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Original Research Article

How Engagement Drives Circularity: Evidence from Eight Danish Construction Companies Extending Material and Product Lifespans

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ABSTRACT

This study examines how small and medium-sized construction companies engage employees and end users in extending the lifespan of products, components, and materials. Based on eight qualitative Danish case studies, the analysis shows that circular economy practices often emerge from disruptions in daily work rather than from formal circular strategies or policy initiatives. Examples include equipment shortages, premature wear, project complexity, customer dissatisfaction, and participation in pilot initiatives. Employees and end users play a central role in identifying problems, proposing solutions, and validating reused materials or alternative practices. These interactions often initiate experimentation with new routines. The analysis further shows that organisational and relational conditions, including employee autonomy, trust-based relationships, and close customer interaction, enable these initiatives to develop and stabilise over time. The findings highlight how circular practices can emerge through practice-based learning processes triggered by operational disruptions and supported by enabling organisational conditions in everyday work practices.

KEYWORDS

Circular Economy, Prevention, Longevity, End Users, Employees, Construction Sector, SMEs.

INTRODUCTION

The circular economy (CE) offers an alternative to the prevalent linear production and consumption model. CE aims to eliminate waste, maximize resource efficiency, minimize environmental impacts, support sustainable development, and foster new business opportunities[1], [2]. Despite its growing popularity, CE has faced criticism from scholars calling for interdisciplinary, critical, and coherent perspectives and a shared understanding of CE [3]. Understanding how CE is conceptualized is crucial to avoid it becoming stagnant or merely a form of "greenwashing" [4], [5].

Many scholars have attempted to define CE[3] and it remains a topic of debate in academia [4], [6]. In this study, CE is understood as a system aimed at maintaining the value of products, components, and materials for as long as possible through strategies such as reuse, repair, and resource efficiency [4].

The construction sector plays a particularly important role in the circular transition. The building sector accounts for around 50% of global raw material use and 36% of final energy consumption [7] Consequently, transitioning the sector towards circular practices is essential. CE in the building sector typically involves keeping materials, products, and components in use for as long as possible with minimal processing. This includes reusing building elements, renovating or retrofitting structures, and designing buildings for adaptability and disassembly[8]. Such inner-loop strategies preserve material value, reduce energy consumption, and minimise waste generation compared to recycling or downcycling [9].

Businesses implementing CE can adopt narrow, slow, close, regenerate and inform strategies to reduce resource use and environmental impacts [10]. Narrowing strategies reduce material consumption by increasing efficiency. Slowing strategies extend product lifespans through durability, repair, and reuse. Closing strategies focus on closing material loops through recycling and remanufacturing. Regenerate strategies aim to restore natural systems by using renewable or biobased resources. Informational strategies, such as documentation and data exchange, support these approaches by improving transparency and enabling collaboration [10]. Table 1 presents these strategies with examples from the construction sector.

Table 1: Circular Economy Strategies and Illustrative Practices in the Construction Sector

CE Strategy	General Description	Examples from the Construction Sector (based on case studies in this analysis)
Narrow	Reducing resource use by increasing efficiency and minimising material inputs [10]	Designing for material efficiency; avoiding surplus materials on site; using prefabrication to reduce waste
Slow	Extending product and material lifespans through durability, repair, reuse, and intensified use [10]	Renovation instead of demolition; reuse of tiles, bricks, flooring; improved machinery storage and handling; equipment sharing to increase utilisation
Close	Closing material loops through recycling, refurbishment, or remanufacturing [10]	Sorting and recycling waste fractions; producing recycled aggregates; refurbishing and reselling heat pumps, solar panels, and ventilation units
Regenerate	Restoring or enhancing natural systems through renewable or biobased materials [10]	Using certified sustainable timber; replacing fossil-based materials with biobased alternatives
Inform	Improving information flows, transparency, and collaboration to support circular practices [10]	Material passports; digital platforms for surplus material exchange; equipment-tracking apps; customer communication on reuse options

Implementing CE in the construction sector requires collaboration across multiple actors. CE initiatives often span organizational boundaries and involve customers, suppliers, policymakers, and other stakeholders[4], [11], [12]. In the construction industry, this collaborative approach is particularly complex because the sector includes many diverse and interdependent stakeholders. Companies therefore move from focusing primarily on internal operations towards inter-organizational collaboration within broader ecosystems, where different actors work together towards shared sustainability goals[13].

Within this context, employees and end-users play particularly important roles. Employees possess practical knowledge of daily operations and often identify opportunities for improving material handling, reuse, and efficiency. Empowering employees to contribute, experiment,

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and take initiative can therefore enhance CE outcomes within construction companies [14]. End-users also influence circular practices, for example through their expectations regarding renovation, reuse, and material choices. Trust between companies, employees, and customers can therefore become an important enabler of circular practices [15].

