find further similarities between the jobs. Again, a set of homogenized groups of jobs was automatically computed by an unsupervised algorithm (Blondel V. et al., 2008; Lambiotte et al., 2009). The aim of the process was obtaining the minimum number of new archetypes with definitely different characteristics. Eventually, the authors obtained 4 clusters (and **4 new archetypes** as well).

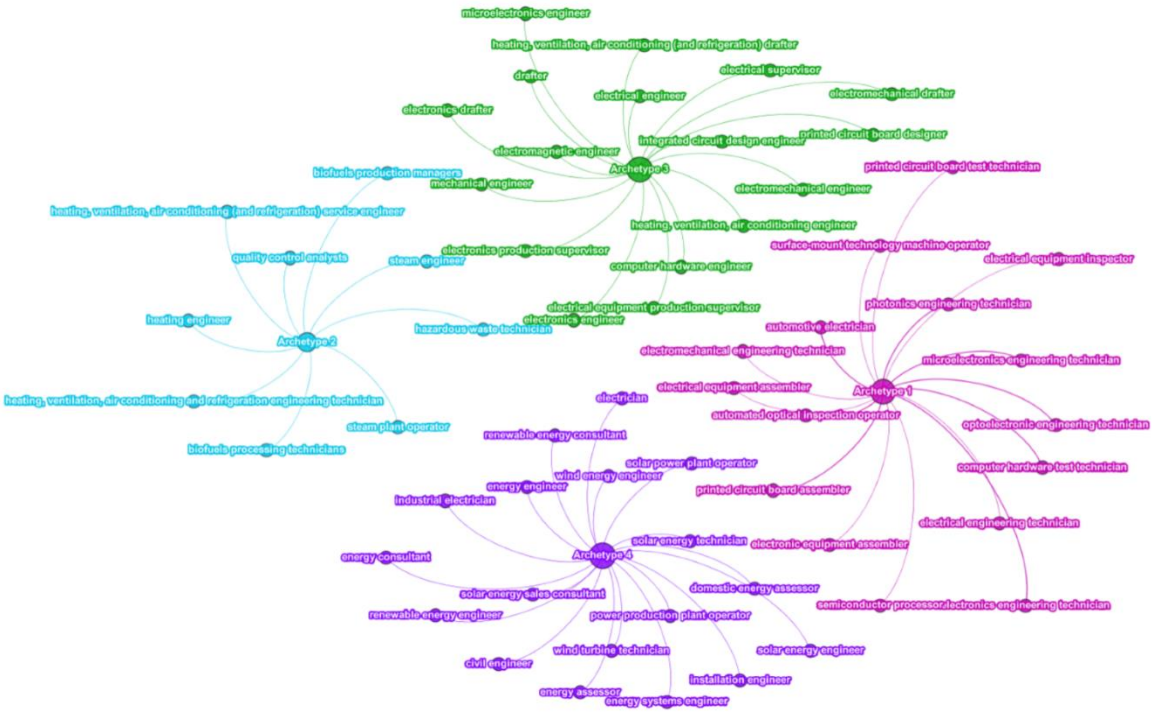

Figure 11: Second clustering of ICDs job profiles and definition of the new archetypes

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Definition of the job descriptions

The job descriptions of the new archetypes were designed joining the job descriptions of the initial job profiles and they were named by experts.

Table 5: Job title and Job description of the new archetypes

Job Title	Job Description
Energy System Supervisor	Energy system supervisor coordinate, plan and supervise the production of electrical systems, electrical equipment, electronic systems, components, motors, and equipment with the feature of energy transmission. they engage in large scale projects such as the design and maintenance of power stations. they manage labourers working on the production line, oversee the quality of the assembled goods, and perform cost and resource management.
Green Energy Engineer	Green energy engineer research alternative sources of energy in order to design systems for renewable energy production (for example, using wind and solar power). they supervise the energy extraction, conversion and distribution processes. they analyze the energy supply and consumption efficiency developing new ways to improve the existing processes, taking into account both the technical and the financial aspects. furthermore, they are able to determine the energy performance of buildings, giving advice on how to improve energy conservation.
Heating & Refrigeration Operator	Heating & refrigeration operator design and install fuel heating and ventilation equipment as well as conditioning and possibly refrigeration systems. they ensure the equipment complies with environmental standards. they follow instructions and blueprints, perform maintance on systems, perform safety checks and repair the systems. they handle hazardous materials used in the systems, and ensure safety precautions are in place, advising on the proper treatment of hazardous waste.
Optoelectronic & Photonics Technician	Optoelectronic & photonics technician install, maintain and repair electrical, electronic and electromechanical equipments. they are specialized at developing of optoelectronic and photonic systems and components, such as photodiodes, optical sensors, lasers and led's and inspecting assembled printed circuit boards.

Finalization of new archetypes

Starting from key technologies obtained from patents analysis and the problems they contribute to solve, which represent a conceptual clustering of the technologies, they were searched in the new archetypes' skills. If a technology belonging to a cluster was already present in the archetype, the other skills belonging to the same cluster were integrated as well. In this way, the authors ensured that archetypes covered all the technologies collected from patents during task 3.1. Besides, we their novelty and originality was guaranteed following an approach almost totally data driven.

Also in this case, a crosswalk between ESCO and O*NET was performed, allowing the collection of skills, tasks and technologies coming from the two databases. In particular, the importance level for each soft skill was retrieved from O*NET. In order to avoid redundant information, several cleaning rules were applied. As regard tasks, only ESCO essential skills were kept and, for what concerns tools, only the ones classified as “hot technologies” by O*NET were taken. As regard soft skills, since a new

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archetype is made by multiple existing archetypes, the value of its soft skills was obtained computing the mean value of soft skills of each profile. In the end, a list of **87** archetypes was obtained and reported in the Appendix; thus, we retrieve their job description, their soft skills, tasks, tools, and their importance level of each soft skills. All this information allowed the development of the back-end data of the Worker Profiler.

3.1.4 Definition of the macro-classes of Archetypes

Once the new and the existing archetypes were defined, the authors proposed a classification into three macro-categories, obtained using both a top-down and a bottom-up approach. Following the **top-down** approach, the archetypes were labelled according to the macro-category declared in ESCO. Through the **bottom-up** approach, the authors validate the goodness of the previous result through a cluster analysis based on the semantic similarity between profiles composing each class. The result of the similarity analysis confirmed the top-down classification and represent a cross-validation process of our categorization. The final three classes of archetypes are Technicians-Operators, Managers-Consultants and Engineering professionals.

Table 6: Archetypes's macro-classes and their definitions

Macro-Class	Definition
Technicians-Operators	Operators & Technicians perform technical tasks connected with research and operational methods in science and engineering. They operate and monitor plants and adjust and maintain processing units and equipment. They supervise and control technical and operational aspects of manufacturing, construction and other engineering operations.
Engineering Professionals	Engineering professionals design, plan and organize the testing, construction, installation and maintenance of structures, machines and their components, and production systems and plants; and plan production schedules and work procedures to ensure that engineering projects are undertaken safely, efficiently and in a cost-effective manner.
Managers-Consultants	Managers plan, direct, coordinate and evaluate the overall activities of enterprises, governments and other organizations, or of organizational units within them, and formulate and review their policies, laws, rules and regulations. Consultants provide advice on how to optimise the use of existing tools and systems, make recommendations for the development and implementation of a business project or technological solution and contribute to project definitions.

