

Procurement Requirements for Carbon Reduction in Infrastructure Construction Projects

– AN INTERNATIONAL CASE STUDY

PROJECT REPORT JUNE 2019

Anna Kadefors, Stefan Uppenberg,
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- An International Case Study

Anna Kadefors, Stefan Uppenberg, Johanna Alkan Olsson, Daniel Balian and Sofia Lingegård

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Foreword

This report is a result of the research project Impres - Implementation of Procurement Requirements for Sustainable Collaboration in Infrastructure Projects. The project was co-funded by Construction Climate Challenge (CCC) and the Swedish Research Council Formas through a grant for the Strong Research Environment ProcSIBE (Procurement for Sustainable Innovation in the Built Environment), and the Mistra Carbon Exit research program. The research activities have been performed in collaboration between the engineering consultancy firm WSP, KTH Royal Institute of Technology in Stockholm, Lund University and the construction company Skanska.

The research team would like to thank the funders and everyone who participated with their time and effort to finalise this project and report. A special thanks to all interviewees and others in Australia, Netherlands, Sweden, UK and USA that have provided valuable input and reviewed cases and texts. Without you this project would never have been possible.

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The Construction Climate Challenge (CCC) is an initiative hosted by Volvo Construction Equipment to promote sustainability throughout the entire construction industry value chain and provide funding for environmental research. The Construction Climate Challenge is a part of the Volvo CE commitment to WWF's Climate Savers Program. Volvo Construction Equipment is a Corporate Advisory Board member of the World Green Building Council.

For more information about the Construction Climate Challenge, please visit www.constructionclimatechallenge.com

For more information about the ProcSIBE project, please visit www.procsibe.se

For more information about Mistra Carbon Exit, please visit www.mistracarbonexit.com

Executive Summary

Introduction

Following alarming reports from the IPCC, climate change has engaged policymakers world-wide to chart policies at different administrative levels to mitigate increasing greenhouse gas emissions. The construction sector causes a substantial part of all greenhouse gas emissions, primarily carbon dioxide. Traditionally in this sector, the focus of carbon reduction measures has been on improving the energy efficiency of buildings. Further, various sustainability assessment schemes (BREEAM, LEED, Green Star, etc.) have been developed to assess sustainability performance. More recently, awareness has increased of the considerable greenhouse gas emissions arising from the manufacturing of construction materials and components, and also from construction processes and transport. Consequently, the infrastructure construction sector is now considered as a major source of greenhouse gases. In the UK, The Infrastructure Carbon Review has estimated that the construction, maintenance and operations of infrastructure assets account for 16% of the nation's total carbon dioxide emissions. It is widely acknowledged that these emissions need to be significantly reduced if the international and national reduction targets are to be met.

About the project

This research project has investigated the institutional and organisational contexts, policies, procurement requirements and implementation strategies used to drive greenhouse gas reduction in large infrastructure projects in five countries world-wide: Australia, The Netherlands, Sweden, the UK and the US (see below for an overview of case study projects). The study is based on interviews with key partners on the client side and in the supply chain of each project. To provide a contextual understanding of the strategies used in these projects, we further include descriptions of the policy background that underlies current strategies and ambitions. Thus, the project traces the pathway from political and organisational goals to actual realisation in projects.

Overview of case studies in the Impres project

Country	Impres case studies
Australia	Sydney Metro Northwest Newcastle Light Rail
The Netherlands	Motorway A6 Almere
Sweden	Results from the Swedish Transport Administration research project Control Station 2018 - an evaluation of carbon procurement requirements in Swedish infrastructure projects.
UK	High Speed 2 Anglian Water (Grafham WTW Resilience and Dalton Piercy WTW)
USA	California High-Speed Rail SFO AirTrain Extension

The title of this research project is *Implementation of procurement requirements for sustainable collaboration in infrastructure projects*, also referred to as *Impres*. The project is a collaboration between the engineering consultancy firm WSP, the KTH Royal Institute of Technology in Stockholm, Lund University and the construction company Skanska. The project is co-financed by Construction Climate Challenge (CCC), a sustainability research

fund and network initiated by Volvo Construction Equipment, and the Swedish Research Council Formas. The latter funding comes through a grant for the Strong Research Environment ProcSIBE, Procurement for Sustainable Innovation in the Built Environment¹.

We expect that results from this research project will be useful for decision-makers on the client side that are in charge of developing policies, procurement strategies and procurement requirements to reduce carbon emissions in the construction sector. Further, client and contractor project managers, environmental specialists and procurement staff responsible for implementing policies will be interested in experiences gained in similar initiatives in other countries. In parallel with this report, scientific articles are being developed by the authors to analyse and discuss the results described in this report more thoroughly in relation to other studies and to theory.

Conclusions

In all countries studied, there is an ongoing process to develop and implement policies for carbon reduction in infrastructure projects, with raised ambitions over time. In some cases, the development has initially been driven by a few dedicated individuals, but today there are frameworks and executive mandates in place that would make it hard to avoid carbon reduction commitments. National and regional reduction policies were found to be important in encouraging clients to develop ambitious carbon requirements that can contribute to setting new industry standards.

Carbon reduction measures such as optimisation of constructions, minimised transport, reuse of excavated material and cement clinker replacement are applied in the studied cases. However, most of these measures are also cost efficient and would – or should – have been undertaken in a normal design and construction optimisation process. The positive side of this is that considerable carbon reductions may be achieved within existing budgets, and in most cases will even reduce cost, and that an increased focus on carbon may contribute to finding more such options. However, it also raises the question of what constitutes a relevant reference case, or baseline. Further, to meet the target levels of the Paris agreement, costly measures will also be needed, and this research identified only a few examples of such policies being implemented.

Goals for carbon reduction are still new to many in the sector, and both clients and industry partners need time to adjust and develop new competencies. In countries with a longer history of carbon management, procurement strategies and requirements have advanced through continuous interaction between clients and industry actors over longer periods of time. Clients are wary of introducing requirements that may limit competition, and requirements to comply with rating schemes or to supply EPDs have been introduced successively to match the development of industry capacity. Award (MEAT) criteria related to carbon are used, but more often to increase awareness of carbon reduction rather than as a substantive basis for selection. Front-runner contractors and material suppliers were found to play important roles in reducing obstacles to innovation-oriented procurement. Moreover, the development of procurement requirements has been aligned with information and training initiatives, tool kits and guidelines to support low-carbon

¹ www.procsibe.se

design and the calculation of emissions. In general, client environmental specialists have taken an active part in supporting the implementation of requirements in supply chains.

Procurement requirements are considered important in driving carbon reductions in all countries, but the preferred style of these requirements vary. This diversity was partly related to general carbon management maturity and partly to general contracting practice and policy culture in the country or region. All countries used some form of contract-level reduction requirements, in most cases set in relation to a carbon emissions baseline. Overall, reduction requirements are perceived to encourage innovation, but our results show that such requirements were often more complex than foreseen and associated with administrative costs. First, to produce change and avoid speculation it is important to set requirements and incentives at the right level, which requires awareness on the client side of both the supplier's competence and of the opportunities for carbon reduction in the specific project. Also, sharp requirements call for equally sharp and transparent performance evaluation. Moreover, much time was spent on calculation and re-calculation of baselines which could detract from measures for actual reduction of carbon emissions. In effect, time constraints in the projects limited the opportunities to involve subcontractors and material suppliers, which meant that all possible reductions were not realised. We conclude that expectations for substantial and innovative carbon reductions through functional reduction requirements may be too high. To influence sub-contractors and suppliers directly, several clients use specific requirements.

Collaborative contracting models are a flexible option to encourage innovation and integrate knowledge of different participants. Many interviewees state the importance of breaking silo-thinking and integrating the supply chain in order to reach greater carbon reductions. Also, long-term alliances allow for continuous learning and more transformational innovation, including incentivising contractors to find ways of fulfilling client goals while building less. However, it should be emphasised that strong client leadership and commitment are essential both to legitimise collaborative contracting models and to achieve more fundamental behavioural change within collaborative projects and alliance schemes.

Clients in mega-projects perceive an obligation to conform to national policy goals and may also have ambitions to be industry-level change agents. Since such projects have vast budgets, last for long periods of time and engage highly competent firms and individuals, they are often expected to show high performance in the area of innovation. However, mega-projects have many goals to fulfil, are technically and organisationally complex and associated with high risks. Therefore, time and willingness to develop new ways of working or implement new technology may be lacking. Further, even large projects may not be long enough to encompass processes to develop, test and approve new solutions. Thus, to support more efficient innovation processes in the industry, a long-term system perspective is needed. Interviewees suggested using smaller pilot projects for quicker testing of new materials, tools and technologies and, once proven, use procurement requirements in large projects to implement these more widely in the market.

Overall, the study shows that the applicability of procurement requirements for carbon reduction is dependent on how well these requirements are aligned with culture, policies and capabilities in the local context. Inspiration may be sought from cutting-edge examples in other countries and regions, but practices may seldom be directly transferred. Also, it is

clear that awareness, competence and capacity on the buyer (client) side is a key success factor. Such client capabilities involve constructive collaboration between procurement functions, environmental specialists and project managers. Further, policy makers need to acknowledge that measures to reduce carbon must align with existing procurement and innovation systems. To reach higher levels of ambition for carbon reduction, such institutional structures may also need to be changed.

Recommendations

Based on the findings, our recommendations to the target group of policy-makers and clients are:

Policy level – national, regional and organisational

- Set high-level goals and policies for carbon reduction in order to sanction ambitious initiatives that contribute to setting new industry standards.
- To reduce barriers for innovation-oriented procurement requirements, engage industry associations and encourage initiatives by supply-side front-runners.
- When developing organisational policies and strategies, address not only ambitions but also what roles the client and other parties should have in implementation.

Project level policies and procurement requirements

- When defining requirements, consider implementation costs for setting and following up requirements. In particular, be careful that focus stays on carbon mitigation measures and that calculation of baselines does not impact negatively on carbon management. Assess and mitigate behavioural risks associated with incentives.
- Ensure that requirements will be effective in influencing all relevant decision-makers in the supply chain (designing engineers, constructors and material suppliers). This implies that time, competence and resources should be available at relevant points in time.
- Apply a long-term learning perspective and acknowledge that different combinations of award and selection criteria, reduction requirements, specific requirements and rating schemes may be preferable over time.
- Align requirements and activities with general contracting models and encourage models that enable integration of knowledge and carbon management in the supply chain.

Innovation and learning

- Develop guidelines, tools and training programs to help build industry capabilities.
- Establish which organisations should drive development, for example commission, host and update guidelines, and provide training and support.

- Communicate plans for raised ambitions well in advance, for example requirements to comply with established carbon management standards and rating schemes.
- Orchestrate long-term innovation by combining small pilot projects to test new solutions with systematic implementation in larger projects to achieve wide market dissemination.
- Establish transparent procedures for updating client standard specifications based on frontrunner initiatives, planned pilots and academic research.
- Innovation should also address contracting and business models: develop institutional capabilities that enable and legitimise long-term, strategic collaborative alliances.

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1. Introduction

1.1. Background and aim

Following alarming reports from the IPCC, climate change has engaged policymakers world-wide to chart policies at different administrative levels to mitigate increasing greenhouse gas emissions. At a global scale the ambition to take action is regulated by the United Nations Framework Convention on Climate Change (UNFCCC) and its consecutive decisions and protocols. Recently, the so-called Paris agreement from 2015 and the latest agreement decided upon at the 2018 COP meeting in Katowice, Poland, clarify how states should account for their emissions. Most countries have developed policies to reduce greenhouse gas emissions including, for example, environmental permits, trading schemes and taxes. It is well recognized that both public and private bodies are central in driving change in this area. Therefore, industry actors work in parallel with government public bodies to ensure that their own goals align with the globally or nationally defined reduction targets. This work is made concrete through different agreements, strategies and plans agreed among industry partners or between public and private bodies jointly. Sector standards, certifications and rating schemes, combined with specific sustainability or greenhouse gas accounting systems, are important vehicles to achieve defined emissions reductions. Procurement is increasingly seen as a key policy tool for governments to drive carbon reduction in the private sector.

The construction sector causes a substantial part of all greenhouse gas emissions, primarily carbon dioxide. Traditionally in this sector, the focus of carbon reduction measures has been on improving the energy efficiency of buildings. Further, various sustainability assessment schemes (BREEAM, LEED, Green Star, etc.) have been developed to assess sustainability performance. More recently, awareness has increased of the considerable greenhouse gas emissions arising from the manufacturing of construction materials and components, and also from construction processes and transport. Consequently, the infrastructure construction sector is now considered a major source of greenhouse gases. In the UK, the emissions from the construction, maintenance and operations of infrastructure assets have been estimated to account for 1/6 or 16 % of the nation's total carbon dioxide emissions in the Infrastructure Carbon Review (HM Treasury, 2013). It is widely acknowledged that these emissions need to be significantly reduced if the international and national reduction targets are to be met.

In the infrastructure sector, large public buyers such as road and railroad administrations, state-owned companies, municipalities and county councils represent a large proportion of the total demand. Their procurement models and requirements not only shape the facilities constructed but also the incentives and motivation of contractors, designing engineers and material manufacturers to develop competencies and new innovative solutions. Thus, such large repeat clients are central to driving long-term innovation in this field (Loosemore, 2015; Loosemore and Richards, 2015). In recent years initiatives have been taken world-wide to include sustainability criteria in infrastructure construction. Infrastructure sector clients increasingly adopt far-reaching policies with goals and visions for sustainable development and reduced climate impact. Tools for supporting sustainable development in infrastructure projects are now available on the international market, most notably sustainability assessment schemes such as CEEQUAL, BREEAM Infrastructure, the IS

rating scheme, Envision, and sustainability frameworks such as SUNRA, and the carbon management framework PAS 2080. Recent guidelines such as those by UK Green Building Council (UKGBC, 2017) and IISD and i24c (Wuennenberg and Casier, 2017; 2018) address the role of public procurement in this field and provide best practice examples. However, it is not evident how to design and implement procurement models and incentives that efficiently contribute to greenhouse gas reductions in infrastructure construction projects. A complicating factor is that measures have to be taken by a great number of individuals and organisations in the supply chain. Policies and procurement requirements to reduce carbon need to be integrated into a wide range of structures, processes and practices.

Studies of sustainable procurement in general have found that procurement policy and practices vary significantly between regions, and that national policy context is important in determining both focus areas and measures (Brammer and Walker, 2011). This implies that it is important to capture and learn from experiences gained thus far in various countries world-wide, but also to acknowledge that the transfer of practices between regions is challenging and that procurement strategies must be adapted to national and organisational contexts.

1.2. Research project overview

The research project has investigated the institutional and organisational contexts, policies, procurement requirements and implementation strategies used to drive greenhouse gas reduction in large infrastructure projects in five countries world-wide: Australia, The Netherlands, Sweden, the UK and the US. The study is based on interviews with key partners on the client side and in the supply chain of each project. To provide a contextual understanding of the strategies used in these projects, we further include descriptions of the policy background that underlies current strategies and ambitions. Thus, the research project traces the pathway from political and organisational goals to actual realisation in infrastructure construction projects.

The results are presented as case study descriptions, including interview quotes. This richer empirical material differentiates this report from guidelines for greenhouse gas reduction in infrastructure construction. The accounts and views of individuals provide a deeper insight into the wide range of factors that affect the choice of strategy as well as the outcomes. The case descriptions also explicitly address difficulties, limitations, barriers and risks that may occur when transferring measures between organisations and countries. This presentation style encourages readers to independently interpret the data and evaluate the implications for their own practice.

The title of the project is *Implementation of procurement requirements for sustainable collaboration in infrastructure projects*, also referred to as *Impres*. The project is a collaboration between the engineering consultancy firm WSP, KTH Royal Institute of Technology in Stockholm, Lund University and the construction company Skanska. The project is co-financed by Construction Climate Challenge (CCC), a sustainability research fund and network initiated by Volvo Construction Equipment, and the Swedish Research Council Formas. The latter funding comes through a grant to the Strong Research

Environment ProcSIBE, Procurement for Sustainable Innovation in the Built Environment².

The following section provides a background to some key technical issues, for example the main sources of greenhouse gas emissions in the infrastructure construction sector and the measures that may be taken to reduce these emissions. After this, there is a discussion of different types of procurement requirements and how they are classified in the report.

1.3. Carbon emissions and reduction opportunities in infrastructure construction

In line with definitions in the UK Infrastructure Carbon Review (HM Treasury, 2013), ‘carbon’ is hereafter used in this report as shorthand for the carbon dioxide equivalent of all emissions of greenhouse gases, quantified as ‘tonnes of carbon dioxide equivalents’ (tCO₂e). ‘Capital carbon’ refers to emissions associated with the creation, refurbishment and end-of-life of an asset; this includes all direct emissions from construction but also ‘embodied carbon’ which refers to indirect life-cycle emissions from production of construction material and products. ‘Operational carbon’ describes emissions associated with the operation and maintenance of an asset. ‘Whole life carbon’ combines both capital and operational carbon.

The majority of carbon emissions from infrastructure construction is associated with capital carbon, the major sources being production of materials (primarily concrete, steel and asphalt) and from the use of fossil fuels (diesel) for excavation, crushing and transport of rock and soil masses. The proportions shown in Figure 1 are based on a carbon footprint assessment of all major projects in the Swedish national plan for infrastructure investments for the period 2018 - 2029.

There are many different activities in infrastructure projects where carbon should be considered and measures for reducing carbon emissions taken, both during planning and design and during construction. According to PAS 2080 (BSI, 2016), the following carbon emissions reduction hierarchy should be followed by all value chain members when identifying opportunities to reduce carbon:

1. Build nothing: evaluate the basic need for an asset and/or programme of works and explore alternative approaches;
2. Build less: evaluate the potential for re-using and/or refurbishing existing assets to reduce the extent of new construction required;
3. Build clever: consider the use of low carbon solutions (including technologies, materials and products) to minimise resource consumption during construction, operation and use;
4. Build efficiently: use techniques (e.g. construction, operational) that reduce resource consumption during construction and operation.

² www.procsibe.se

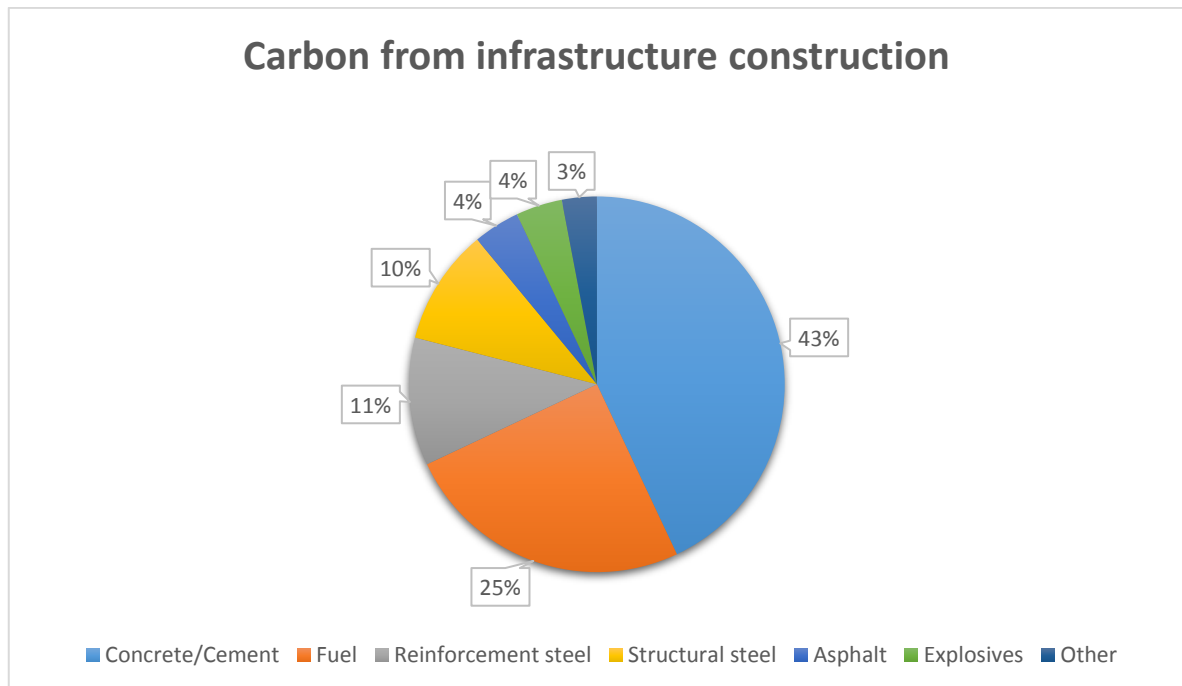


Figure 1: Major sources of carbon from infrastructure projects, based on a carbon footprint assessment of all major projects in the Swedish national plan for infrastructure investments for the period 2018 – 2029 (Trafikverket, 2018).

Some examples of potential reduction opportunities that can be identified in different project phases by applying this hierarchy are:

Planning and design:

- Choice of location of transport infrastructure
- Minimising amount of constructions (bridges, tunnels etc.)
- Minimising need for ground reinforcement (steel and concrete piles)
- Optimisation of mass balance and need of transport work
- Optimisation of constructions for use of less material
- Choice of technical systems
- Optimisation of energy and material use over life cycle
- Use of alternative construction material, like wood or composites

Construction

- Cement clinker replacement in concrete (fly-ash, GGBS³ etc.)
- Choice of production method for constructions (on-site, off-site, 3D-printing etc.)
- Low-temperature technique and/or renewable fuel in asphalt plants
- Choosing low-carbon alternatives in procurement of e.g. steel based on EPDs
- Re-use of masses and material within and between projects
- Minimising transport work through optimised logistics
- Use of bio-fuels for construction equipment and vehicles
- Use of renewable energy on site
- Minimising waste

³ Ground Granulated Blast Furnace Slag

1.4. Procurement requirements and specifications

In the European Union as well as in the OECD countries, the focus on public procurement as a policy instrument has increased in recent years (European Commission, 2017a). Traditionally, many public clients have prioritised lowest investment cost and only to a limited degree have they included social and environmental criteria. However, the new EU Procurement Directives from 2014⁴ express that public procurement can be used with a strategic purpose to attain secondary policy objectives (European Commission, 2017a). In particular, ecological and social sustainability and innovation procurement have been promoted (Wuennenberg and Casier, 2017; 2018). In 2017, the EU committed to a program for professionalising public procurement, including the development of support functions and training material (European Commission, 2017b). Studies of sustainable and green public procurement (SPP/GPP) as well as innovation procurement have shown that this area is complex and dependent on mutual interaction between demand-side requirements and supply-side development over longer periods of time (Brammer and Walker, 2011; Uyarra et al., 2017). Further, policy ambitions must be balanced with primary procurement objectives, and the organisational capacity of buyers is an important prerequisite (OECD, 2015b).

There is no straightforward way to classify procurement requirements for construction projects. Partly, this is because two different classification bases interact: the procurement base and the construction procurement base. In the procurement domain, requirements are classified according to the different stages in the procurement process that follows the public procurement law. The main categories are:

- *Prequalification criteria*: in a selective (restricted) tendering process, these criteria are used to select the tenderers that qualify for the next step. Some criteria may be mandatory for all tenderers to fulfill. There may also be a pre-qualification questionnaire (PQQ) or first step tender submission to rank tenderers as a basis for pre-selection.
- *Qualification criteria*: mandatory criteria that all tenderers must fulfill when an open tendering process is used.
- *Award criteria*: criteria that are used to rank tenders and identify the (winning) Most Economically Advantageous Tender (MEAT). Award (or MEAT) criteria may be price, quality, environmental performance, competence, plans and processes, etc. In public procurement following the EU directives, award criteria should be weighted in the tendering documents.

However, the Competitive Dialogue process blurs these distinctions, since there is a prequalification process, followed by a dialog/design process, followed by the final supplier selection.

The construction procurement classification base refers to the realm of *technical specifications and other specific requirements*. Such specifications may concern the finished constructed facility, the production processes and equipment, or the competence of individuals. Often, technical specifications are divided into detailed specifications and functional (or performance) specifications. Functional specifications leave it open to tenderers to decide how to achieve a function, while detailed specifications specify which technical solutions, materials or processes should be used. In construction, design-build

⁴ Directives 2014/23-25/EU

contracts are based on functional requirements, while detailed requirements are associated with traditional, or design-bid-build, models. In many countries, however, there is increased use of integrated strategies where contractors are involved earlier in the process and collaborate with the client and the design consultants to jointly define the design (McKinsey, 2018; Wondimu et al., 2018).

Rating schemes provide another base for specification, where the infrastructure asset may receive a certification or label provided that certain product and/or process criteria are fulfilled. For carbon reduction these are typically sustainability assessment schemes (SAS). Management standards are similar to rating schemes in some respects, but general environmental management systems, like ISO 14000, have not been considered in this study, only the framework for Carbon Management in Infrastructure, PAS 2080:2016.

Regarding carbon reduction in construction, clients in many countries have chosen to specify or reward percentage reductions of emissions in relation to a baseline. This can be done in various ways and project stages depending on the procurement strategy. Such requirements are sometimes referred to as “functional”, since they leave it open to contractors how to achieve the reduction goals, but they do not generally set a performance level in terms of a specified carbon budget for a project.

In our case study descriptions and discussions, we classify requirements using the following four categories:

- Selection and award criteria (qualification and MEAT criteria)
- Technical specifications and specific requirements (functional, detailed, process, competence)
- Sustainability Assessment Schemes/Rating Schemes
- Carbon reduction requirements

1.5. About the report

This report primarily describes the empirical findings of the project. The discussion brings up some key themes in previous research, but an overview and summary of the literature in the field is not provided. In parallel with this report, scientific articles are being developed by the authors to analyse and discuss the results described in this report more thoroughly in relation to other studies and to theory.

We expect that results from this research project will be useful for decision-makers on the client side that are in charge of developing policies, procurement strategies and procurement requirements to reduce carbon emissions in the construction sector. Further, client and contractor project managers, environmental specialists and procurement staff responsible for implementing policies will be interested in experiences gained in similar initiatives in other countries.

The report is organised as follows:

- The Introduction outlines the background to and aim of the study.
- The Method section describes the selection of cases and methodological aspects and discusses limitations.

- The Overview of Sustainability Assessment Schemes section provides an overview of such schemes for infrastructure construction, and analyses how they handle the area of carbon reduction.
- The five country-based case study sections present the empirical data. For each country, the policy context is summarised under the “Carbon context”-heading. Then, the studied construction projects are described based on interview data and project documentation. The countries are presented in alphabetical order.
- In the Discussion section, the case study findings are compared and discussed.
- Conclusions and recommendations

2. Method

A case study approach is a 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 is unclear and contains many variables (Merriam, 1998; Yin, 2014). In our case studies, the empirical basis consists of a combination of interviews, project documentation, web sources and written input from local experts. The projects studied vary in size, type of asset and the phase the project was in when the interviews were performed. In this section, we describe the research process in more detail.

2.1. Selection of case study countries and projects

The countries and projects were selected based on a combination of how accessible they would be to study, their potential to generate interesting data and geographical spread. Thus, the cases should have ambitious climate requirements. The research partners WSP and Skanska both have local branches and subsidiaries all over the world, and such local presence partly determined which countries and projects were selected. WSP contacts were used to identify and gain access to projects in Australia, Sweden, UK and US. In most projects studied, local WSP representatives have been involved as consultants and in some cases Skanska have been involved as contractors. The initial plan was to study two cases per country, one very large project and one of a more standard type. This ambition was however not fulfilled in all countries, for different reasons. Thus, The Netherlands was not originally part of the study since neither company was represented there, but was added due to their ambitious and frontline systems for driving carbon reduction. In this case contacts of the academic partners were used, but only one project could be included within the time and budget available. In the UK, the Anglian Water case was included due to its significant experience; however it is not a single project but an alliance-based program. The intention was to include also a “normal” project from the UK, but this did not work out in the timespan available. The Swedish case study uses a partly different methodology, because it was coordinated with another research project, Control Station 2018, to evaluate the carbon reduction strategy of the Swedish Transport Administration.

Large projects may comprise several subprojects over a long time period. In such cases, the main focus has been on the most recent version of procurement requirements and sustainability policy. However, earlier versions of requirements and policies were also investigated to understand the development over time. Further, sub-projects were in different project stages, varying from early planning to construction and finalisation. In planning the interviews, Impres prioritised later project stages and procurement requirements affecting contractors.

2.2. Data collection and analysis

Interview focus and interviewees

Interviews were performed with client representatives as well as with other parties in the supply and value chains, primarily contractor and consultant representatives but also manufacturers of construction materials. Interviewees were selected with the aid of local WSP and SKANSKA connections who were involved in the projects and could identify the most relevant functions and individuals. The interviewees represented the different levels of the project management and execution, from the board level to project management, environmental specialists and procurement functions. Depending on project phase and

availability, different combinations of roles were interviewed in different projects. In general, interviews lasted for 2-3 hours. For a summary of interviews see Table 1.

An interview guideline was developed in an iterative process within the Impres project team (see Appendix I). The questions were based on six categories aiming to capture information about procurement requirements used in the case study projects as well as personal experiences and views. The categories were:

1. Sustainability procurement requirements for reduction of carbon emissions in the project
2. Basis for/origin of requirements, such as policies, standards or certifications
3. Organisation and processes for implementing and following up requirements
4. Mechanisms for learning and improvement
5. Results
6. Perceived key success factors and barriers

The detailed interview guideline was comprehensive, but different questions were posed to different actors depending on their role. As an example, the category “Origin of requirements” was relevant for interviews with client authorities but not for suppliers. The chosen set of questions was communicated to the interviewees at least one week before the interview. The interviews were semi-structured (Kvale, 2008), and follow-up questions were posed spontaneously during the interview. At least two interviewers participated and took different roles in taking notes and leading the interview. Most interviews were carried out by the Swedish WSP Impres partners, although research members participated in some. Most interviews included more than one interviewee, and local WSP representatives often participated as well. A few interviews were performed by Skype. In the Swedish case study, based on the Control Station project, there was a greater number of interviews. A variety of forms were used, including interviews with project teams, individual interviews and focus groups of clients, consultants, contractors and material suppliers. All interviews were voice-recorded and transcribed. For a comprehensive list of all interviewees see Appendix II.

Before the interviews, the interview team performed a desk study of relevant documents on the policy and project levels. For national policy, internet-based sources were used while the interviewees and local WSP staff provided organisational and project documents.

The Carbon context sections

For each country, a section called “Carbon context” was developed. The purpose was to provide a background to the procurement requirements and models used in the studied projects. For Australia and UK, the input to these sections was provided by the local WSP representatives. For the US, the section was written by the Impres team based on internet sources and checked by local WSP representatives. In the Swedish case, the WSP representatives in the Impres team wrote the section. For The Netherlands, the research institute IBR was commissioned to provide input, since much information is available only in Dutch. Input was further complemented by information from the project interview, internet sources and research articles.

Table 1: Projects and actors interviewed. For a full list see Appendix II.

Country	Project	Actors interviewed (number of persons)	No of interviews
Australia	Sydney Metro Northwest	Client: Sydney Metro Authority (3) Contractor: Northwest Rapid Transit (1) Designer: WSP (2) Supplier: Hanson precast (1), Liberty OneSteel (1)	4
Australia	Newcastle Light Rail	Client: Transport for New South Wales (1) Contractor: Downer (1) Designers: WSP (3), Aurecon (1)	2
The Netherlands	A6 Almere	Client: Rijkswaterstaat (2) Contractor: Parkway6 (1)	1
Sweden	Research project Control Station 2018	3 project interviews + interviews with clients (23), consultants (16), contractors (22) and suppliers (15).	17
UK	Anglian Water, Grafham WTW Resilience and Dalton Piercy WTW	Client: Anglian Water (2) Contractor: Mott MacDonald Bentley (MMB) (1) Designer: Stantec (1) Other: @One alliance (1)	1
UK	HS2	Client: HS2 Ltd. (3) Contractor: SCS (Skanska Costain Strabag) JV (1)	2
USA	California High-Speed Rail	Client: California High-Speed Rail Authority (4) Contractor: California Rail Builders (1) Designer: WSP (1) Supervisor: HNTB (1) Supplier: Gerdau Steel (1)	5
USA	SFO AirTrain Extension	Client: San Francisco International Airport (1) Contractor: Skanska US (2) Designer: WSP (2)	3

Development of case studies and analysis of data

Immediately after each interview, notes were summarised and organised according to the interview guidelines headings (Appendix I) in order to get an overview of the key findings in each area. The note summaries were sent back to the local WSP representatives to check that the Swedish interviewers had not missed important aspects or misinterpreted interview statements. The summaries were used to discuss key findings and preliminary interpretations within the research team.

The case studies were written based on the notes and the interview transcripts, largely following the headings in the interview guidelines. The case study texts were then sent to interviewees for approval and comments. In developing the cases, interview quotes have been included to illustrate key points. These have often been assigned to the organisation (client, consultant, contractor or supplier), but not always to a specific individual.

