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Sustainable Public Procurement in Large Infrastructure Projects—Policy Implementation for Carbon Emission Reductions

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Abstract: The infrastructure construction sector is a significant source of carbon emissions, and more stringent procurement requirements are central to meeting reduction targets in this demand-led and project-based industry. This paper aims to analyze the implementation of international policies for reducing carbon emissions in infrastructure construction, focusing on the interaction between policy ambitions and procurement practices. Based on case studies of large projects and their contexts in five countries worldwide: Australia, the Netherlands, Sweden, the UK, and the US, a cross-country comparison is performed of how policies and practices for carbon reduction develop across multiple implementation levels. Three levels are included in the analysis: policy, industry, and project level. We identify the projects as either drivers of policy goals, frontrunners in industry-level development processes, or translators of national policy. These roles, and the associated pathways for carbon emission reduction, are context-specific and depend on the policy ambitions at the national or regional level, the maturity of the supplier market, and, often, on the strategies of individual champions at the project level. Long-term learning processes, both within and between the various levels, are essential for advancing carbon reduction.

Keywords: policy implementation; sustainable public procurement; infrastructure; CO_2 reduction; carbon emissions; cross-country comparison; green public procurement; case studies

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1. Introduction

Following alarming reports from the Intergovernmental Panel on Climate Change (IPCC), climate change has motivated policymakers globally to chart policies at different administrative levels to mitigate the increasing emissions of greenhouse gas; primarily pertaining to carbon emissions. As a part of the global ambitions of the United Nations Framework Convention on Climate Change (UNFCCC) it is well-recognized that public and private actors are central to fulfilling these goals and ensuring actions on the ground, which has been emphasized even further in the Paris agreement [1]. There is a growing awareness of the significant environmental impact of the construction industry [2]. Notably, the building and infrastructure construction sector represents 38% of global carbon emissions [3]. Until recently, initiatives to reduce such emissions in the industry have mainly targeted improvements in energy efficiency during the operational life of buildings. Embodied carbon, which is released during manufacturing, transportation, construction, and end-of-life phases, has historically mainly been overlooked, despite corresponding to around 10% of total emissions [4].

Lately, several initiatives have, as encouraged by international agreements, been implemented by the infrastructure construction sector to account for and reduce carbon emissions, including sustainability criteria, certifications, labeling systems, and, lately, greenhouse gas (GHG) protocols under SCOPE 1–3 [5]. However, as infrastructure owners and clients outsource most of their construction and maintenance activities to private sector contractors, procurement strategies and requirements become central to cutting carbon emissions in the sector (e.g., OECD [6]). It has been argued that public procurement can drive the reduction of carbon emissions and the innovation of green products and services, especially in sectors such as infrastructure construction, where public clients represent a large share of the market [7,8]. The ambition to use public procurement as a tool to promote environmental and wider sustainability benefits has been named green public procurement (GPP) and sustainable public procurement (SPP) [9]. In the European Union, as well as in the OECD countries, procurement policies to address goals for ecological and social sustainability have been promoted through, for example, the amendment of the EU procurement directives [10,11]. SPP can be defined as the pursuit of sustainable development objectives through the purchasing and supply process [12,13]. GPP can be seen as one part of the broader sustainable procurement; only focusing on “goods, services, and works with a reduced environmental impact throughout their life cycle” [14]. Factors identified as hinderances and drivers in the implementation of GPP and SPP policies are to a large extent similar for both categories, since they relate to policy implementation, where sustainable development is the overall aim, see e.g., Sönnischen and Clement [9]. Moreover, linked to the UN Global 2030 Agenda on 17 sustainable development goals, the term SPP is becoming increasingly employed in the academic literature. Based on this partly shared scope, the term SPP will be used in this paper.

It has been argued that the scientific literature on national sustainable and innovative public procurement policy is limited [15,16] and that more cross-country comparisons are needed to grasp the full complexity of SPP implementation [13,17,18]. The construction industry is based on temporary, often decentralized, project organizations, involving a large number of interdependent actors [19,20]. For this reason, and to capture the multilayered pathways of carbon emission reduction ambitions and actions, this study provides a cross-country comparison, in the form of case studies of infrastructure construction projects and their policy contexts.

Aim and Objectives

This paper aims to analyze the translation of international policies for carbon emission reduction into the development of procurement rules and concrete carbon emission reduction practices in large-scale infrastructure projects in five countries worldwide: Australia, the Netherlands, Sweden, the UK, and the US.

To operationalize this aim, two research questions have been formulated:

1. What factors influence the implementation of carbon emission reduction goals in the studied projects?
2. Which role is taken by the projects in the implementation process?

The study is positioned in the knowledge spheres and literature on multilevel governance and SPP implementation.

This paper consists of six sections. The introduction includes, besides the aim and objectives, a background on the research area. This section is followed by a section describing the analytical point of departure, which presents an overview of prior research on multilevel frameworks, addressing factors affecting SPP implementation. The third section describes the methodological approach. The fourth section presents interviews and documents the study results; structured in three levels: policy, industry, and project. In section five, cross-case analysis is discussed and concluding remarks are made, including reflections on the implications of the findings.

2. Analytical Points of Departure

This paper has two points of departure. First, it understands the implementation of global norms (in this case the reduction of carbon emissions) as a multilayered challenge influenced by a multitude of factors, including the structure and character of the particular area of international policy, how politically topical the matter is, the mechanisms for incorporating international policy into national policy (which differ between countries), and the relation and collaboration structures between the state and industry sectors [15,16]. A multilevel approach is especially relevant in large-scale infrastructure construction, where temporary projects have a high level of autonomy and are frequently seen as key drivers of (and potential obstacles to) innovation [17]. This autonomy implies that project-level actors can choose to take different positions in relation to higher-level policies when setting their procurement requirements. Hence, to capture how carbon emission reduction ambitions are formed in the infrastructure sector, a multilayered perspective that also encompasses the project level is essential, as seen in previous research [18]. Furthermore, cross-country comparisons, focusing specifically on the infrastructure sector, are needed to understand the strategies available to policymakers and projects, depending on the local context. In he current literature on SPP, which is rather case study focused, this is often missing [15,16].

Our second point of departure addresses implementation processes of carbon emission reduction policies at a more detailed level. Here, we lean on a review of SPP literature, focusing on factors influencing implementation. This literature was identified in a three-step literature review. As a first step, an initial literature study was performed that only included SPP literature related to the construction sector. This field has so far mainly focused on factors affecting implementation, specific criteria in the procurement process [19–22].and technical issues regarding environmental impacts and rating schemes [23,24]. As this literature was found to be limited, the search had to be subsequently enlarged to include other sectors. In the second step, we focused our review on articles that developed a framework, since they present a more systematic and holistic understanding of the barriers or paths to SPP; see Table 1. Identified factors include the importance of top management commitment and a shared vision in a project, the role of engaged individuals in the organization, the organizational culture (mostly of the procuring client), and the project budget. Other important factors relate to the supply chain and the compliance and integration of sustainability among involved actors, influencing the availability of green products and services on the market.

Table 1. Overview of the most common factors affecting the implementation of SPP identified in the literature. Factors are explained and categorized as drivers or barriers, and references to frameworks mentioning these factors are made.