Figure 12 shows the three classes of job profiles and the relationships between the jobs.

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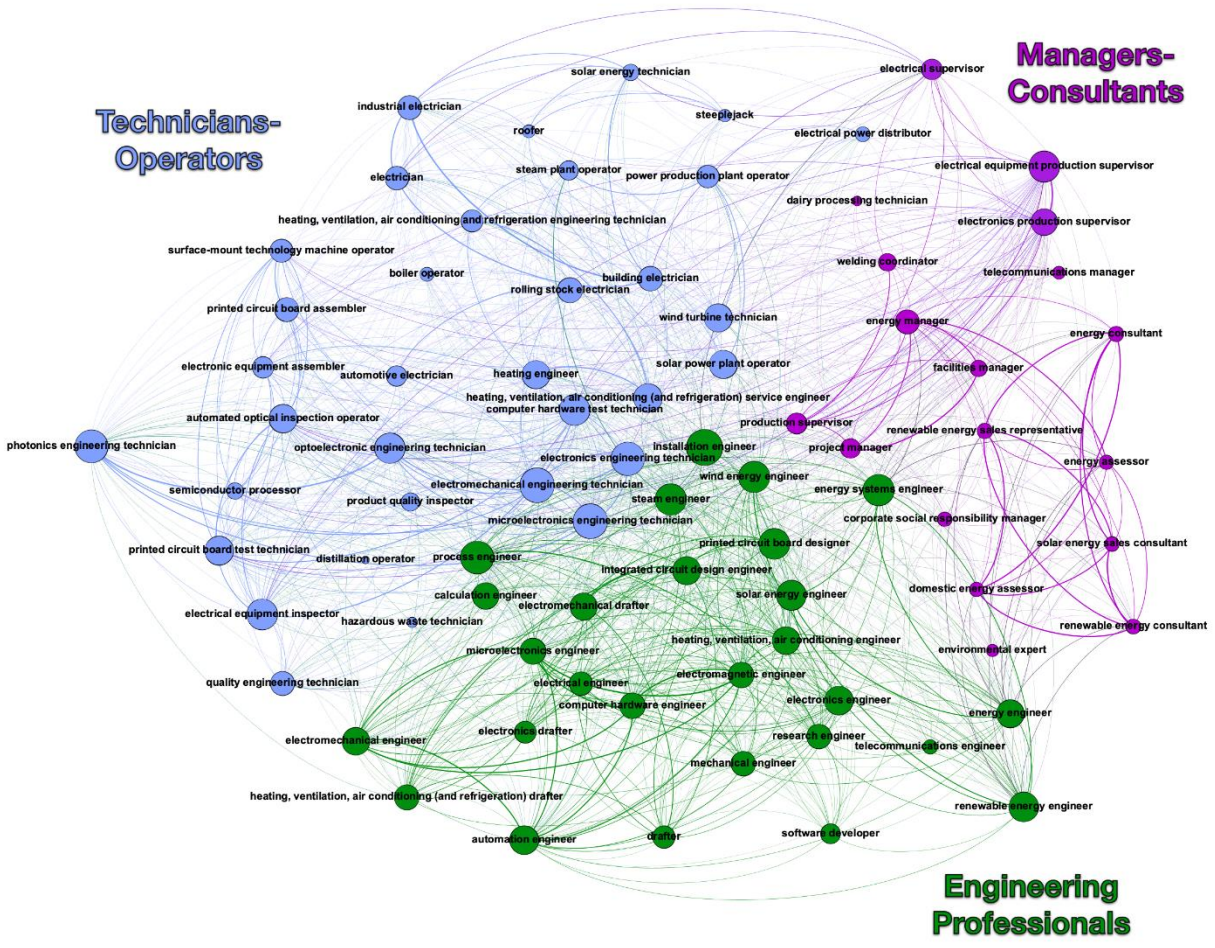

Figure 12: The three macro-classes of jobs and the job profiles that belong to each group.

3.2 Mapping the Skills Mismatching

In the present paragraph, the authors propose a methodology to map skills mismatching of real workers, in relation to the new requirements pushed by technological evolution. Once new archetypes and skills have been detected, they were used as input for the semi-automatic creation of questionnaires. According to the specific archetype, a set of rules was established to quantify the gaps. After that, a User-interface was developed to make the Worker Profiler accessible.

3.2.1 Semi-automatic Design of Questionnaire

The questionnaire is based on close-ended questions regarding:

- Proficiency on Soft Skills;
- Management or use of Tools;
- Tasks performed.

First of all, the worker will select the macro job profile that he/she embodies. The latter will be the first funnel of the questionnaire.

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After that, the worker will select the proficiency level for each proposed soft skill. The level of optimal proficiency for soft skill will be retrieved from O*NET. Furthermore, the list of key technologies will be proposed, asking if the worker usually uses or manages them. Finally, the worker will be asking to select the tasks (or the most similar) that she/he usually perform.

The output of the assessment will be the detection of the **3** archetypes the worker embodies the most, and the difference between the skills he/she currently owns and the ones that he/she needs to acquire. The assessment will provide several analytics to measure its main characteristics. The algorithmic workflow of the worker profiler is presented in figure 13.

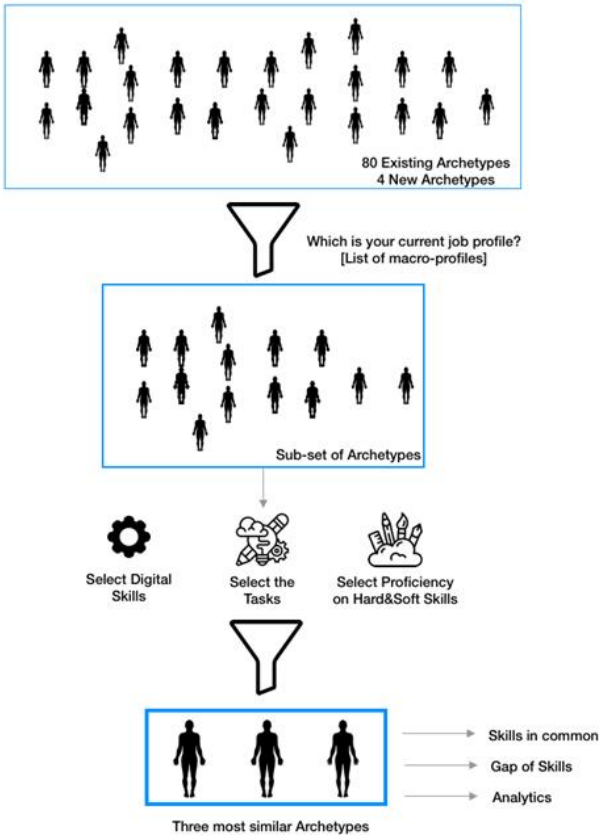

Figure 13: Representation of how the worker profiler works and the main outputs of the tool

3.2.2 Development of the questionnaire UI

The platform was designed and developed following minimalist UI principles, with the objective of having a clean looking, multi-device and multi-platform UI, fully working in PCs but also in Tablets and Mobile devices. For these reasons we relied on responsive Bootstrap code augmented with some ad-hoc CSS code, carefully selected Javascript libraries and a collection of SVG Icons. The color palette was chosen to resemble the official website colors and enhance recognizability between project's platforms.

