BUILDING A SUSTAINABLE FUTURE WITH WIND ENERGY:

AZERBAIJAN'S AMBITIOUS PLANS FOR KARABAKH

Dissertation in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE WITH A MAJOR IN WIND POWER PROJECT MANAGEMENT

UPPSALA UNIVERSITET

Uppsala University
Department of Earth Sciences, Campus Gotland

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17 May 2023

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Approved by:

Supervisor, Heracles Polatidis

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ABSTRACT

Transitioning to renewable energy is critical for reaching global sustainable development goals. As an oil-rich country, Azerbaijan has recognized the need to develop its renewable energy sector. It has set ambitious goals for increasing the share of renewables in its energy mix and establishing a green energy zone in the Karabakh region. The purpose of this master's thesis is to assess the potential of wind energy in Azerbaijan's Karabakh region and surrounding areas and identify the best scenario for its development. Four scenarios were evaluated via the PROMETHEE II Multi-Criteria Decision Analysis (MCDA) method based on their economic, environmental, technological, and social factors. Interviews with real stakeholders were undertaken to elicit weights for the criteria, and a sensitivity analysis was conducted to evaluate the robustness of the results. The findings were shared with the stakeholders, and their input was integrated into the final analysis. According to the findings, Scenario 4, which includes more installed capacity and increased investment, is best suited for the growth of wind energy in the Karabakh and surrounding areas from the perspective of developer and governmental body. In contrast, renewable energy expert and the public prefer Scenario 1, with less land use and less capacity. The findings indicate that for the effective development of wind energy in the area, a balanced approach taking into account the opinions of all stakeholders, is essential. This study contributes to Azerbaijan's long-term development by offering valuable insights into the potential of wind energy in the Karabakh region and surrounding areas and supporting informed decision-making for its expansion.

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At the end of my master's degree program, I want to express my appreciation to everyone who has supported and was with me during my journey. Firstly, I am deeply grateful to Mr. Polatidis, my supervisor. His guidance, feedback, and unwavering support have been invaluable throughout my research. I am grateful for his patience and dedication, as his suggestions and insights have helped me refine my work.

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Finally, I want to express gratitude to my family, and my wife, for supporting and encouraging me throughout my academic journey. Their unwavering support has motivated and inspired me. Thank you for your guidance and support.

NOMENCLATURE

AEP	Annual Energy Production
CO_2	Carbon dioxide
COP26	26th Conference of the Parties to the United Nations Framework Convention on Climate Change
GIS	Geographical Information System
GW	Gigawatt
GWEC	Global Wind Energy Council
IEA	International Energy Agency
IRENA	International Renewable Energy Agency
LCOE	Levelized Cost of Energy
LLC	Limited Liability Company
MCDA	Multi-Criteria Decision Analysis
MODS	Multiple Objective Decision Support
MW	Megawatt
MWh	Megawatthour
OJSC	Open Joint Stock Company
REN21	Renewable Energy Policy Network for the 21st Century
TWh	Terawatthour

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CHAPTER 1. INTRODUCTION

Azerbaijan is a country with a lot of potential for renewable energy due to its location and climate, especially when it comes to wind energy. The country has a vast land area with various landscapes that are perfect for producing wind energy. It is situated at the intersection of Asia and Europe, has access to the Caspian Sea, and is a crossroads for both continents. The government of Azerbaijan recognizes the value of renewable energy and has set goals to increase its use in the country's energy mix (IEA, 2022a). Wind energy is expected to play a significant role in achieving these goals, with numerous projects already underway or planned. As a result, the development of wind energy projects in Azerbaijan has increased in recent years.

One of Azerbaijan's ancient historical areas is the Karabakh region. Azerbaijan's government has designated turning this area into a green energy zone as a top priority among its ongoing development and reconstruction initiatives. Karabakh and surrounding areas can use wind energy to meet their energy needs and lessen reliance on fossil fuels thanks to its geographic location and wind potential. Additionally, investing in wind energy can boost the local economy and open up new job opportunities. The Karabakh region and surrounding areas have significant wind energy potential concentrated primarily in Kalbajar and Lachin districts. The Ministry of Energy of the Republic of Azerbaijan has released data indicating an estimated wind energy potential of 2,000 MW in the region (Ministry of Energy of Azerbaijan, 2022a).

The purpose of this master's thesis is to assess the potential of wind energy in Azerbaijan's Karabakh region and surrounding areas and identify the best scenario for its development. Specifically, the research aims to address the following question: "What are the key factors influencing the feasibility and viability of wind energy development in Azerbaijan's Karabakh region, and which scenario presents the most sustainable and economically viable option?" Four scenarios were evaluated via the PROMETHEE II Multi-Criteria Decision Analysis (MCDA) method based on their economic, environmental, technological, and social factors. Interviews with real stakeholders were undertaken to elicit weights for the criteria, and a sensitivity analysis was conducted to evaluate the robustness of the results. The findings were shared with the stakeholders, and their input was integrated into the final analysis. According to the findings, Scenario 4, which includes more installed capacity and increased investment, is best suited for the growth of wind energy in the Karabakh and surrounding areas from the perspective of developer and governmental body. In contrast, renewable energy expert and the public prefer Scenario 1, with less land use and less capacity. The findings indicate that for the effective development of wind energy in the area, a balanced approach taking into account the opinions of all stakeholders, is essential. This study contributes to Azerbaijan's long-term development by offering valuable insights into the potential of wind energy in the Karabakh region and surrounding areas and supporting informed decision-making for its expansion.

This master thesis is divided into six chapters. Chapter 2 includes a review of the literature on global renewable energy trends and policies, the importance of transitioning to renewable energy for sustainable development, Azerbaijan's renewable energy policies, targets, and the wind energy potential in the Karabakh region and surrounding areas as well as an introduction to Multi-Criteria Decision Analysis (MCDA) methods. Chapter 3 includes the MCDA methodology followed and an introduction to the specific MCDA method PROMETHEE II, which was used to evaluate the various scenarios. The case study and results are presented in Chapter 4, which includes the creation of multiple scenarios, the identification of stakeholders, the establishment of criteria, the holding of interviews and the elicitation of weights, and the MCDA outcomes. The results are discussed and analyzed in Chapter 5, including two interview rounds with real stakeholders and sensitivity analysis. Finally, Chapter 6 summarizes the key results, limits, and future research areas of the thesis.

CHAPTER 2. LITERATURE REVIEW

The previous academic research and publications on the subject are examined in the literature review part of this master's thesis. The first part 2.1 covers renewable energy and its significance for sustainable development, followed by section 2.2, which represents an examination of international trends and policies in the growth of renewable energy. The potential of wind energy for sustainable development is highlighted in section 2.3. The overview examines Azerbaijan's energy industry and its reliance on fossil fuels in section 2.4. Section 2.5 continues with a discussion of Azerbaijan's renewable energy landscape with an emphasis on projects and policy. The final part, section 2.6 concludes an overview of Multi-Criteria Decision Analysis (MCDA).

2.1 Transitioning to renewable energy and its importance for sustainable development

Due to its potential to promote both sustainability and economic growth, renewable energy is being emphasized on a worldwide scale as a new paradigm. Using unbounded resources would improve energy security and should be a big part of the new approach. Additionally, to ensure the efficient use of energy, the new model should be complemented with the utilization of available and emerging technologies. 80% of the world's energy is used through the use of fossil fuels, which are sources of pollution that hasten global warming (Vidadili et al., 2017). Furthermore, the unsustainable nature of the existing equilibrium between energy use and environmental concerns has been brought to light by climate change. During the past several decades, the capacity for renewable energy has dramatically increased over the globe. This can be achieved by an increase in renewable energy promotion programs, initiatives to increase energy security in response to climate change, and a substantial decline in the price of renewable energy technology. This is a positive development because using renewable energy can positively affect society, the economy, and the environment (Vidadili et al., 2017).

A transition to a sustainable future is mostly dependent on energy efficiency and renewable sources. Significant economic prospects are provided by renewable energy, including the overcoming of energy poverty. The globe will become unsustainable if non-renewable energy replaces renewable energy, which will have an impact on all states worldwide. The majority of studies on climate change and its effects indicate that emerging states may be among its first sufferers (Energy Charter, 2013).

2.2 Global trends and policies in renewable energy development

Modern energy trends are defined by consistently using renewable energy sources for energy production.

Several different policies have been put into place in recent years by countries worldwide to promote the growth of renewable energy. The key to the quick deployment of "green" energy infrastructure has been the effective execution of support mechanisms and the setting of indicative objectives for increasing the percentage of renewables in the country's energy mixes (Kurbatova and Perederii, 2020). 179 countries set targets in 2018 to raise the share of renewable energy sources in their national energy mixes (REN21, 2019). Moreover, numerous governments amended their previously set renewable energy objectives in 2018. The objectives for energy transformation across the economy continue to be minor, even though newly updated targets have become more ambitious in scope. However, only around 10 states have overall economic targets for using at least 50% renewable energy as of the end of 2018, and only Denmark has a target for using 100% renewable energy in total final energy consumption. Just a small number of countries today have made substantial progress in developing renewable energy, where its share has surpassed the 50% threshold. In contrast, in the majority of states, non-renewable energy sources continue to rule the energy markets (REN21, 2019).

