Barriers to Renewable Energy Transition in Slovakia

BSc. Global Responsibility & Leadership

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CFBGR03610: Capstone Project

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June 5th, 2024

Abstract

The transition to renewable energy sources is imperative for addressing the global climate crisis. However, this transition faces numerous obstacles, particularly in countries like Slovakia. This thesis investigates the barriers hindering the renewable energy transition in Slovakia, focusing on legislative/regulatory, socio-cultural, financial, and technological challenges. Through direct qualitative content analysis, 50 documents including government reports, academic studies, and media articles were examined to identify and categorize these barriers.

The findings reveal that legislative/regulatory barriers are the most significant, with regulatory uncertainty and difficult permitting processes posing the greatest challenges. Additionally, the lack of clear policies and inadequate policy reinforcement exacerbates these issues. Socio/cultural barriers, such as negative perceptions of renewable energy and a general lack of public understanding, further impede progress. Financial barriers, though less frequently cited, include high initial investment costs and extended payback periods. Technological challenges primarily involve difficulties in integrating renewable energy into the existing grid infrastructure and a shortage of skilled professionals.

This comprehensive analysis provides valuable insights into the multifaceted barriers Slovakia faces in its renewable energy transition. It offers policymakers and stakeholders a detailed understanding of the challenges and potential strategies to address them effectively, thereby facilitating a smoother and more efficient transition towards sustainable energy sources.

Key Words: climate change, greenhouse gas emissions, renewable energy transition (RET), barriers to RET, Slovakia

I hereby declare that this bachelor thesis is the work of my own and has not been published in part or in whole elsewhere. All literature used is attributed and cited in references. The language of the thesis is English.

1. Introduction

In recent decades, our world has been thrust into a state of unprecedented climate crisis. Rising temperatures and a surge in extreme weather events serve as evident reminders of a planet in distress, with human-induced climate change at the heart of this crisis (Connors et al., 2021). The relentless combustion of fossil fuels for energy, transportation, and industrial processes has been the primary driver of this global phenomenon (Clarke et al., 2015). The release of greenhouse gasses (GHG) from these activities has led to a dangerous heat-trapping effect in the atmosphere, causing our planet to warm (Jasoria, 2023). The Monthly Mean Global Surface Temperature is present in Figure 1, where we can see a rapid increase in surface temperature compared to pre-industrial era. It is crucial to note that human activities over the past 150 years are responsible for nearly all the GHG increases in our atmosphere (Al‑Ghussain, 2018). This increase in CO_2 emissions is recorded by Mauna Loa Observatory in Hawaii, which has the longest record of direct measurements of CO_2 in the atmosphere as it was started in 1958. This data can be seen in Figure 2, which shows a rapid increase in CO_2 levels over the last 70 years (*Global Monitoring Laboratory*, 2024).

The main solution to confronting the pressing issue of climate change, is navigating our energy consumption away from fossil fuels and towards low-carbon alternatives (Stein, 2019). These low-carbon energy sources, also called renewable energy sources (RES) such as solar, wind, and hydroelectric power, are currently the best bet for achieving sustainable development (Dinica, 2006). Sustainable development is understood as a development that meets the needs of the current generation without compromising the ability of future generations to meet their own needs (Mensah, 2019). In the European Union, there are aggressive targets and goals set for lowering fossil fuel consumption and switching to renewable energy sources. The targets proposed by the Energy Transition Commission include a reduction of 80–85% in coal use, a drop of 55-70% in gas use, and a reduction of 75–95% in oil consumption by 2050 relative to 2022 levels (Mazzanti, 2023). Since around two-thirds of GHG emissions stem from energy production and use, energy sector is at the core of efforts to combat climate change (IRENA, 2017).

GHG emissions are the main driving force behind shifting from fossil fuels with European Union being responsible for emitting 3.6 billion tons of CO_2 per year 2022 (IEA, 2023) and Slovakia alone emitted 35.4 million tons of carbon in 2022 (Karatayev et al., 2023). These are substantial numbers that need to rapidly decrease, also because of the EU climate law that was adopted in 2021, which aims to achieve climate neutrality by 2050 and it is therefore EU's binding obligation (Velten, 2023). Currently, CO_2 emissions are still increasing, and many argue that the EU is not doing enough to combat its GHG emissions. Furthermore, just two months ago (April 2024), a group of female activists from Switzerland known as KlimaSeniorinnen won a case against the Swiss government for violating the human rights of its inhabitants by not doing enough to address climate change at Europe's highest human rights court. Therefore, in order to defend human rights, the Swiss government needs to reduce emissions much more. (Dickie et al., 2024). This further stresses the importance of the climate crisis as well as highlighting the importance of the current energy issue.

This paper explores why the transition to renewable energy sources is not happening faster as it should be, in order for us to prevent the further exacerbation of climate change related catastrophic events. In order to do so, the aim of the research question is to explore the barriers to renewable energy transition that are present in Slovakia, a country in Central Europe. In 1993, the Slovak Republic (SR) was established, country entered the European Union (EU) in May 2004 and the International Energy Agency (IEA) in 2007. It also joined the Organization for Economic Cooperation and Development (OECD) in 2000 (Integrated Slovak Ministry of Economy, 2019). Slovakia was chosen as a country with a large potential for renewable energy sources especially wind and geothermal energy, due to its geographical characteristics and natural resources (Fabrègue, 2024). Even though Slovakia has large potential in RES (see appendix for more information), only 17% of the energy mix is from RES in 2021 and around 20% of electricity produced is from RES in 2022 (Karatayev et al., 2023). In this bachelor thesis the main focus in put on the barriers that are preventing the Renewable Energy Transition, as understanding the barriers is the only way we can move towards eliminating them. While studying the potential of RES in Slovakia as well as barriers preventing the implementation of RES in Slovakia, it was decided that the focus of this thesis is on electricity sector only as focusing on energy production in all sectors, such as transportation or heating would require much larger research. This is considered as the limitation of the study as this limited scope may not provide a comprehensive understanding of the overall energy transition in Slovakia.

This thesis is structured into 7 main sections, with additional schemes and appendix at the end of the paper. The introduction and background are meant to familiarize reader with the background of this research as well as with the relevance on the large-scale level as well on the small-scale level (relevant for Slovakia). Literature review focuses on presenting the barriers to renewable energy transition followed by methodology. The results to the research are presented in the last section which answers the research question. The figures, appendix and references can be found at the bottom of the document. The appendix contains information which is relevant as it provides information on definition of terms used throughout the document and on the potential of RES in Slovakia.

2. Background

2.1.Global actions aimed at reversing the consequences of climate change.

Climate change is one of the biggest challenges of the 21st century (Rocha et al., 2022). The consequences of climate change on society are alarming, and there is little likelihood of completely reversing them. (Nunez, 2023). Climate change solutions entail economic and social costs which will ultimately bring benefits to all areas of life as they aim to prevent a climate crisis to the extent that could mean the destruction of society and life as we know it today (Rocha et al., 2022). Reducing the use of fossil fuels, which are linked to the release of significant amounts of greenhouse gases, is one strategy to slow down climate change and the rise in global temperatures (Beer et al., 2023). Additionally fossil fuels are a limited resource, and their availability and cost are influenced by fluctuations in the market and geopolitical tensions, therefore continuing reliance on them as a source of energy poses an essential risk to the economy's growth (Karatayev et al., 2023).

The formal recognition of climate change as a significant global issue began to emerge in the latter half of the 20th century (Abbass et al., 2022). One of the earliest notable events in this regard was the establishment of the **Intergovernmental Panel on Climate Change (IPCC)** by the United Nations in 1988. The IPCC was tasked with assessing the scientific knowledge on climate change, its impacts, and potential mitigation strategies. The most thorough scientific publications on climate change produced globally, the IPCC's six assessment cycles and six Assessment publications, have been released since 1988 (*History… IPCC*, 2024). In subsequent years, international efforts to address climate change gained momentum. The **United Nations Framework Convention on Climate Change (UNFCCC)** was adopted at the Earth Summit in in Rio de Janeiro in 1992, providing a framework for global cooperation to stabilize greenhouse gas concentrations in the atmosphere (Kuh, 2018). The adoption of the UNFCCC marked the first international treaty aimed at addressing climate change. Members of the United Nations Framework Convention on Climate Change (UNFCCC) gather annually to assess progress and discuss international climate change measures. As of right now, the Convention has 198 Parties, and its most recent meeting took place in November 2023 /will be further described on page 7/ (What is … UNCC, 2024).

In 1997, the **Kyoto Protocol** was negotiated and in 2005 it entered into force as a landmark international agreement under the UNFCCC. As a result of the protocol's heavier burden on developed nations, who bear the primary responsibility for the current high levels of greenhouse gas emissions in the atmosphere due to more than 150 years of industrial activity, it established legally binding emissions reduction targets for these nations (Poulopoulos, 2016). The main key point of the Protocol was the development of market-based mechanisms that were supposed to help the member countries achieve their targets. These were: the international emissions trading allowing countries that exceeded their emission reduction targets to purchase credits from countries that had surplus allowances. This created a commodity out of carbon also known as “carbon market” (Poulopoulos, 2016). Two mechanisms were created, which allowed developed countries with emission reduction targets to invest in emission reduction projects in either developing countries under Clean Development Mechanism, or to invest into other developed countries under Joint Implementation Mechanism. Upon verification of these projects the investing country received Certified Emission Reductions (CERs), which the country can use to meet part of its emission reduction targets (Millock, 2013). However, one weakness of the Kyoto Protocol is that two nations, the United States and China, who are two of the world’s greatest contributors to excessive GHG, did not join the Kyoto Protocol.

Subsequent climate conference was the **Copenhagen Summit** in 2009 which wasn't a legally binding treaty like the Kyoto Protocol, but a political agreement, also known as the Copenhagen Accord. The main goals were raising funds to support developing nations in combating climate change and capping the rise in global temperatures by committing to large emission reductions (*COP15…* European Environment Agency*, 2023*). The Copenhagen Accord set the stage for further discussions and the eventual approval of the Paris Agreement in 2015, even though it did not produce a comprehensive and legally binding agreement. It brought attention to the necessity of greater ambition and collaboration in the fight against climate change on a worldwide scale (Maslin et al., 2023).

Unlike the Copenhagen Accord, which is not legally binding, the **Paris Agreement** is a major step towards limiting global warming to well below 2°C above pre-industrial levels and pursuing efforts to keep the temperature increase to 1.5°C (Key aspects… UNCC, 2024). Furthermore, it represents a universal commitment to combating climate change, as it doesn't apply anymore only to developed countries, but to all countries. It is seen as an important step as it sets an expectation of progressively stronger action over time (Bodansky, 2016).

