Department of Thematic Studies

Environmental Change

Växjö's Fossil Fuel-Free Ambition: A Case Study on the Challenges of Achieving Carbon Neutrality in a Small City

Bin Meng

MSc Thesis (30 ECTS credits)

Science for Sustainable development

Linköpings universitet, SE-581 83 Linköping, Sweden

Copyright

The publishers will keep this document online on the Internet – or its possible replacement – for a period of 25 years starting from the date of publication barring exceptional circumstances.
The online availability of the document implies permanent permission for anyone to read, to download, or to print out single copies for his/hers own use and to use it unchanged for non-commercial research and educational purpose. Subsequent transfers of copyright cannot revoke this permission. All other uses of the document are conditional upon the consent of the copyright owner. The publisher has taken technical and administrative measures to assure authenticity, security and accessibility.
According to intellectual property law the author has the right to be mentioned when his/her work is accessed as described above and to be protected against infringement.
For additional information about the Linköping University Electronic Press and its procedures for publication and for assurance of document integrity, please refer to its www home page: https://ep.liu.se/.

© 2024 Bin Meng
This work is licensed under the Creative Commons Attribution 4.0 International License. To view a copy of this license, visit http://creativecommons.org/licenses/by/4.0/

Table of Contents

Abstract

The Swedish municipality of Växjö has set the ambitious climate goal of becoming a fossil fuel-free city by 2030. Växjö has long strived to become an eco-smart, green and healthy, growing and inclusive city, and create a community that stops causing any negative climate impacts by 2030. The study uses the qualitative research method of case study. The policy document and municipal published reports from Växjö municipality provide the empirical data. Four online interviews were conducted to provide the first-hand data. This thesis aims to critically analyze the challenges and constraints that Växjö faces in its process of fossil fuel-free ambition achievement. And answering three research questions: the current strategies, challenges (in technology, policies, and social aspects), and solutions implemented by Växjö Municipality. The conclusion shows that Växjö has fall behind in achieving carbon neutrality by other Swedish peer cities, and there are gaps between symbolic actions (e.g. green branding) and real sustainable practices. The transition to a just and inclusive framework is needed to reconcile the rhetoric with reality for Växjö. This research fills the gap of a deeper understanding of complex dynamics in a small municipality like Växjö to achieve carbon neutrality and fossil fuel-free ambition, contributes to understanding the complex dynamics of local sustainability efforts, and contributes to the growing literature on energy transition theory in a specific city. It also offers practical insights for other municipalities, especially the small cities that pursue the similar climate goals.

Key words: Växjö, Fossil fuel-free, energy transition, challenges, sustainable transportation

Lists of Abbreviations

BBR: Swedish National Building Code

C40: C40 Cities Climate Leadership Group

ETS: Emissions Trading System

EV: Electric Vehicle

G20: Group of Twenty

GCoM: The Global Covenant of Mayors for Climate & Energy

CCS: Carbon Capture and Storage

CDR: Carbon Dioxide Removal

GHG: Greenhouse gas

ICLEI: Local Government for Sustainability

JRC: Joint Research Centre

LEZs: Low-emission zones

MLP: Multi-Level Perspective

NECP: Sweden's Integrated National Energy and Climate Plan

SAF: Sustainable aviation fuel

SDGs: Sustainable development goals

UNFCCC: United Nations Framework Convention on Climate Change

VEAB: Växjö Energi

1. Introduction

1.1 The Role of Cities in Climate Action

Climate change is an urgent challenge that can only be addressed through the actions of many stakeholders. Among the driving factors, the exploitation and consumption of fossil fuels is one of the significant factors that exacerbates climate change (Lazarus et al., 2018). How to eliminate the conflicts between the consumption of energy and the demand for economic and societal development is an urgent and tricky problem (Mokal et al., 2023). Cities play an important role in mitigating greenhouse gas (GHG) emissions and transitioning to more sustainable futures. Cities are not only located at key to sustainable settlements but also where economic activities take place and more than half of humans lives, accounting for over 70% of CO_2 emissions worldwide associated with fossil fuel consumption (Bazaz al., 2018). The developed industries and infrastructure in cities lead to more opportunities and the responsibility for local governments to achieve and charge toward carbon neutrality (Liu & Xi, 2024). Cities also have the ability to institute new policy, test out different technology, and bring communities together in a manner that has the potential for significantly reducing emissions (Yang, 2023).

With the implementation and approaching of SDGs and the Paris Agreement, cities are expected to contribute more to the achieving of carbon neutrality by around 2050 (Ramaswami et al., 2021). However, large cities often dominate sustainability efforts. For example the network of the C40 Cities Climate Leadership Group (C40 for short), which is a global organization that engages nearly 100 cities around the world, is committed to tackling climate change and is dedicated to urban sustainability, is leading by large cities like New York, London, and Beijing (C40.n.d.). Usually, smaller municipalities are more likely to face challenges in achieving such transitions.

1.2 Problem Formulation

Researchers (Lamb et al., 2020) have studied incremental emission reductions, highlight the 'discourses of climate delay' can be challenging for cities' transformative actions. The discourses like 'waiting for better technology' or 'shifting responsibility to others,' hinder cities from achieving carbon neutrality or net-zero emissions in a short time. And the research on how to support cities in achieving carbon neutrality such as comprehensive policy design, technological innovation, and behavioral changes is crucial for cities to achieve transformative climate actions within timeframes.
Sweden aims to achieve carbon neutrality and phase out fossil fuels by 2045 (The Ministry of Infrastructure, 2020). The Swedish net-zero target is considered one of the most ambitious and legally binding targets globally (ECUI, 2020). Swedish municipalities set up their specific climate goals to achieve carbon neutrality and net-zero emissions ("Zeroing In on Cities", 2024). Vanhuyse et al. (2023) conducted a study regarding Swedish municipalities

seeking to achieve carbon neutrality and elaborated on the mitigation-related policies of nine Swedish cities. They found that the municipalities that focused on territorial emissions instead of consumption-based emissions, had specific and ambitious climate targets but soft policy instruments which led to gaps between plans and practices. Their study showed that cities do not employ enough emission reduction measures aimed at high-emission industries and often rely on information and communication but often lack mandatory regulations.

Although Scandinavia is known for its sustainability leadership, large cities often steal the spotlight (Nikel, 2025). Compared with the actions of achieving carbon neutrality in large cities, small cities usually have more challenges and barriers during their ambitious climate target implementation, those challenges remain understudied despite their climate action innovation and achievement (Acuto, M., et al., 2018). Växjö is one of those small cities. Early in 1996, Växjö's municipality launched an ambitious called "Fossil Fuel-Free Växjö", the ambition was considered one of the earliest declarations of becoming fossil fuel-free in the world (Wälitalo et al., 2020). In 2015, the document called "Växjö Declaration" was handed over to the Swedish Minister of Environment, sought to urge the Swedish government to take meaningful action in order to achieve fossil fuel-free together with Växjö. Later, this "1996 Växjö Declaration" evolved into the "Sustainable Växjö 2030", which established more sustainable goals, and integrated energy technologies, sustainable urban planning, and other measures to achieve the municipality's goals (Växjö Kommun, 2019). Växjö's work in this area made the city win global awards and recognition (Pesch et al., 2019), such as the 2018 European Green Leaf Award by the European Commission, the 2007 Sustainable Energy Europe Award (Växjö kommun, n.d.). Now, there are just a few years left to 2030, whether the fossil fuel-fuel goal truly be met in Växjö? And what challenges and gaps remain behind this ambitious goal's achievement? Do any limitations lie in municipal solutions? Is the green branding of Växjö just greenwashing or implementing effective policies and practices? Those problems are worth in-depth exploring.

1.3 Research Aim and Research Questions

Research Aim

This study aims to critically analyze the challenges and constraints that Växjö faces in its process of becoming fossil fuel-free. Through the analysis of the empirical and primary data, the study will focus on identifying the challenges in policies, technology, and systemic barriers that hinder the process of the achievement of fossil fuel-free target.

Research Questions

1. How does Växjö work to become a fossil fuel-free city by 2030?
2. What are the systemic and practical challenges that hinder Växjö in achieving its fossil fuel-free target by 2030?
3. How is the municipality seeking to address those challenge?

1.4 Significance of Studying Växjö's Case

The reseach of climate governance usually highlight the leadership of large cities, smaller cities' climate efforts are not always be regarded as importance (Acuto, M., et al., 2018).The studying of Växjö's case contributes to the growing literature on Swedish municipality's challenges in the implementation of climate target, particularly contributing to the literature related to the theory of energy transition as well as the transition in small cities. This analysis and findings can contribute to the academic literature on policy implementation challenges. Moreover, by analyzing Växjö's experiences, the study can serve as a comparative study with other places that have set similar goals. This comparative aspect can provide an understanding of best practices and common challenges in the aspect of a fossil fuel-free transition.

The study of Växjö's case and its fossil fuel-free strategies can provide valuable lessons for other cities, especially for the smaller cities that have the similar climate targets (Andersson & James, 2018). The principles and approaches behind, can be adopted by other cities (Ahmed & Nguyen, 2022), Växjö's practices highlight the potential obstacles and the learned lessons for other cities and remind them of the challenges might face in their own carbon neutrality and other climate goals' achievement (Dyer & Ögmundardóttir, 2018). The difficulties and challenges during the green energy transition are diverse, might include economic barriers, policy gaps and societal inertia(Vuthi et al., 2024). By studying the case of Växjö, other cities can be inspired and act better when they confront similar issues in their own contexts.

1.5 Structure of the Thesis

The content of the thesis is divided into six main chapters.

Chapter 1: Introduction
This chapter introduces the role of cities in climate action achievement, discuss why Växjö's commitment to becoming a fossil fuel-free city worth to explore as well as the significance of studying Växjö's practices and experience. It also outlines the research aim and the research questions.
Chapter 2: Background
This chapter focus on the role of city and collaborative governance in climate actions pursuing. The theoretical framework of energy transition theory, Residual Emission and Just Transition are introduced. As well as the relevant practices of other cities from the current research. The overview of the study area-Växjö is introduced in this chapter. This chapter aims to establish the foundation of the theoretical framework for the study.
Chapter 3: Method
This chapter details the methodology used in the study, including the research approach-qualitative research, the research method is the case study, the method of data

collection, and the analysis methods. The overview of the study area-Växjö is introduced in this chapter. Delimitations and limitations of the research will be elaborated on as well.

Chapter 4: Results

Based on the collected data, this chapter explores Växjö's current strategies for the journey of becoming fossil fuel-free, the main challenges in this journey, and the related solutions. The outcomes are based on the policy documents, empirical materials, and transcripts of conducted interviews, and analyzed under the theoretical framework of energy transition theory, as well as the concepts of residual emissions, and just transition, response to the research questions one by one.

Chapter 5: Discussion

This chapter discusses Växjö's green image, and the need for civilization-critical perspectives, as well as transition should be just and inclusive.

Chapter 6: Conclusion

The last chapter summarizes the key findings of the research, and how the study can contribute to the related literature on fossil fuel-free cities, and explore their implications for other cities. The reflections for future study are discussed.

2. Background

2.1 The Role of Cities and Collaborative Governance in Climate Actions

With the promotion of SDGs and sustainability, cities are expected to contribute more to the achieving of carbon neutrality by around 2050. And the role of cities in climate governance as well as greenhouse gas mitigation has been extensively examined (Krause et. al., 2019), (Ramaswami et al., 2021). City government plays a core role in shaping the extent of cities' climate planning and ambition that align with national and global climate targets. The effectiveness of climate governance is demonstrated through the policy design and implementation, and also by integrating multi-stakeholder and geographically diverse collaboration (Reckien et al., 2018).

Collaborative Governance in City Level

Urban areas often leverage their governance structures to set ambitious targets for emissions reduction. In some countries, such as the United States, cities are often seen as climate change leaders (Foss, 2018). Research indicates that cities that engage in collaborative governance with climate initiatives, under mutual learning and promotion, those cities typically achieve their climate goals much faster compared to the cities with less partnership-oriented approaches (McNaught, 2024). For example, C40 Cities Climate Leadership Group (C40 for short) is a prime example that highlights how cities can cooperate and utilize their powers to create impactful climate action plans. C40 is a global organization that engages nearly 100 cities around the world, including large cities like New York, London, and Beijing, as well as smaller and localized cities like Austin. Mayors of C40 cities are committed to tackling climate change and are dedicated to urban sustainability, aiming to reduce their carbon emissions in half by 2030 (C40.n.d.). The C40 network serves as a platform that allows the involved cities to share experiences and best practices (Lee & Van De Meene, 2012). The prominence of C40 also provides evidence of the power of urban governance, especially collaborative governance with partnerships across sectors, which can improve efficiency when implementing the same climate actions (Bauer & Steurer, 2014).

In addition, ICLEI (Local Governments for Sustainability), which is a global network with more than 2,500 local and regional governments involved, impacts the policies, committed to sustainable urban development, share and exchanges the experience of sustainability, and drive the achievement of climate neutrality (ICLEI, n.p.). The global initiative of ICLEI's Global Covenant of Mayors for Climate & Energy (GCoM), which is the broadest global alliance of climate leadership, aims to support cities to reduce emissions and adapt to climate change. More than 13,500 cities and local governments are involved in the initiative. With the support from the network of ICLEI, GCoM partners are working towards a world that accelerates climate ambition, helping each other to meet the targets of the Paris Agreement and co-create a low-emission and climate-resilient future (GCoM, n.p.).

2.2 Theoretical Foundations of Carbon Neutrality

2.2.1 Energy Transition Theory

Energy transition theory started to flourish after the proposal of international climate agreement of the Kyoto Protocol in 1997 and later the Paris Agreement in 2015 (Cheng & Lee, 2022). With the European Union and other regions commit to decrease carbon emissions and achieve carbon neutrality, energy transitions is considered to be a key process to achieving those climate goals (Romania et al., 2023).

Energy transition theory investigates the socio-technical transitions from one dominant energy system (such as fossil fuel-based like oil, gas, and coal) to another (such as renewable energy-based like solar, wind, and hydropower) (Benneworth et al., n.d.). It interdisciplinary framework that examines the processes, drivers, and barriers, and highlights the multi-interactions between technologies, policies, and societal practices that drive the transitions of energy systems (Grubb et al., 2015). The key research dimensions of the theory include: Socio-technical Systems, Technological Change, Policy and Regulation, and Multi-Level Perspective (Kern & Rogge, 2016), (Geels et al., 2017). The theory encourages cities to adopt renewable energy, support energy-efficient buildings, and implement policies that support the transformation of phasing out fossil fuels. It explores how societies transform their energy systems over time, focusing on all the related sectors, such as changes in technological, social, economic, and political aspects which required for this shift (Büscher, 2022).

Overall, energy transition theory is a multi-purpose tool that can be used to study how energy transitions happen and has evolved from a focus on the changes just from technological sectors to a more comprehensive understanding of the social, political, economic, and environmental factors that affect the transitions (Yang et al., 2024). With the implementation of SDGs and the process towards carbon neutrality and urban decarbonization globally, the study of energy transition theory is important in guiding policymakers, researchers, and industry/business to the shift towards a more sustainable energy system. It highlights the role of policy frameworks and means of implementation as important factors in understanding the success of transitions.

