WIND ORIGINAL EQUIPMENT MANUFACTURERS' SUSTAINABILITY STRATEGY DEVELOPMENT: HAS SUSTAINABILITY BEEN ACHIEVED?

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ABSTRACT

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Abstract

Wind energy is widely regarded as the most promising renewable energy source for moving away from energy derived from fossil fuels and progressing the sustainable energy transition. However, aspects exist for wind power that are not environmentally friendly. Wind turbines are designed and produced by original equipment manufacturers who have immense influence over wind energy's negative environmental impacts like end-of-life management and rare earth element use. Wind energy is regarded as sustainable, but is it really? This thesis aims to gain insight on wind turbine manufacturers' perspective on their sustainability performance and the factors influencing sustainability decision making. Qualitative research was conducted by analyzing documentation addressing sustainability published by wind original equipment manufacturers, like sustainability reports. The results of this thesis show that wind power original equipment manufacturers consider their sustainability performance as a main focus and consider themselves leaders and innovators. Factors that influence their decisions around sustainability are related to research and development, innovation, top management decision making, cost, profitability, risk management, and stakeholder priorities. This thesis has implications in practice for policy makers and wind original equipment manufacturers' customers to fully understand the commitment when promoting wind energy and setting decarbonization goals that are relying on wind power, because negative impacts exist when analyzing wind power beyond the operational life cycle phase. Wind energy is a valuable renewable energy option because it helps society move away from energy derived from fossil fuels. However, the downsides to the environment need to be considered and planned for in the long term, which wind original equipment manufacturers play a key role.

Keywords
wind energy, wind original equipment manufacturer, sustainability strategy, sustainable business model, renewable energy, energy transition

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Tiivistelmä Tuulivoimaenergiaa pidetään yhtenä lupaavimmasta uusiutuvan energian lähteistä fossiilisista polttoaineista luovuttaessa ja siirryttäessä kohti kestävämpiä energialähteitä. Tuulivoimalla on kuitenkin näkökohtia, jotka eivät ole ympäristöystävällisiä. Tuulivoimalat ovat alkuperäisten laitevalmistajien suunnittelemia ja valmistamia, näillä laitevalmistajilla on valtava vaikutus tuulienergian negatiivisiin ympäristövaikutuksiin voimalan koko elinkaaressa. Negatiiviset näkökohdat liittyvät käyttöiän päättymisen hallintaan ja harvinaisten maametallien käyttöön. Tuulienergiaa pidetään kestävänä, mutta onko se todella kestävää? Tämän opinnäytetyön tavoitteena on tutkia päätöksiä tuuliturbiinien valmistajien näkökulmasta kestävän kehityksen suorituskyvystä ja kestävän kehityksen päätöksentekoon vaikuttavista tekijöistä. Laadullinen tutkimus tehtiin analysoimalla tuulivoimaloiden alkuperäisvalmistajien julkaisemaa kestävän kehityksen käsittelevää dokumentointia, kuten raportteja. Tämän opinnäytetyön tulokset osoittavat, että tuulivoiman alkuperäiset laitevalmistajat pitävät kestävän kehityksen suoritettaan painopisteenä ja pitävät itseään johtajina ja innovoijina. Alkuperäisvalmistajien kestävään kehitykseen päätöksiin vaikuttavat rajapinnoissa tekijät kuten tutkimus ja kehitys, innovaatiot, ylimmän johdon päätöksenteko, kustannukset, kannattavuus, ja riskienhallinta sekä sidosryhmien prioriteetit. Opinnäytetyön tarkoitus on tukea ympäristöpolitiikan päätöksentekoa sekä antaa tuulivoimaloiden valmistajien asiakkaille tietoa tuulivoimala bisneksestä siirryttäessä kohti hiilineutraleita vaihtoehtoja, sillä tuulivoimalat sisältävät yllättäviä negatiivisia kestävään kehitykseen liittyviä haasteita tarkaltessa koko tuulivoimalan elinkaarta. Tuulienergia on kuitenkin arvokas uusiutuva energianlähde, sillä tuulivoimalaenergia voi auttaa yhteiskuntia siirtymään pois fossiilisista energialähteistä. Uusiutuvan tuulienergian haittoja luonnolle on kuitenkin arvioitava ja ennaltaehkäistävä pidemmällä aikavälillä. Tuulivoimalavalmistajilla on luonnollisesti suuri vaikutus arviointeihin sekä suunnitelmallisuuteen kohti kestävää kehitystä sekä ympäristöystävällisyyttä.	
Asiasanat tuulivoima, tuulivoimaloiden valmistajat, kestävä kehitys strategia, kestävä kehitys yritysmalli, uusiutuva energia, energian siirto	
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1 INTRODUCTION

1.1 Background

The transition away from energy derived from fossil fuel has received significant attention due to concerns about climate change. This attention to energy is justified, as mitigating climate change is the most pressing challenge of our time, as it is linked with several other sustainability problems and has damaging cascading effects (Bocken et al., 2019). Mitigating climate change requires cumulative carbon dioxide emissions be limited and if society wants to stabilize anthropogenic global warming, net zero carbon dioxide emissions from human activity must be achieved (IPCC, 2021). Commitments have increasingly been made by governments, businesses, and organizations to sustainability to help mitigate climate change, as solving this challenge requires actions from multiple actors. One potential solution that has emerged as a valuable tool in transitioning away from fossil fuels is wind energy. Perhaps wind energy is the most important tool, as wind energy has been recognized as the most promising renewable energy source (Bórawski et al., 2020). The benefit of wind energy is that during the operation phase of a wind turbine, emissions are not generated when the turbines convert the wind's kinetic energy to electrical energy (Alsaleh & Sattler, 2019).

While the exact date for when the first windmills were invented is unknown, utilizing the power of wind has been implemented for thousands of years (Golding, 1955). The technology has evolved significantly since its inception, from vertical shaft windmills to horizontal shaft wind turbines, but the core basis of this technology has remained the same; harnessing wind, an unlimited resource, to create power to grind grain, move water for irrigation, and now electricity. Feasibility for wind turbines to be used on a larger scale for electricity production only occurred recently in the 1980s and because of technological advances, wind is now one of the most cost-effective renewable technologies available (Taylor, 2003; Welch & Venkateswaran, 2009).

The market for wind energy is only expected to increase (International Renewable Energy Agency [IRENA], 2019; Global Wind Energy Council [GWEC], 2021b). In 2021, the global cumulative installed wind power capacity reached 743 gigawatts (GWEC, 2021b), whereas only in 2007 was the total capacity worldwide less than 100 gigawatts (Statista, 2020). China has the most installed wind capacity, followed by Europe and then the United States (GWEC, 2021b). Projections expect that China and India will be the leading countries for new onshore wind turbines until 2050 (IRENA, 2019). To provide perspective, as of 2022, the United States had 135 gigawatts of wind power capacity which could supply the equivalent of 42 million homes (American Clean Power, 2022). As of 2016, the wind turbine market was valuated at approximately $81 billion and is expected to reach $134 billion by 2023 (Doshi, 2017). Furthermore, the International Renewable Energy Agency (IRENA) expects that energy produced by onshore and offshore wind turbines will be the dominant energy source globally in 2050, accounting for over a third of global electricity demand (IRENA, 2019).

Most turbines installed today are on land (onshore), but the opportunity for offshore developments has received growing attention, as offshore capacity is expected to double from 2018 to 2023 (GWEC, 2019). Offshore wind turbines are gaining momentum as estimations predict that offshore wind farms in the European Union can get 50% more power than onshore (Bórawski et al., 2020). The benefit of pollution-free energy is inherently obvious when looking at wind turbines through the lens of only the operational lifetime, which is a factor that has led to wind energy's prominence in the sustainable energy transition away from fossil fuels. However, sustainability does not encompass only the operational phase, and a broader view of the product's life cycle must be considered.

Commitments by governments to decarbonization and moving away from fossil fuels by implementing wind energy can be seen, for example, in the United States and the European Union. In the United States, President Joe Biden signed the *Tackling the Climate Crisis at Home and Abroad* Executive Order in 2021 stating that the United States must have net-zero emissions by 2050 and a plan must be developed to double the amount of energy produced by offshore wind by 2030 (Exec. Order No. 14008, 2021). Furthermore, the State of New Jersey has set a goal to have 7,500 megawatts of offshore wind energy by 2035 and 1,100 megawatts of wind turbine capacity is being planned off the coast of southern New Jersey (Ocean Wind, n.d.).

In the European Union, Directive 2018/2001/EC (2018) has established a target that at least 32% of energy is from renewable sources by 2030. In 2016, the European Commission had estimated that 25% of electricity would be produced by wind in 2050. Interestingly however, in 2021, this goal has doubled to 50% by 2050 which is 1,300 gigawatts of capacity (Wind Europe, 2021). Additionally, Member States of the European Union, like Finland, have even more ambitious goals, as Finland set a goal to be carbon neutral by 2035. The Finnish Innovation Fund, Sitra (2021), reported that to reach this goal, onshore wind energy needs to be developed as it is the most cost-efficient solution and emphasized that, "not developing the full economic potential of onshore wind or demand side flexibility has large and costly consequences for the Finnish power system" (p. 22). Moving to increased share of wind energy is also expected to reduce the levelized cost of energy in Finland by almost 30% compared to 2021 (Sitra, 2021). This emphasis on wind energy, especially now that wind energy is being relied on for the energy transition, demonstrates the importance of not overlooking the challenges with this technology.

Wind turbines have apparent benefits related to emissions during the operation phase and are cost effective. However, the entire life cycle of the wind turbine has social and environmental impacts that cannot be ignored, especially if a product or service is being deemed as sustainable. These impacts are apparent in the supply chain with the use of critical rare earth elements, end-of-life material management like blade disposal, visual concerns, public acceptance, among other issues. For example, the turbine blades are very difficult to recycle leading to landfill disposal as the most common disposal practice (Rentizelas et al., 2021), which has resulted in blade waste being a substantial and pressing waste stream to handle presently and in the future (Hao et al., 2020). In the wind energy sector, original equipment manufacturers (OEMs) are responsible for the design of the wind turbines and usually manufacturer important components, hence, are important in mitigating these environmental impacts. With one problem solved with moving away from fossil fuels, is society creating new problems that will affect future generations' access to a decent quality of life and should this technology really be revered at the forefront of the energy transition.

The energy transition is and will be a long and complex process. Complex transitions, like the energy transition, are difficult to manage as problems are embedded in how people live (Rotmans and Loorbach, 2009). The potential problem with relying on wind energy so heavily for the energy transition is that as these transitions occur over such long periods of time, there should be diversity and variation with the technologies being adopted (Rotmans and Loorbach, 2009). This provides room to learn about the technology before locking into one option for a long-time commitment. Broman and Robèrt (2017) stated that societal leaders often do not understand the basic causes for ecological and societal problems, thus opportunities are missed for new solutions. Furthermore, even if problems are recognized, they may be viewed as normal that can be dealt with later as a benefit that outweighs the cost which results in an unsustainable basic design (Broman and Robèrt, 2017). This thesis is concerned that wind is being too heavily relied upon by society, and all the impacts are not being fully considered.

A review of academic literature found a research gap related to this thesis topic. The academic literature showed that life cycle assessments of wind turbines have been studied more than the sustainability strategy development of wind original equipment manufacturers. Interestingly, a literature review by Zwarteveen et al. (2020) related to the global adaptation of wind energy and the barriers faced, showed that the point of views of OEMs were not represented in the sample. Furthermore, Lapko et al.'s (2019) study on closed loop supply chains in the green energy sector found that finding recycling solutions now of the turbine blades is not a priority as the interviewed company is expecting recycling technology to be advanced when the turbines are to be decommissioned in the future. Because research is not robust in this area, and wind energy is being promoted so heavily in the energy transition, it is imperative to investigate OEMs' position in solving these challenges.

1.2 Aim of the thesis

This study is rooted in the field of Corporate Environmental Management (CEM), where the fundamental challenge is how organizations can implement sustainability into their operations, especially the environmental aspect of sustainability. Wind turbine manufacturers play a vital role in mitigating the life cycle challenges of the turbines. This thesis aims to gain insight on wind OEMs' perception of their sustainability performance and the factors influencing their sustainability decisions. One can assert that this technology's positive outputs outweigh the negative environmental impacts, but this thesis is focused on understanding wind OEMs' position on this challenge. For instance, because the output (renewable energy) is considered inheritably sustainable, how does this affect all other sustainability considerations and sustainability strategy?

This thesis topic critically analyzes a sector for areas of improvement when the core business is already helping progress the sustainable energy transition. However, this makes the sustainability strategy even more interesting because these companies have a solid commitment to sustainability with their product. As this thesis aims to better understand the sustainability priorities of wind turbine manufacturers, one can make a more informed judgement if society should be making commitments to wind energy. The insight gained from this thesis should help one understand the wind OEMs' position and role in finding solutions to the environmental impacts that exist with wind power. The research questions this thesis aims to explore are the following:

1) How do wind OEMs describe their sustainability performance?
2) What factors influence wind OEMs' sustainability decisions?

1.3 Structure of the thesis

This Master's Thesis structure contains 5 sections. This section (Section 1) provided background on the wind energy sector and the aims and relevance of this thesis. Section 2 provides the theoretical framework of relevant concepts, insight into wind turbine environmental impacts and integrates the academic literature related to OEM sustainability strategy. Section 3 explains the research methodology to answer the research questions including the research design and methods. Section 4 provides results and analysis. Section 5 finishes by providing the discussion and conclusions with the insights gained, research significance, limitations, and offers potential ideas for future research.

