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# 'Green Skills' : What Do Companies Do With It? The Case of Building Automation

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## ABSTRACT

In recent times, 'Green Skills' has become a buzzword in international, national and local policies. Green Skills are considered to be an important precondition to achieving the United Nations' Sustainable Development Goals. However, until now, there has been a research gap in how companies, characterised by the particularities of their business, introduce Green Skills. This study analyses how actors understand Green Skills and how they perceive whether the company meets related requirements for Green Skills. The focus is on building automation, a sector that is considered key in reducing the $CO_2$ footprint of construction. Taking the example of Cologne, a metropolitan area in Germany with above-average summer heat, and by using qualitative methods, the study shows that companies need, in particular, employees with digital skills, skills in working with environmental regulation, skills to cooperate across trades and crafts in the value chain and the ability of cross-cutting environmental awareness. The study illustrates that Green Skills cannot simply be defined as a particular category of skills, because Green Skills intersect with other skills; at the same time, Green Skills in building automation show characteristics that are also relevant when considering other businesses.

## 1 | Introduction

Companies need employees who have appropriate Green Skills. At least this is a broadly shared view of politicians and practitioners, who advocate bringing the United Nations' Sustainable Development Goals to life. A particular focus is on climate protection and the necessity to reduce $CO_2$ emissions (ILO 2015, 2019; European Commission 2022; UN 2023; UNESCO 2022; UNIDO 2022). Research already exists on the introduction of Green Skills in regulatory frameworks of different vocational education and training systems on a macro level (CEDEFOP 2024). In addition, studies focus on teaching-learning processes in vocational schools and in courses of providers of further training (Pavlova and Singh 2022; Rosenberg et al. 2020). Several pilot projects illustrate related teaching-learning processes on an intermediate skill level (Melzig et al. 2021; Michaelis and Berding 2022; Weber and Pfeiffer 2023). Up to now, however, there is a research gap on how companies, with the peculiarities of the business sector they belong to, meet their needs for Green Skills. However, such a view is crucial because it provides a differentiated view on the extent to which the overall political goals and societal ambitions aimed at fostering sustainability transformations have an impact on Green Skills in companies. Up to now, there have been few studies on what companies do to cope with existing needs for Green Skills, and particularly about how the responsible individuals in the companies understand Green Skills and how they impart them (see Lobsiger and Rutzer 2021; Albertz and Pilz 2025).

This paper focuses on companies involved in building automation, which is part of the construction sector. Construction is one of the most environmentally damaging economic businesses, as it generates a large percentage of global $CO_2$ emissions (UN 2024). Representatives of the building automation business consider their products and services as drivers for sustainable building and $CO_2$ reduction (Aouichaoui et al. 2024; Caldas et al. 2022). The sector has generated innovations, such as shading systems that can be automatically adjusted by using sensors (Al-Masrani and Al-Obaidi 2019; Choi et al. 2017), and intelligent windows that control natural ventilation to keep the heat out during the day, but ventilate intensively at night (Chenari et al. 2016; Saber et al. 2021). Modern building automation systems use weather data and forecasts to plan room temperature in advance. Another example is the innovation of green roof systems that are integrated into a comprehensive automation concept to utilise evaporative cooling (Straube 2024). The focus of this contribution is on those sustainability transformations that are considered to reduce $CO_2$ emissions and therefore aim at counteracting global warming. It must be considered, however, that the focus here is on *Green Skills* in companies involved in building automation; the study does not include the tangible, measurable impacts of these Green Skills on the $CO_2$ footprint of work in building automation. In addition, the study does not include the impact of building automation technology on buildings and related impacts on climate change (Aouichaoui et al. 2024).

It is also important to bear in mind that politicians and academia frequently understand Green Skills in the normative sense that such Green Skills should contribute to socially just sustainability transformations (Eadson and van Veelen 2023; UN 2023). In this study, *just transformation* relates to Green Skills with regard to attitudes, knowledge and dispositions that enable the learners to develop a forward-looking, responsible personality able to communicate and cooperate with others in reducing the $CO_2$ footprint of their work; Green Skills therefore include social skills and personality-enhancing skills (Auktor 2020; De Haan 2002, 2010; Slingenberg 2009). Other studies, however, argue that socially just transformations mean that these transformations have an impact on society. They warn that the less privileged sector of the labour market should not be excluded from learning Green Skills, which are considered to be valuable for their future employment (Kwauk and Casey 2022; Neimark et al. 2020). Due to the focus of the study, we cannot include such tangible, measurable impacts of Green Skills on the societal structure and social inequality.