2.2.2 Other Concepts from Additional Dimensions

Residual Emission

Residual emission is defined as the carbon emissions in urban areas that are difficult to avoid or completely eliminate due to the limitation of financial and technological reasons (JRC, 2024). The Commission's Joint Research Center (JRC) of the EU considers residual emissions to be a challenge to the achievement of carbon neutrality and has proposed a framework for cities on how to manage and mitigate residual emissions. The framework emphasizes the principle of "mitigation is the first", which means to mitigate the residual emissions of cities effectively, should control and reduce the emissions prioritize than find a compensation solution after the occurrence of emissions. JRC also emphasizes the

importance of collaborative governance in the aspect of identifying the constraints to reducing residual emissions.
In the report of IPCC (2022), residual emission was considered the hard-to-abate sectors that act as a considerable barrier to achieving net-zero emission targets. And the concept of CDR (Carbon Dioxide Removal) was introduced, which is a process of capturing the CO_2 from anthropogenic activities in the atmosphere and storing that CO_2 in geological or ocean durably. The primary purpose of CDR is to mitigate the CO_2, especially to offset the residual emission which can not be eliminated completely. CDR is considered an an essential element of scenarios that limit warming to 1.5°C (or below 2°C) from the Paris Agreement.

Just Transition
Another key concept that can greatly impact a city's efforts to achieve carbon neutrality is Just Transition. The concept highlights the importance of protecting workers, communities, and other vulnerable groups involved in the fossil fuel phasing-out transition, creating new job's opportunities and leaving no one behind (United Nations Development Programme, 2022). Just Transition theory acts as a framework to balance societal environmental targets with social equity and welfare states (Galgóczi & Poche, 2023). Heffron and McCauley (2018) argued that the concept of just transition has the potential to integrate climate, energy, and environmental (CEE) justice and provide a new framework for analyzing and ensuring equity throughout the transition of fossil fuels phase-out.
By integrating Just Transition principles into practice, policymakers are encouraged to involve labor unions and local businesses in the environmental-related decision-making process. This collaborative approach can impact the transition process and lead to more sustainable and accepted policy outcomes for multiple stakeholders (Newell & Mulvaney, 2013).

2.3 Policies for Carbon Neutrality from Multiple Levels

2.3.1 Global Agreement and EU's Urban Climate Governance

Global and transnational policies are crucial in urban planning and facilitating the shift towards fossil fuel-free urban decarbonization. Global efforts and international frameworks, such as the Paris Agreement and UN Sustainable Development Goals (SDGs) are the most famous related frameworks. There are several other policies and frameworks. For example, the initiative of Ambient (outdoor) air pollution, which is published by the World Health Organization (WHO), aims to reduce air pollution (Greenhouse gases are also air pollutants) with a focus on various successful policies that can reduce air pollution from many sectors, such as industry, energy source, transportation, waste management, and urban planning (WHO, 2024).

European Green Deal and EU's Emissions Trading System
Intending to become the first climate-neutral continent by 2050, the European Union (EU) launched the European Green Deal in December 2019 and has implemented strong measures in different aspects toward achieving carbon neutrality (Hainsch et al., 2020). The Green Deal provides a climate framework and target for the

EU cities as well as urban areas, to invest in renewable energy, phase out fossil fuels, and adopt renewable energy-based systems like district heating. The Green Deal outlined the goals and set up the policies to decrease greenhouse gas emissions (GHG) drastically (reductions from 40% to 65% compared to 1990 levels), minimize fossil fuel usage, and offset other emissions through diverse measures. Aiming for a more sustainable future across relevant sectors, such as energy, transport, and agriculture (Filipović et al., 2022). For example, the EU invests in the development of renewable energy massively, such as solar power and wind, in order to phase out the usage of fossil fuels (Musiał et al., 2021). Many EU nations have reduced their share of coal and other fossil fuel energy and transit to renewable energy. And the Green Deal promotes sustainable urban mobility and energy-efficient building renovations (European Commission, n.p.). Raising energy efficiency is another crucial strategy in the European Green Deal, which includes enhancing industrial energy use and reducing energy waste in homes and businesses. The role of energy transition and renewable energy development in boosting carbon emission efficiency has been a key focus, especially in developed countries (Dong et al., 2022).

Moreover, the Emissions Trading System (ETS) which operates by the EU is one of the world's biggest carbon emissions trading systems. The system sets a cap on carbon emissions, the involved companies in the system can trade their emissions for allowances, which aim to encourage the industries to reduce the emissions (Verbruggen et al., 2019). For the environmental benefits regarding the EU ETS, Gulbrandsen and Wettestad (2022) claimed that the EU ETS has been praised for its ambitious goal setting in the Green Deal package, aiming to further its role of reducing carbon emissions, including maritime and logistical aspects. Bayer and Aklin (2020) used statistical models to conclude that the EU ETS reduced carbon emissions much more than the amount explained by lower emissions requirements during the 2008 financial crisis. They estimated that with the policy of EU ETS, approximately 1.2 gigatons of carbon emissions were mitigated (2008 to 2016).

2.3.2 Sweden's Climate Target

Sweden aims to achieve carbon neutrality and become a fossil-free welfare society by 2045. In order to achieve its net-zero target, Sweden adopted its Climate Policy Framework in 2017, which consisted of a Climate Act, climate targets, and the Swedish Climate Policy Council (SCPC) (The Ministry of Infrastructure, 2020). The Swedish target is considered one of the most ambitious climate targets on a global basis that legally binding net-zero goal (ECUI, 2020).At the national level, 39 out of 290 Swedish municipalities have the target to achieve carbon neutrality and net-zero emissions by a target year before 2045 ("Zeroing In on Cities," 2024).

Sweden's Integrated National Energy and Climate Plan (NECP) was first published in 2019. The plan includes improvement strategies for energy efficiency, carbon emission reduction, and renewable energy usage on a national basis. Cities in Sweden, align their urban planning with Sweden's climate target and receive funding and other support from the Swedish government to carry out energy transition (The Ministry of Infrastructure, 2020). In addition, "Sweden's long-term strategy for reducing greenhouse gas emissions" (Government Office of Sweden, 2020) highlights how the development of fossil-free technology and the usage of clean energy align with Sweden's climate framework to reduce climate impact.

2.3.3 Climate Policy Adaptation in Växjö: From Global Frameworks to Local Action

As more countries are aware of the significance of carbon neutrality, it's clear that multidisciplinary approaches and innovative solutions will be key to tackling the global climate crisis. Successful society transitions require the support of policies, multi-stakeholder collaboration, and the implementation of related strategies, to address challenges during the implementation of climate actions. Effective governance involves aligning policies across different stakeholders, fostering public-private partnerships, and ensuring equity through a just transition framework, to balance economic restructuring with social protection (Galgóczi & Pochet, 2023). Moreover, the G20's emphasis on circular economy, and environmental governance through integrated policies and actions. Such approaches provide practical insights into designing frameworks that balance diverse sustainability objectives, and then achieve the climate goals effectively (Terra Dos Santos et al., 2023).

The support from the international and national frameworks is essential for Växjö and its progress towards fossil fuel-free ambition. Collaboration and cooperation with other organizations, regions, and networks are also indispensable to Växjö's sustainability achievement. For example, global frameworks like SDGs and The Paris Agreement, provide Växjö with the direction and pathway of sustainability, which is the foundation for urban planning. Additionally, Växjö is affected by Sweden's Integrated National Energy and Climate Plan (NECP), which provides the support of finance and policies at the nation's level to help Växjö in the aspects of renewable energy transition and carbon emission reduction. Moreover, Växjö is also a member of ICLEI (Local Government for Sustainability). With the support from ICLEI's global network, ICLEI members benefit from peer knowledge and resource sharing, to help the adoption of energy-efficient technologies, sustainable urban planning, and the implementation of fossil fuel-free plans.

2.4 Växjö's Ambition of Becoming Fossil Fuel-Free

2.4.1 The Overview of Växjö

Växjö with coordinates 56°52′37″ N, 14°48′33″ E, which is part of Kronoberg located at the southeast of Sweden Växjö, is a locality and the seat of Växjö Municipality in Kronoberg County (Kronobergs län) in Sweden's Småland province (Växjö Kommun, n.d.). Växjö had 97,137 inhabitants (2022). Its name is thought to derive from the old Swedish words väg ("road") and sjö ("lake"), which means the road over the frozen (Växjö Kommun, n.d.). Växjö Sjö, farmers used in winter pathway to marketplace later became the city.

Växjö is located in a forest-rich county and the forest has long been an important base for the business sector.A large part of Växjö's energy needs are met through district heating from the Sandviken plant, which is a combined heat and power plant located on the industrial area of Sandvik in Växjö. The agency belongs to the municipal energy company Växjö Energi AB (VEAB.se).

Växjö adopted a policy of achieving fossil fuels-free early in 1996. During the past few decades, the phasing-out of fossil fuels leads to the improvement of local environment, the GHG emissions reduce significantly (Lelieveld et al., 2019), (Joshi et al., 2023). One of the cornerstones of Växjö's fossil fuel-free plan has been its investment and innovation in

renewable energy, particularly biomass, which benefit from its abundant forest resources of timber (Tonhauzer & Morvova, 2016). By converting waste wood and other organic materials into energy, Växjö create the energy supply system of more sustainable. Besides the biomass-based infrastructure, Växjö has made other essential investments in renewable energy, such as solar power and wind (Brinkley, 2018). The installation of solar panels has been encouraged in public buildings and resident's homes. Wind farms are supported in the region as well. These efforts have further diversified and expanded Växjö's energy system structure, making it less reliant on fossil fuels and more advantageous in the energy markets (Ahmed et al., 2022).

2.4.2 Historical Context of Växjö's Climate Actions

Växjö stands on a long history of dedication to environmental matters. Växjö's sustainability journey can be tracked from the 1970s when environmental issues started to occur due to local industrial activities and deforestation. The main environmental concern at that time was the pollution in the local lakes. Växjö's municipality took action to restore the polluted lakes and made strategies to reduce the pollution.

In 1996, Växjö declared to become a fossil fuel-free city, which was the first city in the world to make such an ambitious climate commitment (Växjö Kommun, 2016). The 1996 Declaration of Växjö set goals for carbon emissions reduction and the alternative to fossil fuel energy, such as the renewable energy sources of biomass and wind power. After the launch of 1996 Declaration, Växjö developed the local district heating systems that used bioenergy, source was the wood chips locally. This heating system significantly reduced the city's reliance on fossil fuels for heating, and it was one of the earliest large-scale district heating systems in the world.

During the 2000s, Växjö adopted further strategies of renewable energy sources diversity, promoting the use of bio-energy. Following the policy of a "fossil fuel-free city", Växjö is keen to develop its power plant, water treatment facilities, and other industries that seek to foster the local carbon neutral target (Andersson & James, 2018). The 1996 Växjö Declaration evolved into the policy framework of "Sustainable Växjö 2030", the framework was launched in 2019, and provides the roadmap for the whole municipality's journey towards its sustainable goals, to achieve fossil fuel-free by 2030 is one of the goals within the framework. In the 2020s, Växjö remains committed to becoming a fossil fuel-free city by 2030 and is on track to reach carbon neutrality and aligned with Sweden's national climate goals and other global climate policies.

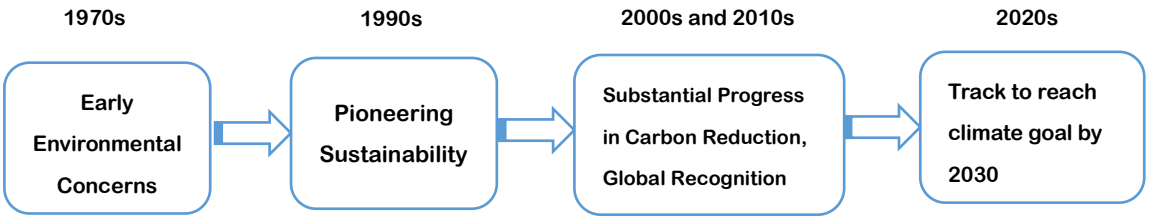

Figure 2. Historical background of Växjö's climate efforts

2.4.3 Global Recognition and Green Branding of Växjö

Växjö is considered successful in its climate work, and also gained a reputation for its sustainability internationally, making the city win awards and recognition as a pioneer and leader in sustainable development (Ahmed & Nguyen, 2022). Växjö has been titled "The Greenest City in Europe" since 2007 by BBC (Energy Cities, n.d.). Later, Växjö won the 2007 Sustainable Energy Europe Award, the Union of Baltic Cities Environmental Award, and the 2018 European Green Leaf Award by the European Commission. The green reputation of Växjö appeals to the increasing number of visitors, researchers, and policy-makers (Pesch et al., 2019).

In the study of Andersson and James (2018), the authors examined how Växjö took advantage of its green branding to highlight its position as a pioneer in urban sustainability and carbon neutrality achievement. They found that Växjö municipality benefits a lot from its green branding, not only advocating for the city which boosts local tourism, but also attracting eco-friendly investments and innovative businesses from diverse paths. However, Andersson and James also found the green branding of Växjö was more like a symbol of the city, gaps between the symbolic branding and the realities of practices exist. The details of problematizing Växjö's green image will be elaborated in the Chapter Discussion.

3. Methods

3.1 Research design

3.1.1 Case Study Strategy

The study focuses on Växjö's 2030 fossil fuel-free ambition, seeking to explore the complexities and challenges during the transformative journey. The research design of a case study is employed for the study. According to Yin (2018), a case study is specifically suitable for the thesis, because the case study seeks to reveal the outcomes of policy implementation in a reality practice, able to address the research questions of "how" and "why" that related to the barriers existing in real-world context rather than the research question of "what", and the multiple data source of primary (interview) and secondary (policy documents, reports) of the study can provide diverse perspectives.

Therefore, a case study is an appropriate research method for the study. Firstly, the case study helps to explore the complexities of a single city that seeking to achieve the goal of being fossil fuel-free in the context of Växjö, offering a thorough understanding within a small city context. Additionally, the case study allows for an exploratory approach, particularly in revealing the specific and actual challenges faced by Växjö. Moreover, by focusing on a real-world case, providing empirical evidence of how Växjö can work towards achieving a fossil fuel-free goal, which is useful in public policy-making and other social aspects.

According to the framework of Yin (2018), the exploratory approach is adopted for the study, to identify research objectives and questions in an understudied area, and identify the challenge during the transformative journey of Växjö.

Unit of Analysis

When conducting a case study, analysis units should be defined. The primary unit of analysis is Växjö's municipal-level fossil fuel-free ambition. Under the primary unit, two sub-units are elaborated to capture the multiple perspectives:

- Policy Implementation: examine the gaps between Sustainable Växjö 2030 goals (related to fossil fuel-free) and on-the-ground outcomes.
- Challenges raised by stakeholders: explore the challenges identified by the participants through interviews.

Rationale for Case Selection

Växjö's fossil fuel-free ambition is selected as a critical case for the following reasons:

- Energy transition is now a hot topic in the academic community globally. Växjö declared the ambition of becoming a fossil fuel-free vision in 1996, which was one of the first cities in the world. Växjö's early climate commitment makes it a typical case to study.
- Växjö's fossil fuel-free ambition started in the 1990s, has made some progress so far. The related quantifiable results are available in the public documents, which provide empirical data for the study and analysis.

•Due to time and resource constraints, it is better to focus on a specific topic of fossil fuel-free ambition that already have accessible documents and literature, rather than a broader goal (e.g. Sustainable Växjö 2030 as a whole).
•As a small city, Växjö's experience (e.g., limited resources, limited local engagement) can represent the challenges of small cities that have similar climate targets. And potential to generate replicable insights for similar municipalities.

3.1.2 Reasoning Approach: Inductive Reasoning

Inductive and deductive reasoning are the logical reasoning approaches that guide the basic structure of a study. In the research design of this study, inductive reasoning is employed in the study analyze qualitative data and draw the conclusion (Heit & Rotello, 2010). This approach is suitable useful for exploratory research, as it allow to generate theories or explanations, and be used to generate predictions or to make forecasts (Sauce & Matzel, 2017).

