WP3. Setting the professional skills of “new workers” in industrialised construction

Survey and validation-Final report-Spain

April 2024

Content

Introduction

This document presents the main results of the survey and the validation process that have been implemented in Spain as part of the *BuildOffsiteEU project: offsite industry - towards innovation in construction sector*. The main objective of the survey is to obtain information on the skills of the construction workforce needed for the transition to industrialized construction, improving energy efficiency and circular economy, and to know which of these skills need to be updated.

Four professional profiles with different levels of qualification have been chosen, taking into account that these are personnel in the sector who can cover the most common construction activities. Different skills have been proposed withing each profile, organized in three main groups: Managerial, Transversal and Technical skills.

Those competencies referenced in the European multilingual classification of Skills, Competences, Qualifications and Occupations (ESCO) were included within each group and respondents were asked to rate whether each one is currently present and/or needs to be updated in order for the workforce to transition from traditional to industrialized construction. They were also asked to indicate whether any other, not included in the list, should be considered as a current competency and/or as a competency to be updated.

The four groups of selected occupations were:

- *Electrical installer-Solar energy technician.*
- *Heating, ventilation, air conditioning and refrigeration engineering technician- HVAC engineering technician.*
- *Roofers-Ceilling instalers.*
- *Bricklayer.*

The survey, which was anonymous, was developed using Google Forms and sent by e-mail to potential respondents.

Once the process of collecting responses to the survey had been completed, a report was drawn up with the main results and sent to experts for final validation. This validation was carried out by means of an online, anonymous survey using the Google Forms tool. This survey has two main sections:

- Evaluation of the skills to be updated
- Evaluation of the National Report in relation to the quality of the information included, both qualitative and formal.

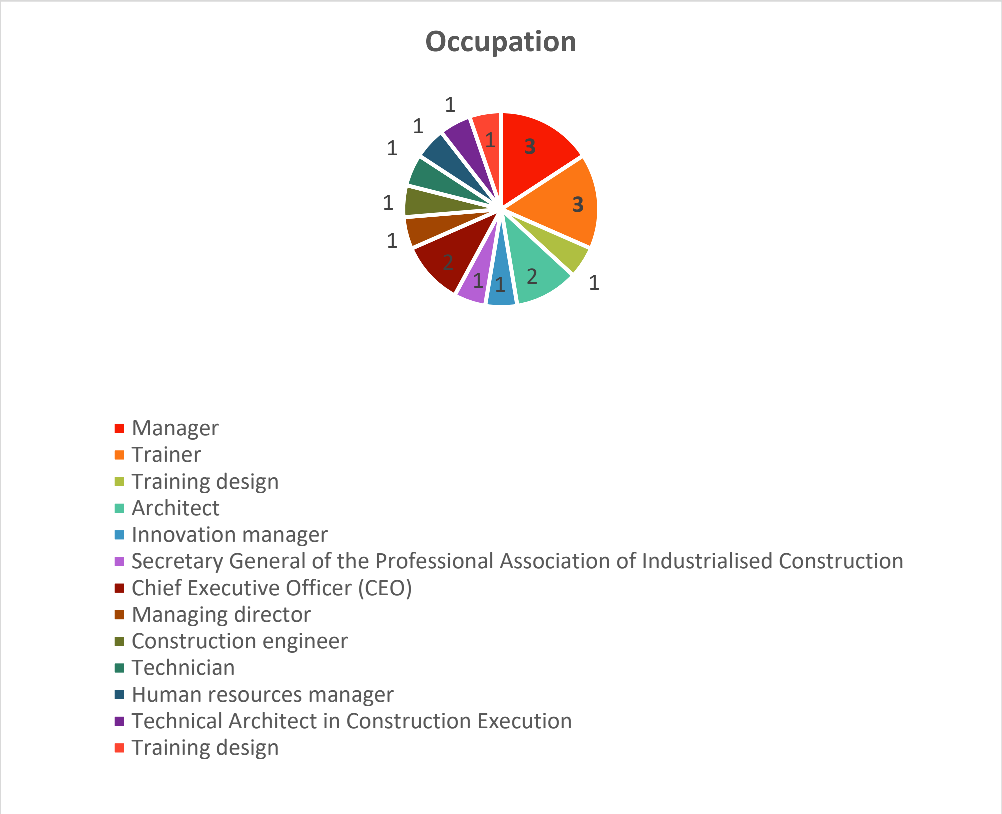
The results can be seen in the second part of this report.

Main results of the online survey

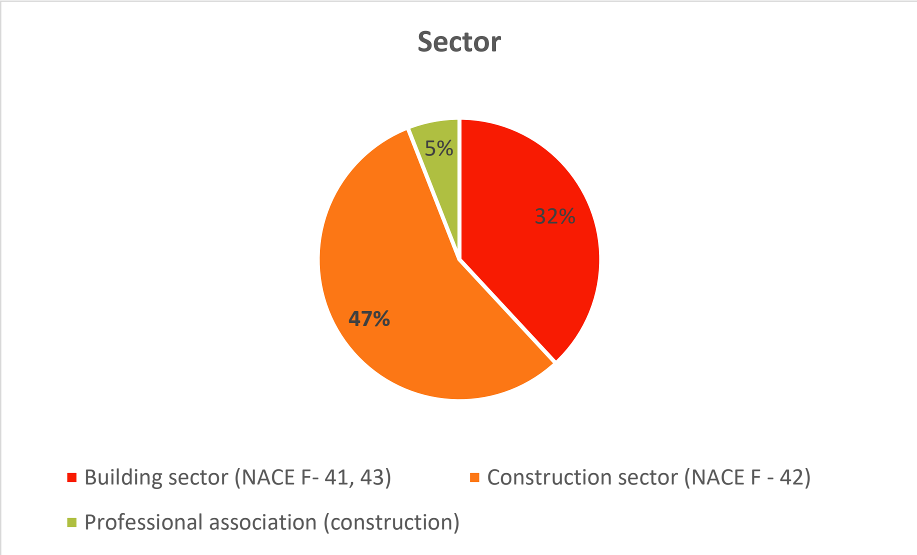
The main results of the survey are presented below (see Annex 1 for the questionnaire). The first block of questions included questions related to the profile of the participants to find out their current occupation, the area of activity within the construction sector where they work (according to the company's NACE), their job position, their gender and their age.

The results obtained in each of these areas are as follows.

Respondents' profile

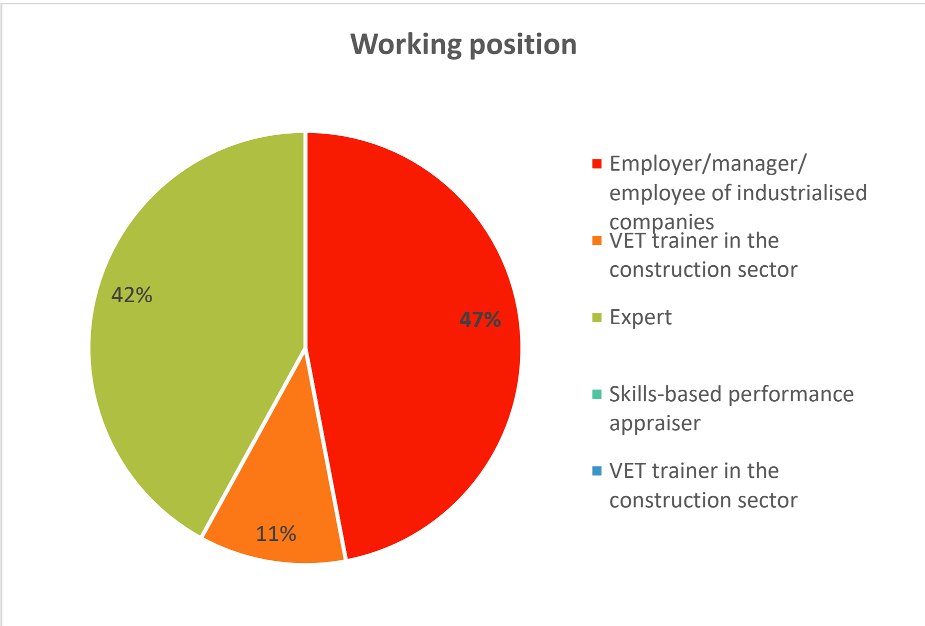


A total of 19 completed surveys were received. The main results indicate heterogeneity in the respondents, with different profiles, ranging from Manager to Technician, Training Design Expert and Architect (with two other respondents in each of these categories).



In relation to the sector of activity, the largest group of respondents is found in the Construction sector (NACE F-42), which corresponds to Civil engineering (47%), followed by those in the building construction (NACE F-41) and Specialized construction activities (NACE F-43).

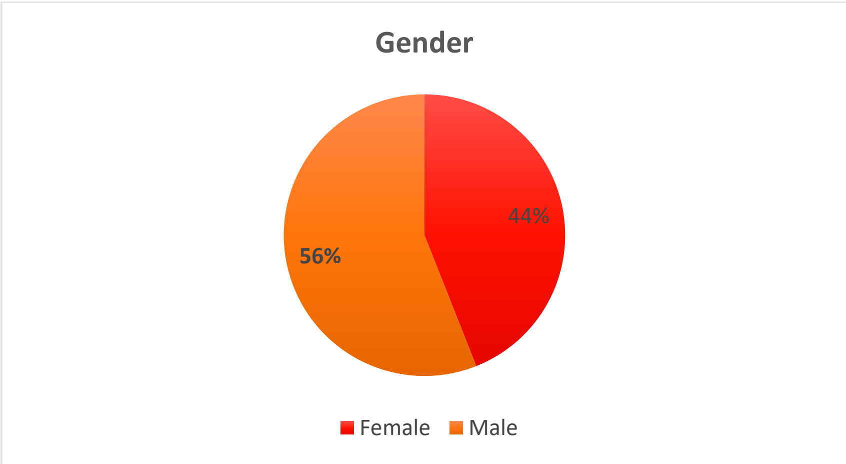
The next question is aimed at inquiring about the Working position currently held by the respondent. The results are shown in the graph.