Factors Effecting the SPP Implementation	Content	Ex of Frameworks
Policy and regulation	Driver: familiarity with policy. Barrier: lack of legislation.	Trindade et al. 2017 [25] Cheng et al. 2018 [26] Rainville, 2018 [27] Brammer and Walker, 2011 [28] Vejaratnam et al. 2020 [29] Sourani and Sohail, 2011 [18]
Knowledge and awareness	Driver: information and training for clients on policy implementation of SPP to increase skills on SPP and create more awareness. Barrier: knowledge and awareness of environmental criteria, environmental performance and technical expertise among clients.	Trindade et al. 2017 [25] Brammer and Walker, 2011 [28] Vejaratnam et al. 2020 [29] Sourani and Sohail, 2011 [18] Varnäs et al. 2009 [20] Testa et al. 2012 [21] Testa et al. 2016 [22] Lăzăroiu et al. 2020 [23] Pot, 2021 [24]

Table 1. *Cont.*

Factors Effecting the SPP Implementation	Content	Ex of Frameworks
Organizational culture	Driver: client ability to adapt to change and internal collaboration within the client's divisions. Barrier: resistance to change regarding procurement, passive and reactive culture in the supply chain.	Trindade et al. 2017 [25] Vejaratnam et al. 2020 [29] Sourani and Sohail, 2011 [18]
Change agents, champions driving development	Driver: individuals in the organization driving the development, organizations should encourage individuals to become change agents to reach the full potential of SPP. Barrier: -	Trindade et al. 2017 [25] Cheng et al. 2018 [26] Grandia, 2015 [30]
Financial constraints	Driver: sustainable solutions can reduce costs and increase returns. Barrier: e.g., project budget.	Brammer and Walker, 2011 [28] Vejaratnam et al. 2020 [29] Lăzăroiu et al. 2020 [23] Pot, 2021 [24]
Top management and leadership vision	Drivers: strong leadership, top management commitment. Barrier: lack of political and top management commitment.	Brammer and Walker, 2011 [28] Vejaratnam et al. 2020 [29] Sourani and Sohail, 2011 [18] Lăzăroiu et al. 2020 [23]
Supply chain	Driver: earlier and longer-lasting collaborative activities with suppliers, increased compliance, share best practices, create common visions. Barrier: lack of integration in the industry.	Trindade et al. 2017 [25] Rainville, 2018 [27] Sourani and Sohail, 2011 [18] Lăzăroiu et al. 2020 [23] Vejaratnam et al. 2020 [29]
Availability of green products and services	Driver: procurement of results not products. Barrier: lack of green products on the market.	Trindade et al. 2017 [25] Rainville, 2018 [27] Brammer and Walker, 2011 [28]

To gain a better understanding of how to use these frameworks in a multilevel approach, we classified them based on sector/country, the context/level covered, and type of study; see Table 2. Case studies are the dominant approach in the articles. Such studies have a greater potential to grasp the complex relations involved in the implementation of SPP, while the studies using surveys provide fewer details, especially if they cover multiple sectors, or geographical contexts. However, most of the identified studies do not include all three levels of policy implementation and/or development; the ones doing so and that have used a survey or questionnaire method are less likely to provide details on the complex relations between the factors and levels. For example, Brammer and Walker's [28] widely cited survey-based study of procurement practices includes all sustainability dimensions and all sectors in 20 countries. However, it has been argued that designing efficient procurement policies for a specific field, such as carbon reduction, requires deep and contextualized knowledge [31]. Several authors have called for cross-country studies, to provide such an understanding [28,32,33].

Based on the multilayered approach and the possibility of different actors to taking on different roles, we argue that the field needs to be broader, including the coordination of the supply chain, e.g., knowledge and information transfer, co-development of products, and the project-based context; see e.g., [34–36]. To create an analytical support structure, in a third step we used an aggregated overview of the implementation barriers identified in the SPP frameworks (Table 1) and our multilayered understanding of governance to perform an assessment at three different administrative levels: policy, industry, and project level. The policy level relates to the national, and in some cases, the regional, policy level. In this first level, we are particularly interested in the relationship with global climate goals and national policy ambitions, and their relation to the projects' policy ambitions. The second level, the industry level, relates to market development and maturity and the projects' relation to this level. The third level, the project level, relates to organizational culture, change agents, leadership approach, and knowledge.

Table 2. Frameworks for SPP identified in the literature review, presented with sector, country, context levels, and methodology.

Reference	Sector/Country	Context	Methodology
Brammer and Walker, 2011 [28]	Not defined/ 20 countries	Policy, industry, project	Survey
Cheng et al. 2018 [26]	Not defined/ Not defined	Policy, project	Literature review
Grandia, 2015 [30]	Construction and others/ Netherlands	Project	Five case studies
Lăzăroiu et al. 2020 [23]	Construction and others/ Not defined	Policy, industry	Literature review
Pot, 2021 [24]	Pumping station/ Netherlands	Policy, industry	Case study
Rainville, 2018 [27]	Not defined/ Not defined	Industry, project	Literature review
Sourani and Sohail, 2011 [18]	Construction/ UK	Policy, industry, project	Interviews and case studies
Testa et al. 2012 [21]	Not defined/ Italy	Policy, project	Three case studies - questionnaire
Testa et al. 2016 [22]	Not defined/ Italy	Policy, project	Case study and survey
Trindade et al. 2017 [25]	Not defined/ Portugal	Policy, industry, project	Three case studies
Varnäs et al. 2009 [20]	Construction/ Sweden	Project	Case study
Vejaratnam et al. 2020 [29]	Not defined/ Not defined	Policy, industry, project	Systematic literature review

Based on Tukker and Ekins [37], who described three approaches to policy implementation for resource efficiency, focusing on market mechanisms, top-down governance, and bottom-up activities, we identified three roles that projects can assume in the implementation of carbon emission ambitions; also indicating that we do not see reduction ambitions as a top-down enterprise. First, we see them as frontrunners, who align their ambitions with state/regional policy, but drive development processes specifically aimed at the industry level; second, as translators, who follow and implement top-level policies through the use and continuous development of requirements and different developed assessment tools; and third, as drivers of carbon emission reduction, by setting higher goals than the policy defines. In setting their approach, project-level actors will balance multiple factors, including the alignment between international, national, and regional policies, as well as their own ambitions and the maturity of the supplier market.

3. Method

3.1. Methodological Approach

Our methodological approach was inspired by grounded theory [38]. Therefore, we let the empirical material, framed by the multilayered approach, direct the analysis. Our analysis was further based on previous research on the factors influencing sustainable procurement processes (see Table 1), but recognized that when translating international policies into project-level ambitions, national institutional context plays an important role in defining pathways for carbon emission reduction.

3.2. Case Study Approach

A case study approach is consistently described as the form of qualitative inquiry most suitable for a comprehensive, holistic, and in-depth investigation of complex issues, where the boundary between the context and issue in focus is unclear and contains many variables [39,40]. Our literature review showed that there is a lack of holistic, multilevel studies on SPP in general, and several studies pointed at the need for cross-country comparisons of SPP practices within the specific field in focus. There is a lack of literature on SPP practices in the construction sector in general, and the sector has a high impact on global carbon emissions. This article is based on cases from five countries, consisting of 10 projects in total. The main reason for selecting these projects (and their clients) was that they all had implemented climate requirements that were ambitious, in relation to their respective policy contexts. Thereby, we could get a better picture of how SPP policies interact with project-level practices and structures in driving carbon reduction. Other selection criteria were geographical spread (covering countries with different approaches to the implementation of global policy ambitions) and the accessibility of the cases studied. Notably, some of the projects studied are among today's largest infrastructure development projects, thereby acting as showcases at a global level.

The empirical basis of the study consists of a combination of interviews, project documentation, web sources, and written input from local experts. For each country case, 1–3 projects were investigated. The projects vary in size, type of facility, and which phase the project was in when interviews were performed. Since the focus was on procurement, projects in later stages (i.e., construction rather than planning) were prioritized when selecting cases and interviewees. Furthermore, the projects were all investment projects for large technical infrastructure systems, mainly for public transport purposes, except for Anglian Water, which includes water infrastructure.

Large projects may comprise several sub-projects running over a long period. In such cases, the main focus has been on the most recent procurement requirements and sustainability policies. Basic information on the projects is found in Table 3.

Table 3. Summary of cases and projects.

Country and Project	Project Information
Australia: Sydney Metro Northwest	Sydney Metro Northwest is a part of Sydney Metro, Australia's largest public transport project. The SMNW project consisted of 36 km rail line and 13 new and upgraded stations. The client Sydney Metro was previously a part of Transport for New South Wales (TfNSW), but has since become an authority of its own, responsible for delivering the full Sydney Metro project. Three major contracts were awarded in 2013 and 2014 to construct and operate Sydney Metro Northwest. The project opened in May 2019.
Australia: Newcastle Light Rail	Newcastle Light Rail is a 2.7 km long railway and a key part of revitalizing the city center of Newcastle. The client was the Transport for New South Wales (TfNSW). The Newcastle Light Rail opened in 2019.
Netherlands: A6 Almere	A6 Almere project is part of a program for a motorway between Amsterdam and the city of Almere. This study focused on the fourth of five projects. The client is Rijkswaterstaat (RWS), the Dutch Road, and Waterways Administration. The contractor's responsibility comprises the design, build, finance, and maintenance (DBFM) of the project. Construction started in 2017 and the opening is planned for 2022.
Sweden: Three road and railway projects	The Swedish case study is based on three road and railway projects: two smaller; and one very large project. The Road 44 project is a new 2 + 1 road in the Southwest of Sweden, opened in 2019. Railway Söderhamn-Marmaverken is an upgrading project aimed to increased railway capacity and opened in 2018. Ostlänken (The East Link) is a proposed high-speed railway between Stockholm, Göteborg, and Malmö, and the opening is planned for 2035. In all cases, the Swedish Transport Administration is the client.