The subsection below describes the details of the main blocks of the platform.

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- ***Landing Page***

Figure 14: Landing page of the worker profiler

The picture above shows the landing page, the entry point to the Digital Maturity & Skill Assessment platform. The landing is divided in 6 main blocks:

1. **Navigation header:** fixed in a top position with the links to the available sections. The header is fixed at the top of the UI and is user authorization dependent. E.g: if the user is logged in all sections are shown. If not, the user can only access the FAQs, Privacy Policy and Login page.
2. **Main Image:** Is the first thing the user sees when accessing the platform, and includes the landing image, the project icon and a two-liner with the project title. The content of this block adapts to the size of the device accessing the platform, so it covers all the visual area of the device. Under the Project logo and name, a link to the official project website is also present.
3. **Icons:** Is a collection of 4 icons with a title and subtitle linking to the 4 main functionalities of the platform. If the user is not logged and tries to access one of the sections of the platform requiring credentials, the user will be redirected to the login window.
4. **Description:** Provides a brief description of the project's objectives. This section is an informative section helping the user to acquire contextual information.
5. **Social Links:** Provides links to the official project social platforms.
6. **Footer:** includes the EU flag, the H2020 project number and the text stating that the project, and thus the platform, has received financial support from the EU commission. The footer as well as the navbar are inherited by all the pages in the platform.

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- ***User Panel***

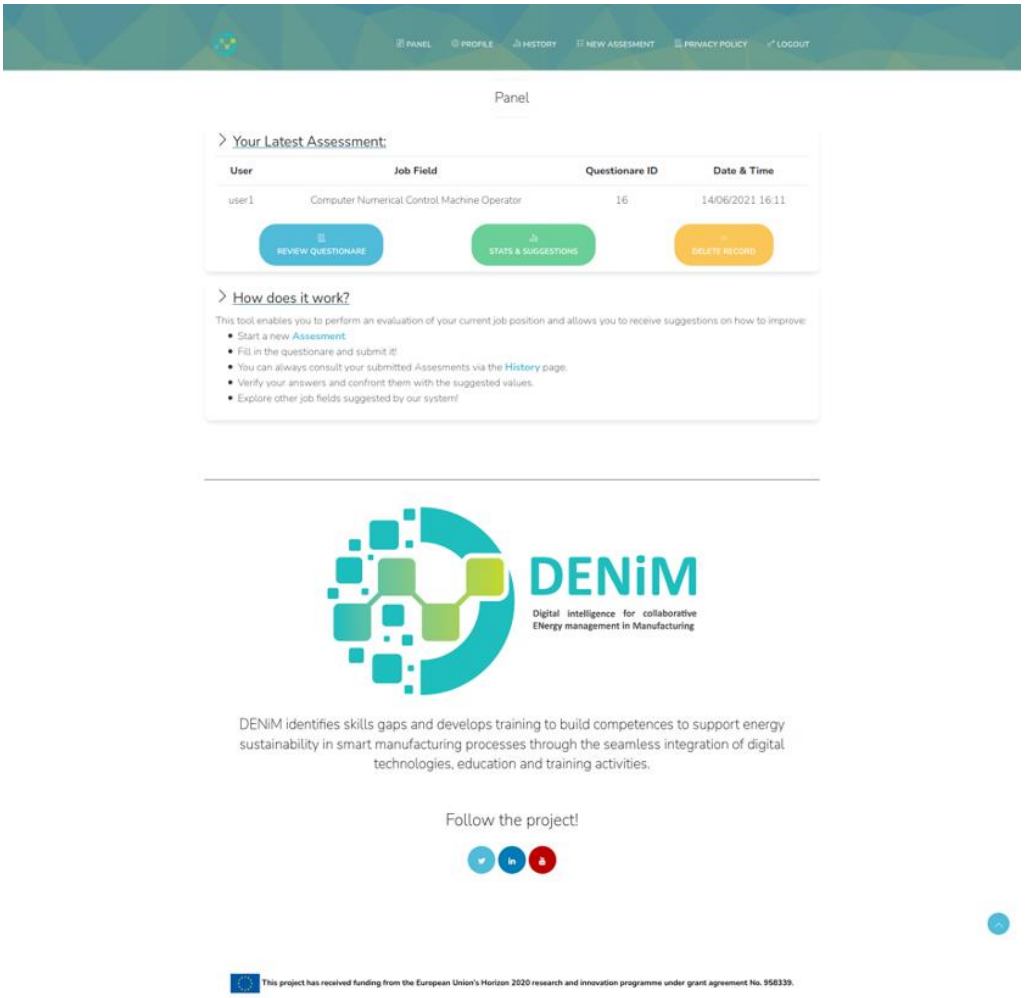

Figure 15: User panel of the worker profiler

The user panel is the first page a user sees after the login, it is divided into three sections:

1. **Latest Assessment:** a quick overview on the latest Assessment the user submitted, in this section are displayed the general information regarding the assessment and three buttons that will connect the user to the *Review*, *Statistics and Suggestions* sections, also a button to delete the current assessment is present. These buttons are similar across the whole platform to enhance recognizability. Hovering the mouse over the buttons will show a tooltip that will briefly explain the action performed by every button.
2. **Tutorial:** a section that quickly informs the user of what to expect when using the platform, with some links to the various sections of the platform.
3. **Objectives:** A quick overview of the objectives, this time focusing on the platform itself, followed by the Project logo and some social links.

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- ***How It works: New Assessment***

This section represents the heart of the platform itself, from the *New Assessment* section it is possible to start a new assessment via the dynamically generated questionnaire. This section is protected by an authentication mechanism, only stakeholders with credentials have access to this part of the system. The Assessment process can be divided into two phases, this division has been implemented to limit the user error and enhance user experience, every action that can be performed by the user will unlock the next action that can be taken, and the user will be notified via UI elements.

1) Generation of a questionnaire: In this phase the user can choose the *macro job field* and subsequently the *job field*. This information will be fundamental when generating a new questionnaire based on the *archetype* chosen by the user. The user is guided during the generation process via UI elements and contextual info regarding the *archetype* and *macroclass* chosen are displayed to let the user acquire contextual information before the generation of a new questionnaire. This will enable the user to carefully test and select the most appropriate *archetype* before generating the questionnaire.