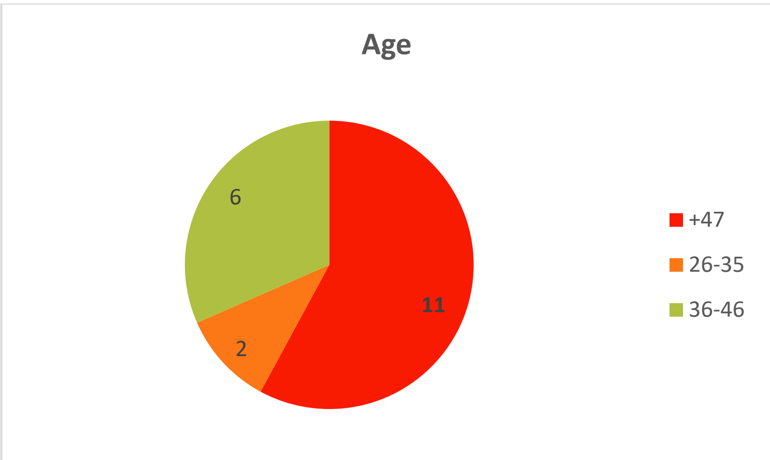
The majority of respondents indicated that their job is in the category Employer; manager; employee of industrialized construction companies (47%), followed by the category Expert in the sector and/or in training in the sector (42%).

The group with the fewest participants is that of Trainer; tutor in Vocational Education and Training in the construction sector (with 11% of respondents).

In relation to the gender expressed by the respondents, the distribution by sex shows that 56% are men and 44% are women, which results in a fairly equal proportion of the participants.



The age distribution of the participants indicates that 58% are over 47 years of age; 32% are between 36-46 years of age and the remaining 10% are between 26 and 35 years of age.



Assessment of skills

The survey presents below the questions aimed at finding out the level of competencies that the employees of the different professional profiles selected currently have and should have:

- *Electrical installer-Solar energy technician. ESCO codes 7411.1 y 7411.1.4.*
- *Heating, ventilation, air conditioning and refrigeration engineering technician- HVAC engineering technician. ESCO codes 3115.1.5 y 3115.1.17.*
- *Roofer-Ceiling installer. ESCO codes 7121 y 7123.1.*
- *Bricklayer. ESCO code 7112.1.*

For each of the profiles, respondents were asked about three types of skills:

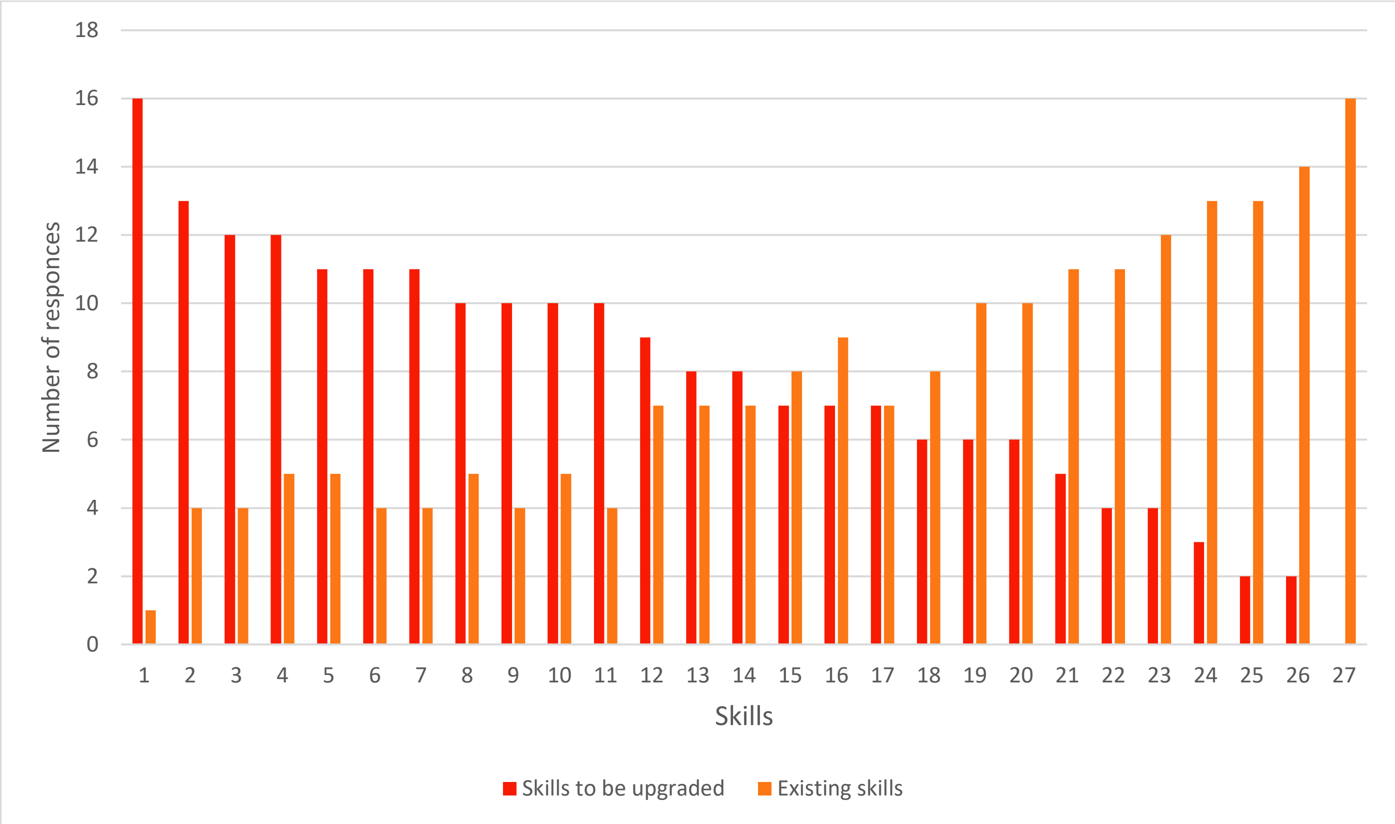
- *Managerial skills.*
- *Transversal skills.*
- *Technical skills.*

The following are the results of the surveys for each group of skills and for each profile or group of profiles.

1. Electrical installer –Solar energy technician

The group of skills corresponds to this profile includes a total of 25 proposals as Technical, one as Managerial and another one as Transversal.

The following graph shows the main results of the survey, in terms of Skills to be upgraded (red bars) and Existing skills (orange bars).



1 Use BIM models
2 Interpret 3D digital plans
3 Follow health and safety procedures in construction and working at heights
4 Install smart devices
5 Calculate needs for construction supplies
6 Write inspection reports
7 Calculate solar panel orientation
8 Install automation components
9 Use diagnostic tools for electronic repairs
10 Check compatibility of materials
11 Mount photovoltaic panels
12 Work in a construction team
13 Use precision tools
14 Measure electrical characteristics
15 Install inverters
16 Test and resolve equipment malfunctions
17 Assemble sensors
18 Assemble electrical and mechatronic components and units
19 Repair wiring
20 Replace defect components
21 Install wiring, lightning and protection system
22 Use measurement instruments

23 Interpret 2D plans
24 Provide power connection from bus bars
25 Work under voltage
26 Install electrical household appliances
27 Install electric switch boxes

As can be seen in the graph, the responses were spread across all the proposals. The results obtained in relation to the skills currently possessed by the workers of this profile show that the proposals that obtained 15 or more responses were *Installing electrical switch boxes* (89.5% of respondents); *Work under electrical voltage* (78.9%); and *Install electrical household appliances* (78.9%); and Follow health and safety procedures in construction and working at heights (74%).

Between 10 and 14 responses are *Provide power connection from bus bars* (73.7%); *Interpret 2D plans* (73.7%); *Use measurement instruments* (68.4%); *Install wiring, lighting and protection systems* (68.4%); *Assemble electrical components and assemble electronic units* (57.9%); *Repair wiring* (57.9%); *Replace defect components* (57.9%); *Install converters* (57.9%); *Use precision tools* (52.6%); and *Assembe sensors* (52.6%).

The proposal with the fewest responses was Use BIM models, with only one response.

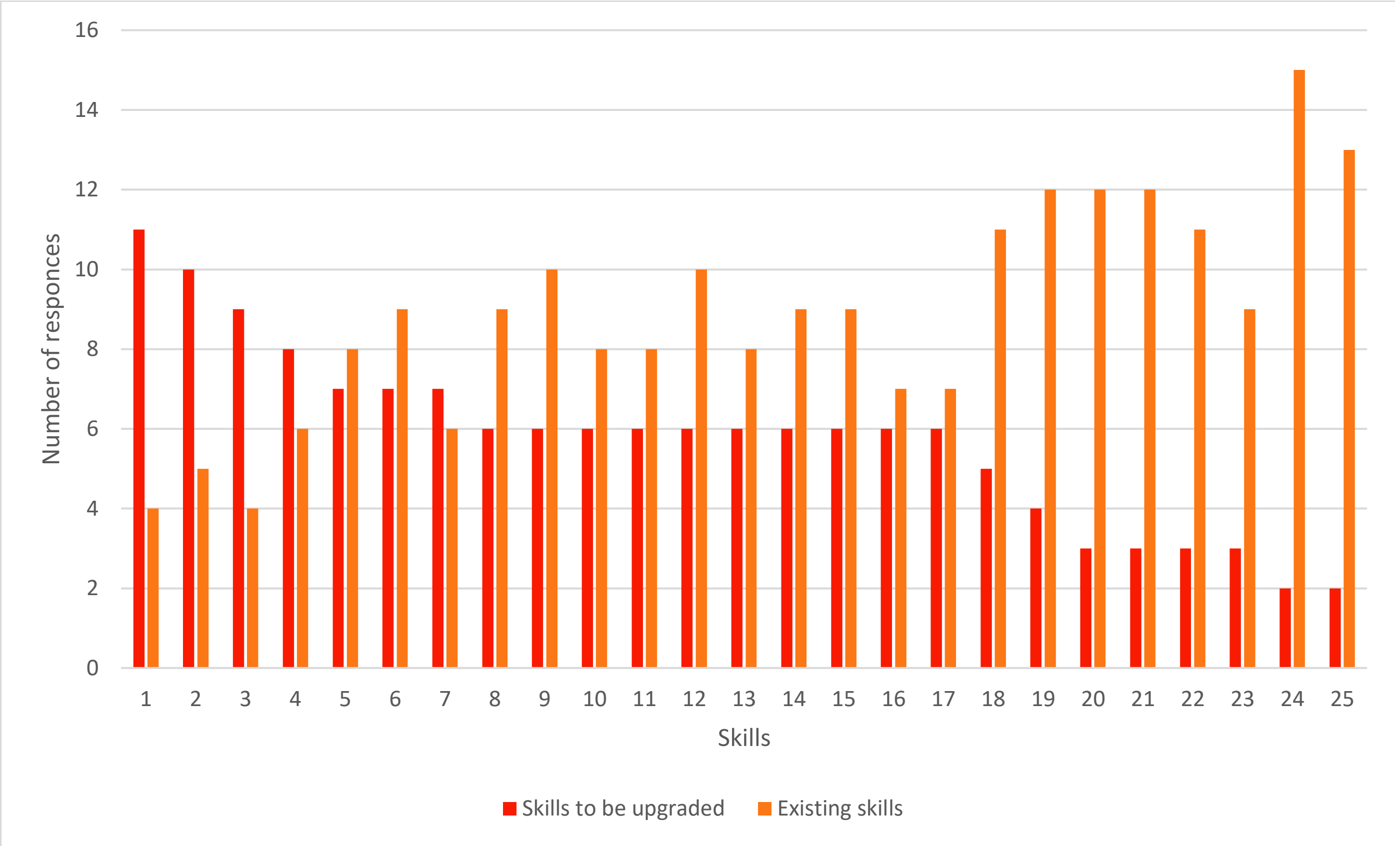
In relation to the skills that should be updated among the list of proposed skills, as shown in the graph, the highest score was obtained by *Using BIM models* (82.2% of responses), followed by *Interpreting 3D digital plans,* with 68.4% of responses.

