



# The Why, What, and How of Environmental Performance Measurements in Civil Engineering Projects

An Analysis of Environmental Sustainability in Civil Engineering Projects

Master's thesis in Design and Construction Project Management

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AND CIVIL ENGINEERING



MASTER'S THESIS ACEX30

# The Why, What, and How of Environmental Performance Measurements in Civil Engineering Projects

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Department of Architecture and Civil Engineering  
CHALMERS UNIVERSITY OF TECHNOLOGY

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Cover:  
The 17 Sustainable Development Goals (SDGs) (United Nations Development Plan, 2022).  
Further explained at p.8.

Department of Architecture and Civil Engineering  
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### ABSTRACT

The thesis researches how environmental performance measurements (EPMs) can be used in civil engineering projects as a tool to work with environmental sustainability and project performance. The civil engineering industry has a significant environmental impact, and the project involves many different actors and processes. Using EPMs could be a way for all involved parties to gain an understanding of the impacts created, identify areas of improvement, and create a higher focus on sustainability in the industry. The aim of the thesis is to discover with an understanding and guidance of the use of EPM. Also identify what areas are of focus and how the tool can be approached for efficient and realistic use. The thesis is done in collaboration with the engineering consultancy firm WSP, and their management departments of infrastructure and construction. The research is based on theoretical information from literature, empirical findings from interviews regarding current project management from project managers, and analysis of sustainability reports and requirements from regions and WSP. The findings of the result are then presented by answering the questions of *why*, *what*, and *how* regarding the use of EPM, also discussing possible challenges. The conclusion is presented as a general guide for the civil engineering industry but also based on concrete information from the participating company to give concrete examples. Suggestions for future work for the industry is presented as well as further research areas that could give even more in-depth insight.

**Key words:** Environmental Performance Measurements, Civil Engineering, Construction, Environmental Sustainability, Sustainable Construction, Green Construction, Key Performance Indicators, Environmental Indicators, Environmental Management, Infrastructure, Urban Development, Project Performance

Användning av miljöprestandamätningar inom samhällsbyggnadsprojekt

En analys av miljömässig hållbarhet inom samhällsbyggnadsprojekt

*Examensarbete inom mastersprogrammet Design and Construction Project Management*

LOVISA LUNDBLAD

Institutionen för arkitektur och samhällsbyggnadsteknik

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## SAMMANFATTNING

Examensarbetet undersöker hur miljöprestandamätningar kan användas i samhällsbyggnadsprojekt som ett verktyg för att arbeta med miljömässig hållbarhet och projektprestanda. Samhällsbyggnadsindustrin har en enorm miljöpåverkan och projekten involverar många olika aktörer och processer. Att använda miljöprestandamätningar kan vara ett sätt för alla inblandade parter att få en förståelse för de effekter som skapas, identifiera förbättringsområden och skapa ett högre fokus på hållbarhet i branschen. Syftet med uppsatsen är att skapa en förståelse och vägledning för användningen av miljöprestandamätningar. Även identifiera vilka områden som är i fokus och hur metoden kan användas på ett effektivt och realistiskt sätt. Examensarbetet görs i samarbete med ingenjörskonsultföretaget WSP, och deras managementavdelningar för infrastruktur och bygg. Forskningen bygger på teoretisk information från litteratur, empiriska resultat från intervjuer gällande aktuell projektledning från projektledare samt analys av hållbarhetsrapporter och krav från regioner och WSP. Slutsatserna av resultatet presenteras genom att svara på frågorna om *varför*, *vad* och *hur* angående användningen av miljöprestandamätningar. Rapporten diskuterar även möjliga utmaningar med genomförandet. Slutsatsen presenteras som en allmän vägledning för samhällsbyggnadsbranschen men tar även upp konkreta exempel baserat på information från det deltagande företaget. Förslag på framtida arbete för branschen presenteras liksom ytterligare forskningsområden som skulle kunna ge ännu mer djupgående insikter.

**Nyckelord:** miljöprestandamätningar, samhällsbyggnad, konstruktion, miljömässig hållbarhet, hållbart byggande, grönt byggande, nyckeltal för prestanda, miljöindikatorer, miljömanagement, infrastruktur, urban utveckling, projektprestanda

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## Preface

I would like to say thank you to my supervisor and examiner at Chalmers, Martine, for helping me through the process and giving me guidance and feedback making it possible to carry the work forward.

I also want to say a huge thank you to WSP Management, and more specifically the department of Infrastructure south in Stockholm, for being a part of this study and the employees for participating with invaluable information and thoughts. Thank you, Sara and Lars, for introducing me to the company and helping me through the process. A special thanks to Sara for making me become a part of the team and involving me in activities during my work with the thesis.

Gothenburg January 2022, Lovisa Lundblad

## Notations

BIM – Building Information Model  
BVB – Byggsvarubedömning (the construction product assessment)  
CO<sub>2</sub> – Carbon dioxide  
EMAS – EU Eco-Management and Audit Scheme  
EMS – Environmental Management Systems  
EPM – Environmental Performance Measurements  
GHG – Greenhouse gas  
ISO – International Organisation for Standardisation  
KPI – Key Performance Indicators  
LCA – Life Cycle Assessment  
LOU – Lagen om offentlig upphandling (the public procurement act)  
PMM – Performance Measurement Management  
UN – United Nations  
UNEP – UN Environmental Program





# 1 Introduction

The civil engineering industry is a large industry that is active all over the world. The industry helps develop societies, create efficient infrastructure, and build homes. Even though the good that comes from its work is plenty, it also comes with other impacts. The environmental impact of the industry is hard to miss, and at times the construction industry alone, stood for 30% of global greenhouse gas-emissions, 40% of the global material employment and 45% of global waste disposal (Singh C. S., 2018). The projects of development and built are often extensive and requires a lot of resources when it comes to aspects such as materials and energy. Even though the sustainability work within the sector has come a long way, and work is still in progress, the implementation of environmental prioritising is hard and the topic is often overshadowed by other factors of success such as economy and quality (Presley & Meade, 2010). The concept of sustainable construction has therefor become more important, summarising the work within the industry to aim to *“deliver long term affordability, quality and efficiency, value to clients and users, whilst decreasing negative environmental impacts and increasing the economic sustainability”*. The aim captures all three aspects of sustainability, economic, social, and environmental. When it comes to the environmental impacts of the industry, one of the characteristics of sustainable construction presented by the UN environmental program (UNEP) is stated as, *“environmental aspects should be considering in the project and should include short-term as well as long-term aspect”* (Bal, Bryde, Fearon, & Ochieng, 2013).

To reach a significant improvement in sustainability worldwide the UN has developed 17 sustainability goals to be met by 2030. To meet these, and increase their performance in green acts, many companies and organisations have set their own goals and requirements when it comes to sustainability, environmental impact, and climate neutrality (United Nations Development Plan, 2022). To be able to set and follow up goals like this, performance measurements can be used. A commonly used tool to determined performance and benchmark goals is to use Key Performance Indicators (KPIs). Using the KPI approach includes strategical steps to determine specific areas and align the quantifiable focus areas with the strategical mindset and goal of the organisation. To further focus this use of method of measurements to the goal of sustainability, sustainability- and environmental performance measurements can be used. This to identify impacts of a company's products and services and, and in a strategical way analyse the work that is done today, what improvements can be implemented and in an efficient way report back to stakeholders (Epstein & Wisner, Performance Metrics, 2013).

To reach sustainability many technical aspects of a project is needed to take into consideration, together with the goals and visions from higher authorities. Even if techniques and tools for sustainable work within the construction sector has been developed there is still a lack of good implementation. The width of the industry also makes it hard to keep a consistency between all different clients, owners, stakeholders, and contractors (Lin, McKenna, Ho, & Shen, 2019). The implementation of sustainability is no longer a secret for success within companies, but the questions is not about if sustainability should be taken into consideration, but how. Even if the general concept of sustainability is well known, it does not provide any guidance on how the concept can be implemented into corporations' strategies.

This creates the questions of how drivers can be identified, managed, and measured. Some barriers that complicate the matter is long time stamp for results, uncertainty and impacts that are hard to quantify. The measuring can be done in different forms, with different outcomes. Depending on the companies and its services different approaches can be used, and different methods can be more suitable depending on companies' activities (Epstein & Roy, 2001). To reach the end goal, performance indicators need to be developed. Different indicators can be used in different situations to be able to quantify sustainability performance. The chosen strategy needs to be translated into data that can be measured and monitored. Sustainability goals in organisations are often broad, and to be able to use them efficiently it is needed to break them down to more specific objectives. This should also be clear when implementing new strategies, methods, technologies etc. to which performance measurement the new approach is valuable to (Epstein & Roy, 2001).

## 1.1 WSP Sverige AB

The company participating in this report is a global engineering consultancy firm, WSP. The company offers a broad range of services within urban development and technical solutions. The Swedish organisation is divided into seven different business areas; bridge and water construction, management, construction planning, civil engineering, advisory, systems and environmental. During 2019 the company's revenue was divided over their active sectors as following (WSP Sverige, 2019)

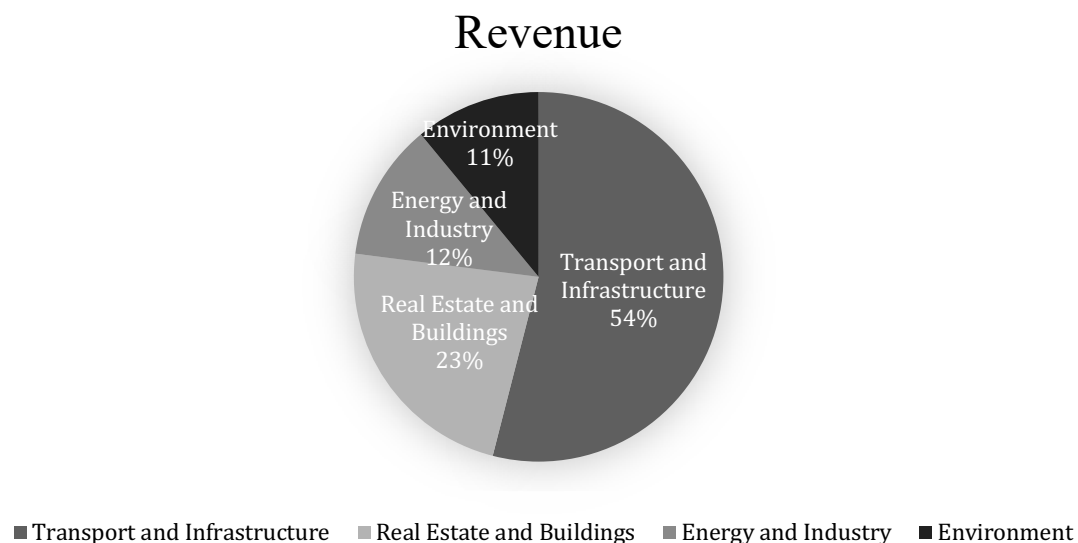


Figure 1. Division of global revenue in different sectors 2019 (WSP Sverige, 2019).

The department in collaboration for the research is WSP Management, Infrastructure. The business area works with project management task within infrastructure and construction projects for various clients, mostly within the public sector. The department of building construction and civil engineering was also included in parts of the study.

## 1.2 Aim

The aim of the study is to research how Environmental Performance Measurements can be used in civil engineering projects. This will conclude in researching *why* they should be used, *what* type of concrete measurements are most relevant to be used in the specific area of civil engineering, and *how* these measurements can be implemented and bring value to a project and organisation.

The end-goal of the report is to answer the following four questions of *why*, *what*, and *how*, and what challenges that may exist.

1. Why is there a need to use performance measurements for environmental impact in the civil engineering industry?
2. What indicators connected to environmental impact in the civil engineering industry is there a need and a possibility to track and measure?
3. How can these performance measurements be determined and transformed into useful KPIs?
4. What challenges may exist with implementing such methods?

## 1.3 Limitations

The research will have limitations to its scope. Firstly, the research will be limited to project that have their base in the civil engineering sector. This mostly focuses on urban development-, infrastructure- and construction projects. It will focus on the development, design, and construction phase of projects, and not the maintenance or running of finished projects. When it comes to the area of sustainability it will be limited to the environmental aspects. The other two aspects of social and economic sustainability might be mentioned throughout the report to receive a full picture of the sustainability concept but is not its focus nor its aim. The environmental indicators will try to be limited to quantifiable measurements.

The theoretical framework used is focused on performance management, both in general and in civil engineering. Examples and cases will be limited to civil engineering and narrow down in sustainability and environmental- impact and goals. The empirical information collected during the research is limited to one consultancy company in the urban development industry, WSP, and their projects, experiences, and reports. The methods used for the report will consist of already existing framework and approaches.

Even if theoretical framework is based of international sources, the interview- and case study is based of organisations and authorities from Sweden. Mentioned approaches and methods may be applicable all over the world but the empirical data collected is limited to Swedish standards.

## 2 Method

The report is based on three different areas of study. A literature-, interview- and case study. These to give information, facts, and insights on the current situation of environmental work within civil engineering projects and potential implementations of environmental performance measurements. The literature study was performed to provide with a theoretical framework to create a base for the topic. This by providing both accurate and credible methods that can be used within the limitations of the study and an insight of the status of the industry. Based on the findings in the literature study relevant questions for the interviews could be developed (Bell, Bryman, & Harley, 2019). The interview study was performed to give a current view of how work within actual project is performed, what are relevant areas to discuss, and which are realistic approaches. Lastly, documents from regions and participating company regarding sustainability were analysed and presented as a framework of what visions, goals and requirements that are documented.

The result from all three studies have later been analysed together in the aim of answering the four main research questions. Here, methods from the literature have been applied together with the empirical findings from the interviews and selected documents. This later continues to discussions regarding the results, leading up to conclusions, suggestions, and possible future areas of research.

### 2.1 Literature Study

The aim of the literature study is to gain information on the subject of environmental suitability and its use in civil engineering projects. This by looking at previous research and examples within the area, as well as existing methods and framework. The literature consists of printed and digital publications where the main sources used has been scientific databases such as Chalmers Library, Google Scholar, Research Gate and ScienceDirect. Keywords used for searches has included, but not limited to, “Environmental Performance Measurements”, “Sustainability in Construction”, “Key Performance Indicators”, “Environmental Measurements in Civil Engineering” and “Project Performance in Civil Engineering”.

### 2.2 Interview Study

The study is qualitative and based on the experiences, interpretations, thoughts, and opinions from the interviewees. The questions are formulated to give the interviewees the possibility to describe how they work in their current, and if applicable, past projects together with reflections. Since the study is based on individual experiences, every interview becomes unique, and a semi-structured approach was selected to be able to ask supplementary questions when needed to gain further understanding (Bell, Bryman, & Harley, 2019).