Another aspect to consider is that building automation is an economic sector that is characterised by 'green jobs' (Apostel and Barslund 2024, 1; ILO 2015, 1) and 'green employment' (Vona et al. 2019, 1021). This calls for particular attention in analysing the relationship between Green Skills and other skills that are necessary in this economic sector. Therefore, we define Green Skills for this study as follows: Green Skills are comprehensive competencies that can be characterised by the analytical categories that are frequently used to analyse skills in the work process; these are practically applied skills (such as technical skills), social and personality-enhancing skills (Auktor 2020; Billett and Pavlova 2005; De Haan 2010; Pavlova 2017). At the same time, due to the peculiarities of building automation companies and their ambitions for reducing the $CO_2$ footprint of the construction sector, these Green Skills show specific peculiarities (Fastenrath and Braun 2018b; Ramsarup et al. 2019). Thus, Green Skills are not a new category of skills; they can be captured by using concepts established in vocational education research. At the same time, Green Skills are specific because they are new skills that emerge in the context of sustainability transformations.

This study takes a local view in examining the research field. The view is on the metropolitan area of Cologne in Germany, where ecological circumstances, such as the impact of climate change with above-average summer heat, heavy precipitation and floods of the river Rhine, have contributed to the need for the local government to initiate climate-resilient development strategies and strategic measures (Cologne 2024). The local activities are framed by supraregional, national and EU-wide regulation (Fries et al. 2024). In addition to environmental regulation, vocational education and training should promote local development by enabling the learners to carry out sustainable work practices; in this regard, vocational schools and universities of applied sciences play a particular role in Germany (Pilz and Li 2020). This illustrates that the companies in the research region must be examined within their multifaceted and multi-scalar settings (Fuchs 2024).

This contribution analyses how the responsible individuals in building automation companies understand and impart Green Skills. The following research questions are pursued: How do companies engaged in building automation meet their needs for Green Skills, and what kind of training do they perform? What do the actors consider to be relevant contextual preconditions that influence the company's requirement and development of Green Skills?

In the following, the paper relates literature on Green Skills to existing studies on skills in building automation. The paper then clarifies the design and method. Section 4 presents the findings by reconstructing interviewees' understanding of Green Skills and related activities in the companies and illustrates the relevant contextual preconditions. The section on discussion and conclusion integrates the findings in the literature and indicates directions for further research.

## 2 | Green Skills

Due to various activities to promote Green Skills on an international, national and local scale, the narrative of Green Skills has become a buzzword since the 2010s (Affolderbach 2022). In general, the term refers to skills that are intended to qualify, sensitise and motivate learners through initial vocational training, study programs and further training measures that reduce the $CO_2$ footprint of their work (Affolderbach 2022). Green Skills therefore require environmentally oriented learning (Albertz and Pilz 2025).

To specify the 'greenness' of Green Skills and to capture their particular form, studies frequently seize on environmental regulation as a yardstick (see, for the United States: Consoli et al. 2016, 2019; for the European Union: Bachtrögler-Unger

et al. 2023; Santoalha et al. 2021). These studies usually focus on different industrial sectors (Auktor 2020); however, the predominant view on sectors provides little information about the particularities of Green Skills, because these studies refer to Green Jobs and broad task descriptions. Ramsarup et al. (2019) therefore suggest including the peculiarities of the companies within their surroundings. In line with other research on vocational education (Auktor 2020; De Haan 2002, 2010; Slingenberg 2009), they offer a comprehensive understanding of Green Skills, as described in the following with a particular view on companies of building automation.

Frequently, studies understand Green Skills in companies as *practically applied skills* (Ritter and Sauer 2017). These skills enable the learners to carry out technical handling of work equipment and work objects and enable them for organisational execution of processes; both require cognitive-analytical thinking and experiential knowledge (Ritter and Sauer 2017). Given the massive expansion of digitalisation in many companies, these skills include the abilities to introduce, use, design and produce digital technologies; recent studies therefore recognise a connection between Green Skills and digital skills (Bachtrögler-Unger et al. 2023; Santoalha et al. 2021). Such connection is also noted for building automation (Çetin et al. 2021), where digitally based products and services contribute to the efficient use of electricity, heating and cooling energy and intelligent building systems (Saric and Glatte 2024).