Other skills that, in the opinion of the respondents, should be upgraded for this profile would be: *Calculate needs for construction supplies*; *Use diagnostic tools electronic repairs; Check compatibility of materials; Install photovoltaic panels* (with 63.1% of responses for each option). The participants were asked if they considered that there were other current skills that they considered important. One of them has included: *to coordinate in an adequate way with the rest of the works, trades and technicians of the construction process, abandoning attitudes of lack of professionalism and cooperation*.

And in relation to other skills that should be updated, the following have been indicated: Avoid excessive eagerness to make changes to make processes cheaper without adequate maturity of the alternatives after a detailed and programmed analysis of the objectives of the projects in accordance with the general programming of the works, and Identify the factors related to electrical installations that have a greater positive impact on the decarbonization of the building stock.

2. Heating, ventilation, air conditioning and refrigeration engineering technician – HVAC engineering technician

In this profile, two proposals have been included in the group called Managerial skills, one as transversal and 22 as technical. The chart with the responses received on those considered current and those that should be updated is shown below.



1 Leading a team
2 Interpret 3D digital plans
3 Install and maintain home automation systems
4 Install heating, ventilation, air conditioning and refrigeration ducts
5 Arrange equipment repairs
6 Monitor utility equipment and use testing equipment
7 Install ventilation equipment
8 Apply health and safety standards
9 Conduct routine machinery checks
10 Ensure compliance with environmental legislation
11 Advise on fitted ventilation systems
12 Drain hazardous liquids
13 Install refrigeration equipment
14 Lay pipe installation
15 Perform refrigerant leak checks
16 Install geothermal heat pump
17 Resolve equipment malfunctions
18 Lead a team perform maintenance on installed equipment
19 Handle refrigerant transfer pumps
20 Install air conditioning device
21 Install electrical and electronic equipment
22 Install heating furnace
23 Install heating pump

24 interpret 2D plans
25 Install heating boiler

Regarding Managerial skills, two proposals: *Arrange equipment repairs* and *Leading a team*. There is a clear difference in the respondents' opinions on these two skills: while *Arrange equipment repairs* is considered to be a current skill (52.6% vs. 42.1%); *Lead a team* is not considered to be current and therefore needs to be updated (36.8% vs. 68.4%). In the section on Transversal skills, it was proposed to *Apply health and safety standards*. The result shows that 63.1% considered it to be current compared to 42.1% who considered that it should be updated.

In the group of current skills, the highest scores were *Interpret 2D plans* (84.2%); *Install heating boiler* (73.7%). *Installing air conditioning device* and *Installing electrical and electronic equipment* received 68.4 %. On the other hand, 63.1% indicated the following skills: *Handle refrigerant transfer pumps*; *Install air conditioning device and Install electrical and electronic equipment*.

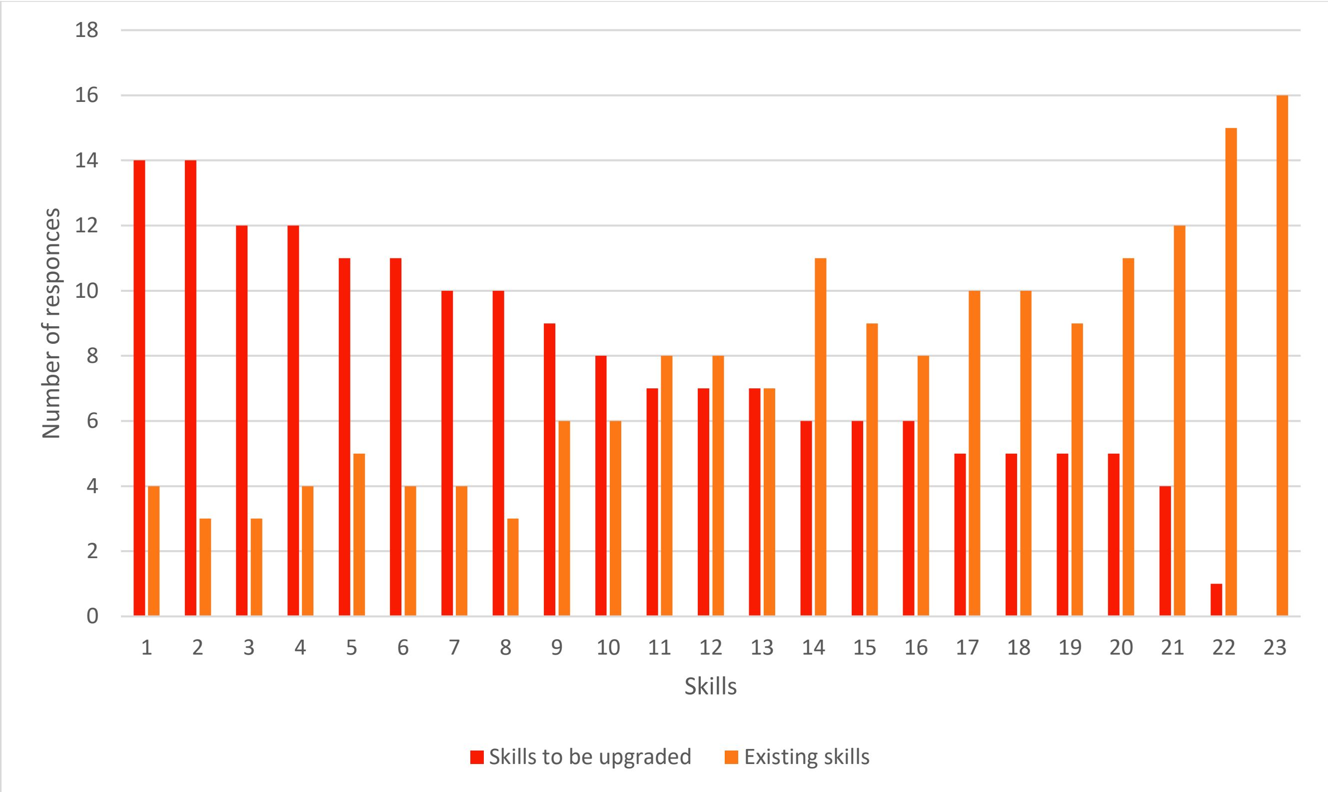
In relation to the assessment of technical skills that do need updating, the highest score was obtained by *Installing and maintaining home automation systems* and *Interpreting 3D digital plans*, with 57.9% of responses for each. The rest of the proposals received less than 10 responses, and, among them, the following stand out: *Advise of fitted ventilation system* (47.4%); *Control services for the provision of public services* (42.1%); *Install heating, ventilation, air conditioning and refrigeration piping* (42.1%), *Install geothermal heat pump* (42.1%).

In the case of the skill called *Ensure compliance with environmental legislation*, although 63.1% of respondents indicated that it is a skill that is currently held among the group of professionals in this profile, it was also indicated as a skill that needs to be updated (52.6% of the responses).

- *Survey participants indicated in the section on other current skills that "It is not understood that "install"/"repair" type skills are for an engineer"; and in the section on other skills that the following should be updated:*
- *Avoid excessive theocratization of the installation engineer who, in our experience, always ends up in the hands of the installation company.*
- *Identify the factors related to cooling, heating, ventilation, or air conditioning installations that have the greatest positive impact on the decarbonization of the building stock.*
- *Recognize the importance of the design of installations and the selection of equipment and materials being based on scientific evidence and current regulations: data provided by manufacturers, calculation procedures, diagnostics, or standardized tests.*

3. Roofer – Ceiling installer

In the group of skills of this profile, a total of 23 proposals have been included in the survey, of which three have been considered Transversal, two Managerial and the remaining 18 Technical.



1 Programme a Computer Numerical Controller (CNC)
2 Interpret 3D digital plans
3 Install connections of modular roof elements
4 Prepare the roof for solar system (PV and solar thermal system)
5 Assess conservation needs
6 Establish green roof
7 Follow safety procedures when working at heights
8 Sort waste and demolition materials
9 Inspect construction supplies and calculate needs for construction supplies
10 Recognize construction and isolation materials
11 Follow health and safety procedures in construction
12 Lay roof with materials for roofing like clay tile, asphalt composite shingles, built-up roofing and rolled roofing
13 Apply restoration techniques
14 Build scaffolding
15 Install lightning protection system
16 Install roof windows
17 Construct roof structure with construction profiles
18 Install insulation material and roll roofing
19 Interpret 2D plans

20 Operate tolls for cutting materials
21 Use measurement instruments
22 Inspect roof's installed gutters
23 Lay roof tiles

The two skills considered as Managerial have received more responses in the assessment that they need to be updated than in the section that they are currently present in both profiles, with 63.1% of responses each: *Assess conservation needs* and *Inspect construction supplies and calculate needs for construction supplies*.