The questions were put together to be able to get an understanding of the current situation and awareness of environmental work in projects. Based on theories and knowledge found in the theoretical framework, but also the companies own sustainability documents. All this to get an idea of how the actual work is aligned with existing methods and visions and possible new implementations.



The results are later summarised and presented to see similarities, differences, trends, and further thoughts on the topic mentioned in the different interviews.

### **2.2.1 Collection of Data**

The interviews were semi-structured and focused on qualitative data based on the knowledge and experiences from work and projects of the interviewees. The semi-structured method was chosen to enable supplementary questions when needed (Bell, Bryman, & Harley, 2019). The base questions were pre-determined but could differ between interviewees depending on their role in the company. One set of base questions (appendix 1) were prepared for the interviewees with a leading role in projects. Here questions focused on how the managers work in their projects and their perceptions on implantation of sustainability into single projects. Another set of base questions (appendix 2) were prepared for interviewees with a general sustainability responsibility in the organisation. Those questions focused on how the organisation as a whole works with sustainability, focus areas, goals and follow ups in projects. The interview study includes a total of nine interviews, where eight interviews are with people on leading roles in projects and one person with a general sustainability responsibility in the organisation. The selection of interviewees was based on getting a spread when it came to both experience and project type. This to receive a full view of the areas included in “civil engineering”. Five of the interviews were performed online via Teams and four of the interviews were performed face to face. All the interviews were performed in Swedish, recorded, and later transcribed and translated to English. All the interviewees were aware of the recording and had given their consent.

Since the participants were all working on different types of projects, throughout this study a grouping was done dividing the projects into three different types. This to be able to spot differences and similarities between them. The projects were divided into groups regarding infrastructure, building construction and urban development. The groups were defined as following.

*Infrastructure projects - Projects regarding infrastructure of roads, tunnels, and bridges.*

*Building construction projects - Projects regarding construction of buildings, houses, schools, and apartments.*

*Urban development projects – Projects regarding exploitation of existing areas, city land, renovation of existing city parts. Groundwork, changing the development of existing areas and no clear new construction of buildings or other construction types.*

#### **2.2.1.1 Participants**

A total of nine interviews was conducted. Eight of the interviewees have leading roles in different civil engineering projects and one of the interviewees had a role with specific sustainability responsibilities within the company. The experience of the interviewees differed between three and twenty years. All interviewees with leading roles in projects worked as consultants at WSP and were placed on different projects for

different clients. All participants are kept anonymous but presented with their role and current project type to get an understanding of the spread of the study.

	Role	Current Project Type	Experience (years)
1	Project Manager	Urban development / Building Construction	> 15
2	Project Manager	Infrastructure	> 15
3	Project Manager	Building construction	> 10
4	Project Manager	Infrastructure	< 5
5	Project Manager	Urban development	< 5
6	Project Manager	Urban development	> 5
7	Design Manager / Internal support for sustainability	Urban development / Building Construction	> 5
8	Project Engineer	Infrastructure	< 5
9	Environmental Responsible	General guidance of sustainability for the civil engineering department	> 5

Table 1. List of interviewees.

### 2.2.2 Reliability

To make sure the research is trustworthy there are four different aspects that has been taken into consideration:

1. *Credibility*
2. *Transferability*
3. *Dependability*
4. *Confirmability*

(Bell, Bryman, & Harley, 2019)

The *credibility* of the study can be ensured by making sure to eliminate the risk of misinterpretation of the interviewee's answers on the questions. This was established by sending the transcribed and translated interviews to the respondents for approval and give them the possibility to comment if any misunderstanding or miss phrasing had occurred. This respondent validation secures that the result of the study is in line with the respondents and increased the credibility (Bell, Bryman, & Harley, 2019). All interviews were also promised anonymity, reducing the risk of dishonest answers or being bias. When it comes to the *transferability*, this study is based on the interviews from a relatively small group of employees at a large consultancy company, WSP. Even if the interviewees were placed on different project for different clients, and therefor represent different parts of the industry, this is still just a small

representation. Because of the issue of describing one culture and background regarding the questions the transferability might be reduced. But, on the other hand, as stated earlier the study covers a broad representation of the industry which can strengthen the transferability of the results (Bell, Bryman, & Harley, 2019). Since the aim of the study is to give a general description and idea of how approaches can be used in the industry overall this spread of sources seems like a good fit for the purpose of the study. The *dependability* of the study can be dependent on how well records were kept during the process (Bell, Bryman, & Harley, 2019). Since the interviews were conducted by one person, all sessions were recorded and then later transcribed. This to make sure the full concentration was directed on each part of the process. Firstly, to be able to during interviews engage fully in the session with the interviewee and ask follow-up questions. And later, focus fully on transcription and getting the full range of answers on record. Lastly, the *confirmability* of a study is reached knowing the researcher have been acted in good faith (Bell, Bryman, & Harley, 2019). The intention of the interviews study was to objectively interpret the answers, giving all the interviewees the same prerequisites and later also a chance to look over their transcribed interview and alert for misinterpretations if needed. To keep in mind is that a full confirmability can be hard to obtain when it comes to a social study. To keep in mind also is that the researcher was located at the company's office and therefor had relationship to both the company and some of the interviewees, which can affect the aspect of objectivity.

## 2.3 Case Study

Documents regarding requirements, goals and focus areas connected to sustainability in civil engineering projects from regions and a company were analysed. The most relevant information for the aim of the study has been summarised. This to see how guidelines and requirements are used and on what environmental areas the focus is directed. This can lay as ground to later analyse where focus in single project should be directed and where there might be need of improvements or further work. The findings of the study are directed towards the areas regarding environmental impacts in the project phase of a civil engineering project.

The requirement from the regions is limited to larger cities in Sweden. This since it is the country of where the study is performed. Besides that, the cities often act as clients when it comes down to civil engineering project. This to give an example and general idea of what type of requirements that can be set from both a regional aspect and, from a client and project owner in Sweden. The requirements can be used as guidelines of what areas there is a requirement to measure environmental impact and what standards that are set.

The results from WSPs work on sustainability is to give an example of how the strategical approach from a company in the industry can look. Also being able to connect to the result from the interview study which is based on participants from the same company.

### 3 Literature Study

The literature study consists of existing research and information. It will present an overview of the area of sustainability and its role in construction projects. Then continue to lay a ground for performance measurements and its implementation in general and specifically in sustainability. Further, performance indicators will be explained and how they can be determined.

#### 3.1 Sustainability in General

Sustainability is a concept more often used all over and refer to as the “Development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. Meaning to preserve and not to use up nor waste the resources humans are provided by nature and can thus be divided in to three main categories: Environmental sustainability, economic sustainability, and social sustainability (Burgess & Barbier, 2017).

##### 3.1.1 UN Goals

To be able to create a more sustainable world the UN collaborated and proposed “The 2030 agenda for sustainable development”. The work was presented as 17 sustainable development goals (SDGs) to be adopted by all nation members of the UN. The goals were to cover all three dimensions of the term sustainability (United Nations Development Plan, 2022). The goals are set out to reach sustainability when obtaining all of them. The 17 goals also each have a main objective of one of the three sustainability dimensions: social, economic, or environmental (United Nations Development Plan, 2022).

Nr	Goal	Dimension
1	No poverty	Economic
2	Zero hunger	Economic
3	Good health and well being	Economic
4	Quality education	Social
5	Gender equality	Social
6	Clean water and sanitation	Economic
7	Affordable and clean energy	Economic
8	Good jobs and economic growth	Economic
9	Industry, innovation, and infrastructure	Economic
10	Reduced inequalities	Social
11	Sustainable cities and communities	Environmental
12	Responsible consumption and production	Environmental
13	Climate action	Environmental
14	Life below water	Environmental
15	Life on land	Environmental
16	Peace, justice, and strong institutions	Social
17	Partnerships for the goals	Social

Table 2. The 17 sustainability development goals (United Nations Development Plan, 2022).

The goals are widely used as a map for countries, industries, and people to show what and how to act more sustainable. Many companies use the goals and fit them into their own goals and visions for their business.

### 3.1.2 Environmental Sustainability

One of the three categories in the concept of sustainability is the environmental sustainability. This area has its focus on the human impacts that are made on the environment and our surroundings. Preserving natural resources, sparing the climate, and keeping our biosphere intact are some issues to consider. The definition can be summarised as the balance of human society to satisfy their needs while not exploiting the ecological systems (Morelli, 2011).

## 3.2 Sustainability in the Construction Industry

The construction industry has a great responsibility when it comes to sustainability. The industry alone has at a time stood for about 30% of global greenhouse gas-emissions, 40% of the global material employment and 45% of global waste disposal (Singh C. S., 2018). This has made it a must for the industry to take on the challenge to improve and develop for the better. The summarised concept of sustainable construction is to *“deliver long term affordability, quality and efficiency, value to clients and users, whilst decreasing negative environmental impacts and increasing the economic sustainability”*. According to the UN environmental program (UNEP), sustainable construction should follow following characteristics:

- *Routinely designed and maintained to optimise the entire lifespan*
- *Sustainability considerations and requirements should be taken in building legislation and standards*
- *Environmental aspects should be considering in the project and should include short-term as well as long-term aspects*
- *Policies and incentives provided by the government to support sustainable building and construction practices*
- *Investors, insurance companies, property developers and buyers of buildings are aware of sustainability considerations and should take an active role to encourage sustainable building and construction practices.*

(Bal, Bryde, Fearon, & Ochieng, 2013)

The three different dimensions of sustainability, social, economic, and environmental, can occur in the concept of sustainable construction. Here is the social sustainability addresses how constructions are developed in a way of improving the quality of life. The economic sustainability addresses factors such as opportunities like employment, competitiveness, maintenance, and productivity in the industry. The environmental sustainability is involved in most stages of an actual construction process. All from design choices, processes in production, maintenance, and overall work with decreasing the amount of pollution, emissions, raw material usage, maintenance of environment and biosphere (Baloï, 2003).

One of the most discussed long-term solutions is to adapt to more cyclical processes. This might give less of a direct impact but can result in long-term sustainability and solutions that can overtake linear and environmental damaging processes overall. This

can include designing and building more energy optimised constructions, environmentally friendly materials, use processes with a lower carbon dioxide outlet, recycle materials and minimise waste on site (Miyatake, 1996). The adaption to sustainable construction can not only benefit from the sustainability in general, but also boost companies by material savings from reuse and waste recycling, lower energy consumption, lower life cycle costs, higher life length on projects and over all safer work (Baloi, 2003).

Barriers when it comes to sustainable work and measurements are that existing tools, techniques, and indicators are very broad and creates a lack of effectiveness when evaluating sustainability. There is also a lack of cohesion between definitions of what is sustainable and one single definition or measurement. With many different methods and guides it can be hard to find the right path to follow. This may lead to unnecessary work, or analyses in the wrong area that do not result in any useful information (Khan, et al., 2018). In a study on a construction projects environmental impact, it showed that the most common problems with maintaining the green approach related to misinterpretation, non- compliance, lacking communication and negligence. Which can all be an effect of bad habits or lack of knowledge with sustainable approaches (Baloi, 2003). The measuring and analysis of sustainability in projects can often relate to extra work, there is a need for efficient calculations and good implementation of methods. This especially in the design phase when everything is an estimation.

### **3.2.1 Processes and Activities**

There are many different stages, activities, and processes at work in the construction industry, differing depending on project. It is hard to set one stand-alone concept of “sustainable construction”. Going all through development, design, construction, maintenance and waste, many different parties are involved and work in different ways with different areas. An attempt to narrow it down into part processes that are in need to be done to reach a sustainable end goal was done, concluding in six principles:

- 1. Minimise recourse consumption*
  - 2. Maximise recourse reuse*
  - 3. Use renewable or recyclable recourses*
  - 4. Protect the natural environment*
  - 5. Create a healthy, non-toxic environment*
  - 6. Pursue quality in creating the built environment*
- (Miyatake, 1996).

When it comes to a construction project, the sustainability aspect can be looked at in different stages, the design, and the construction. In the design phase involves the planning, modelling and design choices of what the future product is to be. The design phase can also be divided in to two groups, the scheme design, focusing on existing prerequisites, and the detailed design focusing on the new product. The construction phase is the actual process of building or creating the product. Here the actions taken place on site are relevant, approaches and process choices are in focus (Baloi, 2003).

Design (Scheme)	Design (Detailed)	Construction
Effects on existing land	Structure	Site layout
Water resources	Materials	Traffic / Transports
Atmosphere	Energy layout	Chemical emissions
Ecology	Aesthetics	Noise and vibrations
		Waste

Table 3. Examples of different environmental impact areas in the different phases (Baloi, 2003).

The choice of materials has a significant impact, and during a life cycle analysis of construction materials used in a residential construction, concrete accounted for 60% of the total energy and concrete and mortar combined accounted for 99% of all the CO<sub>2</sub> emissions (Singh, Berghorn, Joshi, & Syal, 2011). An activity shown by studies to have relatively low impact on the environment is the transportation of materials. According to different case studies the transportation only stands for about 1% of the total environmental impact from a construction project. This often because materials are locally produced, but even if not, it does not give that much impact compared to other processes. It is first when all the materials are shipped over longer distances it can become an issue (Buyle, Braet, & Audenaert, 2012).

### 3.2.2 Actors and Stakeholders

When it comes to larger projects there is the dimension of involvement of many different actors. The full process involves different steps with different players that all have different agendas and objectives. This can create a disruption in the sustainability concept, being hard to get everyone align. The line can involve clients, contractors, suppliers, consultants' engineers, and architects (Mokhlesian & Holmén, 2012). A good stakeholder- engagement includes frequent communication and feedback. This can help the project when it comes to synchronising all different priorities and can thus be a good compliment to sustainability development. There is higher change of long-term success if expectations from and to stakeholders are being taken into consideration (Bal, Bryde, Fearon, & Ochieng, 2013).