2 THEORETICAL FRAMEWORK

This section will provide the theoretical framework of this study by first delivering an overview of the terms commonly used in the field of Corporate Environmental Management like sustainability and corporate social responsibility. An understanding of these terms as discussed in the scientific literature is important and relevant as this is a foundation the following section discusses business strategy and sustainability strategy development relevant to the aims of this thesis. After understanding the important terms, the role of sustainability reports in relation to the sustainability strategy is discussed. The second half of this section discusses the environmental impact challenges that exist with wind turbines.

2.1 Corporate sustainability implementation

Section 2.1 will discuss relevant terms, sustainability implementation in practice, and the role of sustainability reporting. The roles of traditional business areas like business strategy and business model will be discussed with their interaction with sustainable business areas like sustainability strategy and sustainable business model. Sustainability reporting will be discussed to provide background as to what can be expected from these reports and their relevance to the research aims of this thesis.

2.1.1 Relevant terms

This section discusses the terms sustainability, sustainable development, and corporate social responsibility (CSR). The CEM field has many terms which are closely related and often used interchangeably with many interpretations of the definitions. Even though the terms are often used interchangeably, the following text attempts to provide a foundational understanding and origin of the relevant terms in this study. This section further discusses how these terms are used in practice and the associated challenges.

The origin of the terms sustainability and sustainable development goes back to 1987 when the "Our Common Future" report was issued by the United Nation's Brundtland Commission. This report defined sustainable development as, "meet[ing] the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987, p.41). This definition was further developed as sustainability attempts to satisfy social, environmental, and economic conditions, also known as the Triple Bottom Line (Elkington, 2011). Foundational aspects of sustainability are that the actions are voluntary, transparent, and go beyond what is required by law or regulations.

Business has moved from a shareholder approach to stakeholder approach which expanded the demands and expectations on a business from only one interest group, usually stockholders, to many more. As more stakeholder interests have become involved, stakeholders have communicated that business must do more than make profit and follow the law (Carroll, 2015). In practice, sustainability is commonly incorporated into organizations through what is termed corporate social responsibility (CSR). Corporate social responsibly started to emerge in the 1950s (Carroll, 2015) and further gained prominence in organization's strategic management in the early 2000s (Grant, 2013). The early definitions of CSR related more to firms' obligation to look beyond only stockholders' desires (Carroll, 1999), but this term has evolved to encompasses the environmental and social pillars of sustainability as well.

Corporate social responsibility can be seen as the middle area between firms strictly focusing on financial gains or social and environmental interests (Grant, 2013). Carroll (2015) simplifies that CSR includes economic, legal, ethical, and voluntary expectations, like philanthropic actions, that society expects of organizations. Of these factors, society requires that the economic and legal aspects be prerequisites for business to exist, ethical factors are expected, and philanthropic aspects are desired by business. Because of the shift towards the stakeholder approach, metrics beyond financial gain, like sustainability and CSR, have emerged as interests for nearly all businesses and is only expected to grow (Carroll, 2015).

An exact definition for CSR has not been unanimously agreed upon, as at least 37 different definitions of CSR have been identified (Dahlsrud, 2006). Nevertheless, what is common in CSR definitions is that environmental, social, and economic factors are considered through voluntary actions beyond what is required by law, while considering stakeholders beyond only shareholders (Dahlsrud, 2006). Some researchers do not view the lack of a universal definition of CSR as a disadvantage. For example, van Marrewijk (2003) reasons CSR should be specific to the organization and not be a one-size-fits all approach, and Broman and Robèrt (2017) further explain it would be unwise to commit to one definition when many sustainable future possibilities exist. This stance is also in agreement with contingency theory which claims a single best way to manage or organize a business entity does not exist as the optimal way depends on the company's circumstances (Grant, 2013).

A foundational agreed upon definition of sustainability does not exists, resulting in the absence of an operational definition of sustainability that can be used as a starting point for a sustainability strategy development (Broman & Robèrt, 2017; Franca et al., 2016). Thus, difficulties exist in assessing the sustainability performance of an organization as pinpointing when sustainability has been achieved is subjective. Sustainability actions are voluntary and go beyond what is required by law, and thus there is debate regarding how far they need to be pursued (Carroll, 2015). Glavič, & Lukman (2007) proposed that more rapid advancement in sustainable development can be achieved if these unambiguous definitions and imprecise usage of terms are not used. This results in difficulties in developing a business strategy that integrates sustainability goals. Because the terms sustainability and CSR are so closely related and often used interchangeably, they will also be used interchangeably in this study. In the next section, sustainable business models and sustainable strategy development will be discussed further.

2.1.2 Sustainability in practice

This section will discuss how sustainability is implemented in practice using sustainable business models and sustainability strategies. Business models and strategy go hand in hand as the business model reflects the organization's realized strategy (Casadesus-Masanell & Ricart, 2010). The business strategy is the connection between the company and their environment and is how the company will achieve its goals, like sustainability goals (Grant, 2013). Due to society's heightened focus on climate change, sustainability, and increased demands from stakeholders, organizations have begun to develop sustainability strategies and adopt business models for sustainability, to incorporate the triple bottom line approach in their business operations (Schaltegger et al., 2016). As this thesis is interested in sustainability strategies, this section will provide more insight into this area.

Sustainable business models and sustainability strategies within organizations are crucial to mitigating climate change as business plays a key role in alleviating environmental impacts. Solving the challenges faced by society today will most likely not occur unless organizations implement sustainable development (Schaltegger et al., 2016). A long-term approach is needed for sustainability goals, which is why strategy is so important, as strategy is focused on what the organization will become in the future (Grant, 2013). One scenario in which the interaction between business strategy, business model, sustainability strategy, and sustainable business model could occur is shown in Figure 1, which will be discussed further below.

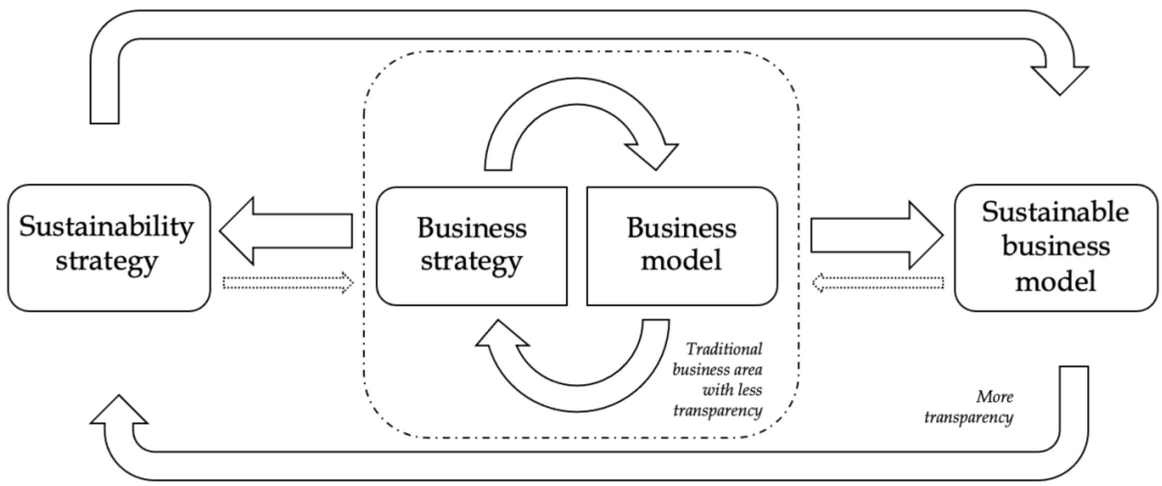

FIGURE 1 Relationships of strategy decision making
Note to figure: Arrows represent flow of information during decision making

To implement CSR and sustainability into organizations in practice, this can be done by developing and implementing a sustainable business model, which is an innovation of the standard business model and sometimes referred to as a business model for sustainability. A business model is how the company will approach business in terms of what products are offered, pricing, and production, in addition to how the firm is distinct from their competitors (Rasmussen, 2007). A sustainable business model is a business model that contributes to sustainable development for not only the company but also society, which then creates a competitive advantage through enhanced customer value (Lüdeke-Freund & Dembek, 2017).

Research on sustainable business model innovation is rather new and is considered an emerging field of study (Geissdoerfer et al., 2018; Lüdeke-Freund & Dembek, 2017), which is a reason why sustainable business model is separated from traditional business model in Figure 1. Lüdeke-Freund and Dembek (2017) have observed through a literature review of sustainable business model research that it can be argued that the traditional business model area and sustainable business model area are separate distinct areas of focus with two-way interaction, like Figure 1. However, Lüdeke-Freund and Dembek (2017) have also found evidence of more integration with the sustainability aspects being a sub-area within the traditional business model. Stubbs and Cocklin (2008) have observed sustainability often being treated as a supplement to an organization's business model and practices.

The business model an organization chooses to implement is decided through the strategy (Casadesus-Masanell & Ricart, 2010). While a single definition of strategy is not uniformly agreed upon, in a broad sense, the strategy is how the company will achieve its goals (Grant, 2013). It is not a detailed plan, but a theme that guides the actions and choices of an organization (Grant, 2013). The success of a strategy can be attributed to effective implementation of long-term goals that are clear, understanding the competitive environment, and using resources adequately (Grant, 2013).

As more pressure has been put on organizations to address social and environmental concerns, strategy has evolved to address these concerns through a sustainability strategy. The sustainability strategy communicates how sustainability issues are handled in practice within an organization (Baumgartner & Rauter, 2017). Exact details about a company's business strategy beyond aspects like the vision statement, strategy statement, and values, may not be publicly available for large companies (Grant, 2013), however, information about the company's sustainability strategy should be more publicly available due to transparency being an important aspect in sustainability work. This is why sustainability strategy and sustainable business model are located outside the dashed line in Figure 1, which represents this transparency aspect.

Company management holds a key role in the success and prosperity of business and meeting its goals. An organization's strategy can be found through written and oral communications of management and through decisions made through which the strategy is implemented (Grant, 2013). The ability for organizations to succeed can be attributed to managers having a sufficient understanding of how business models work (Casadesus-Masanell & Ricart, 2010). Similarly, several researchers have found that the organization's management is the main force for if sustainability is successfully implemented (Rasmus & Steger, 2000; Rauter et al., 2015; Schneider et al., 1996; Stubbs and Cocklin, 2008; Walls & Hoffman, 2013). Rauter et al. (2015) also stressed the importance of managers to take a long-term approach to the decisions regarding sustainability with a clear course of action. Therefore, if an organization like wind OEMs want to implement sustainability in their practices through its business model, management support and leadership is vital.

Various researchers have attempted to classify the methods in which organizations implement their sustainability strategy, as shown in Table 1. Nawaz & Koç (2019) found in a review of sustainability reports of 20 of the most sustainable companies from the Global 100 list, that nine main themes exist for sustainable strategies including, for example: resource optimization, research and innovation, employee relations, and health and safety. Stewart et al. (2016) categorized the sustainability tactics into the following four categories: production, product, supply chain, and value proposition. The Framework for Sustainable Development (FSSD), developed by a Swedish non-governmental organization, aimed to close this gap on how to systematically implement sustainability to move towards a sustainable society (Broman and Robèrt, 2017). While the other sustainability strategies identified in Table 1 have tried to classify different approaches to sustainability implementation, the FSSD attempts to provide the framework and strategy for how to begin to implement sustainability in practice which is why it is included in Table 1. The FSSD has been implemented in practice at organizations like the Volvo Group, IKEA, Polarbröd, Aura Light, and Scandic Hotels (Broman and Robèrt, 2017).

Sustainable business models exist, as shown in Table 1, however, some researchers assert a business model does not exist which integrates sustainability comprehensively (Franca et al., 2016; Ritala et al., 2018) and no universal solutions or recommendations exist to achieve the sustainability balance (van Marrewijk & Werre, 2003). Figure 1 demonstrates this lack of integration as the traditional business areas are separate distinct entities from the sustainability areas. Additionally, many researchers have found that little attention and guidance has been given to the actual implementation of corporate sustainability (Baumgartner & Rauter, 2017; Bocken et al., 2014; Engert & Baumgartner, 2015). Figure 1 demonstrates through the smaller dashed arrows flowing inwards towards the traditional business areas that information may be flowing between the sustainable business areas to direct the traditional busines areas, but it may also be more of the case that the traditional business areas are dominating and directing the sustainability areas.

TABLE 1 Examples of sustainable business models (1-4) and sustainable strategy development (5)

1	Boken et al., 2014	**The sustainable business model archetypes** • Maximize material and energy efficiency • Create value from waste • Substitute with renewable and natural processes • Deliver functionality rather than ownership • Adopt a stewardship role • Encourage sufficiency • Repurpose for society and environment • Develop scale up solutions
2	Nawaz & Koç, 2019	**Organizational sustainability themes** • Resource optimization and minimization of waste and emissions • Business and operational excellence • Corporate citizenship and social development • Research and innovation • Procurement, supply chain, and logistics • Governance • Sustainability management tools • Employee relations • Health, wellness, safety, and security
3	Orsato, 2006	**Generic competitive environmental strategies** • Eco-efficiency • Beyond compliance leadership • Eco-branding • Environmental cost leadership
4	Stewart et al., 2016	**Four types of sustainability approaches** • Production-oriented • Product-oriented • Supply chain-oriented • Value proposition- oriented
5	Broman & Robèrt, 2017	**Operational procedure of the Framework for Strategic Sustainable Development** • Learn about the sustainability challenges, areas of opportunity, and preliminary goal setting • Assess current situation and define how the organization promotes and violates sustainability principles • Generate potential solutions to the challenges identified in steps A and B • Prioritize solutions found in step C and form a plan of action

Managers feel implementing sustainability concepts related to the environmental pillar is difficult in practice, as it is not clear what actions should be taken first and for what reason (Orsato, 2006). The fundamental question of what is considered sustainable, what boundaries are considered, and how far an organization needs to go to be considered sustainable is ambiguous and is an organizational decision. Rauter et al. (2015) have concluded that there is a necessity to discuss at an elementary level what a business model for sustainability means, as no definite goal exists to be reached in terms of sustainability. Loorbach and Wijsman (2013) understand that becoming a sustainable business is usually associated with the company transitioning to new ways of thinking rather than only optimizing existing ways of operating. This is also a core challenge in the field of CEM as to how organizations can mitigate environmental impacts to satisfy the environmental pillar of sustainability. Ultimately, a clear road map for companies to follow to implement sustainability does not exist, even in businesses involved in renewable energy, which makes implementation in practice difficult.