Hence when companies are moving from linear activities towards CE activities, they are also moving from a focus on their own operations to an inter-organizational and systemic collaboration within an ecosystem perspective, where various stakeholders work together towards a common goal [16]. Here, collaboration can be understood as: "a process in which autonomous or semi-autonomous actors interact through formal and informal negotiation, jointly creating rules and structures governing their relationships and ways to act or decide on the issues that brought them together; it is a process involving shared norms and mutually beneficial interactions" [17].

However, implementing CE in the building industry requires a shift from traditional linear models to more circular practices. This transition is facilitated by engaging various stakeholders, including customers and employees. Empowering employees to contribute, experiment, and take initiative can significantly enhance CE outcomes [14]. Therefore, involving employees in decision-making processes and providing them with the necessary skills and knowledge can significantly improve the adoption of CE practices within construction sector companies [18]. However, collaboration across the value chain is also vital for a successful CE implementation. This involves inter-organizational and systemic collaboration, where diverse stakeholders work together towards a common goal [16], [18]. Such collaboration ensures that CE initiatives are comprehensive and effective, addressing the complex challenges of sustainability in the construction sector. Another important enabler for the success of such collaborations is also the existence of trust between the actors involved [15].

At the same time, the construction sector faces several barriers to implementing CE, including the absence of clear governance strategies, underdeveloped waste management systems, and limited awareness among end users about circular solutions [13]. Homeowners often lack guidance and incentives to demand circular solutions, which reduces pressure on developers and suppliers to adopt CE practices [13]. As a result, there is still a need to better understand how circular practices develop within the construction sector and how different actors become involved in these processes. This article addresses the following research question:

What challenges and enablers do construction SMEs encounter when involving employees and end-users in efforts to prolong product, component, and material lifespans, and what triggers the initiation of such engagement processes?

In this study, a distinction is made between triggers and enablers of circular engagement. Triggers refer to specific events or disruptions that initiate changes in practices, such as equipment failures, economic constraints, customer feedback, or participation in pilot initiatives. Enablers, in contrast, refer to organisational, structural, or relational conditions that allow such initiatives to develop and stabilise over time, including employee autonomy, trust-based relationships, and close interaction with end-users. In this way, triggers can be understood as initiating moments that open space for change, while enablers support the development and stabilisation of new circular practices.

To answer this question, the study draws on qualitative case studies of eight Danish small and medium-sized enterprises (SMEs). The empirical material consists primarily of semi-structured interviews with company representatives, supplemented by follow-up conversations and observations conducted between January 2023 and June 2024.

Denmark provides a relevant setting for this investigation due to its long-standing focus on sustainability and supportive policy environment for CE adoption. The construction sector is

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dominated by SMEs, which often operate within trust-based networks. These relationships between companies, employees, and end-users create favourable conditions for collaboration, knowledge sharing, and the development of circular practices. By examining Danish cases, this study explores how trust and everyday interactions influence efforts to prolong product and material lifespans.

PRACTICES AND LEARNING IN CIRCULAR CONSTRUCTION

The analysis is grounded in practice theory and learning theory, with a focus on how circular practices unfold in real-life settings within the construction sector. Practice theory helps illuminate how decisions are made on construction projects, often shaped by on-site demands and contextual situations [19], where numerous stakeholders influence the actual practices [20].

When companies attempt to implement circular practices, they often start by modifying formal elements such as procedures or developing circular policies [21]. However, these top-down changes are often not enough. Successful implementation requires integration with, or transformation of, existing practices on the ground. In the construction sector, this means aligning new requirements with the everyday routines of the building professionals.

Circular practices in the construction sector

Circular practices refer to what actually happens in the construction sector when circular principles are implemented - how people select materials, manage machinery, and handle waste on site, as well as how they make more strategic decisions such as whether to renovate or rebuild a home. To practitioners, certain ways of working simply make sense in their local context, which is why circular practices often vary widely between projects and actors. Understanding how building professionals make decisions in practice is therefore essential for shaping and embedding circularity into their routines [22]. Recent circular economy research highlights that circular practices often emerge through everyday interactions, relational dynamics, and situated problem-solving among actors involved in implementing circular initiatives rather than through formal procedures alone [15]. An issue that becomes particularly relevant when new circular strategies do not align with existing routines. Although organizations frequently assume that employees follow job descriptions, day-to-day practices are continually adapted in response to site-specific demands, material availability, and practical constraints [23].

Corporate practices tend to form through habitual, repeated actions [24]. These embedded routines make practices relatively resistant to change, yet it is precisely these routines that must evolve if CE principles are to be effectively implemented in the construction sector. Because such routines are often implicit, they can be difficult to identify, but they surface through the narratives and stories practitioners share on-site or in project meetings, revealing the social context in which work unfolds [22].