2.3 Potential of wind energy for sustainable development

One essential component of renewable energy is wind energy. Because of the enormous potential that wind has to offer, research into wind energy consumption is crucial. There is wind in every country, and wind turbines may be installed on land or offshore. Last year saw the addition of about 78 GW of wind power capacity, the third-highest year ever but the lowest level in the previous three. This was accomplished despite a difficult economic climate, a disrupted global supply chain, and crises in the global health and energy sectors (GWEC, 2023). The major source of use of renewable energy, apart from hydroelectric electricity, is wind energy. In 2017, 52% of the world's renewable energy consumption came from wind, while 21% came from solar (Ersoy et al., 2019). Wind energy production increased by a record 273 TWh (up 17%) in 2021. This was the fastest growth rate among all renewable energy technologies, and it was 55% faster than what was accomplished in 2020 (IEA, 2022b). Since it can provide enormous volumes of electricity at reasonable prices, wind energy is one of the most popular renewable energy sources (Farkat Diógenes et al., 2020). Between 2008 and 2015, the cost of wind energy generation fell by one-third. Instead of lowering unit investment costs, this has been accomplished by raising capacity factors - larger towers with bigger blades (IEA, 2016). Onshore wind development has still faced a number of obstacles. These obstacles, which may be broadly defined, include institutional, technological, and social hurdles, as well as market failures, market distortions, economic and financial factors (Diógenes et al., 2020). Some of these obstacles may be overcome by offering developer incentives, while others, such as inadequate transmission infrastructure, limited access to financing, and a stable macroeconomic climate, need for direct government intervention (Farkat Diógenes et al., 2020).

2.4 Azerbaijan's energy sector and its dependence on fossil fuels

As a post-soviet country, the Azerbaijan Republic's economy is heavily dependent on oil and gas production, which poses the biggest threat to the development of renewable energy sources. The main barrier to Azerbaijan's long-term economic growth, as a result of falling oil prices and the depletion of oil reserves, is its dependence on fossil fuels. The combination of these recently discovered obstacles has prompted Azerbaijan to diversify its economy through a green economy, which would open the door for transition to renewable energy and long-term economic stability while resolving the nation's social and environmental problems. Azerbaijan has a lot of potential, particularly for wind and solar energy. Azerbaijan can fulfil its own energy demands, promote energy-based economic growth, and protect the environment by reducing emissions by utilizing these renewable energy sources (Vidadili et al., 2017).

Natural gas and oil resources are plentiful in Azerbaijan. According to the June 2018 BP Statistical Review of World Energy, at the end of 2017, its oil reserves, which totalled 7 billion barrels, represented 0.4% of the world's reserves. In the Caspian Sea and basin, oil is produced both onshore and offshore, with offshore production making up around one-quarter of the total. Oil and gas make up more than 98% of the country's entire energy mix, which is largely reliant on fossil fuels. Supply security is unaffected, but a country's high reliance on fossil fuels increases greenhouse gas emissions and puts it at risk from fuel price fluctuations (IEA, 2020).

More than 90% of Azerbaijan's exports are oil and gas. After the discovery of the Shah Deniz gas field in the 2000s, oil and gas output significantly surged, reaching records in 2010. The government and foreign corporations have made significant investments in the energy industry, and the development of a number of new power plants as well as the modernization and renovation of the gas and electricity networks, have increased supply security and dependability (IEA, 2021).

2.5 Azerbaijan's Renewable Energy Landscape: Policies and Projects

The section covers a wide range of topics related to Azerbaijan's renewable energy sector. Specifically, section 2.5.1 delves into the country's current renewable energy policies, while section 2.5.2 focuses on the most recent wind energy projects in Azerbaijan. Section 2.5.3 provides insight into Azerbaijan's wind energy potential in Karabakh, and section 2.5.4 discusses the barriers and challenges hindering the development of wind energy in Azerbaijan.

2.5.1 Azerbaijan's current renewable energy policies and targets

Azerbaijan places a high priority on the development of renewable energy sources in addition to traditional energy sources. By 2030, the government aims to have a share of 30% from renewable sources in the total energy mix (Ministry of Energy of Azerbaijan, 2022a).

“Azerbaijan 2030: National Priorities for Socio-Economic Development” document, approved by the Decree of the President of the Republic of Azerbaijan dated February 2, 2021, includes applied issues in the direction of tackling climate change as well as involved issues of renewable energy in all areas of the economy based on the principles of the green energy space in Azerbaijan in paragraph 5: "Clean environment" and "Green growth country" (Ibadoghlu, 2022). On July 22, 2022, the Republic of Azerbaijan's Socio-Economic Development Strategy for 2022–2026, which was outlined in the National Priorities was adopted. Energy efficiency will be increased, according to the Strategy, and renewable energy sources will be expanded (Azerbaijan-2026, 2022).

The government's function as the primary actor (via public utilities) and the other role that hydrocarbon resources play are the main focuses of the existing legislative framework governing the energy market. Below are the five primary laws that should serve as the basis for all policies and plans used in the energy sector:

1. The Law on Energy (1998);
2. The Law on Electrical Power (1998);
3. The Law on Electrical and Thermal Power Plants (1999);
4. The Law on Utilization of Renewable Sources in Electricity Production (2021);
5. The Law on Efficient Use of Energy Resources and Effectiveness of Energy (2021).

The last two new laws were passed in 2021. The Law on the Use of Renewable Sources in the Generation of Electricity is the most crucial for the growth of the renewable energy industry. This was the first law passed solely concentrating on renewable energy sources. The Legislation outlines the duties and obligations of the government and generators, the available assistance channels, and the regulations for the renewable energy industry. The Law on Efficient Use of Energy Resources and Effectiveness of Energy, which was established in response to the abovementioned law, included renewable energy sources to the list of resources that should be supported coming future. However, the statute places relatively little emphasis on renewable energy sources. In actuality, the phrase "renewables" appears just twice in the text, both times in generic listings. The Law has superseded the Law on the Utilization of Energy Resources, which had additional provisions relating to renewable energy sources, including the notion of creating a special fund to assist in utilizing energy resources including renewable energy sources (Mustafayev et al., 2022).

To support efforts to reduce the impact of climate change, Azerbaijan announced at the 26th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP26) in Glasgow the country's goals to reduce greenhouse gas emissions by 40% by 2050 and create a zero-emission zone in liberated territories (Hajiyev, 2021).

2.5.2 Recent wind energy projects in Azerbaijan

Khizi-Absheron Wind Power Plant, which is a 240 MW wind farm pilot project under construction, is implemented in accordance with the implementation agreement signed between the Ministry of Energy of Azerbaijan and ACWA Power Company of Saudi Arabia. The project's investment cost is $300 million. Following that, newly signed Memorandum of Understanding between ACWA Power and the Ministry of Energy of Azerbaijan calls for the creation of a battery energy storage system as well as implementation agreements for 1GW and 1.5GW of onshore and offshore wind, respectively (ACWA Power, 2023).

An agreement to develop up to 10GW of renewable energy projects has been signed between United Arab Emirates-owned Masdar Renewable Energy and the Azerbaijani Ministry of Energy. The company is currently developing solar and wind projects with a combined capacity of 4GW, with the ability to add an additional 6GW in a potential second phase. Two implementation contracts have been signed for the preliminary phase. In the first concept, 1 GW each of onshore wind and solar PV was proposed. Projects for green hydrogen and offshore wind totaling 2GW are included in the second (Ministry of Energy of Azerbaijan, 2023).

Fortescue Future Industries (FFI) and the Ministry of Energy of the Republic of Azerbaijan have agreed to collaborate in order to research and develop viable green hydrogen and renewable energy projects in Azerbaijan. The Agreement will look into up to 12GW of prospective projects from renewable energy sources and green hydrogen generation in Azerbaijan in an effort to further solidify the tight partnership between Azerbaijan and Fortescue (Ministry of Energy of Azerbaijan, 2022b).

According to the interview of the Director of Azerbaijan Renewable Energy Agency, there are contracts for implementing projects with a 25 GW capacity in addition to pilot projects with ACWA Power (wind) and MASDAR (solar) (Abdullayev, 2023). The amount of electricity generated by these plants is excessive for the Azerbaijani market. It is necessary to export or convert this energy into hydrogen or other decarbonization-promoting forms. Currently, there are two export routes under consideration. One of these entails the transmission of energy through undersea cable along the Black Sea. Another route allows for exporting to Turkey and European markets via the liberated areas of Azerbaijan and Nakhchivan along the Zangezur corridor (Abdullayev, 2023).

2.5.3 Azerbaijan wind energy potential in Karabakh

There are enormous wind resources in Azerbaijan which is estimated to have a 3000 MW potential for economically and technically feasible renewable energy sources (Nuriyev et al., 2022). The offshore wind technical potential of Azerbaijan is estimated by the World Bank to be 35 GW in shallow waters (for fixed foundations) and 122 GW in deep waters (for floating foundations), with a total potential of 157 GW (World Bank, 2021).

Karabakh, which is an integral part of Azerbaijan (see Figure 1) and is located in the southeastern part of the Lesser Caucasus, has a fascinating nature. After the liberation of the Karabakh region and surrounding areas, President of the Republic of Azerbaijan Ilham Aliyev signed an order on May 3, 2021, aimed at creating a "green energy" zone in the newly regained territories. As part of the efforts to establish the Green Energy Zone, various investigations are underway to examine in depth the renewable energy potential of the liberated areas, including solar, wind, biomass, thermal, geothermal, and others. These investigations aim to determine the precise coordinates of the territories, as well as to develop energy supply through the construction of wind and solar power plants, along with hydropower plants in reservoirs, lakes, and small rivers (Ministry of Energy of Azerbaijan, 2022a).

