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Article

Embodied Carbon Reporting by German Real Estate Institutional Investors

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ABSTRACT

Background: The building sector is one of the largest contributors of greenhouse gas emissions across the globe. The European Union pledges to become climate neutral by 2050. To reach this goal, member states will need to account for embodied carbon emissions. Currently, in Germany, there are no regulations that require institutional real estate investors to account for the embodied carbon of their buildings. However, existing voluntary measurement frameworks could be used for embodied carbon accounting. Hence, this is the first systematic study exploring public disclosures by German institutional real estate investors on their embodied carbon emissions to improve the transparency of their emissions.

Methods: The study uses a mixed-methods research design. Secondary data was collected using purposive sampling of German institutional real estate investors and investigating their public disclosures via corporate websites. This data was then used to shape exploratory semi-structured interviews with industry experts from those institutions responsible for addressing sustainability issues.

Results: While the built environment sector is one of the major contributors of carbon emissions and is under pressure to disclose these in a transparent way in order to evaluate opportunities for reductions, the current public disclosures are limited and lack substance, suggesting that institutional real estate investors in Germany are yet to adequately quantify their environmental impact regarding embodied carbon and, thus, need to improve reporting on their progress towards climate neutrality.

Conclusions: This study gives an overview of embodied carbon measuring and accounting tools, current and proposed regulations in Germany, and sets the foundations for best-practice recommendations on embodied carbon accounting across Europe.

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KEYWORDS: climate neutrality; European Union; carbon reporting; public disclosures, sustainability; embodied carbon; Germany; real estate investors; fund; accounting; whole life cycle; life cycle assessment

ABBREVIATIONS

BMWK, Bundesministerium für Wirtschaft und Klimaschutz (Federal Ministry for Economic Affairs and Climate Action); BREEAM, Building Research Establishment Environmental Assessment Methodology; BVI, Bundesverband Investment und Asset Management e.V.; CRREM, Carbon Risk Real Estate Monitor; DGNB, Deutsche Gesellschaft für Nachhaltiges Bauen (German Sustainable Buildings Council); EC, embodied carbon; ECORE, EPBD, Energy Performance of Buildings Directive; EPRA, European Public Real Estate Association; ESG-Circle of Real Estate; EPC, energy performance certification; EU, European Union; GHG, greenhouse gas; GRESB, Global Real Estate Sustainability Benchmark; HQE, Haute Qualité Environnementale; INREV, European Association for Investors in Non-Listed Real Estate Vehicles; KSG, Bundesklimaschutzgesetz (German Federal Climate Change Act); LCA, life cycle assessment; LEED, Leadership in Energy and Environmental Design; LETI, London Energy Transformation Initiative; NFDR, EU Non-Financial Reporting Directive; ÖKOBAUDAT, Informationsportal Nachhaltiges Bauen (Sustainable Construction Information Portal); RICS, Royal Institution of Chartered Surveyors; SFDR, EU Sustainable Finance Disclosure Regulation; UK, United Kingdom; WLC, whole life cycle

INTRODUCTION

The buildings sector is a major emitter of greenhouse gases (GHG) [1]. While companies increasingly make detailed disclosures on their sustainability performance, estimations and reporting on embodied carbon (EC) is limited, leaving the investors puzzled if the businesses are indeed aware of their EC emissions and how they consider these emissions in their business strategies. RICS notes that the real estate industry is making progress on addressing sustainability. However, not at the pace required to address climate emergency [2].

In the European Union (EU), buildings are responsible for 40% of the energy consumption and for 36% of GHG [3]. Throughout the property life cycle [4] these emissions primarily result from construction and operations followed by renovations and demolition [1]. Globally, around 11% of GHG emissions constitute EC emissions in buildings. EC makes up 10%–20% of the buildings' total carbon emissions [5]. At the country level the focus has been on regulations for the reduction of operational emissions of buildings, since they comprise a bigger part of the emissions than embodied emissions [6]. So far, building materials and the construction of buildings have been neglected by the EU. Energy performance certifications (EPC) for buildings have been a requirement in

Europe since 2003 [7,8]. Decarbonisation of the energy sector with the use of renewable energy has supported this process [7].

With buildings becoming more energy efficient to accommodate the increasingly stringent EPC regulations (Energy Performance of Buildings Directive 2010/31/EU and Energy Efficiency Directive 2012/27/EU revised 2018 and 2019 through to amending directive 2018/844/EC and due to be further revised), the share of EC emissions increases relative to the whole life cycle emissions [7]. In highly energy-efficient buildings, the EC emissions may have a share of 45%–50% up to 90% in extreme examples, whereas in buildings following current energy performance regulations in their respective countries, the EC emissions would only make up around 20%–25% [9]. Despite the life cycle thinking and the EC accounting being applied for 20 years [10], regulations to measure and report EC in the construction industry are only slowly being considered or implemented around the world. The EU also stops short of regulating EC accounting but does have the subject on its agenda [11].

Building emissions need to be reduced over the entire lifecycle [12], and that not only by reducing energy demand, but also by decarbonizing the energy supply and addressing EC in buildings [12]. Given the role of EC in buildings, the question remains as to how EC is accounted for by institutional real estate investors in their buildings. In 2021 the share of the five largest institutional real estate markets (including Germany in 5th place) stood at 65% [13]. While investors in many countries take varied approaches to meeting the respective targets, this study focuses on Germany.

Germany is the largest institutional real estate investment market in the EU [13] with a share of 28% [14] and generates the highest GHG emissions [15]. Further to that, Germany has recently stipulated more ambitious targets on the road to net zero with climate neutrality by 2045 [16]. To reach this goal the building and construction sector will need to further reduce its emissions. While in relative terms German institutionally investable real estate stock is performing at the global average (measured as emissions per building area) [17], EC in buildings and its accounting will play an important role in the process of decarbonization of the buildings sector in Germany. With the country's building sector missing its sectoral emission targets a second time since 2021 [18], it is expected that greater transparency on EC accounting in Germany will support an improved understanding of this issue in other jurisdictions.

Given the scarcity of literature on this topic, based on evidence from the German institutional real estate investment market, the aim of this study is to close the research gap and to investigate whether these investors choose to report their EC emissions and if so, how they opt to account for EC emissions from their buildings. As the EU has an old building stock with 85% of buildings completed before 2001, 85%–95% of these buildings is expected to be still standing in 2050 [19].