In a study performed by Bal, Bryde, Fearon & Ochieng in 2013 on stakeholder engagement in relations to sustainability it was stated that performance targets of sustainability are a must to encourage further work in sustainability, and these needs to be shared with all stakeholders (Bal, Bryde, Fearon, & Ochieng, 2013). The aim of performance measurements is to measure and present performance and by this also be able to identify areas in need of improvement. When it comes to stakeholder, all stakeholder's performance is in need to be measured to see if their decided outcomes are met. A definition of performance is needed to be decided in all different areas to know what to measure, and with which approaches. Given a measurement of the stakeholder's performance creates a foundation to start from when determine the overall sustainability performance. The performance measurements should also be a two- way street, where stakeholders can give feedback on approaches, identify areas of errors and with this also keep up the engagement and motivation. The use of performance measurements was shown to be a key factor in a successful stakeholder engagement when it comes to sustainability, where the key factors included:

- *Identifying all key stakeholders*
- *Relating the stakeholders to different sustainability-related targets*

- *Prioritising the stakeholders*
- *Managing stakeholders*
- *Measuring their performance*
- *Putting targets into actions*

(Bal, Bryde, Fearon, & Ochieng, 2013)

Even though stakeholder involvement is an important factor to be able to peruse more environmentally friendly actions in all areas, in some cases clients and stakeholder may lack the information that is needed to make a sustainable choice. What different impacts that can be made by following different options is not clear. This makes it impossible to make a move based on sustainability since the information on what action gives away what impact does not exist. This problem can be based of low sustainable awareness and lock of mandatory information (Ochieng, et al., 2014). Companies are often keener to adapt to the greener process if there are incentives put in place for it. This can be tax, rental rates, help from governments etc. It has also been showed that people are willing to pay more for greener buildings, proving that the greener choice can be more beneficial for companies in the long run (Presley & Meade, 2010).

### 3.2.3 Infrastructure and Urban Development

With an increased urbanisation more pressure is put on infrastructure projects. This creates a demand for the civil engineering sector to develop tools to measure and monitor urban development, both through engineering and management (Sahely, Kennedy, & Adams, 2005). Governments spend a significant amount on new infrastructure every year. This to keep on developing the cities and create new and improved ways of livening. Infrastructure constructions often have large impacts on the environment and should be developed to bring sustainability in all three factors, economic, environmental, and social. Unfortunately, the environmental and social impact of infrastructure projects are often not assessed correctly and therefor only discovered after the project implementation (Shen, Wu, & Zhang, 2011).

A case study on an urban water system in Toronto displayed how sustainability criteria can be used in infrastructure projects. One thing that was detected early on was that the data that was needed to be collected was hard to gather since often information was scattered out on various departments, both on companies and governments side. This means that the collected data that gave out the frame for environmental indicators performance was not easily obtained (Sahely, Kennedy, & Adams, 2005).

The infrastructure industry has become a huge source of greenhouse gas-emissions. Most of these come from the development and use of materials and components needed for those type of projects (Kadefors, Uppenberg, Alkan Olsson, Balian, & Lingegård, 2019).

<b>Carbon emission source</b>	<b>Percentage out of total emissions from infrastructure projects</b>
Concrete / Cement	43 %
Fuel	25 %
Reinforcement steel	11 %



Structural steel	10 %
Asphalt	4 %
Explosives	4 %
Other	3 %

Table 4. Carbon emissions from planned investments in infrastructure projects in Sweden 2018-2019 (Kadefors, Uppenberg, Alkan Olsson, Balian, & Lingegård, 2019).

### 3.3 Performance Measurements

Measuring performance is a common action within companies. It can be conducted systematically and regularly throughout the operations or as an evaluation of one project. Performance measurements is an important tool for companies and organisations to be able to make supported decisions and examine their status. The measuring of performance can be made on many different areas in an organisation but has traditionally been used most often with a financial focus (Parker, 2000).

#### 3.3.1 KPIs

Key Performance Indicators, also known as KPIs, can be described as a set of measurable quantities of data collected to present performance. These values are used to measure progress and performance with obtaining different goals. There can be high-level KPIs that describe overall performance or low-level KPIs that are more specific to one area of the project. Using the indicators is a way of communicating information in a concrete way and generate measurables based on specific objectives. KPIs are often used in business situations as a tool to analyse performance (Klipfolio, 2021). The use of KPIs makes it possible to compare the estimated value to the performed value and evaluate effectiveness and efficiency. The most easily used KPIs are those who can be easily gathered, quantified, and measured in units. This could be in SEK, kg, CO<sub>2</sub> etc. (Cox, Issa, & Ahrens, 2003). KPIs have become an important tool for companies to keep on developing and monitoring their results. If an organisation does not have enough information about their work, they cannot control it. KPIs can be used to either create and developing a guiding function that steers the organisation in the right direction and helps when implementing strategies, or, and motivational function that uses goals to motivate workers and stakeholders to reach the desired outcome (Velimirović, Velimirović, & Stanković, 2011)

KPIs can be defined by following questions:

- *What is the desired outcome?*
- *Why does this outcome matter?*
- *How are you going to measure progress?*
- *How can you influence the outcome?*
- *Who is responsible for the business outcome?*
- *How will you know you have achieved your outcome?*
- *How often will you review progress towards the outcome?*

##### 3.3.1.1 KPIs in Construction Projects

Project performance in construction projects is often reviewed when the project is finished. By implementing KPI based performance indicators it opens for continues

checking of the project and better support for ongoing decision making, “*what gets measured gets managed*” (Rathnayake & Ranasinghe, 2020).

Based on a literature review for determining KPIs and Performance Indicators for performance in a construction project in Sri Lanka, KPIs were detected by selecting the main sections of a green building policy. This resulted in KPIs based on the main areas in the policy, and then also dividing the KPIs into two different stages, based on the design-phase and the construction-phase (Rathnayake & Ranasinghe, 2020). The same approach was used in research on renovation projects. The KPIs were determined on existing policies to be able to draw key number from. The KPIs were here also chosen based on that they were able to be quantified in specific metrics, such as kg CO<sub>2</sub> per kg emission (Kylili, Fokaides, & Jimenez, 2016).

### **3.3.2 Sustainability Performance**

Due to more pressure on performing well when it comes to sustainability, more companies feel a need to use sustainability performance framework. This to create understandable values to use internally and externally. The sustainability impacts of company’s products, services and processes are in need to be identified and measured. Much of the information that is in need to be captured is not routinely identified and implementing new tools, metrics and techniques is necessary to gain a correct picture of the company’s sustainability status (Epstein & Wisner, Performance Metrics, 2013).

The importance of using performance measurements lays in the ability for the company, as well as stakeholders, to be well informed about the performance and the possibility to compare different investments, actions, and approaches to each other. To be able to act in a sustainable way it is necessary to know the current impacts and what opportunities there are for change (Schaltegger, Etxeberria, & Ortas, 2017). This also makes it possible for managers to make well informed and up to date decisions during the project process. (Bassioni, Price, & Hassan, 2004).

One approach for sustainability measuring involves the three steps of formulating the sustainability strategi, developing plans and programs and designing appropriate structures and systems. When sustainability aspects of the company’s activities have been identified a strategy is needed to be developed than is in line with the companies’ goals. If activities such as energy consumption or greenhouse emissions are high impact activities strategies, goals or focus areas may be developed in order to increase those specific areas. The development of plans and programs can take two roads, aim to improve environmental and social performance, which can conclude in changes in routines or new business strategies, and promoting sustainable, which can conclude in communicating and marketing sustainable products to stakeholders. Designing appropriate structures and management systems translates the strategy into action. Many companies use well known frameworks such as ISO14000 to guide them in their choice of implementation and strategy (Epstein & Roy, 2001). There are many different existing frameworks for performance measurements. This makes it important to know that they all address different aspects of a successful project, and their results cannot be compared to each other (Bassioni, Price, & Hassan, 2004).

A positive attribute of using sustainability performance measurements is that, unlike financial measurements which rely on past and current performance, they predict or motivates towards future changes and performance. This also makes feedback on performance an important factor to be able to adapt changes. Many companies work without quantifying their actions and impacts on the environment, and only act in a way because they think it is sustainable. Using the performance goals makes it possible to both set up concrete ways of reaching them and getting proof on that the action have a positive impact (Epstein & Roy, 2001).

A proposed framework to developing performance measurements contains following steps:

- *Setting priorities*
- *Identifying the casual relationships*
- *Developing appropriate measures*
- *Collecting and analysing data*
- *Reviewing the framework*

(Epstein & Roy, 2001).

### **3.3.3 Green Construction Performance Measurements**

To ensure improvement in the green processes it is important to have the right tools and methods to analyse how to improve and continue the process. This creates a huge need for management to implement strategies and performance measurements to make it possible to see what is done and where there is need of improvement. Performance measurement management (PMM) has become more common in the industry. Closely linked to PMM is effective indicators of performance, and one important characteristic is that they should not only focus on financials. It is becoming more and more important to measure performance in the construction industry in other ways than just financially. But indicators that often result in a measurement of an overall “project success”, even if containing different factors besides cost such as time, productivity, default etc., does often not mention sustainability (Presley & Meade, 2010). As green construction becomes more popular, and necessary for both the companies and stakeholder, many different “grading systems” for sustainable construction have been developed (Presley & Meade, 2010).

Putting actions into measurable quantities also makes it possible for benchmarking. Benchmarking is a way of comparing performance to the best in the market and evaluate their own business. In construction benchmarking can be used to determine one’s position in relation to other companies or try to learn and incorporate ideas from the best in the industry. KPIs are an easy measurement to use when benchmarking (Presley & Meade, 2010). However, because of the lack of standardisation in construction project it can be harder to have easy access measurements. Studies show that service industries, such as the construction industry, tend to not use performance indicators as much as companies in the product manufacturing industry (Campos, de Melo Heizen, Verdinelli, & Miguel, 2015).

When developing KPIs for construction projects some things need to be considered:

“

- *KPIs are general indicators of performance that focus on critical aspects of outputs or outcomes*
- *Only a limited, manageable number of KPIs is maintainable for regular use. Having too many (and too complex) KPIs can be time- and resource – consuming*
- *The systematic use of KPIs is essential as the value of KPIs is almost completely derived from the consistent use over a number of projects.*
- *Data collection must be made as simple as possible*
- *A large sample size is required to reduce the impact of project specific variables. Therefore, KPIs should be designed to use on every building project.*
- *For performance measurements to be effective, the measures or indicators must be accepted, understood, and owned across the organisation.*
- *KPIs will need to evolve, and it is likely that a set of KPIs will be subject to change and refinement*
- *Graphic display of KPIs need to be simple in design, easy to update and accessible.* “

(Chan & Chan, 2004)

Even though many techniques and methods on sustainability have been developed there has been a lack of good implementation due to lack of coordination between all construction parts. There is also a lack of consistency in the industry on what methods to use (Lin, McKenna, Ho, & Shen, 2019). When it comes to performance indicators in construction projects, according to research made on projects in the public sector, sustainability and environmental measures was the least used out of the performance measurements (Adams, Muir, & Hoque, 2014). But, in another study on Green Building and what factor that have an impact on the industry, environmental factors were in the top.

### **3.4 Sustainability Indicators**

There is a need for sustainability metrics to be developed and implemented in the construction industry. This to be able to evaluate the effectiveness, both when it comes to cost and environmental impact, when it comes to bigger development projects. It could be used as a catalyst to promote investments in sustainable projects and technologies. The challenge when it comes to developing such metrics systems is to evaluate all aspects of sustainability, social, economic, and environmental (Tatari & Kucukvar, 2012). Indicators can be simple, holding the value of one variable, or composite, holding the value obtained from several variables (Bockstaller & Girardin, 2003).

#### **3.4.1 Environmental Performance Indicators**

Environmental aspects in sustainability and its indicators can be described as “*are the essential tools for tracking environmental progress, supporting policy evaluation and informing the public*” (Tudorica, Banacu, & Colesca, 2021). Environmental indicators can be divided in to four categories, the state of the environment, corporate environmental policy, environmental management systems and, the products and processes of the company (Azzone & Noci, 1996).

One method to measuring sustainability is through the two concepts: indicators and criteria. With indicators the environmental state can be measured and monitored by numbers and variables. The criteria are the benchmark of which the indicator is compared against to determine its sustainability. The criteria are used to see if the indicators are reaching the set goals or sustainability. Indicators are not useful alone but becomes interesting when being compared to other indicators, for example when monitoring changes. It is also important to identify relevant indicators and know how to interpret their data to use it to develop strategi for change (Sahely, Kennedy, & Adams, 2005). The indicators that are most often used in companies have been shown to be the once that are directly connected with legal documents or policies. This can indicate that using environmental legalisation documents is a huge influence when implementing environmental measuring (Campos, de Melo Heizen, Verdinelli, & Miguel, 2015).

Performance indicator can be quantitative or qualitative. The quantitative indicators are efficient to use for defining “the state of the environment” and can give an indication on how the companies activities impacts the environment. Indicators that often are connected to company activity and used widely over all industries when comparing are, emissions, waste, energy, and transportation (Azzone & Noci, 1996).

### 3.4.2 Identifying Performance Indicators

Working with environmental performance there is a need to identify and select which environmental indicators that should be used. To start the company’s key characteristics needs to be defined. This to be able to understand what policies the company follows and what their environmental goals are. This to be able to break down indicators that are representative and fitting for a specific company and aligning with their visons and actions (Azzone & Noci, 1996).

One method for identifying environmental performance indicators within a company has been developed for the purpose of creating recognised and comparable indicators between companies. The method involves identifying the environmental problems, both in general (macro-level) and within the company’s activities (micro-level). This method uses the goals from higher management level to then divide them into concrete actions. Since the method can be adapted depending on goals and actions this is fitting for the civil engineering industry, where different project may have different prerequisites. General environmental issues can be identified by using global goals, agreements, and protocols. Then the comparison can be made with the company’s activities to see which activities that are relevant for the specific company (Müller & Sturm, 2001).

Protocol, goal, etc	Global problem	Macro – micro link	Impact on industry’s environmental performance	Impact on industry’s financial performance
Goal X	Yes	Yes	Yes	Yes
Goal Y	Yes	No	Yes	Yes
Goal Z	No	Yes	No	No

*Table 5. Example on identification of environmental performance indicators. This result would conclude in selection of environmental problem connected to goal X and goal Y (Müller & Sturm, 2001).*

When the environmental problems have been selected there is a need to quantify the company's impact and contribution to the specific selections of problems. Here a classification can be done, to decide which activity and variable contributes to which environmental problem. Then a characterisation can be done to answer to which extent the activity contributes to the environmental problem (Müller & Sturm, 2001).

<b>Environmental Problem</b>	<b>Environmental activity</b>	<b>Sub-activity</b>		<b>Environmental performance Indicator</b>
Waste disposal	Solid and liquid waste	Solid non-mineral waste	-Non-hazardous - hazardous	Waste disposal
		Liquid waste	-Non-hazardous - hazardous	
Depletion of non-renewable energy resources	Energy purchase	Purchased fossil energy  Purchased electricity	oil gas natural gas	Non-renewable primary energy input

Table 6. Example of identified environmental performance indicators based of analysis of chosen environmental problems (Müller & Sturm, 2001).

The presentation of defined indicators in a chosen quantity and measure can be performed in different ways depending on the context, and then also be interpret in different ways. Either it can be presented in absolute terms, in terms of ratios relative to activity or in benchmarked values. The format should be chosen depending on what meaning that wants to be brought from the values (Azzone & Noci, 1996).