As Transversal skills have been proposed three ones and only one received higher scores in the group those that have to be updated: *Follow safety procedures when working at heights* (73.7% of responses compared to 42.1%). The respondents' opinion on the other two is that the professionals of this profile already have this competence and it would not be necessary to update it: in the case of *Follow health and safety procedures in construction*, 52.6% of responses compared to 57.9%; and in the case of *Construction roof structure with construction profiles*, 36.8% of responses compared to 68.4%.

In the Technical skills group, in the section on current skills, *Lay roof tiles* (94.7 % of responses) and *Inspect roof's installed gutters* (84.2%) stand out above the rest.

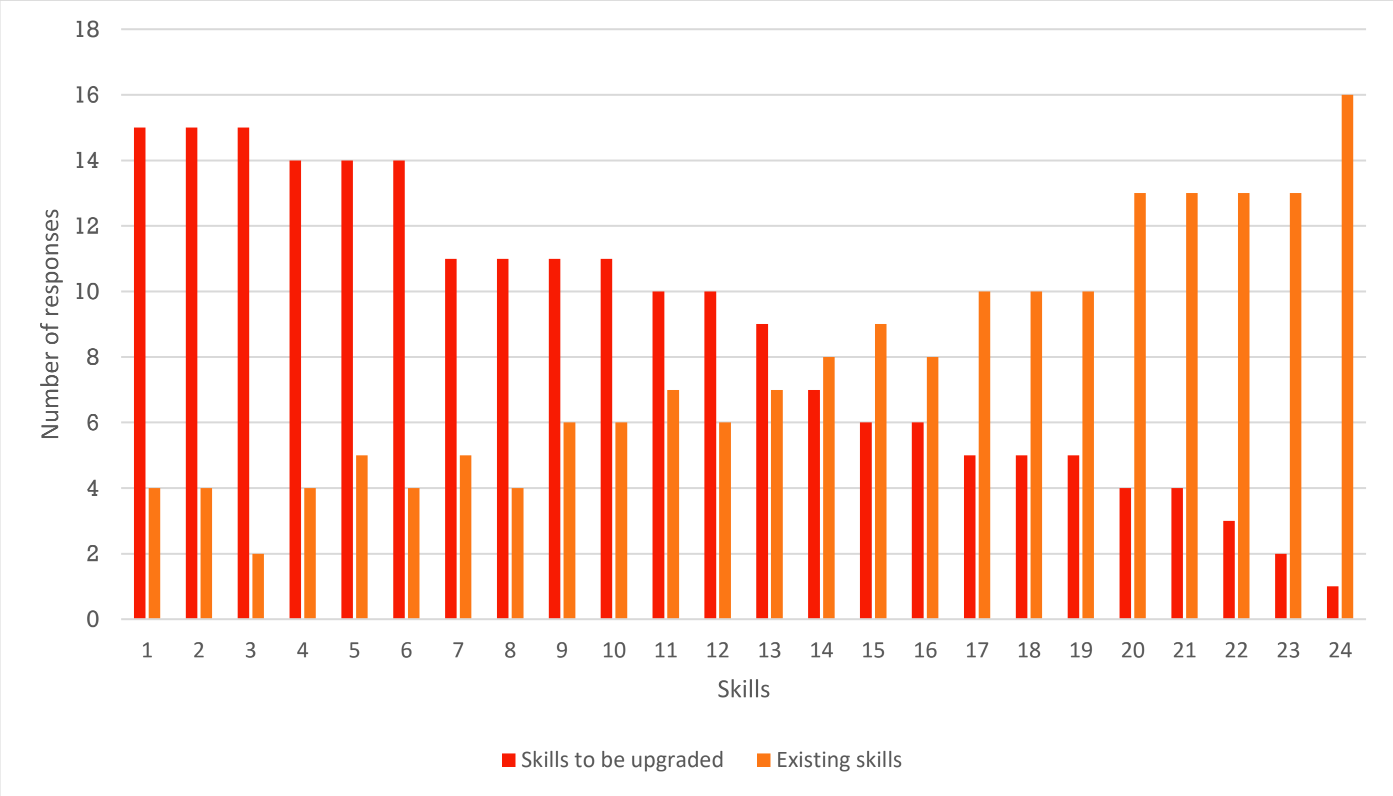
In relation to the group of skills to be updated, *Interpret 3D digital plans* and *Sort waste and demolition materials* scored the highest (73.7% considered them a priority for updating), followed by *Program a computer numerical control (CNC) controller* and *Establish green roof*, with 68.4% of responses each, and *Prepare the roof for solar system* (63.1%). *Lay roof with materials for roofing like clay tile, asphalt composite shingles, built-up roofing and rolled roofing* and *Apply restoration techniques* with 57.9%. The remaining skills received less than ten responses.

In the section on current skills that respondents could have included, one respondent indicated that "many masons do not have the capacity for the "evaluation" skill that would correspond to a higher level (foreman/technician...)".

Finally, in the section on other skills that should be updated but were not proposed in the survey, *preventing the generation of waste on the construction site and dealing adequately with waste that cannot be prevented* has been included.

4. Construction worker-Bricklayer

The last professional profile evaluated is that of construction worker, bricklayer. The graph shows the result of the answers received for each proposed skills in terms of existing skills and those that should be upgraded.



1 Interpret plans for modular construction
2 Install connections of modular building elements
3 Prepare the envelope for PV walls
4 Working ergonomically
5 Recognize impact of materials lifetime for maintenance and demolition
6 Interpret 3D digital plans
7 Follow safety procedures when working at heights
8 Sort waste and demolition materials
9 Use building materials and components reuse
10 Recognize dry construction methods
11 Assess conservation needs
12 Follow health and safety procedures in construction
13 Install insulation material on floor and walls
14 Recognize construction and insulation materials
15 Prepare fasade cladding
16 Install windows
17 Inspect construction supplies and calculate needs for construction supplies
18 Install construction profiles and different kind of bricks

19 Apply restoration techniques
20 Work with mortar and concrete
21 Use measurement instruments
22 Interpret 2D plans
23 Work on demolition processes
24 Brick laying

A total of 24 skills has been proposed in this professional profile, three of them for the managerial skills, two for the transversal skills and 19 of technical skills.

In relation to managerial skills, the main results indicate that *Inspect construction supplies and calculate needs* is considered to be a competence that professionals with this profile already have (68.4% of responses) compared to *Working ergonomically* which was considered to be upgraded by 78.9%.

In relation to the skills considered to be transversal, two were proposed: *Follow health and safety procedures in construction* and *Follow safety procedures for working at heights*. Both were considered to be upgraded by more respondents than those who considered them to be current: 47.4% compared to 68.4% and 42.1% compared to 73.7% respectively.

The last block of proposed skills refers to those considered to be technical. A total of 19 proposals were rated by the participants in the survey, and as regards the one considered most current, the highest number of responses was obtained by *Brick laying* (94.7%), followed by *Work on demolition processes* (89.5%) and *Work with mortar and concrete, Interpret 2D plans* and *Use measurement instruments* (with 78.9% of responses each).

In relation to the skills considered most in need of updating, the one that received the highest score was *Prepare the envelope for the installation of photovoltaic curtain walls* (84.2% of responses), followed by four ones with 78.9% of responses each: *Install connections of modular building elements*, *Use building materiales and components reuse, Sort waste and demolition material* and *Interpret plans for modular construction*. Other skills that received at least ten responses were as follows:

- *Recognise construction and insulation materials (52.6%).*
- *Install insultation material on floor and walls (57.9%).*
- *Recognise dry construction methods (68.4%).*
- *Recognise impact of materials lifetime for maintenance and demolition (73.7%).*
- *Interpret 3D digital plans (73.7%).*

One respondent has included "*taking into account the construction of plasterboard systems for ceilings, wall cladding and partition walls which is very important in industrialised construction, as well as masonry and brickwork with ceramic blocks and bricks*" as a current competence to be highlighted.

Validation process

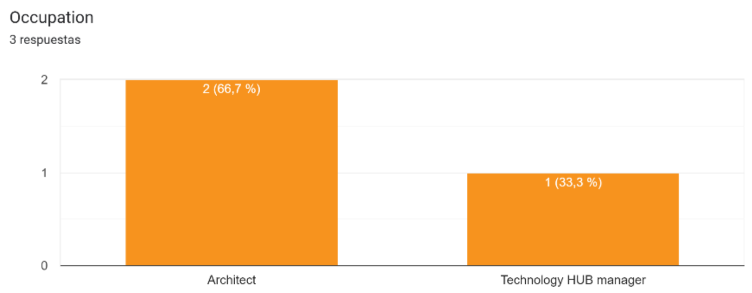
Once the responses to the surveys had been compiled, a report was drawn up containing the main results obtained. The next step was to send the report to experts in order to validate the information gathered in the report and also to find out their opinion on the level of importance of the proposed skills for industrialised construction. Se han obtenido tres encuestas cumplimentadas. A continuación se presentan las principales conclusiones de este proceso de validación.

The main findings of this validation process are presented below.

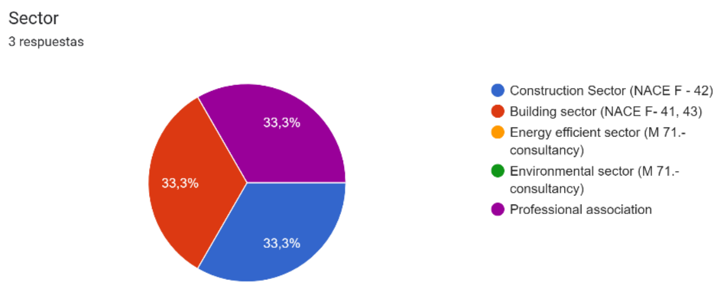
Participants' profile

The first block of questions was aimed at finding out the profile of the participants. Only one of the three respondents indicated their organisation, the rest considering that, as it was an anonymous survey, this information was not necessary. The organisation to which the person who did indicate it belonged was the Colegio Oficial de Aparejadores y Arquitectos Tecnicos de Madrid (Official Association of Quantity Surveyors and Technical Architects of Madrid).

The occupation of the people who completed the survey is divided between architect and technology HUB manager. Graphically it can be seen below.