Table 3. *Cont.*

Country and Project	Project Information
UK: Anglian Water @one Alliance	Anglian Water is a large water and wastewater company. The collaborative @one Alliance was formed to design and build more than half of Anglian Waters capital investment program: around 800 schemes worth approximately GBP 1.2 billion between 2015 and 2020. Two projects were studied: Grafham WTW Resilience and Dalton Piercy WTW.
UK: High Speed 2	High Speed 2 (HS2) is a high-speed railway under construction in the United Kingdom. The project studied is Phase 1 from London to Birmingham (176 km). HS2 is being developed by High Speed Two (HS2) Ltd, a NDPB (non-departmental public body) established by the Department of Transport. HS2 uses a two-stage early contractor involvement (ECI) approach for their main works civil contracts. Four contracts were signed in 2017 (Stage 1, design development) and 2020 (Stage 2, detailed design, and construction). Full operation is planned for 2029.
USA: California High-Speed Rail	California High Speed Rail, CHSR, aims to connect the Californian state from North to South. The California High-Speed Rail Authority was formed in 2003 to oversee the planning, design, build, and operation of CHSR. The studied project is the fourth construction package of Phase 1, a 35-km railway stretch situated in Central Valley. Full operation of Phase 1 is planned for 2033.
USA: SFO AirTrain Extension	San Francisco International Airport (SFO) AirTrain Extension project comprises design and construction of an elevated guideway, long-term parking, and a new AirTrain station, to allow passengers to transit to the airport terminals. The AirTrain extension had an estimated budget of USD 207 million and was completed in 2021.

3.3. Data Collection

For each case, a desk study of the projects and policy documents was performed to gain a solid knowledge of the policy context. A policy background document was developed in collaboration with local representatives of the consultancy firm WSP, which was a partner in the research project. Furthermore, documents including national and regional policy documents for carbon emission reduction, project sustainability policies, calls for tenders, and sustainability guidelines were reviewed. Based on the document study, a semi-structured interview guide was designed, including the following main areas: sustainability procurement requirements for reduction of carbon emissions in the project; the basis for/origin of requirements, such as policies, standards or certifications; organization and processes for implementing and following up requirements; mechanisms for learning and improvement; and perceived key success factors and barriers. For the full interview guide, see Supplementary Material—Interview guide. Interviews were performed with client representatives, as well as with other parties in the supply and value chains; primarily with contractor and consultant representatives, but also with manufacturers of construction materials. Respondents were selected to represent different levels of project management and execution, from the board level to project management, environmental specialists, and procurement functions. Depending on the development phase of the project and availability, different combinations of roles were interviewed in different projects. In general, interviews lasted for 2–3 h. For a summary of the included projects and respondents, see Table 4. The interviews were performed by a team of at least two interviewers to improve the validity. The team consisted of researchers and representatives from WSP working on the projects. The Swedish case was coordinated with another project to follow up the implementation of the climate requirements of the Swedish Transport Administration. Therefore, there was a larger number of interviews, and a variety of interview forms were used. Several were group interviews, and one interview was conducted via Skype. All interviews were voice recorded (with the permission of the interviewees), transcribed, and sent out to the respondents for approval. Similarly, case summaries were written up, and then reviewed and approved by respondents, as seen in the detailed case summaries in the project report [41]. Additionally, the procurement criteria used in the projects for carbon emission reductions have been summarized and discussed in a previous article [19].

Table 4. Overview of respondents in the case studies. The number in brackets indicates more than one respondent present at the interview.

Country	Project	Actors Interviewed	Number of Interviews
Australia	Sydney Metro Northwest	Client Contractor Designer Supplier (2)	4
Australia	Newcastle Light rail	Client Contractor Designers (2)	2
Netherlands	A6 Almere	Client Contractor	1
Sweden	Three road and railway projects	3 project interviews + interviews with clients, consultants, contractors and suppliers. In total 80 persons from 16 companies	17
UK	Anglian Water, Grafham WTW Resilience and Dalton Piercy WTW	Client Contractor Designer	1
UK	High Speed 2	Client (2) Contractor	2
USA	California High-Speed Rail	Client Contractor Designer Supervisor Supplier	5
USA	SFO AirTrain Extension	Client Contractor Designer	3

3.4. Operationalization of Our Point of Departure

Analysis was performed in three steps. In the first step, we assessed the carbon emission reduction ambitions of the cases' context country and compared them to the ambitions at the client and project levels. In this analysis, we used the policy background paper developed as part of the research project, as well as the interviews. In the second step, the interview transcriptions were analyzed, focusing on factors influencing the implementation of carbon emission-reduction policies at the industry and project levels (see Table 1). Interview transcriptions were read as a whole and analysis was performed in an iterative process until reaching satisfaction [42].

In the third step of analysis, we categorized the projects in relation to our interpretation of Tukker and Ekins [37] classification of implementation roles: driver, frontrunner, and translator.

4. Results

In this section, we first assess the carbon emission reduction ambitions of the case countries and compare them at national/regional and project levels. Second, we identify factors influencing the implementation of requirements at an industry level. Finally, factors influencing the implementation of carbon emission mitigation measures on the project level are presented. The section is based on data from both document studies and interviews.

4.1. Translation of National and Regional Policy Ambition into the Projects

Australia had committed to reducing emissions by 26–28% from 2005 levels by 2030 under the Paris Agreement [1]. The country had further set a renewable energy target to reduce carbon emissions [43], and there has also been an ongoing debate around a carbon emission tax. The climate goals of the state of New South Wales were more ambitious than national goals and included a climate change policy plan and a Renewable Energy Action Plan. Carbon reduction in infrastructure projects is, however, primarily driven by individual government agencies. Transport authorities in Australia and New Zealand collaborate in a Transport Authorities Greenhouse Group (TAGG), which has developed joint guidelines and tools, mainly for road construction. In the state of New South Wales, the major public infrastructure client, Transport for New South Wales (TfNSW), had ambitions to drive change in the sustainability field and had developed their own sustainability design guidelines (SDGs) and a carbon estimate and reporting tool (CERT). These ambitions were reflected in the Newcastle Light Rail project. In the Sydney Metro project, ambitions were set even higher, aiming at global leadership. The Sydney Metro Sustainability Manager had been a leading champion in pushing forward the sustainability policies of TfNSW for many years, and described the journey in the following way: "*We have a major sustainability story [...] as an organization I think the DNA, the natural sort of position is to be world-class [...] so that's our mantra, we want to leave transformative legacies.*" He also emphasized the important role of an ambitious state-level policy to justify requirements and gain support from politicians. The formulation of the procurement requirements in the SMA was described as a strictly hierarchical process, where contract requirements should be possible to backtrack all the way up to the highest strategy level and priced to be approved by the financial board. Moreover, in TfNSW, every new version of the SDGs must be approved by the executive team.

The Netherlands, in the Climate Act, aims for a reduction of 95% carbon emission by 2050 compared to 1990. The government has encouraged carbon reduction for several years, primarily through soft law policies, such as the general sustainability initiative, Green Deals, where public and private actors form coalitions. The main public road and waterways client, Rijkswaterstaat (RWS), has a history of being a leading client and the interviewees perceived that there is a direct relationship between the government goals to be fossil free and carbon neutral by 2050, RWS sustainability goals, and the specific project goals. RWS aims to take one step forward in each large project in terms of environmental sustainability, including carbon emission reductions. In the relatively early Almere project, however, RWS sustainability goals were not as developed as they are today. Therefore, pressure came from the municipality of Almere, which adopted high sustainability goals, as they were to host an international horticultural exposition in 2022. The road construction project became an integral part of their sustainability work.