Due to its extensive potential for the use of wind power facilities, wind energy is the preferred renewable energy source in Azerbaijan when compared to other alternative energy sources (Vidadili et al., 2017). According to preliminary studies, it was found that the Karabakh and surrounding areas have good wind potential, particularly in the mountainous areas of the Lachin and Kalbajar districts, see Figure 2 and Figure 3. According to the research, these regions have a wind power potential of about 2000 MW (Ministry of Energy of Azerbaijan, 2022a). There are large areas in the mountainous region of Karabakh where the average yearly wind speed is 7-8 m/s at a height of 100 meters. The Kalbajar and Lachin districts, which border Armenia, have an average yearly wind speed of 10 m/s (Ministry of Energy of Azerbaijan, 2020a).

The potential for producing power from renewable resources in these areas would enable Azerbaijan to develop the "smart cities and villages" that it desires in its liberated areas. All of the aforementioned evidence indicates that Azerbaijan aims to develop the foundation of its energy supply system. Moreover, as Azerbaijan plans to export power to Europe via the "Green Energy Corridor," this will improve the country's future electricity export potential (Najafova, 2022).

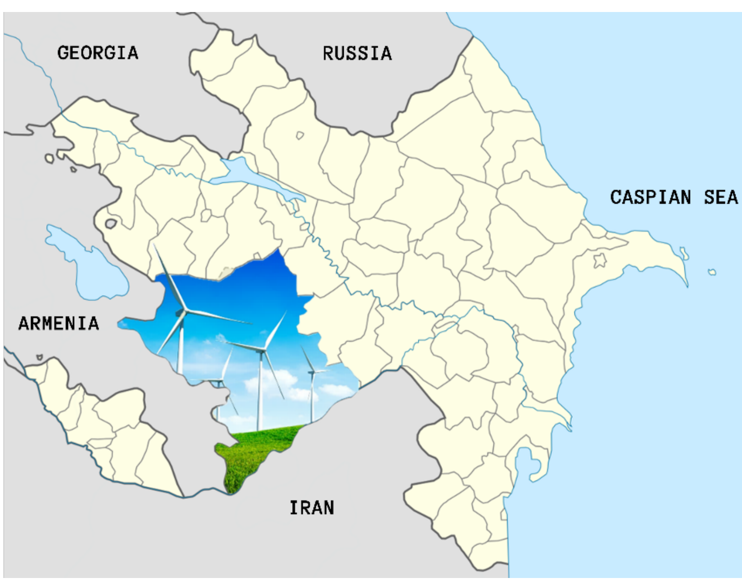

Figure 1. The map of Azerbaijan Republic with highlighted Karabakh region and surrounding areas (formulated by the author)

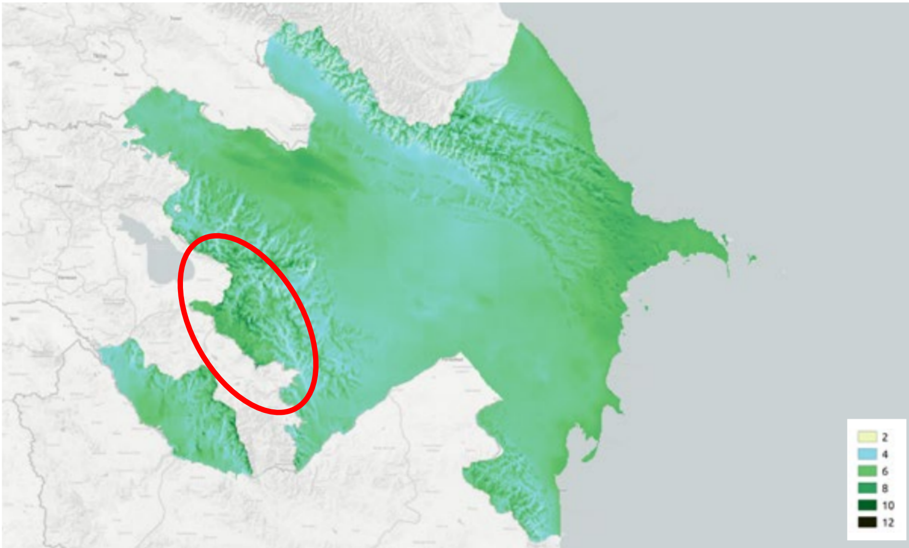

Figure 2. Wind speeds at 100m hub height (in m/s) (IRENA, 2019)

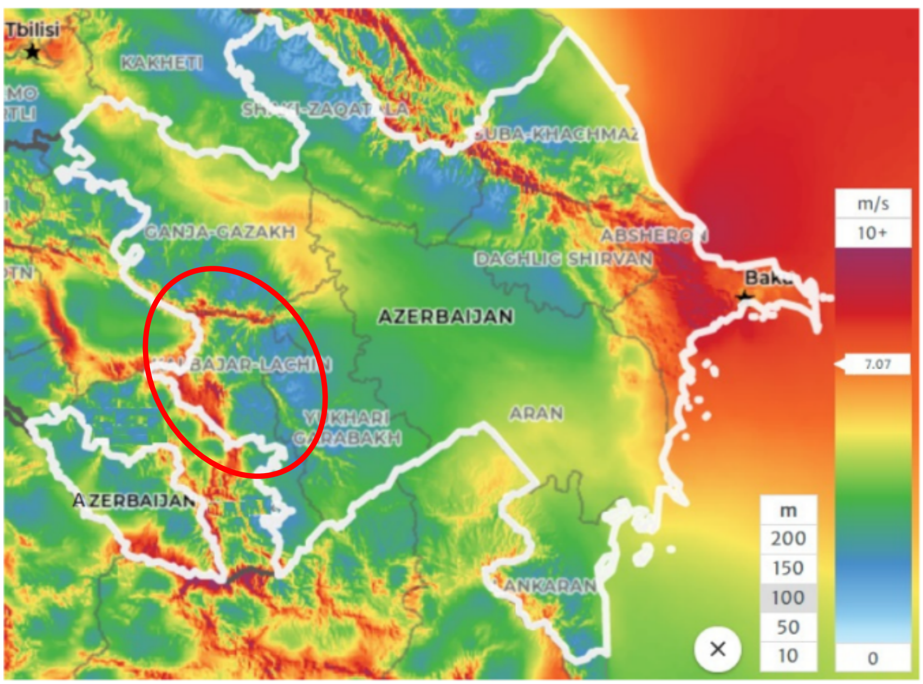

Figure 2. Mean wind speed at 100m altitude (Global Wind Atlas, 2023)

2.5.4 Barriers and challenges to wind energy development in Azerbaijan

Several countries, especially those with abundant energy resources, have less interest in alternative energy due to rising costs due to low oil prices on the global market (Hamidova et al., 2022).

High costs and expenses are regarded as one of the main barriers to the growth of the renewable energy sector in Azerbaijan, especially wind energy. This is a result of the high cost of technology. Moreover, Azerbaijan's history of employing renewable energy is extremely limited when compared to a number of wealthy nations (Hamidova et al., 2022). In addition to the above-described problems, there are two other significant barriers to the use of renewable energy in Azerbaijan that may be noted:

(1) Weak legislative framework and (2) a lack of network connection regulations (IRENA, 2019).

One should be aware that the government continues to exert significant influence over Azerbaijan's energy sector. Its monopoly extends to the supply, transmission, distribution, and production of electricity. As a result, one of the problems is that the republic is not attractive to investors since there is no vibrant electrical market (Hamidova et al., 2022). Azerenerji OJSC generates and transmits the country's electricity. They manage high-voltage power transmission lines that range in voltage from 110 KV to 500 KV, maintain power lines, and integrate new technology. Also, they share power with other countries. Azerishiq OJSC which is also monopoly, is responsible for the supply and distribution of electricity (IRENA, 2019).

The process of transitioning to "green energy" sources in Azerbaijan should therefore be carried out carefully, with the application of a comprehensive approach to environmental, economic, and energy security issues. In these circumstances, abruptly abandoning traditional energy carriers can result in an increase in prices and an energy crisis (Ibadoghlu, 2022).

2.6 An overview of Multi-Criteria Decision Analysis (MCDA)

Methodological approaches that incorporate social, environmental, and economic factors in decision-making models, including stakeholder involvement, are required to develop energy projects (Estévez et al., 2013). The most common tools used to aid decision-making in the energy sector are life cycle cost analysis and cost-benefit analyses (Strantzali and Aravossis, 2016). It can be challenging and occasionally unclear to evaluate how effectively these are valid and often used tactics can capture complex social ramifications and reflect them in monetary terms (Estévez et al., 2013). Multi-objective issues are rated and ranked using a set of decision-making techniques known as multi-criteria decision analysis (MCDA) (Estévez and Gelcich, 2015). In order to maximize benefits over traditional cost-benefit analyses, MCDA methodologies are frequently used in planning and decision-making for sustainable energy (Wang et al., 2009). MCDA methodologies may include both quantitative and qualitative data into decision models to examine ramifications when financial analyses are inaccurate. Moreover, participatory MCDA methods offer participants a structured and formal approach to engaging in the decision-making process (Grafakos et al., 2017). As a result, MCDA may support social learning, agreement, and acceptability problems by assisting stakeholders in understanding subjective value judgments.

The mechanisms for choosing between alternatives are understandable, but the algorithms for incorporating different inputs into the decision-making model are difficult to comprehend in a collaborative process. One of the most prevalent outranking variations is PROMETHEE (Belton and Stewart, 2002). The PROMETHEE evaluates choices pairwise across a number of criteria to determine which solutions are superior. As with any outranking strategies, PROMETHEE allows for additional exploitation and deductive procedures to assist the decision-makers in making the best choice (Haralambopoulos and Polatidis, 2003).

