Changing the mindset; Switching from a financial perspective to a strategic perspective regarding energy-efficient procurement

“We can’t solve problems by using the same kind of thinking when creating them” Albert Einstein

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07-06-2019

Abstract

The industrial sector is witnessing a slow but progressive change in how products are manufactured due to the integration of environmental issues into product development. This shift is particularly important considering that the industrial sector accounts for approximately 20% of global greenhouse gas emissions. In order to accomplish a systematic change that results in sustainable manufacturing processes, both strategic and long-term perspectives need to be implemented by businesses and organizations. For this reason, this Master Thesis will evaluate the decision-making behind purchased machinery and equipment required for production in Siemens Gamesa Renewable Energy Aalborg, since the first filter towards sustainable product is to minimise energy consumption throughout the supply chain and optimize existing equipment. To address the problem in hand, the stakeholders involved in the design and purchase of machinery and equipment were interviewed to understand pathways and drivers that dictate the current decision-making process at the plant. Moreover, three existing products that presented inefficiencies at the plant were evaluated to expose current barriers that hinder the implementation of a sustainable supply chain. The two main barriers encountered were the lack of sustainability assessments tools that can proof reliability in long-term opportunities and uncertainty of the environmental requirements and standards that should push towards a sustainable production environment. As a consequence of these issues, a supplier selection strategy is proposed to become transparent and engaging with the variety of stakeholders. Furthermore, a method to calculate emissions is explained to predict the potential environmental impact of machines and equipment to make a responsible selection based on quantitative calculations. Finally, the framework proposed will support strategical decision-making to predict consequences of value creation towards environmental, social and economic sustainability.

Key words: sustainability, circular economy, sustainability assessment, industrial ecology, energy efficient procurement, sustainable design, carbon neutrality, decarbonization

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List of Acronyms

A: Activity (Air emissions formula)

C: Control Efficiency (Air emissions formula)

CO2: Carbon Dioxide

E: Emissions (Air emissions formula)

EF: Emission Factor (Air emissions formula)

EPA: Environmental Protection Agency

GHG: Greenhouse gas

HSE: Health, Safety and Environment

IE: Industrial Ecology

IEA: International Energy Association

IPCC: Intergovernmental Panel on Climate Change

Kg: Kilograms

MIT: Massachusetts Institute of Technology

mmBTu: Metric Million British Thermal Unit

ppm: parts per million

SDGs: Sustainable Development Goals

SGRE: Siemens Gamesa Renewable Energy

1. Introduction

1.1. Climate change and decarbonization

"Climate change increasingly poses one of the biggest long-term threats to investments"

Christiana Figueres on Climate Change
Secretary of the UNFCCC

Climate change already impacts the way the climate functions and will keep changing well into the future (EEA, 2017). The overwhelming majority of climate scientist agree that human activities are the main causes of climate change, reflected by the steadily improved collection of data over the years. These changes have been taking place since the era of industrialization where vast amounts of coal, oil and gas were extracted and burnt for energy purposes. Ever since, the concentrations of CO_2 have been released into the atmosphere much more rapidly than the natural carbon cycle and have increased from 280ppm, during the warmer interglacial periods, to 400ppm in 2013 as Figure 1 represents (NOAA, 2015).

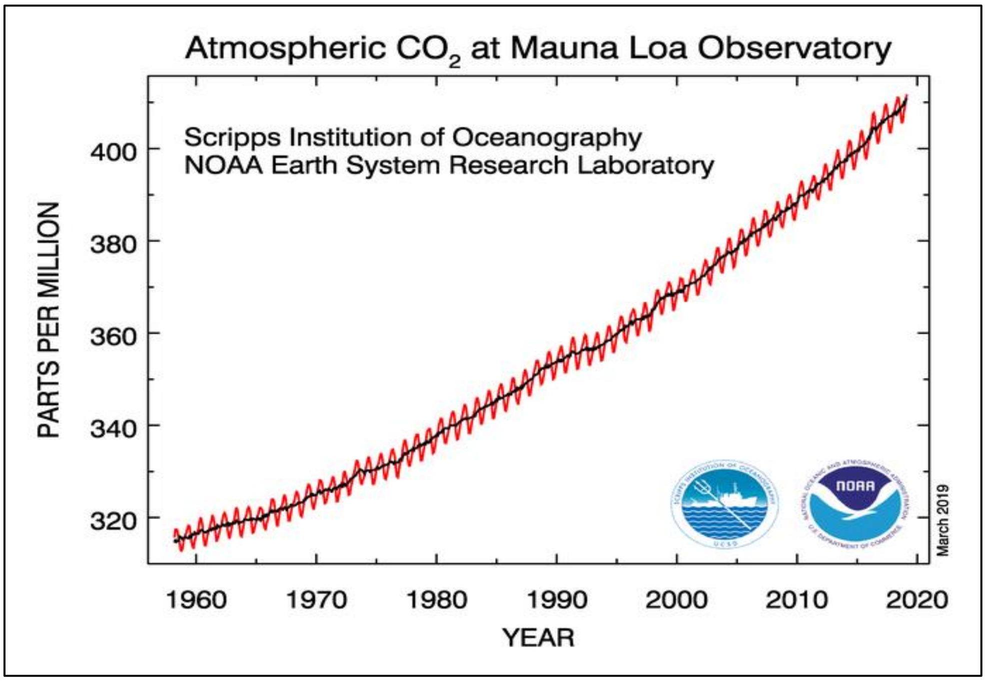

Figure 1. Full CO2 record from the Mauna Loa Observatory in Hawaii (Source: NOAA, 2015)

As the levels of CO_2 and other greenhouse gas (GHG) increase, there is more heat trapped in the atmosphere and the global temperature of the Earth rises. This causes significant changes to climate as the IPCC states "the atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level have risen, and the concentrations of greenhouse gases have increased" (IPCC, 2013). Parallelly, it seems like everything counts in the race to become energy leaders and this problem is opening new coal war frontiers as China and America increase coal dependency and also European countries such as Poland or Germany (BP, 2018). To this day two thirds of our electricity consumption is generated from dirty fossil fuels, constant tendency since 1990 and will keep growing by 30% by 2040 which is equivalent to adding another China and India to today's energy demand. On the other hand, renewables are expected to count for 40% of the projected demand (UN Environment Programme, 2019).

In order to mitigate the effects of climate change, human activity should limit the amount of CO_2 emissions and other GHG into the atmosphere. This rectification will depend on how humans produce and reduce energy, what policies and regulations are implemented and what new technologies come available to aid a fast transition (OECD, 2011). For these three key factors to thrive, countries will need a strong government support and trust to impulse environmental projects and put fossil fuels dependency in the past. To allow new energy consumption trends a dramatic reduction of fossil fuels dependency needs to take place by decarbonizing the existing and "outdated" energy system which is progressing comparatively slow, at approximately 0.3% per year. Nevertheless, research shows optimistic results since this trend has continued to increase during the past two centuries (Nakicenovic, 1996). But what is decarbonization and how could it benefit our society? According to leading organizations in the energy and environmental fields, decarbonization has the following definitions:

Organization	Definition	Reference
Intergovernmental Panel on Climate Change (IPCC)	"Decarbonization denotes the declining average carbon intensity of primary energy over time"	(IPCC, 2007)
Grantham Research Institute for Climate Change and Environment (LSE)	"The decarbonization of the power sector means reducing its carbon intensity; that is, the emissions per unit of electricity generated"	(LSE, 2014)
The Deep Decarbonization Project (DDPP)	"Energy efficiency and conservation, decarbonizing electricity and fuels, and switching end uses to low-carbon supplies"	(DDPP, 2015)

Table 1. Definitions for decarbonization (Source: self-generated)

In a nutshell, a transition towards a decarbonized economy is an economy based on low-carbon power sources that have a minimal output of GHG emissions into the atmosphere, but more specifically it refers to the carbon dioxide gas (IPCC, 2012). Low-carbon economies can present multiple benefits such as environment, energy security, health and industrial competitiveness to avoid catastrophic climate change, among others (UNDP, 2016). Therefore, the design and implementations of carbon neutral strategies are binding to achieve social, economic and environmental goals (IPCC, 2007).

Moreover, a rapid transition from the current energy system will require the support of businesses, governments and other stakeholders who can lead the industrial decarbonization on the local and regional levels by setting coordinated effort across the economy. This will also put pressure in current regulations, policies and incentives e.g. encouraging investment in local renewable energy projects for self-consumption. Thus, new policies will push environmental targets forward e.g. Siemens-Gamesa Renewable Energy (SGRE) promotes a low-carbon economy and aims to become carbon neutral by 2025 according to their Annual Sustainability Report 2018 (SGRE, 2018). The proposed targets by numerous companies need to become a reality and this will only be possible with trust and economic support to break the current socio-technical regime and allow new windows of opportunities to arise, such as technological breakthroughs, further lowering zero-carbon energy prices, changing costumer's preferences and a regulatory push (de Pee, Pinner, & Somers, 2018). As professor Sergey Palstev stated during an Energy Workshop for MIT, "Achieving low-carbon goals requires strong interaction among decision-makers from different economic sectors and geographic locations who often must balance multiple objectives" (Palstev, 2018). Thus, the sooner organizations and industries understand the importance of their decisions and adapt a decarbonization strategy the easier it will be for all human kind to face future adversities related to climate change (EU, 2018a).

1.2. The role of industries: Corporative environmentalism

The industrial sector provides a vital source of wealth, prosperity and social value across the world which consists of three main categories:

- Mining and quarrying
- Manufacturing
- Electricity, gas and water supply

The different activities related to industry usually categorized under plant, factories, or mills, cover a wide size of operations which account for over 21% of the world's GHG emissions (IPCC, 2014). The total industrial CO_2 values include emissions from mining, manufacturing and construction for which manufacturing is responsible for about 98% of total direct CO_2 emissions (IPCC, 2018). Most CO_2 emissions arise from the combustion of fossil fuels like coal to provide energy in the form of heat to obtain the physical and chemical transformations that convert raw materials into industrial products (IPCC, 2018). Which is exactly what SGRE is doing in its production plants to manufacture wind turbine components.

Nevertheless, recent results have shown that coal demand in the global energy mix continues to decline but after several years of free-fall, the coal market experienced a mini-revival in 2017 and 2018, with both global consumption and production increasing, China and India being the main drivers see Figure 2 (IEA, 2019).

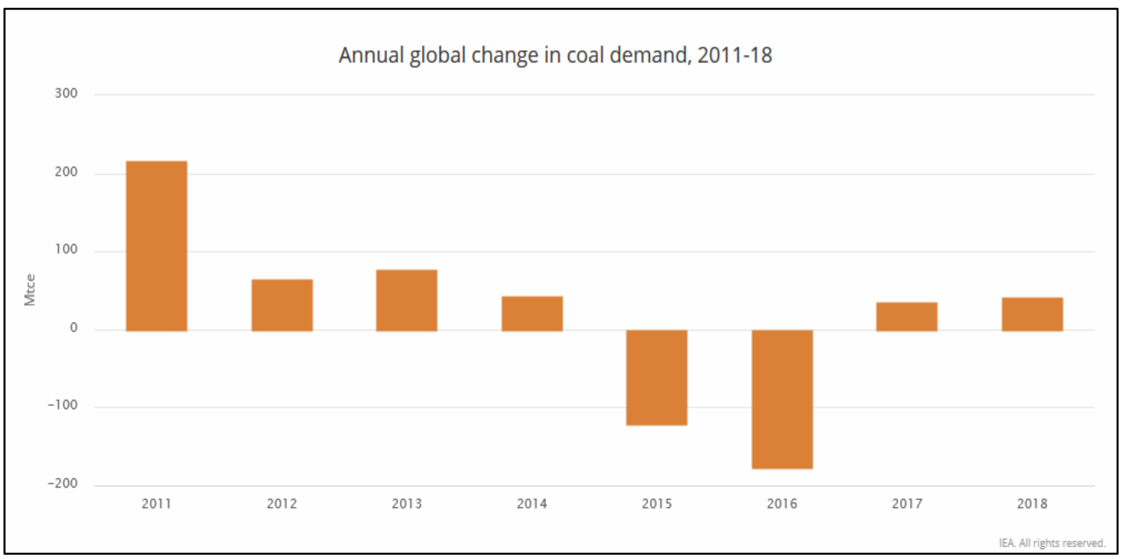

Figure 2. Annual global change in coal demand 2011-2018 (Source: IEA, 2018)

If we want to decrease carbon intensity and shift towards rapid CO_2 improvements a rapid shift in the industry sector is required if emissions reduction targets set in the Paris Agreements are to be achieved. For this to happen, reductions in energy intensity must be realized through technological changes (e.g. changes in the production mix, integration of energy-efficient technologies, energy management teams, etc.) to define a reference 'best practice technology' (IPCC, 2018). This change is known as 'industrial ecology' which as T.E. Graedel states "Industrial Ecology (IE) is a new ensemble concept in which the interactions between humans' activities and the environment are systematically analysed. As applied to industry, IE seeks to optimize the total industrial material cycle from virgin material, to finished product, to ultimate disposal of waste” (Graedel, 1994). This means that the industrial system should be looked at not as an isolated system from its surroundings of the natural world but interconnected with them as represented in Figure 3. This approach will optimize the energy resources, energy and capital of a product from ‘cradle to grave’.

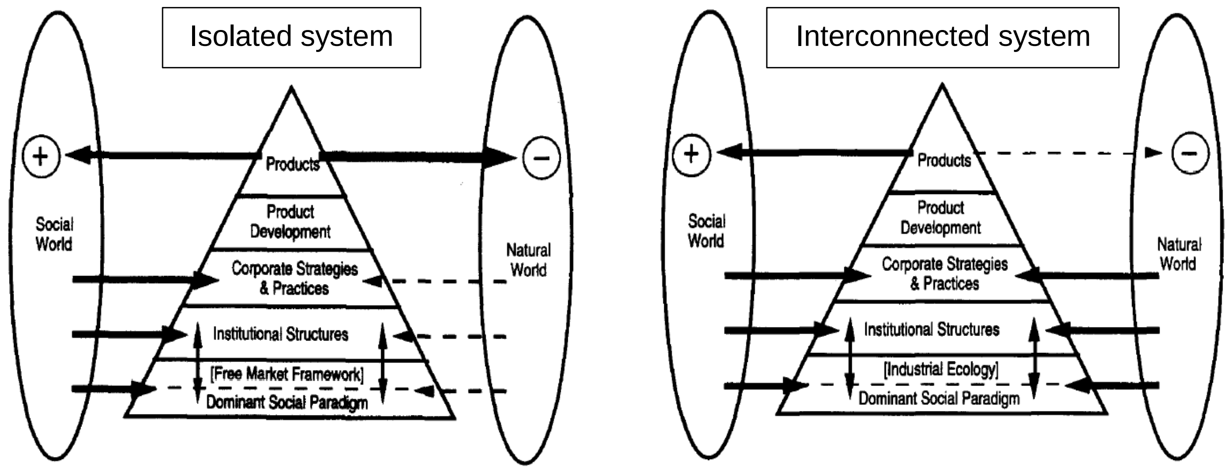

Figure 3. The emergence of an eco-industrial infrastructure (Source: Graedel, 1994)

Nonetheless to embrace this mindset, skills need to be built through training employees for orchestrating change such a training in environmental management, effective teamwork, sustainable mindset, time management and problem solving. Especially, mutual adjustments form a top-down approach in managerial positions, is always needed. Depending on the stakeholders training and the company’s practices toward environmental targets, their efforts can be measured. For example, Dyllick and Muff created a framework in their paper *“Clarifying the meaning of sustainable business: Introducing a typology from business-as-usual to true business sustainability”* to classify companies based on their efforts to integrate sustainable management (Dyllick and Muff, 2016).

BUSINESS SUSTAINABILITY TYPOLOGY	Concerns	Values created	Organizational perspective
	(What?)	(What for?)	(How?)
Business-as-usual	Economic concerns	Shareholder value	Inside-out
Business Sustainability 1.0	Three-dimensional concerns	Shareholder value	Inside-out
Business Sustainability 2.0	Three-dimensional concerns	Triple bottom line	Inside-out
Business Sustainability 3.0	Starting with sustainability challenges	Creating value for the common good	Outside-in
The key shifts involved:	**1st shift: broadening the business concern**	**2nd shift: expanding the value created**	**3rd shift: changing the perspective**

Figure 4. Business Sustainability levels (Source: Dyllick and Muff, 2016)

From Figure 4, the first phase of sustainability represents the relevant concerns considered by most companies which are purely economic and tend to shift towards social and environmental concerns that affect society to increase shareholder value. Dyllick and Muff call it Business Sustainability 1.0. In a more advanced phase the value created by business shifts from shareholder towards a wider perspective which includes people, the planet and profit, resulting in the "triple bottom line" which is called Business Sustainability 2.0. These phases remain in an "inside-out" mentality, meaning that the company's strategies cannot be affected by the environment (inside-out). Instead, they propose that the outside should affect the company (outside-in) to reach the highest-level Business Sustainability 3.0. e.g. due to climate change, a company can reduce energy consumption and change production practices, as described in Figure 3. Thus, to reach the most advanced stage, Dyllick and Muff consider that it's not enough to reduce ones negative environmental impact but to go the extra mile and make a positive impact in critical areas for society and the planet (Dyllick and Muff, 2016).

1.3. Opportunities and Risks

The consequences of climate change will affect all industries weather directly or indirectly (Winn et al., 2011). The industries that have a greater repercussion in climate change will be the so-called carbon-intensive sectors such as utilities or heavy manufacturing where carbon costs are directly related to the amount of electricity purchased/required to produce the desirable product. Nevertheless, for the agile firm, adapting to climate change can also present opportunities such as revision of business models to allow for greater efficiencies in terms of materials, energy, development of new cleaner technologies, products and active participation in whole new energy markets that were not available a decade ago e.g. carbon markets and emissions trading. Thus, integrating environmental aspects into different sectors across an organization will strengthen the link between economic and environmental goals and reinforce the company's reputation (Busch et al., 2012).