A preliminary analysis of data, found in the Discussion section of this report, was performed focusing on themes relating to the main research questions. The themes discussed are:

- Project ambitions in relation to global and national climate change policy
- Requirements: types, advantages and problems
- Implementation and learning aspects

2.3. Limitations

This study has several limitations. Regarding the ‘Carbon context’ sections, the political and institutional environments differ between countries in ways that may be hard to fully comprehend and interpret. We have tried to validate our descriptions but may have missed important background factors that were overlooked or taken for granted by the local informants. Pertaining to the project-based case studies, the studied projects are very large and complex, and this complexity is hard to address both in terms of empirical investigations and when synthesising findings into a report. Further, since we often interviewed several projects members at the same time, each perspective might not have received full attention. In some cases, interviewees cancelled their participation with short notice and were not possible to get hold of again. We may also have missed some critical views due to clients and contractors being interviewed at the same time. However, since the Impres research team includes members that are well aware of the complexity involved in implementing policy and carbon requirements as well as of typical problems arising in construction contract relationships, perspectives missing in some cases may still be discussed based on findings in other cases or the international research literature.

Being aware of these limitations, we avoid strong normative statements, as to which practice is the more successful, as well as very specific recommendations. Instead, we highlight similarities and differences between strategies and discuss the pre-requisites for success in implementing them. Further, since procurement requirements are developed and implemented in a changing context, we explicitly address how learning and development over time is enabled.

3. Overview of Sustainability Assessment Schemes

A sustainability assessment scheme (SAS) for infrastructure projects includes pre-defined sets of sustainability criteria which a user, often designers and contractors, uses for sustainability management and certification. The value of using an SAS is not only limited to sustainability criteria, but they also provide guidance for the process of data collection, analysis and comparisons etc. (Nguyen and Altan, 2011). They provide a systematic source of references for the civil engineering sector to apply the principles of sustainable development.

This section presents a comparison of sustainability assessment schemes for infrastructure projects and their ability to address carbon management, in order to better understand the applicability of an SAS as procurement requirements for reducing carbon in infrastructure projects. The selected topics for comparison are presented in the list below and complemented with sub categories seen in Table 2 in chapter 3.6.

- Carbon Management criteria
- Type of Life Cycle perspective
- Mandatory Carbon quantification
- Encouragement of Carbon reduction
- Monitoring
- Verification

The sustainability assessment schemes included for this study were: *Envision*, *CEEQUAL*, *BREEAM Infrastructure (Pilot)* and *IS Rating scheme*, based on relevance to carbon management in infrastructure projects. The carbon management standard *PAS 2080* is also included in the comparison to understand the difference of SAS's with general sustainability purpose and a standard with a carbon focus.

3.1. Envision

Envision is a sustainability assessment scheme developed by the *Zofnass Program for Sustainable Infrastructure* at *Harvard University* and the *Institute for Sustainable Infrastructure* (ISI, 2015). The main purpose of *Envision* is to improve the sustainability performance and resiliency of physical infrastructure.

Envision mainly concerns early project stages such as planning and design and comprises a framework of sustainability criteria and objectives. Moreover, a central point of the scheme is to look further than the specific project by considering the interests of affected communities.

Climate and Risk is one of five sustainability categories and is where carbon management criteria are presented. The other categories are: *Quality of life*, *Leadership*, *Resource Allocation* and *Natural World*. Worthy to note is that neither *Climate and Risk* nor any other category is mandatory to comply with for a final *Envision* certification. Sustainability criteria can also be omitted from the total scoring if considered to be inapplicable to the project.

Awards and recognition are available as options for the *Envision* practitioner and received after an official third-party verification. The awards are based on different achievement

levels, where the lowest level aims to slightly exceed regulatory requirements and the most ambitious level involves restorative measures.

3.2. BREEAM Infrastructure

Building Research Establishment's Environmental Assessment Method (BREEAM) is a UK-based sustainability assessment scheme for the built environment (BRE Global, 2015) where a specification for infrastructure is currently available as a pilot version.

Like the standard *BREEAM* assessment scheme, the primary aim of the BREEAM Infrastructure (Pilot) version is to mitigate environmental impact, taking a life cycle perspective, as well as improving social and economic impacts. This is achieved by integration and use of the scheme during early stages of design and construction.

The scheme will enable practitioners to measure, evaluate and reflect their performance against best practices. A final assessment is performed by BRE-licensed assessors who issue a certificate of compliance with the scheme criteria. To be eligible for a final certification, there are minimum requirements that must be fulfilled in certain sections. However, these sections do not include carbon management – allowing compliance with the scheme whilst not managing carbon.

However, criteria covering carbon management are found in several sections – mainly in *Carbon and Energy* and *Integrated Design*. The categories are: *Resilience, Stakeholders, Local Wellbeing, Transport, Land use and ecology, Landscape and heritage, Materials, Pollution, Waste and Water*. Achievable credits are divided into *strategy* and *project*, where an LCA would result in strategic credits and reporting construction results would award project credits. The life cycle perspective of the scheme is cradle to grave and includes an optional stage consisting of benefits and loads beyond the system boundary.

3.3. CEEQUAL

CEEQUAL (formerly *Civil Engineering Environmental Quality Assessment and Awards Scheme*) is a UK-based sustainability assessment scheme currently separated into two versions; one for *Projects* and one for *Term Contracts* (CEEQUAL Ltd, 2012). The *Projects* scheme has been selected for study in this report. Notably, *CEEQUAL* was bought by the BRE Group in 2015 and a new manual integrating CEEQUAL with BREEAM Infrastructure (Pilot) is under process (CEEQUAL, 2018).

Like many sustainability schemes, the criteria are formed to encourage higher performance than local regulation requires in environmental, economic and social aspects. As an incentive to reach high-level criteria, awards are made only after a third-party evaluation.

Climate change is mentioned in the CEEQUAL manual along with international aims of carbon reduction (CEEQUAL Ltd, 2013). The focus is to educate the practitioner in the topic and to encourage mitigation measures. Carbon emission reduction is further motivated by combining carbon management criteria with related topics, such as reduced energy use and cost savings.

Carbon reduction criteria are found in several sections throughout the scheme although mainly present in the *Physical resources* section. Other sections are: *Project Strategy, Project Management, People and Communities, Land use and Landscape, The Historic Environment, Ecology and Biodiversity, Water Environment* and *Transport*. Several of the

scheme criteria are classified as mandatory, meaning that they cannot be omitted from the total score – although compliance with the criteria is not demanded.

The life cycle perspective for a full life cycle assessment includes stages from material extraction to decommissioning of the physical infrastructure. If the practitioner instead chooses to exclusively assess carbon, instructions to apply a life cycle perspective are absent.

3.4. IS Rating Scheme

The *IS Rating Scheme* is an Australian sustainability assessment scheme for infrastructure developed by the *Infrastructure Sustainability Council of Australia* (ISCA, 2014). It not only provides criteria to be fulfilled but also provides guidance and tools for sustainable design, procurement, construction and operation.

Carbon criteria are found in the section *Using resources*, in subcategories *Energy and Carbon* and *Materials*. Other categories are *Management and Governance*, *Emissions, Pollution & Waste*, *Ecology*, *People and Place* and *Innovation*. The criteria found in *Materials* considers Carbon emission associated with material acquisition, product manufacturing, transportation, maintenance and replacement, while *Energy and Carbon* criteria concerns carbon related to the construction and operation activities.

To set a frame for the carbon management, the IS Rating Scheme uses the global framework Greenhouse Gas Protocol to set definitions for three different emission scopes. Scope 1 addresses carbon sources owned or controlled by the constructor or operator. Scope 2 addresses carbon related to the production of electricity used. Finally, Scope 3, addresses carbon released by sources not owned, nor controlled, although indirectly related to the infrastructure.

The *IS Rating* practitioner has some freedom to tailor both life cycle perspective and scope. Further, requirements for carbon reduction varies between sections. The *Materials* section only requires quantification of carbon as a minimum level for scoring, while the *Energy and Carbon* section requires baseline setting and implementation of reduction measures for scoring (Edge Environment, 2015). The scheme also provides a method for how to define a baseline.

3.5. PAS 2080

Presented as the world's first specification for carbon management in infrastructure, *PAS 2080* offers a systematic way to manage carbon throughout the whole life cycle of infrastructure projects (GCB, 2016). The standard consists of two parts, a manual with requirements and a complementary guidance for each required procedure.

PAS 2080 encourages communication and collaboration within the value chain and includes requirements to be achieved by each value chain member. The requirements are separated into different categories: *Requirements for all value chain members*, *asset owner/manager requirements*, *designer requirements*, *constructor requirements* and *product/material supplier requirements*. These categories represent requirements for carbon quantification, baseline setting, reduction targets, monitoring, reporting and continual improvement.

Producing an LCA for carbon is considered a prerequisite for successful carbon management, and *PAS 2080* covers all relevant life cycle stages (BSI, 2016).

3.6. Comparison of schemes

This section provides a comparison of the sustainability assessment schemes analysed in Table 2. A notable result is the lack of a specified carbon baseline in most schemes, making it uncertain for the practitioner how to calculate any carbon reductions. There is also a big variation of life cycle perspectives, where only *BREEAM* and *PAS 2080* require a cradle to grave assessment of carbon.

Reduction of carbon emission is encouraged by every SAS studied. However, in *Envision* and *CEEQUAL* this is only mentioned in higher achievement criteria. Further, the subject of reduction target setting and guidance for identifying reduction measures are absent in most schemes.

Monitoring of carbon emissions is not present as a requirement in *Envision* or *CEEQUAL*, with these schemes being more orientated towards the design phase of infrastructure projects. *BREEAM*, *PAS 2080* and *IS Rating Scheme* all reward carbon monitoring during construction and *PAS 2080* and *IS Rating Scheme* also reward monitoring during the operation phase.

PAS 2080, *BREEAM Infrastructure (Pilot)* and *IS Rating scheme* stand out in the comparison as the most suitable for carbon management. It is however important to remember that *PAS 2080* is a standard specified for carbon management and does not cover any other environmental impacts. This also explains the mandatory compliance of carbon management in *PAS 2080*, while being voluntary in other sustainability schemes.

Table 2. The topics of carbon (GHG) management are answered with yes (checkmark) or no (x) for each individual SAS (including PAS 2080).

GHG Management Topics	Envision	CEEQUAL	BREEAM Infra.	PAS 2080	IS Rating System
GHG management criteria	✓	✓	✓	✓	✓
<i>Dedicated section</i>	✓	✗	✓	✓	✓
<i>Mandatory compliance</i>	✗	✗	✗	✓	✗
Life cycle perspective	✓	✓	✓	✓	✓
<i>Cradle to grave</i>	✗	✗	✓	✓	✗
GHG quantification required according to minimum criteria	✓	✓	✓	✓	✓
<i>Carbon equivalents as required metric</i>	✓	✗	✓	✓	✓
<i>User vehicle emission accounted</i>	✓	✗	✓	✓	✓
<i>LCA as encouraged method</i>	✓	✓	✓	✓	✓
Reduction of GHG emission encouraged	✓	✓	✓	✓	✓
<i>Required according to minimum criteria</i>	✗	✗	✓	✓	✓
<i>Baseline specified</i>	✗	✗	✗	✓	✓
<i>Target setting encouraged</i>	✗	✗	✓	✓	✗
<i>Guidance to identify reduction measures</i>	✗	✗	✓	✓	✗
Monitoring construction GHG encouraged	✗	✗	✓	✓	✓
<i>Required according to minimum criteria</i>	✗	✗	✗	✓	✓
Verification process available	✓	✓	✓	✓	✓
<i>Verification required</i>	✗	✓	✓	✗	✓

4. Case study Australia

For the Australia case study, the projects Sydney Metro Northwest (SMNW) and Newcastle Light Rail (NLR) were interviewed. Results from the interviews and a study of the Australia carbon context is described in the following sections.

4.1. Australia Carbon Context

Government level

The Garnaut Climate Change Review (a.k.a. The Garnaut Review) was an independent report studying the impacts of climate change on the Australian economy. The report was commissioned by Australia's Commonwealth, State and Territory Governments in 2007, with the Final Report released on 30th September 2008. In November 2010 Ross Garnaut was commissioned once again by the Australian Government to provide an independent update to his 2008 review, this update being issued in May 2011 reiterating the findings from the initial review.

The initial Garnaut Review was released two years after The Stern Review in the UK and followed in its footsteps by analysing the economic effect of climate change in a national and international context and to what extent global mitigation “provides the greatest excess of gains (specifically economic) from reduced risks of climate change”.

The report submits that Australia is particularly vulnerable to climate change and champions a cap-and-trade emissions trading scheme as the preferred form of mitigation of climate change. It also indicated that the stabilisation of carbon intensity at 550 Parts Per Million (PPM) as feasible and 450 PPM as desirable.

Under the Paris Agreement, Australia has committed to reduce emissions by 26-28% on 2005 levels by 2030. This represents a 50-52% reduction in emissions per capita and a 64-66% reduction in the emissions intensity of the economy between 2005 and 2030 (Australian Government, 2015). Australia is currently on track to meet its commitment to reduce emissions by five per cent below 2000 levels by 2020, which is equivalent to 13% below 2005 levels.

A key instrument in Australia reducing its carbon emissions under the Paris Agreement is the Renewable Energy Target (RET). Under the RET, Australia is aiming to increase renewable energy to 33,000 gigawatt hours per year (GWh/year) by 2020. A Carbon Tax was introduced on 1st July 2012, requiring large business, defined as those emitting over 25,000 tonnes CO₂e/p.a. to purchase emission permits at a fixed price of \$23 per tonne. The Carbon Tax was then repealed in July 2014 by the Abbott Government becoming the first nation to reverse action on climate change. Since 2014, the Australian Government has failed to implement a price on carbon, with ongoing debate on various tools and mechanisms.

The state of New South Wales (NSW) is committed to matching the prior federal target of 20 per cent of energy sourced from renewables by 2020 (now altered to a fixed 33 000 GWh/year by 2020). The NSW Renewable Energy Action Plan annual report for 2016 shows that NSW drew 14% of its energy from renewable sources. Beyond 2020, the NSW government has launched an ambitious climate change policy that could see the state achieve zero emissions by 2050 along with \$500 million of funding towards energy and climate change initiatives in the Climate Fund Strategic Plan.

The Queensland Government has committed to investigating a renewable energy target for Queensland of 50% by 2030. To help deliver on this commitment, the Government has established the Renewable Energy Expert Panel to provide advice on credible pathways to achieving a 50% renewable energy target for Queensland by 2030. Currently, approximately 7% of the state's electricity comes from renewable sources.

The Australian Capital Territory (ACT) Government recently announced an increase in its renewable energy target from 90 to 100 % by the year 2020 (ACT Government, 2018) which will help reduce carbon emissions from electricity consumption during both construction and operation. Action Plan 2 (AP2) was released in October 2012 to provide a pathway for the ACT to achieve the Territory's legislated 2020 carbon reduction targets and envisaged a carbon neutral city by 2060. More recently, the ACT Government moved to amend this goal by bringing forward the date for carbon neutrality to 2050 (ACT Government, 2016).

Soft law initiatives and partnerships

Carbon management for infrastructure projects in Australia is primarily driven by the policies and guidelines from individual government agencies rather than by legislation. Many government agencies are requiring projects to undertake a sustainability rating, either an Infrastructure Sustainability (IS) Rating or Green Star Rating. See Table 3 below for policies in Australia.

Transport for New South Wales (TfNSW) state that they are committed to delivering a sustainable transport system for New South Wales⁵ and there are several layers of policies, frameworks and statements underpinning the objective of reducing carbon (TfNSW, 2013). They also identify a number of tools specific to project delivery to assist staff, contractors and industry partners to achieve TfNSW's sustainability policy objectives. One such tool is the IS Rating Scheme, run by Infrastructure Sustainability Council of Australia (ISCA), where TfNSW require IS rating for applicable projects with a CapEx > \$50 million, and for sensitive sites with a CapEx < \$50million. The government body NSW Department of Planning & Environment also require IS rating for infrastructure projects if it is a Critical State Significant Infrastructure (CSSI). Projects can be deemed as CSSI if they are major transport and services developments that have a wider significance and impact than just the local area, and is essential for the State for economic, environmental or social reasons. CSSI proposals are determined by the Minister for Planning.

Two other tools used by TfNSW are the Sustainable Design Guidelines (SDG) and the Carbon Estimate and Reporting Tool (CERT), both described more below.

⁵ <https://www.transport.nsw.gov.au/industry/doing-business-transport/sustainability-at-transport>

Table 3: Policies for sustainability ratings on infrastructure projects in Australia.

Government Agency	Requirement
NSW Department of Planning & Environment	IS Rating required on “critical State significant assets”
Transport for NSW	IS Rating required on all projects over \$50M. All other projects with a contract value >\$20M are required to undertake a Transport for NSW Sustainable Design Guideline v4 Rating (assessed by Transport for NSW)
Sydney Metro	All packages in program covered by IS Rating or Green Star Rating
QLD Department of Transport and Main Roads	IS Rating required on all projects over \$100M
Main Roads WA	IS Rating required on all projects over \$100M
Vic Roads	IS Rating required on all projects over \$100M
Level Crossing Removal Authority	All projects in program
Melbourne Metro	All packages in program covered by IS Rating or Green Star Rating

Tools and certification schemes

Transport Authorities Greenhouse Group (TAGG) – Carbon Gauge and Greenhouse Gas Assessment Workbook for Road Projects

Road traffic and transport authorities in Australian and the NZ Transport Agency have formed a Transport Authorities Greenhouse Group (TAGG) to share information regarding estimating, reporting and minimising carbon emissions. The TAGG recognises that there needs to be a common approach to estimating the carbon emissions from road projects and as a result, it has developed a Greenhouse Gas Assessment Workbook for Road Projects (TAGG, 2013) to provide road designers, builders, managers and operators a means of consistently estimating carbon emissions at the key stages of construction, operation and maintenance.

The TAGG has also developed the Carbon Gauge which is a spreadsheet-based tool to assist with the implementation of carbon calculation methods described in the workshop. Carbon Gauge provides a means of estimating the materially significant whole of life carbon emissions during the major road activities of construction, operation, and maintenance calculated over a 50-year life. The calculator does not estimate design phase carbon emissions for a road project. These emissions are not materially significant in the whole of life emissions for a road project, unless significant amounts of air travel are undertaken. However, it is recognised that the design phase of a road project is still important as the decisions made during this phase can have a large impact on emissions relative to construction, operation and maintenance.

The majority of road authorities in Australia require major projects to measure and report carbon emissions using the Carbon Gauge tool.

Transport for NSW Sustainable Design Guidelines and Carbon Estimate and Reporting Tool

The Transport for NSW Sustainable Design Guidelines have been continuously updated since their inception in 2009, and the latest (Version 4.0) was released in 2017 (TfNSW, 2017). These guidelines introduce a range of sustainability outcomes and initiatives to improve the sustainability performance of transport infrastructure. These include specific credits and requirements to address construction and operational phase carbon.

To measure and report reductions of carbon, Transport for NSW has developed the Carbon Estimate and Reporting Tool. All projects with a CAPEX > \$15M are required to use the tool and to demonstrate at least a 5% reduction in carbon, with additional points achieved for achieving higher reductions (there are five levels, to the highest being a >25% reduction). Projects are required to measure and report carbon at concept design and detailed design, as well as every 6 months during construction and at practical completion.

ISCA, IS Materials Calculator

The IS Materials Calculator is used to target credits for 'Material footprint measurement and reduction (Mat-1)' for projects undertaking an IS Rating. The aim of this credit is to reward design and practice that reduces lifecycle environmental impacts of materials. The IS Materials Calculator uses a multi-impact 'EcoPoint' indicator to award credits, however it also reports carbon emissions. Projects are awarded points on a sliding scale for reductions in 'EcoPoints' from 0 – 30%.

4.2. Sydney Metro Northwest

Sydney Metro is considered to be Australia's biggest public transport project. The new standalone railway will deliver 31 metro stations and more than 66 kilometers of new metro rail. Sydney Metro consists of three projects, in different phases:

- Northwest, operational around 2019
- City and Southwest, operational around 2024
- West, a new line out to Paramatta

Sydney Metro Northwest, formerly the North West Rail Link, is the first stage of Sydney Metro and will be the first fully-automated metro rail system in Australia. The Sydney Metro Northwest project consists of 16 construction sites and is delivering eight new railway stations and 4,000 commuter car parking spaces to Sydney's growing North West. Construction is ongoing at all sites and Northwest will be operational in 2019. Three major contracts were awarded in 2013 and 2014 to deliver and operate Sydney Metro Northwest.

Client: Since 2018 Sydney Metro Authority, previously Transport for New South Wales (TfNSW). At the time of the interview the client Sydney Metro was a part of Transport for New South Wales, but has since become an authority of its own responsible for delivering the different parts of Sydney Metro.

Tunnels and Stations Civil works: \$1.15 billion design & construct contract awarded to CPB John Holland Dragados (CPBJHD), formerly Thiess John Holland Dragados in 2013. This contract involves building the 15 km twin tunnels between Bella Vista and Epping, the longest railway tunnels to ever be built in Australia.

Surface and Viaduct Civil works: \$340 million contract awarded to the Impregilo-Salini joint venture in 2013. This contract involves building the 4 km elevated skytrain between Bella Vista and Rouse Hill, including a 270-metre cable-stayed bridge over Windsor Road at Rouse Hill.

Operations, Trains and Systems (OTS): \$3.7 billion operations contract awarded to Northwest Rapid Transit (joint venture with John Holland as biggest partner) in 2014. This contract involves delivering eight new railway stations, 4,000 commuter car parking spaces, Sydney's new metro trains and upgrading the railway between Chatswood and Epping. It is the largest Public Private Partnership ever awarded in NSW.

Interviews for the SMNW project were performed in November 2017 in Sydney with the Executive Director Safety, Sustainability and Environment, a Sustainability Manager and a Planning approvals representative from the client, Sydney Metro Authority (SMA). Interviews were also held with the Senior Sustainability Manager from the contractor Northwest Rapid Transit (NRT), the QEHS Manager from the concrete supplier Hanson Precast, the Customer and Market Relationship Manager from the steel supplier Liberty OneSteel and consultants from WSP working with design and sustainability in the project.

Policy background and client position

The Sustainability Strategy for SMNW was developed in 2012, outlining key strategic objectives for the project. SMA has an ambition to be world class which stems from the highest level and permeates the organisation for sustainability management. Sustainability has a seat in the executive team of the client organisation, and the Executive Director Safety Sustainability and Environment states that “We have a major sustainability story just in where we are and what the transport system is enabling, and that’s a narrative I want to build. [...] as an organisation I think the DNA, the natural sort of position is to be world class, not world class 10 years ago, world class today so that’s our mantra, we want to leave transformative legacies, we’ve got values up here that say we want to achieve things and fight with integrity. So as an organisation it’s very value based. I think some of those values are around being leading and innovative. So that’s from the executive, but it’s up to us as individuals whether we engage with that or not. Fortunately, I’ve been able to do that.”

The SMA is responsible for three major projects which are in different stages, and sustainability objectives and requirements have developed over time between the projects. Within the Sydney Metro line, however, the opportunities for further improvements in sustainability are small, since most aspects in the system are fixed. The client team is therefore looking forward to the new line to Paramatta as an opportunity to further revise their product.

The Construction Services division at TfNSW have developed their own Sustainable Design Guidelines (SDGs), which are now used for many projects, although not in the largest ones such as Sydney Metro. The first version of the guidelines was detailed and prescriptive, and there has been criticism from the design consultants that the SDGs limit creativity. According to the client, however, the benefits of describing the “how” outweigh that possible negative aspect. At that time, there was a need for the client design team to define what good, sustainable design is: “When the first version of SDGs was introduced they really got people to think about what they already should be doing”. Thus, the SDGs provided guidance to an industry that was at that stage relatively inexperienced. However,

the SDGs have become less prescriptive as a result of the feedback TfNSW got, and in the 4th version (introduced in 2017) there are several options for how to meet most requirements. The interviewees within SMA describe the development as a learning process: “the change reflects going away from just being a compliance task to getting people to really think about how to do things better”.

A competent and committed client organisation is seen as a key prerequisite in order to drive development. 50 employees are working with planning and environmental issues in the client organisation, and eight of these form the unit responsible for sustainability.

For each project, the SMA develops a high-level business requirement specification, where sustainability objectives are included. In the Sydney Metro Northwest Sustainability Strategy, the objectives for carbon and energy management are stated as:

- Improve the shift toward lower carbon transport.
- Reduce energy use and carbon emissions during construction.
- Reduce energy use and carbon emissions during operations.
- Support innovative and cost effective approaches to energy efficiency, low-carbon/renewable energy sources and energy procurement.

Initially, the client sustainability managers focused on measures to reduce carbon emissions related to building, operating and maintaining the asset. Here, procurement requirements for the delivery process, material selection and energy efficiency in operations were important.

However, an assessment of the carbon emissions over 100 years showed that the delivery of the project stood for only 10% of whole life carbon and the energy for operating the transport system for 90%, because the trains are powered by electricity from coal power plants. With reference to a New South Wales renewable energy plan, the project in 2011-2012 made a policy decision to offset emissions from train operation. For various reasons it was also decided that the responsibility for offsetting should remain with Sydney Metro. Since there was not sufficient supply of green power in the existing market for renewable energy in New South Wales, there was a need to promote investment in new renewable capacity. The process of finding an appropriate solution for this and gaining approval from various internal and external stakeholders has been long and tedious. According to the Executive Director Safety, Sustainability and Environment, the investment will be “profitable in the end”. By the time all projects are in operation, Sydney Metro will be the largest “off-taker” in Australia. Formally, the same offset obligation should apply to all transport projects in New South Wales, but for example Newcastle Light Rail (NLR), which is also part of TfNSW, has chosen another model, requiring the operations contractor to offset for renewable energy.

Procurement requirements

An overview of implemented requirements for carbon reduction is presented in Table 4.

Table 4: Procurement requirements related to mitigation of carbon in Sydney Metro Northwest.

Type of requirement	Requirement
Selection and award criteria (qualification and MEAT criteria)	Questions about carbon management capabilities included in Prequalification Questionnaire and weighted in tender evaluation
Technical specifications and specific requirements (functional, detailed, process, competence)	Specified requirements for replacement of cement depending on strength classes (MPa), 30% or more (referring to from Greenstar requirements of 30 % cement clinker replacement). Minimum 60 % of bar and mesh should be produced through energy reduction processes such as Polymer Injection Technology. Min 15 % of reinforcing steel from suppliers that use optimal off-site fabrication techniques such as engineered reinforcing bar carpet, engineered/customised mesh or prefabricated reinforcing cages.
Sustainability Assessment Schemes/Rating Schemes	Green Star rating for stations IS rating for infrastructure
Carbon reduction requirements	LCA requirement for 15-25 % reduction of whole of life embedded carbon for material, where a part is reduction from cement. The requirement levels depend on type of contract and potential for reductions. The LCA requirement is demonstrated by using Greenstar LCA-tool or ISCA materials calculator. 20 % carbon reduction from electricity use and major fuels, during construction, by offsetting.

Sustainability was included in the Prequalification Questionnaire (PQQ) and also in the tender evaluation for contracts. The basis for evaluation was tenderers' answers to questions about carbon footprinting: how they will manage it and how targets will be reached. However, since there are many aspects that are important in a large project, each aspect will carry a small weight. For example, if price is weighted as 75% and design and delivery as 12.5% each, and sustainability is included as one of several aspects in the design criterion this will imply a weighting for sustainability of around 1%. Thus, the client concludes that what is important is to have sustainability competence in the tender assessment teams to make sure that the contractors' sustainability people have the necessary skills and latitude: "what is really important to focus on in tender evaluation is not so much the scoring requirements but the quality of CVs and the level of resourcing that teams put into sustainability."

The SMA sustainability management team describes the formulation of the procurement requirements as a strictly hierarchical process, where the high-level business requirements are translated first into strategy, then to objectives, and finally to targets and contractual requirements. Contract requirements should thus be possible to "back-track" all the way up to the highest strategy level. Targets are mapped against the different contracts and based on an analysis of costs and benefits, which means that different requirements are included in each contract. This rigor is necessary since all requirements must be approved by the financial board. As the sustainability director says, "you can't just write a contract

requirement without having gone on that journey, because someone's going to say: 'has it been priced?'"

The main sustainability assessment frameworks used in Sydney Metro are Green Star and ISCA. Green Star is primarily used for buildings and ISCA for infrastructure. For stations there is a boundary conflict between underground stations and the commercial towers built on top. To avoid the interface and better communication with property developers and architects who are familiar with Green Star but not with ISCA, SMA are moving towards using Green Star for stations too. Thus, the Sydney Metro delivery strategy for future parts of the project is to capture value around stations through commercial, retail and residential development in packages with the stations. This underpins the strategy to use Green Star ratings for stations developments (more suitable for property), and ISCA for linear infrastructure.

In the Sydney Metro Northwest project, there were several overlapping requirements documents and sustainability assessment schemes used: the SDGs, Green Star and ISCA. This meant that there was much paperwork for the contractors to complete, who felt that they were spending time and money on activities that had no effect on sustainability. Based on these experiences, the client team have tried to reduce the number of requirements as far as possible in the forthcoming projects. Thus, the SDG framework is not used (except in a few specific cases) for this reason: "We saw that making SDG compliance a requirement didn't add any value since most of it was already documented by using ISCA. Three hundred out of 570 requirements could be removed in this way and get the same outcome." Some things from the SDG are instead included in requirements such as sustainability targets in the appendices to the project deed.

Incentives for doing better than a certain level in IS ratings have been tried in SMNW, but were considered problematic and not straightforward and will not be implemented in the City and Southwest contracts. According to the client, one of the problems was that since it was free to choose how to reach extra credits in the rating, there was much focus on easy measures, such as documentation of competence, instead of actions leading to actual improvements in sustainability. The next step will be to limit which credits will entitle compensation.

Pertaining specifically to carbon reduction, the SMNW project has both requirements in technical specifications, like 30% cement clinker replacement and offsetting of electricity used in construction, and performance requirements for total reduction compared to a baseline for embedded carbon in materials. Each contract develops their own baseline for carbon reductions, where the process is specified by ISCA and Green Star. The baseline definition is however still described by the client team as a complicated issue. One aspect is that projects move from a scoping phase to definition design and further to concept designs quickly, where the definition design stage is the last time the project is designed as a whole. After that point, concept designs are developed for each contract individually, and are never added up again. When each contract develops their own baseline, the client sees a risk that the baselines are "fattened" to make it easy to show reductions in the real design. But they also think that experience, increased client design competence and more rigor in what's an acceptable baseline probably will reduce those risks over time.

Requirements on 30% cement replacement have been challenging, but ultimately successful. The main issues have been related to aesthetic requirement for concrete colour defined by the architect. The project has also been successful in achieving sustainability requirements for steel.

There is a requirement to offset 20% of carbon emissions associated with construction energy. At first, the contractor planned to meet this by purchasing 'green power', but this turned out to be too expensive, so they decided to instead purchase carbon credits for an afforestation project.

In some cases, there had been opportunities to do more. As such, an innovative design to save large amounts of steel in cable trays was turned down since the client did not wish to review their standard specifications.

Organisation and processes for implementing and following up requirements

The Sydney Metro Northwest project comprises at the most 25,000 people, 15 JV partners and over 200 design packages, and the contractor representatives emphasise the challenge of implementing requirements in an organisation of this size and complexity. The sustainability manager of the contractor JV's design consultant began by identifying around 500 sustainability requirements in the project deed and lifted them out to the sustainability management plan, of which the carbon and energy management plan is a part. In this process he translated the requirements into a language more suited to the general disciplines of energy and structural engineering, so that the design staff would understand what to do to fulfill them. In order to prove final compliance and achieve the required sustainability rating, two people were responsible for tracking how the issues were being taken care of and to trace them back to the original requirements.

The selection of subcontractors is based 70% on price and 30% on non-financial criteria, which include sustainability performance. A questionnaire is used to assess that part, and to ensure that subcontractors actually perform according to what they have promised, the contractor performs random audits. There are also energy audits of the sites to identify hotspots and work with the site personnel to find opportunities for reducing energy use from, for example, site lighting and re-charging of power tools. The contractor's sustainability staff have tried to make subcontractors use hybrid construction vehicles, but these are often locked into contracts with equipment suppliers. Hybrid vehicles are used on many other sites, but to make contractors use them in this project there should have been specific requirements in the contracts. In general, the interviewees find that people on site are supportive of sustainability initiatives and want to do good, as are SMEs. For example, there is a green travel policy that has been successful. However, personnel may often need support and education.

Some requirements are forwarded directly to the supplier/sub-contractor. This is the case for materials, like the requirement for 30% cement clinker replacement. Project-level requirements, such as for overall reductions and ratings are, however, not forwarded. For example, the project is undertaking a carbon footprint to achieve IS rating, once in design and once for the finished facility. If reports are not submitted and the project does not achieve the required sustainability rating level it is the contractor who will incur financial penalties. According to the contractors' sustainability manager this means that it is sometimes difficult to get the necessary deliveries from the subcontractors, since there are

no clear incentives or penalties in their contracts. He thinks that it would have been easier to manage if there had been a clear line from requirements in the project deed to the requirements that are then forwarded to the suppliers. This accountability problem is related to the size and complexity of the project: there are multiple joint venture parties which may point at each other when overall targets are not met.