As the share of renewable energy sources in developing countries energy mix rises, emphasis must be put on fostering participation and accurately estimating societal implications. In order to do this, MCDA has the capacity to adopt best practices that enable the participation of numerous stakeholders and their values in an organized and transparent manner (Estévez et al., 2021).

According to Ribeiro et al. (2013), many papers on sustainability criteria in power system design were identified, and it was found that approaches explicitly expressing economical, social, and environmental criteria come primarily under the umbrella of MCDA. While utilizing multi-criteria decision methodologies, need to keep in mind that there are no universal best options because the outcomes are based on human judgment of several factors. The subject of long-term strategic electrical decision-making was addressed in this article. Considering the various parameters, they develop a framework for evaluating power generation possibilities. The program was created in a user-friendly environment and employs multi-criteria decision analysis, which includes a set of thirteen criteria spanning from economic considerations to environmental, social, and technological problems. The approach combines an additive value function aggregating direct weighing findings with trade-off analysis. Based on the results, the overall conclusion is that all respondents would be prepared to increase the costs of electricity generation if other factors other than economic ones were considered. This statistic alone demonstrates MCDA's value. Respondents with diverse viewpoints scored the examined scenarios differently, which is to be expected when utilizing multi-criteria methods (Ribeiro et al., 2013).

The study, which is based on Polatidis and Borràs Morales’s (2016) work, proposes a methodological framework for assessing and choosing wind power projects using MCDA approaches. The methodology encompasses stakeholder preferences and blends technical and social evaluations to discover suitable projects with better implementation potential. The case study of a wind farm in the United Kingdom highlights the framework's usefulness in addressing the issues that wind power projects face and suggests a new approach for a more relevant project option (Polatidis and Borràs Morales, 2016). The process entails creating alternative scenarios and assessing them using resource-based, economic, environmental, social, and technological factors. The PROMETHEE II outranking approach is used to find an acceptable compromise solution among the developed project options, and stakeholders are requested to weigh the criteria. Overall, the research offers a valuable method for evaluating and selecting wind power projects, which can boost the actual application of wind farms and contribute to the development of sustainable energy systems (Polatidis and Borràs Morales, 2016).

An approach for environmental planning for wind power plant site selection utilizing a PROMETHEE-based outranking method in a geographic information system was suggested by Ghobadi and Ahmadipari (2018). The study emphasizes the relevance of choosing a site for wind power stations, which calls for a geographical evaluation that takes technical, economic, and environmental factors into account. To calculate the weights of the criteria and rank the options, the authors used the analytic hierarchy process and PROMETHEE methodologies in geographic information systems (GIS). According to the study, the PROMETHEE technique can be used to create models for the location of renewable energy facilities in future research. This study makes a significant addition to the field of planning for renewable energy sources and confirms the need for decision support systems that can efficiently assess the appropriateness of probable locations for the construction of wind power plants (Ghobadi and Ahmadipari, 2018).

One of the critical factors in choosing the best locations for wind power projects is spatial analysis (Sotiropoulou and Vavatsikos, 2021). In order to increase the effectiveness and precision of the site selection process, several researches have suggested combining GIS with multi-criteria decision-making techniques. One of the multi-criteria decision-making techniques that have been applied in the process of choosing a location for a wind power facility is the PROMETHEE II approach. PROMETHEE II is an extension of the original PROMETHEE method and includes additional features and improvements. It provides a more refined and nuanced approach to multi-criteria decision-making compared to the original PROMETHEE method, allowing for a more accurate and comprehensive evaluation of alternatives (Goswami, 2020). In order to allow a GIS-assisted wind farm suitability study, Sotiropoulou and Vavatsikos (2021) created a novel decision-making framework that incorporated PROMETHEE II, GIS technology, and a spatial interpolation model. In contrast to the absolute performance in relation to the analytical criteria, the technique outranked the prospective sites. To guide future large-scale wind farm installations, the suggested framework is a flexible method that may be utilized as a strategic planning tool by decision and policymakers at the regional and national levels (Sotiropoulou and Vavatsikos, 2021).

CHAPTER 3. MATERIALS AND METHODS

3.1 Introduction

The method used to perform the study is described in depth in this chapter, along with further information on the instruments utilized. According to the literature reviewed, the Karabakh region and surrounding areas have a huge renewable energy potential, particularly wind energy, which might help to develop sustainability in the area and decrease the region's dependency on nonrenewable energy sources. Nonetheless, the region has endured a lack of investment and infrastructure as a result of the occupation, limiting its capacity to benefit from its natural resources.

The aim of this study is to assess and investigate several possibilities for building a sustainable future using wind energy in Karabakh by creating several scenarios in order to address the following question: "What are the key factors influencing the feasibility and viability of wind energy development in Azerbaijan's Karabakh region, and which scenario presents the most sustainable and economically viable option?". The feasibility and possible influence of various scenarios on electricity generation, environmental sustainability, initial investment and land use efficiency will be assessed in this study. Based on these criteria, the various scenarios were reviewed, and the PROMETHEE II MCDA method was used to evaluate the scenarios based on their overall performance. This strategy enabled a methodical and impartial examination of the numerous situations, allowing for informed decision-making. Additionally, its simple use and extensive comparison of outcomes yield a precise result. Figure 4 depicts an illustration of this process.

The outcomes of this study will allow policymakers, energy firms, and investors with information to help them make informed decisions regarding wind energy developments in the region. The findings of this research may also assist in identifying potential barriers to wind energy growth and ways to overcome them. It may also help Azerbaijan establish more effective sustainable energy strategies, contribute to the country's national environmental goals and improve sustainability, particularly in the Karabakh region and surrounding areas.

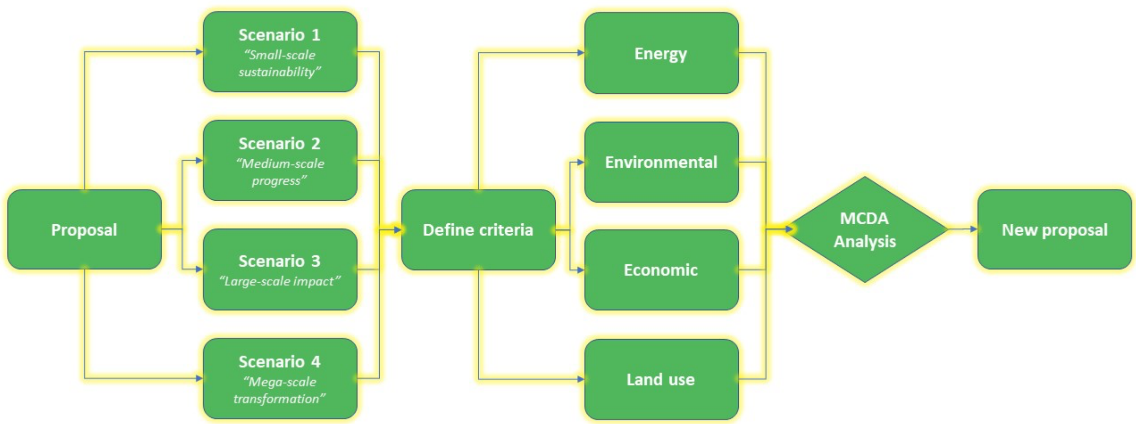

Figure 4. Methodology flow chart illustration

3.2 PROMETHEE II

The method got its name from the abbreviation of the full name: Preference Ranking Organization METHod for Enrichment Evaluations. The PROMETHEE MCDA tool is a strategy for making decisions that allow assessing options based on several criteria. The approach was developed by Brans and Vincke in the 1980s and has since been well-liked in a number of academic fields, including engineering, economics, and environmental management. With the use of the PROMETHEE tool, decision-makers may evaluate complex choice problems that consider a range of factors, such as energy, environmental effect, and social concerns. Comparing and ranking alternatives based on pairwise comparisons of the criteria, it implies evaluating and ranking alternatives using preference functions to indicate their general desirability. PROMETHEE MCDA tool is a useful tool for decision-makers who wish to evaluate and compare several options while taking a range of different aspects into consideration (Brans and Vincke, 1985).

In the PROMETHEE II methodology, the first step is to make pairwise comparisons between the alternatives based on various criteria. This allows for a systematic assessment of the relative importance or preference of one alternative over another. These pairwise comparisons capture the decision-maker's subjective judgments and preferences (Behzadian et al., 2010). The second phase involves the use of a relevant preference function for each criterion. This function quantifies the preference or desirability of each alternative with respect to a specific criterion. It translates the qualitative judgments into quantitative values, providing a framework for objective comparison. The global preference index is calculated to determine the overall preference or dominance of one alternative over another. It considers the pairwise comparisons and the preference functions to generate an overall ranking based on the collective preferences across all criteria. Additionally, the methodology includes the determination of positive and negative outranking flows for each alternative (Behzadian et al., 2010). The positive outranking flow represents the strength of an alternative's dominance over other alternatives, while the negative outranking flow captures the strength of an alternative being dominated by others. These flows contribute to the partial ranking of alternatives. Finally, the net outranking flow is calculated for each decision alternative, which combines the positive and negative outranking flows. This net flow reflects the overall performance of an alternative in relation to others, considering both its dominance and being dominated.

By applying these steps iteratively for all decision alternatives, the PROMETHEE II methodology enables the evaluation and ranking of alternatives based on multiple criteria. It provides a systematic and structured approach to decision-making, considering the preferences and judgments of decision-makers in a comprehensive manner.