In addition, the last convention of UNFCCC was held in November 2023 called the **COP28**. What was most important about this conference is that it declares the importance of transitioning away from fossil fuels, as we are not on track to accomplishing zero-net emissions by 2050. Another important point of COP28 was that it was the first time that the global stock take was concluded. The global stock take is a procedure used by nations and interested parties to determine where they are and are not collectively making progress in achieving the objectives of the Paris Climate Change Agreement. According to the analysis, there is a significant difference between the amount of CO_2 equivalent that countries have committed to reducing by now and the amounts needed to keep global warming to 1.5 °C by 2030. These differences range from 20.3 to 23.9 gigatons. One additional important finding is that in order to reach net-zero CO_2 emissions by 2050, global GHG emissions must be reduced by approximately 43% by 2030 and 60% by 2035 from 2019 levels. (Bansard et al., 2023).

2.2. Importance of Energy Transition for Slovakia

Slovakia is underperforming on SDG 7 indicators related to affordable and clean energy, as Figure 3 illustrates. This is because Slovakia's ability to produce renewable energy is less than the EU average of 21.8% (European Commission, 2023). Transitioning to renewable energy is important for Slovakia because as a member of the European Union it has to **comply with the targets of the European Union (**from now on mentioned as EU**)**. The European Commission has acquired a set of proposals to make the EU's climate, energy, transport, and taxation policies fit for reducing net GHG emissions by at least 55% by 2030 (Fit for 55), compared to 1990 levels (*The European…* European Commission, 2021). The European Union wants its economy to emit zero net greenhouse gases by 2050 in order to become climate neutral. Each and every EU member must be actively pursuing this goal in order to accomplish so. The European Green Deal, a set of policy efforts paving the way for the EU to transition to a green economy, is centered around this goal (Widuto, 2023). The transition into renewable energy is important for both the EU as a whole and for individual member states like Slovakia. Slovakia, like other member states, is subject to various directives and targets aimed at promoting renewable energy and reducing greenhouse gas emissions. The renewable energy transition plays a crucial role in aligning Slovakia's energy policies with those of the EU, fostering regional cooperation, and ensuring compliance with European energy standards (Integrated…Slovak Ministry of Economy, 2019).

Another key justification for Slovakia's switch to renewable energy is **economic development**, which should have a number of positive effects including boosting general health and welfare and opening up new avenues for investment, innovation, and green jobs (IRENA and ILO, 2021). Different study by IRENA states that the new job creation in renewables and energy efficiency sectors will generate more jobs than the number of jobs that would be lost from the conventional energy sector (IRENA, 2017). Investing in renewable energy infrastructure, such as wind farms, solar parks, and biomass facilities, can provide jobs in construction, production, installation, and maintenance. Additionally, developing a renewable energy industry can attract investment and promote innovation, contributing to long-term economic competitiveness (Dvořák et al., 2017).

Slovakia's energy transition is also being driven by the need for **energy security or independence**, as the country, like other post-Soviet nations, has been heavily dependent on Russian energy supplies (Team, 2017). Slovakia imports 30% of its gross available energy in the form of coal, 90% of its natural gas, and 100% of its nuclear fuel and oil from Russia, as it is the main supplier of Slovakia's energy resources. In addition, natural gas and nuclear fuel from Russia are important components in the production of energy (Karatayev et al., 2023). Currently Slovakia relies heavily on imported fossil fuels, which can leave it vulnerable to supply disruptions and price fluctuations. By investing in renewable energy sources domestically, Slovakia can enhance its energy security and reduce dependence on foreign energy sources (ÖLZ et al., 2007, p. 10). Furthermore, the European Commission's REpower EU plan, which was introduced in reaction to Russia's invasion of Ukraine, aims to rapidly reduce dependence on Russian fossil fuels (Siddi, 2022), therefore the importance of moving away from fossil fuel imports from Russia is even greater.

Lastly poor **environmental sustainability & public health** concerns are connected to the use of fossil fuels (Bertrand, 2021). For the year 2022, Slovakia has been responsible for 35.4 million tons (Mt) of carbon emissions (IEA, 2023). Slovakia has high levels of air pollution resulting from industry, transport, agriculture, and wood burning. To improve air quality, protect public health, and preserve the environment, stronger industrial rules, better transportation, and cleaner heating systems are urgently needed (European Climate & Infrastructure and Environment Executive Agency, 2023). By reducing reliance on fossil fuels and transitioning to clean, renewable energy sources, Slovakia can improve air quality and general public health (Hulbert, 2022).

3. Literature review

3.1. Framework: Barriers to RET

Even though global actions, aimed at reversing the effects of climate change were present, the results are insufficient. Renewable energy technologies are essential for improving sustainable solutions that drastically reduce GHG emissions. These technologies can help with the energy transition by offering things like energy security, sustainable development, and efficient use of local resources. On the other hand, RES adoption is very difficult (Juszczyk et al., 2022). Barriers to renewable energy transition are contextual in nature. This means that the significance of each barrier varies from one country to another, based on that country's technical potential, socio-economic, geographic, and political conditions, as well as institutional, regulatory and market barriers, for example inconsistent pricing structures (Shahzad et al., 2022). This section describes the main barriers preventing the implementation of RESs and is structured into four sections (legislative/regulatory, financial, socio/cultural, technological).

3.1.1. Political, regulatory, and legislative barriers

Adoption of renewable energy technology may be hindered by a lack of policies and regulations that support its development (Kariuki, 2018). Energy policy is a special sector of policy dealing with energy problems and its target is to guarantee the supply and consumption and distribution of such huge amounts of energy as we currently need (Kanna, 2023). Clear laws and regulations are necessary for the renewable energy industry to exist since renewable energy sources are expensive technologies that require a large number of investors to support them. In many countries, the absence of clear policies regarding private investment and the prolonged permission process for private sector projects further impede the private sector's involvement in renewable energy initiatives (Kariuki, 2018). This is creating issues as prosumers are increasingly important in transition to renewable energy sources, however ineffective and unstable policies may not provide an environment where it would be possible for prosumers to be included in the energy production (for more information about prosumers, see appendix). Furthermore, the deployment of renewable technologies is impeded by lengthy administrative procedures for approval and permits, as well as policy instability with abrupt changes (Ali et al., 2017). Moreover, "getting these permits can last forever" and there are a lot of technical, financial, and environmental requirements to meet (Juszczyk et al., 2022). In one study about transition to RES in Indonesia, lengthy permits are highlighted as one of the major obstacles causing delays in energy projects in Indonesia, as the process of obtaining project approval involves more than fifty permits and is therefore causing delays in project implementation, extending the projected duration by several months or even years (Chelminski, 2015).

Governments place more emphasis on the conventional energy sector than on renewable energy sources because RES are still relatively new in many nations. By providing smaller government subsidies for renewable energy than for conventional energy, they provide only a limited amount of policy reinforcement in the field of renewable energy (De Moor, 2001). This means that the cost competitiveness of renewable technologies and fossil fuels is even bigger, and this keeps renewable energy at a disadvantage. For example, coal companies in Australia and Indonesia still receive government subsidies for mining and exploration (Seetharaman et al., 2019).

In several countries, power utilities maintain a monopoly over electricity production and distribution. Independent power producers are frequently unable to make investments in renewable energy projects or sell electricity to utilities or other third parties through "power purchase agreements" in the absence of an appropriate regulatory framework. Therefore, policymakers' failure to implement steps to attract private investors is holding down many nations' progress toward renewable energy, as large-scale renewable energy projects require substantial amounts of capital to run (Kariuki, 2018). Moreover, RET is hampered by institutional and administrative obstacles, such as the absence of strong and committed institutions, a lack of clear responsibilities, and non-transparent permitting procedures (Ali et al., 2017).

3.1.2. Financial and economic barriers

Financial/economic barriers are another barrier to RET. The adoption of renewable energy technologies is influenced by various factors, including initial capital, transaction costs, economic status, and the availability of incentives and subsidies (Kariuki, 2018). Initial capital investment in renewable energy is typically higher compared to conventional energy sources, leading to higher generation costs (Dinica, 2006). Solar power plants, for instance, have historically been considered costly, but costs have significantly decreased over time. Similarly, onshore wind and small hydro power plants are very costly, although they can already compete with coal-fired plants under favorable local conditions (Ali et al., 2017).

Energy projects often entail steep upfront costs with long payback periods, which can deter producers aiming to minimize initial investment while maximizing profits (Patel & Parkins, 2023). Moreover, the payback periods for renewable energy projects can be longer compared to traditional energy sources, making it challenging for investors to regain their initial investments in a timely manner (Liu et al., 2023). The high cost of investment remains a significant barrier to implementing sustainable renewable energy solutions. Renewable energy sources' competitiveness is greatly impacted by financing costs as, although having lower running costs, they need a larger initial investment than conventional energy sources (Seetharaman et al., 2019).

The market pricing of fossil fuels may not accurately reflect their true costs; hence it is frequently thought to be unfair to compare the costs of renewable and conventional energy sources. This is due to the fact that the expenses associated with producing power do not account for the effects that nuclear and fossil fuel-based technologies have on the environment and human health. The persistence of cost discrepancies with renewable energy sources is attributed in large part to this failure to internalize the external costs of generating power from conventional technologies (Dinica, 2006). Additionally, studies have indicated that wind and solar energy from new plants in EU can be cheaper than coal and nuclear power plants when considering environmental and health risks (Tarek & Bassim, 2020).

To promote renewable energy adoption, many countries and regions offer various forms of support and incentives (Ali et al., 2017). However, renewable energy developers face challenges in securing financing at rates comparable to fossil fuel projects, as investments in fossil fuels still dominate the energy sector. Limited financial instruments and organizations for renewable project financing contribute to perceived risks, discouraging investors. High capital costs, lack of capital, and long payback periods often render projects economically unviable (Mazzucato & Semieniuk, 2018). Thus, addressing these financial barriers is crucial for accelerating the transition to renewable energy and achieving sustainable energy goals (Seetharaman et al., 2019).

3.1.3. Technological barriers

Renewable projects are confronted by technological and infrastructure barriers and challenges. Study by Nasirov et al. finds that for the technological assessment of RES a high level of technical basis is needed, such as qualifications, requirements, specifications, and standards that change from country to country (Tarek & Bassim, 2020). Additionally, since maintenance needs to be carried out regularly, equipment, components and spare parts will require an increase in production costs and since these items need to be imported from other countries, the overall cost will be increased even further (Seetharaman et al., 2019).

Technical challenges hindering the development of renewable energy include both insufficient technology and inadequate infrastructure necessary to support these technologies (Kariuki, 2018). Advanced renewable energy technologies are often limited in availability, particularly in developing nations, impeding their widespread adoption. Even when accessible, the purchasing costs for such technologies tend to be very high (Babayomi et al., 2022). Moreover, renewable energy power plants, typically situated in remote areas, necessitate additional transmission lines for connection to the main grid. Given that most current grid systems are ill-equipped for renewable energy integration, significant strengthening of the transmission network is needed to balance the geographical patterns of renewable energy resources (Strielkowski et al., 2021).