The client has an extensive organisation for general quality assurance. At the highest level, there is an audit that traces the contract requirements back to the business requirements defined for the project. The next level is a third party independent certifier (IC) to verify that the contractor's design fulfills the requirements in the contract. This is a government obligation for infrastructure projects to ensure that safety requirements are met. The IC is often an external engineering consultancy. In addition to this, there is the internal design review performed by the client. Thus, the contractor receives parallel comments from both the client and the IC. As for sustainability, contractors report monthly on the key targets, and data are collected in a central database. This works well for the larger contractors but has been difficult for the smaller ones. The contractor says that they probably should have had a person working for them on each site just to ensure that the required data is reported. Withholding payment would increase pressure, but the procurement unit is generally reluctant to do this for failures to deliver on sustainability: "I think a part of it is a cultural thing. And I don't think sustainability really is as understood in procurement as it needs to be. So, it's still seen as a nice to have. (...) they are sort of saying "ah, what's the hassle of holding up a payment versus getting the sustainability guy to come down and yell at me?" Well, they'll usually choose me yelling at them rather than holding up a payment."

However, follow up is very much based on face-to-face contacts, where the sustainability team and contractor project management meet every 14th day for discussion on process. There is much engagement with the contractor in almost all contracts, and it is seen as important that the client sustainability team has the design skills to "interrogate" how sustainability is implemented in the contractor's design package.

Mechanisms for learning and improvement

The SMA has previously engaged in spreading their knowledge by external presentations and are happy to share their contracts and other material that they develop. Their contracts are used by many other clients in Australia. There are also contacts and sharing on the international level, where a network is established with projects in the UK, Hong Kong and the US. Today, however, they are less proactive in sharing than they used to be, but are still open and always respond to requests for sharing. This is partly due to limited resources, but also because SMA tends to move ahead more quickly than others follow. Further, they have shared much material with ISCA but are disappointed that they have not got more back, such as evaluations and examples from other projects.

There are fewer relationships to universities, which are seen as difficult to organise. There is a lack of resources and differences in focus between academia and industry, but also timing issues: relationships take time to establish while projects quickly move forward. This is however something the client team wishes to develop in the future.

On the contractor side, there exist many sustainability networks to share experiences and opportunities to improve practices on projects. There is a requirement in ISCA to engage

in knowledge sharing and share both good and bad experiences and contribute with case studies. This is also seen as important by the contractors.

Perceived key success factors and barriers

The clients emphasise the importance of having the project directors and executive level on board. To gain their support it is important to demonstrate value, which is often reputational rather than strictly financial. So, if something costs more, there has to be another value to compensate.

For carbon reductions, costs may be a barrier when offsetting comes at a premium. However, the executives in Sydney Metro are still supportive: “Our executives seem to have it in their head that it’s a good thing to do. It would be very different if they weren’t on board. I don’t think there is any rule around what works and what doesn’t, it’s really about the people you are dealing with. Some people like the dollars and that is the only thing they look at. Some people look at their kids and say well can I look them in the eye if I don’t do this sort of stuff.”

The Executive Director Safety Sustainability and Environment also says that it is important to keep on communicating and explaining: “the main lesson I think I’ve learned is that nothing is a no-brainer. So it’s a no-brainer means that you just assume that people get it, you assume that people understand what you’re doing. I’ve just learned that that’s a very naïve position to take.”

The contractors stress the importance of having a high engagement from the organisation. Several people in the sustainability team have acted as champions in disseminating sustainability knowledge throughout the organisation, and this has resulted in a high penetration. Site managers are proactive in asking for what they can do and there has been more support than push-backs: “People want to be proud of the project”. High ambitions from the client is considered important, but broader engagement is also necessary.

A clear communication of the expectations is seen as another key success factor, so that subcontractors have a clear understanding of what is expected from them. This has not always worked in the project, which has been partly due to the overwhelming number of overlapping requirements. “In order to get the message out to 25,000 people, you should simplify it as much as possible and identify the key requirements that really drive development rather than include too many aspects that are perhaps less relevant.”

4.3. Newcastle Light Rail

The construction of the 2.7 km long Newcastle Light Rail is a key part of revitalising the city centre of Newcastle, which lies 160 km north of Sydney, and will provide a frequent and reliable travel option throughout the city centre. The government is investing more than \$650 million in the program to transform the city centre by strengthening connections between the city and waterfront, creating job opportunities, providing new housing and delivering attractive public spaces connected to better transport. The light rail will be constructed along the old rail corridor and thereby removes a barrier in the city. The Newcastle Light Rail project was approved in August 2016 and major construction started in September 2017. Newcastle Light Rail will be operational in 2019.

Client: Transport for New South Wales (TfNSW)

Designer: Aurecon and WSP (50/50 JV)

Contractor: Downer is the Managing Contractor for construction and operation. CAF is Spanish supplier providing rolling stock.

Interviews for the NLR project were performed in November 2017 in Sydney with the project Sustainability and Environmental Manager from the client, the Sustainability Manager from the contractor and the Lead Design Manager and other consultants from the designer working with sustainability and design in the project.

Policy background and client position

As described in section 4.1 above, both IS rating and the Sustainable Design Guidelines (SDGs) are tools available for TfNSW to implement their sustainability policy. The NLR design team describe a development where both ISCA and Green Star started out as voluntary ratings but have now become more or less standard and often mandated through conditions imposed on planning approval. This has led to overlaps between ISCA and the SDGs where both schemes have similar criteria for some areas. The client has recognised this and confirms that NLR is one of the last projects having to use both ISCA and SDG. Future projects will be required to use just one of the schemes. The client also mentioned that they plan to focus on certain areas/credits in ISCA and the SDGs in future projects and require the achievement of certain credits for these areas, like for energy and carbon emissions. When asked if requirements for a certain assessment scheme like ISCA can conflict with regulations for public procurement, the design team states that it has been tried and that it is not a problem since ISCA is an independent and “not for profit” organisation.

Procurement requirements

An overview of implemented requirements for carbon reduction is presented in Table 5.

The sustainability procurement requirements for NLR are designed entirely as requirements for the delivery of the contract; there were no requirements during tender evaluation. The client states that “Weighting is tricky and depends on project, and there’s not much time in the tendering process. It’s too early to ask questions about concrete, steel etc. and where they are going to get it from, in the RFT [request for tender]. You don’t have enough info then.”

There are no incentives for exceeding the rating requirements and no specific penalties for not reaching the required rating levels. But the design team reports that if they don’t reach the requirements they must justify this to TfNSW, and there will probably be penalties for contract breach somewhere for not meeting all the technical requirements of the client. There would also be unwanted reputational damage to the business.

Table 5: Procurement requirements related to mitigation of carbon in Newcastle Light Rail.

Type of requirement	Requirement
Selection and award criteria (qualification and MEAT criteria)	None
Technical specifications and specific requirements (functional, detailed, process, competence)	<p>Specified requirements for replacement of cement depending on strength classes (MPa), 30% or more (referring to from Greenstar requirements of 30 % cement clinker replacement).</p> <p>At least 25 per cent of site-based electricity energy needs has to be purchased from Green Power or renewable sources during construction of the asset – requirement from SDG 3.0</p> <p>Requirement of use of TfNSW's Carbon Emissions Reporting Tool (CERT) – requirement from SDG 3.0</p> <p>100 % green energy requirement for operation, by offsetting</p>
Sustainability Assessment Schemes/Rating Schemes	<p>ISCA Excellent rating</p> <p>SDG 3.0 (Transport for NSW Sustainable Design Guidelines v3.0) Gold rating (there are four levels, gold is second highest)</p>
Carbon reduction requirements	Requirement of reduction of carbon emissions, including development of baseline - a part of IS rating requirement

Regarding reductions of carbon emissions, there are no quantified baselines in the requirements. A reference base case is instead calculated in detailed design based on the bill of quantities and using the CERT tool. Reductions of carbon footprint are then calculated at the “as built” stage based on materials used, substitution of cement clinker, material transportation etc. The IS Material calculator is also used in parallel for the IS rating, and the ISCA design rating is submitted after the design phase. The design team mention that previous experiences from Sydney Metro show that it can be difficult to set a carbon baseline and reduction targets at early stages of the projects, as a lot happens in the projects over time and the levels can become irrelevant later on. The designer’s sustainability manager problematises further regarding the nature of baselines: “The challenge of emission balance and reductions are always about what is the original base case. I’m struggling with the fact that in theory all the smart ideas might be generated already in the beginning at a concept level, and then when you come to detailed design you might compare the outcome towards what would be the worst possible. It’s driving you to think – what would be the worst possible case? Baselineing is really a challenge to the rating schemes”. Nevertheless, it is important to try to include actions for carbon reductions from early design, states the client representative. He also adds that the use of SDG 3.0 is more of a reporting requirement rather than a reduction requirement, but that version 4 of the SDG will include more reduction criteria.

Other parts of the sustainability requirements for NLR that the design team highlights as valuable are requirements for use of whole of life cost analysis for key project decisions, and the innovation bonus included in SDG 3.0. The whole of life cost analysis is regarded as important because of the industry debate over high maintenance costs. The analysis also

provided figures for life cycle cost savings as arguments for the design team to suggest retention of a bridge instead of tearing it down and replacing it with a new bridge, thereby also saving carbon emissions. The innovation bonus in SDG is possible to achieve if a project already has met the compliance level and if the innovation can meet a number of defined criteria. The bonus is not monetary but makes it possible to get an additional 10 % towards the final rating score. The contractor on the other hand, sees limited incentives to exceed sustainability targets and implement innovations since there is no innovation bonus or other incentives for them.

The client, designer and contractor all confirm that the NLR project is meeting the sustainability requirements, and that there is evidence to prove this and to describe the actions taken. Some of the actions that the design team highlights for having contributed to lower carbon emissions are:

- Retaining a bridge instead of replacing it with a new bridge
- Volume reductions of various materials, for example in design of light rail track
- Substitution of cement clinker for fly ash in concrete
- Australia's first catenary-free Light Rail Vehicle operation, based on innovative supercapacitor technology, a solution that reduces material use and also benefits many other sustainability aspects.

Concrete with 30% fly ash was seen as a “premium” product in the beginning, and was therefore more expensive, the contractor says. But that is not the case anymore. It has become a standard product and the focus on carbon and cement substitution have increased in the industry, the designer adds. The client thinks that the requirements are driving better concrete products and that without the requirements, it may not have happened. However, an interviewed supplier of precast concrete for Sydney Metro say that even though they see Green Star requirements as driving cement substitution with fly ash, they would probably do it anyway, at the 30% level, because it is good business. But higher levels of cement substitution would force them to change processes, which they would not do without anyone paying for it.

The design team state that value engineering (optimising resource use for constructions) is their normal way of working and conclude that a lot of the specified actions for reducing carbon emissions would have happened anyway. But they also think that certain criteria in SDG and ISCA are driving, for example, to increase the use of recycled material as far as possible. Without that driver there could be more hesitation over using recycled material because of risks of contamination, and then it could be easier not to use it.

Organisation and processes for implementing and following up requirements

In the design phase of the NLR project, the lead project designer and the design sustainability team together decided what actions to take in order to reach gold level in SDG. One of the actions was that the sustainability manager of the design team arranged a series of sessions with targeted groups of designers to break the requirements down into details, and to check that they were doing what they should. “Some people need education, but mostly they just need us to sit down with them and tell them what needs to be done out of the SDG requirements”, the design sustainability manager describes.

For follow up of compliance in design, interdisciplinary coordination reviews were made at 30%, 70% and 100% of finalised design, when the team sits together for three days to go through everything. Coordinated with this, TfNSW requires periodic updates at key project milestones, 30% and 70% design, and does a full review at 100%. At those reviews, all documents go to TfNSW for verification where their sustainability group looks at it and judge whether the project fulfills the requirements.

The design representatives describe the client as being very hands on and wants to know a lot about the project, making the design JV “reporting maybe more often than we have to”. The collaboration between the client and the design JV is described as an active interaction with reporting along the way, and the design team stress that it is important with a dedicated client.

The design JV was novated, transferred, as partner to the contractor for the design-build contract by TfNSW to complete detailed design for the project. This gave the client TfNSW greater continuity and control over design outcomes. The design JV is AEO-certified (Authorised Engineering Organisation), which assures that the consultants have the skills and competencies to ensure delivery of railway projects.

The main contractor reports on sustainability (energy, water, waste etc.) to the client every six months, and the subcontractor reports back to main contractor on a monthly basis. However, the main contractor sees that sometimes it is a problem for the subcontractors to meet the necessary requirements or even to know what to do to meet them. There can, for example, be problems meeting the requirement for 30% cement clinker replacement because of interference with standards from RMS (Roads and Maritime Services). The contractor also sees a risk that environmental resources can't cover all the follow-up needed, and that they sometimes have no resources for pushing requirements to suppliers. There's a need for more resources. The suppliers sometimes don't appreciate being asked for sustainability performance, even though the general picture is that they are mostly OK with it.

Mechanisms for learning and improvement

The client describes the work with developing the sustainability requirements as a long and ongoing process. They are a team of 3 – 4 people that have been working with carbon footprints and the SDGs for nine years. What started as an optional requirement has shifted to compulsory and with tracking over time. They are also now considering whole of life emissions, including operational emissions, while previously focusing mostly on the project delivery phase. The same development is seen in Sydney Metro. Every new version of the SDG must be approved by the executive team. TfNSW is also trying to get the SDG to be used for road projects managed by RMS, although RMS has their own guideline, not yet compulsory, similar to version 1 of the SDG.

The design team sees the development over time as a constantly ongoing education, as people bring experiences from different projects with them to the next project. This creates an increasing, and more general awareness of sustainability aspects and solutions. They think that they are getting better at understanding what possible sustainability solutions the industry can provide since the suppliers tell them and want to sell it to them.

Over the years, the business has become very good at working with IS Rating Scheme in a consistent way, the contractor says. They are also suppliers of both asphalt and rolling stock and see increasing requirements for sustainability reporting for those products and have therefore begun to develop EPDs for them. Sustainability is something that is talked about all the time, the contractor sustainability manager says. Although he also thinks that they could develop even more regarding sustainability.

Perceived key success factors and barriers

Both client and designer see conservatism and lack of experience as important barriers to overcome to get low-carbon solutions into the projects. Lack of time, knowledge and resources and a perceived risk of increased costs are also contributing to this. The client and contractor also say that they don't see financial incentives (meaning both penalties and incentives) in place yet to support the development of low-carbon solutions.

The client believes that it is important to have an organisation in place that has the necessary knowledge and tools to achieve carbon reductions. This includes knowledge of contractual requirements and compliance. Carbon management is still seen as something extra and there is a challenge in "going from gold plating to business as usual". He also thinks that more focus is needed on the whole of life perspective and operational phase and how it is impacted by delivery. To achieve this, it is necessary to consider carbon at early stages in the planning and options selection of the project. The designers say that procurement models can be a challenge in this. If the contractor and operator are procured late and separately there might be no way to influence the operator contractually, so assumptions made in design might not be realised at the end of the day.

The designers say that the client needs to be clear on what they want, and it has to be measurable. They emphasise that you need prescriptive requirements and details if you want a given outcome. The successes in the NLR project is said to depend on the possibility to "play" with the design, testing a lot of options, and that they have had a good and active cooperation with the client. The parties involved have also reached a certain level of maturity, having done this before and therefore know what needs to be done.

All the interviewees mention engagement, the desire to do it, and collaboration as important success factors. This can be supported by highlighting that carbon reductions are often economically viable because of material savings etc. The contractor would also like to think that delivering projects in a low-carbon way would help win future work.

5. Case study, The Netherlands

The motorway project A6 Almere was interviewed as case study for the Netherlands. Results from the interviews and a study of the Netherlands carbon context is described in the following sections.

5.1. Carbon context, The Netherlands

Government level

The carbon reduction goals set by the Dutch government are in accordance with the Paris Agreement from 2015. There is a goal to be energy neutral – that is both fossil-fuel free and carbon neutral – by 2050. However, several initiatives to reduce carbon emissions date much earlier. First, the Dutch national government adopted sustainable procurement as a main goal and developed a Sustainable Procurement Programme in 2009, followed more recently by an Action Plan for Responsible and Sustainable Procurement by governments 2015-2020 (PIANOO, 2015). Another important factor was the Dutch national procurement law from 2012⁶, which required tenders to be evaluated according to Most Economically Advantageous Tender (MEAT). There are also government-led soft law initiatives where public authorities establish voluntary partnerships with stakeholders, as described in the following section.

Recently, however, Dutch government and non-governmental organisations in the built environment, transport, energy, agriculture and industry started negotiation on a Climate Agreement which will contain binding carbon reduction standards for these areas. The first draft of this agreement was available in July 2018, and the most important aspects will be included in a special Climate Act. The aim of the Climate Agreement and the Climate Act will be a reduction of 95% carbon emission by 2050, and 49% by 2030, compared to 1990. The act will contain a national reduction goal, a goal for renewable energy use and the obligation for the national government to make a climate plan to achieve these goals.

PIANOO, Professioneel en Innovatief Aanbesteden, Netwerk voor Overheidsopdrachtgevers, the Dutch Public Procurement Expertise Centre, was set up in 2005 to improve standards of procurement and tendering in all government departments. As of 1 January 2017, PIANOO is part of the Netherlands Enterprise Agency (RVO.nl), under the Ministry of Economic Affairs and Climate Policy.

Soft law initiatives and partnerships

The two major soft law initiatives are the Climate Coalition and the Green Deal GWW.

The Dutch Climate Coalition (Nederland's Klimaatcoalitie NKC) was launched in 2014 by the Ministry of Infrastructure together with various environmental organisations, with the aim of making the Netherlands climate-neutral by 2050.⁷ Besides infrastructure, the coalition also includes energy and food suppliers and has more than 700 participants. For infrastructure, members include government bodies as well as large private sector clients, contractors and service providers. The Climate Coalition claims to have established a 12% reduction of carbon emissions between 2014 and 2018.

⁶ Aanbestedingswet, amended in 2016. <https://www.pianoo.nl/en/public-procurement-law-netherlands>

⁷ <https://www.klimaatcoalitie.nl/>

The Green Deal GWW approach is a government initiative to promote sustainable growth and innovation in society in general. A Green Deal is an agreement between a coalition of companies, civil society organisations and local and regional government to collaborate and share knowledge to achieve certain sustainability goals. In 2013, the Green Deal GWW (Grond-, Weg- en Waterbouw) was established to secure sustainability in procurement of infrastructure projects for roads, rail and waterways. Parties involved are: the central government, Prorail, the Dutch provinces, the Association of Water Boards, municipalities, consultancy firms, construction companies, construction suppliers, and industrial- and stakeholder associations. In 2017 the successor Green Deal Duurzaam GWW 2.0 (Sustainable GWW) was signed by 60 stakeholders, including the group that participated in the 2013 Green Deal. This deal formulates new goals on carbon emissions and sustainability, e.g. 20% carbon reduction by 2020 (compared to 1990) and 50% less usage of primary resources by 2030 (compared to 2017). Green Deal Duurzaam GWW has been used in several pilot projects and ensures that sustainability is an integral part of the entire infrastructure construction process (planning, procurement, construction, usage and maintenance).⁸

Tools and certification schemes

To support the implementation of the Duurzaam GWW, a strategic program was developed by Rijkswaterstaat and the Dutch Public Procurement Expertise Centre PIANOo. This ‘Aanpak Duurzaam GWW’ consists of four instruments to address sustainability goals in the procurement process: Omgevingswijzer, Ambitieweb, CO2 Performance Ladder and DuboCalc. The Omgevingswijzer and the Ambitieweb are used to map sustainability ambitions within both users’ own organisations and infrastructure projects. The CO2 Performance Ladder and DuboCalc tool are then used to determine the ‘most economically advantageous tender’ (MEAT). The contracting authority assesses and monetises the proposed quality and selects the winner by comparing tender prices minus the monetised quality.

Omgevingswijzer and Ambitieweb

The Omgevingswijzer (Environmental Compass) is a tool to analyse several sustainability factors and compare possible solutions.⁹ It is mostly used in the preliminary stages of the project, when there is a specific location but several options to realise the project, to map and discuss opportunities to increase sustainability (including the potential for carbon reduction) with all parties involved. It has been used in many infrastructure projects and by a variety of contractors.

Ambitieweb (Ambition monitor) is a tool to describe the ambition level concerning sustainability. It consists of 12 sustainability aspects which can be translated into goals for projects. It is, among other things, used to describe the possible level of carbon reduction within the project’s scope and the way it should be implemented and monitored. In the Aanpak Duurzaam GWW Ambitieweb follows up on the results of the Omgevingswijzer. The outcome of the Ambitieweb process can be translated into goals for the MEAT award criteria within the procurement process.

⁸ www.duurzaamgww.nl

⁹ <https://www.omgevingswijzer.org/>

CO2 Performance Ladder

The CO2 Performance Ladder is a certification scheme that gives companies a competitive advantage in the tendering process based on their management efforts and systems to reduce carbon caused by the company's activities and processes. The first version of the CO2 Performance Ladder was developed in 2009 by ProRail, a state-owned company which is responsible for railway development and management. In 2011, the Foundation for Climate-Friendly Procurement and Business (SKAO) was established to manage the system. The ladder is based on the concept of Capability Maturity Models, CMM. There are five steps, where a higher level corresponds to a higher maturity and effort by the company put into carbon reduction. A CO₂ Awareness Certificate specifies what step in the ladder the organisation complies to. It is issued by accredited certification bodies, and certified organisations are audited each year.

The ladder contains 11 environmental effects including human toxicity, ozone layer and global warming. Each step has its own demands in terms of carbon reduction, both within the own organisation and within the supply chain. As described in the ladders' user manual:

- Levels 1, 2 and 3 concern carbon management and reduction targets within your own organisation
- Level 4 also focuses on carbon reduction within the supply chain as well as on innovation
- At Level 5, the company shows that it has achieved the ambitious targets which it set itself, including through cooperation within the sector and by independently adjusting procurement, products and/or processes inhouse.

In their submission, tenderers indicate what level of the CO2 Performance Ladder they will comply with. The certificate can be provided at the tender submission stage, at the earliest, and at the latest within one year of signing the contract. The commercial benefit is that holders of the certificate will have their tender price reduced by a value corresponding to their certificate level. A tenderer who is certified for a higher step thus has improved chances of winning a contract. Once the tender has been awarded, the level of ambition or step becomes part of the agreement. Whenever the tenderer doesn't realise the level of ambition in a certain period there is a penalty of 1.5 times the discount awarded.

Follow-up studies have shown that the CO2 Performance Ladder led to improved energy management and introduction of carbon reduction measures beyond business-as-usual among construction and civil engineering firms (Rietbergen et al. 2015; Rietbergen et al. 2017). It has increased awareness of the causes of carbon and measures to reduce them. However, up to now most measures implemented have primarily affected administrative support processes and not core business processes. Other findings were that the targets that were set by companies could not be considered ambitious, and that assessment criteria and principles were interpreted differently by different auditors. Thus, clients were recommended to introduce minimum requirements. It is also the case that most companies are now certified on level 5, which means that the system needs to be modified to encourage continuous improvement. There is however a requirement on level 5 to participate in industry development projects.

DuboCalc – the Sustainable Building Calculator

While the application of the CO2 Performance Ladder applies to companies and partly to their supply chains, DuboCalc focusses on the materials used in a project. DuboCalc is a software tool, based on life cycle analysis (according to ISO 14040 standard and Environmental Assessment Method Buildings and Construction) of all the materials and energy used over the lifetime of the constructed facility, from the sourcing of raw materials to demolition¹⁰. It also estimates the energy consumed by infrastructure works during the utilisation phase. The environmental effects are expressed in carbon equivalents and also in shadow prices, based on the costs of preventing emissions from arising. A lower value indicates lower environmental impact. A baseline is established by the client using the DuboCalc tool; emission factors are sourced from a global generic database maintained by an independent consultancy firm. Results are expressed in terms of a level of environmental shadow price, ECI/MKI (Environmental Cost Indicator/Milieukostenindicator). The ECI value is transformed into a monetary value according to a formula (the ECI value and monetary value are inversely related). The contracting authority sets a functional reduction span and the tenderer designs the infrastructure facility and calculates the price and the ECI for the project, which both are offered to the contracting authority. The contracting authority selects the tenderer with the lowest price and ECI value combined to undertake the work. If the tenderer later fails to reach the offered ECI level there is penalty of 1.5 times the discount awarded.

DuboCalc is most suitable for Design and Construct and DBMFO (Design, Build, Maintain, Finance, Operate) projects, for which the contractor develops the design, and which are awarded based on best price-quality ratio according to the competitive dialogue procedure. The first project using the DuboCalc method and the CO2 Performance Ladder together was in the RWS Design and Construct contract for N61 Hoek-Schoondijke, where production started in 2012. A simpler version of the DuboCalc model, DuboMat, has been developed by the Municipality of The Hague to be used on smaller projects¹¹.

Other certification schemes and developments

Alongside the first soft law initiatives and agreements, the development of sustainable standards in construction projects started in 2009 when the Dutch Green Building Council implemented BREEAM (Building Research Establishment's Environmental Assessment Method) in their national framework for infrastructure in 2009, the so called BREEAM-NL Infra. BREEAM-NL Infra is, however, not a certified instrument.

The introduction of these instruments and certificates, including the CO2 Performance Ladder, have caused big construction companies to warn that an extensive growth of certification requirements only increases the administrative burden without a substantial impact on the project's emissions.¹² However, the new version of the CO2 Performance Ladder addresses this criticism since the last steps of the ladder are more focussed on cooperation on carbon emission within the supply chain.

¹⁰ <https://www.dubocalc.nl/en/>

¹¹ <https://www.dubomat.com/>

¹² <https://www.cobouw.nl/bouwbreed/nieuws/2016/02/bouw-wil-minder-certificaten-en-meer-echte-duurzaamheid-101233633>

5.2. Motorway A6 Almere

The A6 Almere project is part of 5 billion Euro program for a motorway between Amsterdam and the city of Almere. The client is Rijkswaterstaat (RWS), the Dutch Road and Waterways Administration. The overall program is split into five projects and phases, of which the A6 Almere project is one.

The contract for the A6 project was signed in May 2016, between RWS and Parkway6, which is a joint venture between Duravermeer and Besix. The contractor's responsibility comprises Design, Build, Finance and Maintenance (DBFM) of the project, and the building phase is planned to be finished in 2019.

Case study interviews were performed in May 2018 in the Netherlands with the contractor Parkway6, and the Stakeholder/Environmental Manager and Technical Manager from Rijkswaterstaat (RWS), the Dutch Road and Waterways Administration.

Policy background and client position

The interviewees perceive 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. They consider sustainability and carbon neutrality to be important issues in The Netherlands. RWS has three main goals within sustainability: Climate and energy, Circularity and Durable and sustainable development. More specifically, RWS is required to be energy neutral by 2030. This goal was introduced in 2017. For Climate and energy, the goal is to achieve 20% reduction in carbon emissions by 2020 compared to 2009. This is to be achieved by the use of solar panels and wind power. For the upcoming project, the requirement is to generate more energy than will be used for operations.

When the A6 project was initiated, government policies for sustainability were not as developed as they are today. The pressure for sustainability then came from the municipality of Almere, which will host the Floriade World Expo in 2022, a large exhibition for agriculture and food, which is held every 10th year. The municipality extended the scope of the Floriade to encompass sustainable systems and food in the urban environment. In connection to these ambitions, RWS was challenged to make the A6 project as sustainable as possible. At that time, there was some resistance to increase sustainability ambitions.

The A6 client team includes a technical manager, a stakeholder/environmental manager and an advisor focused on sustainability and who links to other projects and to RWS centrally. This team writes the requirements in cooperation with the procurement unit. There is a push from RWS and the top project management to analyse how the project can go one step further from the standard requirements. This support from higher levels in the organisation is seen as important.

The tendering process for this type of contract in the Netherlands is based on the Competitive Dialog process, where the client engages in parallel planning and design development processes with several contractors. This is a two-stage process as outlined below:

- Phase 1 (3 months): In the first phase, European contractors may submit tenders, and tenderers are then reduced to three in a dialog process. Each tenderer presents

their team and a plan for the main project process which is evaluated by the client. In this stage, costs are not the focus. However, the client sets a maximum allowed price and the contractors must state that their tender will not exceed that level.

- Phase 2 (5-6 months): In the second phase, the three qualified contractors develop their plans and designs further, along with estimations of cost and time. There are also negotiations with lenders for financing. There are five formal meetings between the client team and each contractor, plus informal meetings. Final selection is based on a combination of quality, time and price.

A committee of 5-6 people on the client side manages the procurement, and the contractors are reimbursed for a part of their tendering costs (around 23-30%). The system is expensive since three parallel designs and financing solutions are developed and much client input is required. Therefore, there is currently a discussion in The Netherlands about whether the Competitive Dialog model is viable.

Procurement requirements

An overview of implemented requirements for carbon reduction is presented in Table 6.

Table 6: Procurement requirements related to mitigation of carbon in Motorway A6 Almere.

Type of requirement	Requirement
Selection and award criteria (qualification and MEAT criteria)	Maximum 5% fictive tender discount based on CO2 Performance Ladder rating Maximum 5% fictive tender discount based on calculated DuboCalc Environmental Cost Indicator performance for tender
Technical specifications and specific requirements (functional, detailed, process, competence)	"Energy Neutral" operation – PV panels have to be installed to compensate for operation energy need
Sustainability Assessment Schemes/Rating Schemes	None
Carbon reduction requirements	Included in DuboCalc requirement

The interviewees explain that there are three major tools and concepts that address the RWS Energy and climate goal and relate to procurement: the CO2 Performance Ladder, DuboCalc and Energy neutral. As described in the carbon context section above, the two former represent possibilities for contractors to get a reduction in the tender price. The CO2 Performance Ladder and DuboCalc have been applied by RWS for around five years. As for the CO2 Performance Ladder, certification on the highest level (level 5) entitles bidders to a maximum of 5% discount on the tender sum. For a joint venture, this requires that all partners are on the highest level. According to interviewees, the CO2 Performance Ladder has been important in raising the level of awareness in the industry. However, it is seen as a disadvantage that it no longer discriminates between tenders since all the large construction companies are now certified at the highest level.

The DuboCalc tender discount is determined for each project individually. The discount is based on how much the project can reduce its environmental impact in relation to a baseline, expressed in terms of a level of ECI (Environmental Cost Indicator). The baseline is set by the client before the Competitive Dialogue process based on a conceptual design, which is what the client's cost estimation is also based on. The RWS client team decide a level of reduction that they consider achievable but still challenging for this specific contract, and the maximum ECI reduction for achieving this level. In the A6 project, the ECI baseline was calculated as 12 million ECI-units and the maximum tender reduction was set at a level of 6 million ECI-units, which implies a 50% reduction in ECI. Tenderers could get a fictive discount of maximum 10 million Euro if they managed to achieve this level, which equalled approximately 5% of the tender sum.

According to the client, it is difficult to set the baseline and level for max reduction – it should not be too easy or too hard for the contractor to reach the maximum tender discount. The reduction target is related to the project conditions and to how conservative the baseline is. In the A6 project, the decision to aim for a 50% reduction was based on experience from previous contracts where 30% reduction was used as a target, a target which was later considered too easy for contractors to reach. In the A6 project, Parkway6 was the only contractor that proposed the maximum reduction for a ECI of 6 million, though a second contractor offered 7 million. Based on this result, the client team concluded that the requirement was set at the right level this time.

To reduce the ECI level, the contractor will look at how quantities of materials can be reduced, but also try to find alternative materials and synergies with other projects. In the A6 project, a thinner layer of asphalt accounted for a large part of the reduction. Lowering transportation distances for materials, transporting by boat and buying recycled materials were also important.

The requirements for Energy Neutral mean that contractors are obliged to compensate for the energy that is needed for the use phase of the infrastructure (primarily for lighting and signalling), by installing solar panels (PV). Due to this requirement, contractors have begun to install LED lights so that fewer solar panels are needed. LED lighting systems are more expensive and would not have been profitable for the contractor without the Energy Neutral-requirement. Thus, some goals that RWS have set up are for the benefit of society and add costs to the asset.

There has been a development over time in the style of requirements: “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 about. Now we are just thinking: well, when we want something, we have to ask them.” Thus, when RWS sees that a new technology has been developed, such as low-temperature asphalt, they may include a requirement to use the new product in subsequent projects. Another example is that RWS has started to require LED lightning. This also means that the client takes the risk involved in introducing new technology, which may sometimes be too high for one contractor company.

Organisation and processes for implementing and following up requirements

In the Dutch system, much of the verification that requirements have been met is performed by parties outside of the project. This is the case for the certification of the company for a

specific step in the CO2 Performance Ladder. The DuboCalc system is also maintained by consultancy companies on the industry level.

Much of the work undertaken by contractors to reduce carbon emissions is performed at the tendering stage, since this is when the contractor will benefit from any improvements made. If the contractor does not fulfil the level offered in the tender, a penalty of 1.5 times the value of the discount is applied. The verification is made in several steps. First, the contractors' DuboCalc calculations are verified by an independent certified institute before being included in the contract. A year after the contract is signed, a more developed estimation of the final ECI-result is required, which also is audited. If there are changes in the project scope that entitle the contractor to cost compensation, there will also be changes in the required ECI.

