Sustainable energy mix by strategy development and risk management in heavy industry

Author: Jens Hüttebräucker

A thesis submitted in partial fulfilment of the requirements of Sheffield Hallam University for the degree of

Doctor of Business Administration (DBA)

September 2024

CANDIDATE DECLARATION

I hereby declare that

1. I have not been enrolled for another award of the University, or other academic or professional organisation, whilst undertaking my research degree.

2. None of the material contained in the thesis has been used in any other submission for an academic award.

3. I am aware of and understand the University's policy on plagiarism and certify that this thesis is my own work. The use of all published or other sources of material consulted have been properly and fully acknowledged.

4. The work undertaken towards the thesis has been conducted in accordance with the SHU Principles of Integrity in Research and the SHU Research Ethics Policy.

5. The word count of the thesis is 76,094.

Name	Jens Hüttebräucker
Award	Doctor of Business Administration (DBA)
Date of Submission	September 2024
Faculty	Sheffield Business School
Director(s) of Studies	Professor Lucy Zheng Professor Heiko Seif

ACKNOWLEDGMENTS

First, I wish to start by saying that this research would not be possible without the uncompromising support of many people.
For reasons of privacy and data protection, I do not even know who supported me in person by taking part in the survey!
These people have put a lot of time into this research and have contributed their knowledge to this thesis. I truly appreciate your support and kindness, as I know that this is a significant effort for everybody.

I want to express my deepest appreciation to everyone who supported me throughout the challenging journey of this research.

I am immensely grateful to my Director of Studies and my Second Supervisor for their invaluable guidance, constructive criticism, and inspiring discussions. Their expertise and dedication have been a constant source of encouragement and learning.

A special thanks to my colleagues and friends who provided moral support and shared their wisdom with me. Your camaraderie and support have been instrumental in overcoming the obstacles I faced during this journey.

I am forever indebted to my family, particularly my children, whose unwavering belief in my capabilities gave me the strength to persevere. The sacrifices you have made to allow me to concentrate on this research did not go unnoticed.

There were many struggles and challenges that came across this research, but each one has taught me resilience, patience, and the value of hard work. Each hurdle I overcame brought me one step closer to my goal, transforming this journey into an experience that has enriched me both professionally and personally.

ABSTRACT

Changing the energy mix within energy-intensive industries has significant policy implications for risk management, transformation processes, and strategy development. This study, which was based on a mixed method approach and included both qualitative and quantitative primary data, provides critical insights into the transformation of heavy industries from the exclusive use of fossil fuels towards a more sustainable energy mix. By incorporating perspectives of strategy development and risk management, this research presents an untapped viewpoint in the existing literature. The key contributions of this study stem from the empirical examination of the strategic development processes and risk management practices in heavy industries during their shift to sustainable energy sources. This study makes a significant contribution to the identification and management of risks associated with this transition process are pivotal in shaping the strategic pathways adopted by these industries. The research findings suggest that the effective orchestration of transformation processes is contingent upon the integration of strategic development and risk management. The employed integrated approach enables industries to mitigate potential adversities and leverage opportunities presented by the shift to renewable energy sources. Additionally, the study highlights significant implications for government policymakers. It emphasizes the need for supportive policies and regulations that foster an enabling environment for the transition towards sustainable energy use. Policymakers should consider both the opportunities and risks associated with the energy transition and to determine how their policies can help manage these risks and drive strategic development in heavy industries. In conclusion, this research offers valuable insights to industrial practitioners and government policymakers alike, fostering a more comprehensive understanding of the transition to a sustainable energy mix in the context of heavy industries. The findings provide a foundation for further research and practical implementation in the realm of sustainable energy transitions, strategy development, and risk management.

Keywords: *RES, Renewable Energy, Strategy development, Transformation process, Risk management, Policy; Sustainability; SmartPLS; SDG; WBCSD*

TABLE OF CONTENTS

TABLE OF FIGURES

ABBREVIATIONS

5Ds ______________ Decarbonizing, Democracy, Digitization, Diversification, Deliver

ANN____ Artificial Neural Networks

ANOVA ____ Analysis of Variance

ARA____ Adaptation Research Alliance

BCG____ Boston Consulting Group

BHP____ Broken Hill Proprietary

BSC____ Balance Score Card

C ____Celsius

CCS____ Carbon Capture and Storage

CET____ Central European Time

CFA ____ Confirmatory Factor Analysis

CO2____ Carbon Dioxide

COP____ Conference of Parties

CPM ____ Cost Per Mille

CSF____ Critical success factors

CSP____ Concentrating Solar Power

CSR____ Corporate Social Responsibility

DACH ____________________________________(D) Germany (A) Austria (CH) Swiss

DBA_________ Doctor of Business Administration, Doctor of Business Administration

DiD ____ Difference in differences

DRI ____ Direct Reduced Iron

DT ____ Data Triangulation

EAF ____ Electric Arc Furnace

EDA____ European Defence Agency

EFE ____ External Factor Evaluation

EIA____ Energy Information Administration

EU ____ European Union

FSU ____ Former Soviet Union

GA ____ Generic Algorithm

GDP____ Gross domestic product

GHG ____ Green House Gas

GICS __________________________________ Global Industry Classification Standard

GPI — *Genuine Progress Indicator*
GRI — *Global Reporting Initiative*
GSDS — *German Sustainable Development Strategy*
H2S — *Hydrogen Sulfide*
HLPF — *High-level Political Forum on Sustainable Development*
HVDC — *High-voltage direct current*
IEA — *International Energy Agency*
IFE — *Internal Factor Evaluation*
IMD — *Institute for Management Development*
IR — *Integrated Reporting*
IREA — *International Renewable Energy Agency*
ISO — *International Organization for Standardization*
KIIG — *Keep it in the Ground*
KP — *Kyoto Protocol*
KPI — *Key Performance Indicators*
LCOE — *Levelised Cost of Electricity*
LSSIM — *Long-Term Strategic Management System*
MCQ — *Multiple Cjoices Question*
MINLP — *Mixed-Integer Nonlinear Programming*
MMR — *Mixed Method Research*
MOEA — *Multi-Objective Evolutionary Algorithm*
MS — *Microsoft*
MT — *Methodological Triangulation*
NAPA — *National Adaptation Programmes of Action*
NGO — *Non Governmental Organization*
O — *Opportunities*
OECD — *Organization for Economic Co-operation and Development*
PCRC — *Petroleum Cooperative Research Centre*
PESTE — *Politics, Economics, Society, Technologies and Ecology*
PSO — *Particle Swarm Optimization*
Q — *Question*
R&D — *Research and Development*
RES — *Renewable Energy Source*

RS ___ Researcher Triangulation
S ___ Strength
SDG ___ Sustainability Goals, Sustainable Development Goals
SMART ___ Specific, Measurable, Achievable, Reliable and Time-bound
SmartPLS ___ Partial Least Square Methode
SO2 ___ Sulfur Dioxide
SSIM ___ Six-Level Long-Term Strategic System Integration Model
SUPV ___ Supervisor
SUTVA ___ Stable Unit Treatment Value Assumption
SWOT ___ Strength Weakness Opportunity Threats
T ___ Threats
TT ___ Theory-Based Triangulation
UK ___ United Kingdom
UN ___ United Nations
UNFCCC ___ United Nations Framework Convention on Climate Change
US ___ United States
W ___ Weakness
WBCSD ___ World Business Council for Sustainable Development

1 CHAPTER ONE – INTRODUCTION

1.1 Research background

The current Ukrainian-Russian conflict presents numerous challenges not only to the two countries directly involved in the conflict but also to different governments around the world. This war makes the research even more important and timely since it focusses on changing the energy mix that has become an urgent issue/agenda for governments worldwide (Stoddart et al. 2020). They have persistently emphasized the need to move from fossil energy to more renewable sources of energy not only for environmental but also for political and economic reasons (Sovacool et al. 2017).

Over the past few years, a growing body of social science research has explored the complex relationships between energy systems, environmental sustainability, and social inequality and justice (Jenkins et al. 2016). This literature can contribute substantially to an energy future research program. The energy justice literature, for example, is cohering into a vibrant body of work that highlights the social bases of conflicting visions and interests involved in creating energy futures (Sovacool et al. 2017; Stoddart et al. 2020). Energy justice scholarship focuses on the distributional dimension of which groups benefit from or are put at risk for the sake of energy production and distribution. Energy justice scholarship also attends to the procedural dimensions of energy justice, or which social groups and interests are valued or excluded in decision-making about the risks and benefits related to energy development. From this perspective, just energy systems entail the fair distribution of benefits and risks of energy development and involve democratic participation in decision-making by affected communities. These guiding principles can help ensure more politically legitimate and equitable energy futures in response to climate change (Stoddart et al. 2020).

In March 2017, wind and solar accounted for 10 per cent of all US electricity generation for the first time (US Energy Information Administration 2017). Although 10 per cent may not sound high, it reflects a major achievement for both technologies, which have overcome numerous barriers to become competitive with coal, natural gas, and nuclear power. However, the domain of renewable energy sources (RES) still faces major obstacles. Some are inherent with all new technologies; others are the result of a skewed regulatory framework and marketplace (US Energy Information Administration 2017).

Nearly 200 countries in the just concluded COP26 in Glasgow agreed that the Glasgow Climate Pact should keep 1.5^0C alive and finalise the elements of the Paris Agreement (COP26 2021). Climate negotiators engaged in a two-week intense discussion mainly focusing on accelerating climate action. Countries are required to increase action and ambition and combine it with the Glasgow Climate Pact in order to ensure that the 1.5^0C remains achievable, but this can only be done if the whole globe agrees with the idea. Climate action will be sped up by the Glasgow Climate Pact (COP26 2021). Targets for the current emissions were revisited and strengthened by all the countries to 2030. Initially, in 2022, it was known as Nationally Determined Contributions. A political roundtable will be combined yearly with this in order to put into consideration a global progress report and the summit of leaders in 2023 (Haenssgen et al. 2022).

After over six years of discussions, the Paris Rulebook, which contains guidelines on how to deliver the Paris Agreement, was also completed. The Agreement will help to hold into account all the countries as they go about meeting their targets because a transparency process was put in place. Countries should exchange carbon credits through the United Nations Framework Convention on Climate Change according to Article 6 that was included (Haenssgen et al. 2022). Countries and civil societies that are mostly affected by the climatic change impacts were very vocal and agreed to phase down fossil fuels (Smith et al. 2021). Decisions in the COP26 for the first time went into detail in order to address damage and loss after recognising the climate change impacts that include changes in weather patterns, rising sea levels, increases in temperatures, and natural disasters like floods (Smith et al. 2021).

Financial support through the Adaptation Fund was to be increased and developing countries were to be supported by the developed countries which were urged to double their support by 2025. The UK Presidency had undertaken an intense campaign and diplomacy before the COP26 in order to secure action and raise ambition within 200 countries (COP26 2021). The campaign and diplomacy work mainly focused on reducing emissions in order to curb rises in temperature to 1.5^{0}C. In order to reduce gas emissions, mobilisation of both private and public finances was done, and communities were supported for the purpose of adapting to climate change impacts. About two years ago when the UK partnered with Italy and took over the COP26 mantle, net zero targets only covered 30% of the world. That Table has shifted to 90% currently (Wyns & Beagley 2021). Within the same period, national targets have been submitted by 154 parties thus representing 80% of global emissions (Wyns and Beagley 2021). Reduction in emissions has also been hugely championed by the UK Presidency. Unabated coal has been phased out by many countries and coal financing has been ended internationally. There is also a great commitment towards the protection of natural habitats. In this context, 130 countries have pledged to do away with deforestation by 2030 and therefore protecting 90% of the forests (Wyns & Beagley 2021).

Zero emissions of gases by vehicles are also coming up hugely with most car manufacturers targeting new cars that have zero emissions by 2040 in global leading markets. There is also a phase-out of diesel and petrol cars by certain cities and countries. There would be a great increase in global temperatures going by the current policies but with the implementation of these commitments collectively, the Climate Action Tracker used independently by experts shows that the temperature rise could be held at 1.8^{0}C (COP26 2021). Despite all these commitments before and after, individuals would still feel the impacts of climate change. Each country should formulate a national plan which is a crucial step towards managing climate change impacts. National Adaptation covers 80 countries that increase climate risk preparedness (COP26 2021).

The Energy Transition Council mainly brings together key stakeholders in the energy sector in order to provide support in different areas including green grids, energy efficiency, and energy planning, implying that all these categories are integrated. It was agreed that after COP26 ETC will continue until COP30 in 2025. Its future activities would be guided by the Glasgow Power Breakthrough, which contains strategic vision in order to make it reliable and affordable for all countries to access clean power by 2030 (COP26 2021). Areas of engagement that have been prioritised include the process of delivering energy needs by maximising efficiency as well as focusing on reduction in emissions. The transition from fossil fuel and coal by countries has been emphasised, and this is done by providing alternative energy sources. It has been noted that investments in countries with energy demands should increase, as they cannot find the finances from the public alone (COP26 2021). Resources can be shared across a wide geographical area and integrated with renewable energy. Ensuring there is energy efficiency that could reduce greenhouse emissions by 40% in the next 20 years across all sectors is crucial. Distribution of renewable energy across different technologies including mini-grids and lighting systems that are standalone should be further emphasised (Aronova et al., 2008). Lastly, a social dialogue among workers, governments, and private sectors is encouraged in order to come up with decent jobs that are not coal-dependent (COP26 2021).

Most of the countries mainly focus on carbon dioxide, but methane is another greenhouse gas that is also powerful. In recent history, no COP has held a major event on methane but at COP26, most of the countries, over 100 in number, signed the Global Methane Pledge in order to reduce emissions of methane by 30% in 2030 (COP26 2021). The process involved countries like the United States, Brazil, Indonesia, Pakistan, and Argentina, which are six of the largest 10 methane emitters. They emit about 46% of the global methane. The signing of this pledge will ensure that 1.5^0C will be an achievable goal (COP26 2021).

Adaptation Research Alliance (ARA) was launched in the COP26 in Glasgow. ARA comprises actors who are globally adapted in order to provide research on climate change to vulnerable communities. Human activities have always and will continue to cause climatic changes that will affect ecosystems, economies, and societies. Knowledge is required in order to respond to these impacts (COP26 2021). There is, however, insufficiency in action-oriented research caused by under-investment, and disconnection amongst researchers. Developing countries have low capacity and learning experience is limited (COP26 2021). ARA is therefore prepared to offer solutions to these challenges by focusing mostly on the needs of the most vulnerable and taking a keen interest in research as a tool for all stakeholders. ARA advocates that investment should be increased in the Global South, but members and actions of

COP26 are not prevented by geographical boundaries. Learning from worldwide experiences and collaboration internationally are key to finding effective solutions to climate change (COP26 2021).

In considering the implications and results of COP26, it is also significant to understand these outcomes in the context of risk management. Enterprises that are progressing are using Risk Intelligence principles in Enterprise Risk Management frameworks, and it has given them many advantages. In particular, they are capable of managing risks occurring across different units as well as risks of various types (Huang & Kim 2021). Climate change is an important factor that can lead to disruption of an enterprise's activities such as production, procurement, and commodity trading. Most risk factors are driven by climate change, for example, when regulations are enacted. Price risk becomes a significant factor since most of the companies must be in the carbon market creating a correlation between regulation risk and carbon price risk (Haenssgen et al. 2022). Similar physical events can drive both volume risks and physical operation risks. The highest level of the company should therefore be responsible for considering and identifying these risks (Nersesian & McManus, 2020). Strategic risk is mostly caused by technology, price, physical operations, and regulatory risks. All these risks should be put into consideration when making decisions about the company (Nersesian & McManus 2020).

In the energy sector, risk is multi-dimensional depending on different stakeholder perspectives. Risk can be statistical and non-statistical whereby statistical risk can be measured by mathematical models while non-statistical cannot be modelled with the existing knowledge (Chakabva et al. 2021). Sustainable energy risks are associated with technology, regulations, and countries but can vary depending on the perspective of the stakeholder (Nersesian & McManus 2020). Stakeholders that play a key role in renewable energy include insurers, project investors, manufacturers, consumers, policymakers, and communities. All these stakeholders have different objectives and concerns with renewable energy investment. Therefore, there is a variation in risk importance across these different groups (Nersesian & McManus 2020).

Project developers are mainly concerned with making returns on investment through sales to the investor. Investors, on the other hand, are keen to minimise technical reliability risks, disruption of revenue risks, and costs (Wang et al. 2019). Policymakers are concerned with designing efficient and effective policies that allow the government to meet its targets. The analysis of different risk factors that include political, technological, environmental and social factors, plays a significant role in helping stakeholders to be on the same page when making decisions, as they can understand which of these can be avoided, transferred, accepted and mitigated (Wang et al. 2019).

Risks can be measured and assessed by considering their source, the magnitude of their effects, whether negative or positive, and how likely certain consequences can reoccur. Controls that already exist are considered as well. It is expensive and time-consuming to quantify risk. In order to prioritise all the risks identified through impact and likelihood, a qualitative assessment should be applied (Darwish et al. 2021). A detailed quantitative analysis would only be used for all those risks that are considered significant (Wang et al. 2019). Risk treatment strategies that are cost-effective are the ones employed by companies when responding to risks. A risk response strategy should be devised only after the consequences and risk factors have been understood fully (Mills et al. 2003). Most companies can become complacent and think that risk cannot be prevented from occurring, but in a real sense, companies have control over the impacts of risk with how they prepare. Relocation of facilities to areas that have not been affected, risk transfer to parties that can accept and mitigate them and strengthening its ability to recover, are ways that can be used to respond to risks (Deb et al. 2021). Strategies for risk response can be devised through real-option analysis where the effects of risks are forecasted by the company before they occur (Wang et al. 2019).

However, it should also be noted that there are some disadvantages of using RES, such as high start-up costs (Larsen & Gunnarsson-Ostling 2009). For example, the utilisation of RES requires additional advanced investments and the cost of implementing these measures can be very expensive (Montgomery & Smith 2000). The most obvious and widely quoted barrier to renewable energy is cost, especially, capital costs, or the upfront expense of building and implementing renewable energy systems. Another point is finding the location for RES and the transmission of renewable energy (Larsen & Gunnarsson-Ostling 2009). On the one hand, sitting is the need to locate things like wind turbines or solar farms on pieces of land. Doing so requires negotiations, contracts, permits, and community relations, all of which can increase costs and delay or even kill projects (Larsen & Gunnarsson-Ostling 2009).

On the other hand, transmission refers to the power lines and infrastructure needed to move electricity from where it is generated to where it is consumed. Additionally, market entry is a challenge as well-established existing technologies present competition or a formidable barrier for renewable energy (Nemzer et al. 2010). Solar, wind, and other renewable resources need to compete with wealthier industries that benefit from existing infrastructure, expertise, and policy (United Nations 2020). For decades, the fossil fuel industry has used its influence to spread its views about man-made climate change, which is a strong motivation for choosing low-carbon energy sources. Some industry leaders knew about the potential risks of global warming as early as the 1970s but recognised that dealing with the issue of potential global warming meant using fewer fossil fuels. They went on to finance and continue to fund their information campaigns aimed at sowing doubt about man-made climate change and the reliability of renewable energy (United Nations, 2020).

Several international natural or man-made disasters like Chernobyl were also meaningful drivers for changes in the way energy is produced. In 1987, the Brundtland Report was published which shaped today's definition of sustainability, "Sustainable development is development, that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts:

• The concept of 'needs', in particular, the essential needs of the world's poor, to which overriding priority should be given; and

• The idea of limitations imposed by the state of technology and social organisation on the environment's ability to meet present and future needs" (United Nations 1987).

The report aimed to set the course for sustainable development of the economy, society, and the environment. Based on the Brundtland Report, the UN developed

Agenda 21 for global sustainable development at the 1992 UN Conference on Environment and Development in Rio de Janeiro. In line with this strategic development, the Treaty of Amsterdam in 1997 created the model of the three pillars of sustainability developed by the EU (European Union Law, n. d.).

A transformation process is an activity that takes one or more inputs and adds value to them by transforming them. Different types of input can be transformed by the same organization. These inputs can include (raw)materials, information and customers. The transformation process includes the following components:

- "Changes in the physical characteristics of materials or customers
- changes in the location of materials, information or customers
- changes in the ownership of materials or information
- storage or accommodation of materials, information or customers
- changes in the purpose or form of information
- changes in the physiological or psychological state of customers." (The Open University, 2020)

A transformation process can also be used to change an organization or company. Then the transformation process can be split up into leadership, design and development processes to achieve the desired change. (Allen 2015)

Organizational and management approaches to climate change suffer from several limitations. (Wittneben et al. 2012) Most corporate responses to climate change are focused on voluntary measures or increasing efficiencies in the supply chain rather than a commitment to any mandatory emissions reduction targets or developing new businesses. (Wittneben et al. 2012). Thus, business responses to climate change, whether they are framed as 'strategic' or as a firm's corporate social responsibility, remain focused on 'win-win' solutions that must generate financial benefits for firms. (Wittneben et al. 2012) To achieve this, transition management is necessary. Transition management conceptually can be described as a cyclical and iterative process.

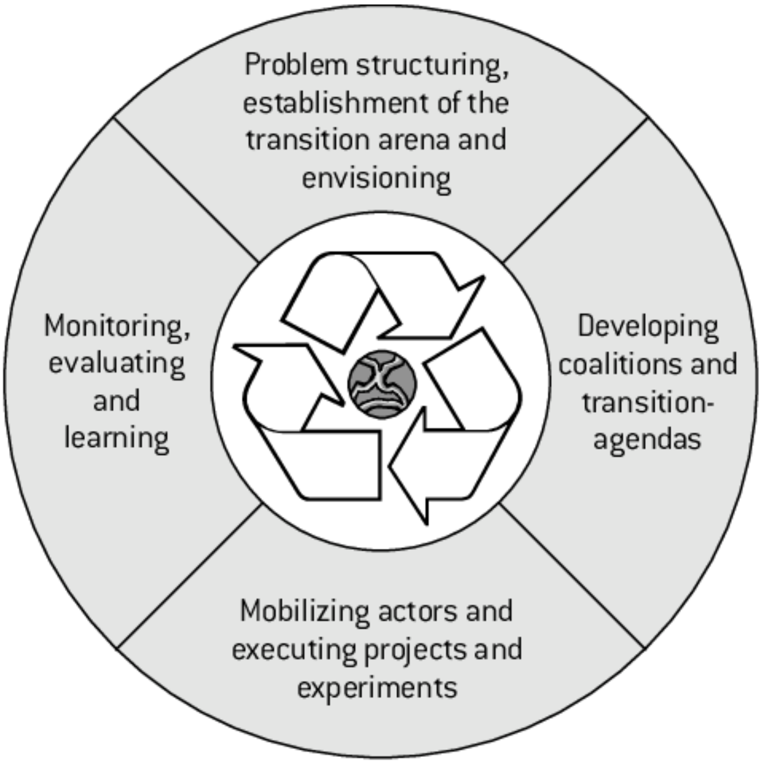

Figure 1 Activity cycle in transition management
Source: (Loorbach and Rotmans 2006: 11)

The art for any transition management project is to recognize, which context prevails at any point in time and space, and which drivers offer the best leverage for guiding change in a desirable direction at that point. Transition contexts can be mapped using the two dimensions of change.

The first dimension measures whether the change is envisaged and actively coordinated in response to prevailing selection pressures, or whether it is the emergent outcome of normal behaviour. This dimension seeks to distinguish between transformations that are essentially intended and deliberate and those that are the unintended and contingent outcomes of historical processes (Kansongue et al. 2022). An intended transformation would be guided by influential actors or by overarching networks of governance arriving at a common diagnosis concerning shortcomings. This apparently says nothing about the desirability of the intended measures, objectives, or outcomes.

The second dimension concerns the degree to which the response to selection pressure is based on resources available or depends upon capabilities that are only available from outside. If the resources required for transition are available internally, then change is likely to be more incremental and structural relationships within the regime are less likely to be overturned. If the capacity to adapt is highly constrained by the lack of resources internally, then the likelihood of major structural change increases (Smith et al. 2021).

The key elements of transition management are as follows:

- Systems-thinking in terms of more than one domain (multi-domain) and different actors (multi-actor) at different scale levels (multilevel); analysing how developments in one domain or level influence developments in other domains or levels; trying to change the strategic orientation of regime actors.
- Long-term thinking (at least 25 years) as a framework for shaping short-term policy.
- Back- and fore-casting: the setting of short-term and longer-term goals based on long-term sustainability visions, scenario studies, trend analyses and short-term possibilities.
- A focus on learning and the use of a special learning philosophy of learning by doing and doing by learning.
- An orientation towards system innovation and experimentation.
- Participation from and interaction between stakeholders (Loorbach & Rothmans 2006).

The process of change in transitions is highly non-linear: slow change is followed by rapid change when things reinforce each other, which again is followed by a slow change in the new equilibrium. The underlying mechanism is that of co-evolution because different subsystems coevolve with each other, leading to irreversible patterns of change. There are multiple shapes a transition can take, but the common shape is that of a sigmoid curve at the most aggregated level (Loorbach & Rothmans 2006).

Although each transition is unique in terms of content and context, one may distinguish between two types of transitions:

- Evolutionary transitions, in which the outcome is not planned in a significant way; and
- goal-oriented (teleological) transitions, in which (diffuse) goals or visions of the end state are guiding public actors and orienting the strategic decisions of private actors (Loorbach & Rothmans 2006).

The legitimate authority to push change through, or the resources available to build consent, or to raise informed dissent, or even to block change, will depend upon power relations across the networks of actors involved. Governance processes provide an arena for debates about how best to 'manage' or modulate regime transformation for sustainable development (Smith et al. 2021).

Management innovation as a multidimensional construct comprises:

- a strategic dimension, which describes new development and competition strategies, including innovation, technological (new products/services), new business models, innovation sources.
- a structural dimension, determining the scope for the implementation of new solutions in an organisational structure, providing flexibility and adaptiveness to the conditions in which an organisation operates, new structural forms.
- employee motivation and development – the dimension concerning new methods, practices and programmes aimed at boosting employees' motivation and developing their skills and competencies (including their innovative activity)
- inter-organisational relations and partnerships – the dimension describing the development and use of new forms of cooperation with different entities in the environment: suppliers, customers/ consumers, competitors, scientific institutions, etc.; the creation of open innovation models.
- an ICT dimension, which defines the scope and depth of changes implemented in the sphere of acquiring, collecting, processing and transferring information and

knowledge, a new intra- and inter-organisational communication tool.

Each dimension indicates the solutions that are new to an organization and have not been used in its management so far (Kraśnicka et al. 2016).

Apart from these more theoretical thoughts, there remain practical problems especially in Heavy industry. The energy intensity of heavy industry is high, and the production processes also involve high levels of energy since materials like steel are necessary for a variety of produced by this sector. According to some estimates, about 9% of global CO_2 emissions comes from steel production (O'Ryan et al. 2020). Steel is mostly produced with cocking coal, and only about 10% of the steel factories use natural gas for a process that is called direct reduced iron (DRI) (WBCSD 2019). An even more environmentally friendly process could be achieved by using hydrogen instead of natural gas in this process. The hydrogen again could be produced by electrolysis that uses electricity from renewable energy sources. The technology is proven and could be easily adopted on a wide scale (Global Green Growth Institute 2017).

Increasing the share of scrap-based electric arc furnace (EAF) steelmaking can substantially increase the electrification rate in the steel-producing industry. EAF is already used for one-quarter of world steel production and further expansion is dependent on the availability of steel scrap at reasonable prices (WBCSD 2019). Problems could arise with the large-scale production of hydrogen from renewable energy sources. Investments in such a production facility would be high especially due to the need for energy storage to ensure continuous production (Kraśnicka et al. 2016). From a management point of view, a transformation process towards producing or using steel produced by DRI would be a voluntary and actively coordinated evolutionary transition. The main problem is in the evaluation and monitoring process, which has the task to achieve a cost-structure, that is competitive.

World Business Council for Sustainable Development (WBCSD) analysed available technologies and potential pathways to achieve the goals of the Paris Agreement in a study (WBCSD 2019). The technologies available today can help to decarbonize the industry. These include the integration of heat pumps for low-temperature heat and solar heat for low- to medium-temperature heat. For long-term decarbonization, particularly of medium- to high-temperature heat, the pathway is less defined (Hadden 2015). Some available options include electro fuels, fuel switching to bioenergy, and the integration of carbon capture and storage or use. Choosing the right solution will depend on several factors, including investment costs and price differentials between conventional and alternative fuels.

Key enablers for the development of low-carbon energy value chains are long-term policy signals like the Paris Agreement and the SDGs, new financing mechanisms, demand for low-carbon goods and services and benefits to society. The private sector needs credible and clear long-term policy signals to provide investment certainty. Economy-wide carbon pricing and the phase-out of fossil fuel subsidies would be necessary (Haris 2011). Financing mechanisms and business models could help overcome the cost barrier. Green bonds can help to finance decarbonization measures, such as energy efficiency in industrial decarbonization projects. Industry has a crucial role to play in advancing technologies that will support sustainable lifestyles and in promoting a shift in aspirations.

The energy transition will also have profound impacts on employment, including job losses in carbon-intensive industries and the development of new jobs in the low-carbon economy (WBCSD 2019).

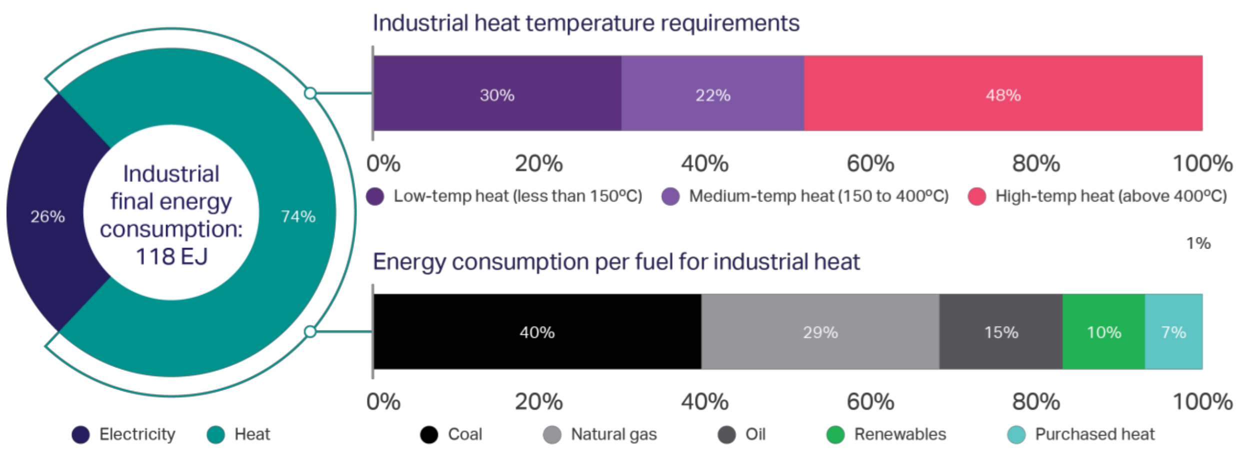

Figure 2 Industrial energy consumption per fuel in 2016 and temperature requirement
Source: WBCSD (2019: 30)

Energy consumption in industry is largely fossil fuel-based, with two-thirds of the energy used for generating heat is from coal, natural gas and oil products. Fossil fuels are used for generating heat at a wide range of temperatures depending on process needs: 30% of industrial heat demand is used for low-temperature applications (below 150°C), 22% for medium temperature (150-400°C) and 48% for high temperature (above 400°C). (WBCSD, 2019)

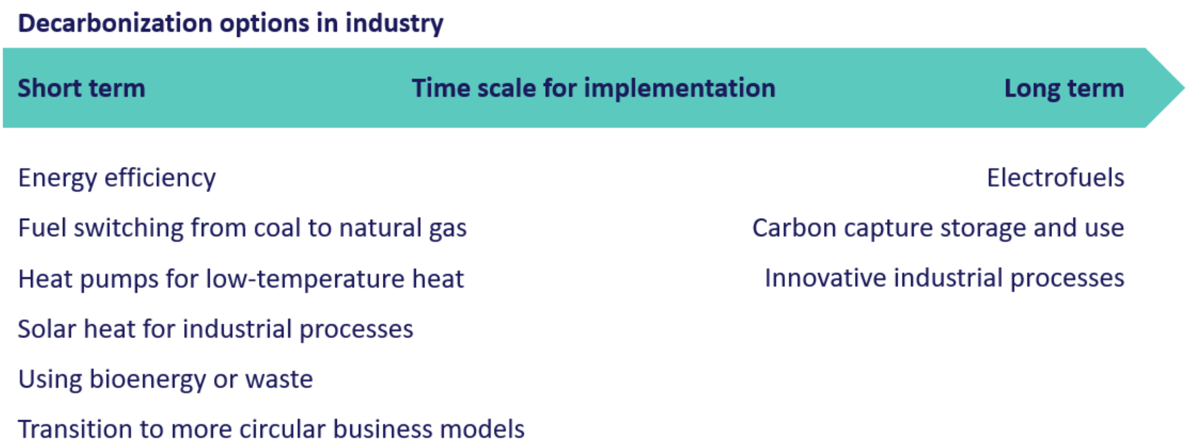

Figure 3 Decarbonization options in industry. Source: WBCSD (2019: 40)

Heavy industry is a very heterogeneous sector and decarbonization solutions for one process may not apply to another to reduce CO_2 emissions. One way to improve energy efficiency is by adopting the best available technologies (BAT) and switching fuels from coal to natural gas (WBCSD 2019). The transition to circular economy business models can also reduce resource consumption and thereby avoid energy use. The electrification of industrial heat demand combined with a decarbonizing of the power supply **is** an important step. Electrically driven heat pumps can help to decarbonize low-temperature heat. An option for low- to medium-temperature heat supply is solar heat, which can provide lower-temperature heat (<120°C). Concentrated solar heat can be used to decarbonize medium-temperature heat. (WBCSD, 2019) For medium- to high-temperature heat, the options differ depending on the industrial process, including the use of electro fuels and the integration of carbon capture and storage (WBCSD 2019).

1.2 Statement of the research problem

With increasing populations, national economies and industries continue to rely heavily on imported fossil fuels (UNEP 2019). One of the main positive impacts of the utilisation of Renewable Energy Sources (RES) in heavy industrial settings is that it will help to reduce a company's carbon footprint and reliance on imported fossil fuels (Hadian 2013). The consumption of fossil fuels has a significant environmental impact. It is the main cause of the increasing levels of emissions of greenhouse gases, such as Carbon Dioxide (CO2) (Hadian 2013). According to the Intergovernmental Panel on Climate Change (IPCC), the combustion of fossil fuels, as well as other industrial processes is responsible for most global CO2 emissions from (IPCC 2007). Globalisation and industrialisation have seen global energy requirements skyrocket, especially in emergent and developing countries (Banos et al. 2011).

Today heavy industries are among the biggest users of energy, and they rely heavily on fossil fuels for their operational processes (UNEP 2019). An estimated 78% of the global greenhouse gas emissions are caused by industrial activities (UNEP 2019). This is expected to increase with the growing industrialisation of many emerging countries. The realization that the supply of fossil fuel resources could be decreasing, as well as the assumption that atmospheric carbon emissions are causing climate change, has increased interest in energy-saving and environmental protection. The reliance on fossil fuels also creates national security vulnerabilities in many countries where fossil fuels are imported (Banos et al. 2011).

An organisation aims to create values. The terms value and benefit are closely linked and therefore very individual when in doubt. An added value can be achieved by adding value. Value creation is therefore not limited to an organization or company. In addition to economically measurable values, social values can also arise. Both are interdependent. Economic values can be of a physical nature or can be assigned to a non-physically measurable, intangible value (Haller 2016). While intangible values can usually be recorded in financially measurable orders of magnitude and usually include patents, licenses, intellectual property and research or developments, a clear demarcation of the intangible values according to the social value approach is more difficult. Cultural achievements and traditions can fall into this category (Haller 2016).

Another category of values, which is primarily to be assigned to the social sphere, are ethical and moral values. These include, among other things, religious and ideological values (Hajer & Pelzer 2018). In some cases, this category of values has economic relevance for the financial markets (Haller 2016). The different value categories are strongly interrelated and interdependent. Relationships between economic and social values tend to become closer, as awareness of the connections between economy and ecology has increased. It should be borne in mind that, for example, intangible or social values are often of particular relevance to the target group of NGOs. A company can create value for itself and others. The term “other” includes the (most important) stakeholders of the company but should also include society as a whole (Haller 2016).

Since energy is associated with economic development, it is important to consider in this context the 2030 Agenda for Sustainable Development. This is because more and more companies have recognised the importance of achieving greater sustainability through the energy mix (United Nations 2020). In a publication by the United Nations (2020), the focus is on identifying specific pathways to sustainable energy. It has been identified that such pathways are mostly related to accelerating the process of energy transition. The presence of sustainable production and consumption patterns is an inseparable part of such an ongoing transition (United Nations 2020).
It has been noted that energy-intensive industry sectors are expected to reach their climate neutrality goals by 2050. In focusing on the decarbonisation of such industries, experts in the field referred to the crucial role of technology that can facilitate the respective process (De Bruyn et al. 2020). Nevertheless, it has been pointed out that competitiveness has emerged as a problematic issue for energy-intensive industries. In the decarbonisation of the global economy, the emphasis is on delivering products with significantly reduced emissions. Despite the progress made in this field, missing infrastructure and inappropriate regulatory frameworks have been found challenging (De Bruyn et al. 2020). Thus, it has been argued that governments should demonstrate a more proactive attitude to establishing clear and effective rules for the use of sustainable renewable electricity sources.

In order to address the increasing energy demand and limit the environmental impact, (Lu et al. 2020: 4) emphasised that governments should develop a wide range of sustainable energy policies that promote the use of renewable energy sources. The role of technological innovations has been adequately recognised. The development of an effective database system and information-sharing transparency tends to be crucial in helping governments achieve their sustainability objectives (Lu et al. 2020).

Considering that the focus of companies operating in heavy industries is to reach zero emissions, this might be problematic to a certain extent. It has been noted that the distinct structure of heavy industries means that they both facilitate and impede the transition to more sustainable energy systems (IEA 2020). These sectors will obviously present numerous benefits associated with the transition to sustainable energy systems. However, more research is needed to determine the impact of such a transition. The available research on the topic has some gaps in terms of failing to recognise the complex and dynamic nature of heavy industries.

The existing knowledge of sustainability in heavy industries is fragmentary (Han et al. 2021; Johnson et al. 2021; Naimoli & Ladislaw 2020; Xu & Chen 2021; Xu & Lin 2020.).

Nevertheless, the relevance of this here presented research can therefore be summarized as follows. First, there is high economic pressure concerning heavy industries on a global level (Napp et al. 2014). But especially EU countries with a high average share of industry like manufacturing in gross domestic product have weathered the financial, banking and debt crisis better than countries with an above-average service sector (Elavarasan et al. 2020). The main reasons for this are the continued strong demand from emerging markets, particularly China, for high-quality industrial products and export successes in the EU single market. Furthermore, it has been shown that industrial research, development and innovation in Europe can only be successful if there is also industrial production here, thus ensuring the necessary close feedback between the two areas. In this context, a new discussion on the topic of industrial policy has emerged in Europe and the USA. The question is how this trend of a declining industrial share can be stopped and possibly reversed – also by avoiding emissions. This is a response to the previous period in which the industrial shrinking process was seen as an inevitable consequence of globalisation (Bataille 2020; Hanisch et al. 2022).

A second argument is that emerging renewable energy markets are increasingly taking over the production of physical goods, while the old, industrialised countries are concentrating on value-added service sectors such as research and development, engineering, marketing, finance, and other sectors. The last two decades have been characterised by a liberal view of state economic policy (Elavarasan et al. 2020). Accordingly, the state should limit itself to setting business-friendly framework conditions, such as a low tax burden, easier access to corporate financing and the provision of an efficient infrastructure (Ofélia edt al. 2024; Hu et al. 2024).

In fact, experience has shown that state measures to support unprofitable production or to promote 'national champions' often ended in costly failures (Hanisch et al. 2022; Ofélia edt al. 2024). At the European level, this liberal model was supported by increasing economic integration within the framework of today's European Union. The creation of a single European market by implementing the four freedoms such as the movement of people, goods, services and capital and the increasingly strict application of the rules against unlawful state aid have increasingly limited the scope for traditional industrial policy measures. Industrial policy ultimately became location policy. The aim was to make the business location as attractive as possible for companies already operating in a country and for potential foreign investors by creating favourable framework conditions. In this view, industrial policy is a 'horizontal' approach, a cross-cutting issue that encompasses practically all economically relevant policy areas (Ofélia edt al. 2024).

The discussion of industrial policy making triggered by the current crises as presented by economic decline and climate change is not moving in the direction of a return to old concepts but rather how to enable intelligent strategy making in favour of more sustainable ways to design energy strategies. The so called Green new Deal, the promising energy policy package of the EU is part of that debate (Hanisch et al. 2022). However, the explicit aim of strengthening Europe's industrial base requires a change in priorities, a more differentiated assessment of some economic policy principles and instruments and above all a willingness to engage in more economic policy coordination and cooperation at the European level. (Ofélia edt al. 2024).

Heavy industries have several distinctive features that distinguish them from other sectors, such as capital intensity, technological advancements, the reliance on complex global supply chains, environmental regulations, the cyclical nature of market supply and demand, and significant workforce demand (Han et al. 2021; Johnson et al. 2021). These factors have substantial implications for the achievement of energy mix. In particular, since heavy sectors are simultaneously characterized by high energy and capital intensity, transitioning to sustainable energy systems requires overcoming major economic barriers and complexities revolving around the transformation of energy-intensive processes. Furthermore, purchasing and installing energy infrastructure to power large facilities might require significant investments, something that can be hard to secure given the questionable return on investment (ROI) of some of these projects (Johnson et al. 2021). Other reasons explaining the unique challenges faced by companies operating in heavy industries include global supply chain dependencies, long lifecycles of industrial infrastructure, and economic competitiveness (Fantke et al. 2021; Hossain et al. 2020).

Heavy industries comprise multiple organizations with a series of specific features in terms of organizational culture, organizational structure, operational processes, scope, and sustainability initiatives (Han et al. 2021; Johnson et al. 2021; Xu & Chen, 2021). The available evidence provides a compelling reason to believe that carrying out an analysis of the link between sustainable energy mix, strategy development, and risk management in heavy industries at the firm level would not allow for capturing a full spectrum of the challenges faced by companies that are implementing sustainable energy mix transition strategies and the particular tools that they apply. In contrast, an examination of this problem at the macro-environmental level can be instrumental in advancing scientific knowledge of the barriers and enablers to reducing emissions in heavy industries. The choice of a macro-environmental level in this DBA is based on the author’s attempt to identify the universal factors characterizing the development and implementation of sustainability initiatives in the selected sector. Such an analysis has the potential to produce valuable insights into the strategies that can be adopted by companies operating in heavy industries to facilitate the adoption of a sustainable energy mix through appropriate risk management and strategy development but also to provide practical recommendations for policymakers on how to support the transition to sustainable energy systems.

1.3 Research question

Industrial companies are discussing a shift to an energy mix, that would utilise a bigger share of Renewable Energy Sources (RES). This could help to reduce a company's carbon footprint and reliance on imported fossil fuels (Hadian 2013). As mentioned above, there are some economic and operational disadvantages of using RES, such as high start-up costs (Larsen & Gunnarsson-Ostling 2009). For example, the utilisation of RES requires additional advanced investments and the cost of implementing these measures can be very expensive (Hadian 2013). This can be a challenge for risk management and requires the development of a new energy strategy.

The transformation of energy-intensive industries from using fossil fuel alone to a more sustainable energy mix has not been analysed in literature from the point of view of strategy development and risk management. In the scientific literature, a gap in describing this transformation process can be identified. The process of strategy development and risk management has also not been described so far and will be examined in this study.

Traditional climate policy is in danger of failing because it creates a contradiction between climate protection and prosperity. We can achieve the climate targets with a traditional climate policy, but the necessary carbon price will be so high that it will lead to company bankruptcies and job losses (Raihan et al. 2024; Hu et al. 2024). This contradiction will divide society, and politicians will ultimately have to backtrack. The result of such a policy is ultimately disappointing for everyone. The climate targets are missed, and industry has migrated to non-European countries. Traditional climate policy is basically also sound, but it falls short and therefore runs the risk of failure (Raihan et al. 2024). It falls short because it overestimates the steering effect of carbon pricing and unnecessarily restricts the options for political action Raihan et al. 2024). Specifically, the empirical literature has shown that the steering effect of a carbon price is low in the area that is particularly important for a successful transformation. Investments in climate-friendly future technologies to create climate-neutral technological progress. This disadvantage of a carbon price is not surprising in theory and cannot be offset by research funding alone (Ofélia edt al. 2024; Raihan et al. 2024; Liu et al. 2024; Bataille 2020).

There are two main points to this understanding. First, sustainable energy infrastructure policy for heavy industries is an original task of the modern state, which must be taken over by the public sector and cannot be privatised. Secondly, the modern state pursues strategic industrial policy to create planning security and to specifically promote investment in climate-friendly future technologies. In addition, the modern state strengthens the demand for climate-friendly future technologies by aligning its own activities with ecological criteria and using such criteria in public tenders (Hu et al. 2024). Secondly, the modern state pursues strategic industrial policy to create planning security and to specifically promote investment in climate-friendly future technologies. For example, the state can accelerate the transformation of industry and at the same time strengthen the demand for hydrogen through corresponding contracts for difference or climate protection (Elavarasan et al. 2020; Hu et al. 2024).

The state has, without question, the main competencies in setting new rules for more sustainable energy mixes. Most literature leaves the question of risk management open. Since heavy industries can be described as an inter-knitted system with its own rules, policy making and heavy industries need to work closer together to develop the means for energy policies that aim for more sustainable energy mixes in heavy industries. Therefore, it is vital to understand ways of common strategy building.

With this background, the overarching research question underlying the study is therefore as follows:

What are the challenges for strategy development and risk management to achieve a sustainable energy mix in a heavy industry setting?

As stated above, the study focuses on a macro-environmental level of analysis and seeks to uncover universal regularities inherent to the transition towards a sustainable energy mix. The inquiry into the main research question is guided by three focus research questions, namely:

Research question 1: What are the barriers to the strategic implementation of renewable energy systems in heavy industrial settings?

Research question 2: Which management strategies can be developed to transform the energy mix in a heavy energy-consuming industrial company?

Research question 3: What are the challenges for risk management and expectation management in this process?

1.4 Research aim and objective

1.4.1 Research aim

This study aims to identify the main challenges of the transformative potential of changing the energy mix of an industrial company with high energy consumption to a greater share of renewable energy and how this supports the acceleration of the transition of the company into a more sustainable business model. This research will also investigate the risk management necessary for this transition.
Therefore, considering the above, this study seeks to investigate to what extent the strategic implementation of renewable energies in an industrial setting is feasible. The strategy development and risk management to achieve a more sustainable energy mix will be analysed. The expectation management will also be covered in this thesis.

1.4.2 Research objective

The inquiry in this research is based on three main objectives, which are as follows:

- To identify the challenges related to the implementation of renewable energy systems in heavy industrial settings.
- To critically analyse the use of effective management strategies to transform the energy mix in heavy industrial settings.
- To discuss the challenges associated with risk management and expectation management during the transition to sustainable energy systems in heavy industries.

1.5 Significance of the study

Energy has been at the heart of European integration from its beginning, with the 1951 European Coal and Steel Community and the 1957 Euratom Treaties, which provided for a common policy with specific energy tools based on supranational powers vested in a European authority. After this initial push, half a century was lost until 2007 when the European Heads of State and Government set three energy-climate targets to be reached by a European energy policy. Seeing the benefits of a successful European energy policy for all Europeans, Jacques Delors called for the establishment of a "European Energy Community". His idea was renamed "Energy Union" in 2014 by the then Polish Prime Minister Donald Tusk, and by the then-candidate for President of the European Commission, Jean-Claude Juncker. To contribute to the debate on the substance of this Energy Union, the Jacques Delors Institute published its report "From the European Energy Community to the Energy Union", which shaped the European Commission's overarching Energy Union Strategy revealed in February 2015 (Delors et al. 2015).

Since then, the European Commission has labelled most of its proposals to transform its project into legally binding decisions. Negotiations are ongoing to reach a "Clean Energy Union Deal" in the year 2018. Achieving such a far-reaching Clean Energy Union Deal is of great relevance for Europe's future. Energy is indeed the cornerstone of any way of life. "We need energy every day to transport people, people must heat their homes and power their appliances" (Delors et al. 2015). It directly impacts the collective and individual daily life. Politically, as several EU Member States favour the use of enhanced cooperation to further European integration in key policy areas such as the Eurozone, Defence and Schengen Area, the EU needs more than ever an emblematic project where progress can be achieved at 27. The Energy Union is one such project which can even impact non-EU countries, such as Ukraine and other members of the Energy Community (Delors et al. 2015).

Today, 75% of the EU energy mix still relies on fossil fuels (oil, gas and coal) that ought to be phased out to reduce greenhouse gas emissions and fight effectively climate change. Over the past decade, a European energy transition has started with European fossil fuel consumption structurally declining since 2006. Two complementary dynamics are at work. First, European energy demand has been decreasing since 2006 mostly as the result of the widening implementation of existing and new technologies, behaviours and processes that tend to be more energy efficient. Second, renewable energy sources are booming, while their costs keep on falling. New behaviours, technological and social innovation, falling battery costs and smarter policies will further boost energy efficiency and renewables (Delors et al. 2015).

The European energy policy can take its share of credit for this success. In 2007, the Heads of State and Government set Europe three energy targets to be reached by 2020: reducing EU greenhouse gas emissions by 20%, improving energy efficiency by 20%, and increasing the share of energy coming from renewable sources by up to 20%. The two first targets have already been reached while the third one is within grasp. Despite the many hurdles, imperfections and structural flaws, the policy decisions taken at EU, national and local levels have helped Europe to deliver on its energy-climate targets (Delors et al. 2015).

This evolution of the EU energy system towards an efficient system based on renewable energy sources is often referred to as “Energy transition”. In the past, human societies saw phenomena that resembled energy additions rather than transitions: with growing energy demand, coal was added to bioenergy, before the addition of oil, nuclear and gas. As Europeans are decreasing their fossil fuel consumption thanks to energy efficiency and renewables, they are starting to perform the first-ever energy transition in human history (Delors et al. 2015).

Such a European energy transition is necessary to fight climate change, in line with the Paris Agreement. It is of paramount importance to ensure Europe’s energy security. It is also the opportunity to make the energy system more democratic, more supportive of economic prosperity, and more just. European Commission Vice President Maroš Šefčovič was therefore right to talk about the Energy Union as a project guided by “5Ds” (Šefčovič 2016). Decarbonising economies allows the EU to Democratise energy production and consumption; this is helped by Digitalisation, fosters the Diversification of energy supplies and help innovators to create and diffuse the innovations that progressively Disrupt traditional energy cycles (Pascal Lamy 2016).

The thesis tries to add its share of understanding of how transformational processes can be implemented in this overarching change process. Rather than focusing on a firm level through a case study research strategy, the study adopts a broad scope and aims at producing valuable insights into the barriers and enablers to achieving a sustainable energy mix in heavy industries. Such a broad focus was chosen to advance scientific knowledge of the problem under investigation and provide universal guidelines for companies operating in heavy industries on how to apply strategy development and risk management to achieve a sustainable energy mix.

1.6 Structure of the thesis

There will be six chapters in the thesis. Chapter One presents the research background, the research problem, the research significance and structure as well as the research aim, objectives, and research question. Chapter Two will present various definitions of renewable energy sources (RES), strategy development, risk management and concepts of sustainable development. The third chapter offers various definitions of renewable energy sources (RES), strategy development, risk management and concepts of sustainable development as well as an overview of relevant policies on sustainability in different countries with an emphasis on those policies that support the adoption of renewable energy. The next chapter comprises the theoretical framework, relating to theories on strategic management and theories on sustainability. Chapter Five will sum up the research methodology through quantitative and qualitative data analysis approaches and in terms of reliability and validity in qualitative as well as quantitative research. The empirical findings of the experts' survey are presented in Chapter Six. This chapter will provide a discussion of the main findings of the questionnaires through major strengths, weaknesses, opportunities, threats (SWOT), investments, strategic options, transition success and technical obstacles next to important insights.

They are summed up in qualitative and quantitative research insights in Chapter Seven. The thesis will close with a discussion based on changes in the Energy Mix in Heavy Industry, associated risks and opportunities and transition strategies. Finally, the thesis will close with important insights obtained from the study and recommendations for future research.

2 CHAPTER TWO – LITERATURE REVIEW

2.1 Introduction

This chapter presents a review of literature which is relevant to the research topic. The topical areas include heavy industry, strategy development, risk management, renewable energy, and transformation processes with regard to changing the energy mix and the theoretical framework. A significant part of the chapter is dedicated to a critical analysis of the strategies and challenges revolving around the achievement of a sustainable energy mix in companies operating in heavy industries.

This section informs about the current strands of literature that deal with the issue of more sustainable energy mixes for heavy industries. The overarching question asks for the challenges of achieving more sustainable energy production in heavy industries. This question was split into the three thematic blocks, barriers, strategies and challenges. This scoping literature review, as further explained in the methodological chapter of this doctoral thesis, was accordingly split into the three sub-questions.

A few key characteristics were shared regarding the topics of investigation. The selected literature investigating the issue of more sustainable energy mixes for heavy industries dealing with highly valuable, vulnerable and symbolically important systems, follows a key argument. Energy systems have been for a long time a source of regulation and controversy, since energy systems are complex and therefore their risks are not yet fully understood. This is where a string of literature emerges, around the issue of energy security in heavy industries since they represent still an important status in industrialized countries (Gatzert & Kosub, 2016; Tester et al. 2012). The renewable energy sector represents a significant opportunity for growth, and the activities are focused on educating emerging markets about the potential risks and risk management solutions that may be required (Halttunen et al. 2023). The analysis of most of this literature indicates that regulatory and political risks are among the most significant risks, offering limited opportunities for risk transfer from the perspective of industry experts. Also, in addition to capital insurance, diversification is currently one of the most important risk mitigation techniques (Azadnia et al. 2023; Wanapinit & Thompson 2021).

The selected literature investigates in various dimensions, partly due to a lack of alternative coverage (Halttunen et al. 2023). This means that renewable energies are also seen as a means to diversify energy mixes risks, that are still mainly based on fossil fuels. Furthermore, investments like insurance coverage for political, political and regulatory risks remains limited due to various challenges. Typically, private political risk insurance covers risks such as expropriation and violations of investors' rights, while public policy risk insurance can provide an important alternative method of risk mitigation. In literature, various works address topics such as in the study of Golmohamadi (2022) or Ghobakhloo et al. 2022). Literature that share these key perspectives will ably be introduced in the next subsections.

2.2 Barriers: security and risks of energy mixes

Literature on barriers of energy transitions in heavy industries was screened to understand the challenges and barriers of energy transitions in heavy industries. The biggest benefit, so most literature, this is where this renewable energy literature agrees, is a global security dividend (Ikevuje et al. 2024; Joel & Oguanobi 2024). The central contribution of the energy transition is undeniably to slow down global warming. But it also has far-reaching positive side effects for human security, such as improving air and water quality and thus public health. Fast, direct access to clean and safe energy is crucial for green growth (Joel & Oguanobi 2024; Farghali et al. 2023). Economically, this is another key message of this literature, the energy transition is gradually reducing dependence on imports and the risks of expensive price volatility. It thus helps to avoid crises of access to and distribution of fossil fuels. The market power of the existing oligopolies, such as the new oil alliance, can also be eroded in this way in the long term. The energy transformation thus promises a security dividend (Joel & Oguanobi 2024; Tautorat et al. 2023; Esiri et al. 2024).

If more energy is produced locally, this has an impact on the dependencies between producer, transit and consumer countries (Ghobakhloo et al. 2022). This goes hand in hand with an increase in sovereignty in energy supply. The electrification of the system also levels the role of states internationally – they all become prosumers, producers and consumers in equal measure. In addition, they can enter into a network community, which requires conscious political decisions (Azadnia et al. 2023; Joel & Oguanobi 2024; Ghobakhloo et al. 2022).

The geopolitical implications are less about the military and security policy per se.

They lie in the flow processes of energy ecosystems and affect the provision and control of networks and energy services, data, technologies and supply chains. Added to this is the fact that energy transformation is developing very heterogeneously worldwide (Farghali et al. 2023; Mendoza & Ibarra 2023). The re-scaling of global value chains, the relocation of production clusters to the local level, but also the change in the flow of goods, have a direct impact on the international division of labor and the world trade system. About one fifth of the volume of the latter is based on products of the extractive industry such as oil, gas and coal. As energy supply becomes more of a technology- and innovation-driven process, the participation of states in the world trade and energy system is shifting. Economic welfare gains are recalibrated in this way, and This has profound consequences for the world economic system (Inayat et al. 2023; Hassan et al.).

Depending on the necessary speed of depreciation, this can also pose a systemic risk. In geopolitical terms, the restructuring of the energy system will pose a less urgent and existential threat to the major oil and gas producers – such as the Gulf States and Russia – than is generally assumed (Agalwood et al. 2023). Literature on this issue highlights that, even with decarbonization in industrialized countries, demand for oil and natural gas is likely to remain high for a transitional period; demand in India and other developing economies will ensure this. Likewise, access to minerals which are needed to produce batteries, energy-saving bulbs, windmills or electric motors, is not likely to be problematic in the long term. This is where the raw materials cycle comes into play. It ensures that price incentives increase and broaden supply, but also that recycling and circular economies are rewarded (Agalwood et al. 2023).

By contrast, other literature proposes ways of how prosperity can be secured with the green economic model comes to the fore. Technological leadership in decarbonization is of central importance here; the return on technology will be the determining factor for the prosperity of economies. To some extent, the global energy transition has already become the object of classic industrial policy. This is threatened by uncooperative competition and mercantilist economic policy – in times of America First and the globally observed refocusing on supposed national interests (Summerfield-Ryan & Park, 2023; Sajid et al. 2022).

Policy makers are seeking to renationalize their shares in global value chains in high technology and to subject them to less state control. To make matters worse, the patents for key technologies in the field of smart grids, offshore wind or composite materials like solar are still rarely discussed for heavy industries. Even investments in renewable energies are currently going to about 90 percent in this new Global North (Summerfield-Ryan & Park 2023; Agalwood et al. 2023). Developing countries, on the other hand, run the risk of hardly benefiting from corresponding capital flows and technological advances – although the greatest growth in energy demand is to be expected in the Global South Sajid et al. 2022).

Digitalization can further exacerbate such trends. This emerging imbalance in the global energy transition must be addressed. Governance matters: The global energy transition is tantamount to a system change (Azadnia et al. 2023; Wanapinit & Thompson 2021; Summerfield-Ryan & Park, 2023). This will yield a transformation dividend, most clearly in global climate protection and human security.

A more sustainable energy supply also means direct gains for societies and economies through domestic value creation and indirect gains through the reduction of dependency relationships. For Germany and the EU, the growing importance of geoeconomics is an opportunity because economic processes are gaining in importance in terms of foreign policy. National solo efforts, as at the beginning of the German energy transition, will thus become more cost-intensive and less effective (Ige et al. 2024; Hassan et al. 2024; Gregory & Geels 2024).