Inductive Reasoning

Inductive reasoning is a bottom-up and data-driven process that starts with specific observations and moves toward broader theories (Sauce & Matzel, 2017). The inductive principle involves collecting primary data and then identifying patterns or trends. In this study, through the analysis of qualitative data collected from documents and interviews, by the coding and thematic analysis, commonality or trends (e.g., challenges of inadequate economic policies, behavioral resistance) are identified. The outcomes of the analysis then inform the conclusion about the gaps between policy frameworks and the reality practices in the achievement of Växjö's fossil fuel-free ambition.

3.1.3 Ethical Considerations

Ethical aspects should be considered when conducting research, especially when human interactions take place. Ethical reasoning is a crucial process when designing or conducting scientific research. In general, ethics is the description of good or bad, right or wrong, such as beliefs and values, or critical thinking about the issues related to society and humans (Beach, 1996). In scientific research and study, ethics are associated with studying reality, human knowledge, argument validity, and morality. Which is the process that decides or discusses which is right or wrong. For example, is the aim or topic of the research correct or value currently? Is it worth a more profound study to benefit the human or society? This ethical reasoning should be conducted by scientists themselves before the research starts. Besides ethical reasoning, other ethical issues also need to be considered carefully when planning research (Oliver, 2009). For example, permission is essential when collecting specific data of an organization or a single person. Ethical debates are the discussion of how to conduct research or interviews. Such as, is it better to collect the primary data through interviews or surveys? Is it better to interview the policy-maker or the companies who implement the policies?

In this study, the interviewees' permission is significant. When conducting the interview, oral permission from interviewees was obtained before recording the interview. The interview was only recorded after their permission. Moreover, permission to cite a quote from the

dialogue of the interview was made, and I only cite the sentence when they permit. If the interviewees want to keep their words confidential, quotes in the paper are cited anonymously. Besides, the interviewee's right to know is respected. The published thesis will be sent to all the interviewees.

3.1.4 Scope and Boundaries

When performing a study, scope and boundaries should be established before starting to do the case study analysis. Delimitations help to simplify the data and narrow down the focus of the study. For example, the scope of geography, timeframe, boundaries for data collection, and the focus aspects. The details of the study delimitations can be seen in Table 1.

Table 1. Delimitations of the study

Serial No.	Type of Delimitations	Descriptions
1	Geographical Scope	The research objective of the study focus on the scale of Växjö city.
2	Timeframe	1. The study focuses on the period leading up to 2030, which is Växjö's target year for becoming a fossil fuel-free city. 2. Timeframe of conducting interviews for primary data collection is from 1st September, limited to October 31st, 2024.
4	Interviewee focus	The interviewees are limited to specific key stakeholders. such as local politician regarding sustainability, municipal officials, and related local businesses.
5	Research Focus	Focus specifically on the elements of Växjö 's fossil fuel free ambition, excluding broader environmental issues.

3.2 Data Collection

3.2.1 Data Sources

- Interview

Interviewing is one of the most useful and effective methods for collecting primary qualitative data. It involves initiating participants' lived experiences and interpreting the meaning from dialogs, with a focus on the co-construction of knowledge between interviewer and interviewee, the process requires careful attention to context (Brinkmann, 2023, pp. 1-33). It is suitable when performing a case study that seeks to in-depth understand the reasons behind the phenomenon and the complexity of real-world issues (Knott et al., 2022).

Rationale for Using Interviews for the Study

Conducting interviews can capture crucial stakeholders's perspectives, and provide insights that directly respond to the research questions within a real-world context. Obtain firsthand insights from actors directly involved in Växjö's fossil fuel-free ambition, such as

officer/environmental strategists who work at Växjö municipality, politicians from the Sustainability Committee, and Växjö companies that have signed the Växjö Declaration.
Conducting interviews can address the exploratory research questions, elaborate on the research questions (challenges emerge during policy implementation) for "how" and "why" (Yin, 2018), and identify unanticipated practical barriers, that cannot be fully answered by document analysis or surveys.
Conducting interviews can provide in-depth insights, related personal experiences, and emotional responses that cannot be gained from methods (Hussein, 2022). Besides the cross-validate findings from policy, reports with lived experiences, strengthen the credibility of the study.
Conducting interviews, especially semi-structured interviews offers flexibility, is particularly useful for questions that require detailed explanations, and clarification on certain points can be achieved by asking follow-up questions (Roulston, 2018).

Interviewee Selection Criteria and the Rationale
The interviewees are directly relevant to Växjö's sustainability and fossil fuel-free ambition. Heterogeneity and diversity, which are also to be considered. All the four interviewees work at Växjö. The recruitment of interviewees starts in early September 2024, and ends in late October, which takes about two months. Within the timeframe, thirteen potential interviewees were contacted by email, five responded to the email and four people agreed to be interviewed. The four interviewees are P1 (Environmental strategist from Växjö Municipality), P2 (Politician from Green Party and Sustainability Committee), P3 (Strategy manager from Växjö Energi) and P4 (Technical Manager from Greenpipe Group AB). Details of the interviewee can be seen in Table 3.
The four interviewees are selected for the following reasons. Firstly, interviewing municipal officer and politician can provide the perspectives of climate-related policy development and implementation, and revealing the practice challenges from cross-sectoral coordination and public engagement. For example, Interviewee of Växjö's municipality (P1), P1 works as an environmental strategist at Växjö Municipality for 25 years, mostly involves climate work, monitoring the progress towards Växjö's climate goals and fossil fuel-free ambition. P1 is also involved in developing sustainability programs, plans, and strategies for the city, as well as working with politicians regarding climate issues. P1 fully understands the progress and main challenges of Växjö's fossil fuel-free initative, as well as the efforts of the municipality seeking to tackle the challenge. Interviewee of politician (P2) is Green Party councilor, the Deputy Mayor of the Sustainability Committee in Växjö, as well as the vice chairman of the energy company and tourists. P2 is directly involved in the climate efforts of Växjö and is in charge of formulating the related policies, can respond to the research questions sufficiently from a political perspective.
In addition, interviewing the representatives (P3, P4) from local company, can bring the businesses perspective of potential bottlenecks from biomass alternative and price mechanism during energy transition journey in Växjö, as well as other insights about fossil fuel-free ambition. For example, Växjö Energi (VEAB) is the local energy supplier, VEAB is one of the crucial actor and the actual implementer for Växjö's fossil fuel-free ambition. And because the energy industry highly depends on fuel, the green transition from the energy

industry plays a core role in the progress of Växjö's fossil fuel-free plan. VEAB is one of the signatories from Växjö Declaration, the Declaration is a network composed by local company or industries that are involved in and contribute to Växjö's fossil fuel-free ambition. Greenpipe Group AB (GGAB) is also the signatory from Växjö Declaration, interviewing the representative (P4) from the GGAB can provide information about company's actual difficulties on the path of green transformation. Therefore, the perspective from local key companies is crucial to the study.

Table 3. Details for the interviewees

Reference number	Roles	Organization	Expertise/Contribution
P1	Environmental strategist	Växjö Municipality	25 years experience of monitoring the progress towards Växjö's climate goals
P2	Politician	Green Party councilor. Sustainability Committee	Politician directly involves in the work on Växjö's climate goals
P3	Manager of Strategy and External Relations	Växjö Energi (VEAB)	Växjö energy supplier which is the actual implementer of fossil fuel-free ambition
P4	Technical Manager	Greenpipe Group AB	Växjö energy related infrastructure provider, commit to local sustainability

- Materials of Policy and Reports

Selection Data and Criteria

The published documents which are used for the study, are the policy documents, Växjö Municipal reports, and academic journals. The unpublished sources of secondary data, such as manuscripts in preparation and other unofficial raw data, will not be collected for the study.

The selection criteria for the data are reliability, relevance, and timeliness. Select the data from authoritative sources, and it should be highly directly relevant to the Växjö Fossil Fuel-Free ambition as well as the research questions. The timeframe of the data is important because energy policy can change over time, outdated data may lead to biased conclusions, so the most recent data is preferred.

Based on the selection criteria, the most recent policy document from municipal level, "Sustainable Växjö 2030" which was published in 2019, is the policy framework for the study. Three municipal reports directly relevant to the research questions provide the empirical

data for the study. They are: "Detailed follow-up Sustainable Växjö 2030" (Swedish named: Fördjupad uppföljning Hållbara Växjö 2030), "Annual report Växjö municipality 2023" (Årsredovisning Växjö kommun 2023) and "Transport plan 2025". In addition, published literature and reports from authoritative media or institutions complement the data, the most recent and related materials are used in the study, to provide the academic data, and the third perspectives complement the self-promotional tendency of municipal reports, and support the analysis. The details of the selection documents can be seen in Table 2.

Table 2. Main source of policy and reports

Type of data	**Name of the documents**	**Details**
Policy framework	Sustainable Växjö 2030 (Växjö kommun, 2019)	Provides a roadmap for the entire Växjö Municipal Group, guiding policies and actions to ensure the city meets its sustainability goals.
Municipal Reports	Detailed follow-up Sustainable Växjö 2030 (Växjö kommun, 2022)	Provides an in-depth follow-up analysis of Växjö's sustainability program, uses 50 indicators to track trends of Växjö's sustainability goals.
	Annual report Växjö municipality 2023 (Växjö kommun, 2024)	Provides a comprehensive overview of the Växjö's performance referring to the goals.
	Transport plan 2025 (Växjö kommun, 2021)	Serves as the benchmark for evaluating transportation sector align with the city's climate goals.
Other Sources	Analysis of future carbon-neutral energy system-The case of Växjö Municipality, Sweden. (Ahmed, & Nguyen, 2022)	Literature source. Elaborated the practice of becoming a fossil fuel-free energy system in Växjö. Provide academic data and perspective.
	Altruism or entrepreneurialism? The co-evolution of green place branding and policy tourism in Växjö, Sweden. (Andersson & James, 2018)	Literature source. The study examined how Växjö took advantage of its green branding to highlight its pioneer position in small city's sustainability and carbon neutrality.
	Växjö Energi - 100 % fossil free production of heat and power. (Interreg Europe, 2022)	Report from the platform of Interreg Europe. The report highlighted that Växjö Energi has achieved 100% fossil-free production of heat and power since 2019.

	Discover the charm of Växjö, Sweden's greenest city (Nikel, 2025)	Report from Forbes. Positioning the energy transition in Växjö as the great practice for small city in global. Provide public narrative perspective.

Växjö Fossil Fuel-Free ambition and Sustainable Växjö 2030

Växjö's municipality launched the "Fossil Fuel-Free Växjö" ambition in 1996, aimed to reduce its dependence on fossil fuels and set a goal to become the first city in the world entirely free from fossil fuel usage by 2030 (Wälitalo et al., 2020). This 1996 ambition evolved into the "Sustainable Växjö 2030", which is the roadmap of sustainability for the whole municipality. "Sustainable Växjö 2030" is an integrated strategy to achieve the municipality's sustainable goals that cover the dimensions of environment, society, and the economy. Among those goals in "Sustainable Växjö 2030", achieving fossil fuel-free is one of the core pillars and major targets (Växjö kommun, 2019).

3.2.2 Data Collection Procedures

- Data Collection of Policy and Reports

The data of policy and reports were collected online. The national-level policy document, "Sweden's Integrated National Energy and Climate Plan (NECP)" was downloaded from the official website of the European Commission, "EU energy policy" section. The municipal level of policy document as well as the municipal reports of Växjö, all obtained from Växjö Municipality's official website, the section of "Växjö Municipality's sustainability work". Other data, published literature were accessed at Google Scholar and other Literature search tools. Reports from other media were collected from official website separately.

- Data Collection of Interviewing

Interview Routine

All the interviewees are reached and interacted with Outlook. The website of Växjö Kommun provides the email addresses of potential interviewees, specifically under the section of Politics and Democracy - Sustainable Development Committee. An email to the information office can also help to reach the related official, which is the method that helped me to get in contact with P1. All the interviews are conducted online by Zoom. The software makes transcribing and text analysis during and after the interview to be much more easy and more efficient. For example, the digital tool *Otter* is used to record the dialogues during the interviews, which is a useful application when transcribing the tape-recorded sound. It can help to transcribe the dialogues to text automatically, and the outcomes of transcripts can be saved as a digital Word document to export for further analysis. The exported digital textual documents need to be checked manually to ensure high accuracy. And the incorrect words and sentences will be deleted to minimize unnecessary data. Furthermore, for the analysis of textual data generated from interviews, the tool *NVivo* was used after the interviews for coding, analyzing and visualizing the data. All the used software can be seen in Table 4.

Table 4. The software used when conducting an interview

Name of the software	Function of the software	Time period used
Zoom	Online meeting	During the interview
Otter	Record dialogues and transcribe to textual data	During and after the interview
Nvivo	Analyze textual data. Coding, identifying the themes and visualizing the analysis outcomes	After the interview

The Interview Questions

The interviews are semi-structured. Interview questions are designed according to the different interviewees and their roles. The questions also directly respond to the research questions. The length of each interview is around twenty minutes. The total questions are eight to twelve, questions are designed beforehand. However, some questions may vary and depend on the answers from the interviewees. The questions would be divided into four sections: Background of the interviewee, General questions related to the fossil fuel-free ambition, Specific questions related to the challenges of the fossil fuel-free ambition, Reflections on Success and Future Prospects.

The questions for P1 (from Växjö Municipality) are as follows. Other interview questions can be found in the Appendix 1 and Appendix 2.

Background of the interviewee

1. Please introduce yourself, your organization, and your role.

General questions related to the Fossil Fuel-Free plan

2. How do you describe Växjö's current achievement according to the Fossil Fuel-Free plan?
3. What do you think are the unique aspects or highlights of Växjö's Fossil Fuel-Free Plan compared to other regions?

Specific questions related to the challenges the Fossil Fuel-Free plan

4. What do you think are the main challenges in implementing and achieving the Fossil Fuel-Free plan by 2030?
5. Does Växjö Municipality have specific solutions or support measures to address these challenges? How do you assess the effectiveness of these solutions?
6. Do you see any deficiencies or aspects for improvement in these solutions that need to improve for those solutions?

Reflections on Success and Future Prospects

7. What are the successful experiences of implementing the Fossil Fuel-Free plan that you think can be learned for other regions?
8. Do you believe Växjö will succeed in reaching the Fossil Fuel-Free target by 2030? Why or why not?

Table 5. The detail of interviews

Interviewees	Organization	Interviewed Date	length of Interviews
P1	Växjö Municipality	September 20, 2024	33 Minute
P2	Green Party councillor, Sustainability Committee	September 23, 2024	18 Minute
P3	Växjö Energi (VEAB)	October 10, 2024	19 Minute
P4	Greenpipe Group AB	October 24, 2024	22 Minute

3.3 Data Analysis

Thematic Analysis-Inductive Reasoning

Qualitative content analysis is a "research method for the subjective interpretation of the content of text data through the systematic classification process of coding and identifying themes or patterns" (Hsieh & Shannon, 2005, p.3). This study employs thematic analysis with an inductive reasoning approach to analyze two types of data: policy documents and reports, and interview transcripts. Transcripts were processed by NVivo for systematic coding. NVivo is designed to find insights in unstructured textual data like interviews and surveys, making the coding and analysis process more structured and highly accurate (Allsop et al., 2022). NVivo 14 is the software version. The policy and reports were analyzed manually for content extraction and thematic coding, as the policy and reports are written with clear structure and subheadings, manually coding and extracting the content and data is easier and more direct. The analysis steps for both data types are elaborate as follows.

Analysis for Interview Transcripts (Using NVivo)

Step1: Coding in NVivo

Create the first level of code with the three research questions, then select the relevant passages of text and create a child code under the first level of code. For example, "What are the key challenges for Växjö in achieving its goal of becoming fossil fuel-free city by 2030?" is the second research question, name the code to (RQ2) Challenges, which is the first level of code (parent code). Then open the file of each participant, select the relevant paragraphs of text, and create the child code under the parent code of "(RQ2) Challenges". Based on the context of interview dialogues, select the relevant words and code the text under the child code like "less renewable energy in transport", "transportation related".