Grid integration emerges as a predominant obstacle hampering the advancement of renewable energy projects (Seetharaman et al., 2019). In order to move past these issues grid infrastructure has to be tailored for the implementation of RES. This can be done through: a. flexibility assessments, which are needed to assess the flexibility needed to balance the variability of RES; b. flexibility needs, which identify specific requirements for flexibility in future grid; and c. least-cost combinations measures in order to determine the most cost-effective combination to meet future grid requirements done through analysis of different scenarios. Successful grid integration measures being implemented in California, Germany, Denmark, South Africa, or Spain can be seen. State of California, for example has effectively combined solar and wind energy with just slight adjustments to the way the grid operates (Martinot, 2016).

The operational and maintenance understanding of renewable energy technology is lacking because of the relatively recent emergence and insufficient development of RES. There might not be as much skilled labor available to install, run, and maintain renewable energy technologies. It's possible that the project creators don't have the necessary business development, financial, or technological expertise (Seetharaman et al., 2019). Additionally, stakeholders may be unaware of the features of renewable energy technology, as well as its financial and economic costs and benefits, geographical resources, operating experience, maintenance requirements, financing options, and installation services. These stakeholders include consumers, managers, engineers, architects, lenders, and planners (Beck et al., 2004).

On top of that, insufficient standards, procedures, and guidelines concerning durability, reliability, and performance hinder the large-scale commercialization of renewable energy (Chisale & Lee, 2023). A prominent technical challenge confronting renewable energy today pertains to be energy storage. Despite the infinite availability of sun and wind, their supply is intermittent, posing a significant obstacle to electricity grid operation, which necessitates the balance between supply and demand. Addressing these issues requires the development of large batteries capable of offsetting periods when renewable resources are unavailable (Seetharaman et al., 2019). However, implementation of these batteries can also pose few challenges such as: high capital requirement, environmental impacts (improper disposal can lead to soil and water contamination), grid overloading (over-reliance can lead to grid overloading), low technological maturity (low stage of development and readiness for practical implementation and widespread adoption). By overcoming challenges related to battery storage it is possible to enhance grid reliability and contribute to a more resilient and sustainable energy infrastructure (Ratshitanga et al., 2024).

3.1.4. Socio/cultural barriers

In general, it can be said that people encounter two types of problems in their environment. Firstly, these are problems that do not deviate from the routine course of social life, or they do not cause large reactions from the public. They are seen but remain unnoticed in the routine of social events. Secondly, we can talk about problems that go beyond the framework of normal routine. The public considers their persistence harmful for themselves and for the entire society. The public is as well experiencing unnecessary suffering and therefore asks the responsible institutions to solve or remove the problem in an appropriate way. Sociologists call these "non-routine" problems social problems. The term social problem can therefore be understood as "a situation in the life of a considerable number of people, which is in conflict with their norms and needs, and which they are willing and able to solve through collective action” (Schneider, 2003).

According to the literature the widespread adoption of renewable energy technologies faces several socio-cultural barriers, hindering their adaptation in various communities. Social acceptance is considered as a major issue in RET and in the research by Wüstenhagen et al. there are identified 3 dimensions of social acceptance. These are socio-political acceptance, which refers to the broadest and most general level of social acceptance, encompassing societal acceptance of policies and technologies; Community acceptance dimension focuses on the specific acceptance of siting decisions and renewable energy projects by local stakeholders, such as residents and local authorities; Market acceptance highlights the importance of market acceptance in the overall social acceptance of renewable energy technologies (Wüstenhagen et al., 2007).

Socio-political acceptance includes obstacles such as households' reluctance to embrace renewable energy due to concerns about its reliability and a lack of knowledge and awareness about renewable energy technologies and systems, particularly among rural populations (Kariuki, 2018). Public understanding is hindered by inadequate information about ecological and financial advantages, limited awareness of renewable energy technologies, and uncertainties surrounding the financial feasibility of installation projects (Seetharaman et al., 2019).

Community acceptance issues include a phenomenon called 'Not in my backyard' (NIMBY) syndrome, which further complicates the situation, as individuals may support renewable energy in principle but oppose its implementation in their neighborhoods. NIMBY effect is a result of a complex web of interrelated elements, such as technology choice, community response or negative externalities, that affect how the public views and responds to the installation of urban infrastructure, such as waste management systems (De Souza et al., 2023). Furthermore, plans for renewable energy projects are frequently opposed by a range of stakeholders, including the general public, elected officials, community organizations, and environmental groups. These parties raise issues with the projects' potential effects on the landscape, environmental degradation, and the lack of community consultation (Seetharaman et al., 2019).

When compared to conventional coal-fired power plants, the installation of renewable energy plants, such as wind and solar farms, presents a substantial difficulty because of their large land requirements. This change in land usage can negatively affect agriculture, tourism, and other alternative sources of income, as well as cause disputes over how best to use the property. Therefore, it is important to consider market acceptance issues and potential conflicts that could arise from the land-use changes associated with renewable energy development (Cogato et al., 2023). In addition, the design, construction, operation, and maintenance of renewable energy plants require a competent labor force, which is a prerequisite for the shift to renewable energy (IRENA and ILO, 2021). The lack of qualified experts in this sector, however, represents a major obstacle to the widespread use of renewable energy sources. Comprehensive awareness campaigns, stakeholder participation, and strategic planning are necessary to address these socio-cultural obstacles to reduce conflict and advance the sustainable integration of renewable energy into communities (Seetharaman et al., 2019).

4. Methodology

For this research the Qualitative Content Analysis (QlCA) was used. This is a research methodology or a procedure of systematic analysis and interpretation of contents of texts (words, phrases, statements, communications, documents, etc.), images (photos, video, etc.) or any other reality that doesn't include quantification or numbers (Mayring, 2000). There are three distinct approaches that can be used while working with QICA. These are conventional content analysis, directed and summative content analysis (Hsieh & Shannon, 2005). For the purposes of this study the directed content analysis was used, as this method makes it possible for the researcher to use existing theory or theoretical framework to develop the initial coding scheme prior to beginning to analyze the data (Hsieh & Shannon, 2005). The goal of directed approach to content analysis is to validate or extend conceptually a theoretical framework or theory. For this research the literature review mentioned in the previous section is used as a theoretical framework.

Firstly, the research question was identified, which states as follows: What are the main barriers of Renewable Energy Transition in Slovakia. Sample of 50 Documents was selected for the analysis. These documents were chosen by searching through official government websites, google scholar, news websites, university library using keywords such as "renewable energy transition in Slovakia, barriers to energy transition in Slovakia, legislative barriers of RET in Slovakia, financial barriers of RET in Slovakia. These documents were next divided into 4 groups based on where they were obtained from. Among these 4 groups are government documents, academic studies, reports from organizations, and media/news articles. Some of these documents consist of the Recovery and Resilience plan (RRF) of Slovakia, which is a temporary instrument that is the centerpiece of Next Generation EU - the EU's plan to emerge stronger and more resilient from the current crisis (*Plán Obnovy*, 2021). Another important document that was used for the analysis is the Integrated National Energy and Climate Plan for 2021 to 2030 by Slovak Ministry of Economy, which is a strategic document defining the energy sector's primary objectives and priorities to 2035 with an outlook to 2050 (Integrated…Slovak Ministry of Economy, 2019). Next, industry reports from organizations dealing with the issue of renewable energy implementation such as The Slovak Association of Photovoltaic Industry and Renewable Energy (SAPI), which is a professional interest association whose main mission is to support the development of sustainable renewable energy in Slovakia were used.

Academic studies and research papers were used as well, together with media reports and news articles from websites such as Euractiv (https://www.euractiv.com). Euractiv was selected because it is the only medium in Slovakia which is systematically involved in this topic as it analyzes and connects Slovak energy policies with the foreign ones. For the purpose of proper analysis all the relevant articles from year 2021 until recently were selected from Euractiv. These were found by typing "renewable energy in Slovakia" on the Euractiv website and all the relevant documents were selected.

Since directed content analysis was used the categories of the codes are applied before starting the coding process. They were created by developing a study's framework based on the literature review done in advance to this step. Literature review was done by using desk research and analyzing secondary data about barriers to renewable energy transition from existing literature. The main categories that were found are: legislative/regulatory barrier, financial barrier, socio-cultural barrier, technical barrier. Some documents mentioned different barriers as environmental or market barriers, however these barriers were not included, as they were mentioned only in a few articles and only the barriers that were included in all the documents were used to create the theoretical framework.

These documents were uploaded into the qualitative data analysis software ATLAS.TI, and each document was carefully analyzed, and the text was reduced into categories, also called codes.

Content analysis relies heavily on the coding process to identify patterns or themes that are either directly conveyed in the text or are inferred from it (Hsieh & Shannon, 2005). This is why in order to ensure that correct codes were selected from the documents, most of the times the coding was done when the text directly pointed out the barrier by stating words like “barrier”, “challenge”, “obstacle”. There were sometimes when these words were not present, however out of the context it was understandable that this section directly points out to one of these barriers. As an example, a short section of one code is provided: “There are some significant negative beliefs, attitude and perceptions to renewable energy”.

Furthermore, if the same barrier was mentioned multiple times throughout the text, it was counted only as one code and not multiple. Once all the articles were analyzed and codes were created, the group codes were made. These were made for organization purposes as it was easier to see how many codes each barrier has. The number of citations created for each code was put into the brackets after the name of each code (which can be seen further in the visualizations, in the analysis section). In the final step the visualizations were made, using a Network function in the coding software. All the relevant codes were selected and connected to each other. Once this step was completed the visualizations were downloaded and inserted into the document.

5. Analysis - Barriers to renewable energy transition in Slovakia

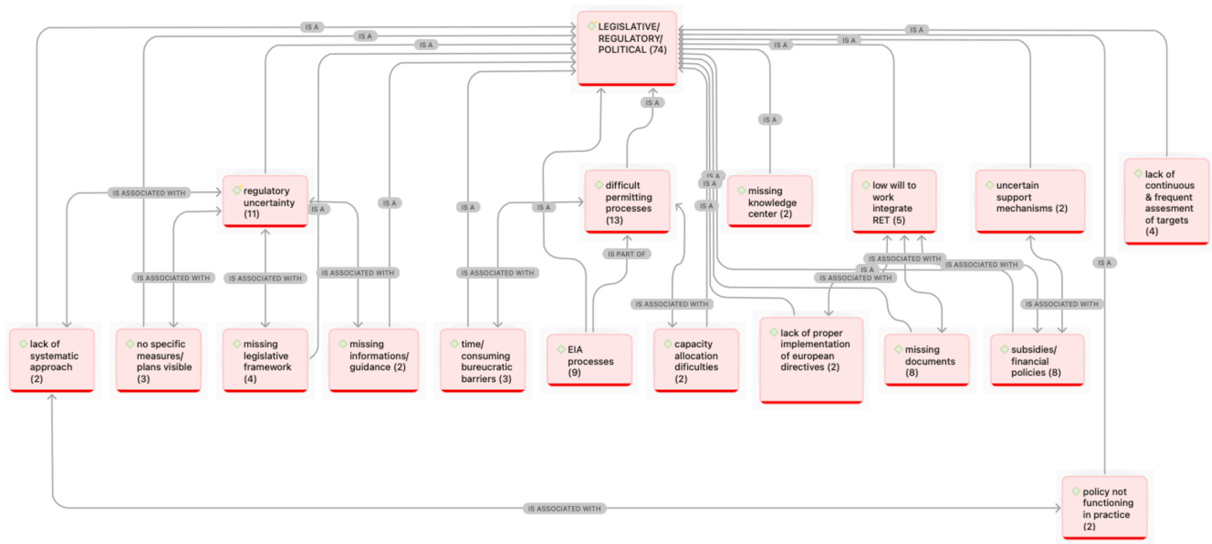
Legislative/regulatory barriers were mentioned in the documents 74 times as this is the number of citations regarded to this barrier. **Regulatory uncertainty** was mentioned as a barrier in 11 documents. For the purpose of facilitating the rapid expansion of renewable initiatives and efficiently incorporating renewable energy into the country's energy grid, the current legislative framework is still insufficient. The legal environment consists of a range of national and local legislation that include both broad and specific standards. However, these regulations often lack specificity, and it lacks concrete measures for execution. This poses a problem as regulatory stability and predictability are central for businesses to plan their energy supply, as otherwise, they cannot develop their long-term strategies.