Circular practices in the construction sector thus concern how CE principles, such as reuse, durability, modularity, and resource efficiency, are operationalized in specific projects. For example, if a project team is accustomed to working with conventional suppliers, they may continue to do so even when alternative materials or suppliers are available, or even explicitly preferred by end users. This illustrates the persistence of established routines and the challenge of integrating new circular options into everyday workflows. At the same time, external pressures, including customer demands, employee suggestions, and regulatory incentives, also influence the adoption of circular practices [8]. These pressures can prompt teams to reconsider established routines and make space for new approaches that support material longevity and resource efficiency. In practice theory, such practices are understood as configurations of actors, material arrangements, competences, and shared understandings that shape how work is performed in specific contexts.

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Learning as a way to change circular practices in the construction sector

Learning is essential for changing established circular practices in the construction sector, as it enables individuals and groups to apply new knowledge through both individual reflection and social interaction [19], [22]. Traditional approaches that focus on transferring knowledge through training, guidelines, or documentation often fail to create lasting behavioural change because they do not address how practices are enacted in everyday work. Instead, meaningful change tends to occur through social learning, where actors collaborate, share experiences, and adapt practices within their professional communities [25].

Differences in how practitioners understand circularity, for example, how to assess environmental impacts or apply reuse strategies, can create uncertainty in building projects. Social interaction helps address these uncertainties by allowing practitioners to compare interpretations, negotiate solutions, and build shared understandings. Such learning processes resonate with the concept of double-loop learning, where actors may question existing routines and assumptions [26]. Advancing circularity in the construction sector therefore requires continuous reflection, dialogue, and collaborative experimentation across roles and disciplines, allowing new insights to be integrated into evolving work practices.

This study contributes to the circular economy literature in three ways. First, it shows how circular practices in construction SMEs often emerge through operational disruptions in everyday work rather than through formal circular economy strategies or policy-driven initiatives. Second, it conceptualises these processes through a distinction between triggers, understood as disruptions that initiate experimentation, and enablers, understood as organisational and relational conditions that support the stabilisation of emerging practices. Third, the study highlights the role of employees and end-users as key actors in practice-based learning processes that enable the gradual development of resource-extending strategies in the construction sector.

QUALITATIVE CASE STUDY METHOD

The empirical material presented in the following section is based on case studies including eight companies working in the construction sector. The analysis addresses the practices in the individual companies as well as the learning occurring in the collaboration in and between the company and involved actors.

Case selection

The basis for sampling consisted of companies that had previously participated in research projects on CE in collaboration with Aalborg University and the Network for Business Sustainability in Northern Denmark (NBEN). NBEN is a knowledge network founded on a triple-helix model of collaboration among local authorities, industry, and Aalborg University, and currently includes more than 130 member organizations. Over the past decade, NBEN has conducted sustainability screenings for companies across Northern Denmark. Its members are considered proactive in the field of CE, particularly those with a demonstrated interest in collaborative CE efforts.

Accordingly, the case companies were selected from this group of CE-engaged collaborators. This targeted selection aimed to generate data and insights on how companies collaborate for CE and with whom these collaborations occur.

Although the selected companies are affiliated with NBEN, the identified collaboration strategies are anticipated to have relevance and applicability beyond this network, and to inspire less proactive companies in the sector.

To gain rich insights into circularity practices involving employees and end-users, a purposeful theoretical sampling strategy was adopted [27]. This approach emphasizes strategic case selection based on theoretical relevance rather than statistical representativeness [28], [29].

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The sample was curated based on three key principles:

- Sector Relevance: Only companies within the building sector were included to enable exploration and theorization of sector-specific practices.
- Collaboration Experience: Companies with documented experience in CE collaboration were selected to ensure a focus on relevant, practice-based insights.
- Proactive Circularity: Companies that stood out positively compared to peers in their approach to circularity were prioritized, indicating a higher level of maturity and innovation in CE practices.

This information-oriented case selection strategy [30] intentionally targeted companies already active in CE rather than relying on random sampling. While this introduces a bias that limits broad generalizability across all industries, it allows for in-depth understanding of behaviours and strategies among companies already experienced in CE collaboration.

20 NBEN affiliated companies within the construction sector were screened for their relevance in this research, but only 8 were selected. This sampling strategy implies that the selected companies are more actively engaged in circular economy initiatives than the sector average. The aim of the study is therefore not to explain why companies adopt CE in general, but to gain in-depth insights into how circular practices emerge and develop within companies already experimenting with such initiatives.

A qualitative case study is made with a narrative approach to make it possible to reconstruct chains of related events [29]. The understanding of related events was achieved by studying interviews and written material and through observations, such as participation in site visits. The narratives focus on 1) When relevant decisions regarding circular practices are made and why, 2) Changes in procedures and practices, 3) The practices carried out, and 4) Identifying practices of importance to implementing CE in the organization. Moreover, these past events were discussed with the respondents.