Comprehensive Green Skills in companies also include *social skills* and *personality-enhancing skills*. Social skills are the ability to communicate and cooperate with others at work, such as teamwork and leadership skills. Personality-enhancing competencies mean to develop a forward-looking, responsible personality (Auktor 2020; De Haan 2002, 2010; Slingenberg 2009). These skills include, for instance, awareness, mindfulness, motivation, planning ability and responsibility for sustainable work (Cabral and Dhar 2020). In this particular sense of social and personality-enhancing abilities, Green Skills are the (hardly tangible) part of just sustainability transformations (Eadson and van Veelen 2023; UN 2023). Regarding building automation, studies consider Green Skills as the ability to think innovatively and to assess the usefulness of the particular technology (Stifterverband and McKinsey 2021). In addition, they point to the ability to develop a farsighted perspective and to cooperate across the boundaries of different trades and professions to complete a building (Fastenrath and Braun 2018b; Ramsarup et al. 2019). These few studies on Green Skills in building automation hardly provide a satisfactory overview of practically applied (such as technical) skills, social and personality-enhancing Green Skills in this business field. However, the studies already indicate that there is some overlap when assigning specific Green Skills that are necessary in building automation under the categories of practically applied (such as technical) skills, social and personality-enhancing skills (see Huismann and Hippach-Schneider 2022).

Companies act within contextual preconditions, which can be specified in the following manner. The *availability of Green Skills on the labour market* is a relevant contextual precondition for the company. If the skills available on the local labour market do not match the demand of the company, there is a need for training (Fuchs and Westermeyer 2024). In Germany, there is a wide-ranging shortage of employees with Green Skills, which suggests that companies must train their staff (Vogelsang and Pilz 2022). In addition, activities of a company can only be understood if their integration in the *value chain* is considered. Green Skills must be analysed in upstream and downstream parts of the value chain where companies have interfaces with their suppliers, subcontractors and clients (Aouichaoui et al. 2024; Fastenrath and Braun 2018b; Ramsarup et al. 2019). Public *regulation* also plays a role. Regarding Green Skills, regulation relates to governmental environmental rules and requirements, as well as to standards, norms and certifications (Vona et al. 2018, 2019). Moreover, regulations set by the vocational education and training system must be considered (Rausch-Berhie et al. 2024).

Figure 1 summarises the analytical framework: This study uses the general categories, which vocational education literature frequently applies to describe comprehensive competencies, here as dimensions to specify Green Skills in companies of building automation. The study considers that companies and their skill requirements are shaped by contextual preconditions.

## 3 | Design and Methods

Based on systematic web research and snowballing sampling, the research team found that in the Cologne metropolitan region, 26 companies in total have a focus on building automation or have building automation as an important part of their business activities. These companies produce sensors, actuators, gateways and comprehensive automation systems; they design, plan, prepare, commission, install, maintain and offer further services for building automation technology on construction sites. Most of these companies have their focus on a

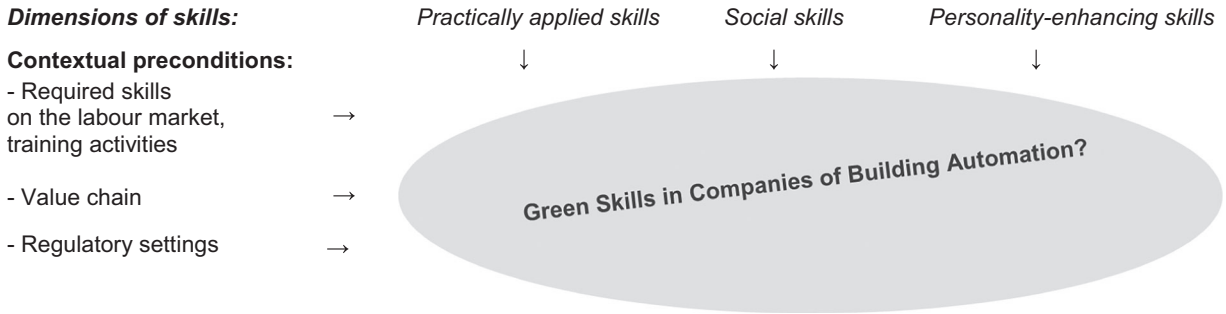


**FIGURE 1** | Overview of the analytical framework (own figure).

few of these functions, particularly in design and planning, whereas others integrate various functions and act as general contractors. Sometimes, subcontractors of these companies undertake installation work on the construction site.