BACKGROUND

Defining Embodied Carbon

Broadly, EC refers to GHG emissions which are described as global warming potential using carbon dioxide equivalents and commonly referred to as “carbon”, although carbon dioxide is meant [20]. While the researchers’ interest in EC had recently increased [21,22], there is still no agreement on the complete definition of EC [6,23–25]. Nevertheless, in general for buildings, EC reflects all GHG emissions that are produced during the production of the building materials, including the transportation, assembly, and disposal of the construction materials and products, so to the production and end-of-life production [20]. According to RICS embodied carbon in buildings are “the resultant emissions from all the activities involved in the creation and demolition of a building” [26]. However, the measurement depends on the bases and methods on which we are yet to agree.

Embodied Carbon Accounting Methods

EC may be measured using various bases: (1) cradle-to-gate, (2) cradle-to-site, (3) cradle-to-end of construction or cradle-to-practical-completion, (4) cradle-to-grave, or even (5) cradle-to-cradle, etc. [27–31]. The cradle-to-grave approach allows for a full life cycle assessment (LCA), covering all phases from the extraction and production of new materials and construction, through the maintenance and replacement of the building, up until the demolition of the building. Figure 1 summarises the various bases.

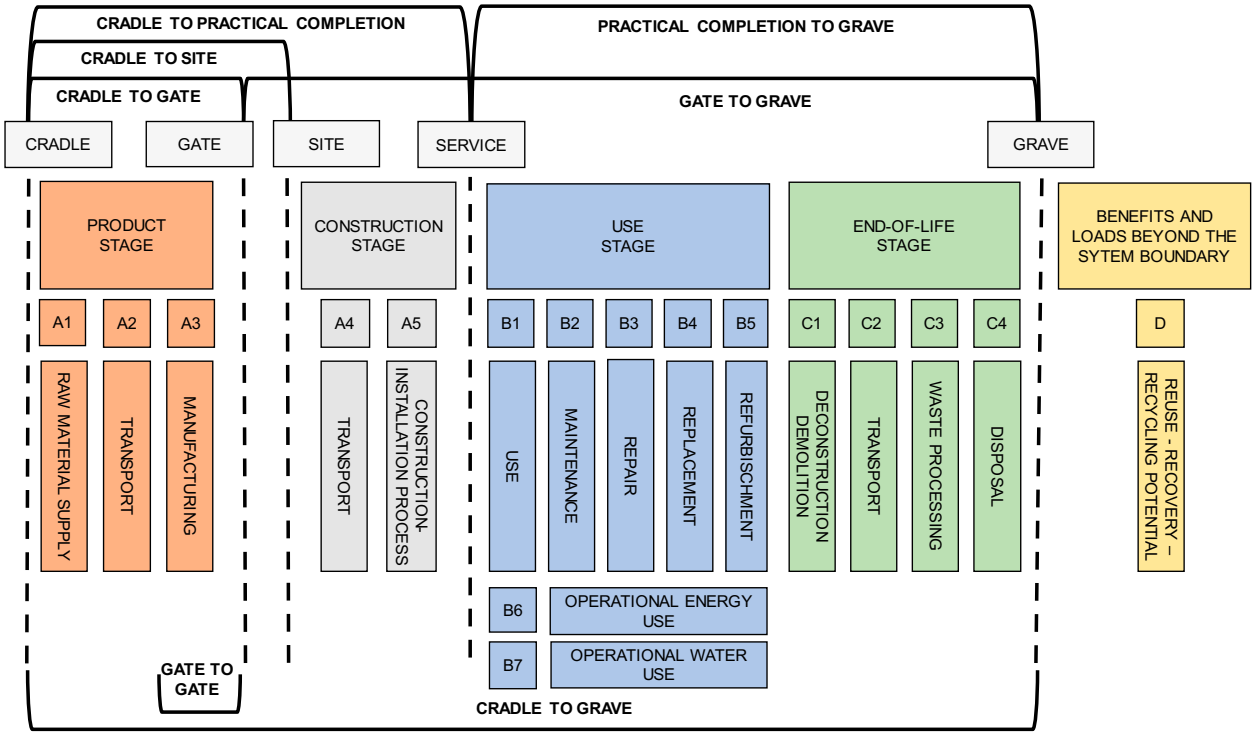

Figure 1. EC accounting bases [28–31].

Contrary to operational emissions, which can be easily measured, the estimation of EC is more complicated as EC can only be estimated. This is a more time-consuming act requiring a detailed footprint analysis with inconsistent approaches. Amongst the best method to quantify emissions is the LCA method [32,33]. LCA has been in use for over two decades [34,35] and is currently the standard approach in the building industry [10]. However, within the LCA method, there are three different emissions inventory methods: “process LCA”, “input-output LCA” and “hybrid LCA” (compare ISO 14040/44) leading to different results [36,37]. The most commonly used emissions inventory method in the building industry seems to be the “process LCA” [37]. “Process LCA” tracks the actual process, materials, and energy needed in the production and delivery chain, use phase, and end-of-life of a product [37].

LCA, defined by the International Organization for Standardization in ISO14040 “as the compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle” [38], is not precise as ISO14040 does not standardise the LCA’s calculation methods for the various stages of the LCA. Thus, results vary greatly depending on which LCA methodology is chosen [39,40]. LCA of buildings in the EU is set out by Standards of the CEN Technical Committee 350 (CEN/TC350). Further, EN 15978:2011 (Sustainability of construction works. Assessment of environmental performance of buildings. Calculation method EN) classifies the phases for different life cycle stages. However, while expanding on the terms and definitions set out in CEN/TC 350, it does not provide details on methodologies nor prescribes classifications for minimum standards of performance. Internationally, the methodology and benchmarks for LCA techniques differ [41]. Each country uses evidence linked to its national resources and specifics of their construction sectors [42] and thus diverges in terms of scope, types of buildings covered, life cycle stages, building elements, energy used in operation, and wider environmental impacts [41]. LCA requires systematically collected data on building materials, construction, transport, energy, and disposal processes [40] with the overall credibility of LCA conclusions depending on the quality and availability of the relevant datasets [42]. In Germany, this data is supplied via ÖKOBAUDAT provided by the German Federal Ministry for Housing, Urban Development and Building (Bundesministerium für Wohnen, Stadtentwicklung und Bauwesen). ÖKOBAUDAT is a standardized database compliant with EN 15804, designed for the ecological evaluations of buildings [43]. ÖKOBAUDAT encompasses the life cycle assessment using databases of building materials, construction, transport, energy, and disposal processes, collected in a systematic way for specific building assessment systems [43]. Software tools such as GaBi [44], ecoinvent [45,46], and One Click LCA [47], can be combined or used on a standalone basis.