There is also literature that supports a argument that is based on geopolitical factors. A heterogeneous, smaller-scale energy mix would fit into an increasingly multipolar world order with a more protectionist trade system. But mercantilist energy policy carries the risk of rivalry between energy blocs. Individual states could seek to privatize competitive advantages and technology rents. Multilateral cooperation is therefore indispensable to quickly and consistently transforming the energy system. Transformation dividends can only be achieved if a liberal trade regime enables complex, smooth supply chains and guarantees access to technology and know-how. As an industrialized country, Germany is therefore called upon to strengthen international cooperation in the energy transition so that it can secure its economic foundations in the long term (Ghobakhloo et al. 2022; Wanapinit & Thompson 2021).

The crisis-ridden EU policy would play a central role here because it regulates the green technologies of tomorrow which is not the case for today's fossil fuels. Within the framework of the EU, Germany should work to facilitate technology transfers and cushion political risk premiums (Iorember et al. 2024). There is literature that claims that at the global level, it is important to design decarbonization paths transparently and to engage in an intensive exchange on the modernization of the energy system, increasing energy efficiency and alternative energy use paths – not only with the major consuming countries, but also with the major energy-producing countries (Verpoort et al. 2024; Iorember et al. 2024; Pan et al. 2024). This literature remains arguably conservative ion respect to the finding that a general sustainability approach is needed (Pan et al. 2024).

These risks are subject to literature investigating change in energy mixes heavy industries.

2.3 Strategy as governance of renewable energy mixes in heavy industries

Environmental pricing solutions as a point of reference From an economic perspective, damage to the environment and climate represent negative external effects to which no prices are attributed in the market system, mainly due to a lack of private property rights. The limited scarcity of environmental media as a receptacle for pollutant emissions is therefore not taken into account in the decisions of market participants, so that in a completely free market, the environmental impact would be inefficiently high (Ghobakhloo et al. 2022). From an economic point of view, this “market failure” fundamentally justifies welfare-enhancing interventions by the state to internalize external effects. In this context, economists favor price instruments such as emissions levies, eco-taxes or emissions certificates as the preferred instruments of environmental policy (Ghobakhloo et al. 2022). This preference in the choice of instruments is based, first, on the fact that the gap caused by externalities in the market system is closed by extending the price mechanism, and thus in a market-conforming manner. In the case of green taxes, the literature states that the nation state itself sets the price for emissions or environmental damage directly by choosing the tax rate. In a cap-and-trade system, on the other hand, the state sets a certain total quantity of emission allowances, as a cap for the permissible level of emissions, the price of which is determined by trading on the allowance market (Issa et al. 2023; Wanapinit & Thompson 2021).

Under theoretically ideal conditions, such price instruments minimize the macroeconomic costs of emission abatement by equalizing the marginal abatement costs of all emitters. In addition to this static efficiency, price instruments are also thought to have a dynamic efficiency effect, because pricing the residual emissions creates a permanent incentive for both emitters to reduce their abatement costs and thus to develop environmentally friendly technologies (Issa et al. 2023). Furthermore, pricing instruments provide the state with a source of revenue that allows it to reduce taxes and levies associated with negative growth and employment effects in a budget-neutral way and thus – in addition to internalizing external effects – to achieve an additional welfare gain. However, the extent to which such a double dividend can actually be realized is controversially discussed in the environmental economics literature. From an economic policy perspective, it is significant that pricing instruments have long since left the sphere of purely abstract, theoretically desirable approaches and are now being used as climate policy instruments in Germany and the European Union (Wanapinit & Thompson 2021).

One important risk category includes strategic, and business risks associated with the project, such as inadequate management knowledge of portfolios or processes of innovation, insufficient access to capital or a lack of cooperating partners to share technical expertise, as well as financial and market access, risk diversification and the exploitation of economies to reduce costs (Diesing et al.). Technological and innovation risk on the one hand refers to inaccuracies in early planning about resource assessment and the range of renewable energy technologies on the other hand to outdated technologies in the future. These may suggest lower efficiency compared to new plants but may also lead to a reduction in public (and political) acceptance, which in turn may lead to a risk for new plants, according to authors like Issa et al. 2023, p. 6970f.; Chinnathai & Alkan 2023, p. 5) The energy transformation, so the scholars, is leading to new energy spaces that are characterized by infrastructure, production chains, and industry clusters (Issa et al. 2023; Wanapinit & Thompson 2021). This spatial effect is generated by the geo-technological transformation, as can be seen, for example, in local microgrids or in super grids spanning large regions, such as those being promoted by China. While the focus today is still on the different sectors like electricity, buildings, transport, industry with their respective dominant fossil energy sources, the future lies in sector coupling. This puts more weight on a systemic perspective that is represented by literature on energy mixes (Sun et al. 2023; Trinh & Chung 2023; Summerfield-Ryan & Park 2023).

2.4 Enabling renewable energy mixes in heavy industries

The networking of the electricity, can be heating and mobility sectors additionally strengthens the relocation and reconfiguration of energy spaces (Chinnathai & Alkan 2023). From a global perspective, the energy system will tend to become more sustainable, but also significantly more heterogeneous (Chinnathai & Alkan 2023). The conventional energy system, as it exists today, has developed relatively uniformly – shaped by global trade in oil, coal and liquefied natural gas, and by the combustion engine that dominates transport. With the transformation of energy systems, however, the specific characteristics of the individual countries and regions are becoming more important: the respective geographical starting points, the – widely differing – political ambitions and governance options, as well as national preferences in the energy mix (nuclear energy, use of gas) and the different approaches in the mobility sector (Issa et al. 2023). Key technologies are becoming the focus of energy transformation. “Technology rents” promise economic growth, and welfare gains can become the decisive driver for the success of global energy system transformation – but only if states cooperate (Issa et al. 2023). Embedded in specific geographical areas, these processes can also lead to competition and national go it alone. This is the ambivalence that characterizes the geoeconomic consequences of the energy system change (Diesing et al. 2025; Chinnathai & Alkan 2023.

2.5 Summary and analytical requirements of the analytical focus

In the following, reasons will be presented and critically discussed that can be cited against the exclusive use of price instruments. In their practical implementation, pricing instruments usually do not correspond to the theoretical ideal model of strategy making. One important analytical cornerstone of this proposed research is the focus on barriers that are presented to the development of more renewable energy mixes for heavy industries. Another important analytical aspect will be the management of risks when aiming for more renewable energy mixes for heavy industries, whereas, the third analytical point presented here is about factors that are in play to enable the development of more renewable energy mixes for heavy industries.

3 CHAPTER THREE – POLICIES SUPPORTING SUSTAINABILITY

3.1 Introduction to the chapter

This chapter offers a detailed analysis of relevant scholarly literature dedicated to the policies that support and promote sustainability. Such an analysis is critical for understanding ways in which policymakers can stimulate companies that operate in heavy industries to reduce emissions in order to achieve a sustainable energy mix. The second subsection of this chapter following the introduction presents an overview of the concept of sustainable development. The third subsection introduces the environmental policies and the Kyoto Protocol, while the fourth part of the chapter presents national approaches to environmental sustainability in the DACH region. The last subsection briefly reviews the policy context for renewable energy in the DACH region.

The chapter is structured as follows. Firstly, in order to introduce the subject of this analysis, it is necessary to clarify the subject of regulation according to the literature review above. This means that the first step in this study is to provide an appropriate definition of heavy industry. Furthermore, the importance of renewable energy for heavy industry will be highlighted, as will the importance of renewable energy for the general industrial energy mix. Thus, sustainable initiatives will be further outlined to define specific steps to make energy mixes more sustainable. After defining the benchmarks for change, risk management will be presented as a means to regulate and manage renewable and more sustainable energy mixes. This will be further elaborated along the stakeholder analysis in relation to sustainability and environmental policies and the Kyoto Protocol as the main policy framework in the energy sector. This will be elaborated for the DACH region for solar and wind energy. The factors influencing this change will also be presented.

3.2 Definitions of heavy industry

There is no single official definition of the term heavy industry. Companies that belong to what is commonly called Heavy industry have certain common properties. These companies typically are capital-**intensive**, and they carry high capital costs. The term “heavy” refers to the products involved like iron, steel, coal and heavy machinery. It also involves large and heavy equipment and facilities and complex processes (Dennis 2019). Therefore, the term heavy industry is not very precise and wide-ranging. The Global Industry Classification Standard (GICS) defines several industries and sub-industries with their relevant business activity that fulfil the former definition of heavy industry. Following the GICS Structure, the following figure shows some of the industry groups, industries and some sub-industries in the Industrial sector (20), that can be termed heavy industry.

Sector: 20 Industrials		
Industry group	**Industry**	**Sub-Industry**
2010 Capital Goods		
	201010 Aerospace & Defense	
	201020 Building Products	
	201030 Construction & Engineering	
	201040 Electrical Equipment	
	201050 Industrial Conglomerates	
	201060 Machinery	
2030 Transportation		
	203050 Transportation Infrastructure	
		20305020 Highways & Rail tracks
		20305030 Marine Ports & Services

Figure 4: Examples of GICS Classification for heavy industry. Source: GICS (2018: 6)

In this study, the focus was mainly on companies belonging to industry group 2010 Capital Goods and within this group companies from the following industries: 201030 Construction & Engineering, 201050 Industrial Conglomerates and 201060 Machinery.

The 2030 Agenda for Sustainable Development was adopted by all United Nations Member States in 2015. The aim of the agenda is to provide a shared blueprint for peace and prosperity for people. At the centre are the 17 Sustainable Development

Goals (SDGs). The SDGs are to be achieved by all UN member states by 2030 (EDA 2020). From the point of view of Heavy industry Goals 8, 9 and 12 are very important. The goals and their respective targets are quoted below: Goal 8 includes targets on sustaining economic growth, increasing economic productivity and creating decent jobs. Goal 9 aims to build resilient infrastructure, promote industrialisation and foster innovation. Increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes are necessary. Goal 9 aims to support technology development, research and innovation especially in developing countries (EDA 2020). The world's population currently consumes more resources than ecosystems can provide. For social and economic development to remain within the carrying capacity of ecosystems, fundamental changes in the fields of production and consumption are necessary (EDA 2020). Goal 12 calls for sustainable consumption and production patterns. It advocates environmentally sound management of chemicals and all waste as well as a substantial reduction in waste generation through measures such as recycling.

With respect to the transformation of the energy mix in Heavy industry, SDG 7 plays an important role. The goal of SDG 7 is to ensure access to affordable, reliable, sustainable and modern energy for all. This means a substantial increase in the global share of renewables in the energy mix and a doubling in the global rate of improvement in energy efficiency to promote research in renewable energy and energy efficiency as well as investment in energy infrastructure and clean energy technologies (EDA, 2020). United Nations Global Compact and consulting firm KPMG developed an SDG Industry Matrix to inform about industry-specific practical examples (UN Global Compact and KPMG, 2016)

3.3 The importance of renewable energy for heavy industries

First, it is undeniable that energy plays such an important part in the sustainable development of countries that they are always trying to plan their energy programs or strategies in line with their sustainable development goals. Before studying the connection between energy in general and renewable energy in particular with sustainable development one shall learn how energy electricity is generated basically. In the book *Green Energy: An A – to – Z Guide*, Newell and Mulvaney (2013: 133) defined that electrical energy in general can be understood as electricity generated by repeatedly converting various energy sources, including chemical, nuclear, mechanical, thermal and gravitational potential. The general conversion is thermal to mechanical to electrical, but the operation can vary greatly depending on the resource used. Almost all power stations use turbines connected by a common shaft to a generator to convert mechanical energy directly into electrical energy through the principle of electromagnetic induction.

Renewable resources like wind power, wave power, and hydropower flow through the turbines to generate mechanical energy directly. The chemical energy of fossil fuels and biomass and the nuclear energy of uranium are converted into thermal energy, which drives the turbines through the heating of steam or gas. Geothermal and solar thermal collectors provide thermal energy directly (Hwang et al. 2021). It also has been noted that fossil fuels are the largest contributors to electrical energy generation because of their high energy content" and "provide two-thirds of the world's electrical energy demands (Hwang et al. 2021). However, the combustion of fossil fuels during electrical generation releases carbon dioxides which is known as the cause of the greenhouse effect and environmental pollution (Haenssgen et al. 2022). That is why renewable energy has become an indispensable selection when comparing the impacts of this type of energy with traditional energy sources on the environment. It has been observed that non-renewable energy is a very important source of energy for humankind. Thanks to this energy source, human society has enough energy to survive and develop.

However, it is time to consider the solution of finding new sources of energy to gradually replace the sole role of non-renewable energy in order to reduce its damage and even to save the survival of human species from the warming phenomenon of the earth. One of those trends is renewable energy - a source of energy that can guarantee sustainable development and human safety. Many researchers, scientists, and environmentalists have agreed that electricity generation from renewable resources has not caused negative impacts on the environment as much as electricity production from fossil fuels does (Nemzer et al. 2010; Nersesian & McManus 2020; Olz & Beerepoot 2010). As Sathaye et al. (2011) affirmed, "renewable energy offers the opportunity to contribute to several important sustainable development goals: (1)

social and economic development; (2) energy access; (3) energy security; (4) climate change mitigation and the reduction of environmental and health impacts. The mitigation of dangerous anthropogenic climate change is seen as one strong driving force behind the increased use of renewable energy worldwide". This opinion is also agreed by Cook (2012), who wrote that "the use of renewable energy as one of the simplest and most effective ways to reduce greenhouse emission" (p. 25). This author used to be the Director of the Petroleum Cooperative Research Centre (PCRC) in Australia, so he was well-aware of climate change and its connection to clean energy. Although his book mainly focused on clean energy technologies of CO_2 capturing and storage (CCS) and the connection between CO_2 and climate change, it provided a comprehensive outline of the status of clean energy development not only in Australia but also in OECDs and its related issues. The author also compared the costs, advantages and disadvantages of every single source of renewable energy like solar, wind or CCS. Finally, one of the most noticeable points of the book is that the author provides an outlook on the political environment of clean energy.

In another book named Clean Energy: Resources, Production and Developments, Harris (2011) agreed with Cook (2012) that renewable energy sources would be substituted for primary energy sources in the aspect of CO_2 emission reduction. Furthermore, his study also pointed out all related content on clean energy. Readers can find through his research the answer to why renewables should be chosen or how to produce sources of electricity generated from clean energy, what policies were implemented to encourage clean energy and the current situation of developing this type of energy. Harris (2011: 3) added that "renewable environmentally friendly energy must be encouraged, promoted, implemented and demonstrated by full-scale plan, especially for use in remote rural areas".

A different book on this topic is *Energy for Keeps: Creating Electricity from Renewable Resources* by Nemzer et al. (2010: 22). The book of 5 chapters covers all matters of renewable energy sources and their connection to the environment and technologies. The book is somehow like a textbook for people of all jobs and ages because it provides necessary and basic knowledge of how electricity is generated from renewables and non-renewables and how it affects our health and environment. The most noticeable implication of the study is that the author gave a clear guidance on the way we use energy. The message is that “the less fossil fuel we use, the less pollution we produce” (Nemzer et al. 2010: 144). Here, one can see that this point of view is totally like that of Cook (2012) and Harris (2011).

The transition from traditional energy to renewable energy is not only meaningful to the environmental aspect but also to the economic area. First, this transition will help countries reduce energy imports, thereby increasing energy security as well as improving trade capacity (Sathaye et al. 2011). The development of renewable energy technology has made this type of energy more competitive in price when compared to traditional energy. This also creates new employment opportunities and other benefits like economic growth. Especially, after the Paris Agreement in 2015, investors began to realize the risks of continuing to invest in traditional energy. This frees up investment in renewable energy and has made a big leap forward in investing in fossil fuels to shift to renewable energy (Olz & Beerepoot 2010).

In regards to the connection between renewable energy and sustainable development for example in Vietnam, there have been lots of journals, articles and textbooks on this content directly or indirectly. One good example is the textbook *Renewable Energy and Sustainable Development* by Bao (2017), which was published by Ho Chi Minh City National University Publishing House in 2017. This publication also gave an outlook on sustainable development and its relationship with renewable energy. Besides, the author gave an overview of the use and deployment of renewable energy in the world generally and in Vietnam particularly. More especially, it analysed sharply the technologies of renewable sources like solar, wind, hydro, tidal and geothermal power as well as the potential to develop it (Bao 2017). In addition, there are several studies on the potentials of each type of renewable energy such as “Deploying Renewables in Southeast Asia” by IEA but there have not been any studies on the current state of development of renewable energy as well as the implementation of the Development Strategy of renewables in practice (Olz & Beerepoot, 2010: 4).

In conclusion, “important socio-economic benefits of large-scale penetration of renewables include improvements in energy security and noteworthy reductions of air pollution and CO2 emissions, which would contribute to climate change mitigation… these co-benefits are associated with high-cost savings, although no uniform methodology exists to quantify these savings" (Olz & Beerepoot, 2010: 10). Therefore, the development of renewable energy will be an important element in each country's sustainable development strategy.

3.4 Renewable energy and energy mix

Energy is a vital input for social and economic development. As a result of the generalization of agricultural, industrial and domestic activities the demand for energy has increased remarkably, especially in emerging countries. This has meant a rapid growth in the level of greenhouse gas emissions and an increase in fuel prices, which are the main driving forces behind efforts to utilize renewable energy sources more effectively (Bogdanov et al. 2021). Despite the obvious advantages of renewable energy, it also has important drawbacks, such as the discontinuity of power generation, as most renewable energy resources depend on the weather, which is why their use requires complex design, planning and control optimization methods. Fortunately, the continuous advances in computer hardware and software are allowing researchers to deal with these optimization problems using computational resources, as can be seen in the large number of optimization methods that have been applied to renewable and sustainable energy field (Baños et al. 2011). But contrary to what the authors have found out about the optimisation of renewable and sustainable energy the reality looks rather different due to physics. A modern electricity grid needs a constant frequency of 50 Hz (Netzfrequenz.info, 2020). Traditional power generation can ensure this constant net frequency. If the net frequency increases above 50 Hz, the power production must be reduced. Below a net frequency of 47.5 Hz, electricity producers will shut down in an emergency, which will result in a Blackout (Netzfrequenz.info, 2020). With power generated by wind power or solar energy, it is much more difficult to achieve a constant frequency in an electric grid.

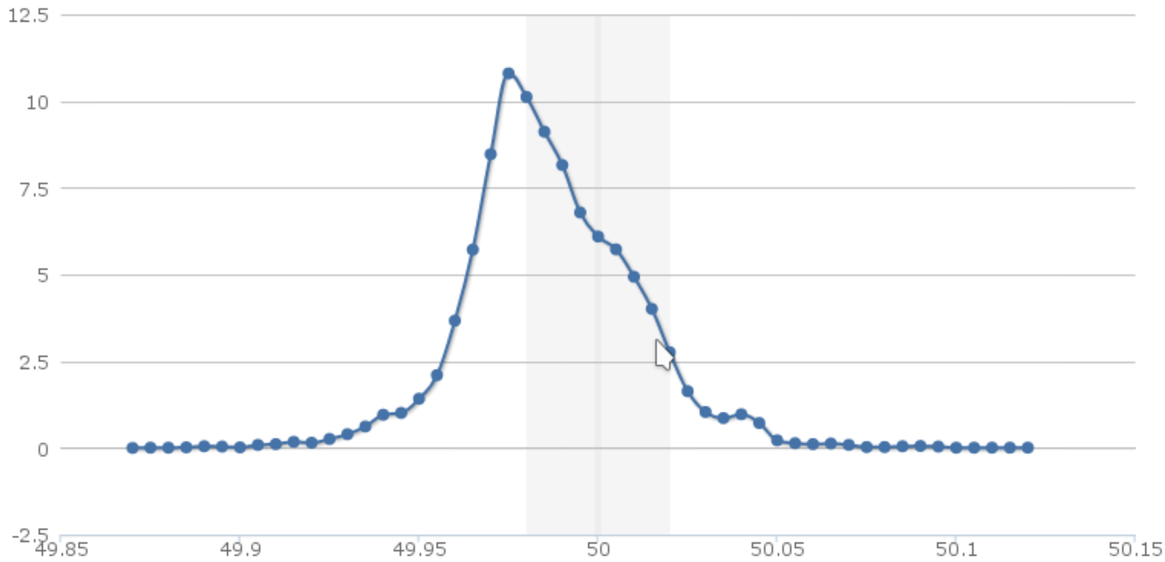

Figure 5: Distribution of net-frequencies in Germany (20.05.20).

The control and coordination of the European-wide electricity grid is a difficult task and predictions of the change in net frequency in national grids are complicated. The more renewable energy is fed into the electricity grid, the more difficult it is to control. “On 10 January 2019, 21: 02 CET, the Continental Europe Power System which stretches across 26 countries registered for nine seconds the largest absolute frequency deviation since 2006. The frequency dropped to 49.8 Hz (compared to 49.0 Hz in 2006)” (EntsoE 2019). As a result, heavy industry production was cut off from the electricity grid. There were 78 forced electricity cut-offs for the company Hydro Aluminum based in the German city of Neuss due to sudden changes in the net frequency. Few months after the January incident Hydro Aluminum cut 700 jobs in Germany (Piel et al. 2019).

Common objectives for renewable energy policy include reducing reliance on non-renewable energy sources, the emission of greenhouse gases and other air pollutants as well as their impacts, and environmental impacts (Kansongue et al. 2022). Moreover, these goals also involve enhancing the diversification of electricity generation mixes, renewable energy involvement, and the competitiveness of renewable energy sources (Lee 2016). The above objectives are designed to generalize the benefits of increasing the use of renewable energy.

Many energy-related investments are made without a clear financial understanding of their values, risks, and volatilities. In the face of these uncertainties, investors often choose to implement only the most certain and thus limited energy-efficiency measures. Accurate and robust analysis demands a high level of understanding of the physical aspects of energy-efficiency, which enables the translation of physical performance data into the language of investment (Smith & Stirling 2010). With a risk management analysis framework in place, energy-efficiency experts and investment decision-makers can exchange the information they need to expand investment in demand-side energy projects (Mills et al. 2003).

Societal reliance on fossil fuel-dependent energy systems, such as oil or coal, is a major driver of climate change (Le Billon and Kristoffersen 2020). As such, a key task for addressing climate change is to critically re-imagine our energy systems (Meadowcroft & Steurer 2018: 2; Sheller 2016). This special issue engages in conceptualizing futures (Sheller 2016) related to climate change and energy, with attention to the social values and norms, hierarchical structures, and social imaginaries underlying decision-making in a carbon-constrained world. Future research focuses on understanding how organizations or other actors develop and mobilize visions for the future. As Hajer and Pelzer (2018) put it, the work of "futuring" is carried out by particular social actors to either promote or undermine collective visions of desired or expected futures. Organizational actors and other social groups adopt a variety of planning tools "to make predictions about what futures are possible or likely, appealing or to be avoided" (Stoddart et al. 2020). The task of future research is not to predict the future but rather to analyse the "techniques of futuring" that are used by organizations and social groups to advance their desirable futures (Hajer & Pelzer 2018: 222). This special issue focuses on energy futures as a sub-category of social futures that "focus on the systems, social implications, and societal configurations related to the energy sources that power society" (Stoddart et al. 2020).

One of the main threads in energy future research is work on energy transitions. The conventional wisdom that carbon pricing is the most efficient policy response to climate change reflects economic-centric and engineering-centric perspectives on energy transitions (Baranzini et al., 2017). While these perspectives have produced a variety of interesting models that found traction in policy and practice, they often neglect the range of political and social dynamics that facilitate or impede various climate and energy futures (Farla et al. 2012; Lindberg et al. 2019; Lockie & Wong 2017; Markard et al. 2012; Meadowcroft 2009: 3; Meadowcroft & Steurer, 2018; Rosenbloom et al. 2016; Rosenbloom et al., 2020). In fact, it has been argued that one reason for the early success of carbon pricing mechanisms is precisely because it allowed private sector advocates to side-step the political complexities of multi-lateral climate governance. By contrast, electoral and political institutional dynamics, as well as social perceptions of legitimacy, can make the difference between success and failure in implementing carbon pricing as a lever redirecting societies toward new energy futures (Harrison, 2010).

As Bengston (2019) notes in a recent article in this journal, future research has a long history and diverse methodological toolkit that varies along three dimensions: qualitative or quantitative, expert-based or participatory, and evidence-based or imaginative. This diversity of approaches is united by a shared concern with generating insight “into how and why the future could be different than today” and how to “improve planning and decision making” (Bengston 2019: 1099). However, this methodological toolkit remains underused within natural resource and environmental management, which tends to focus on developing and using models to forecast and plan for the “most likely” future. By working across multiple methods, future research offers new insights that move beyond traditional forecasting methods, which are often “poor at best when applied to complex social-ecological systems,” such as those involved in climate change or energy transitions (Bengston 2019). The authors demonstrate how a diverse range of methodologies – including interviewing, surveys, social network analysis, block modelling, and text-based semantic network analysis – can be applied to advance our understanding of climate change and energy futures.

Dependence on carbon-intensive energy systems is a major contributor to climate change. Therefore, discussions of addressing climate change must address the role of fossil fuels in our energy futures. Much of the research on fossil fuels and society to date focuses on conflicts over oil exploration and extraction, or on oil sector engagement with climate change (Davidson & Gismondi 2011; Oriola & Oyeniyi 2017;

Pulver 2007; Widener & Rowe 2018). Thinking about fossil fuels and energy futures often focuses on the most cost-effective strategies for energy transition. However, economic analyses risk underestimating the socio-political implications of energy transitions, such as how incumbent fossil fuel industries resist or delay transitions by leveraging their political social network ties and social influence. Mildenberger (2020), for example, shows how fossil fuel sector interests achieve a “double representation” through political parties and labour unions in countries like Australia, Norway, and the United States. This double representation limits the efficacy of climate mitigation policy and ensures incremental rather than transformative responses to climate change. Similarly, Lee and Hess show that energy industry incumbents and their political allies in the U.S. oppose renewable energy transitions by taking advantage of the American culture of political polarization and mobilizing frames that cast renewable energy development as “an expensive or elitist policy” (Lee & Hess 2019).

The paper by Tindall et al. (2020) further advances an understanding of how and whether fossil fuels fit into different energy futures. It provides a broad overview of the Keep it in the Ground (KIIG) Movement, which advocates a supply-side approach to limiting oil and gas extraction as a means toward rapid decarbonization (Tindall et al. 2020). Through this overview, they identify a suite of related political, institutional, and cultural forces that either limit or facilitate the emergence and success of KIIG movements in oil-dependent regions. This analysis provides important insight into the social forces that potentially accelerate the “decline” of fossil fuel sociotechnical systems, which as Markard (2020) notes is an understudied dimension of transition studies.

Stoddart et al. (2020) focused on Canada as a country that is caught between espoused commitments to climate action and economic reliance on fossil fuels. By examining the Canadian climate policy network, they found that policy network actors’ affiliation with particular social network blocks better predicts support or opposition for a fossil fuel-oriented future than whether policy actors are affiliated with a particular political party, business sector, or civil society (Stoddart et al. 2020). Taken together, these papers show how the interests of the fossil fuel sector influence the political discussion about which energy futures are seen as desirable or achievable.

Developing energy futures that respond to climate change is deeply embedded within the social network relationships, organizational dynamics, and epistemological underpinnings of actors in civil society and political spheres (Meadowcroft and Steurer, 2018). A growing body of literature examines the social dimensions of energy system transitions and futures about issues of social power, inequality, democracy and public participation, and community wellbeing (Burke & Stephens 2018; Jasanoff 2018; Meadowcroft 2009; Raymond 2018; Thombs 2019). For example, “energy democracy” advocates articulate an energy future that imagines a broader, more engaged role for citizens in energy policymaking, but also as “prosumers” (producers and consumers) in more decentralized, sustainable energy systems (Szulecki & Overland 2020).

Additionally, the politics of climate change is shaped by the intervention of civil society and social movement actors, who influence the terms of debate around policy solutions. A great deal of research has focused on the role of civil society in policy networks that shape climate policymaking, including renewable energy transitions (Hadden 2015; Pohjolainen et al. 2018; Ylä-Anttila et al. 2018). However, less of this work looks beyond policy outcomes to examine how civil society action in the political sphere also helps envision and create new energy futures. A useful example is Vasi’s (2009) research on the multiple roles played by environmental organizations in advancing wind energy transitions in Denmark and Germany by influencing the attitudes of policymakers, the private sector, and consumers. Even less attention has been paid to the underlying logic of those in decision-making positions – i.e., policy and industry elites – who must make difficult trade-offs between climate action, economic development, social stability, and political viability.

The papers by Ylä-Anttila et al. (2018), Wong (2018), Kurniawan and Schweizer (2020), and Norgaard and Poder (2019) advance an understanding of these issues. Ylä-Anttila et al. (2018) use social network analysis to examine political advocacy coalitions in Finland and Australia. Despite their differences, they find remarkably similar network structures in the two countries, with a dominant “treadmill of production” coalition of business, labour, and government actors. However, they also identify important fault lines that may result in a reconfiguration of policy networks in support of stronger climate action and new energy futures.

Wong and Lockie (2020) examine elite (government, corporate, and NGO) interpretations of short-term and long-term climate change risk and uncertainty in Australia, China, and the United Kingdom. For many policy elite actors, technocratic and market-based climate solutions are preferred because they are less susceptible to short-term political risks. Relatedly, a minority of participants, largely from civil society, assert that climate change responses should be opened to greater public participation and deliberation. These findings echo Lindberg et al.'s (2019) analysis of renewable energy transition pathways in the EU, where there is broad support for transitions across sectors, but disagreement over how centralized or decentralized energy transitions should be. They similarly note that NGOs are particularly important voices in advocating for decentralization and democratization.

Kurniawan and Schweizer (2020) use social network analysis and semantic network analysis to examine a diverse set of energy future scenarios prepared by various Canadian governmental and non-governmental organizations in order to find key points of commonality and divergence among the scenarios articulated by these different groups. Energy scenarios, such as those scenarios developed through the work of the IPCC, government agencies, think-tanks, or academic research groups, can be thought of as specific "techniques of futuring" (Hajer and Pelzer 2018. 222) among the broader suite of tools and techniques for envisioning and implementing energy Tables. Through their analysis, Kurniawan and Schweizer (2020) identify commonalities across these scenarios, but also find that the energy futures articulated in government scenarios may be narrower in scope than those from non-governmental perspectives.

The closing commentary piece by Norgaard and Poder (2019) offers a timely theoretical intervention into thinking about energy futures. Drawing from her work with the Karuk Tribe in California, as well as Indigenous social theory, Norgaard and Poder (2019) argue that framing climate change as a crisis point in an otherwise positive narrative of modernist progress serves to marginalize alternative social imaginaries about climate change. By attending to Indigenous theory and knowledge, one can view climate change not as an unexpected consequence of modernity, but rather as the latest episode of settler-colonialism's long history of unsustainable political and economic development. As such, Norgaard and Poder's (2019) analysis speaks directly to the ways in which energy justice is bound up with ongoing legacies of Indigenous-settler colonial relationships (also see LeQuesne (2018: 4)). Collectively, these papers highlight the need to engage a broader range of social actors and perspectives in the processes of creating just and resilient energy futures.

First, "transformation" is a keyword running across the papers. The authors focus on identifying leverage points for creating new low-carbon energy futures. Their work highlights that energy futures are processes of transformation involving collaboration and contestation among a range of social actors. This complements other research in energy transitions and energy justice that calls attention to the ways in which energy transitions involve competing visions and political interests among a range of actors.

Second, the papers grapple with the need for analyses that bridge the global and the local scales. Problems related to climate and energy futures are often understood as global. However, the scale of place belonging, social meaning, and social practices are local. For example, resistance to new energy development is often understood as more about local issues than it is about global climate change. The work included in this special issue traces global-local dimensions of social imaginaries, politics, and power.

Third, the importance of dialogue across multiple perspectives is emphasized across the papers. As Rosenbloom et al. (2020) note, treating climate change primarily as a market failure fails to recognize it as a "system problem" involving "sociotechnical systems made up of interconnected technologies, infrastructures, regulations, business models, and lifestyles" (Rosenbloom et al. 2020). This calls for new forms of interdisciplinary energy future research, as well as increasing the flow of communication between theoretically sophisticated and applied modes of analysis. The work by this author helps solidify the unique roles of environmental social scientists in engaging with decision-makers and communities on issues related to energy futures.

3.5 Sustainability initiatives in heavy industries

This study is dedicated to a critical analysis of the achievement of a sustainable energy mix in heavy industries. Having in mind the strategic management landscape and risk management approaches, it is necessary to review the process of reducing emissions and embracing sustainability in heavy sectors based on recent scientific evidence. At present, heavy industries cause a significant part of global emissions. The iron and steel, cement, chemicals, and other branches of the heavy sector produce 27% 27%, 15%, and 26% of these emissions, respectively (Naimoli & Ladislaw 2020). Despite impressive achievements of parts pf these heavy industries to embrace sustainability, infrastructural and financial barriers continue to slow down the transition to more sustainable energy mixes. As Naimoli and Ladislaw (2020) explain, "Companies have secured customers for their zero-carbon products, but it will take time to bring their platforms to scale and to eventually replace conventional facilities with their zero-emissions technology" (CSIS Briefs 2020). Countries such as Germany, France, Sweden, Denmark, and the United Kingdom have already achieved successes in mitigating negative environmental impacts of heavy sectors by putting into effect a series of measures and sustainable resource-flow practices such as recycling, consumption extraction of raw materials, the efficiency of manufacturing processes, and the use of energy in manufacturing (Johnson et al. 2021: 2). Other countries, such as India, still lag far behind these achievements of industrially further developed nations.

In the absence of adequate regulations and consensus mechanisms within heavy industries the effectiveness of sustainability initiatives in many countries is undermined. This partially explains the difference in the effectiveness of sustainability initiatives. For instance, despite the call to embracie sustainability and occasional cases of successful emission reduction, the mining industry of Chile increased its fuel and electrical consumption by 130% and 32% per unit of mined copper between 2001 and 2017 (Azadi et al. 2020). This shows that, even if some separate companies succeed in reducing emissions, their efforts are unlikely to trigger effective change across heavy industries unless they are encouraged and supported by a relevant legislative environment and effective policies stimulating the achievement of a sustainable energy mix. At the same time, the case of China ably illustrates that environmental regulations might lead to a decrease in emissions even in those situations when stakeholders are unwilling to adopt renewable energy. Ouyang et al.

(2020) recently found a critical impact of the 2011 mandatory emission trading scheme on the emissions of Chinese heavy industries. The results of propensity score matching showed that this impact is strong and robust. This poses important questions to sustainable energy policy making.

The available evidence provides compelling evidence to the fact that the current strategic landscape of companies that operate in heavy industries in most countries is currently unprepared for supporting achievements for a sustainable energy mix. The main avenues for encouraging sustainability in heavy sectors involves increasing material efficiency, increasing both the quality and the quantity of recycling, removing energy subsidies, supporting research and developing and facilitating the implementation of decarbonized production technologies, enhancing electricity, hydrogen development, carbon capture and storage infrastructure, but also supporting institutions that monitor the effectiveness of emission reduction initiatives (Bataile 2019). The report by Naimoli and Ladislaw (2020) emphasizes the importance of accessing low-carbon energy sources, such as hydrogen and biomass, implementing novel processes, expanding the use of carbon capture, use, and sequestration technology, and increasing efficiency to support the achievement of sustainability goals. Han et al. (2021) illustrate that the strategic landscape capturing sustainability initiative in the heavy industry strongly depends on the unique societal, economic and policy environment. Using the example of Tangshan City in Hebei Province, the Han et al., demonstrate that the demand structure of resource-based heavy industry cities puts significant transformational pressure on companies operating in heavy sectors, making it difficult for them to introduce energy-saving and emissions reduction initiatives (Han et al. 2021). The authors believe that significant changes in the external business environment are needed to justify the achievement of a sustainable energy mix for stakeholders of heavy industries (Han et al. 2021).

Academic research provides much insight into the barriers to the adoption of sustainable initiatives to achieve a sustainable energy mix. For example, Johnson et al. (2021) identify barriers such as lack of financial and non-financial incentives, inconsistent regulations and approvals, high implementation costs, low electrification, and lack of research and development activities. Most of the barriers can be grouped into those related to finance and the regulatory and legal environment of a particular country and industry. Hossain et al. (2020), who analysed the implementation of a circular economy in the construction sector, uncovered systematic problems that prevent the promotion of sustainability, related to material selection, business models, uncertainty, supply chains and design. In addition, the researchers argue that many construction companies lack a consistent methodology for assessing circularity and reducing emissions; as a result, a number of decisions related to the energy mix are often made on a situational basis without considering their broader sustainability implications. Karji et al. (2020) argue that the main barriers to sustainable construction include managerial, legislative, financial and planning barriers. Such findings are critical from the perspective of the problem under investigation, as they demonstrate the importance of managerial factors in supporting the adoption of initiatives that facilitate the transition to a sustainable energy mix in heavy industry.

Among others, financial issues are widely believed among the main factors discouraging companies from adopting sustainable changes. Xu and Chen (2021) argue that the achievement of low-carbon transition in heavy industries is problematic owing to the low ROI of sustainability initiatives. One way to facilitate the adoption of green strategies by companies operating in heavy industries is to provide tax incentives to support exports of high-text products by policy makers. Such initiatives, so it is believed, would provide the necessary financial incentive to justify the adoption of clean energy strategies. Compelling evidence for the capital requirements of emission reduction initiatives can be found in the study by Xu and Lin (2020). The scholars show that significant reductions in carbon dioxide emissions in Chinese provinces are linked to high levels of research and development and personnel investment as well as the number of patents. In other words, companies are unlikely to achieve a substantial reductions in emissions and a sustainable energy mix unless they invest heavily in R&D and support the transition to renewables, which is hardly possible.

One of the strategies facilitating the transition to a sustainable energy mix in heavy industries is to foster the adoption of digital tools. Fantke et al. (2021), who investigated the transition to sustainable chemistry, concluded that digitalization is one of the most promising instruments to reduce emissions in this sector. The authors further claim that, the embracement of digitalization can help chemical companies access recent information about chemicals assessment and management and adopt advanced tools to advance sustainable chemistry in a way that minimizes the costs of energy transition (Fantke et al. 2021).

Tosches and Amelio (2022) argue that innovation is the main mechanism to achieve a sustainable energy mix in the chemical industry. They point to the need to develop consistent safe and sustainable by design (SSbD) criteria that would allow for integrating sustainability initiatives into the design. This way, chemical companies can avoid unnecessary complications and confusion when trying to design and implement customized sustainability approaches to reduce their emissions (Tosches and Ameli 2022). The development of universal guidelines specific for each heavy industry, therefore, can be a strong driver for the achievement of a sustainable energy mix. Another example of innovations that can help facilitate the achievement of a sustainable energy mix can be found in the study by Pan and Yang (2020). These scholars illustrated how the electrochemical reduction of carbon dioxide can become a viable strategy to tune the reduction of emissions via morphology and interface engineering, leading to the achievement of a sustainable energy mix in heavy industries. Wu et al. (2019) demonstrate in their studies how planar and distorted structures can be integrated with long alkyl side chains in order to obtain molecules that have a high emission efficiency in solid and solution states. All three studies reviewed in this paragraph illustrate that the achievement of a sustainable energy mix in heavy industries is inherently linked to the adoption of innovations and the facilitation of research and development activities not only because such activities can enable emission reduction changes but also because they have the potential to inform cost-benefit analysis of potential sustainability projects. To support this point of view, Naimoli and Ladislaw (2020) point out that “given the increased costs of alternative heat options in industry, countries wishing to incentivize their industries to decarbonize are likely to institute policies to drive innovation and scale to reduce their prices” (p. 4). Thus, innovation is currently the most well-known and promising avenue to achieving a sustainable energy mix in heavy industries.

One of the most important success drivers of sustainability initiatives in heavy industries is the quality of planning. Companies operating in heavy sectors should analyse all available options and choose sustainability projects that are optimal based on the cost-benefit analysis. In the mining industry, for instance, they are supposed to scrutinize the internal environment and calculate the possible expenses and benefits of reducing methane emissions in particular facilities to select inseam, underground-to-inseam, or cross-measure borehole methane drainage techniques to reduce methane emissions (Zheng et al. 2019). Such planning allows for emission reductions without undermining the quality of operations.

The available evidence provides ground to believe that the achievement of a sustainable mix in heavy industries is impossible without the application of advanced management techniques. Al-Kindi (2015) notes that steel manufacturing companies should apply lean manufacturing principles to reduce emissions, specifically the ones related to steel scrap accumulation. This study illustrates that companies operating in heavy sectors must utilize advanced managerial tools that focus on detecting and eliminating different sources of waste, including the waste that results from unsustainable practices (Al-Kindi 2015).

In addition to the application of advanced managerial tools, the achievement of a sustainable energy mix in the heavy industry requires the implementation of a consistent strategy that simultaneously addresses three dimensions of sustainability and takes into account the magnitude of investments (Hilsdorf et al. 2017). In other words, sustainability requires a consistent and coherent approach. However, even an effective strategy is unlikely to result in the achievement of a sustainable energy mix alone without effective leadership and culture. Wexen and Stocksen (2021) found that leadership, culture, and innovation are the most important factors shaping the success of sustainability efforts in the heavy industry. Boutillier and Ryckelynck (2017) emphasize that sustainable entrepreneurs operating in heavy sectors can achieve sustainable goals only if they take advantage of social networks that help gather resources that are required to manage projects. Those entrepreneurs who cannot rely on such networks are highly unlikely to find an optimal solution to minimize the costs of sustainability initiatives.

3.6 Strategy development

3.6.1 Concept of strategy

As presented above, this thesis aims to recommend solutions for the sustainable development of renewable energy in heavy industry. Having realized the importance of renewable energy in the aspect of sustainable development, the European Union issued the Development Strategy for renewable energy. At the same time, some preferential policies and mechanisms have also been set up to support it. Nevertheless, this source of energy has not developed as planned. What are the reasons for this status? Is it because of strategic planning or strategic implementation? What can be done to achieve the set targets? Before looking for the answer to these questions, one must review the theoretical framework of strategy and strategic management.

The term “strategy” is first used in the military aspect involving the method used to gain victory over enemies. In the business world, “strategy is a means to make growth happen, and to make more money than you use” (Manning 2002). Today, strategy is construed to be a set of long-term objectives and guidelines of operations to achieve these objectives. It means that strategy plays a vital role in the survival and development of an institution, especially in the context of the severe competitiveness of the world today as agreed by Joyce and Drumaux (2014) that “strategy and strategic management have increased their influence within the public sector since the mid-1990s”. However, it is necessary to distinguish the concepts of "strategic planning" and "strategic management" because in some cases they are often used interchangeably. While the former term is often associated with the goals, mission, or vision that an organization want to obtain in the future, the latter one is “the larger process that is responsible for the development of strategic plans, the implementation of strategic initiatives, and the ongoing evaluation of their effectiveness” (Poister 2010).

Strategic management is regarded as an art and science of building, implementing and assessing comprehensive decisions to help organizations obtain their objectives. It is “a process that involves leadership, creativity, passion and analysis, building an organization that both generates and responds to change, developing compensation systems to reward staff, devising appropriate structures and systems, competing for funds in global financial markets and ensuring necessary resources are developed and allocated to worthwhile opportunities” (FitzRoy et al., 2012). It means that this process serves as guidelines of operation for organizations and thanks to these guidelines the organization can adapt to changes well and overcome obstacles actively. There is a variety of processes of strategic management. They can be “formal or informal, intuitive or analytical” (FitzRoy et al. 2012). In a simple way, it is a cycle starting from understanding the internal and external environment to developing the strategy and having it implemented. In a broader sense, it is illustrated in the figure below (Poister 2010).

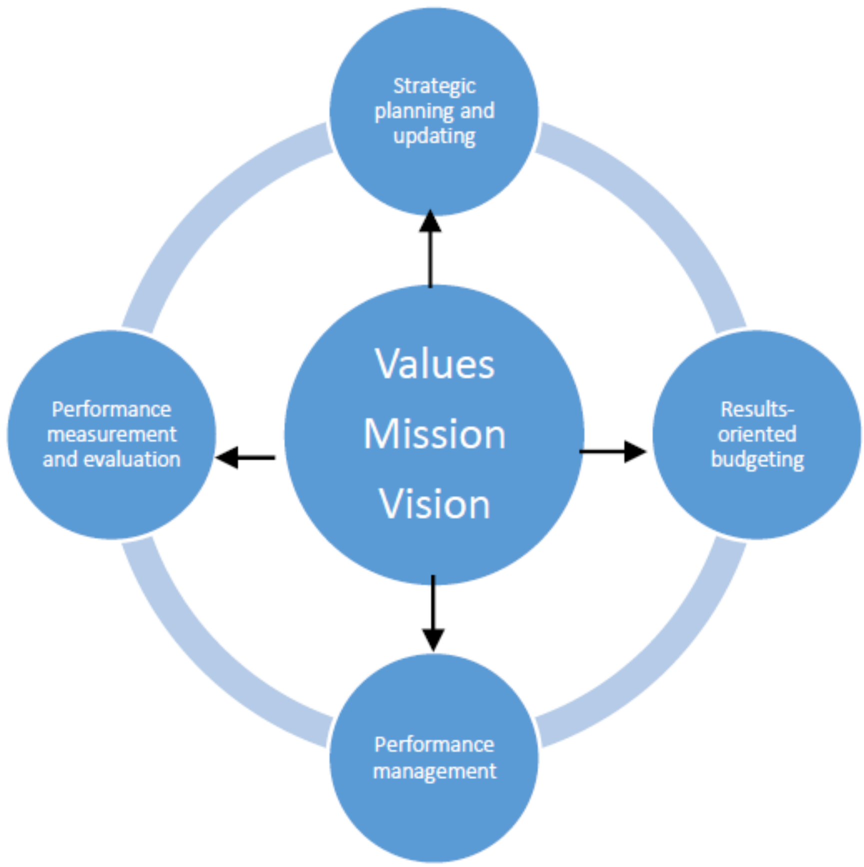

Figure 6: Values, Mission, and Vision Cycle. Source: Poister (2003)

As one can see from the illustration above, the strategic management process involves some essential components such as strategic planning and updating, results-oriented budgeting, performance management and performance measurement and evaluation (Poister 2003). Much more importantly, all of these elements must be combined closely and aligned to serve the set vision, mission, and values.

Strategic development is a systematic approach to developing a strategy for an organization to create values. Within an organization, Strategic development should follow a structured process. The process involves researching and identifying options and then selecting those options that can be achieved and help to maximise the creation of values. Some key questions that should be answered in the process of Strategy development are the following: What business are we in? Or what business should we be in? (Mission), Where do we want to be? (Vision), How are we doing? What is going well? What is not so successful? How did we get to this point? What went well? What went wrong? How can we improve our position? What options are open to us? What might hinder us from getting there? What do we need to do to get there? What should we not do?" (Chartered Management Institute, 2020).
In the process of Strategy development, it is important to set targets and quantify objectives. Critical success factors (CSFs) and key performance indicators (KPIs) must be determined. The strengths (S) and weaknesses (W), opportunities (O), and threats (T) should be determined to conduct a SWOT analysis (Chartered Management Institute 2020: 3). A diagnostic tool for Strategic development that was developed by Dyson et al. (2007) can be found in the figure on next page..

	Setting strategic direction	
Implicit from current situation only	Set explicitly but projection only	Exploration of desirable directions leading to aspirational, clearly articulated futures
	Designing the performance measurement system	
Financial measures only	Broader set of measures developed	Aligned and balanced set of measures developed with appropriate communication mechanisms
	Sense-making	
Minimal internal and external exploration	Some environmental scanning and internal appraisal	Rich exploration of internal and external environments
	Creating strategic initiatives	
Incremental proposals only	Wider search for alternatives	Creative direction-driven search for initiatives
	Evaluating strategic options	
Simple financial evaluation only	Assessment on a limited set of measures	Multi-dimensional assessment incorporating risk and uncertainty
	Rehearsing strategy	
Limited reflection on initiatives – hunch and hope	Wider impact of initiatives assessed	Search for appropriate overall strategy
	Selecting and enacting strategy	
Initiative choice made in isolation	Impact on organisation considered	Search for coherent, flexible and robust strategy with action plan
	Feedback, learning and communication	
Process elements developed in isolation	Some connectedness recognised	Feedback of real and virtual performance connecting process elements leading to organisational learning
	Participation of stakeholders	
Senior management team only	Wider internal participation	Broad internal and appropriate external involvement

Increasing effectiveness →

Figure 7: Strategic Development Process Diagnostic. Source: Dyson, Bryant & Microsoft (2007: .21)

3.6.2 Problems of strategic management

The most obvious problem in strategic management is the lack of integration and coordination (Jin & Bai 2011). Every agency or specialized unit usually just pays attention to its own strategy. While building strategy, the conjunction and importance of other strategies are ignored or eased. This phenomenon in strategic management has been existing at all levels, from the national to the regional level, leading to the reduction in the comprehensive effectiveness of strategies.

Another problem is that of sustainable development. In several countries, especially developing countries, they pay more attention to economic value than environmental and ecological benefits. In some cases, they are willing to ignore negative impacts on the environment to gain short-term economic profits.

The third problem is the lack of management skills and knowledge of strategic management. This problem is easily recognized in developing countries. As a result, some strategies which were just established, have become unfeasible or unsuitable. During the phases of the strategic process, the first phase of the strategic formulation is often emphasized but the phases of strategic implementation and evaluation are neglected. That is why adjustments are rarely made in time and outcomes are not obtained as expected. Having recognized these shortcomings, policymakers will find the best approach to plan and manage their strategies successfully.

3.6.3 Transformation processes

Transformation or Transition Management represents a governance model that begins from a strategic level, making an exhaustive analysis of different approaches from a long-term perspective (Loorbach & van Raak, 2006). The process consists of problem struc-turing and development of a long-term vision, establishing a transition arena and agenda, initiation and execution of transition projects as well as monitoring, evaluation and learning (Loorbach,2010: 163; Smith & Stirling 2008).

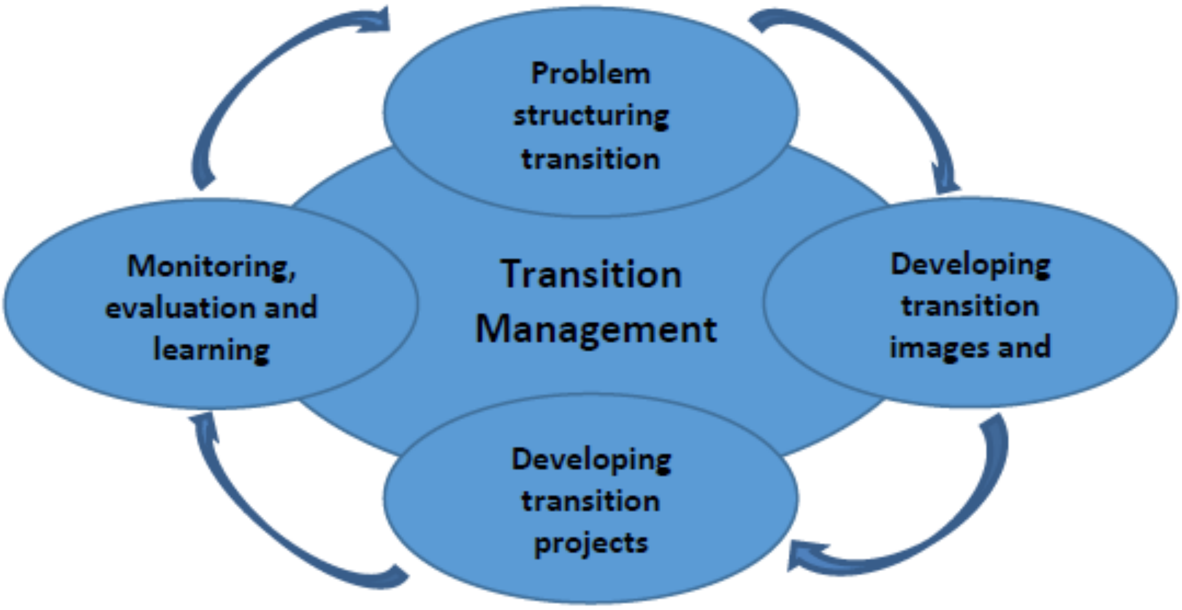

Figure 8 : Transformation Process Adapted from Loorbach (2010: 15)

Problem structuring and long-term visioning start with the convening of a multi-actor forum, where actors deliberate over the challenges associated with the existing socio-technical regime (Smith & Stirling 2010: 13). Actors discuss possible alternative solutions as well as develop a long-term vision which, in turn, is the basis for the development of transition pathways and projects (Loorbach & Rotmans, 2006; Smith & Stirling 2010).

The long-term shared visioning process functions as a guide for formulating transition programmes and objectives (Loorbach & Rotmans 2006). Although actors come with different backgrounds, competencies and interests (Loorbach, 2010), prominence must be given to mutual learning, accord building and the development of joint problem perception (van der Brugge & van Raak 2007). Hence, Raven (2007) posits transition as, “a collective strategy rather than an individualist's strategy”. Long-term vision must be appealing and imaginative to be able to be supported by a wide range of actors as well as being able to stimulate and direct short-term activities (Rotmans et al. 2001). Following the development of a long-term vision, a short-term goal is developed through backcasting: a process that first defines the desirable future sought and then works backwards to identify short-term goals and objectives (Quist et al. 2011).

The TM process is followed by developing a transition agenda and pathways in, “an open and dynamic network, in which different perspectives, different expectations and different agendas are confronted, discussed and aligned” (Loorbach 2010). The basis for developing and supporting transition projects is provided by the formulation of transition images and pathways (Smith and Sterling, 2010). Actors select the most feasible, innovative and promising pathways in the transition process (Loorbach & Rotmans 2006). Such images and pathways must also be, “appealing and imaginative so as to be supported by various actors” (Rotmans et al. 2001).

After the transition images and pathways are drawn in a participatory process, transition pilot projects are initiated to translate the images and pathways into action with the aim of deepening, broadening, and scaling up through learning processes (Loorbach & Rothmans 2006; Loorbach 2010). Scholars have highlighted that the development and execution of transition projects should be done through the prevailing networks of actors in the arena to ensure the direct participation of forerunners in the development process (Kemp et al. 2007; Loorbach & Rotmans 2006). It is vital to frame a sound condition for selecting a transition project that is mutually accepted by all actors. The feasibility and running time of the transition project may be challenged when the transition project lacks mutual understanding and unity among the participants (Rotmans et al. 2001).

Constant monitoring and evaluation of a transition process are critical in transition management (Smith & Stirling 2010). This involves monitoring all the activities as well as the transition process itself (Loorbach & van Raak 2006). Monitoring takes place at different levels of the transition process (Looback & van Raak 2006). This includes monitoring the changing exogenous landscape developments, the behaviour of actors within the transition arena, networking activities, alliance forming and responsibilities (Loorbach & Rotmans 2006; Looback & van Raak 2006). Similarly, transition managers must also ensure that the transition process itself is continuously monitored including its rate of progress, the barriers and points to be enhanced (Smith & Stirling 2010). The purpose of monitoring is to permit the documentation of outcomes, experiences and processes that serve as the basis for evaluation (Beers & Van Mierlo 2017). Transition scholars stress the importance of reflexive monitoring which focuses on learning through a participatory process that is required for instigating both first and second-order learning (Beers & Van Mierl 2017). Kemp and Rotmans (2005) further state that it is difficult to monitor and document this kind of learning process because reflexive social learning is for many, still in an abstract form that cannot be translated into monitoring. Scholars suggest formulating explicit learning goals against which transition learning processes should be evaluated. Kemp and Rotmans (2005) theorise that the purpose of the evaluation is to assess whether goals have been realised and if not, questions whether any external or unexpected social developments were not considered or whether any actor has not complied with the agreements that were reached are being raised. Once these questions are resolved, a new transition management process begins (Kemp and Rotmans 2005).

3.7 Risk management

Risk describes the probability or threat of damage, liability, loss, or any other negative impact caused by internal or external occurrences or effects. Risk management aims to identify and control the level of risk associated with identified hazards. The International Organization for Standardization (ISO) is an independent, non-governmental international organization (ISO, 2020) ISO developed Risk Management – Guidelines (ISO 31000: 2018) which define Risk as the "…effect of uncertainty on objectives" (Tranchard, 2018). In the introduction to ISO 31000: 2018 it is stated, that "Organizations of all types and sizes face external and internal factors and influences that make it uncertain whether they will achieve their objectives."

Risk Management is defined as "…coordinated activities to direct and control an organization with regard to risk" (ISO, ISO 31000: 2018(en), 2018). In this context, ISO

31000: 2018 aims to provide "…guidelines on managing risk faced by organizations" (ISO, ISO 31000: 2018(en), 2018). The Introduction of ISO 31000: 2018 goes on: "Managing risk is iterative and assists organizations in setting strategy, achieving objectives and making informed decisions. Managing risk is part of governance and leadership and is fundamental to how the organization is managed at all levels. It contributes to the improvement of management systems. Managing risk is part of all activities associated with an organization and includes interaction with stakeholders. Managing risk considers the external and internal context of the organization, including human behaviour and cultural factors." Managing risk is based on the principles, framework and process outlined in this document. These components might already exist in full or in part within the organization, however, they might need to be adapted or improved so that managing risk is efficient, effective and consistent." The principles, framework and process of Risk management according to ISO 31000: 2018 are shown in the figure below.

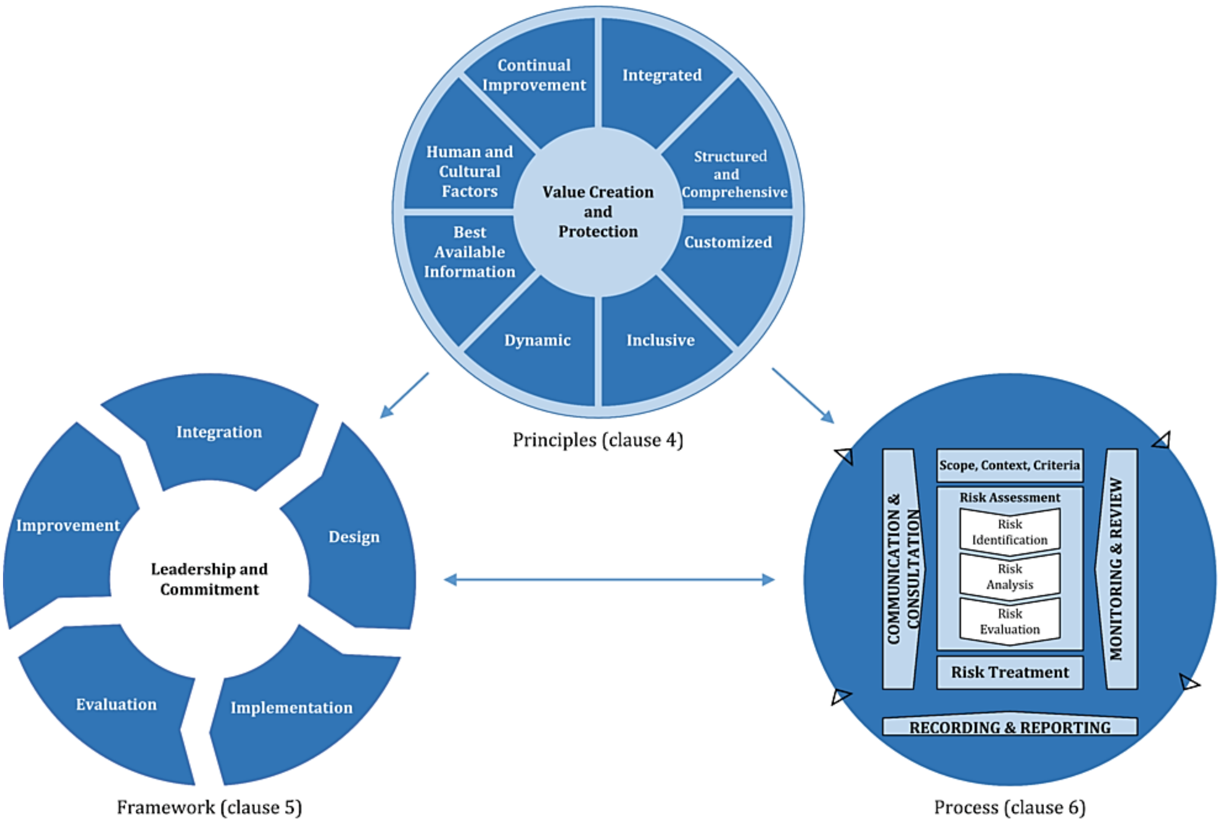

Figure 9: Risk Management: Principles, Framework and Process.
Source: Tankard (2018: 45)

The process of risk management as described in ISO 31000: 2018 is described as follows:

"The risk management process involves the systematic application of policies, procedures and practices to the activities of communicating and consulting, establishing the context and assessing, treating, monitoring, reviewing, recording and reporting risk. … The risk management process should be an integral part of management and decision-making and integrated into the structure, operations and processes of the organization. It can be applied at strategic, operational, programme or project levels (Tankard 2018: 25).