The 26 companies were contacted. A considerable number thereof, namely 10 companies, agreed to carry out interviews. These companies are specialised in different areas. Five of them are **g**eneral **c**ontractors for construction, with building automation departments; these appear with the abbreviation **GC** and the number of the interview (**I**) in Section 4; two are **e**ngineering **o**ffices (**EO** and the number of the interview), and three **d**eveloper who design, implement hardware and software (**D** and the number of the interview). If all company interviewees agreed on an issue, we referred to it as: *I 1–I 10*. In addition to the 10 interviews in companies, the team conducted three interviews with local public actors to complete the picture. These are interviewees in the **b**uilding **s**upervisory **a**uthority (**BSA** and the number of the interview), who are relevant with regard to the implementation of environmental regulation in buildings, in the local **u**niversity of **a**pplied sciences (**UA** and the number of the interview), who offer studies in building automation, and in the local **e**conomic **p**romotion **a**gency (**EPA** and the number of the interview) who are engaged in local companies' sustainability transformations.

The interviewees were executives, environmental specialists, planners, individuals involved in human resource management and training and technical experts in the companies. The study is based on semi-structured interview guidelines. After clarifying the interviewees' particular understanding of Green Skills, the interviews included questions about the companies' needs for Green Skills, activities such as training measures, the role of digitalisation and further technical and organisational peculiarities of the processes within the company. The questions also covered contextual preconditions, such as the local labour market, the integration of the companies in value chains and the impact of regulation. The interviewees referred to Green Skills of employees who are professionals, specialists and experts directly involved in processes of building automation. Employees who were only indirectly involved were not included, such as secretarial or cleaning staff, who also need Green Skills but those are less specific than for building automation. The questionnaire for the further local actors was adapted to the different actors' tasks.

The interviews took place from April to July 2024. Frequently, the interview not only included a single interviewee but two or three individuals who were experts on this issue. The interviews lasted about 60 min, with some being longer, particularly when the meeting included company tours. The information gained from the interviews was supplemented by web research. This research included websites of the companies and other organisations, and further web-based research on documents of policy makers, vocational and training institutions and further organisations, in the region and beyond.

The interviews were documented with a recording device and recording software; they were transcribed verbatim. Some information, such as that gained on a company tour, was documented in memory logs. The team used explanatory, interpretive procedures to analyse the statements within the interview protocols (Flick 2009). Given the qualitative framework, the results were interpreted in several discussion rounds within the team. In this process, the meaning of relevant statements was distilled through an in-depth analysis of these protocols. This careful procedure then allowed for the abstraction of the logic of meaning (Flick 2009). Finally, open interpretative-qualitative methods (Soeffner 2004) were combined with systematising evaluations to gain more generalisable results (Kuckartz 2018). The authors translated the interview quotations, which are cited in Section 4, from German to English.

## 4 | Results: Green Skills in Building Automation Companies

Consistent with the analytical structure suggested above, the following starts with the interviewees' understanding of Green Skills. Then, the section elaborates on the skill requirements of companies and related training activities. Finally, the section shows contextual preconditions that the interviewees considered as relevant for the implementation and expansion of Green Skills.

### 4.1 | Understanding of Green Skills

In essence, all interviewees referred to the skills of architects, engineers, technicians, planners and further professionals in building automation (*I 1–I 10*). They explained that Green Skills develop with emerging green jobs and green employment, as described in literature (see Apostel and Barslund 2024; Vona et al. 2019). The interviewees did not perceive Green Skills as a separate category of skills (see Huismann and Hippach-Schneider 2022; Vogelsang and Pilz 2022). Due to this understanding, the interviewees did not perceive Green Skills as a new topic, but as an issue that was introduced in the company some time ago or since the beginning (*GC I 1*, *GC I 2*, *D I 3* and *GC I 4*). For example, an interviewee employed in a general contractor company expressed:

> *Nobody even knew that it was called Green Building or Green Skills and the like, but it was simply an optimal operation of systems.*
>
> (GC I 4)

The interviewees emphasised that practically applied technical skills are key, due to the company's task to offer efficient technological solutions to the customers (*I 1–I 10*). When asked what kind of technical competencies are particularly relevant, the interviewees mentioned abilities to design, assess and use digitalised tools, devices, products and services. This is in line with the literature that emphasises the twin transition of green and digital skills (Bachtrögler-Unger et al. 2023).

The interviewees not only referred to technical competencies per se, such as the handling of tools; they particularly stressed that the knowledge and application of the changing sustainability regulations is a basic competence, although this is beyond the practically applied technical skills that literature frequently mentions (see

Ritter and Sauer 2017; Santoalha et al. 2021). In building automation, the increasing digitalisation is defined and enforced by environmental laws, technical norms, certifications and standards. The interviewees emphasised that Green Skills in building automation basically mean that the employees must be familiar with the comprehensive, detailed and frequently changing environmental regulations about construction and building automation (*I 1–I 10*), as specified in the section on regulatory frameworks below in this paper.