### 3.4.3 Carbon Accounting

Producing carbon accounting reports can one way of displaying the effects and problems and give a reference to what goals are needed to reach for. Carbon management accounting can be the method to successfully operate and implement carbon accounting into a corporate. This includes to identify current operations with a carbon impact, forecasting the future emissions, identify how reduce can be made and what effects this would have on different company areas and support the implementation of measures on the area and monitor them (Schaltegger & Csutora, 2012).

Carbon accounting can be used in two different ways, identifying un-sustainability "carbon accounting of un-sustainability" or identifying sustainability improvements "carbon accounting for sustainability improvements". Where the first identifies what negative impacts carbon emissions have and can create clarity and awareness of the issue and identify weakness in areas. The second one is used to support identification on choices and implementations. It can give an illustrated result on how well new measures have performed and what implementation is the most efficient. Different functions and scopes can be used for carbon accounting, so it is important to be specific and know what is measured. The detection of key indicators is important because they can be different depending on the industry, company, and wanted result.

CO<sub>2</sub> per produced unit can give one aspect, CO<sub>2</sub> per earning in sales gives another. Existing environmental policies, strategies and goals are essential to make any sense to numbers and have some general goals to compare to (Schaltegger & Csutora, 2012).

### **3.4.4 LCA**

The Life-cycle assessment is a technique to determine the environmental impact by analysing the whole life span of the product, “cradle to grave”. This goes all from material extension to final waste handling. The LCA tool is often used in decision making (Bueno & Cheung, 2015).

A standard for the LCA approach had been developed by ISO. This also contained a four-step approach for conducting a life cycle assessment, with the four steps being, goal and scope definition, inventory analysis, life-cycle impact assessment and interpretation (Singh, Berghorn, Joshi, & Syal, 2011).

#### **3.4.4.1 LCA in Construction Projects**

In a case-study of civil engineering performed by Ortiz, Castells & Sonnemann in 2009 the LCA method was used in road construction and waste disposal. The LCA analysis came with results on how to develop concrete solutions on the problem areas and implement strategies such as recycling of building materials. The LCA can also be used in different ways with different focus, either on only the materials and components, or on the whole project. Some direct differences are that an LCA on a whole project differs, all projects are different with new prerequisites and approaches, but the LCA on materials and components can stay mostly the same. When using the LCA in construction projects it has been mostly focused on environmental impacts. It often promotes changes such as material changes and better use of renewable energy and do not focus so much on the cultural or social aspects of the product. Main environmental areas in civil engineering projects detected by the LCA are global warming potential acidification, energy consumption, inefficient land use, water shortage, air pollution, traffic congestion, deterioration of ecological systems, high consumption of energy and waste management, where the main source of climate change lays in emissions and greenhouse gases (Ortiz, Castells, & Sonnemann, 2009).

Further development of the LCA method has been adapting the use of BIM models as a complement. BIM models makes it possible to obtain a huge amount of information about a construction and all its specific parts. This can be a way to get a precise description of a designs parts and use this to perform LCA to get an idea of the possible environmental impacts from the materials from that design (Stadel, Eboli, Ryberg, Mitchell, & Spatari, 2011).

The use of LCA in construction projects can though encounter some difficulties. It can be hard to predict the impact of processes performed on site. Not only their quantifiable impact with emissions, but also how site development and waste may impact the surrounding environment. Furthermore, a construction project includes a huge amount of different building materials and the unique nature of each project. This makes it a lot more time consuming to perform a life cycle assessment on every

single material used and then try to combine all data (Singh, Berghorn, Joshi, & Syal, 2011).

### 3.4.4.2 Benchmarks

Many different systems for benchmarked values for LCA have been developed, these often parts of regulation systems and certifications. Two different ways of creating benchmarked values for the LCA is to either use values from analysis and LCA assessments from the building sector and compiling it down to benchmark value or use existing environmental goals and policies to benchmark. Both have their advantages and disadvantages, were the first get a more precise value it also demands much time and data to process while the second one can be a more assessable approach but not always result in as well-grounded values (Trigaux, Allacker, & Debacker, 2020). The values used in benchmark systems can be divided into different types and when setting benchmarks, it is important to know what to compare to.

Value type	Definition	Example	Time period
<b>Limit values</b>	Minimum value for acceptance	Lowest accepted value of CO <sub>2</sub> emissions according to greenhouse gas-policy	Short-term
<b>Reference values</b>	Precent value for a project	Measured value of CO <sub>2</sub> emissions for ongoing project	Short-term
<b>Best practice values</b>	Value reached in best practiced project or example	Lowest measured value of CO <sub>2</sub> emissions out of all projects within the organisation	Medium- or long-term
<b>Target values</b>	Most successful theoretical possible value	Lowest pre-calculated or predicted value of CO <sub>2</sub> emissions	Medium- or long-term

Tabell 7. Example of different types of benchmark values for LCA (Trigaux, Allacker, & Debacker, 2020).

### 3.4.5 Eco-Efficiency

Efficiency is explained as the ratio between an input and an output. Eco-efficiency can therefore be explained as the relationship between an output and a measured environmental activity. The goal of eco-efficiency is to make environmental impact and its relation to economic value quantifiable in an easy communicable and useful way. The method can then help in decision making by comparing the ecologic outcome of different products and processes (Saling, et al., 2002). It has also been described as “*the efficiency with which ecological resources are used to meet human needs*” (Tatari & Kucukvar, 2012).

Eco-efficiency measures the efficiency of consumption of resources compared to economic value (Burrit & Saka, 2005)

$$Eco - efficiency = \frac{Economic\ Value}{Environmental\ impact}$$



To be able to determine the ecological impact there are six aspects to consider: the consumption of raw material, the consumption of energy, land use, resulting emissions, the toxicity potential, the abuse and risk potential (Saling, et al., 2002) (Tatari & Kucukvar, 2012). The important thing to remember when it comes to eco-efficiency is that there are no general standards or rules for the calculations or variables. This means that there is no standard to relate to, and it is hard to compare results with different actors in the industries. There are also no rules or standardised method on how to compile the data that is used as factors (Müller & Sturm, 2001).

### 3.5 Existing Sustainability Framework

It exists many different frameworks and methods that can be followed to reach a more sustainable result. Many are also directly developed to answer the civil engineering industries needs and provide a general guide for sustainability. The focus of these frameworks often lays on the performance of the finished product. A more recent approach to this is to try incorporating the frameworks earlier in the design phase, to make sure both the process until the finish is done in a sustainable way, as well as the performance of the finished construction. The framework can work with quantitative or qualitative data. For example, kg CO<sub>2</sub> gas emissions can be used as quantitative, as how a construction impacts the surrounding environment is qualitative (Ding, 2008).

Important to keep in mind is that the different frameworks are not connected to each other. Each one can have its own criteria and point system. This means that it is hard to compare projects that have been based on different sustainability framework to each other (Ding, 2008). The existing framework also has an important role in making sure actions are being taken, and it has been shown that the values on environmental performance indicators existing in environmental framework are also the values that companies tend to measure. This means that the environmental areas not having a benchmarked value in the framework are often not monitored by companies whatsoever (Kocmanová, Klímková, & Karpísek, 2012). Many sustainability evaluations tool's purpose is to compare and award facilities up on its performance related to the sustainability criteria. They are often presented in the form of rating systems, this because: it creates a common metrics for all parameters, they make the measurement of sustainability manageable, they are straightforward and easily interpreted to goals and achievement (Bueno & Cheung, 2015).

#### 3.5.1 Environmental Management Systems (EMS)

Environmental management systems are used in organisations to in a structured way approach environmental challenge. EMS's are often complied by goals, information systems, policies, data collection plans and reports. The EMS should be aligned with the environmental policy of the company in question and contain following attributes:

- *Goals and methods for meeting environmental requirements.*
- *Methods for maintaining correct documents for their goals.*
- *Structure and organisation for responsibility of different tasks and areas.*
- *Preventative- as well as emergency actions.*
- *Employee training on the EMS and its areas*
- *Plan on presentation of progress and achievements. Environmental performance metrics to measure activities, see progress and improvements.*

(Christini, Fetsko, & Hendrickson,, 2004)

Two well used standards for sustainability are ISO14000 and the European Union's Eco-Management and Audit Scheme (EMAS). The ISO14000 is a process focused standard and the EMAS is more focused on performance measurements in relation to sustainability. There is also a growing standard within companies to release sustainability reports with an overall insight on the company's sustainability work. The reports are often circled around data and not so much about their concrete strategies for improvement (Epstein & Wisner, Performance Metrics, 2013)

### 3.5.2 ISO

ISO14001 is a standard released by The International Organisation for standardisation (ISO). The specific standard of 14001 focus on a standardised way for businesses to implement environmental management systems and improve their work with environmental matters. Using the EMS ISO14001 has shown to help companies reduce environmental impact in activities such as pollution and waste management, but the outcome of its use can differ depending on how companies implement it. Organisations that use the ISO14001 can get a certificate that is given after an assessment from a third body company and then renewed every couple year. The framework for performance indicators on an organisations performance from ISO can describe two things. Firstly, indicators for how the managers work with influencing positive sustainability work in the company, and secondly how the company is performing sustainability in its production process (Campos, de Melo Heizen, Verdinelli, & Miguel, 2015)

In a study done on the most common activities with an environmental impact in relation to ISO14001 in construction, following activities were registered (Yusoff & Nordin, 2015).

<b>Environmental activity</b>	<b>Environmental impact</b>
Emissions to air of particulate matters SOX, NOX, Co, and CO2 from machinery exhaust.	Air Pollution
Emissions to air of dust and particulate matters	Air Pollution
Physical attributes, Vibration and Noise	Disturbance to existing structure/Nuisance, Noise
Generation of construction waste	Land use
Leakage of Oil into land	Land contamination
Generation of Scheduled waste	Hazardous to human's health
Discharge of surface runoff	Water pollution
Resource use	Resource depletion
Discharge to water of leaked oil, chemical fertiliser from planting works, etc.	Water pollution

Table 7. Result from study on most common environmental impacts in construction (Yusoff & Nordin, 2015).

One factor that can make it hard to implement the framework is that it can be hard to identify all environmental actions and impacts that are included in the construction

industry (Chiarini, 2019). A unique attribute of the construction industry is that it is often related to bids and tenders from public administrations or general contractors who has a great impact in the contractual parts. Clients can often have environmental focus as a factor in their choice of stakeholders and suppliers. This can be a factor that drives companies to obtain the ISO14401 certificate. This can unfortunately be used in the wrong way, making companies get the certification only to get an advantage when it comes to the clients, and not making sure to follow the proper guidelines to make an environmental change for the better (Yusoff & Nordin, 2015). One factor that can make it hard to implement the framework is that it can be hard to identify all environmental actions and impacts that are included in the construction industry (Chiarini, 2019).

### 3.5.3 EMAS

The EU Eco-Management and Audit Scheme (EMAS) is an Environmental management system developed to provide companies a framework for evaluation and reporting of their environmental performance. (European Commission, n.d.) The minimum selection of environmental indicators to register and their absolute and relative values presented by the EMAS are as follows (Jasch, 2000) (Official Journal of the European Union, 2019).

	<b>Absolute</b>	<b>relative</b>
Production output in kg, items etc	Production output (PO)	
Raw material consumption	Kg	Kg/PO
Energy consumption	KWh	KWh/PO
Water consumption	m <sup>3</sup>	m <sup>3</sup> /PO
Total waste	Kg	Kg/PO
Waste qualities	Kg	In % of total waste
Wastewater	m <sup>3</sup>	m <sup>3</sup> /PO
Air emissions	Kg	Kg/PO

Table 8. Environmental indicators values (Jasch, 2000).

## 4 Interview Study

An interview study was performed with the purpose of collecting primary information about the environmental work within civil engineering projects. The focus of the study was firstly on experiences from the project manager working as consultants out in active projects, and secondly on general sustainability work within their organisation. Combining the two together to get a mapping of the work of sustainability, and more specific environmental impacts, from organisational visions out to actions in single projects.

The interview study contains questions divided into three main categories:

1. Sustainability in general
2. Environmental goals
3. Environmental areas and activities

### 4.1 Empirical Findings

The result from all interviews has been summarised and is presented here. The answers have been divided into different categories depending on what topic the question covers. A selection of the interviewee's answers may have occurred, eliminating irrelevant answers for the study and side-tracks.

#### 4.1.1 Projects

The participants of the interview study all worked on different project, in different stages. The spread of projects contained infrastructure projects, building construction, urban development, and city renovation. The infrastructure projects included bridge and road development and renovation, the building construction included development and construction of neighbourhoods with apartment- and school buildings, the urban development and city renovation included general changes in urban planning and existing infrastructure of streets to either upgrade or prepare for new construction in the area.

#### 4.1.2 Organisational Work

The organisation aims to help development of sustainable buildings, transportations, cities and technical solutions. The company wants to be able to work for the future by the advice and work they give their clients. When it comes to general sustainability goals for the organisation, they are set on a higher management level where they evaluate the relevant aspects of their work, this to set goals within fields that are relevant for them. One interviewee reflects over that the company has been successful with this and that they work systematically to cover the relevant areas. Further it is reflected over that WSP is a large company with many different departments, and the work with sustainability might differ a bit between the different business areas. For WSP Sweden the focus areas have been concluded to; transportation, energy use, purchase and use of consumable materials and competence and innovation in development of new services. Then based of these they set quantitative goals that can be checked. One specific goal that has been set is to reduce the CO<sub>2</sub> emissions in their projects by 50% until 2030, in relation to the emissions in 2020.

The gathering of information from their projects on environmental impacts, to make sure they can follow up their goal, is something the company is working on right now. WSP have already reduced their emissions in their own operations but measuring the impacts out in projects is a bit more complex and difficult. The company needs to summarise the performance of the project from 2020 to be able to create a baseline that they later can compare with. This includes climate- and energy calculations that have been used in projects.

### **4.1.3 Sustainability in Projects**

An overall sustainability awareness is said to exist in all the project of the interviewees, but it highly depends on the client. As consultants they work for the client and by their requirements. This often refers to general laws and regulations for the area, sustainability policies for the client organisation or certifications for the specific project. One interviewee highlights that one of the goals for the organisation is that the sustainability aspect should be thought about in all their project, but that it is unclear if this is something every employee on the company is aware of. One project manager says that even if they use some tools to calculate environmental impact, they could work on approaching the environmental question in a more strategical way straight from the start. As soon as one part of a project performs well in the area of sustainability the rest might be forgotten, making one success in the area overshadow the rest.