The author must have applied weighting to each of the chosen criteria prior to entering data into the PROMETHEE II tool. Ideally, the weighting of assumptions would include feedback from the stakeholders, so in order to weight the criteria, the author interviewed 4 stakeholders through bilateral meetings in two rounds, concentrating on their primary objectives when taking a project into consideration. A systematic framework known as Multiple Objective Decision Support (MODS) is used to assess choice alternatives in light of many frequently conflicting criteria (Hajkowicz et al., 2000). A MODS's method goal is to assign a set of cardinal or ordinal values to a set of objectives/criteria to show their relative importance. The method utilized to gather data from decision makers about the relative weighting of evaluative criteria is a crucial part of MODS. The relative worth of each decision alternative is then determined by ranking algorithms using this information. In this study, the Fixed Point Scoring technique of MODS was applied (Hajkowicz et al., 2000). In this method, the decision-maker must assign a predetermined number of points to each criterion. The relevance of the criterion is indicated by the point total. Since this is a measurement that many decision makers are acquainted with, percentages are frequently utilized. Fixed point scoring's main benefit is that it requires participants in a decision dilemma to make trade-offs. By using fixed point scoring, it is only feasible to give one criteria more weight by giving another criterion less weight. Making a decision in this situation is challenging and calls for thorough evaluation of the relative weight of each factor (Hajkowicz et al., 2000).

CHAPTER 4. CASE STUDY AND RESULTS

4.1 Creation of various scenarios

Choosing different scenarios allows for a more thorough examination of the possible implications of wind energy projects. Created scenarios named as below, based on the capacity of wind power which assumed to be installed:

- Scenario 1 *"Small-scale sustainability"* (200 MW),
- Scenario 2 *"Medium-scale progress"* (400 MW),
- Scenario 3 *"Large-scale impact"* (600 MW),
- Scenario 4 *"Mega-scale transformation"* (800 MW).

These scenarios may represent alternative project sizes or configurations, each with its own set of possible consequences. It is possible to evaluate the strengths and limitations of each scenario and determine which scenario is the most practical and useful overall by examining each scenario.

4.2 Establishment of criteria

To evaluate the above-mentioned scenarios, four categories of criteria were identified: energy, environmental, land use, and economical. These criteria were evaluated using data from similar cases in the literature and modified to the current case study's conditions, size, and particularities. Several criterion assessment methods have been used.

4.2.1 Energy criteria

The AEP for each scenario were calculated using below mentioned formula:

AEP = 8760 hours x Installed Capacity x Capacity Factor

Capacity factor were determined based on the average data from Global Wind Atlas, official presentation of relevant energy authority of a country which is available online (Yusifov, 2018) and according to the Mustafayev et al., 2022 figures. The capacity factor from Global Wind Atlas in a range of 25%-50% for the Karabakh region, red ring represent the areas with the higher capacity factor (see Figure 5), official presentation shows 33% while according to the Mustafayev et al., (2022) tables, in calculations for proposed projects in Karabakh region 30% were used. So, 30% were used in criteria evaluation.

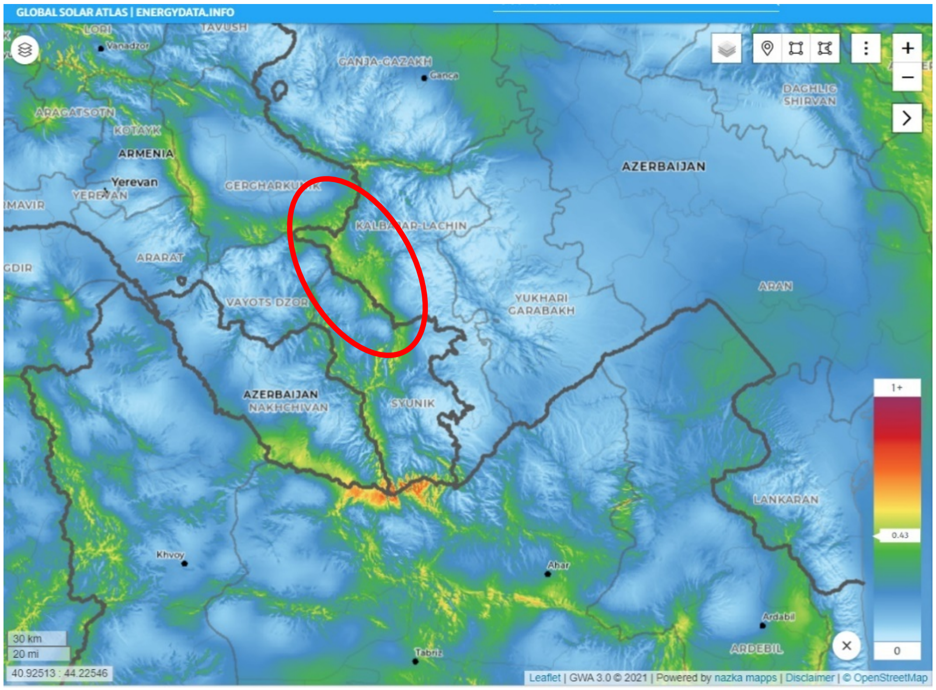

Figure 5. Wind energy capacity factor in Karabakh region and surrounding areas (Global Wind Atlas, 2023)

4.2.2 Environmental criteria

The corresponding avoided carbon dioxide (CO_2) emissions were estimated using the most recent annual emission factor of 0.4 tCO_2/MWh from a similar project in Azerbaijan that is presently under development and adapted to the capacity of the current case study (Ministry of Energy of Azerbaijan, 2020b). Following equation used to calculate total CO_2 amount which will be avoided:

Total emissions = Total electricity generated x Emissions factor

4.2.3 Land use criteria

According to Denholm et al. (2009), the range for permanent direct impact area is around 0.06 hectares/MW to approximately 2.4 hectares/MW. Nonetheless, roughly 80% of the projects analyzed indicated direct land usage of less than 0.4 hectares/MW. The distribution of direct impact area consists of turbine area (10%), roads (79%), substation (6%), transmission (2%) and other (2%) (Denholm et al., 2009). Direct impact area is the disturbed land as a result of physical building of infrastructure and defined based on the required turbine spacing as a function of rotor diameter. So, 0.4 hectares/MW were used for the evaluation of each scenario.

4.2.4. Economic criteria

According to the Ministry of Energy of the Republic of Azerbaijan (2020b) last approved industrial scale wind power project in Azerbaijan, initial investment cost was around 1.25 M$/MW. For each scenario with multi-megawatt turbines initial investment cost of 1.25 M$/MW is assumed.

4.3 Summary of Criteria

The results of the calculations made for each criterion as described in Section 4.2 are shown in Table 1.

Table 1. Evaluation of each scenario based on the different criteria

Criteria	Direction of preferences	Units	Scenario 1	Scenario 2	Scenario 3	Scenario 4
AEP	MAX	MWh	525,600	1,051,200	1,576,800	2,102,400
CO_2 emissions avoided	MAX	tCO_2/MWh	210,240	420,480	630,720	840,960
Initial investment	MIN	mln USD	250	500	750	1,000
Land use	MIN	Hectares/MW	80	160	240	320

4.4 Stakeholders identification

The project involves the typical large number of stakeholders of various types. Four stakeholders were chosen for this study to illustrate the various preferences that genuine participants may have. This stakeholder selection is more symbolic, and its primary goal in the context of this study is to allow a form of sensitivity analysis on the criterion weights. These are described below:

- ***Renewable energy expert***
- ***Developer***
- ***Governmental body***
- ***Public***

4.4.1 Renewable energy expert

A renewable energy expert is a professional who has specific knowledge and skill in renewable energy. These professionals are well-versed in the most recent technology breakthroughs, best practices, and market trends in renewable energy. They can offer useful insights and recommendations for renewable energy projects such as feasibility studies, project design, planning, construction, commissioning and operation and maintenance. Renewable energy experts are critical stakeholders in these projects since their knowledge and skills may contribute to the project's success.

In our case, a renewable energy expert is an individual who possesses a background in thermal physics acquired from Ukraine Polytechnical University and has over 10 years of experience as a Deputy Chairman of the State Agency on Alternative and Renewable Energy Sources of the Republic of Azerbaijan, which was liquidated in 2019. The Agency was responsible for various tasks related to renewable energy. These included participation in developing and preparing public policies for creating infrastructure, creating regulatory documents, and monitoring activities in the sector. At present, this individual is operating as an independent renewable energy expert and as an energy advisor at one of the biggest construction companies in Azerbaijan “AS Group” (www.asgroup.az), which has ambitious plans for development of renewables in Karabakh region.

4.4.2 Developer

A firm or organization that has the responsibility of planning and constructing renewable energy projects is known as a developer. They often have knowledge of local legislation and incentives for renewable energy projects, as well as expertise in project management, funding, and construction. Developers find and acquire suitable locations for renewable energy projects, attract investments, manage the installation process, and supervise the project's operation and upkeep.

A developer who acts as the director of a “Provitaz Alternative Energy” LLC company in Azerbaijan's renewable energy industry was questioned during the interview. The developer has an academic background in automation and computing technologies from Sumgait State University and around 10 years of expertise in the renewable energy area. The LLC was founded by a Norwegian national who moved to Azerbaijan around 10 years ago and this is a highly reputable organization that specializes in the production of solar panels as well as other innovative forms of alternative energy technology (www.provitaz.com).

4.4.3 Governmental body

The government is concerned with ensuring a project's conclusion is ideal for all parties involved. planning for the economy, society, and environment with an eye on sustainability, all the while sticking to energy policies and working to achieve the goals that have been set.