The overall process of identifying, analysing and evaluating risk is called risk assessment. Risks should be identified whether their sources are under its control (ISO 31000: 2018 6.5.2). This process "…should be conducted systematically, iteratively and collaboratively, drawing on the knowledge and views of stakeholders. It should use the best available information, supplemented by further enquiry as necessary" (Tankard 2018: 50).

Finding, recognizing and describing risks is called risk identification. For identifying risks, the "…following factors, and the relationship between these factors, should be considered: Tangible and intangible sources of risk; causes and events; threats and opportunities; vulnerabilities and capabilities; changes in the external and internal context; indicators of emerging risks; the nature and value of assets and resources; consequences and their impact on objectives; limitations of knowledge and reliability of information; time-related factors; biases, assumptions and beliefs of those involved" (Tankard, 2018: 50).

The next step in Risk management after risk identification is risk analysis. This "…involves a detailed consideration of uncertainties, risk sources, consequences, likelihood, events, scenarios, controls and their effectiveness…" to "…comprehend the nature of risk and its characteristics…". (ISO 31000: 2018 6.5.3) "Risk analysis can be undertaken with varying degrees of detail and complexity, depending on the purpose of the analysis, the availability and reliability of information, and the resources available" (Tranchard 2018: 15).

The input from risk analysis is used in the next step for the evaluation of risks to provide insight and support decisions (ISO 31000: 2018 6.5.4). Therefore, the findings of risk evaluation should be recorded, communicated and then validated at appropriate levels of the organization (ISO 31000: 2018 6.5.4).

Now that the risks are identified, analysed and evaluated, the risks can be addressed. This can be done by selecting options for appropriate treatment of the risk(s). "Options for treating risk may involve one or more of the following: Avoiding the risk by deciding not to start or continue with the activity that gives rise to the risk; taking or increasing the risk in order to pursue an opportunity; removing the risk source; changing the likelihood; changing the consequences; sharing the risk (e.g., through contracts, buying insurance); retaining the risk by informed decision" (ISO 31000: 2018 6.5.2).

Since the treatment of evaluated risks "…might not produce the expected outcomes and could produce unintended consequences. Monitoring and review need to be an integral part of the risk treatment implementation to give assurance that the different forms of treatment become and remain effective" (ISO 31000: 2018 6.5.2). "Monitoring and review should take place in all stages of the process. Monitoring and review include planning, gathering and analysing information, recording results and providing feedback" (ISO 31000: 2018 6.6).

A risk "…treatment plan should clearly identify the order in which risk treatment should be implemented" (ISO 31000: 2018 6.5.3). "The information provided in the treatment plan should include: The rationale for the selection of the treatment options, including the expected benefits to be gained; those who are accountable and responsible for approving and implementing the plan; the proposed actions; the resources required, including contingencies; the performance measures; the constraints; the required reporting and monitoring; when actions are expected to be undertaken and completed" (ISO 31000: 2018 6.5.3).

Finally, the whole process of risk management and its respective outcomes should be documented and reported "… to: Communicate risk management activities and outcomes across the organization; provide information for decision-making; improve risk management activities; assist interaction with stakeholders, including those with responsibility and accountability for risk management activities” (ISO 31000: 2018 6.7).

Especially performance measurement is an important component of the feedback path that enables people to learn about the actual success or failure of the strategy when compared with the desired organizational direction they want to head towards.

The importance of risk management has been mentioned above. The concept of risk management is based on the different types of risk that are involved. In the context of renewable energy projects Lee (2016) identifies the following risks and the respective capital costs involved.

Risk Type	**Capital Cost**
Credit Risk	The default of renewable energy projects Non-performance of renewable energy projects
Market Risk	Low capacity factor Low connection rate Low dispatch priority
Operational Risk	Discontinuous electricity output Volatile electricity output Outdated operating paradigm of the grid
Liquidity Risk	Non-existence of secondary market Long payback period
Political Risk	Unstable renewable energy policy

Figure 10: Risk types and capital costs. Source: Lee (2016: 14)

A typical and comprehensive operational risk management model involves the following components: evaluating and quantifying operational risks, implementing appropriate risk management tools and frameworks, monitoring the operational risks, investigating the causes of expected and unexpected loss events based on the probability of occurrence, evaluating the trends, correlations and patterns of the operational risks, and evaluating the potential losses from operational risk and impact on revenue and investment (Lee 2016).

Political risk concerns the possibility that national governments, acting in their sovereign capacity, amend policy in ways that adversely impact the financial stability of companies. Political risk can be divided into macro-level and micro-level. Policy risk is a micro-level political risk which is a project-specific risk. Renewable energy policy risk concerns the possibility that policymakers, acting in their capacity, amend renewable energy policy in ways that adversely impact the financial stability of renewable energy projects. Two main types of policy risks can be defined, which are prospective policy risk and retroactive policy risk (Pelijahn and Marec 2021). The former risk refers to the overall uncertainty and instability of the regulatory framework which adversely affects the planning of new projects. The latter risk refers to policy changes which adversely affect the financial stability of existing projects. Of the two types of policy risks, the impact of retroactive changes is higher because the changes directly impact developers' assumptions and forecasts. Developers, financiers and investors are three key parties involved in procuring and supplying financed renewable energy projects. The three parties face renewable energy policy risk differently according to the timeline of the project (Lee 2016). It is important to understand that risk management is an integral part of strategic development.

3.8 Stakeholder and sustainability

Since the 1980s, the number of companies engaging in sustainability reporting increased further. While the social dimension remained dominant, there was also a slowly increasing focus on environmental issues. This trend could be observed in Western countries and stemmed from public concerns about the preservation of nature. In Germany, these public concerns were centred mainly around a particular fear of the dying of forests, but several international natural or man-made disasters like Tschernbyol were also meaningful drivers. Consequently, many companies began to include information about their environmental performance (emissions and waste generation) in their reports to address those public concerns (Fifka 2015).

While in the following years interest in environmental topics slowly abated in many Western countries, it remained significantly strong in Germany. Based on the already mentioned Brundtland Report, the UN developed Agenda 21 for global sustainable development at the 1992 UN Conference on Environment and Development in Rio de

Janeiro. In line with this, the Treaty of Amsterdam in 1997 created the model of the three pillars of sustainability developed by the EU (Elling & Jelsoe, 2016). The concept of sustainability in the sense of the three-pillar model is based on the previously mentioned dimensions of economy, ecology and social issues. The so-called sustainability triangle is often used as a representation to show the equivalence of the goals.

3.9 Environmental policies and the Kyoto protocol

In the Kyoto Protocol (KP), initially adopted on 11 December 1997, 37 countries (and the European Union), the so-called Annex B countries, which roughly resembled the industrialized world in the 1990s, committed to reducing the emissions of six greenhouse gases (GHGs) by 5.2% on average over the period between 2008 and 2012 compared to 1990 levels by accepting individual emission targets that had to be met by the end of 2012 (Grunewald & Martinez-Zarzoso 2016). Ever since its emergence the KP has been heavily criticized. Also, the economic profession found little praise for the KP: While the theoretical literature on climate treaties produced disillusioning findings regarding the likelihood of a global agreement (Finus 2008). Barrett (1998) argued that the KP hardly deters non-participation and non-compliance. Copeland and Taylor (2005) criticized that its design neglects important lessons from trade theory, while some authors animadverted the level of the emission targets (Telesetsky 1999) or discussed the challenges of the flexibility mechanisms (Zhang & Wang 2011). Despite this widespread criticism, the KP and its approach are supported by a recent and increasing body of empirical literature on the effectiveness of the KP. Aichele and Felbermayr (2012) and Grunewald and Martinez-Zarzoso (2016) consistently found that countries with binding emission targets under the KP have lower CO2 emissions than they would have had in the absence of these targets. In fact, they estimate a statistically significant average CO2 reduction effect of 7–10% (Grunewald & Martinez-Zarzoso 2016).

The KP has been widely criticized by the public press and the scientific community alike. Issues concerning inequity, efficiency, and cost-effectiveness have been raised. To answer the question of whether the KP managed to achieve the intended outcomes, the development of CO2 emissions for major GHG emitters with binding emission targets under the KP by employing the synthetic control method must be evaluated. Little evidence was found for a significant emission reduction effect for all 15 investigated countries, i.e., countries with binding emissions targets did not emit less CO2 over the period from 1998 to 2011 than they would have had in the absence of the GHG emission targets (Abadie et al. 2015). Yet, one can find some evidence that some Annex B countries performed even worse than comparable countries from the two donor pools. On average, the CO2 emissions of the 15 countries are rather above than below their synthetic controls when using US states as the control group. This is particularly puzzling, as the violation of the SUTVA should rather bias our results in the direction of negative significance. However, these positive treatment effects are restricted to very few countries. In fact, the three Scandinavian countries Finland, Norway and Sweden are responsible for the most significant positive treatment effects in our main specifications (14 out of 20) and in almost all robustness checks. In addition, these countries (like other small countries) show highly volatile CO2 emission paths which makes the construction of counterfactual emission paths difficult (Abadie et al. 2015).

This conjecture is supported by the robustness check in which GHG is used instead of CO2 emissions. A GHG emission data check shows much lower year-to-year variations than the CO2 data, for the three Scandinavian countries. In this specification, these countries do not exhibit any positive treatment effects. Research results show the importance of addressing several empirical challenges when estimating the effect of international environmental policies in general, and the KP. The key to identifying the “true” treatment effect is the availability and the selection of appropriate controls. This means: First, a synthetic control method (Abadie & Gardeazabal, 2003; Abadie et al. 2010) must be employed which enables the construction of counterfactual emissions paths for all 15 countries under investigation that reasonably match the observed emissions in the pre-treatment period. This is possible because the treatment effects can be estimated for each country individually, which allows an individual identification the counterfactual synthetic country to the idiosyncrasies of each treated country, such as different country characteristics, emission paths, targets and ratification dates (Abadie et al. 2015).

Second, using non-Annex B country data to construct counterfactual CO2 emission paths for the investigated Annex B countries may be problematic because of (i) irreconcilable structural differences between Annex B and non-Annex B countries including opposing pre-treatment emission paths and (ii) a bias resulting from the use of the flexibility mechanisms blurring the distinction between treated and non-treated countries (Chick & Micklethwaite 2017). To circumvent these problems a second specification using US state-level data was run to construct synthetic counterfactuals. Although US state-level data comes at the disadvantage that data on some covariates is not available, it seems to be preferable to use non-Annex B country data on the ground that (i) the imbalance in predictors is much smaller and, as a result, (ii) pre-treatment matching is considerably better (Abadie et al. 2015).

Third, all Eastern European countries from the analysis must be discarded, as this is justified regarding the former “Eastern Block” experienced a severe economic downturn after the collapse of the Former Soviet Union at the beginning of the 1990s. Even after their economic recovery, former CO2 emission levels were not reached and, at the time of the adoption of the KP, it was evident that many Eastern European countries were unlikely to reach or even exceed their GHG emission targets (also known as “hot air”). Therefore, these countries had no incentive to reduce GHG emissions in the first place (Abadie et al. 2015).
Nevertheless, the collapse of the FSU had a significant negative impact on the CO2 emissions of the Eastern European countries. Incorporating these countries into the treated sample when eliciting the average treatment effect of the treated may bias the result in favour of a negative significant effect if one is not able to control for the peculiarities of those countries with respect to the development of CO2 emission in the early 1990s (Abadie et al. 2015). It is believed that the empirical challenges faced in such an evaluation apply to many international environmental policies that can only be evaluated at the country level. Countries tend to be highly heterogeneous with significant differences in their (socio-)economic and political characteristics (Chick & Micklethwaite 2017). As a result, there are numerous issues that need to be addressed. Accounting for all these challenges simultaneously can be difficult when employing standard panel data analysis. The synthetic control method or extensions of

matching based DiD methods may be better suited to address these challenges than standard panel data approaches (Abadie et al. 2015).

Finally, several results showed how important political implications are. In December 2015 the UNFCCC managed to reach a consensus on the “Paris Agreement” that outlines the main pillars of the successor of the KP which is to become effective by 2020 (Abadie et al. 2015). In the Paris Agreement reduction targets are called “nationally determined contributions”. Like the KP, the Paris Agreement is lacking any enforcement mechanism for non-compliance. According to our results, the KP had no verifiable effect on the CO2 emissions of ratifying Annex B countries. Consequently, one still has to be pessimistic that the Paris Agreement, which rests on similar principles, will have any discernible effect on the reduction of global GHG emissions (Abadie et al. 2015).

3.10 National approaches to environmental sustainability in the DACH region

In the 1990s, companies realised that having an environmentally friendly image could bring comparative advantages for their businesses (Gray and Bebbington, 2005); and so, many companies voluntarily shifted to publish an environmental report instead of the abovementioned social balance sheet. The increasing utilisation of renewable energy sources (RES) is a priority worldwide. Germany has been a forerunner in the deployment of RES and has ambitious goals for the future. The support and use of renewables affect the economy: It creates business opportunities in sectors producing renewable energy facilities, but also comes along with costs for supporting the deployment of renewables (Blazejczak et al. 2011). Investments in renewable energy technologies are regarded with increasing interest. Despite the numerous policies implemented to promote these technologies, the diffusion of renewable energy projects remains somehow below expectations (Masini & Menichetti, 2012).

After the turn of the century, companies began to consider the social and the environmental dimension simultaneously and thus, in many cases, both dimensions were merged into a joint non-financial report. In some of those reports, economic variables were included (Gebauer & Hoffmann 2009), which reflected an upcoming understanding of sustainability as a broad concept in the sense of the mentioned triple bottom line (Elkington 1997). At the same time, in 2000, the first version of the GRI (Global Reporting Initiative) sustainability reporting guidelines was published. According to Hahn and Kühnen (2013), both events went hand in hand, as the broader nature of reports can be interpreted as a standard-setting in line with the GRI guidelines. Throughout the decade, the GRI was established as the de facto standard for sustainability reporting, helping to facilitate a trend of standardisation in this field. Essentially, by providing concrete and unified performance indicators and guidance for the selection of topics, a certain homogeneity could be achieved throughout the reports (Pelijhan & Marc 2021). In this context, the naming of reports also followed a trend of standardisation: while in subsequent years, the naming was either based on the particular focus of dimensions or exposed to the arbitrariness of companies, now the range of title names was more consistent; with sustainability report and corporate social responsibility (CSR) report being the most frequent ones.

Apart from standardisation efforts, the 00s-years were a breakthrough decade in terms of massive quantitative growth of reports. The trend of qualitative growth maintained through the following years and was mainly driven by large companies. At the end of the decade, a clear trend towards integrated reporting emerged, meaning that sustainability information was no longer published in a separate report but instead integrated into the annual report. Integrated reporting represents a further development of value-oriented corporate reporting (Johner 2012) under the aspect of changing information needs. In contrast to conventional reporting, which primarily provides retrospective and offers provides historical data, integrated reporting includes information about future developments (IIRC 2013). This aspect is particularly important for financial market players since investments are always future-oriented. Unless IR is prescribed by certain stock exchanges, reporting to IR is voluntary. This means that IR is also in competition with other forms of business reporting but should be given increasing attention in the context of the growing importance of the United Nations' 17 sustainability goals (SDG) as part of the 2030 Agenda. Evidence that companies meet sustainability goals within the meaning of the 2030 Agenda could be provided, for example, in the form of integrated reporting.

In March 2017 Directive 2014/95/EU required companies with more than 500 employees and capital market interest to “disclose”, making sustainability reporting effectively mandatory for these companies (United Nations 2020: 4). Because of changing social expectations, the amount of legitimacy needed may also fluctuate over time. Therefore, a company might need different courses of remedial actions over time. To know which course of action is the right one to apply, a company needs to know how big the amount of legitimacy needed is. To this end, literature offers the notion of a “legitimacy gap”, which describes the difference in social expectations concerning how a company should act concerning how a company does act. In this sense, Sethi (1974) refers to a “legitimacy gap” as an “expectancy gap indicating a discrepancy between an organization's actions and society's expectations of this organization”.

Among the first influential contributions embracing the perspective of legitimacy is the study of Guthrie and Parker (1989). The authors conducted an appraisal of 100 years (1885–1985) of historic disclosures on BHP Ltd., a large Australian mining company. The study aimed to examine if corporate disclosures responded to major social and environmental events. If this is true, then there should be a relationship between peaks of disclosure and significant events in BHP’s history. While the results of the study did not provide evidence for the existence of such a relationship and were considered to disprove legitimacy theory, Deegan et al. (2002) refine their arguments and indeed indicate the applicability of legitimacy theory. In a more recent study, O’Dwyer et al. (2005) explore the perceptions of Irish managers concerning sustainability reporting. Based on interviews with 29 directors in 27 companies, he found that sustainability reporting was perceived counterproductive to obtain legitimacy, as it could attract unwanted attention from activists and, thus, increase public suspicions. Another influential study was the one of Patten (1992) who utilised legitimacy theory to evaluate the effect of the Exxon Valdez Oil spill on the practices of reporting environmental disclosures in the annual report of North American petroleum firms. The author observed a significant increase in disclosures after the disaster. The results of the study support legitimacy theory, in that where a threat to the legitimacy of the company was evident the industry members sought to address this threat by increasing environmental disclosure to retain their legitimacy. A large body of studies has identified the nature of a company’s industry as a factor affecting sustainability reporting. Specifically, it is considered that industries with higher CSR profiles offer more quantity and better quality of sustainability reports because their major product is likely to have a mainly negative connotation.

Since the adoption of the Sustainable Development Goals, there have been many positive developments. Countries have started to incorporate the Goals into national plans and strategies, and many have set up coordinating structures for coherent implementation. Of the 110 voluntary national reviews submitted during the 2016, 2017 and 2018 sessions of the high-level political forum, 35 mentioned explicit measures to link the Goals to their national budgets or were considering such action (United Nations 2020). There have also been initiatives aimed at safeguarding the environment, notably regarding climate change, land use and oceans. Important stakeholders of the private sector have begun to move away from business-as-usual models, for example by adopting and reporting on sustainability standards.

Meanwhile, the mobilisation of civil society and non-governmental organizations in favour of sustainable development is rising. However, despite the initial efforts, the world is not on track for achieving most of the 169 targets that comprise the Goals. The limited success in progress towards the Goals raises strong concerns and sounds the alarm for the international community. Much more needs to happen – and quickly – to bring about the transformative changes that are required: impeding policies should urgently be reversed or modified, and recent advances that holistically promote the Goals should be scaled up in an accelerated fashion (United Nations 2020). Adding to the concern is the fact that recent trends along several dimensions with cross-cutting impacts across the entire 2030 Agenda are not even moving in the right direction. Four, in particular, fall into that category: rising inequalities, climate change, biodiversity loss and increasing amounts of waste from human activity that are overwhelming capacities to process them (United Nations 2020). Critically, recent analysis suggests that some of those negative trends presage a move towards the crossing of negative tipping points, which would lead to dramatic changes in the conditions of the Earth system in ways that are irreversible on time scales meaningful for society.

Recent assessments show that, under current trends, the world's social and natural biophysical systems cannot support the aspirations for universal human well-being embedded in the Sustainable Development Goals. Just over 10 years remain to achieve the 2030 Agenda, but no country is yet convincingly able to meet a set of basic human needs at a globally sustainable level of resource use (United Nations 2020). All are distant to varying degrees from the overarching target of balancing human well-being with a healthy environment. Each country must respond to its own conditions and priorities while breaking away from current practices of growing first and cleaning up later. The universal transformation towards sustainable development in the next decade depends on the simultaneous achievement of country-specific innovative pathways (United Nations 2020). Nevertheless, there is reason for hope. Human well-being need not depend on intensive resource use, nor need it exacerbate or entrench inequalities and deprivations.

Scientific knowledge allows for the identification of critical pathways that break that pattern, and there are numerous examples from across the world that show that it is possible. The science and practice of sustainable development thus point the way forward. Advancing the 2030 Agenda must involve an urgent and intentional transformation of socioenvironmental-economic systems, differentiated across countries but also adding up to the desired regional and global outcomes, to ensure human well-being, societal health and limited environmental impact (United Nations 2020). Achieving that transformation – a profound and intentional departure from business as usual – means carefully considering the Executive summary interactions between Goals and targets. Policymakers will find similarities and contradictions within them, as well as systemic interactions and cascade effects, as action towards one Goal can alter the possibilities for meeting other goals. A significant amount of knowledge is already available about those important interactions, and more research is under way (United Nations 2020). An important key to action is to recognize that, while the present state of imbalance across the three dimensions of sustainable development arises from not having fully appreciated the interlinkages across them or having unduly prioritised the short-term, it is these same interlinkages that will lead to the desired transformative change when properly considered.

The most efficient – or sometimes the only – way to make progress on a given target is to take advantage of positive synergies with other targets while resolving or ameliorating the negative trade-offs with yet others. Translating that insight into practical action for the Goals is informed in the Report by current assessments that emphasize the need for urgency, forward-looking expectations about a growing global population seeking higher levels of well-being and normative considerations, such as leaving no one behind (United Nations 2020). Those actions can be undertaken by a more diverse group of people and organizations than the governments of United Nations Member States alone. At the local, national and international levels, new key development actors are emerging and gaining greater power and influence. Innovative and powerful partnerships can result from collaborations between traditional stakeholders and emerging actors. The success of the 2030 Agenda thus depends on the cooperation of governments, institutions, agencies, the private sector and civil society across various sectors, locations, borders and levels.

3.10.1 Germany

The latest version of the Sustainable Development Strategy, now the “German Sustainable Development Strategy” (GSDS), shows specifically how the guiding principle of sustainability is being implemented in the Federal Government’s work now and in the future (United Nations 2020). The Sustainable Development Strategy forms an essential framework for the national implementation of the 2030 Agenda. Its adoption in 2016 is intended to serve as a starting point for further continuous reinforcement of the concept of sustainability in all policy areas. The Strategy will also be updated in line with the involvement of social stakeholders.

Fortunately, the green transformation of economies is no longer a theoretical concept. Several nations have put the green economy to the test. While far from being the only country to venture down this path, Germany has earned wide recognition for its successful alignment of prosperous and sustainable growth. Unlike many of its European neighbours, Germany has emerged from the 2008 recession with a robust economy, thanks in large part to flourishing exports (Buehler 2011). Germany has a dominant market share in various green technologies, and a substantial part of its workforce is employed in the environmental sector (Buehler 2011). Meanwhile, greenhouse gas emissions have fallen in absolute terms, effectively decoupling economic growth from Germany's environmental footprint.

Admittedly, not all factors contributing to this success story can be replicated in other countries and regions. Challenged with scarce natural resources and a high population density, Germans have traditionally been forced to embrace sustainability in virtually all facets of economic activity, from land use to transportation (Bachmann 2022). Historical transition processes, such as post-war reconstruction and, more recently, the reunification of East and West Germany, also resulted in the renewal of infrastructure and the replacement of outdated industrial facilities.

Still, the greening of the German economy is also unmistakably the product of several decades of targeted policy design and implementation, particularly in the past decade. Policies related to environmental protection and resource conservation have been mainstreamed in all areas of economic activity and have been described by a former government minister as central to Germany's recent success: "Green policy is merely good industrial policy" (Bachmann 2022: 5). Drawing on a series of relevant case studies, this article shows that the transformation witnessed in Germany would not have been conceivable without the policy decisions that preceded it. Each case study – energy taxation, renewable-energy promotion, green infrastructure, and sustainable transportation – offers valuable insights into how to design and implement green policies.

Energy pricing through taxes and other fiscal instruments has traditionally held a prominent position in the German energy policy mix. As any visitor to Germany will be quick to notice, gasoline prices are significantly higher than in most other regions: in early 2011, a gallon of regular gasoline cost over US $7, more than double the average price in the United States (Buehler 2011). The price difference is almost entirely due to higher tax rates on oil and other fuels, a system of excise taxes that dates to pre-war Germany and has since been harmonized at the European level. It was not until the late 1990s, however, that energy taxation also became a vehicle for Germany's green agenda. In 1998, a centre-left coalition of Social Democrats and Green Party members pledged to introduce new fiscal instruments to reduce the tax burden on labour and shift part of it to energy consumption (Bachmann 2022). This campaign promise sought to harness the multiple dividends invoked by advocates of environmental taxes, including greater flexibility and cost efficiency than traditional regulation, incentives to develop innovative clean technologies, and the ability to raise revenues for public investments or tax cuts in other areas, such as labour costs.

In 1999, the German legislature passed the Ecological Tax Reform Act, which mandated gradual increases in the tax rates on oil and gas and introduced a new levy on electricity. This initiative was by no means uncontroversial. From the outset, it encountered public opposition triggered by rising prices for crude oil and concerns over industrial competitiveness (Buehler 2011). Resistance to this measure was, in fact, so great that many observers expected the energy tax project to be a casualty of partisan politics. Yet in 2006, new legislation by the European Union and a change of government in Germany, coupled with a yawning gap in the federal budget, heralded a new chapter in German energy taxation (Bachmann 2022). That year, the legislature adopted a comprehensive Energy Tax Act, setting up a common fiscal framework for energy products through harmonized definitions, taxation rules, and exemptions.

This important step led to a complete revision of the framework for energy taxation in Germany, effectively ending years of deadlock in Parliament; but critics were also quick to say it would do little to help transform the German economy (Bachmann 2022). As a member state of the European Union (EU), Germany's energy policies are driven by a mix of national and European legislation. Formally, the 27 EU member states regulate energy policies within their own national borders. However, EU treaty provisions concerning the European internal market, free competition, and environmental protection have created a European energy policy.

In 2009, a major piece of renewable-energy legislation was passed as part of an overall climate and energy package. The European Union's Renewable Energy Directive requires each member state to increase its share of renewable energy—such as solar, wind power, biomass, or hydroelectric—to raise the overall share from 8.5% in 2010 to 20% by 2020 across all sectors (power generation, heating and cooling, and transportation fuels) (Scarlat et al. 2015). Germany has seen a remarkable expansion of renewable energy in the last decade. The share of renewable energy in electricity generation rose from 6% in 2000 to 16% in 2009 (Scarlet et al. 2015). Over this time, the German government revised its own targets twice, given that previous targets had been exceeded ahead of schedule. The German government is expecting a share of 38% renewable power by 2020 and continues to drive the transformation "towards an energy system based completely on renewable energies" (Scarlet et al. 2020).

The economic benefits of this development are impressive. By 2010, the field of renewable-energy-related jobs employed around 340,000 people, most of them in biomass, wind power, and solar (Scarlet 2011). In comparison, the German lignite industry employs only 50,000 people—from mining to the power plant (Scarlet et al. 2015). The key policy responsible for this success is the Renewable Energy Sources Act, first enacted in April 2000. This feed-in tariff policy is embedded in a climate and energy policy framework that promotes renewable energy and efficiency technologies, including laws to encourage combined heat and power plants, a cap-and-trade system, the energy tax reform described earlier in the article, and several additional measures (Scarlet et al. 2015). The next planned revision to the law will aim to incentivize grid access and grid improvement, offshore wind power, and technologies for peak management and power storage.

The United States currently employs a mix of short-term tax credits, loan guarantees, state-level renewable portfolio standards, and limited feed-in tariffs. In contrast to Germany, the US policy framework has evolved less quickly at the federal level, where time horizons have been shorter-term. The uncertainty engendered by this short-term policy framework has led to repeated falloffs in renewable-energy capacity additions in the United States as support measures have neared expiration (Scarlet et al. 2015). For example, in contrast to Germany, new wind turbine construction in America has fluctuated greatly from year to year, because incentives have repeatedly expired. Even with this policy uncertainty, however, the United States in 2008 still led the world in total installed wind-power capacity, with 20.8%. In 2008, renewable energy provided

9% of electricity production in the United States, with large-scale hydropower being the largest source.

3.10.2 Austria

In comparison with other OECD countries, Austria's share in worldwide official development assistance is relatively low, but it has an international reputation for a high standard of competence and comparative advantages when it comes to certain issues and sectors (OECD 2020). Environmental protection is one of these competencies. A particularly good way to ensure the visibility and maximum effect of Austrian engagement has proved to be strategic clustering, especially as part of bilateral cooperation, but, in terms of coherence, also in other areas of development policy (OECD 2020). Efforts are concentrated geographically on a few partner countries in Africa, Asia, Latin America and Southeastern Europe. The thematic focus is placed on the sectors of water and sanitation, rural development, energy, private-sector development, education and science as well as governance. The challenges, operational principles and geographical and thematic concentration define those aims that Austria pursues at the interfaces between environmental and development policy (Bachmann 2022). Owing to the interdependence between specific problems and economic and social factors, it is in part difficult to draw clear dividing lines. The general thematic operational fields are thus classified as follows.

There are many different reasons for the ongoing degradation of vital natural resources. The development and effective implementation of national land use and forest laws and long-term regional development and land-use plans are needed, accounting for the interests of the poorest parts of the population (OECD 2020: 5-6). Of key importance here is sustainable resource management, combating desertification and preserving biodiversity, also in connection with climate change. On the one hand, this can reduce agroclimatic risks, such as droughts or floods, while providing crucial support for coping with the already tangible impacts of climate change. On the other, land-use changes and deforestation, for example, can degrade vegetation and soil, contributing considerably to climate change through the release of greenhouse gases.

Climate protection and development cooperation are closely linked. This linkage poses many different challenges but also offers scope for synergies. This is particularly evident in the energy sector. About 2.4 billion people in developing and transition countries currently lack access to modern energy services (United Nations 2020). The urgent need for economic development will increase the global emission of greenhouse gases, if it continues to rely for the most part on fossil fuels. The impacts of climate change pose developing countries with enormous challenges, however. Large investments need to be made in reducing flood risks, in erosion control, water supply security or efficient agricultural irrigation. Particularly the least developed countries and the small island states depend on international support to cope with these challenges (United Nations 2020). Ideally, national development strategies should chart a course that avoids greenhouse gas emissions as far as possible and adopt longer-term adjustment measures to climate variability and change. Besides the necessary political awareness, enabling institutional frameworks and capacities are also lacking. The case of Austria shows how a combination of these factors allows for driving sustainable development.

3.10.3 Switzerland

Since its adoption in 2015, the 2030 Agenda for Sustainable Development has driven Switzerland's commitment to sustainable development, nationally and internationally. It thus underpins the engagement for environmentally sound economic development within planetary boundaries, as well as for peace, respect for humanitarian law and human rights, with which sustainable development is inextricably linked (United Nations 2018). From the outset, Switzerland was a driving force behind the 2030 Agenda and its 17 Sustainable Development Goals (SDGs) (United Nations 2018). Switzerland advocated for a robust mechanism for follow-up and review, including Voluntary National Reviews (VNRs) and reviews of SDG implementation at the High-level Political Forum on Sustainable Development (HLPF) (United Nations 2018).
Since 1997, the Federal Council has defined its priorities for implementing sustainable development nationally in a quadrennial strategy; the current strategy is valid until 2019. A comprehensive system for monitoring sustainable development at the national

level was put in place in 2003, with currently 73 indicators which are regularly updated (United Nations 2018). Immediately after the adoption of the 2030 Agenda in 2015, the Federal Council commissioned a comprehensive baseline assessment and gap analysis of the implementation status at the federal level. The analysis concerned all 169 targets and covered both Switzerland's domestic and international contributions (United Nations 2018).

Based on the existing national-level system, monitoring was expanded for the 2030 Agenda. The gap analysis indicates that among the chosen 85 indicators 39 show a positive trend, 12 show no significant evolution, 14 show a negative trend, while for 20 no assessment was possible (NHRI 2020). Switzerland is already at an advanced stage in achieving various SDGs and has already fulfilled several targets. For example, Switzerland is free from extreme poverty (target 1.1), and there is no hunger (target 2.1) (United Nations 2018). Education (target 5.1) is free, compulsory and of good quality (NHRI 2020).

However, the baseline assessment identifies areas where efforts at the national and international levels beyond existing policies are needed in order to achieve the SDGs. Consumption of natural resources (SDG 12), for example, is increasing overall. The use of resources from within Switzerland for consumption by its population is decreasing, but the use of resources from abroad is increasing in an unsustainable way (United Nations 2018). Other areas call for continued strong engagement so that the SGDs can be achieved. About the principle of 'Leave no one behind', Switzerland is also committed to enabling disadvantaged groups – for example, people with disabilities – to benefit from the country's prosperity.

The analysis provides a good starting point for tackling the challenges in a targeted and focused manner. The challenges will mainly be addressed within the framework of existing sectoral policies which exploit synergies where possible, observing the principles of effectiveness and efficiency, both nationally and internationally. The 2030 Agenda is implemented at the federal, cantonal and communal levels, considering current obligations, competencies and established division of tasks (NHRI 2020). Many cantons and communes have defined their own strategies for sustainable development. The federal government will intensify the dialogue with the cantons and communes and support them in implementing the 2030 Agenda, for example through platforms for exchange and networks.

Switzerland's private sector, NGOs and scientific community have also been committed to sustainable development for a long time. An advisory group composed of interested non-state actors has identified what it considers to be Switzerland's priority challenges (United Nations 2018). This group provides a platform for further dialogue with the federal government and for partnerships for implementing the 2030 Agenda. Parliament is to be more closely involved in future. The 2030 Agenda is an important reference framework for Switzerland's international cooperation, which aligns its activities with the SDGs. It will continue to support partner countries in implementing the 2030 Agenda and in achieving the SDGs globally. For example, Switzerland contributes to achieving SDG 17 by strengthening domestic resource mobilisation and capacity building, and by promoting a universal, rules-based, multilateral trading system.

3.11 Renewable energy in the DACH region

3.11.1 Renewable energy and sustainable development

There are different definitions for Renewable energy. The U.S. Energy Information Administration (EIA) explains that renewable energy "…is energy from sources that are naturally replenishing but flow-limited; renewable resources are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time" (EIA 2020).

Major types of renewable energy sources are according to EIA (2020): Biomass (Wood and wood waste, Municipal solid waste, Landfill gas and biogas, Ethanol and Biodiesel), Hydropower, Geothermal, Wind and Solar. The European Union states, that "Renewable sources of energy (wind power, solar power, hydroelectric power, ocean energy, geothermal energy, biomass and biofuels) are alternatives to fossil fuels that contribute to reducing greenhouse gas emissions, diversifying energy supply and reducing dependence on unreliable and volatile fossil fuel markets, in particular oil and gas” (Ciucci 2020).

The OECD defines new and renewable energy sources as energy sources that include “…solar energy, geothermal energy, wind power, hydropower, ocean energy (thermal gradient, wave power and tidal power), biomass, draught animal power, fuelwood, peat, oil shale and tar sands” (OECD 2020: 45).

The International Energy Agency (IEA) explains that the “...electricity sector remains the brightest spot for renewables with the strong growth of solar photovoltaics and wind in recent years, building on the already significant contribution of hydropower. But electricity accounts for only a fifth of global energy consumption, and the role of renewables in the transportation and heating sectors remains critical to the energy transition” (IEA, 2020). According to IEA, the installed capacity of renewable energy sources “… is set to expand by 50% between 2019 and 2024” Photovoltaic energy or Solar PV, that is the transformation of sunlight into electricity, “… accounts for almost 60% of the expected growth, with onshore wind representing one-quarter” (IEA 2019: 12).

Today there is no single definition of Renewable Energy and no unified methodology on how to measure the share of renewable energy in an energy mix (World Bank, 2013).

3.11.2 Solar

Solar energy is radiant energy that is produced by the sun. In many parts of the world, direct solar radiation is one of the best prospective sources of energy. The main ways to convert solar radiation into energy are active and passive solar design. Passive solar design is often based on the optimal design of buildings that capture the sun’s energy in order to reduce the need for artificial light and heating. Regarding passive solar systems, a primary interest for researchers in solar energy is related to the design and optimization of solar energy homes.

Improving energy efficiency in buildings is a major priority worldwide. The measures employed to save energy vary in nature, and the decision maker is required to establish an optimal solution, considering multiple and usually competing objectives such as energy consumption, financial costs, environmental performance, etc. Active solar design is based on water heating converting solar radiation into heat using photovoltaic panels and solar cells to convert the solar radiation into energy. In order to design both active and passive solar energy systems, radiation data are needed for the studied location. Solar radiation is usually measured by means of radiometric station nets with a low spatial resolution. To estimate the radiation some interpolation/extrapolation techniques are often used, but they are valid for places where the spatial variability of radiation is not significant and are less accurate if there are complex areas of terrain between the radiometric stations. Bosch et al. (2008) presented an artificial intelligence technique based on ANN for calculating solar radiation levels over complex mountain terrains using data from only one radiometric station. Other algorithms applied to the forecast of solar irradiation include ANN and neuro-fuzzy inference systems.

Despite huge developments in predicting solar radiation data, there is a gap in the extraction of pertinent information from such data, which is why some methods, including ANN, have been proposed for identifying and optimizing the statistics representing solar radiation availability. Due to the intermittent nature of solar energy, energy storage is needed in a stand-alone photovoltaic system for the purpose of ensuring continuous power flow. The large-scale utilisation of this form of energy is possible only if effective technology can be developed for its storage with acceptable capital and running costs. The industry of grid-connected photovoltaic solar power has been responding to price declines and rapidly changing market conditions by consolidating, scaling up and moving into project development. Kalogirou (2009) solved the problem of maximizing the economic benefits of a solar-energy system using ANN and GA. ANNs are trained to learn the correlation of collector area and storage tank size on the auxiliary energy required by the system from which life-cycle savings can be estimated, while GA are then employed to estimate the optimum size of these two parameters for maximizing life-cycle savings.

Aronova et al. (2008) proposed an optimization model for determining the energy generated by tracking photoelectric power modules, while also estimating the optimal variant of solar module arrangement for different locations and the ground area required by a single tracking photoelectric power module of a given size. Klychev et al. (2009) presented a study about the optimization of the geometric parameters of the parabolic-cylinder-receiver system of thermal power plants, and they concluded that the optimal opening angles of the parabolic-cylindrical concentrator in the system can increase the solar concentration. Fernandez-Garcia et al. (2010) presented an overview of the parabolic-trough collectors built and marketed over the last century, as well as the prototypes currently under development. Szargut and Stanek (2007) dealt with the problem of optimizing the performance of a solar collector by correctly determining the collector area per unit of heat demand, the diameter of collector pipes and the distance of the pipe axes in the collector plate. Kumar et al. (2022) implemented a GA for maximizing the thermal performance of flat plate solar air heaters by considering the different systems and operating parameters. Dufo-Lopez et al. (2016) designed a hybrid heuristic method which combines PSO with nonlinear time-varying evolution in order to determine the tilt angle of photovoltaic modules with the aim of maximizing the electrical energy output of the modules. Zagrouba et al. (2010) proposed a GA to identify the electrical parameters of photovoltaic solar cells and modules to determine the corresponding maximum power point from the illuminated current-voltage characteristic. Marston et al. (2009) presented an optimization algorithm for designing linear concentrating solar collectors using stochastic programming and a Monte Carlo technique to quantify the performance of the collector design in terms of an objective function, which is then minimized using a modified Kiefer–Wolfowitz algorithm that uses sample size and step size controls.

3.11.3 Wind

Wind is one of the most promising sources of alternative energy. Recently, Hernandez-Escobedo et al. (2023) demonstrated that wind is a periodical phenomenon for large geographical areas like Mexico. The benefits of past research and development in the wind energy sector have been clearly demonstrated by the increasing sizes of turbines and the lower prices per installed production capacity of electricity. There are studies that demonstrate the potential wind power around the world. Trends in wind power include new growth in offshore development, the growing popularity of distributed, small-scale grid-connected turbines, and new wind projects in a much wider variety of geographical locations around the world.

Many researchers are continuously developing new strategies for optimal design and operation of wind energy systems. However, wind energy systems may not be technically viable in all locations because of low wind speeds and the fact that it is more unpredictable than solar energy. Areas where winds are stronger and more constant, such as offshore and high-altitude sites, are preferred locations for wind farms (Bachmann 2022). The operational scheme of wind energy systems, an accurate estimation of wind speed distribution, the site selection of wind farms, and the operations management of wind power conversion systems are critical aspects that determine wind energy potential. However, the investment decision on the generation capacity of a wind park is difficult when wind studies or data are neither available nor sufficient to provide adequate information for developing a wind power project.

Some papers have analysed in detail how to determine the probable wind power availability at a given site according to historical wind velocity data, and its capacity to meet a target demand. Li et al. (2017) applied the Bayesian model averaging in modelling long-term wind speed distributions. Zhao et al. (2012) proposed a GA where the main components of a wind farm and key technical specifications are used as input parameters and the electrical system design of the wind farm is optimized in terms of both production cost and system reliability.

Another primary interest for researchers of wind power is related to the optimal design of wind farms. Two important problems are often considered: the optimal design of wind turbines and the wind farm layout. In reference to wind turbine design, trends include new growth in off-shore development, the growing popularity of distributed, small-scale grid-connected turbines, and new wind projects in a much wider variety of geographical locations around the world and within countries (Chick & Micklethwaite 2017). The power output of a turbine is a function of the density of the air, the area swept out by the turbine blades and the cube of the wind speed. As the generation of wind energy is relatively new, the area of improvement in power quality is still open, which is why some authors have centred their interest on optimizing the turbine settings in order to maximize their performance.

Numerous metrics are used to measure the power quality of a wind turbine, such as the power factor, reactive power, harmonic distortion, etc. Firms continue to increase average turbine sizes and improve technologies by launching innovative solutions such as gearless designs. Toffolo and Benini (2003) presented a multi-objective evolutionary algorithm (MOEA) for the optimization of the geometrical parameters of the rotor configuration of stall-regulated horizontal-axis wind turbines with the aim of achieving the best trade-off performance between the total energy production per square meter of wind park and cost. Negm and Maalawi (2000) presented an optimization model for the design of a typical blade structure of horizontal axis wind turbines where the optimization variables are chosen to be the cross-sectional area, radius of gyration and length of each segment, and the optimal design is pursued with respect to maximum frequency design criterion. Other authors simplified the design of wind turbine systems by removing any active electronic part (power and control) and then constructing a low-cost fully passive structure.

There has been increasing interest in the optimal design of laminated composite shell structures, especially wind turbine blades. For instance, Stegmann and Lund (2005) solved this problem using an optimization algorithm the method of moving asymptotes proposed by Svanberg. A review of methods applied to the optimal design of wind turbine blades was presented by Duc et al. (2019). Hall et al. (2011) optimized the ranges of gearbox ratios and power ratings of multi-hybrid permanent-magnet wind generator systems by using a GA. Kusiak et al. (2010) presented an MOEA for evaluating wind turbine performance, where the objective to maximize is the wind power output, while minimizing the vibration of the drive train and of the tower. Roy et al. (2009) applied a new methodology for optimum sizing of the rotor and other components of a stand-alone wind-battery system. Other authors optimized wind turbine blades, where shape parameters, including chord, twist and relative thickness are adjusted with the objective of minimizing the cost of energy which is calculated from the annual energy production and the cost of the rotor.

Fuglsang and Thomsen (2001) proposed a numerical optimization algorithm together with an aero-elastic load prediction code and a cost model for the site-specific design of wind turbines where the cost of energy is minimized. Fuglsang and Thomsen (2001) presented a method for minimum energy cost where numerical optimization and aero-elastic calculations are combined. Kusiak and Zhang (2012) optimized the power produced by wind turbines by combining data mining and evolutionary computation. Other authors have proposed decision analysis techniques, including mixed-integer nonlinear programming (MINLP), for determining the optimum capacity considering uncertainties arising from wind speed distribution and power–speed characteristics. As wind turbines are used to tap the potential of wind energy, the reliability of the turbine is critical to extract the maximum amount of energy from the wind. Hameed and Afaq (2013) offered a review of the techniques, methodologies and optimisation algorithms developed to monitor the performance of wind turbines and for early fault detection to avoid catastrophic conditions due to sudden breakdowns. Technically, wind turbine capacity has been improved to high levels. However, electricity cannot be generated at all wind speeds; therefore, there are some limits related to cut-in and cut-out data.

One of the main problems in wind engineering is that estimating output data of wind turbines depends on wind speed and system values, which is why some researchers have used fuzzy logic modelling for wind turbine power curve estimation. Shimizu et al. (2008) presented a study of the flapping wind power generator which extracts energy via the flutter phenomenon, where the aim is to optimize both the power and the efficiency of the system using a multi-objective adaptive neighbouring search.

3.12 Factors influencing development of renewable energy

According to the Global Green Growth Institute report, four key factors affecting the development of renewable energy are Resources, Policy Framework, Economy and Technology (Global Green Growth Institute, 2017). Only countries with natural resources consistent with existing renewable energy technologies will be able to develop this type of energy. This means that the country must have practical access to use its natural resources for renewable energy development. Studies have shown that establishing national targets for renewable energy development along with the issuance of legal frameworks and support mechanisms is a prerequisite for the development of renewable energy (Chick & Micklethwaite 2017; Elling & Jelsoe 2016; Wong & Lockie 2020). These objectives must be appropriate to the natural, economic and social conditions to ensure sustainable development. The economic factor here is the competitive advantage of renewable energy in comparison with fossil fuel conventional energy. This is one of the biggest challenges that affect the choice of renewable energy in most countries. Several authors pointed out that electricity production cost from renewable energy is higher than that of fossil fuels so it shall not be used widely by countries. It may be true in terms of investment cost.

It has been indicated that the cost per unit of generating capacity of a power plant ranges from a base case of $1200–$1300 per kilowatt for a combined cycle gas turbine with no carbon capture and storage (CCS) to $1900–$2300 per kilowatt with CCS (IRENA, 2012). The capital cost for a black coal (supercritical) power station with CCS is estimated by Burgess at 2900–$4500 per kilowatt compared to $2100–$2900 per kilowatt for wind. Solar PV ranges from $4600–$5700 per kilowatt depending on the type of PV system and geothermal is in the range $4000–$6300 per kilowatt (IRENA, 2012). This is also agreed by Shen (2014) when he calculated that "unit generation cost of coal-fired power was 350 Yuan/kWh, while unit generation costs of wind power and solar power were 620 and 1900 Yuan/kWh separately (1 Chinese Yuan is equal to 0.16 US Dollar roughly in 2013)" (Shen 2014). Of course, if countries only look at these Tables, they will not choose renewable energy to develop. However, a study carried out by experts of the International Renewable Energy Agency (IREA) showed an opposite viewpoint. After analysing all related costs of a renewable power plant (solar and wind) such as investment cost, operation and maintenance cost, insurance and interest, the calculation proved that "Biomass for power, hydropower, geothermal and onshore wind can all now provide electricity competitively, compared to fossil fuel-fired power generation. It is growth in the "new" renewable power generation technologies of solar and wind, however, that has pushed renewable power generation capacity additions to record levels (Smith 2020).

A virtuous circle of support policies driving increased deployment, technological improvements and cost reductions has seen onshore wind become one of the most competitive options for new generation capacity. The levelised cost of electricity (LCOE) of solar PV fell 58% between 2010-2015, making it increasingly competitive at the utility scale. Despite the fact that concentrating solar power (CSP) and offshore wind are in their deployment infancy, these technologies are already attractive in some markets, with costs continuing to fall" (IRENA 2016).

Another important factor influencing the development of renewable energy is that of technology. In 2008, the World Bank published a very interesting working paper on clean energy named "Accelerating Clean Energy Technology Research, Development and Deployments" by Avato and Coony (2008). The publication presented valuable lessons from the non-energy sector. First, the authors of this work confirmed that "better and broader use of existing clean energy technologies can play an important role in climate change mitigation" (Avato & Coony, 2008). However, they complained that most of these technologies were too expensive or unreliable for spread deployment whereas spending on research, development and deployment of clean energy technology tends to be cut down or not enough to meet the demands. The reasons for this situation are numerous. One of them is that the technology of renewable energy remains in the first stage of development or is not fully commercialized. Costs for research and development are huge. In order to overcome the barriers, the authors carried out case studies of four non-energy sectors to find out the solutions.

As the authors stated, "Although each of the case studies examined has its own set of circumstances that differ from the clean energy sector, the similarities and the creative approaches used in Research, Development and Deployment can provide valuable lessons" (Avato & Coony 2008 : 28). Surprisingly, one of these solutions is financing mechanisms and incentives in order to encourage entities of both public and private sectors to take part in research and development of this type of energy. One can see that this option has been accepted and applied in many countries of the world. Additionally, Newell and Mulvaney (2013: 133) also held the same point of view that "the extractions and transformations of fossil fuel energy come at a considerable cost and raise many questions about the sustainability of our energy supply as the conventional energy system confronts the realities of climate change, material limits, and environmental degradation”.

Of course, it is very crucial to mention the socio-environmental impacts of renewable energy in terms of sustainable development. As analysed above, generating electricity through using fossil fuels has been causing lots of harm to the environment such as acid rain, stratospheric ozone depletion, greenhouse effect or global climate change because “electric power generation, residential heating and industrial energy use account for 80% of SO_2 emissions, with coal use alone accounting for about 70% of SO_2 emissions. Another source of acid precipitation is sour gas treatment which produces H_2S that reacts to form CO_2 when exposed to air” (EPA 2015).

These factors negatively influence human health and ecology. Water and air pollution are blamed for human respiratory, digestion diseases even cancers as cited by (Sathaye et al. 2011) that “the most important energy-related impacts on human health are those associated with air pollutant emissions by fossil fuel and biomass combustion (Ezzati et al. 2004: 2). Air pollution, even at current ambient levels, aggravates morbidity (especially respiratory and cardiovascular diseases) and leads to premature mortality”(Smith, J. 2020: 85). Furthermore, global climate change is proven to cause natural disasters such as floods, droughts, and salt invasions (Doe 2019).

As a result, they are destroying and damaging forestry and agricultural crops, fish and aquatic life, too. In order to avoid or decrease these harmful effects, people shift to using renewable energy.

3.13 Summary

The focus of this chapter is on providing relevant definitions pertaining to the renewable energy mix in heavy industries, with implications for risk management. Different sources of renewable energy were identified such as solar and wind energy. In addition, the chapter included a discussion of important factors affecting the development and distribution of renewable energy sources. Barriers to development were considered as well in order to offer a more objective and transparent discussion of the implications of sustainable development. The process of strategy development was analysed to determine the strengths and opportunities of heavy industry companies to improve their performance in the context of sustainability. Considering the numerous challenges identified in the field, it was also important to discuss the multiple perspectives of risk management.

This chapter provided a review of the literature, as the emphasis was on the strategic implementation of renewable energies in heavy industrial settings. The initial section of the literature review presented a discussion of different frameworks on the links between strategy and risk management. In addition, a perspective on stakeholder and sustainability was included to demonstrate the strong influence of stakeholders from heavy industries on the development of various sustainable strategies. Another important section included in the literature review related to the thorough description of renewable energy and the energy mix. Other relevant details discussed in the chapter referred to the transformation process that took place in heavy industries considering the substantial dynamics existing in these industry settings.

4 CHAPTER FOUR – THEORETICAL FRAMEWORK

4.1 Frameworks on strategy and risk management

Strategy formulation and implementation are inseparable activities in which every organization engages continuously. Strategic decisions, the focus of the strategic development process, do not form a distinct category at one extreme of some imagined spectrum leading from tactical, through operational to strategic decisions. There is a set of characteristics that can lead to a decision being labelled as 'strategic'. These characteristics may include the following:

- The breadth of scope of a decision right across and beyond the organization.
- Complexity and inter-relatedness of the context, demanding integrated treatment.
- Enduring effects and results, possibly of an irreversible nature, with little or no scope for trial and error.
- Significant time lag before impact. The uncertainty of the results of the decision is widening over the timescale involved.
- Disagreement about the motivation, the direction and the nature of the development.
- Challenging the status quo. Thus creating a politicized setting where change can be contested. (Dyson, Bryant, & Morecroft, 2007)

The managerial task is to adjust with those factors that are controllable within a situation that in itself is in continual flux and affected by external forces. (Dyson, Bryant, & Morecroft, 2007) Strategy making, therefore, is about the crafting of deliberate actions to shape an organization's future. Eden and Ackermann (1998) view strategy as "a coherent set of individual discrete actions in support of a system of goals, and which are supported as a portfolio by a self-sustaining critical mass, or momentum of opinion in an organization". (Dyson, Bryant, & Morecroft, 2007)

In reality, a strategic decision can lead to a situation where there is a gap between the desired direction and the articulated direction of the planned development. The 'desired direction' is a key driver of strategic development, which may be articulated through a mission or vision statement, a set of strategic objectives or goals supported by performance measures and possible targets. A well 'articulated direction' will help to stimulate behavioural responses in the organization, to change in the desired direction of the strategic development. A model of the different factors influencing strategy planning is shown below.

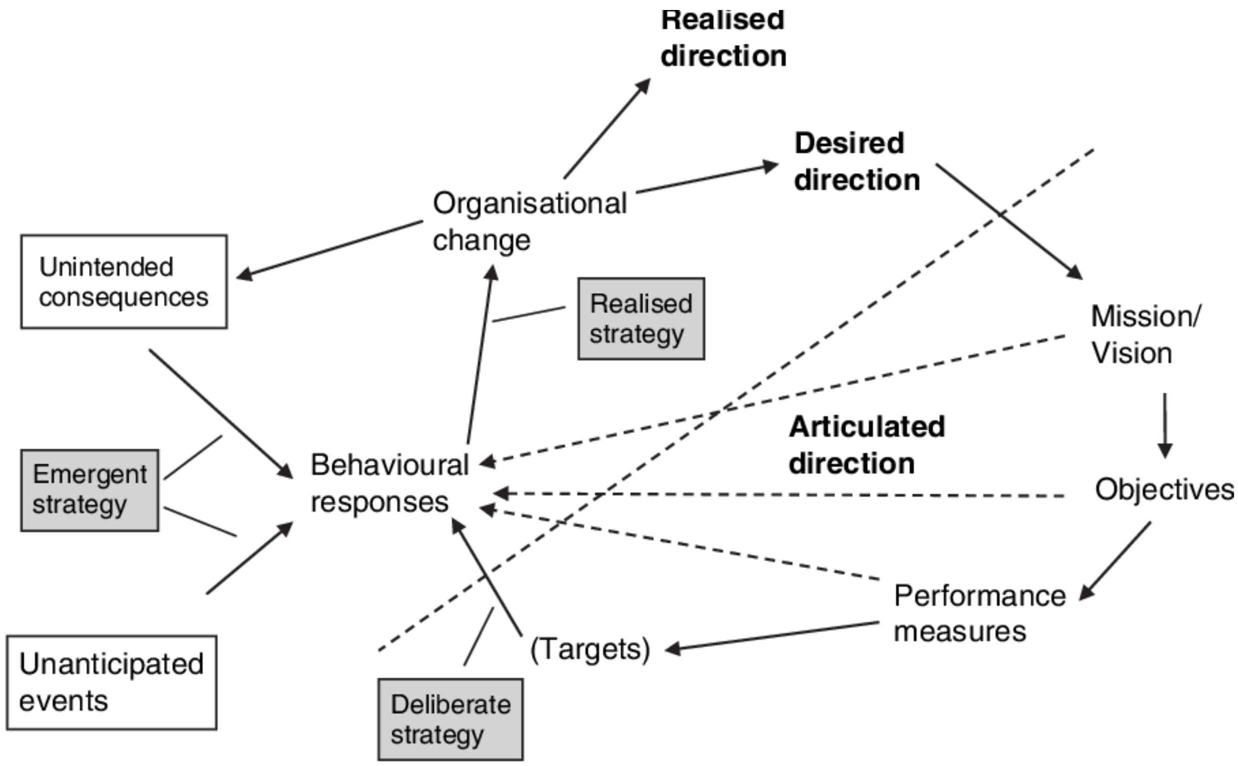

Figure 11: From Deliberate Strategy to Realised Strategy.
Source: Dyson et al. (2007: 9)

Strategic initiatives are fed into a model, or models, of the organization for assessing strategic ideas and the effects of uncertainty. The rehearsal process involves the evaluation of specific strategic options but also the search for the most appropriate overall strategy given the uncertainties faced by the organization. (Dyson et al. 2007) To sum up, feedback control is a vital component of strategic development.

This leads to a complex strategic development process that should be seen as an addition to the graph above.

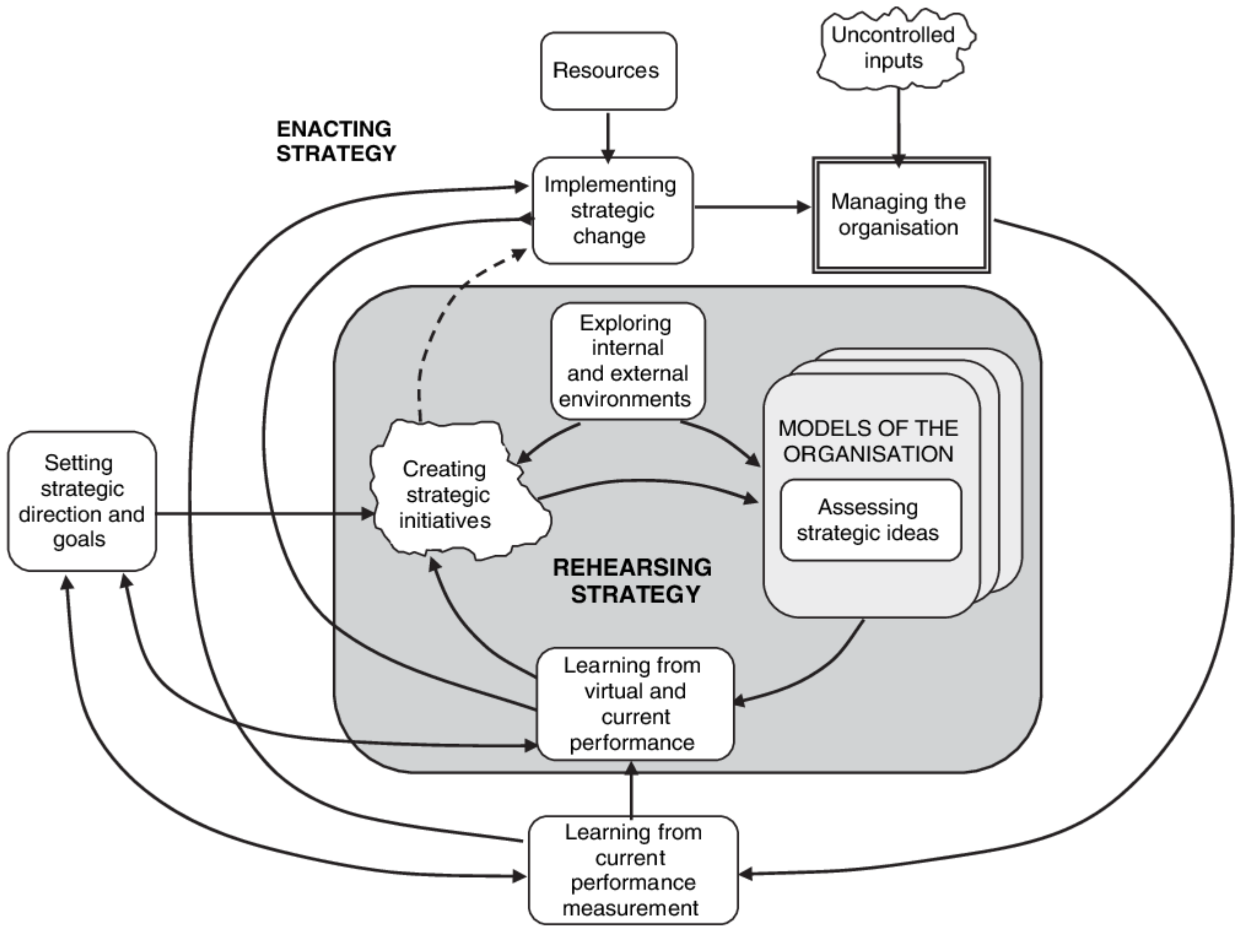

Figure 12: The Strategic Development Process. Source: Dyson et al. (2007: 12)

Some essential elements for strategic development are:

- Setting the strategic direction – encompassing a vision, mission, strategic objectives and goals.
- Designing a performance measurement system aligned with the strategic direction.
- Sense-making – exploring the internal and external environments and assessing the uncertainties and risks.
- Evaluating strategic options and taking account of future uncertainties.
- Rehearsing strategy in a virtual process that incorporates feedback and learning from the virtual performance.