WSP has developed some different sustainability tools that can be used and guide the sustainability work in projects. These implements the UN goals that the company has aligned with their business strategy. Depending on the client there are sometimes sustainability co-ordinator or other environmental experts as part of the project team. Sometime the responsibility of sustainability falls on the project manager. The sustainability co-ordinators often have the responsibility to do follow-ups and check that the work aligns with the demands in the contract. The work of the environmental experts is more about technical expertise around their specific area.

### **4.1.4 Environmental Goals and Requirements**

When it comes down to environmental goals in the projects it depends on the client. It is rare that any internal goals are set for single projects, even if there almost always is implied that sustainability should be taken into consideration in a general way. The set framework and policies that the client have in their organisation becomes the documents that are followed. Of course, also the law and governmental regulations are requirements that they set out to follow. Many of the projects, when it comes to urban development, city planning and infrastructure, are set out to create a more social sustainable society. The projects are then planned and adopted for the needs of social sustainability, but it is rare that there are any environmental goals with set values to refer to. There is a requirement for all contractors to be ISO certified.

There are often no special requirements for the project managers regarding how to work with sustainability and environmental question. The requirements are in line with how the client work and their existing guidelines within their organisation and that translates as the standard for all their projects. This often also follows to

contractors and other stakeholders. Sometimes there can be special requirements for a project, where leading documents and procurements have specified that they need to work sustainably, and it is then the project managers role to make sure that is followed. As one interviewee states, all projects are different and goes through different political instances, and therefor might need different goals. One highlights the importance of doing regular follow-ups, on for example the work of the contractors. This to make sure the sustainability question is implemented in the everyday work and not just becomes a project on the side. Further, the goals and requirements could be talked about more to make everyone understand why they exists. Now they are often just put as a document because they need to. If you do not have the understanding of why it is easy to be unsuccessful trying to live up to them, one project manager states.

Three of the project managers brought up examples of projects where they had worked with developing clear environmental goals for their specific project. In all cases they had started looking at goals in the planning phase and then together with stakeholders held workshops to find the focus areas for the specific project. Later, continuing into the design phase, it became more concrete on exactly what is to be done and how it could be measured or examined to live up to the set goals. The goals that were assembled in the planning stage then got broken down in to smaller and more concrete actions that could be performed and sometimes also measured.

The difference between the pre-construction and construction is also mentioned by several. When goals are assembled on areas involved in the design phase, such as materials and design, the performance in those areas can often be calculated or estimated on forehand and with that get followed up in the construction. Planning and preparing for the production are of course also done, but those activities might be a bit harder to estimate.

All agree on that if environmental goals are included and set from the start that makes a difference in how you act in the project. It makes it harder to take detours or stray away for greener options. But, if implemented you need to make sure that it gets followed up, otherwise it is not trustworthy. That also raises the question if it is possible to follow up such goals in an efficient way in all projects. One reflection is that it can be hard to implement that kind of follow up in single project, especially in smaller project where resources such as money and people does not exist. There are some tools out there that can be used, such as byggvarubedömningen BVB (the construction product assessment) and CO2 calculations, but no real structure on how goals or follow-ups can be performed.

#### **4.1.5 Environmental Topics and Activities**

The most challenging environmental impacts differed some between the different projects. The answers that were given was often in form of an estimation or guess since no advanced investigation had been done in the projects comparing the different activities and impacts. General environmental impacts, such as CO<sub>2</sub>-emissions were mentioned by most, but often no further specification on from what source. Some difference of topics was noted depending on what type of project the manager was referring to. Some more specific topics were mentioned such as building material in form of concrete and steel and specific complications with existing land.

<b>Environmental impact</b>	<b>Specifically mentioned</b>	<b>Interviewees project type</b>	<b>Relevant project phase</b>
Co2-emissions		Infrastructure / Building construction / Urban development	Design / Construction
Construction / Building materials	<ul style="list-style-type: none"> <li>- General</li> <li>- Concrete</li> <li>- Steel</li> <li>- Resource management</li> </ul>	Infrastructure / Building construction / Urban development	Design (detailed)
Transports	<ul style="list-style-type: none"> <li>- Long supplier chains</li> <li>- Deliveries from abroad</li> </ul>	Urban development / Building construction	Construction
Machinery on site	<ul style="list-style-type: none"> <li>- Diesel use</li> </ul>	Urban development	Construction
Effects on existing land / environment	<ul style="list-style-type: none"> <li>- Sulphide mountains</li> <li>- Biosphere</li> <li>- Noise</li> <li>- Air pollution</li> </ul>	Urban development	Design (scheme)
Water resources	<ul style="list-style-type: none"> <li>- Stormwater</li> <li>- Rain</li> </ul>	Urban development	Design (scheme)
Waste	<ul style="list-style-type: none"> <li>- Construction materials</li> <li>- Soil / land</li> <li>- Rocks</li> <li>- Hazardous waste</li> </ul>	Urban development / Building construction	Construction
Chemicals			Construction

Table 9. Mentioned environmental impacts.

One project manager highlights that the awareness of environmental impacts seems to change from one to another, depending on what is the “trend” for that moment. Occasionally the political climate has its focus on CO2 emissions making the awareness of that peak, but soon something new happens in the world and the focus shifts. It is important to not get lost in one general focus areas but make sure to determine what sustainable questions are most important for a specific project and work systematically with, for example, checklists that everyone understands.

When it comes to the question of if information regarding impacts created by the different activities is provided on forehand, almost everyone answers yes. But the information is limited to some specific topics. Information on building materials is easy accessed in “byggvarubedömningen, BVB” (the construction product assessment), which is used in almost all projects, but even that can be limited to materials used in house constructions and there is not that much information for the infrastructure projects. The topic of CO2 calculations is mentioned by a few and taken

as an example on how to measure impact, but that it is not something they usually work with. It also seems that the knowledge or routine of that method is not that well known, and that it can come down to a question of time, resources, and money. The gathering of information and data on specific activities in a project can be a heavy workload so using standardised frameworks or values can be one way to make it easier and more user friendly, one project manager says.

Information technique	Environmental Topic
CO2 calculation	CO2-emissions
Byggsvarubedömningen, BVB	Construction materials / products
Certification frameworks	Overall sustainability performance
Grönytefaktor	Ecosystems and biodiversity
Ceequal	Impacts by bridge constructions
LCA analysis	Building materials

Table 10. Mentioned approaches to gather environmental information.

#### 4.1.6 Environmental Awareness and Prioritising

Almost all interviewees agree that the environmental impacts are a factor that is taken into consideration when making decisions, but that it might not be as prioritised as other. The economics is mentioned by everyone to be the highest prioritised aspect when making decisions in a project. The quality, aesthetics and time aspect often also seems to weigh more than the environmental aspect. One project manager mentions that it would be great to have environmental factors, such as CO2 calculations, presented already in the procurements process and using that as one of deciding factor. That could also inspire companies to deliberate more innovative in their solutions.

The perception of the awareness of sustainability in all lines from client to contractor differs a bit. Some think that the awareness is there, and some do not. A trend is that there might be a general awareness about sustainability but no deeper knowledge. Therefor situations may occur were stakeholders want to work more with sustainability but do not know how or who to turn to. The big span of the topic can also be a hurdle and make it hard to fully understand what “sustainability” means, and that there is a need for more concrete examples on how to work with it. The awareness and acting can depend on what stakeholders are part of the project. Bigger organisations often have their own “sustainability policies” in place which makes it standardised for them to work with it, while smaller firms often do not. It is mentioned that the knowledge might be there, and different firms can have held courses and spread awareness amongst their employees, but that they do not always bring that with them down to single projects. If the demand does not exist sustainability often is not worked with. If goals, demands or requirements comes from either the client or the government first then it is taken seriously. Some say that if the topic is not fully implemented in the project, it can feel hard, unusual, or questionable to bring up environmental questions on a project meeting. Even if sustainability gets prioritised more and more and there is a positive trend, it is still a significant variety in both maturity and competence.

It is brought up that there might also be a general lack of understanding in the industry of whom has the knowledge in sustainability and environmental questions. Clients can assume that all the environmental work and knowledge falls on the project manager,



while in fact the manager needs support, and therefore don't bring any further sustainability consultants on board for the project. It is mentioned that it can become a problem if a sustainability co-ordinator comes in late in a project, after the design phase, since there is a possibility that much work needs to be changed and re-done. Thus, in that aspect, bringing in experts early can be beneficial, not only for sustainability, but also when it comes to cost and time.

The aspect of the procurement process is brought up by some. Working on infrastructure- and urban development projects almost exclusively implies the use of "lagen om offentlig upphandling, LOU" (the public procurement act). This is followed strictly, so the demands included there are sure to be lived up to. This can create some restrictions. To win a procurement the areas included in the act are the ones that get all the focus. This often does not include any demand or priorities including sustainability or environmental impact, and if so the economy and quality aspect is considered more important. One possible improvement mentioned could be to include the sustainability aspect when using LOU, and that that could be a way to make people implement more sustainable acts in their approaches. Another aspect is that the project relevant for this is often financed by the taxpayers. This makes it important to keep down costs to relevant actions, often making the environmental aspect fade with today's priorities. The sustainability issue in the civil engineering industry is often very connected to politics, especially if the owner of projects are municipalities or cities, and a few mention the need of regulations to come from that direction. If a project manager wants to implement a sustainable, but also a more expensive, approach they would want approval coming from a higher authority saying that is okay, one interviewee says. The people in the project do not always have the authority to approve those decisions. It would be easier to act in favour of sustainability if the acceptance from the region or municipality is clear and stated from the beginning.

## 5 Case Study – Regions and Company

The study consists of an analysis of active sustainability reports and documents on environmental requirements. Including in the analysis are document from regional- and organisational/company level regarding project in the civil engineering sector. This to see what laws and requirements on environmental impact and reporting there are and what areas they cover. Further, to investigate how these requirements and goals align and are followed through down projects.

### 5.1 Empirical Findings

The relevant information disclosed in the document is presented by the different authorities. The findings are limited to content regarding civil engineering projects, sustainability, and environment.

#### 5.1.1 Regions

Different regions in Sweden have developed their own requirements for the use and development on their land. The regions are also often the owner of civil engineering projects and acts as clients for consultancy firms and contractors.

##### 5.1.1.1 General Requirements

The city of Stockholm, Gothenburg and Malmö have together with Trafikverket (The Swedish transport administration) set joint environmental requirements for construction contracts. The requirements apply to all stakeholder involved in projects with the mentioned cities and Trafikverket. The requirements are general base requirements and might not cover all environmental areas, so further project specific requirements might be added. The requirements are in first-hand produced for infrastructure- and land development projects. It is also stated that, since new methods and techniques constantly are developed, customers are open for suggestions regarding improvements that can improve the environmental performance or reduce cost to reach bettered environmental efficiency (Trafikverket, 2018).

The requirement includes that the contractor shall run a strategical work including three instances (Trafikverket, 2018)

- *Environmental policy*

Produced by the company's management and containing commitments of binding requirements of a continues development on environmental efficiency.

- *Goals- and risk assessments on relevant environmental- impacts and risks.*

- *Routines*

Assessments on relevant environmental- impact and risks, self-check-ups of environmental work, procedures for deviances and corrective- and interfering approaches, and preparedness and actions in the case of emergencies.

The areas included in the environmental plan are requirements regarding fuel, light vehicles, heavy vehicles, work machines, chemical products, materials, and products where focus is on steel, concrete and cement (Trafikverket, 2018).

#### 5.1.1.2 The City of Stockholm

The city of Stockholm has implemented six requirements regarding exploitation and construction on their lands. The requirements are compiled in a document of “sustainability requirements regarding construction on city property”. The document consists of six requirements (Stockholms Stad, 2021).

- *Efficient energy use*

The requirement covers the energy usage of the finished building. This includes energy for heating, water, cooling and property energy.

- *Efficient transports*

The requirement includes the demand of parking places for bicycles and cars. This with a general guideline to make it easier to use bicycle as a transportation and try to reduce the usage of cars.

- *Stormwater*

Requirements for stormwater where the stormwater plan should follow the city’s specific strategy and guide.

- *Biological diversity and coherent ecosystems*

Requirements of “Grönytefaktor” (Green Surface factor) where a plan connected to the detailed building plan should be produced presenting how greenery is planned to be place in the area to promote biodiversity. The factor of “GYF” shall be calculated and presented.

- *Environmental assessment of building materials / A chemical free Stockholm*

The requirement of environmental assessment of building material includes of environmental judgement for the material in a BVB system, or similar. Materials containing zinc or copper should not be in contact with running water.

- *Other sustainability requirements of building materials*

The requirement is set on the building materials of wood and natural stone. Where the wood shall come from sustainable forestry based on documentation of its sustainable origin and the natural stone shall come from fair production or mining.

Accounting on the different requirements shall be done before significant instances of the project process, such as for building permit and final notice on building permit. Many of the requirements have their focus in the design of the finished building and its surrounding and reducing the environmental impact from it during its lifetime. Also creating a social environment that promotes sustainable acts. The environmental requirements that are applicable and measurable during the design and construction phase of the projects are mostly restricted to the handling of building materials.

### 5.1.1.3 The City of Gothenburg

The real estate department of the city of Gothenburg have set requirements regarding that sustainably ecological construction should be promoted during exploitation of their land. The act of environmentally friendly construction is produced by the real estate department from the city of Gothenburg and can support during projects. The act is in the shape of a checklist that is used for accounting of the sustainability and used for follow-up and assessment. Their environmental plan is also aligned with the national goals of environmental quality (Göteborgs Stad, n.d.). The focus areas of city's environmental plan are set to durability, health and indoor climate, environmental impact, resource management, noise protection, energy management, moisture protection, and other aspects. All focus areas shall be handled in four different phases during a project (Göteborgs Stad, 2019).

*Planning – implementation of the mindset*

*Design phase – check-up on routines and checklists*

*Production / construction – Accounting of documents*

*Operation – Verify measuring*

The area of environmental impact in the plan has its goal to “reduce the negative environmental impact of the building in a lifetime perspective” and is mostly approached by guidance for the choice and use of materials.

Control area	Responsible party	Project phase
Building materials shall been through an environmental assessment	Contractor	Design and construction
Copper pipes may not be used	Contractor	Design and Construction
Wood shall be certified	Contractor	Design and Construction
Tropical- and impregnated wood shall not be used	Contractor	Design and Construction
Light sources shall contain a small amount of quicksilver	Contractor	Construction
“GYF” requirements from the city of Gothenburg is acquired	Contractor	Design and Construction
Stormwater requirements after consultation from the city	Project manager	Design
General requirements from the city regarding machinery, fuel, vehicles, and chemicals	Contractor	Construction
Chemicals and fuel are safely stored and handled correctly when managed as waste	Contractor	Construction

Accounting of climate impact from the frame- and base construction in gram CO2 per A-temp	Consultants	Design and Construction
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Table 11. Environmental impacts mentioned in “program för miljöanpassat byggande”.