### 4.2 | Availability of Adequately Skilled People on the Labour Market

The interviewees stressed that it is difficult to find adequately skilled people on the local labour market (*I 1–I 10*). Therefore, companies undertake various activities to become attractive employers and to introduce students to work life. The companies offer internships and possibilities for students to work (*GC I 1*, *GC I 2*, *GC I 5*, *EO I 6*, *GC I 7* and *EO I 9*). They present themselves at graduate fairs and congresses of universities to initiate contacts early (*GC I 4*). Particularly larger companies develop study programs for building automation together with the local university of applied sciences and sometimes also with other universities of applied sciences in Germany (*GC I 1*, *EO I 6*, *D I 8*, *EO I 9*, *BSA I 11* and *UA I 12*). Some of the companies also search for professionals nationwide, and some also internationally (*GC I 4*, *D I 8*).

The interviewees perceive a considerable 'gap' between the applicants' formal academic education and the operational needs of the company (*GC I 5*). The practically applied skills, which are regarded as important, include especially the technical skills that are relevant on the construction site, for example to 'know how difficult it is to screw a heating pipe under the ceiling' (*GC I 2*). These skills go along with social and personality-enhancing skills, particularly the ability for teamwork on the construction site. There is an urgent need for cooperation between different trades and crafts and therefore to communicate and cooperate with individuals who have different professional habitus, routines and practices (see Fastenrath and Braun 2018b; Ramsarup et al. 2019). An interviewee explained that

> *[...] a high level of teamwork is required to build a building. It's not just the building services planner, or the heating engineer, or the plumber, there are also architects, there are colleagues who take care of the facade. All of this must work together, then there is a roof, then there are all sorts of other things. And it all has to work together, the ability to work as a team, even in building services, I'm thinking of cooling, heating and effective use.*
>
> (GC I 2)

In addition, interviewees also stressed that the employees must be aware, sensitive and motivated to act in a climate-friendly manner and thereby relate to personality-enhancing competencies (*GC I 1*, *GC I 4*, *D I 8*, *D I 10* and *BSA I 11*; *EPA I 13*).

> *So, it's not like you study it somehow, but rather you study it [...] through these lenses (of sustainability). [...] A good architect, in my view, is someone who automatically creates a design that should be sustainable.*
>
> (GC I 1)

The quote above describes Green Skills as an all-encompassing attitude and disposition for environmental awareness. Similarly, another interviewee described that applicants and employees ask for sustainability-related tasks and expressed it like this:

> *They (the applicants) are asking more questions about what they are actually doing for the energy transition, what they are doing to reduce $CO_2$, what the carbon footprint is and so on. This is a very, very new trend, it didn't exist before.*
>
> (GC I 4)

Due to such requirements related to Green Skills, the companies must react, as described in the following.

### 4.3 | Training Activities

There are various training programmes particularly focused on the technical and regulation-related skill requirements (*I 1–I 10*). Frequently, the technical training is offered by suppliers of tools, devices and systems. Such training takes place online or face-to-face, and the length ranges from less than an hour to several days. In exceptional cases, training lasts several months or 2–3 years. This long-term training is usually embedded in broader training programmes (so-called academies) of large companies that not only relate to Green Skills but also to human resource development in the broader context. Large companies frequently have introduced sustainability plans that include Green Skills. An interviewee described how the company has a sustainability plan for the whole group.

> *[...] which basically sets out main goals like: At a certain point in time, 50% of our projects must be at least sustainable according to such and such a level [...]. And out of 1000 people, we now have eight sustainability people who do nothing but sustainability.*
>
> (GC I 1)

Although interviewees in smaller companies emphasised the individual motivation and specific necessities for imparting Green Skills, larger companies frequently have developed a sustainability-related vision, mission and strategy. These findings are in accordance with the literature, which shows that larger companies have more capacity to provide systematically structured training (see Fuchs and Westermeyer 2024).

However, in general, informal learning is widespread. An interviewee described how the employees frequently learn hands-on when they perform their job by asking their colleagues:

> *One colleague will probably say, [...] I don't feel like sitting here for hours in a training course. I'd rather go and ask [name]. The other colleague will say, no, I don't feel like asking [name], I'd rather sit in a training course for three hours and drink coffee.*
>
> (EO I 9)

Informal learning also includes team meetings and knowledge exchange in workshops and conferences. The interviewees explained that the building automation sector is like a community, and colleagues who are employed in different companies frequently help each other. Beyond existing fields of competition, which are subject to confidentiality, informal exchange takes place and is based on trust that exists within the local community, where colleagues know each other from former university courses, or because they formerly worked in the same company (*D I 3*, *GC I 4*, *EO I 9* and *D I 10*).