Obtaining permits and licenses for renewable energy projects is a **time-consuming and bureaucratic process**, which discourages investors and developers from pursuing projects. It was mentioned to be a non-transparent and lengthy process as it takes on average for an investor 10 years from the moment when the investor comes with an offer to its implementation. It is among the longest in Europe. Furthermore, frequent changes in legislation undermine consumer confidence.

Difficult permitting process were identified in 13 documents. Permitting processes were found to be difficult, time-consuming, not flexible and in some cases even outdated. It is estimated that around 80 GW of capacity is currently bogged down in permitting procedures, several of which have been stalled for years. Outdated methodology is an issue as some documents are outdated and therefore the information in them is not relevant. Such an example can be seen in wind turbines, as the document about the distance of wind turbines from built-up residences was written 20 years ago. Another example is an absent methodology for defining suitable areas for developing RES.

Furthermore, permitting processes for smaller RES take longer than for larger RES. This is presenting a problem also for prosumers or businesses that want to make their own electricity from small scale installations. Repower Recovery Plan identified several barriers connected to slow permitting processes: these were overloaded offices, regulations not reflecting current challenges and problems arising from lack of coordination and redundant procedures. In Slovakia, the process of acquiring licenses and permits for renewable energy projects typically takes two to four years and entails a number of processes and legal requirements, such as environmental impact assessments.

Scheme 1: Legislative and regulatory barriers.



Source: Author´s work with Atlas.ti.

The implementation of a project using geothermal, solar or wind energy requires different permits, and different institutions are involved. Individual proceedings differ in their sequence and difficulty. Photovoltaics do not affect the environment like geothermal wells or hydropower plants. With them, you need several permits, several steps, and therefore the permit process is much longer and more demanding. Additionally, permitting of new hydropower projects is subject to "strict scrutiny" from the Ministry of Environment and environmental NGOs, as in the past there were several projects which were not constructed in accordance with key EU directives on the protection of biotopes and environment. Lastly, as a quote from an interview for Euractiv (Jenčová I., 2023) suggests: "Permitting processes are neither flexible nor fast enough, so at present we are far from thinking that renewable sources will fully replace the used fossil or nuclear energy sources.". Therefore, it is necessary to simplify administration in permitting processes.

The **environmental impact assessment (EIA)** is one of the permitting procedures and it evaluates the potential environmental and social impacts of the project and involves public participation to address concerns and ensure sustainability. It was mentioned as a barrier in 9 documents. SAPI states that EIA is the barrier of utmost importance, referring to its non-existing limits (as of 0 kW) and unpredictability of such process. Furthermore, one study mentioned that 79% of respondents rated EIA process as the most problematic part in the barriers to RET.

EIA process is critiqued as the assessment is mandatory to every project without exception to small installations. One example that was mentioned was about wind installations, as every wind installation in the Slovak Republic, including small installations up to 10 kW of installed capacity, or micro or hobby projects, are a subject to the full EIA process. This is a strict process, and it was further mentioned that an investor in any neighboring EU member state will not encounter such a strictly legally defined requirement. Another example was about geothermal wells, as according to the current laws in Slovakia, every single geothermal well is required to be assessed as part of a mandatory assessment, despite the fact that the parameters of the wells are not exactly known before the actual implementation and hydrodynamic test. This process prolongs the implementation of the well by about a year, which is a significant factor that discourages potential investors. This ultimately has an impact on a number of existing and other potential projects. Re-evaluating this process and including geothermal wells in the investigation procedure can significantly help the development of more RES in Slovakia.

Missing documents were mentioned as another barrier in 8 documents. Various documents were found to be missing in the analysis of the texts, these are: lack of information about the possibilities of using existing geothermal resources, missing documents and data on available sustainable sources of biomass for energy purposes, lack of documents about the use of hydrogen, missing land-use planning information as well as missing up-to-date strategic document containing a technical analysis of the potential with identified locations suitable for wind power plants.

Apart from missing documents, there is a **lack in more detailed long-term plans** (found in 2 documents). Many times, there are measures mentioned in the energy policy however the plans to integrate them are missing. One example is the implementation of smart grids, which are mentioned strictly descriptively in the energy policy with a vague task to develop them, therefore no specific measures or plans are visible.

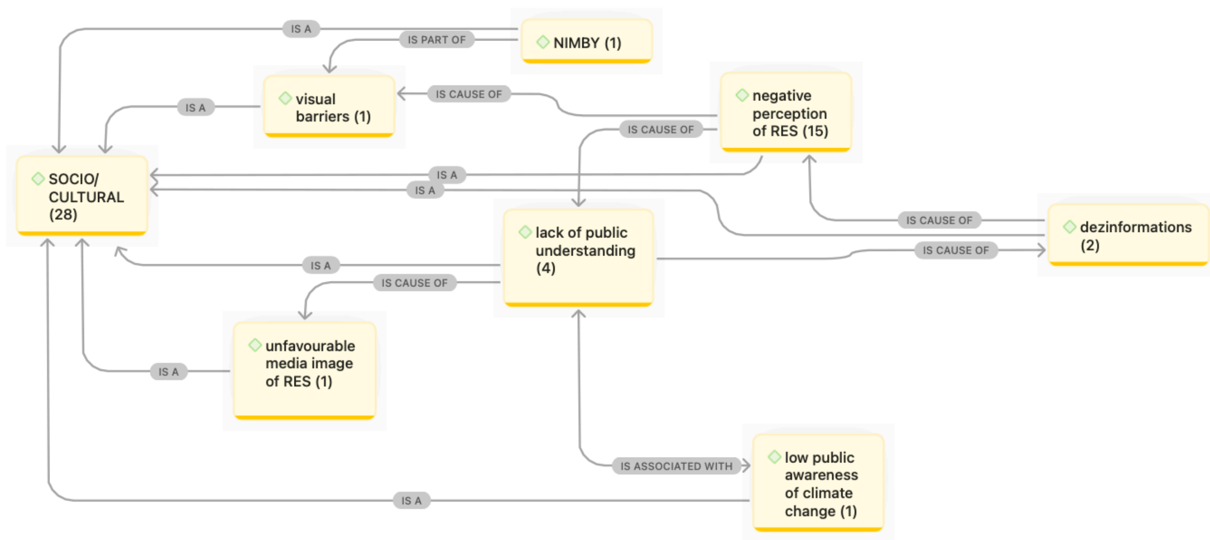
There is a **lack of strategy as well as lack of continuous targets tracking** concerning with renewable electricity targets. The insufficiency of comprehensive explanations within the law and its supplementary regulations necessitates monitoring and timely adjustments. Regular monitoring by the government, lawmakers, and the general public can be facilitated by putting in place follow-up and evaluation procedures. Furthermore, in the Integrated National Energy and Climate Plan for the years 2021-2030, target shares of RES were set, however are not realistically achieved. Therefore, documents strongly recommended following the already adopted strategies and continuously monitoring their progress as well as a **consistent implementation of European directives** is needed to overcome this barrier.

Currently, there is **no functioning knowledge center** in Slovakia, where state administration bodies, entrepreneurs, and non-governmental organizations in the field of the environment can obtain information about the best available techniques (BAT), which would also contribute to the support of the development and application of BAT and other innovations. One document also suggested the need for better education regarding RES, which could help overcome barriers to their further development.

Another concern mentioned in the documents was that consumers who are interested in RES should have a network of contact points available to help them with all administrative procedures, guide them in finding an accredited installer, that can explain what subsidies are available and direct them to the most suitable financing options.

This means in order to implement RES projects with the production of green electricity, state support is essential. However, this is not the case in Slovakia as systematic measures to reduce subsidies and the consumption of fossil fuels need to be put in place. This can be done through increasing energy efficiency and the use of RES that meet sustainability criteria. It is necessary that Slovakia **stops subsidizing non-ecological resources**, in order for RES to become more affordable and therefore implemented more.

Scheme 2: Socio-cultural barriers.



Source: Author´s work with Atlas.ti.

Transitioning to renewable energy sources in Slovakia encounters **societal barriers** that hinder progress toward a sustainable energy future. There were 28 citations produced about societal/cultural barriers. These obstacles include the public's lack of awareness about the implications of climate change, disinformation, and negative attitudes towards renewable energy sources, as well as an ingrained reluctance to change societal norms. **Negative perception of RES** was found to be the biggest socio-cultural barrier, as it was coded in 15 documents.

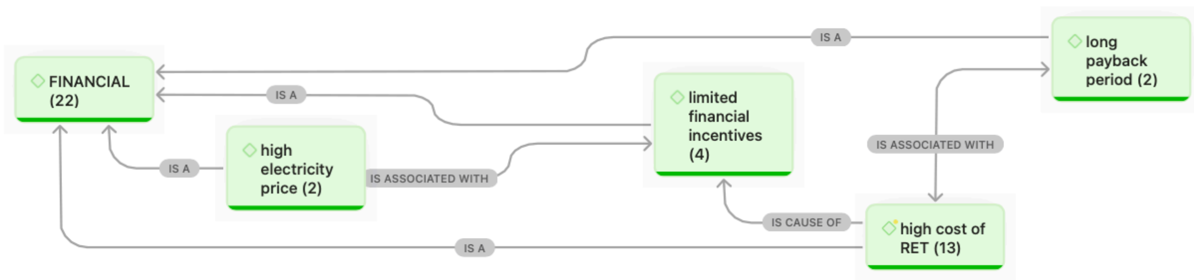
According to the findings of a June 2021 study named "Support for RES in Slovakia" by the Slovak Climate Initiative, 68% of participants are in favor of increased use of RES, with 24% strongly in favor and 45% leaning toward support. On the other hand, 23% are inclined to oppose expanded use of RES, while 8% are strongly against it. This indicates that there may be obstacles preventing broader support for RES, as indicated by the relatively narrow difference between the percentage of people who are strongly in favor (24%) and those who are leaning toward opposition (23%).