Voluntary Embodied Carbon Calculation Tools

Possibilities of EC accounting exist through voluntary building certifications aimed to lower the environmental impact of buildings during their life span by providing third-party "green" building labels [48–50]. However, only some of these certifications include LCA or can be used as a management tool during the life cycle of a building [51]. In Germany, the most popular certifications for new buildings are Deutsche Gesellschaft für Nachhaltiges Bauen (DGNB), Leadership in Energy and Environmental Design (LEED) in the United States and Building Research Establishment Environmental Assessment Methodology (BREEAM) [52,53].

DGNB is the most advanced sustainability certification in the world [54]. However, despite its international adaptability, it is mostly used in German-speaking countries [54]. The DGNB offers certification for all building types based on the entire lifecycle of a building, incorporating both embodied and operational carbon emissions [55] and builds on three principles: (a) LCA, (b) holistic assessment, and (c) performance evaluation [54,56]. On the other hand, the he LEED certification, used in more than 178 countries [57], addresses a variety of buildings, it also covers LCA including design, construction, operations, and maintenance, thus also incorporating EC accounting [58,59]. With four levels of certification, LEEDS provides a holistic approach well beyond energy, water, and health. Another voluntary certification also used for German buildings is BREEAM, currently in use in 89 countries [60]. Besides newly built projects, existing buildings and refurbished ones can be certified bearing in mind specific local requirements e.g., around climatic conditions [61,62]. Within BREEAM under the category 6. Materials, LCA is performed for EC [63]. However, BREEAM In-Use for existing buildings does not require LCA and thus does not incorporate EC in this specific certification.

Other voluntary EC assessment tools, ratings, or frameworks that could be used for EC accounting in Germany include Carbon Risk Real Estate Monitor (CRREM), ESG-Circle of Real Estate (ECORE), Global Real Estate Sustainability Benchmark (GRESB), London Energy Transformation Initiative (LETI), Green House Gas (GHG) Protocol [64] and the RICS professional statement on Whole life carbon assessment for the built environment [27]. Developed in Germany, CRREM allows investors to assess the risk of their assets based on analysis of regulatory requirements and analysis of energy and emission data to attain the Paris agreement target by 2050 [65]. CRREM currently only encompasses Scope 1 and Scope 2 emissions and not Scope 3. EC trade-off is currently only analysed in the impact of retrofit and its effects on total carbon performance by as alternative to the operational savings [66]. The German ECORE is an ESG scoring standard developed for real estate investors to make real estate portfolios more "transparent, measurable, and comparable" [67] and hence uses three clusters of analysis: governance, energy consumption, and energy and waste emissions [67]. The Dutch GRESB issues ESG

performance reporting for real estate owners [68]. While GRESB includes Scope 1 and Scope 2 emissions, reporting on Scope 3 is optional, hence EC accounting is automatically built in [69]. LETI designed by the UK's built environment professionals "to put the UK on a path to net zero carbon future" [70], offers the EC Declaration Template as an Excel Sheet online as a download free of charge to calculate the EC in buildings [71]. The GHG Protocol is an Excel-based carbon accounting tool that considers Scope 1 and Scope 2, and Scope 3 for the emissions from everything else incl. such as suppliers, distributors, and product use. Finally, the RICS professional statement on Whole life carbon assessment for the built environment can be used to calculate EC emissions [27,72].

Policies, Regulations, and Political Agenda in Germany

Climate regulations in Germany are governed by the Federal Climate Change Act (Bundesklimaschutzgesetz, KSG). The 31 August 2021 amendment to the act stipulates Germany's goal to become climate neutral by 2045 and specifies gradual GHG reductions by 88% by the year 2040, to neutrality by 2045. The German Environment Agency (Umweltbundesamt) monitors the GHG emissions for each sector and assesses compliance with KSG. This is then bi-annually examined by the Expert Committee on Climate Questions (Expertenrat für Klimafragen), with its first report released on 25 August 2022 [73]. This is a critical protocol, as, should the GHG emissions be exceeded for a specific sector, the relevant federal ministry would implement an "immediate program" to ensure the attainment of the emissions goals of the sector for the future years which may trigger amendment to KSG. Moreover, since 2021, there is a tax on carbon dioxide emissions related to the combustion of fossil fuels through the Brennstoffemissionshandelsgesetz (Fuel Emission Trading Act) that commodifies emissions at a price of EUR 30/tonne of carbon dioxide [74,75] and since 2020 the Building Energy Act (Gebäudeenergiegesetz) sets out energy performance requirements for specific types of buildings including the use of EPC and renewable energy use in buildings [76]. However, the Building Energy Act only regulates energy consumption.

The federal government in Germany has already considered the subject matter of EC in buildings (also known as "grey energy"). This was documented in a study conducted in 2017–2018, commissioned by the Federal Institute for Research on Building, Urban Affairs and Spatial Development (Bundesinstitut für Bau-, Stadt- und Raumforschung) [77]. Furthermore, the federal government has already implemented life cycle assessment requirements for new construction and refurbishments of federal government buildings in the Building Tasks of the Federal Government [78] including accounting LCA for the buildings led out through its (Leitfaden Nachhaltiges Bauen) thus referencing Bewertungssystem Nachhaltiges Bauen of the Federal Building Ministry (Bundesbauministerium), both the two central and comprehensive

Instruments of the Federal Government, to achieve its Sustainability principles [79].

Germany's Climate Action Status (Eröffnungsbilanz Klimaschutz) of the Federal Ministry for Economic Affairs and Climate Action (Bundesministerium für Wirtschaft und Klimaschutz, BMWK) in January 2022 stressed that that the climate action taken is inadequate and climate targets for 2022 and 2023 will not be met unless the rate of emission reductions is tripled, thus calling for new regulations and other measures to be implemented soon [80].

The new Buildings Energy Act [76] is expected to include references to sustainability aspects and energy requirements for buildings' production and use and introduce a digital building resource passport to promote the circular economy. Besides, the decarbonisation of the heating in buildings through the Energy Act, the Climate Action Status BMWK paper also states that that the government will prepare the basis to take a closer look at EC and life cycle costs [18].