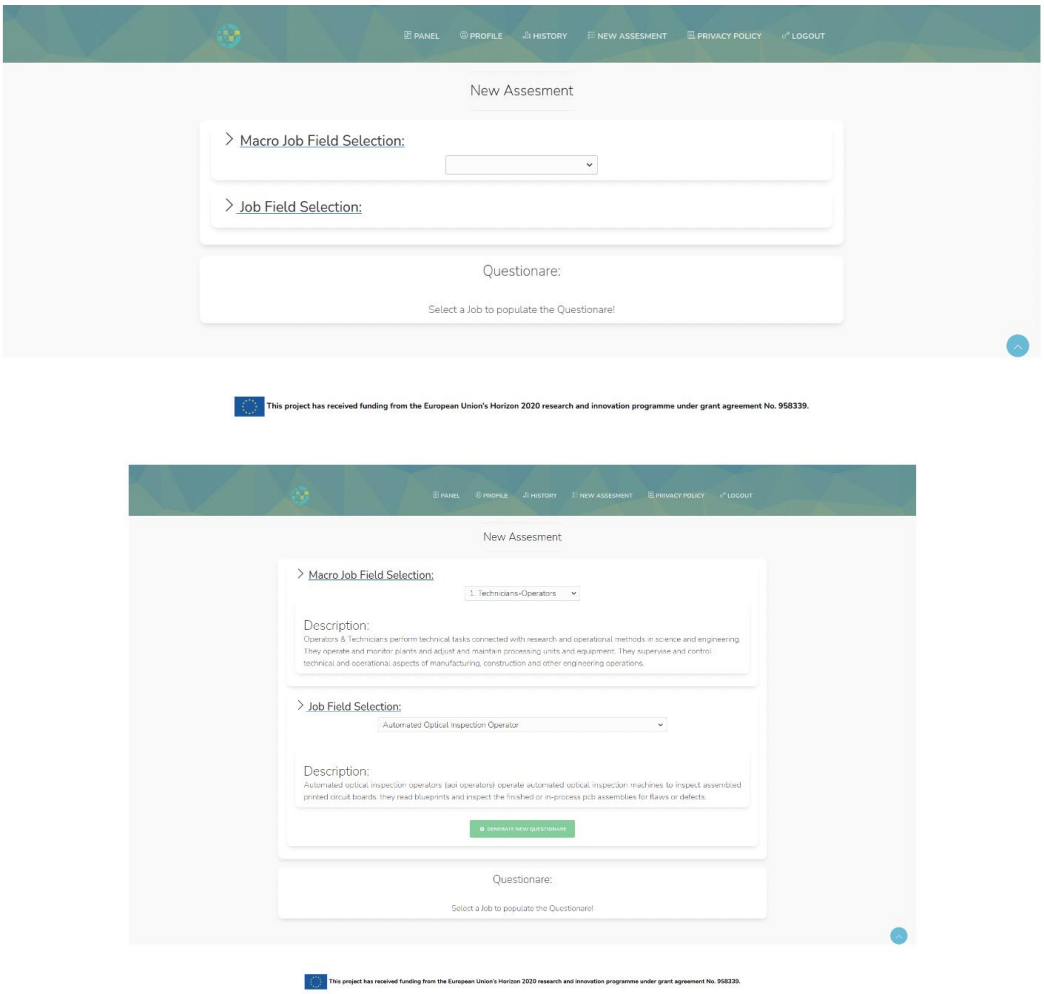

Figure 16: Generation of the questionnaire

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2) Submission: The generated questionnaire is divided into three main parts to facilitate the submission. The first two parts are related to Tools and Tasks, the user is required to select the ones that he is familiar with. The selection is proposed via a simple checkbox to ensure that the minimum number of clicks is needed for the user to advance to the next part. All the tools and tasks suggested by the system are extrapolated from the database using the *archetype* chosen by the user at generation phase as a guide.

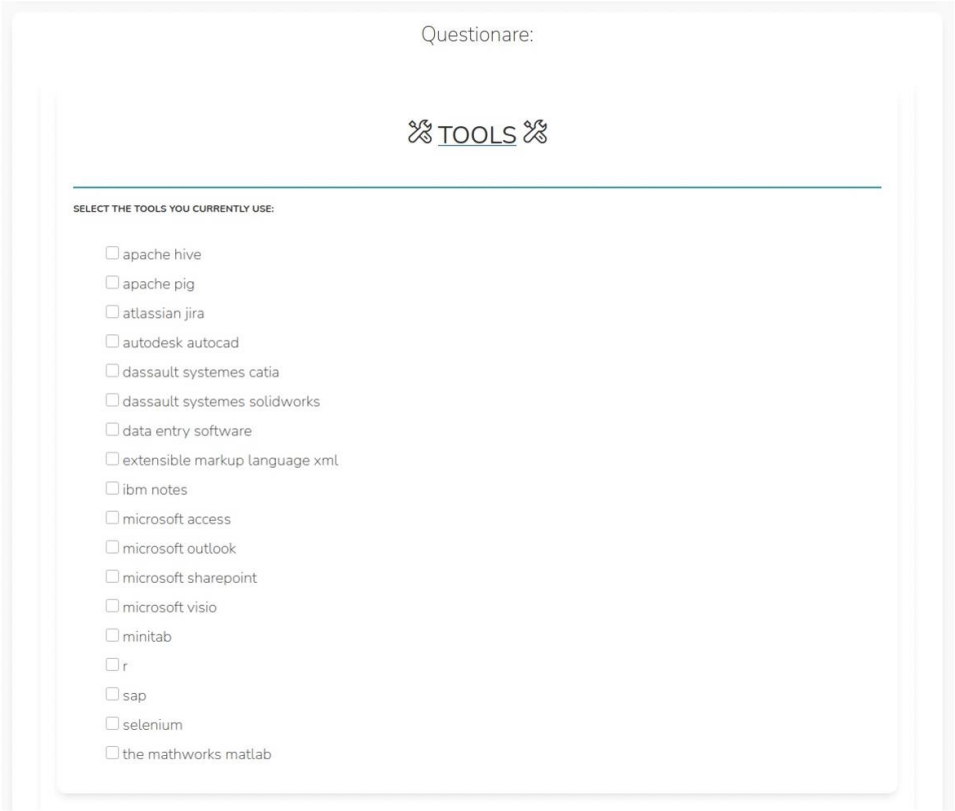

Figure 17: Selection of tools

The third and final section of the questionnaire will require the user to answer with a numeric value to the soft skill questions, where 1 is acknowledged as the lowest value and 5 the highest. A definition of what the different levels mean will be integrated in the platform.

At the end of the questionnaire a submit button will be present.

Clicking on the submit button will visualize a popup to let the user read and accept the privacy policy, the questionnaire can be submitted and saved to the database only if the privacy policy has been accepted. All the personal data gathered and processed will be done according to the applicable laws and regulations (e.g GDPR) and to the requirements detailed in the deliverables D10.1 "Humans: H – Requirement No. 1" and D10.2 "Protection of Personal Data: POPD –Requirement N0. 2" furthermore the processing of personal data will be compliant with the directives from WP2 and D.2.3.