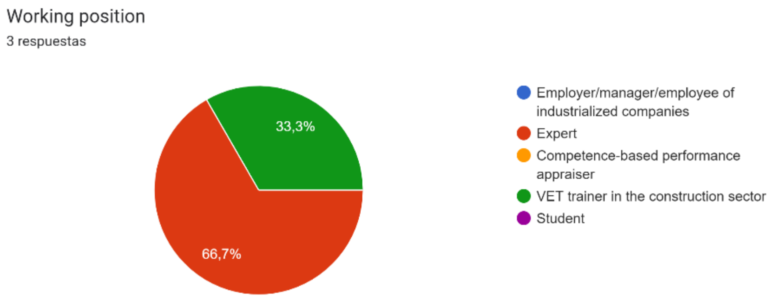


When asked about the sector activity in which they are engaged, the results indicate the following.

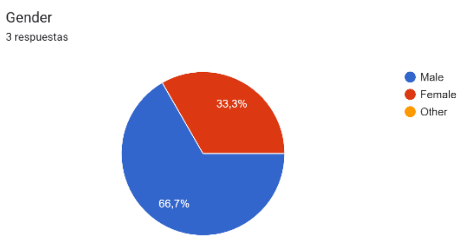


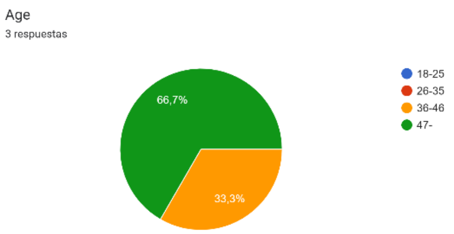
As can be seen in the graph, each respondent reports a different activity among those proposed: construction sector (NACE F-42), building sector (NACE F-41, 43) and professional association.

The next question is aimed at finding out the job in which the respondent carries out his/her professional activity. The results indicate that two of them are experts in the sector and/or in training in the construction sector and the other one is a VET trainer in the construction sector.



The two-remaining data on the profile of the respondents are gender and age: two men and one woman; two are over 47 years old and the other has indicated the range 36-46.





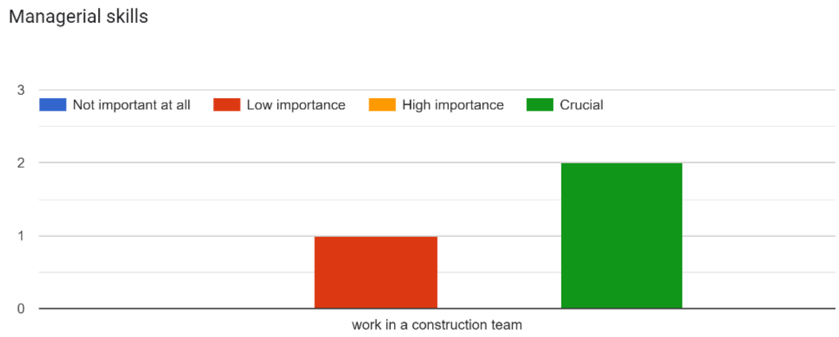
Validation results

The next block of questions is aimed at finding out the respondent's assessment of the importance in industrialised construction of each of the s proposed in the survey for each of the four selected profiles. Respondents have indicated their assessment on a scale ranging from Not important at all to Crucial.

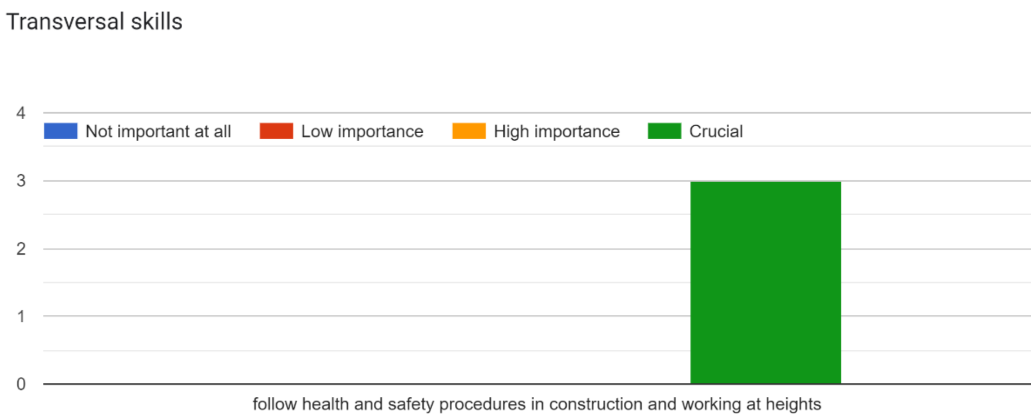
The results are detailed below for each of the profiles.

1. Electrical installer –Solar energy technician

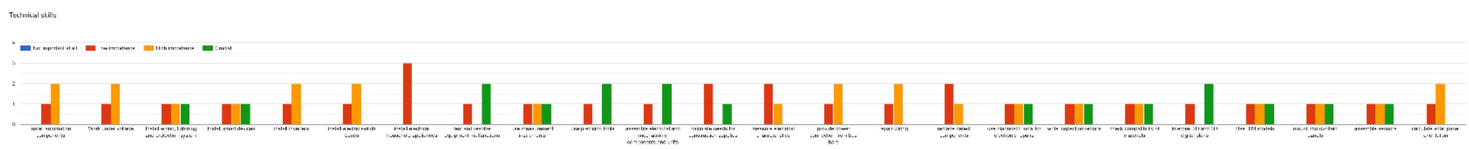
In relation to the proposed **managerial skill**, *Working in **a construction team***, the results of the participants' assessment indicate that it is considered Crucial (two responses) but also Unimportant (one response).



The following skills evaluated are the so-called transversal ones, in which only the following has been included: *Follow Health and Safety procedures in construction and working at heights*. The results indicate unanimity in considering it crucial in industrialised construction.



A total of 24 skills have been proposed in the technical section and the results of the respondents' assessment show differences. These are shown graphically below.

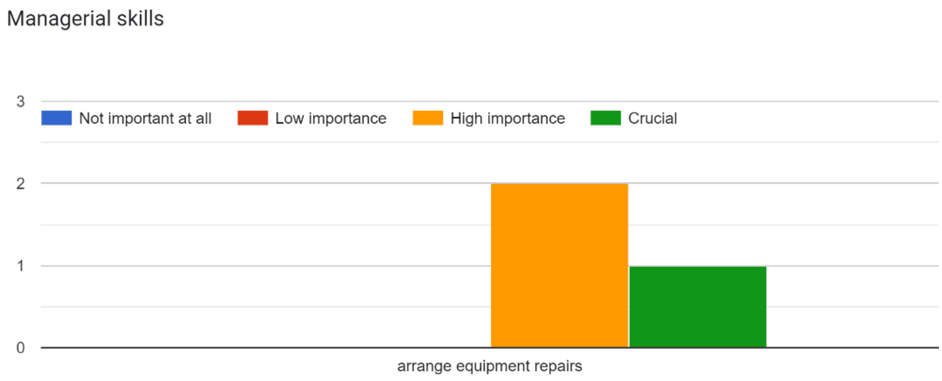


None of the proposals was rated as Not at all important. At the other extreme, none were considered crucial by all respondents. The following skills received two responses in the crucial category: *Test and resolve equipment multifunctions*; *Use precision tools*; *Assemble electrical and mechatronic components and units*; and *Interprete 2D and 3D plans.*

There was unanimity in the assessment of the skill *Install electrical household appliances* as low important for industrialised construction.

2. Heating, ventilation, air conditioning and refrigeration engineering technician – HVAC engineering technician

Arrange equipment repairs has been proposed as a managerial skill. Two respondents rated it as high important and one as crucial.

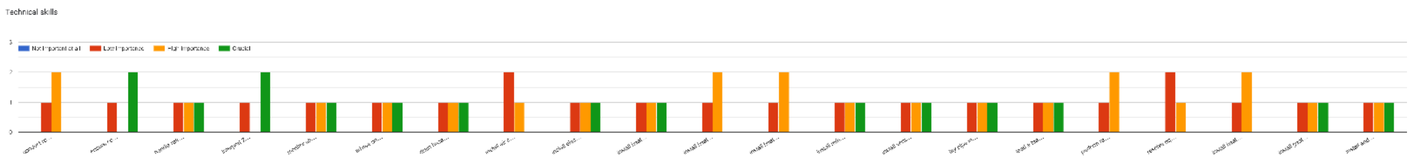


Applying health and safety standards has been proposed as a transversal skill in this profile, considered as crucial by two of the respondents and as very important by the other, as shown in the graph.

In the group of so-called technical skills, respondents rated a total of 21 ones. They did not coincide in any of their assessments, considering two of them as crucial, *Ensure compliance with environmental legislation* and *Interprete 2D and 3D digital plans*.

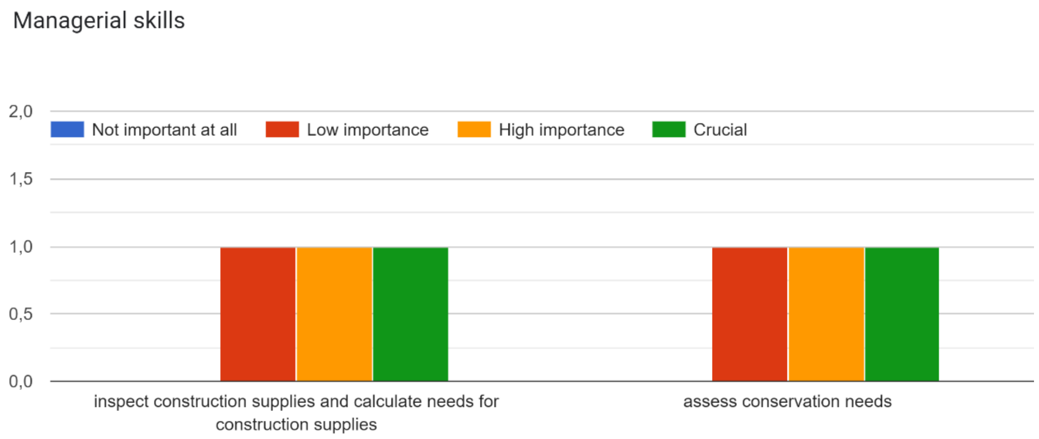
The ones considered as low importance for industrialised construction by two respondents are *Install air conditioning device* and *Resolve equipment mulfunctions*. And as of high importance, also with two responses: *Conduct routinary machinery checks*; *Install heating furnaces*; *Installing heating, ventilation, air conditioning and refrigeration ducts*; *Perform refrigerant leak checks*; and *Installing heat pump*.