The German DGNB has already proposed that the scope of the building passport should encompass the transparency for buildings WLC for a lifetime of at least 50 years [81] with the buildings' service life set between 50 and 100 years [82]. The DGNB proposal also outlines that WLC carbon emissions of the building should be disclosed together with primary energy from non-renewable energy sources [81]. More recently in Germany, the focus seems to be on raised expectations for new buildings, which comprise the accounting of EC with a motion in Leipzig [83] and think-tank initiative of Bauwende [84]. To summarise, the LCA and EC accounting for buildings is speedily gaining importance in German government agendas.

Policies, Regulations, and Political Agenda in Selected European Countries

In anticipation of future EC accounting regulations in Germany, it is important to understand the position of the European Union on this matter. Following the revision of the EU's Energy Performance of Buildings Directive (EPBD) [85], the EU is debating on starting to measure EC emissions from buildings [11]. The leaked EPBD draft document intended to require EU countries to provide an overview of measures that lead to the reduction of WLC GHG emissions in buildings [85] and calculate the global warming potential EPC for new buildings larger than 2,000 sqm from 1 January 2027 and for all new buildings starting 1 January 2030 [86]. Currently, the negotiations on EPBD are ongoing, with the recently approved European Parliament position [85] and expected to be concluded in summer 2023 [87]. If countries had common standard calculation tools for LCA in place to fulfil the minimum level(s) common EU framework [85], this could be used for the required disclosure. Moreover, voluntary standards are being developed by the EU. In March 2020 the European Commission adopted the new Circular Economy Action Plan [88] which is

part of the European Green Deal making climate neutrality and zero net emissions by 2050 legally binding in the EU. Amongst the 35 objectives of the Circular Economy Action Plan, some relate to the EU sustainable products norm which will result in new measures for the constructions and buildings sector as potentially making a major impact in reducing emissions [88]. These will include sustainability of construction products, recycling, promoting durability, digital logbooks for buildings, integration of LCA for public procurement, and EU sustainable finance framework [88].

The World Green Buildings Council has developed an EU Policy Roadmap to address WLC impact across various policies [89]. The roadmap outlines recommendations to reduce emissions (including EC) of buildings by 2050 stressing that since the European building stock is old and inefficient, renovation rates need to double [89]. Further, it recommends calculations and regulations of WLC and measures for the circularity of construction materials [89]. Countries such as Belgium [90], the Netherlands [7,91,92], the UK [93], France [7,94,95], Denmark [7], Finland [96], and Sweden [97] have already implemented, or are about to implement LCA or WLC in their regulations and establish information databases.

Embodied Carbon Disclosures

Reporting on sustainability provides opportunities for signalling corporate responsibility for sustainability issues in the real estate sector [98–103]. A recent PwC survey suggests that CEOs who are most exposed to climate change will be more prone to address it [103]. Furthermore, 87% of global investors believe that corporate reporting includes unsubstantiated sustainability claims [101,103]. It is often suggested that to ensure market transparency, companies should use consistent disclosure methods [99]. Reporting sustainability information through environmental certificates can improve the financial performance of commercial real estate companies [104,105] and enhance asset liquidity [106]. However, as noted by MSCI [107,108] reporting on environmental targets in the real estate sector, with Scope 3 emission estimated at 88% of all emissions, seems to lag behind some other sectors with only 22% of companies considering Scope 3 emissions [107]. Globally, the MSCI pilot study of 16 funds contributing to the Pan-European Quarterly Property Fund Index suggests that 57% of institutional real estate investors set targets for Scope 3 development emissions [108]. However, given low response rate in their study, it is likely that this is not reflective of the global market. Nevertheless, due to the voluntary nature of sustainability performance reporting, real estate companies are facing a lack of a standardised approach of the informational content of sustainability reports.

Similar to wider environmental reporting [109], using standardised methods of information disclosure for reporting on EC is still in its infancy

with no consistent rules on calculation and methods of disclosure or methods to interpret the disclosed data [110]. Similarly, industry bodies such as Carbon Disclosure Project, European Association for Investors in Non-Listed Real Estate Vehicles (INREV), European Public Real Estate Association (EPRA), Global Reporting Initiative, and GRESB provide frameworks for voluntary sustainability disclosures. However, they do not provide detailed guidance on systematic EC reporting.

Environmental reporting disclosures reflect the relevance of environmental issues to the companies' management [109,111], with EC being a critical element of such disclosures [112]. Detailed and systematic data can provide confidence in evaluating the environmental effectiveness of businesses [113]. Thus, one would expect that companies, which made a substantial investment into sustainability and measurement of their carbon footprint (including EC), would more likely provide more objective quantitative evidence, while others in the absence of hard evidence would be more likely to use qualitative less detailed narratives [114]. However, qualitative disclosures have a greater effect on business reputation amongst executive and investor stakeholder groups [115]. Given these complexities, content analysis is commonly used to distil environmental disclosures from companies reporting documentation [109,116].

WLC and EC are on the agenda not only of the German government but have also been implemented in their buildings' laws by other European countries. The real estate investors should therefore attend to the subject matter of WLC and, thus, EC in their buildings.

RESEARCH DESIGN AND METHODOLOGY

Given the lack of consistency in identification, accounting, and reporting of EC and a scant literature on the EC performance of institutional real estate investors, we investigate: (a) if the institutional real estate investors in Germany account for the EC in their buildings and (b) if so, how is this undertaken by them. This is performed via a two-stage process. We start by conducting a directed content analysis, which is based on the appearance of specific codes and allows for establishing the EC reporting practices [116–118]. This process is followed by semi-structured interviews with industry experts, which are used to gain more detailed insights into the issues surrounding the EC reporting practices.

Directed Content Analysis

In the context of this study, the content analysis is used to test if German institutional real estate investors report on EC and if so, how they achieve this. Given that EC is a current key political topic [12], the content analysis serves here to correct the "optical illusion" that EC reporting is on the agenda in Germany and to establish the nature of EC reporting. This method, due to its flexibility and systematic nature, has been used by researchers investigating similar topics [119–122].

The selection of the directed content analysis is based on past research on conventional, directed, and summative content analysis, suggesting that the directed content analysis is most appropriate when coding is guided by a theory [123]. The process logic map is presented in Figure 2.