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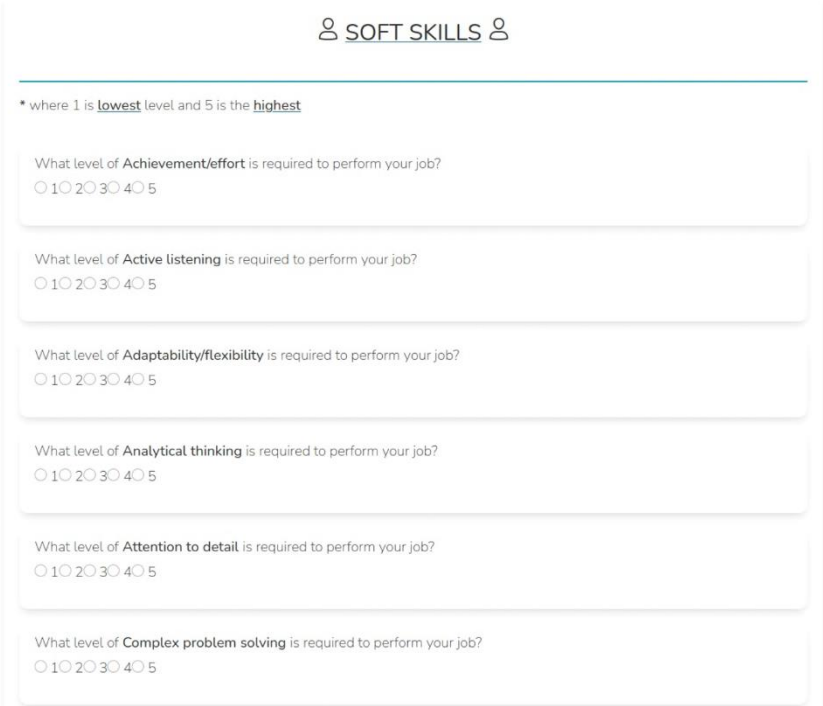

Figure 18: Selection of soft skills

To inform the user that the assessment has been submitted correctly he will be redirected to a success page, in which three actions will be permitted (via buttons), to *Review* the questionnaire, view the *Statistics and Suggestions* or *Delete* the assessment from the database, for each button, tooltips will be visualized when hovering over with the mouse to help the user understand which actions they'd like to take next. Each button is similar to the ones present in the *User Panel* to enhance recognizability throughout the platform.

- ***Output: Review***

This section focuses on the comparison between the **answers provided** by the user via the assessment and the **reference archetype** chosen in the questionnaire generation phase. It provides the user e summary of all the submitted answers and enables the user to review their process or their evaluation with a particular archetype. Tables and UI elements have been used to represent the data provided by the system, focusing on simplicity of visualization and user experience.

The Review section is divided into three main parts:

1) **General Information**: This section will provide general information about the submitted questionnaire, i.e. Questionnaire ID, job field selected, date and time.

2) **Tools and Tasks**: This section will provide a recap of the submitted answers and the suggestions provided by the system. For ease of use and visualization a simple table has been chosen, differentiating between *selected* tools and *suggested*. A similar table will be provided for the tasks section.

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Review

General:

User	Job Field	Questionare ID	Date & Time
user1	Automated Optical Inspection Operator	11	03/06/2021 12:34

Job Field Description:

Automated optical inspection operators (aoi operators) operate automated optical inspection machines to inspect assembled printed circuit boards. they read blueprints and inspect the finished or in-process pcb assemblies for flaws or defects.

TOOLS

Selected	Suggested
• Atlassian jira • Dassault systemes solidworks • Ibm notes • Microsoft sharepoint • R • Sap • Selenium	• Autodesk autocad • The mathworks matlab • Data entry software • Microsoft access • Apache pig • Microsoft outlook • Dassault systemes catia • Microsoft visio • Minitab • Apache hive • Extensible markup language xml

Figure 19: Results of the Worker Profiler (a)

3) **Soft Skills**: In this section the answer related to the soft skills will be presented in a simple table containing for each row the name of the soft skill, the answer provided and a UI element that provides an evaluation of the latter. If the answer provided satisfies the requirements in terms of soft skill of that particular archetype, a green check will be visualized, otherwise a red x. This approach will enable the user to quickly and consistently understand the evaluation of the answer provided.

SOFT SKILLS

Name	Selected	Valutation
Achievement/effort	3	×
Active listening	4	✓
Adaptability/flexibility	2	×

Figure 20: Results of the Worker Profiler (b)

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- ***Output: Statistics & Suggestions***

The Statistics & Suggestions section has been developed in a similar manner to the *Review* section to allow recognizability of the data provided.

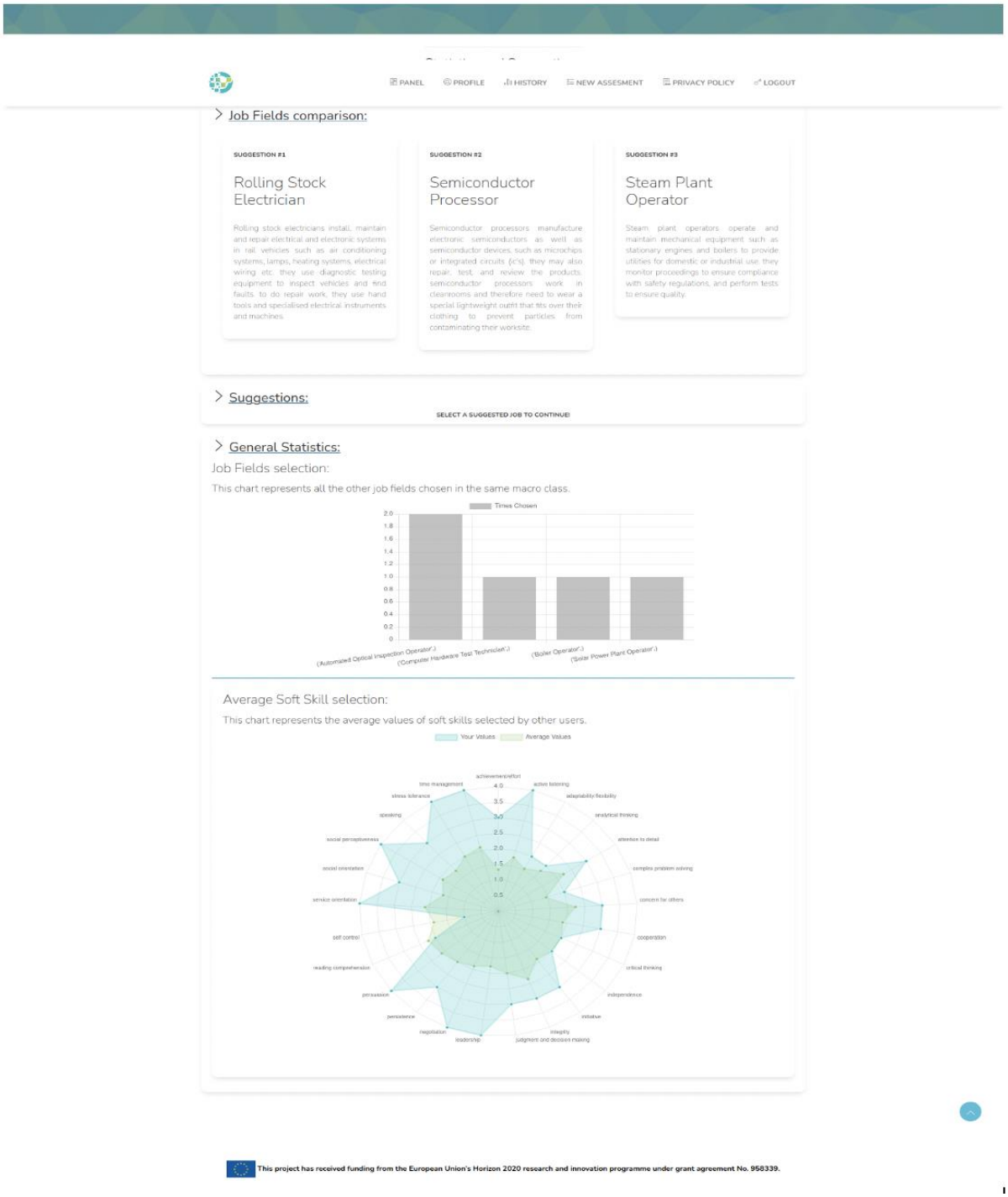

Figure 21: Statistics & suggestions (a)