During the contract period, the contractor reports monthly on the ECIs. A new system for registering ECIs was been developed jointly by the client and the contractor for the A6 project. According to interviewees, this system might become standard for future projects but it is too early to know. For the maintenance phase, there are also annual follow-ups of energy consumption and of renewable energy generation.

Mechanisms for learning and improvement

RWS often acts as a pace-setter for new ways of working in the Dutch construction sector. Requirements and practices used by RWS are often copied by other clients on the regional and municipal levels. This has happened, for example, with the Energy Neutral requirements. Often it is former employees or consultants who have worked for RWS who bring the ideas to their new employers or customers. Other clients may contact RWS for advice on what requirements to use in their projects. RWS also host a knowledge-sharing website.

Whilst each project sets its own goals, project teams are pushed by RWS to go one step further than the previous project. The interviewees belong to a small group of key RWS employees with experience of raising project standards. They also have contacts with universities and other external parties to discuss ideas, and requirements are then formulated in close collaboration with the procurement unit. The client interviewees are currently searching for new goals to push for in the next project: "Every project takes a few years, so you can be better than the previous project. In our case for the A6 Lelystad there is a green light, people want us to be sustainable so that's important. Our own bosses need to back us, to be with us and they said 'well analyse, take a look what you can do better for the environment' Then we are just thinking, this is possible, that we have to analyse that, just explore, and then when it's possible to do, then we make requirements for that or we try trigger the contractors in some way."

The contractor companies also have their own development goals and internal projects, and many of them are related to sustainability in some way. The drivers are, however, often combined: "We have quite a lot of projects on, well, most of them are not really 100% on sustainability but normally it's combination of, say, creating a new market or creating higher profitability and sustainability." An important driver is to get an advantage in the tendering process, for example by optimisation of logistics, reuse of rainwater etc.

To achieve a level 5 rating in the CO2 Performance Ladder, there is a requirement that companies must engage in industry-level development activities. Some such activities are driven by the Netherlands Green Building Council, though “Bouwend Nederland” is another industry development initiative that has workgroups for sustainability.

Perceived key success factors and barriers

According to the client, it is important that they start to think about what requirements to set at an early stage, long before the tender is issued. For example, the Lelystad project which is now being planned for will be tendered in one and a half years.

The contractor emphasises that it is important to make sustainability and carbon reduction a joint effort based on shared goals. An important aspect is to avoid contractors focusing on the wrong things: the advantage of the DuboCalc system with the ECIs is that it provides hard numbers to steer on, but there is also a risk that there will be a lot of calculation efforts to lower the ECI factor but no actual measures to reduce carbon impact. “If you make it too smart you get sort of the calculation tricks, and if you don’t make it smart enough nothing is going to happen. (...) The smarter you make it, the more you get tricks I think.”

This is a balance since it is also considered vital to have incentives. Getting publicity for achieving sustainable goals can, however, also be important, since it will affect possibilities to attract the best students as employees: “So I think it’s both getting a monetary incentive for the contracting parties and (...) the recognition for achieving sustainable goals. Making it cool or good to achieve sustainable goals instead of just making money.”

The client perceives contracts to be the main barrier, especially in relation to innovation. Contracts must be strict to be calculable, but to encourage innovation the client must also give trust and space to the contractor, and that is hard to combine. However, RWS wants to have proven concepts, especially on main highways and waterways. As the contractor says: “I think that’s one of the main challenges: how are you going to get innovation if you want a proven concept and how will you get reliable results if you allow for innovation.”

It also takes time to update standards to incorporate new or sustainable technology. For example, it is currently not allowed to use a high proportion of reused concrete in road construction. For recycled materials, both environmental and technical parameters must be tested. Further, the interviewees say that it is often assumed that innovation should be driven in large projects, but these are often associated with high risks and substantial effect on society. It takes a long time to develop a new product and only quite small steps can be taken within a project. To reduce risks and speed up the innovation process by shorter test cycles, the interviewees suggest that RWS should work more systematically with smaller pilot projects. There is currently a pilot project to test recycled sand from asphalt, but it is too late to use that product in the A6 project.

6. Case study Sweden

The Swedish case study is based on an evaluation of the Swedish Transport Administration's (STA) carbon reduction requirements in the research project Control Station 2018. Results from interviews and analyses in the Control Station project and a study of the Sweden carbon context is described in the following sections.

6.1. Sweden Carbon Context

Government level

Sweden has a long tradition of ambitious environmental politics with the aim to be a forerunner to inspire other countries to follow. In 1991 Sweden was one of the first countries to introduce a carbon dioxide tax on fossil fuels and in 1999 the Swedish Parliament introduced 15 environmental quality objectives. One of those objectives was Reduced Climate Impact.

In 2014 a report from The Royal Swedish Academy of Engineering Sciences and The Swedish Construction Federation¹³ presented findings regarding climate impact from the construction process from a life cycle perspective, focussing specifically on material use (IVA 2014). The report concluded that the annual carbon from construction processes in Sweden, including buildings and transport infrastructure, is significant and of the same order of magnitude as car traffic carbon emissions.

The report recommended several measures for improvements:

- Open a dialogue between industry representatives, authorities and politicians to develop policies that will to reduce emissions from the construction sector.
- The government should give affected authorities, such as the STA, a mission to develop procurement models in cooperation with the industry to stimulate a reduction in climate impacts from investment projects.
- Government research councils, such as Formas and Vinnova, need to highlight climate impacts from the construction process when allocating resources.
- The construction industry and researchers need to develop standardised methods for calculating carbon emissions.
- Clients, contractors, project developers and others should analyse climate impacts from the construction process, to identify their own role and increase knowledge in the area.
- Municipalities should highlight the climate impacts of construction during planning and land allocation agreements, requiring carbon emission calculations to be performed in a standard way to help develop fair and common goals.

In preparation for the COP 21 conference in Paris 2015, the Swedish Government launched an initiative called Fossil Free Sweden (2018). This initiative gathered stakeholders from all sectors who wanted to strive for a carbon neutral nation. More than 350 companies, municipalities, regions and organisations are currently taking part in this initiative. A national coordinator has been installed to support stakeholders in their transition, and to work as a mediator between them and politicians.

¹³ The contractors' industry association Sveriges Byggindustrier, BI

In June 2017 the Swedish Government voted “yes” for a Climate Policy Framework in line with the Paris Agreement from COP 21 to come into effect from 2018. The framework consists of new climate goals, a Climate Act and the establishment of the Swedish Climate Policy Council – all based on an agreement within the parliamentary Environmental Objectives Council.

The Climate Act ensures that the government considers their climate goals in any new resolution. It requires the Swedish Government to present an implementation plan every fourth year to demonstrate how their climate goals will be reached, and to present a climate declaration in their budget every year. The first climate declaration was presented during the autumn of 2018, and the first implementation plan is scheduled to be presented during 2019. The Climate Policy Council assesses how the Government’s policies comply with the climate goals.

The new climate goal states that Sweden will have net zero emissions by 2045 (the previous goal was 2050) and strive for “negative net emissions” of carbon from 2045 onwards. Emissions are compared to a baseline year of 1990, with carbon cuts expected to account 85% of the overall reduction and with “compensation measures” accounting for 15% - equalling net zero emissions. The “compensation measures” could, for example, be CO₂ uptake through forestry or investments in renewable energy abroad. These measures are proposed to continue after 2045, contributing to the “negative net emissions” goal.

Further climate goals include decreasing carbon from national transport with by 70% percent at latest by 2030 (compared to 2010), excluding national flights as they these are regulated by the EU Emission Trading System (ETS). National emissions which are not regulated by the EU ETS shall at latest 2030 be at least 63 % lower by 2030 (against the corresponding emissions of 1990 baseline) and at latest 2040 be at least 75 % lower by 2040. To reach the goals of 2030 and 2040 no more than 8% and 2%, respectively, of reductions shall be reached by compensation measures.

Soft law initiatives and partnerships

With the new Climate Policy Framework and goal of carbon neutrality 2045, the Fossil Free Sweden initiative has encouraged industries to produce roadmaps for reaching this goal (Fossil Free Sweden, 2018). These roadmaps outline when and how each industry will reach the goal, and what technical developments and investments are needed, and what barriers exist. The roadmaps include proposals regarding commitments needed from industry stakeholders and government.

The industries currently committed to the Roadmap for fossil free competitiveness are: aviation, concrete, cement, steel, construction and civil engineering, food retail, haulage contractors, mining and mineral and the forestry sector. Several more roadmaps for other industries are under development. The Roadmap for construction and civil engineering aims to halve its emissions by 2030 and reach climate neutrality by 2045.

Skanska led the roadmap development for the construction and civil engineering sector, with the support of other major stakeholders in the industry. Today, The Swedish Construction Federation is responsible for the implementation of the roadmap. The goals for the industry are as follows:

- To between 2020-2025 having identified carbon sources and set goals for reduction
- To show strong trend towards carbon reduction by 2025
- To reach 50 % reduction of carbon emission by 2030, compared to 2015.
- To reach 75 % reduction of carbon emission by 2040, compared to 2015.
- To reach a net zero carbon emission 2045

The roadmap for construction and civil engineering encourages all stakeholders in the industry to cooperate to reach the climate goals. With today's technical solutions, the report suggests that there is the potential to cut carbon by 50% by 2030. However, to reach carbon neutrality there is a need for both innovation and political involvement in the form of creating new incentives and laws. The major source of carbon in the Swedish construction industry is the production of building materials such as cement and steel, while the climate impact from electricity and heating is nearing net zero due to the high share of fossil free electricity production and district heating. Creating circular material flows and developing new services and ways of working through digitalisation both have the potential to reduce carbon.

Prior to the sector wide work with roadmaps described above, the topic of reducing carbon in infrastructure construction had been acknowledged and driven by different actors. In 2011 a working group for Sustainable Production within the collaboration initiative FIA (Swedish acronym for "Renewal in the Civil Construction Sector") produced a guideline for how the sector should reduce carbon and improve other sustainability aspects. This was adopted by Swedish Green Building Council, SGBC, in 2013 as the start of a new division, Sustainable Infrastructure, with the purpose of promoting sustainability in infrastructure projects. SGBC has since then arranged several courses and conferences focusing on carbon management in infrastructure projects, the latest an international conference, CCC Summit, in 2018 co-arranged with the Construction Climate Challenge (CCC) initiative and hosted by Volvo Construction Equipment. The Swedish Transport Administration (STA) was the host for the FIA project and hosts the National Construction Forum in collaboration with the Swedish Construction Federation and the Swedish Federation of Consulting Engineers and Architects. The purpose of the Construction Forum is to provide a platform for dialogue across the sector on productivity, innovation, sustainability and other common issues. The Forum launched the project "Guidelines for Carbon Reductions in Planning and Design" in 2018 with the aim of providing industry with the knowledge to implement best practice measures for reduced carbon emissions.

Mistra Carbon Exit, launched in 2017, is a four-year research programme with the aim of identifying and analysing the technical, economic and political opportunities and challenges associated with Sweden reaching the target of net zero greenhouse gas emissions by 2045. The programme is based on four case studies, of which transport infrastructure and buildings is one. The project consortium includes a broad representation from industry, authorities and civil society.

The STA is responsible for planning, building and operation of state roads and railways and has been a key industry actor driving sustainability and carbon issues for a long time. Their guiding environmental policy (Trafikverket, 2010) sets out their aim to fulfil national goals and policies and presents the four-step method used to choose measures to meet transportation needs in a sustainable way. The method uses the following hierarchy:

1. influence transport need and choice of transport mean;
2. more efficient use of current system;
3. reconstruction of infrastructure; and
4. new construction of infrastructure

Since 2016, the STA has implemented procurement requirements for the mitigation of carbon in the construction, operation and maintenance of transport infrastructure, and for their own procurement of railway-specific material. The STA has also conducted several studies regarding climate change mitigation in rail and road projects, which have inspired the industry Roadmap regarding use of materials and requirement setting. The STA requirements and background are described further in the case study below.

Tools and certification schemes

Life Cycle Assessment (LCA, based on ISO 14040 standards) and certified Environmental Product Declarations (EPDs, based mainly on ISO 14025 and EN15804 standards) have been important tools for the Swedish construction sector's development of measures and strategies for reduction of carbon emissions. The Swedish Environmental Management Council¹⁴ developed the International EPD System¹⁵ in the mid-1990s and was a strong driver for increased use of LCA and EPD both in Sweden and internationally. Since 2014 the International EPD System has been managed by EPD International as a part of IVL Swedish Environmental Research Institute. The 200-km Bothnia Line railway project in northern Sweden published the first EPDs for infrastructure¹⁶ in 2010, both for the infrastructure as a whole but also for separate assets such as tunnels, bridges etc. Both EPDs and the underlying LCA became important areas for further development, in Sweden as well as internationally.

In 2013 the engineering consultancy company WSP was commissioned by the STA to develop the first version of the carbon calculation tool Klimatkalkyl, based to a large extent on the LCA and EPDs for the Bothnia Line. The initial purpose of this tool was to make it easier to produce carbon footprint calculations for infrastructure projects based on input from bills of quantities for cost calculations and generic carbon emission data for different infrastructure components. The tool was first used to produce a carbon footprint calculation for all larger road and railway projects in the National Transport Plan for 2014-2025. Klimatkalkyl has since been further developed and is now available in version 6.0 as a web-based tool open and free to use by anyone. Since 2015 consultants and contractors must use the tool for all projects with a budget of 5 million Euro or more. Before STA developed Klimatkalkyl, the contractors NCC and Skanska had developed their own tools for carbon footprint calculations with the goal of integrating them with cost calculations, and this experience provided important input to the Klimatkalkyl model.

In 2013 SGBC started several development projects to test the international version of CEEQUAL in Sweden together with industry actors. The first formal CEEQUAL rating in Sweden was awarded in 2016 and today more than 30 projects in Sweden have gone through CEEQUAL certification. Most of the certifications have so far been initiated by contractors and not by clients. It is the only sustainability assessment scheme used for

¹⁴ Miljöstylningsrådet

¹⁵ <https://www.environdec.com/>

¹⁶ <https://www.environdec.com/Detail/?Epd=6167>

infrastructure projects in Sweden and has primarily been used as a framework for sustainability in a broad sense, not specifically for carbon management.

SUNRA is a sustainability framework, not a third-party certification system, developed by ERA-NET ROAD, a collaboration between 15 national road administrators in Europe in 2013. A Swedish version, SUNRAse, has been developed by the STA in collaboration with VTI (Swedish National Road and Transport Research Institute) which reflects national goals and can be used on rail projects. SUNRA consists of 26 sustainability themes, of which carbon emissions is one. The aim of the framework is to help in defining, integrating and measuring sustainability in transport infrastructure projects, but it doesn't include any specific carbon calculation tools, methods or similar. SUNRA has been used to set carbon reduction targets for the East Link railway project and will be developed further by STA.

6.2. Swedish Transport Administration Carbon Requirements

The description of the Swedish Transport Administration's (STA) carbon requirements is based on results from the research project Control Station 2018, performed by WSP for the STA. The purpose of this project was to evaluate the effect of the carbon requirements on different actors in the supply chain and to recommend further development of the requirements (Nilsson et. al., 2019). Interviews were performed with STA representatives, contractors, consultants and material suppliers involved in infrastructure projects with carbon reduction requirements. In total 80 persons from 16 companies were interviewed.

The following project teams were interviewed:

Road 44

The STA is building a new 2+1 road between Lidköping and Källby, Southwest of Sweden. The construction phase of the project has been ongoing since October 2016 with Skanska as the Design & Build contractor. The interviewees from the STA include design engineers and the climate change mitigation coordinator, and from Skanska the interviewees were a project/design engineer and a sustainable business developer.

Ostlänken, The East Link

Ostlänken is a proposed high-speed railway between Stockholm, Göteborg and Malmö, expected to be ready for operation between the year of 2033 and 2035. The client of the proposed high-speed railway is the STA with Sweco as the contracted planning and early design consultant. Interviewees from the STA consist of a project manager, an environmental and climate specialist and the head of procurement for the project. From Sweco the interviewees were the geology and hydrology coordinator, the coordinator for geo mechanical engineering and infrastructure and the climate change mitigation coordinator.

Railway Söderhamn-Marmaverken

The STA is upgrading a railway between Söderhamn-Kilafors, where the first part between Marmaverken and Söderhamn is currently under construction. The purpose is to increase the capacity of this stretch by building additional tracks while maintaining the existing ones. STA has assigned NCC as Design & Build Contractor, working together with the designing consultant Tyréns. Interviewees from the STA include the project manager, an environmental specialist, head of procurement and project manager of

Control Station project. Interviewees from NCC include a project/design engineer, the EHS coordinator, and from Tyréns an environmental consultant.

Other interviews have been performed with representatives from the supply chain of typical STA infrastructure projects. These interviews have focused on general experience and views of the carbon requirements and the calculation tool Klimatkalkyl and not on specific projects. The interviews were performed in Sweden during spring 2018 for the following groups of supply chain representatives:

Client, the STA

Project managers, sourcing managers, procurement directors, head of sustainability etc.

Contractors

Project managers and engineers, sustainability and environmental experts and managers of sourcing from several construction companies. Focusing on experiences from working on projects with a total budget above 5 million Euros.

Consultants

Sustainability, environmental and climate experts, as well as design and planning engineers from several consultant companies.

Material suppliers

Suppliers of concrete and steel products and railway specific material, like sleepers.

Policy background and client position

The main driver for the STA to introduce carbon reduction requirements has been the national climate goal of net zero carbon by 2045 (previously by 2050). The STA is not formally required to introduce such requirements by the Swedish Government, however their view is that the requirements are needed to fulfil the Swedish Transport and Infrastructure Policy: *To ensure the provision of economically efficient, sustainable transport services for the general public and businesses throughout the country.*¹⁷ Based on that interpretation, the STA has set the goal that construction, operation and maintenance of national infrastructure shall be carbon neutral by 2045 and has designed procurement requirements accordingly.

In designing their model, the STA has been inspired by requirements on CO₂ emissions from light passenger and commercial vehicles by the EU Commission. There are several aspects that the STA has adopted from the EU example. Firstly, there is a long-term perspective, letting the industry know in advance the requirements that will be set in the future. Another aspect is to be technology neutral, by requiring a CO₂-emissions performance level instead of specific technical solutions. The intention is to stimulate that the most cost-efficient solutions are selected.

More inspirations from the EU include monitoring performance through climate declarations, where the car manufacturers present their average of CO₂-emissions for all vehicles sold annually. This incentive model has been adopted also for infrastructure construction project, by including a financial bonus for results surpassing required levels and punitive measures if requirements are not met. Undertaking an impact assessment to

¹⁷ <https://www.government.se/government-policy/transport-and-infrastructure/>

raise awareness and to identify priorities before introducing requirements is also inspired by the EU example.

Procurement requirements for reduced carbon emissions

An overview of STA's requirements for carbon reduction is presented in Table 7.

Table 7: Procurement requirements related to mitigation of carbon in Swedish Transport Administration's infrastructure projects.

Type of requirement	Requirement
Selection and award criteria (qualification and MEAT criteria)	None
Technical specifications and specific requirements (functional, detailed, process, competence)	<p>For localisation and planning/early design contracts, with project budget above 5 MEUR:</p> <ul style="list-style-type: none"> - Perform carbon calculation with Klimatkalkyl. - Describe implemented reduction measures and recommended reduction measures for next project phase in report <p>For projects below 5 MEUR:</p> <ul style="list-style-type: none"> - Maximum carbon emission levels specified for cement/concrete and reinforcement steel (different levels for projects opening 2020-2024 and 2025-2029) - EPDs required for material above and construction steel - at least 20 per cent of the energy used for construction equipment and vehicles must be based on renewable fuel or electricity from renewable energy sources <p>For procured railway specific material:</p> <ul style="list-style-type: none"> - Maximum carbon emissions specified per product (with timetable for raised requirement levels) - Emission levels must be verified by product specific EPDs by delivery
Sustainability Assessment Schemes/Rating Schemes	None
Carbon reduction requirements	<p>Design and build contracts above 5 MEUR with start of operation 2020-2024:</p> <ul style="list-style-type: none"> - 15 % carbon reduction compared to baseline. Verified by carbon declaration based on Klimatkalkyl by end of project, and EPDs required for cement/concrete, reinforcement steel, construction steel <p>Design and build contracts above 5 MEUR with start of operation 2025-2029:</p> <ul style="list-style-type: none"> - 30 % carbon reduction compared to baseline. Verified by carbon declaration based on Klimatkalkyl by end of project, and EPDs required for cement/concrete, reinforcement steel, construction steel

The STA launched its carbon reduction requirements for contracted suppliers in 2016. Infrastructure projects with a total budget over 50 million SEK (around 5 million Euro) and with a planned operation start of 2020 or later, have a carbon reduction target, which must be verified against a project baseline. The target covers the planning, design and construction stages, and includes setting a baseline through the tool Klimatkalkyl provided by the STA. For design-build contracts with an estimated operation start between 2020 and 2024 there is a target of 15% carbon reduction compared to the baseline. Projects estimated to be finalised 2025-2030 are required to achieve a 30% reduction compared to the baseline.

If the targets are exceeded, a bonus can be awarded based on a percentage of the contract value (normally maximum 1 per cent). Further requirements beyond 2030 are currently under development. Compliance with requirements must be demonstrated through a climate declaration for the finished project, developed with Klimatkalkyl.

The purpose of these requirements is described by STA as to provide a business model for the supply chain to incorporate carbon reductions in the delivery of the project. The requirement model is therefore designed with the purpose of achieving cost effective carbon reductions by allowing actors to freely choose the reduction measures with the lowest costs. Compensation measures and carbon offsetting are not accepted as reduction measures.

At the planning stage, requirements involve identifying carbon hot spots and to suggest and implement measures for mitigation by using the Klimatkalkyl tool. There are however no quantitative requirements for carbon reductions in this stage. In separated detailed design and construction only contracts, the required percentage of reduction is divided between contractors and consultants developing construction documents. In the case of a design and build contract, the specified reduction requirement becomes a contract requirement for the main contractor to fulfil with design and construction measures. The STA goal is to reach the reduction levels as an average for all projects and the requirements can be adjusted for individual projects depending on the type of project. Reduction requirements and bonus models are specified in each procurement contract.

For minor infrastructure projects with a budget of less than 5 MEUR there are requirements directed towards the carbon performance of certain materials and use of fuel. There are stipulated maximum carbon levels for reinforcement steel and concrete that must be verified by EPDs based on the European standard EN15804. For construction steel there's also a requirement for EPDs, but without any requirement for emission level. The requirement for fuels is that at least 20 per cent of the energy used for construction equipment and vehicles must be based on renewable fuel, or on electricity from renewable sources. Also, for the material and fuel requirements, higher performance requirements are defined after 2025.

For railway specific materials (e.g. sleepers and switches) procured directly by STA, the invitation to tender (ITT) specifies maximum carbon emissions per product that has to be verified by EPDs provided by the suppliers. There are also bonus mechanisms for exceeding the requirements and a timetable for raised requirement levels over time.

Carbon baselines are developed by consultants in the planning or design phase, depending on the type of contract. The calculation tool Klimatkalkyl must be used and calculations are based on the bill of quantities used for project cost estimates. The tool calculates carbon from assigned materials and construction activities with emission factors described as representative for "business as usual" technology in 2015. If detailed quantities are not known, for example in early planning stages, the tool also includes templates for different construction elements (e.g. a railway bridge, a road tunnel etc.) based on generalised values from previous projects.

In many interviews, the development of the carbon emissions baseline is described as problematic and that much time has been spent on revising and recalculating baselines

when they are later perceived to be inappropriate. Because of this, and because templates and emissions factors in Klimatkalkyl are sometimes regarded as incorrect or not relevant for the specific project, interviewees describe a risk of more effort being focused on performing calculations rather than finding and implementing reduction measures. One possible way to get more focus on the reduction measures, suggested in the interviews, is to test an alternative method for verifying carbon reductions, by ‘back-calculating’ the effect of reduction measures. This would mean that the initial analysis is used to identify carbon hot-spots from which carbon reduction strategies and measures can be developed and prioritised, without necessarily setting a strict “Baseline”. Focus would thereafter lie on implementing the measures and quantifying the effects of each of them, for example the effects of using low-carbon concrete. That would give a good understanding of the relative reduction potential of each measure and a clear goal to aim for, and at the end of the project, the resulting reductions can be quantified when the final scope and details of the project are known.

The interviewees present many examples of implemented measures to reduce carbon without increased cost. However, these measures are mostly related with optimisation of material use and optimised logistics for rock and soil handling, which are standard procedures performed in most of their projects. But there are also examples of procurement of materials (e.g. reinforcement steel) with less climate impact than the baseline alternative, verified with EPDs from the material supplier.

Although requirements have been implemented in both design and construction project phases, interviews show that the functional reduction requirements have not yet propagated through the supply chain to the material suppliers. Suppliers of, for example, cement, concrete and steel products say that they are ready and have developed EPDs for products they consider low-carbon alternatives, but that they so far have seen no demand in infrastructure projects.

Organisation and processes for implementing and following up requirements

For planning and design contracts, it is stipulated in the requirements that “The consultant must work actively and systematically to minimise emissions of climate gases from both traffic as from construction, operation and maintenance of infrastructure.” The consultants are also required to document how they have implemented measures in planning/design and suggestions for prioritised mitigation measures for the next project phase. Follow up of requirements both for planning/design and build contracts are coordinated with regular meetings, such as planning meetings.

However, the interviews have shown that all members of the supply chain say that there is a need for more guidance in how to work systematically with carbon management and to focus more on the reduction measures instead of calculation procedures. It was suggested that the requirements should be more specific regarding for example expected meetings, roles and processes for carbon management, to help consultants and contractors make realistic estimations of the resources needed to implement climate reduction requirements and price them more correctly in the tender. Most interviewees also mention a need for more knowledge and support of how reduction measures can be implemented and that it is important that the client, specially the project management, shows leadership regarding priority and implementation of reduction measures.

Although Klimatkalkyl is perceived as a good tool in general terms, it is apparent from the interviews that many users see potential for improvement – primarily related to the templates used for construction parts and components. One suggestion is that such templates should be reviewed regularly in close dialogue with the industry to ensure that they are perceived to be relevant and representative.

Mechanisms for learning and improvement

The interviews show that the STA's climate requirements play an important role by signalling to the industry that the climate change issue is important. Virtually all interviewees find it positive that the STA implement long-term requirements and believe that the direction is the right one. As the requirements are well known and communicated in the industry, they are perceived to contribute to creating long-term guidance for the industry. The requirements are also mentioned as contributing to knowledge sharing and development of a systematic approach to climate impact reduction.

The STA's intention is to regularly review how their requirements and incentive models are perceived by their suppliers, to inform improvements in future requirements. The research project Control Station 2018 is the first of such reviews. STA are also actively collaborating and following trends in other countries such as Norway and the Netherlands to find inspiration and learn from similar transport authorities. The STA is also developing and disseminating material for learning through their website, such as tutorials for Klimatkalkyl, Q&A etc., and it arranges and participates in sector conferences for sharing experiences and knowledge.

Most of the interviewees see their current project as an opportunity to learn and understand how to handle the STA's carbon requirements. Many interviewees point out that they will be able to implement more measures in a future project based on what they have learnt today. With this said, there are few examples of official mechanisms for joint learning regarding carbon reductions in the supply chain, both on the project and sector level. Experience is instead shared personally from one project to the other and through informal networks within the companies. The need for industry-wide guidelines and standards for how to achieve carbon reductions are highlighted in several interviews. Many interviewees also say that there is a need for more and stronger collaboration in the supply chain to reach more substantial carbon reductions. In some interviews it was recommended that new, innovative, methods should be tested in smaller projects instead of in very large projects, since the complexity of the large projects makes it hard to include and prioritise testing new methods.

Perceived key success factors and barriers

Throughout the supply chain, a major barrier to reduced carbon is the perception that existing technical requirements make it difficult to implement innovative solutions. These technical requirements are either set by the STA, or by national or European building codes. The use of concrete is a frequent example where conventional Portland cement types often are said to be prescribed by the client, while contractors and suppliers suggest types of concrete with cement clinker replacement (mainly fly-ash and GGBS) with lower carbon.

Also in cases where regulation does allow the use of relatively innovative measures, many interviewees have experienced fear and unwillingness to try new things – both from the

client side and other members of the supply chain. This is explained by the interviewees as no one being willing to take the risk, especially when being required to deliver transport infrastructure with a guaranteed operational life of 100 years or more.

Another barrier mentioned is the difference in dedication for climate change mitigation between different departments in the client organization, often resulting in contradictory goals and requirements. Engaged client management with clear objectives is considered to be an important success factor. This was expressed by a consultant in one of the interviews as: “Perhaps you duck from this question at times and go on with business as usual. I think it is a part for the client side too, to push for the necessary implementations to be performed, so you can’t duck from it.”

Many contractors perceive a lack of resources and time to perform carbon reducing measures other than what they usually have done in previous projects. There doesn’t seem to be enough time to think about new methods for climate change mitigation, as it is said to be one of many aspects to consider in their complex projects. Contractors who have suggested new types of material report being required by the STA to perform tests, which they don’t have time nor resources for. The lack of time and resources is stated as a major impediment to carbon reduction, and one contractor states that this ambition is the first to be discarded when projects are required to reduce costs. Limited knowledge about climate change mitigation is mentioned as an important barrier by non-environmental technical specialists. Checklists and tools are seen as success factors, especially to reach the more challenging reduction requirements. As a technical expert from one project explains: “It is important to have checklists and tools, because it is difficult for us to know what we can do more than optimising masses. What more could you think about? I would like a list. You could go through the list in a project meeting and say, ‘have you done this?’”.

Price and contract form are mentioned as further barriers and success factors respectively. Interviewees from contractors and project teams state that tender evaluations based on lowest price for planning and/or design contracts can result in poorly performed baseline calculations by consultants, giving the contractor a difficult task to prove carbon reductions. The contract form is portrayed as crucial for the quality of delivery. Consultants say that flexible budget contracts, instead of fixed price contracts, give them time and better possibilities to not only perform high-quality baseline calculations, but also to perform studies and develop recommendations for relevant carbon reduction measures to the client and contractor. Most contractors prefer being included early in a project and see construction-only contracts as limiting options for carbon reductions.

The possibility of offsetting costs related to carbon reduction measures by receiving a financial bonus is considered by many to be an important success factor. As said in one of the project interviews: “Are we as a company willing to pay more to our suppliers to decrease carbon? Yes, perhaps we are, if we also can get payed more. So a bonus system works well.” This statement comes after explaining that they do pay more for the benefit of sustainability, even without requirements or other incentives from the STA, but that there is a limit to their ability to pay more and that a financial bonus would help. However, many of the contractors consider today’s bonus levels to be too low to have any major impact on their ambitions or choice of measures to achieve carbon reductions. As a response, the STA-representative says that: “I have an idea for the requirements beyond 2030 to include a bonus system that reaches all the way to 100% reduction.”

7. Case study UK

For the UK case study, the railway project High Speed 2 and the water and wastewater company Anglian Water were interviewed. Results from the interviews and a study of the UK carbon context is described in the following sections.

7.1. UK Carbon Context

Government level

The Stern Review (The Economics of Climate Change), 2006, was an independent review commissioned by the Chancellor of the Exchequer, reporting to both the Chancellor and to the Prime Minister. Led by UK economist Nicholas Stern it:

1. examined the evidence on the economic impacts of climate change itself; and
2. explored the economics of stabilising carbon in the atmosphere.

The key message from the final report was that “The benefits of strong, early action on climate change outweigh the costs”. This Review, together with the IPPC’s Fourth Assessment Report (2007), paved the way for the UK Government’s Climate Change Act.

Following parliamentary debate, the Climate Change Bill passed into law in November 2008. The Act sets a duty on “...the Secretary of State to ensure that the net carbon account for the year 2050 is at least 80% lower than the 1990 baseline.” This was deemed to be “...consistent with limiting global temperature rise to as little as possible above 2°C” (Committee on Climate Change¹⁸). The first five carbon budgets (2008-2032) have already been set in law. The first carbon budget (2008-12) was met and the UK is currently on track to outperform the second (2013-17) and third (2018-22) carbon budgets, but is not on track to meet the fourth (2023-27). As of 2014, UK emissions were 35% below 1990 levels. Carbon emission projections are modelled by the Committee for several UK sectors (power, buildings etc.) but ‘construction’ or ‘civil Infrastructure’ is not isolated. Also, sectors do not have the same reduction target; for example, aviation emissions in 2050 are assumed to be the same as 2005 levels.