During the criterion weighing procedure, an Advisor to the minister of Energy of the Republic of Azerbaijan was interviewed. The interviewer has a bachelor's and a master's degree in engineering economics from Azerbaijan State Oil and Industry University and has over 15 years of expertise in the energy industry. The Ministry of Energy is responsible for enforcing state policies and regulations in the fuel and energy industries as the central executive authority (www.minenergy.gov.az). The job responsibilities of an Advisor include making suggestions for improving the legal acts regulating the relevant field, analyzing relevant information, participating in the preparation of projects and other responsibilities.

4.4.4 Public

As a stakeholder in wind energy projects, the general public may be interested in environmental issues. They may be interested in learning how CO_2 amount which can be avoided during the operation of renewable energy power plants.

A Chief Adviser from the State Environmental Expertise Agency under the Ministry of Ecology and Natural Resources of the Republic of Azerbaijan, who specializes in environmental impact assessment, was interviewed to clearly clarify opinions from an environmental standpoint. The Agency is responsible for conducting state environmental assessments, which involve reviewing and approving environmental impact reports for businesses operating in accordance with the "Environmental Impact Assessment" law of the Republic of Azerbaijan (www.eco.gov.az). She graduated from the State Public Administration Academy with a foundation in international relations and more than ten years of experience in the environmental area.

The criterion preference elicitation exercise will be carried out by these four stakeholders.

4.4.5 Interviews and weights elicitation

The author used an online application to interview selected stakeholders in two rounds. The first interview was held on April 13, 2023, with a renewable energy expert who also had the position of deputy head at the State Agency on Alternative and Renewable Energy Sources. An expert recently shared his perspective on the most essential criteria in the renewable energy area. He said that the initial investment is the most crucial factor and received the highest priority with 45 points. The second most important factor is the AEP, with 30 points. Land use criteria were given 15 points, and reducing CO_2 emissions held a weightage of 10. The expert explained that the initial investment is fundamental for renewable energy projects and emphasized the importance of AEP, as it directly affects the financial viability of the projects. The criteria for land use and reduction of CO_2 emissions were also considered significant as they effect the environment and the sustainability of the project in long-term perspective.

The author held a second interview with a developer on April 14, 2023, with expertise in executing small renewable energy projects in the Karabakh region. During the discussion, the developer highlighted the most important criteria for renewable energy projects and assigned a weightage to each. According to his experience, the AEP and initial investment criteria have the most influence on the financial element of any project; thus, each criterion was assigned 30 points. The developer also mentioned the significance of land use requirements, giving them a weightage of 25 points. Reducing CO_2 emissions, on the other hand, was deemed less significant and scored 15 points.

The author interviewed a governmental body and public stakeholder on April 17, 2023. As mentioned previously, the public stakeholder was represented by an employee of an environmental agency. The government body offered its viewpoint on renewable energy project criteria, awarding AEP the highest priority with 40 points since it contributes to national goals. Because it reduces financial contribution, the initial investment received the second-highest priority with 30 points. Both land usage and CO_2 reduction received 15 points. The public stakeholders allocated weightage to each criterion in the interview with the public stakeholder based on their perspective, with CO_2 reduction and efficient land use being the essential criteria, each with 30 points, while AEP and Initial investments with 20 points each. The author acquired significant insights into the varied opinions on the criteria for renewable energy projects through interviews with both the governing body and public stakeholders. The governing body prioritized national aims, while public stakeholders emphasized the need to resolve environmental problems such as reducing emissions to the atmosphere and more efficiently managing land. Weights elicitation of all stakeholders shown in Table 2.

Table 2. Weights elicitation of the different criteria

CRITERIA / Decision-Makers	AEP	CO_2 avoided	Initial investment	Land use
	Weights			
Renewable energy expert	30	10	45	15
Developer	30	15	30	25
Governmental body	40	15	30	15
Public	20	30	20	30

4.5 MCDA results

This subchapter presents a graphical depiction of the MCDA results, with each graph indicating the preference of its particular stakeholder.

The renewable energy expert's preference is shown in Figure 6. Scenario 1 is his top choice, while Scenario 4 is least desired option.

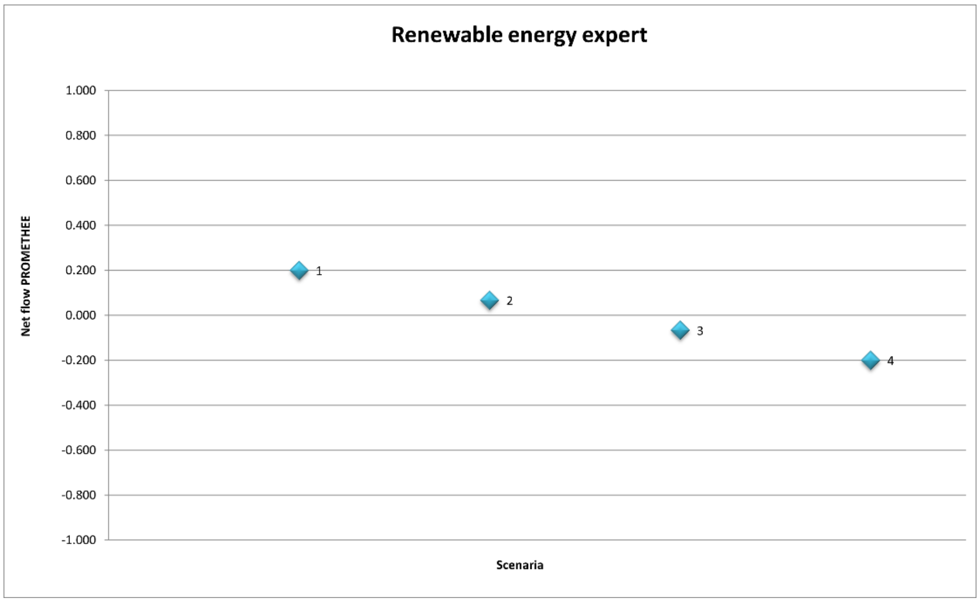

Figure 6. Renewable energy expert’s preference

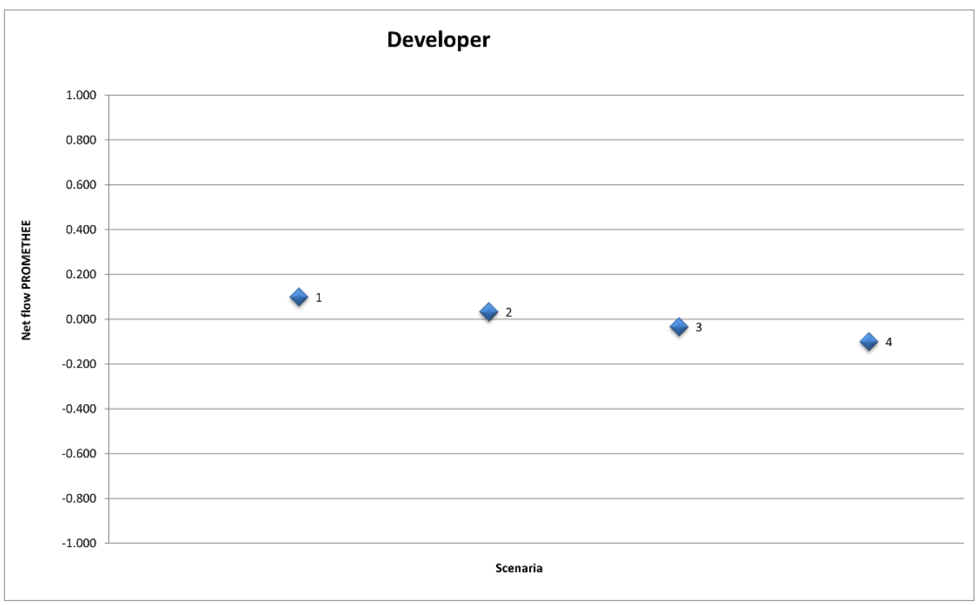

Figure 7. Developer’s preference

In Figure 7, the developer's preference shows that Scenario 1 is the most preferred option, while Scenario 4 is the least one.

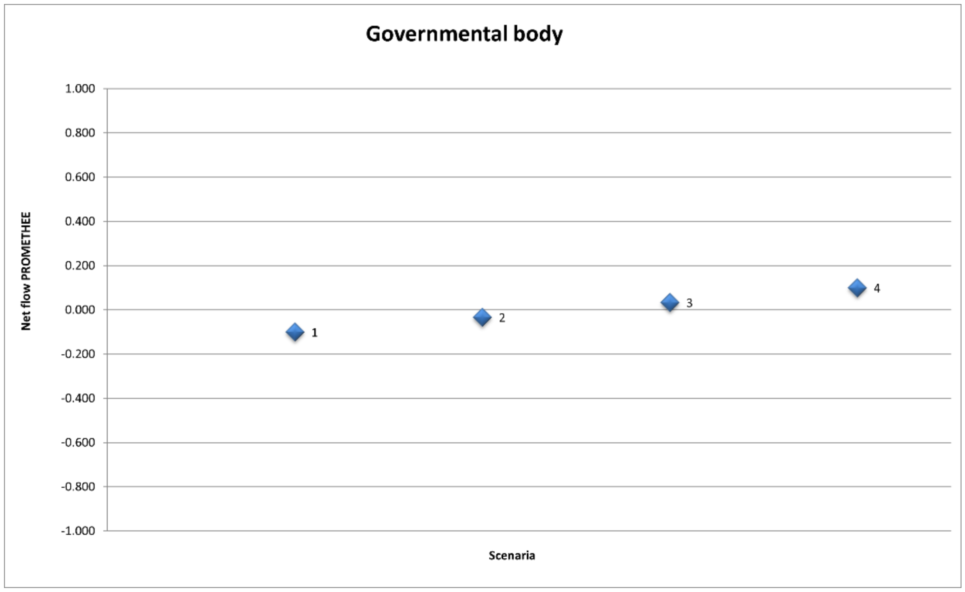

Figure 8. Governmental body’s preference

According to Figure 8, the governmental preference shows different results than previous two stakeholders. The most preferred one in Scenario 4 and the least one is Scenario 1.