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The objective of this section is to allow the user to:

- **Browse** through the **suggestions provided** by the system: The system developed provides the user with 3 suggested archetypes that are deemed to be similar by the system, to the archetype chosen in the questionnaire generation phase, and are appropriate to the answers submitted. Visually the user will be presented with 3 suggestions in the form of interactable cards, when the user selects one particular card, a new section will appear in the appropriate section and the user will be notified via UI elements. The user can at any moment select another card and dynamically change the data visualization. On the back-end, the suggestions provided by the system are calculated taking into account three main aspects, in order of importance, soft skills, tools and tasks. The system takes the answers provided by the user and calculates a "similarity score" for every archetype in the same macroClass as the one selected by the user in the questionnaire generation phase, finally the three archetypes with the highest score are selected to be presented as suggestions to the user.

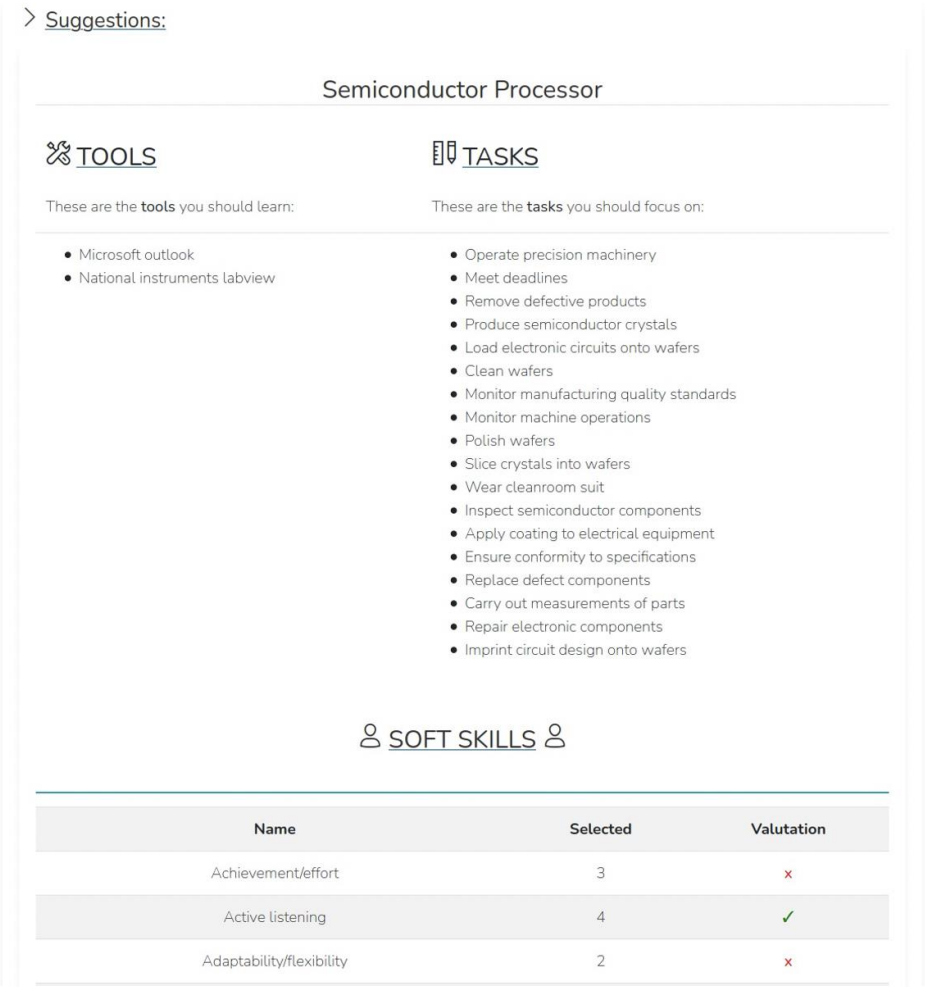

Figure 22: Statistics & suggestions (b)

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As stated above this section will be presented in a similar way to the Review section to allow for recognizability of the presentation, the only difference being that the comparison is done between the **answer provided** by the user and the **archetype suggestion selected** via the interactive cards. Tables and UI elements have been used to represent the data provided by the system, focusing on simplicity of visualization and user experience. In the first table the *Tools* and *Tasks* that the user needs to acquire for this particular *archetype* are presented. In the second table the evaluation of the answers related to the soft skills will be presented in a simple table containing for each row the name of the soft skill, the answer provided and a UI element that provides an evaluation of the latter. If the answer provided satisfies the requirements in terms of soft skill of that particular archetype, a green check will be visualized, otherwise a red x. This approach will enable the user to quickly and consistently understand the evaluation of the answer provided.

- **Visualize general statistics**: In this section the user will be able to visualize different dynamically generated graphs. For example the number of times other *archetypes*, in the same *macroClass*, have been chosen by other users. The average values of each *soft skill* calculated taking into account the answers from all the users in the same *macroClass*, compared to the current user's answers. All the graphs are interactable and developed via the use of the library chart.js.

- ***History & Security***

The History section will present the user a list of all the *assessments* made in the past, coupled with basic information to permit the differentiation between them. For every row three buttons will be present, these buttons will redirect the user to the *Review* section, *Statistics & Suggestions* section, or to *Delete* the assessment. If the user hovers on top of one of these buttons with the mouse a brief tooltip describing the action will appear. The list is ordered in a reverse chronological order to facilitate the usage. This section is protected by an authentication mechanism, only stakeholders with credentials have access to this part of the system.