As training courses and informal exchange are necessary to perform the work tasks, the interviewees emphasised that financial costs play a lesser role (*I 1–I 10*). They stressed that, compared to financial costs, time is more relevant, because time resources of engineers, architects, technicians and planners to fulfil the tasks are limited. Although it could be argued that time and money are interchangeable, this comment by the interviewees, however, puts into perspective that lacking financial resources does not always appear as the most important limitation in imparting Green Skills (Vogelsang and Pilz 2022). Costs, however, are a factor when it comes to the implementation of new sustainable technologies on the construction site, as the following illustrates.

### 4.4 | Value Chain

There are restraints on the market for the products and services of building automation, because this largely innovative and expensive building technology frequently generates substantial costs for the *customer*. The interviewees described how, particularly in recent times of enormously increased construction costs in Germany, the readiness to invest in green building technology has weakened, even if such investment would pay off in the long term. Expensive, prestigious large-scale projects in prominent locations of metropolises are more likely to have advanced technologies than inexpensive residential and office construction projects. In addition, some customers do not regard a high level of digitalisation as useful, or they see the gadget as a toy. Moreover, customers have concerns about data safety and cybersecurity (*GC I 4*, *EO I 9* and *D I 10*). Thus, the demand for Green Skills necessary for innovative solutions in building automation is limited due to market restraints of these technologies.

Apart from these limitations, interviewees considered Green Skills in the value chain as necessary, especially after the building is completed. *Actors who operate and use the building* need Green Skills to run the building in a sustainable manner, and interviewees consistently emphasised that there are considerable deficits (*I 1–I 10*). An interviewee reported on the use of building air conditioning technology:

> *In the past, you pressed a button, and the system started. That is over. [...] When you commission a building today, it is not a matter of pressing the red button. No, you have to go through lots and lots of different commissioning phases that bring everything together. [...] Very important point, just switching it on doesn't work, then no water comes out or the ventilation doesn't work.*
>
> (GC I 2)

Another interviewee reported that many users of buildings do not know how to run the systems. For example, the heating of a kindergarten continuously worked day and night, also at times when nobody was in the building, such as on public holidays (*GC I 7*). Another interviewee expressed:

> *When you look at how much energy is wasted in buildings, it is breathtaking. There is an incredible amount that could be done, and I would argue that we could do a lot more [...]. It starts with the construction of buildings, with the firing of concrete and does not end with the operation of the buildings.*
>
> (D I 3)

The interviewees stressed that particularly the operators of the building, who are the facility managers, need new skills that they frequently do not have (*GC I 1*, *GC I 4*, *GC I 5* and *EO I 9*). An interviewee explained:

> *[...] that sometimes the operator lacks qualified staff for the tasks required to operate central building automation. [...] Yes, because sometimes they have difficulty finding anyone who does more than simple works in facility management. And then no one is put in front of the PC, and then there are error messages [...]. And then the person doesn't know how to change [...] setpoints, and then the pumps or valves are simply set to manual because they don't know how to change the heating correctly [...]. (The facility manager thinks) 'Oh, I'll just open them'.*
>
> (EO I 9)

To avoid such gaps in knowledge and practice, building automation companies offer instructions and handouts as recommendations. The interviewees frequently stated that they regard the transfer of such Green Skills as the task of their companies. However, Green Skills for the operation of the building is more difficult, as buildings exist for decades, which raises the question of how to transfer these operational Green Skills over time.

The interviewees' statements on Green Skills related to the *suppliers and subcontractors* confirm studies which illustrate that Green Skills require competencies to cooperate in value chains across trades and crafts (see Fastenrath and Braun 2018b). Although *suppliers* frequently offer training in how to handle the technology, with regard to *subcontractors*, who employ workers with the 'shovel in the hand', as an interviewee expressed (*GC I 1*), often there is friction in communication and coordination. The companies, which plan and prepare the installation, carry out 'inspections' of the subcontractors on the construction site (*GC I 5*). They must ensure that their planning adheres to the specifications on $CO_2$ emissions (*GC I 5*). This illustrates the relevance of Green Skills also for subcontractors on the construction site (see Ramsarup et al. 2019; Schaupp 2024).