The distribution of ratings can be seen graphically below.

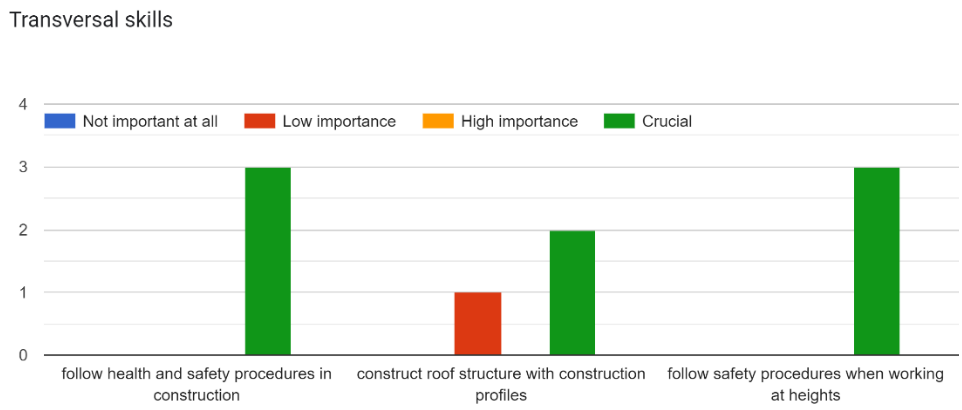


3. Roofer – Ceiling installer

For this profile two proposals in the managerial skills section: *Inspect construction supplies and calculate needs for it* and *Assess conservation needs*. Each of these has received a different rating, ranging from low to crucial, with a response on each of the values, as is shown below.



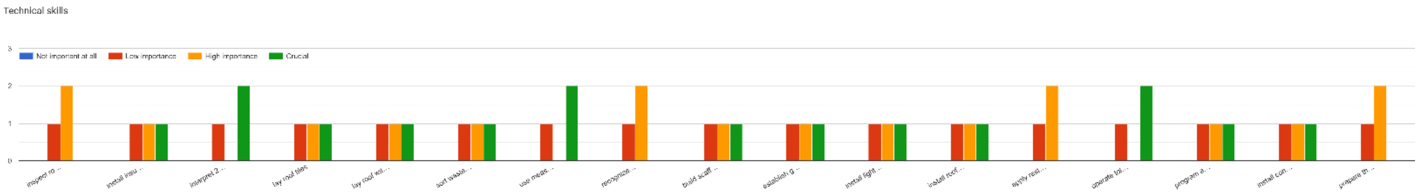
Three skills were proposed as transversal skills: *Follow health and safety procedures in construction*, *Construct roof structure with construction profiles* and *Follow safety procedures when working at heights*. The two skills related to risk prevention were unanimously rated as crucial, while the skill to install profiles was rated as of low importance by one respondent.



In the section on technical skills, respondents rated a total of 17 proposals, none of which received a unanimous assessment of their importance for industrialised construction. Two of them considered it crucial *to Interpret 2D and 3D plans*; *Use measurement instruments* and *Operate tools for cutting materials*.

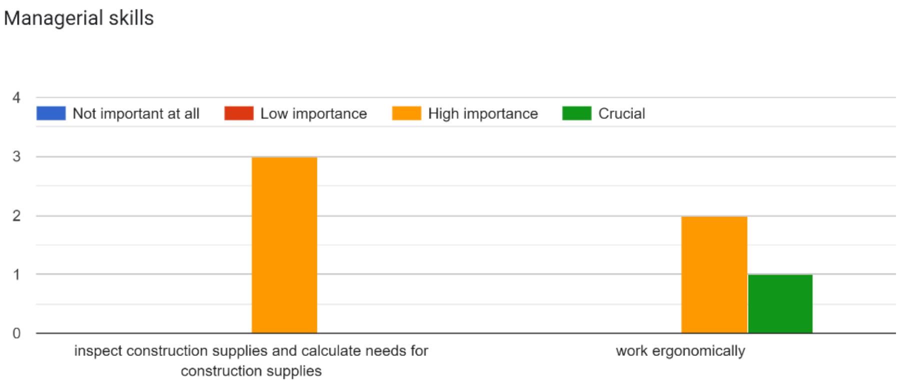
Inspect roofs' installed gutters; *Recognise construction and insulation materials*; *Applying restoration techniques* and *Preparing the roof for the solar system (PV and solar thermal system)* were rated as of high importance by two respondents.

None of the proposed skills was rated as being of no importance at all, and several of them were rated equally, as can be seen in the graph.

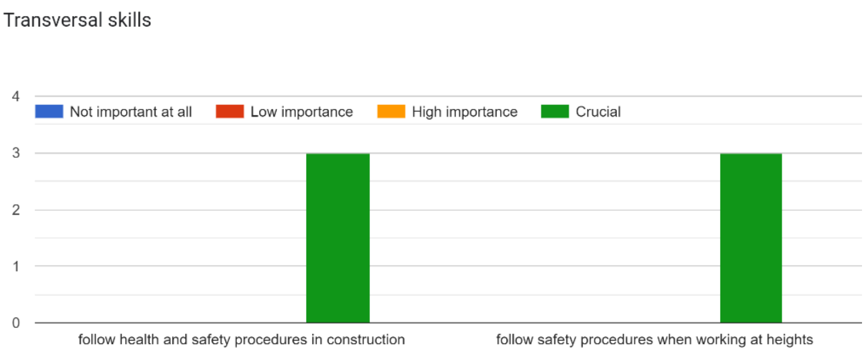


4. Construction Worker-Bricklayer

For this profile, two skills have been included in the group of those considered as managerial. Respondents agreed that one of them was very important (*Inspecting construction supplies and calculate needs for carrying out the work*), while two respondents rated the other one as very important (*Work ergonomically*), compared to one respondent who considered it crucial.



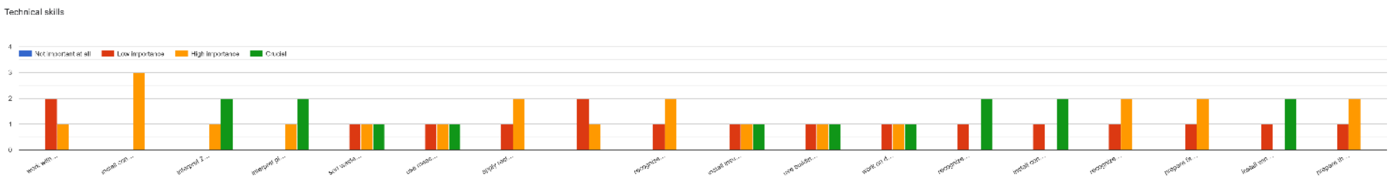
In the group of transversal skills, the respondents coincided in valuing both proposals as crucial: *Follow health and safety procedures in construction* and *Follow safety procedures when working at heights*.



In relation to the technical skills of this profile, there has been a coincidence in the rating of very important given to *Install construction profiles and different kinds of bricks*. Two respondents considered the following proposals as crucial for industrialised construction: *Interpret 2D and 3D plans*; *Interpret plans for modular construction; Recognise dry* construction methods; Install connections of modular building elements; and Install windows.

Two of the 18 technical skills: *Working with mortar and concrete* and *Laying bricks* were rated as not important for industrialised construction by two of the respondents.

Below is a graph showing the different ratings.



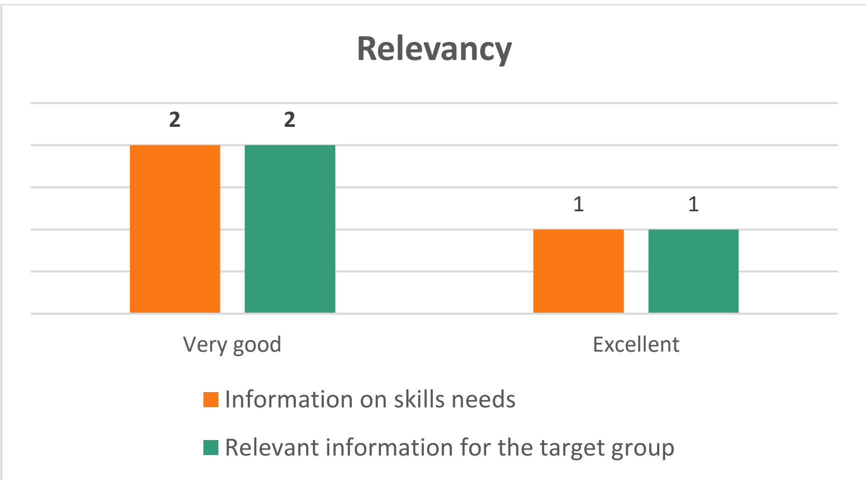
Results of evaluation of the Survey Report

In this second section of the validation questionnaire, respondents were asked to evaluate the National Report against the results of the previous online survey. This evaluation has been carried out in several aspects with the aim of detecting possible deficiencies in the information provided in order to ensure the quality of the information.

The results obtained in this second part are shown below, organised by the different quality sections that have been assessed.

Relevancy

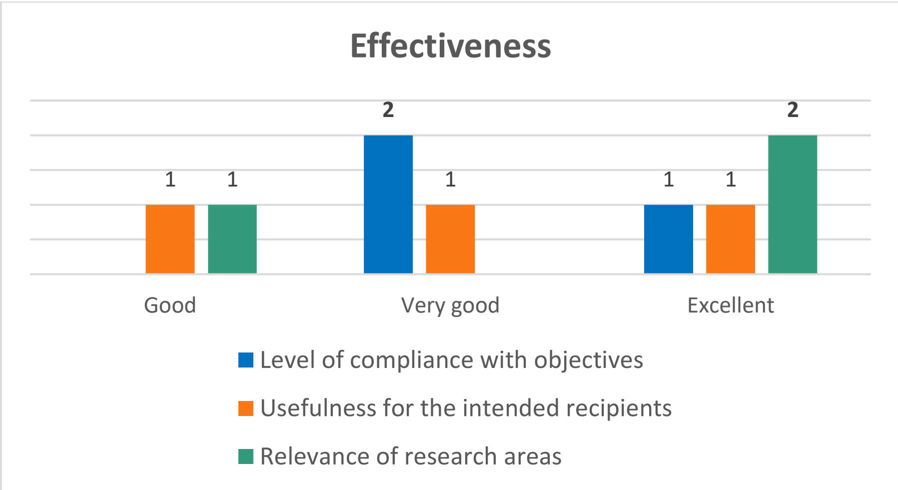
In this section, the validators have been asked about two aspects: whether the conclusions of the Report meet the objective of knowing the skills needs to be updated in industrialised construction to improve the aspects of circular economy and energy efficiency, and whether the content presented is relevant to the needs of the target group. The final evaluations can be seen in the following graph.