Data collection and analysis

The main data collection for the case study took place from January 2023 to June 2024, where 12 interviews were made with a total of 17 respondents from the companies. Follow-up telephone interviews were conducted when additional information was required (Supplementary to the first 12 interviews).

The 12 interviews were semi-structured [29], [31] and lasted between 1h and 3 h with an average of 1½ hours. The main elements addressed in the interviews were:

- Work roles of respondent(s)
- Introduction and content of daily practices
- The concept of "circularity" and sources of knowledge on circularity
- Circular practices related to suppliers
- Internal communication processes and collaboration related to circular practices.
- Collaboration with end users
- Open question: Things that the respondent would like to add or discuss.

While the number of interviews per company varied, the interviews were complemented with follow-up conversations, site visits, and observations, which allowed clarification of practices and provided additional contextual insights. The aim of the study was not statistical comparison between cases but analytical understanding of how circular practices emerge in different organisational contexts. The transcribed material was classified into different themes related to the aim of the study. This approach is suitable to identify patterns in the text [32]. First, interview transcripts were read and coded to identify recurring themes related to circular practices, employee involvement, and collaboration with end-users. In a second step, these themes were compared across cases to identify patterns in triggers, challenges, and enabling conditions for circular practices.

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EMERGENCE OF CIRCULAR PRACTICES IN CONSTRUCTION SMES

In the analysis, circular practices are examined as evolving practices shaped by interactions between actors, material arrangements, and situated problem-solving within everyday work contexts. An overview of the construction SMEs is provided in Table 2.

Each of the 8 selected cases is introduced in the following with focus on the circular strategies they are working with, and the initiatives selected for the following analysis are highlighted as practices. They are chosen based on the following parameters: 1) They should involve end users and/or employees. 2) The company has identified them as central for their daily practices. 3) They have been implemented for long enough for the companies to have gained experience with their positive and negative consequences.

The cases analysed in this study are all SMEs. Larger construction companies were also screened during the selection process, but no relevant cases were identified for inclusion in the analysis.

Table 2: Circular practices in the case companies. Their core-initiatives are highlighted in bold. Regenerate is not included as a strategy as no CE initiatives on this strategy was identified in the cases.

Com-pany	Size Nr. of employees	Type	Narrow	Slow	Close	Inform
A	45	General contractor (private housing)	Take back systems from suppliers	**Extending lifetime of equipment and intensifying its use in the building process**	Sorting waste	Fleet management involving employees
B	50	General contractor (Business)	Using surplus materials in other building sites	**Extending lifetime of equipment and intensifying its use in the building process**	Sorting waste	Fleet management involving employees
C	60	Carpentry and Construction Services	Using surplus materials in other building sites	**Focus on renovation and reuse of building materials**	Sorting waste	Close collaboration with employees and costumers
D	120	Carpentry and Construction Services	-	**Focus on reuse of building materials**	Sorting waste	Close collaboration with employees
E	15	Carpenter	**Reduce waste and collaborate with SE**	-	Sorting waste	Data exchange with CE
F	10	Contractor	**Reduce waste and collaborate with SE**	-	Sorting waste	-
G	12	Electrical company	-	**Take back and resale of heat pumps**	Sorting waste	Online reuse store

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H	50	Electrical company	-	**Takeback and resale of solar panels and e.g. ventilation systems**	Sorting waste	Homepage with reuse options

During the case analysis 4 different perspectives on circular practices was identified. Each of these are analysed below by focusing on the actual practice, the situations, and the learning processes that led to these practices and the role of end users and/or employees in implementing the practice. In the following the cases are analysed with regards to their CE practices and learning that have followed the initiatives.

Disruption – how the strategies were initiated and practices changed

While regulatory frameworks and public awareness form an important background condition for the circular transition in the building sector [13], the cases illustrate how specific disruptions acted as triggers for changes in practices within the companies. In other words, regulation shaped the broader context, but the immediate initiation of new practices often emerged from practical challenges encountered in daily work. The companies in this study implement strategies that they at first hand explain is a response to regulatory pressures. But this section digs a bit further into their changes in practices and what disruptions that caused them to happen.