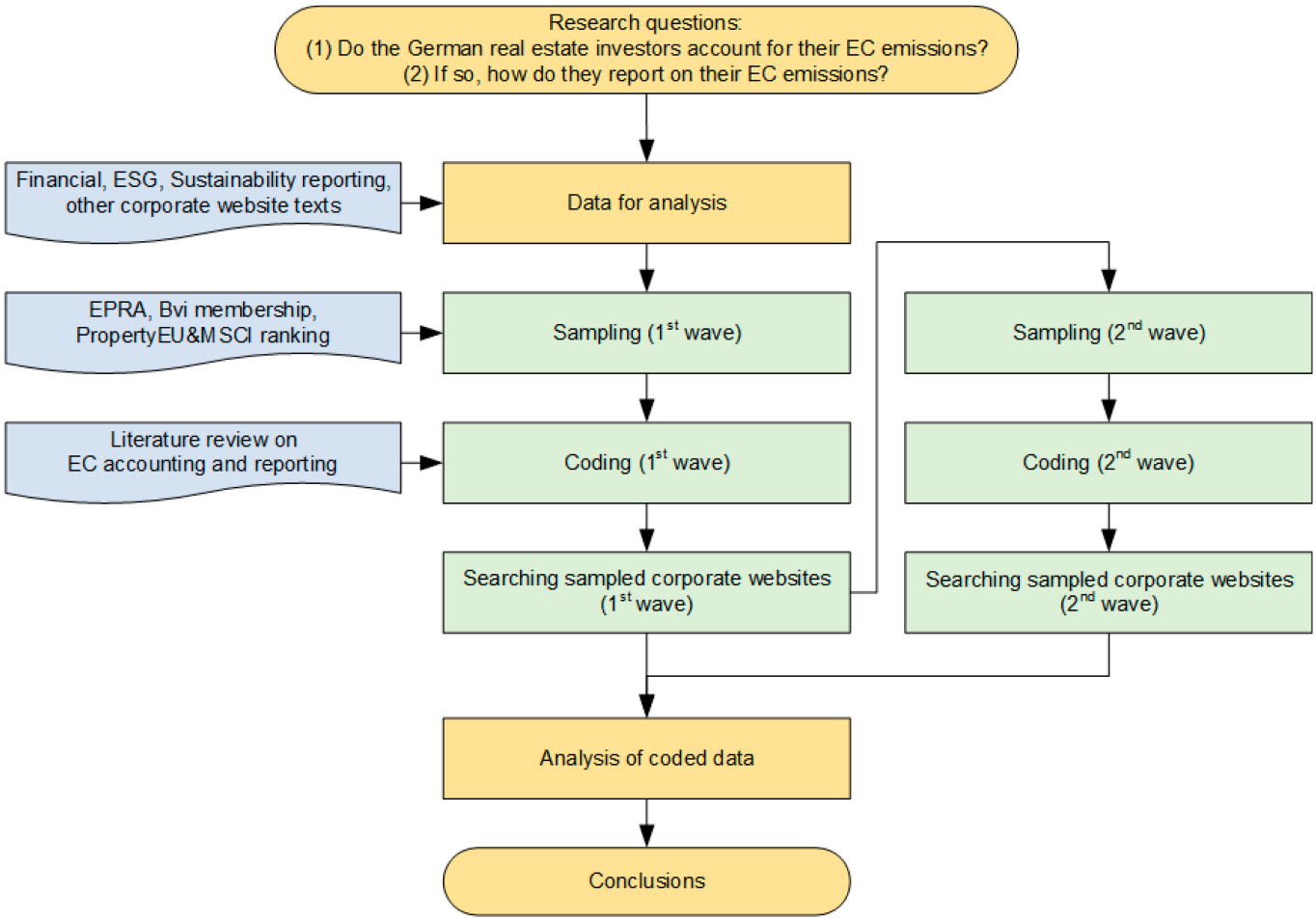

Figure 2. Directed Content Analysis—Logic Map.

Data collection

Following the literature, we used codes relating to EC reporting in the context of the whole life cycle theory and stemming from that building sustainability certifications. To explore how commercial real estate investors in Germany account for EC in their buildings, data was gathered via the company websites and in particular their sustainability and financial reporting sections with the aim to identify annual financial statements, ESG reports, Sustainability reports or ESG Roadmaps on the assumption that these would be the main external communication tools used by businesses to signal their accounting for EC. In case of the lack of codes in these documents, the codes were used to search other areas of the companies' websites.

Sampling

The data was collected through purposive sampling [124] by which real estate investment companies were chosen from (a) members of Bundesverband Investment und Asset Management e.V. (BVI)—an association of German investment funds, (b) members of the European Public Real Estate Association (EPRA), (c) organisations listed in the PropertyEU&MSCI top dealmakers European ranking [125] and (d) based on the researchers' professional consultancy experience in the real estate investment sector. BVI and EPRA members lists were used as these include major real estate institutional investors active in Germany (BVI) and in Europe (EPRA). Notably, the majority of EPRA's membership consists of public institutional real estate investors active across a number of markets with many players active in the German market. The PropertyEU&MSCI ranking [125] has been effectively used to validate the sample from sources (a) and (b).

Coding

EC-related codes were established using the a priori approach [126], where the codes were identified prior to the analysis based on keywords relating to the lifecycle theory and linking EC back to sustainability certifications. This method is used on the assumption that EC reporting codes would occur frequently enough to provide insights supporting consistent meanings [127] communicated by German institutional real estate investors. These consistent meanings relating to EC were sought in the above-mentioned publicly available documents published by real estate investment companies. Codes used included the explicit evidence—"embodied carbon", implicit such as "BRREEAM", "CRREM", "DGNB", "GRESB", "LEED", and "ÖKOBAUDAT" and indirect indications for potential EC evidence—"ESG report", "sustainability report", "ESG Road map", "carbon reduction road map", "carbon reduction", "grey energy", and "graue Energie".

Searching corporate websites

The data was collected in two waves, between 1 and 30 August 2022 and then between 21 and 31 January 2023. The two-wave approach has been taken because the 1st wave frequently identified documents relating to 2020 or older, which may not fully represent the current status of the EC accounting.