In **Sweden**, the goals (officially taken in 2019) state that Sweden will have net zero emissions by 2045 and strive for "negative net emissions" of carbon emissions from 2045 compared to 1990 [44]. These goals had not yet been decided at the time of the interviews, but both private and public actors anticipated higher goals and were working in that direction. The main infrastructure client, the Swedish Transport Administration (STA), has developed a model to drive carbon emission reduction in their procurements. Since 2015, consultants and contractors in all projects exceeding EUR 5 million have been obliged to use a carbon calculation tool, the so-called *Klimatkalkyl*, to calculate the project's carbon footprint and ensure that the project achieves the carbon emission reduction goals set by the client. These goals are aligned with the percentages expressed in the national emission reduction targets and will be raised over time. For smaller projects, however, prescriptive requirements are set. The studied projects had implemented the requirements applicable for larger projects.

In the **UK**, the carbon budgets were defined at the national level in 2008, through the Climate Change Act [45]. Based on the Act and the carbon budgets, the government's industrial strategy from 2013, "Construction 2025", set a target of achieving a 50% reduction in carbon emissions in the built environment by 2025, from a 1990 baseline. The two UK cases, Anglian Water and High Speed 2, were described as flagship projects and frontrunners regarding carbon emission reduction. Both have strong sustainability visions, anchored in national-level visions and ambitions. Anglian Water clearly expresses the ambition to contribute to the Climate Act, while for the HS2 project, the overarching national goals and the Climate Act were translated into goals and ambitions in the development agreement set for the project by the Department for Transport. In this agreement, HS2 is required to "... minimize the carbon footprint of the Project as far as practicable ..." No target is specified, but it is stated that HS2, "... will be an "exemplary" project that is built and operates sustainably ..." In defining its level of ambition, the project has committed to reducing their carbon impact by 50% to align with the Construction 2025 goals.

In the **US**, at the time of the interviews, national ambitions for carbon emission reduction had been cut back, but at the regional level, the State of California still took a more ambitious stance. Even back in 2006, California had adopted a carbon emission reduction policy based on the Global Warming Solutions Act law [46], requiring a reduction to 1990 levels of carbon emissions. The two Californian projects aligned their ambitions with this regional policy. The SFO Airtrain Extension project conformed to the San Francisco Environmental Code, also adopted in 2006, which is even stricter than the regional Californian target. The project had sustainability guidelines for planning, design, and construction, formed to also comply with criteria that SFO itself had added to be used in the projects if considered feasible. The interviewed project LEED team officer stated that their visionary leadership for supporting sustainability goals was central and in-line with the aim to become carbon neutral. "It's part of their sustainability stewardship. They want to be ahead in the curve." In the CHSR project, the (former) CEO of the CHSR authority aimed to use the market power of this huge and long-lasting project to raise the level of environmental concern in the whole industry. Referring to the large size of the project, he explained that, "*I think it is a unique opportunity but also on some level a responsibility to try to take advantage of that opportunity.*"

4.2. Industry-Level: Market Development and Leadership

In the **Australian** cases, a small team within TfNSW had been working for several years with the sustainability design guidelines to purposefully drive development in the infrastructure industry. By updating the SDGs, the client allowed suppliers to incrementally adjust to new requirements. The client design manager described this as an interactive learning process: "*We're just getting better at capturing what the industry can do ... and making it a case of what the industry should do.*" The guidelines were initially based on prescriptive requirements to provide guidance on sustainable design solutions to the still inexperienced industry. The SDGs have gradually become more open, and the fourth version is mainly based on performance requirements, with the previous prescriptive requirements included as options to meet them. In parallel, the IS Rating Scheme was developed by the Infrastructure Sustainability Council of Australia (ISCA). Both ISCA and Green Star (for buildings) started out as voluntary ratings but have now become more or less standard. ISCA includes requirements for carbon reduction in relation to a baseline and a tool to develop the baseline. To drive industry learning, ISCA mandates engagement in knowledge sharing (both good and bad experiences). Sustainability, therefore, has become regarded as part of normal design, and suppliers have pushed the development of new technology forward to gain a better position when competing for future projects.

In the **Netherlands**, various collaborative agreements and strategies on how to reduce the use of fossil fuels have been developed by various actors (state, industry, NGOs, etc.) to meet national ambitions. One example is the Dutch Climate Coalition, which is specifically targeting public procurement in the infrastructure sector, including goals for carbon emission reduction. Another example is a "deal", DGW 2.0, which involved a wide range of infrastructure construction clients and suppliers. Two tools have played a central role in the development of procurement requirements for carbon emission reduction and sustainability, more generally, in the Dutch construction sector: the CO_2 Performance Ladder and DuboCalc. The CO_2 Performance Ladder is a certification system for company-level carbon work, while the DuboCalc tool focuses on the environmental performance of construction projects, including carbon footprints. Both are used to enable tender discounts based on carbon performance and are supported by certification and auditing bodies. The CO_2 Performance Ladder, especially, has widely raised carbon awareness in the industry, but since all large contractors are now certified at the highest level, the system no longer discriminates between tenders. The DuboCalc tool is particularly used for large projects with private financing and in combination with a competitive dialogue process.

In the **Swedish** case, the government had launched an initiative called Fossil Free Sweden (2018) in preparation for the Paris agreement. This initiative gathered stakeholders in developing sector-specific roadmaps for carbon emission neutrality, and construction was one of these sectors. The Swedish Transport Administration (STA) is the main infrastructure client. By connecting their reduction requirement levels to the general national reduction goals, the STA aimed to communicate to the industry that they were serious about climate reduction and to provide predictability regarding future directions. The STA has further developed materials, such as tutorials for the Klimatkalkyl tool, and hosted industry conferences to disseminate knowledge and information. However, there was some criticism from the industry that the Klimatkalkyl tool does not reflect current construction practice, and interviewees emphasized that continuous dialogue between the industry and client was needed to keep it up to date. Furthermore, the reduction requirements were open and did not offer any guidance to suppliers regarding what measures to take to reduce their carbon emission impact. The interviewees pointed at the need for industry-wide guidelines and standards and stronger collaboration in the supply chain, to implement carbon emission reduction more efficiently. In addition, the contractors taking part in the roadmap work said that they had the ability to implement more carbon emission reduction measures, but that the requirements were initially set too low to provide sufficient financial incentives for this.

In the **UK**, which was preparing large investments in infrastructure, several government initiatives had been taken to support environmental improvement in the infrastructure industry. The base for this work was the 50% carbon emission reduction target put on the sector, which was perceived to require substantial changes. The government actively promoted industry associations and groups, such as the Infrastructure Client Group and the Green Construction Board (2011), to drive development in terms of environmental efficiency and innovation. Government–industry reviews identified performance opportunities, both in the sector in general (Infrastructure Cost Review [47]) and related to carbon emission reduction (Infrastructure Carbon Review [48])). A key statement in the Infrastructure Carbon Review, which was developed by the Green Construction Board with a high level of involvement by Anglian Water, was that “reducing carbon, reduces costs,” by saving materials, reducing energy demand, and creating operational efficiencies. A need to establish “stretching” targets for carbon impact was emphasized, and traditional standards should be challenged. Furthermore, pursuing a low carbon agenda was seen to stimulate innovation, and performance specifications were recommended over traditional specifications.

In the **US** the CHRS project in California had an explicit strategy to leverage market power and raise requirements, to drive innovation in the supplier market over time. There was a concern that too high requirements would limit competition and drive costs. The CHSR project comprised several successive sub-projects, and the client authority clearly communicated that requirements would be raised over time, thereby allowing suppliers to prepare and make investments. Consistency was reinforced by establishing relationships with research and environmental organizations, which then created external expectations on CHSR that would be hard to walk back from. Sustainability policies were established in the new organization early on, to identify meaningful and relevant focus areas. The Sustainability Implementation Plan clarified how the sustainability policy would be integrated into procurement documents. Due to the immature supplier market, the first project started on a very basic level, using "*if feasible*" requirements for carbon emission reduction. In addition, requirements for EPDs were for informational use only. In this way, green alternatives had a possibility to develop on the market over the course of several sub-projects. For the steel suppliers, however, some requirements were seen as easy to fulfill, due to previous experience from the building sector, which is ahead of infrastructure. In the SFO project the sustainability requirements were integrated in procurement documents and a workshop was held with the client and the contractor, to establish a proactive approach to the sustainability criteria. The SFO also had sustainability guidelines for planning, design, and construction guidelines that were formed to comply with the set criteria. In this way, the client supports the contractor with the use of new criteria. EPDs for products were used in the SFO project as well, and documentation and information about the materials were critical to fulfilling the aim of low carbon materials from suppliers.