One of the reasons for negative attitudes towards RES are due to concerns about visual aesthetics, noise, or other perceived drawbacks. These are present even in communities that might theoretically support the shift to clean energy (NIMBY syndrome). Study by Beer et al. (2023) explored negative beliefs, attitudes, and perceptions towards renewable energy in Slovakia. In this study, the attitudes of tourists visiting tourist sites in Slovakia were researched. They were asked whether it would be disturbing for them to have renewable infrastructure built on 6 potential areas. One of the potential areas for development is the High Tatras region, which according to the questionnaire results showed a significantly negative impact on the future visit of the site. The development of renewable infrastructure was unacceptable for 44.3% of the respondents. Another area was in the proximity of Spiš Castle (the largest castle in Central Europe), which received 30% of rather negative attitudes towards fictitious renewable infrastructure. However, from the results of the study it was concluded that agricultural or industrial locations received more positive response towards possible renewable infrastructures in the region.

Another societal barrier are the **misconceptions and misinformation** about RES that are present in the society. A often held misperception is that the main beneficiaries of renewable energy facilities are their owners, with the community as a whole receiving little or no benefit. The **unfavorable media image of RES** is also hindering implementation of RES. On top of that the cost of renewable energy have been decreasing over time, however some local communities still view renewable projects as expensive compared to fossil fuel-based options. This creates an issue as they may not fully consider the long-term benefits and potential savings associated with renewable energy investments.

Generally Central European countries have relatively **low levels of climate ambition** in comparison to other EU countries. First of all, the awareness of climate change is relatively large, however air quality issue receives more attention due to widespread and immediate health concerns. Secondly, public awareness about the score and implications of climate change is relatively low. This is a visible issue as the main objective of the updated National Adaptation Strategy was to improve Slovakia's readiness to face the adverse effects of climate change, as well as raising overall awareness of this issue. Additionally increasing climate ambition and overall awareness of climate change in Slovakia would have visible benefits as addressing climate change will have positive effects on air pollution as well.

Scheme 3: Financial barriers.



Source: Author´s work with Atlas.ti.

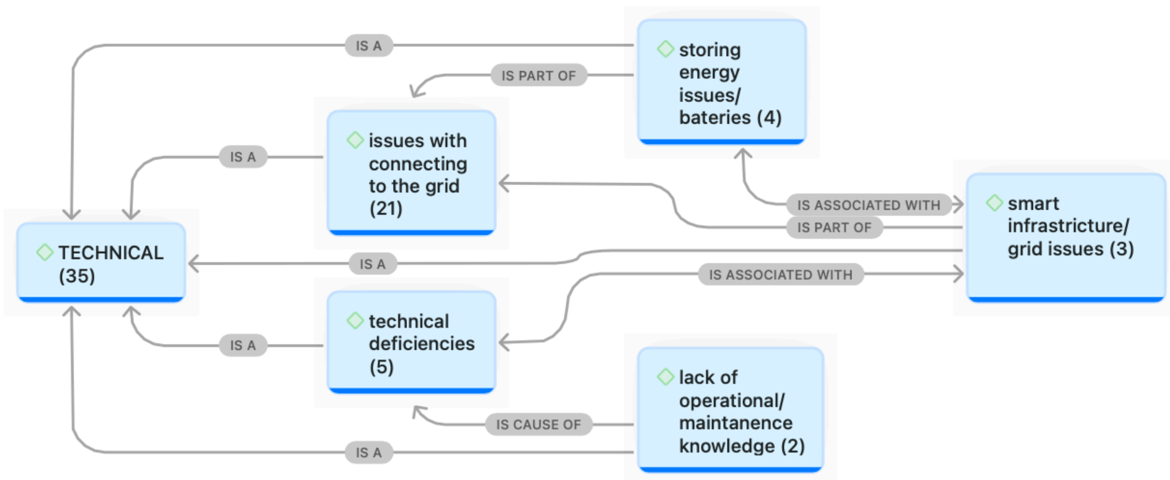
There were 22 citations made about **financial barriers.** In this section limited financial incentives, high investment costs, long payback period as well as high renewable electricity price were identified to be the main barriers.

As it was previously mentioned in the legislative/regulatory barriers there are **low financial incentives** present, such as subsidies or tariffs that would support renewable energy sources. This results in **high electricity from renewable sources**, because of fossil fuels externalities. This is because electricity from coal or natural gas is given bigger remissions and therefore electricity from renewable sources ends up being more expensive. Furthermore, there were **high connection fees** identified, as it is necessary to pay around 20% of the investment costs only for the connection fees, which is making the whole investment much more costly.

High cost of RES is an enormous barrier. It was estimates that the low-carbon transformation will bring new additional costs which were measured at 1.8 - 4.2% of the GDP per year. RES are very costly infrastructures, and an example can be geothermal energy which has very high upfront cost both for the exploratory digs as well for the actual geothermal pump. The exploratory digs need to be dogged into the depth of up to 4000 m and to dig one meter it costs around 1200€. Furthermore, shipping costs are also increasing the overall costs, which was exacerbated by the need for extra components, or some other parts of the RES structures (such as wind turbines).

Additionally, a **long payback period** was identified to be another barrier as depending on the source, but it can take on average 8-10 years for the investment to start being profitable as the first couple of year the loan was being repaid.

Scheme 4: Technological barriers.



Source: Author´s work with Atlas.ti.

There are 35 citations produced about technical barriers. **Difficulty with integrating RES into the current grid infrastructure** was found to be an issue in 21 documents. With the growing share of electricity production from irregular sources, such as the sun and wind, significant technical deficiencies appear in the transmission network. This means that today's network is not ready for this method of electricity production as an ageing infrastructure of electricity networks is likely to struggle to adapt to intermittent power plants (such as wind and solar energy sources). This older infrastructure presents difficulties in power transmission, including energy losses, higher costs, limited inter-connectivity with other grids and limited power storage capacity. Some other shortcomings of the current grid infrastructure are for example connected to the concept of inertia, which is the ability of rotating machines to keep providing kinetic energy to the system. The reduction of inertia has a negative effect on the stability of the system. Other problems present are for example issues with maintaining minimum voltage, or system overload. This is posing a huge issue for prosumers, mostly businesses or firms that want to generate their own electricity but cannot do so, because there are issues with connecting their new sources into the existing grid. Furthermore, distribution companies claimed that the existing infrastructure could not handle the high number of prosumers, which could lead to its collapse. This means that major network infrastructure investment will be required in the upcoming years to eliminate the bottlenecks from integrating new power plants, particularly ones that generate energy from renewable energy sources, and to integrate new approaches such as smart or micro-grids. Smart grids are the main solution to these issues as it allows flexible system management and active participation of consumers (prosumers).

Another issue can be both Technical and Regulatory barrier and it is concerned with the grid infrastructure and with connecting new resources to the network. In Slovakia, there is a low limit set for connecting new devices into the grid, an example is the limit for new photovoltaic and wind power plants, which was set at the level of 407 MW. Today, this volume is practically all used up, while the developers do not have information about which projects have reserved this capacity and for how long. There is no application queue either. At the same time, the reservation of capacity does not mean that the projects will be implemented. The resulting situation puts developers in an unpleasant situation where they do not know what projects they are competing with, nor when, where and how much of the capacity will be available again. This is a huge problem that prevents effective technical planning and investment preparation.

Currently, **electricity storage** remains complicated and not very developed, presenting significant financial barriers to Slovakia's renewable energy transition. It was coded as a barrier 4 times. However, in the future, efficient and reliable energy storage will be crucial for a sustainable network. As the Euractiv portal recently reported, the Ministry of Economy aims to support investments in electricity storage through the recovery plan, considering technologies such as battery storage, hydrogen, and pumping stations. These storage solutions are also incorporated into the Integrated National Energy and Climate Plan (NECP).

To address technical deficiencies, it will be necessary to find a suitable combination of various technologies and measures. One promising approach is the integration of multiple types of decentralized resources into a so-called virtual power plant. This method involves combining regular and irregular energy sources, supplemented by battery storage or other forms of energy storage. A well-configured virtual power plant can provide system services from numerous small domestic sources, contributing to a more stable network.

With the growing share of electricity production from irregular sources, such as the sun and wind, significant **technical deficiencies** are emerging in Slovakia's transmission network. Today's network is not equipped to handle this method of electricity production, and as the proportion of electricity from these sources increases, so do the problems. In Europe, there are three main electricity grids - Northern European, Continental, and Irish - and the status of these networks varies. Although the problems arising from irregular sources are similar, each network deals with them differently. To mitigate these technical deficiencies, it will be necessary to find a suitable combination of several technologies and measures.

Slovakia, like other European countries, suffers from a lack of qualified renewable energy installers with adequate training and accreditation. These professionals are crucial for energy modernization and the installation of equipment such as heat pumps. Article 18 of the Renewable Energy Directive requires member countries, including Slovakia, to self-assess, locate, and increase the number of photovoltaic panel and heat pump installers needed to meet national targets for renewable energy development.

In addition to the shortage of renewable energy installers, there is also a significant lack of qualified technical experts in the labor market and services sector, particularly those with knowledge and skills in the field of renewable energy sources (RES). This includes energy produced using heat pumps, biomass, solar energy, and geothermal energy, as well as intelligent technologies and energy services. Furthermore, many businesses have noted a significant lack of knowledge and experience sharing between companies, which hampers the exchange of good practices and know-how essential for advancing the renewable energy sector.

6. Discussion

The aim of this thesis was to analyze the barriers preventing the Renewable Energy Transition in Slovakia, with four primary barriers identified based on the theoretical framework. Analysis of this study revealed the specific barriers impeding Slovakia's transition. The results indicate that the most significant barriers are legislative and regulatory, as they accounted for the largest number of identified obstacles. Conversely, financial barriers were the least cited, suggesting they are the smallest obstacle to the renewable energy transition in Slovakia. The literature review supports this finding, noting that under favorable local conditions, renewable power plants can compete with coal-fired plants despite their perceived higher costs. This indicates that mitigating financial barriers requires creating a stable environment, achievable through addressing legislative/regulatory, socio-cultural, and technological barriers. The theoretical framework for the barriers was created prior to conducting the analysis of the documents, therefore similarities and differences in the information obtained in the framework and in the codes that were created during the analysis of the barriers of RET in Slovakia are discussed in this section.