As a comment, one of the respondents indicated that "*industrialised construction cannot be approached from the traditional construction point of view, the model has to be changed*".

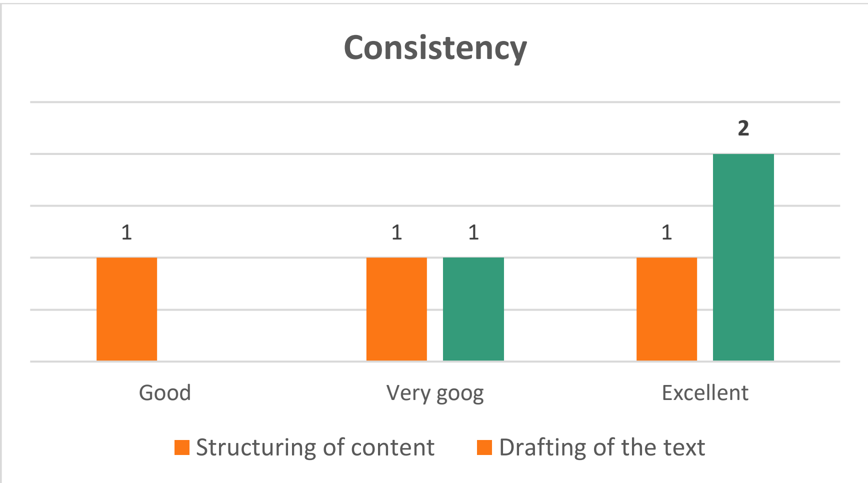
Effectiveness

In this section, the respondents' assessment of whether the information presented in the Report is in line with the objectives pursued by the Report, whether it can be used by the members of the target group for the intended purposes and whether the areas of research developed are relevant to the content was investigated. The following graph shows the different assessments.



Consistency

The evaluation of the formal aspects of the text includes two questions: on the presentation of the content and on the grammatical and stylistic characteristics in which it is written. The opinions of the respondents are as follows.

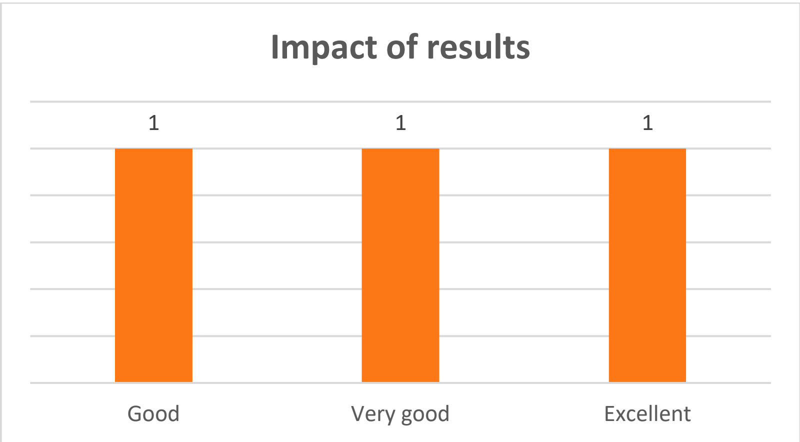


Efficiency

In the section on the effectiveness of the information presented in the evaluated document, the question has been whether the results provide the basis for ensuring the improvement of the skills of industrialised construction workers, improving energy efficiency and the circular economy.

Impact

The last section refers to the opinion of the validators on the impact that the information presented can have on the achievement of the objective of identifying the key skills of the workforce in industrialised construction systems. The graph shows the opinion of the respondents.



Conclusion

No changes to the content were considered necessary. It was only noted that one of the validators pointed out that there has to be a change in the construction model for industrialised construction to develop.

Final conclusions

The main findings of the survey are summarised below, highlighting in particular the information on those skills that have been found to be upgreaded.

The profile of the respondents is male, over 47 years old, employer, manager, employee of an industrialised construction company, whose professional activity is carried out in a company in the construction sector (NACE F-42), and whose professional profile corresponds to that of an architect, trainer and participant in training design.

In relation to the profile of **Electrician Installer/Solar energy technician**, the following should be updated *Work in a construction team* (**Managerial skill**) and *Follow health and safety procedures in construction* (**transversal skill**). In relation to **technical skills**, those considered to be the most current among the workforce of this profile are *Work under voltage*; *Install electric switch boxes*; *Install electrical household appliances*.

Those considered upgraded are:

- *Use BIM model.*
- *Write inspection reports.*
- *Interpret 3D digital plans.*
- *Install smart devices.*
- *Avoid the excessive desire for change to make processes cheaper without the proper maturation of alternatives.*
- *Identify the factors related to electrical installations that have the greatest positive impact on the decarbonisation of the building stock.*

For the profile of **Heating, ventilation, air conditioning and refrigeration engineering technician - HVAC engineer/technician**, *Arrange equipment repairs* (as **managerial skill**) has been assessed as current, and *Leading a team* has been considered as updatable. In the section on **transversal skills**, *Apply health and safety standards* was considered as existing rather than upgraded.

The most evaluated as current **technical skills**, aren: *Interpret 2D plans*; *Install heating boiler Installing air conditioning device* and *Installing electrical and electronic equipment*.

The participants in the survey considered the following to be upgradable from the list of proposals:

- *Interpret 3D digital plans.*
- *Installing and maintaining home automation systems.*
- *Ensure compliance with environmental legislation.*

The next profile assessed is the **Roofer – Ceiling installer**. The two proposed managerial skills have been considered upgraded: *Assess conservation needs* and *Inspect construction supplies and calculate needs for construction supplies*.

In relation to transversal skills, *follow health and safety procedures in construction* and *Construction roof structure with construction profiles* have been assessed as current, and *Follow safety procedures when working at heights* has been considered as upgraded.

The **technical skills** considered to be current were: *Lay roof tiles*; *Inspect roof's installed gutters*; *Use measurement instruments*.

Those considered the most upgraded have been:

- *Sort waste and demolition materials.*
- *Interpret 3D digital plans.*
- *Program a computer numerical control (CNC) controller.*
- *Establish green roof.*
- *Prevent the generation of waste on the construction site and deal adequately with waste that cannot be prevented.*

The last professional profile evaluated was **Construction worker: bricklayer**. Among the **managerial skills**, *Inspect construction supplies and calculate needs* was considered current, compared to *Work ergonomically* that could be upgraded.

The two proposed **transversal skills** have been assessed as upgradeable by the participants are: *Follow health and safety procedures in construction* and *Follow safety procedures for working at heights*.

In relation to technical competencies, the following have received the highest scores as current *Brick laying*; *Work on demolition processes*; *Use measurement instruments*; *Interpret 2D plans*; and *Work with mortar and concrete*.

The following skills have been considered upgradeable:

- *Prepare the envelope for PV walls.*
- *Install connections of modular building elements.*
- *Use building materials and components reuse.*
- *Sort waste and demolition material.*
- *Interpret plans for modular construction.*

There were not many coincidences between the results of the survey and the assessment made by the validators in relation to the skills that need to be updated as they are crucial. Thus, for the profile of **Electrician Installer/Solar energy technician**, there were only two coincidences in this sense: the survey indicates that it is necessary to update *Work in a construction team* (managerial skill) and *Interpreting digital plans in 3D* (as a technical competence), and both were valued as crucial for industrialised construction.

In the profile of **Heating, ventilation, air conditioning and refrigeration engineering technician - HVAC engineer/technician**, among the skills considered as crucial for industrialised construction are *Apply health and safety standards* (transversal competence), *Interpret 3D digital plans* and *Ensure compliance with environmental legislation* (technical skills), evaluated as upgradeable by the survey.

For the profile of **Roofer – Ceiling installer**, only two skills have been rated as upgradeable and crucial: *Follow safety procedures when working at heights* (transversal) and *Interpret 3D digital plans* (technical).

And, finally, for the profile of **Construction worker: bricklayer**, there were four coincidences between the survey (considering the skills upgradeable) and the validation process (considering it crucial *Follow health and safety procedures in construction* and *Follow safety procedures for working at heights* (transversal ones) and *Install connections of modular building elements* and *Interprete plans for modular construction* (technical skills).

Annex 1 – Online survey questionnaire

Respondents' profile

Occupation:

Sector:

- *Construction Sector (NACE F - 42)*
- *Building sector (NACE F- 41, 43)*
- *Activities related to energy efficiency (M - 71)*
- *Activities related to environmental sector (M - 71)*

Working position:

- *Employer/manager/employee of industrialised companies.*
- *Expert in the sector and/or training in the construction sector*
- *Competence-based performance appraiser.*
- *VET trainer in the construction sector.*
- *Student / trainee.*

Gender:

- *Male*
- *Female*
- *Other*

Age:

- *18-25*
- *26-35*
- *36-46*
- *+ 47*

1. ELECTRICIAN INSTALLER - SOLAR ENERGY TECHNICIAN

Skills	Existing skills	Skills to be upgraded
Managerial skills		
Work in a construction team		
Transversal skills		
Follow health and safety procedures in construction		
Technical skills		
Install automation components		
Work under voltage		
Install wiring, lightning and protection system		
Install smart devices		
Install inverters		
Install electric switch boxes		
Install electrical household appliances		
Resolve equipment malfunctions		
Use measurement instruments		
Use measurament tools		
Assemble electrical components		
Assemble mechatronic components and units		
Calculate needs for construction supplies		
Measure electrical characteristics		
Provide power connection from bus bars		
Repair wiring		
Replace defect components		
Use diagnostic tools for electronic repairs		
Write inspection reports		
Check compatibility of materials		
Interpret 2D plans		
interpret 3D digital plans		
Use BIM models		
Mount photovoltaic panels		
Assemble sensors		
Calculate solar panel orientation		

Other existing skills. Please write down any other skills that belong to existing "Traditional" skills.