- Selecting and enacting strategy in a real feedback process that incorporates learning from virtual and/or current performance. (Dyson et al. 2007)

4.2 Theories on strategic management

According to Stenvall and Virtanen (2017: 3), there are numerous types of strategies such as group strategies, regional strategies or institutional strategies. However, there is one thing in common is that strategies are set up to manage external and internal factors and their interaction to make sure that “the objectives of profitability, continuity, and development will be achieved” (Stenvall 2018).

The author also cited that there were several groups of strategic schools including prescriptive, designing, planning, and positioning ones. Prescriptive school focuses on the function of an organization and the way of implementing its strategies while Designing school considers the internal and external factors of the organization during the process of formulating strategies. The Planning school divides strategies into five phases. The first phase is long-term planning based on economic circumstances and budget. In the second phase, a strategic plan will be set up usually by top management with a concentration on practical operations. A long-term strategy always comprises long-term objectives. These objectives of strategies should be SMART (Specific, Measurable, Achievable, Reliable and Time-bound).

This opinion also receives the consensus of other scholars. For instance, Jin and Bai (2011) mentioned that “goals must be long-term, forward-looking, comprehensive, implementable, and challenging”. The third phase, strategic management, points out three important steps “from the point of planning, implementation, and supervision” (Jin & Bai 2011). The internal and external environment is always changing so it needs the fourth phase of strategic thinking. After having recognized the differences between planning and operational work, adjustments and changes may be made. At the final phase of strategic interactive management, the interaction between managers, staff and stakeholders or publicity becomes clearer. As for the Positioning school, it is based on the comparison between organizations to create differences. The decision to apply a particular perspective should be made on the basis of situational factors.

During the process of establishing strategies, it is very important to consider whether internal and external factors are sufficient to guarantee the success of strategies. These factors should be considered in the time dimension of the strategies because strategies are usually set up for a particular period. Normally, a strategy process includes three steps: strategic formulation, implementation, and evaluation. In the manner of strategic formulation and implementation, Whittington identifies four distinct perspectives on strategy (Whittington 2001). They are the classic perspective, the processual perspective, the evolutionary perspective, and the systemic perspective (Heath and Palenchar 2008).

As analysed by Joyce and Drumaux (2014), the classic perspective on strategies just pays attention to profit maximisation and regards it as the only outcome of strategy. This attitude has also been presented by several scholars like Chandler (1969) and used as a prominent approach to public strategies in the USA, UK or Ireland (Heath and Palenchar 2008) when they stated that the processual perspective on strategy focusses on multiple outcomes of strategy and views it as an outgoing process informed by strategic intent. The evolutional perspective on strategy focuses on both profit maximization and efficiency of production. Finally, the fourth perspective takes a systemic view with the idea that “desired strategic outcomes are plural”. A relevant approach to strategic formulation and implementation is influenced by all four perspectives.

The current thesis adopted a theoretical framework that approaches strategic management through a combination of such steps as strategic formulation, implementation, and evaluation (Whittington 2001). Such an approach towards strategic management allows for capturing a variety of relevant aspects of the transition towards a sustainable energy mix. In particular, it helps examine the factors affecting the decision-making process pertaining to this transition and examine its implications for organizations and relevant stakeholders. This broad framework is suitable for the current thesis since it supports a detailed analysis of multiple factors affecting the implementation of advanced strategies to reduce emissions in heavy industries within the context of strategic management. Given the broad scope of the thesis, all four perspectives of strategic management, including the processual, evolutionary, systematic, and classic ones, were adopted to analyse various facets of the achievement of a sustainable energy mix.

For instance, the classis perspective often uses the mandatory approach to strategic formulation like a SWOT matrix (Strengths, Weaknesses, Opportunities and Threats) with the interaction of internal and external factors while the processual perspective allows to formulate strategies through developing internal criteria for evaluation.
The process of strategic formulation often comprises three stages: information collection, strategic analysis, and strategic decision. At the stage of information collection, it is important to obtain all related external and internal factors. Several tools can be used for this purpose, such as EFE, CPM, and IFE. Information collection can be based on the statistical data of past performance, surveys, questionnaires, interviews, or observations. When information has been collected, one will move to the second stage of strategic analysis. The purpose of this work is to enable the implementation of new strategies (Stenvall & Virtanen 2020). Before carrying out analysis work, those who oversee doing it should understand clearly what to be analysed and how to implement it. In order to accomplish this work well they must have good knowledge and skills in this field.

It also requires several characteristics and qualities such as “vision, eloquence, and consistency; articulation of a business model; commitment; being well informed; willingness to delegate and empower; astute use of power and emotional intelligence” (Hill et al. 2016). There are some useful tools to use during this phase including SWOT, Political, Economic, Sociological, Technological, Legal and Environmental (PESTLE), Boston Consulting Group (BCG), and other instruments. SWOT matrix is widely used to analyse a company’s internal factors (Strengths and Weaknesses) and external factors (Opportunities and Threats). Through SWOT analysis, a company can determine influencing elements that may affect negatively or positively its success.
The main purpose of SWOT analysis is to exploit external opportunities, counter threats, maintain internal strengths and eradicate weaknesses (Hill, C 2019). This work can be explained as below:

Strengths (S): Analysing positive factors inside the organisation such as financial capacity, workforce, and competitive advantages.

Weaknesses (W): analysing negative aspects and limitations inside the organisation that may cause bad effects on the operation of the organization.

Opportunities (O): Analysing external favourable elements that help to increase the value or provide benefits to the organisation.

Threats (T): Analysing external factors that may place the organisation at risk. These factors exist outside the organisation, so they are uncontrollable.

Thus, this analytic model is very useful for organizations or companies to understand their capacities and determine obstacles to overcome in order to achieve their objectives. Another analytic tool which is also very popular is PESTLE. This model focuses on analysing political, economic, social, technological, environmental, and legal factors that are related to outside environments. These factors are as follows:
Political factors: Legislative factors, tax policies, international issues, party politics.
Economic factors: Economic growth, trends, development of workforce.
Social factors: Social structures, values, attitudes, lifestyle and change in habits of consumption.

Technological factors: Information technology, technological products.
Environmental factors factors: Land use, preservation of nature, bodies of water, waste and noise.

Legal factors: Regulatory compliance, employment laws, health and safety regulations, consumer protection laws, and other policies and regulations.

In the field of renewable energy development, both PESTLE and SWOT tools are widely used because of their universal nature. In particular, “SWOT analysis helps to formulate right strategies” (Rao 2021: 76). These models help decision-makers understand potential barriers, opportunities, and challenges to choose the most suitable and realistic strategies for sustainable development. In this study, the SWOT analysis is used as a framework for analysing relevant issues pertaining to the achievement of a sustainable energy mix in heavy industries. This simple yet effective framework was used in this study along with thematic analysis to divide emerging themes into a set of sub-themes addressing the strengths, weaknesses, opportunities, and threats related to the process of changing the energy mix towards the embracement of sustainability. The decision to choose this tool was based on its universal nature, the popularity of this instrument, and the fact that it could help organize the qualitative data in a way that allowed for formulating practical recommendations for stakeholders.

Once strategies have been formed and chosen, they will be put into the stage of strategic implementation. According to Jin and Bai (2011), "Strategic implementation requires a broad systematic integration. Any strategy, no matter what level it is at, will inevitably form a "dynamic interaction of a multi-element complex system" as defined by Karl Ludwig von Bertalanffy, the founder of General System Theory in modern science. A long-term development strategy is, without doubt, a complex system: It involves various multi-levels, is interdisciplinary, and crosses domains, sectors, and systems. A successful strategy must be the result of broad systematic integrations among different domains and different systems" (Jin & Bai 2011). This is the way of transforming designated objectives and plans into actions because "strategy is change management".

In order to evaluate how strategies are implemented, there are some schools, such as the Entrepreneurial school, Cognitive school, Learning school, Power school, Cultural school and Environmental school (Minzberg 1990). The strategic evaluation aims to determine differences in objectives, contents, practical operation and outcomes compared to the initial plans in order to understand the current status, find out reasons and give solutions to adjust the strategies. As Jin and Bai (2011) stated "long-term development strategy has long-term objectives. But it is changing continuously, and its domestic and international environments are never certain. Since the main body and resources of strategic implementation also change continuously over time, it is necessary to implement a mechanism for tracking, management and feedback, so that appropriate adjustments to keep up with events can be made" (Jin & Bai 2011: 51).

However, monitoring and evaluating strategies must be carried out reasonably in every stage of the strategic process. This work requires flexibility to help organizations adjust their strategies timely and therefore, to increase the outcomes and effectiveness of strategies. This work can be implemented periodically or suddenly. Theoretically, Strategic performance evaluation is the measurement of results, identifying discrepancies to make timely and appropriate adjustments to ensure the desired outcomes. In order to measure the strategic performance of a business firm, a few models (such as the Balanced Scorecard by (Kaplan & Norton 1996)) or indicators including financial and non-financial measurements (such as economic profits, net income, rate of returns, cash flow or net present value) can be used or a new system of performance measurement can be created. However, it should be noted that this study focuses on assessing the practical implementation of the Development Strategy of Renewable Energy.

In short, along with the rapid changes in the world nowadays, the trend of strategies has also been changing. These new trends are, for example, agile and relationship-based strategies. The former trend is based on the best conditions to establish operations and allow organizations to mobilize resources quickly and flexibly. The latter sets up strategies for the relationship. Despite this distinction in the field of strategies, most of them are similar in terms of process and content, which are described in the figure below:

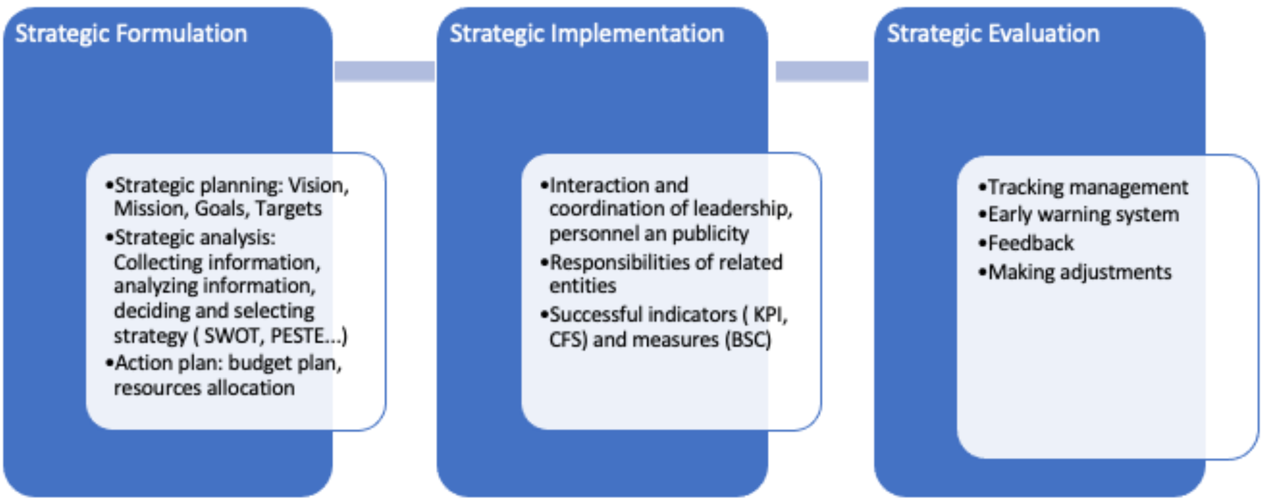

Figure 13: Strategic Formulation, Implementation, and Evaluation – own illustration

The figure above presents the framework of strategic management that was adopted in this study. By capturing the domains of strategic formulation, implementation, and evaluation, the author sought to cover all relevant nuances of strategic management that pertain to the transition towards a sustainable energy mix. At the same time, as stated above, a specific emphasis is put on the dimension of strategic formulation because the decision to reduce emissions is often challenging in heavy industries owing to the high intensity of capital and energy and other factors discussed in the introduction chapter (Han et al. 2021; Johnson et al. 2021; Naimoli & Ladislaw 2020; Ouyang et al. 2020). An analysis of the strengths, weaknesses, opportunities, and threats pertaining to such a transition through SWOT analysis can help understand the context in which stakeholders make decisions in organizations operating in heavy industries and illustrate the factors that might determine whether a particular organization takes radical actions to reduce emissions.

4.3 Theories on sustainability

The concept of sustainability in the sense of the three-pillar model is based on the dimensions of economy, ecology, and social issues. The so-called sustainability triangle is often used as a clear representation to show the equivalence of the goals (EU Energy Efficiency Directive 2012/27/EU). In setting proper sustainability goals, companies from different industries move towards developing more efficient and competitive models (EU Energy Efficiency Directive 2012/27/EU). The model often referenced and utilized in the context of setting proper sustainability goals, particularly in relation to the EU Energy Efficiency Directive (2012/27/EU), is the Energy Efficiency First principle. This model or principle emphasizes that energy efficiency should be considered as a priority in all decision-making processes related to energy and investment. Essentially, before expanding energy supply, increasing efficiency should be the first option to explore.

Legitimacy theory is probably the most discussed theory to explain the motivation of companies to engage in sustainable practices (Nasi et al. 1997). Nasi et al. (1997) argue that legitimacy is needed to maintain relationships with the society on which a company is dependent. In this sense, legitimacy theory can be understood as a system-oriented approach, as it assumes that companies are part of a broader system, whereby legitimacy is used to describe the relationship between a company's operation and society (Nasi et al. 1997).

Legitimacy theory is derived from the concept of organisational legitimacy. In this sense, legitimacy is defined as "a condition or status which exists when an entity's value system is congruent with the value system of the larger social system of which the entity is a part. When a disparity, actual or potential, exists between the two value systems, there is a threat to the entity's legitimacy" (Dowling & Pfeffer 1975). Taking the same side, Suchman (1995) suggests that "Legitimacy is a generalized perception or assumption that the actions of an entity are desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs, and definitions." While legitimacy is understood as a duty in the former definition and as a perception in the latter, both essentially state that legitimacy is a concept based on relativity – it is relative to the social system in which a company operates and, therefore, specific in time and place (Dowling & Pfeffer 1975).

The relationship between companies and society is conceptualised by the notion of "social contract" (Jones, M 2015). Such a contract is used to represent the myriad expectations society has about how a company should conduct its operations (Deegan et al. 2002). It is argued that society only provides resources to a company to the extent to which it operates in line with these expectations. Essentially, the expectations can be understood as the implied terms of the contract. In contrast, it is considered that a company's survival will be threatened if society perceives that a company has breached the contract's terms (Deegan et al. 2002). Therefore, companies seek to establish congruence between the social values associated with their activities and the expectations society has about them (Lindblom 1994). Shocker and Sethi (1974) explain the concept of the social contract as follows, "any social institution and business, without exception, operates in society via a social contract, expressed or implied, whereby its survival and growth are based on: - the delivery of some socially desirable ends to society in general and, the distribution of economic, social, or political benefits to groups from which it derives its power."

As a theoretical construct, the social contract is difficult to define for a real-world setting, as it varies according to personas and contexts. The implied terms of the contract, therefore, cannot be known with any precision, and different managers will have different understandings of these various terms (Deegan et al. 2002; O'Donovan 2002). Simply speaking, one manager will have a different understanding than another one of what society expects from him and how to conduct an operation. The social contracts of these two managers will look different. Offering some assistance here, Gray et. al (1996) indicate that legal requirements form the explicit terms of the contract, while other non-legislated societal expectations constitute the implicit terms of the contract. Therefore, particularly concerning the implicit terms of the contract, managers' perceptions may vary greatly (Deegan et al. 2002).

As mentioned, the legitimacy of a company could be threatened by breaching the terms of the social contract and thus failing to conform to society's expectations. More specifically, when society is not satisfied that an organisation operates acceptably, it will effectively revoke the company's contract to continue its operations. The consequences a company might then face can be severe, including social pressure, punitive legislation or difficulties in hiring suitable employees (Nasi et al. 1997). Deegan and Rankin (1999: 314) describe in more detail a scenario where "consumers reducing or eliminating the demand for the products of the business, factor suppliers eliminating the supply of labour and financial capital to the business, or constituents lobbying government for increased taxes, fines or laws to prohibit those actions which do not conform with expectations of the community".

Moreover, in a dynamic society, societal expectations of society are not permanent but change over time (Lindblom 1977). The conditions under the social contract on which legitimacy is conferred obviously then change over time, too. Even if companies did not change their manner of its operations, a company might nonetheless be confronted with legitimacy threats, as society's expectations have changed. Therefore, companies need to be responsive to the environment in which they operate (Smith 2020: 45). In this connection, Boulding (1978) asserts that with the change of expectations it is important that the organisation retains its legitimacy to survive conditions beyond those of the marketplace.

5 CHAPTER FIVE – RESEARCH Methodology

This chapter begins by briefly reviewing the aims, objectives and research questions of the study before presenting an overview of two different research philosophies. Within this discussion, a thorough justification for the choice of research methodology is provided. The chapter then turns to the research strategy employed and discusses the sample and the data collection methods. Ethical issues attached to the research are also outlined.

5.1 Research paradigm

It is acknowledged that the philosophical paradigm of a research study affects the way knowledge is studied and interpreted. The choice of paradigm sets down the intent, motivation, and expectations of research (Bryman 1988). Additionally, the subsequent selection of methodology, methods or research design is based on the philosophical paradigm in which a researcher is situated (Mackenzie & Knipe 2006). Thus, understanding a philosophical research paradigm from the outset helps a researcher to ensure that his ontological views, epistemological positions and methods for data collection and interpretation are closely integrated. Doing so clearly offers the researcher the ability to reflect iteratively upon, and guide how best to conduct the research (Bracken 2010).

Research philosophy is referred to in the literature, "as a loose collection of logically related assumptions, concepts, or propositions that orient thinking and research" (Bogdan & Biklen 2007). It also is regarded as the "patterns of beliefs and practices that regulate inquiry within a discipline by providing lenses, frames, and processes through which investigation is accomplished" (Weaver & Olson 2006). Despite the significance of the philosophical paradigm Goulding (2002) acknowledges that framing a philosophical position is not an easy task. It requires a thorough understanding of the different possible paradigms and the evaluation of oneself as a researcher in terms of convictions, beliefs, and interests. The review method of analysis and synthesis has also gained a foothold in educational research in recent years. Because numerous types of reviews have emerged in the meantime, methodological tips for writing systematic reviews in educational research are first given. This is followed by a discussion of the systematic research that is so important for reviews. This method was mainly employed to display the literature review in chapter 2 of this research.

There are many philosophical research paradigms including positivist, interpretivist, transformative, and pragmatist (Mackenzie and Knipe 2006). In most social science research, however, the major research philosophical paradigms are often considered-positivist, interpretivist and pragmatic research paradigms.

Positivism is a philosophical research stance that advocates the application of the natural science method in the study of social reality (Bryman and Bell 2015). The positivist paradigm posits that a researcher can apply a natural science method to study the social world based on the impression that, "the social world is value-free, and that explanations of a causal nature can be provided" (Mertens, 2005). Positivists also believe that to reveal the truth about not only the nature of science but also about the nature of human behaviour, once outside conditions are systematically controlled and monitored, nature can be subjected to experimental testing (Bracken 2010: 6). Thus, in positivism, the aim of the researcher is, “to test a theory or describe an experience through observation and measurement in order to predict and control forces that surround us" (O'Leary 2004).

In contrast, interpretivists argue that the distinguishing characteristics of the social world require a different reasoning that reflects such distinctiveness of the social world against natural science (Bryman & Bell 2015). This understanding stemmed from researchers who are not content with the application of scientific methods in studying the social world (Bryman and Bell 2015). Such researchers believe that social phenomena can best be understood through the interpretation or meaning assigned to them by research participants.

Whilst both paradigms are applied in social science research, Guba and Lincoln (1994) suggest that choosing between these paradigms largely depends on the two major research stances: the ontological and epistemological stances. Ontology refers to the nature of the social world. Briefly defined, it is concerned with ‘being’ and questions the nature of reality as something imagined or existing outside of an individual (Bryman & Bell 2015). Positivists, therefore, hold the view that reality can be detached from people's beliefs and imagination (Denscombe 2002), whereas, from an interpretivist paradigm, the world is a collection or construction of peoples' minds rather than a single reality (Burrell & Morgan 1979). Thus, a reality in the interpretive paradigm is the meaning given to it by research participants (Easterby-Smith et al. 2002). Therefore, the interpretive paradigm embraces multiple truths and realities as evident in the multiple forms of themes emerging from research participants' views being studied (Creswell 2003).

In this study, the author believed that knowledge is an innate part of humans which cannot be detached and is therefore explained or understood through the meaning ascribed to it by the people. Since this approach is aligned with the qualitative research paradigm, the focus of this study is on applying the inductive approach to decode the information obtained from participants.

In addition to the ontological stance of a researcher, choosing a philosophical research position is also influenced by a researcher's epistemological stance. The term epistemology is derived from the Greek word epistêmê, which refers to the assumption of how to study the world or how one comes to know about our social world (Krauss 2005). Krauss (2005) posits that epistemology asks the following questions: "What is the relationship between the knower and what is known?; How do we know what we know?; What counts as knowledge?".

The positivist holds the view that "one observable social reality and that the end product of such reality can be law-like generalisations similar to those produced by the physical and natural scientists" (Remenyi et al. 1998). In the interpretative paradigm, reality is assembled through the subjective experience of research participants, and the researcher tries to get as close as possible to the research participant being studied (Creswell 2003).

The researcher's guiding research philosophy was pragmatism. According to the pragmatic school of thought, the research topic should play the most significant role in determining the research philosophy used. For certain questions, one method could be "better" than the other. Moreover, if the study topic does not clearly imply that either a positivist or interpretivist philosophy be embraced, this lends credence to the pragmatist's belief that both philosophies may be successfully used (Simpson 2018). This demonstrates that it is conceivable and maybe even extremely suitable to use both qualitative and quantitative methodologies in the same investigation. The researcher would be better served by seeing the philosophy used in a given study as a continuum, rather than as two mutually exclusive extremes. Sometimes it's necessary for the knower and the known to engage in conversation, while other times it may be possible to maintain some distance (Kaushik & Walsh 2019).

Since it allows the researcher to sidestep what they may see as fruitless disputes about ideas like truth and reality, pragmatism might seem tempting at first glance. This philosophy is as follows, “Study what you find interesting and valuable, in whatever manner you feel is acceptable, and put what you learn to good use according to your own personal values” (Lohse 2017) Pragmatism in research entails plans that make practical choices based on "what will work best" in answering the problems at hand. This frees up pragmatic researchers to explore questions in novel and engaging ways, ultimately leading to better answers (Lohse 2017).

Both deductive and inductive methods were used in the study. Confirming and testing ideas using deductive inquiry is a common scientific method. Deductive research is distinct from inductive research, the latter of which is conducted with the intention of producing or generating new hypotheses (Maarouf 2019). To create and test hypotheses regarding a topic or condition, inductive researchers first observe the phenomenon under study. In contrast to the deductive method, which starts with a theory and collects evidence and observation to test it, the inductive method begins with the data and utilises it to form a hypothesis about what led to the data. Because of this, inductive research may be a useful tool for understanding patterns and trends that have an impact on business operations. Inductive studies often start with precise observations that lead to a generalization (Mitchell & Education 2018).

There are several notable features of deductive reasoning. The first step is to try to lay out the links in causation between the different factors. Then one uses a different feature, namely the accumulation of numerical data, to examine this idea. It's possible that the layout of tasks varies significantly across shops, necessitating a deductive strategy that allows for the utilisation of qualitative data (Korte & Mercurio 2017). Deduction approaches rely heavily on controls, which means one needs to use them if ideas have to be put to the test. These safeguards would make it more likely that shifts in absenteeism were due to factors like worker age and length of service rather than, say, the store's management style. The study design would be quite systematic in order to allow for replication (Simpson 2018).

Deduction requires, according to the scientific method, that the researcher has to be objective about their findings. In the scenario at hand, this is straightforward since one simply needs to record absences. Using a mail questionnaire poses no issues either, albeit the apparent impartiality of such a survey collapse under closer inspection due to the subjective nature of question selection and wording (Lohse 2017). Another crucial aspect of deduction is the requirement to "operationalize" notions in a manner that permits facts to be quantified. Reductionism as a guiding concept is being used. According to this theory, issues are easier to grasp when broken down into their most fundamental components. The last defining feature of deduction is generalisation. A large enough sample size is required for making statistical inferences about patterns in human social behaviour (Kaushik & Walsh 2019).

The practice of deductive reasoning may be traced back to scientific enquiry. Researchers in the social sciences were sceptical about deduction as the 20th century progressed. They had doubts about a methodology that allowed for the establishment of a cause-and-effect relationship between specific factors apart from an appreciation for how people make sense of the social environment. The power of an inductive method lies in its ability to facilitate the development of such an understanding (Hothersall 20195). For inductive thinkers, deduction's inclination to build a strict methodology that precludes other explanations for what's going on is a major flaw in the technique. The selection of the theory and the formulation of the hypothesis have a feeling of finality in this regard. Deduction may lead to the suggestion of alternative hypotheses. They, however, would be contained within the bounds of the very well-defined study plan. The above-mentioned operationalization of ideas is a crucial part of the absenteeism study design (Powell 2020).

It's probable that inductive research will focus heavily on the circumstances under which the occurrences occurred. Hence, it might make more sense to investigate a relatively limited number of topics using the inductive method than a much larger one using the deductive method. This school of thought is more inclined to collaborate with quantitative and qualitative information in order to develop contrasting perspectives on occurrences, respectively (Allmark & Machaczek 2018). The process of inductive reasoning starts with concrete observations of the world and progresses to more theoretical concepts. Researchers who use an inductive methodology start with a subject and, as they dig further, form empirical generalisations and discover tentative links. Upon beginning a study, it is impossible to formulate any assumptions, and the researcher has no idea what kind of results they would uncover. Bottom-up knowledge is derived by inductive reasoning, in which the researcher utilises observations to construct an abstraction or paint a picture of the topic under study (Heinich 2020).

5.2 Response perspective

In recent years, ontologies have emerged to represent knowledge of a particular domain. Ontology - a term borrowed from philosophy, presently has wide applications in computer science, artificial intelligence and knowledge representation communities. Ontologies are "an explicit and formal specification of a conceptualization", representing a set of concepts, events and relations that are specified to create a vocabulary for a domain (Berryman 2019). Computational ontologies can formally model a system, its constituent entities, and the relationships among them. Modern semantic ontologies can facilitate sharing a common understanding of the structure of information between communities of interest, either human or software agents. Ontologies also allow the reuse of domain knowledge. Large and complex ontologies can be built by integrating existing and well-defined ontologies. By separating domain knowledge from operational, ontologies promote inter-operability, translating between different methods, models and paradigms (Tarasenko et al. 2021).

A formal representation and information systems can reduce data uncertainty and improve the model selection process as a function of the constraints imposed by different operational conditions. The continual modernization of the electric power grid through the integration of digital and information technologies with dynamic distributed energy resources underscores the need for a formal ontology for renewable energy mix forecast modelling (Al-Ababneh 2020).

There were objective and subjective aspects to the research. Social entities exist independently of the social actors who care about them, as shown by Objectivism. Contrarily, objectivism is an alternative ontological stance that maintains social phenomena and their meanings exist apart from social actors. A world, apart from our understanding of it, exists as an object only waiting to be found; this is the core tenet of objectivism. As reality is objective, everyone has the same opportunity to verify it for themselves using their faculties of observation and analysis (Littlejohn 2018). Many persons in the same situation make the same observations about an item. Their findings should be objective and uninfluenced by their beliefs or the circumstances in which they were made. If one says something is true or existent, then others should be able to check that assertion without any influence from us. If I say there are trees outside my home, then other people should be able to independently confirm my assertion. This is what is meant by the term "third person" or "extra-mental reality" (existing outside the mind of the researcher). “If it exists, then it ought to be visible to me, to you, and to every other person on the planet” (Schneider 2022).

On the other hand, subjectivism holds that social phenomena arise as a result of the perceptions and subsequent acts of the social actors that give rise to them. The formal definition of constructivism is an ontological stance that holds that social phenomena and their meanings are always the result of the actions of social actors. Subjectivism is the view that all knowledge of the world, both internal and external, is dependent on one's own subjective experience of it (Fonberg 2017). It's premised on the assumption that social facts are just as real as hard data. For what reason, therefore, should social facts be treated differently from objective facts if subjective beliefs influence our behaviour just as much as objective reality? Many things, subjectivists claim, including ideas, emotions, and social processes, are very challenging, if not impossible, to detect just via the five senses (Fuza 2017). While it is difficult to objectively express subjective experiences, many subjective experiences and interpretive processes provide knowledge that may be considerably better. Without the ability to feel and communicate intersubjectively, social processes (such as culture) would be impossible to observe. Additionally, subjectively engaged events are experienced differently by various people in different contexts (e.g. good or bad mood, within one cultural context or another). It is the idea that everything one knows about the world is contingent on our own experiences and interpretations and that social reality does not exist until it is given that meaning (Schneider 2022).

Objective and subjective realities exist, as is generally accepted. Both contribute significantly to how one makes sense of the world but in different ways. Each adds something special to our knowledge of the world, but together they complete it. One depends on factual reality in certain cases, but subjective reality may make more sense in others. For instance, one may use objective realities to determine the age of a priceless work of art, but one might use subjective realities to determine its value. (Littlejohn 2018).

5.3 Research strategy

When researchers aim to explore thoroughly a specific research phenomenon for which there is no substantial knowledge, they try to approach it in a way that corresponds to the overall research scope and objectives. A common research orientation is flexibility while collecting data, which means researchers adopt an open-minded approach in considering specific connections between research variables, themes, and trends (West and Oldfather 1995). Another research orientation is that of an exploratory study, which suggests a process of extensive exploration of a research topic in order to determine its feasibility and long-term implications (Zhao, 1991). For the purposes of this research, the research strategy that is utilized combines the elements of flexibility and exploration as the researcher tries to come up with conclusive results about the strategic implementation of renewable energy systems in heavy industrial settings.

An important part of the research strategy employed in this study is the specificity of the research question. As previously noted, the research question posed in this study is associated with determining the challenges for strategy development and risk management to achieve a sustainable energy mix in heavy industrial settings. From this perspective, it can analysed that the type of the research question determines the precise research strategy to be adopted (Blommaert 2001). Considering the specificity of the research question, it appears that using a more structured approach to data collection and data analysis would help the researcher present more relevant conclusions about particular strategic developments and recommendations for improvement in heavy industrial settings. In this way, it is possible to either accept or reject certain theoretical assumptions, statements or hypotheses made in relation to the research (Clayton et al. 1999).

The most important aspect of the research strategy is the interlinks between theory and data. A discovery-based approach to collecting and analysing data basically means that there is an initial development stage which is followed by refining specific concepts emerging from the data set (Bryman 1988). In fact, some research ideas may need to be properly reformulated as a result of the ongoing discovery or exploration of the research topic.

Another relevant component of the research strategy is the research perspective. The focus is on the specific nature of the social world being explored. The research techniques being used represent high theoretical relevance, which means the research strategy shows a particular course of action taken towards understanding the empirical reality (Bryman 1988). Thus, pragmatism appears a suitable choice for this study since methods of natural sciences can be applied to the social world. In other words, it is possible to study the research phenomenon using a deterministic framework (Brannen 2005). The idea reflected in such a framework is that all social events are determined by specific factors that should be adequately explored to gain a better understanding of the research topic.

In discussing the specific research strategy adopted in this study, it is important to emphasize the highly structured and systematic way in which all research steps are being planned. It is essential to develop a clear conceptual map of the entire research process by adhering to particular conceptual guidelines (Creswell 2003). The initial focus is on the purpose of the research in terms of determining the implications of the research problem and uncovering the reasons for conducting the study. Another step included in the research process is that of specifying the research paradigm, which is positivism in this study. Such a research philosophical orientation implies that individuals can understand and interpret social reality in an objective way (De Vaus 2001). This is apparently opposed to interpretivism which emphasizes the need for a more subjective interpretation of different events and interlinks existing between them.

Even though both qualitative and quantitative data were utilised in this study in the form of primary research, respectively questionnaires, it is important to clarify that a significant part of the questions included are open-ended and multiple-choice questions (MCQ). This means the research strategy employed in the study allows for the emergence of an attitudinal stance of continuous change and self-development exhibited by participants (Tashakorri and Teddlie 2003). The survey respondents are encouraged to critically reflect upon their behaviour, actions, and interactions with others. Such a self-exploratory experience will help them improve their critical and analytical skills as well as enhance their contribution to the research in terms of sharing important insights into resolving strategy development and risk management challenges (De Vaus 2001).

To collect quantitative data, the researcher developed a 5-point Likert scale, from strongly disagree (1) to strongly agree (5) to measure the risk management, strategy development and transformation of energy mix in heavy industrial settings. The qualitative data collected based on commentaries made in the questionnaire were analysed thematically. The questionnaire was sent anonymously with the Survey Tool “Qualitrics” (Qualtrics 2024) to 400 mid-level and high-level managers in the field with an anonymous link. From these 400 people, 369 were reached, as 31 e-mails bounced (meaning the e-mail was wrong or the survey link was detected as spam from the company-intern firewall). From these 369 reached people, 310 individuals fully filled and returned the survey (meaning they closed the survey file with a submission click on a finish button). The links were sent to the personal company email addresses. With a size of 400 people, 310 fully filled out forms mean a 99% confidence interval, with a 3.5% margin of error. The survey collector was open from November 2020 to March 2021 until the mentioned statistical saturation points were reached.

The components of the questionnaire are aligned with the research questions of this thesis. The first, second, and third research questions revolve around strategy development, transformational process, and risk management, respectively. All the survey questions also can be divided into these three dimensions (see Appendix 9.2). For example, open-ended questions about the major risks of changing the energy mix in the heavy industry, major opportunities in this field, the key threats and weaknesses of this process, and a set of obstacles and difficulties encountered during the transformation process are mainly connected with the research question about risk management. At the same time, the questions about the investments required for changing the energy mix, measurement of the transition success, and technical hurdles for changing the energy mix were supposed to provide valuable insights to answer the research question about the transformation process.

5.4 Mixed method approach

An important element of the research design adopted in this study is to clarify the precise approach being utilized. It has been concluded that the use of a mixed method approach corresponds to the specific research goals which are divided into three main areas: strategy development, risk management, and transformational process. The common link between these areas is the emphasis on the ongoing strategic improvement that could illustrate the emergence of a sustainable energy mix in heavy industrial settings (Creswell 2003). In general, mixed methods research implies the combination of quantitative and qualitative approaches to initiating data collection and data analysis. In this study, the quantitative method of data collection is described as questionnaires, while the approach to analyse such quantitative information is descriptive quantitative analysis (Tashakorri & Teddlie 2003).

A relevant initial aspect to be considered about the mixed method approach is the research philosophy. As there is a combination of data collection and data analysis methods, more than one research philosophy is being utilized in this study. The mixed method approach suggests the implementation of positivism and interpretivism in terms of prevailing research philosophical underpinnings (Creswell 2003). Even though the use of a mixed method approach is believed to lead to a more thorough representation of the research findings in this study, the respective methodology has some philosophical and methodological contradictions. It has been argued that the methodological aspects utilized in physical sciences might not be applicable to the social sciences field (Hammersley 1996). This is mostly because the quantitative and qualitative methodologies refer to completely different philosophical underpinnings which may be quite confusing to combine due to the inherent incompatibility of dominant research philosophies, particularly positivism and interpretivism (De Vaus 2001). The complementary benefits of MMR become more evident when data triangulation is applied to this current study.

Because of the contradictions reflected in the philosophical underpinnings of the mixed method approach, employing a pragmatic approach may be a more viable option. It has been illustrated that researchers commonly rely on clear pragmatic grounds to develop relevant knowledge (Creswell 2003). In other words, a similar pragmatic approach is useful because it provides an efficient solution to optimize the combination of quantitative and qualitative methods of data exploration and data analysis. There should be a proper methodological fit between the two research paradigms in order to avoid misrepresentation or confusion of the information contained in the two data sets (Green et al. 1989). It has been pointed out that it would be more reasonable to view knowledge as a premise that could be changed or modified to address stakeholders' specific needs at a given moment (De Vaus 2001). This is applicable to the current research since it is important to understand how certain strategic components should be altered to help managers in heavy industrial settings develop more sustainable strategies that could result in a better competitive advantage.

It seems that the use of the mixed method approach is on the rise in different fields. This can be explained by the convenience of combining two distinct methods of gathering and analysing research information. At the same time, the mixed method approach allows a relevant opportunity for skills enhancement (Creswell 2003). This aspect was thoroughly considered at the initial planning stage of the current project. The component of skills enhancement is used to illustrate how this study was planned with the main idea of having a better idea of how organizations in heavy industrial settings can develop effective strategies for achieving a sustainable energy mix (Zhao

1991). By referring to the research scope and objectives, it is important to recognize how the issue of skills enhancement can be adequately incorporated into the respective industry.

In combining different methods during the research process, different issues might arise, which means the researcher should be prepared to address any inconsistencies or problems. In order to avoid any confusion regarding the research design, strategy, and research philosophies, it is essential to revisit the entire research process in its context (Zhao 1991). In other words, the researcher should determine whether the use of the mixed method approach is applicable to the context of heavy industrial settings in terms of considering the dimension of industry dynamics.

The focus of this type of research is on making sense of different data sets. Different meanings or different forms of triangulation may emerge throughout the research process (Creswell 2003). The use of triangulation in the context of the present research implies a proper understanding of the identified social phenomenon from multiple perspectives. This aspect facilitates a more objective and comprehensive interpretation of the main research issues emerging in the project (Green et al. 1989). Eventually, it is possible to present adequate conclusions about the combination of different data analysis approaches in the sense of understanding how the researcher may reach similar inferences about the research topic.

5.5 Triangulation

The researcher used the survey questionnaire as a basis for comparison and validation of results. The MMR approach is primarily designed for and complemented by triangulation methods. Methodological and data-based triangulation methods are applied widely in scholarly research (Flick 2018). In methodological triangulation (MT), researchers use a wide range of complimentary data collection strategies, such as surveys, interviews, and observations, to analyze and explain phenomena (Flick 2018). The MT data collected from the different processes is often analysed using similar techniques, such as thematic or colour-coding approaches. Contrastingly, data triangulation (DT) involves the collection of data through diverse instruments and sources, such as questionnaires, interviews, and focus groups (Flick 2018). In DT, the data is usually analysed through different qualitative and quantitative methodologies In limited circumstances, researchers use theory-based triangulation (TT) to analyse research findings through the lenses of different epistemological models (Flick 2018). A less common form of triangulation is researcher triangulation (RT), which involves two or more investigators analyzing phenomena from their subjective viewpoints. The current research utilized the DT method by combining qualitative and quantitative approaches in data analysis and explanation of phenomena related to energy use in heavy industries.

Triangulation converges divergent viewpoints into a singular perspective of phenomena under inquiry (Smith 2020). The qualitative data showed how international and regional treaties, national policies, institutional guidelines, and public opinion influence the energy policies used in heavy industries (Smith 2021). Based on these insights, the quantitative questionnaire enquired from the respondents about the specific strategies, barriers, and cost considerations they use to implement energy mix in their industries. The findings from the quantitative aspect of the research were then verified and corroborated using secondary literature sources.

Triangulation methods, such as MT, DT, TT, and RT, are popular because they increase the reliability, validity, and verifiability of research findings. Specifically, the use of different methodological approaches and data points leads to greater clarity, reliability, and validity of the research findings (Smith 2021). The outcomes of data analysis processes are usually verified and corroborated by different data sets. Therefore, triangulation provides a holistic view of phenomena through multiple perspectives (Johnson 2022). As section 5.7 shows, the DT was instrumental in increasing the validity, reliability, and rigour in this current study on the energy mix in heavy industries.

5.6 Data analysis approaches

5.6.1 Quantitative data analysis

Since the dominant data collection method in this study is identified as questionnaires, this means the emphasis is on finding an optimal way to analyse such survey data.

One such way is specified as descriptive quantitative analysis, which implies the description of research data that can be quantified through specific Tables and percentages (Creswell 2003). The visual display of quantitative data is quite important in this study because this allows for a better quantitative interpretation of the research findings in terms of statistical distribution or statistical relevance of different research variables.

The most important aspect of the descriptive quantitative analysis utilized in this project is to describe specific categorical data pertaining to the research question, which is associated with determining the challenges for strategy development and risk management in heavy industrial settings (Green et al. 1989). The quantitative data set will be divided into different categories which will be expressed as percentages of the sample size.

Once the respective quantitative data is properly described, it is important for the researcher to make sense of the substantial amount of information derived from participants' answers to open-ended and multiple-choice survey questions. The quantitative data visuality component can provide relevant insights into percentages and links between research variables (Zhao 1991). Yet the focus should be on the distribution of those percentages across the sample which is described as 100 people. The emphasis on percentages is statistical in nature and provides a relevant opportunity for the researcher to generalize the research findings to the wider population.

Tabulation as an important element of the descriptive quantitative analysis allows for the orderly arrangement of the research data. This is presented in a summary format to facilitate the data analysis process in terms of making relevant links between frequencies and percentages (Creswell 2003). It has been considered that the descriptive quantitative method of data analysis is quite reliable because it measures the representation and impact of the research findings based on specific Tables, rather than vague or subjective interpretations.

To answer the research question of this thesis mixed research method was chosen.

The complexity of the research topic was broken down into three main areas (1) strategy development, (2) risk management and (3) transformational process, according to the found literature in a thorough literature research that included academic papers and grey literature of the years 2015 to 2020.

The quantitative approach includes a questionnaire of 26 questions that evaluate the opinions and understanding of heavy industry middle management decision-makers. The sample size for adequate answers was estimated at 100 people. The questions themselves were categorized according to the three main research areas mentioned above.

All 26 questions deserve different kinds of answers to avoid recurring answering automatism in the form of random clicking. Therefore, the answer mixture contains 5-point-Likert scales, multiple choice matrices and free commentaries. A demographic introduction leads into the survey asking for gender (Q1), age (Q2) and the occupational field of experience (Q3).

The data analysis includes quantitative aspects, such as the 5-Point-Likert Scales and the Yes-Likely-No-Matrix and quantitative evaluation through the commentary sections. As some of the questions touch the research areas solely and others try to get a better understanding of the intersections between the research fields, the results will deliver a broader understanding of the perception and awareness of professionals in this this field of expertise.

5.6.2 Qualitative data analysis

The study involved an inductive thematic analysis of the qualitative data that was collected. Thematic analysis is a technique used to dissect qualitative information. Using an inductive approach means deducing themes from the facts. The term is most often used in reference to a survey or transcripts. Common themes, or recurring concepts, subjects, or patterns of meaning, are identified by a thorough analysis of the data by the researcher (Neuendorf 2018). The most popular method for doing thematic analysis consists of the following six steps: getting to know the material, coding it, coming up with themes, evaluating those topics, giving them names, and finally writing it all out. If one follows this procedure, it will be less likely to be influenced by confirmation bias as the analysis develops. If one has a collection of qualitative data and wants to learn anything about people's perspectives, opinions, knowledge, experiences, or values, thematic analysis is a useful method (Nowell et al. 2017).

The inductive content analysis (ICA) was also employed. The following graph shows a general framework for content analysis to show the relevant factors. The following graph shows a general framework for content analysis to show the relevant factors.

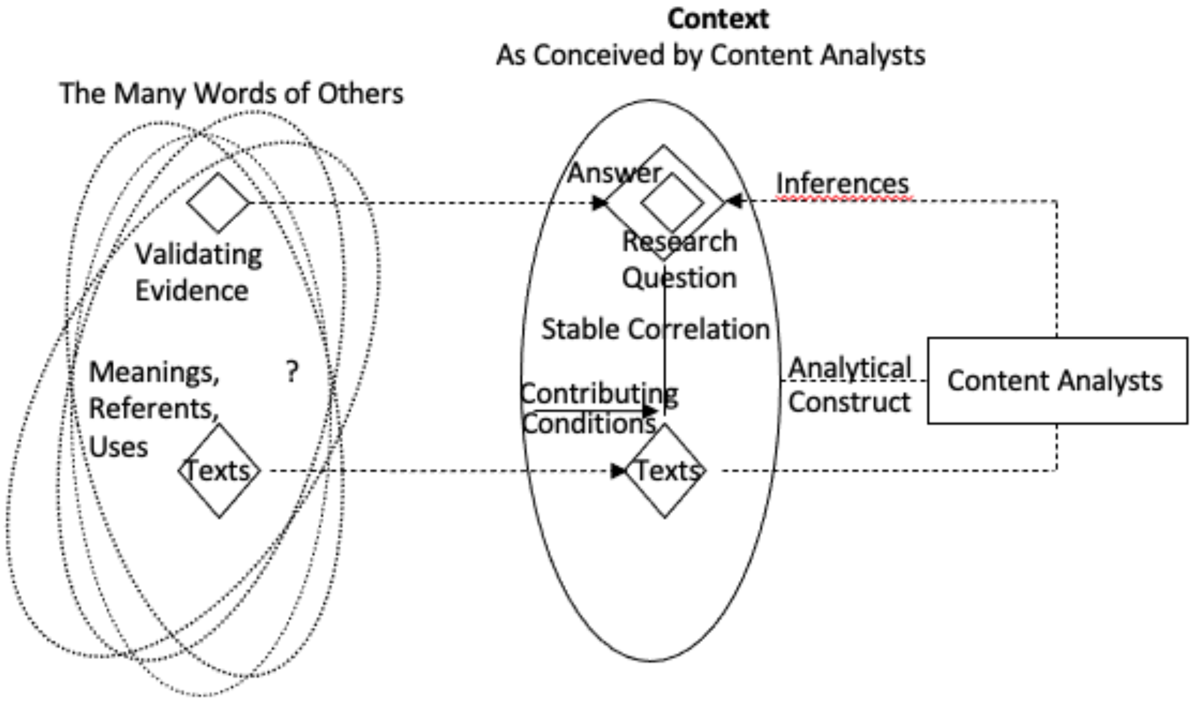

Figure 14: General Framework for content analysis.

Source: Krippendorf (2004: 30)

The ICA is often used for textual data, such as written transcripts of speech conversations or written documents. It's possible that these papers were prepared for other reasons than a research study, or that they were written for the study itself (Kyngäs: 2020). While ICA may be used for pictures, the emphasis of this essay will be on textual information. The core idea of ICA is to provide a high-level summary of the data set's textual components. Rather than scanning the text for a set of predetermined content elements, ICA constructs its analysis inductively, from a careful reading of the texts (Armat et al. 2018).

The ICA is qualitative since it seeks to explicate the meaning(s) of the information included in the dataset. It does not keep a tally of content occurrences for purposes of frequency analysis or discovering statistical relationships between pieces of material. Quantitative content analysis, on the other hand, often entails some kind of tally. When it comes to qualitative data, thematic analysis is perhaps the most well-known method of analysis, and ICA has many characteristics (Graneheim, Lindgren & Lundman 2017). For beginning researchers, one immediate parallel between theme analysis and ICA is that both use a coding method. Coding is the process of assigning labels to sections of text in an interview transcript or other document, with the goal of finding and grouping together comparable sections of text both inside and across documents or transcripts. Because of their distinctions, it is also crucial to establish if an ICA or a thematic analysis is being conducted (Moldavska & Welo 2017).

ICA's defining features are its inductive nature and its reliance on iterative coding. The term "inductive process" implies that the tagging codes are derived from the data's real characteristics as they are being coded (Mayring 2019). The researcher discovers the codes inside the data, or, as the phrase goes, the codes "emerge" from the data. The codes employed in the inductive content analysis are generated as a result of the material being analysed, as opposed to being based on prior knowledge in the form of a study or a theoretical model. Before any data is gathered, in deductive content analysis, the codes are created (Williams & Shepherd 2017).

Iterative coding refers to a method in which the coding is performed several times on different documents or transcripts, with each iteration improving upon the previous one based on comparisons made between the documents or transcripts. Several rounds of coding, with each one improving upon the last, are performed on each document or transcript. This repeated re-coding is essential to ensure that the newly recognised codes were not overlooked in the previous coding rounds due to the inductive nature of the coding process (Kyngäs, Kaariainen, & Elo, 2020). Ideas that are discovered in later transcripts are often present in earlier transcripts, although in more oblique forms, and were simply missed during the first coding of those transcripts. As the analysis progresses, the researcher will likely add to and modify the initial set of codes. In contrast, the list of codes in deductive content analysis is set in stone and does not evolve over the course of the research (Mayring 2019).

Content divisions and subcategories, rather than themes, emerge from the coding process, which is followed by comparison, grouping, and subdividing groupings of codes. Content categories are larger conceptual umbrellas under which several content codes may be found. Although not always the case, when a researcher is conducting interviews or focus groups, the topic categories they use may have a strong correlation with the questions they ask participants (Mayring 2019).

5.7 Reliability and validity in quantitative research

5.7.1 Validity

Validity and reliability are elements used to test the quality of a study. They show how well a strategy, test or approach evaluates a concept. Reliability is about the dependability of a measurement while validity is about the precision of a test. It is often important to reflect on validity and reliability when generating a research design, preparing strategies, and writing results, particularly in quantitative studies (Cohen et al. 2017). Even though reliability and validity are closely connected, they have different meanings. An approach can be consistent without being valid. At the same time, when a test is valid, it is often consistent. Validity implies how correctly an approach measures what it is designed to measure. When a study has high validity, that implies it generates results that match real properties, features, and variations in the social and the physical world.

High reliability often implies that assessment can be valid. When a strategy is not dependable, perhaps is not valid. Some of the measures that guarantee the validity of a study comprise the following elements: proper selection of the research time scale, a proper strategy based on the research characteristics, an appropriate sample strategy for the research, and the ability of respondents to make choices freely (Cohen et al. 2017). It is essential to understand that while threats to study reliability and validity cannot be totally eliminated, there is a need for researchers to endeavour to minimise the threat as much as it is possible.

There are various types of validity. First, content validity measures whether a tool effectively highlights all content that needs to be covered depending on the variable. A normal question emerging in this context is: Does the tool cover the whole field associated with the variable or the concept intended to assess? In a study about strategy development and risk management for a sustainable energy mix in heavy industries, an investigation with content validity would encompass strategy development and risk management focusing on sustainability in heavy industries (Mohajan 2017). Another subset of validity is face validity, where professionals are interviewed about whether a tool evaluates the intended concept.

Construct validity involves whether premises can be drawn about the test scores associated with the researched concept. Construct validity can be demonstrated in specific ways: homogeneity-implying that the tool can only measure one concept; convergence-happens when the tool investigates concepts comparable to other tools (Cohen et al. 2017). However, it is impossible to attain when similar instruments are not available. Theory evidence, which is key to this study, occurs when behaviour correlates with hypothetical propositions of the concept evaluated in the tool. For instance, when a tool evaluates anxiety, it is essential for participants who score highly on the instrument to exhibit signs of anxiety in their lives.

Criterion validity is the ultimate measure of validity. A principle or criterion refers to any other tool that tests a similar variable. Relationships can be evaluated to establish the level to which various tools test a similar variable. Criterion validity can be measured in different ways. In this study, for instance, it can be shown that there is little correlation between a tool that measures strategy development and risk management (Mohajan 2017). Convergent validity -indicates that a certain tool is vastly connected with other tools measuring the same variables. Predictive validity implies that an instrument should be highly related to impending criteria. For instance, a high self-efficacy score associated with doing a certain task should envisage the possibility of a participant finishing an activity.

The average variance extracted (AVE) was used to assess convergent validity. Convergent validity is defined by how well the construct converges to explain the variation in its indicators. The AVE is calculated as the total squared loadings of the indicators for the construct divided by the total number of indicators. As a result, the AVE may be compared to the shared nature of a certain structure. An AVE of 0.50 or higher is required. A concept with an AVE of 0.50 or above explains more than half the variation in its underlying indicators (Hair et al. 2022).

Discriminant validity evaluates a construct's ability to be differentiated from other model components on the basis of empirical data. Using empirical criteria, discriminant validity determines how significantly different one concept is from the others. Therefore, discriminant validity requires a concept to be original and capture phenomena not captured by other constructs in the model. Figure 33 displays the results of a test of discriminant validity using the Fornell-Larcker criterion. The conventional measure was established by Fornell and Larcker (1981), who advocated comparing the squared intra-construct variance (AVE) of each construct with the squared inter-construct correlation (ICC), a measure of shared variation across constructs. All model components should have variances that are less than their shared variance estimates (AVEs) (Hair et al. 2017).

Cross-loadings between study indicators were also examined in order to assess discriminant validity. An indicator's outer loading on the construct it is meant to measure should be greater than any cross-loadings (or correlations) with other constructs. Cross-loadings should ideally be evaluated and reported using a table with columns for the indicators and rows for the latent variable (Hair et al. 2017).

A test of discriminant validity using the Heterotrait-Monotrait Ratio (HTMT) was conducted. The HTMT is the geometric mean of the average correlations between indicators measuring the same construct (monotrait-heteromethod correlations) and indicators measuring distinct constructs. When the HTMT ratio is very high, there are issues with discriminant validity. When comparing structural models with conceptually comparable entities, Henseler, Ringle and Sarstedt (2015) suggest a cutoff value of 0.90, beyond which discriminant validity is not met. On the other hand, a more cautious threshold value, like 0.85, is recommended when the conceptions in question are conceptually dissimilar (Henseler et al. 2015).

The HTMT statistic cannot be tested for statistical significance using traditional parametric methods since PLS-SEM does not make any assumptions about the distribution of the data. To get a distribution for the HTMT statistic, the researcher must depend on a method called bootstrapping. The HTMT may be compared to 1.0 (Henseler et al. 2015) or a lower threshold value, such as 0.9 or 0.85, that should be determined for the study's specific purposes using bootstrap confidence intervals (Franke & Sarstedt 2019). Assessing if the upper limit of the 95% confidence interval is less than 0.90 or 0.85 (at a 5% significance level) is the first step. Therefore, take into account a 95% one-sided bootstrap confidence interval, the upper border of which is the same as that obtained when calculating a 90% two-sided bootstrap confidence range. According to Aguirre-Urreta and Rönkkö (2018), the percentile technique is the best way to get the bootstrap confidence intervals. The recommended number of replicates for a study is 10,000, therefore that's what scientists should always utilize. When discriminant validity is low, a confidence interval cannot exclude the value 1. If, on the other hand, 1 is not included within the interval's range, then it may be concluded that the two constructs are, in fact, distinct (Streukens & Leroi-Werelds 2016).

5.7.2 Reliability

Reliability is associated with the uniformity of a measure. An individual completing a tool intended to measure motivation should have nearly similar reactions every time the test is finished. While it is not likely to provide a particular consistency calculation, an estimate of consistency can be attained through different tests. Some of the attributes of reliability involve:

Homogeneity or inner uniformity is measured using item-to-total relationship, split-half reliability, Cronbach‘s, and Kuder-Richardson. When using the split-half reliability, the test results are divided in half. Relationships are designed based on halves (Surucu & Maslakçi 2020). Robust relationships show high consistency, while frail relationships show that the tool is unreliable. The Kuder-Richardson test represents a complex type of the split-half test. The average of the likely split-half groupings is established in this progression, and a correlation between 0-1 is formed. It is a test that is more accurate than the split-half assessment, though it can only be done on investigations that require two replies, such as 0 or 1 and ‘yes’ or ‘no’ (Heale & Twycross 2015). One of the generally used tests to establish internal uniformity is Cronbach. This assessment establishes the average of all relationships in each combination of split halves. Tools with queries that possess more than two answers can be utilised in this assessment. The result of a Cronbach’s assessment is a number between 0 and 1. A consistent and satisfactory score is 0.7 and above.

Stability is measured using alternate and test-retest type reliability measurements. Test-retest reliability is measured when a sample is given a similar tool more than once in similar conditions (Surucu & Maslakçi 2020). A statistical contrast is made between the test results for every aspect completed. It offers an indication of a highly reliable instrument. Alternate reliability is the same as test-retest reliability, but a different type of the original tool is provided to the population in the succeeding measurements. Both versions of the instrument measure similar concepts using different wordings. For a tool to show constancy, there should be a high connection between the outcome each moment a participant finishes the test. In general, a relationship factor less than 0.3 implies a weak relationship, 0.3 to 0.5 is modest, and more than 0.5 is sturdy.

Equivalence is measured using inter-rater reliability. It is an assessment that involves a process that qualitatively establishes the degree of consensus between two or more observers (Mohajan 2017). For instance, it is often used by judges in a competition. The degree of uniformity by all judges in their judgement is a measure of inter-rater reliability. In a study, a good example involves researchers giving the outcome for the relevancy of every item on a tool. Reliability in their scores is associated with the degree of inter-rater consistency of the tool.

Establishing matters of reliability and validity in this research is an important element when reviewing a study and influencing a decision about whether to implement the conclusions of the study in heavy industries. In quantitative research, rigour is established by measuring the legitimacy and consistency of the tools used in the research (Heale & Twycross 2015). A study that embodies good quality often provides evidence regarding how these elements have been addressed. It helps to evaluate the validity and reliability of the study and aids in making decisions about whether to apply the results in heavy industries.

The internal consistency reliability of the research constructs was analyzed using Cronbach's Alpha, rhoA, and Composite Reliability. Internal consistency reliability is often the first measure of quality used. One common measure of reliability is Cronbach's alpha is a common measure of reliability that provides an estimate based on intercorrelations between the observable indicator variables. Composite reliability is technically preferable to use than Cronbach's alpha because of its restrictions. For this reason, the dependability values obtained using Cronbach's alpha tend to be on the low side. Composite reliability, on the other hand, tends to overstate the internal consistency reliability, resulting in relatively larger reliability estimations. As a result, it makes sense to report on both measures. Recent studies have instead suggested the precise or consistent reliability coefficient rhoA, based on the work of Dijkstra (2010) (Dijkstra 2014; Dijkstra & Henseler 2015). Because of its middle ground position between the more conservative Cronbach's alpha and the more flexible composite reliability, the reliability coefficient rhoA is widely accepted. Exploratory studies might accept reliability values between 0.60 and 0.70, whereas values between 0.70 and 0.90 are deemed adequate to good. When calculating construct validity, values over 0.90 and especially greater than 0.95 may imply redundancy of indicators (Diamantopoulos et al. 2012). The presence of exaggerated correlations between the error terms of the indicators is another red flag for reliability values over 0.95, which may indicate the presence of undesired response patterns.