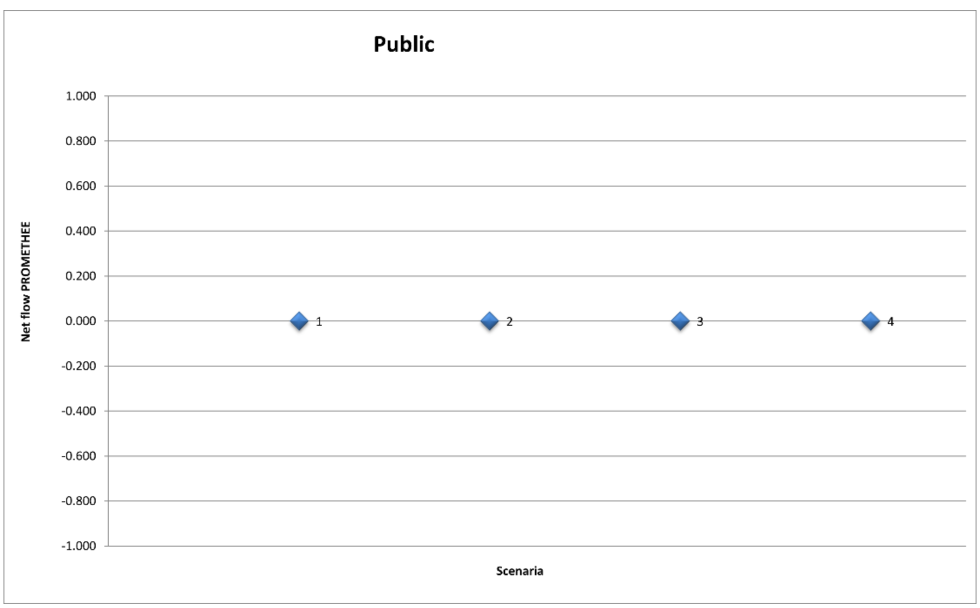

Figure 9. Public’s preference

Finally, public's preference shown in Figure 9. Based on the points which was given by the stakeholder to each criterion, the results look similar.

CHAPTER 5. DISCUSSION AND ANALYSIS

This chapter will discuss and analyze the outcomes from the previous Chapter 4, consider feedback from stakeholders and make some sensitivity analyses.

5.1 Discussion

Based on interviews with different stakeholders, it is evident that there are multiple opinions on the most important criteria for renewable energy projects. Renewable energy expert rank initial investment as the most critical aspect, followed by AEP and land usage, with CO_2 reduction seen as the least crucial. The developer places a high value on AEP, and initial investment, but the governmental body prioritizes AEP first, followed by the initial investment. On the other hand, the public stakeholder prioritizes CO_2 reduction and efficient land use.

To provide a comprehensive perspective, it is evident that renewable energy experts prioritize the initial investment criteria when it comes to the development of renewable energy projects. This preference highlights their pragmatic approach and emphasizes the importance of considering economic factors in the decision-making process. It's interesting to note that when investing in renewable energy projects, the investment criteria can vary depending on the specific circumstances of each wind energy project. For example, if we take Scenario 1 with 200 MW capacity, a lower investment criterion may be more beneficial due to lower operational costs, land leasing costs or easier permitting requirements. However, if we look at a Scenario 4 with 800 MW capacity, the initial investment criterion may still be a priority, despite the higher overall cost. This is because large industrial wind energy projects can have advantage of economies of scale, leading to lower LCOE and increased revenue with a higher AEP. It's essential to consider these factors as well, when making decision on the investment for a wind energy project.

Depending on the size and specific circumstances of a wind energy project, developers may have varying preferences for specific criteria that can impact their decision-making process. For instance, in smaller projects like Scenario 1, both the initial investment and annual energy production criteria may be equally important for developers.

On the other hand, in larger projects like Scenario 2, developers may prioritize other factors like land use and CO_2 reduction, which have a greater impact on the environment and local communities. It's important to note that the preferences of smaller wind energy project developers may differ from those of larger companies. This may be due to differences in available resources and experience implementing large-scale industrial projects. Ultimately, prioritizing specific criteria will depend on each project's unique circumstances and each developer's goals. As such, careful consideration and analysis of all relevant factors are crucial to ensure the success and sustainability of any wind energy project.

When the governmental body assesses various renewable energy projects, including wind energy projects, several criteria come into play. For instance, it is understandable that the AEP criterion is given more weight as it aligns with Azerbaijan's national renewable energy target. Similarly, the initial investment required to execute the project may be considered a priority to reduce the financial burden on the government and other stakeholders. It is worth noting that Azerbaijan currently prioritizes attracting investments from abroad for renewable energy development (Brasier, 2022). As mentioned in Chapter 2, on the 14th of July, 2021, the President of Azerbaijan officially signed the "On the Use of Renewable Energy Sources in the Production of Electricity" into law, along with a Presidential Decree that provides further details on the implementation of this Renewable Energy Law. This law seeks to provide various support mechanisms for renewable energy, including but not limited to guaranteed tariffs, foreign investment, scientific research, and the promotion of active consumers. One key aspect of this law is that it provides for two methods of selecting investors for renewable energy generation: auctions and direct negotiations. This means that interested parties can choose to participate in auctions where the investor with the most competitive bid wins the project, or they can opt for a more traditional method of direct negotiation. In addition to these factors, the government also favor projects that have a significant impact on the environment and local communities, such as those that address land use and CO_2

reduction. Furthermore, job creation and economic growth are also essential considerations during the evaluation process.

An interview conducted with the representative of the environmental agency on the preferences of the public regarding renewable energy projects has revealed that several factors influence the decision-making process. These factors encompass a range of considerations, including environmental concerns, social impacts, and economic benefits. Among these, it was found that the public is particularly focused on criteria that positively impact the environment, such as reducing CO_2 emissions and minimizing land use. As mentioned earlier, at the recently concluded 26th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP26) held in Glasgow, Azerbaijan made a bold and ambitious pledge to reduce greenhouse emissions gas emissions by a whopping 40% by the year 2050. During the conference, the country's representative deputy minister of Ecology and Natural Resources Rauf Hajiyev made this announcement. Moreover, the country has also planned to establish a zero-emission zone in its liberated territories (Hajiyev, 2021). In addition to this, the representative from the public also places a high value on criteria that benefit the local community, such as job creation and economic development.

Wind energy projects are undeniably complex and involve various perspectives due to multiple criteria. However, it is imperative to understand that environmental concerns must be taken seriously, just as financial factors are crucial. Finding a balance between these two considerations is of utmost importance to promote sustainable renewable energy development in Azerbaijan.

5.2 Feedback and sensitivity analysis

The author conducted a second round of interviews with the stakeholders. He shared the ranking results with them and asked for their feedback. The author also inquired if the stakeholders wanted to adjust the weighting points.

The interview with the expert in renewable energy was on the 4th of May 2023, and he agrees that Scenario 1, with a capacity of 200 MW, is the most suitable option for the Karabakh region at present. He notes that there is insufficient grid infrastructure to export large capacities from Karabakh. He believes that 200 MW is sufficient for the current pace of resettlement in Karabakh until 2030. However, he acknowledges that exporting green energy will take more time due to the need for an extensive network of high-voltage power lines and a new export line.

However, at the same day during the interview the developer did not agree with the results of the evaluation, which indicated that Scenario 1 was the preferred option. According to the developer, maximizing AEP and minimizing land usage are crucial for their revenue. Therefore, the developer altered the weights assigned to each criterion, giving 50 points to AEP, 20 points to land usage, and 15 points to each of the remaining criteria. Figure 10 displays the updated ranking of the developer's preferences.

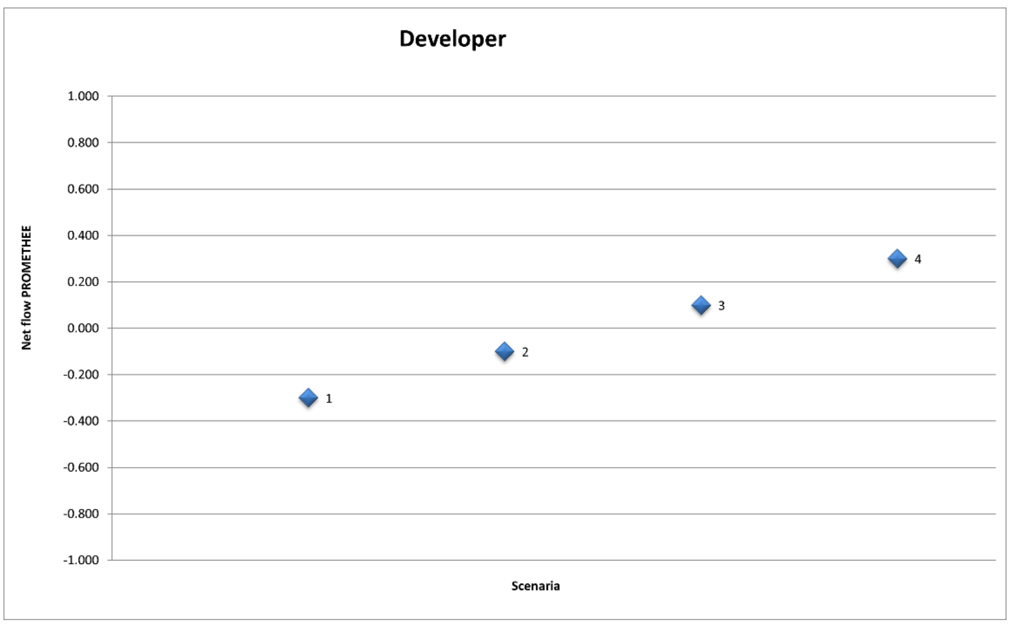

Figure 10. Developer’s revised preference (sensitivity analysis)

On May 8, 2023, there was a second interview with a governmental body. After reviewing the results, he agreed that Scenario 4, which has a capacity of 800 MW and the highest AEP, is crucial for meeting national goals and targets in the renewable energy field. He noted that this result is a huge step forward in our country's pursuit of a sustainable and green future.