In response to upcoming infrastructure investments in the UK, several government initiatives have addressed development needs in this sector. The Infrastructure Cost Review in 2010 (HM Treasury, 2010) focused on opportunities for cost reductions, and the Infrastructure Clients Group (ICG) was established in connection to that review. Based on the Climate Change Act and the carbon budgets, the Government’s industrial strategy from 2013, Construction 2025, sets a target of a 50% reduction in carbon emissions in the built environment by 2025, from a 1990 baseline. The same year the Infrastructure Carbon Review was published (HM Treasury, 2013¹⁹). A key statement in this document, strongly based on experiences from Anglian Water, was that “reducing carbon reduces costs”, by saving materials, reducing energy demand and operational efficiencies. Another message was that pursuing a low carbon agenda stimulates innovation, making businesses more

¹⁸ <https://www.theccc.org.uk/tackling-climate-change/reducing-carbon-emissions/carbon-budgets-and-targets/>

¹⁹ Reference to Green Construction Board: states that the share of emissions associated with infrastructure will increase from 53% to 80% in 2025 and over 90% in 2050. Today capital carbon and operational carbon together accounts for 16 % of total emissions, but capital carbon will increase in importance, from 4% to 7 in 2025 and 18 in 2050.

competitive and improves their “export potential”. The need to establish “stretching” targets and baselines for carbon impact to measure against is emphasised. The Infrastructure Carbon Review recommends use of performance and outcome specifications before traditional specifications, and also states that traditional standards will need to be challenged. Decision-makers are explicitly urged not to wait for perfect tools and methods before taking action and high level sponsorship is considered a key enabler. The Review recommended ten cross-sector actions; Action 8 was “Low carbon PAS: BSI should consider the development of a publically available specification (PAS) on carbon reduction in infrastructure, based on emerging best practice...” (p.28). From this action flowed the development of PAS 2080:2016.

‘Construction 2025’ (2013) contains the strategic priority of ‘Low Carbon and sustainable construction’ with one of the two identified commitments falling to the Green Construction Board. The UK Government mandated the use of BIM Level 2²⁰ for all centrally procured public sector projects from 04 April 2016.

Soft law initiatives and partnerships

The Green Construction Board was established in October 2011 as a consultative forum for government and the UK design, construction, property and infrastructure industry. In 2013 it published a ‘Low Carbon Routemap for the Built Environment’ to indicate when Government policy and regulations would impact both Operational and Capital carbon. It co-commissioned and championed the Infrastructure Carbon Review (ICR), as well as annual reviews of progress by the ICR’s endorers against their various commitments.

PAS 2080:2016 was published in May 2016 by the British Standards Institution. This document is not a “standard” but a Publically Available Specification (PAS) which requires a less rigorous approval process prior to publication. The PAS addresses ‘Carbon Management in Infrastructure’ in the context of UK carbon emissions but could also be applied to non-UK projects. The PAS emphasises the need for value chain members to work collaboratively to reduce carbon, and it defines roles and actions for all value chain members regarding: Leadership and governance; the Carbon management process; Quantification of carbon; Target setting, baselines and monitoring; Reporting; Continual improvement. Claims of conformity may be made for a specific “asset or programme of work” by a specific organisation (or “claimant”). Such claims can be independently certified, third-party validated or self-validated; however, claimants would need to be compliant against each requirement. Several UK organisations (e.g. National Grid, HS2, TfL) have expressed a desire to become PAS 2080 “compliant”. In 2016, Anglian Water became the first organisation in the world to be verified against PAS 2080, for their investment programme²¹.

Prior to PAS 2080, many carbon practitioners referred to the BS EN 15978:2011 standard ‘Sustainability of construction works. Assessment of environmental performance of buildings. Calculation method’ (BS 15978). On the face of it, this standard does not appear

²⁰ Source: BIM Level 2 involves all parties using their own 3D CAD models, and exchanging data.

²¹ <http://www.anglianwater.co.uk/about-us/management-systems/> and <http://ourperformance.anglianwater.co.uk/outcome-smaller-footprint.html>

to be applicable to infrastructure as it “...specifies the calculation method, based on Life Cycle Assessment (LCA) and other quantified environmental information, to assess the environmental performance of a building...” (p.7). However, its definition of “buildings” includes civil engineering works. Therefore, it provided a more useful and appropriate lifecycle model for civil infrastructure than the existing PAS 2050:2008 (‘Specification for the assessment of the life cycle greenhouse gas emissions of goods and services’). Hence, BS 15978 began to be used to provide the lifecycle definitions of civil construction works, from materials through to end-of-life.

Tools and certification schemes

CEEQUAL, soon to be merged with ‘BREEAM Infrastructure (pilot)’, is an international evidence-based sustainability assessment, rating and awards scheme for civil engineering, infrastructure, landscaping and works in public spaces. Originally developed in the UK by ICE (Institute of Civil Engineers) and launched in 2003, assessments can award points to projects for a number of carbon initiatives, including Policies & Targets for resource efficiency, Life-Cycle Assessment, Implementing reductions identified in the LCA etc. According to CEEQUAL: “By the start of 2015, more than 260 Final Awards and almost 100 Interim Client and Design Awards have been achieved. More than 250 further projects and contracts are currently being assessed” (CEEQUAL, 2018).

Rail: The RSSB (Rail Safety and Standards Board) commissioned the development of the Rail Carbon Tool, which it launched in 2015. This tool is not mandatory within the rail industry but its use is encouraged and it has been used on several large UK rail projects. There are currently no guidelines for the expected scope of a rail carbon study and the tool itself is flexible, providing very little pre-defined structure. Carbon factors are currently based on the Bath University ICE (Inventory of Carbon and Energy) v2.0.

Highways: Highways England has developed a Carbon Tool (with carbon factors based on Bath University ICE v2.0) covering construction materials, transportation of materials to / waste away from site and the construction process. Replacement materials (during operation) are not immediately catered for but could be modelled. The tool is aimed primarily at “contractors” (i.e. construction companies) rather than designers.

Environment: The Environment Agency²² has recently developed a ‘Carbon Planning Tool’ which comprises a Carbon Modelling Tool and a Carbon Calculator. The use of this tool is mandatory on Agency projects.

Carbon Infrastructure Transformation Tool: “The open-source plug-in works with all industry standard project planning tools and enables project managers to make decisions about how to minimise the amount of carbon they generate” (Costain²³). The tool has been developed in partnership with the University of Edinburgh’s Business School and funding has come from the Construction Climate Challenge initiative hosted by Volvo Construction Equipment.

²² The EA is a Government agency responsible for flood and coastal risk management as well as business environmental permitting.

²³ <http://www.costain.com/news/news-releases/costain-reveals-revolutionary-tool-to-drive-down-carbon-in-construction-and-infrastructure/>

7.2. Anglian Water, Grafham WTW Resilience Scheme and Dalton Piercy Refurbishment

Anglian Water is the largest water and wastewater company in England and Wales (by geographic area). It serves about six million customers in the East of England and has about 4,200 employees. Within the Anglian Water @one Alliance the company collaborates closely with consultants and contractors to deliver more than half of Anglian Water's capital investment programme. The @one Alliance will design and build around 800 schemes worth approximately £1.2billion between April 2015 and March 2020, known as AMP (Asset Management Plan) 6 – the current five-year investment period. The alliance partners are Anglian Water Asset Delivery, Balfour Beatty, Barhale, MMB (Mott MacDonald Bentley), Sweco, Skanska and Stantec.

Interviews for the Anglian Water (AW) projects were performed in April 2018 in UK with a carbon specialist from AW, a representative from the contractor Mott MacDonald Bentley (MMB), the head of engineering from @One Alliance, a network representative also from the AW organisation and the AW Director of Asset Management.

Policy background and client position

Water is a privatised and regulated industry in the UK, and the performance of water companies is monitored by Ofwat (the Water Services Regulation Authority). The regulation is based on five-year Asset Management Plans (AMPs). That is, every five-year period delivery plans and associated costs, are submitted to Ofwat by water companies. The regulator compares water companies by efficiency in a league table based on a number of topics²⁴ and sets prices for services. The Anglian Water client team describe how important it is to reach a high position in the league table since they then get allowance for more spend to invest more, while a lower ranking will not give such possibilities. For more than ten years, carbon reduction has been a key objective in the business strategy of Anglian Water. Over this period, the company has climbed to a top position in the ranking. Ofwat has not included carbon targets for any of its previous AMPs but required companies to develop carbon baselines for AMP5 (2010 – 2015).

Anglian Water has developed an 'Anglian Water Carbon Story'²⁵ to describe and visualise their ambitions and progress with reducing carbon emissions related to a time line. The starting point in 2006 was an insight that climate change and population growth will be challenges to their business in the future. The company's responsibility covers a very large coastal area in east England, and about 30 per cent of their assets are below sea level and thus at risk from sea level rise. Demand for water will also increase because of population growth, and the area is already the driest in the whole of UK. Anglian Water concluded that climate change would require disruptive changes in their sector and decided to introduce carbon reduction targets.

The interviewees further describe how they realised that the way of working with the supply chain had to be radically changed to be able to work more efficiently to reduce both carbon and cost. This led to the launching of the @One Alliance in 2005. In 2007 a strategy for measurement and baselining of capital (embodied) and operational carbon was set for the

²⁴ <https://www.discoverwater.co.uk/environmental-performance>

²⁵ https://www.corporateleadersgroup.com/reports-evidence-and-insights/pdfs/aw-carbon-story/at_download/file

2010-2015 business plan. In 2009 Anglian Water set targets of a 50 per cent reduction in capital carbon, and a 10 per cent reduction in operational carbon, by 2015 from a 2010 baseline. Those targets were set within the Alliance, “back to back with the supply chain”, for a £2 billion investment programme during that period. The outcome of carbon reductions together with cost reductions were followed up for all individual schemes within that investment programme. The results showed that the strategy to reduce carbon also led to increased cost-efficiency in the majority of cases. Thus, Anglian Water coined the expression “reduce carbon, reduce cost”, which has since been adopted as a “mantra” by the infrastructure construction sector at large in the UK. In 2015, a follow up showed that Anglian Water had met the targets and reached 54 per cent reduction in capital carbon and exceeded 10 per cent reduction in operational carbon in real terms.

In consultation with a range of stakeholders, and as part of the 2015-2020 business plan, Anglian Water developed a list of ten outcomes that they committed to deliver to their customers and the environment. The outcomes are aligned with relevant UN Sustainable Development Goals and one of them is a smaller carbon footprint. Anglian Water intends to lead by example in reducing emissions and conserving natural resources. The carbon targets were further updated to deliver a 60 per cent reduction of capital carbon by 2020, and to exceed a 7 per cent reduction in operational carbon by 2020 (from a 2015 baseline). In 2017, the company introduced a new target of carbon neutrality by 2050.

Anglian Water sees their strategy of setting bold reduction targets as a way to introduce disruptive innovations in technology and working practices in their sector. The head of engineering says “50 per cent 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 provide that. Because there is no other way to do that, you will never reach anywhere near the 50% target otherwise.”

Anglian Water has been a very active part, through their Director of Asset Management (who left the position in 2018), in the UK Green Construction Board, sharing their experiences and success story and emphasising the “reduce carbon, reduce cost” message. This way, they have contributed to developing the awareness of and possibilities in carbon and cost reductions in the UK infrastructure sector, including through the HM Treasury Cost Review (2010), HM Treasury Carbon Review (2013) and PAS 2080 (GCB, 2016). Together with some 50 other organisations in the infrastructure sector they have endorsed the Infrastructure Carbon Review. In October 2016 Anglian Water became the first PAS2080 verified organisation globally.

Business Model

As described above, the @One Alliance delivers all major projects/schemes within the AMPs. Thus, the projects/schemes are not procured in a traditional way. The headline *Procurement requirements*, which is used for corresponding sections for the other case studies in this report, is therefore termed *Business Model* here. An overview of key business model components is presented in Table 8.

Table 8: Key components in the @One Alliance business model.

Business model component	Content
Alliance design and procurement of alliance partners	<p>Identification of key elements for alliance model based on analysis and benchmarking of supply-chain models from different sectors</p> <p>Selection process of alliance partners based on collaboration commitment</p> <p>5 + 5 + 5 year alliance contract with 7 partners</p> <p>Evaluation of partner's performance every five years with renewal or replacement</p>
Requirements/targets at the project/scheme level	<p>Common carbon reduction targets, for current AMP 60% reduction in capital carbon</p> <p>"Zero-fee" based model. Carbon and efficiency targets have to be exceeded to receive profit from gain share</p> <p>Baseline for targets set with AW standard calculation tool for cost and carbon</p>

The development of the Alliance model started in 2004 by analysing and benchmarking supply chain models from different sectors (retail, manufacturing, automotive etc.). Six key elements were identified as common denominators for these models: alignment, incentives, collaboration, integrated teams, visible programmes and minimising of waste. Anglian Water then conducted a selection process among relevant contractors and consultants with preferred bidder status. The process assigned much weight to their collaborative ethos. The Director of Asset Management described it as a tough process testing the limits of the commitment for collaboration. The key question asked was whether potential partners would stick to the agreement even if it would turn out to be hard to reach any profit to share even after several years. The Alliance was then formed as a virtual joint venture where each partner provides staff and contributes to the overall @One Alliance organisation in proportion to its individual share and receives a proportional share of the joint profits. Every five years, Anglian Water and the @One Alliance leadership team evaluate each partner's contribution. Based on this assessment, partners may be renewed, replaced or supplemented. The Alliance contract makes it possible for the partners to get an agreement for up to 15 years (5 + 5 + 5 years). The model is designed so that alliance partners can be rewarded for not building an asset, which is of high importance to reach targets – in fact it is the first carbon reduction strategy, as defined by PAS 2080:2016: 'Build nothing'.

A "zero fee" model is employed in the Alliance, i.e. when costs are incurred, only the basic staff costs, without overhead and profit, is paid to the parent companies. To receive any profit, the team must exceed the gainshare scheme efficiency targets, and delivering low carbon solutions is a key approach in delivering against efficiency targets due to the relationship with cost. The gainshare runs over the 5-year AMP period, but there is also a pot for each year that will be shared out to all construction members. The Head of Engineering describes the business model as "We are back-to-back with the client; if he feels pain we feel pain, we all feel pain and that again is the key essence of the Alliance. This is our commercial kind of model." He further continues: "So it's not as in traditional models where it really is of interest to partners to put bums on seats, so that you receive a fee for people being there; as such the more people you get the more fee you get. It really

is quite a simple economic principle. The alliance is not like that because we are actually operating a zero-fee model.” One of the contractor alliance members says that a strong driver for companies to accept this model is that they know that they can have a 15-year long relationship if they do well, and that this leads to a different mindset: “We are driven at a high level right to the grass roots to deliver low carbon, low cost solutions and it’s really what it’s about. It’s not building for building’s sake and not engineering for engineering sake but it’s delivering for the customer.”

An AMP period normally includes 850 to 900 schemes, ranging widely from small infrastructure jobs of maybe a few £100,000s up to those comprising £50-60 million. Carbon reduction targets are set across the programme and are outcome-based, i.e. performance is measured in relation to a baseline. The carbon baselines are set scheme by scheme. Anglian Water have developed their own Costing & Optimisation Tool which is used to develop baselines for both carbon and cost for each scheme. Baseline data are based on 2008 UKWIR (UK Water Industry Research) methodologies, University of Bath ICE (Inventory of Carbon and Energy) database, CESSM (Civil Engineering Standards Method Measurement) workbook, DEFRA (Department for Environmental Food & Rural Affairs) emission factors, together with Anglian Water’s own detailed inventory of “normal” specifications of all components and construction processes. The only time a carbon baseline is updated is if there are changes in scope, conditions, affordability or similar. This is seen as an essential feature in the model: “If we were to just continually update the carbon baseline every time we found a difficult or challenging scheme then all that would happen is that we would just be making numbers up. It would be a numbers exercise.”

The baseline and targets, but no details on what the solution should look like, are given to the delivery team who then design and build that asset and then move it into operations. According to the Anglian Water Carbon Specialist, this is when the collaboration starts: “What do the options look like? What does a really good low carbon, low cost solution look like, which meets the needs of our customers, which meets the outcome at lower cost, lower carbon, less power on site, all of the other different targets that we have?” There is currently a 60 per cent carbon reduction target and a 22.5 per cent efficiency (cost reduction) target, above which suppliers make a profit. The suppliers are currently reaching both carbon target and ~30 per cent in efficiency.

Organisation and processes for implementing and following up requirements

The @One Alliance is a fully integrated team without strict divisions into separate specialties (silos), like design, project management, construction, commissioning etc. The alliance members behave more like partners. Expertise from commissioning and construction is involved from the start of the design process to ensure experiences from previous projects is captured. Similarly, design experts can be involved in construction and commissioning, all with the purpose to break down silos, widen their knowledge and bring everyone together in collaborative groups and start listening to each other. One key factor to make the alliance work is stated to be the 15-year framework. Both client and contractor representatives say that it gives security, providing that you know what you are doing and that you are able to perform, and also an environment in which people feel that they can grow.

The Head of Engineering explains the difference to traditional relationships in the following way: “I’m going to say something now that people still find controversial, but in the open contracting world it’s a master slave relationship. It’s client and it’s contractor. You do as I tell you and you will do this and it becomes adversarial and it’s just about competition. You stop getting beaten by the stick or taking the stick off and beating them back. Our relationship is not like that. Our relationship is one of trust and all that, if you like. Brinkmanship is gone and that is absolutely done by leadership and it’s done by common goals. While you still have an adversarial contract you’ll never achieve any of this. Never, and I’m absolutely convinced on that basis.”

Digital 3D models and rehearsal rooms are also key components in the working model, both in supporting collaboration and to secure the function of novel design solutions. The purpose and function of the rehearsal rooms are compared to a theatre area: “We would never go and put a play on without actually doing a dress rehearsal, script rehearsal and actually running it through before the performance. If you imagine construction as the ultimate performance, you get everything together, you rehearse it and then you go to site and deliver it right first time”, the Head of Engineering says.

In general, by forming the @One Alliance and the integrated way of working in the supply chain, Anglian Water has taken a longer-term and more holistic approach to capital projects. Some of the key components in this approach are:

- A policy of standard products. The number of variants has been reduced and a catalogue of 141 standard products has been developed.
- Using digital technologies and fully integrated BIM models to virtually test and operate assets with the help of augmented reality before construction.
- Introducing a circular economy material passporting approach which includes considering leasing of assets (e.g. stainless-steel tanks) and returning products to manufacturer for recycling (e.g. nozzles).
- Using no-dig pipe techniques, such as directional drilling, where possible. 80% of pipe projects now use directional drilling.
- Considering no-build options primarily, i.e. challenging the need of the asset by investigating how the customer outcomes can be met without building a new asset.

The implementation of this model in two schemes is described below.

Grafham WTW Resilience Scheme

Grafham Wastewater Treatment Work (WTW) is located near Huntingdon and serves a population of 829,000 including Northampton, Huntingdon and Bedford. It is estimated that approximately 614,000 people would be affected by a major outage at Grafham WTW. As part of Anglian Water’s AMP5 Final Business Plan programme, the Grafham WTW Resilience scheme was identified as being needed to mitigate the effect of a major outage to the works. The scheme is being delivered through Anglian Water’s Special Projects framework within the @One Alliance. Mott MacDonald is the principal designer and JN Bentley is the principal contractor, with an approximate project value of £28 million.

The original planned solution for this scheme included building a new 37 km, metre-wide water pipeline at a baseline cost of £60 million and baseline carbon emissions of 44,000 tonnes CO₂. The Alliance delivery team instead developed an alternative solution of using

an existing 50-year-old bitumen-lined pipeline in combination with innovative flow reversal and a new service reservoir to add resilience. But this new solution contained significant risks since failure would impact some hundreds of thousands of customers. “So it was a lot of fear involved”, the Network Manager says. Two years of planning, detailed inventories of the system, digital 3D modelling, flow reversal trials and a formal “Risk & Value” process were needed to finalise the solution. In this way, the alternative solution required quite substantial up-front investments to test its robustness. However, in the end this solution resulted in a 57 per cent reduction in cost and a 62 per cent reduction in carbon, compared to the baseline. According to the Head of Engineering, this result would have been hard to reach if the scheme had been procured as a traditional design and build contract. According to interviewees, the original solution would probably have been more profitable for the contractors in a traditional procurement model.

Dalton Piercy refurbishment

A second project, Dalton Piercy refurbishment, is a major project to protect Hartlepool’s water supplies into the future. Hartlepool Water, owned by Anglian Water, is investing around £4 million to improve the water treatment works near Dalton Piercy. Work includes the installation of new pumping station, a reservoir by-pass and improvements to the instruments and electrical systems that are essential to delivering high quality water to the community. The scheme is a close collaboration between Anglian Water’s @One Alliance and Hartlepool Water’s operational staff.

A traditional design of the Dalton Piercy refurbishment scheme would have included pipes underground, cable ways, trenches etc., which would mean a construction process including “digging lots of holes, importing lots of stone, putting lots of assets under there which I won’t be able to find”, the Head of Engineering says. He describes the alternative solution, that was implemented, as a result of re-thinking where the basic idea was to put as much as possible of the assets above ground instead: “The key was on this model to just turn it upside down! The only thing that’s under that concrete slab now is drainage because unfortunately I’ve not beaten gravity yet”. From inception of the scheme, the design was developed utilising standardised products and proven designs from previous @One Alliance projects based around maximising the amount of off-site manufacturing. The design was undertaken within 3D modelling packages, creating individual models for different project elements. In the end, the new design reduced the time for construction on site by 67 per cent, the target being 50 per cent.

Mechanisms for learning and improvement

In general, Anglian Water express a high commitment to learning and improvement. The Alliance model was developed based on extensive research of relevant experiences in other sectors. Further, creative collaboration to challenge established practice is at the heart of the @One Alliance model, and this strategy has clear implications for learning and competence development. Breaking down silo thinking to allow collaboration across all project teams, departments and companies as a whole is important. Main suppliers are actively engaged in early pre-project phases to help explore options, and members of the alliance also get the opportunity to “walk a mile in somebody else’s shoes”, meaning that a process engineer that has designed a process can go to site to commission it, or a civil engineer that has designed a structure can have the opportunity to go out and help build it.

Such rotation is perceived to create a greater and deeper understanding that enables individuals to work in a wider range of positions and fields. As described above, the long-term collaboration also allows for structured continuous improvement and development of standard solutions.

Anglian Water further engage in the broader local community to share their experiences and knowledge. This is partly related to future recruitment needs, and they are engaged in local schools to sponsor education, career support and apprenticeships in the technical area. They also support a PhD student in the field of circular economy.

Anglian Water has also been very active in sharing their experiences and success story. This way, they have contributed to developing the awareness of and possibilities in carbon and cost reductions and have also gained a position as a role model for other clients regarding carbon reduction. Other water and wastewater companies in UK have been interested in the One Alliance model and are now also trying to adopt alliances models. When asked how they see possibilities for other parts of the infrastructure sector to implement a similar way of working as the @One Alliance, the Anglian Water representatives say that their business makes it possible to have a more holistic view of everything and allows them to plan and structure accordingly rather than just mobilise project by project. On the other hand, they don't perceive the differences to other parts of the sector to be that big: "There is nothing to stop it. It is all about the leadership. Leadership in the top saying this is what we demand from our supply chain and our employees and what we do. And we want collaboration, and these are the goals."

Also in an international context, Anglian Water is seen as a role model and innovation leader in both carbon reduction and collaborative contracting models. For example, a World Economic Forum case study article²⁶ describes the Anglian Water @One Alliance, where "Collaborate to the maximum and share best practices with your partners" is identified as one of the key lessons learned.

Perceived key success factors and barriers

The Head of Engineering says that when Anglian Water first started the carbon journey, a lot of people dismissed the idea that carbon reductions would also lead to reduced costs since the relationship was not proven. But by the end of the first AMP period with carbon targets, and when Anglian Water had mapped every single job against carbon and cost, there was overwhelming evidence that they were closely related. Being able to provide such quantitative data is therefore perceived to be an important key success factor.

Further, interviewees emphasise that carbon is "front and center" in their work, meaning that they look for carbon everywhere, not just in the big-ticket items but also in the small elements used over and over again. This implies that it is important to get the right people, and the supply chain is therefore selected largely on behavioural factors. They stress that in this type of relationship-based contracting, trust is a key factor and that the relationship is very different from a traditional contract.

The Alliance representatives perceive the greatest barriers to introducing a new way of working for carbon reduction as related to culture. It is seen as hard to overcome the

²⁶ Case Study prepared by the Boston Consulting Group as part of the Future of Construction Project at the World Economic Forum

traditional industry mindset when attempting to change processes and systems that have been running for maybe 50 years.

The alliance members repeatedly mention how important leadership is for success in achieving carbon reductions. They emphasise that it requires a drive from the top and that the Director of Asset Management has been that driver. He had a vision that he has shared and has worked hard to align everyone with, in order to get the Board, investors and everyone to understand the Alliance model. The interviewees however also say that leadership is not about just one person or the managers, but that all levels in the organisation have to be involved and committed. “So, what it takes is a lot of work, a lot of effort to actually imbed that culture and then not only imbed but actually develop it because cultures can grow, and cultures can die. It really is that simple and it takes a lot of work and to do that people have got to want to be here, have got to want to be part of it” the Carbon Specialist explains.

7.3. High Speed 2, HS2

High Speed 2 (HS2) is a planned high-speed railway in the United Kingdom, directly linking London, Birmingham, the East Midlands, Leeds and Manchester. The railway will have 530 km of track, and high-speed trains will travel up to 360 km/h. The two phases of the project are:

- Phase 1 – from London to Birmingham, with the first services scheduled for 2026.
- Phase 2 – from the West Midlands to Leeds and Manchester, scheduled for full completion by 2033.

Phase 2 is split into two sub-phases:

- Phase 2a – from the West Midlands to Crewe, with the first services scheduled for 2027.
- Phase 2b – from Crewe to Manchester, and from the West Midlands to Leeds, with the first services scheduled for 2033.

HS2 is being developed by High Speed Two (HS2) Ltd, a NDPB (Non-Departmental Public Body) established by the Department of Transport in 2009, with the project estimated to cost £56 billion. In July 2017, the Phase 1 route was approved by Parliament.

In July 2017 it was announced that four consortia (Joint Ventures, JVs) had been picked by HS2 to deliver the seven major Main Works Civils Contracts (MWCC) packages of Phase 1. The contractor interviewed in this case study is part of the SCS JV (Skanska Construction UK Ltd, Costain Ltd, STRABAG AG), which was awarded both southern packages: the Euston Tunnels and Approaches section (S1), worth £740m, and the Northolt Tunnels section (S2), valued at £1bn.

The other MWCC JVs are²⁷:

- Align JV (Bouygues Travaux Publics, VolkerFitzpatrick, Sir Robert McAlpine)
- EK JV (Eiffage Genie Civil SA, Kier Infrastructure and Overseas Ltd)

²⁷ <https://www.gov.uk/government/speeches/main-civil-engineering-works-contracts-for-stage-1-of-hs2-phase-one>

- BBV JV (Balfour Beatty Group Ltd, VINCI Construction Grands Projects, VINCI Construction UK Ltd, VINCI Construction Terrassement)

For the MWCC, HS2 uses the Early Contractor Involvement (ECI) model, where the contractor is procured at an early stage, primarily based on non-price qualification criteria. ECI involves a two-stage process: During Stage 1, the Outline Scheme Design is developed in parallel with a target cost. If the outcomes of this process meet HS2's requirements and budget restrictions, a design & build contract will be signed for the detailed design and construction of the project (Stage 2).

Interviews for the HS2 project were performed in November 2017 in UK with the Climate Change Specialist, the Phase 1 Carbon Manager, and the Sustainability Manager from HS2 Ltd. An interview was also performed in April 2018 in UK with the Carbon Specialist from one of the assigned contractors, SCS (Skanska Costain Strabag) Joint Venture.

Policy background and client position

The main guiding document for HS2 Ltd is the Development Agreement, which acts as the contract with the project's UK Government sponsor, the Secretary of State for Transport (2014). This agreement includes requirements in numerous areas, including minimising carbon emissions. HS2 is required to "...minimise the carbon footprint of the Project as far as practicable...", though no target is specified in the Agreement. However, there is also a requirement that HS2 "...will be an "exemplary" project that is built and operates sustainably...". The project has defined its level of ambition, which has been informed by the UK Government's Construction 2025 Strategy document (2013) and engagement with other infrastructure client organisations through the Infrastructure Clients Group, on which HS2 Ltd sits. HS2 decided to include carbon as a part of the Environmental Impact Assessment, and this included modal shift (mainly of freight from road to rail). Moreover, the HS2 project has committed to reducing their carbon impact by 50%. 'Construction 2025' includes a vision for 2025 of a "...50% reduction in greenhouse gas emissions in the built environment" (p. 5). HS2 Ltd has also signed up to the Infrastructure Carbon Review (HM Treasury 2013) which states that "...reducing carbon reduces costs..." (p.3). HS2 further aspires to pursue lean design for the project following the hierarchy outlined in PAS 2080: Build nothing – Build Less – Build clever – Build efficiently.

The highest-level carbon-related policy in HS2 is the Sustainability Policy, with five themes including 'environmental protection and management' (HS2 Ltd, 2017a). Beneath this Policy, there is an Environmental Policy which sets out HS2's environmental principles which align with requirements in the EIA (HS2 Ltd, 2017b). In this policy, one principle is to minimise the carbon footprint of HS2.

According to HS2's sustainability team, several drivers were important in shaping the agenda for carbon reduction: sponsor requirements, the consent process, the strategic case for HS2 (including its carbon mitigation case), and the aspiration to be an exemplar project. Air quality issues are also perceived to be another major driver in the UK. "So there's lots of expectations, lots of obligations, legal and contractual, that mean that we have to introduce all these requirements", says the HS2 Climate Change Specialist.

Procurement requirements

In the main work civil contract tendering documents for Phase One, the Reference Designs were defined broadly in terms of the land corridors required for the infrastructure assets to be built, including access roads, along with heights and environmental requirements for noise, vibration and impact on the landscape. In this early stage, contractors can save carbon through strategic decisions such as replacing a more carbon-intensive asset with a lower carbon alternative, e.g. embankment in lieu of bridge, provided that all other criteria are met. Sustainability was included in Prequalification Questionnaire (PQQ) and also in the tender evaluation. Table 9 outlines the main carbon related requirements that the MWCC candidates had to meet at Tender Stage.

Table 9: Procurement requirements related to mitigation of carbon in the MWCC and Enabling Works contracts for Phase 1 in HS2.

Type of requirement	Requirement
Selection and award criteria (qualification and MEAT criteria)	ISO 140001 compliance (pre-qualification requirement) Design challenge/design exemplar evaluated on bidder's carbon management capability (award criterion)
Technical specifications and specific requirements (functional, detailed, process, competence)	Carbon management plan PAS 2080 compliance within 12 months of contract award (Tier 1 contractors) Euro 6 vehicles (air quality)
Sustainability Assessment Schemes/Rating Schemes	BREEAM New Construction and BREEAM Infrastructure Excellent
Carbon reduction requirements	Reduction in carbon impact in relation to baseline. 50% reduction for main civil works, 30% for enabling works.

In tendering for Stage 1 of the Phase One main work civil contract, the bidders were required to respond to a design challenge focused on carbon reduction. A range of exemplar route sections were provided in the tendering documents: a viaduct, a headhouse, an embankment, etc. The bidding contractors were required to provide exemplar designs for these sections and submit a whole life assessment of the carbon impact for each, and also describe the processes they went through to develop the designs, for example different types of workshops. The client team then evaluated the competence, approach and methods of each bidder rather than absolute reductions they claimed could be achieved. “We wanted them really to focus on driving down the quantities of materials and being intelligent in their design rather than just being intelligent to their quantification.” The client team further describe the balancing problem in tender selection on qualitative criteria: “there are lots of things that are important to HS2, but the more important things that there are, the more questions we ask, and the more questions we ask, the less each question is worth. So you need to find the balance of having enough value to question, to make it worthwhile asking.”

The requirements that stem from the overall goal to reduce whole life carbon emissions are particularly challenging. The requirements vary between contracts reflecting the different timescales over which the contracts are being delivered (e.g. enabling works finish in 2020,

main work civils finish in 2026). The goal for the MWCC's is 50%, while for the enabling works it is 30%. For the MWCC's, this goal focuses on capital carbon since this is the area of biggest impact and potential for reduction. The Baseline to measure carbon reductions against is developed in Stage 1. Carbon reduction targets are applied at a contract level, rather than (e.g.) an asset level. HS2 requires an 'As-built' carbon footprint to be produced, which will form part of the final asset management register.

In Phase 1, there is also a need to fulfill requirements for level Excellent in BREEAM New Construction for stations and BREEAM Infrastructure (to be merged with CEEQUAL) for infrastructure. But this means that no significant additional effort is required to achieve the BREEAM credits relating to the carbon footprint, and HS2's aspirations regarding carbon reduction go beyond this. However, the client's view is that there is additional value in achieving the BREEAM Excellent rating from a wider sustainability perspective, considering the broader spectrum of sustainability areas aspects covered under BREEAM. Otherwise, the client representatives say, there might be questions about whether those wider sustainability benefits are actually delivered since they would not be independently verified: "It would be conspicuous by its absence." Furthermore, rating schemes such as BREEAM are recognised industry standards and the contractors are usually familiar with them which facilitates their implementation.

HS2 focuses strongly on performance requirements to drive innovation. There are few cases of specific input requirements. One is the requirement for Euro 6 vehicles, but this is driven by goals for air quality and not by the carbon goals.