Company A. Company A faced a challenge where their machinery, including excavators, dump trucks, concrete mixers, and compactors, was often occupied when new projects began. Additionally, economic constraints prevented them from investing in new, expensive equipment. To address this, they involved their most experienced employees, project managers responsible for the building sites, in devising a solution. They decided to "rent" machinery for specific building sites, incorporating the rental costs into the project budgets. As elaborated by the Manager in this quote:

"It was essential the employees who came up with the solution, and we have had close to no complaints about the system. They really all like that they can always get the machines they need, and they even borrow them from each other." (Manager, A)

This incentivized project managers to only have the necessary machinery on-site for the required days or weeks. Furthermore, they invested in an app to track their machinery usage. As a result, the company maintained service levels with significantly fewer machines, thanks to effective fleet management. Their daily practices were thereby changed. As express in the interview with a project manager:

"We used to have empty garages all summer but now we can almost not fit our machines into the space we have".(Project manager, A)

From a CE perspective this is relevant because it decreases the need for new machinery by intensifying the use. In this specific case the disruption that initiated the change was based on economic constraints. This shift relied on strong trust between management and project managers, as the company depended on employees' honest reporting, shared responsibility, and willingness to coordinate across sites. They need to trust that the machinery needed will be available even when it is not on the building site from the beginning of the project to the end.

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Company B. Company B struggled with construction machinery like excavators, compactors, and generators wearing out faster than expected. The main reason: machines were routinely left outdoors at building sites, exposed to rain, sun, and frost, conditions that led to corrosion, cracking, and early breakdowns.

To tackle the issue, the project managers actively participated in developing new solutions. Instead of investing in expensive new facilities, teams began organizing simple protective measures, such as shared covered areas and heavy-duty covers. Some sites even repurposed materials from previous projects to build basic shelters. They lso recognized the importance of returning machinery to the storage when not in use for extended periods. As expressed by the manager during the interview:

"Once they saw how small changes made a big difference they were really motivated, also they did not have to wait for repair or new machinery due to break downs." (Manager, B)

As a standard procedure, routine check were made when the machines are at storage. By having the machines at storage more often increased the frequency of routine check and made them fail less, as expressed by the Blacksmith in the company:

"Before, we thought machines breaking down was just part of the job. Now we're getting more years out of them without extra cost." (Blacksmith, B)

From a CE standpoint, this change extended the life of machinery and reduced the need for new equipment, simply by improving how existing assets were treated, driven by day-to-day insights from the people using them.

Company C: Company C previously took on large construction projects, often exceeding 20 million DKK, but these proved difficult to manage both financially and operationally. Budgets slipped, coordination was complex. Learning from these experiences, Company C made a strategic shift: they now focus exclusively on smaller renovation and building projects under 5 million DKK. This change allows for better resource planning, and a more hands-on approach to material reuse, as expressed by the project manager:

"We learned the hard way that bigger doesn't mean better. Smaller projects let us stay close to the process and actually make reuse work." (Project Manager, C)

Along with this shift came several concrete practice changes. Reuse is now considered early in the projects, with architects involved in identifying what materials can be sourced secondhand or salvaged from the site. Material storage and logistics are simplified, often using on-site containers to hold reclaimed items until needed. But this is supplemented with a central storage. As expressed by one of the carpenter employed in the company:

"On big projects, everything had to fit a fixed plan. Now we can adapt, if we find 50 square meters of good parquet, we design around that. If we repair an old house we can also use materials that fit better than new ones. We reuse and provide a better service." (Carpenter, C)

From a CE perspective, this approach significantly increases the practical reuse of materials and minimizes waste. It also shows that learning from failure can lead to new habits and better align reuse and economic realities.

Company D. Company D handles renovation work for insurance cases, typically involving damage repair in private homes. In the past, these jobs often led to customer dissatisfaction when newly installed materials, like tiles, flooring, or fixtures, did not match the existing ones.

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Replacing larger areas just to ensure a visual match was both costly and wasteful. Furthermore, for insurance cases the cost of changing larger areas is not covered by the insurance. To address this, Company D began systematically using reused building materials that closely resembled the original ones, especially for visible finishes like tiles, bricks, and roofing. The goal was to create a look that respected the original style of the home while reducing costs and material use. As expressed by the manager:

"Reused materials often have the same patina and color tones as the damaged ones. That makes a huge difference in how the final result looks." (Manager, D)

This approach not only improved aesthetics but also led to fewer customer complaints. As explained in the interview with one of the craftsmen:

"Before, we'd get complaints because 'new' looked out of place. Now, people are impressed that we found something that actually fits." (Craftsman, D)

From an operational perspective, the change also enabled better use of local material reuse depots and on-hand salvaged stock, reducing waiting times and transport costs. It does however cost more man-hours since the processes are more complex.

Implementing this practice required trust between craftsmen and customers, as homeowners needed confidence that reused materials would meet their expectations in terms of quality and aesthetics. From a CE standpoint, this method supports high-value reuse, returning materials to similar applications, and extends the lifespan of existing materials while reducing the need for newly produced ones. In this case, the key driver wasn't cost or climate pressure, but aesthetic quality and client satisfaction, which in turn encouraged wider adoption of reused materials.