Even if an organization would like to understand all their impacts, it is difficult and challenging to identify all environmental and social impacts (Baumgartner & Rauter, 2017). This especially applies to analyzing the supply chain of a product, which is no exception for OEMs, as hundreds of suppliers that manufacture components are involved that are generally small and medium sized businesses (Lundie et al., 2019; Surana et al., 2020). Lundie et al. (2019) found for a German based wind OEM that tier 0 carbon dioxide equivalent emissions, meaning emissions originating directly from the company, were only 1% or even less. As the wind OEMs do not have direct control over the supply chain, there needs to be collaboration and transparency with suppliers and OEMs must rely on these suppliers to reduce their own impacts and to make sustainability progress. The activities throughout the supply chain are often beyond the control of the business which creates a challenge in implementing sustainability as there could be a lack of trust and reluctance to share information between suppliers (Stewart et al., 2016).

Companies frequently only address sustainability aspects partly, and long-term implementation of the sustainability matter is not successful (Stewart et al., 2016). Van Marrewijk and Werre (2003) have identified six levels of motivation for why organizations implement CSR from hardly any motivation to incorporating sustainability in all aspects of the organization. According to Scheltegger et al., (2016), if the organization is only implementing sustainable values for the customers without adding value for the broader range of impacted stakeholders, then the value is not truly sustainable. Alonso-Martinez et al. (2021) found that firms highly committed to sustainability with sustainable business models already established, usually focus on one dimension of the triple bottom line more than another. Similarly, Ritala et al. (2018) found that for large corporations listed on the Standard and Poor (S&P) 500 index, it is more common for the corporation to implement a sustainable business model that is more environmentally focused, like maximizing energy and material efficiency, than the social or economic leaning models. The research summarized in Table 1 also supports that organizations tend to focus on specific areas of sustainability, rather than integrating sustainability holistically as a foundational core value that influences the entire company's operations. However, some researchers have reasoned that corporations do not have resources to solve all societal problems, thus it is more reasonable for organizations to focus on the problems it is best prepared to undertake that can help it gain the most competitive advantage (Porter and Kramer, 2006).

If a company adopts a sustainable business model and wants to make contributions to undertaking challenges of today, it is not enough to merely adopt sustainable practices as the performance of these initiatives need to be assessed (Alonso-Martinez et al., 2021) and a long-term view must be taken (Engert & Baumgartner, 2015). The success of the sustainability strategy has been found to be dependent on organizational structure, culture, leadership, management control, communication, and employee motivation and qualifications. (Engert & Baumgartner, 2015). The company culture has a direct influence on how employees comprehend and contribute to corporate sustainability measures (Cornelissen, 2017; Linnenluecke & Griffiths, 2010; Schneider et al., 1996). As discussed earlier, the company management plays a key role in if the sustainability strategy is successful, and part of achieving success is how the management contributes to and influences the company culture.

In some cases, firms are not driven to implement sustainable practices for altruistic reasons, but because incorporating CSR can positively affect the financial performance of the organization (Alshehhi et al., 2018; Carroll, 2015). Porter and Kramer (2006) believe the most important action a company can do for society is to contribute to a thriving economy. Firms can optimize the demands from government regulation and social issues to gain a competitive advantage from CSR (Porter and Kramer, 2006). Additionally, firms that adopt sustainability practices, like resource reduction measures, have been shown to have workplace productivity that is superior compared to firms who operate under the business-as-usual mindset (Delmas & Pekovic, 2013). Ultimately, benefits exist for companies to consider implementing CSR in their business operations and in developed countries, CSR considerations are expected from stakeholders.

To reiterate, the business strategy and business model are interlinked, as the object of the strategy is to select the business model the company will follow (Casadesus-Masanell & Ricart, 2010). Hence, the same logic can be used when going a step further when looking into sustainable business models and sustainability strategies. These concepts exist together and tell stakeholders the sustainability priorities of the organization and how they plan to achieve them. It is common for the companies that adopt a sustainable business model to communicate their sustainability commitments to their stakeholders through sustainability reports, which are discussed further in the next section.

2.1.3 Role of sustainability reporting

Communication to stakeholders about an organization's commitment to sustainability can be achieved through public reports called a sustainability report or CSR report, which will be referred to as a "sustainability report." Corporate social responsibility reporting started to emerge in the 1970s (Mathews, 1997) and publication of these reports has become increasingly more common. Sustainability reporting allows a firm to disclose its positive and negative economic, environmental, and/or social impacts, along with future strategic sustainability commitments (Global Sustainability Standards Board [GSSB], 2020). Firms can prepare sustainability reporting according to standards like the Global Reporting Initiative Sustainability Standards (GRI Standards) which sets the aim for the report's contents to be in common language for stakeholders to understand and increase comparability of reports. As stated earlier, the corporate strategy is not a strict plan, but a theme that guides business actions and decisions (Grant, 2013). Hence, it can be expected that the theme guiding sustainability decisions for wind turbine manufacturers can be found within these reports.

Sustainability reports are considered non-financial reports as the information does not focus on the financial aspects of the business operations, like the annual report that is required to be disclosed for publicly traded companies. Additionally, while it is known that implementing sustainability practices can have a positive impact on financial performance (Alshehhi et al., 2018; Carroll, 2015), it is still a challenge for how sustainable business models can capture the economic value of the environmental and social benefits (Bocken et al., 2014). Hence, sustainability reporting overall is generally not reporting on financial aspects.

In the European Union, Directive 2014/95/EU requires transparency of social and environmental information by identifying and communicating sustainability risks of large organizations with an average of over 500 employees. However, this Directive does not give specific requirements on the format and how detailed the information needs to be provided. For example, the Directive says organizations "may rely" on certain frameworks like the GRI Standards or Eco-Management and Audit Scheme (EMAS). A similar requirement does not exist in the United States. This lack of standardization makes comparisons and assessments of sustainability between organizations difficult. Stewart et al. (2016) noted that a limitation to their review of sustainability reports was a lack of consistency in theoretical frameworks in the study samples.

Sometimes these reports are unfortunately merely marketing or public relation schemes (Cornelissen, 2017) and are used to influence stakeholder's perceptions (Stubbs & Cocklin, 2008). Porter and Kramer (2006) believe that CSR ratings do not communicate the whole picture because the criteria are not consistent, which leads to an inability to judge if the criteria have been met. The reports can also contain greenwashing, or an over inflation of actions undertaken (Hahn & Lülfs, 2014). For example, promoting a business activity as highly sustainable when that activity is required by law is considered greenwashing.

Unfortunately, one needs to keep greenwashing in mind when reviewing sustainability reports and that publishing a sustainability report does not directly correspond to the company being sustainable (Stubbs & Cocklin, 2008).

Despite the challenges with sustainability reports, these reports are important sources of information in the field of CEM. These reports can provide insight into the organization's environmental and social impacts leading to how these challenges will be addressed, if at all, through the organization's sustainability strategy. Especially if the report is prepared according to GRI Standards, the reporting should include insights on how the company plans to contribute, or not contribute, to sustainability related topics and the long-term strategy (GSSB, 2020).

A foundational aspect of the GRI Standards is that the strategy is transparent, hence sustainability reporting is a valid source to gain insight about wind OEMs' sustainability strategy. Disclosure 102-14 is dedicated to strategy that is to be issued by the top decision makers in the company. Disclosure 102-47 requires a list of material topics that have been prioritized by the company and stakeholders, often called a materiality assessment. The materiality assessment identifies and prioritizes social, environmental, and financial issues based upon the importance of both stakeholders and the organization. Even if the report is not according to GRI, the possibility exists that the report includes how sustainability goals are incorporated into decision making and disclose the sustainability strategies**.** To be able to identify these challenges within the sustainability reports related to wind turbines, the following section will discuss environmental impacts associated with wind energy.

2.2 Wind turbine design, environmental impacts, and the OEMs' role

Section 2.2 will introduce the basics of wind turbine design followed by environmental impacts during the life cycle of the wind turbine including impacts encountered in the operation, supply chain, manufacturing, and end-of-life. This section was developed by utilizing information found in the scientific literature from a partial systematic literature review. Search terms were selected that are relevant to the research topic and questions including the four themes of terms: "wind energy," "original equipment manufacturers," "sustainability strategy," and "life cycle." The literature found that life cycle assessments of wind turbines have been studied more than the sustainability strategy development of OEMs. According to the International Organization for Standardization, a life cycle assessment (LCA) compiles and evaluates the inputs and outputs of a product system during its lifetime to define the environmental impacts (International Organization for Standardization, 2016). The limited academic literature found directly related to OEMs' sustainability strategy will be incorporated throughout this section. This baseline knowledge presents the importance and relevance of this study and to understand what areas can be improved upon. If no plan is in place to find solutions to these challenges presented below, new problems will be formed that impact society and the cycle of ongoing unsustainable practices will continue.

2.2.1 Wind power implementation, design, and operation

Wind turbines are designed, assembled, and occasionally manufactured and produced by original equipment manufacturers like Vestas, Siemens Gamesa Renewable Energy (Siemens Gamesa), General Electric, Goldwind, Envision, Mitsubishi, Suzlon, and Nordex. These wind turbine manufacturers are located across the world and while over 35 OEMs exist, the market has become increasingly concentrated. Only three OEMs including Vestas, Siemens Gamesa, and GE Renewable Energy are expected to hold 60% of the market share by 2028 (Wood Mackenzie, 2019) and in 2021, these three OEMs had a global installed wind capacity of 309 gigawatts (General Electric Company [GE], 2021; Siemens Gamesa Renewable Energy, S.A. [Siemens Gamesa], 2021a; Vestas, 2021c). The spot for largest OEM fluctuates, but Vestas was the largest in 2021, accounting for 17% of the global installed capacity (Vestas, 2021a). This sector operates in the business-to-business context as the turbines are generally purchased by energy companies to add renewables to their energy mix, wind farm developers, and in some cases, businesses that want their own on-site turbine. A commercial wind turbine purchased by an electricity company can range in price from $1.3 million to $2.2 million per megawatt (MW) of capacity (Wind Industry, n.d.).

The design phase is important to mitigating environmental impacts of the turbine, as this stage includes material selection. However, research has shown that economic factors are most important consideration in OEM decision making (Landeta-Manzano et al., 2018; Zwarteveen et al., 2021). Wind turbines are designed with an average life cycle of 20 to 25 years. This lifetime is less than other renewable energy sources like photovoltaics and biomass heat systems which have an expected life of 25 to 40 years and 20 to 30 years, respectively (National Renewable Energy Laboratory, n.d.). Horizonal axis turbines have been the more commonly installed design for the past 40 years and the typical structure showing the main components is exhibited in Figure 2.

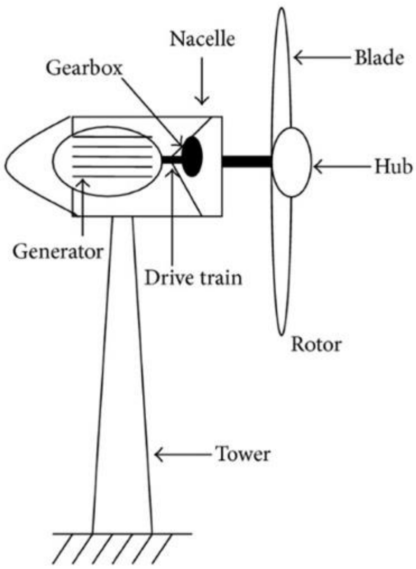

FIGURE 2 Components of a horizontal axis wind turbine (Arturo Soriano, 2013)

For explanatory purposes, the material composition of a Vestas V100-2.0 onshore model is shown in Table 2 which was the most sold model by Vestas in 2017 with a power rating of 2.0 MW (FTI Consulting Inc., 2018). Table 2 provides a high-level overview of the components that comprise a wind turbine and demonstrates the materials needed in turbine manufacturing. This breakdown is similar for offshore turbines that are comprised of steel (~83%), cast iron (~11%), copper (~1%) and other miscellaneous components (~5%) (Topham et al., 2019).

TABLE 2 Components of Vestas V100-2.0 Model (Vestas, 2018)

Material	Percent of Wind Turbine Composition
Steel and Iron	85%
Reinforced Glass and Carbon Composites	6.1%
Polymers	5.2%
Aluminum and Aluminum Alloys	1.5%
Electrical components	0.9%
Copper and Copper Alloys	0.5%
Lubricants and Fluids	0.3%
Other	0.4%

Steel and iron compromise most of the turbine which is used in the tower and nacelle, followed by reinforced glass and carbon composites which are needed for the blades. The blades and gearboxes are the most complex components of the turbine, while the generator is among the least complicated (Surana et al. 2020). The blades are usually made of a composite material which must be extremely durable due to the operational strain. The wind area and tower height were found to have the most influence on the sustainability performance of the turbines (Lundie et al., 2019). If the OEM aims to achieve technology innovation and cost reductions, this occurs at the component level rather than final product level (Surana et al., 2020).