Do the same coding process to other research questions RQ (parent code), until all the context of the files finish coding and classify to the right level of relevant code.

Step 2: Themes Development

Run a "Word Frequency Query" in the NVivo to create the "word cloud", which might suggest identifying and emerging the themes. Group the related codes into the broader themes. Reorganize the code hierarchies.

Step 3: Inductive Exploration

After all the coding, review the coded data and assemble the text from the related themes that emerged across all the participants. Analyze the identified themes within the theoretical framework (e.g. energy transition theory, just transition and residual emission), to address the research questions.

Analysis of Policy and Reports

Policy document and other reports (listed in Table 2) were analyzed manually. Key sections and data were extracted, coded under the research questions (e.g., "district heating", "promote EV adoption", "challenge of transport and travel"). And create broader themes.

Synthesis of the Findings

Compare the themes of transcripts (NVivo-based) and reports (manual), to identify the convergences and discrepancies between the two data sources. And discover the gaps between policy instruments and reality practice in the journey of Växjö's becoming fossil fuel-free. Finally use the assembled themes and text/quotes in Chapter 4 of Result.

3.4 Limitations of the Methods

- Time Constraints

Given the scope of a master's thesis, the time available for collecting data, analyzing the case, and writing it is limited. Conducting interviews is designed to limit to the date of October 31st, 2024. Therefore, some potential challenges or other related aspects of Växjö's green transition to fossil fuel-free plan might not be fully explored.

- Shortcoming of the Document Study

The document study on empirical data of municipal reports does not include the views of different stakeholders. The municipal reports usually have the tendency to brand and promote themselves, and also have the potential to weaken the failures and shortcoming when implementing the municipal goals. And the method cannot obtain subjective experiences. Besides, it is difficult to verify information directly from the source, and often lacks the depth in data analysis. Thus, document studies are often supplemented with other methods, such as interviews, which can provide a more comprehensive view of the research topic, just like the research design of this study.

- Biases for the Interviews

The primary data is based on interviews. The interview answers might limited to their knowledge and experience, biases are inevitable for the interviewees. The answers in the interviews are from the perspective of the participants' job, all four interviewees are well-educated and work in an organization highly relevant to Växjö's fossil fuel-free ambition, which means the four interviewees have a higher sustainable awareness than the general public. This might lead to more biases in the result.

- Availability and Richness of the Data

Sometimes due to specific reasons, the interviewees of municipality officials and business representatives are not fully transparent with some information, which might lead to the deficiency of certain core data. The local residents' perspective is not explored. Moreover, the interviewees are just four people, and the collected primary data is considered to be far from sufficient. The documents of policy and municipal reports compensate for the data source for the study and supplement with more perspective and quantifiable results.

- Lack of a Systemic Perspective

The study only focuses on Växjö's fossil fuel-free ambition instead of the "Sustainable City "as a whole. It might lead to the overlook of other dimension, such as the social equity, do the vulnerable groups access equitable opportunities during the energy transition? Also, the outcomes of the ambition may somehow depend on implementing other policies, such as energy efficiency for buildings, and sustainable transport planning.

- Other External Factors

The international and national level of energy and climate-related policies, as well as technological innovation, are developing and evolving quickly. Broader external factors like global economic conditions and unexpected events (such as national policies, economic crises, regional war, COVID epidemic) could affect Växjö's progress toward its fossil fuel-free goal. If new climate-related policies are launched or new technologies are introduced, the findings of this study might not be applicable anymore. And since the study focuses on current challenges, the external factors are not in the scope of consideration.

4. Results

This chapter explores Växjö's current strategies for the journey of becoming fossil fuel-free, the main challenges in this journey, and the related solutions. Those elaborations are the response to the overall research aim, as well as the research question one and research question two. The outcomes are based on the policy documents, empirical materials, and transcripts of conducted interviews, and analyzed under the theoretical framework of energy transition theory (Geels et al., 2017), as well as the concepts of residual emissions (IPCC, 2022), and just transition (Heffron & McCauley, 2018), response to the research questions one by one.

4.1 Växjö's Strategies for Becoming Fossil Fuel-Free

This section elaborates on Växjö's strategies for becoming fossil fuel-free in 2030, responding to the first research question of "How Does Växjö Work to Become a Fossil Fuel-Free City by 2030? ". The thematic analysis will be made through the key dimensions of the energy transition theory framework (Technological Innovation, Policy and Regulation, Multi-Level Coll abortion), to reveal the current strategy and its potential gaps. The material used for the thematic analysis is the policy document and reports, as well as the transcripts of interviews, the details of the material can be seen in "3.2.1 Data Sources".

4.1.1 Technological Innovation: Renewable Energy Sector

The share of renewable energy in Växjö has increased significantly, from 33% in 1993 to 74% in 2021(Växjö Kommun, 2022). While the average share of renewable energy use in Sweden in 2020 was just around 60%. The share of renewables in Växjö is high, mainly because the local energy production is renewable since 2019. Among all the energy sources, almost 74% of the energy came from renewable sources, 22% from fossil sources, and 4% from nuclear power (Växjö Kommun, 2024). Other remarkable achievement in energy sector include the completely phase out of peat, oil use has reduced by 95%, petrol use has decreased by 52%, meanwhile the use of biomass (wood) in energy sector has increased by 250% (Växjö Kommun, 2022). The energy supply and the share of renewable energy can be seen in Table 6.

Table 6. Energy supply and share of renewable energy in different sectors in Växjö in 2021

Sector	Energy supplied (GWh)	Share of renewables (percent)
Housing	991	96
Public and commercial facilities	616	91
Industrial and agricultural premises	167	77
Transport and working machinery	690	26

Source: "Detailed follow-up Sustainable Växjö 2030" (Swedish named: Fördjupad uppföljning Hållbara Växjö 2030), P16.

District Heating

Energy used in the sector of electricity and heating is almost all renewable, displacing natural gas and oil (Växjö Kommun, 2022). The long-term electricity demand in Växjö can increase up to 72% in 2050 which could foster diverse levels of investments in the green electricity market (Ahmed & Nguyen, 2022).

Opinion from expert: Simon Hunkin (Interreg Europe Policy Learning Platform) said that: "*The practice of Växjö Energi of achieving 100% fossil free company since 2019 is an excellent achievement. District heating systems in city bias is more cost-effective than individual heating installations. And the practice also help the local economy development and provides an income for forestry owners* "(Interreg Europe, 2022).

Interview insights: P1 (Environmental strategist, Växjö Municipality) said: "*We have been very good at reducing the emissions from the energy sector. Right now, electricity and heating that we are producing here is renewable*". P3 (Strategy Manager, Växjö Energi) emphasized: "*We have just biomass as a fuels source today, and we have kept that strategy since 2019. So since then, we have not used any fossil energy. When talking about the energy we have already received in the district heating and then also district cooling net*".

Wind and Solar Expansion

The electricity production of Växjö increased dramatically in 2023, because of the contribution of two new wind farms (Målajord and Furuby). This means the share of renewable energy in Växjö has enhanced (Växjö Kommun, 2022). Meanwhile, the use of solar energy in Växjö has increased by over 1,300%, even though solar is just a small share of the local energy supply (Växjö Kommun, 2024). The investments in solar cells still keep increasing on municipally owned premises, businesses, and households.

4.1.2 Policy and Regulation: Drive Systemic Change

Binding Climate Targets and Fossil Fuel-Free Ambition

The plan of "Sustainable Växjö 2030" is the guidance and roadmap for the city's sustainability, it provides the policies and strategies that conduct the entire city's development and activities can meet the environmental, social, and economic goals that Växjö's commit to sustainability and the fossil fuel-free ambition. The plan comprises one declaration, five overall goals, nine challenges, and three principles for the plan implementation (Växjö kommun, 2019).

As a small city, Växjö was the first city in the world to make the commitment to become fossil-fuel-free in 1996, inspiring a transformation toward sustainable living. Earning the title of Europe's greenest city, CO_2 emissions in Växjö have been mitigated by more than 70% since the 1990s (Nikel, 2025). Växjö determined to set an example for climate-smart urban and create a community that stops causing any negative climate impacts by 2030. Everyone is invited to contribute to the declaration. Climate and eco-smart is one of Växjö's overall goals in the "Sustainable Växjö 2030" plan, to become fossil fuel-free by 2030 is the target. The achievement of the goal of climate and eco-smart includes the shift to renewable energy

sources, less dependence on fossil fuels, improved energy efficiency, and recycling of resources. Another key objective is transport and travel. Under the context of fossil fuel-free ambition and pressure, transportation and traveling contribute a large proportion of Växjö's local carbon emissions. Moreover, Växjö aims to serve as a role model in wood construction and renewable energy production, thus sustainable housing and green infrastructure are other core aspect that is essential for achieving the fossil fuel-free target. Sustainable urban planning here involves improving the energy efficiency of buildings (Växjö kommun, 2019).
Moreover, In order to make sure that the climate goal and ambition are still on track, goal monitoring is crucial, various indicators and key figures will be checked. The in-depth analyses of the implementation of "Sustainable Växjö 2030" will be conducted every four years (2022, 2026, 2030).

Sustainable Transport Incentives

Transport Plan 2025 serves as the benchmark for evaluating the transportation sector to align with the Växjö's fossil fuel-free ambition. In order to mitigate and minimize the emissions from the transportation sector, Transport Plan 2025 from Växjö municipality has implemented the strategy of prioritizing and encouraging public transportation which is based on renewable energy, and expanding the networks of bicycle lanes and pedestrian paths (Växjö Kommun, 2021). The efforts that provide more accessible and sustainable public transportation options. Innovation in transportation technology is being explored. Sustainable aviation fuel from biomass has been in the R&D stage of Växjö Energi (VEAB) since 2019.
Progress has been made in transportation to meet the Växjö's fossil-free target. For example, more than 50% of new car registrations in Växjö were for electric vehicles (EVs) or hybrids in 2023. Investments in public transport, cycling, and pedestrian pathways are increasing, aiming to reduce car dependency. As well as to promote EV adoption and set up more charging infrastructures, which seeking the raise of renewable energy share in transportation (Växjö Kommun, 2021).

4.1.3 Multi-Level Collaboration: From Local to National

Diverse Levels of Collaboration

The principle for the implementation of "Sustainable Växjö 2030" is vital to the program, One core principle is collaboration. Växjö Municipality emphasizes the collaborative as well as the engagement of everyone who lives in Växjö. Different stakeholders, such as municipalities, businesses, and residents should work together and all contribute to the same climate goal and the achievement of a fossil fuel-free plan (Växjö Kommun, 2019). The collaboration between governments, cities, and communities can help the achievement of fossil fuel-free and mitigate climate change effectively.
In the interviews, three participants mentioned that multi-level and multi-sector collaboration is the main experience supporting Växjö's journey toward becoming fossil fuel-free and achieving other climate goals. P2 (politician, Green Party councilor) highlighted that: "*The cooperation between political parties have been a very important way to actually keep the track, even if the minority has changed over the years, the long term goals for sustainability and Fossil Free has was still.*" P1 (Environmental strategist, Växjö Municipality) explained: "W*e have also been able to find resources with subsidies from the European Union and the*

government for many of our investments that have made us come further. " P3 (Strategy Manager, Växjö Energi) mentioned: "*We collaborate with the rest of Sweden. We have a very good collaboration with other energy companies, both regarding how to manage combined heat the power plants."*

Climate City Contract 2030

Växjö actively participates in different levels of network and ambition. Växjö partners with 23 Swedish cities under the Viable Cities program. The Climate City Contract states the commitments of the parties to increase the ambition for sustainable urban development and climate neutrality. The purpose of this program is to provide a platform for signatories' cities to share best practices in climate efforts and secure EU funding. And to accelerate the steps of the climate transition in specific Swedish cities by 2030 and align with the framework of Agenda 2030, meanwhile contributing to the recovery of the Swedish economy for the era of post-COVID (Viable Cities, 2023). The contract has been revised every year since 2021.

4.1.4 Emerging Contradictions in Växjö's Current Strategies

Regarding the current achievement of Växjö in its fulfilling fossil fuel-free ambition, gaps exist between Växjö's current strategies and its on-ground practices. Under the theoretical principles of residual emission and just transition, the existing contradictions are elaborated as follows.

Lack of Effective Measures in Mitigate Emission from Transport

Växjö's progress reveals the sector resistant to decarbonization—transport. The emission from transport is the core barrier to achieve fossil fuel-free, and difficult to eliminate completely. Yet the current strategies lack the targeted measures of instead of mandatory regulations or other incentives, just reliance on education and running campaigns. For example, according to the report of Detailed follow-up Sustainable Växjö 2030, 95% of Växjö's fossil CO_2 emissions are generated from transport, and only 26% of energy in the transport sector is renewable (Växjö Kommun, 2022). Växjö Energi's Sustainable Aviation Fuel (SAF) project remains in R&D. And due to the business model and economic reasons, it is different to put into production in practice.

Interview Insights: P1(Environmental strategist, Växjö Municipality)cautioned: "*The emissions that we have, the absolute majority from the transport sector. We cannot force people to change cars. We can never force people to use public transporting and cycling. The share of renewable energy in the sector of transportation is going to decrease from 2024 onwards, that is nothing that we can do."* P3 (Strategy Manager, Växjö Energi) acknowledged: *"We still use a lot of fossil fuel in the transport system, and also the aviation sector. We were also part of a project to see if we could produce sustainable aviation fuel from biomass. But so far, it's hard to find a good business model, the normal fossil fuel for aviation is still too cheap, and compared to that, it's hard to produce sustainable aviation fuel."*

Inequity in Energy Transition Journey: Resource Allocation

The transition program of Växjö also demonstrates the potential contradiction in social equity when promoting the fossil fuel-free ambition. For example, Växjö's current strategy promotes EV adoption and setting up more charging infrastructures, as well as public

transport (Växjö Kommun, 2019, 2022). However, there is an uneven distribution of bus routes and EV charging stations between densely populated areas and rural countryside. In addition, the plan of "Sustainable Växjö 2030" emphasizes the local climate goals need the engagement of everyone who lives in Växjö and appealing all the stakeholders to take part in. But actually, some groups (e.g. immigration) are rarely involved and participate in the program or the related campaigns, leading to the inequity in the engagement of the different population group. And the extra costs or high prices for sustainable transition (e.g. installing solar panels at home) hinder low-income groups from contributing to Växjö's climate goal, yet there are no effective economic incentives in the current strategy.
Interview Insights: P1 (Environmental strategist, Växjö Municipality) admitted: *"We run campaigns about Low Carbon Living, but it's it's difficult sometimes. Because everyone is thinking in different ways. And for those campaigns, non-Swedish speakers rarely attend. We might need outreach in immigrant communities.*" P2 (Politician, Green Party councilor) highlighted: *"We are a municipality with a lot of countryside where people are living there. they need the car, and there is no public transportation.* "

4.2 Key Challenges for Växjö in the Progress of Fossil Fuel-Free

To critically analyze the key challenges for Växjö in achieving its fossil fuel-free ambition by 2030, the policy document the "Sustainable Växjö 2030" provides the basic information of existing challenges from the municipality's perspective. In addition, qualitative data from the interviews was organized by the tool Nvivo, to do the categorization, coding, themes identification, and so on. The themaic analysis of the key challenges in the progress is elaborate on core dimensions of the Energy Transition Theory framework (Geels et al., 2017), such as Technological Innovation, Policy and Regulation, Socio-technical Systems, which provides a comprehensive understanding of systemic challenges of becoming fossil fuel-free. In addition, the concepts of Just Transition and Residual Emissions are used as the supplementary dimensions to disclose socio-economic related challenges. The analysis and outcomes in this section respond to the second research question: What are the key challenges for Växjö in achieving its goal of becoming a fossil fuel-free city by 2030?