Company E. Company E builds single-family homes and renovations, which often result in leftover materials, such as unopened boxes of tiles, insulation, or wood panels, that would typically be discarded. The learning process began when a house owner, during a renovation, pointed out how much brand-new material was being thrown away as elaborated by a project manager:

"The customer was right, it didn't feel right to throw away materials that were perfectly fine. It pushed us to rethink how we handle surplus." (Project Manager, E)

This feedback led to a change in practice: the company started donating usable leftover materials to local socio-economic enterprises, which resell them at low cost to DIY builders. The initiative not only reduced waste, but also supported circular resource use and social value creation. However, the new practice turned out to be more time-consuming than expected. To ensure that only reusable materials are handed over, teams must sort and store items carefully, take photos, and coordinate pickup times. This led to the learning that better coordination tools were needed, and the company developed a simple app where employees can upload pictures of available materials, add short descriptions, and notify partner organizations when a pickup is possible. As explained by one of the site foreman:

"It takes more time than just tossing it in a skip, no doubt. But the teams see the point, and with the app it's starting to run smoother." (Site Foreman, E)

Through this experience, Company E has developed a new practice for handling surplus materials, reducing waste volumes on building sites and strengthening relationships with

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community reuse networks. They also learned that not all types of materials can be sold, and the socio economic enterprise running the "material bank" did not accept all types of materials.

From a CE perspective, this evolving practice supports the reuse of high-quality materials in their original form, avoiding both downcycling and landfill. What started as a critical learning moment from a homeowner has turned into a practice that delivers both environmental and social benefits. The new routines also depended on trust among employees, who had to believe that the extra effort of sorting and documenting surplus materials served a meaningful purpose and would be valued by both the company and its partners.

Company F. Company F specializes in building private housing. They were invited to participate in a municipality-led pilot project aimed at reducing construction and demolition waste. The project encouraged local builders to examine their material handling practices and experiment with new ways to reduce landfill contributions and waste in general. As explained by the manager:

"It opened our eyes. We saw how much material was going to waste, not because it wasn't usable, but because there was no system for passing it on." (Manager, F)

They started setting aside surplus materials, like excess plasterboard, insulation, and timber beams, that were previously treated as waste. Rather than disposing of them, they started a new practice and began offering the materials for free to local socio-economic enterprises. They ended up with a close collaboration with a single actor that picks up all their surplus materials. This is an example of how external engagement can trigger internal learning and operational change.

From a CE standpoint, Company F's evolving practice emphasizes the reuse of high-quality materials in their intended form, avoiding unnecessary processing or waste. More than just a technical change, the initiative fostered new collaborations between the contractor and socio-economic enterprises.

Company G. Company G, is an electrical contractor specializing in energy installations. They initially became involved in dismantling and discharging used solar panels through renovation and retrofit projects. The panels were meant to be discarded, but many of them were still functional or could be fully functional with smaller repairs. As elaborated by a technician employed at the company:

"At first, we were just looking for how to get rid of them properly. Then we realized these panels still had value." (Technician, G)

This insight marked the beginning of a new practice. Rather than discarding used panels, the company started sorting and testing them. Panels that passed a basic performance check were cleaned, documented, and made available for resale. Over time, this developed into a structured offering where second-hand solar panels are sold at affordable prices to private consumers, particularly those looking for lower-cost solutions, such as homeowners with small-scale installations. To make this shift, the organization had to learn new competencies. Employees received training in fault detection, safety testing, and legal requirements for resale. They also had to adjust their practices to integrate the extra steps: careful dismantling, transport, storage, and client communication around second-hand equipment. As explained by the project manager during the interview:

"Working with reused panels is different, you have to understand how to evaluate them and the customers have a lot of questions. We had to learn as we went, but it's become a valuable skill set." (Project Manager, G)

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The initiative has become a part of the company's daily operations, supported by shared tools and routines that help assess and manage panel reuse. This practice-based learning process, shaped by direct experience and customer engagement, has allowed Company G to turn a disposal task into a circular business model. From a CE perspective, the reuse of solar panels extends the life of high-value components and makes the solution more accessible to private consumers.

Company H. Company H is an electrical contractor specializing in energy systems, a shift began when employees discussed the amount of usable equipment, especially solar panels and ventilation units, being discarded during renovation work. As emphasized by the electrician during the interview:

"It just didn't feel right throwing out things that still worked." (Electrician, G)

Motivated by a desire to reduce waste, teams began testing and sorting dismantled components.They also found it to be an interesting challenge to maintain these components as it required more skills than just installing new equipment. Moving forward customers were suggested refurbished options as part of their renovation projects.

This growing interest pushed the company to develop new routines. These skills needed to repair the used products were established partly by learning-by doing but also by taking courses. The new skills were gradually built into daily practice as expressed by one of the project technician:

"We didn't have a plan at first, we just figured it out along the way. Now it's part of how we work." (Project Technician, H)

Many customers still wants brand new equipment, especially in new houses. They find it easier to sell these refurbished options in summer cottages where consumer demand is a bit lower. Through this practice-based learning, Company G transformed a waste discussion into a business opportunity.