This specific turbine exhibited in Table 2 is relatively small compared to advancements that have been made in turbine size as turbines are continuously becoming larger with the technological advances. The largest turbine previously on the market was the 14 MW offshore turbine by GE Renewable Energy. The General Electric Halide-X has 107-meter-long blades which exceed the 80-meter wingspan of a Boeing A380 airplane (Arturo Soriano et al., 2013). However, in August 2021, MingYang of China released their 16 MW capacity offshore turbine with 118-meter-long blades that spans the size of six soccer fields (Energy Live News, 2021). As turbine size grows, the cost of energy becomes more competitive and less turbines are needed, but other challenges emerge, like raw material requirements, public acceptance, and lack of knowledge with end-of-life decommissioning.

While the operation phase has lower impacts compared to other life cycle stages, the most common environmental impacts and concerns during this stage include noise, visual interference with the landscape, and threats to wildlife, particularly birds and bats (Saidur et al., 2011). In terms of public acceptance, wind energy is one of the most controversial renewable energy alternatives (Suškevičs et al., 2019). Welch and Venkateswaran (2009) noted that not in my backyard mindset is a major obstacle to siting the wind turbines in the United States. In the United States, it is common practice that the wind turbine owner signs a 5-year contract with the OEM for operation and maintenance services and after this period is over, the owner can decide to extend the contact or operate the turbine on their own, which is a risk (Kocsis and Xydis, 2019). Landeta-Manzano et al. (2018) found that economic factors usually are more important than social issues like community acceptance and community concerns about visual impacts when citing locations for turbines.

To keep wind power and OEMs' business viable, subsidies and incentives have helped support the implementation of wind power. Future investments in wind farms need financial support and appropriate policy (Bórawski et al., 2020). Policymakers' role also was shown in the literature as an important actor in wind energy adaptation. Zwarteveen et al. (2021) found that the most focused on stakeholder in the literature are policymakers and the perspective of OEMs have received hardly any attention. Surana et al. (2020) recommended that governments develop approaches for improving interaction in the global value chain as offshore and onshore wind turbine manufacturing continues to expand. This data and interaction within the global value chain is important as many countries want to support domestic manufacturing chains of green energy technology but cannot do so if a data gap exists (Surana et al., 2020).

Wind energy is available across the world, including in developed and developing countries. Zwarteveen et al. (2021) aimed to understand the drivers for wind energy adaptation in developing countries, but the literature review also included data from developing countries. Their opinion is that for developing countries, the environmental factors are not driving wind energy growth and thus it may be more beneficial for OEMs to brand their product as job creating technology instead of green technology.

2.2.2 Supply chain and manufacturing

For simplicity, the manufacturing of the turbine is going to be combined with supply chain considerations. The manufacturing phase has the largest environmental impacts due to the material and energy inputs needed (Alsaleh and Sattler, 2019; Cooperman et al., 2021; Schreiber et al., 2019). Alsaleh and Sattler's (2019) life cycle assessment demonstrated that the material acquisition and manufacturing had the largest environmental impact, accounting for over 60% of impact for the Gamesa 2 MW onshore wind turbine in the United States. As stated earlier, it is exceedingly difficult to trace the entire supply chain needed for manufacturing. Common to clean energy technologies, a data gap exists on the global value chain for manufacturing of wind turbines (Lundie et al., 2019; Surana et al., 2020). However, researchers have been able to conclude that the supply chain dominates the overall impacts of wind turbines (Lundie et al., 2019).

Steel and iron are the most used materials in the manufacturing of wind turbines and the production of steel and iron is very energy intensive. The carbon dioxide emissions from the steel and iron industry account for approximately 7% of total global carbon dioxide emissions (Souza Filho et al., 2022). Additionally, China produces about 46% of the world's steel (IPCC, 2021) and international trade accounts for up to 64% of total environmental, social, and economic impacts (Wiedmann, 2016). Steel was among the top 10 traded goods in 2006 with the highest global carbon emissions (Wiedmann, 2016).

Wind turbines require lanthanide elements, or rare earth elements, like Praseodymium (Pr-59), Neodymium (Nd-60), and Dysprosium (Dy-66) for the magnet manufacturing (Cristóbal et al., 2020). These elements are considered as critical raw materials due to market and geopolitical factors (Cristóbal et al., 2020). Interestingly, about 16%, or 1300 tons, of the total amount of rare earth elements produced in 2010 were used in magnets destined for wind turbines (Becci et al., 2021; Gutiérrez-Gutiérrez et al. 2015). Neodymium magnets contain about 31-32 by weight percentage of rare earth elements and China controls approximately 80% of the market share for producing these magnets (Yang et al., 2017).

Wind turbine manufacturers also must consider the hundreds of supplier firms that manufacture components which are usually small and medium sized enterprises (SMEs) (Surana et al., 2020). These parts and components need to be transported to the site which consumes energy. Lundie et al., (2019) concluded that if an OEM wants to reduce its carbon dioxide equivalent emissions, collaboration and transparency is essential with the supply chain. Surana et al. (2020) found that between 2006 and 2016, the number of manufacturers for low complexity components increased while high complexity components did not have much change. Also, remember that if these SMEs are in the European Union, they are not required to disclose social or environmental information under

Directive 2014/95/EU which can make it difficult and complicates matters for OEMs to get this information.

Data on rare earth elements reserve estimation and production values is lacking. This uncertainty could lead to demand for rare earth elements needed in wind turbines overshooting the available supply (Cristóbal et al., 2020). For Praseodymium, Neodymium, and Dysprosium, there are high extraction losses with average values of 49.1%, 58,1%, and 46.8%, respectively as these elements are usually extracted as byproducts of other parent materials (Cristóbal et al., 2020). One way to mitigate the impacts of the manufacturing stage would be to extend the lifetime of the wind turbine which would lower the impact per kilowatt-hour of electricity produced (Alsaleh & Sattler, 2019).

2.2.3 End-of-life

Approximately 90% of the turbine components can be recycled (Lapko et al., 2019), however the remaining 10% includes hard to recycle composite materials like fiberglass and carbon fiber which are used in the blades. As the blades are very durable, they are exceedingly difficult to recycle. The disposal is a complex engineering problem, which depends on several factors like the blade design, material composition, recycling technology availability, economics, and legislation, so a universal recycling solution does not exist (Sakellariou, 2018). There are even reports of "blade graveyards" where turbine blades are collected and buried in landfills (Steffen, 2020). Many researchers have identified that there is a lack of circular economy solutions for wind turbine blades (Jensen, 2019; Lapko et al. 2019; Larsen & Sønderberg, 2014, Lichtenegger et al., 2020; Norgren et al., 2020; Rentizelas et al., 2021).

In many European countries, first generation wind turbines are approaching the end-of-life and widespread recycling measures for the blades are not available (Lichtenegger et al., 2020), leading to landfill disposal as the most common disposal practice (Rentizelas et al., 2021). Europe is expected to be the first continent to face this challenge and Europe is expected to have continuous generation of blade waste until 2045 (Lichtenegger et al., 2020). China is expected to have the largest waste stream to manage (Liu & Barlow, 2017). Alsaleh and Sattler's (2019) life cycle assessment of onshore turbines in the United States showed that the end-of-life stage has the least environmental impact, however, in a sustainable society, nature should not be experiencing increasing concentrations of substances produced by society (Broman and Robèrt, 2017).

Overall, practical experience on decommissioning and recycling is lacking (Jensen, 2019) and blade waste is a significant and pressing waste stream (Hao et al., 2020). Recycling options exist like pyrolysis; however, recycling is not a widespread practice, and no universal recycling solution exists (Norgren et al., 2020; Sakellariou, 2018). The main barriers to widespread voluntary implementation of recycling are attributed to the lack of a market for the recycled materials and the cost (Jensen, 2019). Some researchers are on the other extreme that the blades are unrecyclable (Liu and Barlow, 2017). Cooperman et al. (2021)

estimated that for a 20-year turbine lifetime, cumulative blade waste will be approximately 2.2 million tons or about 1% of remaining landfill capacity by volume or 0.2% by mass in the United States in 2050.

In Germany, the blades are mostly incinerated for use in cement kilns (Jensen, 2019). However, Hao et al. (2020) have commented that this is only feasible because landfilling is banned and Rentizelas et al. (2021) have added that this practice is not sustainable due to the transportation involved. Fonte and Xydis (2021) noted that co-processing in cement kilns is the only option that can process the waste of 2022. Another negative aspect that Fonte and Xydis (2021) evaluated in their systemic literature review of potential recycling options in Europe, is that all processes analyzed lose material strength between 30 to 60%. Applications like energy recovery for use in cement kilns exist and are being claimed as a recycling option (Fonte and Xydis, 2021), but one must question if incineration for cement kilns can even be considered recycling and be considered as a long-term solution.

Additionally, as offshore turbine developments are expected to increase, much uncertainty exists about decommissioning as only four developments have reached the decommissioning phase (Topham et al., 2019). Decommissioning offshore turbines can have substantial costs, environmental impacts, and logistical challenges, yet refurbishment and lifecycle extension have not been given much attention (Topham et al, 2019). Even when wind farms are decommissioned, potential long-term impacts on the landscape are cause for concern, which is why the United States and Europe have placed increased pressure on solutions for repowering the turbines rather than full decommissioning (Szumilas-Kowalczyk et al., 2020). As for the Neodymium magnets, no commercial, economically feasible recycling option exists (Yang et al., 2017).

While OEMs are generally not directly responsible with the decommissioning of turbines as it is the responsibility of the turbine owner, OEMs have a responsibility to design the turbines with decommissioning in mind. Lapko et al. (2019) revealed that at least one OEM is not focused on improving the recycling rate of the turbines in the near term and expects recycling technology to have been developed by the time turbines are decommissioned in the future. In a research interview, an OEM senior manager stated that the recycling rate for the turbine is already very high and said that the company is expecting the recycling technology to be advanced by the time the turbine is to be decommissioned in the future (Lapko et al., 2019). The senior manager expanded that the company is more interested in extending the life of the turbines by repurposing the units in emerging markets (Lapko et al., 2019). Pasquali et al. (2020) agree that a design method should be implemented where the turbine can be upgraded.

It appears that the challenges with end-of-life stage for the 10% of materials not recycled will not be driven by economic incentives or landfill space constraints. Cooperman et al. (2021) proposed that recycling technologies and blade material need to be improved or policy changes need to happen to find circular economy solutions for the blades. Fonte and Xydis (2021) recommend the European Union enact new policies to find business opportunities for the recycled materials. To solve challenges of a successful energy transition, political support is essential (Rotmans and Loorbach, 2009). Cooperman et al. (2021) recommends that greater recyclability possibilities or potential for reuse if the choice of polymer in the composite material of the blade is reevaluated and improved. Reed (2008) emphasized in his literature review that to solve environmental problems, stakeholders' engagement and consultation needs to be started as early as possible. Thus, OEMs have tremendous responsibility in convening relevant stakeholders, like recycling processors and customers, to understand interests and concerns.

This thesis aims to explore sustainability strategy development and implementation further as not much information was available in the literature. It is important for industry to consider the environmental impacts of their actions as the industry sector has been identified as the sector with the most greenhouse gas emissions released than any other end-use sectors, more than buildings or end use transport (IPCC, 2021). Hence, the importance for wind turbine manufacturers to implement sustainability strategies. The methods and approach to achieve the aims of this study are discussed further in the next section.

3 DATA AND METHODOLOGY

This section will discuss the research methodology of this study including decision making process when the method of data collection and analysis were selected. This is a qualitative study including wind turbine manufacturers located across the world. The overall aim of the study was to gain more insight on the perceived attainment of sustainability by the OEMs through the sustainability strategies of these companies. The overall research methodology of this study will be discussed in more depth below

3.1 Research methodology

As demonstrated in the previous section, research is not robust that analyzes OEMs' sustainability strategy development and thus a qualitative research approach was selected. This thesis is searching for answers to how and why questions that are more open ended, which further justifies a qualitative approach instead of quantitative (Creswell, 2014). Unlike quantitative research, which is suitable for testing hypotheses using numerical methods, qualitative studies are appropriate when little is known about the research problem and a lack of previous research exists (Creswell, 2014; Hair et al., 2015). Furthermore, qualitative methods allow for data to be interpreted by the researcher, whereas quantitative research assesses the relationship between variables in a manner that can be replicated (Creswell, 2014). Qualitative research has been questioned as to its validity for scientific research as standardization is not to the same level as quantitative research (Lichtman, 2014). However, qualitative research is appropriate when one is trying to explain an outcome (Mahoney & Goertz, 2006), like how this thesis is seeking insight on explaining the outcome of wind turbine OEMs decision making regarding their sustainability strategy. The overall methodology chosen for this study is shown in Figure 3.