The results for legislative/regulatory barriers generated a big number of codes, altogether 19. Out of these 19 codes all of them were similar/connected to the once mentioned in the framework. **Lengthy administrative procedures for approval and permit** were mentioned as a barrier in both the framework and in the results for barriers in Slovakia. In the results section the codes that were corresponding with this barrier are: difficult permitting processes, EIA processes, time consuming/bureaucratic barriers. This made the biggest barrier in both parts; therefore, this can be generalized as one of the biggest legislative/regulatory barriers for renewable energy integration overall. Another barrier that was found in both sections was **lack of clear policies & legal procedures**. The codes that are connected to this barrier are: capacity allocation difficulties, lack of systematic approach, missing documents, missing legislative framework, policy not functioning in practice, uncertain support mechanisms and lack of continuous & frequent assessment of targets. Another barrier in the framework is **limited policy reinforcement** in the renewable energy sector. This was found to be true also in the case of Slovakia, as one of the barriers that was created was named unfavoring subsidies. On the other hand, there was one barrier that was mentioned in the analysis, however not in the framework.

This was a missing knowledge center. There can be multiple reasons for this: either there are more legislative/regulatory barriers preventing the transition to RES in Slovakia than on average in other countries or another reason can be that there were more documents analyzed for the barriers in Slovakia, then for the creation of the framework and therefore we could have expected that more barriers would have been found during the analysis of the documents.

There were 8 codes created for the socio/cultural barriers. The biggest barrier in this section was found to be the **negative perception of renewable energy plants**. This can be connected to the public resistance & opposition that was mentioned as a barrier in the framework. Unfavorable media image of RES and visual barriers are also part of this section. Furthermore, **lack of public understanding** (mentioned in the framework) is connected to 3 codes which are: disinformation, lack of public understanding and low public awareness. Lastly **NIMBY** syndrome was mentioned as a barrier both in the framework as well as in the results section, however this was mentioned only in one document therefore it doesn't represent a very big issue.

As for the technological barrier 6 different codes were created. The biggest barriers in the theoretical framework were inadequate technology and infrastructure issues. **Infrastructure issues** were found to be an issue in 21 documents, under the name "issues with connecting to the grid". "Smart infrastructure" and "issues with storing energy" are both part of this category adding 7 more citations. Inadequate technology was an issue that is connected to two codes which are technological deficiencies and lack of operational/maintenance knowledge.

The last barrier is financial barrier, for which only 5 codes were made and altogether the barrier was found in 22 documents. The framework mentioned high initial cost, which was found to be true also in the documents as "high cost of RET" is another code that was found in 9 documents. "Long payback period" is a name of the code which corresponds to the need for long-term financing which was found as a barrier in the framework. "Limited financial incentives" is a code that can be seen both as a financial as well as legislative/regulatory barrier, however since more information was about the financial aspects the code was added to the financial barrier.

This research project includes various limitations. One main limitation of the research is the sample of the documents. It is visible that there is an unequal number of codes and citations made for each barrier. This number is significant as there were 19 codes made for legislative/regulatory barriers, however only 5 for financial barriers. This can be explained as there are overall more legislative/regulatory barriers than financial barriers, since financial barriers are mostly about the initial cost, however the legislative/regulatory barriers have to cover many different aspects of the energy policy, regulations, spheres. For more holistic research it would be necessary to include more financial documents as well as document from social sciences so that the number of barriers will be more equal. Additionally, when reflecting on the results of the study, socio/cultural barriers weren't as frequent as it was anticipated. What was surprising was that there were only two citations for code with title "disinformation". This is surprising because from the research by Globsec[1], Slovakia scores as the country with the highest degree of belief in conspiracy theories and misinformation narratives out of the countries in Central and Eastern Europe (see in Figure 4) (Roosevelt & Wiśniewski, 2020). This can be a result of the nature of the documents which were more technical, therefore societal topics weren't included as often. Another reason may be that even though societal issues as disinformation are very present in the society, they are not seen as critical, even though they should be. Furthermore, for the future research more documents from social sciences need to be used in order to investigate societal/cultural issues in depth.

Nevertheless, this research is useful as it highlights the most prominent issues that Slovakia is facing in transitioning to renewable energy. It can be useful for policy makers and other stakeholders for several reasons. Firstly, it provides an initial understanding of barriers that can help policymakers to make informed decisions about where to allocate resources and which policies to implement. Secondly, in order to create focused improvement initiatives, policymakers must have a thorough understanding of the range of obstacles which they can use as evidence. By identifying and addressing these issues, policy decisions can better incorporate research, which will ultimately result in more informed and efficient governance (Oliver et al., 2014). Additionally, by identifying these barriers it provides a helpful information on where to next allocate investments. Since this research does not delve too deep into the analysis of each barrier, as it touches only on the main problems, it provides a good starting point for other researchers to focus on expanding on these barriers and therefore move closer towards solving the issue that this thesis is concerned with.

[1] Globsec is a leading think-tank in Slovakia (www.globsec.org).

7. Conclusion

This thesis provides an in-depth exploration of the barriers to renewable energy transition in Slovakia, highlighting the complex interplay of legislative, socio-cultural, financial, and technological challenges. Prior to conducting the analysis, it was hypothesized that certain barriers were more significant than others. Based on this research question the study was conducted and the analysis reveals that the most pressing barriers are legislative/regulatory, with regulatory uncertainty and complex permitting processes being the primary obstacles. These issues are compounded by the lack of clear, consistent policies and inadequate policy reinforcement, which undermine the stability and predictability needed for long-term planning and investment in renewable energy projects.

Socio/cultural barriers also play a significant role in hindering this transition. Negative public perceptions and widespread misinformation about renewable energy technologies contribute to resistance against their adoption. Additionally, a general lack of public understanding and awareness about the benefits and feasibility of renewable energy exacerbates these socio/cultural challenges. Financial barriers, although less frequently cited compared to legislative barriers, remain significant. High initial investment costs, long payback periods, and limited financial incentives deter investors and developers from pursuing renewable energy projects. These financial hurdles are often linked to the broader issue of policy instability and inadequate support mechanisms for renewable energy development.

Technological challenges primarily involve integrating renewable energy into the existing grid infrastructure. The current grid system is often ill-equipped to handle the intermittent nature of renewable energy sources like wind and solar power. Additionally, there is a notable shortage of skilled professionals capable of installing, maintaining, and optimizing renewable energy technologies, which further hampers progress.

To overcome these barriers, a multi-faceted approach is necessary. Policymakers must prioritize creating a stable and supportive regulatory environment, provide permitting processes, and ensure clear and consistent policies are in place. Public awareness campaigns and educational initiatives can help shift negative perceptions and increase understanding of renewable energy benefits. Financial incentives and support mechanisms should be enhanced to reduce the economic burden on investors and developers. Furthermore, significant investments in upgrading grid infrastructure and training skilled professionals are crucial for addressing technological challenges.

This research underscores the importance of collaborative efforts between government, industry, and civil society to tackle the barriers to renewable energy transition in Slovakia. By addressing these challenges through targeted policy interventions, strategic investments, and increased public engagement, Slovakia can accelerate its shift towards a sustainable and resilient energy future. Future research should delve into detailed analyses of each barrier and explore innovative solutions to make it easier for renewable energy technology to be adopted. Additionally, future studies should prioritize an in-depth examination of legislative and regulatory barriers, as these represent the most significant obstacles. This focused approach will ensure that Slovakia not only meets its climate goals but also reaps the economic and social benefits of a cleaner, greener energy landscape.

Scheme 5: Main barriers mentioned in the conclusion - result transcribed into the scheme.

Source: Author´s work with Atlas.ti.

8. Appendix

8.1. Definition of terms

8.1.1. Renewable Energy Sources.

The UN defined renewable energy as energy acquired from natural sources that are replenished at a higher rate than they are consumed. Renewable energy sources have multiple benefits. These include lower energy costs and lower environmental pollution, as well as lesser reliance on fossil fuel energy production, as well as a more efficient way of energy production and supply (Rahaman et al., 2023).

8.1.2. Solar energy.

Solar energy is the most abundant of all energy resources and it is the only energy source that we can completely rely on. An hour and half's worth of solar energy that reaches to the surface of the planet has enough power to meet all of humanity's energy consumption for an entire year (Lai, 2024). Solar power is generated in 2 main ways: by solar photovoltaic (PV) or concentrated solar power (CSP). Solar photovoltaic (PV) is using electronic devices, also called solar cells, to convert sunlight directly into electricity. Solar PV can be found in different sizes. It can range from small solar home kits and rooftop installations of 3-20kW capacity, up to systems with capacity of hundreds of megawatts.

Solar energy is one of the fastest-growing renewable energy technologies and its prices fell by up to 93% between 2010 and 2020. During the same period, the global weighted-average levelized cost of electricity (LCOE) for utility-scale solar PV projects fell by 85% (*Solar Energy*, 2023). It is possible to differentiate between 3 types of PV systems (Hyder, 2024):

- **On-grid/ grid tied system** is a solar PV system which connects directly to the National Electricity Grid.

- **Off-grid system** is an off-grid system that has zero ties to the national grid.

- **Hybrid solar system** combine the technologies of solar panels and solar batteries to provide a backup energy source and a green energy solution. Any solar energy produced by a hybrid PV system is first stored in a home battery solution before being sent to the grid, even if it is still connected to the national grid.

Another method for producing solar power is concentrated solar power, or CSP. In CSP, solar radiation is concentrated using mirrors. The heated fluid produces steam, which powers a turbine to produce energy. Large-scale power stations employ CSP to create electricity. A CSP power station has several advantages over a solar PV power plant, one of which is its ability to store heat in molten salts, which enables the generation of energy even after the sun sets. The cost of thermal energy storage has decreased as the market has developed, making 12-hour storage periods viable. As a result, CSP systems now have longer storage durations. Even though it is sometimes underestimated, CSP with inexpensive thermal energy storage has the potential to incorporate larger shares of variable solar and wind electricity, suggesting that it may play an increasingly significant role in the future (Solar Energy, 2023).

8.1.3. Geothermal energy.

The energy that is present in the Earth's interior as heat is known as geothermal energy. The Earth's core, which is more than 4000°C in temperature, is where this energy source ultimately originates (Geotermálna… Ministry of Environment, 2023). Heat from the core is constantly radiating outward and warming rocks, water, gas, and other geological material (Turgeon & Morse, 2024). By every 100 meters down the earth crust the temperature is rising by approximately 3°C (Brian, 2024).

Geothermal Energy can be obtained in two main ways:

Geothermal waters: these are natural underground waters that are heated by the earth’s heat to such an extent that when they reach the earth’s surface the temperature is much higher than the average annual temperature of the given area (Lacko, 2010).

The temperature of water varies:

a) at smaller depths up to 1000 meters the temperature is between 30-40°C

b) from 2000 meters the temperature is between 70 and 100°C

c) at depths of more than 4000 meters, also called Ultra Deep Geothermal Energy, the temperatures above 130°C can be recorded (Filtration & Dutch Filtration, 2019).

Hot dry rock (HDR): also known as enhanced geothermal system (EGS) is a condition where water is not naturally present at the site, but the artificial fracture system at depth is created and water is injected into the borehole, heated and pumped back up (Gupta & Roy, 2007).