Furthermore, those corporate fields that integrate sustainability will be able to contribute to the initiative proposed by the United Nations called the Sustainable Development Goals (SDGs) and tackle present world problems such as poverty, economic growth, climate change or inequality among others (UN, 2019). The topic of this project of adapting a sustainable mindset to reduce energy consumption across the supply chain, would improve SDG 12 (Responsible Consumption and Production) and 13 (Climate Action) and create a positive impact in today's society. All in all, integrating sustainability can offer the following internal and external benefits (Cheung, 2007):

<u>Internal Drivers</u>

- Improve the environmental performance of the company
- Meet corporate environmental policy
- Better manage risk (e.g. more stable supply of qualified materials in the long-run through ensuring partners)
- Increase reliability of supply chains
- Reduce the cost in the long-run (e.g. though improved efficiencies)
- Improve quality and encourage innovation of products
- Satisfy stakeholders demand
- Achieve greater efficiency in production

<u>External Drivers</u>

- Communicate green corporate image to and hence better reputation of the community
- Increase competitive advantages
- Provide environmentally friendly products and services
- Increase revenue
- Increase positive media exposure
- Help meet local legislative requirements (Aalborg city)

Nevertheless, there are also challenges when trying to integrate changes such as high implementation costs, unclear justification for investment, lack of costumer demand, lack of in-house knowledge or technology availability (OECD, 2000). Perhaps, the biggest factor affecting Aalborg's production plant is the time constraint since implementing sustainable business strategies usually provide results in the long-term. Therefore, it is difficult to sustain internal support in terms of financial investment and motivation for change.

Industrial companies should start this process by setting goals and conducting a detail review of their facilities by integrating an energy team so that environmental opportunities in the long-term can be explored i.e. targets set in the corporate social responsibility plan. The appropriate strategic processes and priorities will measure internal and external energy impacts and assess the following questions: How much energy does our firm use? What impact is it causing? What is the carbon footprint of our suppliers? How does this align with costumers, investor and employee expectations? But, finding answers to these questions will only be achieved if companies are willing to take the risks and bring the resources in balance with the capacity of the environment. This balance is also known as 'dematerializing industrial output' which supports an economy that focuses on the maximization of the utilization rather than on the consumption of the output produced (Stahel, 1997). It is therefore highly relevant and only our responsibility to realise the profitable saving opportunities within the industry sector to create a better future for the generations to come.

1.4. The role of SGRE as part of Aalborg City

When it comes to sustainability, Denmark is a world reference as it leads an ambitious but realistic green climate and energy policy (EPA, 2017). Accordingly, Aalborg forms the fourth largest city in Denmark and has signed to adhering to a long-term vision for a sustainable city outlined in the Aalborg Commitments, which reads: "We will accelerate our efforts towards local sustainable development, drawing inspiration from the sustainability principles set out in the Aalborg Charter. We aim to translate our common vision for sustainable urban futures into tangible sustainability targets and action at local level" (EPHA, 2004). More precisely, commitment number four addresses responsible consumption and lifestyle, which shall be protected and preserved. This implies that households and businesses within the city of Aalborg, such as SGRE, have to actively promote sustainable production and consumption and undertake sustainable procurement practices also known as energy efficient procurement (ICLEI European Secretariat GmbH, 2016).

Besides from the Aalborg Commitments, there are many other commitments Denmark strives to achieve, outlined in the Paris Climate Agreement signed in 2016, to address its role as a developed nation that has a responsibility to commit to a strategical progression towards sustainable development as outlined in the Sustainable Development Goals (SDGs). The SDGs aim to go further by getting countries to strive towards tackling climate change and enhance environmental protection (UN, 2019). Here is where businesses and organizations play an important role since they are part of Aalborg city and should not be alienated from the community (even though SGRE's production plant is located in the outskirts of the city). Aarhus for instance, have initiated their Strategic Business Plans were they put special focus on business development "our creative industries are looking at ways to generate, innovative and evolve new business ideas and methodologies" (Rasmussen, 2017). Likewise, Portland Aalborg contributes to Aalborg sustainability by supplying 20,000 Aalborg households with their extra heat from cement production, thereby providing the city with approximately 50% of Aalborg heat requirement (Aalborg Portland, 2018). Addressing to these commitments are paramount to respond to SGRE's sustainability plans by having not only a responsible consumption of energy resources to produce wind turbine components such as SDG 12 addresses, but also to align the project to respond to Aalborg's long-term sustainable vision. Therefore, this Mater Thesis would render favourable and conducive to the city's decarbonization since it intends to continue developing renewable energy technologies by means of a low-carbon energy generation model.

Additionally, aligning these targets will increase SGRE's marketability in the public realm and highlight itself in the international context by leading by example and addressing the issues of today. Thus, one of the main drivers to peruse this Master Thesis is to create a sustainable environment at the site by integrating an energy efficient criterion for future decision-making around procurement. This proposal is an opportunity to reduce the overall energy consumption at the plant and create a greener space for the city of Aalborg.

1.5. Research Questions

The aim of this master thesis is to find an answer to the main research question: "***How can SGRE Aalborg shift to strategical decision-making regarding energy efficient procurement and move towards carbon neutrality?***". This question is proposed because based on former research during Semester 3 see summary in Appendix A there is an "environmental gap" in the investment structure of SGRE which means addressed. This means that in many occasions there are immediate and "quick-fix" solutions implemented to keep a high number of blades produced, which do not consider future operational costs. For this reason, this research will argue that profitability should not be the sole driver of capital investment decision-making concerning energy reduction projects. This premise is seen as a problem because companies tend to have a neo-classical economic view prioritizing the financial factor (Galbraith, 1967). Instead, a holistic approach should be adopted to include other important factors such as organizational energy culture, power relationships, managers interest and values, strategic intentions and core business. Consequently, this Master Thesis emphasizes the difference between financial and strategic perspective by proposing a new energy framework. On the one hand, the financial perspective includes projects that involve low risk and have an immediate profit to increase production but neglects long-term opportunities. On the other hand, the strategic perspective includes both financial and environmental perspectives with equal importance to sustain a more holistic and balanced approach.

To guide the research, three sub-questions were formulated. To start off, the first sub-question asks, ***"Who are the stakeholders involved and what are the current requirements behind energy efficient procurement in SGRE Aalborg?"***. This sub-question is necessary to identify the people that currently influence the decisions-making process regarding investment in energy saving projects. It will point out, by means of a stakeholder mapping, the level of engagement (affected by project outcome) and influence (setting and modifying requirement) between the different stakeholders within the organization. Thus, these are the people that need to be targeted to close the environmental gap. In addition, the regulations and standards currently used by SGRE will also be explored to determine the requirements, such as ISO standards, that drive investment towards purchases required for manufacturing. Additional standards will be recommended, and the results obtained from the interviews will be utilized to pair the internal decision pathways to a decision-making model.

The second sub-question will analyse three past cases that failed to follow energy efficient criteria due to urgency and need at the time. This will measure the current strategical character of SGRE around energy reduction investments and identify the core problems "***How can purchased products benefit from a sustainability assessment and point out barriers in the current decision-making process?".*** Here, three different cases will be analysed to identify the decision-making process that lead towards energy inefficiencies and why the environmental gap occurs. The project managers that were involved in the projects will be interviewed to get technical specifications of the equipment and their opinion on how the environmental perspective can be integrated in future decisions. The key message regarding this sub-question is to point out the current barriers and that every purchasing decisions should be evaluated with an energy efficient purchasing criterion no matter the urgency. Since, it's not only the cost of the machine (short-term) that should be measured, but the cost of running the machine (long-term) which integrates a holistic approach. A holistic approach provides long-term interconnectedness between social, economic, environmental and technological systems considering stakeholder consultation in every decision that can have an effect on any of these four pillars (Löf, 2018).

The third sub-question will combine the previous sub-questions and formulate a solution *"**What recommendations can be integrated in the investment structure of SGRE to improve future decision-making around procurement and environmental projects?**"*. This sub-question should provide Aalborg's blade production plant with an energy efficient procurement guideline to improve about future investment decisions. The goal is to use the barriers encountered in the current organizational structure described in sub-question one and two, to implement an energy criterion that can reduce energy costs and promote energy efficient procurement to select the most suitable product or system available and with the best energy performance. For this reason, the 'investment structure' is included in this sub-question, because it's vital where SGRE allocates the resources in the most strategic and efficient way possible. This will be done by proposing a position in SGRE that takes ownership of the energy consumption, by endorsing sustainable supplier selection and by proposing a method to calculate future emissions from purchased products such as machinery or equipment for manufacturing blades, there the 'prediction'.

The new recommended energy framework in sub-question three will hopefully reduce the material footprint and promote policies and initiatives for sustainable consumption and production. Finally, the summation of the three sub-questions will answer the main question of the master thesis and allow SGRE to adopt new strategies and techniques and have a better integration of sustainability. Finally, adopting a strategic perspective when purchasing products has the potential to reduce maintenance costs, increase economic benefits, demonstrate leadership, increase reliability and even improve the working environment. Parallelly, creating a resilient business strategy, governance and approaches will reduce energy costs and most importantly ensure the achievement of sustainable goals.

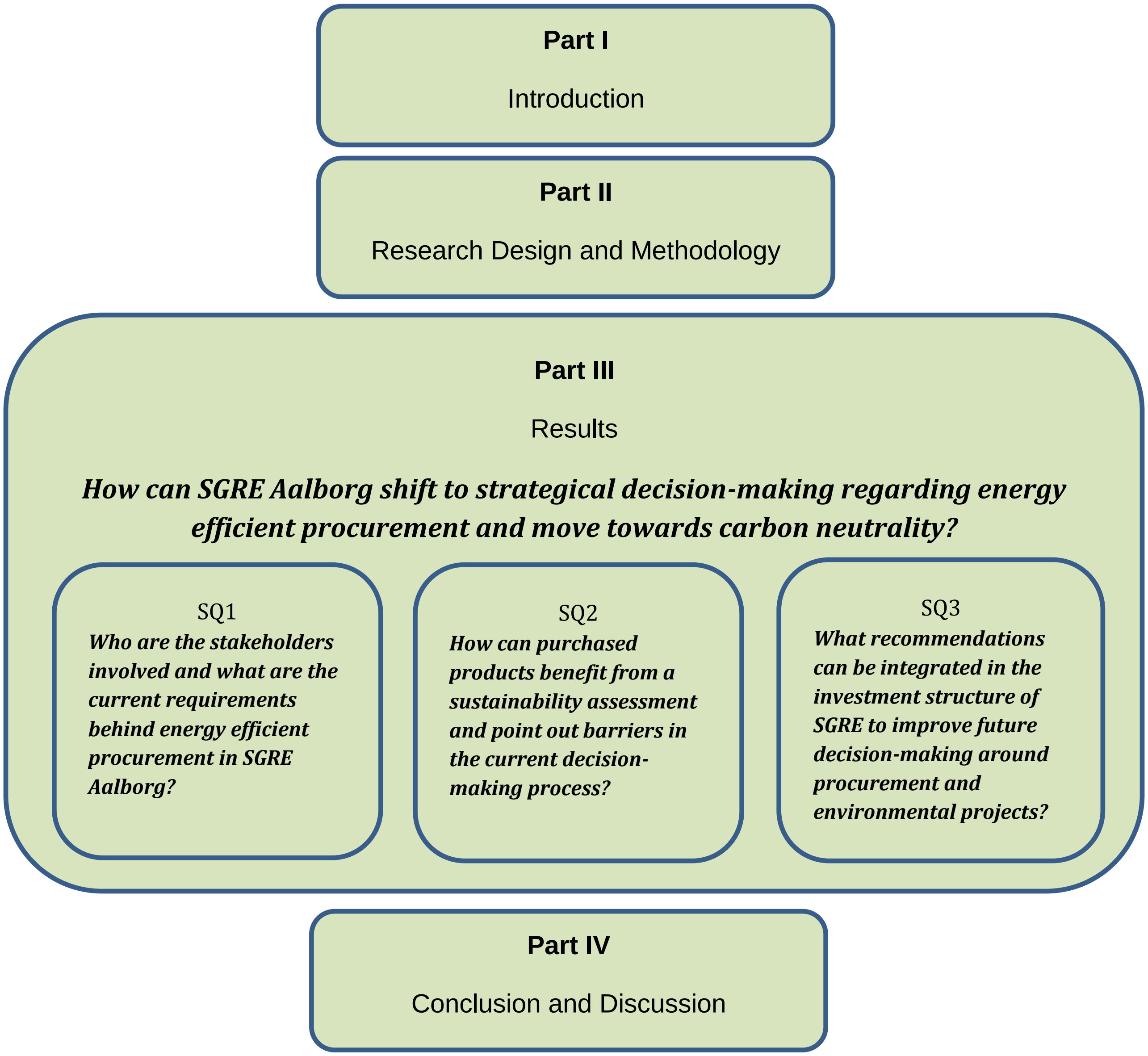

Figure 5. Structure of report (Source: self-generated)

The structure of the following report is depicted by Figure 5 based on the IMRaD structure (Introduction, Methodology, Results analysis and Discussion). The chapter following the introduction is Part II: Research Design and Methodology. Where the specific research design for each sub-question is outlined. Additionally, the methodology, i.e. qualitative and quantitative research methods, are described. Afterwards, the outcome of this research is elaborated in Part III: Results section, depicted in Figure 6. This chapter (results) is structured according to three sub-questions (SQ1, SQ2 and SQ3) and each of the sub-question is answered within its own section.

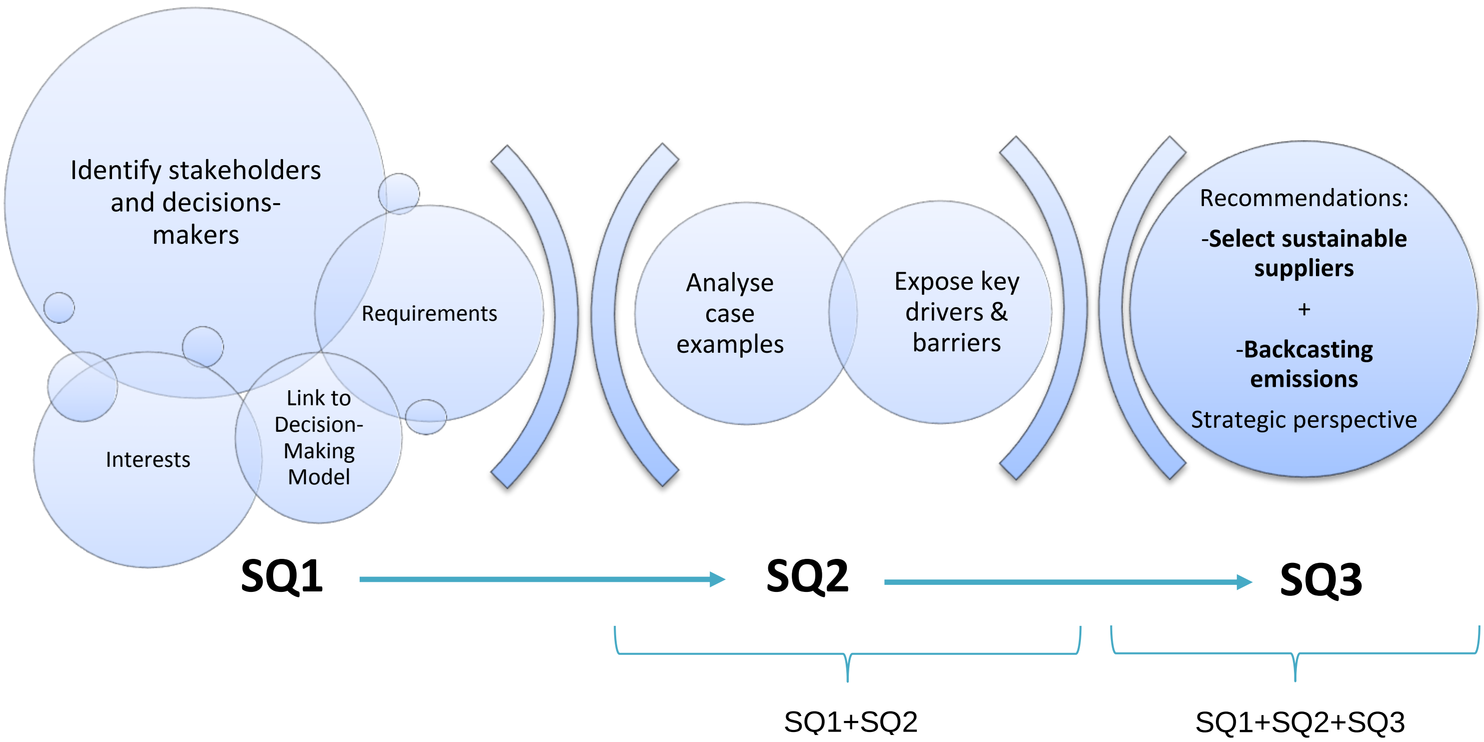

Figure 6. Structure of Results including SQ1, SQ2 and SQ3 (Source: self-generated)

Lastly, the report ends with Part IV: Conclusion and Discussion, where first the results from the previous Part III are summarized. Secondly, the discussion puts this research into a wider spectrum and elaborates on the importance behind having an energy efficient criterion for sustainable procurement in SGRE Aalborg. Finally, suggestions for further research are given.

2. Research Design & Methodology

This chapter aims to describe the overall research strategy carried out in this paper to ensure the components in this study are integrated in a logical and clear order. This section will allow to collect, analyse and interpret the data to provide answers to the research problem. Furthermore, the methods used to collect the data are described and arguments for choosing these methods are outlined.

2.1. Research Design

The research design was developed to provide answers to the research question "***How can SGRE Aalborg shift to strategical decision-making regarding energy efficient procurement and move towards carbon neutrality?".*** Three sub-questions were also formulated to guide the research to this question Table 2 depicts the sub-questions, the methods used to find an answer to the question and the data that was collected through this method. In general, this research is based mainly on qualitative literature analysis, semi-structured interviews and quantitative calculations.

Sub-questions (SQ)	Method	Objective	Data Gathered
Who are the stakeholders involved and what are the current requirements behind energy efficient procurement in SGRE Aalborg?	Semi-structured interviews, literature review, participatory observations (academic, grey and white)	Understand the current decision-making structure and the stakeholders involved. Match with decision-making model. Identify communication gaps	Literature and interviews e.g. organizational structure, name and function of stakeholders, decision-making structure
How can purchased products benefit from a sustainability assessment and point out barriers in the current decision-making process?	Semi-structured interviews, literature review, internal SGRE's documentation review	Create a matrix of comparison between current practices and alternative solution. Highlight that an energy efficient solution could have been chosen instead. Point out barriers encountered by project managers	Interview data e.g. datacentre, product specifications and comparison timeline/matrix of alternative solutions for three different cases
What recommendations can be integrated in the investment structure of SGRE to improve future decision-making around procurement and environmental projects?	Qualitative feasibility analysis of energy efficient criteria integration based on literature review	Create an energy efficient criterion and apply it to all future purchases or projects within the company	Literature review Compare methods applied by other companies Backcasting framework Gap analysis Industrial ecology

Table 2. Summary of methods used to provide answers to the research sub-questions (Source: self-generated)

2.2. Methodology

To investigate the solutions to sub-questions one, two and three it was necessary to develop an analytical methodology with a combination of qualitative and quantitative analysis also known as mixed research methods. Each method used will be described in the following paragraphs.