4.2.1 Challenges in Technological Innovation

Hard-to-Abate Diverse Emissions

Residual emissions from working machines, construction, and agriculture highlight technological challenges. That emission is a significant barrier for Växjö in achieving its fossil fuel-free ambition, and it is considered the hard-to-abate sector. Innovative solutions and circular economy transition can decline or offset that emission, and reduce the negative climate impact. In the interviews, both P1 and P2 emphaized this challenge. P1(Environmental strategist, Växjö Municipality) admitted: *"The remaining emissions are a little oil and other things used in construction.*" P2 (Politician, Green Party councilor) said *"We also have farming with cows, sheep... climate emissions in different ways. If we can go more to a circular economy, then we can lower the impact on the environment."*

Emission from Aviation

Aviation contributes to the territorial carbon emission. Växjö aims to mitigate its carbon emissions by technological innovation in producing sustainable fuel for flights. The project of Sustainable Aviation Fuel (SAF) has been conducted by Växjö Energi since 2018(Växjö Kommun, 2022). However, the carry-out of the project is challenging. The project remains in R&D and has not much progress. The potential price of SAF can be much more expensive than traditional aviation fossil fuel, which makes the project stuck in a dilemma.

P3 (Strategy Manager, Växjö Energi) admitted:*" We part in a project with the aim to see if we can produce sustainable aviation fuel from biomass. So we looked into a process with gasification to have sustainable aviation fuel as the output. But so far, it's hard to find a good business model, the traditional fossil fuel for aviation is still too cheap."*

4.2.2 Challenges in Policy and Regulation

Transport and Travel

The challenge of "transport and travel" is one of the nine challenges which stated in "Sustainable Växjö 2030" (Växjö Kommun, 2019). The use of fossil fuels, transport, and travel contribute to climate change and pollution. Challenges associated with transportation are one of the primary obstacles to the achievement of Växjö's fossil fuel-free goal by 2030. In Växjö, progress has been made in the transport sector, such as the increasing construction and installment in public transport, cycling, and pedestrian pathways, as well as promoting EV adoption and setting up more charging infrastructures, which seek the raise renewable energy share in transportation (Växjö Kommun, 2022, 2024). However, the efforts still can not reduce car dependency systemically, especially in rural areas where is difficult accessible to public transport. In 2020, transport and work machines account for 95% of territorial emissions of fossil CO_2 and almost 60% of greenhouse gas emissions in Växjö. Around 85% of all vehicles in operation remain fossil-fuel-powered, and only 26% of energy in the transport sector will be renewable in 2021 (Växjö Kommun, 2022). In addition, for the role of the airport and the planes of Växjö, the interviewees have different opinions.

Interview Insights: P1 (Environmental strategist, Växjö Municipality) mentioned: *"Main challenge is transport.* We're also counting the airport in this. And I guess the planes will still be used.*"* P2 (Politician, Green Party councilor) highlighted: *"The transportation and the consumption are the main challenges. We are a municipality with a lot of countryside where people need the car, and there is no public transportation. From my point of view, I don't think it's necessary for us to have an airport."* P3 (Strategy Manager, Växjö Energi) admitted: *"I think the transport sector is the main challenge. We still use a lot of fossil fuel in the transport system. And also the aviation sector, that is a huge challenge."*

Insufficient Economic Support

Economic reasons are a primary obstacle to choosing renewable energy and other sustainable alternatives, which is a challenge in pursuing the transition to fossil fuel-free. In Växjö, there is an intrinsic conflict between the climate goal and making a profit. From the local company’s perspective, the policies and incentives associated with price of the products, or business model are important in the transition journey for both companies and customers,

especially when the companies are confronted with the issues of profitability and the achievement of local climate goals at the same time.
Interview Insights: P3 (Strategy Manager, Växjö Energi) noted: *"Today, renewable energy is, fortunately, often more expensive than fossil energy. When we looked at sustainable aviation fuel, we realized that it was much more expensive to produce a renewable alternative compared to the fossil price today, maybe 10 times more expensive."*
P4 (Technical Manager, Greenpipe Group AB) said: *"Structural things like how you're allowed to do business. Is it only the price that is important? Then, of course, environmental things will be less important. That also makes it very hard and challenging to use recycled materials."*

4.2.3 Challenges in Socio-technical Systems

Inertia of Behavior and Mindset

The transformation in social behavior and mindset is crucial in the transition to fossil fuel-free for Växjö. Especially the transformation of consumption patterns, which was highlighted as one of the primary challenges in "Sustainable Växjö 2030" (Växjö Kommun, 2019). The challenges lie in the inertia of behavior and mindset are the core pillars of socio-technical systems that underpin the energy transition theory. Some interviewees considered that some residents have adopted sustainable practices that could contribute to fossil fuel-free targets. However, other interviewees argued that the long-term mindset of the circular is still lacking in Växjö currently. In fact, if the social mindset does not align with the local climate goal, the municipality can not force residents to do so much, such as force residents to change their car to an EV or take the bus, which reflects the shortcomings and gaps in the current policy in Växjö. In addition, one of the reasons for the difficulty in reducing car dependency is the insufficient bus routine for rural areas, which indicates the spatial inequalities and the need for a Just Transition framework that ensures equitable during the fossil fuel-free transition.
Interview Insights: P1 (Environmental strategist, Växjö Municipality) explained: *"We have 45,000 cars in the crew, and we cannot force people to change their cars. And even if we build a lot of cycle paths and make it easier to go by public transporting and cycling. we can never force people to use that, of course. So that is also a challenge."*
P2 (Politician, Green Party councilor) highlighted: *"We need to do the changes that are possible for our society, the people living in the city, they can change their behavior a lot, and I think they are about to do that as well. I see a lot of people by going by bike and going for busses, but still it's very hard to live a life without a car."*
P4 (Technical Manager, Greenpipe Group AB) admitted: *"We don't have a circular mindset yet in the society, which means that when we think about solutions, we most often think small scales. we don't take in account for the long terms."*

4.2.4 Critical Synthesis for the Exsiting Challenges

Sweden aims to achieve carbon neutrality and phase out fossil fuels by 2045. This net-zero target is considered one of the most ambitious globally ("Zeroing In on Cities", 2024). Växjö is the first city to plan to become fossil fuel-free by 2030 in the world (Wälitalo et al., 2020). The fossil fuel-free ambition of Växjö seems even more ambitious than the National target.

Now, there are just five years left by 2030. However, the available systemic challenges, especially the difficulty in reducing car dependency and promoting renewable fuel for private vehicles, the inertia of behavior and mindset, suggest Växjö probably fall short of its target unless significant progress can be made before 2030.

4.3 Municipal Solutions to Address the Challenges

In order to address the systemic challenges of becoming fossil fuel-free by 2030, Växjö municipality has implemented specific solutions. Those solutions are stated in the policy document as well as the municipal reports. Interviews provided information regarding what the municipality had done. The interview data was coded and classified by the NVivo tool as well. The thematic analysis of municipal solutions is also analyzed through the lens of Energy Transition Theory, elaborating on the dimensions of Technological Innovation, Policy and Regulation, and Socio-technical Systems, which corresponds to the analysis of the existing challenges. Meanwhile, the limitations of the solutions are discussed. The critical analysis and outcomes in this section answer the third research question: How is the municipality seeking to address those challenges?

4.3.1 Solutions in Technological Innovation

Project of BECCS

In Växjö, technological innovations are providing potential solutions to reduce carbon emissions, especially to address the residual emission issues. Such as the production of hydrogen, and the pilot project carried out by Växjö Energi called BECCS, this carbon dioxide removal (CDR) project aims to capture emissions and store the CO_2 under the sea, even capture the emissions from biological emissions, the purpose of the project is to decrease the emissions as much as possible to meet the fossil fuel-free ambition and the local climate targets.

Interview Insights: P1 (Environmental strategist, Växjö Municipality) introduced: *"We have studied the possibilities to produce hydrogen, to see if that is possible. One pilot project is that we want to see if we can capture the renewable CO2 from our power plant, and capture and store it under the seawater, which is a project of BECCS being implemented by Växjö Energi. The project means that we would remove emissions from biological emissions, it's not fossil,* but we need to remove them, otherwise, we cannot improve the climate fast enough." P3 (Strategy Manager, Växjö Energi) noted: "We introduce the project of BECCS. We can also *receive negative emissions, so carbon removals to the system, and with that decrease the emission of CO_2 in the atmosphere. BECCS is bio-energy carbon capture storage by all* energy carbon capture."

However, the project of BECCS is still in the pilot stage, the technology is not yet scalable. As P1 admitted: *"We don't know yet if we can actually implement BECCS, because it costs a lot. We're not really sure if we can find the money to do that, but we're trying on a small scale level right now to see how it works. "* In addition, Carbon Capture and Storage (CCS) causes other concerns. Some people considered it might delay the immediate emission reduction targets, fostering a “delay discourse”, where ambitious future targets overshadow the need for immediate, substantive emissions reductions (“Zeroing In on Cities,” 2024).

Those reality issues raise questions about the feasibility of utilizing CCS as one of the technological innovations to foster the 2030 fossil fuel-free ambition.

4.3.2 Solutions in Policy and Regulation

Sustainable Transportation

The challenges in the transport sector are considered the primary obstacles for Växjö in achieving fossil fuel-free (Växjö Kommun, 2019, 2022). Solutions from the municipality are being implemented. Such as, promoting public transport, as well as sharing mobility, build more cycle paths and EV charging stations (Växjö Kommun, 2021). In the interviews, P1 (Environmental strategist, Växjö Municipality) explained: *"We will increase the coverage of public transport where possible to the use of us. We build a lot of cycle paths and make it easier to go by public transport and cycling. We want to introduce electric buses. We will build more charging stations for electric vehicles."* P2 (Politician, Green Party councilor) highlighted: *"We need to make it more attractive to transport with less impact. So we need to do quite a lot of changes with sharing mobility."*

However, despite these efforts regarding sustainable transport, the share of renewable diesel usage is believed to have a substantial reduction from 2024. P1 revealed: *"It was between 25 and 30% in 2023 of the diesel was renewable, but it's now been changed to 6%, which means that emissions will increase a lot from 2024 onwards."* Although this renewable share reduction is mainly from Sweden's national policy of rolling back some policies and incentives regarding transport, which also emphasizes that the current policy and approach to promoting sustainable transportation is fragile. In addition, P3 (Strategy Manager, Växjö Energi) pointed out in the interview that the extremely high cost of the alternative of traditional fossil fuel, such as sustainable aviation fuel (SAF), is a considerable barrier to adopting and implementing renewable energy alternatives.

Sustainable Construction

The residual emissions from the construction sectors are another main challenge identified. Växjö considered to be the pioneer in building houses with renewable sources, has around 30 years of long history in building houses with timber. The wood-building policy was adopted in Växjö in 2005 (Växjö Kommun, 2022). Växjö is still promoting sustainable construction practices, wooden buildings, and energy-efficient designs. In Växjö, at least 50% of the new buildings have wood frames. Moreover, Växjöbostäder made the internal decision that the energy performance for new buildings is required to at least have the production of 70% of the highest permitted primary energy figure in the current Swedish National Building Code (BBR) (Växjö Kommun, 2022). Meanwhile, the techniques for timber construction are still being developed. Välle Broar area of Växjö is the place to be chosen to provide space for innovation and development of timber construction techniques.

In the interviews, P1 (Environmental strategist, Växjö Municipality) highlighted: *"When we were talking about the climate work, for example, energy-efficient constructions and use of wooden buildings instead of concrete and steel. That is, also something that's good for climate. "* P2 (Politician, Green Party councilor) explained: *"When we say we want to build a lot of houses with wood, the companies also have changed their ways of thinking and*

building, and their knowledge of building has developed a lot supported by their researchers of wood building."
However, while using timber as the materials for construction can reduce emissions compared with other unrenewable materials, the process of the construction sector still generates significant emissions, such as the emissions from transportation and wood processing, those hard-to-abate residual emissions are still difficult to deal with. Therefore, using timber in construction can not tackle the carbon emissions reduction entirely, which has a limited passive impact on Växjö's climate target.

4.3.3 Solutions in Socio-technical Systems

Promoting Sustainable Behavior

The engagement and contribution of the Växjö's residents can play a core role in supporting the achievement of becoming fossil fuel-free, especially the behavior associated with the choice of traveling and daily consumption. The municipality is using campaigns to encourage sustainable behavior among residents, and aims to enhance the public engagement in local climate effort. P1 (Environmental strategist, Växjö Municipality) *mentioned these efforts: "We will also try to have campaigns to change people's behavior."*
However, it is still challenging to guide this transition without costing residents extra effort and money, which hinders the voluntary adoption of sustainable behavior and lifestyle for some residents. As P2 (Politician, Green Party councilor) pointed out: *"We are a municipality with a lot of countryside where people are living there. They need the car, and there is no public transportation. You can tell people to change their behavior. But if it means that they need to do more effort or more costly, most people won't change them.*" The difficulty in persuading residents' behavior change not only due to the insufficient of related infrastructure, but also reflects the societal issue of short-term convenience often priority over long-term sustainability (Alexander & Gleeson, 2018). It is a civilization-critical challenge, which critiques the convenience yet unsustainable consumption patterns, and calls for the transition and innovation of economic and social systems. Without addressing these underlying issues, the social transition will remain superficial and hollow.

5.Discussion

Although Växjö has made remarkable progress towards the 2030 fossil fuel-free ambition, the achievement of its ambitions is constrained by the contradictions in Växjö's current strategies, the persistent challenges, and the limitations that lie in municipal solutions. For example, one of the pilot technological innovations of carbon capture and storage (CCS) could raise critical concerns about a "delay discourse" ("Zeroing In on Cities", 2024). In addition, all the interviewees (four) expressed skepticism regarding the achievement of being fossil fuel-free by 2030 in Växjö due to the existing systemic challenges. In this chapter, Växjö's green image is discussed, and the need for civilization-critical perspectives, as well as transition should be just and inclusive.

5.1 Problematizing Växjö's Green Image

Växjö Fall Behind Peer Cities in Fulfilling Climate Actions

The earliest commitment to becoming fossil fuel-free, and the early usage of the biomass heating system, besides the biomass-based infrastructure and the high share of renewable energy, has made Växjö a representative city in the green image (Brinkley, 2018). Reliance on renewable district heating and green branding, but demonstrating path dependency and not enough public engagement, hinder the innovations for energy transitions in Växjö, which makes Växjö fall behind peer cities like Lund and Helsingborg, which have more power in systemic and inclusive innovations in fulfilling climate efforts (Lindvall, 2023). Moreover, bigger cities like Malmö have implemented more ambitious climate policies, such as stricter emissions standards and larger investments in public transport (City of Malmö, 2023). The other Swedish municipality’s climate efforts highlight Växjö needs to adopt comprehensive innovation towards its fossil fuel-free ambition and climate target, in order to remain competitive position in the carbon neutrality landscape.

Gaps Between Symbolic Actions and Real Practices

Växjö's international reputation as "Europe's green city" is largely built on its ambitious climate goals and early adoption of renewable energy (Ahmed & Nguyen, 2022). As a small city, Växjö was considered a pioneer in creating a fossil fuel-free city (Nikel, 2025). Utilizing the green branding of the city, the tourism of Växjö becomes prosperous, appealing to the increasing number of visitors. Meanwhile, the green branding of Växjö also brings investments and businesses from outside the region (Andersson & James, 2018).