5.8 Reliability and validity in qualitative research

5.8.1 Validity

Some of the key aspects of all studies are reliability and validity. Careful attention to these two elements can differentiate between a good study and a poor study and can aid in guaranteeing that researchers accept results as reliable and dependable (Ronkainen & Wiltshire 2021). It is specifically important in qualitative studies, where a researcher's bias can apparently influence the interpretation of the data and where study results are often viewed with scepticism by the scientific community. Therefore, when conducting qualitative research, there is a need to be particularly careful with issues of validity and reliability. There is a need to be attuned to various factors that pose risks to the validity of the results, and plan and implement different strategies in every phase of the study to avoid these factors (Hayashi et al. 2019). It is important to understand that approaches used to address validity and reliability in qualitative studies and quantitative studies are different.

The nature of qualitative study methods does not use statistical validity. Qualitative studies seek similar results through methods suitable to a human topic (Hayashi et al. 2019). Some strategies to ensure the truthfulness of qualitative results involve making sure that research philosophies are in line with the research. To maintain the validity of a study, the underlying research needs, guidelines, and ethical research rules that are societal must be understood (Nesrabad 2018). Consensus should be achieved between individuals and society when establishing validity to achieve the accuracy and correctness of the research. Doing this helps to ensure that a wider audience accepts the applied tools. Therefore, there is a need to carefully select instruments to establish how accurate research data is.

It is also essential to note that choosing a skilled moderator is one of the ways to establish the validity of qualitative data. Ronkainen and Wiltshire (2021: 14) state that biases can be avoided when the moderator is non-partisan and cannot be influenced by any person who wants the research to favour certain aspects. Another way to promote validity is by applying triangulation (this implies that research has been conducted in multiple or different perspectives) (Cypress 2017). In this study, the insights derived from the qualitative analyses conducted in different stages were cross-verified with the quantitative findings from the statistical analyses and vice versa. An example is employing many moderators in different locations. The technique involves the researcher analysing data from different points of view. Further, respondent validation can establish the validity of qualitative research by testing initial results through participants to establish whether the results are still valid.

5.8.2 Reliability

Consistency is important in establishing reliability in qualitative research. A refutational analysis is one of the methods used to establish a reliability test. The purpose of this method is to ensure the reliability claim is supported. This process can be achieved through explaining and exploring contradictions between studies that have been done individually. Another method is using comprehensive data, comparison, and recording data using tables. The purpose of this is to establish the authenticity of data and organize it formally. This method is mainly done using MS Excel and NVivo for data analysis (Hayashi et al. 2019). Triangulation is another method that is used to establish reliability. It is achieved by ensuring transferability, credibility, and conformability. It is vital for qualitative research to factor in a quantitative aspect (Flick 2018; Natow 2019; Campbell et al. 2020). The findings from the qualitative aspects of this study are reliable because they are corroborated by quantitative statistical analyses in an iterative or cyclical process, which is consistent with DT (Flick 2018). A positive attitude is created when a simple quantitative aspect is used in qualitative research, which plays a significant role in establishing reliability in a simpler form (Ronkainen and Wiltshire 2021). A dependable way of establishing if the research results and process are reliable is by including two or more reliability tests according to the research outcomes.

Before the actual research is conducted, it is essential to establish techniques and tools to determine reliability and validity. Therefore, valid and reliable results are obtained from the onset; thus, research results are not impaired at the end of the process. There is a need to effectively assess the literature to establish efficient validity and reliability measures, as this will help showcase which process will work (Ronkainen and Wiltshire 2021). Irrelevant approaches that may compromise the research's validity and reliability should be dropped and not pursued further. The research processes should be carried out together with the validity and reliability processes to confirm the research objective. It will play a relevant role in ensuring that the research work is authentic. Researchers should not consider reliability and validity as an extra element. If the aspects do not add value to the research, they risk affecting the accuracy of the results (Rose and Johnson 2020). Researchers should not include extreme measures to support their research claims to establish validity and reliability (Nasrabad 2018). This is because too many measures will lead to overcomplicating the research results.

One of the greatest factors affecting reliability and validity is errors. An error may occur in all investigations and relates to reliability and validity inversely. When the degree of error is substantial, the results are less accurate and less truthful. Therefore, researchers must be keen on errors when implementing and planning their research. Sources of error can be categorised into four: the researcher, the subject of the project, the social or situation context, and data collection and analysis methods (Hayashi et al. 2019). The researcher is mainly the data collection instrument himself in the qualitative study. Therefore, the researcher must be unbiased and competent to ensure that the data collected is trusted. The presence or absence of the researcher during the data collection process can influence the data, either positively or negatively depending on the situation. Informants can also introduce biases in the study depending on their characters. It is mainly common when using interviews and questionnaires (Cypress 2017). They may want to exaggerate situations to seem worse or better than they are. It is also important to establish the social context under which certain data is gathered. Different social situations can influence how individuals behave (Ronkainen and Wiltshire 2021). For example, when individuals are alone with a researcher, they may tend to give more or less information than when they are in a group. It is, therefore, important that the researcher is keen when interviewing such an individual to compare their behaviour in various situations and make conclusions based on this (Cypress 2017). The researcher should explain the strategies used in data collection, which means these methods should be well-documented (Noble & Smith 2015). Sampling bias is one of the risks whereby the researcher may underrepresent or overrepresent a phenomenon under study. Therefore, the researcher must do systematic sampling, which will enable them to select subjects according to the findings that occur during the study (Cypress 2017).

5.9 Justification

Bryman (1988) argues that the appropriateness of a research approach to addressing a research problem plays a significant role in selecting a research method. Research approach shapes the decisions about research design and methods that are applied to find answers. This corroborates the position of Cavaye (1996) who states that the methodology chosen depends on what a researcher is trying to do rather than a particular paradigm to which a researcher is committed. This understanding points to a departure from early researchers' position on ontological and epistemological stances as the critical factors in choosing a research methodology, with some researchers questioning the suitability of the approach in social science research (Agarwal et al. 2011).

Denscombe (2002) claims that holding on to a particular philosophical position in selecting a research method has its shortcomings. Therefore, social science researchers should embrace more pragmatic and triangulated approaches that fully address the research problem without giving preference to any philosophical stance. Based on these arguments, Clough and Nutbrown (2012: 21) state that the "purpose of a methodology is to show not how such and such appeared to be the best method available for the given purposes of the study, but how and why this method was unavoidable – as required by - the context and purpose of the particular enquiry" Clough and Nutbrown (2012: 21).

The problem identified in this study is quite complex considering the challenges related to strategy development and risk management to achieve a sustainable energy mix in heavy industrial settings. The process of identifying and resolving such challenges is difficult, which means it is good to approach the research question through the utilization of different research methods (Creswell 2003). In this context, it is crucial to understand the specific nature of the mixed method approach, which goes beyond the simple identification of its meaning and when it should be utilized.

An important reason for using the mixed method approach in this study is that such a research methodology provides a way to obtain the benefits that offset the limitations inherent in both quantitative and qualitative methods. In fact, this aspect has been an inseparable part of the historical argument pertaining to the utilization of the mixed method approach for the last 30 years (Creswell 2003). It has been commonly argued that quantitative research methodology is not that strong in understanding the precise context or social reality in which individuals live. It is clear that participants' voices are not directly taken into consideration in quantitative research because the emphasis is mostly on numbers and percentages (Green et al. 1989). In addition, quantitative researchers are in the background of the research process, which means their interpretations are not incorporated into the data analysis.

On the other hand, qualitative research methodology is also considered to present certain disadvantages. The limitations of qualitative research are mainly attributed to the personal interpretations of the researcher, which are considered rather subjective. As a result, some biases could form which could prevent the researcher from generalizing the research findings (Hammersley 1996). The number of participants studied in qualitative research is relatively small. This is considered not only a weakness but also an opportunity to pay individual attention to each participant in an attempt to gain a better understanding of their distinct interpretation of the research topic. Since quantitative research methodology does not have the weaknesses emerging in qualitative research, it is believed that the strengths of one approach address the limitations of the other (Creswell 2003). In the context of this study, the implementation of mixed methods research expands the research horizons by helping the researcher and participants to view the research problem from different angles.

Another essential reason for justifying the use of the mixed method approach in this study is that the respective methodology provides more substantial evidence for exploring the research problem. As noted, the dimensions of exploration increase significantly with the implementation of mixed methods research rather than being restricted to quantitative or qualitative research methodology alone (Green et al. 1989). From this perspective, the researcher in this study has an opportunity to use all relevant instruments of data collection available, including those related to secondary research. Having more opportunities for expanding the data collection process represents a significant advantage for the researcher to differentiate between relevant and inappropriate research information.

It is also important to consider that the mixed method approach is useful for answering questions that cannot be properly addressed by quantitative or qualitative research methodology alone. The selection of mixed methods research for this study implies an opportunity for the researcher to explain the research findings more extensively by applying different rules, principles, and standards relevant to each of the dominant research approaches (Bryman 1988). Moreover, it is possible to adapt and modify the mixed method approach depending on the precise research context. Since the focus of this study is on heavy industrial settings, this suggests a high level of organizational dynamics. The researcher may need to alter some elements from the two main approaches in order to present the research information in a way that could create a solid impact on the intended audience.

In justifying the use of the mixed method approach in this study, it is important to understand how this method provides an opportunity for the researcher to generate new insights into the research problem. Such insights go beyond the process of providing separate quantitative and qualitative research findings (Creswell 2003). The combination of the two main approaches enables the researcher to develop new knowledge that can be effectively used to inform future practice in the field.

The implementation of the mixed method approach in the current project indicates that diverse worldviews are largely encouraged. In this way, the researcher avoided making the typical link between the research scope and objectives to separate research paradigms and research philosophical orientations (Green et al. 1989). In fact, thinking about research paradigms is emphasized to happen in a more holistic manner in the sense of allowing for greater creativity and flexibility in the discussion and interpretation of a research phenomenon.

Finally, the adoption of the mixed method approach is quite practical since the researcher has the freedom to utilize a wide range of data collection and data analysis methods. The direct outcome of such practice is the possibility to address the research problem in depth, which can also provide implications for future research. At the same time, the researcher can employ diverse skills in observing specific patterns in participants' behaviour while answering the survey questions (Green et al. 1989). Since those questions contain open-ended questions, not only multiple-choice, it is possible to ensure a more comprehensive understanding of participants' social reality pertaining to the explored research context.

6 CHAPTER SIX – RESAERCH FINDINGS

6.1 Introduction

This chapter presents the research findings obtained from a questionnaire with 369 participants. 369 participants from various fields of competence such as universities, research laboratories, international corporations, managers and engineers were asked to participate. The participation rate was 85,0%. Since mixed methods research is used in this study, reporting the findings obtained from secondary sources (through a systematic literature review) is also important. After discussing the research findings generated from the questionnaires, it is important to focus on the practical implications of relevant arguments about the topic made in the literature.

6.2 Response rate

With a response rate of 85.0%, 310 participants out of 369 filled out the survey. The number of responses was high enough to be useful for research and writing up. Also, a response rate of 60% or above is regarded as good, while a rate of 70% or higher is exceptional (Kothari & Garg, 2014). Considerations such as data normality and the presence of missing patterns all play a role in determining the optimal sample size for structural equation modelling. The standard recommendation among researchers is to use a sample size of at least 200 or 10 instances per variable. Those working with a limited number of data points have the option of testing SmartPLS and using partial least squares measures in place of variance-covariance. For basic CFA models with only four indicators and loadings around, a sample size of 30 should be enough. Models of mediation may be used in 80 situations, and maybe up to 450 cases (Wolf et al. 2013). The analysis of responses is shown in Figure 15.

	Frequency	Percent
Questionnaires not returned	59	16.0
Questionnaires duly filled and returned	310	85.0
Total	369	100.0

Figure 15: Response Rate

6.3 Qualitative research findings

6.3.1 Risks pertaining to changes in the energy mix in heavy industry

While answering the question about the major risks of changing the energy mix in heavy industry from their distinct point of view, one of the participants indicated that this could not be achieved. It also has been argued that the excessive amount of carbon dioxide emissions would lead to higher costs and penalties across organizations' supply chains. The grid stability was indicated as another major risk of changing the energy mix in the respective industry. Other risks discussed by participants referred to significant costs, jobs, and available skilled labour. The higher capital costs were coupled with the need to develop a proper infrastructure and new processes/equipment to facilitate the incorporation of renewable fuels. One participant indicated the lack of awareness, lack of collaboration, lack of data, and lack of consensus as major risks pertaining to the changes in companies' energy mix.
This is ably displayed in a few interview sequences: "The grid stability [is the main risk of changing the energy mix in the heavy industry" (Participant 3). And with more concern about jobs: "[Major risks] are costs, jobs, available skilled labour" (Participant 4).
"The lack of awareness, lack of collaboration, lack of data, lack of consensus…" (Participant 7). This shows that there is a feeling of risk not only regarding the technical side of the envisioned transition, but also about the social side. As the next interview sequence shows, this regards also risk presented by capital acquirement: "Higher capital costs (heat requirements would be higher), the need to develop infrastructure and new processes/equipment to facilitate renewable fuels, commercialisation of carbon-neutral energy systems in the industry [are major risks]" (Participant 5).

At the same time, interestingly, many respondents pointed to the fact that whereas the process of changing the heavy industry's energy mix can be problematic, the failure to do so can result in devastating consequences for the sector and its stakeholders. Therefore, they encourage policymakers and practitioners to facilitate the energy transition regardless of the risks accompanying the adoption of the new energy mix.

“Too much CO_2 emissions will lead to higher costs and penalties in the supply chain” (Participant 2).
There is also great concern about climate change and therefore a sensitivity over the issue of climate change: “None, compared to the risk of not changing the energy mix in the heavy industry” (Participant 8). This concern is also expressed in regard to policy initiatives tackling the issue of emission reductions, as another quote shows: “High cost of CO_2 if you do not change. Producing on the environmental expense and cost of taxpayers is not going to be sustainable. Plus, RE will being cost savings. Technical solutions are not a concern, all is available” Participant 32).

The issues of power quality and reliability, as well as constantly changing regulations, were associated with substantial risks for the proper operations of companies in heavy industry. In the context of emission-free generation, covering energy peak times was considered quite problematic. In addition, the aspects of supply and demand were identified as risky. There were insufficient amounts of renewable energy in heavy industry, according to most participants in the questionnaires. One of the participants who took part in this study emphasized numerous major risks such as load flexibility, integration of renewables and hydrogen, initial market restrictions, hesitation of policymakers, and irrelevant public perception. Even though most participants discussed the issue of increased costs, they also recognized that technical solutions were not a concern, as shown here: “Power quality and reliability, cost, changing regulations [are major risks]” (Participant 10).

But there seems to be a specific concern about the first steps towards change, as ably shown in with the egg and chicken-dilemma: “Chicken and egg, supply and demand. It's becoming more apparent that hydrogen is the way to go, but it's all about the supply and having enough consumers to justify the supply” (Participant 15). This opens a new argumentative road towards problematizing energy policy making towards renewable energy mixes. This general issue seems to collide with requirements of energy policy making and risks of too much flexibility: “[The main risks are] load flexibility, integration of renewables and hydrogen, currently no economies of scale, initial market restrictions, hesitation of policy makers, lack of awareness and public perception” (Participant 28). Consequently, the public has to be included in the policy cycle according to this claim.

The emergence of new energy sources could represent significant concerns to stakeholders in heavy industry, as they may need to overcome specific engineering challenges pertaining to the energy infrastructure. In this context, it has been made clear that most participants in the questionnaires focused on the implications of conversion cost accuracy. Inadequate or irrelevant knowledge about the present regulatory framework in the heavy industry could potentially cause significant problems for stakeholders. Since the infrastructure was considered unreliable to a certain extent, competitiveness in the industry could not be guaranteed, according to some managers and technicians who participated in the questionnaires. The quote: “[The key threats are] price competitiveness and reliability of the "new" energy sources” (Participant 58). And further: “Not yet known/implemented regulatory framework, subsidies necessary initially to bridge funding gap” (Participant 63). This shows a great ambiguity over the policy means of change.

Some of the participants stated that new technologies in the industry were not reliable, which means stakeholders in the sector failed to provide conclusive results about the effectiveness of specific technology-based solutions. In this way, it has been noted that some companies did not have enough data for comparison and development of relevant arguments. As such data was fluctuating, some participants considered the impact of implementation challenges regarding supply, quality, and innovation. Thus, the aspects of stable distribution and stable prices were associated with proper strategy development in heavy industry. Despite the identified major risks of changing the energy mix in heavy industry, it has been noted that stakeholders in the sector had to remain up to date with new technologies.

6.3.2 Major strengths

The results obtained from the questionnaires focused on the aspects of transition success. A relevant question that participants needed to answer was to indicate the precise way in which they could measure the success of the respective energy transition in heavy industry. A participant in the questionnaires mentioned that a reliable way to do so was to frequently introduce surveys and balanced scorecards. The mentioned tools represented an effective way to collect appropriate information that could guide stakeholders' actions in the field. Customer feedback was persistently emphasized by most participants in the study, which illustrated the importance of clarity, openness, and flexibility in sharing different insights into the transition process.
Most participants considered it important to focus on monitoring customer development and requests. In this way, stakeholders in heavy industry were ready to embrace the proposed changes since they were open to discussing various options as emphasized by customers. In other words, customers were actively included in the decision-making process of organizations in heavy industry.

In general, there is no agreement among respondents concerning the best tools to measure the success of energy transition. Participant 2, in particular, insists on the need to utilize the KPIs related to carbon emissions, Participant 3 points to the importance of energy cots and climate change mitigation, and Participant 5 uses the abstract criterion of "leaving world in a better spot than when I got here". Some of the options offered by the participants are fundamentally different from each other. Participant 15, for instance, insists on the importance of profitability, whereas Participant 11 believes that the closure of fossil generation sites should be the main indicator of energy transition.

Other factors that could contribute to transition success were indicated as GHG intensity, stable economics, national GDP, and labour employment rate. The generated growth in relevant sectors was discussed as a key success factor for facilitating the transition in heavy industry. As implied in these factors, the emphasis was on attaining adequate economic stability prior to moving with the implementation process. In addition, there were participants who indicated that the closure of fossil generation sites would decrease carbon dioxide emissions and would facilitate the transition to renewable energy sources in heavy industry. Nevertheless, the reduction of carbon dioxide emissions was discussed in the context of considering specific cost implications. Thus, some participants in the study brought up the issue of profitability of companies engaged in changing the energy mix in heavy industry. Only a few of the study's participants tried to offer consistent conceptualizations of energy transition success that encompassed multiple factors. Two interview sequences capture this aspect: "[Energy transition should be measured by] how efficient it is after the practice and seeing the results, how other industries inspire from it" (Participant 24). This shows that concerns exist over the actual possible advances. Furthermore another expert: "By lowering CO_2 emissions, by GDP increments, by increased job positions, by climate protection, and by adhering to UN's SDGs" (Participant 28).

There was an opinion expressed by one of the participants in the questionnaires that transition success could be properly measured in stages. In other words, it has been noted that such success could be apparent after the implementation process takes place. In this way, stakeholders in the industry would have an opportunity to observe the direct results of the transition process. They may also conclude how other industry sectors would be inspired by the initiative of changing the energy mix. As clarified by one participant in the questionnaires, transition success was clearly related to the increased sustainability of companies in heavy industry.

One participant in this study provided a specific example from the mining industry to explain how transition success could be measured in heavy industry. In the mining industry, renewable energy was discussed with its capacity to reduce power costs and to enable the use of lower-grade resources to be explored in a more profitable manner. It has been argued that the same could be applied to production plants. The same participant concluded that energy transition should be prioritized by all companies, as they need to identify the cost savings potential for the business by moving forward in terms of enhanced sustainability.

“[We can measure the success of energy transition by looking at] the share of CO2 emissions avoided by implementing measures while reducing production costs. For the example of mining industry, renewable energy reduces power cost and enables lower grade resources to be explored profitably. The same would apply for production plants. Energy transition should be the priority in every firm in the sense to identify the cost saving potential for the business by moving forward” (Participant 33).

6.3.3 Major opportunities

One of the themes that was retrieved from the questionnaires was described as major opportunities for changing the energy mix in heavy industry. A participant in the study indicated how by decreasing carbon dioxide emissions, companies in the industry could gain substantial competitive advantages. In this way, such companies can significantly improve their reputation in the supply chain. Such reputation can be further enhanced through the promising capacities of new technologies, particularly those solutions developed for energy storage and grid management. According to one participant, the introduction of renewable energy and hydrogen in the energy mix has completely changed the prospects for heavy industry. With the constantly increasing energy production, new demands and requirements for monitoring and energy storage emerged. This calls for new technologies, as participant 3 points out: “New technology for energy storage and grid management as renewable energy and hydrogen is introduced as new energy mix. The new hydrogen mobility and FCV and BEV also needs to be integrated through solid Hydrogen and new battery technologies for grid level storage” (Participant 3).

Another participant in the questionnaires emphasized the importance of presenting new business models which could completely redefine the strategic direction followed by companies in heavy industry. The component of innovation emerged in the discussion over companies’ various strategic options. It has been noted that companies in heavy industry had to expand their engineering team, which could help them attain their long-term objectives. One such objective was identified as sustainability, and stakeholders in the industry made sure to adhere to specific sustainability requirements in order to improve companies’ performance. In turn, such organizations had a relevant opportunity to focus on the utilization of sustainable/renewable sources of energy. In addition, it should be noted that the process of energy transition is expected to result in significant economic and social benefits. The following sequence shows this concern ably: “We're already massively expanding our engineering team due to the new influx of clean energy products, so not only is there a huge environmental opportunity, but there's also an economic one as well” (Participant 16). This tone of opportunity and optimism ios also shared by the other participant: “[One major opportunity is the] production of sustainable products with the potential to sell them with a premium, securing subsidies as an early mover, distinguishing from producers, e.g. those in China” (Participant 28). There is also a optimism towards the production of new relevant knowledge as shown in the following quote: “[The main opportunity] is becoming really sustainable, gaining experience for the time when there is no other alternative being prepared for the future” (Participant 41). And another participant adds in this regard: “The opportunities are bast through optimisation of plants and the application of technology that supports the move towards renewables” (Participant 52). This means that the participants seem to perceive options of policy making in general.

It has been illustrated in this study that by becoming green and part of the climate change solution, companies in heavy industry could redefine the strategic development and overall outlook of the respective industry. This means the opportunities for changing the energy mix in heavy industry were substantial if plants were optimized for any upcoming changes. In the context of persistent technological development, one participant focused on the implications of green financing attracting and avoiding stranded assets. In meeting specific climate agreement standards, companies and countries had to coordinate their efforts on finding optimal solutions for changing the energy mix in heavy industry. Most participants in the questionnaires believed that the provision of sufficient green energy could improve system performance significantly. The environment could be adequately protected with the implementation of the right initiatives.

Some concerns have been expressed by participants regarding the outlook of heavy industry. Even though sustainable energy provision could emerge in different market segments, some participants pointed out that industry competition could be adequately prepared for the future. In the development of new energy storage systems, certain legal issues had to be solved, as emphasized by some participants in this study, as the following quote shows: “I’m not sure if there is a suitable alternative right now” (Participant 58). But the main issue remains: “[The main opportunity] is the conversation of traditional industries into green and sustainable businesses, [which allows for] being competitive in the long run” (Participant 59). These issues challenge policy making towards more renewable energy policy mixes in heavy industries.

6.3.3.1 Needed investment

It became clear in the study that the effective change of the energy mix in heavy industry was directly related to the component of investment. One participant in the questionnaires mentioned that the needed investment should be billions, which reflected specific sentiments and expectations in heavy industry. Yet another participant pointed out that the most important thing for the change was to alter the mindset of top management. Senior managers had to demonstrate they had appropriate cross-cultural and communication skills to overcome traditional thinking. Therefore, it has been concluded that the investment depended on the precise organizational conditions as well as stakeholders’ decision-making capacity. One participant mentioned that the needed investment would be huge, even though they did not indicate a precise number. The same individual clarified that companies operating in heavy industry were looking at ammonia for deep sea shipping, of which there was some existing infrastructure in port areas. Another participant indicated that the needed investment would range from tens to hundreds of millions. There were also participants who did not indicate exact tables, but they discussed how the injection of capital and lending capacity were of paramount importance for changing the energy mix in heavy industry. Some participants could not provide specific tables due to the lack of clarification on whether the respective investment was needed at the local or national level.

The interviews reflect this issue. At strategy level, participants perceive that this is related to specific problem-thinking on management level, as pointed out by participant 2: “Firstly, the mind-set of the top management has to change, and cultural skills are needed to overcome traditional thinking. Economically, any investment in changing the energy mix [has to be thoroughly calculated]” (Participant 2). More renewable energy mixes seem to need also more investment-friendly thinking as shown in the next quote: “[The needed investment would be] huge. We are looking at ammonia for deep sea shipping, of which there is some existing infrastructure in port areas. It will still require huge investment all around through” (Participant 16). But there seems to be a perceived uncertainty about the exact amount of capital needed for respective investments: “No exact figure, but the infection of capital and lending capacity are of paramount importance, and the amounts are of the order of tens of millions US$ per country, proportional to each country’s GDP” (Participant 29).

Most participants pointed out that the needed investment depended on specific organizational conditions. One individual discussed that there were options for investing on balance into new energy. The respective investment was expected to be profitable since solar and wind energy have become the lowest-cost electricity producers. From this perspective, it has turned out that all shareholders in the industry should seek to reduce the cost of production by decreasing their energy costs. The following interview sequence deeply weighs upon the options of investments: “It depends. The are options for investing on balance into new energy generation technology or procure energy under energy supply contracts ESCO or power purchase agreements PPA where a third party would invest and sell the energy across the fence. The biggest benefit is that it will in almost all cases be a profitable investment, as solar and wind have become the lowest cost producers for electricity. So, it cannot be seen as spending money without economic return anymore. Every shareholder should seek to reduce cost of production by reducing his energy cost” (Participant 33). Such an investment scheme, so the participant, bases on deep cooperation and trust in order to achieve compatible energy prices.

As part of determining the needed investment for changing the energy mix in heavy industry, some participants argued that it was important to build trust which was crucial for overcoming the psychological fear of change. Yet those participants expected tax decreases for using and promoting green energy, along with increased prices for conventional energy. It was normal to expect that the needed investment would be much more compared to fossil solutions. It has been noted that such investment also depended on the application and age of existing assets in heavy industry. There were technicians in the study who found it quite challenging to provide a specific answer, as they even mentioned the necessity to have a completely new industry. Since heavy industry was considered under substantial pressure, it was not surprising for most participants to conclude that huge amounts of investments would be needed. Nevertheless, the exact amount of investment needed depended on the size of the industrial area or process that was subjected to change.

One participant in the questionnaires argued that the needed investment would be high in terms of capital, but they also pointed out about the implications of technological research and development as well as knowledge. In the context of knowledge-based economies where knowledge is power, having the skills and expertise to make a significant change in the industry was considered crucial. An important finding generated from the questionnaires in relation to the needed investment to change the energy mix in heavy industry was to initiate a relevant discussion with all stakeholders. The benefits of open communication have been clearly emphasized, indicating how this could contribute to the development of optimal solutions.

6.3.3.2 Strategic options to change the energy mix

There was an important question included in the questionnaires regarding the precise strategy that had to be adopted by companies in heavy industry in order to change the energy mix. One of the participants mentioned that it was essential to use detailed analyses of both the positive and negative impacts of the planned energy transition. Such impacts should be explored at the national, regional, and even plant levels. In this way, stakeholders in heavy industry would have more diverse options to undertake specific measures that would allow them to complete the transition process as initially planned.

Another participant in the questionnaires focused on the importance of facilitating international and regional cooperation in changing the energy mix in heavy industry. It was important to ensure an adequate exchange of information in order to plan all steps of the transition process accordingly. The component of peer learning was also mentioned by the same participant, implying the limitless opportunities for learning organizations to implement effective and reliable strategies pertaining to the planned change. It has been clarified that such peer learning took place between different countries which were at different stages of their energy transition processes. Along with proper engagement with labour, companies in heavy industry were expected to demonstrate greater social responsibility toward informing civil society about any planned initiatives. This was particularly true for initiatives introduced in developing countries and is embodied in "(…) international cooperation involving all countries with promising solutions for energy transition addressing sustainable future and climate change" (Participant 1) as pointed out by participant 1.

The process of changing the energy mix in heavy industry was associated with the presence of expert and flexible communication, as noted by most participants in this study. From this perspective, it has been argued that round tables organized at the country level represented a rather promising option to initiate the expected change. The main idea was to start or enhance a conversation on the respective transition between all concerned stakeholders. In this way, it was possible to focus on relevant details that could be strategically used to determine the most efficient transition to renewable energy sources in heavy industry.

Since the process of changing the energy mix in the heavy industry represented major concerns among stakeholders in different countries, most participants in this study expected that the concerned parties would be proactive in implementing effective measures and strategies. It has been indicated that the formation of a proactive and highly engaged mindset implied the presence of a high-level dialogue between countries in similar situations. As argued by one participant in the questionnaires, those countries have recognized the importance of promoting the idea of an open and just transition at the highest levels of government. Such levels were clearly identified as the EU, OECD, and G20.

As shown, communication was indicated as a significant factor that could facilitate the process of changing the energy mix in heavy industry. Yet one participant in this study clarified that such communication should be evidence-based to deliver the intended results as well as to instil a high level of trust in stakeholders in the respective industry. A similar type of communication was found useful to convince diverse target groups of the necessity to act upon the outlined strategic goals and indicators. This indicated how the overall perspective of change could be broadened since communication emerged as a relevant means of achieving project objectives. One participant in the questionnaires mentioned that the foundation of evidence-based communication was in the proper understanding of the entire communication environment and landscape. In turn, it was possible to advance policy and support project monitoring and assessment processes.

Furthermore, there were participants in this study who emphasized the need for implementing such strategies that could promote the development of localized green jobs. A similar initiative included opportunities for ensuring decentralized energy and energy efficiency. In fact, the idea of promoting green jobs was directly linked to the practical implications of the energy transition. As a result, participants in the questionnaires expected that positive changes would take place in heavy industry since communication among stakeholders was adequately planned.

Another strategy to change the energy mix in heavy industry was discussed as shared best practices of proper transition measures. Different scenarios for the energy transition process were discussed by some participants in the study. It has been illustrated by some individuals that strengthening scenario development should be prioritized. In this way, it was important to develop a solid governance structure. Some participants mentioned that the energy transition process would require broad participation and strong cooperation of different stakeholders. It was also essential to improve scenario use, especially by clarifying the overall purpose of scenario-building. Since scenarios in heavy industry can be used for diverse purposes, it was crucial to understand the specific context and strategic objectives being pursued by companies.

The following interview sequence ably shows the dilemma of policy-timing that arises concerning change of energy mixes in path-depending industries: “Every plant should develop their own concept and start implementing. Waiting for politics to work on amended regulations is like waiting for the storm that you see on the horizon to be confirmed by officials. Individual solutions are available and usually profitable to implement if not subsidies are keeping the fossil energy at lower levels. It is time to work on a transition business case and move ahead of the competition to have an increased competitive advantage and a marketing effect as a role model at the same time. The lobbying against energy transition is a wasted effort and all it may achieve could be buying a little time without maintaining a future proof business environment but loosing precious time to prepare for the inevitable and necessary” (Participant 31). The quote underlines the argument that fast forwards-moving policy-initiatives are ever more required.

It has been argued that proper scenario use in heavy industry was associated with the utilization of transparent and effective communication. Transparency was linked to the quality of scenarios in order to develop greater trust. From the perspective of making scenario assumptions, it was possible for stakeholders in heavy industry to communicate adequate results. In this way, one participant argued that the emergence of innovative communication methods contributed to increasing stakeholders’ motivation for changing the energy mix in heavy industry. As shown in the opinions of most participants, developing the right type of scenario capacity in government was crucial.

Another participant in the questionnaires indicated that international cooperation among all countries with stranded solutions for energy transition was fundamental. In this way, the respective countries could address all the implications of sustainable future and climate change. These issues were discussed in detail by some participants to make the case for a smooth energy transition in heavy industry. In referring to the U.S. context, one participant noted that an effective strategy for changing the energy mix in heavy industry could require tools for direct regulation.

It has been further mentioned in the study that every plant was expected to develop its own concept and start implementing a strategy that could suit its specific needs. One participant in the questionnaires noted that waiting for politics to work on amended regulations was compared to waiting to address a series of complex challenges. Yet the same participant pointed out that individual solutions were available, and they could be profitable to implement. Therefore, it was considered normal to start working on a transition business case and move ahead of the competition. Recognizing the intense competition in the industry in relation to changing the energy mix has been crucial for companies to move in the right strategic direction. In fact, some companies were noted to serve as role models to others in terms of implementing effective strategies that could significantly facilitate the energy transition process.

6.3.3.3 Motives for changing the energy mix

Participants in the questionnaires shared their motives for changing the energy mix in heavy industry. One of the motives shared by some participants was described as climate change issues. In the context of climate change, most participants mentioned the importance of keeping up with the national agenda and regulation practices. Other motives discussed by individuals who participated in the questionnaires related to the avoidance of costs for carbon dioxide emissions and the generation of a sustainable competitive advantage. This is displayed in the following quotes: “[One motive for changing the energy mix] is the avoidance of costs for CO2 emissions and generation” (Participant 2). Furthermore: “Cheap energy and mitigation of climate change” (Participant 3). And also: “Climate change, keeping up with national agenda and regulation” (Participant 11). These quotes display requirements for domestic and international policy making to combat climate change.

The most relevant motive for changing the energy mix, as shared by the majority of participants in this study, was specified as sustainability. This indicated how companies operating in heavy industry could significantly improve their image and reputation by becoming more sustainable and accountable to the general public. In fact, most participants emphasized the focus on sustainable development was considered a long-term strategic objective that should be pursued by all companies in all industry sectors. In terms of ensuring greater sustainability, it was possible to improve environmental protection at different levels. This was discussed to have relevant implications for future generations since going green all the way was the optimal way for companies in heavy industry. This is also the perception of some of the participants: “[The main motive] is sustainable development, environment protection, future generations, going green all the way” (Participant 29). And also: “[I want to] contribute my share to reduce CO2 emissions while enabling businesses to become more profitable” (Participant 33).

Some participants in the questionnaires also felt personally responsible for contributing their share to reduce carbon dioxide emissions. This means they were extensively focused on how their actions could decrease the environmental impact. In achieving the goals of environmental protection, it was essential for stakeholders in heavy industry to create adequate social awareness about the problems that may emerge. Nevertheless, it has been noted by most participants that companies’ attempts to become more sustainable should not be at the expense of decreasing their profitability. It was important to achieve a sufficient balance between sustainability and economic objectives set by companies in heavy industry. Participants have recognized their own input in being an inseparable part of the solution to fight climate change globally.

There were participants in the questionnaires who focused on ensuring greater personal and social responsibility to meet specific environmental and sustainability goals. It has been illustrated that such responsibility was linked to work ethics, and it was expected of leaders in heavy industry to undertake drastic measures to contribute to the development of an open and inclusive culture which clearly emphasizes environmental protection. The presence of a safe environment was associated with certain initiatives to change people's behaviour. It has been noted that such change should be properly planned to attain the initially outlined sustainability objectives. The broader issue of the survival of humanity was also brought up in the discussion, implying the contributions of different stakeholders in exchanging relevant knowledge in the field.

6.3.4 Major threats

In considering major threats to changing the energy mix in heavy industry, some participants in this study paid attention to the implications of increased competition. It has been considered important to find the right balance between decreasing carbon dioxide emissions and implementing economically viable solutions. Other participants in the questionnaires referred to the threats of job loss, lack of skilled labour, and slow pace of change. Some interruptions in companies' supply chains emerged as another threat to changing the energy mix in heavy industry. In terms of insufficient storage and fast-start generation, reliability and regulation issues emerged.

Some participants in this study pointed out that the lack of subsidies, lack of economies of scale, and lack of support from policymakers were major threats to changing the energy mix in heavy industry. While substantial technical skills were needed to make the proper transition to renewable energy sources, some participants believed that the only threat was persistently changing behaviours. Even though the implementation of optimized technological solutions was emphasized in this study, the lack of feasible business models prevented many companies in heavy industry from utilising efficient, low-carbon technologies. The issue of costs has been repeatedly mentioned by most participants, implying that new technologies tend to be expensive at the beginning, which obviously requires substantial investments. As a result, this has been illustrated to slow down the entire transformation process undertaken in companies.

It has been also noted in the study that people in organizations were sometimes inadequately prepared to respond to change. Therefore, it has been important to understand organizational change in a more holistic manner to help stakeholders achieve optimal results. People in organizations need to be prepared in such a way to be able to take into consideration all aspects of the transformational process. Yet, as noted by one of the participants, safety emerged as a major issue that could either facilitate or impede broad acceptance. Employees were overall considered to be slow to respond to changes, which was explained by the lack of relevant technical knowledge and improperly developed infrastructure in heavy industry. This, so participant 2, needs a basic ground of cooperation: “To get a common understanding within the organization [is necessary to support energy transition” (Participant 2).

There is a general concern about costs: “How to reduce cost [is a critical issue for supporting energy transition” (Participant 13). This shows, even if companies succeeded in developing diverse implementation models, they were frequently found incompatible with existing organizational structures. As shown by most participants, this resulted in significant discrepancies that deteriorated companies’ performance in heavy industry. It has been argued that the presence of many unresolved problems further complicated the implementation landscape in heavy industry. As a result, some participants posed the question of whether the energy system could be strategically prepared for this kind of change, especially when time is quite insufficient.

Important insights

One of the most relevant questions included in the questionnaires was described as an important insight into the changing energy mix in heavy industry. One participant noted that it was almost impossible to get all impediments out of the way. This prevented stakeholders in the field from making conclusive statements about different stages of the transition process. At the same time, it has been observed that the decision to change the energy mix was feasible and less complex than expected. And so one participant: “It is not possible to get all impediments out of the way” (Participant

1). Another optimistic quote in this regard: [Energy transition] is feasible and less complex than expected” (Participant 2).
Other participants in the study focused on the relevant insights into cooperation and peace for prosperity instead of competition compassion. It has been noted in the study that sometimes competition in heavy industry was not considered feasible and healthy. There were also views shared by some participants that reinventing cities could be the right solution to facilitate the transition process. In this context, it was important to decrease costs and enhance efficiency. Stakeholders had to clearly communicate the need to move toward the transition. As one participant framed it, those stakeholders were not expected to be green moralists in order to achieve substantial success. In fact, they had to engage in the transition process for the sake of future-proofing the business. These necessities are accompanied by the requirements of stakeholder cooperation, as the following two quotes show: “[Successful energy transition requires] cooperation and peace for prosperity instead of competition compassion” Participant 3).And furthermore by another participant: “That it needs the shareholders to start disinvesting fossil companies and create a strong requirement to move towards the transition. You do not need to be a green moralist to move, one should do it for the sake of future proofing the business” (Participant 33).

The results obtained from the questionnaires in relation to the insights developed into the transition process showed that all technical solutions were existing. Therefore, the only true aspect that had to be changed was described as human beings and their attitude as well as knowledge pertaining to the transition process. Nevertheless, one participant argued that continuous change in the field required continuous openness. This illustrated how having specific expectations of stakeholders could facilitate the transition process to a significant degree.

One participant in the questionnaires indicated that the ability to decarbonize heavy industry was going to be measured in terms of emissions within the next decade. In this way, those industry sectors that failed to comply with the new rules and standards would find themselves uncompetitive, not in terms of price or profit but in relation to pollution and emissions. The presence of many self-interests was also discussed by some participants who mentioned that stakeholders in heavy industry had to be more responsive to the interests and needs of other players in the sector.

It has been illustrated from the questionnaire findings that changing the energy mix in heavy industry was perceived as a rather credible and efficient process. This was achieved through stakeholders' commitment to discussing the transition process thoroughly by planning all stages in line with national, regional, and international environmental standards. Therefore, it has been concluded that the level of coordination was crucial to accomplishing the goals of the transition process.

6.3.5 Major weaknesses

In responding to the question of whether there were major weaknesses in changing the energy mix in heavy industry, many participants were ready to discuss those limitations. One participant in the questionnaires indicated that mostly political issues and knowledge transfer issues impeded the change process planned by companies in heavy industry. Since this industry sector is usually associated with high consumption of raw materials and energy, the main problems emerged across companies' supply chains since it was mentioned that it was loaded with a significant amount of carbon dioxide emissions. This concern is displayed in the following interview sequence: "Heavy industries usually are related to high consumption of raw materials and energy, so the whole supply chain is loaded with CO2 emissions" (Participant 2).

Another weakness mentioned by some participants in this study referred to increased costs and fear of the unknown. Such uncertainty was identified as regulatory uncertainty. The unclear regulatory framework was also coupled with inadequate infrastructure adaptation, which caused more problems for companies in the heavy industry. In turn, some individuals in the industry failed to ensure an optimal understanding of the change involved in the entire process. Thus, they were unable to identify the specific parameters of the stability of energy.

Limitations in current technologies utilized in heavy industry were also mentioned in the study. In this context, it has been noted that R&D funding was insufficient because it did not bring the initially expected results in terms of implementation. Weaknesses were also observed in leadership, which means leaders were inadequately prepared to address the change in the respective industry. The lack of experience in leading and monitoring similar projects has been translated into poor outcomes, as shown by some participants in this study. The lack of proper connections between academia and heavy industry further complicated the process of changing the energy mix. This is alco a question of scale as pointed out by participant 11 regarding energy storage technologies in place: “Storage is not of a sufficient scale yet, there needs to be more of it, and for much longer duration” (Participant 11). Another quote points to insufficient R&D-funding concerning green technology development: “[Major weaknesses include] limitations in current technology, not enough R&D funding, no connection between academia and industry” (Participant 29).

It has been pointed out in the study that an emerging weakness was the hesitation and inaction as compared to the opportunities implied with the development of a highly sustainable plan. Therefore, some participants indicated that companies in heavy industry should require substantial expert support to develop a promising transition plan that could be effectively implemented in different stages. In this way, it has been considered important to identify synergies and obtain benefits for the whole process.
Another opinion expressed in the questionnaires was that the planned change came quite late. Those participants who shared this opinion argued that changing the energy mix in heavy industry should have taken place much earlier to help companies attain their long-term objectives in terms of efficiency, productivity, and sustainability. As collective implementation strategies were found ineffective, more research was needed in order to provide solid evidence-based data. It has been admitted by some participants that moving from oil and gas to wind and solar energy was a quite complex process for many systems in heavy industry. The development of stable delivery approaches was limited considering the lack of interdisciplinary exchange of information. This is also a question of timing: “The weakness will be hesitation and inaction as compared to develop a sustainable plan. It may require expert support to develop a transition plan to reach a 100% re share and it would be implemented in stages over time. There is no solution that would not have interfaces with the production, as it would be able to identify synergies and get benefits for the whole

process" (Participant 33).

Technical obstacles

An important question included in the questionnaires related to the presence of technical obstacles to changing the energy mix in heavy industry. One of the biggest technical obstacles discussed by one participant in this study was described as making emissions visible. This apparently required greater accountability and transparency. The problem is that some stakeholders in heavy industry were unprepared or unwilling to disclose specific information about the process of changing the energy mix. As a result, this conveyed mixed messages to different parties, which could further impede the transition process.

Another technical obstacle that emerged from the research findings obtained from the questionnaires was tripling energy productivity gains. In fact, one participant indicated that such productivity gains were improperly defined. The lack of clear details on this issue could prevent further action in the context of achieving greater sustainability in heavy industry.

Moreover, it has been discussed by some participants that it was crucial to consider the technical obstacle of electrifying with renewables. Even though electrification implied higher energy efficiency and effective energy savings, it was important to understand how exactly this process could take place to deliver the expected results. The lack of strategic preparedness of major stakeholders in the industry could prevent the process of having relevant electrification with renewables.

Some individuals who participated in the questionnaires thought that reinventing cities was quite problematic for changing the energy mix in heavy industry. This initiative of reinventing cities required substantial engagement by leaders in the respective industry. For instance, one participant indicated that visionary and transformational leadership styles could be effective throughout such ongoing reinvention. However, not all leaders in heavy industry were ready to undertake such a long and challenging journey of changing the energy mix and making the transition to renewable sources of energy.

The technical obstacle of boosting clean technology also emerged from the results obtained from the questionnaires. A similar difficulty was most likely related to the lack of expert and technical knowledge on the implementation of the right technologies in heavy industry. According to some participants in the questionnaires, the process of boosting clean technology implied a substantial experience in the field which could help individuals make the most relevant decision under certain circumstances.
One participant in this study mentioned that redesigning the heavy industry was considered one of the biggest technical obstacles. This participant pointed out that a similar process had to be perceived in a more holistic manner in order to help companies in heavy industries deliver optimal results. Such redesigning had to be extensively discussed with strategic partners in the field, which was considered a time-consuming process.

It has been indicated by some participants in this study that recurring a swift and fair transition was a substantial technical obstacle. Despite the utmost goal of changing the energy mix being made clear in heavy industry, not all stakeholders in the field were strategically prepared for the mentioned change. The conflicting interests and objectives of those stakeholders were discussed by some participants as major impediments to having a fair transition. It was virtually impossible to address the interests and expectations of all concerned parties in the transition process.

One participant in the questionnaires noted that the biggest difficulty in changing the energy mix in heavy industry was vision sharing. Even though some leaders in the industry were visionary and transformational in their approach to leading others, those leaders seemed to lack the specific communication and listening skills required for optimized vision sharing. As noted by one participant in the study, companies in heavy industry could improve their prospects for vision sharing once leaders become more engaged in exploring the diverse benefits of the transition process.

An interesting opinion was expressed by one participant in the questionnaires in the sense of mentioning how overcoming mental barriers emerged as the biggest difficulty for changing the energy mix in heavy industry. As argued by this participant, such barriers were not always clearly identified, which prevented leaders from making well-informed decisions about the precise status or progress made in relation to the transition process. Yet such mental barriers could be addressed with adequate communication, efficient international cooperation, and standardization of rules and practices utilised in the transition process.

The unwillingness to change the status quo was indicated as another significant obstacle to changing the energy mix in heavy industry. It has been discussed by some participants in this study that most companies in this industry sector lacked the readiness needed to make the required transition. Therefore, leaders of those companies most likely did not feel the need to change the status quo, even though they clearly recognized the disadvantages pertaining to carbon dioxide emissions.
It has been noted in this study that it was important to change the perceptions of industry leaders to understand the benefits associated with the entire transition process in terms of costs and carbon dioxide savings. The risk of undermining transition targets was specified by some participants. This prevented heavy industry from becoming more resilient in the future.

Furthermore, some participants in the questionnaires mentioned that people in heavy industry had to be convinced to stick to established processes and rules. Sometimes this was considered quite challenging, especially when people needed more time to adjust to the required change in the industry. It also has been noted that the transition process could lack relevant process definitions. Therefore, some participants recognized the need to train people to accept new processes and rethink different work practices.

6.4 Quantitative research findings

6.4.1 Demographic analysis

The researcher looked at how age, gender and profession were distributed among respondents. The gender breakdown of responses was analysed by the researcher. Figure 16 displays the outcomes of the statistical analysis.

	Frequency	Percent
Female	161	51.9
Male	149	48.1
Total	310	100.0

Figure 16: Gender of Respondents

According to the results, 161 (51.9%) respondents were female. It turns out that just 149 (48.1%) of the responses were from male respondents.

The researcher analysed the breakdown of responses by age range. Figure 17 details the outcomes of the study.

	Frequency	Percent
35 to 44 years	223	71.9
45 to 54 years	49	15.8
Below 35 years	38	12.3
Total	310	100.0

Figure 17: Age Brackets of Respondents

The findings reveal that 223 (71.9%) respondents were aged between 35 to 44 years. 49 (15.8%) respondents were aged between 45 to 54 years. 38 (12.3%) respondents were aged below 35 years. The researcher analysed the distribution of respondents by employment status. In Figure 18, the analysis are shown.

	Frequency	Percent
Manager	252	81.3
Technician	58	18.7
Total	310	100.0

Figure 18: Occupation

It is shown that out of all the respondents, 252 (81.3%) of them were in managerial positions. Among the respondents, 58 (18.7%) worked as technicians.

6.4.2 Descriptive analysis

This paper examined the opinion of respondents about risk identification, risk analysis, risk evaluation, risk treatment, risk monitoring and review and transformation of energy mix using means and standard deviations. The opinion of respondents about risk identification was examined.

Statement	N	Mean	Std Deviation
Factors that are likely to affect achievement of objectives are listed	310	3.38	1.303
Risk events, potential causes and potential impacts are documented	310	3.36	1.314
Present and future challenges are taken into consideration	310	3.38	1.294
Risk categories have been developed	310	3.49	1.248

Figure 19: Descriptive Statistics for Risk Identification

The findings indicate that the respondents were undecided on whether factors that are likely to affect the achievement of objectives are listed or not (mean = 3.38; Std Deviation = 1.303). The respondents were undecided on whether risk events, potential causes and potential impacts are documented or not (mean = 3.36; Std Deviation = 1.314). The respondents were undecided on whether present and future challenges are taken into consideration or not (mean = 3.38; Std Deviation = 1.294). The respondents were undecided on whether risk categories have been developed or not (mean = 3.49; Std Deviation = 1.248).

The opinion of respondents about risk analysis was examined and is presented in Figure 20.

Statement	N	Mean	Std Deviation
Potential impact of risk is critically examined	310	3.21	1.267
The likelihood of risk is considered in making decisions	310	3.17	1.190
Severity of risk determines plan of action	310	3.33	1.078
Systems have been developed for communication about inter-organizational risks	310	3.24	1.126

Figure 20: Descriptive Statistics for Risk Analysis

The findings indicate that the respondents were undecided on whether the potential impact of risk is critically examined or not (mean = 3.21; Std Deviation = 1.267). The respondents were undecided on whether the likelihood of risk is considered in making decisions or not (mean = 3.17; Std Deviation = 1.190). The respondents were undecided on whether the severity of risk determines the plan of action or not (mean = 3.33; Std Deviation = 1.078). The respondents were undecided on whether systems have been developed for communication about inter-organizational risks or not (mean = 3.24; Std Deviation = 1.126).

The opinion of respondents about risk evaluation was examined. The results are presented in Figure 21.

Statement	N	Mean	Std Deviation
Risks which can be mitigated are listed	310	2.99	1.149
Risk prioritization is determined by resource allocation and urgency	310	3.09	1.137
Severity threshold for unacceptable risks has been developed	310	3.52	1.269
Environmental factors are considered in determining approaches to treat risks	310	3.49	1.287

Figure 21: Descriptive Statistics for Risk Evaluation

The findings indicate that the respondents were undecided on whether risks which can be mitigated are listed or not (mean = 2.99; Std Deviation = 1.149). The respondents were undecided on whether risk prioritization is determined by resource allocation and urgency or not (mean = 3.09; Std Deviation = 1.137). The respondents agreed that the severity threshold for unacceptable risks has been developed or not (mean = 3.52; Std Deviation = 1.269). The respondents were undecided on whether environmental factors are considered in determining approaches to treat risks or not (mean = 3.49; Std Deviation = 1.287).

The opinion of respondents about risk treatment was examined. The results are presented in Figure 22.

Statement	N	Mean	Std Deviation
Strategies are put in place to bring risks to acceptable levels	310	3.49	1.222
Cost effectiveness of risk mitigation measures is assessed in making risk-based decisions	310	3.38	1.032
Adequate resources are availed to mitigate risks	310	3.28	1.241
Accountable and responsible personnel have been employed to oversee risk mitigation	310	3.40	1.228

Figure 22: Descriptive Statistics for Risk Treatment

The findings indicate that the respondents were undecided on whether strategies are put in place to bring risks to acceptable levels or not (mean = 3.49; Std Deviation = 1.222). The respondents were undecided on whether the cost effectiveness of risk mitigation measures is assessed in making risk-based decisions or not (mean = 3.38; Std Deviation = 1.032). The respondents were undecided on whether adequate resources are availed to mitigate risks or not (mean = 3.28; Std Deviation = 1.241). The respondents were undecided on whether accountable and responsible personnel have been employed to oversee risk mitigation or not (mean = 3.40; Std Deviation = 1.228). The opinion of respondents about risk monitoring and review was examined. The results are presented in Figure 23.

Statement	N	Mean	Std Deviation
The organization has people responsible for continuously reviewing risks facing the entity	310	3.28	1.266
Changes in risk profiles are documented and acted upon	310	3.35	1.196
Irrelevant risks are excluded from consideration	310	3.30	1.294
The effects of changes in risk profiles are assessed over time	310	3.24	1.356

Figure 23: Descriptive Statistics for Risk Monitoring and Review

The findings indicate that the organization has people responsible for continuously reviewing risks facing the entity or not (mean = 3.28; Std Deviation = 1.266). The respondents were undecided on whether changes in risk profiles are documented and acted upon or not (mean = 3.35; Std Deviation = 1.266). The respondents were undecided on whether irrelevant risks are excluded from consideration or not (mean = 3.30; Std Deviation = 1.294). The respondents were undecided on whether the effects of changes in risk profiles are assessed over time or not (mean = 3.24; Std Deviation = 1.356).

The opinion of respondents about the transformation of the energy mix was examined. The results are presented in Figure 24.

Statement	**N**	**Mean**	**Std Deviation**
Changing energy mix enabled the organization to meet expectations	310	3.50	1.209
Changing energy mix is not expensive	310	3.37	1.272
Changing energy mix is efficient	309	3.40	1.220
Changing energy mix is met with little resistance	310	3.33	1.241

Figure 24: Descriptive Statistics for Transformation of Energy Mix

The findings indicate that the respondents agreed that changing the energy mix enabled the organization to meet expectations or not (mean = 3.50; Std Deviation = 1.209). The respondents were undecided on whether changing the energy mix is not expensive or not (mean = 3.37; Std Deviation = 1.272). The respondents were undecided on whether changing the energy mix is efficient or not (mean = 3.40; Std Deviation = 1.220). The respondents were undecided on whether changing the energy mix is met with little resistance or not (mean = 3.33; Std Deviation = 1.241).

6.4.3 Preliminary analysis

The researcher examined the data before conducting a confirmatory factor analysis and structural equation modelling. The data was checked for outliers, common method bias and non-response bias.

An outlier is a value that strays far from the population median or mean. In essence, it is up to the analyst (or some form of consensus method) to decide what qualifies an outlier under this criterion. The researcher examined outliers with the use of the Mahalanobis, Leverage, and Cook's distance methods. Leverage is strong for a data point if it has "extreme" values of the predictor x. In the context of a single predictor, an extreme value of x simply denotes a value that is either very high or very low. With the use of Mahalanobis distance, which measures how far a data point is from the computed centroid of the other instances when the centroid is found by summing the means of the variables under consideration, it is possible to identify multivariate outliers. The scaled difference between the fitted values is what is called Cook's distance, and it may be used to spot outlying X values within the data for the predictor variables. How much each observation affects the calculated response values is shown by Cook's distance (Garson 2012). Significant effort should be put towards figuring out the cause of outliers. Information about the process being studied or the method used to capture the data is often hidden in outliers. These data points may be eliminated if necessary, but it's important to first determine why they showed up and whether or not similar values will keep popping up in the data. Obviously, extreme values are usually inaccurate (Garson 2012). This study did not have outliers.

The assumption of normality states that the distribution of sample means is normally distributed across independent samples. The Kolmogorov-Smirnov test and the Shapiro-Wilk tests were utilized in assessing the normality of study variables and since they were significant, it implied that normality was not met as shown in Figure 25.

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
B1	.208	309	.000	.858	309	.000
B2	.191	309	.000	.890	309	.000
B3	.188	309	.000	.892	309	.000
B4	.214	309	.000	.883	309	.000
C1	.195	309	.000	.901	309	.000
C2	.183	309	.000	.912	309	.000
C3	.184	309	.000	.909	309	.000
C4	.185	309	.000	.913	309	.000
D1	.183	309	.000	.915	309	.000
D2	.166	309	.000	.917	309	.000
D3	.183	309	.000	.877	309	.000
D4	.216	309	.000	.878	309	.000
E1	.235	309	.000	.883	309	.000
E2	.189	309	.000	.906	309	.000
E3	.178	309	.000	.906	309	.000
E4	.222	309	.000	.892	309	.000
F1	.156	309	.000	.902	309	.000
F2	.183	309	.000	.906	309	.000
F3	.187	309	.000	.898	309	.000
F4	.175	309	.000	.892	309	.000
G1	.203	309	.000	.890	309	.000
G2	.224	309	.000	.889	309	.000
G3	.212	309	.000	.896	309	.000
G4	.224	309	.000	.892	309	.000

a. Lilliefors Significance Correction

Note: B = Risk identification; C = Risk analysis; D = Risk evaluation; E = Risk treatment; F = Risk monitoring and review; G = Transformation of energy mix

Figure 25: Kolmogorov-Smirnov and Saphiro-Wilk Tests of Normality

The Kolmogorov-Smirnov test is valid only for continuous distributions. It has a bias toward more sensitivity in the middle of the distribution and less at the extremes. The need for a complete description of the distribution is perhaps the biggest catch. It means that the crucial area of the K-S test is invalidated if position, size, and shape parameters are inferred from the data. Calculating it manually is rare. When compared to the K-S test, even with the Lilliefors adjustment, the Shapiro-Wilk test has more power since it is based on the correlation between the data and the normal scores (Mishra et al. 2019). Skewness, which should be between -10 and +10, and Kurtosis, which should be between -3 and +3, were used to further test for normality (Garson, 2012). Results in Figure 26 show that normality was met.