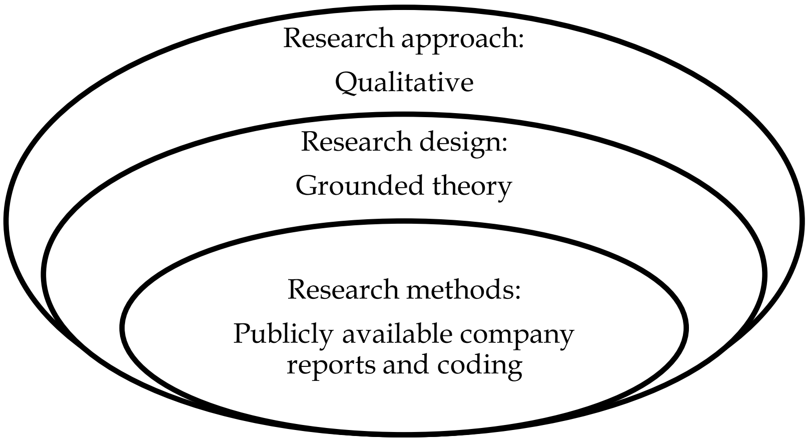

FIGURE 3 Research methodology for this study (Adapted from, Creswell, 2014)

The research design specifies the procedure utilized within the qualitative research approach (Creswell, 2014), and the research design selected for this qualitative study has been based off grounded theory. Grounded theory was developed as a way to derive theory from data (Glaser and Strauss, 1967) and this method provides structure but also flexibility to the researcher (Chun Tie et al., 2019). Additionally, related research to this thesis has used grounded theory for gaining new insights from publicly available company reports like sustainability reports (Nawaz & Koç, 2019). The main concept in grounded theory is coding which allows the researcher to organize the data to find concepts or themes which then results in many ideas that emerge that lead to a new theory (Eriksson & Kovalainen, 2008; Glaser and Strauss, 1967; Hair et al., 2015). Grounded theory is an iterative process between the data collection, coding, and analysis phases which ideally should all be ongoing simultaneously as much as possible (Corbin & Strauss, 2008; Glaser & Strauss, 1967).

Unlike quantitative research which has strict protocols and procedures, qualitative does not have as clear procedures, which is consistent with the grounded theory method. However, Glaser and Strauss (1967) outlined that conducting analysis using grounded theory includes the steps like collecting the data, coding, developing the core coding categories, making comparisons, ending with theoretical sorting. Due to qualitative research and grounded theory research design being iterative and emergent, a strict research plan was difficult to propose from the inception of starting this study, but guidelines for how the research would be conducted to achieve the research aims were developed from the beginning.

The goal of grounded theory is to uncover new theories (Glaser and Strauss, 1967). This is accomplished by the incorporation of both inductive and deduction logic to develop this new theory (Eriksson & Kovalainen, 2008). Grounded theory uses inductive reasoning first through an iterative process of analyzing the data to look for patterns and examples, which emerge as generalizations until a complete set of themes are uncovered (Creswell, 2014). When the sustainability reports were analyzed for this thesis, the reports were read several times which looked for patterns between the reports on how wind turbine OEMs describe their sustainability performance and what factors are influencing the decisions. Then deductive reasoning was used to reflect on the themes identified to ascertain if more evidence could be used and needed to be collected to support the themes. Deductive reasoning uses what one knows generally to draw conclusions about a particular aspect. The interplay between deductive and inductive reasoning allows for theory to emerge during the data collection and analysis phases (Eriksson & Kovalainen, 2008).

Grounded theory is subject to criticism due to the coding process and opinion that this approach is not systematic due to its flexibility. However, this method can be useful in certain research areas, and it has been recognized as an established method within business research (Eriksson & Kovalainen, 2008). For this thesis, grounded theory allowed the researcher the flexibility to view the reporting in its entirety, unlike other methods like quantitative based content analysis which looks for the frequency of key terms. Hence, developing a plan as best as possible for the outline of the study with the research goals in mind was important when using a grounded theory approach, but also recognizing that the plan may change as the analysis was progressing. Furthermore, the results of this study can be expected to be satisfactory as this topic is in a new field of study, but the methodological approach was using grounded theory which is considered an old method (Hair et al., 2015).

This study's research method is through analyzing textual secondary data in the form of sustainability reports or their equivalent to gain new insights. The research method includes the procedure of data collection, analysis, and interpretation (Creswell, 2014). Secondary data is not collected directly for the research project and exists prior to research being conducted (Eriksson & Kovalainen 2008; Hair et al., 2015). These OEMs produce lengthy sustainability reports which provide information in their own words, and this information could potentially answer the research questions. Using existing secondary business data has been recognized that it can be a practical and reputable source of information that can help save time and effort (Creswell, 2014; Hair et al., 2015). Eriksson and Kovalainen (2008) highlighted that secondary data frequently leads to fruitful opportunities for qualitative business research. This method also allows the companies to be identified and make comparisons which allows data to be triangulated from several different sources. When themes emerge from several different data sources, this adds validity to the study (Creswell, 2014). Secondary business data is important for corporate governance and social responsibility research (Hair et al., 2015), which are important and relevant texts in the field of CEM.

However, challenges exist with using secondary data, as it was not generated with the research questions in mind. The reports may leave out important information, be incomplete, or may not be accurate (Creswell, 2014). Eriksson and Kovalainen (2008) noted that secondary data is worthy for qualitative business research because the texts come directly from the source so it can be reasoned they represent accurately. As explained earlier, because the contents of these reports are not fully standardized and the contents are usually voluntary, a lack of consistency between reports can be recognized as a challenge.

Another aspect to recognize with qualitative research is the role of the researcher in data interpretation. Qualitative research involves interpretation of the results by the researcher, which results in the potential for ethical and personal issues to arise (Creswell, 2014). The researcher comes from the field of CEM which influences the interpretation of the results and could result in a potential bias. Additionally, the researcher does not have direct experience working for or with a wind OEM so real-world perspective could be lacking. However, the fact that the researcher has not worked for any of these companies can be seen as a benefit as the researcher brings a different perspective and no bias towards any one company exists.

3.2 Data collection

The research method included collecting secondary data in the form of sustainability reports. Thirty-nine wind OEMs were identified to be relevant to this study, as shown in Table 3. The initial identification looked for all OEMs that could be identified through news releases (GWEC, 2021b; Wood Mackenzie, 2021) and online searches. These OEMs were in business at the time of the study and geographical limitations were not set. Because the sample size was small with less than 50 samples, a qualitative approach was appropriate and further supported (Hair et al., 2015).

Reports were searched for on the company's website and the most recent published report was selected for the analysis. If the report could not be found directly from the company's website, secondary channels were used to try to locate the company's report. If a report could not be located, then the website was reviewed for a CSR policy or sustainability statement. If a sustainability report or policy could not be found, but an annual report was found, then the annual report was reviewed for information about the company's sustainability strategy. Annual reports are financial disclosures, but if no other report or policy could be found, they were included for completeness. Sustainability reports, policies, and annual reports could not be located for all the OEMs identified, as shown in Table 3. Documentation for analysis in this thesis was found for 25 out of the 39 OEMs identified and ranged from three pages to over 100 pages long resulting in over 2,000 pages in total. A sustainability report was found for CSIC (HZ Wind Power), however, the report could not be found in English, so it was not included in the total number companies included in the analysis.

Like stated earlier, when using a grounded theory method, the data analysis starts with data collection as the data collection, coding, and analysis phases should all be ongoing simultaneously (Corbin & Strauss, 2008; Glaser & Strauss, 1967). Questions, observations, and comparisons between companies start to arise during the data collection surrounding the absence of a report, the report length, the date of the latest report, and the report title. While the analysis in this phase was not in depth, these details and comparisons are observations that can provide an indication of what to expect in the analysis and spark inquiry. For example, if the documentation was an annual report, one can expect that sustainability may not be addressed in that document or the length of the report can indicate how much detail is to be expected. Ultimately, questions started to arise in this phase that were further investigated as the data analysis iterations progressed.

TABLE 3 Wind original equipment manufacturers identified for analysis

Company	Headquarters' location	Core business: wind power	Publicly traded	Report available	Document type*	Document year
Bornay	Spain	✓				
CRRC	China		✓	✓	AR	2020
CSIC (HZ Wind Power)	China	✓	✓	✓	SR+	2020
Dongfang Electric Corporation (DEC)	China		✓			
Doosan	South Korea		✓	✓	ESG	2020
Elecon Engineering	India		✓	✓	CSRP	2021
Enercon	Germany	✓		✓	SR	2020
Enessere	Italy	✓				
Envision	China	✓		✓	CNR	2021
Eocycle Europe BV	Canada	✓				
General Electric	United States		✓	✓	SR	2020
Goldwind	China	✓	✓	✓	SR	2020
Hitachi	Japan		✓	✓	SR	2021
Hi-VAWT	Taiwan	✓				
Hyosung	South Korea		✓	✓	SR	2020
Inox Wind	India	✓	✓	✓	AR	2021
Japan Steel Works	Japan		✓	✓	EP	2019
Končar	Croatia		✓	✓	CSR	2020
Mapna	Iran					
MingYang	China	✓	✓	✓	Sr	n.d.
Mitsubishi Heavy Industries	Japan		✓	✓	ESG	2021
Nordex	Germany	✓	✓	✓	SR	2020
NovaWind	Russia	✓				
RRB Energy Limited	India	✓				
SANY	China		✓	✓	ESG	2020
Shanghai Electric	China	✓	✓	✓	ESG	2020
Siemens Gamesa	Spain	✓	✓	✓	CNFS	2021
Sinovel	China	✓		✓	PCSR	2010
Suzlon	India	✓	✓	✓	SR	2018
TECO	Taiwan		✓	✓	SR	2020
TUGE Energi	Estonia	✓				
UNISON	South Korea	✓	✓			
United Power (Guodian)	China	✓				
WEG	Brazil		✓	✓	IAR	2020
Wind World	India	✓		✓	SHE	n.d.
Windey	China	✓	✓			
Vergnet	France		✓	✓	Ar	2019
Vestas	Denmark	✓	✓	✓	SR	2020
VWT Power	United Kingdom	✓				

Note to table: ✓ = yes
* AR= Annual report; Ar= Annual results; CNFS= Consolidated non-financial statement; CNR= Carbon neutrality report; CSR= Corporate social responsibility report; CSRP= Corporate social responsibility policy; EP= Environmental policy; ESG= Environmental social and governance report; IAR= Integrated annual report; PCSR= Philosophy on corporate social responsibility; SHE= Safety, health, and environment policy; SR= Sustainability report; Sr= Social responsibility
+ Report could not be found in English
n.d. = no date
Bold = In the top 15 of wind OEMs with the largest market share in 2020 (Wood Mackenzie, 2021)

3.3 Data analysis and coding

This research has been designed using grounded theory, thus coding was used to analyze the reports. Qualitative research does not have strict steps to follow as with quantitative research (Corbin & Strauss, 2008), but the process used in this Master's Thesis is described here. A grounded theory coding software was considered to be utilized, like MAXQDA, however the researcher wanted full control over the coding process, so a software program was not used. Creswell (2014) has explained that predetermined or expected codes that could emerge from the study can be identified prior to analysis, however, flexibility should be allowed for codes to emerge during the iterative process of grounded theory research. Potential codes expected prior to analysis were identified as follows:

- sustainability and sustainability strategy
- values
- mission
- vision
- green and green energy
- renewable energy
- innovation
- environmental impact
- responsibility
- continuous improvement

The first part of the analysis included reading the materials in their entirety to become familiar with the content of the document. If the report contained a message from the management like the chief executive officer (CEO), that was focused on as company management plays a key role in corporate sustainability implementation. As the reports were read the second time, statements that repeated or stood out to the researcher were recorded in a document containing a section for each OEM. Then during subsequent iterations of analysis, the researcher started to record phrases that related to codes that emerged in subsections of the document under each individual OEM.

The reports were coded to first discover the top categories or themes for the individual firm. Answers to both research questions were considered at the same time during each iteration and each iteration of review allowed for in-depth analysis of the data. In some cases, codes that emerged early on during the analysis did not emerge as significant. The researcher compared the top themes for each individual company with all companies during subsequent iterations to reveal the themes common among the OEMs. The reports were continuously referred to as the top codes started to emerge that were common between the OEMs to gather more information and support for the theme. Once the categories had been fully developed, referring to the reports for more information stopped. The codes were tracked in an Excel spreadsheet, which resulted in Appendix 1 and 2.

4 RESULTS AND ANALYSIS

This section will present the key results and analysis of the documentation found for the OEMs identified in Table 3. General information about the documentation analyzed will be presented first, followed by a summary of the results, and the themes revealed from the coding process that are relevant to the research questions.

4.1 Sustainability reporting of wind OEMs

Thirty-nine wind turbine manufacturers were identified at the time this thesis was conducted to be included in this study. Most of the wind OEMs included in this study are in Asia (26) and the second most common headquarters' location is Europe (10), as show in Figure 4. Wind power is the primary business for 62% (24) of the companies included in this study.

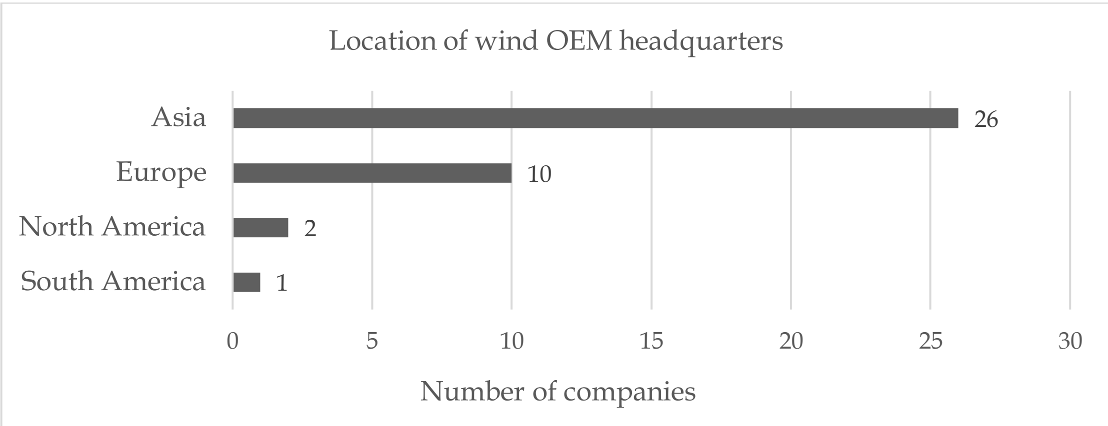

FIGURE 4 Location of wind original equipment manufacturer headquarters

Of the 39 wind turbine manufacturers, suitable documentation that might contain insight on the company's sustainability strategy was found for 64% (25) of the firms, leaving 36% (14) without any statement. Of the 25 firms with suitable documentation, 18 had formal sustainability related reports, leaving seven companies with statements found on their website or annual financial reports. Of the top 15 wind OEMs with the largest market share in 2020, which are indicated in bold text in Table 3, formal reports were able to be located for 12 firms, including CSIC which was not in English. Companies without any statement were generally much smaller companies and privately owned, compared to the other OEMs included in this study.