2.2.1. Mixed research methods

When addressing complex research problems great potential arises if we consider qualitative and quantitative research methods as complementary approaches. Mixed methods research helps to understand the research problem better by utilizing strengths and differences of each method (Clark, 2017). Therefore, qualitative research methods were used to gain knowledge of theories, state of the art approaches, while quantitative methods helped to measure the “environmental gap” of past projects by calculating the economic costs and environmental impacts.

Literature Review

Since the manufacturing Halls and the machinery had limited access, self-generated calculations were beyond the scope of this project. Thus, a major qualitative literature analysis was used to answer all the sub-questions of this paper. This implied the analysis of academic, grey and white literature to get a deeper understanding of the state-of-the-art researches and approaches. The findings covered several topics of interest such as decision-making models, energy efficient guidelines, industrial ecology and carbon backcasting. Furthermore, internal documentation, such as procedures developed by SGRE, were also analysed to understand responsibilities and functions of each department e.g. developing processes or equipment take over certificates (TOC). With regards to literature review the aim was to stick to primary sources and use only those sources published in known academic journals or published houses. The academic sources were found mainly through the AAU library database and google scholar to understand different methods and models that could apply to this research e.g. stakeholder analysis approach. Other grey and white papers where found using and google i.e. Aalborg’s municipality publications (e.g. Aalborg Charter and Aalborg Sustainability Strategy). Moreover, internal procedures that only apply to SGRE as a company where found in their Document House database.

Semi-structured expert interviews

Another source of information were semi-structured interviews, which is a suitable method to gather reliable, comparable qualitative data (Bernard, 1988). This method was chosen as it leaves room for spontaneous alteration of the interview topic, i.e. clarification or further explanation of issues, if necessary. To ensure all relevant topics of interest were addressed during the interview, questions were prepared in advance. They were formulated with respect to the professional background of the interviewee and the research questions of this report. The interviews were held between 10.03.2019 and 25.04.2019. If possible, the interviews were recorded and transcribed (the questionnaires and transcriptions and or notes can be found in the appendices D-G). If recording was not possible, notes were taken during the session. All interviews were conducted in English.

The interviewees were chosen very carefully with respect to their connection with the three cases to evaluate i.e. ventilation system (AHU), Oven Hall 11 or Boiler using heating oil in Hall 11. Other interviewees were considered due to their distinguished experience in the field that could create value to the project i.e. Claus Lindberg Head of Tooling. Experts in this paper are defined as professionals who gained knowledge and skills through practice and/or study in a specific field or subject, to the extent that their findings could help to understand the situation and lead to problem solving (RAND, 2015). Interviewees and their profession are illustrated in Table 3 below. Additionally, experts were consulted via email to clarify specific questions and also added to the table.

Interviewee	Profession and credentials as an appropriate interviewee for this project	Date of interview	Length of interview
Carl Tousgaard (SGRE)	Test and Qualification Engineer. Project Manager for the new ventilation system	07-02-19	55 minutes (Appendix D)
Jan Pedersen (SGRE)	Procurement Real State and Equipment. Purchasing production and equipment machinery (Capex)	12-02-19	50 minutes (Appendix E)
Andrei Sava-S. (SGRE)	Tooling & Design Department. Project Manager of several projects in process Halls	14-02-19	40 minutes
Halil Halilov (Portland)	Energy Engineer. Responsible for energy management at Portland, Aalborg	29-02-19	55 minutes (Appendix F)
Per Justesen (SGRE)	Maintenance department. Responsible for maintenance and operation of equipment	03-03-19	35 minutes (Appendix G)
Claus Lindberg (SGRE)	Head of tooling department	25-04-19	30 minutes

Table 3. Interviewees and credentials (Source: self-generated)

Predictive analysis of case projects for process production

To answer sub-question two and identify the areas where SGRE could improve on energy efficient procurement, a sustainability assessment of three projects was carried out. These projects have been already implemented at Aalborg's manufacturing plant and considered energy inefficient or "quick-fix" solutions by staff members of SGRE. The aim was to compare the current "quick-fix" solutions against an optimal energy efficient alternative to highlight inefficiencies and recommend possible improvements. The three projects selected can be seen below:

1. Ventilation System (Air Handling Unit)
2. Heating oil for Boiler, Halls 1 and 6
3. Oven, Hall 11

The information and specifications for each project was obtained through literature analysis and interview responses from the engineers that participated in the projects. The questions were structured to gather information related to the description of the project, decision-making structure or path of action, stakeholders involved, energy inefficiencies and improvements to avoid future mistakes. The questions also allowed the interviewees to describe their experience during the development of the project and opinion on communication issues with other stakeholders. This provided an in depth understanding of the organizational barriers taking place at the company.

Once the required information was gathered, comparison tables were filled out to contrast the solutions with the optimal alternative. The parameters used in the comparison tables are described in Table 4 which helped reduce the risk of losing sight of satisfying representative data.

Parameter	Reason for parameter
Description	Obtain an overall statement of the characteristics related to the project e.g. location, function, energy source, etc
Life expectancy (years)	To understand the total duration of a product. From the time its installed to the time its completed or fails
Availability	It measures how often the machine is available for use in production. Equipment availability is negatively affected by maintenance down time
Investment cost (euros)	The amount of money spent to exercise the option (It is important to understand long-term financing helps position companies for long-term objectives by taking operational costs into account)
Energy consumption (MWh/year)	Identify the amount of power and energy used by the product
Payback (ROI)	Determine the amount of time it takes for the company to save the amount of money initially invested
Mean Time Between Failure (MTBF)	Predicted time that passes between one previous failure of the product to the next failure during normal operation. Maintenance repairs are also costly
Economic Revenue	Accounts for the excess of revenue over the initial cost

Table 4. Parameters considered to compare solutions (Source: self-generated)

Calculations required for key performance indicators (KPI)

In addition, quantitative methods were intended to be applied throughout this research to cover the technical approach of the research, which required calculations and assessment analysis. To highlight the inefficiencies of fast made decisions in SGRE, such as the three cases that will be analysed in sub-question two, it was important to calculate the return on investment, maintenance time required and the economic revenue of each product against its alternative. These three parameters represent the financial perspective of implementing a product, allowing the managers to associate a cost to the evaluation.

- Payback:

While it is interesting to know how much energy it takes to run an item, energy efficiency is about savings. As energy efficient products tend to cost more than conventional energy technologies, how quickly will the savings cover the product's purchase price? The calculations of simple payback can determine at what point this will occur through the realized electricity savings.

Although simple payback does not take into account compounded savings, discount rates, inflation rates, or replacement costs and this wasn't included as it went beyond the scope of the project (Kagan, 2019).

$$\textbf{Simple Payback} = \frac{\textbf{Cost of energy savings}}{\textbf{Annual electricity savings}}$$

$$\boldsymbol{Annual\ electricity\ savings} = \frac{\left(\boldsymbol{Daily\ hours\ x\ 365\ \frac{days}{year}}\right)\boldsymbol{x\ Watts\ saved}}{\boldsymbol{1000}}\ \boldsymbol{x\ \frac{Cost}{kWh}}$$

- Mean time between failure (MTBF):

MTBF is an important indicator for expected performance and its essential tool during the design and production stages of many products (Christiansen, 2018). For complex, repairable systems that might take place in the production plant, failures are considered to be those out of design conditions which place the system out of service and into a state for repair affecting production output.

$$\boldsymbol{MTBF} = \frac{\boldsymbol{total\ operational\ time}}{\boldsymbol{total\ number\ of\ failures}}$$

- Economic Revenue:

The economic revenue is the surplus profit after a firm has paid all its costs. This profit can come from energy savings compared to the previous substituted product. This profit can be seen as a monetary reward to shareholders to encourage constant improvement and innovation (Rademaekers, 2012). For example, the profits generated from saving energy costs can be reinvested into the purchase of energy efficient products. Moreover, seeking profit will encourage the creation of innovative new products which may consume less energy and be profitable.

$$\boldsymbol{Economic\ profit\ formula = accounting\ profit - opportunity\ cost\ foregone}$$

To determine the value of account profit, the following formula may be used:

$$\boldsymbol{Account\ profit = total\ revenue - explicit\ costs}$$

$$\boldsymbol{Total\ revenue} = \frac{\boldsymbol{sale\ price}}{\boldsymbol{unit}}\boldsymbol{x\ number\ of\ products\ sold}$$

And explicit costs include:

$$\boldsymbol{Explicit\ cost = Wages + Rent + Equipment\ Rent + Electricity + Expenses}$$

The intentions of a cost benefit analysis is to sum up all the important utility values of a product (against alternatives) and finding their optimum together with the payback, maintenance costs or other inputs affiliated with each alternative.

2.3. Limitations of methods

One of the main struggles is founded in the fact that the merge between Siemens and Gamesa is very recent and it’s still going through organizational changes and adjustments that affect their day-to- day operations i.e. assigning managerial positions. Nevertheless, the leaders within the company are continuously working on improving the organizational structure to make sure it facilitates efficient decision-making.

As a result of this situation, some departments seem to function independently or not in complete sink with relevant stakeholders which created misunderstandings and unwanted “quick-fix” solutions when purchasing expensive machinery for the manufacturing Halls. Moreover, company policies and procedures were not enforced causing employee dissension and confusion e.g. unknown standardized regulation that specifies required energy consumption of equipment. These circumstances affected mainly sub-question one and two of this paper because during the interviews some of the interviewees were reluctant to expose their position towards current operating practices within the company. As a student there was no real way to demand a clear and straight answer from the interviewees hence this paper gathers the limited information that was given (see appendix D-G for transcription of interviews).

Consequently, creating a stakeholder mapping and finding out the decision-making structure behind certain projects for sub-question one was a difficult task in hand because even the interviewees failed to identify key stakeholders that should have been involved in decision-making. This lack of organization has a negative effect on the company because having a stakeholder mapping or procedure must be clearly understood by everyone since project managers should always include a critical few who know about, care about and/or affect business issues and outcomes surrounding the decision e.g. the environmental, health and safety department are rarely included in decisions that affect the energy consumption of the plant.

Moreover, sub-question two depended on the precise specifications from the project managers, but unfortunately this data could only be obtained for the ventilation system. As an alternative, instead of comparing the current solutions to an energy efficient alternative with quantitative calculations, the project malfunctions were described in detail for future corrections in decision-making. The goal with this approach is to describe the errors made in the past due to “quick-fix” solutions and provide proof that shot-term solutions can have greater operational costs in the long-term.

For future research, an in-depth stakeholder mapping should be carried out to clarify the role of the stakeholders to measure the level of influence and interest. Preferably with names and responsibilities to assign ownership of a given project. Moreover, a detailed procurement business case should be produced for each purchase regarding equipment or products for manufacturing purposes to support a proposed procurement activity before significant resources are committed. It will also predict long-term opportunities rather than limiting the investment to one year or shorter payback periods. Within this business case, an energy criterion must also be applied to comply with regulations and ensure that energy consumption is always limited to a minimum to create savings.

There are existing limitations influencing the results of this research. Nevertheless, results presented in this research are still valid and the uncertainties will not change the overall results and recommendations of the general study and the outlined method can be utilized for future procurement purchases. These limitations were not perceived as hindering, but rather as an opportunity to improve the succeeding research.

3. Results

3.1. Sub-Question 1: Who are the stakeholders involved and what are the current requirements behind energy efficient procurement in SGRE Aalborg?

Since it has been acknowledged that there is an "environmental gap" in the decision-making process of Aalborg's manufacturing plant, adjustments and recommendations must be integrated. But first, it is necessary to understand the activities taking place at the production plant, the departments and identify who are the decision-makers. This section will investigate internal procedures to determine if energy efficient guidelines and requirements are being followed, or not. Moreover, the results from the interviews to project managers will be analysed to find out the cause and effect of energy inefficient or "quick-fix" decisions that affect the overall energy consumption of the plant. Finally, a decision-making model that matches current practices at the plant will be identified to understand the nature of decision-making process of the organization.

3.1.1. Environmental targets towards a paradigm shift

As many companies now a days, SGRE has a climate change policy to achieve a global low-carbon energy generation model that, "not only reduces environmental impacts but also ensures a sustainable future for generations to come" (SGRE, 2019). This environmental commitment is supported by the amount of wind power installed capacity which result in CO_2 reductions of millions of metric tons per year when compared to conventional fossil-based energy production sources. To keep pushing towards a carbon free future the Corporate Social Responsibility policy sets out basic principles that apply to all SGRE facilities such as:

1) Support GHG emissions reduction goals set in the Paris Climate Agreement and any international agreements that replace it.
2) Support the Sustainable Development Goals to take urgent action against climate change.
3) Foster and implement management systems that make it possible to fight climate change.
4) Advocate a global emissions market that makes it possible to generate the resources needed to finance clean energy projects.
5) Support a culture for an efficient and responsible use of energy and resources.
6) Achieve carbon neutrality by 2025
   - Make reductions and implement energy efficiency measures related to operations across production facilities
   - Continue the transition of electricity supply from electricity sources
   - Green mobility plant to reduce fleet emissions
   - Offset non-avoided emissions through compensation projects

In order to accomplish these targets and allow a smooth transition, SGRE has to undergo many operational changes to favour sustainable manufacturing processes. Therefore, special and immediate focus has to be put in the manufacturing facilities where there are is higher energy consumption from machinery and equipment to produce the wind turbine components. For instance, the bar chart in Figure 7 clearly depicts how much energy Aalborg's blade production plant has consumed to date in comparison to other facilities in Denmark. This occurs mainly because the blade production plant requires large amounts of district heating to heat the blades for coatings and resins and also ventilation for air recycling. Therefore, if SGRE wants to accomplish environmental targets described above, they should strongly reduce the energy consumed for blade manufacturing in this production plant. This transition will not only be good for the environment but also for the company itself because of reduced energy, water, waste disposal or raw materials costs as previously researched (see appendix A summary of semester 3 project).

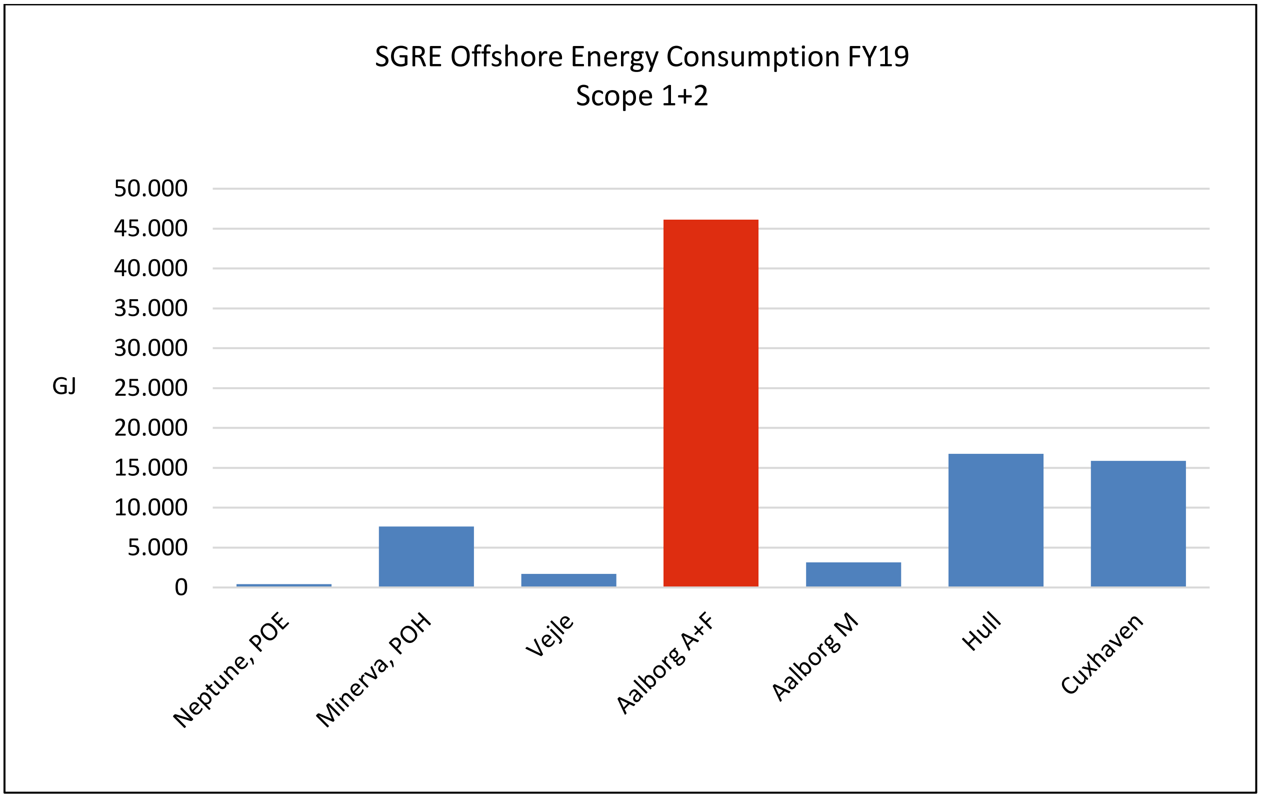

Figure 7. Offshore energy consumption 2019 (Source: SGRE, 2019)

3.1.2. Activities & operations at Aalborg's production plant

The operation to produce wind turbine blades is complex, and for it to be completed successfully, large quantities of energy are required to power each stage of the production chain. Currently, the average utility-scale wind turbine contains roughly 8,000 parts, including blades up to 75 meters in length and towers over 80 meters high, roughly the height of the Statue of Liberty (USAEE&RE, 2018). And due to advancements in technology and composite materials, new towers are being made even taller to capture stronger winds at higher elevations such as the new SG 10.0-193DD offshore wind turbine developed by Siemens Gamesa, with a rotor diameter of 193 meters.

At Aalborg's production plant due to the size and complexity of turbine blades, each blade must be manufactured to the highest quality standards in order to ensure reliability. This fabrication process can be very costly and labour intensive, but the experience of the engineers helps to establish advanced techniques that reduce the time and money it takes during the blade development process (Siemens, 2015). The process in Aalborg's production plant to produce blades takes place in five stages presented in Table 5 below:

1) Pre-assembly area	
• Glass cutting • Root segment assembly	• Degassing • Assembly of overflow containers
2) Assembly area	
• Mold preparation • Material layout • Casting and curing	• Tests • Lighting protection
3) Blade cooling and root processing	
• Demolding • Removal of mandrels and bags • Quality inspection	• Drilling • Tests
4) Post-treatment area	
• Sanding robot • Web cutting • Quality inspections (ext.)	• Repairs and quality inspection
5) Filling+paint and finish area	
• Cleaning • Filling, settling, primer, curing • Painting • Feature adds post painting • Quality inspection • Weighing	• Balancing • Wash • Root cover • Quality inspection • Storage • Shipping

Table 5. Workflow process (Source: Siemens, 2015)

Siemens Gamesa blades in Demark are manufactured using the patented IntegralBlade® technology by Siemens (Siemens, 2015). These blades are unique as they are manufactured in one piece using a closed process requiring only one mould set for the production cycle. The results is a complete unified blade finished in one process with no glued joints which increases safety as there are no weak points that could expose the structure to cracking, water ingress and lightning (Siemens, 2015).