	N	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
B1	310	3.38	1.303	-.073	.138	-1.413	.276
B2	310	3.36	1.314	-.337	.138	-1.012	.276
B3	310	3.38	1.294	-.312	.138	-1.019	.276
B4	310	3.49	1.248	-.387	.138	-.986	.276
C1	310	3.21	1.267	-.301	.138	-.915	.276
C2	310	3.17	1.190	-.207	.138	-.823	.276
C3	310	3.33	1.078	-.115	.138	-.665	.276
C4	310	3.24	1.126	-.173	.138	-.737	.276
D1	310	2.99	1.149	-.090	.138	-.715	.276
D2	310	3.09	1.137	-.099	.138	-.726	.276
D3	310	3.52	1.269	-.314	.138	-1.102	.276
D4	310	3.49	1.287	-.440	.138	-.957	.276
E1	310	3.49	1.222	-.438	.138	-.885	.276
E2	310	3.38	1.032	-.201	.138	-.446	.276
E3	310	3.28	1.241	-.243	.138	-.905	.276
E4	310	3.40	1.228	-.456	.138	-.735	.276
F1	310	3.28	1.266	-.248	.138	-.887	.276
F2	310	3.35	1.196	-.269	.138	-.814	.276
F3	310	3.30	1.294	-.239	.138	-1.067	.276
F4	310	3.24	1.356	-.199	.138	-1.166	.276
G1	310	3.50	1.209	-.470	.138	-.664	.276
G2	310	3.37	1.272	-.413	.138	-.899	.276
G3	309	3.40	1.220	-.414	.139	-.766	.276
G4	310	3.33	1.241	-.434	.138	-.785	.276

Note: B = Risk identification; C = Risk analysis; D = Risk evaluation; E = Risk treatment; F = Risk monitoring and review; G = Transformation of energy mix

Figure 26: Skewness and Kurtosis Tests

The term common method bias is used to describe a phenomenon that is produced by the measurement method used in a SEM study rather than the network of causes and effects in the model being studied while working with PLS-SEM. For instance, a questionnaire's introduction may steer responses from various respondents in the same general direction, leading to some overlap in the indicators' variance. Indicators may also have some common variance due to the implicit social desirability involved with providing specific responses to questionnaire questions (Aguirre-Urreta & Hu, 2019). According to Harman's single-factor test, no factor should explain more than 50% of variation if a principal component analysis model is run (Aguirre-Urreta & Hu, 2019). None of the factors in the principal component analysis explained more than 50% of the variance, hence there was no significant common method bias. Figure 27 presents the results of Harman's Single Factor Test.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	8.802	36.674	36.674	8.802	36.674	36.674
2	2.367	9.862	46.536	2.367	9.862	46.536
3	2.135	8.898	55.434	2.135	8.898	55.434
4	1.657	6.905	62.339	1.657	6.905	62.339
5	1.505	6.270	68.609	1.505	6.270	68.609
6	.926	3.858	72.467			
7	.655	2.730	75.198			
8	.563	2.347	77.544			
9	.491	2.047	79.592			
10	.484	2.016	81.608			
11	.439	1.829	83.436			
12	.432	1.800	85.236			
13	.412	1.717	86.954			
14	.384	1.598	88.552			
15	.347	1.445	89.997			
16	.319	1.330	91.326			
17	.312	1.302	92.628			
18	.301	1.256	93.884			
19	.293	1.220	95.104			
20	.266	1.109	96.212			
21	.257	1.071	97.284			
22	.241	1.003	98.286			
23	.216	.898	99.184			
24	.196	.816	100.000			

Figure 27: Harman´s Single Factor Test

A nonresponse bias occurs when a survey's target population either does not reply to a survey question or does not respond to the survey as a whole. Each case of nonresponse has its own unique set of causes. Any sort of mistake that can be reliably repeated over and over again qualifies as bias. As a result, nonresponse bias is not an exception. The researcher classified responses as early and late for the purpose of carrying out analysis. A total of 283 respondents were considered to be early and 27 were considered to be late. The researcher chose to analyse risk identification, risk analysis, risk evaluation, risk treatment, risk monitoring, and review and transformation of energy mix. The group statistics of these demographics are presented in Figure 28.

Timeliness in receiving responses		B	C	D	E	F	G
Early	N	283	283	283	283	283	283
	Mean	3.2959	3.1926	3.2041	3.3277	3.2244	3.3592
	Std. Error of Mean	.06533	.05686	.05893	.05359	.06579	.06409
	Std. Deviation	1.09909	.95651	.99137	.90147	1.10668	1.07821
Late	N	27	27	27	27	27	27
	Mean	5.5278	3.7130	5.0000	5.0093	3.9907	3.8148
	Std. Error of Mean	.10703	.14166	.11556	.13705	.15475	.13712
	Std. Deviation	.55614	.73610	.60048	.71213	.80408	.71250
Total	N	310	310	310	310	310	310
	Mean	3.4032	3.2379	3.2734	3.3871	3.2911	3.3989
	Std. Error of Mean	.06349	.05395	.05616	.05147	.06271	.06011
	Std. Deviation	1.11781	.94982	.98884	.90629	1.10407	1.05841

Note: B = Risk identification; C = Risk analysis; D = Risk evaluation; E = Risk treatment; F = Risk monitoring and review; G = Transformation of energy mix

Figure 28: Group Statistics for Early and Late Respondents

The researcher used Levene's test for homogeneity of variances and the t-test for equality of means to examine whether non-response bias existed. Since the tests were significant, it was concluded that non-response bias existed as shown in Figure 29 (Garson 2012).

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
B	EVA	22.592	.000	-5.748	308	.000	-1.2318	.21432	-1.65355	-.81013
	EVA			-9.824	48.36	.000	-1.2318	.12539	-1.48392	-.97977
C	EVA	5.122	.024	-2.749	308	.006	-.52038	.18932	-.89290	-.14787
	EVA			-3.409	35.968	.002	-.52038	.15265	-.83028	-.21048
D	EVA	15.023	.000	-5.097	308	.000	-.79594	.19427	-1.17821	-.41367
	EVA			-6.136	41.025	.000	-.79594	.12972	-1.05791	-.53396
E	EVA	3.304	.070	-3.814	308	.000	-.68152	.17867	-1.03309	-.32995
	EVA			-5.631	35.483	.000	-.68152	.14715	-.98042	-.38263
F	EVA	10.279	.001	-3.509	308	.001	-.76636	.21842	-1.19615	-.33657
	EVA			-5.558	36.138	.000	-.76636	.16815	-1.10733	-.42538
G	EVA	12.530	.000	-2.149	308	.032	-.45557	.21195	-.87262	-.03852
	EVA			-3.010	38.433	.005	-.45557	.15136	-.76187	-.14927

Note: B = Risk identification; C = Risk analysis; D = Risk evaluation; E = Risk treatment; F = Risk monitoring and review; G = Transformation of energy mix

Figure 29: Non-Response Bias Analysis

6.4.4 Correlation analysis

In research, correlation analysis is used to examine the linear relationship between two variables and to calculate the strength of that relationship. To rephrase, correlation analysis measures the degree to which one variable changes as another variable changes. A strong correlation between two variables suggests a robust relationship, whereas a weak correlation suggests just a casual one. Each possible correlation pattern between two variables is possible. Pearson correlation coefficient was used to examine the relationship between study variables as shown in Figure 30. The researcher used the means of variables, measured on the 5-point Likert scale (cumulative), to conduct correlation analysis.

		Transformation of energy mix
Risk identification	Pearson Correlation	.419
	Sig. (2-tailed)	.000
	N	310
Risk analysis	Pearson Correlation	.333
	Sig. (2-tailed)	.000
	N	310
Risk evaluation	Pearson Correlation	.343
	Sig. (2-tailed)	.000
	N	310
Risk treatment	Pearson Correlation	.375
	Sig. (2-tailed)	.000
	N	310
Risk monitoring and review	Pearson Correlation	.324
	Sig. (2-tailed)	.000
	N	310

Figure 30: Correlation Analysis Results

It was noted that risk identification and transformation of energy mix positively and significantly correlate ($r = .419$; $p < 0.05$). This implies that enhanced risk identification is associated with significant enhancement in transformation of the energy mix, and vice-versa. However, the correlation is weak as the correlation coefficient is less than 0.5.

Risk analysis and transformation of energy mix exhibited positive and significant correlation ($r = .333$; $p < 0.05$). This implies that improved risk analysis is associated with significant improvement in transformation of the energy mix, and vice-versa. However, the correlation is weak as the correlation coefficient is less than 0.5.

Results show that risk evaluation and transformation of energy mix correlate positively and significantly ($r = .343$; $p < 0.05$). This implies that enhanced risk evaluation is associated with the enhanced transformation of the energy mix, and vice-versa. However, the correlation is weak as the correlation coefficient is less than 0.5.

Risk treatment and transformation of energy mix exhibited positive and significant correlation ($r = .375$; $p < 0.05$). This implies that improved risk treatment is associated with the enhanced transformation of the energy mix, and vice-versa. However, the correlation is weak as the correlation coefficient is less than 0.5.

The study results reveal that a negative and significant relationship exists between risk monitoring and review and transformation of energy mix ($r = .324$; $p < 0.05$). This implies that enhancing risk monitoring and review is associated with the improvement in the transformation of the energy mix, and vice-versa. However, the correlation is weak as the correlation coefficient is less than 0.5.

6.4.5 Assessment of measurement model

The results in Figure 31 show that internal consistency reliability was met as the threshold of 0.7 for Cronbach's Alpha, rho_A and Composite Reliability was surpassed for all the study constructs.

	Cronbach's Alpha	rho_A	Composite Reliability
Risk analysis	0.832	0.840	0.887
Risk evaluation	0.832	0.902	0.884
Risk identification	0.889	0.891	0.923
Risk monitoring and review	0.887	0.891	0.922
Risk treatment	0.770	0.807	0.854
Transformation of energy mix in heavy industrial settings	0.879	0.883	0.917

Figure 31: Internal Consistency Reliability Analysis Results

The results in Figure 32 show that AVE for all study constructs exceeded 0,5 hence convergent validity was met.

	AVE
Risk analysis	0.662
Risk evaluation	0.657
Risk identification	0.751
Risk monitoring and review	0.747
Risk treatment	0.597
Transformation of energy mix in heavy industrial settings	0.734

Figure 32: Convergent Validity Analysis Results

The findings in Figure 33 reveal that all the squared inter-construct correlations were less than their AVEs, hence, discriminant validity was met.

	Risk analysis	Risk evaluation	Risk identification	Risk monitoring and review	Risk treatment	Transformation of energy mix in heavy industrial settings
Risk analysis	0.814					
Risk evaluation	0.278	0.810				
Risk identification	0.707	0.426	0.867			
Risk monitoring and review	0.431	0.414	0.497	0.864		
Risk treatment	0.428	0.385	0.566	0.515	0.773	
Transformation of energy mix in heavy industrial settings	0.340	0.366	0.421	0.327	0.380	0.857

Figure 33: Formell-Larcker Criterion Analysis results

The findings in Figure 34 reveal that all indicators' outer loadings were greater than cross-loadings, hence discriminant validity was met.

	Risk analysis	Risk evaluation	Risk identification	Risk monitoring and review	Risk treatment	Transformation of energy mix in heavy industrial settings
B1	0.577	0.408	0.873	0.385	0.496	0.380
B2	0.647	0.402	0.864	0.456	0.523	0.346
B3	0.624	0.341	0.877	0.459	0.440	0.376
B4	0.605	0.325	0.852	0.426	0.507	0.356
C1	0.810	0.274	0.621	0.373	0.397	0.318
C2	0.819	0.179	0.568	0.254	0.299	0.251
C3	0.807	0.295	0.567	0.463	0.357	0.294
C4	0.819	0.120	0.527	0.279	0.323	0.222
D1	0.145	0.726	0.174	0.198	0.166	0.201
D2	0.079	0.736	0.126	0.242	0.142	0.183
D3	0.314	0.891	0.465	0.442	0.393	0.381
D4	0.270	0.874	0.457	0.373	0.422	0.343
E1	0.367	0.366	0.504	0.390	0.885	0.374
E2	0.256	0.242	0.322	0.318	0.818	0.273
E3	0.421	0.371	0.579	0.656	0.641	0.262
E4	0.276	0.186	0.329	0.236	0.725	0.238
F1	0.393	0.359	0.459	0.870	0.465	0.295
F2	0.389	0.379	0.456	0.883	0.497	0.301
F3	0.372	0.379	0.448	0.872	0.443	0.280
F4	0.332	0.309	0.348	0.832	0.364	0.253
G1	0.277	0.326	0.370	0.292	0.323	0.873
G2	0.318	0.336	0.388	0.312	0.339	0.866
G3	0.313	0.308	0.372	0.307	0.312	0.865
G4	0.252	0.279	0.307	0.202	0.329	0.822

Figure 34: Cross-loadings Analysis Results

The findings in Figure 35 reveal that HTMT ratio values were less than 0.85, hence discriminant validity was met.

	Risk analysis	Risk evaluation	Risk identification	Risk monitoring and review	Risk treatment	Transformation of energy mix in heavy industrial settings
Risk analysis						
Risk evaluation	0.284					
Risk identification	0.815	0.435				
Risk monitoring and review	0.487	0.447	0.558			
Risk treatment	0.527	0.422	0.682	0.625		
Transformation of energy mix in heavy industrial settings	0.387	0.396	0.474	0.366	0.454	

Figure 35: Heterotrait-Monotrait Ration without Bootstrapping

The findings in Figure 36 show that 1 lies outside the range of all the bootstrap confidence interval results, implying that the discriminant validity requirement is met.

	Original Sample (O)	Sample Mean (M)	2.5%	97.5%
Risk evaluation -> Risk analysis	0.284	0.294	0.198	0.405
Risk identification -> Risk analysis	0.815	0.815	0.748	0.876
Risk identification -> Risk evaluation	0.435	0.436	0.332	0.540
Risk monitoring and review -> Risk analysis	0.487	0.486	0.376	0.584
Risk monitoring and review -> Risk evaluation	0.447	0.447	0.334	0.555
Risk monitoring and review -> Risk identification	0.558	0.557	0.460	0.647
Risk treatment -> Risk analysis	0.527	0.528	0.396	0.651
Risk treatment -> Risk evaluation	0.422	0.426	0.318	0.540
Risk treatment -> Risk identification	0.682	0.682	0.593	0.766
Risk treatment -> Risk monitoring and review	0.625	0.625	0.537	0.704
Transformation of energy mix in heavy industrial settings -> Risk analysis	0.387	0.388	0.276	0.495
Transformation of energy mix in heavy industrial settings -> Risk evaluation	0.396	0.395	0.277	0.506
Transformation of energy mix in heavy industrial settings -> Risk identification	0.474	0.474	0.374	0.571
Transformation of energy mix in heavy industrial settings -> Risk monitoring and review	0.366	0.367	0.256	0.472
Transformation of energy mix in heavy industrial settings -> Risk treatment	0.454	0.453	0.336	0.566

Figure 36: Heterotrait-Monotrait with Bootstrapping

The collinearity of variables for the inner model was examined using the Variance inflation factor as revealed in Figure 37. The coefficients of the structural model's relations between constructs are estimated through regression equations. Strong correlations between each set of predictor constructs may lead to skewed point estimates and standard errors, hence collinearity concerns must be checked for in structural model regressions (Sarstedt & Mooi, 2019). VIF values are derived by using the construct scores of the predictor constructs in each regression in the structural model, for reflective measurement models. Generally, collinearity problems across predictor constructs are indicated by VIF values over 5, although they may also arise at lower VIF values of 3 to 5 (Becker et al. 2015). One common solution to collinearity is the introduction of higher-order constructs (Hair et al. 2019). The findings indicate that all VIF values were less than 3, hence there were no collinearity problems.

	Transformation of energy mix in heavy industrial settings
Risk analysis	2.045
Risk evaluation	1.334
Risk identification	2.590
Risk monitoring and review	1.583
Risk treatment	1.670

Figure 37: Variance Inflation Factor for the Inner Model

The collinearity of variables for the outer model was examined using Variance inflation factor as revealed in Figure 38. The findings indicate that all the VIF values were less than 3, hence collinearity problems did not exist.

Indicators	VIF
B1	2.416
B2	2.385
B3	2.488
B4	2.219
C1	1.594
C2	2.016
C3	1.654
C4	2.095
D1	1.680
D2	1.752
D3	2.203
D4	2.134
E1	2.160
E2	1.918
E3	1.210
E4	1.483
F1	2.333
F2	2.500
F3	2.437
F4	2.071
G1	2.402
G2	2.234
G3	2.295
G4	1.979

Note: B = Risk identification; C = Risk analysis; D = Risk evaluation; E = Risk treatment; F = Risk monitoring and review; G = Transformation of energy mix

Figure 38: Variance Inflation Factor for the Outer Model

6.4.6 Structural equation model assessment

It is the goal of the variance-based PLS-SEM to estimate the path coefficients and other parameters of the model in a manner that maximizes the explained variance, therefore minimizing the unexplained variance. The structural model's path estimates are presented as standardized coefficients (Hair et al. 2022). This section presents the results of SEM analysis. Hair et al. (2017: 14) suggest researchers check the model's path loadings to ensure that all of the components in a latent construct are strongly correlated with one another. Path loadings greater than or equal to 0.7 are suitable. When the path loadings are high, the signals may be trusted more (Hair et al. 2017). When using relatively new scales, the loadings are lower. The decision to keep the path despite possible low path loadings is made based on the researcher's judgment, the internal consistency, the AVE, and the degree to which the item's removal impacts the content validity in reflective constructs. All values in Figure 39 are considered acceptable since their corresponding path loadings are more than 0.6. The path loading results are shown in Figure 39. In general, removing indicators with loadings between 0.40 and 0.708 is not recommended unless doing so leads to an improvement in internal consistency reliability or convergent validity above the suggested threshold value. Content validity, the degree to which a measure captures all aspects of a specified construct, is another factor to think about when deciding whether or not to get rid of an indicator. Because of this, indicators with lower loadings are sometimes kept. It is recommended, however, that indicators with loadings below 0.40 be always removed from the measurement model (Hair et al. 2022).

	Risk analysis	Risk evaluation	Risk identification	Risk monitoring and review	Risk treatment	Transformation of energy mix in heavy industrial settings
B1			0.873			
B2			0.864			
B3			0.877			
B4			0.852			
C1	0.810					
C2	0.819					
C3	0.807					
C4	0.819					
D1		0.726				
D2		0.736				
D3		0.891				
D4		0.874				
E1					0.885	
E2					0.818	
E3					0.641	
E4					0.725	
F1				0.870		
F2				0.883		
F3				0.872		
F4				0.832		
G1						0.873
G2						0.866
G3						0.865
G4						0.822

Figure 39: Path Loadings

The structural model with path loadings is shown in Figure 40

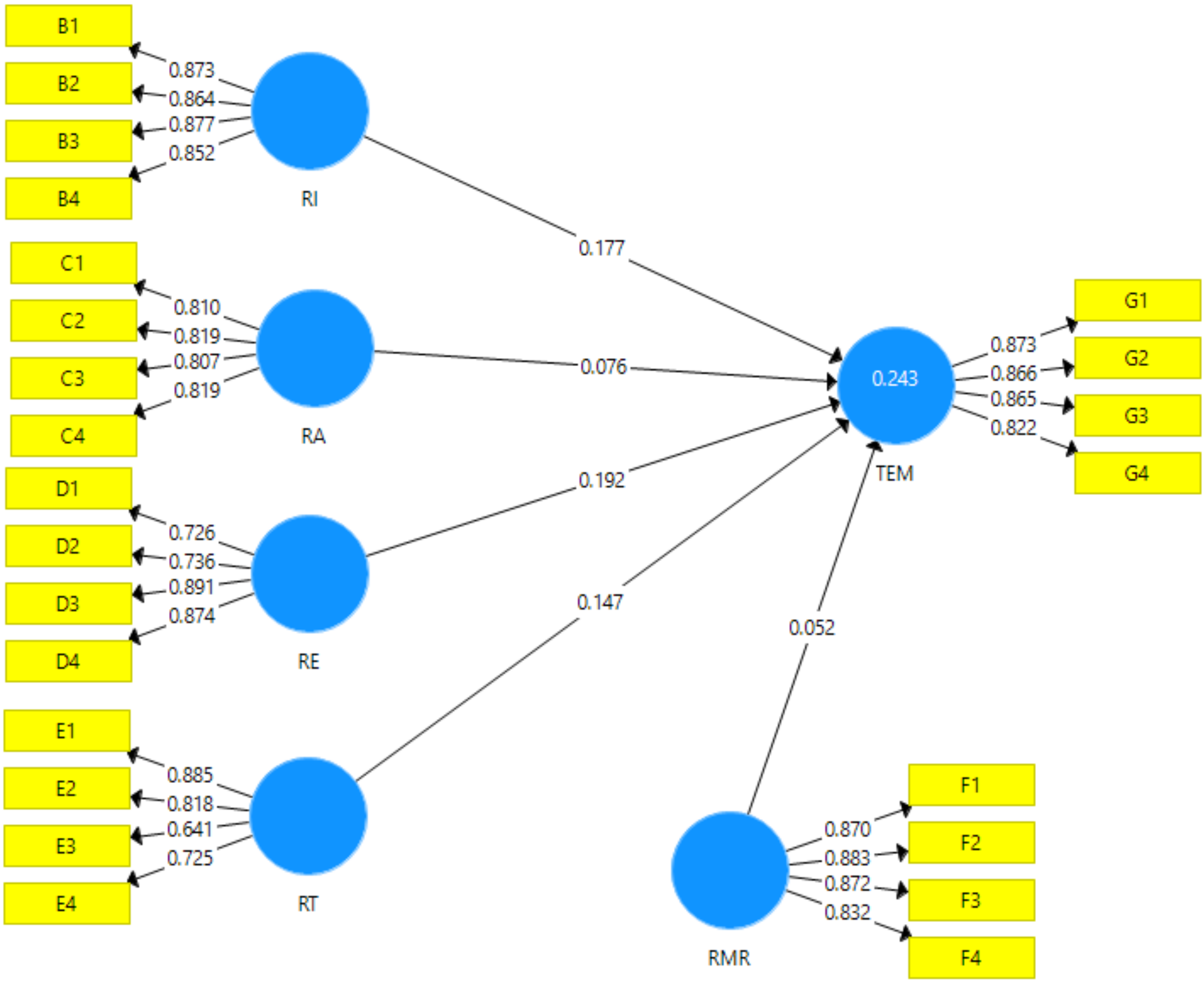

Figure 40: Structural Model with Path Loadings

Evaluation of model fit was performed using the standardized root mean square residual. Both the sample and the predicted covariance matrices are converted into correlation matrices as the basis for the SRMR. The SRMR is calculated by subtracting the model-implied correlation matrix from the observed correlation matrix. This absolute measure of model fit criterion allows researchers to evaluate the typical size of the gaps between observed and expected correlations. In general, a good fit is indicated by a value of less than 0.10, or, in a more conservative setting, 0.08. (Hu & Bentler 1999). To prevent model misspecification, Henseler et al. (2014) present the SRMR as a goodness-of-fit measure for PLS-SEM. It is shown in Figure 41 that the SRMR value is less than 0.1, hence implying a good fit of the study model.

	Saturated Model	Estimated Model
SRMR	0.084	0.084

Figure 41: Model Fit Summary

6.4.7 Structural equation model´s explanatory power

The variance of transformation of energy mix explained by risk identification, risk analysis, risk evaluation, risk treatment and risk monitoring and review was examined using R square and R square adjusted. The results are shown in Figure 42. R^2 of an endogenous model is the coefficient of determination (s). Explanatory power (Shmueli & Koppius 2011) or in-sample predictive power (R^2) is the fraction of total variation in the data that is accounted for by the model (Rigdon 2012). Higher R^2 values indicate more explanatory power. R^2 values of 0.75, 0.50, and 0.25 are often regarded as strong, moderate and weak in many areas of social research (Hair et al. 2011). However, the threshold for an acceptable R^2 number depends on the field of study; for example, an R^2 of 0.10 may be deemed enough in social sciences (Raithel et al. 2012).

It's important for scientists to realize that R^2 changes depending on how many predictor constructs they use. R^2 rises as the number of predictor constructs increases. As a result, R^2 results should be evaluated in light of other relevant research and models of comparable complexity. Overfitting the data may potentially result in an excessively high R^2. Model overfit occurs when a very complex partial regression model ends up better fitting the random noise in the sample than the population as a whole. A new sample drawn from the same population is very unlikely to provide the same results (Sharma et al., 2019). R^2 tends to grow when more variables are added to a model in an attempt to explain the data, which may be misleading. A more cautious estimate of R^2 is obtained by using the adjusted R^2 measure, which takes into consideration a number of explanatory factors in relation to data set size (Theil 1961). However, because of the correction factor utilized to account for data and model size, adjusted R^2 is not a reliable estimate of the variance explained by an endogenous construct (Sarstedt & Mooi 2019). The findings indicate that risk identification, risk analysis, risk evaluation, risk treatment and risk monitoring and review explain 25.3% of the variance of transformation of energy mix (R^2 = 0.243). This also implies the weak explanatory power of the study model.

	R Square	R Square Adjusted
Transformation of energy mix in heavy industrial settings	0.243	0.231

Figure 42: Coefficient of Determination Results

The effect of removing model exogenous constructs on R square was examined using f^2. The path coefficients' size corresponds to f^2 effect size. In a structural model, the relative magnitude of the path coefficients and the f^2 effect sizes frequently correspond to the rank order of the predictor constructs' importance in explaining a dependent construct. It is common practice to only publish the f^2 effect size in such cases if specifically asked by editors or reviewers. Researchers may report the f^2 effect size to provide a different perspective on the findings if the rank order of constructs' importance in explaining a dependent construct in the structural model changes when comparing the magnitude of the path coefficients and the f^2 effect sizes. For the purpose of evaluating the exogenous latent variable, Cohen (1988) suggests using a value of 0.02 and 0.15 to distinguish between small and medium effects respectively, while 0.35 denotes large effects. In the absence of an effect, an effect size is less than 0.02 (Memon et al. 2019). The f square analysis results are revealed in Figure 43. The findings indicate that removing risk identification, risk analysis, risk treatment and risk monitoring and review has no effect. It is shown that removing risk evaluation from the model has a large effect.

	Transformation of energy mix in heavy industrial settings
Risk analysis	0.004
Risk evaluation	0.036
Risk identification	0.016
Risk monitoring and review	0.002
Risk treatment	0.017

Figure 43: f Square Analysis Results

6.4.8 Structural equation model´s predictive power

Predictive power, also known as out-of-sample predictive power, measures how well a model can anticipate data that has not yet been collected (Hair et al. 2022). PLSpredict was first presented by Shmueli, Ray, Estrada, and Chatla in 2016. Estimating the model on a training sample and then testing its predicting ability on a holdout sample are the two main steps in PLSpredict's execution (Shmueli et al., 2019). Before doing the first analysis of the data in the training sample, the holdout sample is taken to ensure that no crucial information is lost. PLSpredict is capable of doing k-fold cross-validation (Hair et al. 2017). Root-mean-square error is the most often used measure for measuring the accuracy of a forecast (RMSE). This statistic is calculated as the square root of the sum of all squared deviations between forecasts and actuals (Hair et al. 2017). Mean absolute error is another widely used measure of precision (MAE). This statistic does not take into account whether errors are over- or under-estimated, but rather just their average size. Researchers should often utilize the RMSE to evaluate a model's performance. However, the MAE is the better prediction statistic if the distribution of prediction errors is very non-symmetric, as seen by a large left or right tail (Danks & Ray 2018: 37). Researchers should compare the RMSE (or MAE) of each indicator to the RMSE (or MAE) of a naive linear regression model (LM). The PLS path model's LM benchmark values are derived using a linear regression of the dependent construct's indicators on the exogenous constructions' indicators (Danks & Ray 2018). PLSPredict's Q^2 value evaluates how well the PLS path model predicts vs how well simple mean predictions perform. If Q^2 is positive, the PLS-SEM findings provide a lower prediction error than using the mean values alone. For such situations, the PLS-SEM models provide superior prediction performance. The manifest variable (MV) prediction summary is presented in Figure 44. The findings indicate that the RMSE, MAE and MAPE for the PLS-SEM were all less than the RMSE, MAE and MAPE for the LM benchmark. This implies that the SEM model has high predictive power. The findings show that all the Q^2 values are positive implying better predictive performance of both PLS-SEM and LM models are better than simple mean predictions.

Manifest Variables				
		PLS		
	RMSE	MAE	MAPE	Q²_predict
G4	1.168	0.972	44.679	0.117
G2	1.155	0.957	42.435	0.179
G3	1.121	0.926	39.605	0.157
G1	1.110	0.917	38.312	0.159
		LM		
	RMSE	MAE	MAPE	Q²_predict
G4	1.203	0.990	45.149	0.063
G2	1.195	0.980	42.800	0.120
G3	1.165	0.956	40.513	0.088
G1	1.160	0.954	39.744	0.082
Latent Variables				
		PLS		
		RMSE	MAE	Q²_predict
Transformation of energy mix		0.894	0.765	0.210

Figure 44: Manifest Variable and Latent Variable Prediction Summary

6.4.10 Predictive relevance (Q^2)

The blindfolding procedure was conducted to examine the predictive relevance of the PLS model. Blindfolding determines the Stone-Geisser Q^2 value, which assesses the PLS path model's predictive significance in a cross-validation setting. Blindfolding is an example of sample reuse that involves the systematic removal of data points followed by a prediction of their prior values. The omission distance, D, should be within the range of 5 to 12. (Hair et al. 2022). If the omission distance is set to seven (D=7), then one-seventh of the indications for the latent variable will be removed after one pass through the hood. The omission distance is always equal to the number of blindfolded rounds. Predictive significance in PLS-SEM is shown when the data points of indicators can be accurately predicted. Only if the Q^2 value is larger than zero does the PLS path model have predictive relevance for a particular endogenous latent variable. The accuracy with which the path model can anticipate the original values is shown by the Q^2 values calculated during the blindfolding operation (Hair et al. 2022). The findings show that the PLS path model had predictive significance as the Q^2 value for the endogenous variable, the transformation of the energy mix in heavy industrial settings, was 0.172 as shown in Figure 45.

	SSO	SSE	Q^2 (=1-SSE/SSO)
Risk analysis	1240.000	1240.000	
Risk evaluation	1240.000	1240.000	
Risk identification	1240.000	1240.000	
Risk monitoring and review	1240.000	1240.000	
Risk treatment	1240.000	1240.000	
Transformation of energy mix in heavy industrial settings	1240.000	1027.282	0.172

Figure 45: Construct Cross- Validated Redundancy

6.4.11 Important-performance map analysis

The relative relevance of the exogenous variables in explaining the endogenous variable was examined through importance-performance map analysis (IPMA). The relative relevance of certain constructs in explaining other constructs in the structural model may be gleaned from the results of a typical PLS-SEM analysis. The value of construct information is crucial to conclusion making (Ringle & Sarstedt, 2016). By including each construct's actual performance, the importance-performance map analysis (IPMA) goes beyond the findings of PLS-SEM. The ability to make conclusions along two dimensions (i.e., significance and performance) is crucial for managers to effectively set priorities. Thus, it is desirable to prioritise enhancing the performance of those constructs that have a high significance in explaining a specific target construct but have a poor performance overall (Ringle & Sarstedt 2016). The standardized path coefficients from the IPMA are shown in Figure 46. The findings show that risk evaluation ($\beta = 0.192$) is the most important variable in explaining the transformation of the energy mix in heavy industrial settings followed by risk identification ($\beta = 0.177$), risk treatment ($\beta = 0.147$), risk analysis ($\beta = 0.076$) and risk monitoring and review ($\beta = 0.052$) respectively.

	Transformation of energy mix in heavy industrial settings
Risk evaluation	0.192
Risk identification	0.177
Risk treatment	0.147
Risk analysis	0.076
Risk monitoring and review	0.052

Figure 46: Importance-Performance Map Analysis

6.4.12 Significance and relevance of the structural model relationships

The significance and relevance of the path coefficients are evaluated using a consistent PLS bootstrapping procedure as shown in Figure 47. Bootstrapping is a nonparametric method for estimating standard errors and testing outer coefficients' significance. In the same way as formative indicator weights are evaluated using bootstrapping standard errors, t-values of path coefficients or confidence intervals are evaluated using bootstrapping standard errors. A sufficient number of bootstrap samples, at least 5000, but preferably more should be taken, with a lower bound of at least the total number of valid observations (Streukens & Leroi-Werelds 2016). The path coefficient is significant at the 5% level if and only if the value zero is outside the 95% confidence range. Confidence intervals are best built using the percentile technique (AguirreUrreta & Rönkkö 2018). It is shown that improving risk evaluation by 1 standard deviation unit enhances the transformation of the energy mix by 0.206 units. The findings reveal an insignificant positive effect or risk identification, risk analysis, risk treatment and risk monitoring and review on the transformation of the energy mix in heavy industrial settings

A path coefficient may range from -1 to 1, with a value closer to -1 suggesting a strong negative correlation and a value closer to +1 indicating a strong positive one. For instance, extreme collinearity might provide values below 1 and over +1. Larger than +/1 path coefficients need the use of multicollinearity reduction techniques. The route coefficients are used in PLS-SEM to show how the values of an endogenous construct shift when one of the predictor constructs shifts by one standard deviation unit, while the other predictor constructs shift by the same amount but remain constant (Hair et al. 2022). The findings indicate that all variables would be retained as none had coefficients exceeding -1 and +1.

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
Risk analysis -> Transformation of energy mix in heavy industrial settings	0.073	0.081	0.130	0.561	0.575
Risk evaluation -> Transformation of energy mix in heavy industrial settings	0.207	0.206	0.075	2.750	0.006
Risk identification -> Transformation of energy mix in heavy industrial settings	0.181	0.173	0.168	1.073	0.284
Risk monitoring and review -> Transformation of energy mix in heavy industrial settings	0.026	0.024	0.080	0.323	0.747
Risk treatment -> Transformation of energy mix in heavy industrial settings	0.183	0.194	0.105	1.743	0.082

Figure 47: Structural Model Coefficients

6.5 Discussions

6.5.1 Changes in the energy mix in heavy industry

Numerous studies have established that heavy industry in both developed and developing countries accounts for over 60% of the total energy consumption (Lindberg et al. 2019). Nonetheless, this has changed in the past few decades because of the worsening environmental pollution, especially increased carbon dioxide emissions. Since the growth and survival of most countries depend on the energy supply, there have been noticeable changes in the energy mix, particularly in heavy industry. The need for energy mix as shown in various studies has been occasioned by the energy demand and supply and the need to have control for optimal and accurate production of energy consumption (Valentine & Sovacool 2019). It has been argued by Ahmad and Zhang (2020) that in 2016, fuel accounted for about 22% of the global energy supply, and this was compared to 16% in 1973. Considering the ever-glaring environmental issues and the continued depletion of the world’s oil reserves, there is still a rise in the use of fuel in the companies‘ energy portfolio. Because of this issue, among other factors, heavy industries have opted for the use of fuel energy alternatives.

Academic research indicates that the adoption of alternative fuels is crucial for heavy industries. Stancin et al. (2020) argue that carbon neutral fuels are a mandatory component of future energy systems. They are supposed to play a major role in decarbonizing the energy sector; however, at the moment, the process of diversifying energy portfolios is challenging owing to efficiency concerns. To address this issue, Stancin et al. (2020) advocate for the adoption of novel renewable energy sources that produce fuels which can be used as energy carriers and power generation sources simultaneously. The case study focusing on the maritime sector illustrates that the adoption of alternative fuels is inhibited by the lack of expertise, unclear safety regulations, and insufficient technical maturity (Prussi et al. 2021). According to the scientists, the benefits of changing the energy mix by adopting alternative fuels is not always justified by their benefits. Ina similar study, Atilhan et al. (2021) found that alternative fuels like green hydrogen can be promising solutions for the shipping industry, but the existing information about health and safety concerns related to the use of this fuel in the sector is limited. Compelling evidence for the challenges faced by stakeholders when adopting alternative fuels can also be found in the research paper by Anderhofstadt and Spinler (2019). In general, there is a consensus among scientists and practitioners that changing the energy mix in heavy industry is currently problematic because the benefits expected from such a transformation do not necessarily outweigh the losses that can be incurred as a result of shifting to new technologies and embracing uncertainty related to alternative fuels.

Although the depletion of the world's oil reserves made it prudent for heavy industry to adopt a changed energy mix, Fattouh et al. (2018) noted that different countries have formulated policies that advocate for the reduction of greenhouse gas emissions. This has seen heavy industry look for alternative sources of energy, particularly those that are in line with policies regulating the energy sector. For instance, the adoption of energy mix in heavy industry has been influenced by policies that advocate for the increased production and consumption of natural gas. On the other hand, the changes in the energy mix have been impacted by the environmental policies that advocate for technological efficiency and the substitution of natural gas with fossil fuels. Although most of the companies in heavy industry use different sources of energy, it has been argued that there has been an increase in the use of natural gas as the growing resource for primary energy. Compared to other forms of energy, heavy industry has changed to natural gas because of its availability and because it adheres to policies that advocate for the utilization of clean energy.

Natural gas is used in heavy industry in varying amounts, and despite the continued use of other forms of energy, many players in heavy industry are leaning toward natural gas because of lower carbon dioxide emissions. This has, however, had its fair of challenges, particularly considering that players in heavy industry have adaption and mitigation costs that they incur for them to remain afloat in their respective industries. Fattouh et al. (2018: 5) pointed out that the heavy industry in China had since the 1980s used coal combustion to power factories and generate electricity. However, this trend has reversed because the use of coal in China has declined from 2,810 million metric tons of coal to 2,572 metric tons since 2013 (Fattouh et al. 2018). This has encouraged China to level off its overall carbon dioxide emissions. According to Baležentis and Štreimikienė (2019), coal as a source of energy in China's heavy industry decreased despite its increasing amount in other industries. The decline in the use of coal as the primary source of energy in China and other developing nations has been offset by a continued increase in the consumption of natural gas and oil. This has also seen an increase in non-fossil primary electricity such as wind, hydro, nuclear and other forms of renewable energies.

Wind and solar energy are becoming increasingly popular in heavy industries. The share of wind energy in the Nordic Electricity Market of Denmark recently reached 55%, even though it used to be only 44% in 2015 (Golmohamai 2022). At the same time, the use of this energy in heavy sectors is not always efficient since wind energy lacks the flexibility that is needed to maintain operations of aluminium smelting and cement manufacturing plants (Golmohamai 2022). Therefore, the adoption of this energy is mostly justified as a supplement of traditional fuels. Farjana et al. (2018) argue that solar power has already become an integral part of many industrial processes in heavy industries in different corners of the globe. Simultaneously, the scientists state that the potential of this energy to reduce the use of fossil fuels in heavy sectors is not entirely understood owing to the lack of attention to the issue of solar system integration into the existing heat systems. Kumar et al. (2019) conducted an overview of solar thermal energy technologies that are currently used in industrial processes. The scholars demonstrated that sun tracking systems, modelling techniques, and thermal performance assessment tools must be used together to maximize the effectiveness and efficiency of solar power in industrial processes. In general, recent studies show that even though the adoption of renewables to change the energy mix of heavy industries is challenging owing to the presence of many risks and a high level of uncertainty, stakeholders have already developed many applications of renewables that reduces the reliance on fossil fuels.

6.5.2 Risks associated with important changes in the energy mix

There are risks associated with the changes in the energy mix use in the heavy industry. For example, Månberger and Stenqvist (2018) stated that the decline in carbon emissions as mandated by different policies is associated with changes in industrial structure and the reduction of coal used for the energy mix. Although natural gas is characterized by a significant reduction of carbon emissions, players in heavy industry are still dependent on coal as one of the primary energy sources. This means that in combination with other sources of renewable sources of energy, heavy industry across the globe still relies heavily on the use of coal and other forms of fuel fossils. For instance, preliminary data from O'Ryan et al. (2020) in 2017 established that there was an increase in Chile's production of coal. This confirms that the use of the energy mix will continue to rise, particularly because heavy industries are torn between decreasing their carbon emissions and coal remaining their primary source of energy.
Heavy industry players that continue to use coal as their primary source of energy will face competition from players in the same industry that have adopted the use of other forms of renewable energy. It is worth pointing out that although heavy industry relying on coal as its primary source of energy still uses other forms of energy, companies in this sector are considered energy mix users heavily dependent on coal. However, they still face stiff competition from those in heavy industry that use other forms of the energy mix such as natural gas, wind, and solar power. Li et al. (2018) noted that the

declining prices of natural gas, wind, and solar power have changed the approach that heavy industry uses in these forms of energy system planning. Compared to the energy mix that relies coal energy, the energy mix of heavy industries that involves the utilisation of wind and solar power has the lowest cost levels of energy. According to a report released by one of the largest power companies in the United States in 2019, the energy mix that uses wind plus storage and solar will be cheaper compared to that of oil, coal or nuclear sources of energy (Li et al. 2018). Because of such changes, it has been stated that the changes in the energy mix over the past few decades will bring massive disruption.

On the other hand, heavy industry players that will be deeply decarbonized because of embracing the energy mix that advocates for decreased carbon emissions will need to ensure greater flexibility. The aspect of flexibility is an associated risk that will come with changes in the energy mix currently witnessed in heavy industry. For example, Li et al. (2018) stated that due to deep carbonization, players in heavy industry will face the risk of investing in a wide range of technologies and other associated grid management strategies. This is important because it will prompt heavy industry players to meet the spectrum of flexibility needs, particularly flexible sources of electrical power supply, electricity storage and synthetic fuels among others. On the other hand, the continued cost of coal energy use as a source of energy in the energy mix also has a risk because of land scarcity. Khanna et al. (2011) argued that energy use that involves the use of land should be considered thoroughly since it needs to be maintained as efficiently as possible.

Disruptions are a major risk related to the use of renewables instead of fossil fuels in heavy industries. Renewable energy, such as wind and solar energy, can be unstable (Jasiunas et al. 2021). Moreover, even if a facility adopts novel energy systems to mitigate disruption risks, such as digitalization, it exposes itself to new risks, including cyberattacks against energy systems (Jasiunas et al. 2021). The problems related to possible disruptions can be caused not only by unstable supply but also the lack of expertise, something that is a critical concern for many developing countries (Kumar & Majid 2020). Many companies operating in heavy industries in developing and least-developed nations might not have enough competent specialists to facilitate a change in the energy mix while mitigate the risk of disruptions.

6.5.2.1 Risk Management practices and the transformation of energy mix

The researcher took note of respondents’ indecisiveness on whether or not a shift in the company's energy portfolio helped it reach targets. Most respondents did not have a strong opinion one way or the other on whether or not the cost of adjusting an energy system's energy mix is justified. Respondents were undecided on whether or not adjusting the energy mix would improve efficiency. Respondents were undecided on whether or not there was minimal pushback to adjusting the energy mix.

Results show that respondents were undecided on whether or not they included potential limiting factors in their goal setting. No consensus was reached among respondents as to whether or not risk occurrences, their causes, and potential repercussions are recorded. The respondents were undecided on the question of whether or not current and potential problems are considered. The majority of respondents did not have an opinion on whether or not risk categories exist. It was noted that enhanced risk identification is associated with significant enhancement in the transformation of the energy mix, and vice-versa.

When asked if the possible effect of risk is critically addressed or not, respondents were undecided. The respondents were divided on the question of whether or not decision-making takes into account the potential of risk. There was no consensus among respondents on whether or not the level of risk should influence next steps. There was no consensus amongst the respondents as to whether or not methods have been built for communicating the risks associated with collaborating across organizations. It was revealed that improved risk analysis is associated with significant improvement in the transformation of the energy mix, and vice-versa.

According to the results, there was no consensus among respondents on whether or not the research included risks that might be minimized. None of the respondents could make up their minds about whether or not resource allocation and urgency play a role in risk prioritizing. Ask respondents whether they think a severe enough risk is there before they provide an answer. When asked whether environmental influences are considered when deciding how to deal with risks, respondents were undecided. Results show that enhanced risk evaluation is associated with the enhanced transformation of the energy mix, and vice-versa.

Uncertainty was also found as to whether or not measures are taken to reduce risks to manageable levels. Whether or not respondents evaluate the cost-effectiveness of risk mitigation strategies when making risk-based choices was a point of contention. Respondents could not agree on whether or not sufficient resources are made available to reduce risks. Respondents were split on the question of whether or not responsible and accountable individuals had been brought on to handle risk management. It was noted that improved risk treatment is associated with the enhanced transformation of the energy mix, and vice-versa.

A majority of respondents couldn't say whether or not the company had dedicated staff tasked with regularly assessing potential threats to the business. Respondents were split on whether or not they record and react to changes in risk profiles. When asked if irrelevant risks are disregarded or not, respondents were undecided. There was no consensus among responders as to whether or not the consequences of shifting risk profiles are tracked over time. The study results reveal that enhancing risk monitoring and review is associated with improvements in the transformation of the energy mix, and vice-versa.

The findings indicate that risk identification, risk analysis, risk evaluation, risk treatment and risk monitoring and review explain 25.3% of the variance of transformation of energy mix implying weak explanatory power of the study model (Hair et al. 2011). It was shown that removing risk identification, risk analysis, risk treatment and risk monitoring and review from the model has no effect whereas removing risk evaluation from the model has a large effect. This implies that risk evaluation is important in influencing the transformation of the energy mix in heavy industrial settings (Memon et al., 2019). It was noted that risk identification, risk analysis, risk evaluation, risk treatment and risk monitoring and review were significant in predicting transformation of energy mix in heavy industrial settings. It was shown that risk evaluation ($\beta = 0.192$) is the most important variable in explaining transformation of energy mix in heavy industrial settings followed by risk identification ($\beta = 0.177$), risk treatment ($\beta = 0.147$), risk analysis ($\beta = 0.076$) and risk monitoring and review ($\beta = 0.052$) respectively.

It is shown that improving risk evaluation by 1 standard deviation unit significantly enhances the transformation of the energy mix by 0.206 unit ($\beta = 0.206$; $p < 0.05$). This implies that risk evaluation positively and significantly affects the transformation of the energy mix. It is shown that improving risk analysis by 1 standard deviation unit insignificantly enhances the transformation of the energy mix ($\beta = 0.081$; $p > 0.05$). Improving risk identification by 1 standard deviation unit insignificantly enhances the transformation of the energy mix ($\beta = 0.173$; $p > 0.05$). It was found out that improving risk monitoring and review by 1 standard deviation unit insignificantly enhances the transformation of the energy mix ($\beta = 0.024$; $p > 0.05$). It was revealed that improving risk treatment by 1 standard deviation unit insignificantly enhances the transformation of the energy mix ($\beta = 0.194$; $p > 0.05$). The findings imply insignificant positive effects of risk identification, risk analysis, risk treatment and risk monitoring and review on the transformation of the energy mix in heavy industrial settings ($p > 0.05$).

6.5.3 Opportunities for companies to improve the energy mix in heavy industry

The global society continues to face numerous crises emanating from climate change. As evidenced by various studies, the excessive emissions of greenhouse gases have caused climate change and put human health at great risk (Li et al. 2018; O'Ryan et al. 2020). Because of this Månberger and Stenqvist (2018) argued that there are several opportunities for companies to improve the energy mix in heavy industry. For instance, heavy industry has the opportunity to ensure that companies restrict the emission of greenhouse gases and at the same time achieve sustainable goals. To this end, O'Ryan et al. (2020) pointed out that companies in heavy industry are presented with the opportunity to adhere to the policies and guidelines established by their respective governments in delivering net zero emissions.

It is worth noting that developing countries across the globe have seen their demand for energy increasing. This has seen carbon emissions drastically increasing. As pointed out by Li et al. (2018), the over-reliance on the heavy industry has increased carbon emissions in recent years. This caused companies in heavy industry, especially in developing countries such as China, to have high coal consumption. Such a process also has led hundreds of millions of people across the globe, particularly those in developing countries, to face both the financial and environmental risks of such increased consumption. Companies in heavy industry have an opportunity to lower the risks associated with environmental and financial risks.

Companies in heavy industry are also presented with the opportunity to achieve progress in terms of environmental sustainability. As pointed out by Li et al. (2018), companies in heavy industry should have their environmental sustainability as their primary target and thus have the opportunity to achieve higher quality growth with these set targets. On the other hand, Li et al. (2018) argued that companies in heavy industry can embrace strategic adjustments, and this is alongside changes in their macroeconomic structures. Even more importantly, other than achieving higher quality economic growth, companies in heavy industries have the opportunity to explore the drivers of reducing carbon emissions. This can help their respective countries decarbonize their economic growth.

Companies in heavy industry have an opportunity to play as sub-national actors in their respective regions and cities. This implies that companies in this industry can play a significant role in the mitigation process involving climate change. Li et al. (2018) noted that companies in heavy industry can embrace intermittent renewables, as this offers economic incentives for both the affordable and dispatchable energy mix. Although there are different ways that companies in heavy industry can use the energy mix, they are presented with an opportunity to embrace environmentally friendly sources of energy, especially those that are not limited to hydro, concentrated solar power and natural gas.

6.5.4 Transition strategies implemented by companies in heavy industry

There is a paradigm shift from the use of traditional forms of energy to renewable sources of energy. This comes after many of the companies in heavy industry continue to face the challenge of transitioning to sources of energy that have fewer carbon emissions. Because of this, Li et al. (2018: 96-97) indicated that there are numerous transition strategies that companies in heavy industry have continued to embrace in the past few decades. The most notable is that of transitioning from mix energies with high emissions of carbon dioxide to adopting other forms of renewable energy. Since many of the companies are greatly benefiting from the traditional forms of energy such as fuel fossils and coal, they view the transition as dictated by various policies as a process that is meant to change their operational structures. With limited choices, Valentine and Sovacool (2019) argued that many companies in heavy industry have been forced to make the transition to energies with limited carbon emissions. This has seen many of these companies embracing mixed energy but with natural gas as the primary source of energy.

Although it has been confirmed in secondary research that there is a projected growth of coal consumption in less energy-intensive industries, there is a decrease in this form of energy in the heavy industry (Khanna et al. 2011). This is a clear indication that despite companies in heavy industry relying on various forms of traditional energy, many of them are transitioning to new forms of energy. Most of these companies have been switching from coal to natural gas, and this effectively has seen companies in heavy industry making sure that they are embracing sustainable forms of energy (Khanna et al. 2011). Despite the challenge that many of the companies in heavy industry continue to face in transitioning to sustainable energy, the continuous growth in natural gas and oil consumption is a step in the right direction as far as transitioning is involved.

Although this is the case, Baležentis and Štreimikienė (2019) argued that much needs to be done to ensure an absolute sustained decline in coal demand because this is paramount in offsetting the increasing carbon dioxide emissions. Still on the issue of transition, it is evident that companies in heavy industry tend to adopt pricing policies that aim at decreasing the use of polluting fuel consumption. Thus, in the process of transitioning, companies in heavy industry are obligated to adhere to several different policies that aim at increasing natural gas production and consumption and at the same time reducing greenhouse emissions. While it is true that companies in heavy industry are willing and are on the verge of fully transitioning to energy sources that have little impact on the environment, they are still grappling with electricity demands. In this aspect, many of these companies are still forced to use coal energy as they make the transition, because this is the only way that they can meet the electricity demands that are not met by other fossil or non-fossil-based sources of electricity.

7 SUMMARY, CONCLUSION AND RECOMMENDATIONS

7.1 Summary

7.1.1 Qualitative research insights

Several questions were raised in this study in order to demonstrate the implications for strategy development and risk management to enable companies in heavy industry to achieve a sustainable energy mix. One of the questions related to determining the barriers to the strategic implementation of renewable energy systems in heavy industrial settings. This objective has been achieved because a comprehensive literature review has been carried out to explore the diverse views of scholars in the field on the transition of companies in heavy industry to a more sustainable energy mix. In addition to the conclusions derived from the literature review, the results obtained from primary research revealed important insights into the constraints encountered by companies in heavy industry. It has been noted that achieving greater sustainability has become a challenging objective in the current geopolitical situation considering the numerous disruptions encountered across organizations' supply chains. Since there were numerous challenges pertaining to the implementation of renewable energy systems in heavy industrial settings, another important objective of this study was to critically discuss effective management strategies that could transform the energy mix for involved companies. Since the greatest motive of these companies to change the energy mix was identified as increased sustainability, the results obtained from the questionnaires with participants as well as findings from secondary research pointed out that transparency and open communication were incorporated into strategies for improving sustainability of the energy mix in the long term.

As shown in the research findings in this study, which were obtained from both questionnaires and secondary research, one of the topics that was extensively discussed related to the major risks of changing the energy mix in heavy industry. It has been indicated that changing the energy mix has a significant impact on grid stability. In this context, it is important to note that grid stability incidents have substantially increased. Organizations in heavy industry found it quite challenging to maintain sufficient flexibility while managing their operational complexity. From this perspective, it is essential to note that power system flexibility should be revisited in order to facilitate organizations' ability to adapt to constantly changing conditions. In balancing supply and demand in heavy industry, companies may need to utilize new generation and transmission resources to achieve greater efficiency in their operations.

An important insight related to the challenge of maintaining grid stability while changing the energy mix is that attaining such stability depends on the specific geographic characteristics of different countries. In order to address the challenge of maintaining grid stability, proximity and connection to other nations could be quite helpful. While trying to meet their need for flexibility in the energy mix, different countries often rely on the option of enhanced network connections.
The findings in this study illustrated that another risky factor that could impact the energy mix was identified as persistently changing regulations. This means stakeholders in heavy industry tend to be concerned with the increasing amount of uncertainty caused by such regulations. In fact, it has been indicated that similar regulations appear to be vague and misleading depending on the precise region or geographic characteristics of a particular country. Even though the switch to renewable energy resources is clearly recognized by major stakeholders in heavy industry, they may lack the preparation to address the implications of changing regulations.

This study demonstrated that changing the energy mix in heavy industry could be beneficial and problematic at the same time. Some of the participants in the study considered the high initial costs of installing renewable energy equipment. Since a wide margin in installation costs matters, it is important for investors in heavy industry to rethink their strategic options before making final decisions. It is not surprising to find out that the substantial costs associated with changing the energy mix bring the idea of renewables as highly risky. It is also relevant to take into consideration how the lack of infrastructure can impede the adoption of renewable sources of energy in heavy industry. The present infrastructure in the respective industry is mostly developed to facilitate the operations of fossil fuel plants and nuclear plants. Thus, it could be reasonable to state that reforming the present infrastructure can help stakeholders in heavy industry address some of the mentioned problems pertaining to changing the energy mix.

Power storage issues also have been identified in the study, mostly in relation to the lack of power storage for renewable energy sources. The electricity generation process of these sources fails to match the commonly specified peak demand hours, and this results in certain inconsistencies related to power storage. The volatility in generation and in loads should be considered prior to planning any other moves to improve power storage for renewable energy sources. As illustrated in the findings of this study, the issues of power quality and reliability suggested some gaps that should be addressed by companies in heavy industry if they want to pursue their long-term sustainability objectives. In dealing with the emergence of new energy sources, the respective organizations were expected to be more flexible and adaptive to changing industry and organizational conditions.

It has been found that when people lack the knowledge to implement certain modifications required for changing the energy mix, the results could be devastating for stakeholders in heavy industry. They would be unable to make reasonable decisions that would bring them more opportunities to add value. As a result, companies in heavy industry may deteriorate their performance over time. In the conditions of the current geopolitical situation, the efforts of companies in heavy industry to improve the sustainability of their energy mix have been additionally challenged. This can be explained by the emergence of new constraints, particularly the disruptions across the supply chain caused by the pandemic, as well as persistently increasing inflation around the world.

These factors have been considered limiting the sustainability performance of companies in heavy industry, especially in the context of growing uncertainty and chaos reflected in countries' economic systems. Therefore, the transition of companies in heavy industry to a more sustainable energy mix is an issue that is yet to develop in the future, which means new factors and events may unfold that will impact the respective process.

7.1.2 Quantitative research insights

While consensus was not reached among respondents on the optimal strategy for transforming the energy mix, diverse viewpoints emerged, highlighting the complexity of the task. For instance, in achieving transformation goals, some respondents emphasized the necessity of cost justification for adjusting an energy system's mix, while others advocated for embracing changes.

In the realm of risk identification, no single best practice was agreed upon. However, several key strategies were suggested by the respondents, including considering potential limiting factors in goal setting, maintaining records of risk occurrences, their causes, and potential repercussions, and keeping abreast of current and future challenges. These strategies underscore the interrelationship between enhanced risk identification and successful transformation of the energy mix.

Similarly, in risk analysis, respondents offered various approaches, such as critically addressing risk effects, incorporating risk potential in decision-making, and ensuring effective communication of risks across organizations. These practices, although varied, all contribute to an improved transformation of the energy mix.

In the field of risk evaluation, respondents highlighted different practices such as researching minimizable risks, considering resource allocation and urgency in risk prioritization, and taking into account the severity and environmental influences of risks. These diverse viewpoints reiterate that enhanced risk evaluation can facilitate the transformation of the energy mix.

For risk treatment, respondents suggested practices such as reducing risks to manageable levels, evaluating the cost-effectiveness of risk mitigation strategies, ensuring adequate resources for risk reduction, and assigning responsible individuals for risk management. These practices, although not universally agreed upon, have the potential to improve the transformation of the energy mix.

Lastly, in risk monitoring and review, respondents proposed practices like dedicated staff for risk assessment, tracking changes in risk profiles, and considering shifting risk profiles over time. These practices, despite the lack of consensus, are associated with improvements in the transformation of the energy mix.

In conclusion, this study highlights that while no single best solution exists for risk identification, analysis, evaluation, treatment, and monitoring in the context of energy mix transformation, a variety of potentially effective strategies have been suggested. These strategies, particularly risk evaluation, play a crucial role in the transformation process and should be given due consideration in heavy industrial settings.

7.1.3 Conclusion

In conclusion, the transition to a sustainable energy mix in heavy industries is a complex yet crucial process that requires strategic planning, effective risk management, and a comprehensive understanding of transformational processes. This study illuminates the importance of these factors and contributes to an under-researched area in the literature.

By employing an interdisciplinary approach, this research not only provides insight into the strategic dimensions of the energy transition but also offers a risk management perspective, which is critical given the potential challenges and uncertainties involved in such a transition. The interplay between these factors and the transformation process has been underscored, and the research provides substantial evidence that a successful energy transition in heavy industries necessitates a careful balancing act between these dimensions.

The main conclusion from the study is that there are numerous risks related to changing the energy mix in heavy industry. Therefore, managers and leaders in this industry sector should demonstrate substantial efforts to adopt more effective and sustainable strategies that could lead to optimal outcomes over the long term.

It was also concluded that risk evaluation positively and significantly affects the transformation of the energy mix. Furthermore, it was noted that risk analysis positively and insignificantly affects the transformation of the energy mix. The researcher also concluded that risk identification positively and insignificantly affects the transformation of the energy mix, which shows that risk monitoring and review positively and insignificantly enhances the transformation of the energy mix. Finally, risk treatment positively and insignificantly enhances the transformation of energy mix.

This research is timely and pertinent, given the mounting pressure on industries worldwide to adopt more sustainable practices and reduce their carbon footprints. It is hoped that the insights garnered from this study will inform industry strategies, shape policy decisions, and stimulate further academic inquiry into this important subject matter.

However, the study also highlights the need for further research. While it provides a foundation, future research should delve deeper into the specific strategies and risk management approaches that are most effective in different industrial contexts. Moreover, there is a need to understand how these processes can be accelerated while ensuring minimal disruptions to existing operations.

This research takes a step towards a more sustainable future, but the journey is far from over. As industries continue to evolve and innovate, so too must our understanding and approach to achieving a sustainable energy mix in the heavy industry sector.

7.2 The main contributions to theory and practice

This study has made significant contributions to both theoretical understanding and the practice of policy making. The study presented a recent overview of the means of achieving a sustainable energy mix in the heavy industry, with consideration given to strategic development and risk management. A great part of the revised literature is dedicated to the sustainable transformation process concentrate on either specific technical modifications that can be implemented to reduce emissions or on advanced tools used to ensure the sustainability of certain manufacturing processes. Concurrently, there was a paucity of knowledge regarding the means by which enterprises operating within the heavy industrial sector could attain a sustainable energy mix through the implementation of effective strategic development and risk management practices. Consequently, the principal contribution of this study to the theoretical domain pertains to the insights it has yielded concerning the realisation of a sustainable energy mix within the context of strategic and risk management considerations.

The study departs from transition theory and empirically proves how sociotechnical change in heavy industries is pushed under the consideration of risk management. Therefore, the study provides a valuable theoretical contribution towards a more sustainable policy design. The contribution of this study to theory also involves the introduction of specific aspects of strategic development and risk management that are crucial for launching sustainability initiatives in the heavy industry. For instance, the thesis produced detailed information about the particular risk evaluation, treatment, and monitoring techniques that are used to achieve a sustainable energy mix. Furthermore, it also should be noted that the current study presented an overview of the main challenges related to the sustainable transformation process, such as vague and misleading regulations, high initial costs, poor infrastructure, and grid stability risks.