Interestingly, of the documents included in the analysis, 13 different names were identified to characterize the report or document like: sustainability report, corporate social responsibility report, carbon neutrality report, integrated annual report, corporate social responsibility policy, and philosophy on corporate social responsibility. Two companies, Siemen Gamesa and Vestas, had separate documents dedicated to their sustainability strategy in addition to their sustainability report. Siemen Gamesa had a 4-page informational presentation on their sustainability strategy that was found on their website (Siemen Gamesa, 2021b) and Vestas had a dedicated webpage to their sustainability strategy (Vestas, 2021b). However, this information is mostly repeated in their sustainability reporting.

Of the reports analyzed, 41% (16) indicated their report followed a reporting framework. Various reporting methods were identified like GRI, International Integrated Reporting Council (IIRC), Sustainability Accounting Standards Board (SASB), Sustainable Industry Classification System (SICS), Stock Exchange of Hong Kong ESG Reporting Index Guide (HKEX), and the Task Force on Climate-related Financial Disclosures Framework (TCDF). Fourteen companies, or 36%, included a materiality assessment in the report which will be discussed further below. Table 4 summarizes the reporting characteristics encountered during the analysis.

TABLE 4 Reporting characteristics

	Companies
Documentation available	25 (64%)
Documentation addresses sustainability	22 (56%)
Uses reporting framework like GRI	16 (41%)
Report contains materiality assessment	14 (36%)
OEMs in the top 15 of market share with sustainability report	12 (80%)

The breakdown of reporting characteristics by region is shown in Table 5 which shows the distribution of documentation that addresses sustainability and documentation that contains a materiality assessment by geographical location. The companies with headquarters in Asia represent the largest share of documents addressing sustainability with 58% of companies reporting about sustainability. Ultimately, 22 documents were used in the analysis to be able to gain insights related to the research questions.

TABLE 5 Reporting characteristics by location

Continent	Companies	Document available	Document addresses sustainability	Contains materiality assessment
Asia	26	17	15 (58%)	9 (35%)
Europe	10	6	5 (50%)	4 (40%)
North America	2	1	1 (50%)	0 (0%)
South America	1	1	1 (100%)	1 (100%)

4.2 Summary of the results

This section will present the themes that emerged during the iterative coding process related to the company's perception of their sustainability performance and the factors that affect their sustainability decision making. Twenty-two companies were included in the coding process as these companies' documentation addressed sustainability. Themes are discussed below in more detail if 50% (>11) or more of the companies identified the topic in their report, as shown in Figure 5. The final coding framework that developed during the coding process can be found in Appendix 1. Some of the codes expected in Section 3.3 were found, but some were not found. The coding framework shown in Appendix 1 encompasses many more codes identified in the text, which was refined from even more codes found, but that were less frequently found. Figure 5 highlights the most common themes among the OEMs that emerged from the coding process.

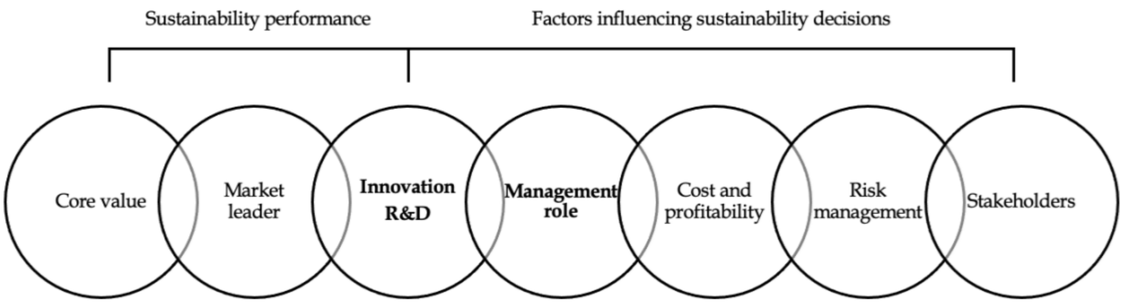

FIGURE 5 Top themes identified
Note to figure: **Bold** text corresponds to the most common theme identified

The documents analyzed showed that wind power OEMs consider their sustainability performance as a main focus and consider themselves leaders and innovators. Factors that influence their decisions around sustainability are related to research and development (R&D), innovation, top management decision making, cost, profitability, risk management, and stakeholder priorities which incorporates supply chain considerations. Innovation and research and development went hand in hand as OEMs viewed themselves as innovative but also innovation, and the related research and development, had a high influence on their sustainability decisions. Less frequently identified themes related to describing sustainability performance included being forward looking, being a benefit for the local society, and describing performance based on the amount of carbon dioxide equivalent avoided. For the factors influencing sustainability decisions, factors like sustainable growth, carbon neutrality, regional decarbonization goals, and CSR reporting being required by law, were found but less frequently cited among wind OEMs, as shown in Appendix 1. Of the potential expected codes indicated in Section 3.3, codes like environmental impact and responsibility did not emerge as significant themes.

Fourteen of the documents reviewed included a materiality assessment. The materiality assessment was focused on during the analysis, if one was available, because it clearly identifies top priorities for the company and its stakeholders. The Global Reporting Index framework is helpful in giving companies a framework to follow, but also requires many disclosures which can make it difficult to discern what is actually a priority if a materiality assessment was not present. The number of areas identified in these materiality assessments ranged from 10 up to 53, hence the value of this method as it makes it much easier for the company and stakeholders to understand what the top priorities are. Of these 14 assessments, the top three topics for each company are shown in Appendix 2.

The top results of the materiality assessment covered topics encompassing all three pillars of sustainability. For example, economic performance, health and safety, and environmental behavior were all ranked as the highest priority for different OEMs. Additionally, the secondary and tertiary priorities shown in Appendix 2 rated climate change related priorities several times. The results of the materiality assessment are discussed below within each section theme, if applicable. The top 3 materiality areas were not able to be identified in the materiality section of Enercon’s Sustainability Report as Enercon is still in the process of developing a comprehensive ranking, thus it was not included in Appendix 2 (Enercon, 2021).

4.3 Sustainability performance

This section will discuss the three areas identified the most by wind OEMs when describing their sustainability performance: sustainability at the core of the business, innovation, and being a market leader. Seven themes emerged during the coding process related to this first research question, but only three themes were common to over 50% of the OEMs with sustainability documentation. However, the four other themes of being forward looking, having less environmental impact, being a benefit for the local society, and describing sustainability performance in terms of carbon dioxide equivalent, are related to the top themes identified, in some cases.

4.3.1 Sustainability at the core of business

Eleven companies like General Electric, Hitachi, MingYang, Nordex, Shanghai Electric, Suzlon, TECO, and Vestas indicated in their reporting that sustainability is at the core of their business. Having sustainability at the core of the business was associated with incorporating sustainability into all business operations and decision making, and a top priority for management and the governing board. This theme was identified at companies whose main business is wind power like Nordex and Vestas, but also at companies that only have wind as a subset of their business, like General Electric and Hitachi.

Vestas, which holds the largest share of the wind power market, has named their sustainability strategy “Sustainability in Everything We Do” (Vestas, 2021c, p. 4). Vestas’ executive management team explained how this strategy aims to ensure the company’s sustainability performance will continue to improve as the business grows (Vestas, 2021c). TECO notes that the goal of integrating sustainability in all operations means sustainability is considered in daily operations in each employee and department (TECO, 2021). General Electric has committed to the sentiment that, "We build the technology that enables a sustainable tomorrow" (GE, 2021, p. i). General Electric’s CEO further noted that including sustainability in all they do is the right approach for business and the planet, and that sustainability is integrated into their overall strategy development (GE, 2021). Nordex’s CEO explained how Nordex’s business model has been based on sustainability which influenced their sustainability strategy (Nordex, 2021). Additionally, Nordex CEO’s statement highlighted that Nordex is contributing to fighting climate change by, “pursuing a holistic approach covering all aspects of our business” (Nordex, 2021, p. 5). Hitachi (2021), whose main business is not wind power, has stated that sustainability is at the center of their business strategy. Shanghai Electric (2021) integrates sustainable development into its daily business management and long-term strategy goals. By communicating that sustainability is at the core of the business demonstrates that sustainability is valued for the company and is part of the corporate culture.

For some companies like Hitachi, TECO, and Vestas, integrating sustainability into all operations also means committing to be a carbon neutral company. Committing to carbon neutrality was a theme that emerged during the coding process; however, it was not cited by more than half of the OEMs that had sustainability documentation. Becoming carbon neutral can mean several things as the boundary limits must be disclosed. For example, the carbon neutral goal could be only for business sites like company owned factories and offices or could encompass the entire supply chain. Vestas has the pledged to be carbon neutral by 2030 without carbon offsets, however this does not include carbon neutrality of the entire supply chain. Hitachi is aiming to become carbon neutral, including the entire supply chain by 2050. General Electric wants to be a net zero company by 2050 including scope 3 emissions, meaning including emissions from sold products.

MingYang is in the top 15 OEMs, however, a formal sustainability report could not be located in any language. The social responsibility section on MingYang’s website was reviewed which noted the company puts green development as a core value, however not much justification explaining how this is achieved could be located for this statement (MingYang, n.d.).

4.3.2 Innovation

Most of the OEMs described themselves as being innovative and this was the most frequent theme found that wind OEMs are associating with their sustainability performance. Siemens Gamesa (2021a) noted in their 2021 Consolidated Non-Financial Statement that innovation is a key business driver in the wind energy sector. Additionally, innovation and research and development were listed as a top priority area in the materiality assessments for Doosan Corporation, Goldwind, Hitachi, SANY, and TECO. Being an innovative wind OEM can indicate to customers that the product will provide a promising return on investment which helps the OEM distinguish itself from the competition.

Solving sustainability challenges, like climate change, are complex and challenging problems and contributing to the solution is seen as a competitive advantage. Innovation is viewed as a way to solve the complex challenge of climate change. Envision (2021), which is the second largest Chinese OEM, believes innovation is essential to solving climate change. Doosan Corporation (2021) has highlighted that innovation is a key driver for the company's future growth, and Sany (2021) has also stated that product innovation and R&D are one of the company's main competitive strengths. For companies whose main business is not wind, like General Electric, the wind part of the business is seen as extremely valuable as it is expected to benefit from the global trends of focusing on climate change and energy transitions.

Companies highlight that their products and services have less environmental impact than other products and services, which can be attributed to research and development which then produces innovative products. The reports highlighted the environmental benefits that wind turbines have during the operational phase, such as carbon dioxide emissions avoided. Companies like Enercon, Envision, Hitachi, Japan Steel Works, and Nordex indicated they believe their products and services have less environmental impact leading to climate efficiency and contribute to the availability of renewable energy. Mitsubishi Heavy Industries found their highest priority in the materiality assessment to be providing renewable energy solutions that contribute to carbon neutrality. TECO noted that product stewardship is the top priority to their stakeholders. TECO (2021) management and Enercon (2021) stated the company makes contributions to the availability of clean energy. Similarly, in Hitachi's (2021) sustainability strategy, one goal is to consider reductions in environmental impacts from the design stage to produce more energy efficient products. Innovation was highly related to R&D which will be discussed further below as a factor influencing sustainability decisions.

4.3.3 Market leader

Eleven companies identified themself as a market leader in sustainability performance like Envision, Inox Wind, General Electric, Goldwind, MingYang, Siemens Gamesa, Sinovel, Suzlon, and Vestas. The top five wind turbine OEMs holding 57% of the market share in 2020, which were Vestas, Goldwind, GE Renewable Energy, Envision, and Siemens Gamesa (Wood Mackenzie, 2021), all indicated in their reporting that they consider themselves a market leader. In addition, of the 12 companies in the top 15 of market share with sustainability documentation, seven companies indicated they are market leaders.

Being a market leader is attributed to, for example, committing to carbon neutrality, the company's research and development history, increasing accessibility to renewable energy, and business performance. Considering suitable reporting could only be found for 22 of the 39 companies identified as operating in wind power, and the market is concentrated, this did not stop almost all 22 companies as identifying as a market leader. Additionally, nine out of the eleven companies that are identified as being a market leader in sustainability are also publicly traded.

Many CEOs have stated their company is the industry leader and driving the energy transition. Forecasts have predicted that Vestas, GE Renewable Energy, and Siemens Gamesa will hold 60% of the market share by 2029 (Wood Mackenzie, 2019). Vestas' CEO stated the company is, "leading the transition to a world powered entirely by sustainable energy" (2021, p.7). General Electric also believes they are leading the energy transition as the CEO has stated General Electric is, "leading the energy to drive decarbonization" (2021, p. 1). Siemens Gamesa (2021a) also wants to be the leading supplier of wind power globally. However, for the 15 OEMs with the most market share in 2020, as shown in Table 3, reports could not be located for three OEMs including Dongfang Electric Corporation, United Power (Guodian), and Windey. These three OEMs are all located in China.