3.1.3. Stakeholders involved

The method to produce blades in Aalborg's plant is unique in the wind industry and in order to replicate the same product to the highest quality possible, a number of experts need to be present throughout the whole process to verify quality. The departments responsible to achieve the desired number and quality of blades per year are: health, safety and environment (HSE), maintenance, operational excellence, real estate, production system, procurement, technology and standards, production planning and quality management. But because this paper will focus on energy efficient procurement related to process, the identified departments and stakeholders will include: technology and standards, HSE, finance, procurement and maintenance.

The problem arises when the organizational structure has internal barriers that impede the correct implementations of environmental management initiatives. For instance, there are frequent misunderstandings between the engineers who want a specific product for process activities and the procurement team or Real Estate department due to economic reasons end up implementing different and unwanted solutions (see Figure 8). Hence, this current approach is not only time consuming but also costly due to misunderstanding that could be avoided. Perhaps, SGRE needs the integration of common and overarching standards such as the ISO:50001 Energy Management certificate.

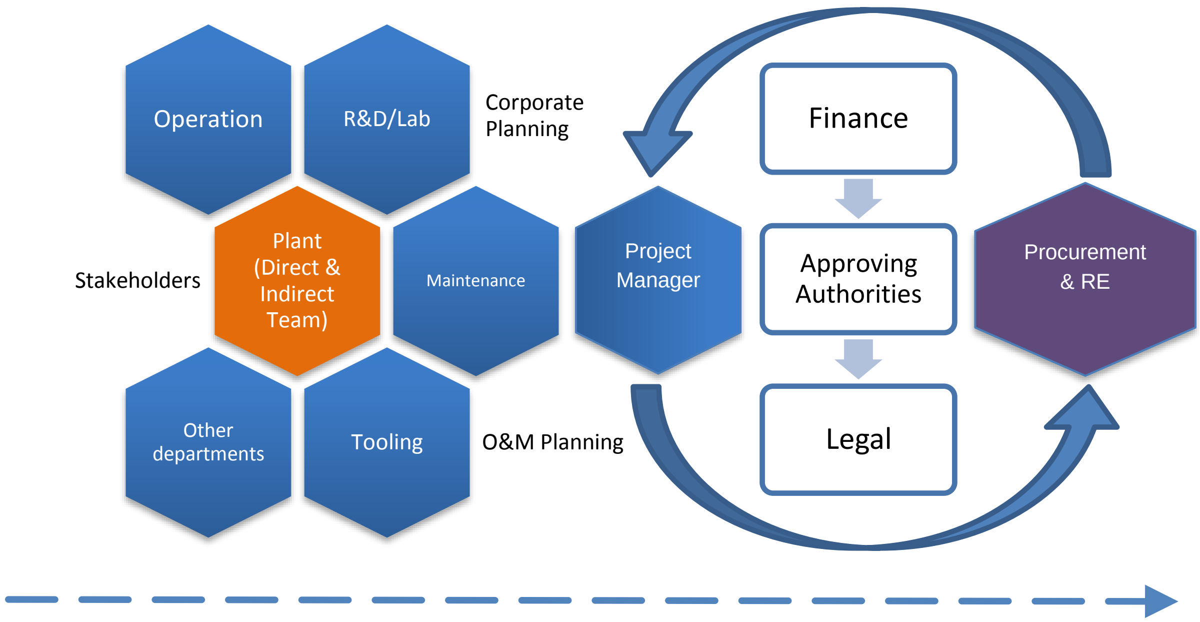

Figure 8. Stakeholders involved in decision-making (Source: self-generated)

Perhaps the integration of an energy controller in constant contact with the engineers and procurement department would be a key, currently missing link, within the organization. The main responsibilities would be to identify energy saving opportunities and make recommendations through business case analysis to implement more energy efficient operations at the plant. This way, if engineers select a specific product or supplier due to environmental performance, they can get support from an energy controller as proposed in Figure 9. This is particularly important since each department has different budgets and economic targets that differ from a common and unified goal. Thus, each department is looking out for their own interest, but the integration of an energy controller or team could combine the costs towards a mutual goal.

There are numerous energy projects that could be implemented at the plant e.g. help Real Estate coordinate an energy map of the energy consumed in the production Halls by the different machines and equipment to obtain real time energy data. Or study why can the reservoir of water Rørdal kridtgrav (located at approximately 4km and 4 degrees in water temperature), be used as a natural coolant for the machinery utilized in production. If similar measures are integrated in Aalborg's production plant, the position of an energy controller could be paid off after a few years from the economic savings generated by energy efficient projects.

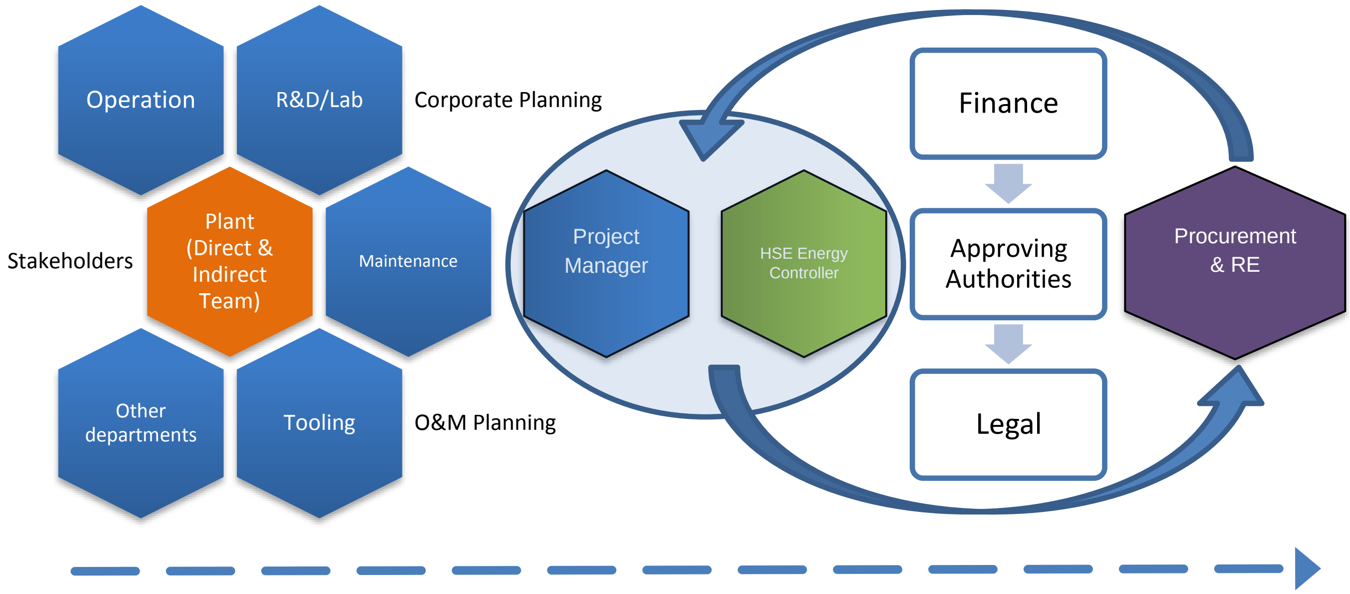

Figure 9. Addition of Energy Controller in stakeholder decision-making (Source: self-generated)

However, this solution is inexistent at the moment within the organization and it can be reflected in the results obtained from the interviews (n=6) directed to staff. For this reason, the objective was to find out what environmental criterion used in the current decision-making process (if any) when purchasing products for manufacturing activities i.e. main drivers, stakeholder's interests, internal communication process, opinions, etc, and determine what areas need to improve for future purchases and practices.

3.1.4. Evaluation of interviews

Guidelines and procedures:

"We don't have official guidelines. If we want new equipment for bigger blades like larger equipment, it's the tooling department that is in charge and deciding the equipment. But they also don't follow any environmental specifications or guidelines" (Per Justesen - Maintenance Department).

Most of the interviewees concluded that even though they follow some national and European regulations, there is no energy efficient criterion or official requirements that guide them towards sustainable practices. This situation presents a contradiction for SGRE, since they are renewable energy providers, but they do not produce in a sustainable manner. The integration of guidelines will provide stakeholders with a solid baseline and knowledge of environmental requirements that will create opportunities and provide more value to the organization by improving productivity, assessing value and performance, enabling communication between suppliers and by encouraging innovation (ISO, 2017). Therefore, SGRE needs to implement official guidelines that strictly integrate sustainability within procurement to shape future decisions and processes.

Prioritization of immediate results:

"Most departments don't care about the electricity or the company's footprint. Who cares how much electricity is used if the production increases? Its s big grey mass with no rights and no wrongs. But at the end of the day it's the production numbers that matter, and a secondary thing is optimization" (Jan Pedersen – Procurement)

SGRE like many other companies in the industry sector, prioritize production but do not address many of the environmental concerns that our society faces today. As already mentioned above, SGRE usually finances industrial investment based on very short payback periods to minimise risks without exploring long-term opportunities. This may be a major hurdle for industrial ecology since businesses are not willing to evaluate the cost, benefit and payback period of energy efficient opportunities and phase them in the industrial system.

Lack of resources and tools to calculate potential opportunities:

"It is very much needed to have somebody that can look at the energy data to produce business case analysis of the products we purchase. There is nobody allocated to find these benefits, so we stick with the simple payback solution" (Carl Tousgaard – Test and Qualification Engineer)

Perhaps one of the biggest fears when dealing with energy consumption is the unknown outcome. But studies have shown that allocating a portion of the capital budget for energy efficiency solutions can help to mitigate energy management issues (USAEE&RE, 2018). Weather this means allocating a team to study and predict operational costs of purchased products or buying the energy efficient equipment that requires an initial higher investment. Energy initiatives, like those in any part of business and the substantial benefits they deliver to the business can come (Winston et al., 2017).

Suppliers:

"Regarding energy efficient requirements you will not find anything in our supplier comparison sheets" (Jan Pedersen – Procurement)

When it comes to supplier evaluation, SGRE has no parameter that measures the environmental performance of a product (see Appendix B). It is surprising because conducting a resource efficiency review should be an important parameter to reduce the energy consumption in the supply chain of Aalborg's production plant. The ISO standard 20400-2017: Sustainable Procurement should be adopted by SGRE when selecting suppliers. It is a powerful instrument to integrate sustainability in procurement decision-making, including supply chains, to manage risks for sustainable environmental, social and economic development (ISO, 2017). For instance, it differentiates the supplier selection by assessing their prevention of pollution, sustainable resources use and climate change mitigation and adaptation. Therefore, this tool can be very useful for SGRE because these standards can assist in addressing cost out initiatives towards environmental issues.

Paradigm shift:

"I don't have much contact with the environmental department, they have never asked. But if they had interest, the final decision wouldn't change, I can promise you that. Because if we choose a machinery that

consumes a great amount of electricity but at the same time produces 50% more number of blades then the revenues will be too big for SGRE to ignore. And they don't care about the electricity or the company's carbon footprint. Who cares how much electricity is used if the production increases?" (Jan Pedersen – Procurement)

The need to meet consumers demands has blinded the industry as we know it today. The manufacturing industry always tends to see that production resides at a higher level of importance even if it has negative effects on the environment. But what if they had the same level of importance? Moving away from the traditional 'take-make-waste' economic model that has prevailed since the industrial revolution requires systemic change (UNEP, 2016). For this transition to occur we need to invest in projects with transformational impact rather than the more incremental, single-installation investments that have been commonplace under current climate policy and project developments (Hoogzaad, 2017). The time is now when environmental issues should not be seen as a problem to be prevented but more as an opportunity to transform management practices to optimize products and services and gain competitive advantage.

Key aspects of interviews

The results obtained from the interviews showed that Aalborg's production plant must overcome numerous barriers to become sustainable. Firstly, the staff needs to understand that it is possible to reduce the energy demand without relinquish effort. With contemporary energy solutions, energy efficiency can save large amounts of energy if a strategical mindset is adopted by not looking at the immediate and fast return but willing to invest and understand that energy saving opportunities can occur in the future.

For this to happen, high investments in energy efficient technology need to be supported by rigorous business case analysis to prove feasibility. This task could be assigned to a technical person who takes ownership of the operational costs regarding machinery and products purchased. The person responsible can be an energy controller located at the plant working with the HSE team who acts as a middle person between the design engineers and the procurement team. The advantage of being present at the plant will allow the person responsible to intervene at the initial stages when the equipment development occurs and undergo a filtering system that evaluates the energy performance of the product. If an energy controller speeds up the process of monitoring, assessing and controlling product purchases there will be less hanging fruits in the current decision-making structure to reduce cost while making the product more attractive and marketable (CPA, 2015).

At the moment, HSE only intervenes at a later stage when the product is already designed, and suppliers are contacted. For example. when certain procedures require a signature of a HSE representative, such as the takeover certificate (TOC) in Figure 10, the checklist doesn't include environmental parameters that can measure the energy performance of the product. It only focuses on health and safety issues. Therefore, this also needs to improve for future approvals.

Required fields	Lifting equipment	Machinery	Transport Equipment	Platform and Ladder	Help Equipment and tools
Developer					
Documentation according to Product Requirement Specification (PRS)	x	x	x	x	x
Tests according to PRS	x	x	x	x	x
Labelling according to PRS	x	x	x	x	x
Visual inspection (components, welding, surface treatment)	x	x	x	x	x
User manual handed over to end user	x	x	1	1	1
Documentation stored accordingly to development process	x	x	x	x	x
Maintenance					
Maintenance documentation according to PRS	x	x	x	x	2
EHS					
Risk assessment	x	x	x	x	1
Production					
Form, Fit and Function according to PRS	x	x	x	x	x
First language user manual in hardcopy	x	x	1	1	1
Received Training	3	3	3		

Table 1 – Required fields

1) Only required if user manual is provided with the equipment
2) Only required if SAP ID and/or Maintenance plan is provided with equipment.
3) Only required if special training is specified

Figure 10. Take over certificate (Source: SGRE, 2019)

Having analysed the main barriers that occur it is also convenient to address the decision-making model that pairs with the given characteristics of the plant. Decision-making is critical for any business to achieve goals and there should always be desiring to achieve the best solutions. The model identified below will describe why SGRE sometimes makes fast solutions which temporary keep the problem from reoccurring to benefit one aspect of the plant i.e. cut down production time. Nevertheless, this approach might have repercussions in other fronts since a “quick-fix” solution is considered inadequate to a problem and will not necessarily eliminate the problem in the long-run e.g. heating oil boilers have been replaced for natural gas boilers (see sub-question two). Which is why company should evaluate the source of the problem in a more in-depth manner from the start.

After evaluating the results obtained from the interviews and identifying the main barriers in the decision-making process, it is convenient to address the decision-making model that fits with current practices. This is important since decision-making models are necessary to understand the logic behind decisions in enterprises and organizations.

3.1.5. Non-rational decision-making model: The satisficing model

The importance of choosing the correct decision-making model, although logical can be a difficult task. All decisions can be categorized into three basic models (Wall, 1993):

1) The rational model/classical model
2) The bounded rationality model
   – Sequential attention to alternative solution
   – Heuristic
   – Satisficing
3) The retrospective decision-making model

Generally, managerial decision-making is rational as it's in the best interest for the company to look at different possible alternatives, outcomes and ratifications, and hence make rational decisions, but when time constraints jeopardize production, some solutions are based on fast decisions that neglect a holistic perspective i.e. bounded rationality model like the case studies presented in sub-question two. Unlike a rational view, the bounded rationality model suggest that it is difficult for managers to make optimal decisions due to the limitations of information gathering and processing (Cristofaro, 2017). For example, if a machine breaks and slows down production, the engineering team will purchase a "quick-fix" replacement based only on time availability and price, neglecting other important factors that affect performance such as the source of energy and consumption, pollution levels, maintenance time or replacement costs. This decision-making process falls down under the bounded rationality model but it is known as the 'satisficing model' introduced by Herbert A. Simon in 1956 which suggests that certain factors limit the decision-making like cognitive capacity or time constraints which entails higher significant risks. Herbert Simon called this "satisficing" because its picking a course of action that is satisfactory and meets minimal requirements under the given circumstances (Simon, 1978). In the case of SGRE, this approach goes against sustainability and conservation of energy since it focuses on one aspect i.e. production time, instead of considering the ramifications from a holistic perspective.

As it will be discussed in sub-question two further below, the production plant in Aalborg has made several "quick-fix" solutions in the past to cut process time and increase product output, even though they have greater operational costs and lead to negative environmental impacts. This tendency occurs because companies and executives make decisions that generate immediate benefits at the expense of potentially greater long-term value which can introduce additional risks into their business model. Unfortunately, there is not yet enough pressure on firms to take this long-term approach by investors. Yet, advisors find themselves caught in a performance paradox. This lack of pressure on firms regarding environmental commitments has to be self-imposed because now a days despite their best intentions, many experts have been justifying their worth based on short-term results rather than performance that is meaningful to the client over the long-term (Duncan et al., 2015).

The performance paradox aids to understand how corporations undervalue the true benefits of financial advice and leaves advisors exposed to clients dissatisfaction (Jakobsen et al., 2017). One of the advantages that SGRE has is that it produces the tools to produce wind power which is globally recognized as a source of clean energy. But the main question, for internal discussion and for future results, should be *how sustainable is SGRE manufacturing the renewable energy tools that will shape the future energy market?* Most importantly*, should SGRE tackle the problems at the source instead of avoiding them to answer the questions of tomorrow?* If these questions are not answered it puts the company at risk of falling short of their original and ultimate objectives of reaching their financial and environmental goals. Therefore, it's necessary to analyse short-term "quick fix" purchases that have occurred at Aalborg's production plant to avoid the same unwanted mistakes in the future and support a responsible energy consumption. For this reason, three real cases that have derived in energy inefficiencies will be analysed in the following section.

3.2. Sub-question 2: How can purchased products benefit from a sustainability assessment and point out barriers in the current decision-making process?