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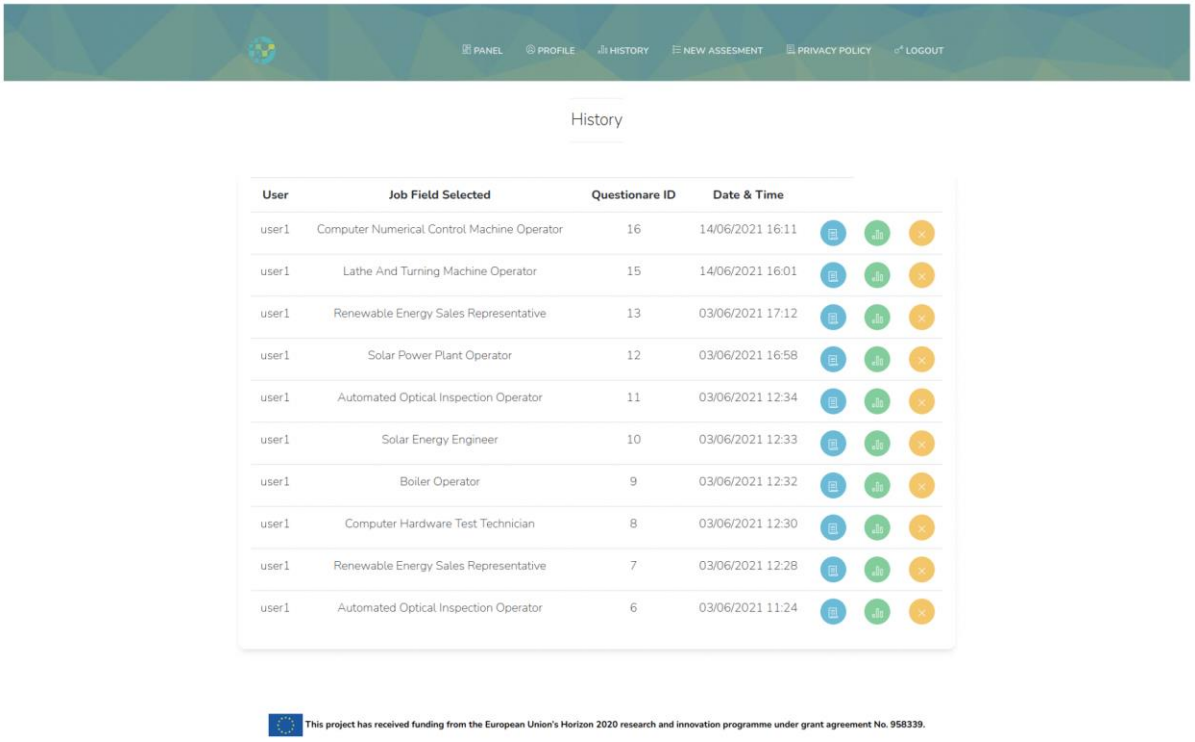

User	Job Field Selected	Questionare ID	Date & Time
user1	Computer Numerical Control Machine Operator	16	14/06/2021 16:11
user1	Lathe And Turning Machine Operator	15	14/06/2021 16:01
user1	Renewable Energy Sales Representative	13	03/06/2021 17:12
user1	Solar Power Plant Operator	12	03/06/2021 16:58
user1	Automated Optical Inspection Operator	11	03/06/2021 12:34
user1	Solar Energy Engineer	10	03/06/2021 12:33
user1	Boiler Operator	9	03/06/2021 12:32
user1	Computer Hardware Test Technician	8	03/06/2021 12:30
user1	Renewable Energy Sales Representative	7	03/06/2021 12:28
user1	Automated Optical Inspection Operator	6	03/06/2021 11:24

Figure 23: History section interface

Regarding the **security**, and apart from the secure communication support, the system includes an authentication mechanism, so part of the system is only accessible if the user is authenticated. The passwords are stored encrypted and the system includes a logger system so the simulation and other relevant actions can be monitored and issues/errors tracked.

3.3 Pilots site Validation

The output of the Worker Profiler are the three archetypes the worker embodies the most and the gap between the skills he/she currently owns and the ones that he/she needs to acquire. Since the Worker Profiler is a tool, the goal of the validation process is to measure if it is *user friendly* and easily fillable by any worker, both considering compilation time and understanding of the compiling process. Moreover, the validation will test if the results and the outputs are coherent, measuring the percentage of erroneous match performed.

3.3.1 Lean Model Canvas

In table 4, the authors define the **Lean Model Canvas** that lays behind the Worker Profiler and allows the design of the validation strategy. It was decided to use the Lean Model Canvas tool, based on the Lean Startup methodology (Ries, 2011), as it allows us to analyze an innovative initiative with respect to the value generated for end users. Furthermore, it is very useful to define a strategy for testing all the elements that allow to create value for the end user.

In table 4 the Lean Model Canvas of the Denim Worker Profiler is represented.

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Table 7: Worker profiler's Lean Model Canvas

Problem	Solution	Unique Value Proposition	Unfair Advantage	Customer Segment
I want to increase my skills raise my level of attractiveness in the job market and in my firm, to be recognized as Key Users of a new Energy Management technology / process	Through an automatic questionnaire, the worker receives a list of skills to acquire to embody the most requested energy efficiency jobs on the market, to increase their importance within the company and their attractiveness outside the organization	***Being the best version of yourself***	Integration between technology and consulting. Transform skill consulting into a product (tool)	Workers (Operators, engineers, managers) involved in Energy management processes
I want to obtain reliable information to detect the best training path for each worker, formalizing their current skills and the ones they need to acquire for maximizing the efficiency of energy management processes	Through an automatic questionnaire, the decision maker receives the skills currently present in the company, standardized according to ICDs. Moreover, the decision maker receives the Energy efficiency skills gap and an indication of the investment necessary for filling the previous gap	***No more waste*** ***(Even in wrong training)***		Decision Makers (Hr Management)

3.3.2 Validation Plan & Testing Methods

The Worker Profiler will be tested starting from August 2021 and in different moments of the project, involving all the Pilots and their workforce detected as relevant and impacted by Energy Efficiency and Management Technologies. The testers will be **at least one** representative for each macro-category, from each pilot firm [**12-15** participants].

In table 5 a framework was used to test the assumptions made for the development of the DENIM worker Profiler. The structure of this framework is composed as follows:

- Extracting the key Assumptions taken into consideration for the design of the tool;
- defining the hypotheses connected to the extracted key assumptions.
- Establishing the testing methods that allow to refute or accept the defined hypotheses and then, understand if the generated assumptions were correct.

The key assumptions, which can be seen in Table 5, are all related to the elements on the Lean Model Canvas of the Denim Worker Profiler represented in Table 4.

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Table 8: Worker profiler's Validation Strategy

Key Assumption	Hypothesis	Testing Methods
The Tool is able to retrieve the three most similar job profile for each worker	Less of 10% of mistakes	After having compiled the worker profiler questionnaire, we will ask the workers to select the job profile that he/she thinks to embody the most. They will select the job from the entire list of archetypes.
Explicitly reporting the definition of each macro-category of professional profiles avoids erroneous category choices	Less of 10% of mistakes	After having compiled the worker profiler questionnaire, we will ask the workers to select the job profile that he/she thinks to embody the most. They will select the job from the entire list of archetypes. We will then identify the macro-category to which it belongs to and we will compare it to the one selected by the worker at the beginning of the worker profiler questionnaire.
The macro-category choice will make the questionnaire affordable in terms of time	Mean compiling time is 30 minutes	Measuring the mean compiling time
The decision maker took advantages from the use of the worker profiler	More than 80% of users consider the tool useful	Questions to measure the customer satisfaction
The user can easily perform a task in the platform	At least 80% of the users, find it easy to perform the listed actions/tasks	Computer Usability Testing - Questionnaire
The user can easily perform a task in the platform	At least 80% of the users, find it easy to perform the listed actions/tasks	Portable Device Usability Testing - Questionnaire
The platform offers good response time and interaction	At least 80% of the tests show response time above given threshold	TTFB – Time to Render Metrics - Questionnaire

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4 Conclusions

Due to the increasingly relevance of energy efficiency in manufacturing and the ever more relevant impact of technological wave on firms and jobs, the goal of this deliverable was to design a set of replicable tools to measure the digitization gap of companies from two interconnected perspectives: technological and of human skill.