### 5.1.2 Company – WSP

This analysis is based on the global and national sustainability reports presented by the company between 2017 and 2020. The company have some general goals that live though the whole organisation. Much of their measured and reported in the reports is connected to their own operations and not the performance of their projects. The content mentioned in this study has been selected to the goals and areas that has a relevance for the civil engineering project the consultants from the company are placed on.

Looking at the general goals from the sustainability reports the UN Sustainable Development Goals are highly prioritised. The activity of the organisation is said to be align with the goals and during the years goals have been added on to the organisations list of priority. Most recently, in 2020, ten of them are mentioned to be extra relevant for the work of the organisation. Included in these ten goals are all the UN goals with a focus on the environmental dimension (WSP, 2020).

Nr	Goal	Dimension
5	Gender equality	Social
6	Clean water and sanitation	Economic
7	Affordable and clean energy	Economic
8	Good jobs and economic growth	Economic
9	Industry, innovation, and infrastructure	Economic
11	Sustainable cities and communities	Environmental
12	Responsible consumption and production	Environmental
13	Climate action	Environmental
14	Life below water	Environmental
15	Life on land	Environmental

Table 12. UN Goals mentioned in the sustainability reports to be relevant for the organisation.

The company works with a global sustainability policy which describes how they should work in their own operations, projects, and act in the society. Four general goals are used as guidance throughout the organisations (WSP Sverige, 2019).

1. *Clients. Prepare their clients for the future by understand trends within urban development, climate changes, technical solutions, and recourses, and use them when providing advice and solutions to the clients.*
2. *Expertise. Provide the clients with expert advisement within sustainability to help them improve their sustainability performance, reduce expenses, create value, and handle risks in their own organisation.*
3. *Operational Excellence. Actively and continuously improve their own environmental and social performance and strengthen their own organisation within sustainability, and by this act as a good example for our employees, stakeholders, and the society as a whole.*

4. *People and Culture. Provide a good work environment where the co-workers feel good and can reach their full potential, also enable the co-workers to participate in meaningful activities in the society we act in.*

Furthermore, a specific goal for the company regarding their work out in their projects is to reduce the climate impact from their project by 50% by 2030 compared to 2020 (WSP Sverige, 2020). ISO14001 is also mentioned to be a standard implemented in the organisation. During 2020 59% of all operations within the organisation were performed under the ISO14001:25 standard.

A materiality analysis is presented in every sustainability report. A materiality analysis is when a company's processes and actions are evaluated and analysed to in the end be prioritised by its relevance. The materiality topics covers social, economic, and environmental areas and are divided into sub-categories that fit the operations of the company. The result of the materiality analysis from the most recent years shows that topics with an environmental focus are all ranked in the upper half both when it comes to impact and importance. The topic of GHG-emissions (greenhouse gas emissions) is the topics that is the most prioritised out of the environmental group, both for internal and external stakeholders. Other environmental topics that are mentioned are waste and supply chain (WSP, 2020).

## 5.2 Summary – Case Study

The three mentioned environmental- or sustainability plans, (Trafikverket, Stockholm and Gothenburg), have both differences and similarities. They all have the purpose to decrease the environmental impact of their own projects, or projects on their land. They all include requirements that are needed to be followed and between them some topics are shared, and some are not. The requirements from Trafikverket have a lot of focus on on-site actions, the city of Stockholm has a focus on the functions of the finished building and its social environment, and the city of Gothenburg tries to focus on all different phases of the construction but also here it is often limited to the finished building. When it comes to the measurable environmental impacts the common area often seems to be the choice of building materials. The city of Gothenburg also stands out with having compiled their requirements into a checklist-format that can be directly applicable to projects.

The goals from the company, WSP, are aligned with the UN Sustainable development goals. When it comes to the environmental focus in their project two specific goals can be highlighted. Firstly, that they should be able to provide an expertise surrounding sustainability, helping their clients to act more sustainable in projects and organisations. And secondly, to reduce the CO<sub>2</sub>-emissions from their projects.

## **6 Summary and Analysis of Results**

The results of the literature-, interview- and case study are here summarised in an example of how the use of environmental performance measurements can be approached. This to give a general example of how, based on the earlier findings in this study, the use of environmental- goals and performance can be approached in civil engineering projects. The result presented is based on comparisons between the three parts of the study and based on discovered similarities, conflicts, and trends.

The chapter is aimed to answer the research questions for the research and the result is presented in that order.

### **6.1 Why is there a Need to Use Performance Measurements for Environmental Impact in the Civil Engineering Industry?**

The literature emphasises the importance of using performance measuring in an organisation as a tool to backup decision making and analysing current status. Actively working to develop sustainability into organisations, and not at least in the civil engineering industry, the use of performance measuring can be a good approach. The end goal of implementing the environmental performance measurements is to reduce environmental impacts. Even if the measuring of performance when it comes to the environmental aspect does not directly equals to reduction in environmental impacts, the tool can give away affects that promotes and pushes towards a more sustainable way of acting.

#### **The Value of Measuring Performance**

The aspect of follow ups is mentioned during the interviews, and that it is an important part to make sure things are conducted in a correct way and that work is fully implemented into the project. The usage of measuring on performance can here be used as an efficient tool to be able to do check-ups that are value based and easy to control. There is an observation that requirements sometimes just are there for the sake of it. The use of concrete measuring on the requirements can make it more applicable and easier to relate to, making sure requirements are met. Looking at some of the requirements of the regions a trend noticed is that even if then intention of greener thinking is there, it can be quite general. Requirements that stated that materials or activities should be handled in a sustainable manor, or as sustainably efficient as possible, can be hard to interpreted. What is sustainable, and what is not? This can create confusion and set targets that are to diffuse to live up to in the way they are intended. As the lack of knowledge on environmentally friendly acts and sustainability in general seems to be a noted trend throughout all levels of a project, it can be important to have stated values to follow to make sure procedures are done sustainably. If the requirements only states, for example, “with as little environmental impact as possible” it can be hard to know what approach is the most suitable if the general knowledge of sustainability is not there. This can be applicable to organisations, companies, and stakeholder, and that more concrete goals can make them act, not just in a way that they think are sustainable but, in a way that is proven to be sustainable.

A unanimous opinion from the interviews was that the use of environmental goals in projects has a positive impact on how you prioritise and work with sustainability. When demands are set, they tend to be followed. This also agrees with the idea of performance indicators in projects and “that what gets measured gets managed”. This must not correlate to exact goals, but if a standard of areas is set to get measured, those areas tend to get managed and worked with. Further mentioned in the interviews is that there sometimes is a tendency that some environmental topics gets forgotten while other gets a lot of attention. When one area performs well when it comes to sustainability that can be interpreted that the whole project performs well, making other areas be forgotten. Setting a standard early in the project covering all important areas that can be measured for environmental performance can reduce the risk of any topics being left in the dark. Further, this can create a broader, and more accurate, sustainability profile for the project that is not just based on just one area. An example of the awareness of different areas is observed by the researcher. In the city of Stockholm’s requirements, a specific requirement on “natural stone” is mentioned where when using the material “natural stone” it isn’t allowed to be imported from certain countries, such as China. The same requirement is also mentioned from several of the interviewees. This can prove that when the requirements or goals are assembled on an area, they awareness of that increases. Some of the interviewees have also experience working on projects where they early on put up a strategical plan on their environmental- and sustainability work. Here the client requested the work, or the project manager had their own motivation to drive the work forward. This resulted in that the environmental aspects were continually followed-up though out the project, something that they otherwise do not do in the same extent. This promotes the idea that setting strategical goals in the beginning of a project helps with the awareness of its sustainability over the whole timespan of a project.

The use of performance measurements can also be adapted depending on what kind of performance you want to measure. Different types of KPIs can be used, and strategically produced based on what is important for the company. Also, what type of goal you want to have set. As presented, different values can give away different information about a project. Currently, based on the requirements from the regions, mostly limit values (minimum value for acceptance) is used. This then becomes more of a must than a goals since it needs to be met for the activity or project to be approved. The company is now also working on determine reference values (precent values for projects) for their projects to in the future be able to compare with their goals for 2030. Both these forms of values are defined as short-term goals. To be able to reach a long-term goal of reduced CO2 emissions, which is a common goal for both the society and company, the implementation of long-term values such as best practice value and target values can be a complement. This to not only have the goals of lower levels of CO2 emissions, but calculated values of what actually is a possible outcome for each project and with this set internal goals within the projects.

## **Stakeholder Engagement**

Further work with follow-ups, reporting and feedback is also simplified with concrete measuring. Since the civil engineering industry involves many different stakeholders, it is important to have a good stakeholder engagement, where communication is frequent and all parties are updated and understood with information and status of the project, to be able to approach sustainability in all areas. It is easier for clients and other stakeholder to get a clear picture of the status and the



project compared to their own goals but also, if implemented throughout the industry, compared to projects from other companies. This can create a standardised benchmarks over the industry, being able to learn from each other. This opens for possibilities to create a competitive aspect between companies and the sustainability of their work. Since the concept of greener buildings can be attractive for buyers and stakeholders, being seen as a more environmentally friendly company and be able to account for this can be a competitive advantage. The use of values such as EPMs can be a way to achieve this.

It is mentioned that including the stakeholders in the measuring of performance can create motivation and engagement. This could be a good way to make sure work involving environmental impact is worked on from multiply directions. The involvement of stakeholders has been shown to be a key factor for sustainable performance. It is mentioned that if stakeholder do not understand the motivation behind actions, it is harder to implement. Using a strategical approach, where goals are decided from the start and then broken down to realistic actions throughout the lifespan of a project, to set up goals consisting of measurable data, priorities and visions from the company can create the answer of why certain actions should be taken. Further, this can promote, for example, contractors' attitude and engagement towards requirements when it is easier to understand what the arguments for the actions are.

An increased stakeholder engagements is also in line with the concept of sustainable construction. As well as presented in the materiality analysis from the company both the external- and internal stakeholders are involved and have a high importance regarding topics such as GHG-emissions.

- *Investors, insurance companies, property developers and buyers of buildings are aware of sustainability considerations and should take an active role to encourage sustainable building and construction practices.*

## **Environmental Focus**

The success factor of a project has historically been based of criteria related to economy. Other aspects such as quality and time has also had an important status. From the results of the interview study, the importance of economy in projects is convincing. The question of sustainability often does not have as strong impact. This can depend on two things. Firstly, that the sustainability aspect has not has that high of a priority in general before. Secondly, that it is hard to evaluate the sustainability of a project and know how to translate it into what is successful or not. Using EPMs can solve the evaluation part, giving the environmental part of a project sustainability a measurable value. Further, to be able to compare the success factor to other projects a common value that could be used industry wide would be needed to be determined. Compared to for example cost and time, the sustainability or environmental impact factor does not have one implemented standard value. The idea of using the environmental factor as a criteria in the procurements process is brought up in the interviews and could be a way to promote innovative thinking when it comes to the projects. This is a possible outcome that the use of environmental performance measurements could support. Based on the earlier studies presented in the literature, even if sustainability and environmental performance measurements are the least used, they are still the once that give the biggest impact. This can support the idea that

the use of environmental performance measurements can be an efficient way to speed up the sustainability work in the industry and shed a light on what impacts the projects in the industry really brings with it.

## 6.2 What Indicators Connected to Environmental Impact is There a Need and a Possibility to Track and Measure?

There are many different areas of environmental impact and different topics can have a difference relevance depending on industry, company, and project. Given the often huge extant of civil engineering projects, time and resources can limit what scope that can be used when it comes to environmental impacts. Therefore, there is a need to detect the most important, relevant, and realistically useful indicators of environmental impact.

### Goals

Different goals can be detected from the different active stakeholders mentioned in the study. These from the sources of global goals of the UN, regional requirements, internal goals of the company, and the general concept of sustainable construction. Looking at the construction industry in general, according to the UN environmental program (UNEP), sustainable construction should follow certain characteristics. One characteristic is to involve both the short- and long-term aspect, concluding that a consistent approach of measuring and follow up should be conducted to be able to control different set instances of a project.

- *Environmental aspects should be considering in the project and should include short-term as well as long-term aspects*

Goals that correspond well to each other comparing the global- and organisational aspect are the Global UN sustainable development goals. Out of the seventeen goals, ten are aligned with the company strategy and out of those ten five are directly related to environmental impacts. The specific goal set from the company's side is mostly in line with the goal of climate action and the focus on reducing their CO<sub>2</sub> emissions. This making the CO<sub>2</sub> emissions an important environmental indicator.

Nr	Goal	Dimension
11	Sustainable cities and communities	Environmental
12	Responsible consumption and production	Environmental
13	Climate action	Environmental
14	Life below water	Environmental
15	Life on land	Environmental

Table 13. UN goals adapted by the company with environmental focus.

Another general goal for the organisation is to use their expertise to help clients with their sustainability performance. This could argue for the need to measure and track several different areas of projects, to be able to analyse their overall performance and find areas in need of improvement. This would then be conducted with the aim of measuring not to follow a goal, but to create a baseline and know what goal to set.

- *Expertise. Provide the clients with expert advisement within sustainability to help them improve their sustainability performance, reduce expenses, create value, and handle risks in their own organisation.*

A frequently mentioned purpose of many of the project is to create social sustainability. This by adapting constructions, city areas and buildings for a more environmentally friendly living. As some also mentions, this can easily take the spotlight and it is therefore important to remember that even if the design of the project is sustainable that does not necessarily mean that the process behind it is.

## **Requirements**

Based on the results from the interviews, the environmental aspects that are focused on are often the ones that are included in the client requirements. Further, those often refers to the requirements of the regions. Looking at the regional environmental requirements there is one requirement that is reoccurring and have some type of measuring connected to it.

- Risk assessment on building materials, often focusing on wood, concrete and steel.

Even if many other requirements are mentioned, the level of accuracy in the requirements can differ and all environmental requirements are not based on specific measurable performance. Many requirements are often defined in a looser manner or as a guideline.

## **Environmental Impact from the Industry**

As revealed in the research there are many different areas of environmental impact sourcing from the civil engineering industry. However, some can be noted to have a bigger impact or relevance for the industry than others. One attempt to concretise focus areas is the six principles within the concept of sustainable construction that are mentioned in the literature.