Following sub-question one, where the decision-making process and the stakeholders are identified, this section will describe the importance of carrying out a sustainability assessment before purchasing products. A sustainability assessment can be presented in the form of a Life Cycle Assessment (LCA), an Asset Integrity Management System (AIMS) or a performance analysis that can predict how the purchase is going to perform its required function effectively and efficiently whilst protecting health, safety and environment (Arvidsson et al., 2018). Currently, SGRE carries out LCA's of the wind turbine components they sell, but not of the machinery and equipment utilised to produce the end products. If sustainability assessments were to be implemented, SGRE would be able to identify the factors that affect the success or failure of a product before purchasing it and prevent unwanted results i.e. energy awareness, perceived benefits, perceived price and efficiency. These measures will prevent unnecessary energy consumption throughout the supply chain and become more efficient at every step of the production process. To exemplify the statement above, three projects are described that were implemented due to the urgency of a situation without going through an LCA, AIMS or performance analysis, consequently ignoring the possible negative operational and environmental impacts they might cause.

3.2.1. Composite curing Oven, Hall 11

The oven used in Hall 11 generates the energy from natural gas for curing the blades and begins the distribution of energy. The most significant components of the oven are the burner, supply fan and filters at a cost of 3 million euros approximately. This specific oven takes 6-7 hours to curate a blade at approximately 540kWh per blade manufactured and SGRE produces 12-14 blades a week, which sums up to 6,480kWh per week or 23,328GJ per week (Andrei Sava, 2019). Moreover, the life expectancy for an industrial oven is quite high and would last approximately 15-20 years which means the best product must be obtained to reduce the operational costs. Generally, such big ovens have the limitations of limited size, transportability and requires large amounts of heat to be pumped into the enclosed space to cure the blades which can be expensive and time consuming.

The oven in Hall 11 is especially inefficient since the extra heat that is left over after curing the blades is not recycled for other uses, which simply means that valid and usable heat is wasted into the atmosphere. It also operates for longer than necessary. Once the blade is cured it keeps running for an extra 1-3 hours which wastes energy. If the oven had a timer or it was shut down immediately after the blade was curated there would be large amounts of energy saved per year. Thus, parameters such as temperature, pressure negativity, insulation, and air flow must be looked at before purchase to have the optimal option to reduce the overall energy consumption. For instance, a waste heat recovery unit can produce 5-10% savings in oven consumption, reducing the annual running costs and emissions (Pask et al., 2017). Therefore, improving the oven's performance should be an important and prioritised task by engineers. Perhaps, the implementation of a sustainability assessment such as an Asset Integrity Assessment (AIM) before purchasing the oven would have ensured a responsible consumption of processes and resources to deliver integrity over the whole life cycle of the oven.

As an alternative, electric heating blankets could also cure the epoxy in the blades and replace the current oven. Hating blankets are currently not being implemented since it would reduce the number of blades produced per week because they would create a bottle neck in area 3B where they repair the blades. This would decrease the number of blades per week to 7-8 blades compared to current 12 blades per week. It all comes down to how the buildings Halls were designed cheaply to cut down costs and not adapted correctly.

3.2.2. Ventilation system

The mechanical ventilation system unit selected for one of the Halls was considered cheap but demanded large operational costs. This option was selected because at the time the production plant required an immediate solution for the paint booth to ensure the production of blades didn't stop without considering the environmental costs of this option. One of the big factors affecting the efficiency of the system was that the diameter of the pipes was selected to be smaller than what the engineers specified since it would save money on materials. Nevertheless, the reduction in material costs by decreasing the diameter of the pipes consequently increased the energy consumption required to operate the system. The desired consumption for the external pressure was 400Pa but the ventilation system operated at 800Pa which means the specific fan power goes from 1,855W/(m^3/s) to 3,496W/(m^3/s) which is extremely high and far beyond the standard. If a proper system was to be applied in the production plant of SGRE, the pressure drop must increase. Moreover, the supply air for the fan would have also a significant difference in the electrical power input going from 2,659W to 24,799W respectively. Now the ventilation system is creating large operational costs for SGRE. Therefore, if long-term risks were considered prior to the purchase, the ventilation system would have minimized business risks associated and perform its required function efficiently. But SGRE did not investigate long return payback periods, thus cheap ventilations systems that can fulfil the immediate requirements are investigated without caring for the energy consumption during its operation.

Despite this, the engineers working at SGRE have specifications to follow but there are constant disagreements with the department of Real Estate (branch in charge of designing the buildings for Siemens Gamesa) since they avoid long-term investments which impede the correct adaptation of the plant for future changes e.g. some process Halls should have been designed bigger for larger blades to fit. These miscommunications jeopardize the optimal performance of the plant and should be addressed immediately to fulfil the needs with the most sustainable practices possible.

3.2.3. Heating oil for boilers in Hall 1 and 6

Halls 1 and 6 used boilers that required large quantities of heating oil instead of natural gas. This decision was taken without consulting the HSE department and the potential emissions produced from the combustion of the heating oil were neglected. Moreover, they purchased excessive amounts of heating oil which now they must either use or sell. Nevertheless, after some pressure from the HSE department they are finally changing the boilers to natural gas which has taken time and economic costs. There are several reasons why natural gas a better option is than oil. On the one hand, natural gas is undoubtedly much greener than oil. Generally, gas boilers have better combustion efficiency than oil boilers because solid fuel is more difficult to convert to heat (Tawil, 2016). On the other hand, it can also be stored and withdrawn when needed and it's cheaper than oil. Therefore, why isn't Aalborg's production plant adapted for similar situations that can occur in the future? Any decisions that increase emissions will have to be reported in the annual sustainability report and paid for. It is necessary to make smart decisions at the initial stages of any project to prevent unwanted results.

3.2.4. Outline of the barriers and drivers encountered

It is also important to point out the barriers encountered by the project managers that took them to implement these "quick-fix" decisions and the drivers that should be motivating SGRE as a company to implement sustainable solutions. The main barriers extracted from the evaluation of the three case examples above are presented in Table 6.

The most significant barrier for integrating sustainable practices in SGRE are mainly high implementation costs and long return paybacks. This implies that eventhough SGRE agrees with a sustainable strategy they might not be able or willing to make the investment required for implementation because at the moment, there is "weak justification of the opportunities" (Lindberg, 2019) e.g. lack of strong business case analysis to justify the investment. Perhaps the divergent priorities between the HSE team and the rest of the departments often do not effectively engage each other. As a result, the HSE team is brought too late into the decision-making process and cannot present an effective case to the financial decision-makers. Feasibly, if there were solid numbers to justify the investment, management and staff would be willing to increase the implementation of energy efficient alternatives instead of short-term solutions.

It sums up to SGRE not factoring in the environmental expenses into the business decision-making since they are not fully aware of the real costs and risks associated with their investment over time (Perera and Putt del Pino, 2013). Consequently, long-term opportunities to improve the processes and production lines are often missed. Nevertheless, sub-question three will try to overcome these barriers and close the environmental gap by recommending ways to adapt strategies and techniques in SGRE decision-making structure.

	SGRE Staff	Experts (Literature Review)
Barriers	Management finds production more important	Management concerns about other matters especially production rather than energy efficiency (State of Green, 2019)
	Maybe new technologies will not satisfy future standards	Lack of top management commitment/ understanding/vision (Mohiuddin, 2014)
	There is a lack of coordination between different sections within the company	Lack of information and knowledge in companies especially in SMEs (Jafarnejad et al., 2013)
	Management concerns about the investment costs of energy efficiency measures	Lack of enforcement for government regulations (Gunningham, 2011)
	Current installations are sufficiently efficient	Lack of financial resources especially in SMEs (Jafarnejad et al., 2013)
	No team taking ownership of the operational costs	
Drivers to include in future decision-making	Reducing energy costs	Reducing the cost of a product by reducing energy cost (IEEP, 2013)
	Improving staff health and safety	Managers vision/understanding (Kiesnere and Baumgartner, 2019)
	Improving product quality	The image of large companies(Bathmanathan and Hironaka, 2016)
	Long-term strategy for energy efficiency	Strategic energy efficiency plan (Jin and Bai, 2011)
	Improving reputation/recognition	
	Improving compliance with company's environmental targets	
What is required to improve energy efficiency?	Training on Energy efficient technologies	Financial incentives (UN, 2014)
	Training on energy management system	Business case analyses (EU, 2014)
	Information on policies and regulations	Raise awareness to the top managers (Tung, 2016)
	Information about cleaner production	

Table 6. Encountered barriers and needed drivers (Source: Self-generated)

3.3. Sub-question 3: What recommendations can be integrated in the investment structure of SGRE to improve future decision-making around procurement and environmental projects?

Once the past cases and main barriers have been identified it is appropriate to recommend an alternative to the problems encountered. This section will propose an initial approach towards improving supplier selection and predicting GHG emissions in the manufacturing Halls of SGRE with the ambition to inform the decision-makers towards a sustainable and more holistic perspective. Selecting sustainable suppliers will act as a first filter and predicting the emissions of a product will provide engineers and procurement teams with valuable information to create awareness and explore alternative energy efficient solutions. If they are not able to avoid carbon emissions it will still benefit SGRE to know possible future costs in their operations. In a nutshell, the following tool or guidance seeks to assist project managers to estimate the potential climate impact of their projects in terms of mitigating GHG emissions and integrate the environmental perspective from an early stage.

3.3.1. The importance of evaluating the environmental impact of purchased products

To date, industry is driven by marketing, costs and competition worldwide. In most companies, environmental issues are the least relevant factor for pushing product innovation because the top departments are the most involved departments, them being top management and the marketing and sales department (Guo and Ma, 2008). Generally, the environmental departments who care about sustainability and achieving environmental targets, don’t usually take part in productions processes as can be seen in sub-question one. Thus, this tendency suggests that there is no straightforward connection between a sustainability assessment such as a life cycle analysis (LCA) or an Asset Integrity Management (AIM) and production, since cutting down process time has become the norm, at least in manufacturing plants (Seger, 2016).

To counter this tendency, all future purchases required for industrial activities such as machinery and processes should go through a sustainability assessment analysis to predict the operational performance, safety and profitability. Starting from the raw material extraction and acquisition, through materials required for production to use and end of life treatment and final disposal to avoid the barriers explained in sub-question two (Keller et al., 2015). Thankfully, there are raising large-scale companies integrating life-cycle considerations in their product development which consequently enables them to adjust the materials (in terms of choice and quantity), products and processes needed to deliver a service as seen in Figure 11.

In essence, it avoids focusing on the immediate results that a product can deliver and adapts a circular economy model for industry which leads to highest GHG emission reductions in the use phase. For instance, in the production phase all processes and activities that are important for production of the product are included (Browning et al., 2002).

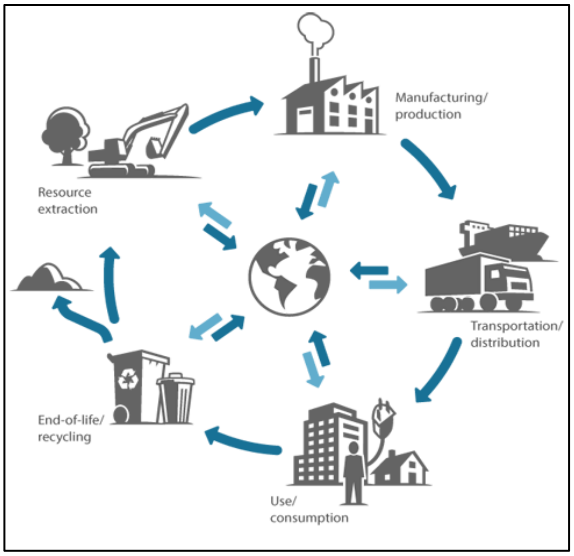

Figure 11. The full life-cycle (Source: Pre, 2016)

However, the environmental impact in the wind industry, currently evaluates the impact of wind turbine components such as the blades, rotor, gearbox, generator, tower, transportation, etc, but there is no environmental evaluation of the equipment and machinery required to produce these parts and this aspect needs to be addressed with urgency. For instance, if a certain machinery is consuming too much energy it can be replaced or optimized to reduce raw materials and energy consumption and this way decrease the carbon footprint (Pommer and Bech, 2003).

3.3.2. The role of suppliers and decision-makers

Considering the amount of energy consumption required to power Aalborg's manufacturing plant, it is binding to look at the supply chain to conserve natural sources and reduce carbon emissions. For this reason, it is crucial how engineers make decisions on how resources are allocated and disposed to produce a product. Another important factor to consider is the selection of suppliers which should not only be based on their ability to respond quickly to changing costumers needs, but most importantly, how well they can help meet SGRE and costumers sustainability goals (see Figure 9). From the interviews carried out (see Appendix D-G) it is clear that the procurement team in SGRE does not include environmental factors to evaluate and select suppliers *"No. You will not find anything regarding energy efficiency requirements in our supplier evaluation"* (Jan Pedersen –Procurement team see Appendix E). This can suppose a problem since sustainable sourcing can save money, reduce waste, improve competitiveness and build business reputation (Molenaar and Kessler, 2017).

SGRE as part of the global industry has the responsibility to manage its operations in the most sustainable way possible. But this transition will only occur if they are backed-up by decisions- makers. For instance, a purchasing manager might want to consider whether the supplier behaves responsibly e.g. ethical standards or sourcing raw materials in an ethical way. A clear example of good practice is Shell who is working on the implementation of the so called Sell Supplier Principles (Shell, 2019) where they prioritize those suppliers who can meet their economic, social and environmental requirements. These include use of energy and natural resources extraction as efficiently as possible to minimise the corporates carbon footprint and at the same time cover health and safety concerns. Another example is Marks & Spencer who made 81€ million during 2010 in energy savings due to their work with suppliers that reduced carbon emissions and improved efficiency and deliverables (M&S, 2015).

Perhaps the procurement team at SGRE should integrate sustainability into existing procurement processes, avoiding the creation of parallel process. The figure below extracted from the ISO standard 20400-2017:Sustainable Procurement, illustrates a typical procurement process for sustainability integration (ISO, 2017).

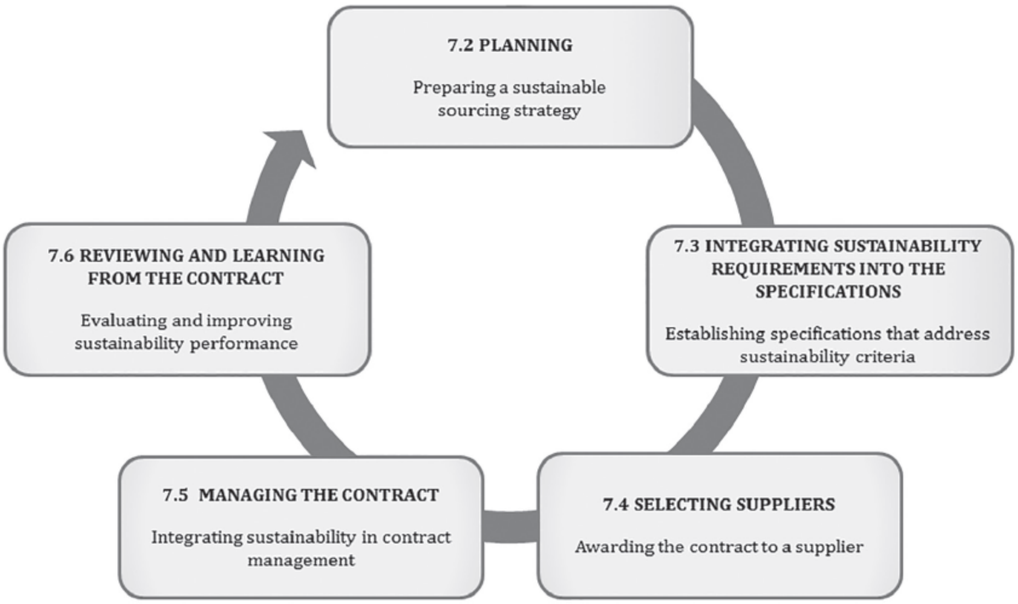

Figure 12. Integrating sustainability into procurement process (Source: ISO, 2017)

For the integration of sustainability aspects to be successful, it should be done in coordination with key stakeholders within the company in order to reflect practical and technical considerations (for key stakeholders see Figure 9). Some of these requirements apply to the goods or services being purchased. Some might apply to the process and manufacturing methods used to deliver goods and other to the supplier organization in itself (ISO, 2017). A starting point for the procurement team of SGRE could be to ask the suppliers the outlined questionnaire in Appendix C obtained from the EPA which intends to help customers quantify their suppliers GHG emissions to develop targets and mitigating risk (EPA, 2018a).

Moreover, another important aspect of sustainable procurement is the growing interest by customers on the environment. What once was behind the curtain now needs to be unveiled and presented to the public because the possibility exists that if customers are not happy with manufacturing practices they will not feel identified with the brand or organization. This can be seen in the form of clients demanding sustainability audits from their providers before creating any business opportunities (Bové and Swartz, 2016). Therefore, green practices need to be integrated in the supply chain as Figure 13 shows and transparently demonstrate that the corporates belief is based on a sustainable approach of material sourcing, suppliers and operations.

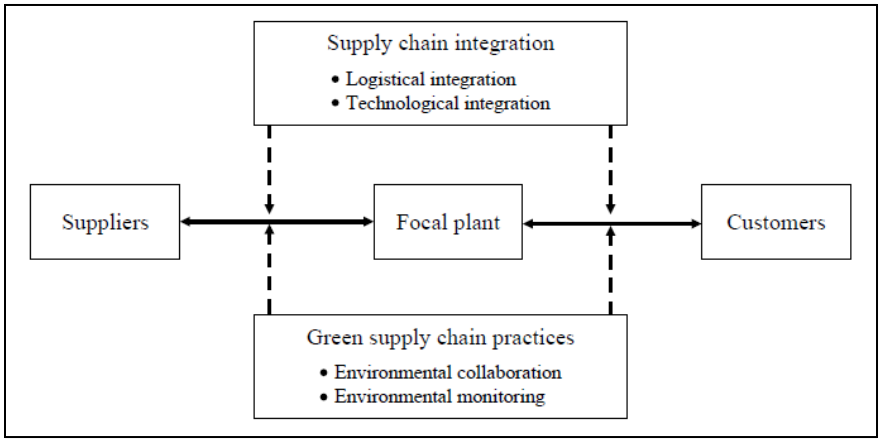

Figure 13. Simplified supply chain with sustainable supply chain practices (Source: ISO, 2017)

As important as it is to include suppliers that care for the environment, it is also important to know at what stage of the supply chain is SGRE consuming large amounts of energy. Fortunately, SGRE has been accounting emissions for Scope 1, 2 and 3 which means they already have the tools to steer towards informed and effective decisions regarding mitigation strategies, and away from poor ones (see appendix A).

To go even further, it is recommended that SGRE combines a sustainable selection of suppliers with predictive scenarios of emissions when purchasing equipment and products for manufacturing processes. If the emitting emissions are estimated at the initial stages i.e. design stage of a product, then strategic decisions can be made around long-term results rather than focusing on immediate returns. By formulating a range of possible futures or scenarios it will allow Aalborg's production plant to "identify the changes that would need to be made to the current system to realise these futures" (Giurco et al., 2010). Thus, selecting sustainable suppliers and predicting emissions of a product before purchase, will work as a predictive tool to avoid future costs.