From a technological point of view, the objective was to define an approach to enable relevant stakeholders (across DENiM pilot partners) to assess their capacity to leverage advanced digital tools with a particular emphasis on supporting the integration of energy efficiency as a key criteria in optimising existing processes. This requires a number of steps, i) a review of the current area of interest for an organisation ii) the assessment of focus area across a number of dimensions (e.g. operational, digital, energy) that informs iii) a representation of the status quo by creating a digital maturity index. The approach taken was to integrate this assessment into an online tool that can be used not only to conduct and analyse the assessment but to support the continuous tracking and re-assessment of digital maturity as an organisation implements initiatives to advance their digital capabilities. This is complemented through other engagement approaches and common goal setting to enable the definition of a road map towards a situation where they can maximise the opportunities for using tools such as those developed in DENiM.

From a human skill point of view, the output consisted in the development of the DENIM Worker Profiler, which is a tool capable of detecting the missing skills of workers in relation to designed archetypes 4.0. Starting from the job descriptions, the pilot's activity sectors and the tools from the state-of-the-art, a set of existing archetypes was identified analysing International Competence Databases (ICDs). The number of existing archetypes retrieved was 83. Thus, since the key technologies detected from patents analysis shows were searched in ICDs to identify the profiles which already owned them. After that, a ranking of the most impacted job profiles was drafted, and the authors identified the similitudes among the obtained job profiles, measuring the similarity between their skills through BERT, designing 4 new archetypes. The final number of archetypes was 87.

Then, the authors propose a methodology to map skills mismatching of real workers, in relation to the new requirements pushed by technological evolution. Once new archetypes and skills have been detected, they were used as input for the semi-automatic creation of questionnaires. According to the specific archetype, a set of rules was established to highlight the differences, considering tools, soft skills and task performed. After that, a User-interface was developed to make the Worker Profiler accessible.

The output of the assessment was the detection of the 3 archetypes the worker embodies the most, and the differences between the skills he/she currently owns and the ones that he/she needs to acquire. The latter represents the starting point to detect ad hoc training courses and to define the customized up-skilling strategy.

This deliverable provides the design and specification of the components that constitute the digital maturity and skills assessment toolkit. Based on this initial specification the toolkit will be implemented aligned with the four DENiM pilot sectors. The toolkit will be subsequently applied and evaluated each pilot and where appropriate enhanced and improved. To conclude, the assessment process aims to be data-driven, efficient and easy to replicable in other contexts and industrial sectors and will offer evidence-based approach to enhance the maturity and workforce skills towards digital and sustainable factories of the future.

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6 Appendix: The archetypes and their macro-classes

Table 9: The existing and new archetypes and the correspondent macro-classes

Archetype Name	Macro-Class
Automated Optical Inspection Operator	Technicians-Operators
Automation Engineer	Engineering Professionals
Automotive Electrician	Technicians-Operators
Boiler Operator	Technicians-Operators
Building Electrician	Technicians-Operators
Calculation Engineer	Engineering Professionals
Computer Hardware Engineer	Engineering Professionals
Computer Hardware Test Technician	Technicians-Operators
Computer Numerical Control Machine Operator	Technicians-Operators
Corporate Social Responsibility Manager	Managers-Consultants
Crop Production Manager	Managers-Consultants
Dairy Processing Technician	Technicians-Operators
Distillation Operator	Technicians-Operators
Domestic Energy Assessor	Managers-Consultants
Drafter	Engineering Professionals
Electrical Engineer	Engineering Professionals
Electrical Equipment Inspector	Technicians-Operators
Electrical Equipment Production Supervisor	Managers-Consultants
Electrical Power Distributor	Technicians-Operators
Electrical Supervisor	Managers-Consultants
Electrician	Technicians-Operators
Electromagnetic Engineer	Engineering Professionals
Electromechanical Drafter	Engineering Professionals
Electromechanical Engineer	Engineering Professionals
Electromechanical Engineering Technician	Technicians-Operators
Electronic Equipment Assembler	Technicians-Operators
Electronics Drafter	Engineering Professionals
Electronics Engineer	Engineering Professionals
Electronics Engineering Technician	Technicians-Operators
Electronics Production Supervisor	Managers-Consultants
Energy Assessor	Managers-Consultants
Energy Consultant	Managers-Consultants
Energy Engineer	Engineering Professionals
Energy Manager	Managers-Consultants
Energy System Supervisor	Managers-Consultants
Energy Systems Engineer	Engineering Professionals

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Environmental Expert	Managers-Consultants
Facilities Manager	Managers-Consultants
Green Energy Engineer	Engineering Professionals
Hazardous Waste Technician	Technicians-Operators
Heating & Refrigeration Operator	Technicians-Operators
Heating Engineer	Technicians-Operators
Heating, Ventilation, Air Conditioning (And Refrigeration) Drafter	Engineering Professionals
Heating, Ventilation, Air Conditioning (And Refrigeration) Service Engineer	Technicians-Operators
Heating, Ventilation, Air Conditioning And Refrigeration Engineering Technician	Technicians-Operators
Heating, Ventilation, Air Conditioning Engineer	Engineering Professionals
Industrial Electrician	Technicians-Operators
Installation Engineer	Engineering Professionals
Integrated Circuit Design Engineer	Engineering Professionals
Lathe and Turning Machine Operator	Technicians-Operators
Mechanical Engineer	Engineering Professionals
Medical Device Assembler	Technicians-Operators
Microelectronics Engineer	Engineering Professionals
Microelectronics Engineering Technician	Technicians-Operators
Optoelectronic & Photonics Technician	Technicians-Operators
Optoelectronic Engineering Technician	Technicians-Operators
Photonics Engineering Technician	Technicians-Operators
Power Production Plant Operator	Technicians-Operators
Printed Circuit Board Assembler	Technicians-Operators
Printed Circuit Board Designer	Engineering Professionals
Printed Circuit Board Test Technician	Technicians-Operators
Process Engineer	Engineering Professionals
Product Quality Inspector	Technicians-Operators
Production Supervisor	Managers-Consultants
Project Manager	Managers-Consultants
Quality Engineering Technician	Technicians-Operators
Renewable Energy Consultant	Managers-Consultants
Renewable Energy Engineer	Engineering Professionals
Renewable Energy Sales Representative	Managers-Consultants
Research Engineer	Engineering Professionals
Rolling Stock Electrician	Technicians-Operators
Roofer	Technicians-Operators
Semiconductor Processor	Technicians-Operators
Software Developer	Engineering Professionals
Solar Energy Engineer	Engineering Professionals
Solar Energy Sales Consultant	Managers-Consultants

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Solar Energy Technician	Technicians-Operators
Solar Power Plant Operator	Technicians-Operators
Steam Engineer	Engineering Professionals
Steam Plant Operator	Technicians-Operators
Steeplejack	Technicians-Operators
Surface-Mount Technology Machine Operator	Technicians-Operators
Telecommunications Engineer	Engineering Professionals
Telecommunications Manager	Managers-Consultants
Welding Coordinator	Managers-Consultants
Wind Energy Engineer	Engineering Professionals
Wind Turbine Technician	Technicians-Operators

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