Results from the cases in general. The analysis demonstrates that the companies' ability to involve employees and end-users depends on particularly trust. Employees engaged in new routines, such as sharing machinery, testing solar panels, or sorting surplus materials, because they trusted that management supported their initiatives and valued their practical knowledge. Likewise, end-users accepted reused solutions only when they trusted the company's professional judgement, especially in cases where reused components diverged from conventional norms of "newness." This confirms existing literature suggesting that collaborative CE practices depend not only on technical solutions but on relational infrastructures that support openness and joint problem-solving [33].

Equally important are the triggers that initiated these engagements, which should be distinguished from the enabling conditions that allowed these practices to develop and stabilise over time. The cases show that disruptions, economic pressures (A), equipment failures (B), project complexity (C), aesthetic mismatches (D), homeowner critiques (E), or external municipal programmes (F), served as triggers that made existing routines untenable. These disruptions opened windows for employees and end-users to engage in alternative practices, aligning with theories of practice-based learning where change emerges from situated problem-solving rather than planned strategic transitions. Thus, the findings reveal that CE engagement often begins not with circular ambitions but with concrete frictions in daily work or customer interactions.

Across the eight cases, the companies encountered a combination of organisational, relational, and operational challenges when involving employees and end-users in CE

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initiatives. A key difficulty lay in translating individual experiences into shared practices, particularly when employees were accustomed to established routines or when customer expectations constrained the use of reused materials. At the same time, the cases show several important enablers: employee autonomy, practical problem awareness, trust-based relationships, and a culture that allowed experimentation and incremental learning. These elements created conditions in which employees and end-users could meaningfully contribute to prolonging product and material lifespans.

DISCUSSION

The analysis of the eight Danish construction sector SMEs reveals that CE practices often emerge from bottom-up disruptions in which frontline employees and end-users play a central role in initiating and shaping new ways of working. This finding adds an important nuance to the existing CE literature, as the cases show that the initiation of circular practices rarely stems from formal strategy, policy expectations, or dedicated CE planning, but instead grows out of concrete operational frictions such as economic pressures, equipment failures, project complexity, customer dissatisfaction, or engagement in external pilot programmes. These disruptions created possibilities where existing routines became untenable and opened space for employees and users to propose and try out alternatives. This insight highlights the importance of understanding CE transitions as situations of practice-based learning rather than as outcomes of strategic intent.

Taken together, the findings suggest that circular economy initiatives in SMEs can be understood as practice-based processes where operational disruptions act as triggers for experimentation, while organisational and relational conditions enable the gradual stabilisation of emerging circular practices.

This finding contributes to the circular economy literature by highlighting how circular practices may emerge through bottom-up disruptions and situated learning processes rather than through formal strategic initiatives. While previous studies often emphasise policy drivers, business models, or technological innovation, the present study shows how everyday operational frictions can create opportunities for employees and end-users to initiate and shape circular practices.

Across the cases, trust emerges as a key enabler of the circular practices developed. Internally, trust between managers and employees allowed staff to propose unconventional solutions, engage in experimentation, and negotiate new routines. This resonates with the literature on learning in organisations [26]. Bottom-up CE initiatives depend on relations, as employees will only share tacit operational knowledge and take responsibility for new practices when they trust that management supports adaptive problem-solving. Externally, trust between companies and their customers shaped the feasibility of offering reused materials and refurbished components, echoing studies that identify trust as a prerequisite for collaborative CE models and reverse value chains [33]. In the construction sector, where material reuse challenges established norms of "newness," trust becomes essential for building acceptance of alternative solutions. Thus, trust facilitated the disruptions and learning processes observed in the SMEs.

CE was not introduced through abstract policy directives or top-down strategic innovation often identified as drivers in the literature [21], but rather through situated learning and problem-solving at the operational level. Employees developed new routines around equipment use, not from formal CE training, but from practical challenges related to cost, availability, and durability. These examples reinforce the importance of practice-based learning, where knowledge is co-created through experimentation and everyday work. This reflects the "slow" and "narrow" strategies discussed by Konietzko et al. [9], where CE is achieved by prolonging the lifespan of resources and using them more efficiently. Importantly, this learning often

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occurred in response to disruptions such as economic constraints, equipment degradation, or customer complaints that created space for change.

The cases show that the SMEs mainly implement narrowing and slowing CE strategies, such as reducing waste, improving equipment utilisation, and extending the lifespan of materials through reuse and renovation. These strategies fit well with existing work routines and can be developed through incremental, practice-based learning. Closing strategies, such as refurbishment and recycling, appeared only in a few cases, and regenerative approaches were largely absent, reflecting the greater infrastructural and organisational demands these strategies place on SMEs. Across several cases informational strategies were present but applied in simple, task-oriented ways, such as apps for surplus materials or equipment tracking. Overall, the strategy pattern indicates that SMEs adopt the CE practices that are easiest to integrate into daily operations, while more complex circular strategies require support beyond the capacity of individual firms.