At the moment SGRE calculates capital expenditure (Capex) and operational expenditure (Opex) to measure the financial performance of a product (Swan, 2015). The following section will add a third parameter to estimate the emissions as a predictive tool from purchased products and equipment, with the ambition to enable the control of crucial factors and mitigate unwanted environmental impacts.

3.3.3. Capex, Opex and Emissions Scenarios

Capital expenditure (Capex)

The capital expenditure (Capex) are the founds used by a company to obtain physical assets such as technology, buildings, machinery, etc, and it's often to carry out new projects or investments. These sort of investments are also made to maintain or increase a company's operations (Casier et al., 2006). The capex expenses are normally depreciated or amortized after several years e.g. machinery or equipment bought to decrease production time of the blades. Therefore the capex expenses are used for a future benefit and making wise decision making around capital expenditure is critical to sustain progression (Mintz and Smart, 2006). The main challenges surrounding capex expenses for any company, especially in industry, are measuring unpredictability and the fact that the payback period of an asset will be paid back in a long period of time.

Operational Expenditure (Opex)

On the other hand, operational expenditure is used to purchase major physical goods or services that will be used for more than one year, which might include:

- Plant and equipment purchase
- Building expansion and improvements
- Hardware purchases
- Vehicles to transport goods

The type of capital expenditures will be influenced by the type of industry of the company. For instance, the asset purchased may be a new product or something that improves the productive life of a previously purchased asset (EY, 2014). The problem arises when the day-to-day environmental expenses such as fuel consumption to evaluate energy efficient alternatives are not factor in these calculations. Environmental considerations might not be a major expense at an initial stage, but it can be quite significant if summed up at the end of the year. This is especially important since the price of carbon is likely to rise and companies will have to pay to become “green” at least in their annual sustainability report (Stam, 2018). For this reason, this paper proposes a way to prevent emissions by calculation the pollution levels before purchase and make a responsible selection based on quantitative calculations.

Emissions Scenario

Energy conservation and emissions abatement is currently an important development strategy for Europe (EU, 2018b). It is significant to analyse how to reduce energy consumption and emissions in SGRE’s manufacturing plants as they require energy-intensive machinery to produce blades, especially in Aalborg’s blade production plant as seen in the previous research paper (see Appendix A).

Therefore, by predicting the emissions, engineers and the procurement team will be a few steps ahead preventing unwanted payments in the future in the form of carbon offsets e.g. green certificates or carbon sequestration projects. Therefore, it is recommended that companies combine calculations of Capex, Opex and Emissions into an integrated framework as presented below in Figure 14.

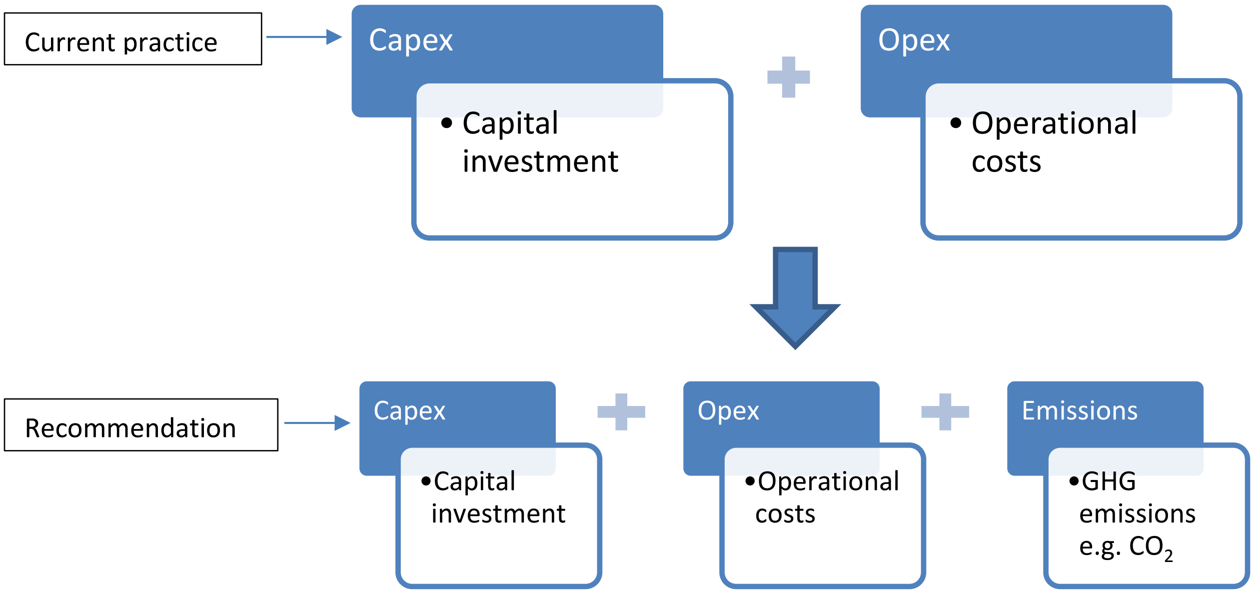

Figure 14. Costs to consider when purchasing products Capex, Opex and Emissions (Source: Self-generated)

Backcasting emissions will provide a robust estimation of emissions, SGRE could determine the negative impacts of a product that is going to be purchased and, based on this data, make a rational decision at an early stage. The following sections describes the stepwise approach to be followed.

General formula to calculate emissions

There's a misconception that calculating emissions is a tedious and complicated road to follow due to the numerous equations and units. Nevertheless, the process can be reduced to a simple equation without having to use costly computer software's. But before we get into the equation to calculate the emissions for any product or machine, it is convenient to give a brief description of the project in hand. The description needs to be presented in clear and concise terms of what the project environmental impact is, either negative or positive. If the new purchase supposes energy savings due to energy efficiency or equipment optimization, then the benefits must be described compared to the replacement (e.g. will it produce large amounts of GHG emissions due to the amount of fuel consumed or does it enable something to be produced in a less carbon intensive manner? Or does it result in the development of tools that allow decisions to be taken that favour the implementation of the lower carbon solutions?) Three general parameters need to be considered when describing the project:

(1) the magnitude of the function or service

(2) the duration or service life of that function or service and

(3) the expected level of quality

After the description of the project, the general formula for calculating air emissions can be applied (Aguinaldo, 2016):

$$\textbf{\textit{Total Emissions (E) = Activity (A) x Emission Factor (EF) x (1 – Control (C))}}$$

Equation 1. Total air emissions calculation

The Equation 1 above describes that the air emissions from any piece of equipment is equal to the activity rate (A) multiplied by the emission factor (EF), multiplied by 1 minus the control efficiency. If all of those parameters are obtained, then the total emissions can be calculated for a single piece of equipment.

- **Calculated emissions (E):** The emission rate is the value that needs to be extracted since E equals to the emissions from one process or from one piece of equipment (Aguinaldo, 2016). Alternatively, this equation can be used for a complex facility with multiple pieces of equipment and processes by applying this same calculation to each piece of equipment and each process and then adding each of them to get the emissions for the entire facility. The most important part to remember is that this equation is valid for only one piece of equipment or process at a time.

  It is also important to note that each process or equipment will emit a certain type of pollutant. For instance, a storage tank with gasoline should only expect emissions of organic compounds, since those are the evaporated losses from the gasoline being stored in the tank. On the other hand, a boiler or engine that combusts fuel can emit contaminants that include volatile organic compounds (VOC), nitrogen oxide (NOx), carbon monoxide (CO), carbon dioxide (CO_2), sulphur dioxide (SOx), and particulate matter. As a third example, a flour silo VOCs shouldn't be accounted for since there are no evaporative emissions form that piece of equipment, instead emissions of particulate should be measured (Aguinaldo, 2016). Therefore, it is important to keep in mind that the types of pollutants will differ from based on the equipment and process type.

  The units of E are typically in mass per time e.g. kg/hour, kg/per day, kg/per month, etc. The duration of the parameter E will depend on the time the equipment or process will be examined which is determined by the activity (A). Most sustainability reports will account their annual emissions in CO_2e or kg/per year, but it varies depending on the accuracy the company wants to deliver.

- **Activity (A):** The activity of a piece of equipment is measured on how long it operates, and it can be measured in various ways (Aguinaldo, 2016). It can be measured by the amount of material processed, either as raw material or finished product; the amount of time that a piece of machinery is active; or the amount of fuel that is consumed per unit time for example, this could be litres of oil consumed by boilers in Hall 1 and Hall 6.

  Most activity data should be easy to obtain, relatively accurate using product specifications from suppliers or bills, invoices and receipts. So, if the unit of measurement is one year then the activity would be how much oil was consumed by the machinery in one year. Table 7 below sets out common emission-releasing activities and sources of information to change this data into GHG emissions. It is best to collect activity data by volume or mass (e. g. litres of petrol used) or duration per time (e.g. hours/per month) as emissions can be calculated more accurate (Defra, 2009).

Emissions releasing activity	Source of information
Electricity use	Total KWh from electricity
Natural gas use	Total KWh from gas
Water supply	Total water supplied in m3
Water treatment	Total water treated in m3
Waste disposal and recycling	Tonnes of waste treated by type (e.g. paper, glass, waste to landfill, etc)

Table 7. Common emission releasing activities (Source: (EPA, 2019)

If the activity data is unknown it will have to be estimated. However, it is required that the project managers are transparent about the estimation technique used and apply quality measures such as comparing the data with historical data to ensure that it falls within a considerable range.

- **Emission Factor (EF):** The EF is a representative value that attempts to relate the quantity of a pollutant released into the atmosphere with the activity associated with the release of that pollutant (EPA, 2018b). Determining the EF can be obtained from look-up tables such as the International Energy Agency (IEA) 2018 edition which contains annual time series of CO_2 emissions (IEA, 2018). It is convenient to manage the units of the EF so that they can cancel out.

- **Control Efficiency (C):** The control efficiency is dependent on whether the piece of machinery or process has an air pollution control device that can alter or lower the emissions of a machine or equipment. The values are generally expressed as percentages; therefore, it is unitless. Engineers can verify if the controller has been installed by inspecting the equipment or reviewing specifications. If the equipment does not have a control device, the emission factor and the information that were used to develop the factor to determine if the control efficiency is built into the equipment's emission factor. A factor of 1 can be used if there is no control or it is built into the emission factor (Aguinaldo, 2016). Moreover, the value of the control efficiency will depend on many factors, such as meteorological condition, process, etc.

Predicting the production of emissions will be very helpful since the price of carbon is expected to rise quickly, currently at 7€ per tonne but a price of 20€ per tonne can be expected over 2021-2030 (De Jong and Dufrasne, 2017). Thus, to counter this increase the energy consumption should strongly decline, especially in the industry sector, and predictive tools could be one way to predict future scenarios and costs.

Air emissions formula example:

As an example, let's take a boiler consuming natural gas. The emission factor is 53.03kgCO_2/mmBtu natural gas (one million British thermal units) combusted for a specific piece of equipment, like a boiler and the boiler uses 10mmBtu per month. Once these parameters are obtained, then the emissions from the boiler can be calculated with the formula presented above, assuming that the control factor is equal to 1:

The activity is 10mmBtu/month and the emission factor is 53.03kgCO_2/mmBtu. If these two values are multiplied together, using the formula, then the result is 530.2kgCO_2/month (=10 x 53.02), which are the emissions from a boiler in a given month. However, if a company is trying to relate emissions to cost, to determine the benefits of energy efficiency, then a cost per unit of carbon will be needed and added in as a factor to the Capex and Opex calculations as visualized above. Sometimes people look at an avoided cost to relate the benefits of energy efficiency, which means, what are the costs that can be avoided if energy is conserved? These avoided costs can include less power plants needed to be built, less money needed to spend on treating the adverse health impacts to the public, etc.

Moreover, if the engineers want to go further and not only predict the emissions during the use stage, they can also calculate the emissions that will be needed to dispatch the equipment at the end of its lifetime. Therefore, two stages must be taken into consideration to round up the initial steps of predicting emissions which are the 'Use stage' (explained above) and the 'End of life', represented in Figure 15.

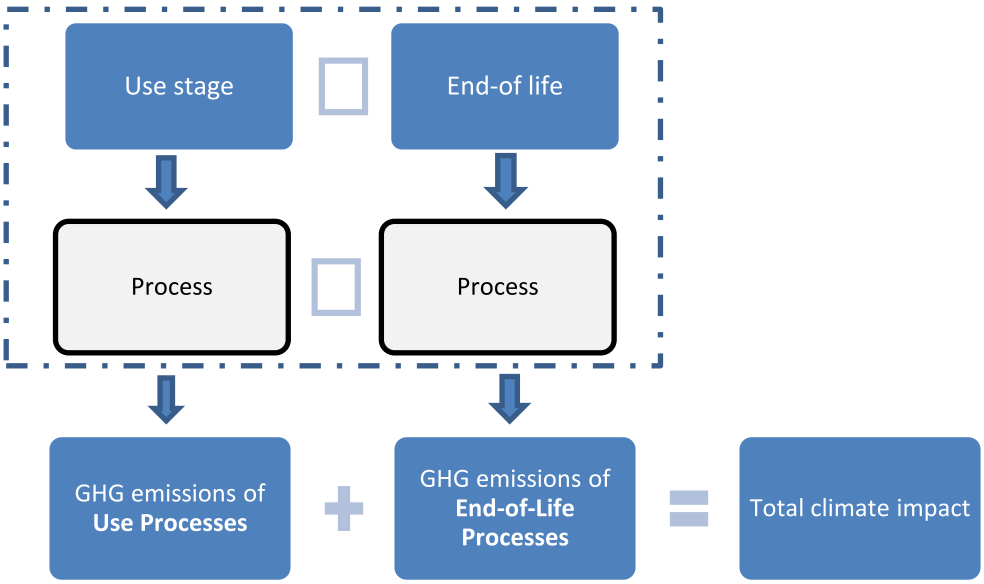

Figure 15. Use stage and end of life for GHG emissions (Source: self-generated)

<u>Use stage</u>

The use stage begins when the consumer takes possession of the product and when the product is dispatched for transport to a waste treatment location after the lifespan. For products that consume energy to fulfil their function, the use stage and their corresponding emissions may account for the largest fraction of impacts over the complete life cycle (Bhatia and Cummis, 2016).

<u>End-of-life</u>

The end-of-life stage begins when the used product is discharged by the consumer and ends when the product is returned to nature (e.g. incinerated) or allocated to another products life cycle (e.g. recycling).

If these steps are done correctly before purchasing new equipment, there is a possibility that SGRE can illustrate the future as well as barriers and opportunities associated with transition pathways. In a nutshell, it will produce tangible data to help decision-makers understand emission trends and formulate mitigation activities, among other functions. Thus, providing them with vital information to take a proactive decision in making and tuning effective policies to achieve the environmental targets (Katsikeas et al., 2016). In addition, the estimated emissions formula can be calculated using software or an excel spreadsheet model with a user-friendly interface that is easy to use for all engineers and staff at the plant. The excel tool can include many other parameters to make the calculations more precise, such as a Life Cycle Assessment which considers emissions from materials, production, distribution, use and end of life. Nevertheless, qualitative visualisation of decision-making can only be the first step towards decisions supported by facts and data (Buchert et al., 2017). For now, the described approach will be sufficient to ease the integration of these calculations in the daily work of SGRE's engineers and other staff.

Furthermore, the estimated GHG emissions and costs associated with them can be calculated to predict the investment SGRE will have to spend to offset the unavoidable carbon emissions in the form of green certificates or carbon sequestration projects. But as researched in the previous project (see Appendix A) purchasing virtual certifications is not the most transparent approach to achieve carbon neutrality. Thus, if the emissions of future procurement purchases are predicted and quantified at the start, SGRE has the opportunity to understand the impacts of products that enable emissions reductions.

Capex	Opex	Emissions
Meaning		
It refers to the expenditure when a company acquires new assets or upgrades existing ones	It refers to those expenses that a business must sustain to run daily operations	It refers to the predicted emissions (e.g. CO_2) new assets will produce for a given time
Way of payment		
Money payed up front	It's paid monthly or annual instalments	It can be payed monthly or annually in the form of green certificates or carbon sequestration projects
Tenure		
Long-term	Relatively short-term	Long-term
Profits		
It is earned slowly and gradually	It is earned for a shorter period of time	It is earned slowly and gradually
Examples		
Buying of fixed assets Expansion of buildings Purchasing machinery	License fees Advertising costs Insurance fees	Emissions from oil, petrol and gas production operations

Table 8. Capex, Opex and Emissions descriptions (Source: Self-generated)

To implement the approach above (see Table 8), SGRE should assign an energy controller or team to close the environmental gap as explained in sub-question one. Typically, managers in one part of the organization focus on buying energy at the lowest possible price and developing a budget and a risk strategy. Elsewhere, managers are working to reduce consumption and improve efficiency. Thus, an energy team can help connect two areas of the manufacturing business which are usually distinct: procuring energy and managing its use (Winston et al., 2017). Even though these two areas might seem antagonistic, they must work closely together to obtain the best product possible that not only performs at the highest level but also has the best energy efficient rating Figure 16.