Beyond the carbon reduction targets, there is no monetary incentive to specifically reward carbon performance, but this is seen as related to the gainshare/painshare arrangement: "...the mantra in the UK is that if you reduce carbon you reduce cost, so we're pushing the message that if you reduce your carbon footprint you will deliver these efficiencies, you will drive innovation. So you will come to a reduced target price. And it's a pain-gain relationship, so they can share in some of the cost saving at the end, if they deliver an acceptable cost." There is also a mechanism through which contractors may suggest and be compensated for solutions that deliver carbon benefits that would otherwise not be implemented because they cost more

Organisation and processes for implementing and following up requirements

It is specified in the contracts that there should be collaboration between the contractors. Since there was no common tool for producing carbon footprints developed in time for Phase 1, the four main civils contractors (MWCC) and HS2 jointly agreed how the baselines for carbon reduction would be produced, for example the level of detail, carbon factors, main assumptions for materials, and which stages of the assets' life-cycle to include in the carbon and environmental impact assessments. According to the contractor's carbon specialist, the overarching baseline carbon quantification work has benefitted by the cross-contract collaboration to ensure a good level of consistency among contracts and allow HS2 to synthesise these figures to develop the total carbon footprint of the project. The broader multilateral agreement was also important in increasing the robustness and credibility of the process. A central joint decision was that the projects should set realistic baselines, based on standard practices in the industry today and not on a worst-case scenario. HS2 defined a 'Baseline' as a "Hypothetical scenario for what impacts would

have been in the absence of measures aiming to reduce impacts.” To work against a realistic baseline was considered important to drive the right behavior and prevent the contractors from getting held up in over-engineering their carbon calculations and manipulating assumptions instead of pursuing actual mitigations. Establishing a robust carbon baseline and agreeing its principles between all contractors as well as HS2 was an extensive process that took a substantial amount of both time and effort to complete - Baselines for HS2 Phase 1 MWCCs were finalised in summer 2018. The SCS carbon specialist was responsible for planning, coordinating and following up this work across all contracts, which in itself is a challenging task in such a large organisation. During Stage 1 (ECI), the MWCC contractors were also working to fulfil the requirements for PAS 2080 certification.

SCS manpower in Stage 1 involves over 350 staff who need to contribute and collaborate in developing the best possible Scheme Design for S1 and S2. “It may sound straightforward to put together these sort of workshops and meetings, but in order to coordinate with 350 people and make sure anything will actually propagate it has to go through a lot of stages, a lot of people, and it needs a lot of chasing to get it through.”

Both client and contractor representatives emphasised that it was important to set the targets at a level that would drive the right behavior. The 50% target is perceived by all parties as very challenging. The contractor’s carbon specialist says that: “...if we are talking about a realistic baseline representing industry practice rather than a worst-case scenario, a 50% reduction against it is a major challenge.” She further added that the figure was “put there to make sure that everyone is pushed to their limits.” The contractors’ interpretation adopted the goal as their own and do all they could to minimise carbon “as far as practicable”. A carbon reduction opportunities register was set up at the beginning of the project to capture all relevant mitigation strategies. The material recorded there is also shared with HS2 via the client’s risk & opportunities management system. Regular internal workshops and meetings are held around these items to follow up on actions and ensure that the opportunities are pursued with the right stakeholders rather than just sitting in a document. These actions demonstrate to the client that the best efforts possible are being made to meet the requirements.

The carbon reduction target is part of the project’s technical specifications, and there is a formal Requirements Departures process to handle a situation where a contractor is not able to fulfill a specification. HS2 will then review the case before making a decision: “we have a process or procedure we follow, and that really is there for us to understand wider implications of accepting or not accepting that departure. And going into the kind of contractual or legal implications of such decisions.” HS2’s lead climate manager however also emphasises that the target is a joint goal: “...we are working collaboratively with our supply chain and will direct innovation capacity and capability via our Innovation Programme to help the supply chain overcome barriers to the realisation of the 50% carbon reduction target.”

Regarding technical assurance of requirements, the client team point to “three lines of defense”. The first line is the contractor’s self-assurance process; the second is the verification performed by HS2. The third line refers to auditing performed by independent parties. However, the client team emphasises the importance of the contractors’ self-assurance: “A lot of what the contractors do is self-assured, because otherwise HS2 would be a massive assurance organisation. The contracts have been awarded to these people

because they've demonstrated that they're very competent and capable organisations, that they have a good track record of delivering this type of infrastructure. And that they've got the necessary experience. Moreover, tier one contractors need to become PAS 2080 certified, which implies that they need to have a management process in place to set carbon targets and baselines, monitor and report, and drive continual improvement."

HS2's carbon manager further emphasises that to clarify uncertainties it is important to involve the contractor early and to be available for them to contact. There have also been several collaboration workshops, to go through the Project Requirements Specifications and make it clear to contractors what HS2 expects them to deliver and when, in line with the technical assurance plan. In this, the aim has been that the contractors should feel comfortable to raise concerns and challenge the requirements.

Carbon reduction is an important aspect in the procurement of subcontractors and suppliers, which means that there is close collaboration with the procurement team. SCS have developed a procurement and supply chain strategy where both information on carbon impact and innovative ideas for how to minimise carbon are requested in the prequalification and invitation to tender questionnaires: "we're not just asking them for data, we are also asking them to at least show some level of commitment towards cutting carbon within their organisation, within their part of the value chain." The HS2 team points to the importance of education programs in order to drive development in the supply chain. However, according to the carbon manager for the enabling works contract, low-carbon requirements are still being framed by the contractor's procurement function and to engage with materials/products suppliers and push for low-carbon options, asking for EPDs etc.

HS2 has a lead climate change specialist, a carbon manager and a sustainability manager to manage the carbon work. There is also a contract with an engineering delivery partner to support the client with resources for technical assurance, also in the carbon area.

On the contractor side, the SCS carbon specialist leads all work related to both carbon quantification and minimisation, including calculations, requests for information, and collaboration with the design and construction to develop and implement carbon reduction. During the early stages of design development, there has been a significant contribution by the designer's carbon lead who played a vital role in raising awareness and engaging on carbon issues with both the designers as well as the client since the very beginning to influence strategic decisions and underpinned the work later taken over by the SCS JV carbon specialist. The carbon specialist is supported by the overarching Environment & Sustainability Manager and the wider SCS Environment team.

Mechanisms for learning and improvement

A formal process for continual improvement is a requirement of PAS 2080 and also part of the BREEAM requirements. HS2's carbon manager encourages contractors to contribute: "I've challenged contractors to challenge me with feedback on requirements or better ways of doing things, or ways in which contractors can work together, collaborate and actually report in a consistent manner, which for us across the program is quite a challenge."

Workshops and open fora are organised to provide collaboration and innovation opportunities, and to encourage contractors to review and question requirements. In case an HS2 technical standard is deemed to be a barrier to innovation, for example regarding

cement replacement, there is space to challenge this. HS2 Ltd sponsored the development of PAS 8820 ‘Alkali-activated cementitious material and concrete’.

Another mechanism for learning and improvement is HS2’s Environmental Opportunities Realisation Process for carbon, materials and waste. Contractors and other parties identify opportunities, which are then logged in HS2’s Risk & Opportunities Management system. Opportunities are identified, prioritised, investigated and, where appropriate, implemented or forwarded to an overall HS2 innovation team that manage the Innovation Programme, where there is a process to support further development and implementation of such ideas.

The HS2 project has a very active innovation and collaboration programme. The project is also an active member of the Green Construction Board, spreading information on the innovation programme, HS2 Supplier Guide, etc. HS2 Ltd has its own Innovation Hub website where regular “challenges” are posted and contributors collaborate to develop solutions; it also has a contractors’ innovation bank, to which ideas can be submitted and then reviewed by an innovation panel. Promising ideas may receive funding or academic support to implement or to develop further.

HS2 Ltd has also helped establish the National College for High Speed Rail, opened in 2017. The college offers apprenticeships, full-time courses (leading to a Higher Education Certificate or Diploma) and shorter CPD (Continuous Professional Development) modules.

HS2 will have a formal learning legacy to communicate learnings and drive improvement. To date, activities relevant to carbon reduction are:

- Presentations at industry events (e.g. Institute of Civil Engineers Global Engineering Congress)²⁸
- Engagement with relevant industry initiatives (e.g. Construction Climate Challenge)²⁹
- HS2’s environmental statement is published publicly as are the associated methodologies³⁰
- Papers published in relevant industry literature³¹
- Part sponsorship of development of PAS 2080 and other standards/specifications (e.g. PAS 8820³²)
- Shared learning with the rail industry through membership with the RSSB
- Work with the Supply Chain Sustainability School to:
 - Develop and promote new e-learning resources (in conjunction with the Green Construction Board)³³
 - Promote uptake of low carbon concrete - event hosted in partnership with Heathrow and National Grid (Supply Chain School, 2018)

²⁸ <https://www.ice.org.uk/knowledge-and-resources/global-engineering-congress-2018/gec-2018-climate-wednesday-am-mark-fenton>

²⁹ <https://constructionclimatechallenge.com/2017/02/09/hs2-supply-chain-vital-for-delivering-low-carbon-and-social-benefits/>

³⁰ <https://www.gov.uk/government/collections/hs2-phase-2a-environmental-statement>

³¹ <https://www.icevirtuallibrary.com/doi/abs/10.1680/jensu.17.00070>

³² <https://shop.bsigroup.com/ProductDetail?pid=000000000030318035>

³³ https://www.supplychainschool.co.uk/documents/elearning/213/story_html5.html?lms=1

Key success factors and barriers

One key success factor highlighted by the client team was collaboration between the contractors. For example, excavation masses in one area can be used as back-fill in another, subject to technical requirements, and construction compounds used by Enabling Works Contractors can be re-used by Main Civils Works contractors. Such collaboration between the contractors is expected, but is also a contractual requirement. The most important measure for reducing carbon impact is seen to be to “use less”, that is to re-use materials, lean design, reduce transportation volumes and distances.

For the client, it has been a challenge to understand how best to translate the overall carbon reduction targets into requirements in the different contract types. Both client and contractor representatives state that an important obstacle is that many people in the industry still think “increased cost” when they hear about carbon reduction and do not see it as an opportunity for efficiency and innovation. HS2’s lead climate manager says: “I think generally there’s an assumption that despite the Infrastructure Carbon Review and PAS 2080 talking about reduced carbon, reduced cost (..) in a lot of instances where you say okay, we want to reduce our carbon footprint, people just think cost, straight away. And they don’t see it as an opportunity for efficiency, for innovation. They see it as, well, that means we’re going to have to put solar panels on the roof, and they cost loads, which they don’t anymore, really. But people just see cost when they think of carbon reduction, rather than ... well, actually, that it means that we’re making everything more efficient.”

The contractor representative mentions a tendency in the industry to assume that higher standards are always related to higher costs, and further that cost estimators price non-standard items higher: “when it comes down to something that’s a little different than standard practice estimators would price up the risk sometimes disproportionately higher. Anything that is more to the unknown side of things tends to get a cost premium that is not necessarily realistic.” An example is cement replacement: “However, when it comes down to projects of this scale that can potentially have a significant impact on the overall stock availability of certain materials, one needs to be particularly cautious when gauging the market and attempting to assess cost implications.”

According to the contractor representative, carbon improvements can often lead to cost savings, especially in infrastructure, but there may still be drawbacks in coupling carbon reduction and cost reduction so closely together: “My own personal view is that this is great to push towards carbon reduction via the ‘less carbon equals less cost’ argument wherever applicable, but this is not the answer to everything. This is very much valid particularly at early design stages where strategic decisions are made, however it may not hold true when it comes down to individual material specification. Therefore, the relationship between carbon and cost savings should be handled with care as not to revert back to a position where anything that will not save cost is instantly discounted even if it saves a lot of carbon. (...)”

8. Case study California, USA

For the California case study, the railway project California High-Speed Rail (CHSR) and the project San Francisco International Airport AirTrain Extension (SFOATE) were interviewed. Results from the interviews and a study of the California carbon context is described in the following sections.

8.1. California Carbon Context

Government level

The U.S. commitment to reducing carbon is currently at a crossroads. While the country is still officially a part of the Paris Agreement until November 4th of 2019, the current federal administration has communicated an intention to withdraw their commitment set under former leadership³⁴. A long-term strategy of carbon emission reduction has previously been developed and communicated by the U.S. in 2016. This strategy included a reduction target of 80 % below the baseline year 2005 to be reached in 2050. However, it is unclear if the target is still in effect.

Even though the U.S. government plans to leave the Paris Agreement, strong commitments from various states, cities and organisations are emerging. In the state of California, the target adopted by law is to reduce carbon emissions to 40% below 1990 levels by 2030³⁵.

The California Global Warming Solutions Act of 2006 (AB 32) requires the California Air Resources Board to set the 1990 level of carbon as the statewide carbon level to be achieved by 2020³⁶. To achieve this goal statewide plans and regulations have been implemented to meet or exceed the goal.

During the fall of 2017, the state of California ratified the Buy Clean California Act (AB 262)³⁷. AB 262 affects public authorities involved in procurement of infrastructure projects, requiring them to (e.g.) request Environmental Product Declarations (EPDs) from contractors and suppliers. The requirement covers specific construction materials: structural steel, carbon steel rebar (reinforcing steel bar), flat glass and mineral wool board insulation. The EPDs shall be of current facility-specific type (Type III, as described in ISO 14025 or a similar robust LCA method). AB 262 also includes a requirement for emission level caps, although in effect by 2019. By January 1, 2019, the department shall establish, and publish in the State Contracting Manual, a maximum acceptable global warming potential for each category of eligible materials. Furthermore, it is also required of a public client to reduce their emissions over time, by reviewing the allowable carbon cap for each material every three years.

The Californian cap and trade program is seen as key to reaching the climate action goals set out by the state (California Climate Investments, 2017). This is done by regulating amounts of allowable carbon emission from major sources, by issuing emission permits. These permits are limited, although tradable, where the funds raised by sales are deposited

³⁴ <http://climateactiontracker.org/countries/usa.html>

³⁵ <https://www.climatechange.ca.gov/>

³⁶ [http://library.amlegal.com/nxt/gateway.dll/California/environment/chapter9greenhousegasemissionstargetsand?f=templates\\$fn=default.htm\\$3.0\\$vid=amlegal:sanfrancisco_ca\\$sanc=JD_Chapter9](http://library.amlegal.com/nxt/gateway.dll/California/environment/chapter9greenhousegasemissionstargetsand?f=templates$fn=default.htm$3.0$vid=amlegal:sanfrancisco_ca$sanc=JD_Chapter9).

³⁷ https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201720180AB262

into a common pot, later distributed to fund, for example, carbon reduction projects and programs. 60 per cent of the available funds are to be distributed to transportation and sustainable community programs.

Soft law initiatives and partnerships

The American Public Transportation Association (APTA) encourages transit authorities to measure their carbon footprints and follow sustainability practices as set out in ISO 14001 (Federal Transit Administration, 2009). The sustainable practices encouraged by APTA are based on an agency's overall performance rather than on a project-level, and a commitment to the sustainability practices requires reducing energy use and overall environmental impact. The impacts are normalised by ridership, making it possible to compare public transportation projects.

Tools and certification schemes

The city of Los Angeles has since 2016 adopted the ISI's Envision Sustainability Assessment Scheme as a policy³⁸ and eligible projects will thereby be certified. Los Angeles County Metropolitan Transportation Authority and the County of Los Angeles Department of Public Works have also recently adopted ISI Envision. The Department of Public Works has 100 of its personnel registered as ISI Envision Sustainability Professionals (ENV SP), the first government agency in the United States to do so.

8.2. California High-speed Rail

California High-Speed Rail, CHSR, aims to connect the Californian state from North to South, improving mobility and driving economic growth (CHSR Authority, 2016a). Full operation is expected by 2029, when a journey from San Francisco to Los Angeles is estimated to take under three hours (compared with six hours by car). The railway is planned to be extended to Sacramento in the North and San Diego in the South at a later date, with a possible connection to Las Vegas. In 2003 the California High-Speed Rail Authority was formed, overseeing planning, design, build and operation of (CHSR Authority, 2016a). The Authority is led by a CEO that directs all activities under a Board of Directors, with the latter setting sustainability policies, amongst other responsibilities (Morales and Boykins, 2013)

The high-speed rail project is divided into several Construction Packages (CPs), where CP4 is a 35 km stretch situated in Central Valley, and the focus of this study. During the interviews for this report, CP4 is in the design and preconstruction phase. Contractors interested in the CPs send their tenders to the Authority, where the first qualification round is based on previous experience, technical competence and ability to perform amongst other specifications. Having passed the initial prequalification requirements, contractors can submit a proposal for how to manage the project in question. The proposals will partially be evaluated by cost and Small Business Participation (SBP), where the Authority has set a goal for 30 per cent SBP.

The design and construction of CP4 was awarded to the California Rail Builders, which is a consortium formed by Ferrovial Agroman, including Euroestudios and OTHON, at an

³⁸ https://www.concreteconstruction.net/business/management/envision-adopted-by-l-a-country-board-of-supervisors-as-a-policy_o

estimated cost of \$444 million. CHSR Authority has also contracted HNTB Corp for project management and follow up on requirement fulfillment for CP4.

Interviews for the CHSR project were performed in May 2017 in California with the (former) CEO, the Sustainability Manager and the Procurement team from the CHSR Authority. Interviews were also performed with Authority project managers and Project Manager from the contractor California Rail Builders. Gerdau Steel was also interviewed to include the perspective of a material supplier.

Policy background and client position

The CHSR operates within the state of California and must therefore conform to the policies regarding reduced carbon made at a state level. The project is included in the cap and trade program and receives 25% of cap and trade proceeds annually.

The CHSR senior management have committed to reduce carbon emissions beyond the California requirements. The project's policy objectives are grounded in California regulation but the CHSR has considered where the project could have more leading-edge policy goals and how to transfer these into contract requirements. The Sustainability Manager describes how everyone from executive level and down are aware of the sustainability values of the project. "To me it is success when sustainability is a core part of the agency", says the Sustainability Manager.

The CEO described the project setting as ideal for driving change given that California is a big market in itself and has a pledge to sustainability. Furthermore, he pointed out the advantage of the large project size and the general commitment to sustainability from the management. The CEO quoted the internal saying in CHSR as "Let's use the power of our contract to force changes." The CEO described the ambition to raise the bar for not only this project but for all coming contracts, and the obligation to use the scale to do something good: "I think it is a unique opportunity but also on some level a responsibility to try to take advantage of that opportunity." The CEO described it: "I think we've pushed beyond what would just have happened on its own. And that's something I think is about personal commitment."

The CHSR applied leading edge requirements and technology. The Environmental Protection Agency's definition of Tier 4³⁹ construction equipment and existing procedures and standards for steel production were applied. "I think the power of what we're doing is utilising existing standards, not creating them, it's utilising them, and utilising many of them in combination", the Sustainability Manager says. The first construction package started with a general idea from the client that they wanted sustainable infrastructure. A set of policies related to sustainability were established covering the whole organisation.

The sustainability manager explained that specific carbon targets for construction had not initially been included, due to concerns related to hindering competition in the bidding process. However, given the growing education within the industry for disclosure in environment product declarations (EPDs), initiated by the LEED sustainability certification scheme for buildings, EPDs were recognised for their value in enabling transparency of carbon emissions performance for products.

³⁹ Emission standard for off-road engines set by the U.S. Environmental Protection Agency

Procurement requirements set for the CPs are influenced by goals and objectives stated in the current Sustainability Policy, grounded in Californian legislation and formed by stakeholder interest and global practices (CHSR Authority, 2016c). During 2016, an updated Sustainability Policy was released (the original was established 2013), having a direct impact on the procurement requirements of CP4. The Sustainability Policy covers environmental, social and financial sustainability, with carbon management being given more emphasis than previously (CHSR Authority, 2016d).

The new sustainability objectives allow the procurement office of the Authority to set aligned requirements when developing procurement contracts. To simplify the transferring of objectives to requirements a Sustainability Implementation Plan clarifies how the sustainability policy will be integrated into procurement documents.

One of the major climate goals of the Sustainability Policy is to maximise carbon reductions. The goals are broken down into the following principles in the Sustainability Policy.

- *100 percent renewable energy for operation*
- *Minimise carbon emissions through design and requirements and achieve net-zero carbon and criteria pollutant emissions in construction*
- *Design and construct high-performance facilities that achieve net-zero energy for operations and are LEED certified at the Platinum level.*
- *Require Environmental Product Declarations for construction materials, including steel products and concrete mix designs, to improve disclosure of materials information and incentivise the selection of better environmental performing products.*
- *Require optimised life-cycle scores for major materials, including global warming potential, while maintaining durability and quality.*
- *Make life-cycle performance of components, systems, and materials a priority.*

Procurement requirements for reduced carbon emissions

An overview of implemented requirements for carbon reduction is presented in Table 10.

The CHSR project aims to reduce carbon during construction. The contractor is required to reduce emissions below regulatory requirements, through more efficient construction equipment, construction procedures, transportation etc. Renewable energy should also be used when feasible. Reduction of carbon is mandatory but there is no reduction target to reach. Specific incentives or penalties are therefore not used. Regarding the life cycle perspective, the contractor is responsible for providing cradle to gate level carbon data, while the authority aspires to calculate the whole life cycle impact themselves.

Table 10: Procurement requirements related to mitigation of carbon in California High-Speed Rail.

Type of requirement	Requirement
Selection and award criteria (qualification and MEAT criteria)	None
Technical specifications and specific requirements (functional, detailed, process, competence)	<p>Where practicable, use post-consumer, post-industrial recycled products and materials or waste materials, such as fly-ash, Ground Granulated Blast-Furnace Slag, crushed glass, recycled aggregate and Tire Derived Aggregate.</p> <p>Use renewable energy when feasible.</p> <p>Evaluate the use of all reasonably feasible renewable energy sources.</p> <p>Conduct a cost analysis that compares the energy costs from renewable sources versus traditional electricity sources provided by local utilities.</p> <p>Evaluate the cost of purchasing green power from organisations that offer green power within the appropriate utility provider.</p> <p>Provide Environmental Product Declarations from suppliers and manufacturers for concrete mix designs used in elements of the Project, including pre-cast and cast-in-place concrete, and all steel.</p> <p>Provide a Sustainability Management Plan (SMP) to demonstrate how the Contractor shall meet or exceed regulatory and Contract requirements during design and construction activities, including establishing a baseline against which progress shall be tracked.</p>
Sustainability Assessment Schemes/Rating Schemes	None
Carbon reduction requirements	<p>Reduce emissions and energy use below regulatory requirements and the estimated baseline by:</p> <ul style="list-style-type: none"> - use of cleaner engines: meeting or exceeding Tier IV and 2004 On-Highway Heavy Duty Engine Emissions Standards - use of cleaner fuels - use of cleaner diesel control technology - efficient use of fuel - use of renewable diesel or bio-diesel - reduction of energy use - efficient energy practices - efficient construction practices - materials delivery streamlining - other Contractor identified initiatives

The contractor is thus required to report an estimation of equipment type, operation hours and energy use. Moreover, a Sustainability Management Plan (SMP) is required. In this plan the contractor must demonstrate how monitoring, and reporting on fuel, energy use and carbon will be performed. The SMP is vital to meeting regulatory and contractual requirements. Additionally, a monthly Sustainability Management Report is required, including data of fuel, power and material consumption. When a project is completed, the contractor will need to produce a contract close-out document, reporting final data on fuel, energy, emissions savings and material use.

All requirements for CP1 are also included in CP4, with one major addition being an EPD requirement for all concrete and steel products used. This functions as a disclosure in tender application but is not included in the bid evaluation. EPDs are used to gain knowledge of how to develop and improve the baseline of the project. The inclusion of EPD requirements was made before the Buy Clean California Act was in effect and was probably an inspiration for the initiative to require EPDs at a state level.

The CHSR Authority accept generic EPDs since not all suppliers have EPDs specific to their products and producing an EPD can be seen as expensive. Asking for product-specific EPDs is therefore considered by the client to risk exclusion of many small and medium-sized suppliers. The actual carbon reduction effect of the requirement is hard to quantify for the project since the requirement is a disclosure and not a reduction obligation. Regarding the requirement of Tier 4, or above, construction equipment, it is considered to drive a reduction of regulated emissions (however not carbon, since they are not regulated). Without those mandatory requirements, the use of low-emission machinery would have been given a lower priority according to the contractor. But it is difficult to say whether the equipment requirements will cause increased costs associated with the need to invest in modern equipment, since there are many other aspects to consider, like efficiency, that will save cost.

Organisation and processes for implementing and following up requirements

The carbon goals were presented in the Sustainability Policy, and then transferred into contract requirements. This process was mainly an internal matter for the CHSR Authority organisation. However, an industry outreach was performed through their website, receiving comments and expressions of interest. Discussions with academia also took place to gain more knowledge for this process. New requirements need the approval of a wide range of personnel within the Authority, and after that the proposed requirements are forwarded to the Authority Board, which makes the final decision.

The contractor follows environmental policies and requirements from at least three sources: internally, i.e. the contractor's own organisation; the legal requirements in the state of California; and finally, requirements of the CHSR Authority. Requirements of carbon reduction are assigned by the CHSR Authority, who appoints a supervisor as their "eyes and ears" to make sure that requirements are met. In turn, the supervisor appoints a local environmental team for construction oversight and audits.

Construction was not yet underway during the time of the interviews. However, a sustainability management plan had been developed by the contractor to describe how the Authority's requirements will be applied throughout the project, and to aid the follow-up progress. The Authority supervisor has the task of reviewing the plan and forwarding it to the CHSR Authority and the Federal Rail Administration for approval. In the event of required adjustments, it is communicated by the supervisor to the contractor, who updates the plan.

All procured concrete and steel for CP 4 will require EPDs, and the contractor expressed having no issues with this. Many steel suppliers are already working with contractors following the LEED assessment scheme for buildings, so they are both familiar with the requirement and able to provide EPDs for their products. The interviewees mention that the requirement does risk limiting the number of available suppliers, but as long as there is

a sufficient variety of suppliers to choose from it is not considered an issue. The filtering of suppliers is seen as positive by both one of the main steel suppliers as well as by the Client Project Manager for CP4 since it stimulates suppliers and manufacturers to use more sustainable processes. Their belief is that even though it might contribute to higher costs in the short-run, it will bring long term benefits.

Data from the construction project will be collected and compiled in a project portal called EMMA, where the Authority can keep track of progress. If the contractor fails to comply with the requirements, fines or canceled payments are the retributive measures. However, this is not the case for the carbon requirements since no reduction level has been set.

Mechanisms for learning and improvement

The first construction package started with a general idea from the client that they wanted sustainable infrastructure. The CHSR then tried to find requirements to implement that idea, relying on California's laws and regulations. The first contract was issued and the development of the second contract was initiated and could learn from the implementation of the first one. In the following packages the idea of setting requirements that affected the material selection was introduced. This had to be done in a way that did not interfere with asset availability, safety, durability etc. Three different universities were engaged to gain more knowledge in this topic.

Internal workshops were held covering lessons learnt from previous CPs before the procurement of CP4, although not specifically regarding sustainability. Additionally, contractors from the previously procured construction packages were also contacted for experience sharing.

For CP1 the Sustainability Managers and others had a meeting with the designers, the contractor and the procurement leads at the start of the contract to explain the meaning of the contract. The Authority organisation has grown since and a communications exercise has been necessary to remind people of the sustainability requirements and activities. The Sustainability Manager describes the issue as "people know it in the back of their mind, but they barely have time to take a deep breath, so..." She needs help with the communication and for someone to drive the conversation and make sure that everything is understood. However, there are not resources for that. The Sustainability Manager and a representative from the procurement team are going to perform sustainability sessions across the program. The focus will be on the sustainability requirements and their purpose, how they are executed in the contract and the results.

Partnering sessions between the authority and the contractor take place every week. Sustainability and environmental issues have been a topic at those sessions. When it comes to experience sharing, learning and improving amongst the contractors, they meet once a month to discuss recent issues.

Perceived key success factors and barriers

The large scale of the project is seen as an important factor by the CEO of CHSR Authority in order to be able to push the limits of conventional procurement requirements. A large long-term project makes it worthwhile for contractors and suppliers to invest in more sustainable procedures and machinery. The setting in California, a state with an outspoken

commitment to reducing carbon, and the strong market in the state have also provided opportunities for change.

Sustainability is a core part of the Authority and seen as important. Personal determination of a few individuals at a high level, e.g. CEO and Sustainability Manager, in the Authority have been important for the inclusion of carbon management requirements, such as the required EPDs for concrete and steel.

Moving on from requirements to implementation, it is up to contractors, project managers and suppliers to reach the objectives of the CHSR Authority. Three success factors mentioned by the HNTB representative are: to trust one another, to communicate, and to be honest. The project manager from the Authority side mentions a fourth success factor as: having history. By having experience from earlier construction packages, previously made mistakes can be avoided. Likewise, successful achievements can be repeated or improved further.

Another success factor mentioned by the Authority is to apply existing standards that aligns with their objectives. By not creating their own standards and instead relying on well tested alternatives, time is saved. For example, the CHSR relies on the EPA to define Tier 4 vehicles, to later use the definition in procurement requirements. The more objective the standards are, the easier it is for the requirement-setting team to administer and track whether they are met. It is also important to use tried and tested methods. It should be a proven fact that the methods actually perform as promised. Otherwise, it is difficult to receive internal agreement for their inclusion as a procurement requirement. Regarding reaching consensus, it is important to identify who the decision makers are and to try to limit the number of people required to concur and streamline the process. As the organisation has grown, this has become more and more difficult. The Sustainability Manager is struggling with need for communication in regard to the requirements but the lack of resources to do so.

An organisational barrier in relation to the growing organisation is the perceived distance between the Authority and the actual 'doers', which can cause tension between the parties. "There is a conception that there on one hand is 'Sacramento' who are a bunch of people setting requirements and on the other hand the "Project" where it is really happening", says the Sustainability Manager. This notion has emerged in the last couple of years as the organisations has grown. It is a new reality where it has become harder to reach people and to make decisions.

A second organisational challenge is the lack of competence. Even though California is a frontrunner state in terms of environmental policy, the project still has problems finding the right skills. Looking at the market, the local availability of environmental competence is limited in certain areas. With a requirement of 30 percent Small Business Participation, it poses a challenge that can cause increased prices or delays in delivery.

One of the barriers of using procurement requirements as a measure to reduce carbon, is the general view that these types of requirements can reduce competition in the market. The requirements might seem difficult to small or medium sized businesses, leaving only the major companies able to bid, which could be exploited with higher asking prices. An example of this is the EPD requirement for concrete and steel products, that could be

difficult for small-scale suppliers to meet due to the cost of producing an EPD. Therefore, industry-wide EPDs are accepted in CHSR since it enables more competitors although the accuracy of the product declaration is lower. However, CHSR wants to prove that the project can be both competitive and use challenging requirements. At the time of the interviews, every design/build contract had come in under the cost estimates. The final result is however difficult to forecast since some measures, like requiring new and efficient construction equipment, will cost more to implement, although consume less fuel and require less maintenance.

8.3. SFO AirTrain Extension

San Francisco International Airport (SFO) is the 7th largest passenger airport in the US, and an 'enterprise department' of the City and County of San Francisco (SFO, 2017a).

SFO currently runs an automated people mover (APM) rail transportation system called AirTrain, which is being extended as a part of the Airport's current five-year development plan (SFO, 2017b). The AirTrain extension will reach from the current car rental center to long-term parking garages 1 and 2, allowing passengers transit to the Airport terminals from these locations. The AirTrain Extension and Improvement Program includes design and construction of an elevated guideway for APM, new AirTrain stations, Long-Term Parking (LTP) Station and Hotel Station and various site improvements. SFO has contracted Skanska for the \$162-million Design-Build project, supported by WSP for design and Sustainability Services, including LEED assessment.

The SFOATE interviews were performed with sustainability directors from both the authority and the contractor Skanska, the contractor project manager, as well as consultants working with LEED certification and design of the project. The interviews with the contractor project manager and consultants were performed in San Francisco in May 2017, while the Sustainability directors were contacted through Skype later.

Policy background and client position

SFO is regulated by several jurisdictions including federal, state, and local agencies. Most of which have specific sustainability or sustainability-related requirements that planning, design and construction projects at SFO must comply with (SFO, 2015). The SFO AirTrain Extension project must conform with state-level policies regarding reduced carbon, as do all projects within the state of California. Additionally, SFO has raised the bar, from the state goal of a reduction of 30 % to be reached 2030, to a 50 % reduction by 2021 using the carbon emissions of 1990 as a baseline. SFO's five-year strategic plan, 2017-2021, includes seven major development goals with corresponding objectives (SFO, 2017). Goal #2, Achieve Zero By 2021, includes objectives such as achieving net zero energy, carbon neutrality and reducing carbon by 50 %, with the year 1990 as a baseline. "SFO is in California, the state that does things before the rest of country does. So it makes sense that SFO would too", explains one of the LEED team Officers in the project.

The San Francisco Department of Environment also has green building requirements that SFO must consider when designing and constructing new projects. The San Francisco

Environment Code⁴⁰ states the sustainability requirements for all San Francisco municipal projects and include:

- Use Precautionary Principle in decision making
- Incorporates specific criteria
- Environmentally preferable purchasing,
- Recycling, and Construction & demolition debris management
- Targets Fossil-fuel free energy by 2030
- Requires LEED v4 Gold conformance for certain projects

Another key document is the amended SF Environment Code from 2008, Ordinance 81-08, which provides carbon reductions for target years (County of San Francisco, 2008). By 2025 carbon is to be reduced by 40 % below 1990 levels and 80 % below by 2050.