4.3. Project Level: Organization, Culture, and Change Agents

In **Australia**, the NLR project was procured using an earlier version of the SDGs with prescriptive requirements, while the requirements in the Sydney Metro project provided more flexibility for the contractor. Sydney Metro also used qualification and award criteria relating to carbon management capabilities. One problem experienced was that SDGs partly overlapped with ISCA requirements (NRL), and ISCA overlapped with the different assessments, as ISCA certification was required for both projects. However, in the NRL project, the SDGs and the requirements from ISCA partly overlapped, and for the stations in the Sydney Metro, the Green Star framework partly overlapped with the ISCA framework. This created burdensome paperwork for the contractors, without benefits for sustainability, and in the future TfNSW will not use their SDGs for projects that are required to have an ISCA rating.

In both projects, the need for sustainability competence was strongly emphasized. There was much face-to-face client engagement with both designers and contractors. The client teams followed up how the sustainability requirements were implemented in the contractor's design. Contractor representatives and design managers also stressed the importance of having high internal competencies to translate and communicate requirements to the various target groups within the project, according to their needs. Members in the sustainability teams frequently acted as champions in disseminating sustainability knowledge. In general, people who had participated in previous projects already had a lot of knowledge, while others had more to learn. As explained by a Design Consultant, "*It's a mixed bag, and not so well integrated yet.*" A client sustainability manager also stressed the need to continuously educate project staff, by saying, "*The main lesson I think I've learned is that nothing is a no-brainer. Saying 'it's a no-brainer' means that you just assume that people get it (...). I've learned that's a very naïve position to take*". The suppliers saw advantages with the prescriptive requirements, since these were easier to communicate and follow up onthe prescriptive requirements, since these were easier to communicate and follow up on.

In the **Netherlands** and the Almere project, carbon performance was rewarded in the design stage of a competitive dialogue process using the DuboCalc tool. Based on the conceptual design, the client established a baseline for environmental performance. When finishing their designs, the tenderers calculated their price and received tender discounts based on their performance in relation to the baseline. This way, it was up to the contractor to select solutions. The client representatives found it difficult to set the maximum reduction at a level that was achievable but still challenging for this specific contract. The level turned out to be right in the Almere project, but in previous projects it had been set to low. In such cases, resources were spent on calculations with no value for sustainability. However, as emphasized by the client project director, prescriptive requirements were also used: "*A few years ago, that is 10 years ago, we said, 'well, functional requirements, that's it,' and really leave it to the contractors to think. Now we are just thinking: 'well, when we want something, we have* *to ask them*". Thus, when RWS sees that new technology has been developed, they may include a requirement to use the new product in subsequent projects.

In the **Swedish** cases, the interviewees expressed a lack of knowledge and support from the client on what measures to implement to achieve the goals for carbon reduction. This was also related to the limited knowledge of carbon emission reduction measures of non-environmental specialists in the projects. This knowledge was mainly disseminated through informal contacts between individuals and projects. Depending on the commitment and competence of the specific individuals and organizational units involved on the client-side, projects also differed in their emphasis on carbon emission reduction. Interviewees called for checklists and tools to achieve more advanced reduction requirements. Furthermore, they found that it took a lot of time in the design stage to perform calculations of both baselines and actual performance, and that this time could have been better used to identify reduction measures. They also expressed a lack of time and resources in the projects to implement the available measures, for example, to perform the tests required by the client for the use of new types of material. Some interviewees argued that tests of new solutions are better suited for smaller projects due to the complexity and multiple goals of large projects, which may make it hard to prioritize testing.

Both the **UK** projects aligned their ambitions with the government discourse emphasizing stretching goals, radical change, and innovation. As a respondent from the Anglian Water Alliance management team argued, "*50% means that you have to do something completely radical. You have to change the very essence of what you and the industry currently do to achieve that, because there is no other way to do that, you will never reach anywhere near the 50% target*". The work of Anglian Water on carbon reduction had already been initiated in 2006 and had inspired both the government's 50% goal and the view that reducing carbon emissions would reduce costs. Both cases also had strong collaboration agendas, and the clients had been highly involved in the collaborative processes and in actively supporting knowledge development in the supply chain. Anglian Water had formed the collaborative @one Alliance involving an integrated team of key supply chain partners for a period of up to 15 years. A robust governance structure was created for cooperation, based on sharp incentives and profit-sharing related to quantitative requirements and targets. Learning and innovating together was a key ambition, and approaches, such as a set of standard designs, joint work to develop the value chain, and the inclusion of no-build options as an alternative, were important outcomes. Client involvement and top management leadership was seen as essential and the head of engineering explained the need to change traditional construction sector client–supplier relations and "*go from a master-slave relationship to trust, which is done by leadership and common goals. It's all about leadership*". The collaboration was very successful, and carbon reduction goals have been changed to reach a 60% reduction in embodied carbon by 2020 and carbon neutrality by 2050.

In the HS2 project, a collaborative, two-stage early contractor involvement approach was used, where the contractors first were engaged in stage 1 to develop the design and target cost. In this case, the work included a carbon footprint baseline to define and operationalize the 50% reduction target. Establishing a robust carbon baseline was an extensive process that took a substantial amount of both time and effort to complete. This target was perceived by all parties as very challenging, especially if no cost increases would be allowed. The contractor's carbon specialist said that, "*we want to push boundaries and see what more can be done and even push the research industry to go down a different route*". The contractors' interpretation was that they should do all they could to minimize carbon "as far as practicable" and needed to demonstrate to the client that the best efforts possible were being made. The client representatives took an active role in supporting contractors to achieve the goals by, for example, organizing training and workshops.

In the **US** and the SFO project, the sustainability manager highlighted staff's high level of involvement in sustainability as the key to success. One of the processes behind this was the Zero Committee that acted as an information broker and accelerator for the triple zero airport campus within the organization. According to the CEO of the CHSR, the project has pushed beyond what would have happened on its own, thanks to staff commitment. It had, however, become more difficult to keep the level of awareness and knowledge of the sustainability values as the project grew and time pressure increased. The sustainability manager described the issue by explaining that, "*people know it in the back of their mind, but they barely have time to take a deep breath*". As a way to mitigate this barrier, a few exercises were performed to remind people of the requirements and activities, including lessons learned from previous work.

5. Concluding Discussion

This final section consists of three sub-sections. First, we assess the role taken by the projects: as driver, frontrunner, or translator of policy. In the second sub-section, we discuss differences in multilevel learning processes within and between the three targeted levels (policy, industry, and project) and the cases. In the final sub-section, we summarize our contributions and discuss our limitations, as well as outline future research.

5.1. Translators, Frontrunners, and Drivers of Policy Development

In this paper, we identify that national policy ambition plays an important role in carbon emission reduction ambitions, although in some contexts (the US and Australia cases), regional (state) policy is more prominent. All studied cases were positioned in a learning and development context of improving carbon emission reduction ambitions, driven by the Paris agreement, but the strategy varied between the countries. Based on the three-folded categorization of projects roles, based on the approach by Tucker and Ekins [37] (see Section 2: analytical point of departure), we categorized the projects as translators, frontrunners, and drivers, in relation to their ambitions toward carbon emission reductions (see Table 5 for an overview). Translator: the project aligns with state/regional policy and implements already developed processes. Frontrunner: the project aligns with state/regional policy and drives development processes in industry development. Driver: the project has a higher project ambition than the state/regional policy and drives goals for carbon emission reductions.