Data analysis

Although MSCI suggests (1) comprehensiveness, (2) ambition, and (3) feasibility, when assessing the company's decarbonisation targets [107,108], in line with previous literature on quality of environmental disclosures [120,128,129], we assumed that the quality of data depends on (1) the quantity of information disclosed and (2) its richness. While the

quantity is based on the codes described below, the richness is measured based on the amount and informative power offered by additional information to describe the EC accounting. Hence, we examined both aspects. As a first step, the collected code results together with key company information such as (1) type (real estate investment trust, property fund, other) and (2) the real estate sectors they invest in (retail, office, industrial, logistics, residential, and other) were used to assess if explicit EC reporting was mentioned and if not, if there is any implicit or indirect evidence of EC reporting. In line with past research [120,128], the first step allowed to identify the occurrence of codes, which in the second step allowed for a detailed analysis of the documents including the identified codes. Many authors use disclosure types, scorning systems, and codes to increase the reliability of capturing and analysing data [127,129–132]. For this analysis, we considered some of the aspects identified such as historical orientation (e.g., past evidence of considering EC), network embeddedness (e.g., evidence of linking EC accounting to the building development and life cycle), endowments (e.g., sustainability certifications), managerial vision and team skills (e.g., commitment to carbon emissions and EC, managerial plans, reporting lines and milestones for EC reporting) [130].

Expert Interviews

The research strategy encouraged the use of semi-structured interviews as a means of inquiry. The main intent of the interviews was to gain a detailed knowledge and understanding of EC reporting amongst German institutional real estate investors. The interviews were structured in two parts: Firstly, questions were asked about the participant profiles and backgrounds; and secondly, questions were asked about their organizational EC reporting. As professional sentiment is able to predict market conditions by over a year [72], the participants were also asked to express their sentiments on future regulations around EC. The themes of the interview questions are listed in Table 1.

Table 1. A list of the themes used to underpin the questions posed to the participants.

#	Themes of the interview questions
1	How their companies measure and account for carbon and EC in buildings (tools, methods, data)?
2	How EC affects their companies' investment decisions?
3	How is EC considered in the context of transaction structuring?
4	What are their companies' plans for the remaining footprint that cannot be further reduced?
5	Where do they see the greatest challenges for EC reporting?
6	Specific issues around EC and wider ESG problems.
7	Potential new German EC regulations.

A purposive sampling (a non-probability sampling technique) was adopted, using explicit inclusion criteria, namely: participants (1) must have a minimum of five years' experience of working in the real estate

sector in EC related capacity, (2) must be currently employed by a German real estate investment company, (3) must have been personally involved in the EC reporting within that company, and (4) must be able and willing to share their insights. This allowed for a small and specifically targeted group of participants to be approached for an interview. All participants were identified via their LinkedIn profiles using the following keywords: "ESG" or "Sustainability" and "Real Estate". Once invitations were accepted, participants were offered the opportunity to have in-person or online face-to-face interviews. All interviews were digitally recorded (each taking 30–60 minutes) and later transcribed verbatim. To preserve the anonymity of the participants and to guarantee their confidentiality, no names were stored in the transcribed text.

Ethical approval

Prior to the interviews, ethical approval was gained. Also, before any interviews were arranged all participants were informed of the nature of the study via a participant information cover letter detailing that their consent and involvement were anonymous and entirely voluntary. At the start of the interview, the interviewer explained this again and reminded the participants that the interviews were being recorded and how the data would be kept and used. After the interview, the participants were given a two–week window to allow them (if they desired) to withdraw their responses. This approach is compliant with the expectations of UK university research ethics regulations.

RESULTS

The findings of the study are presented below under two main section headings: (i) EC reporting by German institutional real estate investors; and (ii) Expert interviews.

Embodied Carbon Reporting by German Institutional Real Estate Investors

This study sought to identify evidence of EC reporting by German institutional real estate investors. Secondary data was collected through company website searches. Sampling was conducted in two waves. The 1st wave of sampling, which identified 38 German institutional real estate investment companies, took place on 1 August 2022. As this wave identified a substantial number of documents potentially not reflecting the current situation, the 2nd wave of sampling was conducted on 21 January 2023 for the original 38 investors and 6 other investors. Table 2 provides an overview of the sources of the sample.

Table 2. Sample size and sources.

Sampling	Total*	BVI**	EPRA***	Property EU/MSCI	Authors
1st wave	38	16	9	14	12
2nd wave (additional investors)	6	0	5	0	1
Total	44	16	14	14	13

*—Note that some investors were identified via more than one source; **—European Public Real Estate Association; ***—-Bundesverband Investment und Asset Management e.V.

Despite continuously discussed issues around sustainability, the analysis of many company websites proved difficult with obscured data or poor links to such information. If the company website did not include a sustainability or ESG report or financial statements, the quality of evidence varied significantly, and it was often not clear if they were directly accounting for EC. Some websites differentiated between private individuals and institutional investors with some information accessible only to registered institutional investors. In such cases, EC disclosures were based on public information. Hence, it is possible that some of these institutional real estate investors provide more details EC emission disclosures to their investors.

Following years of raising the bar for sustainability and ESG reporting, we observed that only 63% of investors produce sustainability, climate-related, or wider ESG reports as their most comprehensive disclosure on their environmental impact. A Further 7% publish white papers or strategy-type reports and 7% publish other reports which make limited references to carbon emissions (financial or CSR reporting), while the remaining ones (23%) only include fragmented information on their websites. Table 3 provides an overview of the most comprehensive source of information for companies included in the 2nd wave. Overall, the information on not just EC emissions but also more widely on sustainability and any type of carbon emissions, on most of the websites, was found to be superficial, inconsistent, and lacking transparency. Even when “carbon emissions” were mentioned, it was unclear what exactly was included in the reporting or calculations.

Table 3. Type of the most comprehensive source of information for the 2nd wave investors.

Type of source	Number	Percentage
Sustainability, Climate, or ESG report	28	63%
Sustainability or Climate Change White Paper/Strategy	3	7%
Other Reports	3	7%
Other website references	10	23%
Total	44	100%

In the 1st wave, out of the 38 companies, 15 (40%) companies have not made EC relating public disclosures. The remaining 23 (60%) companies mentioned that building certifications (LEED, BREEAM, or DGNB) were

used for their buildings or considered for the future. Among those 10 (26%) reported using a combination of all three building certifications, while 3 (8%) used a combination of two building certifications and the rest one type of certification and the remaining 10 (26%) used only one certification (60% of those reported using DGNB).

In the 2nd wave, out of the 44 companies, 15 (34%) companies have not made EC relating public disclosures. The remaining 29 (66%) companies mentioned that building certifications (LEED, BREEAM, or DGNB) were used for their buildings or considered for the future. Among those 14 (32%) reported using a combination of all three building certifications, while 6 (14%) used a combination of two building certifications and the rest one type of certification and the remaining 9 (20%) used only one certification (67% of those reported using DGNB). Table 4 provides an overview of the number of companies reporting using building certifications.

Table 4. Sustainability reporting.