### 4.5 | Regulatory Frameworks

The construction sector and the markets for building automation are controlled by a complex regulation. For building

automation, these settings are the EU Corporate Sustainability Reporting Directive, the EU taxonomy for sustainable activities, the EU supply chain law and ISO standards. The Leadership in Energy and Environmental Design (LEED) is a widely used green building rating system, whereas further international certifications specify the legal frameworks (EU.BAC 2024). In Germany, the Building Energy Act, the Climate Protection Act and the Climate Adaptation Act are relevant laws. Standards, norms and certifications, such as those implemented by the German Sustainable Building Council, specify the requirements. Locally, the building supervisory authority controls the implementation of regulation; moreover, local development plans have steering functions for the built environment at the state level ('Länder'), district level and municipal level.

All interviewees recognised such regulation as a powerful framework for the companies' activities regarding Green Skills (*I 1–I 10*). For example, an interviewee described the EU taxonomy, which defines environmental sustainability of economic activities (European Union 2024), as the 'biggest experiment of all time' (*GC I 1*), because practically every company in Europe has 'to make it measurable how sustainable [the] business is' (*GC I 1*). Moreover, the German Building Energy Act requires related training to fulfil the legal requirements.

In general, the interviewees regarded the market regulation in the EU and in Germany as advantageous because these frameworks create new demands for eco-innovations and therefore new markets for building automation (*I 1–I 10*). Moreover, international standardisation promotes the internationalisation and expansion of building automation markets (*EO I 9*). Interviewees frequently stressed that various regulatory requirements are useful, and they welcomed the resulting 'boost' (*D I 10*). One interviewee stated:

> *We have very high building requirements in Germany, [related to] the issue of energy, energy saving, energy consumption, $CO_2$ savings. [...] That plays into our hands because there is really pressure being exerted in a positive sense. [...] so we are also looking at the building energy law now. Politically, you can stand wherever you want and find it [...] good or bad, but the direction is right.*
>
> (GC I 4)

The public sector is an important client for energy-saving buildings and the corresponding use of building automation. The interviewees all reported that public procurement (particularly building automation technology implemented in school buildings) is relevant, such as it exists particularly at the state level (North Rhine-Westphalia), and in the metropolitan region of Cologne (*I 1–I 10*; *EPA I 13*; see Cologne 2024).

If we shift the view from environmental regulation to vocational education regulation, it must be considered that the latter is hardly relevant for the interviewees (*I 1–I 10*). In Germany, vocational education and training for sustainability is anchored in 'standard occupation description positions' (Bundesanzeiger 2020) and further specified for particular occupations (BiBB et al. 2024; BiBB 2024). Because the employees usually have academic degrees, activities of vocational schools hardly play a role for the interviewees (*GC I 1*, *EO I 6*, *D I 8*, *EO I 9*, *BSA I 11* and *UA I 12*).

## 5 | Discussion and Conclusion

The view at the company level has revealed that in building automation, practically applied Green Skills are largely technical, particularly digital skills. In addition, skills regarding public regulation and standards are relevant practically applied skills. Social skills and personality-enhancing skills play a prominent role; the ability to work in a team is highly relevant in design, planning and particularly on the construction site, where cooperation with other professions and workers is crucial. Beyond specific training, also informal communication, frequently within existing local networks between the involved architects, planners and engineers, facilitates mutual exchange and contributes to skill development. Overall environmental awareness of the employees stands out as a general Green Skill (Figure 2).