4.4 Factors influencing sustainability decisions

This section will discuss the themes identified the most by wind OEMs when discussing the factors influencing their decisions around sustainability including the role of management, cost and profitability, research and development, risk management, and stakeholders. Other themes identified during the coding process, but to a lesser extent, include carbon neutrality, country specific decarbonization goals, CSR reporting laws, and sustainability as a smart business decision.

4.4.1 Management role

Management's role or the company's board was identified in almost all reports and was the most common theme identified as being a key factor in decision making for the company regarding sustainability. The management has the responsibility to direct the company in a way to reach the goals of the company's strategy. If the company had a separate team dedicated to sustainability, the company's organization structure was sometimes provided to show how this body interacted and ranked among the top management. For example, Nordex (2021) has a department dedicated to global sustainability management, which is tasked with developing the sustainability strategy.

The reports reviewed provided statements from top management, like the CEO, which is in accordance with the GRI Standards. This also highlights the prominence of management's role as usually the statement is at the beginning of the report. Sixteen reports contained a separate section in the report for a statement from the management. In some cases, the report contained more than one management statement like in Shanghai Electric's report, a statement is included from the chairman of the board and the company president. These management statements generally reinstate the company's achievements and future commitments. Eighteen out of the 22 companies analyzed are publicly traded, hence it is to be expected that the top management and board play a significant role in the business strategy.

The top management sets the example for employees to follow, so if sustainability is a priority for the company, the management has a key role in the success of the sustainability strategy. If the company is committing to sustainability as a core value, as discussed above, the CEO is usually reinstating that value. Končar's CEO has stated that it is only through leading by example that long-term sustainability goals can be achieved (Končar, 2021). WEG's (2021) CEO emphasized WEG's commitment to ethics, integrity, and transparency.

Ultimately, decisions regarding sustainability are mostly decided by the top management or board in the wind power OEMs analyzed. Management's role is demonstrated also in the materiality assessments, because the most important stakeholder for the company is the top management, as ranking sustainability priorities are influenced by management as a whole entity versus all relevant stakeholders as one entity. The top management must weigh the outcomes and risks around sustainability related decisions. Stakeholders are also highly cited as influencing sustainability decisions, which is discussed further below; thus, the top management and board must decide which stakeholder priorities and company priorities will ultimately be pursued.

4.4.2 Research and development

As stated earlier, innovation was the most common way wind OEMs are describing their sustainability performance, which is highly linked with research and development. Research and development was an area identified as influencing sustainability decisions for many wind OEMs and is the second most common theme after the role of management. Additionally, innovation and research and development were listed as top priority areas in the materiality assessments.

Investing in R&D can be leveraged to find ways to reduce the cost and environmental impact of wind power, further increasing the company's competitiveness. Investing in R&D for finding ways to extend the life cycle of the turbines can lead to lower costs and lower life cycle impacts for the turbines. Siemens Gamesa (2021a) and Nordex (2021) have both been working on finding ways to extend the product lifetime. Hitachi (2021) noted that part of their sustainability strategy is addressing environmental impacts in the design stage. Innovation status is also promoted to the OEMs' stakeholders, like WEG's (2020) report which highlights that the company is in the top 1,000 of publicly traded companies that invest in innovation. This area is related to cost and profitability which were identified as an important factor in the sustainability decision making of OEMs and will be discussed further below in Section 4.4.3.

To solve the challenge of wind turbine blade waste for turbines already in use, working groups like the DecomBlades consortium and a WindEurope task force have been set up. The DecomBlades consortium was started in 2021 and includes 10 partners involved in various aspects of wind energy. GE Renewable Energy, Siemens Gamesa, and Vestas noted they are all members of the DecomBlades project as specialists in blade design and manufacturing. The WindEurope working group aimed to develop industry standards for dismantling obsolete turbines. Nordex (2021), who is a member of the Wind WindEurope group, discussed how the main challenge in wind turbine disassembly is separating the individual components, which is generally the responsibility of the turbine owner. However, Nordex wanted to play an active role in finding a solution. In addition to Nordex, Enercon, General Electric Renewable Energy, Siemens Gamesa, and Vestas were members of this WindEurope task force, and the results were released in 2020.

These companies also have their own pledges to find solutions to the blade problem. One of Vestas' four main sustainability goals as part of its sustainability strategy is to produce zero waste turbines by 2040 (Vestas, 2021c). Siemens Gamesa (2021a) has already launched RecycleableBlade which they note as the first recyclable blade for use in offshore turbines and is also pledging to redesign their turbines to be fully recyclable by 2040.

Enercon and General Electric addressed the use of rare earth elements in the magnets of the wind turbines. Enercon's CEO stated the industry-wide focus on the use of rare earth metals is a challenge for Enercon (2021). Enercon noted that the use of rare earth metals in the magnets allows for higher efficiency leading to more energy yield. General Electric (2021) noted that finding an alternative to magnets with rare earth elements is an area General Electric is positioned to solve and is researching incorporating magnets that do not contain rare earth elements. General Electric (2021) attributes this focus as a result of decarbonization goals and decarbonization goals depending on some technologies that are not fully developed. TECO (2021) also invested in R&D of using magnets with little to no rare earth elements.

4.4.3 Cost and profitability

Cost and profitability were identified as top factors influencing sustainability decisions but was not as commonly cited as the other themes identified in this section. Cost and profitability demonstrate the success of the company and increases competitive advantage, and the economic factor is one of the key pillars of sustainability. Remaining cost efficient is important to companies like Enercon, Suzlon, and Doosan Corporation to ensure the company stays competitive. Economic performance was cited as the highest priority in the materiality assessments for several companies like Končar and Suzlon. Sustainability reporting is considered as non-financial reporting so highlighting cost and profitability in the sustainability report further demonstrates the importance.

Some companies like Doosan Corporation, Enercon, Hyosung, and Siemens Gamesa cited sustainable growth as a factor influencing their sustainability decision making. Doosan Corporation (2021) views sustainable growth as meaning the company developing and expanding in cooperation with the local community and supply chain. Doosan Corporation's (2021) CEO stated the company is focusing on growth and profitability to drive the company into the future. Elecon Engineering (2021) and Goldwind (2021) stated that having an image of a socially responsible company results in sustainable growth as customers prefer products and services that consider social responsibility, thus it makes business sense to be effective at CSR. Suzlon (2018) noted that long term sustainability of the business is dependent on sustainable growth and being in the wind energy sector allows the company to benefit from the growth of renewable energy. WEG (2020) also strives for sustainable growth but also wants to maintain their ideals of addressing sustainability. However, when searching for what sustainable growth means to Hyosung, a clear understanding of sustainable growth could not be found. Hyosung (2021) cites suitable growth as an important factor but does not expand on what it means in practice.

4.4.4 Risk management

Risk management was identified as an important factor influencing sustainability decisions due to the impact risks it can have on business and loss of market opportunities. Companies that identified risk management as an important factor generally mitigate this area by having a code of conduct, ethics guidelines, internal audit processes in place, like Doosan Corporation, Goldwind, and Shanghai Electric. Suzlon (2018) noted that risk management and sustainability are closely associated as identifying and mitigating risks helps the company become sustainable. Risk management is implemented through trying to avoid any potential problems or impacts from operational risks, like implementing a new process or technology, and financial risks, until the risks are understood and mitigated.

One area of risk management relevant to wind OEMs is risk associated with their supply chain because OEMs are depending on suppliers for components and raw materials. Doing business with suppliers who are then revealed to have poor environmental practices reflects poorly on the OEM and reduces credibility for sustainability claims. Staying ahead of potential risks has been cited by Mitsubishi Heavy Industries (2021) as helping strengthen its position in the market. Goldwind (2021) explained that adverting risks related to environmental and social factors is vital in having lasting, stable growth, and lessening negative impacts on stakeholders. Risk management is related to stakeholders which is discussed in the next section.

Doosan Corporation (2021) identified risk management for sustainability areas as a non-financial risk for the company that is addressed by their environmental and social governance team. Doosan Corporation (2021) identified that climate change is an emerging risk for the company that could lead to unstable product development and loss of market opportunities.

4.4.5 Stakeholders

Stakeholders were identified as a factor influencing sustainability decisions. Knowing who a company's stakeholders are is important as sustainability requires collaboration. Within stakeholders, employees, investors, suppliers, and customers were identified as key stakeholders. Enercon (2021) noted their key stakeholders influencing sustainability decisions are customers, employees, and suppliers. Nordex (2021) noted that their sustainability decisions are influenced by the increase demand from stakeholders for information about sustainability issues regarding supply chain. If the company included a materiality assessment in their report, this also further demonstrates stakeholder priorities are of concern and importance.

Almost all the companies agreed collaboration was an important factor for reaching sustainability goals, especially along the supply chain. Maintaining a good relationship with the supply chain means these companies have more opportunities for growth as the supply chain can be a limiting factor if components and materials cannot be procured. Wind OEMs cannot produce every component needed to manufacture the turbines, hence the importance of the supply chain.

Companies like Enercon, Hitachi, and Nordex view the environmental impacts of the supply chain as a priority. Enercon noted that more focus needs to be placed on the supply chain and its climate impacts (Enercon, 2021). As discussed earlier, some companies are pledging to be carbon neutral including their supply chain. In Hitachi’s (2021) sustainability strategy, one goal is to work with their suppliers more on promoting carbon neutrality in the supply chain. Starting in 2021, Hitachi is requiring that 70% of their suppliers develop carbon dioxide emission reduction plans. Doing business with suppliers who have poor environmental practices that are then exposed could damage the company’s credibility and is a risk.

Understanding all the workings of the supply chain is a challenge, but some OEMs have criteria in place to screen suppliers or provide support. Mitsubishi Heavy Industries (2021) reported evaluating and identifying high risk suppliers using questionnaires and internal screening tools and in a 3-year period, 14% of their total suppliers were screened. Only 12 companies were physically inspected in person in fiscal year 2020 by Mitsubishi Heavy Industries. Hyosung (2021) provides technical and financial support to certain suppliers. Končar disclosed that the copper and steel they use are procured through commodity exchanges (Končar, 2021). This means in practice that is virtually impossible to be able to track where these materials were sourced from. Interestingly, Končar also stated the company does not do business with suppliers whose products have caused harm to humans and the environment, which would be exceedingly difficult to verify if the product is purchased on the commodity market. Nordex (2021) believes if the supply chain is not environmentally friendly and resource efficient, a contradiction exists if the wind turbine is promoted as sustainable.

Enercon (2021) does not directly purchase rare earth metals as Enercon purchases magnets that already incorporate the rare earth metals, but said suppliers are subject to the company's screening criteria. Similarly, WEG (2020) noted they ensure they do not purchase conflict raw materials through developing a restricted substances list and code of ethics for suppliers.

5 DISCUSSION AND CONCLUSIONS

In this Master's Thesis the focus was on the sustainability strategy of companies in the wind power industry who manufacture wind turbines, specifically understanding these companies' perception of their sustainability performance and factors influencing sustainability decisions. About half of the companies had statements or reports regarding sustainability. From the available documentation, it was found that these companies view their sustainability performance as leading the market, innovative, and at the core of their business operations. It was also found that sustainability decisions are influenced by research and development, cost and profitability, stakeholders, top management, and risk management. This indicates that mitigating environmental impacts is not the highest priority for these OEMs. This section will discuss the results, answers to the research questions and their significance, research limitations and opportunities for future research.

5.1 Explanation of results and answers to research questions

While these wind OEMs play a role in the energy transition away from fossil fuels, the area of wind energy is not without its own sustainability concerns. This thesis helps gain insight on the wind OEM's role and position regarding sustainability. Wind OEMs play a significant role in mitigating the environmental impacts of wind turbines, especially the environmental impacts during the manufacturing phase, as the OEM plays a main role in the design and material selection (Schreiber et al., 2019). As Lundie et al. (2019) uncovered from the wind OEM in their study, emissions originating directly from the OEM was only 1% or even less. This means that if OEMs want to make significant environmental impact reductions in the life cycle of the wind turbine, wind OEMs need to understand the environmental impacts of the suppliers they are choosing to do business with (Lundie et al., 2019).

Focusing on the supply chain was identified by Stewart et al. (2016) as being one of four sustainability approaches that an organization can take. The wind OEM's suppliers are generally smaller companies with less resources but bear large responsibility toward environmental impacts. Identifying stakeholders as a theme in this thesis as a factor influencing sustainability decisions is thus a positive finding. Actions are not truly sustainable if the company is only implementing sustainability value for only the customer (Scheltegger et al., 2016). Ultimately, a key foundation of sustainability is considering stakeholders beyond shareholders, thus not including stakeholder considerations could invalidate sustainability claims.

Environmental impact was an expected code identified prior to conducting the coding process, however it did not emerge as a common theme.

Sustainability reporting has a record of not disclosing the negative environmental impacts completely due to the threat of jeopardizing the company's reputation (Hahn & Lülfs, 2014). Eighteen out of the 22 companies included in the final analysis are publicly traded meaning the company's reputation is important. It is known that sustainability reporting can be a way to help influence stakeholder's perceptions (Stubbs & Cocklin, 2008). Due to the phenomenon of these reports being overall more positive leaning and that most of the environmental impact is coming from the supply chain and not the OEMs directly, this could be a reason this theme did not emerge.