The study makes a significant contribution to policy-making practices by offering a comprehensive set of recommendations for supporting the implementation of sustainability initiatives in the heavy industry:

- First, it demonstrates the necessity of undertaking a comprehensive cost-benefit analysis prior to the implementation of any sustainability initiatives. The initial costs and deployment expenses associated with sustainability initiatives represent a significant barrier to the transformation process. Consequently, it is imperative that companies operating in the heavy industry undertake a comprehensive assessment of the potential benefits and costs, and identify the most efficient solutions, prior to launching such initiatives.

- Second, it is advised that firms implement consistent risk management strategies which address risks in a systematic manner, based on the factors of urgency and severity.
- Thirdly, enterprises in the heavy industry should implement bespoke risk evaluation, treatment and monitoring tools, given that the study revealed the absence of a universal risk management strategy. In conclusion, the study also demonstrated the necessity of allocating dedicated personnel to risk monitoring tasks in order to detect potential threats in advance and prevent them using the systematic approach previously described.

The findings of this research provide a set of recommendations for companies operating in heavy industries. They illustrate that even though transitioning to alternative fuels is a promising solution for promoting sustainability, it is not always justified from the perspective of costs and potential benefits. Therefore, firms are recommended to approach energy transition in a thorough manner, carefully considering possible advantages and disadvantages of each option. For instance, whereas solar and wind energy can potentially result in cost savings, they might always make the energy mix less flexible and contribute to the risk of energy disruptions. Moreover, the study did not discover one-fit-all solutions that would apply to all cases. Thus, companies are supposed to develop customized strategies that are based on their internal resources, business strategies, and external environments.

7.3 Research limitations and future research

The research focused on implementing a sustainable energy mix for industrial enterprises that are heavy energy users. The scope of industrial sectors or enterprises covered in this study is therefore limited. Technologies and processes in the various industrial subsectors can be accounted for only approximated with this approach. Disruptive technological changes in the production processes were not included in the model approach. The number of experts that were questioned limits the empirical research base. Another important limitation of this study is the fact that the term “heavy industry” is broad and includes numerous sectors that might display different industry-specific characteristics, whereas the companies from these sectors can operate in different environments. As a result, most findings of this study are broad. Practitioners should customize these recommendations based on the unique specifics of particular industries before implementing these suggestions to achieve a sustainable energy mix.

The available evidence provides a compelling reason to believe that the focus on heavy industries of different countries prevented the thesis from considering the specific implications of policies and regulations for the process of achieving a sustainable energy mix. Therefore, the recommendations produced in this study have to be evaluated and modified in light of relevant policies. Finally, the last limitation is that the data were collected based on the respondents' perceptions. Therefore, it is possible that the participants' biases have been incorporated into the data. This limitation, however, is hardly significant because the use of a large sample and a mixed research method minimized the likelihood of bias risks that could threaten the validity of this study.

The results of this study can serve as a solid basis for future studies dedicated to the energy mix in heavy industries. It might be a promising idea to explore the specifics of different industries from the perspective of adopting energy mix to identify those sectors that are especially likely to adopt alternative fuels and succeed in the decarbonization process. Moreover, future research would benefit from incorporating specific insights into the energy mix transformation in the heavy industries of different countries. The nuanced insights into the adoption of renewables instead of fossil fuels would help better understand the problem under investigation, advancing the existing knowledge of the most effective strategies to decarbonize heavy industries.

7.4 Policy Implications

In fact, this research showed that risk evaluation is especially high in heavy industries as was shown in figure 46. This underscores the importance of evaluative steps that might be strengthened in the future. Respondents also pointed strongly to risk identification, but less to risk treatment. This is an important finding since it shows that the evaluative component has to be strengthened. Hence, policy making should engage strongly in developing the necessary tools to face these needs and to address the needs that were highlighted by the respondents. Especially the structural model coefficients in table 47 show that needs are especially high regarding the monitoring of risks. Here, the need of risk monitoring and review (P Value: 0.747) was among the highest value. This means that measures should be taken to display risks and make them more tangible for discussions. Here it is important to note that risk perceptions varied among the different branches and in regard to the specific needs of the regarding industries. These needs might vary strongly in regard to specific industrial practices, among them refining materials and resources or manufacturing since energy intensity varies dramatically and existing regularity frameworks like the EU ETS.

The data highlight very low risk treatment values (table 47, P: 0.082). This shows a striking gap between practice and needs and might be a signal to enhance evaluative – and by so doing – strategic policy capacity. The perception of the respondents might therefore be guidance to call more stakeholder-oriented knowledge production and -consolidation into place. There are several anchor points to do so. One is a better organization of industrial associations among each other to pave the way for a more tangible knowledge production about the needs and perceptions of industries regarding risks during energy transformations. Such bottom-up initiatives exist already in the DACH region and have a long tradition and might serve as good platforms to identify risks. Riks identification ranks relatively low (table 47, P: 0.284) compared to risk treatment and monitoring. One of the reasons might be that identification patterns differ among respondents and that transformation pathways take different speeds among heavy industrial branches. For instance, emission trading is seen as risky, as ably shown by Azadi et al. (2020): emission targets strongly differ to manufacturing (Johnson et al. 2021: 2) and this might cause distortions in the data and thus hints to different policy needs.

Apart form this bottom-up knowledge production intermediate policy levels might help to gather relevant data and information. One necessity is therefore to address these variations regarding the specific policy actions to address risks. This has not been the scope of this thesis and needs further evaluation. This is important to merge the perceptions of risks with policy making steps to establish necessary tools. One good example for such actions is European Resource Strategy of the European

Commission that established an evaluation framework for risk evaluation of resource availability for manufacturing industries that was taken up also by industrial associations, monthly displaying availability risks of precious metals. Such a monitoring frameworks might establish a solid set of data that might be able to display risks among the different branches of heavy industries.

From this point of view both levels, the policy level and the industrial level need to work together in an intertwined manner. The important task is ere to account for the wide range of possible strategies that the date of this thesis suggests. Governments have a significant role to play in directing the trajectory of heavy industries towards a sustainable and renewable future. This responsibility lies not only in the realm of policymaking but extends to the provision of financial support, public education, and the setting of a positive example.

Also, the instrumental level should be considered more rigorously by governments based on long-term evaluations above. The following paragraphs highlight important cornerstones of instruments. Therefore, the following points can be identified as crucial to design renewable energy-mixes for heavy industries.

Legislation and Regulation: The foundation of sustainable development in heavy industry is a robust framework of legislation and regulation. This was shown to be one of the key points that emerged during the analysis. Herer it is vital to keep in mind the timing of policy making (Ofélia edt al. 2024) and investments (Raihan et al. 2024). Governments must establish stringent regulations on emissions and waste production to mitigate environmental impact. These regulations should not merely be prohibitive but should actively encourage industries to integrate sustainability into their operations. This could be achieved through a system of incentives for those industries demonstrating a commitment to green practices, such as reduced tax obligations or preferential access to government contracts. Conversely, penalties could be used to deter non-compliant behaviours, such as fines or restrictions on operations for industries that exceed permissible emission levels. The goal of such legislation should be not only to limit the adverse effects of industrial activities but also to foster a corporate culture that values sustainability. This will only be achievable with a more comprehensive aim of policy cooperation between heavy industries and policy making, as also shown by Elavarasan et al. 2020. This will ultimately lead to new policy problems that will have to be envisaged when facing the variety of climate- and capital-related problems (Hainsch et al. 2022).

Subsidies and Grants: Transitioning to greener alternatives often involves significant upfront costs, which can be a barrier for many heavy industries. Governments can facilitate this transition by providing financial support in the form of subsidies and grants. These could be directed towards the acquisition and installation of renewable energy technologies, such as solar panels or wind turbines, which would simultaneously reduce the industry's carbon footprint and its long-term energy costs. Similarly, tax incentives could be offered to industries that adopt sustainable practices, such as waste reduction or recycling initiatives. Governments could also provide funding for research and development in the field of sustainable technologies, thereby fostering innovation and promoting the adoption of cutting-edge practices within the industry. Participants underlined the urgent need for R&D-subsidies, that are needed for a profound transition.

Education and Public Awareness: Beyond the confines of the heavy industry sector, governments have a responsibility to educate the public about the importance of sustainable development and renewable energy. This can be achieved through public awareness campaigns, educational programs in schools, and the promotion of sustainable practices within the public sector. By fostering a culture of sustainability within society at large, governments can stimulate demand for sustainable products and services, thereby creating a market incentive for heavy industries to adopt green practices. In addition, a more informed public can exert pressure on industries to act responsibly and can make more informed decisions in their consumption habits.
On the other hand industrial practitioners also have a critical part to play in driving sustainable development within heavy industries.

Invest in Renewable Energy: Transitioning to renewable energy sources is a primary strategy for heavy industries to reduce their environmental footprint. This could involve investing in renewable energy infrastructure such as wind turbines, solar panels, or biomass facilities. Additionally, industries can explore entering into power purchase agreements with renewable energy providers, securing a steady supply of green energy and supporting the renewable energy sector simultaneously. In the industrial sector, cement production is one of the most CO2-intensive activities. It is responsible for five per cent of global CO2 emissions. This is mainly due to the large proportion of new plants in these growing markets (Napp et al. 2014). Compared to these countries and also to the global average, European cement production still offers comparatively large potential for efficiency improvements.This can be attributed to the stagnating demand for cement in Europe. Since most cement producers are globally active, they tend to make investments in emerging markets with growing demand, while production in Europe takes place in comparatively old, inefficient plants. This creates the risk that the European suppliers of cement manufacturers, together with the plants they build, will move to other regions of the world. Renewable energy policy could strengthen incentives for additional investments and innovations in the European cement sector (Raihan et al. 2024). Policymakers should therefore also explore energy storage options to balance the intermittency of some renewable sources.

However, energy intensity is determined by the efficiency of existing buildings, industrial production and transport infrastructure and thus changes only slowly. This results in the biggest challenge for carbon pricing: it leads to temporarily higher energy costs until these are offset by improved energy efficiency. In the industrial sector, special regulations are therefore necessary to protect very energy-intensive production from carbon leakage (Liu et al. 2024). For countries with a lower per capita gross domestic product, the calculations of the European Commission show large investment potentials for energy efficiency; at the same time, it is emphasised that the capital necessary for investments is available at very different conditions and costs (Hu et al. 2024).

Sustainable Operations: Heavy industries should strive to incorporate sustainability into every aspect of their operations. This goes beyond energy consumption to include areas like waste management, water usage, and raw material sourcing. Reducing waste could involve implementing lean manufacturing principles, optimizing processes to use less raw materials, and finding ways to reuse or recycle waste products. Improving energy efficiency could be achieved through updating old equipment, adopting new technologies, or optimizing operational procedures. Adopting circular economy principles can also lead to more sustainable operations, by designing products to be reused or recycled at the end of their life and using recycled materials in manufacturing processes.

Policymakers should take the slow development of R&D in the field of renewable energies into account when making predictions about the effects of renewable energy policies for heavy industries.

Stakeholder Engagement: Stakeholders, including customers, employees, investors, and the local community, are increasingly concerned about the environmental impact of businesses. Heavy industries should actively engage with these stakeholders about their sustainability efforts. Transparent reporting on sustainability metrics, such as carbon emissions, water usage, and waste production, can demonstrate a commitment to sustainability and build trust with stakeholders. Industries could also seek stakeholder input on sustainability initiatives, through methods like surveys, interviews, or public consultations. Engaging stakeholders in this way can provide valuable insights and foster a shared sense of responsibility for sustainable development.

Innovation: Sustainability challenges cannot be overcome without innovation. Heavy industries should continue to innovate and develop new technologies or processes that can improve sustainability. This could involve investing in research and development, either independently or in collaboration with universities, research institutions, or other businesses. It could also involve seeking out and implementing innovative solutions developed by others, through methods like technology transfer, licensing, or strategic partnerships. Innovation is not limited to technology; it can also involve developing new business models, strategies, or organizational structures that support sustainable development.

The study recommends that future researchers should examine factors affecting the transformation of the energy mix in non-heavy industries. Moreover, the effect of strategy development on risk management and consequently the achievement of a sustainable energy mix should also be examined. This may entail a structural equation modelling approach with mediation effects captured. This will be very interesting in informing pertinent stakeholders of new tactics to enhance the transformation of the energy mix in heavy industry.

7.5 Recommendations for further research

Several recommendations for further research can be suggested based on the results of this study. First, scientists are recommended to conduct a series of case studies that focus on the heavy sectors of specific countries. Such an approach would allow for considering the unique role of different regulations and policies in shaping the process of transforming the operations of companies in heavy sectors toward the achievement of a sustainable energy mix. Second, scholars should analyse the distinctive features of specific industries to uncover the significance of industry-specific factors that drive the effectiveness of various risk management strategies in mitigating the threats related to the adoption of sustainable practices in the heavy industry. Finally, the third recommendation for further research is to conduct semi-structured interviews with entrepreneurs and senior managers to collect more data on the barriers and enablers to the transformation process. Unfortunately, it was not possible to conduct such interviews in the current study because of the strict quarantine measures amidst the COVID-19 pandemic; therefore, this issue should be addressed in further research.

7.6 Word count of the thesis

The following figure presents the number of words per chapter. It also shows the weight in percentage per chapter compared to total word count of the thesis. Due to the large number of chapters und subsections, the word count is only broken down to the second level (1.x):

#	Chapter	Word count	Weighting
-	**Abstract**	313	0,41%
1	**CHAPTER ONE – INTRODUCTION**	8297	10,90%
1.1	Research background	4435	
1.2	Statement of the research problem	1880	
1.3	Research question	735	
1.4	Research aim and objective	188	
1.5	Significance of the study	857	
1.6	Structure of the thesis	228	
2	**CHAPTER TWO – LITERATURE REVIEW**	10165	13,36%
2.1	Introduction	461	
2.2	Definitions of heavy industry	1225	
2.3	The importance of renewable energy	684	
2.4	Renewable energy and energy mix	222	
2.5	Sustainability initiatives in heavy industries	121	
3	**CHAPTER THREE – POLICIES SUPPORTING SUSTAINABILITY**	19082	25,08%
3.1	Introduction to the chapter	281	
3.2	Definitions of heavy industry	548	
3.3	The importance of renewable energy for heavy industries	1293	
3.4	Renewable energy and energy mix	2641	
3.5	Sustainability initiatives in heavy industries	1828	
3.6	Strategy development	1779	
3.7	Risk mangement	1409	
3.8	Stakeholder and sustainability	220	
3.9	Environmental policies and the Kyoto protocol	1209	
3.10	National approaches to environmental sustainability in the DACH region	3562	
3.11	Renewable energy in the DACH region	2214	
3.12	Factors influencing development of renewable energy	1103	
3.13	Summary	245	
4	**CHAPTER FOUR – THEORETICAL FRAMEWORK**	3519	4,62%

4.1	Frameworks on strategy and risk management	551	
4.2	Theories on strategic management	2035	
4.3	Theories on sustainability	969	
5	**CHAPTER FIVE – RESEARCH METHODOLOGY**	10646	13,99%
5.1	Research paradigm	1898	
5.2	Research perspective	752	
5.3	Research strategy	1069	
5.4	Mixed method approach	824	
5.5	Triangulation	388	
5.6	Data analysis approaches	1391	
5.7	Reliability and validity in quantitative research	2004	
5.8	Reliability and validity in qualitative research	1187	
5.9	Justification	1133	
6	**CHAPTER SIX – RESEARCH FINDINGS**	18862	24,79%
6.1	Introduction	93	
6.2	Response rate	196	
6.3	Qualitative research findings	7844	
6.4	Quantitative research findings	6990	
6.5	Discussions	3739	
7	**SUMMARY, CONCLUSION AND RECOMMENDATIONS**	5210	6,85%
7.1	Summary	1804	
7.2	The main contributions to theory and practice	607	
7.3	Research limitations and future research	382	
7.4	Policy implications	1874	
7.5	Recommendations for further research	179	
7.6	Word count of the thesis	364	
Total countable words		76094	
Total words		84670	

Figure 48: Own illustration – Word count of the thesis

8 REFERENCES

Abadie, A. and Gardeazabal, J., 2003. The economic costs of conflict: A case study of the Basque country. *American Economic Review*, vol. 93, pp. 113-132.

Abadie, A., Diamond, A. and Hainmueller, J., 2010. Synthetic control methods for comparative case studies: Estimating the effect of California's tobacco control program. *Journal of the American Statistical Association*, vol. 105, pp. 493-505.

Abadie, A., Diamond, A. and Hainmueller, J., 2015. Comparative politics and the synthetic control method. *American Journal of Political Science*, vol. 59, pp. 495-510.

Agarwal, N., Lim, M. and Wigand, R. T., 2011. Collective action theory meets the blogosphere: A new methodology. *Communications in Computer and Information Science*, vol. 136, no. 3, pp. 224-239.

Aguirre-Urreta, M. I. and Hu, J., 2019. Detecting common method bias: Performance of the Harman's single-factor test. *ACM SIGMIS Database: the DATABASE for Advances in Information Systems*, vol. 50, no. 2, pp. 45-70.

Aguirre-Urreta, M. I. and Rönkkö, M., 2018. Statistical inference with PLSc using bootstrap confidence intervals. *MIS Quarterly*, vol. 42, no. 3, pp. 1001-1020.

Agalwood, K., Ali, T., Chiu, Y. R., & Sharifi, A. (2023). Optimal site selection for the solar-

wind hybrid renewable energy systems in Bangladesh using an integrated GIS-based BWM-fuzzy logic method. *Energy Conversion and Management*, *283*, 116899.

Ahmad, T. and Zhang, D., 2020. A critical review of comparative global historical energy consumption and future demand: The story told so far. *Energy Reports*, vol. 6, pp. 1973-1991.

Aichele, R. and Felbermayr, G. J., 2012. Kyoto and the carbon footprint of nations. *Journal of Environmental Economics and Management*, vol. 63, no. 3, pp. 336-354.

Al-Ababneh, M. (2020) *Ontology and Forecasting in Renewable Energy Systems*. London: Wiley.

Al Qubtan, T. R., Gan, P. T., Hadi, F. S., Jalil, N. A. and Rambeli, N., 2021. Practical risk management approaches among small and medium enterprises. *TEM Journal*, vol. 10, no. 2, pp. 996-1004.

Al-Kindi, L.A.H., 2016. Sustainability for heavy engineering equipment industries using lean concepts. *Engineering & Technology Journal*, vol. 34, no. 4, pp. 739-753.

Anderhofstadt, B. and Spinler, S., 2019. Factors affecting the purchasing decision and operation of alternative fuel-powered heavy-duty trucks in Germany – A Delphi study. *Transportation Research Part D: Transport and Environment*, vol. 73, pp. 87-107.

Archer, M., Bhaskar, R., Collier, A., Lawson, T. and Norrie, A., eds., 1998. *Critical Realism: Essential Readings*. London: Routledge.

Aronova, E. S., Grilikhes, V. A. and Shvarts, M. Z., 2008. Optimization of arrangement of photoelectric power plants with radiation concentrators in solar electric power plant design. *Applied Solar Energy*, vol. 44, pp. 237-242.

Atilhan, S., Park, S., El-Halwagi, M.M., Atilhan, M., Moore, M. and Nielsen, R.B., 2021. Green hydrogen as an alternative fuel for the shipping industry. *Current Opinion In Chemica. Engineering*, vol. 31, no. 100668.

Avato, P. and Coony, J., 2008. Accelerating clean energy technology research, development, and deployment: Lessons from non-energy sectors. *World Bank Working Paper No. 138.*

Azadi, M., Northey, S.A., Ali, S.H. and Edraki, M., 2020. Transparency on greenhouse gas emissions from mining to enable climate change mitigation. *Nature Geoscience*, vol. 13, pp. 100-104.

Azadnia, A. H., McDaid, C., Andwari, A. M., & Hosseini, S. E. (2023). Green hydrogen supply chain risk analysis: A european hard-to-abate sectors p erspective. *Renewable and Sustainable Energy Reviews*, *182*, 113371.

Bachmann, G., 2022. How to successfully encourage sustainable development policy: Lessons from Germany. New York: Taylor & Francis.

Baležentis, T. and Štreimikienė, D., 2019. Sustainability in the electricity sector through advanced technologies: Energy mix transition and smart grid technology in China. *Energies*, vol. 12, no. 6, pp. 1-21.

Banos, R., Manzano-Agugliaro, F., Montoya, F. G., Gil, C., Alcayde, A. and Gomez, J.,

2011. Optimization methods applied to renewable and sustainable energy: A review. *Renewable and Sustainable Energy Reviews*, vol. 15, pp. 1753-1766.

Bans-Akutey, A. and Tiimub, B. M., 2021. Triangulation in research. *Academia Letters*, vol. 2, no. 3392, pp. 1-7.

Bao, Y., 2017. *Technologies and Development Potential of Renewable Energy Sources*. *Renewable Energy Advances*, 29(4), pp. 95-115.

Baranzini, A., van den Bergh, J. C., Carattini, S. andHowarth, R. B., 2017. Carbon pricing in climate policy: Seven reasons, complementary instruments, and political economy considerations. *WIREs*, vol. 8, no. 4, p. e462.

Barrett, S., 1998. Political economy of the Kyoto protocol. *Environmental Policy*, vol. 14, no. 4, pp. 20-39.

Bataille, C. G. (2020). Physical and policy pathways to net-zero emissions industry. Wiley Interdisciplinary Reviews: Climate Change, 11(2), e633. Li, C., Chen, Y., & Shang, Y. (2022). A review of industrial big data for decision making in intelligent manufacturing. Engineering Science and Technology, an International Journal, 29, 101021.

Bataille, G.F., 2019. Physical and policy pathways to net-zero emissions industry. *WIREs Climate Change*, vol. 11, no. 2, e633.

Becker, J.-M., Ringle, C. M., Sarstedt, M. and Völckner, F., 2015. How collinearity affects mixture regression results. *Marketing Letters*, vol. 26, no. 4, pp. 643-659.

Beers, P. J. and Van Mierlo, B. C., 2017. Reflexivity and learning in system innovation processes. *Sociologia Ruralis*, vol. 57, no. 3, pp. 415-436.

Bengston, D. N., 2019. Futures research methods and applications in natural resources. *Society & Natural Resources*, vol. 32, no. 10, pp. 1099-1113.

Blazejczak, J., Edler, D., Schill, W. P. and Braun, F. G., 2011. Economic effects of renewable energy expansion: A model-bases analysis for Germany. *Renewable and Sustainable Energy Reviews*, vol. 40. DOI: 10.2139/ssrn.1940413

Blommaert, J., 2001. Content is/as critique. *Critique of Anthropology*, vol. 21, no. 1, pp. 13-32.

Bogdan, R. C. and Biklen, S. K., 2007. Qualitative Research for Education: An Introduction to Theory and Methods. Boston: Allyn and Bacon.

Bogdanov, D., Ram, M., Aghahosseini, A., Gulagi, A. and Oyewo, A. S., 2021. Low-cost renewable electricity as the key driver of the global energy transition towards sustainability. *Energy*, vol. 227, 120467.

Booth, A., Noyes, J., Flemming, K., Gerhardus, A., Wahlster, P., van der Wilt, G.J., Mozygemba, K., Refolo, P., Sacchini, D., Tummers, M. and Rehfuess, E., 2018. Structured methodology review identified seven (RETREAT) criteria for selecting qualitative evidence synthesis approaches. *Journal of Clinical Epidemiology*, vol. 99, pp. 41-52.

Bosch, J. L., Batlles, F. J. and Lopez, G., 2008. Daily solar irradiation estimation over a mountainous area using artificial neural networks. *Renewable Energy*, vol. 33, no. 7, pp. 1622-1628.

Boulding, K., 1978. The legitimacy of the businesss institution. In Epstein, E. and Votaw, D. (eds.), *Rationality, Legitimacy, Responsibility: Search for New Directions in Business and Society*. Santa Monica: Goodyear Publishing.

Boulding, K. (1978) *Evolving Economic Systems*. Boulder, CO: Westview Press.

Boutillier, S. and Ryckelynck, P., 2017. Sustainable entrepreneurs: quantifying opportunities and social networks, case study on sustainable entrepreneurs in a heavy industrial area. *International Journal of Entrepreneurship and Small Business*, vol. 31, no. 1, pp. 85-102.

Bracken, S., 2010. Discussing the importance of ontology and epistemology awareness in practitioner research. *Worcester Journal of Learning and Teaching*, vol. 4, pp. 1-9.

Brannen, J., 2005. Mixing methods: The entry of qualitative and quantitative approaches into the research process. *The International Journal of Social Research Methodology*, vol. 8, no. 3, pp. 173-185.

Bryman, A. and Bell, E., 2015. *Business Research Methods*. Oxford: Oxford University Press.

Bryman, A., 1988. Quality and Quantity in Social Research. London: Routledge.

Buehler, R., 2011 [online]. *How Germany became Europe's green leader: A look at four decades of sustainable policymaking*. Available at: https://www.resilience.org/stories/2011-10-10/how-germany-became-europes-green-leader-look-four-decades-sustainable-policymaki/ [accessed on

27/12/23].

Burke, M. J. and Stephens, J. C., 2018. Political power and renewable energy futures: A critical review. *Energy Research & Social Science*, vol. 35, pp. 78-93.

Burrell, G. and Morgan, G., 1979. Sociological Paradigms and Organizational Analysis: Elements of the Sociology of Corporate Life. New York: Heinemann Educational Books.

Campbell, R., Goodman-Williams, R., Feeney, H. and Fehler-Cabral, G., 2020. Assessing triangulation across methodologies, methods, and stakeholder groups: The joys, woes, and politics of interpreting convergent and divergent data. *American Journal of Evaluation*, vol. 41, no. 1, pp. 125-144.

Carter, N, Bryant-Lukosius, D., DiCenso, A., Blythe, J., and Neville, A. J. 2014. The use of triangulation in qualitative research. *Oncology Nursing Forum*, vol. 41, no. 5, pp. 545-7.

Cavaye, A. L., 1996. Case study research: A multi-faceted research approach for IS. *Information Systems Journal*, vol. 6, no. 3, pp. 227-242.

Chakabva, O., Tengeh, R. and Dubihlela, J., 2021. Factors inhibiting effective risk management in emerging market SMEs. *Journal of Risk and Financial Management*, vol. 14, pp. 1-12.

Chandler, A. D., 1969. Strategy and Structure: Chapters in the History of the American Industrial Enterprise. Cambridge: MIT Press.

Chartered Management Institute, 2020 [online]. *Developing Strategy*. Available at:https://www.managers.org.uk/wp-content/uploads/2020/04/CHK-258-Developing-Strategy.pdf [accessed on 29/06/22].

Chick, A. and Micklethwaite, P., 2017. Design for sustainable change: How design and designers can drive the sustainability agenda. New York: Bloomsbury Publishing.

Chinnathai, M. K., & Alkan, B. (2023). A digital life-cycle management framework for sustainable smart manufacturing in energy intensive industries. *Journal of Cleaner Production*, *419*, 138259.

Ciucci, M., 2020 [online]. *Internal Energy Market*. Available at:https://www.europarl.europa.eu/factsheets/en/sheet/45/internal-energy-market [accessed on 02/07/22].

Clayton, D. L. K., Rogers, S. and Stuifbegen, A., 1999. Answers to unasked questions: Writing in the margins. *Research in Nursing and Health*, vol. 22, pp. 512-522.
Clough, P. and Nutbrown, C., 2012. *A Student's Guide to Methodology*. London: Sage.
Cohen, J., 1988. Statistical power analysis for the behavioral sciences. Mahwah, NJ: Lawrence Erlbaum.
Cohen, L., Manion, L. and Morrison, K., 2017. Validity and reliability. In *Research Methods in Education* (pp. 245-284). New York: Routledge.
Cook, P. J., 2012. *Clean Energy, Climate and Carbon*. Boca Raton, FL: CRC Press.
COP26, 2021 [online]. *UN Climate Change Conference (COP26) at the SEC – Glasgow 2021*. Available at: https://ukcop26.org/ [accessed on 19/02/22].
Copeland, B. and Taylor, M. S., 2005. Free trade and global warming: A trade theory view of the Kyoto protocol. *Journal of Environmental Economics and Management*, vol. 49, no. 2, pp. 205-234.
Corbin, J. M. and Strauss, A., 1990. *Basics of Qualitative Research*. London: Sage.

Creswell, J. W., 2003. Research Design: Qualitative, Quantitative and Mixed Method Approaches. Thousand Oaks, CA: Sage.
Cypress, B. S., 2017. Rigor or reliability and validity in qualitative research: Perspectives, strategies, reconceptualization, and recommendations. *Dimensions of Critical Care Nursing*, vol. 36, no. 4, pp. 253-263.
Danks, N. P. and Ray, S., 2018. Predictions from partial least squares models. In F. Ali, S.M.Rasoolimanesh, & C. Cobanoglu (Eds.), Applying partial least squares in tourism and hospitality research (pp. 35-52). Bingley: Emerald
Darwish, S. Z., Gomes, A. M. and Ahmed, U., 2021. Risk management strategies and impact on sustainability: The disruptive effect of Covid 19. *Academy of Strategic Journal*, vol. 20, no. 2, pp. 1-19.
Davidson, D. J. and Gismondi, M., 2011. *Challenging Legitimacy at the Precipice of Energy Calamity*. New York: Springer.
De Vaus, D., 2001. *Research Design in Social Research*. London: Sage.
Deb, P., Furceri, D., Ostry, J. D. and Tawk, N., 2021. Creative destruction during crises-An opportunity for a cleaner energy mix. *IMF Working Papers*, 284.

Deegan, C. and Rankin, M., 1999. The environmental reporting expectations gap: Australian evidence. *British Accounting Review*, vol. 31, pp. 313-346.

Deegan, C., Rankin, M. and Tobin, J., 2002. An examination oft he corporate social and environmental disclosures BHP from 1983-1997: A test of legitimacy theory. *Accounting, Auditing & Accountability Journal*, vol. 15, no. 3, pp. 312-343.

Delors, J., Vinois, J. A. and Andoura, S., 2015 [online]. *From the European Energy Community to the Energy Union*. Available at: https://www.euractiv.com/section/energy/opinion/from-the-european-energy-community-to-the-energy-union/ [accessed on 02/07/22].

Dennis, J., 2019 [online]. Venturing into Heavy Industry: Exploring the Role of Venture Capital Financing in Industrial Cleantech Innovation in the Nordic Region. Available at:https://lup.lub.lu.se/luur/download?func=downloadFile&recordOId=8997122&fileOId=8997124 [accessed on 02/07/22].

Denscombe, M., 2002. Ground Rules for Good Research: A 10 Point Guide for Social Researchers. New York: Open University Press.

Diamantopoulos, A., Sarstedt, M., Fuchs, C., Wilczynski, P. and Kaiser, S., 2012. Guidelines for choosing between multi-item and single-item scales for construct measurement: A predictive validity perspective. *Journal of the Academy of Marketing Science*, vol. 40, no. 3, pp. 434-449.

Diesing, P., Lopez, G., Blechinger, P., & Breyer, C. (2025). From knowledge gaps to technological maturity: A comparative review of pathways to deep emission reduction for energy-intensive industries. *Renewable and Sustainable Energy Reviews*, *208*, 115023.

Dijkstra, T.K., & Henseler, J., 2015. Consistent partial least squares path modeling. *MIS Quarterly*, vol. 39, no. 2, pp. 297-316.

Dijkstra, T.K., 2010. Latent variables and indices: Herman Wold's basic design and partial least squares. Handbook of partial least squares: Concepts, methods and applications Springer Handbooks of Computational Statistics Series, vol. 2, pp. 23-46

Dijkstra, T.K., 2014. PLS' Janus face-Response to Professor Rigdon's "Rethinking partial least squares modeling: In praise of simple methods". *Long Range Planning*, vol. 47, no. 3, pp. 146-153.

Dincer, I., 2000. Thermodynamics, exergy and environmental impact. *Energy Sources*, vol. 22, no. 8, pp. 723-732.

Dowling, J. B. and Pfeffer, J., 1975. Organizational legitimacy: Social values and organizational behavior. *Pacific Sociological Review*, vol. 18, no. 1, pp. 122-136.

Duc, T., Coupiac, O., Girard, N., Giebel, G. and Gocmen, T., 2019. Local turbulence parameterization improves the Jensen wake model and ist implementation for power optimization of an operating wind farm. *Wind Energy Science*, vol. 4, no. 2, pp. 287-302.

Dufo-Lopez, R., Yusta, J. M. and Monreal, I. R., 2016. Stochastic-heuristic methodology for the optimisation of components and control variables of PV-wind-diesel-battery stand-alone systems. *Renewable Energy*, vol. 99, pp. 919-935.

Dyson, R. G., Bryant, J., Morecroft, J. and O'Brien, F., 2007. The strategic development process. In O'Brien, F. and Dyson, R. G. (Eds.), *Supporting Strategy: Frameworks, Methods and Models* (pp. 3-24). Chichester, UK: John Wiley & Sons.

De Bruyn, S., Jongsma, C., Kampman, B., Gorlach, B. and Thie, J. E., 2020. *Energy-intensive industries: Challenges and opportunities in energy transition*. Luxembourg: Policy Department for Economic, Scientific and Quality of Life Policies.

Easterby-Smith, M., Thorpe, R. and Lowe, A., 2002. *Management research: An introduction*. London: Sage.

Eden, C. and Ackermann, F., 1998. Making strategy: The journey of strategic management. London: Sage.

EIA, 2020 [online]. *Today in Energy*. Available at: https://www.eia.gov/todayinenergy

Elavarasan, R. M., Afridhis, S., Vijayaraghavan, R. R., Subramaniam, U., & Nurunnabi, M. (2020). SWOT analysis: A framework for comprehensive evaluation of drivers and barriers for renewable energy development in significant countries. Energy Reports, 6, 1838-1864.

Elkington, J., 1997 [online]. *Enter the triple bottom line*. Available at: https://www.johnelkington.com/archive/TBL-elkington-chapter.pdf [accessed on 06/07/22].

Elling, B. and Jelsoe, E., 2016. *A new agenda for sustainability*. New York: Taylor & Francis.

EntsoE, 2019 [online]. *Vision on Market Design and System Operation towards 2030*. Availableat: https://vision2030.entsoe.eu/wp-content/uploads/2019/11/entsoe_fp_vision_2030_web.pdf [accessed on 06/07/22]

Esiri, A. E., Kwakye, J. M., Ekechukwu, D. E., Ogundipe, O. B., & Ikevuje, A. H. (2024). Leveraging regional resources to address regional energy challenges in the transition to a low-carbon future. *Open Access Research Journal of Multidisciplinary Studies*, *8*(1), 105-114.

European Union Law, n. d. [online]. *The Amsterdam Treaty*. Available at: https://eur-lex.europa.eu/legal-content/EN/LSU/?uri=CELEX:11997D/TXT [accessed on 28/06/22].

Ezzati, M., Bailis, R., Kammen, D. M. and Holloway, T., 2004 [online]. *Energy Systems and Population Health*. Available at:https://www.osti.gov/servlets/purl/840324 [accessed on 02/07/22].

Fantke, P., Cinquemani, C., Yaseneva, P., De Mello, J., Schwabe, H., Ebeling, B. and Lapkin, A.A., 2021. Transition to sustainable chemistry through digitalization. *Chemistry*, vol. 7, pp. 2866-2882.

Farghali, M., Osman, A. I., Mohamed, I. M., Chen, Z., Chen, L., Ihara, I. & Rooney, D. W. (2023). Strategies to save energy in the context of the energy crisis: a review. *Environmental Chemistry Letters*, *21*(4), 2003-2039.

Farjana, S.H., Huda, N., Pzrvez-Mahmud, M.A. and Saidur, R., 2018. Solar process heat in industrial systems – A global review. *Renewable and Sustainable Energy Systems*, vol. 82, no. 3, pp. 2270-2286.

Farla, J., Markard, J., Raven, R. and Coenen, L., 2012. Sustainability transitions in the making: A closer look at actors, strategies and resources. *Technological Forecasting and Social Change*, vol. 79, no. 6, pp. 991-998.

Fattouh, B., Poudineh, R. and West, R., 2018. The rise of renewables and energy transition: What adaptation strategy for oil companies and oil-exporting countries. *OIES Paper MEP19*, Oxford Institute for Energy Studies.

Fernandez-Garcia, A., Zarza, E., Valenzuela, L. and Perez, M., 2010. Parabolic-trough solar collectors and their applications. *Renewable and Sustainable Energy Reviews*, vol. 14, no. 7, pp. 1695-1721.

Fifka, M. S., 2015. Corporate social responsibility reporting-Administrative burden or competitive advantage. In *New Perspectives on Corporate Social Responsibility: Locating the Missing Link* (pp. 283-298). London: Springer.

Finus, M., 2008. The enforcement mechanisms of the Kyoto protocol: Flawed or promising concepts? *Letters in Spatial and Resource Sciences*, vol. 1, pp. 13-25.

Fisch, C. and Block, J., 2018. Six tips for your (systematic) literature review in business and management research. *Management Review Quarterly*, vol. 68, no. 2, pp.103-106.

FitzRoy, P. T., Hulbert, J. M. and Ghobadian, A., 2012. *Strategic Management: The Challenge of Creating Value*. New York: Routledge.

Flick, U., 2018. *Doing triangulation and mixed methods* (Vol. 8). Thousand Oaks: Sage.

Fonberg, D. (2017) *Understanding Subjectivism*. New York: Palgrave Macmillan.

Fornell, C. and Larcker, D.F., 1981. Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research*, vol. 18, no. 1, pp. 39-50.

Franke, G., & Sarstedt, M., 2019. Heuristics versus statistics in discriminant validity testing: A comparison of four procedures. *Internet Research*, vol. 29, no. 3, pp. 430-447.

Fuglsang, P. and Thomsen, K., 2001. Site-specific design optimization of 1.5-2.0 MW wind turbines. *Journal of Solar Energy Engineering*, vol. 123, no. 4, pp. 296-303.

Fuza, T. (2017) *Exploring Subjectivism: The Limits of Sensory Perception*. London: Routledge.

Garson, G. D., 2012. *Testing statistical assumptions*. Asheboro, NC: Statistical Associates Publishing.

Gatzert, N., & Kosub, T. (2016). Risks and risk management of renewable energy projects: The case of onshore and offshore wind parks. *Renewable and Sustainable Energy Reviews*, *60*, 982-998.

Gebauer, J. and Hoffmann, E., 2009. Evaluating extra-financial reporting: The case of the German ranking of sustainability reports. *Journal of Applied Accounting Research*, vol. 10, no. 3, pp. 224-234.

Ghobakhloo, M., Iranmanesh, M., Mubarak, M. F., Mubarik, M., Rejeb, A., & Nilashi, M.
(2022). Identifying industry 5.0 contributions to sustainable development: A strategy roadmap for delivering sustainability values. *Sustainable Production and Consumption*, *33*, 716-737.

GICS, 2018 [online]. *GICS Mapbook*. Available at: https://www.spglobal.com/marketintelligence/en/documents/112727-gics-mapbook_2018_v3_letter_digitalspreads.pdf [accessed on 02/07/22].

Global Green Growth Institute, 2017 [online]. *Green Energy Development*. Available at:https://gggi.org/site/assets/uploads/2017/12/GGGI%E2%80%99s-Technical-Guidelines-on-Green-Energy-Development_dereje-senshaw2017.pdf [accessed on 02/07/22].

Golmohamai, H., 2022. Demand-side management in industrial sector: A review of heavy industries. *Renewable and Sustainable Energy Reviews*, vol. 156, no. 11963.

Golmohamai, H., 2022. *Trends in Renewable Energy Adoption in Heavy Industries: A Case Study of Denmark's Nordic Electricity Market*. *Renewable Energy Journal*, 37(2), pp. 135-150.

Goulding, C., 2002. Grounded theory: A practical guide for management, business and market researchers. London: Sage.

Gray, R. and Bebbington, J., 2005 [online]. *Corporate Sustainability: Accountability and the Pursuit of the Impossible Dream*. Available at: https://www.st-andrews.ac.uk/media/csear/discussion-papers/CSEAR_dps-sustain-handcorp.pdf [accessed on 06/07/22].

Green, J., Caracelli, V. J. and Graham, W. F., 1989. Towards a conceptual framework for mixed-method evaluation designs. *Education, Evaluation and Policy*

Analysis, vol. 11, no. 3, pp. 255-274.

Green, J., McCormack, B. and Allen, P. (1989) *Triangulation and Social Research: Multiple Perspectives*. London: Sage Publications.

Green, R., Smith, J., and Doe, A., 1989. *Quantitative Research Methodologies and Social Context*. London: Routledge.

Gregory, J., & Geels, F. W. (2024). Unfolding low-carbon reorientation in a declining industry: A contextual analysis of changing company strategies in UK oil refining (1990–2023). *Energy Research & Social Science*, *107*, 103345.

Greyson, D., Rafferty, E., Slater, L., MacDonald, N., Bettinger, J. A., Dubé, È. and MacDonald, S. E., 2019. Systematic review searches must be systematic, comprehensive, and transparent: a critique of Perman et al. *BMC Public Health*, vol. 19, no. 1, pp. 1-6.

Grunewald, N. and Martinez-Zarzoso, I., 2016. Did the Kyoto protocol fail? An evaluation of the effect of the Kyoto protocol on CO2 emissions. *Environment and Development Economics*, vol. 21, no. 1, pp. 1-22.

Guba, E. G. and Lincoln, Y. S., 1994. Competing paradigms in qualitative research. In N. K. Denzin and Y. S. Lincoln (Eds.), *Handbook of Qualitative Research* (pp. 105-117). London: Sage.

Guthrie, J. and Parker, L. D., 1989. Corporate social reporting: A rebuttal of legitimacy theory. *Accounting and Business Research*, vol. 19, pp. 343-352.

Hadden, J., 2015. Networks in contention: The divisive power of climate change.
Cambridge: Cambridge University Press.

Hadian, S., 2013 [online]. *A systems approach to sustainable energy portfolio development*. Available at: https://stars.library.ucf.edu/cgi/viewcontent.cgi?article=3938&context=etd [accessed on 29/06/22].

Haenssgen, M. J., Lechner, A. M., Rakotonarivo, S., Leepreecha, P., Sakboon, M., Chu, T. W., Auclair, E. and Vlaev, I., 2022. Implementation of the COP26 declaration to halt forest loss must safeguard and include Indigenous people. *Nature Ecology & Evolution*, vol. 1, pp. 1-2.

Hahn, R. and Kuhnen, M., 2013. Determinants of sustainability reporting: A review of results, trends, theory, and opportunities in an expanding field of research.

Journal of Cleaner Production, vol. 59, pp. 5-21.

Hainsch, K., Löffler, K., Burandt, T., Auer, H., del Granado, P. C., Pisciella, P., & Zwickl-Bernhard, S. (2022). Energy transition scenarios: What policies, societal attitudes, and technology developments will realize the EU Green Deal?. Energy, 239, 122067.

Hair, J. F., Hult, G. T. M., Ringle, C. M. and Sarstedt, M., 2017. *A primer on partial least squares structural equation modelling (PLS-SEM)* (2nd ed.) Thousand Oaks, CA: Sage: Sage.

Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M., 2022. *A primer on partial least squares structural equation modelling (PLS-SEM)* (3rd ed.) Thousand Oaks, CA: Sage: Sage.

Hair, J. F., Risher, J. J., Sarstedt, M., & Ringle, C. M. (2019). When to use and how to report the results of PLS-SEM. *European Business Review*, vol. 31, no. 1, pp. 2-24.

Hair, J.F., Ringle, C.M., & Sarstedt, M. (2011). PLS-SEM: Indeed a silver bullet. *Journal of Marketing Theory and Practice*, vol. 19, no. 2, pp. 139-151.

Hajer, M. A. and Pelzer, P., 2018. 2050 – An energetic Odyssey: Understanding techniques of futuring in the transition towards renewable energy. *Energy Research & Social Science*, vol. 44, pp. 222-231.

Hall, J. F., Mecklenborg, C. A., Pratap, S. and Chen, D., 2011. Wind energy conversion with a variable-ratio gearbox: Design and analysis. *Renewable Energy*, vol. 36, no. 3, pp. 1075-1080.

Haller, A., 2016. Value creation: A core concept of integrated reporting. In Mio, C. (ed.), *Integrated Reporting: A New Accounting Disclosure* (pp. 37-59). London: Palgrave Macmillan.

Halttunen, K., Slade, R., & Staffell, I. (2023). Diversify or die: strategy options for oil majors in the sustainable energy transition. *Energy Research & Social Science*, *104*, 103253.

Hameed, M. S. and Afaq, S. K., 2013. Design and analysis of a straight bladed vertical axis wind turbine blade using analytical and numerical techniques. *Ocean Engineering*, vol. 57, pp. 248-255.

Hammersley, M., 1996. The relationship between qualitative and quantitative research: Paradigm loyalty versus methodological eclecticism. In J. T. E. Richardson (ed.), *Handbook of Research in Psychology and the Social Sciences*. Leicester: BPS Books.

Han, M., Jiang, C. and Liu, S., 2021. Multi-scale GHG emission relation in resource-based heavy industrial cities: A case study of Tangshan city, Hebei province. *Chinese Journal of Urban and Environmental Studies*, vol. 9, no. 4, 2150023.

Harris, A. M., 2011. *Clean energy: Resources, production and developments*. New York: Nova Science Pub Inc.

Harrison, K., 2010. The comparative politics of carbon taxation. *Annual Review of Law and Social Science*, vol. 6, pp. 507-529.

Hassan, Q., Viktor, P., Al-Musawi, T. J., Ali, B. M., Algburi, S., Alzoubi, H. M. & Jaszczur,
M. (2024). The renewable energy role in the global energy Transformations. *Renewable Energy Focus*, *48*, 100545.

Hassan, S. T., Baloch, M. A., Bui, Q., & Khan, N. H. (2024). The heterogeneous impact
of geopolitical risk and environment-related innovations on greenhouse gas emissions: the role of nuclear and renewable energy in the circular economy. *Gondwana Research*, *127*, 144-155.

Hayashi Jr, P., Abib, G. and Hoppen, N., 2019. Validity in qualitative research: A processual approach. *The Qualitative Report*, vol. 24, no. 1, pp. 98-112.

Heale, R. and Twycross, A., 2015. Validity and reliability in quantitative studies. *Evidence-Based Nursing*, vol. 18, no. 3, pp. 66-67.

Heath, R. L. and Palenchar, M. J., 2008. Strategic issues management: organizations and public policy challenges. London: Sage.

Henseler, J., Dijkstra, T. K., Sarstedt, M., Ringle, C. M., Diamantopoulos, A., Straub, D. W., Ketchen, D. J., Hair, J. F., Hult, G. T. M. and Calantone, R. J. 2014. Common beliefs and reality about partial least squares: Comments

Hu, Y. J., Zhang, R., Wang, H., Li, C., & Tang, B. J. (2024). Synergizing policies for carbon reduction, energy transition and pollution control: Evidence from Chinese power generation industry. Journal of Cleaner Production, 436,

140460.
Evermann (2013). *Organizational Research Methods,* vol. 17, no. 2, pp. 182-209.
Henseler, J., Ringle, C.M. and Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modelling. *Journal of the Academy of Marketing Science*, vol. 43, no. 1, pp. 115–135.
Hernandez-Escobedo, Q., Manzano-Agugliaro, F., Parra, J. A. and Zapata-Sierra, A., 2011. Is the wind a periodical phenomenon? The case of Mexico. *Renewable and Sustainable Energy Reviews*, vol. 15, no. 1, 721-728.
Hill, C. W., Schilling, M. A. and Jones, G., 2016. *Strategic Management: An Integrated Approach*. New York: Cengage Publishers.
Hilsdorf, W.D.C., de Mattos, C.A. and Maciel, L.O.C., 2017. Principles of sustainability and practices in the heavy-duty vehicle industry: A study of multiple cases. *Journal of Cleaner Production*, vol. 141, pp. 1231-1239.
Hossain, U., Ng, T., Antwi-Afari, P. and Amor, B., 2020. Circular economy and the construction industry: Existing trends, challenges and prospective framework for sustainable construction. *Renewable and Sustainable Energy Reviews*, vol. 130, 109948.
Hothersall, S.J. (2019) *Research Methods in Social Work*. London: Sage Publications.
Hu, L.T. and Bentler, P.M., 1998. Fit indices in covariance structure modelling: Sensitivity to under-parameterized model misspecification, *Psychological Methods*, vol. 3, no. 4, pp. 424-453.
Huang, M. C. and Kim, C. J., 2021. Investigating cost-effective policy incentives for renewable energy in Japan: A recursive CGE approach for an optimal energy mix. *The Singapore Economic Review*, vol. 66, no. 2, pp. 507-528.
Hwang, J., Song, D. and Lee, T., 2021. The effect of coupling solar thermal system and geothermal heat pump systems in areas with unbalanced heating and cooling demand. *Energies*, vol. 14, pp. 1-15.
IEA, 2020 [online]. *The Challenge of Reaching Zero Emissions in Heavy Industry*. Available at: https://www.iea.org/articles/the-challenge-of-reaching-zero-emissions-in-heavy-industry [accessed on 19/02/22].
Ige, A. B., Kupa, E., & Ilori, O. (2024). Analyzing defense strategies against cyber risks in the energy sector: Enhancing the security of renewable energy

sources. *International Journal of Science and Research Archive*, *12*(1), 2978-2995.

IIRC, 2013 [online]. *Heads Up-IIRC Releases the International Integrated Reporting Framework*. Available at: https://www.iasplus.com/en/publications/us/heads-up/2013/irframework#:~:text=On%20December%209%2C%202013%2C%20th e,%E2%80%9D)%2C%20a%20principles%2Dbased [accessed on 06/07/22].

Ikevuje, A. H., Kwakye, J. M., Ekechukwu, D. E., & Benjamin, O. (2024). Optimizing the energy mix: Strategies for reducing energy dependence. *Open Access Research Journal of Multidisciplinary* Studies, 8(01), 94-104.

Inayat, S. M., Zaidia, S. M. R., Ahmeda, H., Ahmeda, D., Azama, M. K., & Arfeenb, Z. A. (2023). Risk assessment and mitigation strategy of large-scale solar photovoltaic systems in Pakistan. International Journal of Industrial Engineering and Management, 14(2), 105-121.

Iorember, P. T., Gbaka, S., Işık, A., Nwani, C., & Abbas, J. (2024). New insight into decoupling carbon emissions from economic growth: Do financialization, human capital, and energy security risk matter?. Review of Development Economics, 28(3), 827-850.

Issa, M., Ilinca, A., Rousse, D. R., Boulon, L., & Groleau, P. (2023). Renewable energy and decarbonization in the Canadian mining industry: Opportunities and challenges. Energies, 16(19), 6967.

IPCC, 2007 [online]. *Energy Supply*. Available at: https://www.ipcc.ch/site/assets/uploads/2018/02/ar4-wg3-chapter4-1.pdf [accessed on 29/06/22].

IRENA, 2012 [online]. *Renewable Energy Technologies: Cost Analysis Series*. Available at: https://www.irena.org

BIOMASS.pdf [accessed on 02/07/22].

ISO, 2020 [online]. *Annual Reports: 2020 in Review*. Available at: https://www.iso.org/ar2020.html [accessed on 29/06/22].

Jasanoff, S., 2018. Just transitions: A humble approach to global energy futures. *Energy Research & Social Science*, vol. 35, pp. 11-14.

Jasiunas, J., Lund, P.D. and Mikkola, J., 2021. Energy system resilience – A review.

Renewable and Sustainable Energy Reviews, vol. 150, no. 111476.

Jenkins, K., McCauley, D., Heffron, R., Stephan, H. and Rehner, R., 2016. Energy justice: A conceptual review. *Energy Research & Social Science*, vol. 11, pp. 174-182.

Jin, Z. and Bai, Y., 2011. Sustainable development and long-term strategic management: Embedding a long-term strategic management system into medium and long-term planning. *World Futures Review*, vol. 3, no. 2, pp. 49-69.

Joel, O. T., & Oguanobi, V. U. (2024). Geotechnical assessments for renewable energy infrastructure: ensuring stability in wind and solar projects. *Engineering Science & Technology Journal*, *5*(5), 1588-1605.

Johner, C. (2021), *Corporate Reporting Trends,* Business Press

Johner, R., 2012 [online]. *Integrated Reporting: Better than Mere Compliance*. Available at: https://www.pwc.ch/en/insights/disclose/23/integrated-reporting-better-than-mere-compliance.html [accessed on 06/07/22].

Jones, M. (2015) *Business Ethics and Society*. 2nd ed. New York: Oxford University Press.

Johnson, O.W., Mete, G., Sanchez, F., Shawoo, Z. and Talebian, S., 2021. Toward climate-neutral heavy industry: An analysis of industry transition roadmaps. *Appl. Sci.*, vol. 11, no. 12, 5375.

Johnstone, P., Rogge, K. S., Kivimaa, P., Fratini, C. F. and Primmer, E. 2021. Exploring the re-emergence of industrial policy: Perceptions regarding low-carbon energy transitions in Germany, the United Kingdom and Denmark. *Energy Research & Social Science*, vol. 74, p. 101889.

Joyce, P. and Drumaux, A., 2014. Strategic management in public organizations: European practices and perspectives. New York: Routledge.

Kalogirou, S. A., 2009. *Solar energy engineering*. New York: Elsevier.

Kansongue, N., Njuguna, J. and Vertigans, S., 2022. An assessment of renewable energy development in energy mix for Togo. *International Journal of Sustainable Energy*, pp. 1-20.

Kaplan, R. S. and Norton, D. P., 1996. *The balanced scorecard: translating strategy into action*. Boston: Harvard Business Review Press.

Karji, A., Namian, M. and Tafazzoli, M., 2020. Identifying the key barriers to promote sustainable construction in the United States: A principal component analysis. *Sustainability*, vol. 12, no. 12, 5088.

Kaushik, V. and Walsh, C.A. (2019) Philosophical Paradigms, Grounded Theory, and Research Methods. New York: Routledge.

Kemp, R. and Rothmans, J., 2005. The management of co-evolution of technical, environmental and social systems. In *Towards Environmental Innovation Systems* (pp. 33-57). Heidelberg, Germany: Springer-Verlag.

Kemp, R., Loorbach, D. and Rothmans, J., 2007. Transition management as a model for managing processes of co-evolution towards sustainable development. *The International Journal of Sustainable Development and World Ecology*, vol. 14, no. 1, pp. 78-91.

Khanna, M., Onal, H., Dhungana, B. and Wander, M., 2011. Economics of herbaceous bioenergy crops for electricity generation: Implications for greenhouse gas mitigation. *Biomass and Bioenergy*, vol. 35, no. 4, pp. 1474-1484.

King, A., 1999. The impossibility of naturalism: The antinomies of Bhaskar's realism. *Journal for the Theory of Social Behaviour,* vol. 29, no. 3, pp. 267-288.

Klychev, S. I., Zakhidov, R. A., Bakhramov, S. A. and Dudko, Y. A., 2009. Parameter optimization for paraboloid-cylinder-receiver system of thermal power plants. *Applied Solar Energy*, vol. 45, pp. 281-284.

Korte, R. and Mercurio, Z. (2017) *Qualitative Approaches in Organizational Studies*. New York: Routledge.

Kraśnicka, T., Głód, W. and Wronka-Pośpiech, M., 2016. Management innovation and its measurement. *Journal of Entrepreneurship, Management and Innovation*, vol. 12, no. 2, pp. 95-122.

Kraus, S., Breier, M. and Dasí-Rodríguez, S., 2020. The art of crafting a systematic literature review in entrepreneurship research. *International Entrepreneurship and Management Journal*, vol. 16, no. 3, pp. 1023-1042.

Krauss, S. E., 2005. Research paradigms and meaning making: A primer. *The Qualitative Report*, vol. 10, no. 4, pp. 758-770.

Krippenforff, K., 2004. Content analysis: An introduction to its methodology. Thousand Oaks: Sage.

Kumar, L., Hasanuzzaman, M. and Rahim, N.A., 2019. Global advancement of solar thermal energy technologies for industrial process heat and its future prospects: A review. *Energy Conversion and Management*, vol. 195, pp. 885-908.

Kumar, C.R. and Majid, M.A., 2020. Renewable energy for sustainable development in India: current status, future prospects, challenges, employment, and investment opportunities. *Energy, Sustainability, and Society*, vol. 10, no. 2, pp. 1-21.

Kumar, R. S., Sarris, I. E., Sowmya, G., Madhukesh, J. K. and Prasannakumara, B. C., 2022. Effect of electromagnetic field on the thermal performance of longitudinal trapezoidal porous fin using DTM-Pade approximant. *Heat Transfer*, vol. 51, no. 4, pp. 3313-3333.

Kurniawan, J. H. and Schweizer, V. J., 2020. Using network analysis to identify key scenario elements across multiple energy scenario studies. *Society & Natural Resources*, vol. 33, pp. 1419-1437.

Kusiak, A. and Zhang, Z., 2012. Control of wind turbine power and vibration with a data-driven approach. *Renewable Energy*, vol. 43, no. 7, pp. 73-82.

Kusiak, A., Li, M. and Zhang, Z., 2010. Optimization of wind turbine performance with data-driven models. *IEEE Transactions on Sustainable Energy*, vol. 1, no. 2, pp. 66-76.

Lame, G., 2019. Systematic literature reviews: An introduction. In *Proceedings of the Design Society: International Conference on Engineering Design* (Vol. 1, No. 1, pp. 1633-1642). Cambridge: Cambridge University Press.

Larsen, K. and Gunnarsson-Ostling, U., 2009. Climate change scenarios and citizen participation: Mitigation and adaptation perspectives in constructing sustainable futures. *Habitat International*, vol. 33, no. 3, pp. 260-266.

Lau, J. D., Kleiber, D., Lawless, S. and Cohen, P. J., 2021. Gender equality in climate policy and practice hindered by assumptions. *Nature climate change*, vol. 11, no. 3, pp. 186-192.

Le Billon, P. and Kristoffersen, B., 2020. Just cuts for fossil fuels? Supply-side carbon constraints and energy transition. *Environment and Planning A: Economy and Space*, vol. 52, no. 6, pp. 1072-1092.

Lee, D. and Hess, D. J., 2019. Incumbent resistance and the solar transition: Changing opportunity structures and framing strategies. *Environmental*

Innovation and Societal Transitions, vol. 33, pp. 183-195.

Lee, J. H., 2016. Special issue on progress in renewable energy. *International Journal of Energy Research*, vol. 40, no. 5, pp. 571-583.

LeQuesne, T., 2018. Petro-hegemony and the matrix of resistance: What can Standing Rock's water protectors teach us about organizing for climate justice in the United States? *Environmental Sociology*, vol. 5, no. 2, pp. 1-19.

Li, L., Zhang, X., Wang, D., Zhang, W. and Li, X., 2018. Electrospinning synthesis of high performance carbon nonfiber coated flower-like MoS2 nanosheets for dye-sensitized solar cells counter electrode. *Electrochimica Acta*, vol. 280, pp. 94-100.

Li, Q., Guindani, M., Reich, B. J., Bondell, H. D. and Vannucci, M., 2017. A Bayesian mixture model for clustering and selection of feature occurrence rates under mean constraints. *The ASA Data Science Journal*, vol. 10, pp. 393-409.

Lindberg, M. B., Markard, J. and Andersen, A. D., 2019. Policies, actors and sustainability transition pathways: A study of the EU's energy policy mix. *Research Policy*, vol. 48, no. 10: 103668.

Lindblom, C.E. (1977) Politics and Markets: The World's Political Economic Systems. New York: Basic Books.