However, according to Seto et al. (2021), argued that symbolic actions, such as the "Green image" are often prioritized over the transformative social changes in urban climate efforts. In the study of Andersson and James (2018), they found the green branding of Växjö was more like a symbol of the city, instead of substantive carbon neutrality, gaps between the symbolic branding and the realities practices exist. The authors provided an example, the vulnerable groups that can be impacted by Växjö's green initiative and transition, were not always considered in the social transition. This statement can be confirmed from the previous chapters. For example, Växjö municipality failed to promote renewable energy in the transport sector, which remains 85% reliant on fossil fuels, with only 26% of renewable

energy used in transport (Växjö Kommun, 2022). Additionally, for public engagement in the contribution of local climate efforts and sustainable behavior change, Växjö municipality mainly relies on education and campaigns, there are not sufficient economic incentives, and the need for residents living in rural areas are not enough which makes the effect of public engagement to be limited.

The emphasis on the city's green branding also can be regarded as typical 'platform urbanism,' where climate efforts are treated as a digitally mediated commodity, obscuring gaps between fossil fuel-free rhetoric and fossil-dependent transport realities (Barns, 2020). Furthermore, it is believed that the green branding could make the systemic challenges and gaps deeper, and slow the behavioral change in the communities (Seto et al., 2021). Therefore, to avoid the potential greenwashing and symbolism, keep increasing city visibility, and attract diverse resources, the solutions to address the systemic challenges should be designed more accessible, and implementing incentives is more practice than running campaigns in public engagement persuading. The transition towards a framework of just and inclusive is needed to reconcile the rhetoric with reality.

5.2 Towards a Just and Inclusive Transition

The plan of becoming fossil fuel-free by 2030 has made Växjö to be the first city to make such ambitious climate commitment. However, the contradictions lie in Växjö's current strategies, and persistent challenges in residual emissions reduction, transport and travel, economic barriers, and public engagement, also the green branding which could attract external resources, highlights Växjö needs a more comprehensive and inclusive approach for its social transition. Meanwhile, a Just Transition framework is essential and should be considered, particularly for rural areas and low-income populations, to make sure all the residents can benefit from the transition and leaving no one behind (United Nations Development Programme, 2022). This comprehensive, inclusive, and just approach includes stronger collaboration between local, national, and international stakeholders, specific policies to improve sustainable infrastructure, and economic incentives to persuade behavior change. By these measures, Växjö can bridge the gaps between its symbolic green branding and substantive urban sustainability, ensuring a more equitable and effective transition.

6. Conclusion

6.1 Summary of the Results

In the thesis, the research design of the case study offers an in-depth investigation of a single case (Växjö city) within a real-world context. Växjö has a long history of environmental concerns, it was the first city in the world to make the commitment to becoming fossil fuel-free in 1996 (Wälitalo et al., 2020). In the past 30 years, how does Växjö work to become a fossil fuel-free city by 2030 (What are the strategies)? What are the key challenges for Växjö in achieving its goal of becoming a fossil fuel-free city by 2030? And how is the municipality seeking to address those challenges? Those three questions are the research questions for the study and have been answered in Chapter 4-Results.

Firstly, the current strategy and its potential gaps were elaborated under the framework of energy transition theory. Technological innovation has been made in the energy sector, and the share of renewable energy in Växjö has increased significantly, from 33% in 1993 to 74% in 2021, energy used in the sector of electricity and heating is almost all renewable. Policy and regulation drive systemic change and implementation of the "Sustainable Växjö 2030" plan providing the guidance and roadmap for the city's climate efforts. Sustainable Transport Incentives guide Växjö made progress in transportation. For example, more than 50% of new car registrations in Växjö were for electric vehicles (EVs) or hybrids in 2023. From Local to national, multi-level collaboration between governments, cities, and communities can help the achievement of fossil fuel-free and mitigate climate change effectively. Contradictions exist in Växjö's current strategies, such as the lack of effective measures to mitigate emissions from transport and other residual emissions sources, and inequality in resource allocation for some groups of population during the energy transition journey.

Secondly, the main systemic challenges in achieving Växjö's 2030 fossil fuel-free ambition, lie in the residual emissions, transport sector, insufficient economic support,

Behavior and mindset changes Among those existing challenges, three participants in the interviews considered that the challenge associated with transportation is the primary obstacle for Växjö in achieving the goal of being fossil fuel-free by 2030. For example, transport and work machines account for 95% of Växjö's emissions of fossil carbon dioxide around 85% of all vehicles in operation are still fossil-fuel-powered. Those available systemic challenges, especially the difficulty in reducing car dependency and promoting renewable fuel for private vehicles, the inertia of behavior and mindset, suggest Växjö probably fall short of its target unless significant progress can be made before 2030.

Thirdly, solutions undertaken by Växjö municipality to address the challenges. For example, implementing technological innovation, such as the pilot project of BECCS being implemented by Växjö Energi which aims to capture the renewable CO_2 from our power plant, and capture and store it under the seawater, helps to achieve the climate goal faster. And promoting public transport, sharing mobility and cycling, and increasing the share of renewable energy in the transport sector. Promoting sustainable behavior by education and

running campaigns. However, limitations exist in those solutions, which impact the effect of strategy implementation.

Meanwhile, with the peer Swedish cities having more power in systemic and inclusive innovations in fulfilling climate efforts (Lindvall, 2023), Växjö fall behind other Swedish cities in achieving carbon neutrality and urban sustainability. And researchers found the green branding of Växjö was more like a symbol of the city, instead of substantive carbon neutrality (Andersson & James, 2018). Therefore, to avoid the potential greenwashing and symbolism, and keep increasing Växjö's visibility, the transition towards a framework of just and inclusive is required.

6.2 Contributions to the Field and Future Research Thoughts

There are quite a few studies on carbon neutrality and net-zero cities. For example, Seto et al. (2021) conducted a case study of four large cities globally which aiming to achieve net zero carbon emissions by the target year. The research underscored the significance of policy, urban planning and community engagement in the achievement of net-zero target. And concluded that net-zero cities are achievable, through systemic transformation, strategy implement, and multiple collaboration.

Compared with other studies of urban sustainability or net-zero emission achieving, the study of the thesis focuses on micro-level analysis, specifically on Växjö's strategies and challenges in achieving its fossil fuel-free ambition. The study of the thesis fills in the gap of a deeper understanding of how a small municipality like Växjö implements the frameworks of fossil fuel-free goals, contributes to the understanding of complex dynamics of local sustainability efforts, and the growth literature on energy transition theory in a real city context. Meanwhile, the study reflects the evolving economic and social challenges, such as rising costs for renewable energy prices, which adds a contemporary dimension to previous studies. Through understanding and applying the strategies that have enabled Växjö to move and process towards fossil fuel-free target, other cities can also participate in global efforts to combat climate change and contribute to climate commitments, ultimately paving the way for a more sustainable share future.

Due to the delimitations and limitations of the study, some aspects have not been elaborated or discussed. Such as a comparative analysis of best practices that other cities have similar climate goals, and the perspective from another stakeholder, such as the politician have different perceptions towards Växjö's climate goal, as well as insights into the alignment between fossil fuel-free goals and individual capabilities of sustainable household practices. Those aspects can be explored in future related research.

Acknowledgments

Firstly, I would like to extend my deepest gratitude to my supervisor, Naghmeh Nasiritousi, for her extreme support and guidance, since February 2024. Her insights and encouragement have been instrumental in every stage of my thesis's accomplishment. I am especially thankful for her understanding and flexibility as I balanced the demands of new motherhood with the challenges of completing this thesis. Her expertise and encouragement made this journey manageable, and I am incredibly grateful for her mentorship.

Moreover, I am also immensely thankful to the individuals and organizations in Växjö who generously shared their insights, experiences, and resources with me. Their cooperation and willingness to participate in my interviews provided the precious primary data for this thesis, and their dedication to sustainability has been a constant source of inspiration.

A special grateful goes to my family, especially to my husband, Lingdan, for his support, understanding, and maximum care for me and our newborn daughter during this challenging journey. Finally, I would like to extend my heartfelt thanks to my beloved daughter, Rachel, who, at just seven months old, has brought so much joy into my life. Her presence has been a reminder of the importance of my work as well as the thesis, as it is for future generations that we strive for a more sustainable world. Thank you, my little one, for being my constant source of strength and hope.

With gratitude,

Bin Meng

19 November, 2024 in Linköping, Sweden

References

Acuto, M., Parnell, S., & Seto, K. C. (2018). Building a global urban science. *Nature Sustainability*, *1*(1), 2-4.

Ahmed, N., Sheikh, A. A., Mahboob, F., Ali, M. S. E., Jasińska, E., Jasiński, M., Leonowicz, Z., & Burgio, A. (2022). Energy Diversification: A Friend or Foe to Economic Growth in Nordic Countries? A Novel Energy Diversification Approach. *Energies*, *15*(15), 5422. https://doi.org/10.3390/en15155422

Ahmed, S., & Nguyen, T. (2022). Analysis of future carbon-neutral energy system – The case of Växjö Municipality, Sweden. *Smart Energy*, *7*, 100082. https://doi.org/10.1016/j.segy.2022.100082

Alexander, S., & Gleeson, B. (2018). *Degrowth in the suburbs: a radical urban imaginary*. Springer.

Alpenberg, J., Wnuk-Pel, T., Adamsson, P., & Petersson, J. (2019). The use of environmental performance indicators in "the greenest city in Europe." *Baltic Journal of Management*, *14*(1), 122–140. https://doi.org/10.1108/BJM-01-2018-0028

Allsop, D. B., Chelladurai, J. M., Kimball, E. R., Marks, L. D., & Hendricks, J. J. (2022). Qualitative Methods with Nvivo Software: A Practical Guide for Analyzing Qualitative Data. *Psych*, *4*(2), 142–159. https://doi.org/10.3390/psych4020013

Andersson, I., & James, L. (2018). Altruism or entrepreneurialism? The co-evolution of green place branding and policy tourism in Växjö, Sweden. *Urban Studies*, *55*(15), 3437–3453. https://doi.org/10.1177/0042098017749471

Andersson, M., Ödlund, L., & Westling, H. (2019). The role of the Swedish municipalities in the transition towards sustainable energy systems. *WEENTECH Proceedings in Energy*, 124–135. https://doi.org/10.32438/WPE.3319

Arzaghi, M., & Squalli, J. (2023). The environmental impact of fossil fuel subsidy policies. *Energy Economics*, *126*, 106980. https://doi.org/10.1016/j.eneco.2023.106980

Attolico, A., Bloomfield, I., Dvarioniene, J., Gurauskiene, I., Kliaugaite, D., Mezosi, B., & Scorza, F. (2017). Engaged Communities for Low Carbon Development Process. In O. Gervasi, B. Murgante, S. Misra, G. Borruso, C. M. Torre, A. M. A. C. Rocha, D. Taniar, B. O. Apduhan, E. Stankova, & A. Cuzzocrea (Eds.), *Computational Science and Its Applications – ICCSA 2017* (Vol. 10409, pp. 573–584). Springer International Publishing. https://doi.org/10.1007/978-3-319-62407-5_41

Ayalon, M., & Even, R. (2008). Deductive reasoning: In the eye of the beholder. *Educational Studies in Mathematics*, *69*(3), 235–247. https://doi.org/10.1007/s10649-008-9136-2

Barns, S. (2020). *Platform urbanism: Negotiating platform ecosystems in connected cities*. Palgrave Macmillan.

Barrett, B. F. D., Trencher, G. P., Truong, N., & Ohta, H. (2024). How can cities achieve accelerated systemic decarbonization? Analysis of six frontrunner cities. *Sustainable Cities and Society*, *100*, 105000. https://doi.org/10.1016/j.scs.2023.105000

Barrick, L. (2020). Interviews: In-Depth, Semistructured. In *International Encyclopedia of Human Geography* (pp. 403–408). Elsevier. https://doi.org/10.1016/B978-0-08-102295-5.10832-7

Battulga, S., & Dhakal, S. (2023). Energy Demand Modeling for the Transition of a Coal-Dependent City to a Low-Carbon City: The Case of Ulaanbaatar City. *Energies*. https://doi.org/10.3390/en16176291

Bauer, A., & Steurer, R. (2014). Multi-level governance of climate change adaptation through regional partnerships in Canada and England. *Geoforum*, *51*, 121–129. https://doi.org/10.1016/j.geoforum.2013.10.006

Bayer, P., & Aklin, M. (2020). The European Union Emissions Trading System reduced CO_2 emissions despite low prices. *Proceedings of the National Academy of Sciences*, *117*(16), 8804–8812. DOI: 10.1073/pnas.1918128117

Bazaz, A., Bertoldi, P., Buckeridge, M., Cartwright, A., de Coninck, H., Engelbrecht, F., Jacob, D., Hour- cade, J.-C., Klaus, I., de Kleijne, K., Lwasa, S., Markgraf, C., Newman, P., Revi, A., Rogelj, J., Schultz, S., Shindell, D., Singh, C., Solecki, W., & Waisman, H. (2018). Summary for urban policymakers- What the IPCC special report on 1.5C means for cities.

Beach, D. (Ed.). (1996). *The responsible conduct of research*. VCH.

Benneworth, P. S., Coenen, L., & López, F. (n.d.). *Towards a theory for transition regions in sustainable energy innovation: Comparing system innovation and innovation systems*.

Blue, G., Rajewicz, L., Daub, S., & Yunker, Z. (2018). In the Corporate Interest: Fossil Fuel Industry Input into Alberta and British Columbia's Climate Leadership Plans. *Canadian Journal of Communication*, *43*(1), 93–110. https://doi.org/10.22230/cjc.2018v43n1a3309

Bowen, G. A. (2009). Document Analysis as a Qualitative Research Method. *Qualitative Research Journal*, *9*(2), 27–40. https://doi.org/10.3316/QRJ0902027

Brinkley, C. (2018). The conundrum of combustible clean energy: Sweden's history of siting district heating smokestacks in residential areas. *Energy Policy*, *120*, 526–532. https://doi.org/10.1016/j.enpol.2018.05.059

Brinkmann, S. (2023). Introduction to Qualitative Interviewing. In S. Brinkmann, *Qualitative Interviewing* (2nd ed., pp. 1–33). Oxford University PressNew York. https://doi.org/10.1093/oso/9780197648186.003.0001

Bryman, A. and Bell, E. (2015). Business Research Methods. New York: Oxford University Press.