1. *Minimise resource consumption*
2. *Maximise resource reuse*
3. *Use renewable or recyclable resources*
4. *Protect the natural environment*
5. *Create a healthy, non-toxic environment*
6. *Pursue quality in creating the built environment*

Further connection can be done that the resources used in civil engineering project often correlates to building- and construction materials. These resources are also often a huge source of CO<sub>2</sub> emission, where concrete and steel play a huge part. As mentioned, in infrastructure projects, out of the total GHG-emissions 43% comes from concrete or cement and 21% from steel and in a case of a residential construction it accounted for almost all CO<sub>2</sub> emissions. The specific materials of concrete and steel is also mentioned both in the interviews and the regional requirements. This leading to believe that it can be a focus area for the industry and an important factor in single projects, if they have a structure based on concrete. From the interviews the general grouping of building materials is frequently mentioned to be a factor for environmental impact. Methods that can be used to work with the

resource questions that have been brought up include the use of BVB, LCA, carbon calculations and working with resource management.

From the results of the interviews other environmental areas with a measurable impact that is mentioned are transports and waste. The transport focuses on both long supplier chains when it comes to resources, but also on-site transports during the construction. On the other side, the literature study mentions that the impact from transportation is not that big compared to other processes, but that it of course can depend on how many and how long transportation trips that are included in a project. Concluding that the impact from transportations can have a significant variation between projects depending on choices of material sources.

## Project Specifications

As presented in both the literature- and interview study the sector of civil engineering and construction contains a huge range of different projects. Even if almost all projects are unique in design or construction, a general grouping of types of projects existing can be done. This to get a general idea of the attributes and methods of that group of projects. Further, by the finding from the research a general decision on what is environmental area that gets the most attention when it comes a specific type of project. The area of most attention for each project type is determined by the frequency mentioned throughout all parts of the research.

Type of project	Example of project	Area with most attention
Infrastructure	Bridges, roads, tunnels	Materials - Concrete/cement - Steel
Building construction	Houses, schools, apartment buildings	Materials and products in general
Urban development	Groundwork on existing neighbourhoods, exploitation on city land, renovation of existing city areas	Effects on existing land - Ground - Stormwater - noise
All projects		- Transports - Creating a social sustainable environment - Energy during operations

Table 14. Different project types and environmental areas with the most attention based on interviews.

The phases of the projects are also mentioned to be a factor of what actions are taken and what possibilities there are for implementation of new ideas and methods. The phases mentioned in the interview study correlated well to the phases discovered in the theoretical framework, this being the design (scheme), or planning as called in interviews, design (detailed) and construction. The focus on different environmental areas at different times of a project is mentioned in all studies.

Design (Scheme)	Design (Detailed)	Construction
Effects on existing land	Building materials	Transports
Water resources		Machinery
		Waste
		Chemicals

Table 15. Environmental areas mentioned in interviews sorted by project phase.

However, even if the impact of the environmental topics is causing its impact in one phase the work on that topic may spread over different phases. The operation of each area often consists of planning in an earlier stage to then make that area “active” later. For example, the activities in the construction phase are planned before hand, making it possible to measure both in the planning stage and in the performance stage. Observing the literature, benchmarks can be seen to have different objectives and depending on what aspect that wants to be measured the definition of the goals for a specific activity needs to be determined on forehand. If you only set out to use a reference value there is not a requirement for any measuring in the planning phase, while if the goal is set to a target value the theoretical performance needs to be determined on forehand. Therefore, deciding what type of goal that should be used must be determined early on to be able to apply the correct measuring or follow-up in the accurate phase. If a target goal for waste wants to be set some sort of calculation, comparison or other method needs to be used before the construction phase to decide a value the actions made later on can be measured against.

### 6.3 How can Performance Measurements be Determined and Transformed into Useful KPIs?

Depending on industry, visions, and projects, the relevant performance measurements can differ. To further be able to decide what values to base the work on the correct indicators need to be developed based on the specific prerequisites and goals for that organisation, company, or project. Depending on what performance that wants to be measured different types of values can be applicable.

#### Performance Indicators

Performance indicators can be divided into four categories where two of the categories are more relevant for the aim of EPMs in projects. These being *the state of the environment* and *the products and the processes of the company*. The first to be able to set a ground level to compare changes to, and the second to estimate the impact from the projects of the company. These categories have the possibility to be translated into quantitative values. They also correspond to the idea of measurements containing indicators and criteria. Proven by the interview study the indicators that tend to have a focus or be managed in some way in projects are the once that also can be found in the requirements from higher authorities.

The method in the literature for identifying environmental performance indicators can be used as an example. This by using the goal, requirements and activities mentioned throughout the study. Instead of coming up with the relevant for the company, the perspective is changed to projects. Chaining the macro-level to the industry of civil engineering and the micro-level to the single project. Firstly, identify the specific environmental problems, and later determining the suitable indicators. The goals used in the example are the UN development goals with an environmental focus adapted by

the company. If more specific visions exist from a client or for a project, indicators can be used to create a better accuracy.

Protocol, goal, etc	Global problem	Macro – micro link	Impact on projects environmental performance	Impact on projects financial performance
Sustainable cities and communities	yes	yes	no	yes
Responsible consumption and production	yes	yes	yes	yes
Climate action	yes	yes	yes	yes
Life below water	yes	no	yes	no
Life on land	yes	yes	yes	no

Table 16. Example of prioritising of environmental goals.

Resulting in that the focus on the different goals can be ranked from most to least relevant, *Responsible consumption and production* and *Climate action*, *Sustainable cities and communities* and *Life on land* and last *Life below water*. The most relevant goals can then be used to continue and determine environmental performance indicators.

Environmental Problem	Environmental activity	Sub-activity		Environmental performance Indicator
Responsible consumption and production	Material use	CO2-emissions	Concrete Steel Wood	Material CO2-emissions
Responsible consumption and production	On site (production) activity	CO2-emissions	Machinery Fuel Transports	On site (production) CO2-emissions
Responsible consumption and production	Waste disposal	Solid and liquid waste	Recyclable  Non-recyclable	Volume of waste produced in project
Climate action	CO2-emissions			Summarised CO2-emissions produced in project

Table 17. Examples of environmental performance indicators based on results.

## Formats for Indicators

Depending on what performance that is relevant to be measured, different methods can be used. A well discussed approach is to implement more cyclical processes and keep the whole lifespan and journey of all processes in mind. Another aspect is the importance of cost and economy. As stated clearly as the number one aspect in

projects this could be an important viewpoint to include when approaching the work of sustainability to create a realistic way of conduct.

### ***Life Cycle Assessment***

As registered as a result from the interviews it often occurs that one process or activity in a project can get all the attention and therefor also keeping the environmental focus to a limited number of impacts. Using LCA in project could be a solution since the approach itself is designed to identify and count in all impacts from cradle to grave. LCA was also mentioned in the interviews to have been used when getting information about materials and is already implemented with some stakeholders.

A difficult part by using the LCA is that there is a lot of information that needs to be collected from a lot of different sources. It is therefore important to know what limitations to use. As the LCA can be performed with more standardised or specific values and processes it is needed to be define beforehand what is a realistic and efficient way to use the method. Using industry wide standard values might be an easier approach when many different processes are included. Even if the outcome might not be as spot on, it can be a more realistic method that can give a finger point of the environmental performance.

### ***Eco – Efficiency***

As the economical factor has been shown to have the highest priority when it comes to civil engineering projects, this could be a factor that could help promote the work of sustainability. Using Eco-efficiency, the environmental impact of choice gets measured against the economical aspect and can show what environmental impacts results from the investments. This could be an easy way to compare the cost- with the sustainability aspect as you see exactly what you get for the money. Although, it is important to decide on what values that are to be compared to keep it consistent and keep the comparison correct. Used values could for example be CO<sub>2</sub> emissions from materials and the budget for the project.

### **Determining Performance Measurements and KPIs**

The literature presents seven questions that can be used to define KPIs. These can be applicable when knowing what goals that have been set for the whole company or in a single project. By answering the questions, it creates a general guidance on how to implement KPIs to a project. The questions also cover many of the things that were mentioned in the interviews as problem areas, such as clear goals, responsibility, and check-ups. To come up with efficient and usable KPIs for a project the questions can be used after determining what environmental indicator or environmental goal it should focus on and know why and how the specific KPI is used.

As stated in the literature it can be difficult and inefficient to use to many KPIs in a project because it becomes time and recourse consuming. It is also mentioned in the interviews that the work with environmental focus often falls behind much because time and resources are more needed elsewhere. Therefore, it is important to distinct what areas are most important for a specific project to follow and focus on. Making sure the environmental work is done properly and where it is most needed. This also creates a framework for how the KPIs should be handled throughout the project,

making sure that the work is clear and implemented properly from the start, as mentioned during the interviews that otherwise that can create problems.

- *Only a limited, manageable number of KPIs is maintainable for regular use. Having too many (and too complex) KPIs can be time- and resource – consuming.*

When the performance indicators have been decided the questions connected to KPIs can be used to create an understanding and plan for the desired work and outcome. This can help to both know what the KPIs should present, but also why it exists. A general example of answering the questions can be done using the goals of reduction in CO<sub>2</sub> emissions but can be defined even more specific in single projects and specific actions.

**1. What is the desired outcome?**

- *Detect CO<sub>2</sub> - emissions from projects in 2020. (Reference value)*
- *Reduce CO<sub>2</sub> - emissions by 50% by 2030 compared to 2020. (Limit value)*

**2. Why does this outcome matter?**

- *Creating a baseline for future measurements.*
- *Making sure there is a reduction in GHG-emissions from projects.*

**3. How are you going to measure progress?**

- *Using LCA-analyses and CO<sub>2</sub> calculations from projects.*
- *Using LCA-analyses and CO<sub>2</sub> calculations in early stages to help make decisions. Create target values to reach for in early stages. Do check-ups using earlier mentioned methods to track progress.*

**4. How can you influence the outcome?**

- *Since it is based on already performed actions and a reference value there is nothing to influence.*
- *Set goals and target values in early stages. Use that information to make more CO<sub>2</sub> friendly actions. Regular check-ups.*

**5. Who is responsible for the business outcome?**

- *Company management*
- *Project manager / sustainability coordinator*

**6. How will you know you've achieved your outcome?**

- *When all data is collected*
- *The result in 2030 is 50% of 2020s value.*

**7. How often will you review progress towards the outcome?**

- *No progress. Finished when data from all projects is collected.*
- *Reviews will be conducted internally in projects every quarte year. Reviews will be conducted companywide every half year.*

As the company has presented, to be able to come up with a measurable goal they first need to come up with the reference value. If no reference value does not exist there is nothing to compare the future goal to. This could make the start KPIs to be reference



values for the chosen environmental indicators, to later be able to set comparable limit- and goal values. This is also a start to create benchmarks both for single companies and the industry.

## 6.4 What Challenges May Exist with Implementation?

Even if there are positive outcomes that support the use of EPMs, there are also challenges. Numerous examples have been presented where different methods and approaches have been used in the civil engineering industry to strengthen the status and implementation of sustainable actions, but still there is no action that is fully implemented all over.

### Priorities

The priorities in projects often does not stand in the favour for the work with sustainability. The decision for a project often comes from the project owner. Cost and time are highly valued aspects in projects and often what is fought for to keep down. This often results in that new ideas and action can be put aside as they are automatically related to increased cost and time as they probably will need more time and resources to use as not being implemented as a usual routine.

Not to forget is that the engagement of single individuals can be shown to make difference. As shown in the interviews work with sustainability goals have been implemented in some projects and when engaged employees take charge of the vision of a greener project the work gets done. The question might not be about if it is possible, but if the sustainability focus has become normalised enough in the industry to create engagement from all stakeholders. Although the knowledge surrounding the question needs to exist before being able to start any work, but that it also requires a drive to create the knowledge to practical work. Otherwise, the knowledge might be there, but no one dares, wants, or feels the need to use it. The sustainability work that is done today is almost always based on requirements from higher authorities, such as governments, regions, or clients. This also results that if the requirements do not exist the work tends to be neglected. The lack of general and specific requirements can be seen as a hurdle.

### Knowledge

A lack of knowledge and awareness regarding sustainability, and more specific environmental impact, is a reoccurring topic. This can present itself in two ways, a general lack of knowledge on the sustainability area and its importance, or a lack of practical knowledge on how to attack the problem or who to turn to.

For the general knowledge, the reason behind the actions is important to share to create understanding. Although, as mentioned, many times companies hold workshops regarding the topic of sustainability, but it is not always that those lessons are brought back into the projects. Here there might exist a gap between having the knowledge and knowing how or feeling engaged to act on it in projects.

- *For performance measurements to be effective, the measures or indicators must be accepted, understood, and owned across the organisation.*

To implement methods to measure the environmental performance it does not just include spreading awareness about what environmental areas that should be in focus, but also educating in how the actual process of measuring should be conducted. Making sure all relevant stakeholders know how to use chosen methods, if it is carbon calculations or LCA, that should be all known knowledge throughout the project. This can require resources and extra time. As clearly presented in the requirements from the regions, often different activities are held responsible by different actors in the project. Then it is crucial that all who are reporting and collecting data or information know how this is performed so the information then can be summarised. As mentioned, the use of concrete and practical tools such as checklists can be helpful but also here it then it is important that it is clear to all how these should be used.

## **Routines**

As brought up earlier it can be hard to introduce new methods and routines in projects that are understood and accepted by all stakeholders. Even if successfully done, it can be a long process and time consuming. The change also needs to start somewhere, and as mentioned in the interviews that actions are often first taken when coming from higher authorities, government and project owners need to set a start line for the work of tracking environmental impacts and clearly set is as a standing routine. This as requirements from higher authorities is proven to be acted on. But also continuously followed up to keep the work active, once again this can be a time and -resource consuming action. The literature states that to gain any understanding from the values that are measured there is a need to collect information from many projects. Even if the implementation in single projects can be a statement, to gain useful data that can be compared, benchmarked, and develop trends, many projects need to be tracked over a time.

- *The systematic use of KPIs is essential as the value of KPIs is almost completely derived from the consistent use over a number of projects.*

Structures needs to be developed on who has responsibility. Both for who has the responsibility to collect data on different activities and who that collects and summarise the result for the entire project. As this does not seem to be an existing task new work protocols might be in need to be developed. Also setting boundaries, what are we capable to measure and track and what is irrelevant or do not have an efficient method for its use.

## **Standardisation**

To use environmental performance measurements as a tool both internal and external a standard need to be set. As presented performance measurements can be set to many different values. To use it widely common values and measures would have to be set, making sure trends and comparisons can be determined. As there can be different interpretations on sustainability, and even a confusion on what sustainability is, deciding on what to go for can be hard. The common values and interpretations then need to become aware for many stakeholders which itself can be a huge work. The calculations itself sometimes may need to be based on standard values to make the work realistic, these standard values would also need to be determined.

## 7 Discussion

In this chapter the findings of the research are discussed and brought up in new contexts and looked at together with further thought they might bring up. Possible errors and weak parts of the study are also explained and discussed.