Sampling	No reporting	Reporting*	BREEAM	LEED	DGNB
1st wave	15	23	13	15	18
2nd wave	15	29	19	21	23

*—Note that numbers do not add up. Some institutional real estate investors report more than one sustainability certification.

Comparison of reporting between the 1st and 2nd wave resulted in the identification of 12 (32%) companies improving their reporting by using more building certifications, 6 (16%) companies reporting less information, and 20 (52%) either not providing any additional or more up-to-date information.

Among those reporting using building certifications, only two investors (both sampled in the 1st and 2nd wave) clearly stated that they calculated the EC for their buildings. This equals 5% of companies. Of these, one investor transparently reports all emissions including EC emissions, laying out all their methodology, while one other investor mentioned that Scope 3 is accounted for but not for commercial building investments.

As DGNB certifications require LCA carbon accounting for the new certified buildings, the companies using this certification (47% of the 1st wave or 52% of the 2nd wave), at least for their certified buildings with DGNB are deemed to have accounted for EC. However, there is no visibility as to the EC accounting for their remaining building stock. Another issue is that DGNB certifications as examples of what is being done with respect to ESG do not mean that the companies have certified all their buildings in accordance with DGNB. However, a building has a certification alone (e.g., LEED) does not mean that embodied carbon has been quantified or even considered.

Overall, the lack of transparency was surprising, as all sampled companies are professionally managed institutional real estate investors

operating in a highly competitive market, where sustainability is high up on their leaders' agenda [102,103].

The very limited evidence of EC accounting by real estate investors in Germany and limited improvement over the recent months corresponds with the sentiment survey for the global construction industry, undertaken by RICS World Built Environment Forum [2]. In the European construction sector, while 45% of investors admitted that they did not measure EC on their projects, only 20% both measured EC and used the measurements to guide their investment decisions [2,72]. However, if a standard method were available around 19% of the European respondents would measure EC [2].

Expert Interviews

Based on the participants meeting the criteria-based selection process, interviews were conducted using an online platform with three commercial real estate investors, all based and working in Germany, namely: (Participant-A) Head of ESG at an international property investment firm; (Participant-B) Head of Research at an international property investment firm; and (Participant-C) Head of ESG at a national property investment firm.

Given that only one investor comprehensively reports on their EC emissions and that only some of the other investors report on their sustainability certifications (and that even in such cases the reporting is not systematic), three semi-structured expert interviews were conducted to explore in more detail their perceptions on the current situation for EC reporting. These interviews revealed the participants' perceptions of EC accounting (methods and reporting), EC's impact on real estate transactions, and on investment decisions, plans for the reduction of the remaining footprint of their buildings, and sentiments regarding future regulations on EC emissions and reporting.

Current measurement and accounting for embodied carbon emissions in buildings

Concurring with previous literature [41] all participants noted that a standardized method or benchmark to calculate EC in buildings is currently not available. Thus, all participants demonstrated an awareness of the challenges in the measurement of EC emissions. However, Participant-A investing in existing niche property was "still concentrating on building a suitable strategy for operational carbon accounting and acquiring the necessary data, especially that of the tenants" and did not see the EC emissions "currently relevant to the niche properties". Participant-A furthermore noted that their buildings "already exist' and there is "no data for EC available for these niche properties". Participant-B acknowledged that the company is measuring EC for some properties "depending on which fund they are in", but not measuring EC yet in all buildings. Contrary to the others, Participant-C, investing and retrofitting

existing property only, reported that the company has been accounting EC for all their buildings "for several years". The decision on investing in existing property and accounting EC "came from the CEO", Participant-C noted, supporting the recent PwC survey, which suggests that CEOs who are most exposed to climate change will be more prone to address it [103].

Tools, methods, and data used for calculation of embodied carbon emissions

When asked about which tools, methods, or data are used for EC calculation, Participant-A did acknowledge that the CRREM tool was used for carbon risk accounting. However, voluntary building certifications such as BREEAM, LEED, or DGNB were not deemed suitable "since the buildings in the niche market are not included in the certifications". Participant-B reported about their own ways of scoring their buildings but did not expand further on this, though "the company is an ECORE member" and uses GRESB as a risk assessment tool. Where deemed strategically advisable, BRREAM is used to certify buildings. Participant-C declared that they are using the LETI EC Primer [71] to calculate their EC emissions and CRREM to assess operational carbon emissions for their properties in Germany. In line with previous observations [41], Participant-C noted that benchmarks for EC calculations differ for different countries. Nonetheless, their company found that LETI EC Primer [71] and the "British data could well be transferred into Germany" and thus used for their German properties.

Embodied carbon emissions in the context of investment decisions

Participants A and B do not consider the EC emissions in the context of investment decisions at all despite Participant-A's company conducting "technical due diligence and assessing the operational emissions" for new acquisitions. On the other hand, Participant-B's company assesses the building sustainability in a screening process. Participant-B believes that EC may quickly be incorporated into investment decisions if "at the sale of a property portfolio were to be reported with a 40% reduction" due to its sustainability and EC. Due to the large EC emissions in the construction process of new buildings, Participant-C's company seeing the large existing building stock decided to "only invest in the refurbishment of the existing buildings".

Consideration for the remaining footprint that cannot be further reduced

Participant-B was evasive on the question of offsetting and did not consider the remaining footprint. They noted that currently, it feels as if investors are "escaping into the new constructions of buildings". Participant-C acknowledged the consideration of offsetting the remaining emissions in their buildings. While so far, no offsetting project that they analysed had been found to "making sense" for them to offset, their

company donates to a non-profit Vesta project that "adds carbon-removing sand to coastal protection projects to permanently remove carbon dioxide from the atmosphere" [133].

Challenges for embodied carbon reporting

In line with previous observations [40,42], all participants agreed that the biggest challenge was getting accurate data for EC accounting. According to Participants A and B, EC could currently therefore only be estimated. Concurrent with previous literature [41], Participant-C saw the lack of international standardisation in EC calculation as the biggest challenge. Furthermore, Participant-C felt that "market participants are not happy we are discussing and putting the spotlight on EC accounting for buildings" into real estate fora. Participant-C felt that, as long as there are no regulations on EC reporting or the carbon pricing increased further, real estate investors would carry on as before, not including EC emissions in their accounting, underlining the construction sector sentiment as to measuring EC in their projects measured by RICS [72].