Bucharest University of Economic Studies, Romania, VĮrjan, D., Popescu, C. R., Bucharest University of Economic Studies, Romania, Pop, I., Bucharest University of Economic Studies, Romania, Popescu, D., & Bucharest University of Economic Studies, Romania. (2023). Energy Transition and Sustainable Development at the Level of the European Union. *Amfiteatru Economic*, *25*(63), 429. https://doi.org/10.24818/EA/2023/63/429

Büscher, C. (2022). The Problem of Observing Sociotechnical Entities in Social Science and Humanities Energy Transition Research. *Frontiers in Sociology*, *6*, 699362. https://doi.org/10.3389/fsoc.2021.699362

Brändlin, S.A. (2024). How Sweden balances emission cuts with economic growth. https://www.dw.com/en/lessons-from-climate-hero-sweden-renewable-energy-heating-systems-climate-incentives/a-69766330

C40 cities. https://www.c40.org/

Chartier, C. (2015). Energy Democracy: A case study of energy generation in Växjö.
Chen, S., Long, H., Fath, B. D., Fath, B. D., Fath, B. D., & Chen, B. (2020). Global Urban Carbon Networks: Linking Inventory to Modeling. *Environmental Science & Technology*, *54*(9), 5790–5801. https://doi.org/10.1021/ACS.EST.0C00965
Cheng, A. W. J., & Lee, H. F. (2022). Energy Transition towards Sustainable Development: Perspective of Individuals' Engagement Amid Transition Process. *Sustainability*, *14*(16), 10381. https://doi.org/10.3390/su141610381
City of Freiburg im Breisgau.(2023).Voluntary Local Review of the City of Freiburg. https://sdgs.un.org/sites/default/files/vlrs/2024-06/2023_freiburg_vlr.pdf
Cleancities. (2024). Low-emission zones: the essential guide. https://cleancitiescampaign.org/research-list/lez-essential-guide/
Crowley, B. P., & Delfico, J. F. (1996). Content analysis: A methodology for structuring and analyzing written material. United States General Accounting Office (GAO), Program Evaluation and Methodology Division.
De La Peña, L., Guo, R., Cao, X., Ni, X., & Zhang, W. (2022). Accelerating the energy transition to achieve carbon neutrality. *Resources, Conservation and Recycling*, *177*, 105957. https://doi.org/10.1016/j.resconrec.2021.105957
Deseglise, C. (2020). How to drive investment into sustainable infrastructure. https://www.weforum.org/stories/2020/09/how-to-drive-investment-into-sustainable-infrastructure/
Dias, L. P., Simões, S., Gouveia, J. P., & Seixas, J. (2019). City energy modelling—Optimising local low carbon transitions with household budget constraints. *Energy Strategy Reviews*, *26*, 100387. https://doi.org/10.1016/j.esr.2019.100387
Dong, F., Hillebrandt, C., Li, Y., Gao, Y., Zhu, J., Qin, C., & Zhang, X. (2022). Energy transition and carbon neutrality: Exploring the non-linear impact of renewable energy development on carbon emission efficiency in developed countries. *Resources Conservation and Recycling*, *177*, 106002. https://doi.org/10.1016/J.RESCONREC.2021.106002
Dyer, M., & Ögmundardóttir, H.. (2018). Transition of Växjö and Sønderborg towards becoming fossil-fuel-free communities. 171(1). https://doi.org/10.1680/JENER.17.00004
ECUI. (2020). Net zero tracker. Energy & Climate Intelligence Unit. https://eciu.net/netzerotracker.
Elechi, O. O., Piper, D., & C. Morris, S. V. (2013). Case Study Research. In J. S. Albanese (Ed.), The Encyclopedia of Criminology and Criminal Justice (1st ed., pp. 1–5). Wiley. https://doi.org/10.1002/9781118517383.wbeccj358
Energy cities. City of Växjö. https://energy-cities.eu/members/city-of-vaxjo/
European Commission.The European Green Deal:A growth strategy that protects the climate.https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/story-von-der-leyen-commission/european-green-deal_en
Evans, J. (2013). The Psychology of Deductive Reasoning (Psychology Revivals). Psychology Press. https://doi.org/10.4324/9781315819631

Filipović, S., Lior, N., & Radovanović, M. (2022). The green deal – just transition and sustainable development goals Nexus. Renewable and Sustainable Energy Reviews, 168, 112759. https://doi.org/10.1016/j.rser.2022.112759

Foss, A. (2018). Divergent responses to sustainability and climate change planning: The role of politics, cultural frames and public participation. *Urban Studies*, *55*(2), 332-348. https://doi.org/10.1177/0042098016651554

Galgoczi, B., & Pochet, P. (2023). Just transition and welfare states: a largely unexplored relation. *Sociologia Del Lavoro*. https://doi.org/10.3280/sl2023-165003

Geels, F. W., Sovacool, B. K., Schwanen, T., & Sorrell, S. (2017). Sociotechnical transitions for deep decarbonization. *Science*, *357*(6357), 1242–1244. https://doi.org/10.1126/science.aao3760

Geels, F. W. (2018). Disruption and low-carbon system transformation: Progress and new challenges in socio-technical transitions research and the Multi-Level Perspective. *Energy Research & Social Science*, *37*, 224–231. https://doi.org/10.1016/j.erss.2017.10.010

City of Malmö.(2023). Climate City Contract: 2030 Climate Neutrality Action Plan of Malmö. Net Zero City. https://netzerocities.app/_content/files/knowledge/4189/malmo_nzc_ccc_ok.pdf

Government office of Sweden. Ministry of the Environment. (2020). Sweden's long-term strategy for reducing greenhouse gas emissions. https://unfccc.int/sites/default/files/resource/LTS1_Sweden.pdf

Grin, J., Rotmans, J., & Schot, J. (2010). Transitions to Sustainable Development: New Directions in the Study of Long Term Transformative Change (1st ed.). Routledge. https://doi.org/10.4324/9780203856598

Grubb, M., Hourcade, J.-C., & Neuhoff, K. (2015). The Three Domains structure of energy-climate transitions. *Technological Forecasting and Social Change*, *98*, 290–302. https://doi.org/10.1016/j.techfore.2015.05.009

Gulbrandsen, H. L. & Wettestad, J. (2022). Carbon Pricing Under Pressure: Withering Markets? *Journal Citations Report 2021* 10 (1). DOI: 10.17645/pag.v10i1.5437

Hagen, B., Nassar, C., & Pijawka, D. (2017). The Social Dimension of Sustainable Neighborhood Design: Comparing Two Neighborhoods in Freiburg, Germany. Urban Planning, 2(4), 64–80. https://doi.org/10.17645/up.v2i4.1035

Hainsch, K., Göke, L., Kemfert, C., Oei, P.-Y., & Hirschhausen, C. V. (2020). European Green Deal: Using Ambitious Climate Targets and Renewable Energy to Climb out of the Economic Crisis. *DIW Weekly Report*. https://doi.org/10.18723/DIW_DWR:2020-28-1

Hastings, A., & Smith, P. (2019). Decarbonizing Anthropogenic Activity: The Oil and Gas Industry is a Major Component of the Solution. Day 2 Wed, September 04, 2019, D021S007R001. https://doi.org/10.2118/195716-MS

Hastings, A., & Smith, P. (2020). Achieving Net Zero Emissions Requires the Knowledge and Skills of the Oil and Gas Industry. *Frontiers in Climate*, *2*, 601778. https://doi.org/10.3389/fclim.2020.601778

Heffron, R., & McCauley, D.(2018). Just transition: Integrating climate, energy and environmental justice. *Energy Policy*, *119*, 1–7. https://doi.org/10.1016/j.enpol.2018.04.014

Heit, E., & Rotello, C. M. (2010). Relations between inductive reasoning and deductive reasoning. *Journal of Experimental Psychology: Learning, Memory and Cognition*, *36*(3), 805–812. https://doi.org/10.1037/A0018784

Herendeen, R. (2019). Does "100% renewable" trump concern for spatial impacts? Energy Policy, 130, 304–310. https://doi.org/10.1016/j.enpol.2019.04.002

Hsieh, H.F., & Shannon, S. E. (2005). Three Approaches to Qualitative Content Analysis. *Qualitative Health Research*, *15*(9), 1277–1288. https://doi.org/10.1177/1049732305276687

Hussein, H. (2022). Interview Method. In M. R. Islam, N. A. Khan, & R. Baikady (Eds.), Principles of Social Research Methodology (pp. 207–219). Springer Nature Singapore. https://doi.org/10.1007/978-981-19-5441-2_14

IRENA. (2020). Stimulating investment in community energy: Broadening the ownership of renewables. https://www.irena.org/publications/2020/Dec/Stimulating-investment-in-community-energy-Broadening-the-ownership-of-renewables

Joint Research Centre (2024). Residual emissions hold great operational value for cities committed to climate neutrality. https://joint-research-centre.ec.europa.eu/jrc-news-and-updates/residual-emissions-hold-great-operational-value-cities-committed-climate-neutrality-2024-04-17_en

Joshi, A., Pathak, M., Kuttippurath, J., & Patel, V. K. (2023). Adoption of cleaner technologies and reduction in fire events in the hotspots lead to global decline in carbon monoxide. *Chemosphere*, *336*, 139259. https://doi.org/10.1016/j.chemosphere.2023.139259

Johnson-Laird, P. (2010). Deductive reasoning. *WIREs Cognitive Science*, *1*(1), 8–17. https://doi.org/10.1002/wcs.20

Kabeyi, M. J. B., & Olanrewaju, O. A. (2022). Sustainable Energy Transition for Renewable and Low Carbon Grid Electricity Generation and Supply. *Frontiers in Energy Research*, *9*. https://doi.org/10.3389/fenrg.2021.743114

Kaletnik, G., & Lutkovska, S. (2020). Innovative Environmental Strategy for Sustainable Development. *European Journal of Sustainable Development*, *9*(2), 89–98. https://doi.org/10.14207/ejsd.2020.v9n2p89

Kern, F., & Rogge, K. S. (2016). The pace of governed energy transitions: Agency, international dynamics and the global Paris agreement accelerating decarbonisation processes? *Energy Research & Social Science*, *22*, 13–17. https://doi.org/10.1016/j.erss.2016.08.016

Knott, E., Rao, A. H., Summers, K., & Teeger, C. (2022). Interviews in the social sciences. Nature Reviews Methods Primers, 2(1), 73. https://doi.org/10.1038/s43586-022-00150-6

Koglin, T. (2022). Cycling infrastructure in Lund, Sweden. In G. Norcliffe, U. Brogan, P. Cox, B. Gao, T. Hadland, S. Hanlon, T. Jones, N. Oddy, & L. Vivanco, *Routledge*

Companion to Cycling (1st ed., pp. 229–231). Routledge. https://doi.org/10.4324/9781003142041-29

Krause, R. M., YS Park, A., Hawkins, C. V., & Feiock, R. C. (2019). The effect of administrative form and stability on cities' use of greenhouse gas emissions inventories as a basis for mitigation. Journal of Environmental Policy & Planning, 21(6), 826-840. https://doi.org/10.1080/1523908X.2019.1680273

Kroh, J., & Schultz, C. (2023). The more the better? The role of stakeholder information processing in complex urban innovation projects for green transformation. *International Journal of Project Management*, *41*(3), 102466. https://doi.org/10.1016/j.ijproman.2023.102466

Kronsell, A. (2013). Legitimacy for climate policies: Politics and participation in the Green City of Freiburg. *Local Environment*, *18*(8), 965–982. https://doi.org/10.1080/13549839.2012.748732

Ksenia Koroleva, M. B., Diogo Vitorino, K. D., & Novak, J. (2019). Developing a Collective Awareness Platform for Urban Sustainability Challenges: Case Study of the POWER Project. *European Journal of Sustainable Development*, *8*(4), 214. https://doi.org/10.14207/ejsd.2019.v8n4p214

Kurchin and Partners Law Office, & Kurchin, O. (2020). Topical issues of improving the competence of local governments in the field of urban planning in the context of municipal reform. *Vìsnik Marìupol's'kogo Deržavnogo Unìversitetu. Serìâ: Pravo*, *10*(19), 118–124. https://doi.org/10.34079/2226-3047-2020-10-19-118-124

Lah, O., & Lah, B. (2019). Pathways Towards Decarbonising the Transportation Sector. In B. Müller & G. Meyer (Eds.), *Towards User-Centric Transport in Europe* (pp. 51–61). Springer International Publishing. https://doi.org/10.1007/978-3-319-99756-8_4

Lamb, W. F., Mattioli, G., Levi, S., Roberts, J. T., Capstick, S., Creutzig, F., Minx, J. C., Müller-Hansen, F., Culhane, T., & Steinberger, J. K. (2020). Discourses of climate delay. *Global Sustainability*, *3*, e17. https://doi.org/10.1017/sus.2020.13

Lazarus, M., van Asselt, H., & van Asselt, H.. (2018). Fossil fuel supply and climate policy: exploring the road less taken. 150(1). https://doi.org/10.1007/S10584-018-2266-3

LCLEI (Local Government for Sustainability). Local Governments for Sustainability. https://iclei.org/

Lee, C. M., & Erickson, P. (2017). How does local economic development in cities affect global GHG emissions? *Sustainable Cities and Society*, *35*, 626–636. https://doi.org/10.1016/j.scs.2017.08.027

Lee, T., & Van De Meene, S. (2012). Who teaches and who learns? Policy learning through the C40 cities climate network. Policy Sciences, 45(3), 199–220. https://doi.org/10.1007/s11077-012-9159-5

Lelieveld, J., Klingmüller, K., Pozzer, A., Burnett, R. T., Haines, A., & Ramanathan, V. (2019). Effects of fossil fuel and total anthropogenic emission removal on public health and climate. *Proceedings of the National Academy of Sciences*, *116*(15), 7192–7197. https://doi.org/10.1073/pnas.1819989116

Liddle, B., & Sadorsky, P. (2017). How much does increasing non-fossil fuels in electricity generation reduce carbon dioxide emissions? *Applied Energy*, *197*, 212–221. https://doi.org/10.1016/j.apenergy.2017.04.025

Lindvall, D. (2023). What motivates urban climate leaders? A study of urban climate governance in eight Swedish municipalities. *International Journal of Urban Sustainable Development*, *15*(1), 267–281. https://doi.org/10.1080/19463138.2023.2253755

Linton, S., Clarke, A., & Tozer, L. (2022). Technical pathways to deep decarbonization in cities: Eight best practice case studies of transformational climate mitigation. *Energy Research & Social Science*, *86*, 102422. https://doi.org/10.1016/j.erss.2021.102422

Liu, B., Liu, G. Y., Tang, Y., & Cheng, H.-M. (2022). Advanced materials and energy technologies towards carbon neutrality. Science China. Materials, 65(12), 3187–3189. https://doi.org/10.1007/s40843-022-2324-0

Liu, J., & Xi, X. (2024). Pathways and Innovative Mechanisms for Achieving Urban Carbon Neutrality. *Advances in Economics, Management and Political Sciences*, *88*(1), 39–45. https://doi.org/10.54254/2754-1169/88/20241044

Matern, A., Förster, A., & Knippschild, R. (2022). Designing Sustainable Change in Coal Regions. *disP - The Planning Review*, *58*(3), 19–21. https://doi.org/10.1080/02513625.2022.2158588

Mazhar, S. A., Anjum, R., Anwar, A. I., & Khan, A. A.(2021). Methods of Data Collection: A Fundamental Tool of Research. Journal of Integrated Community Health, 10(01), 6–10. https://doi.org/10.24321/2319.9113.202101

McNaught, R. (2024). The application of collaborative governance in local level climate and disaster resilient development – A global review. *Environmental Science & Policy*, *151*, 103627. https://doi.org/10.1016/j.envsci.2023.103627

Mezmir, E., A. (2020). Qualitative Data Analysis: An Overview of Data Reduction, Data Display and Interpretation. Research on Humanities and Social Sciences. https://doi.org/10.7176/RHSS/10-21-02

Mishra, R. K. (2022). Urban decarbonization policy as assembling process: heterogeneous elements, networks and (un)making of target groups in a Swedish municipality between serendipity and design. *Journal of Environmental Policy & Planning*, 1–13. https://doi.org/10.1080/1523908x.2022.2128093

Mokal, M. N., Ahmad, Z., Mahboob, M. N., & Khan, A. A. (2023). Understanding the Relationship of Energy Consumption and Economic Determinants in ASEAN-5 Countries. *Review of Applied Management and Social Sciences*, *6*(4), 653–668. https://doi.org/10.47067/ramss.v6i4.356

Musiał, W., Zioło, M., Luty, L., & Musiał, K. (2021). Energy Policy of European Union Member States in the Context of Renewable Energy Sources Development. Energies, 14(10), 2864. https://doi.org/10.3390/en14102864

Newell, P., & Mulvaney, D. (2013). "The political economy of 'just transition': Bringing democracy and social justice into the energy debate." Energy Policy, 61, 484–492. https://doi:10.1111/geoj.12008

Nikel, D. (2025). Discover the charm of Växjö, Sweden's greenest city. *Forbes.* https://www.forbes.com/sites/davidnikel/2025/02/01/discover-the-charm-of-vxj-swedens-greenest-city/

Oliver, P. (2009). *The student's guide to research ethics* (Reprint). Chapter 1. Open University Press.