In several cases employee engagement emerges as a central enabler of CE, confirming the literature on the importance of empowering operational staff [18]. Employee autonomy and initiative are crucial in implementing reuse strategies. In several cases, employees did not just execute new procedures, they co-developed them, integrating CE into their own routines and identities.

The end-users played an essential triggering and legitimizing role. Customer preferences, whether for aesthetic continuity, reduced waste, or affordable reuse, challenged companies to reconsider standard procedures. This supports claims that demand-side engagement is vital to CE transitions in the construction sector.

However, the data also reveals limits: end-user interest in reused materials was higher in certain segments (e.g., summer cottages, renovation), while new builds often still favoured new products. This highlights the importance of contextual awareness in CE implementation and suggests that consumer education and framing remain necessary.

The companies did not start with fully developed CE practices. Instead, they learned by doing. Practices like reusing solar panels, managing surplus materials, or improving machinery use were developed incrementally, refined through feedback and experience. This highlights the importance of tolerance for trial-and-error, and the value of organizational learning over time.

While public procurement and regulation provide important incentives for circular solutions [8], our findings suggest that the immediate initiation of CE practices in SMEs often emerges from operational disruptions, employee insights, or customer feedback. In this sense, regulation shapes the broader enabling environment, while concrete problems in daily work act as the practical triggers for change.

These findings also have implications for circular economy policy and organisational practice. Rather than focusing solely on regulatory targets or formal strategies, policies may need to support experimentation and collaboration at the operational level, for example through pilot programmes, local reuse networks, or initiatives that connect SMEs with circular resource flows.

CONCLUSION

This study examined how construction SMEs engage employees and end-users in efforts to prolong product, component, and material lifespans within a circular economy perspective. Drawing on qualitative case studies of eight Danish companies, the findings show that circular practices can emerge from concrete disruptions in daily work rather than from formal strategic initiatives.

The Danish SMEs encounter challenges when involving employees and end-users in efforts to prolong product, component, and material lifespans. These challenges include entrenched work routines, limited time and resources for experimentation, customer expectations tied to

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"newness," and the practical complexities of handling reused or surplus materials. At the same time, the cases also reveal powerful enablers that make such involvement possible: high levels of trust, proximity between managers and frontline staff, employee autonomy, and strong relational ties with customers. These organisational and relational features provide the foundation for employees to share tacit knowledge, propose changes, and assume responsibility for new circular practices, while also helping customers accept reused or refurbished solutions.

The analysis further demonstrates that engagement processes are not triggered by circular ambitions alone but by concrete disruptions in daily work. Economic constraints, unexpected equipment failures, customer dissatisfaction, or proactive employees all created moments where existing routines became untenable and opened space for learning. Such disruptions acted as triggers enabling new CE practices to emerge through situated problem-solving. In this sense, the circular transition observed in the SMEs is best understood as an incremental and practice-based process, driven by operational frictions rather than strategic planning. This underscores that effective CE implementation depends not only on policy incentives, but on the organisational cultures, trust-based relations, and learning capacities that allow disruptions to be transformed into opportunities for more circular ways of working.

At the same time, the initiatives identified in this study remain relatively small in scale and highly dependent on committed individuals, relational trust, and favourable circumstances. This underscores that SME-driven CE practices, while valuable learning laboratories, cannot by themselves transform the wider construction sector. Achieving broader circularity will require larger companies to adopt organisational structures that better support employee involvement and customer dialogue, as well as regulatory frameworks and procurement systems that reward experimentation, material reuse, and collaboration across the value chain. Policymakers and managers should therefore focus on creating the conditions that enable practice-based learning, including reducing uncertainties around reused materials, supporting local piloting and experimentation, strengthening collaboration between SMEs and larger actors, and encouraging companies to view operational disruptions not as isolated problems but as opportunities for circular improvement. In this way, practice-based insights from SMEs can inform a more systemic approach to CE transition in the construction sector.

Overall, the study contributes to the circular economy literature by demonstrating how bottom-up learning processes and situated problem-solving can drive circular practices in construction SMEs. The findings show that employees and end-users play a crucial role in identifying opportunities, experimenting with new routines, and legitimising alternative solutions such as reuse and refurbishment. In this way, circular practices often evolve incrementally through everyday work practices rather than through top-down strategic planning.

Future research could explore how similar practice-based learning processes unfold in larger construction firms or in other national contexts where institutional conditions differ.

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ChatGPT (OpenAI, GPT-4.1) was used to improve grammar and language clarity during manuscript preparation. The tool was not used to generate scientific ideas, data, or interpretations. All AI-assisted edits were reviewed and confirmed by the authors

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