Geothermal energy can be used to heat, cool, or power individual homes, as well as whole districts or can be used in industrial processes. There are various advantages of using this energy source as it is a renewable, clean, accessible, and reliable energy source as it can be used 24 hours 7 days a week to produce electricity. Another advantage is that compared to other renewable energy sources like wind and solar it is the most "compact" energy system as in order to produce a GWh (Gigawatt hour), a geothermal plant that uses 1046 square kilometers. To produce the same amount of energy wind energy requires 3458 square kilometers, solar energy requires 8384 square kilometers and coal plants need about 9433 square kilometers (Turgeon & Morse, 2024).

Obtaining geothermal energy however possess various challenges such as minor seismic activity/small earthquakes that can result from injecting the high-pressure streams of water, as well as the initial cost of installing geothermal technology which is very expensive. Even though this is relatively clean energy source, small amounts of greenhouse gasses such as hydrogen sulfide and carbon dioxide can be emitted (Turgeon & Morse, 2024).

8.1.4. Wind energy.

Wind is used to produce electricity by converting the kinetic energy of air in motion into electricity. The energy is being extracted firstly by the rotor, which converts kinetic energy into mechanical energy, and the generator, which converts this mechanical energy into electrical energy (Iberdrola, 2021). Wind energy can be obtained both on land as well as offshore. Onshore wind energy is obtained by harnessing wind energy that is produced on land and an offshore wind energy is obtained by harnessing the wind energy that is produced on high seas, where higher and more constant wind speed can be found, due to the absence of barriers (Iberdrola, 2021).

There are various advantages of wind energy as it produces no greenhouse gasses and wind is available everywhere. The main disadvantages of wind energy mainly concern the aesthetics and noise. As these turbines are big constructions and they produce noise while generating electricity (Lloyd, 2014).

Currently around 7% of the world's electricity is produced from wind energy, and the growth rate of 18% between 2015 and 2020 indicates that wind energy will surpass solar energy as the second largest RES (*World Energy… IRENA*, 2023).

8.1.5. Bioenergy.

Bioenergy can come from two differing types of fuels - biogas, including biomethane, and solid biomass. When it comes to biogas, several sources can be used to produce it, such as sewage from water treatment plants, household waste, and waste produced in agriculture and farming. Solid biomass, on the other hand, includes wood, waste produced during its harvest and processing, and energy crops grown specifically for their high energy potential, such as maize and rapeseed (Lacko, 2010).

When biomass is transformed into fuels for transportation, heat, power, or electricity, bioenergy is produced. Biomass is considered a renewable energy source because it emits only as much CO_2, as the plant obtained during its growth. Biomass provides around 14% of the world's energy (Balat & Ayar, 2005).

8.1.6. Hydropower.

Hydropower is a renewable energy source that is powered by water moving from higher to lower elevations. The kinetic energy of the water flowing through the dam turns a turbine. The generator produces electricity from the mechanical energy of the turbine. Generating energy by hydropower doesn't produce greenhouse gasses, however large hydropower plants have negative environmental effects on local ecosystems (Lacko,2010).

8.1.7. Prosumers.

RES prosumers as "entities" can be individual people, collectives, households, small and medium-sized enterprises (SMEs), such as schools or hospitals, that are active in the energy system, for example by both consuming and producing or only producing RES-based power or heat, by offering energy services such as demand flexibility or storage, by being involved in an energy community, or by owning and operating grid infrastructure. This means that all types of entities can become prosumers, however the only requirement is that producing energy is not part of their main commercial activity. Therefore, large companies that produce energy, for example in industry are not considered prosumers (Energy Prosumers… EEA, 2022).

Studies show that the potential for prosumers in Europe is enormous. It was calculated that prosumers can provide 30-70% of the total electricity, depending on the Member State, with solar and wind energy having the highest potential. Prosumer projects can have wide range of benefits for prosumers themselves as well as for society as a whole. These benefits include social, financial, and environmental benefits. The main environmental benefits are reductions in GHG emissions and air pollution. The social benefits include an increased public support for renewables, citizen empowerment and sense of community. More prosumers that are active in the energy transition may lead to lower energy costs, and selling excess energy may lead to revenues. Lastly, prosumers are better protected from price fluctuations, as they are generating their own energy (Masera et al., 2015).

8.2. Current situation of electricity produced from RES in Slovakia

8.2.1. Electricity energy mix.

In Slovakia's electricity energy mix, the country predominantly relies on nuclear power and fossil fuels, especially on hard coal. For the year 2020, 60% of electricity was generated by nuclear energy. Currently around 20% of electricity is generated by renewable resources, with hydropower plants accounting for 15%, biomass-based sources 4.14% and solar power plants 2.57%. However, despite a large potential for renewable energy, Slovakia still has a low share of wind and solar power in electricity production compared to the EU average as well as large potential for geothermal energy (Maraffko et al., 2023).

8.2.2. Bioenergy in Slovakia.

As of 2022, biomass and biogas account for 201 MW of installed capacity for electricity generation, with an estimated potential of about 4000 GWh per year. Solid biomass was critical in surpassing the Slovakia's overall renewable energy target for 2020. The development of biogas was hindered by the stop state for new projects until 2021. Since the stop state was lifted, no new plants were connected to the grid (Maraffko et al., 2023). There are currently around 90 biogas power plants and 167 biomass power plants built in Slovakia, with exact locations visible on Figure 5 (Štefko et al., 2021).

Currently there are several new projects planned in Leopoldov and Žiar nad Hronom. Biomass has the largest energy potential among RES in Slovakia and it is crucial in the heating sector as biomass heat covers 93.8% of all RES heat consumed in Slovakia (Štefko et al., 2021).

8.2.3. Hydropower energy in Slovakia.

Hydropower is the biggest RES resource in Slovakia, and it plays an important role in the overall electricity market. Hydropower is the key renewable energy source in electricity generation in Slovakia and large hydropower installations cover 14.8% of Slovakia's electricity consumption (Maraffko et al., 2023).

Presently, 70% of the technical hydropower potential is being utilized. And the potential for small hydropower facilities is 1600 GWh per year. There are currently 108 hydropower plants in Slovakia and the figure 6 is showing their locations (Štefko et al., 2021). Currently there are only few new projects planned with the biggest one being a new hydropower dam Čuňovo II, with a planned capacity of 24 MW. By 2030 it is also expected that few small hydropower plants each with capacity below 1 MW will enter the construction phase (Potočár, 2021).

8.2.4. Wind energy in Slovakia.

The country is lagging behind in the development of wind energy. At the end of 2022, Slovakia has still only 3 MW of wind energy capacity installed. In total, there are 2 wind parks consisting of 5 plants harvesting wind energy in the country. In the Study of Wind Energy Potential in Slovakia (2022) elaborated by Energiewerkstatt for SAPI, the country has excellent theoretical potential for wind harvesting. The theoretical wind potential is 6500–7000 GWh per year. There is a plan of creating the first large scale wind energy plants (37 to 43 MW) by a fertilizer producer company Duslo Šaľa with a planned €60 million investment (Valach, 2021).

8.2.5. Solar energy in Slovakia.

According to the International Renewable Energy Agency, Slovakia had around 537 MW of installed PV capacity at the end of 2022. The country receives an average of 1500 kWh per m^2 of solar radiation per year and 6200 GWh per year has been estimated as the technical potential of solar energy (Jowett, 2024). Figure 7 shows perspective places on the territory of the Slovak Republic for the location of photovoltaic stations, with the greatest perspective being in the southern part of Slovakia, while we can get the most electricity from photovoltaic stations in the vicinity of Komárno and Nitra (Štefko et al., 2021). Slovakia will need to implement at least 7,500 MW of solar PV installed by 2050 if it aims to reach its carbon-neutrality. This target as well as the 2030 milestone target is more than double of that set in the NECP. Currently, there is a plan by Železiarne Podbrezová (ironworks and metalworks) to build a new rooftop solar power plant, which will be the largest solar installation in the country (Maraffko et al., 2023).

8.2.6. Geothermal in Slovakia.

Slovakia is not using its potential in geothermal energy, which is considered above average. Slovakia has an estimated geothermal potential of 5,500 MWt, however only a small part of this, which is about 250 MWt is currently being used mostly for recreational purposes and only in four cities, namely, Galanta, Šaľa, Sereď, and Veľký Meder (Cariaga, 2022).

The Pannonian Basin, which Slovakia, and Hungary share, covers a substantial portion of Slovakia's land. The geothermal resources in this formation are thought to be highly abundant. Slovakia has twenty-five potential locations with 150 °C geothermal water at 5000 m depths. The primary usage of these springs is in agriculture. Today, geothermal water is used to heat swimming pools, hospitals, and residential buildings (*Geotermálna…* Ministry of Environment, 2023).

Currently there are few geothermal projects planned in Slovakia with the first geothermal plant aiming to start fully working in 2026. As it received its permit from the Ministry of Environment in 2023. There are two other projects planned that can be finished before 2030 the plants in Prešov and Žiar nad Hronom, both with the planned capacity of 20 MW (Cariaga, 2023).

8.2.7. Prosumers in Slovakia

The role of prosumers, individuals, or entities who both produce and consume energy, is increasingly recognized as pivotal in the transition to renewable energy in Slovakia. Already today, companies throughout the EU are increasingly looking for ways to purchase or self-produce renewable energy. They are joining initiatives like RE100 which represents companies from the commercial and industrial sector aiming to source 100% renewable electricity by 2050 at the latest. The volume of corporate Power Purchase Agreements (PPAs), which are contracts that commit a business to finance renewable energy projects in exchange for long-term access to clean energy at a fixed price is growing in Europe. It increased from 2.2GW of renewable energy capacity supported by PPAs in 2016 to more than 11GW in 2020. Through PPAs, businesses can contribute to the build-up of additional renewable energy capacities as they provide a project with a guaranteed income, which is an important consideration for banks when deciding whether to lend to the project (Popp et al., 2021).

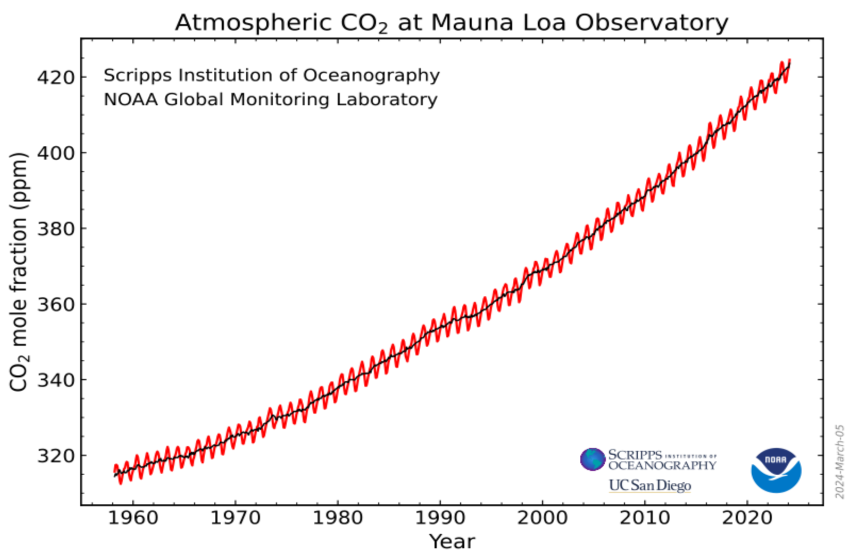
Companies play a central role in the decarbonization of the energy sector. Industry alone accounts for 26% of final energy consumption in the EU, while the service sector is responsible for 14% (Eurostat, 2022). Businesses can speed up the energy transition by contributing with additional renewable energy capacities added to the grid. They can also hold governments accountable on setting ambitious renewable energy targets and developing supportive policy frameworks (Popp et al., 2021).