Patton, M. Q. (2002). *Qualitative research and evaluation methods* (3rd ed.). Thousand Oaks, CA: Sage Publications.

Pesch, U., Spekkink, W., & Quist, J. (2019). Local sustainability initiative: Innovation and civic engagement in societal experiments. *European Planning Studies*, *27*(2), 300–317. https://doi.org/10.1080/09654313.2018.1464549

Portia Oduro, Peter Simpa, & Darlington Eze Ekechukwu. (2024). Renewable energy expansion: Legal strategies for overcoming regulatory barriers and promoting innovation. *World Journal of Advanced Engineering Technology and Sciences*, *12*(1), 168–186. https://doi.org/10.30574/wjaets.2024.12.1.0208

Putri, F. A., Setyowati, K., & Nugroho, R. A. (2019). Achieving Sustainable Public Transportation in the Era of Online Transportation. *Proceedings of the First International Conference on Administration Science (ICAS 2019)*. Proceedings of the First International Conference on Administration Science (ICAS 2019), Bandung, Indonesia. https://doi.org/10.2991/icas-19.2019.58

Ramaswami, A., Tong, K., Canadell, J. G., Jackson, R. B., Stokes, E., Dhakal, S., Finch, M., Jittrapirom, P., Singh, N., Yamagata, Y., Yewdall, E., Yona, L., & Seto, K. C. (2021). Carbon analytics for net-zero emissions sustainable cities. *Nature Sustainability*, *4*(6), 460–463. https://doi.org/10.1038/s41893-021-00715-5

Reckien, D., Salvia, M., Heidrich, O., Church, J. M., Pietrapertosa, F., De Gregorio-Hurtado, S., D'Alonzo, V., Foley, A., Simoes, S. G., Krkoška Lorencová, E., Orru, H., Orru, K., Wejs, A., Flacke, J., Olazabal, M., Geneletti, D., Feliu, E., Vasilie, S., Nador, C., … Dawson, R. (2018). How are cities planning to respond to climate change? Assessment of local climate plans from 885 cities in the EU-28. *Journal of Cleaner Production*, *191*, 207–219. https://doi.org/10.1016/j.jclepro.2018.03.220

Roche, M. Y., Verolme, H., Agbaegbu, C., Binnington, T., Fischedick, M., & Oladipo, E. O. (2020). Achieving Sustainable Development Goals in Nigeria's power sector: assessment of transition pathways. *Climate Policy*, *20*(7), 846–865. https://doi.org/10.1080/14693062.2019.1661818

Roulston, K. (2018). Interviews in Qualitative Research. In C. A. Chapelle (Ed.), The Encyclopedia of Applied Linguistics (1st ed., pp. 1–10). Wiley. https://doi.org/10.1002/9781405198431.wbeal0572.pub2

Saldert, H. (2024). Pathways and Innovative Mechanisms for Achieving Urban Carbon Neutrality. https://doi.org/10.54254/2754-1169/88/20241044

Sauce, B., & Matzel, L. D. (2017). Inductive Reasoning. In J. Vonk & T. Shackelford (Eds.), Encyclopedia of Animal Cognition and Behavior (pp. 1–8). Springer International Publishing. https://doi.org/10.1007/978-3-319-47829-6_1045-1

Scholten, D., & Künneke, R. (2016). Towards the Comprehensive Design of Energy Infrastructures. *Sustainability*, *8*(12), 1291. https://doi.org/10.3390/su8121291

Seto, K. C., Churkina, G., Hsu, A., Keller, M., Newman, P. W. G., Qin, B., & Ramaswami, A. (2021). From Low- to Net-Zero Carbon Cities: The Next Global Agenda. *Annual Review of Environment and Resources*, *46*(1), 377–415. https://doi.org/10.1146/annurev-environ-050120-113117

Sharon Maria, S., Lakshmy, S., Nidhin, D. K., & Shibu, N. K. (2022). Carbon Neutral Communities: Model for Integrating Climate Action into Development Planning. In I. Pal & S. Kolathayar (Eds.), *Sustainable Cities and Resilience* (Vol. 183, pp. 385–396). Springer Singapore. https://doi.org/10.1007/978-981-16-5543-2_31

Small, M. L. (2011). How to Conduct a Mixed Methods Study: Recent Trends in a Rapidly Growing Literature. Annual Review of Sociology, 37(1), 57–86. https://doi.org/10.1146/annurev.soc.012809.102657

Sovacool, B. K. & UNU-WIDER. (2016). *The history and politics of energy transitions: Comparing contested views and finding common ground* (81st ed., Vol. 2016). UNU-WIDER. https://doi.org/10.35188/UNU-WIDER/2016/124-6

Stolz, C. J. (2012). The National Ignition Facility: The path to a carbon-free energy future. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *370*(1973), 4115–4129. https://doi.org/10.1098/rsta.2011.0260

Terra Dos Santos, L. C., Frimaio, A., Giannetti, B. F., Agostinho, F., Liu, G., & Almeida, C. M. V. B. (2023). Integrating Environmental, Social, and Economic Dimensions to Monitor Sustainability in the G20 Countries. *Sustainability*, *15*(8), 6502. https://doi.org/10.3390/su15086502

The Guardian, (2015). What can the world learn from Växjö, Europe's selfstyled greenest city? https://www.theguardian.com/cities/2015/nov/25/what-can-the-world-learnfrom-vaxjo-europes-self-styled-greenest-city

The Ministry of Infrastructure. (2020). Sweden's Integrated National Energy and Climate Plan. https://energy.ec.europa.eu/system/files/2020-03/se_final_necp_main_en_0.pdf

The Global Covenant of Mayors for Climate & Energy (GCoM). https://www.globalcovenantofmayors.org/

Tonhauzer, P., & Morvova, M. (2016). Use of Biomass and Waste for Energy Purposes. *Applied Mechanics and Materials*, *832*, 109–114. https://doi.org/10.4028/www.scientific.net/AMM.832.109

Tozer, L. (2020). Catalyzing political momentum for the effective implementation of decarbonization for urban buildings. *Energy Policy*, *136*, 111042. https://doi.org/10.1016/J.ENPOL.2019.111042

Tracy, S. J. (n.d.). Qualitative Research Methods.

United Nations. (2019). The Future is Now: Science for Achieving Sustainable Development. Global Sustainable Development Report 2019. New York, United Nations. https://sdgs.un.org/gsdr/gsdr2019

United Nations.(2015).Transforming Our World: The 2030 Agenda for Sustainable Development. New York, United Nations, A/RES/70/1. https://sustainabledevelopment.un.org/post2015/transformingourworld

UNFCCC. (2020).Transformational Action Needed for Paris Agreement Targets - United in Science Report.

https://unfccc.int/news/transformational-action-needed-for-paris-agreement-targets-united-in-science-report
United Nations Development Programme. (2022). *What is a just transition and why is it important?* UNDP Climate Promise. https://climatepromise.undp.org/news-and-stories/what-just-transition-and-why-it-important
Växjö kommun. (2010).Växjö – the Greenest city in Europe. 24 August
Växjö Kommun. Facts about Växjö municipality. https://www.vaxjo.se/sidor/politik-och-demokrati/om-vaxjo/fakta-vaxjo-kommun.html
Växjö Kommun.(2015). Växjö Declaration. https://www.vaxjo.se/download/18.313cf36515d1bde9ee3205f6/1499862622076/Vaxjo%20declaration_2015_eng.pdf
Växjö Kommun. (2019). Sustainable Växjö 2030. https://www.vaxjo.se/download/18.35d6e9ef173d516f49758b6/1597041882155/ENG_Hållbarhetsprogrammet%20Hållbara%20Växjö%202030_antaget%20av%20KF.pdf
Växjö Kommun.(2021). Transportplan 2025. https://www.vaxjo.se/download/18.2aa17d2517d7b88b034b7d36/1639128264404/Transportplan%202025%20beslutad%20KF%2020211123.pdf
Växjö Kommun. (2022). Fördjupad uppföljning Hållbara Växjö 2030 (Detailed follow-up Sustainable Växjö2030). https://www.vaxjo.se/download/18.57a9b20e186922bca19c639e/1678364639853/Fördjupad%20uppföljning%20Hållbara%20Växjö%202030.pdf
Växjö Kommun. (2024). Årsredovisning Växjö kommun 2023.(Annual report Växjö municipality 2023). https://www.vaxjo.se/download/18.123e486118f947f069a6c011/1716452446456/Årsredovisning%20Växjö%20kommun%202023.pdf
Växjö Energi - 100 % fossil free production of heat and power. (2022). *Interreg Europe.* https://www.interregeurope.eu/good-practices/vaxjo-energi-100-fossil-free-production-of-heat-and-power
Vanhuyse, F., Piseddu, T., & Jokiaho, J. (2023). Climate neutral cities in Sweden: True commitment or hollow statements? *Cities*, *137*, 104267. https://doi.org/10.1016/j.cities.2023.104267
Verbruggen, A., Laes, E., & Woerdman, E. (2019). Anatomy of Emissions Trading Systems: What is the EU ETS? *Environmental Science & Policy*, *98*, 11–19. https://doi.org/10.1016/j.envsci.2019.05.001
Viable Cities. (2023). Climate City Contract 2030. https://www.vaxjo.se/download/18.7228151618beb6d93dfde794/1701345122823/Klimatkontrakt_Va%CC%88xjo%CC%88_2023.pdf
Vuthi, P., Sudeikat, J., & Peters, I.. (2024). *Analyzing the Transformation Path of the Local Energy Infrastructure*. https://doi.org/10.1007/978-3-031-60023-4_6
Wälitalo, L., Robèrt, K.-H., & Broman, G. (2020). An Overarching Model for Cross-Sector Strategic Transitions towards Sustainability in Municipalities and Regions. *Sustainability*, *12*(17), 7046. https://doi.org/10.3390/su12177046

Whitmarsh, L. (2012). How useful is the Multi-Level Perspective for transport and sustainability research? *Journal of Transport Geography*, *24*, 483–487. https://doi.org/10.1016/j.jtrangeo.2012.01.022

Wiedmann, T., & Allen, C. (2021). City footprints and SDGs provide untapped potential for assessing city sustainability. *Nature Communications*, *12*(1), 3758. https://doi.org/10.1038/s41467-021-23968-2

World Health Organization (WHO). (2024). Ambient (outdoor) air pollution. https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health

Yang, G. (2023). Can the low-carbon city pilot policy promote firms' low-carbon innovation: Evidence from China. *PLOS ONE*, *18*(1), e0277879. https://doi.org/10.1371/journal.pone.0277879

Yang, Y., Xia, S., Huang, P., & Qian, J. (2024). Energy transition: Connotations, mechanisms and effects. *Energy Strategy Reviews*, *52*, 101320. https://doi.org/10.1016/j.esr.2024.101320

Yin, Y., Rader Olsson, A., & Håkansson, M. (2016). The role of local governance and environmental policy integration in Swedish and Chinese eco-city development. *Journal of Cleaner Production*, *134*, 78–86. https://doi.org/10.1016/j.jclepro.2015.10.087

Yin, R. K. (2018). Chapter one. *Case study research and applications.*6th ed.

Yu, zhi-yong. (2023). Can the Growth of the Digital Economy Be Beneficial for Urban Decarbonization? A Study from Chinese Cities. *Sustainability*, *15*(3), 2260. https://doi.org/10.3390/su15032260

Zhang, S., & Chen, W. (2022). Assessing the energy transition in China towards carbon neutrality with a probabilistic framework. *Nature Communications*, *13*(1). https://doi.org/10.1038/s41467-021-27671-0

Zhang, Y., Pan, C.-L., & Liao, H.-T. (2021). Carbon Neutrality Policies and Technologies: A Scientometric Analysis of Social Science Disciplines. Frontiers in Environmental Science, 9, 761736. https://doi.org/10.3389/fenvs.2021.761736

Zhou, X. Växjö: *Moving away from fossil fuels.* (2012). World Science. https://worldscience.cn/c/2012-05-05/582609.shtml

Appendix 1- Interview questions for interviewee from Växjö Sustainability Committee

Background of the Interviewee

1.Could you please introduce yourself, your role, and the organization you represent?

General Questions about Växjö's Fossil Fuel-Free Plan

2.How would you evaluate Växjö's progress so far in achieving its Fossil Fuel-Free target?

3.In your view, what sets Växjö's Fossil Fuel-Free Plan apart from other regions or cities with similar goals?

Specific Questions about Challenges and Solutions

4.What specific measures or policies has the Sustainability Committee put in place to help the achievement of Växjö's Fossil Fuel-Free Plan, and how would you rate their success so far?

5.What do you think are the main challenges that Växjö faces in implementing the Fossil Fuel-Free Plan by 2030?

Reflections on Success and Future Prospects

6.In your opinion, will Växjö succeed in reaching the Fossil Fuel-Free target by 2030? Why or why not?

7.What are the successful experiences of implementing the Fossil fuel-free plan that you think can be learned for other regions?

Appendix 2- Interview questions for interviewee from Växjö Energi

Background of the Interviewee

1.Could you please introduce yourself, and your organization?

General Questions about Växjö's Fossil Fuel-Free Plan

2.What role has your company/Växjö Energi played in Växjö's achievements of the Fossil Fuel-Free plan?

3.Are there any unique initiative or strategies that your company/Växjö Energi has contributed to Växjö's Fossil Fuel-Free Plan?

Specific Questions about Challenges and Solutions

4.From an energy provider's perspective, what do you think are the main challenges in implementing the Växjö's Fossil Fuel-Free plan by 2030?

5.Has Växjö Energi introduced any specific solutions or support measures to address these challenges? How effective of those solutions do you think ?

6.In your opinion, are there any gaps or areas where improvements could be made to better support Växjö in achieving its Fossil Fuel-Free goal? What suggestions would you have for enhancing these solutions?

Reflections on Success and Future Prospects

7.Is there any successful strategies that Växjö Energi has implemented to help the achievement of Växjö's Fossil Fuel-Free plan? What lessons do you think other regions could learn from these experiences?

8.Do you believe Växjö will successfully reach its Fossil Fuel-Free target by 2030?

Appendix 3- Codes list created in NVivo

Name of codes	Files (participants)	References
(RQ1) Current achievement (parent code)	4	17
Crucial progress in emission reduction (theme)	1	3
emission reduction (child code of theme)	1	2
other emissions (child code of theme)	1	1
Crucial progress in energy sector (theme)	2	2
Successful experience in goal achieving(theme)	4	12
diverse collaboration (child code of theme)	3	8
local business contribution (child code of theme)	2	4
(RQ2) Challenges (parent code)	4	23
Behavioral and mindset change challenges (theme)	3	6
Challenges from residual emission and waste management (theme)	2	3
waste management (child code of theme)	1	1
residual emssions (child code of theme)	2	2
Inadequate economical policies (theme)	2	3
Transport sector challenges (theme)	3	10
less renewable energy (child code of theme)	2	2
transportation related (child code of theme)	3	8
(RQ3) Solutions (parent code)	4	28
Sustainable behavior (theme)	2	2
Policies and innovation(theme)	1	2
Innovation (child code of theme)	1	1
collaboration and network (child code of theme)	1	1
Sustainable transportation (theme)	2	6
more renewable energy (child code of theme)	1	3
less climate impact (child code of theme)	2	3
Sustainable urban planning and construction (theme)	2	3
sustainable construction (child code of theme)	2	2
sustainable urban planning (child code of theme)	1	1
Other finding (parent code)	4	5
Achievability of the goal (theme)	4	5