Earlier research suggests that economic factors are more important than other sustainability considerations for wind OEMs (Landeta-Manzano et al., 2018; Zwarteveen et al., 2021), which is consistent with the findings of this thesis that cost and profit are important factors in sustainability decision making. This is expected as the most useful indicator of a firm's performance is profitability (Grant, 2013). Understandably, if any company is not making a profit, it will be a challenge or impossible for social and environmental factors be a focus. For all businesses, profitability is the most useful indicator to discern how the firm is performing, however, pursuing only profit is generally not viable in the long-term as other goals should be prioritized (Grant, 2013).

Innovation and research and development was a common theme for OEMs to answer both research questions. Nawaz & Koç (2019) found innovation to be a sustainable business approach, as indicated in Table 1. This focus could be due to these OEMs trying to find ways for their product to stand out among the competition as a competitive advantage because the market is so concentrated. Also, research and development is helping lower the costs of wind energy and finding solutions to challenging design aspects to lower the environmental impact, which further supports ways to distinguish themselves from competitors.

This thesis found sustainability to be at the core of several OEMs' business. This is promising as moving towards sustainability should be integrated fully with the overall business strategy. Franca et al. (2016) have found that no business model that integrates sustainability holistically exists which is in agreement with Nawaz & Koç's (2019) findings that did not identify this as a sustainable business approach. Based on the results, if sustainability really is at the core of the business, then Figure 1 perhaps has evolved from the previous research to have more integration between the traditional business areas and sustainable business areas. Some researchers have the perspective that the organization can only be considered sustainable if social and environmental priorities are not treated like supplemental areas of consideration (Stubbs & Cocklin, 2008). It could be argued that no distinction between the sustainability portion and business portion for some wind OEMs exists, and both are incorporated and integrated as one in the same. This has been predicted by some researchers that non-sustainable business models will become obsolete (Geissdoerfer et al., 2018; Lüdeke-Freund & Dembek, 2017). It appears the wind industry is moving toward this obsolete prediction, if what is said in the reports is being realized in practice.

It is difficult to make a generalization about these wind OEMs from looking at the codes that emerged, because statements for all the companies in Table 3 could not be found. This thesis was looking at the wind turbine OEMs all equally when the market is very concentrated with a few wind OEMs. However, a broad generalization is not a disadvantage, as contingency theory states that there is not one best way to conduct business as this depends on a firm's specific circumstances, like environmental factors (Grant, 2013). However, a few of the OEMs stated they are committed to continuous improvement, which is promising for sustainability. As stated earlier in this thesis, sustainability in practice is difficult to measure but measuring improvements over time is more feasible. Enercon (2021), General Electric (2021), and Nordex (2021) have pledged to continuously improve their sustainability efforts. This means these companies are looking to continuously improve recyclability of the turbines, improve the environmental footprint, and lower the cost of renewable energy.

To continuously improve, stakeholder involvement is important, but also collaboration between the wind OEMs could potentially help find solutions to challenges. This thesis found that some OEMs have their own internal initiatives to solve similar challenges like blade waste, but limited information was found about collaboration between OEMs. If wind OEMs collaborated on these challenging issues, perhaps this would accelerate finding solutions and lead to continuous improvement of reducing the environmental footprint. The best alternative is these companies be transparent about environmental challenges with wind power so informed decisions can be made about investing in wind power and acting on commitments to continuously improve.

Documentation for analysis did not exist for 36% of the companies, however, publishing a sustainability report does not signify the company is sustainable (Stubbs & Cocklin, 2008). The lack of reporting could be because many of these companies were much smaller like Bornay, Enessere, and TUGE Energi. These reports are resource intensive, especially when following the GRI Standards, and while the company may want to prioritize or does prioritize sustainability, the resources are not available for creating this documentation. Inox Wind (2021) noted that at least in India, because the competition is so high between OEMs, little opportunity exists for smaller companies to enter and compete in the market. Because these companies did not have documentation to be analyzed does not necessarily mean the company does not prioritize sustainability.

However, the lack of sustainability reporting could be due to sustainability not being a priority as the literature has shown environmental factors are not driving wind energy growth in developing countries (Zwarteveen et al., 2021). Companies like China Guodian Corporation, Mapna, RRB Energy Limited, and Windey did not have documentation and are in developing countries. Another possibility is that simply that the documentation could not be located because of language barriers as some websites for the Asian OEMs were primarily not in English, like for Dongfang Electric Corporation. Ultimately, publishing a sustainability report does not directly correspond to the company being sustainable.

5.2 Research results significance

The results of this thesis are significant because insight is gained on the motivations behind wind OEMs' sustainability strategy and shows this industry focuses on the need to make a profit as one of the main drivers. When a company or government wants to support wind energy through purchasing wind energy or issuing subsidies, the understanding should be present that these companies are operating as for-profit businesses and priorities are set according to this premise. This thesis has implications for policy makers who are supporting wind energy because the research has demonstrated that policy makers play a significant role in wind energy's growth, as a literature review found that the most focused on stakeholders in the literature related to wind energy's growth are policymakers (Zwarteveen et al., 2021). Some researchers have questioned if wind energy would have even reached its position as a such a desired renewable energy option and if wind would be financially feasible without the considerable government subsidies and incentives (Welch & Venkateswaran, 2009). Furthermore, Welch and Venkateswaran (2009) have stated that environmental and economic concerns have not been fully balanced with wind energy.

Wind energy is a valuable renewable energy option because it helps society move away from fossil fuels, but the downsides to the environment need to be considered and planned for in the long term. Renewable energy options are usually presented as having zero environmental impact and as clean energy; however, this does not provide the entirety of the situation if other life cycle stages are considered beyond the operation (Savino et al., 2017). The wind OEMs play a significant role in mitigating environmental impacts and addressing these impacts in the long term is accomplished through the company's strategy and sustainability strategy, as strategy directs what the firm will become in the future (Grant, 2013). For offshore wind, the unknowns of this technology should also be recognized as society could be locking into a technology that could have more environmental challenges than onshore wind. If the goal is to reduce greenhouse gas emissions and mitigate climate change, environmental factors need to be considered with a high priority as is profit and economic feasibility.

Wind energy is one tool to help combat climate change, but it will not solve the problem by itself as actions and contributions are needed from other industries, actors, governments, and so forth. Governments are making pledges to become carbon neutral, with wind energy as an option, but future investments in wind need financial support and appropriate policy from government (Bórawski et al., 2019). The larger question should be considered in general that even though these environmental challenges are recognized, it is not enough to consider the benefits outweighing the costs, because this results in an unsustainable basic design (Broman and Robèrt, 2017). The increase in availability of wind power could also lead to growth in electricity demand, as customers could perceive wind power as not having environmental impacts. This has been seen in the trade industry, where any gains in efficiency from technological advances have been cancelled out by growth in demand (Wiedmann, 2016). As Broman and Robèrt (2017) stated, nature should not be expecting increasing concentrations of substances produced by society if we want a truly sustainable society, and currently no wind OEM appears to be meeting this guideline.

5.3 Research limitations and future research

This thesis has research limitations due to only including the most current documentation available and not exploring the company history in depth. Due to time and resource limitations, comparing the intended strategy and realized strategy was not completed. For example, has the company been meeting and realizing the sustainability strategy goals set forth in the past. Future research could complete a more thorough investigation to confirm the credibility of the sustainability strategies of these companies.

This thesis was looking at the wind turbine OEMs all equally when the market is very concentrated with a few wind OEMs. The fact that this thesis overall had 39 OEMs to start, which then was reduced to 25 with documentation available, and then reduced further to 22 wind OEMs with sustainability documentation to be analyzed, could be viewed as a limitation. However, the top five wind turbine OEMs held 57% of the market share in 2020 which included Vestas, Goldwind, General Electric, Envision, and Siemens Gamesa (Wood Mackenzie, 2021), all had documentation that was analyzed in this thesis. If the Chinese OEMs are excluded from the global top 5, this leaves 92% of the market share to Vestas, General Electric, Siemens Gamesa, Nordex and Enercon, with Vestas holding 32% as the overall largest wind turbine OEM in the world in 2020 (Wood Mackenzie, 2021). Because the market is so concentrated, future research could focus on the top market holders.

In fact, the original plan for this thesis was to conduct semi-structured interviews to collect qualitative data with companies that are expected to hold most of the market. Interviews were the researcher’s first choice because the most common way to gather information for qualitative research is through interviews or observations (Lichtman, 2014) and the interview could provide new insight not in the publicly available reports. Invitations for interviews were sent in October of 2021. Two companies denied the interview and one company did not respond. The reason for denying the interviews was that all the information they could provide was on their website and time was not available. The companies approached are located within the European Union and United States. As these companies hold a majority of the market, it was important to have them agree to the interviews. To note, this study was conducted during the coronavirus pandemic, which has strained business resources and many reports reviewed in this thesis cited the coronavirus pandemic as affecting their business operations.

Thus, reluctance to participate due to time and resource constraints is understandable. Since the interview approach was not successful and due to time limitations, the approach of this study changed to analyzing the publicly available secondary data through sustainability reports. Further research could conduct these interviews to build upon this thesis to gain more information on sustainability strategy development.

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APPENDIX 1 CODING FRAMEWORK

			How do wind OEMs describe their sustainability performance?							What factors influence wind OEMs sustainability decisions?														
	Company+	Headquarter's location	Core value	Innovative	Market leader	Forward looking	CO_2 avoided	Less environmental impact	Providing benefit for local society	Cost/profit	Board or top management	Risk Management	Stakeholders	Investors	Customers	Sustainable growth	Employees	R&D/ innovation	Collaboration / supply chain	Good business decision/ competive advantage	CSR reporting required by law	Country decarbinzation goals	Carbon neutrality
Asia	Doosan	South Korea	✓	✓		✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				
	Elecon Engineering	India							✓	✓	✓									✓	✓		
	Envision	China		✓	✓	✓	✓	✓										✓	✓				✓
	Goldwind	China	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	
	Hitachi	Japan	✓	✓				✓			✓		✓					✓	✓		✓	✓	✓
	Hyosung	South Korea				✓		✓			✓	✓	✓		✓	✓		✓	✓				
	Inox Wind	India		✓	✓					✓		✓	✓										
	Japan Steel Works	Japan						✓	✓		✓										✓		
	MingYang	China	✓		✓				✓														
	Mitsubishi Heavy Industries	Japan		✓				✓		✓	✓	✓	✓	✓		✓			✓				
	SANY	China		✓						✓	✓	✓	✓	✓				✓				✓	
	Shanghai Electric	China	✓	✓	✓				✓		✓	✓	✓		✓		✓		✓			✓	
	Sinovel	China		✓	✓											✓	✓	✓			✓		
	Suzlon	India	✓		✓	✓			✓	✓	✓	✓	✓	✓	✓			✓	✓	✓		✓	
	TECO	Taiwan	✓	✓	✓						✓	✓	✓					✓	✓				✓
Europe	Enercon	Germany	✓	✓				✓		✓	✓		✓			✓		✓	✓			✓	
	Končar	Croatia	✓						✓		✓	✓	✓						✓			✓	
	Nordex	Germany	✓					✓		✓	✓	✓	✓	✓	✓			✓	✓	✓			
	Siemens Gamesa	Spain		✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓		✓	✓				✓
	Vestas	Denmark	✓	✓	✓	✓	✓	✓			✓		✓				✓	✓	✓		✓	✓	✓
N.A.	General Electric	United States	✓	✓	✓	✓		✓		✓	✓	✓					✓	✓		✓			
S.A.	WEG	Brazil		✓				✓			✓	✓	✓	✓	✓	✓	✓	✓		✓			

Note to table: ✓ = yes
N.A. = North America
S.A. = South America
+ CSIC (HZ Wind Power) has sustainability report but it cannot be found in English; CRRC, World Wind, and Vergnet did not address sustainability

APPENDIX 2 TOP MATERIALITY AREAS IDENTIFIED

Company	Headquarter's location	Page number(s) of materiality assessment	Number of areas identified	Top materiality topics identfied		
				#1	#2	#3
Doosan	South Korea	71	38	Secure future growth engines (R&D investments)	Attraction of key talents and enhancement of employee competencies	Organizational culture (human resource development/human rights/safety)
Goldwind	China	1	40	R&D and innovation	Wind turbine quality	Response to climate change
Hitachi	Japan	13-15	24	Social innovations using digital technologies and AI	Creating value through co-creation with customer	Response to climate change
Hyosung	South Korea	101	53	Occupational safety and health	Product responsibility and safety	Customer relationship management and maximzing customer satisfaction
Končar	Croatia	17	11	Economic performance	Training and education	Employees or occupational health and safety
Mitsubishi Heavy Industries	Japan	12-15	37	Provide energy solutions to enable a carbon neutral world	Transform society through AI and digitalization	Build a safer and more secure world
Nordex	Germany	19-20	17	Environmental behavior of the group	Environmental footprint of wind power systems	Heath and safety
SANY	China	14-15	24	Technological innovation	Customer service and satisfaction	Protection of employee rights
Shanghai Electric	China	31	31	Trends of industry	Use of energy	Technology and innovation
Siemens Gamesa	Spain	78-80	25	Health and safety	Climate action	Responsible procurement or ethics, integrity, anticorruption
Suzlon	India	38-39	22	Economic performance	Occupational health and safety	Environmental compliance
TECO	Taiwan	15-16	10	Product stewardship	Climate change risks and opportunities	Economic and financial performance
WEG	Brazil	10	18	Ethics and integrity	Innovation and technology	Corporate governance, product compliance, relations with customers
Vestas	Denmark	11	21	Materials efficiency, sourcing, and disposal	Emissions and climate change strategy	Waste management