Potential new German embodied carbon regulations

Contrary to the current developments of the EU debating on measuring EC emissions from buildings [11], the new EPBD draft and calculation for global warming potential for new buildings larger than 2000 sqm from 1 January 2027 and new buildings from 1 January 2030 [85], Participants A and B thought that it would take "a long time" for regulations to be set up for EC reporting. Participant-A thought this would take "up to ten years". Furthermore, Participant-A was sceptical about whether it would be enough to require EC accounting for new buildings as these "only made up around 1% of the buildings" and the construction sector would equally have to be involved in the EC accounting. Participant-C was pessimistic about EC accounting regulations for Germany, claiming "that Germany vs. the rest of Europe lagged some five years behind other countries", which is underlined by the review of other European countries who have implemented or are about to implement LCA accounting for buildings [90,96,97,134].

DISCUSSION

The findings indicate that despite much debate on carbon emissions and their disclosures [135], and the increasing importance of acknowledging and acting on EC emissions, these emissions seem to be still a rather unexplored territory for most of the analysed institutional real estate investors in Germany. Rather than being transparent on their EC emissions in their building stock, they provide limited evidential information and focus on promoting their ESG visions.

Past research does not shed any light on institutional real estate investors' EC reporting. Even, the RICS Sustainability survey [2], first to

spotlight EC accounting of institutional investors in Germany, does not provide material insights.

Although "process LCA" being the predominant method [37] with the overall lack of agreement on systematic EC accounting, investors are not yet accounting EC. For the LCA, databases for construction materials and their emissions are needed. In Germany, this is provided via ÖKOBAUDAT [43], yet this resource does not seem to be used efficiently, or at least it is not reported upon by German institutional real estate investors.

Various voluntary certification schemes for buildings such as DGNB, LEED, and BREEAM provide insights into EC with DGNB embedding the most comprehensive LCA [54,55]. Thus, DGNB has the potential to be used as a starting point for EC accounting. However, other frameworks such as LETI [70], RICS professional statement on Whole life carbon assessment for the built environment [27], and the GHG Protocol [64] may also be considered. Except for one investor, none of these voluntary certifications or frameworks seem to be used for EC accounting for the investors' building stock.

Despite the political agenda to reduce carbon emissions, there are currently no regulations in Germany or the EU that require real estate investors to account for their EC emissions. However, this topic is on the agenda of the German federal government [18], the United Nations—COP26 [81] and COP27 [136], and the EU [11,87]. Other countries such as France, the Netherlands, Denmark, Finland, and Sweden have implemented or are taking up LCA as a requirement for new buildings. Hence, over the coming years, the EU and the German government regulations are expected to bring more transparency on EC emissions, which would potentially trigger more detailed disclosures by institutional real estate investors. However, these disclosure requirements need to be carefully balanced to avoid the risks which are brought forward e.g., by SFDR encouraging new development, accelerating building obsolescence, and potentially propelling urban decay [135].

Analysis of investors' EC disclosures provided evidence that, although sustainability seems to be on the agenda for most of them and building certifications including DGNB are widespread, EC accounting is yet to be transparently implemented. This is striking as many of the institutional real estate investors are very large international listed players who are and should otherwise be transparent about their operations. Is it that the lack of disclosure allows refocusing attention on other areas and leaves more leeway to make clearer disclosure only after the portfolios have been reshuffled to remove least performing buildings? Expert interviews, while providing a more optimistic perspective on the current practices, reinforced the results of the investors' analysis suggesting challenges around data collection, consistency, and consideration of systematic regulations on EC disclosures.

Greater transparency should reduce transitional risk and greenwashing. Here the peer pressure [137] and greater awareness of

what peers are doing [138] are expected to potentially trigger material improvements in EC disclosures. Thus, either self-regulating professional bodies or the German government may need to consider implementing standard definitions, methodologies, and disclosure requirements for EC emissions. However, these should not only address the current understanding of the matter but also prepare the investors for future changes in the electricity mix towards 100% renewable sources and to establish the operational electricity demand for the buildings' life [41] as Denmark did in their LCA methodology and encourage improvements to the existing sustainability of assets instead of promoting obsolete new zero-carbon projects. As previously mentioned, the EU has an old building stock for some 70%–80% of them retrofitting will be of the upmost importance [19].

Investors will need to work hand in hand with building designers to re-use existing building stocks with low EC footprint materials. Retrofitting an existing building, is the easiest way in reducing the upfront EC emissions of the pre-use-phase to meet short term reduction targets for a building [139]. The question for investors will not be whether to retrofit, but rather how soon and how radically to retrofit [140].

CONCLUSION

This study has demonstrated that thus far the EC emission disclosures by German institutional real estate investors are scarce and of limited informative quality. Given these observations, this research suggests careful consideration of improvements to the current EC accounting practices through:

- increasing investors' awareness of the EC topic and what it encompasses for new, retrofitted, and existing buildings;
- in the absence of regulations, agreeing on the measurement of EC using holistic systematic methods based on LCA principles; and
- usage of worldwide standardised and up-to-date benchmarks to support the assessment of EC emissions.

The expert interviews left the interviewees space and flexibility to expand on EC emissions and to confirm the results of our content analysis. Hence, these in-depth expert views offset the small sample limitation.

The results of our research should be treated with caution due to the nature of primary data collection. The data provided on investors' websites may be outdated and thus may not represent the true status of their EC accounting. Investors often make generic references to their portfolios' carbon emissions. Yet they refrain from quantification suggesting that they are yet to deal with this transparently.

Further, we conducted only three expert interviews. While researchers do not agree on sample size for qualitative studies [141], we are conscious that this is a very small sample, and that future research should consider large respondent pools to validate our observations.

As this was the first systematic analysis of institutional real estate investors, we expect that this research will open avenues to explore EC accounting practices and disclosures on EC emissions in the sector outside Germany. Further, it is expected that this research will raise awareness on the topic of EC accounting for buildings, especially existing building stock, and contribute to changing practices to improve market transparency, be it through best practices, self-regulation via professional bodies, or ultimately through changing German and/or EU regulatory frameworks, while avoiding the unintended consequences of the current regulations such as SFDR.

DATA AVAILABILITY

The dataset of the study is available upon a reasonable request.

AUTHOR CONTRIBUTIONS

Article conceptualization, SW and GWR; methodology, GWR and CAB; formal analysis, GWR and CAB; investigation, SW and GWR; writing—original draft preparation, SW and GWR; writing—review and editing, SW, GWR and CAB; visualization, SW and GWR; supervision, GWR and CAB. All authors who have contributed to the article, have read, and approved the submitted version.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

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