### 7.1 Discussion on Results

As seen by the result the use of measurable data on environmental impacts from civil engineering projects is not that widespread or normalised. Some data exists but it is far from a full summary of whole projects. Even if the work that is done is good, it can be hard to get a realistic view of the sustainability of a project if only some parts are highlighted and could instead result in a false interpretation of a projects green intentions. Also, to make sure that one success area does not exclude the others.

Even if EPMs are not a standard for companies or clients there still is a will to come up with new solutions to implement in projects. As mentioned by Trafikverket they are open for new suggestions on new methods and approaches for sustainability in projects, which also corresponds to what was mentioned in the interviews about how clients would react positively with new suggestions. To dare to bring up new methods to clients can then be a way of getting support and help with development and implementation, and together see the benefits.

As seen by the documents from the regions, requirements regarding environmental impacts do exist. The problem can be that they are not always that exact or concrete. If there is a lack of knowledge on the area, it can be hard to decide or know what the most environmentally friendly solutions are. For this reason, an improvement on the requirements could be to in a longer extent work with measurable demands that are concrete and cannot be interpreted in any other ways. Setting general goals to be sustainable are impossible to reach since, how do you know when you are sustainable enough? If the demand comes from higher authorities the decisions get heavily backed up but also creates a purpose for stakeholders and workers in projects. Since the governmental requirements are what should be followed, if the requirements come from them there might create a shift in the current priorities and sustainability could get a higher status. This could make it possible to accept new approaches even if it comes with, for example, higher costs.

A trade for the civil engineering industry is that almost all projects differ from each other. This makes it hard to use an exact template that is the same in all projects. Even if CO<sub>2</sub>-emissions are a huge area that has a lot of focus, the way the emissions are being produced are not the same in all projects. Some projects might include a lot of concrete, while others do not. So, for example if the calculation of CO<sub>2</sub>-emissions were based on the use of concrete that can be misleading depending on the project. But also, if there are many different areas and actions that can be tracked it can become a lot of work to collect data from them all and then also summarise it. Even if all projects differ, some generalisations can try to be made. One can be that materials is often a great source of emissions. Keeping up the work with standardising values for materials and their environmental impact could be an easy way to measure a great source of environmental impact. It can become harder when project include many unique trades and processes.

Different formats of the indicators can be used and give away a difference measure in performance. Using the LCA is relevant to connect to get the full lifespan of a product and get further with the work of cyclic processes. There is also LCA frameworks that are developed from ISO. If ISO already is a requirement in an organisation, this could make the LCA easier to implement if it already is aligned with existing framework. Using eco-efficiency can be a good way to bring in the economic aspects. Since cost is the highest prioritised aspects in projects, using an environmental performance measurement that is including that aspect can be benefitable. This could also be a way of including sustainable measures in procurement stages, such as LOU. But for getting started with measuring impacts, using the basic measuring of the impacts, such as carbon accounting, might be the best alternative. This to get the method implemented and create benchmarks, and thereafter further development with more complex values can be used when the routine is fully implemented. But whatever method that is used, to be applicable in an LOU process a standard format would need to be decided to make it possible to get a correct comparison between projects.

As a main challenge is to make the procedure of measuring easy and efficient, a good start can be to use general values on actions and materials. This to be able to get familiar with the concept and methods as well as getting some kind of indication on the project's performance. If the approaches are too complex and resource- and time consuming in the beginning it can be hard to get them going at all. Keeping in mind that the values might not be 100% accurate but using it more of a way to introduce the concept and invest in the development for the future. Measuring every part of a project can be unrealistic expect from the beginning but keeping focus on the most important topics can be a good start. Even if specific goals are not set yet for projects the measuring of their impact can be an important resource for the future work with sustainability. Collecting reference values makes it possible to set goals for improvement and see the status of the current work.

Since the topic might not be a regular standard amongst all stakeholders it can be hard to know who has the responsibility regarding questions of collection of data, summary, and the general approach of sustainable actions. In the beginning these responsibility areas needs to be defined and the KPI questions can be a tool to help with that.

## **7.2 Sources of Error**

As the study aims to investigate the use of methods and approaches for a whole industry based on limited observations and findings there can be some sources of error to keep in mind. The research has been limited to a few chosen methods. This to try to focus the findings to a possible in real life approach and dig deeper in how this could be used. This can though result those other methods are out there that are as useful, but not covered in this research. Further, the methods used are based on theoretical information and can therefore be interpreted as a hypothesis of how things are conducted. Further studies could be done to confirm the accuracy of the theories. To keep in mind is also the size of the study. The results are based of empirical findings from a limited number of interviews and documents. Even if these can give a finger point to trends, it is not certain that those observations are representative for the whole industry.

## 8 Conclusion

The main findings of the research have been summarised and presented to answer the research questions presented in the beginning of the report. Suggestions for future work within the area is explained as well as possible topics for future studies that can cover unanswered questions or continue to build on the result from this report.

### 8.1 Important Findings

As the civil engineering industry is a required and important industry with a huge demand of developing our living areas and societies, they also have a huge responsibility when it comes to the impact they create on the environment. As the projects of construction are sources of emissions, waste, and environmental changes in different kinds, work needs to be done to create an efficient way to work with sustainable while still being able to continue the efficiency in the projects.

#### Why

The use of EPMs creates concrete values that cannot be misinterpreted. As now many requirements and goals are very general and combining this with a lack of understanding of sustainability in the industry it can be a good way to assure that the work is in line with environmental improvement. Having a concrete measure of impacts makes it possible to do check-ups throughout the project, this to follow the progress and in earlier stages make conclusions if the project follows the right trends or if there is a need for change. As the result shows that when requirements are set, they tend to be met, or at least work with in highest possible grade. Setting requirements based on concrete numbers is a way to make sure sustainable measures are being taken as the result can be shown by the values. It can also create an easy way for stakeholders to see progress and understand the status of the project and promote easy stakeholder engagement. Getting concrete values of the reality which can be used to make easy comparisons creates possibilities to see both problems and successes. This to hopefully increase the focus and prioritising for the sustainability issue in projects and know what areas to work extra with and be able to put in efforts in the right areas.

#### What

To know what areas to focus on and find the right indicators, different factors can be taken into consideration. Since the use of many different indicators and KPIs can be inefficient and complex, it is important to determine focus areas. Goals and requirements can be looked on from higher authorities and the organisation itself. Also, earlier trends from the industry, project specifications and client requirements can be taken into consideration to find specific focus areas. Goals that exist and are implemented by the company are the UN development goals and more specific goals that are set by the participating company are reduction of CO<sub>2</sub>-emissions in projects and expertise to help clients with sustainability progress. Existing requirements are often related to materials used frequently and in huge volumes, such as wood, concrete and steel. A general trend from the industry is that CO<sub>2</sub>-emissions is a huge environmental impact and that this can often be related to materials. Keeping the project specifications in mind, different project types can involve different actions and different areas can be important in different stages of the project. This makes it

important to implement the work with sustainability from the beginning to not miss anything and set up a strategical plan on what to focus on.

## **How**

To know what to focus on in specific projects two aspects can be investigated. Firstly, what are the guidelines or goals from higher levels. What do the organisation work towards and what general struggles do the industry face? Secondly, what technical actions are included in specific projects? How can the earlier mentioned goals and visions be translated into the specific work that is conducted in the projects? To see the impact from the companies, work indicators in the category “*the products and the processes of the company*” can be used. By the example of breaking down environmental problems into actions performed in the report, environmental indicators resulted in being, CO<sub>2</sub>-emissions from materials, CO<sub>2</sub>-emissions produced on site, volume of waste produced, summarised CO<sub>2</sub>-emissions. Important to keep in mind is that this process can be specified depending on project and therefor look different based on that and that the indicators presented are created as an example.

The format of the EPM-values can differ depending on what type of performance it should present. LCA and Eco-efficiency are two examples mentioned that add in the perspective of cyclic thinking and economy. But, as a start the use of basic values, such as CO<sub>2</sub> in kg, can be easier to use to set reference and limit values. The selected focus areas can then be used as KPIs, and by using the KPI-questions a framework of how to work with KPIs can be set and give clarity to how they should be used. This also sets up a clear guide of why, what, when and who, which is important given that there often are many different actors involved in the projects. If EPMs and KPIs on environmental impacts have not been used in the organisation before, a good start would be to measure reference values in projects to get a status and be able to from that set goals and benchmarks. As there are existing methods on measuring impacts, such as carbon accounting, these could be continuing to be used but in a more frequent way. In the beginning, to make the process as easy and usable as possible, standardised values can be used to get a finger point of the performance but also get familiar with the methods, create a usable routine and hopefully further down the line make it a natural way of work in the projects.

## **Challenges**

As EMPs are not yet a well-used concept for all actors in the industry, it would need to be implemented as a new method and can therefor bring with it some challenges. Main challenges detected are related to, priorities in the industry, lack of knowledge regarding sustainability, implementation of new routines and coming up with a good framework for standardisation.

## **8.2 Suggestions for the Industry**

Based on then findings of the study some suggestions on how environmental performance measurements could be adapted and used on different levels are presented.

## **Projects**

Use the goals of the company and the project specifications to come up with focus areas for the specific projects. Use few focus areas in the beginning to get the work started and be developed more over time. As new suggestions on approaches when it comes to performance in sustainability can be a goal for the company as well as a request from clients, dare to bring up the work of sustainability even if it is not a requirement from the beginning.

## **Companies**

Clearly develop goals and make these known throughout the organisation. If the work with sustainability is a priority, make this clear to make sure actions towards this also is followed down into projects and employees feel supported. If workshops and lectures are performed, focus can be about not only knowledge about the area but concrete actions on how it can be handled in the projects. If quantifiable goals are set, create a common measurement that can be used in projects, making it known what type of values the organisation work with.

## **Government**

By setting quantifiable goals already on a governmental level it could enable companies to adapt and at least follow those guidelines and even develop own. If there are goals set on this level, they would be used by the whole industry. It could also enable the creation of a general approach thorough the industry and create possibilities for benchmarking.

## **8.3 Future Research Areas**

As the results of this study presents as a general guide for how environmental performance measurements can be used by organisations in projects there are areas where there are room for further in-depth studies. Here are some suggestions on further areas that can be investigated surrounding the area.

### **Project Case Study**

To get a more precis and accurate analysis of exactly what actions that are included in a project a research, based on one or a couple projects, could be performed. This to be able to follow a real-life project and based on that detect what environmental impacts that project brings with it. Also, not only detect environmental impact, but follow the decision process to see what instances are involved and where there is possibility for change.

### **Application**

The findings in this study can further evaluated. By using the methods of determining goals for an ongoing project and decide environmental indicators and break the project down to activities that should be measured. As the result presented here are much based on theoretical facts the method could be put to the test in practice.

### **The Status of Sustainability in the Industry**

The status of sustainability within the civil engineering industry could be deeper explored. How far has the work been implemented and what enablers and challenges

exists. Dig deeper in what possibilities for a fast growth within sustainability and how the engagement surrounding the subject looks and why.



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# 10 Appendix

## Appendix 1.

### Interview questions for project managers:

#### **Introduction**

1. *What is your position and work tasks?*
2. *How long have you been working in the industry and in your current role?*
3. *What projects are you currently working with?*

#### **Sustainability in general**

4. *What is your perception of sustainability?*
5. *Do you ever reflect over sustainability in your projects?*
6. *Is sustainability something you work with throughout the whole project or are there any differences between start and end of a project process? Example, how you work in the design phase vs in the construction phase?*
7. *Do you have anyone who is responsible for sustainability in your projects?*

#### **Environmental goals**

8. *Do you have any internal environmental goals you work with in your projects?*
9. *Do customers ever put any demands when it comes to the environment on you as project managers in projects?*
10. *Do customers ever put any demands when it comes to the environment on you as consultants in projects?*
11. *Do you ever put any demands when it comes to the environment on contractors / other stakeholder in projects?*
12. *If so, are the goals / demands clear and is it clear on how to act to reach those goals? Both internal / external and for you / other stakeholder*
13. *Do you think the use of environmental goals would do / does any difference in how you act in your projects?*

#### **Environmental areas and activities**

14. *What are the biggest areas / challenges when it comes to environmental impacts in your projects? (Material use, transportation, energy use etc.)*
15. *Is environmental impact a factor you reflect over when making choices on earlier mentioned actions / processes?*
16. *If choices are made on ex. Approach / contractor, are there any information regarding sustainability / environmental impact on forehand? And if so, does this have any impact when making the choice of contractor?*
17. *Do you gather any information on how different actions / processes impacts the environment? If so, how, and what? (Example. Different environmental impacts from material choices, emissions, waste, in kg CO<sub>2</sub>, energy in KWh)*
18. *When it comes to data or information on environmental impacts in projects, do you have access to all the information or is it scattered between different stakeholders?*
19. *Do you have any suggestions on how environmental data can be gathered in the best way?*
20. *Do you work with ISO14001, if so, how?*

21. *Do you use any other sustainability policies / certifications?*
22. *Do you have any approach when it comes to reporting back to the client on the environmental / sustainability status of a project?*

***Finish***

23. *Do you think all stakeholders in a project are aware / prioritise sustainable acts?*
24. *Do you think there are any improvements in general that can be done when it comes to how you work with sustainability in your projects?*
25. *Is there anything else you want to mention on the area that have not been brought up yet?*

## **Appendix 2.**

### **Interview questions for sustainability responsible:**

#### ***Introduction***

- 1. What is your position and work tasks?*
- 2. How long have you been working in the industry and in your current role?*
- 3. What projects are you currently working with?*

#### ***Sustainability in general***

- 4. What is your perception of sustainability in your specific industry?*
- 5. How do you work with sustainability in your projects and in your organisation?*

#### ***Environmental goals***

- 6. Does your organisation have any environmental goals?*
- 7. How do you work to come up with these goals?*
- 8. How do you work to live up to these goals?*
- 9. How do you work to gather data and information from projects within your organisation to be able to surmise your status on your goals?*
- 10. Do you think that the general goals for the organisation is transferred down into single projects?*

#### ***Environmental topics***

- 11. you have any thought on which environmental areas that the industry you are working in have the most impact on? (Which areas are most relevant for you)*
- 12. Is there any environmental area / or process within your organisation that is extra challenging?*
- 13. Is there any environmental area you can think of that could need more attention or that is not put enough effort on?*
- 14. There are many different sustainability frameworks companies can use, do you use any? And if so, which ones? (ISO, EMEA etc).*
- 15. yes, how does the company use / implement this?*

#### ***Finish***

- 16. Do you think all stakeholders in a project are aware / prioritise sustainable acts?*
- 17. Do you think there are any improvements in general that can be done when it comes to how you work with sustainability in your projects?*
- 18. Is there anything else you want to mention on the are that have not been brought up yet?*