In the United Kingdom, Netherlands, and Sweden, the national governments had clear goals and had initiated various types of agreements and collaborations between state authorities and the industry, including structures for reduction of carbon emissions at a project level (e.g., different types of calculation tools). This shows that in these countries, the power, and legitimacy, of a state actor, including the formulation of clear goals and mechanisms to reach them (the development of calculation tools), play a central role in the implementation of carbon emission reductions [37]. The projects in the Netherlands and Sweden can be categorized as translators of policy; they follow the policy goals and work slowly to push emission requirements down. However, the two UK projects studied took an active part in industry initiatives and acted as frontrunners in driving the development of various collaborative innovation processes at an industry level. In the two US projects, explicit directives were lacking, and the projects chose to set high targets and refer directly to overarching international goals. They both had a high ambition and interviewees used wordings such as "raise the level for the industry" and "take sustainability stewardship", which categorize them as drivers. Similarly, in the Australian projects, the client had highly sustainability ambitions and wanted "to leave a transformative legacy" and "change the industry." The requirements used could, however, be backtracked to the regional policy level. These projects were therefore categorized as frontrunners. It is clear from the study that although frontrunners do not formally raise CO_2 reduction goals, they perform an important role in developing actual sustainability performance at an industry level, which can later lead to more ambitious carbon emission reduction goals. This further indicates that ambitious international goals are influential at an industry level and central to reaching high carbon emission reductions in the long run.

Table 5. Projects' carbon emission reduction ambitions and role in relation to national or regional policy.

Country	Project	Carbon Emission Reduction Visions	Project Role in Relation to Carbon Emission Reduction Development
USA, California, regional level more ambitious than the national level.	CHSR: higher ambitions than regional/state level	The project aimed to elevate the level of environmental concern in the industry, raising the bar for prospective contracts, framed as an obligation to do good, due to the size of the project.	Driver
	SFO: higher ambitions than regional/state level	The project aimed to be the first climate-neutral airport. Ambition to be ahead, and strive for developing a strong sustainability stewardship.	Driver
Australia, New South Wales, regional level more ambitious than the national level.	Sydney Metro: aligns with regional/state-level policy	The client aimed to be world-class in sustainability and leave transformative legacies.	Frontrunner
	NRL: aligns with regional/state-level policy	The client had a strong sustainability vision and an ambition to move sustainability ambitions forward in the industry and thereby change the whole transport industry in Australia.	Frontrunner
Netherlands regional level higher than the national level	Almere: aligns with national and regional level policy	The main pressure came from the municipality of Almere, which adopted high sustainability goals. Directly related to the government goals.	Translator
United Kingdom	Anglian water: aligns with national-level policy	The project had ambitions to be a frontrunner and clearly expressed the ambition to contribute to the fulfillment of the national Climate Act through promoting innovation in the sector.	Frontrunner
	HS2: aligns with national-level policy	The project had ambitions to be a frontrunner and an exemplar project concerning carbon emission mitigation. It perceived an obligation to align ambitions with overall national goals and push other actors.	Frontrunner
Sweden	Control Station 2018: aligns with national policy	The Swedish Transport Administration (STA) had developed their carbon emission reduction requirement model in response to national and international reduction goals.	Translator

Previous research has also shown that there are multiple pathways for policy implementation depending on the national context [31]. This means that a translator can have more ambitious goals than a driver and frontrunner. Moreover, a frontrunner could achieve a more significant change than a translator by focusing on strengthening industry-level collaboration and engagement.

5.2. A Multilevel Learning Process and Implementation

In the scientific literature, a lack of clarity regarding regulations [49,50], and a lack of coordination between policy instruments [51] have been identified as major challenges in relation to SPP. This is also visible in different ways in the case studies, such as in Australia, where overlapping sustainability guidelines resulted in burdensome administration, and in the Swedish case, where industry-wide standards were called for to provide more efficient implementation of carbon reduction measures in the supply chain. Previous studies argue that training could be a remedy for this, e.g., [21,26,29,49,50], since training enhances the client competence and thus the ability to set appropriate guidelines and standards. In the studied projects, the need and support for a learning process are emphasized at three levels: project, industry, and policy level, and with slightly different approaches depending on the type of project.

5.2.1. Project-Level Learning

A clear sustainability vision and a strong leadership committed to the visions are often raised in the literature as central factors influencing carbon emission reduction ambitions [28,29,52,53], and these arguments were expressed in several of the investigated projects as well. In the studied projects, visions are often conveyed by sustainability managers and CEOs, confirming the importance of visionary leadership. This is especially emphasized in the driver and frontrunner projects. The scientific literature has shown that individual champions or change agents often play important roles in driving the requirements and help project teams to progress towards sustainable procurement [30,54–56], influencing the culture and behavior of the organization.

In several of the studied projects, it was shown that individuals also played key roles in disseminating knowledge and pushing the sustainability issue within their own organization. However, as also confirmed in the scientific literature, all studied cases experienced challenges in educating staff; stressing the challenge of keeping them engaged in sustainability matters over long project lifecycles. As project organizations grow, diffusion of knowledge and sustaining awareness becomes more and more difficult. Literature focusing on the project level emphasizes that a general lack of environmental knowledge and awareness is a major problem in procuring organizations [26,29], and our study confirms the importance of a constructive collaboration between procurement functions and sustainability managers.

5.2.2. Industry-Level Learning

There are important barriers when using procurement as a tool for driving sustainability at the industry level. First, a lack of green products and services on the market means that identifying sustainable sources of supply may be challenging and as a consequence fewer suppliers will submit tenders [53]. Lack of information on the actual environmental impact of the products [21] also limits the available choices and creates significant barriers for the procuring organizations. It is, therefore, central to establish inter-organizational relationships at an industry level. Previous research points to different ways for the procuring organization to interact with potential suppliers, to share and receive information [34]. However, in a public procurement setting, this comes with restrictions in relation to the public procurement act in different countries, limiting the collaboration possibilities between procurer and supplier before a contract is signed. This requires supplier engagement [35] and, thus, a translation of policy and compliance activities to achieve this [57]. If this translation works, large projects can facilitate the adoption of new standards for their specific sector and increase performance at a general level over time [58]. They can also promote the development of more sustainable products and services; as their size increases, so does their capacity to develop a green purchasing strategy at an operational level, as they, with their greater scale, can reduce the cost for contractors of engaging in product development [6]. However, our study showed that large projects are not always suitable for developing and testing new products, due to their complexity and long implementation spans, suggesting small-scale pilots, and testbeds as a compliment. Several of the studied large-scale projects engaged in both pilot innovation work and implementation of the status quo to support learning and product development that can reduce carbon emissions and, thereby, increase the capacity of the industry to bid for future projects. The studied cases, especially the frontrunner projects, also worked actively to influence market development, arguing against the deeply rooted idea that green products and services are more expensive than conventional ones.

5.2.3. Policy-Level Learning

Several of the studied cases illustrate the importance of a constructive collaboration between government and industry, to raise awareness and readiness in the sector as a whole. In a report from the OECD [6], procurement is described as an ongoing dialogue between the government, frontrunner companies, and purchasing units, with the aim of continuously improving the efficiency of public procurement. A majority of the interviewees emphasized the importance of breaking the silo-thinking in the construction industry and developing methods and structures to integrate competencies between different organizations in the supply chain, as well as at an industry-level, to attain significant carbon emission reductions. In the driver cases, the projects take the lead by setting higher goals than the national level. In the frontrunner cases, the industry-level collaboration takes the form of innovation platforms focusing on innovation/product improvement. In the translator countries, in contrast, collaboration and development is happening in relation to the "reduction ladder" created by the carbon calculation tools, fostering an increased control of the carbon emissions of different parts of the project over time. Consequently, the structures for public–private cooperation become central for the implementation of international goals of reducing carbon emissions in the sector as a whole. The implementation pathway is not the same for all projects and showcases the importance of context-specific aspects [59].

5.3. Contributions, Limitations, and Future Research

This study contributes to the literature regarding policy implementation, construction management, and sustainable public procurement through using a cross-country, cross-level comparison, highlighting different ways to implement and disseminate SPP in infrastructure construction. Our study has shown that:

- International climate policy was important to legitimize and enable individuals to act as champions in the cases we identified as drivers. In other national contexts, it is the basis for organizations to become frontrunners, pushing for carbon emission reductions in the sector as a whole. In the cases we identified as translators, the national level guides how projects work in improving project-level performance. This means that to assess pathways for carbon emission reduction, the country context is essential.
- Factors influencing implementation that are deemed critical are consequently dependent on the national context, views on perceived costs and benefits, market maturity, and the level of carbon knowledge in procuring organizations and projects.
- As stated in the SPP literature, visions, leadership, and motivation facilitate multilevel learning processes and successful SPP.
- Learning is, however, not only built at the project level, but depends on the whole SPP governance structure and is central to the development of collaborations at a market level or in relation to institutionalizing collaborations between clients and procurers.
- Market interaction and a high client competence and engagement, sustained over several projects and longer time horizons, are needed; otherwise, suppliers will not invest in new technology or new knowledge.
- Ongoing dialogue and learning between government clients and market actors are central for driving long-term change and the development of sustainability in the infrastructure sector, since the two main obstacles for successful implementation are: the lack of (i) knowledge in public organizations; and lack of (ii) sustainable products on the market. It is, however, central to acknowledge that this learning can, and will, take different forms in different national contexts.