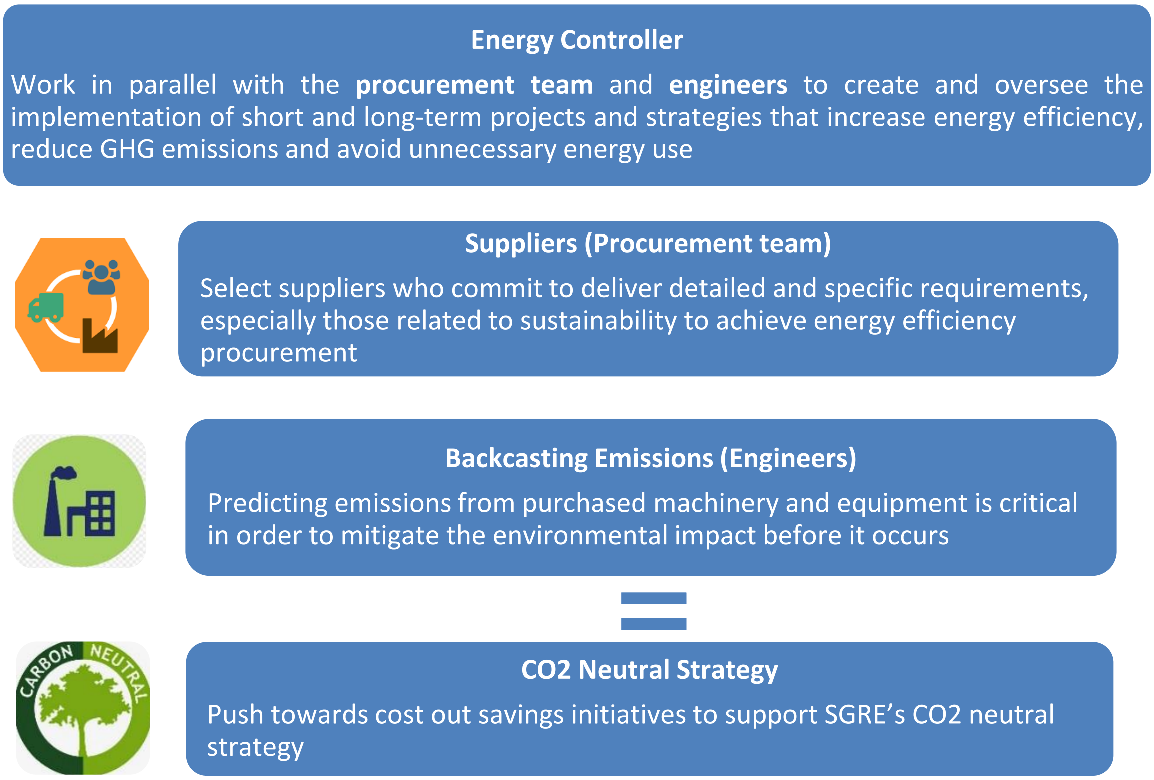

Figure 16. Functions of an energy controller within SGRE (Source: self-generated)

Therefore, coordinating those two areas and prioritising energy consumption and carbon reduction can lead to better choices with more optimal results for the financial and the environmental bottom line (EECC, 2016). These better choices will occur since the new purchased products will have improved energy efficiency performance and the prediction of emissions will anticipate unwanted costs to cover SGRE sustainability targets, such as green certificates or carbon capture projects which, might be affordable for one facility, but SGRE as a whole, will have major annual expenses. Hence, the implementation of this initiative should be applied not only in Aalborg's production plant but in all SGRE facilities to minimise the company's carbon footprint at the core of the problem.

4. Conclusion and Discussion

Parting from semester three project summarised in Appendix A, it is clear that SGRE prioritizes immediate, short-term investments which focus on cutting down production time for blade production. Perhaps the reason behind this tendency occurs due to the current financial incentives for energy efficiency not being high enough for industry. As a consequence, SGRE occasionally purchases machines and equipment that offer temporary or "quick-fix" solutions required for manufacturing blades, like the examples explained in sub-question two, which eventually need to be replaced due to operational and other unwanted costs. Therefore, ***how can SGRE Aalborg shift to a strategical decision-making regarding energy efficient procurement and move towards carbon neutrality?*** First of all, SGRE needs to identify within the company the staff members who may be affected or have an effect on the project outcome. This is crucial since right now there are many miscommunications between departments that could be avoided such as those from engineering and Real Estate (RE). For instance, the RE department might design the building taking into account budget limitations which will bring greater costs in the future i.e. one of the Halls to store blades was designed by RE with a reduced height to cut down costs in building material but increase in blades size was not considered. As a consequence, a bigger Hall is needed to fit in the bigger blades which increases the cost for SGRE considerably. If the decisions were taken considering the opinion of different departments, the immediate and short-term results would be avoided. Moreover, SGRE's current decision-making process is matched to a decision-making model in sub-question one to explain from an academic point of view the negative aspects of the current practices at the company when purchasing products for production.

In addition, case examples that presented energy inefficiencies in the past are described to explain at what stage of the decision-making process they occurred and prevent similar future mistakes. The three cases described included a ventilation system, two boilers using heating oil and an oven for curating blades. The ventilation system was purchased because it was relatively cheap at the time, but it now requires double the energy to operate which means many costs go towards operational hours. The boilers in Hall 1 and 6 used heating oil, producing large amounts of pollution and are currently being replaced. Finally, the heating oil used for the oven in Hall 11 used to curate the wind turbine blades operates longer hours than necessary an doesn't recycle the extra heat for re-use. These three cases presented clear examples of unwanted energy consumption and negative environmental impacts which could easily have an energy efficient alternative, but the absence of investment and ownership derived in greater operational expenses for SGRE.

Finally, this paper tackles the existing environmental gap by proposing a new environmental framework, defined by three clear fronts which can be easily integrated in SGRE organizational structure. The first and most important aspect to include is somebody responsible for the energy consumption who is in constant contact with the engineers and activities taking place in the manufacturing Halls. This role is presented in this paper as an 'energy controller' but it doesn't necessarily have to be a single person, it can also be a team who takes responsibility for optimizing and proposing energy saving opportunities within the manufacturing plant. The second aspect focuses on a sustainable supplier selection approach to reduce the energy consumption across the supply chain. To manage the purchasing activities proficiently, the selection process of sustainable suppliers must become an important criterion for the procurement department within SGRE. Their role becomes crucial, acting as a filter to meet the market uncertainty and must be sustainable in terms of cost, flexibility, quality and green operations. Therefore, by highlighting the role of suppliers and presenting a sustainable supplier comparison questionnaire, this paper can help managers in decision-making by having a standardized criterion and evaluate the suppliers based on the ideal solution. Finally, a method to predict emissions produced by machines and equipment is presented. This practice will approximate the pollutant emission rate of potential purchases such as machinery or equipment during operational life time. This calculation will then be used to determine if it's a responsible purchase that favours cost out energy savings or not. Moreover, backcasting emissions will work together with the supplier selection to support a strategical decision-making and consider cost-out savings by reducing energy consumption at an initial stage. This doesn't mean that the environmental perspective must be prioritized over production time in the manufacturing plant, but it suggests the allocation of more resources towards environmental initiatives.

Now more than ever, the decision-makers within SGRE and other companies have the chance to transform the socio-technical regime and allow new streams of innovations and change. In addition, SGRE has the opportunity to become an important stakeholder within the thriving city of Aalborg and contribute towards their sustainable development goals. Since, achieving energy savings in industry will deliver benefits to the winder city economy. Having reduced air pollution as one of the most important potential benefits among others (IIP, 2015). Therefore, no organization can be alienated from the city and all must be required to contribute towards the city's best interest. For this to happen, SGRE should avoid linear models and support a circular transformation. But it's only possible if SGRE has the courage to acknowledge that the current system is hindering investments and the ability to reach long-term goals.

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Appendix A

Summary Semester 3 report

The research carried out in this report tries to address the responsible path to reduce corporate carbon footprint exposing the paradox of green certificates, also known as Guarantees of Origin (GO´s).

Many companies and businesses use these certificates as a trading mechanism to claim the renewable value also known as "renewable attribute" of electricity produced from renewable sources. This implies that a company buying these certificates can report having zero GHG emissions in their sustainability report. The issue arises because GO´s are only that, a claim, and the physical electricity consumption of the company remains unchanged as do the emissions associated with it. Many studies have shown that voluntary GO´s, don't have a detectable influence on grid emissions, so reduction claims of emission are baseless (Gillenwater, 2014). This report explains the reasons behind this and instead, it suggests reaching carbon neutrality by increasing energy efficient projects. This approach intends to achieve carbon reduction targets in the most transparent and sincere way possible.

The findings suggested that there are currently some barriers in the organizational structure of SGRE in Aalborg that impede the implementation of additional energy related projects. Nevertheless, four possible scenarios that included the implementation of several energy efficient projects were proposed to calculate the economic and environmental benefits. The objective was to motivate SGRE to see the long-term benefits rather than the short-term and immediate results. It's true that many carbon removal solutions are expensive to deploy or measure, so SGRE might be reluctant to invest if there is no certainty of return on investment, which is totally understandable because at the end of the day SGRE operates in a business environment. Nevertheless, if energy efficient projects can drive savings, as shown in the scenarios for this report, business in SGRE can potentially operate more efficiently as a result of focusing on how electricity is used. Then the number of GO certificates could be limited to a minimum financed by savings that could be found in operations. However, for this approach to be properly implemented, resources and experts must be assigned to take ownership of the energy efficient projects.

Throughout the research of this report many limitations were encountered and should be solved if further research is to be perused. First, the list of energy efficient projects provided by Ørsted, must be updated and completed to confirm that the implementation of the proposed projects will work. Secondly, the electricity prices should be calculated considering taxes, hedges and additional costs involved in the energy bill if the final results want to be precise. Even electricity price forecasting for each month and season is recommended. Finally, the organizational structure of Siemens Gamesa must close the gaps extracted from the interviews to influence the successful completion of additional energy projects. Perhaps these gaps will be solved in a few years once Siemens Gamesa embraces all the recent changes that are taking place after the merge, such as leadership changes, short- and long-term goals, accounting systems, ownership of tasks, etc.

In conclusion, the intention of this report is to provide a baseline of discussion towards green carbon trading and electricity markets. This requires transparent and fair accounting principles because the use of GO´s allows companies to report reductions that have not occurred, and it undermines the real carbon footprint of companies (Fischlein, Lu, & Gillenwater, 2013). If companies, especially those in industry keep engaging with this approach it will make us believe that no matter when electricity is consumed it will come from renewable sources. For this reason, there are currently many businesses who call themselves “100% renewable” and this statement must be challenged. Otherwise, investments in renewable energy infrastructure will be hindered, keeping companies away from investing in real energy efficient solutions that could lead to carbon neutrality.

Appendix B

SGRE supplier evaluation

Factor
Strategic Procurement
Supplier evaluation (SPR) - (ExG ExS)
Basic qualification - (ExG ExS)
Payment terms (days) - (ExG ExS)
Warranty baseline (use same value for all suppliers)
Warranty (from delivery) - (ExG ExS)
Max. Total Liability - (ExG ExS)
Experience in Product category
Supplier Claim Performance - (ExG ExS)
Experience in deliveries to SGRE
Acceptance of Siemens WindTime
Organisation
Open Book Policy
Financial situation
Down payment percentage
Down payment Terms
Warranty
Late Delivery
Specifications
SGRE supervision during production
Competence level at key personnel
Conceptual Risk
Other costs (relative) (SPR)
Other costs (absolute) (SPR)
Operations/Industrial
Supplier evaluation (SM) - (ExG ExS)
Other costs (relative) (SM)
Other costs (absolute) (SM)
Supplier Quality Management
Supplier evaluation (SQ) - (ExG ExS)
IMS approved
Criticality
PPQ qualified (ESN Code)
Other costs (relative) (SQ)
Other costs (absolute) (SQ)
Technology
Supplier evaluation (TE) - (ExG ExS)
Other costs (relative) (TE)
Other costs (absolute) (TE)

Appendix C

Example of possible questionnaire to suppliers (Source: EPA, 2018a)

Background Information	
Company Name: Click here to enter text.	Date: Click to enter date.
Number of Employees: Click here to enter text.	
Contact Name: Click here to enter text.	Title: Click here to enter text.
Contact Email: Click here to enter text.	Contact Phone: Click here to enter text.
Environmental Policy and Targets	
Do you have a sustainability/environmental/green policy statement? Yes ☐ No ☐	
If yes, please provide link or attach document: Click here to enter text.	
Do you publish a Corporate Social Responsibility (CSR)/Sustainability report? Yes ☐ No ☐	
If yes, please provide link or attach document: Click here to enter text.	
Do you monitor and track energy consumption at your facility(ies)? Yes ☐ No ☐	
If yes, please describe: Click here to enter text.	
Do you have goals or targets to reduce greenhouse gas emissions and/or energy? Yes ☐ No ☐	
If yes, what is/are the target(s): Click here to enter text.	
Have you received additional requests from stakeholders to disclose environmental information? Yes ☐ No ☐	
If yes, describe the types of information requested and specify the type of stakeholder request the information: Click here to enter text.	
Do you report greenhouse gas emissions and/or energy either publicly or to another customer? Yes ☐ No ☐	
If yes, describe where: Click here to enter text.	
Greenhouse Gas Emissions	
Do you calculate your Scope 1 and 2 greenhouse gas emissions? Yes ☐ No ☐	
If yes, what is the most recent year that data are available? Click here to enter text.	
If yes, please provide:	**Total Scope 1 Emissions:** Metric Tons CO_2e **Total Location-Based Scope 2 Emissions:** Metric Tons CO_2e **Total Market-Based Scope 2 Emissions:** Metric Tons CO_2e
Please provide a description of your major Scope 1 and Scope 2 emissions sources: Click here to enter text.	
Do you seek third party verification/assurance of your Scope 1 and 2 emissions? Yes ☐ No ☐ *If yes, please attach your most recent verification statement*	
Do you calculate your Scope 3 greenhouse gas emissions? Yes ☐ No ☐	
If yes, what is the most recent year that data are available? Click here to enter text.	
For each Scope 3 category, state if it is relevant to your business and provide emissions, if available.	

Scope 3 Category	**Relevance**	**Quantified Sources**	**Emissions**
Purchased good and services	Select	Enter text.	Metric Tons CO_2e
Capital goods	Select	Enter text.	Metric Tons CO_2e
Fuel-and-energy-related activities	Select	Enter text.	Metric Tons CO_2e
Upstream transportation and distribution	Select	Enter text.	Metric Tons CO_2e
Waste generated in operations	Select	Enter text.	Metric Tons CO_2e
Business travel:	Select	Enter text.	Metric Tons CO_2e
Employee commuting	Select	Enter text.	Metric Tons CO_2e

Upstream leased assets	Select	Enter text.	Metric Tons CO_2e
Investments	Select	Enter text.	Metric Tons CO_2e
Downstream transportation and distribution	Select	Enter text.	Metric Tons CO_2e
Processing of sold products	Select	Enter text.	Metric Tons CO_2e
Use of sold products	Select	Enter text.	Metric Tons CO_2e
End of life treatment of sold products	Select	Enter text.	Metric Tons CO_2e
Downstream leased assets	Select	Enter text.	Metric Tons CO_2e
Franchises	Select	Enter text.	Metric Tons CO_2e
Do you seek third part verification/assurance of your Scope 3 emissions? Yes ☐ No ☐ *If yes, please attach your most recent verification statement*			
Energy and Greenhouse Gas Emissions Reduction			
Are you able to compare the greenhouse gas emissions reported above with emissions in a previous year? Yes ☐ No ☐			
If yes, please describe if Scope 1, 2, and 3 emissions have increased or decreased compared to prior years: Click here to enter text.			
Do you have a program and/or procedures to reduce energy use and greenhouse gas emissions? Yes ☐ No ☐			
If yes, please describe: Click here to enter text.			
Do you produce or purchase renewable energy? Yes ☐ No ☐			
If yes, please describe: Click here to enter text.			
Do you have strategies to reduce Scope 3 greenhouse gas emissions? Yes ☐ No ☐			
If yes, please describe: Click here to enter text.			
Do you engage with your suppliers around environmental issues and performance? Yes ☐ No ☐			
If yes, please describe: Click here to enter text.			
Do you collect environmental data from your suppliers? Yes ☐ No ☐			
If yes, please describe the type(s) of data collected and how it is used internally: Click here to enter text.			

Appendix D

Interview with Carl Tousgaard (Test and Qualification Engineer)

Date: 07/08/2019

Duration: 30 minutes

- What are your responsibilities?

All connected to the building all utilities systems and equipment. Right now, two parts of production and equipment; the paint brush (probably most expensive equipment and energy consuming) and HVAC system (not as expensive but extremely energy consuming). Also, ventilation etc... but those are the ones regarding production.

- What are the guidelines or procedures you follow when purchasing new equipment?

We follow national and European guidelines (EN) such as EN 1886 for air handling units but they tend to come from personal experience rather than top-down enforcement since the implementation or mandatory use of these guidelines are not very, at least at an internal level. It would be very helpful if somebody clarified this regulatory issue.

- What are the environmental or energy requirements when purchasing new products?

We have the primary target to reduce investment cost and total running investment. So, we look carefully at the efficiency of the system. But these calculations must go through RE and they only look at the immediate return. The day the after the machinery is installed they leave the plant and we must pay for the running costs.

I have worked in the HVAC systems, paint brush, electrical system, ventilation system… But right now for example the chiller it's quite small and it's not necessary to have this chiller. They are consuming too much but we must go fast and reduce investment cost and not care about running cots. We have a ground water cooling system in Hall 8. We have the permission but it's quite special. You can use filtering instead of mechanical cooling.

You will not find any in our Document House (internal storage od documentation) This kind of technical knowledge is not put in the system. We need to follow the national and EU standards of energy consuming equipment for industrial use and make it clear somehow what the requirements are. What are the maximums of energy, consumption etc. I haven't seen it, but it would be extremely helpful to have some sort of cheat sheet. It would make life easier for our technical guys. Because if we want to buy an expensive piece of equipment and its declined we must be able to back it up with EU energy saving standards. It would be the best. National and EU specially here in Denmark we have extremely clear standards for industry and they should be integrated in the procedures. We know what they are but there must be minimum SGRE requirements as well.

- Do you have a clear understanding of team mates and stakeholders involved to discuss projects ideas or issues?

We still don't have a clear set up of how we need to build a factory. It is not written down who is responsible for this area and who is responsible for that other area. How far will each of our responsibilities go for? And what is the ownership/responsibility of total costs (running shops included). There is no clear road to follow and we need somebody who can follow this responsibility. We have too many political people. It's extremely expensive because we are making a lot of communication errors from day 1, too many travels, too many misunderstandings and in the end too expensive project and poor quality.

- Do these uncertainties have to do with the merge between Siemens and Gamesa?

Before we were fewer open-minded people. E.g. when we build a medical facility I had a team of three people and communication was fluid and efficient. E.g. we also built a plant in china and we started seeing some political interference. E.g. another plant in Canada it was not important factory (RE dept is also in Canada but they never showed up, so it made it easier for us).

Too many people that don't have the deep founded knowledge of the systems and many people come and go too fast. I am working with Torben Justesen (Head of Maintenance and Tooling) to reduce specifically the energy consumption of the district heating and somehow, we are responsible, and this is what should happen with other projects.

- How many people are involved in the purchase of new equipment?

We can take 2 examples: HVAC in Hull RE tried to be responsible and it went completely wrong. Then we have people responsible like a subcontractor. We are responsible for the specifications and technical part of the systems and pointed out exchanged feedback with the company, but we didn't sign. The ventilation system was part of SGRE RE and people also didn't know how to follow.

- Are there business case studies for the projects?

I don't believe they do. I have never seen a practical result. And if they have it should be available in all the equipment and utility equipment. We need it to see the opportunities in the long term. SGRE in the UK decided to install an expensive solar roof instead of meeting our energy design requirements for the plant. Needless to say, that those solar panels only provided a very very small percentage of energy and was a political decision to "improve" the image company. First you need to build a smart factory.

- Is there a database or listing of products and machinery stating characteristics?