The Airport aims to maximise stewardship and sustainability across all campus projects. The LEED team Officer explained it, “They (SFO) want to be ahead in the curve. They want to be the greenest airport in the world. So that’s where the drive is.” SFO works to achieve its strategic plan goal of being the first “triple zero” airport campus in the world, hitting zero net energy, carbon neutrality and zero waste by 2021. To realise its goal of becoming a zero net energy campus, the Airport is setting energy use intensity (EUI) targets as contract obligations for all capital projects, according to the Airport’s Sustainability Director.

Procurement requirements for reduced carbon emissions

An overview of implemented requirements for carbon reduction is presented in Table 11.

San Francisco International Airport (SFO) has general requirements applicable for all projects, which are presented in the SFO Sustainable Planning, Design and Construction Guidelines⁴¹. The Sustainability Guidelines defines two types of requirements, *mandatory* and *expanded*. The mandatory requirements are derived from federal, state or regional legislation, while the expanded requirements are those prioritised or set by SFO team. The latter are only mandatory in the sense that a project needs to assess the feasibility of implementation.

Additionally, there are project specific requirements. In the case of the AirTrain Extension project, the contractor is required to provide LCA data, attained from EPDs of major product and system manufacturers. The contractor is also required to compare EPDs for similar products or systems as a ground for selection. Furthermore, the contractor is required to provide a whole building LCA at every design phase.

Another general mandatory SFO requirement for all (i.e. non-infrastructure) projects is to reach LEED v4 Gold certification, per the Municipal Green Building Code. The AirTrain Extension project is also required to go further and strive for Net Zero carbon emissions for the Long-Term Parking Garage Station. The new version of LEED (v4) includes criteria for decreasing carbon specifically for construction of buildings. The requirement is to reduce emissions by 10% compared to a baseline based on conceptual design. The team’s

⁴⁰ SF Environment Code (<https://sfenvironment.org/policy/environment-code>)

⁴¹ Sustainable Planning, Design and Construction Guidelines, Version 4 July 2015, San Francisco International Airport

highest priority measure to accomplish that target is to use 25% cement clinker replacement (fly ash) in concrete.

Table 11: Procurement requirements related to mitigation of carbon in the SFO AirTrain Extension.

Type of requirement	Requirement
Selection and award criteria (qualification and MEAT criteria)	None
Technical specifications and specific requirements (functional, detailed, process, competence)	<p>SFO Sustainability Stretch Goals:</p> <ul style="list-style-type: none"> - Develop a plan to minimise ecological footprint and carbon emissions associated with stations life cycle. <p>SFO Expanded Requirements:</p> <ul style="list-style-type: none"> - Reduce carbon emissions from natural gas consumption in building HVAC systems - Assign a life-cycle cost for carbon emissions - Perform LCA for material selection and evaluation of alternative design configuration <p>SFO Project-specific Requirements:</p> <ul style="list-style-type: none"> - Provide LCA data to inform the project design and product selection in accordance with the SFO Sustainable Planning, Design and Construction Guidelines - Provide whole building LCA (WBLCA) at each design phase, and utilise BIM with appropriate Revit Module (Tally) for development of the WBLCA. - Provide LCA data using EPDs for the major products and systems as made available by the product manufacturers.
Sustainability Assessment Schemes/Rating Schemes	<p>SFO Project-specific Requirements:</p> <ul style="list-style-type: none"> - Long-Term Parking Garage (LTPG) Station shall be a LEED v4 Gold-New Construction structure and shall strive for Net Zero
Carbon reduction requirements	<p>SFO Expanded Requirements:</p> <ul style="list-style-type: none"> - Calculate carbon emissions from construction activities and take specific measures to reduce these emissions - Perform whole building LCA showing minimum 10% improvement for three impacts including climate change compared to a reference building meeting 2010 CEC requirements.

Notably, the transportation infrastructure (the railway) is currently not under any requirement for carbon reduction because of infrastructure being out of the scope for LEED requirements (LEED is only valid for buildings). To put in place a similar sustainability framework for the infrastructure part of the project, the sustainability assessment scheme Envision is going to be used for the rail construction. However, this will still not guarantee carbon management of the infrastructure because Envision certification does not include any mandatory requirements for carbon reductions.

According to the design team, the importance of LEED for reducing carbon is of minor significance, as they would still have proposed carbon reductions to SFO even if they had not been using the certification. This would however probably not be valid for the infrastructure parts of the projects since the team mention a lack of experience of carbon management for infrastructure from previous projects.

Organisation and processes for implementing and following up requirements

The SFO Sustainable Planning, Design and Construction Guidelines were developed to support project compliance with varying codes and with City-required LEED criteria according to the Sustainability Director. But once again, it is worth highlighting that the Guidelines focus on buildings and doesn't include infrastructure. The AirTrain Extension design team is aware of SFO's requirements, however they received most of the guidance from the LEED assessment scheme. The design team say they normally assess how progressive the client is in terms of sustainability goals and then provides an approach to reach them through tools and methods like e.g. LEED-assessment, carbon reduction, LCA analysis etc. SFO is described by the LEED team as a very progressive client in terms of setting and ensuring projects deliver on sustainability goals.

SFO has recently implemented a Zero Energy and Resilient Outcome (ZERO) Committee. The Committee follows up on every project and provides the project teams with guidance through design development and construction documentation to make sure that all Airport Capital Improvement projects achieve all of their environmental requirements and sustainability targets.

The design team had a kick-off meeting with their client and the contractor, to establish a proactive approach to the sustainability criteria. The contractor is required to submit EPDs to the LEED team for an audit or material review. When construction starts the contractor must provide a monthly update on LEED-criteria, EPDs and LCA to the client.

The Basis of Design document describes how the contractor will meet the requirements in the design phase and acts as a rule book for the contractor during the project. The contractor then develops the construction documents based on this, which means that the Basis of Design must be comprehensive, almost like a specification.

Mechanisms for learning and improvement

Since the AirTrain Extension team is required to use LEED, most mechanisms for learning and improvement are connected to the LEED assessment scheme. LEED requires communication with the responsible architects and meetings between engineers and architects take place during the construction documents phase. In this way the architects are guided towards SFO's sustainability aims.

There is still a learning curve regarding the use of LEED, as the project uses a new version, v4, with substantial differences from previous editions. As LEED only describes what to do in general terms, meetings are set up with contractors and architects to discuss how the criteria are to be met. SFO has a LEED expert in the organisation, who facilitates communication with the project and enables discussion of developments and improvements.

SFO's ZERO Committee acts as an information broker and accelerator for the triple zero airport campus. All capital projects report their achievements and challenges, and the committee creates intersections between the projects to share best practices, key learnings and impactful outcomes. The Sustainability Director describes how there is industry-wide recognition for sustainability standards set by SFO, having published the first guidebook for accomplishing multi-regulatory requirements and stretch goals. The sustainability requirements are integrated into procurement (e.g. RFPs, contract

specifications and requirements) and staff continuously monitoring the industry for future bolder standards to elevate sustainability gains for the campus.

To develop their work with carbon reduction requirements and follow up, regional experts are brought in on a monthly call, to run training classes. There is also an experience sharing initiative where internal team members across disciplines at the airport are transferred across to project, thereby transferring requirement developments and learnings to the next project.

At an industry level, the Airports Council International (ACI) has environmental and sustainability groups, who collaborate and share examples of best practice.

On a more regional level the Green Building coordinator at SFO and the SFO Sustainability Director and the mayor's senior environmental advisor have formed an alliance to streamline work through other divisions at the city.

Perceived key success factors and barriers

The main success factor described by the respondents is the staff. "Highly involved staff in sustainability is a key to success", says the Sustainability Director. She describes how important it is that the staff want to work with sustainability issues and that the management team support it. Visionary leadership is also mentioned as a key to success. The bold commitments, endorsement and support scaffold all projects and build their platform for success, particularly when set by the Airport Director, other City Department Heads and the City/County's Mayor is needed to drive the work in the right direction and succeed. The design team describe SFO as a client that puts in work on the details since they know certain goals must be met.

The contractor says that a long-term stay in the project is a key factor to success for the implementation of requirements. Related to this, they also say that the project delivery model is important and that they put more effort into, for example, PPP (Public Private Partnership) projects because they then also manage the asset. On the other hand, they see a challenge in valuing carbon management in the projects. The contractor's Sustainability Director believes that it can be of value to them, saving time or cost. But that the industry in general seems to think that LCA means high risk and cost and therefore doesn't do it.

One huge challenge for the project in reducing life cycle carbon emissions is that the existing fleet of train cars are not efficient, says the SFO Sustainability Director. When updating the fleet, the best available technology will be used. Other barriers mentioned are: that industries must catch up and enable new technology and that manufacturers need to supply new low carbon construction materials and develop EPDs for those materials. Documentation and information about the materials is critical in SFO's project.

The design team mentions that one barrier to carbon reductions in infrastructure might be that there is too much risk involved. For safety reasons you need to be absolutely sure that new low carbon materials or technology doesn't lead to any increased risks. And if you can't ensure that, because of lack of knowledge or experience, then nothing happens. Another barrier mentioned is the involvement of many different disciplines, which creates difficulties in coordination and information sharing.

9. Discussion

9.1. Project ambitions in relation to global and national climate change policy

The relationship between international law/policy and national law/policy in the area of climate change and sector-specific goals is complex. It entails translation of agreements from global politics into national law, from national law into policy and finally, from policy into action on the ground in the particular sector, in this case the infrastructure construction sector. This “implementation chain” can be seen as a multi-layered dilemma (Gulati 2006; Young 1999; Pressman 1984) which is influenced by a multitude of general factors. Such factors include, for example, the structure and character of international law, the legal culture at national level and mechanisms for incorporating international law into national law, as well as how this law is implemented into practice at sector and corporate level. When policy involves private sector bodies, the private sector organisation and structures for public-private cooperation also become important. Public procurement is such a structure, and in the European Union as well as in the OECD countries, the focus on public procurement as a policy instrument has increased in recent years (European Commission, 2017a). In particular, ecological and social sustainability and innovation procurement are promoted (Wuennenberg and Casier, 2017; 2018).

According to a conceptual model proposed by Brammer and Walker (2011), there are four factors that mediate between national policy context and actual public procurement practices at the organisational level:

1. Perceived costs and benefits of the policy;
2. How familiar the procuring entity is with the policy;
3. The availability or resistance of suppliers; and
4. Organisational incentives and pressures, such as organisational culture and top management support.

This proposition is supported by other studies. For example, lack of clarity in Green Public Procurement (GPP) regulations has been identified as a main implementation problem (Igarashi et al., 2017). Moreover, absence of top management commitment to sustainability in the organisational vision have been found to impede sustainable public procurement (Chiarini and Vagnoni, 2016; Wong et al., 2016). At the organisational level, individuals often play key roles as change agents, by influencing culture and behavior and enabling the organisation to learn and change (Eikelboom et al., 2018; Grandia, 2015; Siebenhüner, 2007). Another aspect often emphasised in policy research is the importance of a proper policy mix. This implies that different policy instruments that address specific aspects are designed to complement each other, rather than just being a collection of individual tools or standards (Wilts and O'Brien, 2019). This mix has to be adapted to the specific context and organisational and legal tradition of a particular country.

Most of the construction projects that have been studied in this research project were selected partly based on their high ambitions for carbon reduction. Below, we summarise and discuss how organisational and project-level policies relate to national and regional policies, industry level collaborations, and initiatives of organisations and individuals.

Case comparison

Australia has no clear national policy to drive carbon reduction, but there are policies at the state level. In New South Wales, for example, all infrastructure projects fulfilling certain criteria are required to be certified according to the ISCA IS Rating scheme. The major client Transport for New South Wales has also developed their own Sustainable Design Guidelines. Further, the Sydney Metro Programme is a lead client aiming for world class sustainability performance. This ambition is strongly driven by individual champions, but support from state policy has been important to justify actions and gain support from politicians.

In the Netherlands, a Climate Act is currently being developed. However, government has encouraged carbon reduction for several years primarily through soft law policies such as the general sustainability initiative Green Deals. One deal, DGW 2.0, involved a wide range of infrastructure construction clients and suppliers. Further, the main public road and waterways client Rijkswaterstaat (RWS) has a history of being a leading client and has assumed a key role in leading on carbon reduction. A system has been developed in collaboration between RWS and PIANOo, the Dutch Public Procurement Expertise Centre, including tools (DuboCalc), databases and a certification scheme (CO2 Performance Ladder) that support sustainable and low carbon construction. The studied A6 project, however, was procured before these measures were in place. Here, the main pressure came from the municipality of Almere, which adopted high sustainability goals as they were to host an international horticultural exposition in 2022. This shows that local government action may also be important in driving national development.

In Sweden, the main infrastructure client Swedish Transport Administration (STA) has developed their carbon reduction requirement model in response to national and international carbon reduction goals. This development started several years before the Swedish Climate Act came into being in 2018. The first initiative to calculate carbon emissions around 2010 was driven by individuals within procurement and environmental functions in two megaprojects: one railway project and one road tunnel. The model was further developed by the Planning Division with the Swedish Transport Administration and reduction requirements were added in 2016. These were inspired by the car and vehicles industry, where reduction policies are based on financial incentives and are raised over time. Requirements have up to now not been set high enough to impact carbon reduction measures, but are perceived to have raised awareness in the sector. However, there are also important industry level collaboration initiatives to create roadmaps and establish commitments to work towards a low carbon regime. Altogether, this means that in some projects, contractors drive carbon goals more actively than the client requires. There are also materials producers involved in these initiatives who are waiting for requirements that call for new, low-carbon materials.

In the UK, a Climate Act including carbon budgets came into force in 2008. Facing large investments in infrastructure, the UK government has taken several initiatives to support improvement in this industry. For example, government-industry reviews have identified performance opportunities in the sector in general (Infrastructure Cost Review) as well as specifically within carbon reduction (Infrastructure Carbon Review). Government has actively promoted industry associations and groups to drive development in terms of efficiency and innovation as well as environmental performance (Infrastructure Client

Group, Green Construction Board, etc.). On the organisational level, the water company Anglian Water has been a forerunner in carbon reduction for more than a decade, a strategy that has been strongly driven by their Asset Management Director. Their key message has been that carbon reduction and cost reduction are associated. By implementing a collaborative alliance contract with their supply chain, Anglian Water has reached (and exceeded) their goal of 50% reduction in carbon emissions and this has helped set the standard for industry more widely. Being the nation's largest infrastructure project, HS2's management team perceive an obligation to align their ambitions with the overall national goals and, based on the Anglian Water example, HS2 has adopted the 50% reduction figure.

US national ambitions for carbon reduction have been cut back by the current government, but the State of California has higher aspirations. Both Californian cases studied have increased their ambition in comparison to the regional policy. For the California High Speed Railway Authority it has been important that the project is a railway with funding from the Cap and Trade program. The high sustainability profile is driven by the former CEO and other champions in the client organisation. It is a very large public project, and the top management perceive an obligation to use their huge market power to promote change on the industry level. Thus, their ambition is not to drive innovation but to drive better practices in the sector. The SFO AirTrain Extension project conforms to the San Francisco Environmental Code which is stricter than the regional target. SFO has also added even stricter extended requirements in their projects, to be used if feasible. This is in line with the aim to become carbon neutral and the cleanest airport in the world. However, most of the environmental targets are set only for buildings and not for infrastructure.

Concluding discussion

In relation to the projects that this study concerns, all five countries are in a learning and development process driven by the Paris agreement. The comparison shows that the general policy structures for the procurement requirements for carbon reduction are context-dependent and influenced by the national culture for policy development. Fundamental differences concern the governance structure where Australia and the US have states with high power while in The Netherlands, UK and Sweden the national level is most important. The concentration on the client side is also a key factor, where for example the Swedish Transport Administration is very dominant while other countries have a greater diversity. Furthermore, some countries and organisations (Australia/NSW, NL, UK) have a longer tradition of carbon management in infrastructure construction while in others (Sweden, US) such ambitions are more recent.

An important observation is that there is not always a clear policy implementation chain between international, national, organisational and project goals. While some clients and projects have implemented national policy, others have been pushing the development of policy and practice. When explicit directives to clients or projects are lacking, organisations and projects may choose to set ambitions high and refer directly to overarching goals. These types of good examples or "lighthouse projects" have the possibility to affect public agencies, upcoming regulation and market adaptation of new technology (Sparrevik et al. 2018). In the CHSR the explicit ambition was to use its volume to drive market development. In the UK, Anglian Water has been a role model for the whole industry. In this way, new measures developed in frontline projects can set new standards that can be adopted by the field (Sparrevik et al. 2018). In these case studies, individual champions

have often played key roles in raising ambitions. We can also see that governments, clients, projects and industry networks take different roles in driving carbon reduction. In Sweden there is a relatively clear top down approach by the Swedish Transport Administration whereas in the two US cases it is more up to the clients and projects to drive development. In New South Wales in Australia, clients have been the primary change agents, while in the UK and the Netherlands industry collaborations and partnerships have been important, although with active support by government in both countries. Suppliers may also act as front runners and set more ambitious goals than those of the client. In the CHSR in the US some of the steel suppliers had already developed EPDs, making the project requirements easier to fulfill. In Sweden, some large contractors have been ahead of the client in implementing carbon reduction measures. Such companies play an important role since a lack of green products and services on the market is one of the main obstacles to innovation-oriented green public procurement (Brammer and Walker, 2011; OECD, 2016; Wong et al., 2016).

The findings clearly point to the role of policy context and institutions and the difficulty of transferring procurement requirements and models between country contexts. Further, policy does not seem to drive cutting-edge development by setting very precise goals and regulations. Rather, policy may legitimise that individuals act as champions and organisations become forerunners. General and less specific policies at the international and national levels may enable clients and projects to adopt higher goals that may subsequently contribute to setting new industry standards

9.2. Requirements: types, advantages and problems

In this section, we describe and discuss different types of requirements used in the case study projects and the experiences gained by clients and supply chains in implementing them. The study shows that different clients and countries tend to favor different types of procurement requirements to drive low carbon design and construction, and also that combinations are common.

We identify four categories of requirements:

- Selection and award criteria (qualification and MEAT criteria)
- Technical specifications and other specific requirements (prescriptive/detailed/closed, performance, process, competence)
- Sustainability Assessment Schemes/Rating Schemes
- Carbon reduction requirements

Note that both rating schemes and carbon reduction requirements can be seen as sub-categories of specific requirements, but are treated separately here since they form important categories of their own in this context.

In Table 12, examples from the cases of requirements in each category are listed.

Table 12: Types of requirements and examples from the cases.

Type of requirement	Examples of requirements in cases
Selection and award criteria (qualification and MEAT criteria)	<p>Tender discount based on organisational capabilities (CO2 Performance Ladder)</p> <p>Tender discount based on carbon footprint calculation/reduction (DuboCalc, see also under reduction requirements below)</p> <p>Organisational competence evaluated based on cv's and resources for environmental staff</p> <p>Organisational competence evaluated based on exemplar low carbon designs (Award criterion)</p>
Technical specifications and specific requirements (functional, detailed, process, competence)	<p>Requirements for competence, roles and processes</p> <ul style="list-style-type: none"> - requirements for carbon manager, etc. - carbon management plans - carbon footprint calculations and documentation - PAS 2080 compatible - SUNRA <p>Carbon performance and documentation requirements:</p> <ul style="list-style-type: none"> - Carbon performance for selected products/material - Renewable fuels/energy - EPDs <p>Technical requirements</p> <ul style="list-style-type: none"> - Cement clinker replacement - Recycled ballast - Steel production requirements - LED lightning - Asphalt
Sustainability Assessment Schemes/Rating Schemes	<p>LEED, BREEAM, Green Star (buildings)</p> <p>BREEAM, ISCA, CEEQUAL, Envision, TfNSW's Sustainable Design Guidelines (Infra)</p>
Carbon reduction requirements	<p>Reduction in embodied or capital carbon in relation to baselines calculated for reference designs or in relation to business as usual</p>

Selection and award criteria

One way to motivate contractors to develop competences and resources to work with carbon reduction and management is to ensure that such investments increase the chance of winning a tender competition. This is perceived as important and desirable by both contractors and clients, and there are examples of such MEAT (Most Economically Advantageous Tender) award criteria being used in our cases. In the Netherlands, contractors may be entitled to a tender discount of up to 5% depending on if, and at what level, the company is certified in the CO2 Performance Ladder system. A higher rating indicates a higher maturity of organisational processes in this field. Tender discounts of up to 5% are also granted based on calculated reductions in environmental impacts, including carbon, according to the DuboCalc tool (further described in the section below on reduction requirements). Evaluating competence and resources for sustainability (and carbon) management was seen as important, and also that this required sustainability competence in the tender evaluation teams. In the HS2 project in UK, potential contractors were

required to submit exemplar low carbon designs for designated constructions provided by the client in the tendering documents. However, policy ambitions must be balanced with primary procurement objectives (OECD, 2015b) and despite the generally positive views on incentivising carbon-related competence in contractor selection, the interviewees also mention downsides and practical limitations which need to be considered:

- To provide substantial incentives for contractors to drive development, the weight assigned to a specific award criterion must be sufficiently high. But in a large infrastructure project many aspects are important, and there is a competition between areas to be included among the award criteria. Thus, clients experience a balancing problem where more criteria mean less weight assigned to each of them and, thereby, a lower incentive power.
- MEAT criteria are often associated with higher transaction costs – they demand more resources from the client to assess and verify than monetary criteria and perhaps also from the tenderers. Such transaction costs include certification processes and audits, for example related to the CO2 Performance ladder in NL. Further, all carbon measures are not feasible to address already at the tender stage for reasons of time and tender costs.
- Over time, tenderers may develop similar competences and therefore receive similar grading. The CO2 Performance ladder, for example, led to increased contractor competences in the first years, but today all contractors are certified to the highest level. Thus, the requirement no longer discriminates between tenderers.

However, MEAT criteria may also be motivated by indirect effects. Climate-related award criteria mean that contractors need to involve staff with sustainability and carbon specialists in the tendering team. Thereby, contractor staff from outside of the environmental unit also become more aware of low carbon design and construction. In sum, our results show that it is important to be aware of the limitations of MEAT award criteria, but also to consider other potential benefits beyond the direct tender incentives.

Technical specifications and other specific requirements

Technical specifications and other specific requirements are requirements that the tenderer, construction process, material, component or completed asset must fulfill. Examples of such requirements in the case studies include: carbon managements plans, technical solutions, type of fuel for vehicles, EPDs for materials and percentages of cement clinker replacement. Some (prescriptive) specific requirements risk limiting competition, since they might rule out companies that fail to fulfill them. An example is requirements for EPDs, which can be too costly for small suppliers to develop. This was a concern in the California High Speed Railway project, where the solution was to introduce this requirement step by step to give suppliers time to prepare.

PAS 2080 (UK) and the CO2 Performance Ladder (NL) are standards for carbon management. The CO2 Performance Ladder is not required, only used in procurement, but HS2 requires contractors to be PAS 2080 certified. In both NL and UK, tenderers are allowed time before presenting certificates for compliance with the standards. The Swedish Transport Administration is developing their own framework SUNRA for sustainability management, and in this case there is no associated certification.

Prescriptive (by interviewees often called “specific”) requirements are most important in the Sydney Metro case in Australia, where they are combined with very high sustainability ambitions. However, Dutch clients have also used this model in situations when they know what technical solution or material they want. These clients have found that prescriptive requirements are efficient to spread practices, materials or components that are already tested to subcontractors and material producers. Prescriptive requirements also allow a large client to assume development risks for new solutions and products which may potentially be used in a wide range of future projects.

Prescriptive processes and competence requirements may further reduce uncertainty and support more efficient learning when new practices need to be developed. In the Swedish interviews, it is suggested that requirements that specify meetings, roles and processes help inexperienced consultants and contractors to make realistic estimations of the resources needed to implement climate reduction requirements and price them more correctly in the tender. This way, fairness in supplier selection is improved since the chances increase that a more informed consultant or contractor with a realistic assessment of the resources required wins the contract.

Sustainability Assessment Schemes/Rating Schemes

Rating schemes have a longer history in the building sector than in infrastructure construction, where most such systems are in early development phases. Indeed, most rating schemes are related to general sustainability and the emphasis on carbon reduction varies (see section 3 in this report for an overview).

In Australia, the IS Rating scheme (ISCA) is an established sustainability assessment scheme for infrastructure construction, and the state of New South Wales requires that all projects over \$50M and critical state significant assets are certified against. This requirement applies to both case study projects: Sydney Metro and Newcastle Light Rail. In the UK, CEEQUAL has long been the most common scheme, and is now merged with the new BREEAM standard for infrastructure. The HS2 railway will be certified according to BREEAM Infrastructure. In the US, the Envision scheme covers early stages of planning and design of infrastructure but is not used in the projects studied. In the Netherlands, no general rating schemes for infrastructure assets are important to date. In Sweden, use of CEEQUAL certification is increasing, mostly driven by contractors, and clients are beginning to require that CEEQUAL is used as a framework for sustainability management. But there are very few examples of client requirements for certification and the STA has stated that they will not require CEEQUAL rating and will rely on SUNRA instead.

Some experiences from the case studies relating to use of sustainability rating schemes are:

- Sustainability rating schemes are primarily used in the UK and Australia. The case study projects in these countries all have higher sustainability ambitions than the local rating schemes require, and these schemes have therefore not been important in driving performance. However, in Australia certification is mandatory and in HS2, the client representatives say that it would be strange not to certify a project which has a high sustainability profile. Further, the use of BREEAM Infrastructure is considered to facilitate implementation of sustainability-related practices since it is well known to suppliers. Thus, in high profile projects rating schemes may provide predictability and legitimacy even though they do not drive development.

- Rating schemes are associated with extensive reporting and many process requirements, and projects may choose which areas to focus on to get points. Thus, projects may acquire a certification without undertaking any measures to reduce carbon impact. To avoid this, several clients identify a need for specifying not only the required certification level but also a subset of requirements that suppliers must fulfill.
- In general, sustainability rating schemes include large numbers of requirements and high administration costs are a downside of such schemes. Especially in Australia, the issue of partly overlapping schemes for buildings and infrastructure assets was raised. If a building rating scheme is used for the stations and an infrastructure scheme for those parts, there will be interfaces where the two schemes overlap and perhaps also areas which are not covered at all. For the SFO project in California, high sustainability ambitions, including whole building LCA and LEED Gold certification of buildings, excluded the infrastructure. The lack of an established sustainability assessment scheme for infrastructure resulted in lower requirements for the infrastructure parts compared to the building parts. In Australia, on the other hand, Transport for New South Wales had developed internal sustainable design guidelines which partly overlapped with requirements for IS rating. The client then had to map and review the total range of requirements, and in the end removed over 300 of their own requirements. This illustrates the importance of a proper policy mix where the different instruments are complementing each other (Wilts and O'Brien, 2018).

Reduction requirements

Requirements to reduce capital carbon emissions in relation to a reference state (baseline) are found in all countries. Such requirements are used by clients to stimulate contractors to develop carbon efficient solutions without prescribing which measures to take. Thus, reduction requirements are generally being seen as associated with innovation and efficiency. There are however significant differences in how these systems are designed, for example how baselines are set, which reduction levels are required and how performance is verified, and in how important reduction requirements are in relation to other requirements.

Australia, New South Wales

In Australia, requirements for reduction of carbon emissions are included in the ISCA IS Rating scheme along with a standard calculation tool to establish baselines and outcomes. As stated above, this sustainability rating scheme is compulsory for larger and critical transport projects financed by the State of New South Wales. The client sets the required reduction target for each contract, usually between 15 and 25 per cent. However, reduction requirements do not seem to have a prominent role in driving carbon reduction in Australia, where development is instead primarily advanced by prescriptive requirements. The interviewed client representatives see the baselining as a challenge to the rating schemes, since baselines that are set in early stages will become irrelevant as projects develop. Another problem is that contractors have an interest in fattening baselines, although the clients think that these risks may decrease over time as client competence increases and practices become more rigorous.

The Netherlands

In the Netherlands, the system to stimulate carbon reductions is based on the national calculation tool. The client establishes a baseline for environmental impact, including carbon, using standard data and the DuboCalc tool. For the largest projects, the reduction requirements are used in combination with the Competitive Dialogue (CD) procurement model. A reduction goal is set based on a careful analysis of the reduction opportunities in the specific case in relation to experiences in previous projects, and the aim is that it should be realistic but challenging. The goal is expressed in terms of maximum and minimum levels for tender discounts, where the awarded level depends on how far below the baseline the contractor offers to go. In the A6 project, the maximum discount amounted to 5% of the contract sum. In the CD process, each tendering contractor develops a design and a tender price, and also identifies opportunities for reductions in environmental impact. The reduction levels of the winning tenderer become parts of the contract and there are substantial penalties if they are not met: 1.5 times the awarded discount. The environmental impact levels are audited in several steps by independent institutes.

Sweden

In Sweden, the Klimatkalkyl carbon reduction model was launched in 2015 by the Swedish Transport Administration. It is used for all projects with a contract sum over 5 million Euro. The reduction targets depend on the year in which the constructed facility will be taken into operation and are raised over time matching the development of national carbon emission goals. There is a bonus of up to approximately 1% of the contract sum which is awarded if targets are met or exceeded. An important objective has been to encourage the most cost-effective measures to be implemented first, which is why a global reduction model was chosen. The model is new and is currently (2018) under review. It is perceived to have raised awareness, and the idea of a common tool for all projects is appreciated, but several implementation issues have been identified and the model is often questioned by contractors. In some cases, much time and resources are spent on discussions and recalculations of the baselines. Moreover, the tool itself does not cover all aspects and is not perceived to represent actual industry practice, which creates some resistance. The application in practice varies and, in many cases, the formal guidelines are not followed. The bonus thresholds have also been discussed, since it has often been easy to reach the maximum level. Further, most firms in the value and supply chains have not been affected since overall reduction requirements are not broken down and forwarded to them. A need for training, implementation support and guidelines has also been identified based on the experiences gained thus far, and it has been suggested to complement the reduction requirements with prescriptive requirements to speed up implementation.

UK

In the UK, the private water company Anglian Water has been a role model in setting carbon reduction requirements. Their model is based within a governance scheme which is overseen by the water regulator Ofwat and allows for long-term (up to 5+5+5 years) collaborative relations with key suppliers. Anglian Water has established an alliance with key suppliers and has also developed its own tools for setting baselines for both carbon and cost. Baselines are set project-by-project, but incentive payments are issued based on yearly and 5-year performance evaluations. The large flagship project HS2 adopted the same

reduction figure as Anglian Water, 50%, which also corresponds to target levels defined in the UK Government's construction strategy. In both cases, the level was set to be challenging and communicate that new innovative practices will be necessary, since such a high goal is not possible to reach if working as usual. In HS2, a collaborative two-stage Early Contractor Involvement model is used for the Major Civils Construction Works contracts, where the carbon baseline was calculated in the first stage along with the design and a target cost. The baseline calculation model was developed in collaboration between the client and the four main engineering contractors, and they jointly agreed that this baseline should be realistic and represent industry practice and not a worst-case scenario. However, especially in the first stage, the contract is open and consequences of not meeting the goal are not clearly specified. Since the established industry position is that reduced carbon impact will lead to cost reductions, no separate carbon bonuses are included. Instead, contractors are expected to benefit from carbon reduction through the gainshare-painshare model in the target cost contract.

US, California

In the US, reductions in carbon impact are compulsory but there is no baseline or specified target. There is a list of what type analyses that contractors should undertake, and contractors are required to state measures they have taken to reduce climate impact in relation to what can be considered normal industry practice.

Concluding discussion

Different combinations of requirements are used in different countries. Rating schemes are used in Australia and the UK, and management standards are used in the NL (CO2 Performance Ladder) and the UK (PAS 2080). In the UK and Sweden, overall reduction requirements in relation to a baseline are most important. In the NL as well, this type of requirement is central, but used as an award criterion. In Australia, reduction requirements are included in the required rating scheme, but development is driven more by prescriptive requirements set by strong clients. In CHSR in California, prescriptive requirements for EPDs are in focus, while reduction requirements are open and not related to a baseline.

Overall, carbon reduction requirements are perceived to encourage innovation. Such requirements thereby align with a policy trend that major public clients increasingly rely more on performance specifications and collaborative models (Scheepbouwer and Humphries, 2011; Lahdenperä, 2012; OECD, 2015a; Wondimu et al., 2018; McKinsey, 2018). Key to this trend are high expectations regarding the innovativeness and general capacity of contractors (Volker et al., 2018). However, in previous research as well as in the cases studied, functional requirements have also been associated with implementation issues, since it takes time for contractors and other suppliers to develop competences and respond to new requirements. Further, previous research has shown that contractual incentives are often more complex to design and implement than the parties have foreseen, often produce unwanted side effects and sometimes function more as symbols than as sharp contractual instruments (Bresnen and Marshall, 2000; Kadefors and Badenfelt, 2009; Rose and Manley, 2010). The case studies illustrate that carbon reduction requirements are no exception. Below, we list some of the experiences gained when implementing contractual reduction requirements.