The SPP field has matured in terms of both managerial and scientific aspects. Thereby, a focus on factors influencing carbon emission ambitions at the project level has become partly obsolete, and a more holistic view encompassing multiple administrative levels involved in governing and implementing SPP needs to become more central to the research field. Even if factors influencing the SPP are similar in the different cases, the methods of navigating between them are different in different national contexts. This means that suggestions on how to further improve SPP need to be contextualized to avoid requirements that increase bureaucracy and/or transaction costs without delivering results in terms of real carbon emission reductions.

The study indicates the importance of engaging in industry collaboration and joint development of products and standards, a perspective that is shared with the sustainable supply chain management field [34,36,60]. This is especially visible in frontrunner projects; it is, however, clear that it is not solely a market-based approach, as goals and visions are in line with national ambitions. Some of the frontrunner projects rely heavily on a "cut carbon, cut cost" discourse, motivating the industry to innovate jointly. It is, however, important to note that such policies will eventually reach a dead-end where more proactive strategies are needed to meet long-term goals. Tukker and Ekins [37] argue that the resource efficiency agenda is at a cross-roads where policymakers advocate for proactive approaches, while industry leans on a business-as-usual scenario and resource scarcities are addressed within the current paradigm. However, the study showed that some frontrunners develop "no-dig", "no build" practices, breaking away from the business-as-usual scenario, which seems promising for more radical carbon emission reductions in the future.

For the translators, the focus lies at the project level and largely on the calculation of carbon emission reductions. Such focus could potentially overlook what is big and what is small in terms of carbon emission reductions. However, some of these projects are embedded in an innovative structure, developed in collaboration with the procuring organization, which may ensure that carbon reductions are kept at a steady rate and in-line with national and global ambitions. Drivers are pushing the carbon emission context, as there is a discrepancy between national and global goals. However, it is important to note that none of the three types of projects are driving the international agenda. To reach further carbon emission reductions, it is clear that considerable cultural, managerial, and operational changes are required [25]. The next step in carbon emission reduction policy and the magnitude of action needed will depend on the actual projects' multilayered context. The construction industry is project-based, and an important part of sustainable development and carbon emission reduction can be overlooked when not considering the whole life cycle of the facilities and including, for example, the maintenance phase in the project, or at least already have requirements taking this into account in procurement, see e.g., [61–63].

This study has some identified limitations. The investigated projects and countries were chosen because they were deemed leaders in their implementation of requirements for carbon emission reductions and can, therefore, not be seen as average infrastructure projects. However, they are good representatives of flagship projects that act as drivers for different types of actions, and, as such, they provide a good overview of both success factors and challenges. The study focused on the construction phase of the infrastructure lifecycle, and a broader scope could, therefore, be of value in future research. Further studies developing the different roles taken in SPP implementation, and focusing more on the interactions between the different levels in each case, would also bring important contributions to the SPP field in a broader sense.

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References

1. United Nations. The Paris Agreement. Available online: https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement (accessed on 26 June 2021).
2. European Union. Construction and Demolition Waste. 2015. Available online: https://ec.europa.eu/environment/topics/waste-and-recycling/construction-and-demolition-waste_en (accessed on 27 May 2021).
3. UNEP. Gloval Status Report for Buildings and Construction: Towards a Zero-Emission, Efficient and Resilient Buildings and Construction Sector. Available online: https://globalabc.org/resources/publications/2020-global-status-report-buildings-and-construction (accessed on 27 May 2021).
4. World Green Building Council. Bringing Embodied Carbon Upfront. Available online: https://www.worldgbc.org/sites/default/files/WorldGBC_Bringing_Embodied_Carbon_Upfront.pdf (accessed on 27 May 2021).
5. World Resources Institute. The Greenhouse Gas Protocol. Available online: https://www.wri.org/initiatives/greenhouse-gas-protocol (accessed on 26 June 2021).
6. OECD. The Role of Public Procurement in Low Carbon Innovation. Available online: https://www.oecd.org/sd-roundtable/meetings/theroleofpublicprocurementinlow-carboninnovationapril2016.htm (accessed on 25 January 2019).
7. European Union. Buying Green—Handbook on Green Public Procurement, 3rd Edition. Available online: https://ec.europa.eu/environment/gpp/pdf/Buying-Green-Handbook-3rd-Edition.pdf (accessed on 25 June 2019).
8. Hafsa, F.; Darnall, N.; Bretschneider, S. Estimating the true size of public procurement to assess sustainability impact. *Sustainability* **2021**, *13*, 1448. [CrossRef]
9. Sönnichsen, S.D.; Clement, J. Review of green and sustainable public procurement: Towards circular public procurement. *J. Clean. Prod.* **2019**, *245*, 118901. [CrossRef]
10. Wuennenberg, L.; Casier, L. Low-Carbon Innovation for Sustainable Infrastructure. The Role of Public Procurement; IISD and i24c. Available online: http://i24c.eu/wp-content/uploads/2018/03/Low-Carbon-Innovation-for-SustainableInfrastructure-The-role-of-public-procurement_v2.2_web.pdf. (accessed on 25 January 2019).
11. European Commission. Strategic Public Procurement—Brochure. Available online: http://ec.europa.eu/DocsRoom/documents/25984 (accessed on 25 January 2019).
12. Walker, H.; Miemczyk, J.; Johnsen, T.; Spencer, R. Sustainable procurement: Past, present and future. *J. Purch. Supply Manag.* **2012**, *18*, 201–206. [CrossRef]
13. Ruparathna, R.; Hewage, K. Sustainable procurement in the Canadian construction industry: Current practices, drivers and opportunities. *J. Clean. Prod.* **2015**, *109*, 305–314. [CrossRef]
14. Commission of the European Communities. Public Procurement for a Better Environment. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52008DC0400&from=EN (accessed on 12 May 2019).
15. Adam, C.; Hurka, S.; Knill, C.; Peters, B.G.; Steinebach, Y. Introducing Vertical Policy Coordination to Comparative Policy Analysis: The Missing Link between Policy Production and Implementation. *J. Comp. Policy Anal. Res. Pract.* **2019**, *21*, 499–517. [CrossRef]
16. Homsy, G.C.; Liu, Z.; Warner, M.E. Multilevel Governance: Framing the Integration of Top-Down and Bottom-Up Policymaking. *Int. J. Public Adm.* **2019**, *42*, 572–582. [CrossRef]
17. Eriksson, P.-E. Exploration and exploitation in project-based organizations: Development and diffusion of knowledge at different organizational levels in construction companies. *Int. J. Proj. Manag.* **2013**, *31*, 333–341. [CrossRef]
18. Sourani, A.; Sohail, M. Barriers to addressing sustainable construction in public procurement strategies. *Proc. Inst. Civ. Eng. Eng. Sustain.* **2011**, *164*, 229–237. [CrossRef]
19. Kadefors, A.; Lingegård, S.; Uppenberg, S.; Alkan-Olsson, J.; Balian, D. Designing and implementing procurement requirements for carbon reduction in infrastructure construction—international overview and experiences. *J. Environ. Plan. Manag.* **2021**, *64*, 611–634. [CrossRef]
20. Varnäs, A.; Balfors, B.; Faith-Ell, C. Environmental consideration in procurement of construction contracts: Current practice, problems and opportunities in green procurement in the Swedish construction industry. *J. Clean. Prod.* **2009**, *17*, 1214–1222. [CrossRef]
21. Testa, F.; Iraldo, F.; Frey, M.; Daddi, T. What factors influence the uptake of GPP (green public procurement) practices? New evidence from an Italian survey. *Ecol. Econ.* **2012**, *82*, 88–96. [CrossRef]
22. Testa, F.; Annunziata, E.; Iraldo, F.; Frey, M. Drawbacks and opportunities of green public procurement: An effective tool for sustainable production. *J. Clean. Prod.* **2016**, *112*, 1893–1900. [CrossRef]