Other skills to be upgraded. Please write down any other skills to be upgraded.

2. HEATING, VENTILATION, AIR CONDITIONING AND REFRIGERATION ENGINEERING TECHNICIAN - HVAC ENGINEER/TECHNICIAN

Skills	Existing skills	Skills to be upgraded
Managerial skills		
Arrange equipment repairs		
Lead a team		
Transversal skills		
Apply health and safety standards		
Technical skills		
Conduct routine machinery checks		
Ensure compliance with environmental legislation		
Handle refrigerant transfer pumps		
Interpret 2D plans		
Interpret 3D digital plans		
Monitor utility equipment and use testing equipment		
Advise on fitted ventilation systems		
Drain hazardous liquids		
Install air conditioning device		
Install electrical and electronic equipment		
Install heating boiler		
Install heating furnace		
Install heating, ventilation, air conditioning and refrigeration ducts		
Install refrigeration equipment		
Install ventilation equipment		
Lay pipe installation		
Lead a team perform maintenance on installed equipment		
Perform refrigerant leak checks		
Resolve equipment malfunctions		
Install heating pump		
Install geothermal heat pump		
Install and maintain home automation systems		

Other existing skills. Please write down any other skills that belong to existing "Traditional" skills".

Other skills to be upgraded. Please write down any other skills to be upgraded.

3. ROOFER - CEILING INSTALLER

Skills	Existing skills	Skills to be upgraded
Managerial skills		
Inspect construction supplies and calculate needs for construction supplies		
Assess conservation needs		
Transversal skills		
Follow health and safety procedures in construction		
Construct roof structure with construction profiles		
Follow safety procedures when working at heights		
Technical skills		
Inspect roof's installed gutters		
Install insulation material and roll roofing		
Interpret 2D digital plans		
Interpret 3D digital plans		
Lay roof tiles		
Lay roof with materials for roofing like clay tile, asphalt composite shingles, built-up roofing and rolled roofing		
Sort waste and demolition materials		
Use measurement instruments		
Recognize construction and isolation materials		
Build scaffolding		
Establish green roof		
Install lightning protection system		
Install roof windows		
Apply restoration techniques		
Operate tolls for cutting materials		
Program a CNC controller		
Install connections of modular roof elements		
Prepare the roof for solar system (PV and solar thermal system)		

Other existing skills. Please write down any other skills that belong to existing "Traditional" skills".

Other skills to be upgraded. Please write down any other skills to be upgraded.

4. CONSTRUCTION WORKER: BRICKLAYER

Skills	Existing skills	Skills to be upgraded
Managerial skills		
Inspect construction supplies and calculate needs for it		
Work ergonomically		
Transversal skills		
Follow health and safety procedures in construction		
Follow safety procedures when working at heights		
Technical skills		
Work with mortar and concrete		
Install construction profiles		
Interpret 2D plans		
Interpret plans for modular construction		
Sort waste and demolition materials		
Use measurement instruments		
Apply restoration techniques		
Recognize construction and insulation materials		
Install insulation material on floor and walls		
Use building materials and components reuse		
Work on demolition processes		
Recognize dry construction methods		
Install connections of modular building elements		
Recognize impact of materials lifetime for maintenance and demolition		
Prepare fasade cladding		
Install windows		
Prepare the envelope for PV walls		
Lay bricks		
Interpret 3D digital plans		

Other existing skills. Please write down any other skills that belong to existing "Traditional" skills".

Other skills to be upgraded. Please write down any other skills to be upgraded

Annex 2. Online validation questionnaire

Respondents' profile

Occupation:

Sector:

- *Construction Sector (NACE F - 42)*
- *Building sector (NACE F- 41, 43)*
- *Activities related to energy efficiency (M - 71)*
- *Activities related to environmental sector (M - 71)*

Working position:

- *Employer/manager/employee of industrialised companies.*
- *Expert in the sector and/or training in the construction sector*
- *Competence-based performance appraiser.*
- *VET trainer in the construction sector.*
- *Student / trainee.*

Gender:

- *Male*
- *Female*
- *Other*

Age:

- *18-25*
- *26-35*
- *36-46*
- *+ 47*

Part I-Individual ranking of the skills to be upgraded

Please, using the scale: Not important at all/Low importance/High importance/Crucial, indicate how important is this skill for Offsite construction.

1. ELECTRICAL INSTALLER

	Not important at all	Low importance	High importance	Crucial
Managerial skills				
Work in a construction team				
Transversal skills				
Follow health and safety procedures in construction and working at heights				
Technical Skills				
Install automation components				
Work under voltage				
Install wiring, lightning and protection system				
Install smart devices				
Install inverters				
Install electric switch boxes				
Install electrical household appliances				
Test and resolve equipment malfunctions				
Use measurement instruments				
Use precision tools				
Assemble electrical and mechatronic components and units				
Calculate needs for construction supplies				
Measure electrical characteristics				
Provide power connection from bus bars				
Repair wiring				
Replace defect components				
Use diagnostic tools for electronic repairs				
Write inspection reports				
Check compatibility of materials				
interpret 2D plans				
interpret 3D digital plans				

Use BIM models				
Mount photovoltaic panels				
Assemble sensors				
Calculate solar panel orientation				

2. HEATING, VENTILATION, AIR CONDITIONING AND REFRIGERATION ENGINEERING TECHNICIAN - HVAC ENGINEER/TECHNICIAN

	Not important at all	Low importance	High importance	Crucial
Managerial skills				
Arrange equipment repairs				
Transversal skills				
Apply health and safety standards				
Technical Skills				
Conduct routine machinery checks				
Ensure compliance with environmental legislation				
Handle refrigerant transfer pumps				
Interpret 2D plans				
Interpret 3D digital plans				
Monitor utility equipment and use testing equipment				
Advise on fitted ventilation systems				
Drain hazardous liquids				
Install air conditioning device				
Install electrical and electronic equipment				
Install heating boiler				
Install heating furnace				
Install heating, ventilation, air conditioning and refrigeration ducts				
Install refrigeration equipment				
Install ventilation equipment				
Lay pipe installation				
Lead a team perform maintenance on installed equipment				
Perform refrigerant leak checks				
Resolve equipment malfunctions				
Install heating pump				

Install geothermal heat pump				
Install and maintain home automation systems				

3. ROOF LABOURER

	Not important at all	Low importance	High importance	Crucial
Managerial skills				
Inspect construction supplies and calculate needs for construction supplies				
Assess conservation needs				
Transversal skills				
Follow health and safety procedures in construction				
Construct roof structure with construction profiles				
Follow safety procedures when working at heights				
Technical Skills				
Inspect roof’s installed gutters				
Install insulation material and roll roofing				
Interpret 2D plans				
Interpret 3D digital plans				
Lay roof tiles				
Lay roof with materials for roofing like clay tile, asphalt composite shingles, built-up roofing and rolled roofing.				
Sort waste and demolition materials				
Use measurement instruments				
Recognize construction and isolation materials				
Build scaffolding				
Establish green roof				
Install lightning protection system				
Install roof windows				
Apply restoration techniques				
Operate tolls for cutting materials				
Program a Computer Numerical Control (CNC) controller				

Install connections of modular roof elements				
Prepare the roof for solar system (PV and solar thermal system)				

4. BUILDING CONSTRUCTION LABOURER: BRICKLAYER

	Not important at all	Low importance	High importance	Crucial
Managerial skills				
Inspect construction supplies and calculate needs for construction supplies				
Calculate needs for construction supplies				
Work ergonomically				
Transversal skills				
Follow health and safety procedures in construction				
Follow safety procedures when working at heights				
Technical Skills				
Work with mortar and concrete				
install construction profiles and different kind of bricks				
Interpret 2D plans				
Interpret 3D digital plans				
Interpret plans for modular construction				
Sort waste and demolition materials				
Use measurement instruments				
Apply restoration techniques				
Recognize construction and insulation materials				
Install insulation material on floor and walls				
Use building materials and components reuse				
Work on demolition processes				
Recognize dry construction methods				
Install connections of modular building elements				

Recognize impact of materials lifetime for maintenance and demolition				
Prepare facade cladding				
Install windows				
Prepare the envelope for PV walls				

Part II-Evaluation of findings regarding the Survey report.

Please indicate from a Scale from 1 to 4 (where 1=bad, 2=good 3=very good 4 =excellent) your view on project's findings regarding on skills of workforce needed for industrialized construction improving energy efficiency and circular economy and what skills are needed to upgrade.

Quality Criteria: Relevancy

The findings are satisfied regarding the needs of skills to be upgraded for industrialized construction improving energy efficiency and circular economy.

1. ☐
2. ☐
3. ☐
4. ☐
5. Comments

Based on the need of the target group is the content relevant and up-to date.

1. ☐
2. ☐
3. ☐
4. ☐
5. Comments

Quality Criteria: Effectiveness

The output matches the description given.

1. ☐
2. ☐
3. ☐
4. ☐
5. Comments

The output can be easily used by its intended target group.

1. ☐

2. ☐
3. ☐
4. ☐
5. Comments

The areas of investigation are relevant regarding the content.

1. ☐
2. ☐
3. ☐
4. ☐
5. Comments

Quality Criteria: Consistency

The overall content of the findings is presented in a logical and to the point manner.

1. ☐
2. ☐
3. ☐
4. ☐
5. Comments

No grammar, spelling, and punctuation errors exist.

1. ☐
2. ☐
3. ☐
4. ☐
5. Comments

Quality Criteria: Efficiency

The findings provide the basis to ensure the skills to be upgraded of the workers for industrialized construction improving energy efficiency and circular economy.

1. ☐
2. ☐
3. ☐
4. ☐
5. Comments

Quality Criteria: Impact

Can these findings contribute to reaching higher level objectives, i.e identification of key skills in the industrialized systems?

1. ☐
2. ☐
3. ☐
4. ☐
5. Comments

Conclusion

No changes required

☐ YES
☐ NO

.

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2022-1-ES01-KA220-VET-000087862

FUNDACIÓN
LABORAL
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Associated partner

Co-funded by the European Union

This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.