An important aspect is that it is difficult to set requirements at the right level. If performance criteria or incentive levels are set too low, contractors will not focus enough on carbon reduction. If incentives or risks are high, on the other hand, contractors may gear towards maximising incentive outcome by creative accounting in setting (fattening) baselines, calculating and reporting rather than on measures to reduce carbon. This is something that the interviewed clients wish to avoid, and two strategies to ensure contractors to engage in innovative behavior to achieve carbon reduction are identified in the case studies:

1. First, there is a “school-book” model, which aims to establish a very clear incentive structure combined with transparent and comprehensive systems for calculation of baselines, verification of performance and penalties for non-compliance. This requires competent clients and extensive support systems with reliable tools and actors with high legitimacy. The Netherlands comes closest to this approach, and in the A6 project the fact that only one contractor aimed for a maximum tender discount was seen as a proof that the requirements were set at the right level. The Anglian Water model is also based on sharp contracts and supplier evaluation processes that allow non-performing contractors to be laid off. The Swedish model includes penalties and bonuses, but in this case the precision in the incentive model would need to be further developed in order to more effectively produce the desired behavior based on a hard school-book approach.
2. A second strategy, associated with collaborative contracts, is to explicitly focus on producing behavioural change and stimulate innovation by setting ambitious goals, which purposefully should be challenging to the point that they are perhaps not achievable. This model relies strongly on selecting contractors with high competence and collaboration skills. Organisational measures to support collaboration and innovation are central, and carbon reduction goals are more of joint commitments than contractual requirements. Both UK cases operate on this basis, although one is a one-off mega-project and the other a long-term alliance. In the two-stage model of HS2, the first stage is fuzzy and open, partly because of the lack of previous experiences of the baselining model used. In this case, setting a realistic baseline demonstrating commitment to innovation was seen as proof that the desired mind-set and behavior was achieved. Anglian Water combines a sharp and transparent incentive structure with a strong focus on innovation and collaboration. Leadership is considered essential to achieve the ambitious targets of this scheme.

Another issue that has been raised in some interviews is what has been labelled “the psychology of baselining”. This refers to a tendency to count construction works that are left out of a scheme as savings that contribute to reaching carbon reduction goals, while added works lead to re-baselining. For example, when a bridge is removed it is counted as a saving but when a bridge is added the baseline will be adjusted. Clearly, this question deserves further attention in systems that aim to establish rigorous incentive models for carbon reduction.

Further, setting and updating baselines often require significant effort from scarce resources such as carbon specialists and skilled engineers. Thus, there is a risk that more time is spent on creating input data for measuring carbon reductions than on finding ways

to reduce impact. Another aspect is that the case studies show that reduction requirements take time to trickle down to subcontractors and suppliers. In Sweden, the material producers report that they have not been affected at all by the carbon reduction requirements and similar experiences are mentioned in other countries (and also in relation to overall reporting and rating requirements). This means that the full potential of carbon emission reductions achievable with current technology is not reached by using overall reduction requirements only. In Australia and more recently also The Netherlands, clients have used prescriptive requirements to influence actors further out in the supply and value chains. Altogether, reduction requirements may seem straightforward and appealing, but they are not quick fixes and need to be considered in relation to total transaction costs, market maturity and institutional context. An alternative, or complementary, approach is to investigate more in detail which decisions and practices that should be affected to reduce carbon emissions, and then analyse what is the best way to achieve such changes. Combinations with specific requirements, rating schemes, expert support and guidelines may often be preferable. As will be discussed in the next section, different strategies are effective depending on the maturity of the actors.

9.3. Implementation and learning aspects

Lack of knowledge and awareness of green public procurement procedures has been identified as a major implementation barrier (Brammer and Walker, 2011; Testa et al., 2016). In this section we discuss implementation and learning issues, first on the level of the individual project and then on the long-term, industry level.

Implementation in projects

Goals and measures for carbon reduction are new to many in the infrastructure sector, and both clients and industry partners need time to adjust and develop new competencies (OECD, 2016). The measures to achieve carbon reductions in infrastructure projects are multifaceted: they involve encouraging or allowing for new construction materials, optimising designs to use less materials and energy over the life cycle, coordinating use of masses within and between projects, minimising emissions from transport and site operation, as well as documentation, reporting and verification of requirements. Thus, similar to green public procurement in the construction sector in general, a wide range of project functions and supply chain partners are affected (Wong et al., 2016). Further, projects are temporary, and all decisions have a window of opportunity. At each point in time numerous aspects compete for attention by managers, designers and contractors. The focus of main contractors is on design optimisation and transport of masses, while time is often too short to involve subcontractors and suppliers in carbon reduction work. In most of the case study projects, interviewees representing environmental functions emphasise the importance of being available to the supply chain to inform, motivate and ensure that documentation is delivered. In Sweden, a lack of support from client expertise in carbon management has been identified as a key implementation obstacle in some projects. Thus, if requirements are to be implemented as intended, it is important that organisations have adequate skills and knowledge.

One way to address resource and time constraints is to move some of the organisational learning regarding carbon management from the project level to the organisational level, for example by management standards and rating schemes. The CO2 Performance Ladder system in the NL and the PAS 2080 guide both focus on organisational systems, while

project-based rating schemes such as IS Rating scheme, CEEQUAL and BREEAM Infrastructure also provide a common reference and knowledge. Another measure to increase knowledge in the supply chain is to offer education and training, for example in the Supply Chain Schools organised in the UK and Australia. Such measures align with the findings of Testa et al. (2016) that information and training sessions, tool kits and guidelines are important to spread green public procurement practices. In Sweden the National Construction Forum has also recently started developing common guidelines for carbon reductions for the civil work sector.

Many interviewees further emphasise the importance of breaking silo thinking and integrating competencies from different organisations in the supply chain in order to attain higher levels of carbon reduction. Opportunities for collaboration vary depending on the chosen delivery model, and more collaborative models carry a higher potential for integration than the traditional arms-length models (Sanchez, et al., 2015). Experience from Anglian Water shows that strong client leadership and commitment is essential both to legitimise collaborative contracting models and to achieve more fundamental behavioral change within such schemes. Financial restrictions have been identified as an important barrier to green public procurement (Brammer and Walker, 2011; Cheng et al., 2018). In the UK, the industry discourse (“reduce carbon, reduce cost”) has focused on communicating that reductions in carbon emissions in the infrastructure sector often lead to reductions in costs. In the other countries studied, this relationship has been less salient, although it is a common observation that measures that reduce carbon have most often been taken with the primary objective to save costs.

Further, in line with the findings of Testa et al. (2016) our interviewees highlight that a strong cooperation between the purchasing department and departments dealing with environmental issues within public client organisations (and within contractor firms) is important to be able to include carbon reduction criteria in procurement. In projects that aim to drive market development there is always a discussion about how new requirements impact on price and competition. Further, new follow up measures may be needed to render environmental requirements more powerful, and these may require active collaboration by procurement functions.

However, the review of requirements in the previous section clearly points at the limited innovation and change potential at the level of individual projects. Thus, the following section addresses the need for long-term learning between projects, organisations and government.

Long-term learning

Studies of sustainable and green public procurement (SPP/GPP) as well as of innovation procurement have shown that this area is complex and dependent on mutual interaction between demand-side requirements and supply-side development over longer periods of time (Brammer and Walker, 2011; Uyarra et al., 2017). Ambitions are often limited by the availability of green products and services on the market (Brammer and Walker, 2011; OECD, 2016; Wong et al., 2016). However, suppliers with the potential to provide innovation also indicate that the lack of interaction and understanding with the procuring organisations and over-specified demands in tenders constitute the main barriers for innovation procurement (Uyarra et al. 2014). Thus, OECD (2016) describes procurement

as an ongoing dialogue between the government, front-runner companies and purchasing units.

Our observations confirm this picture. How high requirements and ambitions can be set depends on the capacity of suppliers, client competence and support of internal procurement units. To drive innovation in the construction sector, actors that have a long-term perspective spanning many projects have a considerable advantage (Loosemore and Richards, 2015). Several of the organisations and projects studied have such long-term strategies and ambitions. In California, the CHSR project has an explicit strategy to leverage market power and raise requirements to drive innovation in the supplier market over a very long time. The project is an independent public body and can set its own requirements but, as mentioned above, there is a concern that too high requirements would limit competition and drive costs. However, the CHSR project comprises several successive sub-projects and the authority clearly communicates that requirements will be raised over time, thereby allowing suppliers to prepare and make investments. Consistency is reinforced by establishing relationships with research and environmental organisations, which create external expectations on CHSR that will be hard to walk back from. The Swedish Transport Administration has a similar ambition: their model is based on a long-term and transparent plan for requirements to be raised over time. In the Netherlands, the largest infrastructure client RWS has a policy to take one step forward in each large project in terms of environmental sustainability, including carbon reduction. In the Australian case studies, the Transport for New South Wales and Sydney Metro Authority have similar long-term strategies, where Sydney Metro has the ambition to always perform at a “world-class” level. In the UK, the example of Anglian Water demonstrates the learning potential of a long-term collaboration that allows for continuous improvement and standardisation. The large projects Crossrail and HS2 have developed innovation strategies, and industry-level collaborations have been established to help innovations to spread between projects. Thus, industry associations may be central actors, and more generally it is important to acknowledge how industry-level development activities interact with project-level activities and competencies.

Further, several interviewees mention that it is often assumed that innovation is most effectively driven in large projects. Clearly, mega-projects have a special role to play in innovation because of their visibility, market power and opportunities to engage the most competent individuals. Accordingly, the largest projects studied perceive that they are obliged to set high standards regarding sustainability even without explicit owner directives. However, really large projects are also often organisationally complex, bureaucratic and have many societal goals to fulfill. Thus, it may be hard to give a specific innovation process the attention required. Moreover, several interviewees point out that development of new products and innovations often require lengthy testing to gain approval for use in infrastructure projects, and that no project is large enough to encompass such processes. To speed up the innovation process, they suggest setting up pilot projects within smaller construction projects to test new solutions and then use the large projects to roll them out more broadly. This means that both large and small projects should be parts of a wider eco-system to orchestrate long-term innovation on the industry level.

This kind of structured learning between projects calls for large and competent clients who scan the environment for developments in technology and processes and who also know

the maturity of the suppliers. In the Australian cases, the client functions have driven development between projects this way, and in the Netherlands a small group of environmental experts within RWS handle sustainability requirements for large projects and successively raise requirements between projects based on experiences gained. Hence, the system for updating the standard specifications of large public clients is mentioned in many interviews as a significant obstacle to change, and the projects that are set up as independent entities perceive their freedom to choose which requirements to follow as an important advantage. Thus, the system for updating client standard specifications needs to be transparent and part of the innovation system.

In general, the results point to the importance of an ongoing dialogue between key public clients and the market, which requires both client competences and resources. For policy-makers, this means that policies should address not only the ambition levels but also the client role, resources and support for learning processes. In this respect, the current EU policy focusing on professionalising procurement should be a step in the right direction.

10. Conclusions and recommendations

In all countries studied, there is an ongoing process to develop and implement policies for carbon reduction in infrastructure projects, with raised ambitions over time. In some cases, the development has initially been driven by a few dedicated individuals, but today there are frameworks and executive mandates in place that would make it hard to avoid carbon reduction commitments. National and regional reduction policies were found to be important in encouraging clients to develop ambitious carbon requirements that can contribute to setting new industry standards.

Carbon reduction measures such as optimisation of constructions, minimised transport, reuse of excavated material and cement clinker replacement are applied in the studied cases. However, most of these measures are also cost efficient and would – or should – have been undertaken in a normal design and construction optimisation process. The positive side of this is that considerable carbon reductions may be achieved within existing budgets, and in most cases will even reduce cost, and that an increased focus on carbon may contribute to finding more such options. However, it also raises the question of what constitutes a relevant reference case, or baseline. Further, to meet the target levels of the Paris agreement, costly measures will also be needed, and this research identified only a few examples of such policies being implemented.

Goals for and measures of carbon reduction are still new to many in the sector, and both clients and industry partners need time to adjust and develop new competencies. In countries with a longer history of carbon management, procurement strategies and requirements have advanced through continuous interaction between clients and industry actors over longer periods of time. Clients are wary of introducing requirements that may limit competition, and requirements to comply with rating schemes or to supply EPDs have been introduced successively to match the development of industry capacity. Award (MEAT) criteria related to carbon are used, but more often to increase awareness of carbon reduction rather than as a substantive basis for selection. Front-runner contractors and material suppliers were found to play important roles in reducing obstacles to innovation-oriented procurement. Moreover, the development of procurement requirements has been aligned with information and training initiatives, tool kits and guidelines to support low-carbon design and the calculation of emissions. In general, client environmental specialists have taken an active part in supporting the implementation of requirements in supply chains.

Procurement requirements are important in driving carbon management in all countries, but the preferred style of these requirements vary. This diversity was partly related to general carbon management maturity and partly to general contracting practice and policy culture in the country or region. All countries used some form of contract-level reduction requirements, in most cases set in relation to a carbon emissions baseline. Overall, reduction requirements are perceived to encourage innovation, but our results show that implementation of such requirements was often more complex than foreseen and associated with substantial administrative costs. To produce change and avoid speculation it is important to set requirements and incentives at the right level, which requires awareness on the client side of both the supplier's competence and of the opportunities for carbon reduction in the specific project. Also, sharp requirements call for equally sharp and transparent performance evaluation. Moreover, much time was spent on calculation and re-

calculation of baselines which could detract from measures for actual reduction of carbon emissions. In effect, time constraints in the projects limited the opportunities to involve subcontractors and material suppliers, which meant that all possible reductions were not realised. We conclude that expectations for substantial and innovative carbon reductions through functional reduction requirements may be too high. To influence sub-contractors and suppliers directly, several clients use specific requirements.

Collaborative contracting models are a flexible option to encourage innovation and integrate knowledge of different participants. Many interviewees state the importance of breaking silo-thinking and integrating the supply chain in order to reach greater carbon reductions. Also, long-term alliances allow for continuous learning and more transformational innovation, including incentivising contractors to find ways of fulfilling client goals while building less. However, it should be emphasised that strong client leadership and commitment is essential both to legitimise collaborative contracting models and to achieve more fundamental behavioural change within collaborative projects and alliance schemes.

Clients in very large mega-projects perceive an obligation to conform to national policy goals and may also have ambitions to be industry-level change agents. Since such projects have vast budgets, last for long periods of time and engage highly competent firms and individuals, they are often expected to show high performance in the area of innovation. However, mega-projects have many goals to fulfil, are technically and organisationally complex and associated with high risks. Therefore, time and willingness to develop new ways of working or implement new technology may be lacking. Further, projects are not long enough to encompass processes to develop, test and approve new solutions. Thus, to support more efficient innovation processes in the industry, a long-term system perspective is needed. Interviewees suggested using smaller pilot projects for quicker testing of new materials, tools and technologies and, once proven, use procurement requirements in large projects to implement these more widely in the market.

Overall, the study shows that the applicability of procurement requirements for carbon reduction is dependent on how well these are aligned with culture, policies and capabilities in the local context. Inspiration may be sought from cutting-edge examples in other countries and regions, but practices may seldom be directly transferred. Also, it is clear that awareness, competence and capacity on the buyer (client) side is a key success factor. Such client capabilities involve constructive collaboration between procurement functions, environmental specialists and project managers. Further, policy makers need to acknowledge that measures to reduce carbon must align with existing procurement and innovation systems. To reach higher levels of ambition for carbon reduction, such institutional structures may also need to be changed.

Based on the findings, our recommendations to the target group of policy-makers and clients are:

Policy level – national, regional and organisational

- Set high-level goals and policies for carbon reduction in order to sanction ambitious initiatives that contribute to setting new industry standards.

- To reduce barriers for innovation-oriented procurement requirements, engage industry associations and encourage initiatives by supply-side front-runners.
- When developing organisational policies and strategies, address not only ambitions but also what roles the client and other parties should have in implementation.

Project level policies and procurement requirements

- When defining requirements, consider implementation costs for setting and following up requirements. In particular, be careful that focus stays on carbon mitigation measures and that calculation of baselines does not impact negatively on carbon management. Assess and mitigate behavioural risks associated with incentives.
- Ensure that requirements will be effective in influencing all relevant decision-makers in the supply chain (designing engineers, constructors and material suppliers). This implies that time, competence and resources should be available at relevant points in time.
- Apply a long-term learning perspective and acknowledge that different combinations of award and selection criteria, reduction requirements, specific requirements and rating schemes may be preferable over time.
- Align requirements and activities with general contracting models and encourage models that enable integration of knowledge and carbon management in the supply chain.

Innovation and learning

- Develop guidelines, tools and training programs to help build industry capabilities.
- Establish which organisations should drive development, for example commission, host and update guidelines, and provide training and support.
- Communicate plans for raised ambitions well in advance, for example requirements to comply with established carbon management standards and rating schemes.
- Orchestrate long-term innovation by combining small pilot projects to test new solutions with systematic implementation in larger projects to achieve wide market dissemination.
- Establish transparent procedures for updating client standard specifications based on frontrunner initiatives, planned pilots and academic research.
- Innovation should also address contracting and business models: develop institutional capabilities that enable and legitimise long-term, strategic collaborative alliances.

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Appendices

Appendix I - Interview Guideline

Initial questions

Please describe your current position and previous experience

Please describe your role in this project

1. Sustainability procurement requirements for reduction of greenhouse gas (GHG) emissions in the project.

1.1. What kind of procurement requirements for reduction of greenhouse gas emissions are used in the project?

- Which project phases do they apply to?
- Do the requirements refer to tender evaluation or to the implementation of the contract?
- Are they formulated as mandatory requirements, or connected to incentives/penalties?
- Are there requirements with a life cycle performance perspective?
- Do requirements include specifications for how to quantify the baseline, reduction measures and goals for emissions reductions? How?
- How do the requirements relate to what can be regarded as “normal” in this type of project?

1.2. What other sustainability requirements (than those pertaining to GHG reduction) are used in the project?

2. Basis for/origin of requirements, such as policies, standards or certifications.

2.1. Please describe your organisation’s sustainability policy/approach, especially for GHG reduction

- Which were the main drivers and barriers for the development of a sustainability policy and requirements?
- Can you describe the process of developing the sustainability (GHG) policy and goals?
- Which are the main actors that have been involved in this process?
- Have national and international political policies and legal frameworks played a role in your policy development? How?
- Has your general sustainability policy influenced procurement requirements for GHG reduction? If yes how? If no why?

2.2. Please describe the process and organisation for developing the requirements for this project.

- Which actors formulated the requirements for this project?
- Please describe how policy and requirements have evolved over time, both within the project and in a broader context, if possible.

2.3. In what way have sustainability certification schemes, standards or similar been used for the definition of policy or requirements setting?

- Which are the main drivers and barriers for using these types of frameworks /tools?

- 2.4. How have other project-specific factors (such as type of contract, individual competence and champions, organisation) influenced the formulation/style of requirements?

3. Organisation and processes for implementing and following up requirements

3.1. Describe the process and organisation for implementation and follow up of requirements

- Please describe the measures for reduction of GHG emissions that have been implemented in the project
- What routines are there for implementation of requirements for different phases/actors?
- How were routines developed? By whom?
- How free is the project to form its own organisation and process?

3.2. Describe your organisation's capability to handle/comply with sustainability requirements, especially regarding GHG reduction.

- Do you have the necessary human resources and competence?
- Do you have the necessary funds and timespan?
- Do you consider the required requirements to be realistic?

3.3. How do you evaluate compliance with the requirements?

- Who monitors and verifies compliance?
- How do you deal with non-compliance of requirements?
- How do you solve requirement uncertainties?

4. Mechanisms for learning and improvement

4.1. Please describe how you develop/improve your work with GHG reducing requirements, regarding formulation of requirements and follow up/monitoring?

- How are experience, progress, good and bad examples shared and used within and between projects?
- Is your organisation involved in any research project or similar regarding sustainability and/or climate?

5. Results

5.1. To what extent have goals been reached?

- Which of the measures for reduction of GHG emissions have been most successful? Have reductions been quantified?
- Which measures have been less successful? Why? What would you have done differently?
- Are reduction measures implemented as a consequence of requirements? Or would they have been realised anyway? Why?

6. Key success factors and barriers

6.1. Which drivers and success factors do you think are the most important in setting and implementing goals and procurement requirements for reduction of greenhouse gas emissions?

6.2. What are the most important challenges and barriers?

For example: type of requirements; in which phase the requirements are formulated; monitoring during and after the project; type of contract; use of certification schemes, policies, goals; competence and support; dialogue with suppliers; other projects; good and bad examples; resources; laws and codes; politics; clear directives; empowerment; engaged persons; other...

- 6.3.** What, in a project like this, is the single most important factor for achieving real reductions of GHG from the construction and management of the infrastructure?

Appendix II – Overview of interviews

Case study interviews performed within Impres project

Country	Project	Interviewees	Date
Australia	Sydney Metro Northwest	1. Senior sustainability manager- Northwest Rapid Transit, contractor. 2. Design and sustainability – WSP.	2017-12-01
Australia	Sydney Metro Northwest	1. Executive Director Safety, Sustainability and Environment, Sydney Metro Authority (SMA). 2. Planning approvals - SMA 3. Sustainability Manager - SMA 4. Two representatives of design and sustainability, previous contract – WSP.	2017-11-29
Australia	Sydney Metro Northwest	QEHS Manager - Hanson precast.	2017-11-29
Australia	Sydney Metro Northwest	Customer and market relationship manager – Liberty OneSteel	2017-11-30
Australia	Newcastle Light rail	1. Sustainability and Environmental manager, Newcastle Light rail - TfNSW 2. Sustainability manager – Downer (contractor). 3. Three representatives for design and sustainability – WSP.	2017-11-30
Australia	Newcastle Light rail	1. Lead design manager – Aurecon. 2. Representative for design and sustainability – WSP.	2017-12-30
Sweden	Ostlänken	1. Geology and hydrology coordinator – Sweco. 2. Coordinator of soil engineering and infrastructure – Sweco. 3. Coordinator of climate change mitigation – Sweco. 4. Environmental and climate specialist in Ostlänken – The Swedish Transport Administration (STA). 5. Project manager, Ostlänken Norrköping – STA 6. Head of sourcing, Ostlänken – STA	2018-05-18
Sweden	Road 44	1. Designing engineer – STA 2. Designing engineer – STA 3. Sustainably business development – Skanska. 4. Sustainably business development – Skanska. 5. Designing engineer – Skanska. 6. Coordinator of climate change mitigation - STA	2018-05-02

Sweden	Söderhamn – Marmarverken	<ol style="list-style-type: none"> 1. Designing engineer – NCC. 2. QA coordinator – NCC. 3. Environmental consultant – Tyréns. 4. Environmental specialist – STA 5. Project manager – STA 6. Sourcing – STA 7. Project manager carbon requirement research – STA 	2018-05-03
The Netherlands	A6 Almere	<ol style="list-style-type: none"> 1. Contractor Duravermeer, in JV, Parkway6 with Besix. 2. Environmental manager – Rijkswaterstaat (RWS). 3. Technical manager – RWS. 	2018-05-14
UK	Anglian Water, Grafham WTW Resilience and Dalton Piercy WTW	<ol style="list-style-type: none"> 1. Carbon specialist – Anglian Water. 2. Representative contractor – Mott MacDonald Bentley (MMB). 3. Head of engineering – Stantec, @One alliance. 4. Networks – Anglian Water. 	2018-04-26
UK	HS2	<ol style="list-style-type: none"> 1. Climate Change specialist – HS2 Ltd. 2. Phase 1 carbon manager – HS2 Ltd. 3. Sustainability manager – HS2 Ltd. 	2017-11-15
UK	HS2	Carbon specialist – SCS JV (contractor)	2018-04-25
USA	California High-Speed Rail	Regional Energy manager, West USA and Mexico – Gerdau Steel	2017-04-24
USA	California High-Speed Rail	<ol style="list-style-type: none"> 1. Sustainability Manager – California High-Speed Rail Authority (CHSRA) 2. LCA expert – WSP 	2017-04-25
USA	-	Representative of Institute for Sustainable Infrastructure (Envision)	2017-04-24
USA	California High-Speed Rail	<ol style="list-style-type: none"> 1. Procurement manager - CHSRA 2. Sustainability Manager – CHSRA 	2017-04-27
USA	California High-Speed Rail	<ol style="list-style-type: none"> 1. CEO - CHSRA 2. Sustainability Manager – CHSRA 	2017-04-27
USA	California High-Speed Rail	<ol style="list-style-type: none"> 1. Design and Construction Manager - CHSRA 2. Project Manager – HNTB 3. CEO – California Rail Builders 	2017-04-28
USA	SFO AirTrain Extension	<ol style="list-style-type: none"> 1. LEED Expert – WSP 2. Revit, LEED consultant – WSP 3. Sustainability director - Skanska US 4. Design-Build Manager – Skanska US 	2017-04-24

USA	SFO AirTrain Extension	1. Sustainability director – Skanska US 2. Design-Build Manager – Skanska US	2017-10-03
USA	SFO AirTrain Extension	Sustainability Director, SFO	2017-06-07

Appendix III – Overview of procurement requirements in case studies

Overview of procurement requirements for carbon reduction in case studies.

Type of requirement	Sydney Metro Northwest, Australia	Newcastle Light Rail, Australia	Motorway A6 Almere, the Netherlands
Selection and award criteria (qualification and MEAT criteria)	Questions about carbon management capabilities included in Prequalification Questionnaire and weighted in tender evaluation	None	Maximum 5% fictive tender discount based on CO2 Performance Ladder rating Maximum 5% fictive tender discount based on calculated DuboCalc Environmental Cost Indicator performance for tender
Technical specifications and specific requirements (functional, detailed, process, competence)	Specified requirements for replacement of cement depending on strength classes (MPa), 30% or more (referring to from Greenstar requirements of 30 % cement clinker replacement). Minimum 60 % of bar and mesh should be produced through energy reduction processes such as Polymer Injection Technology. Min 15 % of reinforcing steel from suppliers that use optimal off-site fabrication techniques such as engineered reinforcing bar carpet, engineered/customised mesh or prefabricated reinforcing cages.	Specified requirements for replacement of cement depending on strength classes (MPa), 30% or more (referring to from Greenstar requirements of 30 % cement clinker replacement). At least 25 per cent of site-based electricity energy needs has to be purchased from Green Power or renewable sources during construction of the asset – requirement from SDG 3.0 Requirement of use of TfNSW's Carbon Emissions Reporting Tool (CERT) – requirement from SDG 3.0 100 % green energy requirement for operation, by offsetting	"Energy Neutral" operation – PV panels have to be installed to compensate for operation energy need
Sustainability Assessment Schemes/Rating Schemes	Green Star rating for stations IS rating for infrastructure	IS rating (Excellent) SDG 3.0 (TfNSW Sustainable Design Guidelines v3.0) Gold rating (there are four levels, gold is second highest)	None
Carbon reduction requirements	LCA requirement for 15-25 % reduction of whole of life embedded carbon for material, where a part is reduction from cement. The requirement levels depend on type of contract and potential for reductions. The LCA requirement is demonstrated by using Greenstar LCA-tool or ISCA materials calculator. 20 % carbon reduction from electricity use and major fuels, during construction, by offsetting.	Requirement of reduction of carbon emissions, including development of baseline - a part of IS rating requirement	Included in DuboCalc requirement

Type of requirement	Swedish Transport Administration, Sweden	High Speed 2, UK
Selection and award criteria (qualification and MEAT criteria)	None	ISO 140001 compliance (pre-qualification requirement) Design challenge/design exemplar evaluated on bidder's carbon management capability (award criterion)
Technical specifications and specific requirements (functional, detailed, process, competence)	<p>For localisation and planning/early design contracts, with project budget above 5 MEUR:</p> <ul style="list-style-type: none"> - Perform carbon calculation with Klimatkalkyl. - Describe implemented reduction measures and recommended reduction measures for next project phase in report <p>For projects below 5 MEUR:</p> <ul style="list-style-type: none"> - Maximum carbon emission levels specified for cement/concrete and reinforcement steel (different levels for projects opening 2020-2024 and 2025-2029) - EPDs required for material above and construction steel - at least 20 per cent of the energy used for construction equipment and vehicles must be based on renewable fuel or electricity from renewable energy sources <p>For procured railway specific material:</p> <ul style="list-style-type: none"> - Maximum carbon emissions specified per product (with timetable for raised requirement levels) - Emission levels must be verified by product specific EPDs by delivery 	<p>Carbon management plan</p> <p>PAS 2080 compliance within 12 months of contract award (Tier 1 contractors)</p> <p>Euro 6 vehicles (air quality)</p>
Sustainability Assessment Schemes/Rating Schemes	None	BREEAM New Construction and BREEAM Infrastructure Excellent
Carbon reduction requirements	<p>Design and build contracts above 5 MEUR with start of operation 2020-2024:</p> <ul style="list-style-type: none"> - 15 % carbon reduction compared to baseline. Verified by carbon declaration based on Klimatkalkyl by end of project, and EPDs required for cement/concrete, reinforcement steel, construction steel <p>Design and build contracts above 5 MEUR with start of operation 2025-2029:</p> <ul style="list-style-type: none"> - 30 % carbon reduction compared to baseline. Verified by carbon declaration based on Klimatkalkyl by end of project, and EPDs required for cement/concrete, reinforcement steel, construction steel 	Reduction in carbon impact in relation to baseline. 50% reduction for main civil works, 30% for enabling works.

Type of requirement	California High Speed Rail, USA	SFO Airtrain Extension, USA
Selection and award criteria	None	None
Technical specifications and specific requirements (functional, detailed, process, competence)	<p>Where practicable, use post-consumer, post-industrial recycled products and materials or waste materials, such as fly-ash, Ground Granulated Blast-Furnace Slag, crushed glass, recycled aggregate and Tire Derived Aggregate.</p> <p>Use renewable energy when feasible.</p> <p>Evaluate the use of all reasonably feasible renewable energy sources.</p> <p>Conduct a cost analysis that compares the energy costs from renewable sources versus traditional electricity sources provided by local utilities.</p> <p>Evaluate the cost of purchasing green power from organisations that offer green power within the appropriate utility provider.</p> <p>Provide Environmental Product Declarations from suppliers and manufacturers for concrete mix designs used in elements of the Project, including pre-cast and cast-in-place concrete, and all steel.</p> <p>Provide a Sustainability Management Plan (SMP) to demonstrate how the Contractor shall meet or exceed regulatory and Contract requirements during design and construction activities, including establishing a baseline against which progress shall be tracked.</p>	<p>SFO Sustainability Stretch Goals:</p> <ul style="list-style-type: none"> - Develop a plan to minimise ecological footprint and carbon emissions associated with stations life cycle. <p>SFO Expanded Requirements:</p> <ul style="list-style-type: none"> - Reduce carbon emissions from natural gas consumption in building HVAC systems - Assign a life-cycle cost for carbon emissions - Perform LCA for material selection and evaluation of alternative design configuration <p>SFO Project-specific Requirements:</p> <ul style="list-style-type: none"> - Provide LCA data to inform the project design and product selection in accordance with the SFO Sustainable Planning, Design and Construction Guidelines - Provide whole building LCA (WBLCA) at each design phase, and utilise BIM with appropriate Revit Module (Tally) for development of the WBLCA. - Provide LCA data using EPDs for the major products and systems as made available by the product manufacturers.
Sustainability Assessment Schemes/Rating Schemes	None	<p>SFO Project-specific Requirements:</p> <ul style="list-style-type: none"> - Long-Term Parking Garage (LTPG) Station shall be a LEED v4 Gold-New Construction structure and shall strive for Net Zero
Carbon reduction requirements	<p>Reduce emissions and energy use below regulatory requirements and the estimated baseline by:</p> <ul style="list-style-type: none"> - use of cleaner engines: meeting or exceeding Tier IV and 2004 On-Highway Heavy Duty Engine Emissions Standards - use of cleaner fuels - use of cleaner diesel control technology - efficient use of fuel - use of renewable diesel or bio-diesel - reduction of energy use - efficient energy practices - efficient construction practices - materials delivery streamlining - other Contractor identified initiatives 	<p>SFO Expanded Requirements:</p> <ul style="list-style-type: none"> - Calculate carbon emissions from construction activities and take specific measures to reduce these emissions - Perform whole building LCA showing minimum 10% improvement for three impacts including climate change compared to a reference building meeting 2010 CEC requirements.

For the Anglian Water case, procurement requirements are not applied on the project level in the same way as for the other cases. Key components in the @One Alliance business model is therefore presented instead below.

Business model component	Content
Alliance design and procurement of alliance partners	<p>Identification of key elements for alliance model based on analysis and benchmarking of supply-chain models from different sectors</p> <p>Selection process of alliance partners based on collaboration commitment</p> <p>5 + 5 + 5 year alliance contract with 7 partners</p> <p>Evaluation of partner's performance every five years with renewal or replacement</p>
Carbon requirements/targets at the project/scheme level	<p>Common carbon reduction targets, for current AMP 60% reduction in capital carbon</p> <p>"Zero-fee" based model. Carbon and efficiency targets have to be exceeded to receive profit from gain share</p> <p>Baseline for targets set with AW standard calculation tool for cost and carbon</p>