23. Lăzăroiu, G.; Ionescu, L.; Uţă, C.; Hurloiu, I.; Andronie, M.; Dijmarescu, I. Environmentally responsible behavior and sustainability policy adoption in green public procurement. *Sustainability* **2020**, *12*, 2110. [CrossRef]
24. Pot, W.D. The governance challenge of implementing long-term sustainability objectives with present-day investment decisions. *J. Clean. Prod.* **2021**, *280*, 124475. [CrossRef]
25. Trindade, P.C.; Antunes, P.; Partidário, P. SPP toolbox: Supporting sustainable public procurement in the context of socio-technical transitions. *Sustainability* **2017**, *10*, 67. [CrossRef]
26. Cheng, W.; Appolloni, A.; D'Amato, A.; Zhu, Q. Green Public Procurement, missing concepts and future trends—A critical review. *J. Clean. Prod.* **2018**, *176*, 770–784. [CrossRef]
27. Rainville, A. Standards in green public procurement—A framework to enhance innovation. *J. Clean. Prod.* **2018**, *167*, 1029–1037. [CrossRef]
28. Brammer, S.; Walker, H. Sustainable procurement in the public sector: An international comparative study. *Int. J. Oper. Prod. Manag.* **2011**, *31*, 452–476. [CrossRef]
29. Vejaratnam, N.; Mohamad, Z.F.; Chenayah, S. A systematic review of barriers impeding the implementation of government green procurement. *J. Public Procure.* **2020**, *20*, 451–471. [CrossRef]
30. Grandia, J. The role of change agents in sustainable public procurement projects. *Public Money Manag.* **2015**, *35*, 119–126. [CrossRef]
31. Correia, F.; Howard, M.; Hawkins, B.; Pye, A.; Lamming, R. Low carbon procurement: An emerging agenda. *J. Purch. Supply Manag.* **2013**, *19*, 58–64. [CrossRef]
32. Wanzenböck, I.; Wesseling, J.; Frenken, K.; Hekkert, M.; Weber, M. A Framework for Mission-oriented Innovation Policy: Alternative Pathways Through the Problem-solution Space. *SocArXiv* **2019**. [CrossRef]
33. Wong, P.S.P.; Ng, S.T.T.; Shahidi, M. Towards understanding the contractor's response to carbon reduction policies in the construction projects. *Int. J. Proj. Manag.* **2013**, *31*, 1042–1056. [CrossRef]
34. Dahlmann, F.; Roehrich, J.K. Sustainable supply chain management and partner engagement to manage climate change information. *Bus. Strategy Environ.* **2019**, *28*, 1632–1647. [CrossRef]
35. Amann, M.K.; Roehrich, J.; Eßig, M.; Harland, C. Driving sustainable supply chain management in the public sector. *Supply Chain. Manag. Int. J.* **2014**, *19*, 351–366. [CrossRef]
36. Badi, S.; Murtagh, N. Green supply chain management in construction: A systematic literature review and future research agenda. *J. Clean. Prod.* **2019**, *223*, 312–322. [CrossRef]
37. Tukker, A.; Ekins, P. Concepts Fostering Resource Efficiency: A Trade-off Between Ambitions and Viability. *Ecol. Econ.* **2019**, *155*, 36–45. [CrossRef]
38. Glaser, B.; Strauss, A.L. *The Discovery of Grounded Theory: Strategies for Qualitative Research*; Aldine: Chicago, IL, USA, 1967.
39. Yin, R.K. *Case Study Research. Design and Methods*, 5th ed.; SAGE Publications: New York, NY, USA, 2014.
40. Merriam, S.B. *Qualitative Research and Case Study Applications In Education*; Jossey-Bass: San Francisco, CA, USA, 1998.
41. Kadefors, A.U.S.; Alkan-Olsson, J.; Balian, D.; Lingegård, S. *Procurement Requirements for Carbon Reduction in Infrastructure Construction Projects: An International Case Study. Report and Executive Summary*; KTH Royal Institute of Technology: Stockholm, Sweden, 2019.
42. Bryman, A.S.R.M. *Social Research Methods*, 5th ed.; Oxford University Press: Oxford, UK, 2016.
43. RET; Australian Government. Renewable Energy (Electricity) Act, No. 174. Available online: https://www.legislation.gov.au/Details/C2014C00229 (accessed on 12 May 2019).
44. Karlsson, M. Sweden's Climate Act – its origin and emergence. *Climate Policy* **2021**. [CrossRef]
45. The Climate Change Act (c 27). UK Public General Acts. Available online: https://www.legislation.gov.uk/ukpga/2008/27/contents (accessed on 12 May 2019).
46. Global Warming Solutions Act Assembly Bill (AB) 32. Available online: https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=200520060AB32 (accessed on 12 May 2019).
47. HM Treasury. Infrastructure Cost Review: Main Report. Available online: https://www.gov.uk/government/publications/infrastructure-cost-review (accessed on 12 May 2019).
48. HM Treasury. Infrastructure Carbon Review. Available online: https://www.gov.uk/government/publications/infrastructure-carbon-review (accessed on 12 May 2019).
49. Moretti, L.; Di Mascio, P.; D'Andrea, A. Environmental impact assessment of road asphalt pavements. *Mod. Appl. Sci.* **2013**, *7*, 1–11. [CrossRef]
50. Igarashi, M.; de Boer, L.; Pfuhl, G. Analyzing buyer behavior when selecting green criteria in public procurement. *J. Public Procure.* **2017**, *17*, 141–186. [CrossRef]
51. Wilts, H.; O'Brien, M. A Policy Mix for Resource Efficiency in the EU: Key Instruments, Challenges and Research Needs. *Ecol. Econ.* **2018**, *155*, 59–69. [CrossRef]
52. Chiarini, A.; Vagnoni, E. Environmental sustainability in European public healthcare: Could it just be a matter of leadership? *Leadersh. Health Serv.* **2016**, *29*, 2–8. [CrossRef]
53. Wong, J.K.W.; Chan, J.K.S.; Wadu, M.J. Facilitating effective green procurement in construction projects: An empirical study of the enablers. *J. Clean. Prod.* **2016**, *135*, 859–871. [CrossRef]

54. Siebenhüner, B.; Arnold, M. Organizational learning to manage sustainable development. *Bus. Strategy Environ.* **2007**, *16*, 339–353. [CrossRef]
55. Eikelboom, M.E.; Gelderman, C.; Semeijn, J. Sustainable innovation in public procurement: The decisive role of the individual. *J. Public Procure.* **2018**, *18*, 190–201. [CrossRef]
56. Sergeeva, N.; Zanello, C. Championing and promoting innovation in UK megaprojects. *Int. J. Proj. Manag.* **2018**, *36*, 1068–1081. [CrossRef]
57. Meehan, J.; Bryde, D. Sustainable procurement practice. *Bus. Strategy Environ.* **2011**, *20*, 94–106. [CrossRef]
58. Sparrevik, M.; Wangen, H.F.; Fet, A.M.; De Boer, L. Green public procurement—A case study of an innovative building project in Norway. *J. Clean. Prod.* **2018**, *188*, 879–887. [CrossRef]
59. Hodge, G.; Greve, C. Public-Private Partnerships: Governance Scheme or Language Game? *Aust. J. Public Adm.* **2010**, *69*, S8–S22. [CrossRef]
60. Hoejmose, S.U.; Roehrich, J.K.; Grosvold, J. Is doing more doing better? The relationship between responsible supply chain management and corporate reputation. *Ind. Mark. Manag.* **2014**, *43*, 77–90. [CrossRef]
61. Lenferink, S.; Tillema, T.; Arts, J. Towards sustainable infrastructure development through integrated contracts: Experiences with inclusiveness in Dutch infrastructure projects. *Int. J. Proj. Manag.* **2013**, *31*, 615–627. [CrossRef]
62. Lingegård, S.; Lindahl, M. Integrated Product Service Offerings for rail infrastructure—benefits and challenges regarding knowledge transfer and cultural change in a Swedish case. *J. Clean. Prod.* **2015**, *98*, 166–174. [CrossRef]
63. Georghiou, L.; Edler, J.; Uyarra, E.; Yeow, J. Policy instruments for public procurement of innovation: Choice, design and assessment. *Technol. Forecast. Soc. Chang.* **2014**, *86*, 1–12. [CrossRef]