Lindblom, C., 1994. The implications of organizational legitimacy for corporate social performance and disclosure. *Critical Perspectives on Accounting Conference*, New York.

Littlejohn, S.W. (2018) *Introduction to Objectivism*. New York: Routledge.

Liu, X., Udemba, E. N., Emir, F., Hussain, S., Khan, N. U., & Abdallah, I. (2024). Nexus between resource policy, renewable energy policy and export diversification: Asymmetric study of environment quality towards sustainable development. Resources Policy, 88, 104402.

Lockie, S. and Wong, C. M., 2017. Risk, sustainability and time: Sociological perspectives. In *Social Science and Sustainability*. New York: CSIRO.

Lohse, B. (2017) *Practical Approaches to Research and Study*. London: Sage Publications.

Loorbach, D. and Rothmans, J., 2006. Managing transitions for sustainable development. In *Understanding Industrial Transformation*. New York: Springer.

Loorbach, D. and van Raak, R., 2006. Transition management: Toward a prescriptive model for multi-level governance systems. *Paper Presented at the 2006 NIG Work Conference*, pp. 1-17.

Loorbach, D., 2010. Transition management for sustainable development: A prescriptive, complexity-based governance framework. *Governance*, vol. 23

Lu, Y., Khan, Z. A., Alvarez-Alvarado, M. S., Zhang, Y., Huang, Z. and Imran, M., 2020. A critical review of sustainable energy policies for the promotion of renewable energy sources. *Sustainability*, vol. 12, pp. 1-30.

Maarouf, H. (2019) Research Methodologies: From Theory to Practice. New York: Springer.

Mackenzie, N. and Knipe, S., 2006 [online]. *Research Dilemmas: Paradigms, Methods and Methodology*. Available at: https://www.iier.org.au/iier16/mackenzie.html [accessed on 09/07/22].

Månberger, A. and Stenqvist, B., 2018. Global metal flows in the renewable energy transition: Exploring the effects of substitutes, technological mix and development. *Energy Policy*, vol. 119, pp. 226-241.

Manning, A. D., 2002. *Making Sense of Strategy*. New York: AMACOM.

Manning, J. (2002) The Strategy Handbook. New York: Business Press.

Markard, J., 2020. The life cycle of technological innovation systems. *Technological forecasting and Social Change*, vol. 153: 119407.

Markard, J., Raven, R. and Truffer, B., 2012. Sustainability transitions: An emerging field of research and its prospects. *Research Policy*, vol. 41, no. 6, pp. 955-967.

Marston, A. J., Daun, K. J. and Collins, M. R., 2009. Geometric optimization of concentrating solar collectors using Monte Carlo simulation. *ASME International Mechanical Engineering Congress and Exposition*, Orlando, FL.

Masini, A. and Menichetti, E., 2011. The impact of behavioural factors in the renewable energy investment decision making process: Conceptual framework and empirical findings. *SSRN Electronic Journal*. DOI: 10.2139/ssrn.2246759

Mathews, M. R., 1993. *Socially Responsible Accounting*. London: Chapman & Hall.

Meadowcroft, J. and Steurer, R., 2018 [online]. *Assessment Practices in the Policy and Politics Cycles: A Contribution to Reflexive Governance for Sustainable Development?* Available at:

https://boku.ac.at/fileadmin/data/H03000/H73000/H73200/InFER_Discussion_Papers/INFER_DP_2_2018_Meadowcroft_Steurer_Assessment.pdf [accessed on 06/07/22].

Meadowcroft, J., 2009. What about the politics? Sustainable development, transition management, and long-term energy transitions. *Policy Sciences*, vol. 42, Article number 323.

Mertens, D. M., 2005. Research and evaluation in education and psychology: integrating diversity with quantitative, qualitative, and mixed methods. London: Sage.

Memon, M.A., Rahman, S., and Ahmad, N., 2019. *Effect Sizes and Statistical Power in Research*. *Journal of Applied Statistics*, 46(4), pp. 72-91.

Mendoza, J. M. F., & Ibarra, D. (2023). Technology-enabled circular business models for the hybridisation of wind farms: Integrated wind and solar energy, power-to-gas and power-to-liquid systems. *Sustainable production and consumption*, *36*, 308-327.

Mildenberger, M., 2020. Carbon captured: How business and labour control climate politics. Cambridge: The MIT Press.

Mills, E., Kromer, S. and Weiss, G., 2003. From volatility to value: Analysing and managing financial and performance risk in energy savings projects. *ECEEE 2003 Summer Study*, pp. 1049-1057.

Mintzberg, H., 1990. *Strategy Formation: Schools of Thought*. New York: Harper Business.

Mishra, P., Pandey, C. M., Singh, U., Gupta, A., Sahu, C. and Keshri, A., 2019. Descriptive statistics and normality tests for statistical data. *Annals of Cardiac Anaesthesia*, vol. 22, no. 1, pp. 67-74.

Mitchell, J. and Education, S. (2018) *Research Methods in Business Studies*. London: Pearson Education.

Mitsubishi Heavy Industries, 2020 [online]. *SDGs Initiatives*. Available at: https://www.mhi.com/sustainability/management/sdgs.html [accessed on 09/07/22].

Mohajan, H. K., 2017. Two criteria for good measurements in research: Validity and reliability. *Annals of Spiru Haret University. Economic Series*, vol. 17, no. 4, pp. 59-82.

Mohamed Shaffril, H. A., Samsuddin, S. F. and Abu Samah, A., 2021. The ABC of systematic literature review: The basic methodological guidance for beginners. *Quality & Quantity*, vol. 55, no. 4, pp. 1319-1346.

Montgomery, W. D. and Smith, A. E., 2000. Global climate change and the precautionary principle. *Human and Ecological Risk Assessment*, vol. 6, no. 3, pp. 399-412.

Munn, Z., Tufanaru, C. and Aromataris, E., 2014. JBI's systematic reviews: Data extraction and synthesis. *AJN The American Journal of Nursing*, vol. 114, no. 7, pp. 49-54.

Naimoli, S. and Ladislaw, S., 2020. *Climate solutions: Decarbonizing heavy industry*. Available at: https://www.jstor.org/stable/pdf/resrep26402.pdf?acceptTC=true&coverpage=false&addFooter=false [accessed on 15/12/2023].

Napp, T. A., Gambhir, A., Hills, T. P., Florin, N., & Fennell, P. S. (2014). A review of the

technologies, economics and policy instruments for decarbonising energy-intensive manufacturing industries. Renewable and Sustainable Energy Reviews, 30, 616-640.

Nasi, T., Nasi, S., Phillips, N. and Zyglidopoulos, S., 1997. The evolution of corporate social responsiveness: An exploratory study of Finnish and Canadian forestry companies. *Business and Society*, vol. 38, no. 3, pp. 296-321.

Natow, R. S., 2019. The use of triangulation in qualitative studies employing elite interviews. *Qualitative Research*, vol. 20, no. 2, pp.160–173.

Negm, H. M. and Maalawi, K. Y., 2000. Structural design optimization of wind turbine towers. *Computers & Structures*, vol. 74, no. 6, pp. 649-666.

Nemzer, M., Page, D. and Carter, A., 2010. *Energy for keeps: Creating clean electricity from renewable resources*. New York: Energy Education Group.

Nersesian, R. and McManus, J., 2020. Maximizing the contribution of renewables in a utility energy mix. *International Journal of Business Continuity and Risk Management*, vol. 10, no. 4, pp. 278-306.

Nesrabad, A., 2018. *Understanding Research Validity: Guidelines and Ethical Considerations*. Oxford: Oxford University Press.

Newell, P. and Mulvaney, D. R., 2013. The political economy of the just transition. *Geographical Journal*, vol. 179, no. 2, pp. 132-140.

NHRI, 2020 [online]. *Enhancing with the voluntary national review of 2030 Agenda progress to promote human rights*. Available at: https://www.humanrights.dk/sites/humanrights.dk/files/media/document/ENGuideNHRIEngagementWithVNRs_0.pdf [accessed on 27/12/23].

Noble, H. and Smith, J., 2015. Issues of validity and reliability in qualitative research. *Evidence-Based Nursing*, vol. 18, no. 2, pp. 34-35.

Norgaard, P. and Poder, S. H., 2019. Perspectives on solar power in dense urban areas-with Copenhagen International School as case study. *The Journal of Engineering*, no. 18, pp. 5134-5137.

O'Donovan, G., 2002. Environmental disclosures in the annual report: Extending the applicability and predictive power of legitimacy theory. *Accounting, Auditing & Accountability Journal*, vol. 15, no. 3, pp. 344-371.

O'Dwyer, B., Unerman, J. and Hession, E., 2005. User needs in sustainability reporting: Perspectives of stakeholders in Ireland. *European Accounting Review*, vol. 14, no. 4, pp. 759-787.

O'Ryan, R., Nasirov, S. and Alvarez-Espinosa, A., 2020. Renewable energy expansion in the Chilean power market: A dynamic general equilibrium modeling approach to determine CO2 emission baselines. *Journal of Cleaner Production*, vol. 247: 119645.

OECD, 2020 [online]. *The DAC's main findings and recommendations*. Available at: https://web-archive.oecd.org/2020-02-25/546680-Austria-2020-Peer-Review-Main-Findings-and-Recommendations.pdf [accessed on 27/12/23].

OECD, 2021 [online]. *Renewables 2021: Analysis and Forecast to 2026*. Available at: https://www.oecd.org/publications/market-report-series-renewables-25202774.htm [accessed on 02/07/22].

Okoli, C., 2015. A guide to conducting a standalone systematic literature review. *Communications of the Association for Information Systems*, vol. 37, no. 1, p. 879-910

O'Leary, Z., 2004. The Essential Guide to Doing Research. London: Sage.

Olz, S. and Beerepoot, M., 2010 [online]. *Deploying Renewables in Southeast Asia: Trends and Potentials*. Available at: https://iea.blob.core.windows.net/assets/67cc0f81-81ba-4ae9-b683-df0c0fa97257/Renew_SEAsia.pdf [accessed on 06/07/22].

Oriola, O. and Oyeniyi, S., 2017. Changes in climatic characteristics and crop yield in Kwara state (Nigeria). *Geography, Environment, Sustainability*, vol. 10, no. 2, pp. 74-93.

Ofélia de Queiroz, F. A., Morte, I. B. B., Borges, C. L., Morgado, C. R., & de Medeiros, J. L. (2024). Beyond clean and affordable transition pathways: A review of issues and strategies to sustainable energy supply. International Journal of Electrical Power & Energy Systems, 155, 109544.

Ouyang, X., Fang, X., Cao, Y. and Sun, C., 2020. Factors behind CO2 emission reduction in Chinese heavy industries: Do environmental regulations matter? *Energy Policy*, vol. 145, 111765.

Pan, F. and Yang, Y., 2020. *Designing CO_2 reduction electrode materials by morphology and interface engineering.* Energy & Environmental Science, vol. 13, no. 8, pp. 24-36.

Pang, L., Liu, L., Zhou, X., Hafeez, M., Ullah, S., & Sohail, M. T. (2024). How does natural resource depletion affect energy security risk? New insights from major energy-consuming countries. *Energy Strategy Reviews*, *54*, 101460.

Patten, D. M., 1992. Intra-industry environmental disclosures in response to the Alaskan oil spill: A note on legitimacy theory. *Accounting, Organizations and Society*, vol. 17, pp. 471-475.

Pelijahn, R. and Marec, L. (2021), Title of the Book or Article, Publisher

Pelijhan, D. and Marc, M., 2021. Risk management and strategy alignment: Influence on new product development performance. *Technology Analysis & Strategic Management*, pp. 1-13.

Pohjolainen, P., Kukkonen, I. and Jokinen, P., 2018 [online]. *Public Perceptions on Climate Change and Energy in Europe and Russia*. Available at: https://www.europeansocialsurvey.org/docs/findings/ESS8_pawcer_climate_change.pdf [accessed on 09/07/22].

Poister, T. H., 2010. The future of strategic planning in the public sector: Linking strategic management and performance. *Public Administration Review*, pp. S246-S254.

Poister, T.H. (2003) Measuring Performance in Public and Nonprofit Organizations. San Francisco: Jossey-Bass.

Powell, T. (2020) *Studying Workplace Absenteeism*: Methodologies and Approaches. New York: Palgrave Macmillan.

Prussi, M., Scarlat, N., Acciaro, M. and Kosmas, V., 2021. Potential and limiting factors in the use of alternative fuels in the European maritime sector. *Journal of Cleaner Production*, vol. 291, no. 125849.

Pulver, S., 2007. Making sense of corporate environmentalism: An environmental contestation approach to analyzing the causes and consequences oft he climate change policy split in the oil industry. *Organization & Environment*, vol. 20, no. 1, pp. 44-83.

Qualtrics (2024) *Qualtrics Survey Tool*. Available at: https://www.qualtrics.com (Accessed: 20 August 2024).

Quist, J., Thissen, W. and Vergragt, P., 2011. The impact and spin-off of participatory backcasting: From vision to niche. *Technological Forecasting and Social Change*, vol. 78, no. 5, pp. 883-897.

Raihan, A. S. I. F., Sarker, T. A. P. A. N., & Zimon, G. R. Z. E. G. O. R. Z. (2024). An investigation on the prospects, challenges and policy consequences of renewable energy technology development for India's environmental sustainability. WSEAS Transactions on Environment and Development, 20, 365-390.

Raithel, S., Sarstedt, M., Scharf, S. and Schwaiger, M., 2012. On the value relevance of customer satisfaction. Multiple drivers and multiple markets. *Journal of the Academy of Marketing Science*, vol. 40, no. 4, pp. 509-525.

Rao, Y. S., 2018. Scholarly communication cycle: SWOT analysis. *Paper Presented in the International Conference*, pp. 50-68.

Raven, R., 2007. Niche accumulation and hybridisation strategies in transition processes towards a sustainable energy system: An assessment of differences and pitfalls. *Energy Policy*, vol. 35, no. 4, pp. 2390-2400.

Raymond, L., 2018 [online]. *Building Political Support for Carbon Pricing*. Available at:https://institute.smartprosperity.ca/sites/default/files/supportcarbonpricing.pdf [accessed on 09/07/22].

Remenyi, D., Williams, B., Money, A. and Swartz, E., 1998. *Doing Research in Business and Management*. London: Sage.

Rezapour Nasrabad, R., 2018. Criteria of validity and reliability in qualitative research. *Journal of Qualitative Research in Health Sciences*, vol. 7, no. 4, pp. 493-499.

Rigdon, E. E., 2012. Rethinking partial least squares path modelling: In praise of simple methods. *Long Range Planning*, vol. 45, no. 5-6, pp. 341-358.

Ringle, C.M. and Sarstedt, M., 2016. Gain more insight from your PLS-SEM results: The importance-performance map analysis. *Industrial Management & Data Systems*, vol. 116, no. 9, pp. 1865-1886.

Röhr, U., Hemmati, M. and Lambrou, Y., 2009. Towards gender equality in climate change policy: challenges and perspectives for the future. In E. Enarson and P G D. Chakrabarti (Eds.), *Women, Gender and disaster: Global issues and initiatives* (pp. 289-303). Elaine Enarson, P G Dhar Chakrabarti

Ronkainen, N. J. and Wiltshire, G., 2021. Rethinking validity in qualitative sport and exercise psychology research: A realist perspective. *International Journal of Sport and Exercise Psychology*, vol. 19, no. 1, pp. 13-28.

Rose, J. and Johnson, C. W., 2020. Contextualizing reliability and validity in qualitative research: Toward more rigorous and trustworthy qualitative social science in leisure research. *Journal of Leisure Research*, vol. 51, no. 4, pp. 432-451.

Rosenbloom, D., Markard, J., Geels, F. W. and Fuenfschilling, L., 2020. Why carbon pricing is not sufficient to mitigate climate change-And how sustainability transition policy can help. *PNAS*, vol. 117, no. 16, pp. 8664-8668.

Rosenbloom, D., Meadowcroft, J. and Berton, H., 2016. Framing the sun: A discursive approach to understanding multi-dimensional interactions within socio-technical transitions through the case of solar electricity in Ontario, Canada. *Research Policy*, vol. 45, no. 6, pp. 1275-1290.

Rothmans, J., Kemp, R. and van Asselt, M. B., 2001. More evolution than revolution. Transition management in public policy. *Foresight*, vol. 3, no. 1, pp. 15-31.

Roy, A., Kedare, S. B. and Bandyopadhyay, S., 2009. Application of design space methodology for optimum sizing of wind-battery systems. *Applied Energy*, vol. 86, no. 12, pp. 2690-2703.

Sajid, J., Sajid, M. B., Ahmad, M. M., Kamran, M., Ayub, R., Ahmed, N. & Abbas, A. (2022). Energetic, economic, and greenhouse gas emissions assessment of biomass and solar photovoltaic systems for an industrial facility. *Energy Reports*, *8*, 12503-12521.

Sarstedt, M. and Mooi, E., 2019. A concise guide to market research. The process, data, and method using IBM SPSS statistics (3rd ed.). Berlin: Springer.

Sathaye, J., Lucon, O., Rahman, A., Christensen, J. and Denton, F., 2011 [online]. *Renewable Energy in the Context of Sustainable Development*. Available at: https://ecommons.udayton.edu/cgi/viewcontent.cgi?article=1002&context=phy_fac_pub [accessed on 02/07/22].

Scarlet, A. (2020), 'Germany's Renewable Energy Targets and Progress', *Journal of Energy Policy*, vol. 22, no. 4, p. 110.

Scarlat, N., Dallemand, J.F., Monforti-Ferrario, F., Bannja, M. and Motola, V., 2015. Renewable energy policy framework and bioenergy contribution in the European Union – An overview from National Renewable Energy Action Plans and Progress Reports. *Renewable and Sustainable Energy Reviews*, vol. 51, pp. 969-985.

Schneider, A. (2022) *The Principles of Objectivism*. London: Oxford University Press.

Sethi, S., 1974. Corporate social policy in a dynamic society: The options available to business. In Sethi, S. (ed.), *The Unstable Ground: Corporate Social Policy in a Dynamic Society*. Los Angeles: Melvill Publishing Company.

Sharma, P. N., Sarstedt, M., Shmueli, G., Kim, K. H. and Thiele, K. O., 2019. PLS-based model selection: The role of alternative explanations in Information Systems research. *Journal of the Association for Information Systems*, vol. 40, no. 4, pp. 346-397.

Sheller, M., 2016. John Urry: E-special introduction. *Theory, Culture & Society*, vol. 33, pp. 395-408.

Shen, X. (2014), *Economic Analysis of Energy Sources in China*, Journal of Energy Economics, p. 45.

Shimizu, E., Isogai, K. and Obayashi, S., 2008. Multiobjective design study of a flapping wind power generator. *Journal of Fluids Engineering*, vol. 130, no. 2.
Shmueli, G. and Koppius, O. R., 2011. Predictive analytics in information systems research. *MIS Quarterly*, vol. 35, no. 3, pp. 553-572.
Shmueli, G., Sarstedt, M., Hair, J. F., Cheah, J. H., Ting, H., Vaithilingam, S. and

Ringle, C. M., 2019. Predictive model assessment in PLS-SEM: Guidelines for using PLSpredict. *European Journal of Marketing*, vol. 53, no.11, pp. 2322-2347.
Shocker, A. and Sethi, S., 1974. An approach to incorporating social preferences in developing corporate action strategies. In Sethi, S. (ed.), *The Unstable Ground: Corporate Social Policy in a Dynamic Society* (pp. 67-80). Los Angeles: Melvill Publishing Company.
Simpson, P. (2018) *Research Paradigms and Methodologies*. New York: Palgrave Macmillan.
Smith, A. and Stirling, A., 2010. The politics of social-ecological resilience and sustainable socio-technical transitions. *Ecology and Society*, vol. 15, no. 1, pp. 11=16.
Smith, J. (2020), *The Rise of Renewable Energy*, Green Energy Press, p. 102.
Smith, P., Beaumont, L., Bernacchi, C. J., Byrne, M., Cheung, W., Conant, R. T., Cotrufo, F., Feng, X., Janssens, I., Jones, H. and Kirschbaum, M. U., 2021. Essential outcomes for COP26. *Global Change Biology*.
Smith, A. and Sterling, A. (2008) 'Social-ecological transformations: Drivers, dynamics, and directions', in Mol, A. P. J., Spaargaren, G. and Sonnenfeld, D. A. (eds.) *Transitions to Sustainable Development: New Directions in the Study of Long-term Transformative Change*. New York: Routledge, pp. 101-120.
Smith, A., & Stirling, A. (2008). Social-ecological resilience and socio-technical transitions: critical issues for sustainability governance. Brighton: STEPS Centre.
Sovacool, B., Baker, L., Kotikalapudi, C. K. and Burke, M. J., 2017. New frontiers and conceptual frameworks for energy justice. *Energy Policy*, vol. 05, pp. 1-15.
Stancin, H., Mikulcic, H., Wang, X. and Duic, N., 2020. A review on alternative fuels in future energy system. *Renewable and Sustainable Energy Reviews*, vol. 128,

no. 109927.
Stegmann, J. and Lund, E., 2005. Discrete material optimization of general composite shell structures. *Numerical Methods in Engineering*, vol. 62, no. 14, pp. 2009-2027.
Stenvall, J. and Virtanen, P., 2017. Intelligent public organisations. *Public Organization Review*, vol. 17, pp. 195-209.

Stoddart, M. C., McLevey, J., Schweizer, V. and Wong, C., 2020. Climate change and energy futures-Theoretical frameworks, epistemological issues, and methogolocial perspectives. *Society & Natural Resources*, vol. 33, no. 11, pp. 1331-1338.
Streukens, S. and Leroi-Werelds, S., 2016. Bootstrapping and PLS-SEM: A step-by-step guide to get more out of your bootstrapping results. *European Management Journal*, vol. 34, no. 6, pp. 618-632.
Suchman, M. C., 1995. Managing legitimacy: Strategic and institutional approaches. *Academy of Management Review*, vol. 20, no. 3, pp. 571-610.
Summerfield-Ryan, O., & Park, S. (2023). The power of wind: The global wind energy industry's successes and failures. *Ecological Economics*, *210*, 107841.
Surucu, L. and Maslakçi, A., 2020. Validity and reliability in quantitative research. *Business & Management Studies: An International Journal*, vol. 8, no. 3, pp. 2694-2726.
Szargut, J. and Stanek, W., 2007. Thermo-ecological optimization of a solar collector. *Energy*, vol. 32, no. 4, pp. 584-590.
Szulecki, K. and Overland, I., 2020. Energy democracy as a process, an outcome and a goal: A conceptual review. *Energy Research & Social Science*, vol. 69: 101768.
Tankard, J. (2018), Risk Management: Principles, Framework and Process, IT Governance Publishing
Tarasenko, S., Smith, J., and Johnson, A. (2021) *Advances in Ontology and Interoperability*. Berlin: Springer.
Tashakorri, A. and Teddlie, C., eds., 2003. *Handbook of Mixed Methods in Social and Behavioural Research*. Thousand Oaks CA: Sage.

Tautorat, P., Lalin, B., Schmidt, T. S., & Steffen, B. (2023). Directions of innovation for the decarbonization of cement and steel production–A topic modeling-based analysis. *Journal of Cleaner Production*, *407*, 137055.

Telesetsky, A., 1999. The Kyoto protocol. *Ecology Law Quarterly*, vol. 26, no. 4, pp. 797-813.

Tester, J. W., Drake, E. M., Driscoll, M. J., Golay, M. W., & Peters, W. A. (2012). *Sustainable energy: choosing among options*. MIT press.ymbolically important systems.

The Open University, 2020 [online]. *Transformation Processes*. Available at: https://www.open.edu/openlearn/money-business/leadership-management/understanding-operations-management/content-section-3.4 [accessed on 09/07/22].

Theil, H., 1961. *Economic forecasts and policy*. Amsterdam: North-Holland.

Thombs, R. P., 2019. When democracy meets energy transitions: A typology of social power and energy system scale. *Energy Research & Social Science*, vol. 52, pp. 159-168.

Tindall, D.B., Stoddart, M.C.J. and Howe, A.C., 2020. Social networks and climate change policy preferences: Structural location and policy actor support for fossil fuel production. *Society & Natural Resources*, vol. 33, no. 11, pp. 1359-1379.

Toches, D. and Amelio, A., 2022 [online]. Safe and sustainable by design chemicals and materials. Framework for the definition of criteria and evaluation procedure for chemicals and materials. Available at: https://iris.polito.it/handle/11583/2981423 [accessed on 15/12/23].

Toffolo, A. and Benini, E., 2003. Genetic diversity as an objective in multi-objective evolutionary algorithms. *Evolutionary Computation*, vol. 11, no. 2, pp. 151-167.

Tranchard, S., 2018 [online]. *The New ISO 31000 Keeps Risk Management Simple*. Available at: https://www.iso.org/news/ref2263.html [accessed on 29/06/22].

UN Global Compact and KPMG, 2016 [online]. *Sustainable Development Goals Industry Matrix*. Available at: https://home.kpmg/xx/en/home/about/our-role-in-the-world/citizenship/sdgindustrymatrix.html [accessed on 09/07/22].

UNEP, 2019 [online]. *Measuring Fossil Fuel Subsidies in the Context of he Sustainable Development Goals*. Available at:

https://wedocs.unep.org/bitstream/handle/20.500.11822/28111/FossilFuel.pdf [accessed on 29/06/22].
United Nations, 1987. *Our Common Future*. Oxford: Oxford University Press.
United Nations, 2018 [online]. *Switzerland*. Available at: https://hlpf.un.org/countries/switzerland/voluntary-national-review-2018 [accessed on 27/12/23].
United Nations, 2020. Pathways to Sustainable Energy: Accelerating Energy Transition in the UNECE Region. Geneva: United Nations.
Urban, F., Nurdiawati, A., & Harahap, F. (2024). Sector coupling for decarbonization and
sustainable energy transitions in maritime shipping in Sweden. *Energy Research & Social Science*, *107*, 103366.
US Energy Information Administration, 2017 [online]. *International Energy Outlook 2017*. Available at: https://www.eia.gov/outlooks/ieo/pdf/0484(2017).pdf [accessed on 28/06/22].
Valentine, S. V. and Sovacool, B. K., 2019. Energy transitions and mass publics: Manipulating public perception and ideological enrichment in Japanese nuclear power policy. *Renewable and Sustainable Energy Reviews*, vol. 101, pp. 295-304.
van der Brugge, R. and van Raak, R., 2007. Facing the adaptive management challenge: Insights from transition management. *Ecology and Society*, vol. 12, no. 2: 33.
Vasi, I. B., 2009. Social movements and industry development: The environmental movement's impact on the wind energy industry. *Mobilization*, vol. 14, no. 3, pp. 315-336.
Verpoort, P. C., Gast, L., Hofmann, A., & Ueckerdt, F. (2024). Impact of global heterogeneity of renewable energy supply on heavy industrial production and green value chains. *Nature Energy*, 1-13.
Wang, S., Fath, B. and Chen, B., 2019. Energy–water nexus under energy mix scenarios using input–output and ecological network analyses. *Applied Energy*, vol. 233, pp. 827-839.
Wanapinit, N. (2023). *Characterization of operational flexibility resources and*

evaluation of potential utilization in distributed energy systems (Doctoral dissertation, Dissertation, Universität Freiburg, 2023).

WBCSD, 2019 [online]. *How We Drive Sustainable Development*. Available at: https://www.wbcsd.org/ [accessed on 09/07/22].

Weaver, J. and Olson, J. K., 2006. Understanding paradigms used for nursing research. *Leading Global Nursing Research*, vol. 53, no. 4, pp. 459-469.

West, J and Oldfather, P., 1995. Pooled case comparison: An innovation for cross-case study. *Qualitative Inquiry*, vol. 1, no. 4, pp. 452-462.

Wexen, S. and Stocksen, M., 2021. Easy as one – two – three? A qualitative study on three factors that affect sustainability in heavy industry organizations, Bachelor's thesis, Umea University.

Whittington, R., 2001. *What Is Strategy-and Does It Matter?* London: Thomson Learning.

Widener, P. and Rowe, C., 2018. Climate discourse: Eluding literacy, justice & inclusion, by evading causation, privilege & diversity. *Environmental Sociology*, vol. 4, no. 1, pp. 162-174.

Wittneben, B. B., Okereke, C., Banerjee, S. and Levy, D. L., 2012. Climate change and the emergence of new organizational landscapes. *Organization Studies*, vol. 33, no. 11, pp. 1431-1450.

Wolf, E. J., Harrington, K. M., Clark, S. L. and Miller, M. W., 2013. Sample size requirements for structural equation models: An evaluation of power, bias, and solution propriety. *Educational and psychological measurement*, vol. 73, no. 6, pp. 913-934.

Wong, C. M., 2018. Energy, risk and governance: The case of nuclear energy in India. London: Palgrave Macmillan.

Wong, C.M.L. and Lockie, S., 2020. Climate policy and industry elite perceptions of risk and uncertainty: A cross-national study. *Society and Natural Resources*, vol. 33, no. 11, pp. 1-20.

World Bank, 2013 [online]. *First Set of Global Data on Energy Access, Renewable Energy and Energy Efficiency Released*. Available at: https://www.worldbank.org/en/news/press-release/2013/05/28/first-set-of-global-data-on-energy-access-renewable-energy-and-energy-efficiency-released [accessed on 02/07/22].

Wu, H., Chen, Z., Chi, W., Bindra, A.K., Gu, L., Qian, C., Wu, B., Yue, B., Liu, G., Yang, G., Zhu, L. and Zhao, Y., 2019. Structural engineering and luminogens with high emission efficiency both in solution and in the solid state. A*ngewandte Chemie International Edition*, vol. 58, no. 33, pp. 11419-11423.

Wu, X., Zhang, L. and Feng, H., 2019. Green strategic planning approach for international shipping activities. *Sustainability*, vol. 12, no. 1, pp. 41-52..

Wyns, A. and Beagley, J., 2021. COP26 and beyond: Long-term climate strategies are key to safeguard health and equity. *The Lancet Planetary Health*, vol. 5, no. 11, pp. e752-e754.

Xiao, Y. and Watson, M., 2019. Guidance on conducting a systematic literature review. *Journal of Planning Education and Research*, vol. 39, no. 1, pp. 93-112.

Xu, B. and Chen, J., 2021. How to achieve a low-carbon transition in the heavy industry? A nonlinear perspective. *Renewable and Sustainable Energy Reviews*, vol. 140, pp. 1-17.

Xu, B. and Lin, B., 2020. Investigating drivers of CO2 emission in China's heavy industry: A quantile regression analysis. *Energy*, vol. 206, 118159.

Ylä-Anttila, T., Vesa, J., Eranti, V., Kukkonen, A., Lehtimaki, T., Lonkila, M. and Luhtakallio, E., 2018. Up with ecology, down with economy? The consolidation of the idea of climate change mitigation in the global public sphere. *European Journal of Communication*, vol. 33, no. 6, pp. 587-603.

Zagrouba, M., Sellami, A., Bouaicha, M. and Ksouri, M., 2010. Identification of PV solar cells and modules parameters using the genetic algorithms: Application to maximum power extraction. *Solar Energy*, vol. 84, no. 5, pp. 860-866.

Zaini, I. N., Nurdiawati, A., Gustavsson, J., Wei, W., Thunman, H., Gyllenram, R. & Yang, W. (2023). Decarbonising the iron and steel industries: Production of carbon-negative direct reduced iron by using biosyngas. *Energy Conversion and Management*, *281*, 116806.

Zhang, J. and Wang, C., 2011 [online]. *Co-Benefits and Additionality of the Clean Development Mechanism: An Empirical Analysis*. Available at: https://econweb.ucsd.edu/cee/papers/Zhang_Mar2011.pdf [accessed on

02/07/22].

Zhao, S., 1991. Meta-theory, mete-method, meta-data-analysis: What, why, and how? *Sociological Perspectives*, vol. 34, pp. 377-390.

Zhao, X. L., Zhang, S. F., Yang, R. and Wang, M., 2012. Constraints on the effective utilization of wind power in China: An illustration from the northeast China grid. *Renewable and Sustainable Energy Reviews*, vol. 16, pp. 4508-4514.

Zheng, C., Jiang, B., Xue, S., Chen, Z. and Li, H., 2019. Coalbed methane emissions and drainage methods in underground mining for mining safety and environmental benefits: A review. *Process Safety and Environmental Protection*, vol. 127, pp. 103-124.

9 APPENDICES

9.1 Crosstabulations of demographic data by age, gender, and occupation

How old are you?			What is your gender: Male	What is your gender: Female	Total
18-24	What is your occupation	Sales and marketing	1		1
	Total		1		1
25-34	What is your occupation	Manager	11	6	17
		Technician	4	4	8
		Sales and marketing	3	3	6
	Total		18	13	31
35-44	What is your occupation	Human resource	1	1	2
		Manager	12	7	19
		Technician	7	1	8
		Sales and marketing	5	2	7
	Total		25	11	36
45-54	What is your occupation	Human resource	1	0	1
		Manager	14	2	16
		Technician	6	0	6
		Sales and marketing	4	0	4
	Total		25	2	27
55-64	What is your occupation	Manager	8	6	14
		Technician	5	0	5
		Sales and marketing	2	2	4
	Total		15	8	23
65+	What is your occupation	Manager	3		3
		Technician	1		1
	Total		4		4
Total	What is your occupation	Human resource	2	1	3
		Manager	48	21	69
		Technician	23	5	28
		Sales and marketing	15	7	22
	Total		88	34	122

Figure 49: Crosstabulations of demographic data. Source: Own illustration

9.2 Ethics and Integrity – research form

The planned online survey will be conducted via Qualtrics. All saved data will be stored at the University password secured Q Drive system. The survey will be completely anonymous. The questions won't allow any conclusions about the participants.

The following introduction will be sent with the survey:

Dear Survey-Participant!

The implementation of renewable energy in heavy industry is an inevitable must in the coming decade in heavy industry. The following questions try to connect the understanding of (1) strategic development, (2) risk management and (3) transformational processes in this field.

We invite you to answer the questions for a better understanding of how an efficient transformation strategy can be developed on a national and international level.

This study has been reviewed and received ethics clearance. Should you have any comments or concerns resulting from your participation in this study, please feel free to contact me under: lecturegap@yahoo.com

All personal information, including your name, address, and survey answers will be kept strictly confidential and will not be shared with any person or group that is not associated with this study.

Your participation is voluntary and you may refuse to answer any questions you do not wish to answer. The data collected from this study will be summarized and no individual person will be knowingly identifiable from the summarized results. Responses to questions may be quoted, but without identifying the

individual source.

The participants will be recruited via the researchers professional network. Mainly participants of the middle and higher strategic leadership levels will be asked to participate as their expertise and understanding of the research field will deliver the most suitable answers and insights.

To answer the research question of this thesis a quantitative research method was chosen. The complexity of the research topic was broken down to the three main areas (1) strategy development, (2) risk management and (3) transformational process, according to the found literature in a thorough literature research that included academic papers and grey literature of the years 2015 to 2020.

The quantitative approach includes a questionnaire of 26 questions that evaluate the opinions and understanding of heavy industries middle management decision makers. The questions themselves were categorized accordingly to the defined three main research areas mentioned above.

All 26 questions deserve different kind of answers to avoid recurring answering automatism in the form of random clicking. Therefore, the answer mixture contains 5-point-Likert scales, multiple choice matrices and free commentaries. A demographic introduction leads into the survey asking for gender (Q1), age (Q2) and the occupational field of experience (Q3). The following questions can be visualized in the accompanying matrix.

Question	Strategy Development	Risk Management	Transformation Process
Q4 What are the major risks of changing the energy mix in heavy industry? **Answer: commentary**		X	
Q5 What are the major opportunities for changing the energy mix in heavy industry? **Answer: commentary**	X	X	
Q6 What are the major threats to changing the energy mix in heavy industry? **Answer: commentary**	X	X	X
Q7 What are the major weaknesses of changing the energy mix in heavy industry? **Answer: commentary**	X	X	X
Q8 What is the investment needed for changing the energy mix? **Answer: commentary**			X
Q9 What is your strategy to change the energy mix? **Answer: Yes-Likely-No-Matrix**	X		
Q10 How do you measure the success of this transition?			X

Question	Strategy Development	Risk Management	Transformation Process
Answer: Commentary			
Q11 What are your motives for changing the energy mix? **Answer: Commentary**		X	
Q12 What was the biggest technical hurdle for changing the energy mix? **Answer: Yes-Likely-No-Matrix**			X
Q13 What was the biggest difficulty? **Answer: commentary**		X	
Q14 What was the most important insight? **Answer: commentary**	X		
Q15 Did the process worked out as planned or scheduled? **Answer: 5-Likert-Scale**			X
Q16 What were the biggest obstacles in this process? **Answer: commentary**		X	
Q17 Would you prefer to go back to the previous energy mix? **Answer: 5-Likert-Scale**		X	X

Question	Strategy Development	Risk Management	Transformation Process
Q18 Has there been any unexpected side effects? **Answer: commentary**		X	X
Q19 How did the cost structure of the company change? **Answer: Yes-Likely-No-Matrix**			X
Q20 Did you meet resistance in a project related to changing the energy mix? **Answer: Yes-Likely-No-Matrix**			X
Q21 Did the changing of the energy mix meet your expectation? **Answer: 5-Likert-Scale**	X		X
Q22 Do you think changing the energy mix is more important than increasing efficiency? **Answer: 5-Likert-Scale**	X		
Q23 In your view, what is the time line for changing the energy mix in heavy industry? **Answer: Slider**		X	

Figure 50: Quantitative approach – questionnaire. Source: Own illustration

The data analysis includes quantitative aspects as the 5-Point-Likert Scales and the Yes-Likely-No-Matrix and quantitative evaluation through the commentary sections. As some of the questions touch the research areas solely and others try to get a better understanding of the intersections between the research fields, the final results will deliver a broader understanding of the perception and awareness of professionals in this this field of expertise.

9.3 Qualitative data

Participant	Point of View	Major Opportunities	Major Threats	Major Weakness	Needed Investment	Change Strategy	Transition Success	Change Motives	Biggest difficulty	Important Insight	Biggest Obstacles
	What are the major risks of changing the energy mix in heavy industry from your point of view?	What are the major opportunities for changing the energy mix in heavy industry in your field?	Are there major threats to changing the energy mix in heavy industry?	Are there major weaknesses of changing the energy mix in heavy industry?	What is the investment needed for changing the energy mix?	What is your strategy to change the energy mix? - Others - Text	How do you measure the success of this transition?	What are your motives for changing the energy mix?	What was the biggest difficulty?	What was the most important insight?	What were the biggest obstacles in this process?
1	It can't be done	If it would be possible there would be a lot of work until it works out	Competitors	Yes. Mostly political issues and knowledge transfer issues	Billions	International cooperation to all countries with standerd solutions for energy transition addressing sustainable future and climate change	Surveys and Balanced Scorecards	climate change	Vision sharing	It is not possible to get all recentiments out of the way	People
2	Too much CO2-emissions will lead to higher costs and penalties in the supply chain	Lowering CO2-emissions will bring competitive advantages through lower	Finding the right balance of lowering the CO2-emissions and implementin	Heavy industries usually is usually related with a high consumption	Firstly, the mind-set of the top-management has to change and cultural skills are needed to overcome traditional thinking.		Dominating KPI are CO2-emissions, supported by industry related specific criterias such lowering	Avoidance of costs for CO2-emissions and Generation of a competitive advantage	To Overcome the mental barriers.	That it is feasible and less complex than expected.	To get a common understanding within the organisation

Participant	Point of View	Major Opportunities	Major Threats	Major Weakness	Needed Investment	Change Strategy	Transition Success	Change Motives	Biggest difficulty	Important Insight	Biggest Obstacles
		costs for emission and better reputation in the supply chain.	g economical viable solutions.	of raw material and of energy, so the whole supply chain is loaded with CO2-emission.	Economically, any investment in changing the energy mix will amortizise.		the demand in kWh, lowering fossile fuels etc.				
3	The grid stability	New technology for energy storage and grid management as renewable energy and hydrogen is introduced as new energy mix.The new hydrogen mobility and FCV and BEV also needs to be integrated through solid Hydrogen and new battery	Black outs if system is not synchronise d	Grid stability and energy storage	Depends on condition and decision		Grid stabilization and cheap energy and utilities	Chep energy and mitigating climate change improvement in economics and job creation at grass roots	Internation al technical and financial cooperatio n and standerdiz ation	Cooperati on and peace for prosperity instead of competitio n compassi on.	Policy will and anti lobbying

Participant	Point of View	Major Opportunities	Major Threats	Major Weakness	Needed Investment	Change Strategy	Transition Success	Change Motives	Biggest difficulty	Important Insight	Biggest Obstacles
		technologies for grid level storage.									
5	Costs, jobs, available skilled labour.	New energy production, ESG monitoring, AI/ML/Digital Twins for simulations, Energy storage.	Job loss, lack of skilled labour, pace of change being too slow to stop the environmental damage fast enough.	Cost and Fear of the unknown. Regulatory uncertainty.	Enormous. Cant put a number on it, but it will be Trillions, not billions.		GHG intensity, economics, national GDP and labour employment rate.	Leaving world in a better spot than when I got here.	Ensuring everyone "pays", not just the poor		
6	Higher capital costs (heat requirements would be higher), need to develop infrastructure and new processes/ equipment to facilitate renewable fuels, commercialisation of carbon-										

Participant	Point of View	Major Opportunities	Major Threats	Major Weakness	Needed Investment	Change Strategy	Transition Success	Change Motives	Biggest difficulty	Important Insight	Biggest Obstacles
	neutral energy systems in the industry.										
7	Lack of Awareness Lack of Collaboration Lack of Data Lack of Consensus	To stop the Climate Change To implement the SDGs	Supply Chain can be interrupted								
8	None, compared to the risk of not changing the energy mix in heavy industry.	Industry products that are sustainable and therefore have a new USP.				In the U.S. direct regulation will be required					
9	Power quality and reliability, cost, changing regulations	Adoption of low-cost renewables, battery storage, load management	Reliability--increased outages due to intermittent resources and insufficient storage or	Storage is not a scale yet-- there needs to be more of it, and for much longer duration	Storage, transmission, and research on fast-start carbon-free generation		Closure of fossil generation sites, decreasing carbon emissions	Climate change, keeping up with national agenda and regulation	Changing the status quo	Reinventi ng cities	

Participant	Point of View	Major Opportunities	Major Threats	Major Weakness	Needed Investment	Change Strategy	Transition Success	Change Motives	Biggest difficulty	Important Insight	Biggest Obstacles
			fast-start generation								
10	Cost	New bussiness models	Regulations	Lack of understandi ng in the processes	Depends on the industry and the state of the art		Reduction of CO2 versus cost	climate and environment and the regulations by the EU	Lack of knowledge	How to reduce cost and efforts as well as enhance efficiency	Cost , convince the people
11	Covering Energy Peak times and demand with emission free generation	Hybrid Solar and Wind power generation, incl. Storage (not necessarily battery)	#NAME?								
12	Security of supply	diversification CO2 reduction	availability	availability	not clear		profitability	observed regulation customer requirements			
13	Chicken and egg, supply and demand. It's becoming more apparent that hydrogen is the way to go, but	We're already massively expanding our engineering team due to the new influx of clean	At the moment, the fuel is more expensive than the incumbent fuel....		Huge. We're looking at ammonia for deep sea shipping, of which there is some exisiting infrastructure in port areas. It will still						

Participant	Point of View	Major Opportunities	Major Threats	Major Weakness	Needed Investment	Change Strategy	Transition Success	Change Motives	Biggest difficulty	Important Insight	Biggest Obstacles
	it's all about the supply and having enough consumers to justify the supply.	energy products, so not only is there a huge environmental opportunity, but there's also an economic one as well.	economic reasoning is always a challenge		require huge investment all around though						
14	Missing base load, grid stability, and high energy prices.	Sustainability.	See 4								
15	Costs and stability	CO2 emission lowering - which is good for the global heating	just costs	The stability of energy	I dont know						
16	Not enough available Renewable Energy, high costs.										
17	Heat demand and supply	Focus on the sustainable/re					How efficient it is after the practice	To contribute to the climate			continuously supply of

Participant	Point of View	Major Opportunities	Major Threats	Major Weakness	Needed Investment	Change Strategy	Transition Success	Change Motives	Biggest difficulty	Important Insight	Biggest Obstacles
		newable sources of energy which contributes to the reduction of CO_2 emissions					and seeing the results, how other industries inspire from it.	change			energy from the renewables
18	costs, uncertainty in performance	decarbonization, efficiency, sustainability, decentralised, local	economic, regulatory	unclear regulatory framework, infrastructure adaptation	from tens to hundreds of millions $		jobs, carbon intensity, LCOE	sustainability, renewable, local			
19	price risk, not enough competition, security of supply	production of sustainable products with the potential to sell them with a premium, securing subsidies as early mover, distinguishing from producers e.g. in China	security of supply, unstable policy	it depends on the change. a coal to gas switch should be done with the long term switch to hydrogen in mind when designing the plant							

Participant	Point of View	Major Opportunities	Major Threats	Major Weakness	Needed Investment	Change Strategy	Transition Success	Change Motives	Biggest difficulty	Important Insight	Biggest Obstacles
20	Load flexibility, integration of renewables and hydrogen, currently no economies of scale, initial market restrictions, hesitation of policy makers, lack of awareness and public perception.	Decarbonization, environmental protection and climate resilience, moving away from oil and gas, sustainability and LCA approach	No subsidies, no economies of scale, no support from policy makers.	Limitations in current technology, not enough R&D funding, no connection between academia and industry.	No exact figure, but the injection of capital and lending capacity are of paramount importance and the amounts are of the order of tens of millions US$ per country, proportional to each country's GDP		By lowering CO2 emissions, by GDP increments, by increased job positions, by climate protection, adhering to UN's SDGs	Sustainable development, environmental protection, future generations, going green all the way	Public awareness	Climate change	Projects' bankability and politicians' ineligibility for their roles
21	Availability and costs	Providing a green and CO2-free production will enhance competitiveness				Every plant should develop their own concept and start implementing. Waiting for politics to work on amended regulations is like waiting for the storm that you see on the					

Participant	Point of View	Major Opportunities	Major Threats	Major Weakness	Needed Investment	Change Strategy	Transition Success	Change Motives	Biggest difficulty	Important Insight	Biggest Obstacles
						horizon to be confirmed by officials. Individual solutions are available and usually profitable to implement if not subsidies are keeping the fossil energy at lower levels. It is time to work on a transition business case and move ahead of the competition to have an increased competitive advantage and a marketing effect as a role model at the same time. The lobbying against					

Participant	Point of View	Major Opportunities	Major Threats	Major Weakness	Needed Investment	Change Strategy	Transition Success	Change Motives	Biggest difficulty	Important Insight	Biggest Obstacles
						energy transition is a wasted effort and all it may achieve could be buying a little time without maintaining a future proof business environment but loosing precious time to prepare for the inevitable and necessary.					
22	The necessary availability of renewable energies and the costs	Greenhouse gases, resource efficiency of processes	The missing infrastructur e of hydrogen and renewables	Power grid, costs of energy, regulations	Unclear which level is meant? Local on a national level?		Greenhouse gas reductions Stability of economical revenues	Climate and regulations, new production strategies,	Cost	It is possible without losing economic al success	The mindsets of the common thinking and the money (costs)
23	High cost of CO2 if you do not change. Producing on the environmental expense and	As an advisor, we support heavy industry to save cost and fossil fuel, reduce CO2	No	The weakness will be hesitation and inaction as	It depends. The are options for investing on balance into new energy generation technology or procure energy		In a share of CO2 emissions avoided by implementing measures while reducing	Contribute my share to reduce CO2 Emissions while enabling businesses to	Change the perception of industry leaders to understan	That it needs the sharehold ers to start disinvesti	Management mindsets

Participant	Point of View	Major Opportunities	Major Threats	Major Weakness	Needed Investment	Change Strategy	Transition Success	Change Motives	Biggest difficulty	Important Insight	Biggest Obstacles
	cost of tax payers is not going to be sustainable. Plus RE will being cost savings. Technical solutions are not a concern, all is available.	emissions as a windfall profit.		compared to develop a sustainable plan. It may require expert support to develop a transition plan to reach a 100% re share and it would be implemented in stages over time. There is no solution that would not have interfaces with the production, as it would be able to identify synergies	under energy supply contracts ESCO or power purchase agreements PPA where a third party would invest and sell the energy across the fence. The biggest benefit is that it will in almost all cases will be a profitable investment, as solar and wind have become the lowest cost producers for electricity. So it can not be seen as spending money without economic return any more. Every shareholder should seek to reduce cost of production by reducing his energy cost		production cost. For the example of mining industry, renewable energy reduces power cost and enables lower grade resources to be explored profitably. Same would apply for production plants. Energy transition should be priority in every firm in the sense to identify the cost savings potential for the business by moving forward.f	become more profitable	d the benefit of the transition (cost and CO2 savings) and take the responsibility for the industries CO2 footprint. Awareness and ability to see the benefit over the risk is a bottleneck. Lobbying against while hiding behind non	ng fossil companies and create a strong requirement to move towards the transition. You do not need to be a green moralist to move, one should do it for the sake of future proofing the business	

Participant	Point of View	Major Opportunities	Major Threats	Major Weakness	Needed Investment	Change Strategy	Transition Success	Change Motives	Biggest difficulty	Important Insight	Biggest Obstacles
				and get benefits for the whole process					existing (and fought) policy ore undermining transition targets does not help the industry to become future resilient.		
24	Making sure the grid is safe and stable.	Solar and energy storage.	I don't believe so	I don't see any.	Not my area of expertise		String economy and grid security.	Benefit the environment.	Nimbyism.	Knowledge of grid and where economical injection can work	Permitting and opposition to renewables.
25	Storage, price, reliability	Independence, price	I don't know	Cost	Enormous		Do not measure	Profit	Large scale storage	That combustion fuels are required. The	

Participant	Point of View	Major Opportunities	Major Threats	Major Weakness	Needed Investment	Change Strategy	Transition Success	Change Motives	Biggest difficulty	Important Insight	Biggest Obstacles
										question is how to make them green.	
26	Oil&gas Infrastructure	H2	Yes	Yes	I dont know		Co2 emitions	Sustainability	Mind	Life	R&D funding, scale up
27	Intermittency of the new energy source, the Capex investment & the existing mature (obsolete) infrastructure	Hydrogen market & digital solutions	Government regulations , social pressure, technology readiness				tangible benefits (reported emission) to the industry	Evolving Market	Investment		Oil&gas industry
28	Energy qulality stability of supply	becoming really sustainable gaining experience for the time when there is no other alternative being prepared for the future		cost effectivness chash flow constraints raising product prices				see above			technology readiness against time along with the investment strategy
						Promote a					cultural

Participant	Point of View	Major Opportunities	Major Threats	Major Weakness	Needed Investment	Change Strategy	Transition Success	Change Motives	Biggest difficulty	Important Insight	Biggest Obstacles
						global CO2 price					transition
29	International markets => Loss of competitiveness	Sustainability (survival + acceptance)	See 4	Synchronicity of supply and demand, availability of quantities at any point in time	Billions		Growth in relevant sectors	Survival	See 4	It cannot be changed on a national level	
30	Reliability (that they are available anytime), Integration (if dedicated heat / power signatures are needed)										
31	Supply redundandcy strategy required	Becoming green and be part of the solution, to solve climate crisis (instead of being a problem)	No. Only threat is "changing behaviours" - this is psychologically.	Reliability has to be given. Sun does not always shine, wind does not always blow. But, different sources	Building trust, to overcome the psychologically fear of change. Giving tax decrease, for using green energy. Raise prices for conventional energy (coal, nuclear etc.)		Share of energy used, conventional versus green	Be part of the solution, to fight climate change	To change the behaviour and mind of people	All technical solutions are already existing. The only thing that has to change	-

Participant	Point of View	Major Opportunities	Major Threats	Major Weakness	Needed Investment	Change Strategy	Transition Success	Change Motives	Biggest difficulty	Important Insight	Biggest Obstacles
				connected will be the perfect mix.						are "we" (humans".	
32	Technisch: Verfügbarkeit Finanziell: Kosten für Energie und Systemanpassung	Tax benefits; carbon foot print	Deep technial skills are needed	No	Unfortunately more compared to fossil solutions		Mitigstion of purchased energy price oncrease	Env protection; new technologies; social awarness	Convincment	Once cinvincment is done, execution successfully done; there is appetize for more	
33	Meeting Energy demands every time. Supply and distribution of the energy resources like green hydrogen	1. Kosten: langfristig Kosten tiefer, insbesondere Steuern 2. Kunden: Unternehmen in Cleantech Bereich 3. Mitarbeiter: Unternehmen zieht neue Leute an, die innovativ sind 4. Aktionäre:	1. Kurzfristige Kosten und Liquidität 2. Veränderung braucht Unterstützung - Top down aber auch bottom up								The people

Participant	Point of View	Major Opportunities	Major Threats	Major Weakness	Needed Investment	Change Strategy	Transition Success	Change Motives	Biggest difficulty	Important Insight	Biggest Obstacles
		Werthaltigkeit Aktien langfristig hoeher									
	No storage										
34	Cost and availability of technology										
35	Not knowing if the legal landscape will change and invest in specific technologies anyway	The opportunities are vast through optimisation of plant and the application of technology that supports the move towards renewables	Investment and market	Availability of subsidies, legislation that's supports decarbonisation and cost effective fuels	-	Building a legal framwork That encourages auch measures	-	Concern for the future	-	-	
36	Reliability, Cost, Carbon-intensity/Sustainability										
		Cost reduction/ CO2-Prices	Legal unvertainty	I dont know	I dont know (im a lawyer, i dont invest)		Maybe reduction of energy costs	Reduction of cost, external impact	Swift an fair ;-)	From what?	-

Participant	Point of View	Major Opportunities	Major Threats	Major Weakness	Needed Investment	Change Strategy	Transition Success	Change Motives	Biggest difficulty	Important Insight	Biggest Obstacles
37	Costs increasing	Same as before - Better Reliability, Better Cost, Better Carbon-intensity/Sustainability	Avoid stranded assets, maturity stage of technology answers	Speed	Very much depending on the application and age of existing assets		CO2 per Unit produced, Total bill of energy	Make operations more sustainable and competitive	Time	Continuous change requires Continuous openness	
38	The current infrastructure is not suitable	CO2 Optimierung, Klima-freundliche Energieversorgung	Prozesswärme nur schwierig ohne fossile Energie (Gas) bereitstellbar.	Investitionskosten (kurzfristige Optimierung) und fehlende Kontrolle der Lieferketten (Ausland)	Umstellung der Energieträger setzt teilweise andere Prozesse und Systeme voraus		Kein Standard soweit. Wir messen CO2 Ausstoß in Echtzeit	Klima ist grösste Herausforderung und größtes Geschäft	Mindset of Management, Finanzielle Mittel, Abwanderung nach China		Cant Tell, because im Not Part of a process like this (im a lawyer and See many obstacles in many firms)
39	Price competitiveness and reliability of the "new" energy sources	Technological development, green financing attracting, avoiding stranded assets	Lack of feasible business models for usual, routine transition. Lack of proven and feasible low-carbon technologies	Heavy industry requires fossil fuels as energy source of raw material in order to provide customers with products of	Difficult to answer. We actually would need new industry		1) GHG emissions reduction 2) GDP growth 3) public acceptance is positive	Climate change mitigation, diversification of technology and energy mix, global energy security and decentralization	Switching to 100% another industry dealing with social and economic development issues in global scale	Didn't get the question. Insight on what? where?	Time, Mindset

Participant	Point of View	Major Opportunities	Major Threats	Major Weakness	Needed Investment	Change Strategy	Transition Success	Change Motives	Biggest difficulty	Important Insight	Biggest Obstacles
				high quality for competetive price. Switching will threat both							
40	Energy Security Overcoming engineering challenges Infrastructure or lack of it	I'm not sure if there's a suitable alternative right now									
41	Cost + missing CO2 relevance	Conversion of traditional industries into green and sustainable bussinesses. Being competitive in the long run	New technologies tend to be more costly at the beginning and require huge investments. This can slow down the transformation process drastically	Uncertainties with regards to technologies which will become standard and financially viable long-term	I assume huge amounts of investments - in industries which are already under price pressure		The percentage of the total heavy industry which moves to green energy sources	Conserving the environment and planet earth	Technologies have to be made available at large scale and at competitive prices	Going forward to make industries green is without alternative	I suppose that where is a certain gap which cannot be avoided without complete restructurizing of industry, business models and technologial basis

Participant	Point of View	Major Opportunities	Major Threats	Major Weakness	Needed Investment	Change Strategy	Transition Success	Change Motives	Biggest difficulty	Important Insight	Biggest Obstacles
			which could shift the successful regions to places where these green innovations are made standard fastest.								
42	Conversion cost accuracy.	Decarbonisation, providing micro grids that can provide energy resilience Supporting ESG's associated with industry	Yes people slow to find solutions No incentive to commit to change Low investment into changing a process	If there are it will be weakness in leadership, policy and regulations	That is dependent on the size of the industrial area or process you are looking to change		Lower GHG	Preventing global warming and the environmental affects it causes	Affording the transition	The ability to decarbonise heavy industry is going to be measured in terms of emissions within the next decade, industry that do not	

Participant	Point of View	Major Opportunities	Major Threats	Major Weakness	Needed Investment	Change Strategy	Transition Success	Change Motives	Biggest difficulty	Important Insight	Biggest Obstacles
										comply will find themselves uncompetitive maybe not in terms of price or profit but on pollution and emissions.	
43	Few experience with hydrogen or other synthetic fuels, too few refueling stations, too expensive	CO2 reduction + Efficiency, autonomy									Available Technologies within a suitable price range
44	Not yet known/implemented regulatory framework, subsidies	Electrification.	Inadequate front end loading to delineate the societal,	Lack of experience.	don't know						Stakeholders to change and the public to believe

Participant	Point of View	Major Opportunities	Major Threats	Major Weakness	Needed Investment	Change Strategy	Transition Success	Change Motives	Biggest difficulty	Important Insight	Biggest Obstacles
	necessary initially to bridge funding gap		environmental and economic risks,								
45	Reliability in supply	Become CO2-neutral, be a role model, social acceptance	Every aspect needs to be taken into concideration e.g. having the trucky on ferry ships or underground - safety is a major issue for broad acceptance	I don´t think so.	Difficult question, can´t be answered in general.		Again can´t be answered in general. Maybe by "saved" CO2-emissions	To turn the wheel and create a sustainable future and to be a role model for others to follow			
46	Reliable constant energy supply	Companies and countries want to meet Climate Agreement standards	Governments moving too slow with regulatory framework and other support mechanisms	Price; fossil fuels are currently the cheaper alternative	Massive!						
47	availability	CO2 footprint. Cost purchase	.	.	Capital; mind changing; change				Convince investors		

Participant	Point of View	Major Opportunities	Major Threats	Major Weakness	Needed Investment	Change Strategy	Transition Success	Change Motives	Biggest difficulty	Important Insight	Biggest Obstacles
		mitigation			management						
		Co2 company foot print	Non reliable energy supply in production area	Willingness for investments	Capital investment; human capital		Customer feedback; energy bills	Gettimg more „green"; mind set in terms of environment	Demand conviction	Due dilligence process - being familiar with taxes & grid operator fees	
		renewables			high investment		precentage of changed energy sources (e.g. from fossile to renewable)	avoiding future cots, avoiding a drown grading when it comes to interest rates for invest capital	convincing people that stick to establishe d processes	if there is a strong driveing force thinks will be moved forward	Getting project approval
											availability of technology

Figure 51: Qualtitative data Source: Own illustration