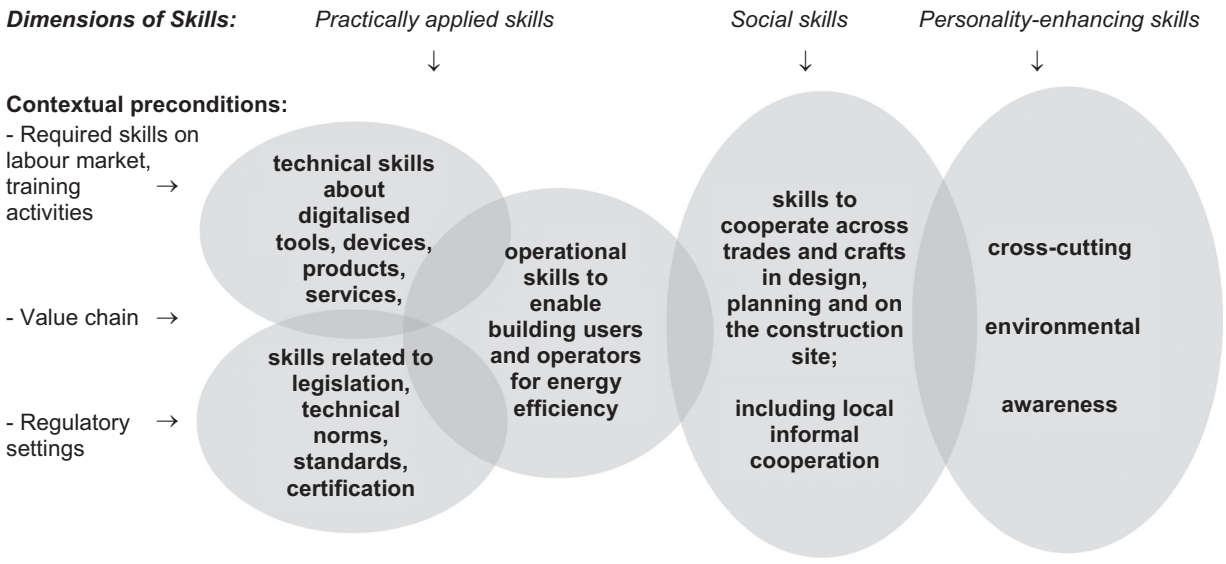


**FIGURE 2** | Findings of the study of kinds of Green Skills, embedded in the analytical framework (own figure).

The study showed that Green Skills in building automation cannot simply be defined as a particular category of skills, because companies' demand for Green Skills intersects with the demand for skilled work in general; this is in line with the literature (Apostel and Barslund 2024; ILO 2015; Vona et al. 2019). However, the results show that Green Skills in building automation include specific skills, which Figure 2 illustrates in the grey bubbles.

Figure 2 also illustrates that the different skills (technical and regulation-related skills, social and personality-enhancing skills) overlap, which speaks for the chosen comprehensive understanding of Green Skills and related teaching-learning processes (see Huismann and Hippach-Schneider 2022).

The study showed that companies act within contextual preconditions; for instance, they are embedded in value chains. Although literature on skills in the building sector already emphasised that the ability to cooperate across trades and crafts (business-to-business) in value chains is important (Fastenrath and Braun 2018b; Ramsarup et al. 2019), the results of this study specify that the value chain must be conceptualised including the operators and users of building automation. These actors frequently lack the skills to use the building automation technology, resulting in inefficient usage of the technology. Such skills are scarcely included in research on Green Skills; however, obviously, the correct and environmentally friendly use of products, and how the companies care for these skills, also appears as a relevant topic for other industrial sectors (see Auktor 2020).

Another finding is that customers are frequently not willing to accept higher costs for environmentally friendly new technologies. Although this, principally, sets limits for market development and related needs for Green Skills, environmental policies, such as public procurement of climate-neutral building activities, have a significant impact on the market development and related Green Skills (see Onuoha et al. 2018). The issues of market development and public procurement, which promote eco-innovations and therefore create related requirements of Green Skills, point to a relevant field for researchers and politicians. The relevance is not limited to building automation but relates to other economic sectors.

As a local case study, this paper has limitations, relating to the question of how the insights gained can be transferred to other regions and countries. Although the work-based needs of technical, social and personality-enhancing skills in building automation could speak for similar developments in this sector internationally (Li et al. 2023; Li and Pilz 2023; Pilz and Li 2020; Persson Thunqvist et al. 2023; Wolf 2021), regulation and public procurement differs between countries and regions, be it in Europe (CEDEFOP 2024), in the United States (Consoli et al. 2016; Vona et al. 2018, 2019) or countries of the Global South (Owusu-Agyeman and Aryeh-Adjei 2023; Pavlova and Singh 2022; Rosenberg et al. 2020). Moreover, further spatial preconditions differ, for example, between cities, or between cities and rural regions (Pavlova 2018; Röhrer et al. 2020). These differences call for a geographically sensitive view (Braun et al. 2018; Fastenrath and Braun 2018a; Strambach and Pflitsch 2018).

Another limitation relates to the ecological and societal impacts of Green Skills, which could not be included in this study. However, there is an obvious need to analyse such issues (Affolderbach 2022; Gonon 2022; Williams 2024). Not only is *Green* Skills a highly normative term and therefore needs critical consideration, especially if we consider the broad spectrum between approaches that range between green growth and post-growth (Affolderbach 2022; Schulz and Braun 2021; Pavlova 2018). In addition, counterproductive dynamics pose huge challenges for societies to realise the goals of $CO_2$ reduction, such as rebound effects, when $CO_2$ reduction is not achieved because the saved resources are wasted elsewhere (Schulz and Bailey 2014). Another example is greenwashing, when companies try to give themselves a green image without actually, systematically implementing corresponding activities (Williams 2024). All this speaks for a comprehensive perspective on Green Skills, including a critical view on how, and to what extent, they contribute to sustainability transformations.

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