Currently, to conduct a business focused on generating electricity, a license is required in Slovakia. However, there is an exception to this rule that enables small businesses to produce their own energy, without requiring a license, if the installed capacity of a given facility is below 1 MW. Study shows that there is a large interest among companies in all V4 countries (Slovakia included) in purchasing or self-producing electricity from renewable energy sources. With few exceptions, all companies that participated in the survey are planning to achieve a 100%

renewable electricity supply by 2050, with many seeking to reach this target by or before 2030 (Popp et al., 2021).

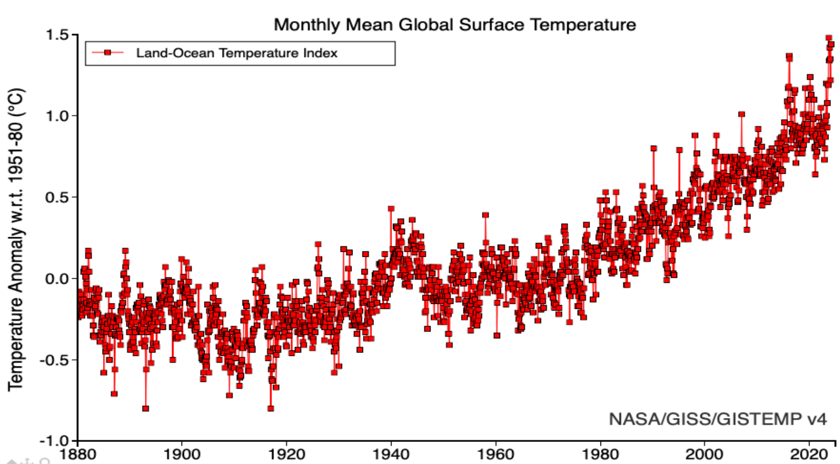
9. Additional Figures

Figure 1: Atmospheric CO_2 at Mauna Loa Observatory.



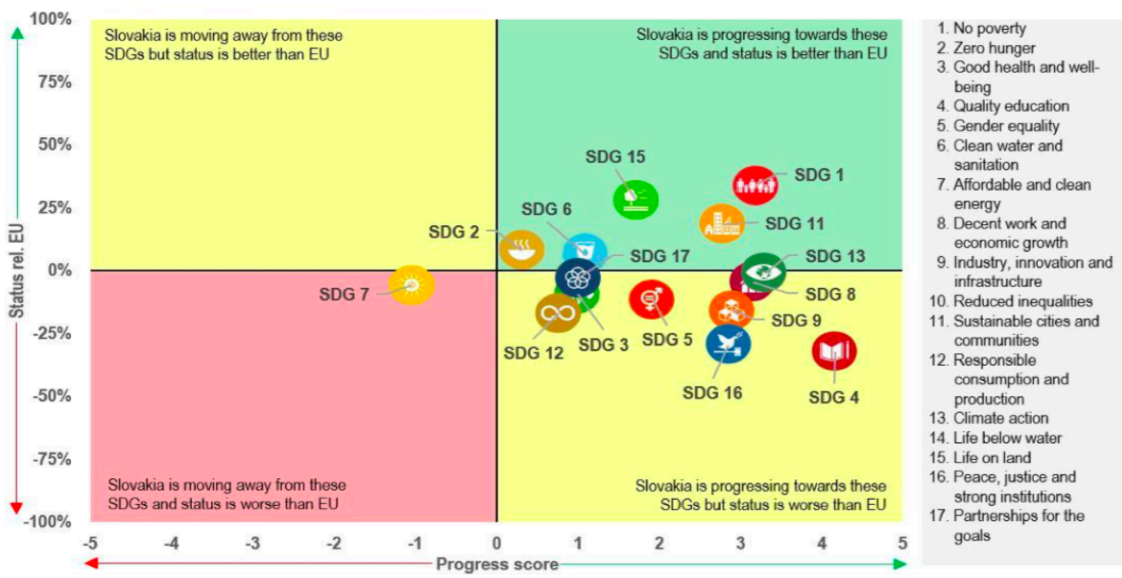
Source: Global Monitoring Laboratory (2024).

Figure 2: Monthly Mean Global Surface Temperature.



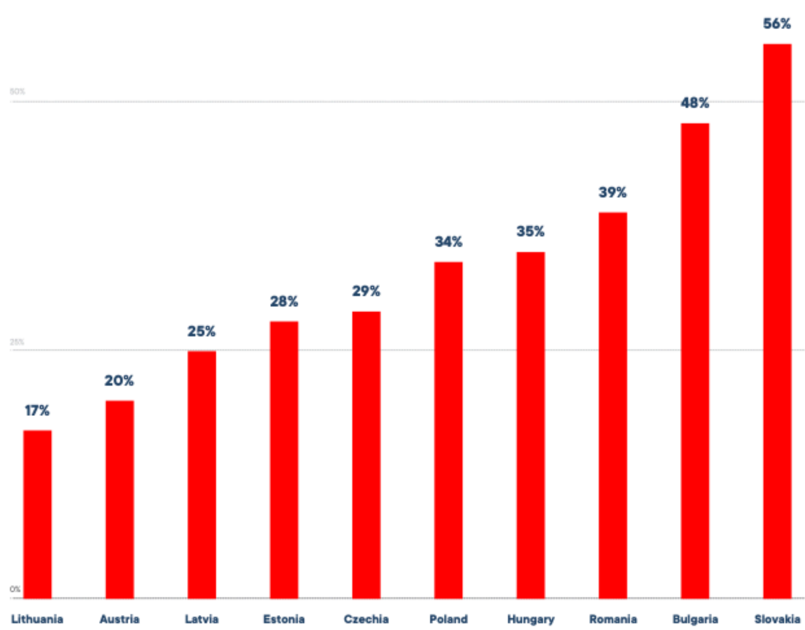
Source: Hansen et al., (1999), the figure was updated online in 2024.

Figure 3: Progress towards the SDGs in Slovakia in the last 5 years.



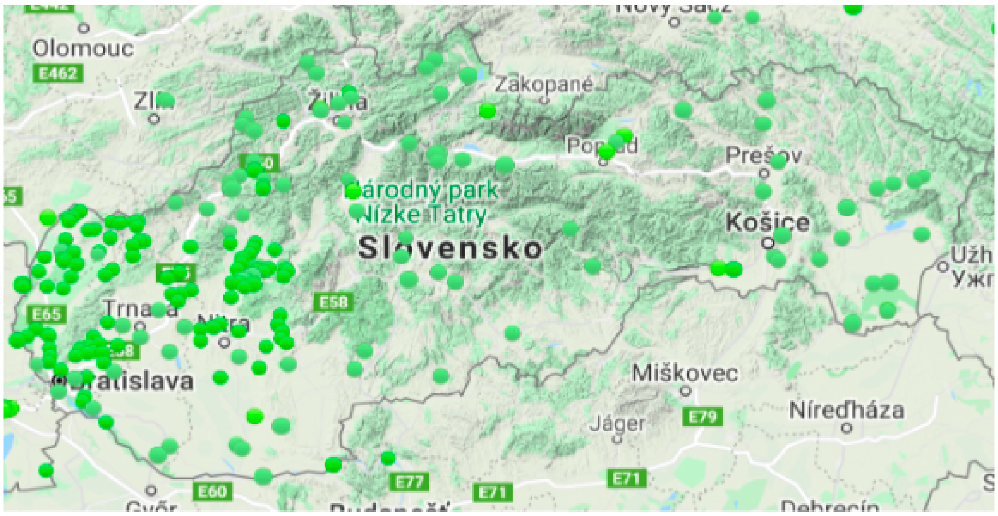
Source: European Commission, (2023).

Figure 4: Degree of belief in conspiracy theories and misinformation narratives



Source: Roosevelt & Wiśniewski (2020).

Figure 5: Location of biogas and biomass power plants of the Slovak republic.

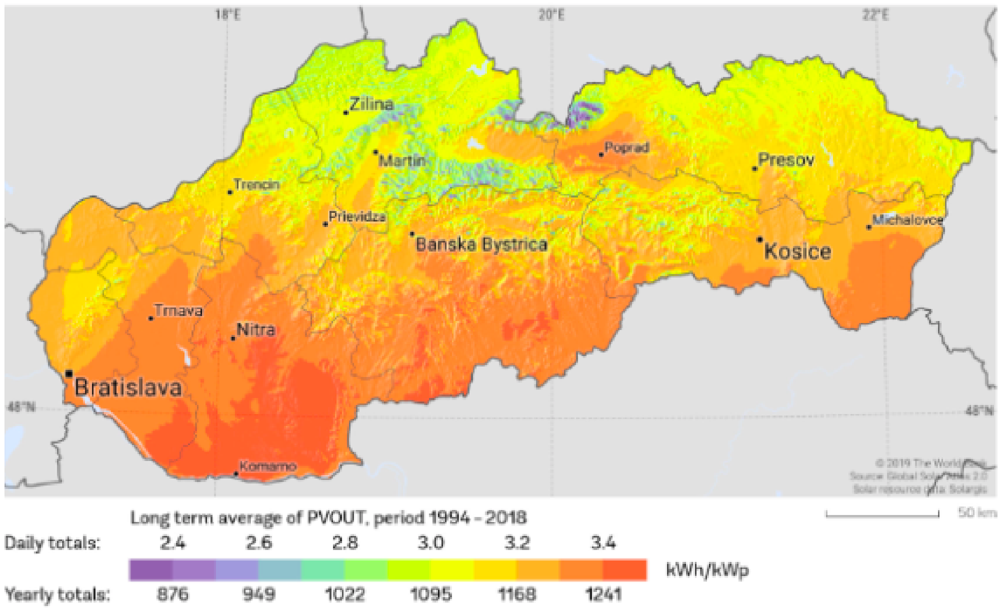


Source: Štefko et al., (2021).

Figure 6: Location of hydropower plants of the Slovak republic.

Source: Štefko et al., (2021).

Figure 7: Photovoltaic power potential of the Slovak republic.



Source: Štefko et al., (2021).

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