No, we don't have. But there is only a handful of equipment that need to be listed:

- Ventilation
- heating
- Light
- HVAC
- Compressed air
- Paint brush

The rest is equipment running for a few hours. Maybe you can save a little bit, but the main focus should be put on the blades production. A listing of the equipment I just mentioned.

- What improvements or solutions do you suggest to integrate energy efficient solutions when designing/purchasing new equipment?

What is most important is follow the regulations because they describe what you need to do. And you need people from our side Process Engineers, not people from RE, we are the owners and pay the monthly cost. So, people from our side to understand what we need to follow with the design institute, national requirements. Next step, contractor supplier or sub-contractor delivering the equipment fulfil the national and EU standards. And we are missing this every time because the resources building the factory are maybe a carpenter or… something else from RE and don't have the knowledge to look carefully in this direction. They cannot do this kind of work.

We have a controller when purchasing pens, but we do not have an energy controller and that's what we are missing. HSE? Jannie has very important and extremely high valuable numbers for benchmarking but we need somebody who can transfer these numbers to technical solutions and implementation and evaluation of technical solutions and we do not have this. And Jannie has a very good foundation but we need somebody who can interpret those numbers. We need an energy responsible.

E.g. The chiller was a fast-easy solution, but we did not look at the environmental consequences so it’s worth looking at the decision making behind it. We are putting out fires for the last years and once we put it out we move to another fire/problem and forget what cause the previous fire. It’s a vicious circle in this company.

Appendix E

<u>Interview with Jan Pedersen (Procurement department)</u>

<u>Date: 12/02/2019</u>

<u>Duration: 45 minutes</u>

- Can you describe your responsibilities in the procurement department?

You can say that looking from a helicopter, procurement is a support department. This means we don't have the mandate to take a final decision. We are a support function for the users, for the factory. So, if we look from the helicopter, buyer says we need to buy a new machine with certain specifications and he asks us to find a supplier. Once I collect the data/quotations from a number of suppliers and I present them to the end user for his selection. Normally at this stage there are some discrepancies because he wants to buy the most expensive one and I want to buy the cheapest option, so we have a discussion, again we agree, and I negotiate the final price on the machine from the solution we agreed to go for.

That as I said is from helicopter view. From a real on ground perspective there is a lot of things and you are not the first to talk about the total cost of ownership. Us in procurement get the fact that perhaps an expensive product might have cheaper operational costs and save money overall. We in procurement get that. But no one has yet showed a model where you can compare the real total cost of ownership. Calculating the electricity consumption is the easy part, but what about the water consumption, scrapping in its end life, repairs, there are a lot of parameters that need to be taken into consideration and just picking one of them is wrong.

The point is that you might have two machines, a cheap one and an expensive one and the cheap option might spend twice as much electricity as the expensive one. But the most expensive one weighs 20 tonnes more than the cheap one which means it will cost a lot of money to scrap it. Perhaps a better foundation is also needed. There are a lot of problems. But at the end of the day we ask okay given all these parameters, give us a model. How would you calculate all the important parameters and find the total cost of ownership between these two products?! And if they say well" we just took the consumption of electricity" … that's a valid point but I can ask 1000 more questions. For which they cannot answer so we stick with the simple solution. That doesn't mean that we shouldn't look at it. But I just wanted to explain my concerns to you. That's the complexity of it. We don't see the ISS people as enemies but there are many parameters to take into consideration.

- Do you follow any national EU standards, regulations, internal procedures when purchasing new products?

No. Not when it comes to purchasing products.

- How about standards regarding energy requirements?

No. You will not find anything regarding energy consumption requirements. The ones you find in the Document House are very general and we don't follow it anymore. When we talk about Capex it is about electrical handroll machine into buildings like ventilation systems. It is very difficult to make a specific rule, precise rule. When we were at Siemens AG we had a network of procurement guys who made Capex and they created the study Capex behind purchasing. They had documents that covered everything. Like sustainability, consumption, etc… In Siemens Gamesa it is not mandatory to use. This is not a mandatory rule. This document was made in Germany and it included energy efficiency for components.

- Why was this document used in Siemens AG and not now in SGRE?

Because nobody took it up. No one felt they had the time to take up this task. If you do this, you must sit down and apply yourself to understand the details. This document was also directed to bigger machines which might no apply to our business. At Siemens AG they needed that heavy machinery but no here. It was way too detailed for us. This document called CETEMA is only an example of how it could be done applicable for huge machines.

A lot of these things are mentioned in the PRS. Which describes what the engineers want.

- Who intervenes and how does the ordering structure work?

We have this supplier comparison sheet we take a lot of different parameters into consideration. Cost, down payment, liability, performance in past projects, etc... all these things we evaluate. There is a spreadsheet we use with all this information. We have several suppliers that we have a contract with.

- Do you buy from the same suppliers or do they vary?

It a big group but we tend to move in the same circles. If a new supplier comes in he would have to have a better price to convince us. New suppliers need a learning curve to deliver exactly what we need.

- How does the decision-making process start and finish?

The department of Claus Lindberg design the product and how it would look like and they create a product specification (PRS) once this is ready it comes to me. They tell me we will need this and this and the quantity and sometimes they have suggestions from suppliers who they like and have performed well in the past, otherwise I decide who to ask. Sometimes they highlight things they want us to focus on. And then we send it out.

The process engineers decide the components we need to buy. I don’t decide the types of components they want in the machinery. But I am pretty sure that in the requirements there is a section regarding environment. Not energy efficiency but something to do with the environment.

- When purchasing a product what do you consider most important value, cost, risks?

I am from procurement s for sure price is important. I need to make sure that the company doesn’t pay more than it should. But that is the final step. Before that there are a lot of steps of comparison such as performance, availability, financial risk etc. We in procurement would love to have time to negotiate. But almost always we are under time pressure. So, the most important thing is that we receive what we need at a certain time. If it doesn’t do that it will cost output and if we jeopardize output that mean a lot of money lost for SGRE. Also, if the most expensive machinery can be delivered on time. They will push me to buy that. Because maybe the difference is big in our head but compared to not being able to produce is huge.

- Would you find useful having an energy controller who mediates between engineers and procurement?

If the environmental aspect is included yes. It is very much needed to have somebody that can look at the numbers If consumables want to be taken in to consideration technician need to put them into their specifications. They need to inform us about the total consumables. And as I said consumables is not the only thing to take into consideration. There are a lot of variants.

- Does SGRE do business case analysis before purchasing new products?

Some business case of buying machines would disappear. The better the BA the quicker the answer is yes. But these considerations must come from people who send the specifications i.e. the engineers. But they don’t want to include it in their considerations why should they? Its time consuming. And they have a budget but not a budget on the consumables. It is all taken from a production point of view.

- Does HSE have influence in the decision-making process before the product is purchased?

They have never asked. But if they had interest the final decision wouldn't change I can promise you that. Because if we choose a machinery that consumed great amount of electricity but at the same time produces 50% more number of blades the revenues will be too big for SGRE to ignore. And they don't care about the electricity or the company's footprint. Who cares how much electricity is used if the production increases? Its s big grey mass with no rights and no wrongs. But at the end of the day is the production numbers that matter, and a secondary thing is optimization.

Then we can talk about electricity consumption. I think the biggest achievement our department has is taking a stand regarding the components use in the machinery. Were we say, well not anymore, but in the old contract it said that the supplier was obliged to use energy efficient components from Siemens. Now today it only says you have to use Siemens components. But in the old days energy efficacy was a specific point in the contract. If you buy a product that tis not Siemens because it is more energy efficient it will trigger the alarms and won't look good for the company. The Siemens components are really good and reliable but to some extent maybe they are energy inefficient compared to some other out in the market.

- What solutions would you propose to include the energy efficient perspective and HSE in the decision-making process?

I would say, the best solution is talk to the design department and say would it be possible to incorporate in your specifications that the consumables are efficient. And they have to inform about that. That could be an option. In the quotation from the supplier if they mention the energy consumption then we have space in our comparison to put it in as a parameter. But sometimes the suppliers don't even know.

Appendix F

Interview with Halil Halilov (Energy Engineer at Aalborg Portland)

Date: 29/02/2019

Duration: 50 minutes

- How does Portland integrate environmental impacts into their operations?

The product prioritization should always be the environment. Here in Portland the prioritization of production usually first comes first health and safety together with environment, because our environmental requirements usually link to the emissions we release and if all those prioritizations get their own checkmarks then we ca produce something. When we start producing the product we check the quality f the product and quantity it can produce. The energy consumption process comes after this. But first we need to make sure its environmentally responsible and safe for the people living around the plant. They are considered on the same level of importance. It's not as black and white but H&S is always first then environment.

- How and why do you recycle your excess energy?

We redirected to heat the slurry water content of up to 35%. In this tube gravity carry's the slurry and at the end there is a burner at 300 degrees. It "cooked" the slurry into the artificial minerals called cement quenchers. A bi product of this process we create a lot of flue gases which contain a lot of water and has internal energy. The excess gases which are a bi product are used in the other chimneys. We sell the excess energy to the city in the form of district heating. The percentage that we give for Aalborg energy consumption is very significant number. In the future is planned to be even more significant.

- Are you part of the HSE team?

I am partially working with the HSE team for the energy part if things. I am a lot more involved in the technical production and process department. The energy numbers that she is managing I interpret for the technical solutions that are implemented here. Partially it is in my interest to screen the overall uses and build business cases around how we use and can improve the energy usage. The municipality expects us to have certain requirements so we need to be strict about our environmental numbers. This is how we get out permit to operate, by meeting the requirements and regulations that cover our impacts.

- Would you be involved with the equipment that is purchased for process?

Every time we purchase equipment I am involved from the beginning. The team who is responsible to assess the best way to spend the money already know but I predict the aftermath of that investment and calculate the energy savings. I look at the operational costs of the equipment.

- What is the most important characteristic a supplier should have?

They have to provide the product that best performs. It is easier to require those demands from products that are used in all industries but us in the cement industry there are very specific pieces of machinery we can purchase. It's not like the bulbs for instance int h offices. Nevertheless, the energy specifications are always looked at.

- Did it ever happen that energy or environmental aspects have been overlooked?

Not to my knowledge. Those decisions have to be approved by me. I am responsible for the energy presentation of the equipment the environmental side from an environmental engineer or HSE team.

- How would you suggest that energy efficient requirement is integrated in a company like SGRE's production plant?

Firstly, one of the biggest reasons why I am here is because I am one of the people responsible for keeping the environmental and energy certificates. Having those certificates have a meaning for Aalborg Portland for the image and he economical part. If we don't have those certificates we cannot operate. Secondly my role is to ensure that we are saving energy. Saving energy has an economic impact which is positive with the client in many ways. E.g. when I see something that can be changed and I see a BC that can be built around it for instance more robust, less downtime, overall better performance. BC the economical art is one of the best arguments.

- Would you consider there is a good level of communication between departments?

Here it was already very well-functioning so I didn't have to put an effort on getting the teams together and making sure the environmental aspects are met. That was part of the company.

- How do you suggest manufacturing companies become stronger if they have poor communication between departments?

The easiest answer is communication and good management. Managers for each department has their ow agenda. Technical is production and HSE is environment and safety. But everyone knows the sacrifices needed to make the image of the company better. They argue a lot but then something changes or because something needs to change. They have their strengths in their own department and they know which their jobs is.

- What ISO standards have you been approved on?

– 90001 quality
– 140001 environmental
– 150001 for energy management
– 450001 Work place health and safety

They have all been approved and each year we have an internal and external for which a third party comes and checks. Buero Veritas.

- What about the wind turbines you want to install that still need to be approved?

I am not very knowledgeable in the political side but for what I know the wind mills are coming and when they come they will produce one part of electricity for Portland. The energy it will provide will be quite small. They are a very costly investment so it's a show of commitment to renewable energies.

- How do you prioritize projects value, risk, cost?

I currently have 20-25 energy saving projects for which some of them require large investments of money and other are small changes and require small investment costs but could save great amounts of energy. All the projects matter and add up to the overall energy savings. I don't prioritize any of the above but consider them holistically ad equal. The risk is something I don't explore a lot but it is interesting that you mention it. There is a risk all over no matter what you do. I'll look into it further.

- How can SGRE improve the decision-making process towards energy efficiency?

The economic value is the best answer. If you give me this amount in X amount of years it will double. SGRE is about RE and sustainability so it's in their best concern to have the best possible energy image. Other than that here in Portland energy presentation has always been important that I never have to incline people and these problems flow and you always have people supporting you.

Appendix G

<u>Interview with Per Justesen (Maintenance department)</u>

<u>Date: 03/03/2019</u>

<u>Duration: 40 minutes</u>

- How did the decision process of the boiler, using heating oil for Hall 1 and 6 occur?

The case was that we needed to put more heat in the curing of the blades to decrease the lead time of the blades. The industrial engineer department wanted to put more heat in there, so it was a quick fix. All fired boilers seemed like a good option no matter the energy and then the project started.

- For how long is this solution going to be operating?

I have no idea. Right now, we are doing another system where we use the natural gas fired boilers. What I think is the most interesting is the decision-making process went along here. Industrial engineering wanted some extra heat, so they just went ahead with it. We tried to make a suggestion or an alternative to this project, but it was their decision.

- At what stage of the decision-making process did the department of HSE intervene?

They didn't. For this project they didn't intervene at all. There is no environmental criteria to be followed and if that pushes for non-efficient equipment that allow immediate solutions or "quick fix". If industrial engineers want some heat then they don't have to ask anyone, they just did it.

Do your responsibilities include recommendation of upgrades, equipment selection, perform feasibility studies, etc… therefore, advice on the proper selection of equipment and machinery for Aalborg's production plant?

Not right now. I am not sure who to go to either. Me and the department have been talking about it, how to make it more energy efficient but we don't have anybody to turn to. Torben Justesen is our boss but I don't think he has anything to say in it. We talk to Jannie Kristensen in a weekly basis but if we have a suggestion it just stays there. We need somebody who can do all the calculations and verify that investments in energy efficient solutions will save money. Perhaps some sort of business case to show real numbers and prove possibilities. We cannot do this because it would add to the job we already have.

- Do you think more energy efficient requirements are needed or perhaps a responsible energy controller be useful?

Somebody that can interpret Jannie's number would be the perfect link. It's a very good idea. If there is somebody I can turn to, that has the technical skills and acts as a project manager perhaps, not necessarily sit down for long meetings but discuss ideas and different possibilities. I also have a history in making greener calculations and if we want to do this in the right way we need to make a map of our energy consumption in the factory. To target weaker areas and identify the big loads.

- Do you follow guidelines or requirements when recommending/installing new equipment?

Are there procedures/guidelines that dictate minimum environmental requirements of a purchase/project? (Excel sheets have very little data input for environmental performance of a product (Document House PRO-40421 CAPEX Approval Matrix).

We don't have anything. If we want new equipment for bigger blades like larger equipment, it's the tooling department that is in charge and deciding the equipment. But they also don't follow any specifications or guidelines. I have been asking that for a year. But again, we don't know who to turn too. We talk a lot with the tooling department and we both need to be clear on the national and EU guidelines.

Right now, communication between departments is very cluttered. Its like nobody is in charge. But I guess it has to come from the top like Ken Kaser to make it happen.

- Who needs to sign to purchase of equipment/machinery for process in your department and how many other representatives from different departments?

We have a TOC certificate (take over certificate, tooling has closed the assignment and the customers have the responsibility) and in our department and right now its ISS, maintenance (us) and industrial engineers but funnily enough there is no production involved. When signing these certificates, a time ago industrial engineers were not included sometimes, and I asked for them to revise it. So, its not very clear the stakeholders that are participating.

- Who is the HSE representative who you talk too to sign these certificates?

It's the HSE officer called Charlotte, she signs some of them. When we are designing new equipment, she must also sign some certificates for the safety part but nothing regarding the energy consumption of the machinery or equipment i.e. machine pollution. I think this would be a very good point to add to the TOC certificate = energy savings. The procedure is mapped in the document house and it's a global procedure.

Required fields	Lifting equipment	Machinery	Transport Equipment	Platform and Ladder	Help Equipment and tools
Developer					
Documentation according to Product Requirement Specification (PRS)	x	x	x	x	x
Tests according to PRS	x	x	x	x	x
Labelling according to PRS	x	x	x	x	x
Visual inspection (components, welding, surface treatment)	x	x	x	x	x
User manual handed over to end user	x	x	1	1	1
Documentation stored accordingly to development process	x	x	x	x	x
Maintenance					
Maintenance documentation according to PRS	x	x	x	x	2
EHS					
Risk assessment	x	x	x	x	1
Production					
Form, Fit and Function according to PRS	x	x	x	x	x
First language user manual in hardcopy	x	x	1	1	1
Received Training	3	3	3		

Table 1 – Required fields

1) Only required if user manual is provided with the equipment
2) Only required if SAP ID and/or Maintenance plan is provided with equipment.
3) Only required if special training is specified

- Do you think it's possible to integrate environmental perspective into the current decision-making process behind equipment and machinery? If yes, how?

Yes definitely. We can see a lot of low hanging fruits and a lot of opportunities to save energy much better than what we are doing now. It's difficult to say where exactly they have to intervene because if you need energy savings in this then you also need a technical person who can understand the numbers. A good stage is for them to revise the PRS of the products because then they can go back to the tooling department and ask what about the energy savings? They don't have much intervention.

There needs to be an energy efficient controller that can understand how the equipment works and has the technical expertise. We need the business case to support energy efficient projects.

From my understanding SGRE want to become CO2 neutral by 2025 so we need to do something and implement solutions here first, at production how we operate. We are way behind and don't see it realistic, but we can give it a try.

- What are your interests regarding new projects and what do you prioritize (or your department)? Is it value, cost, risk?

Its uptime, availability of the equipment. Make it work 100% of the time. The environmental side is at the bottom low priority. And again, we are trying but nobody is listening. If we find an energy efficient solution like a ventilator or motor its more expensive, I ask the controller can we buy this? But they always pick the cheap one.

Hall 1 and 6 is a very good example of how the company thinks. The only solution for this not to happen is to increase humidity. But what people didn't take into account is that if you increase humidity in winter you need a lot of heat to evaporate all this water that we are putting in and its very expensive. To make up for that two big boilers at either side help with the heating of the building. And you can't use DH because you don't have the infrastructure to operate it.

- What can Hall 12 (future new process building) learn from past mistakes and integrate an environmental perspective from the start?

Communication has to be more fluent and we need to know who to target without a doubt. Therefore, some sort of stakeholder mapping would be ideal to know each function and their influence on the project. Also if we want to become more sustainable we need to take the building (Hall 12) as a whole and not look at specific equipment. Take all into account and perhaps include solar power. The roof can have 100m2 and why not implement a renewable energy source to power a percentage of our energy?