In the last round of the decision-making process, which took place on May 9, 2023, a representative from the environmental agency was interviewed to discuss the results of the various scenarios presented. However, during the conversation, she expressed her disagreement with the results as none of the scenarios seemed to have a clear preference. All the options were ranked equally, which made the decision-making process more complicated. To address this issue, the representative made some adjustments to her weightings by giving 45 points to the land use criteria, 30 points to CO_2 reduction criteria, 15 points to AEP and 10 points to initial investment criteria. She also explained her choice with the fact that being an expert of the expertise service, during initial assessment they prefer firstly land use, then CO_2 reduction, AEP and lastly, initial investment. According to her, economic considerations are not a priority for the public, and the results indicated that Scenario 1 stands out due to its low land use (see Figure 11). They assess the fact that how efficiently can be used each hectare of the land.

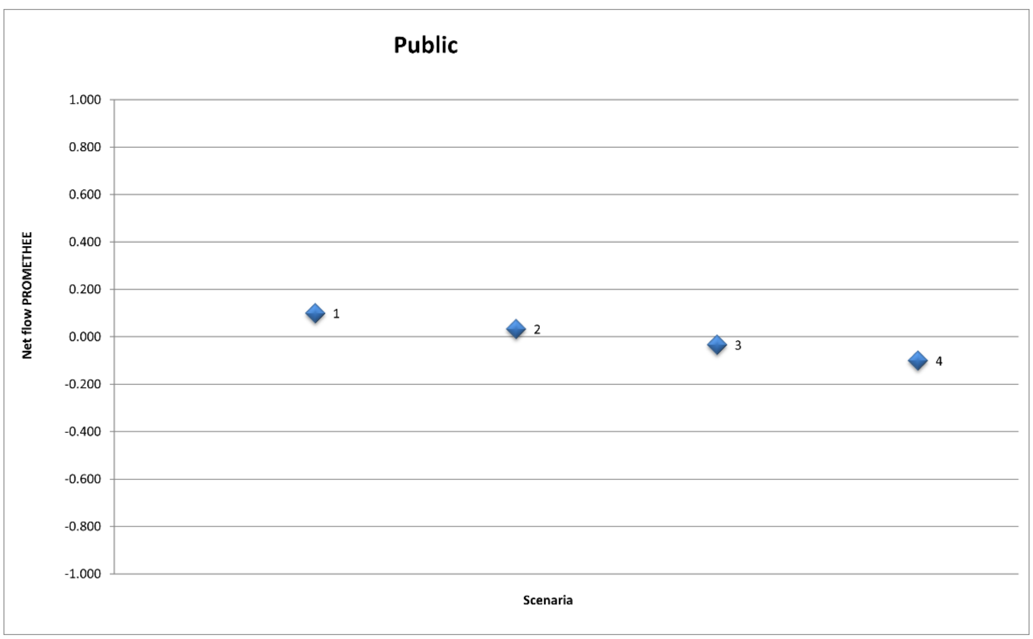

Figure 11. Public's revised preference (sensitivity analysis)

When it comes to wind energy projects, sensitivity analysis is an incredibly important tool that is utilized for the purpose of making informed and effective decisions.

Essentially, sensitivity analysis allows project stakeholders to assess how various changes to different project criteria can impact the overall outcome of the project. These criteria might include things like initial investment, land use, CO_2 reduction, and annual energy production. By conducting sensitivity analysis, stakeholders are able to evaluate the decision-making process in a more reliable and comprehensive way, while also identifying any associated risks or uncertainties. Given the fact that wind energy projects often involve multiple stakeholders with different priorities and interests, the ability to conduct sensitivity analysis is absolutely essential to ensuring project success and viability.

To support above mentioned aspect and assess robustness of MCDA approach, the author conducted two additional sensitivity analysis, wherein they added 10 points to the AEP criterion and subtracted 10 points from the less significant criteria for each stakeholder's initial weighting. The results of this analysis were quite revealing. Specifically, the renewable energy expert and developer had consistent rankings across all scenarios. However, the developer's preferences changed significantly after the analysis. Initially, the developer favored Scenario 1, but after the sensitivity analysis, they ranked all scenarios equally (see Figure 12). On the other hand, the public exhibited a clear preference for Scenario 4 (see Figure 13).

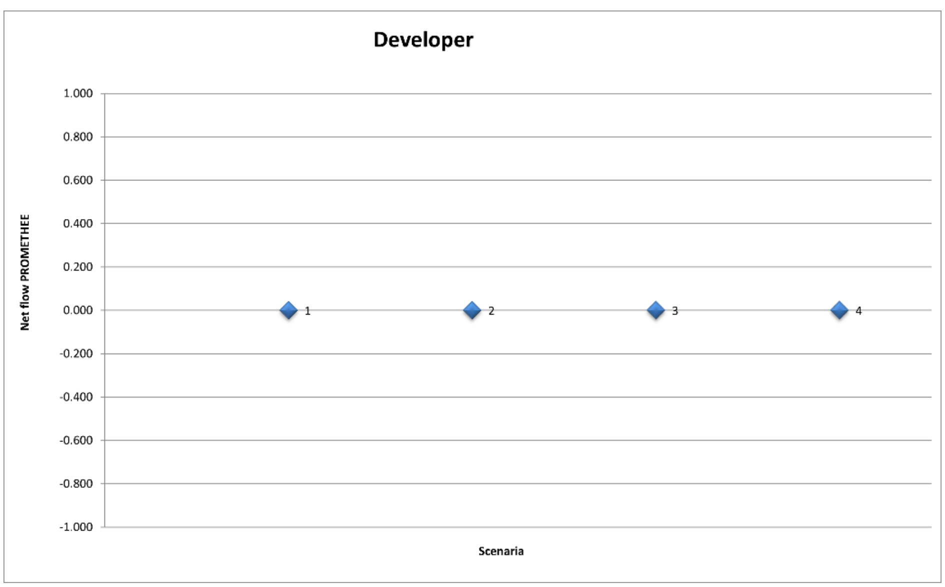

Figure 12. Developer's preference (sensitivity analysis-1)

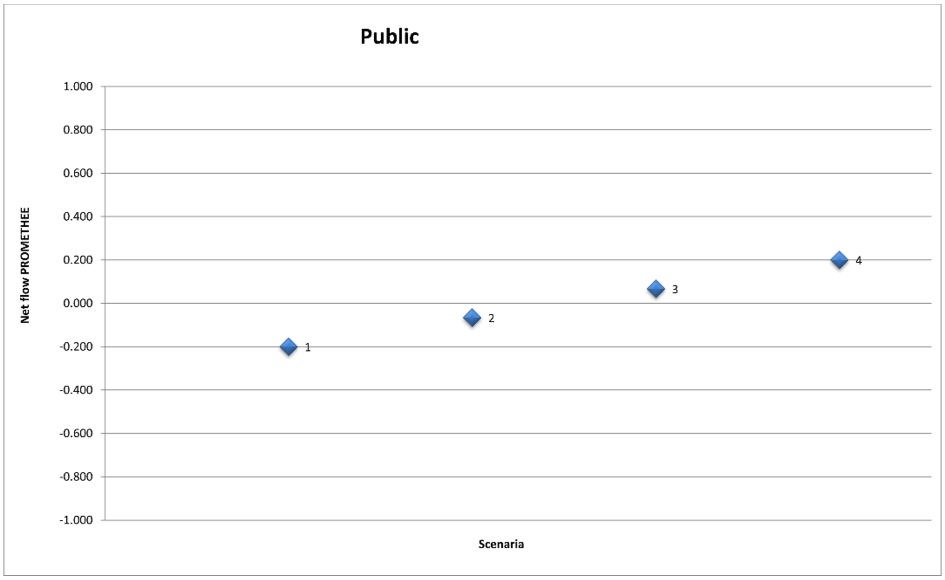

Figure 13. Public's preference (sensitivity analysis-1)

The importance of taking into account environmental factors was highlighted in a second analysis. The initial stance of the renewable energy expert and the governmental body involved in the project favored Scenario 1 and Scenario 4, respectively, based on investment and AEP criteria. However, when CO_2 emissions criteria were prioritized in the analysis, rankings for both parties shifted, with no significant difference in preference for each scenario. Interestingly, the developer's preference changed from Scenario 1 to Scenario 4 (see Figure 14), while the public also expressed a preference for Scenario 4 (see Figure 15).

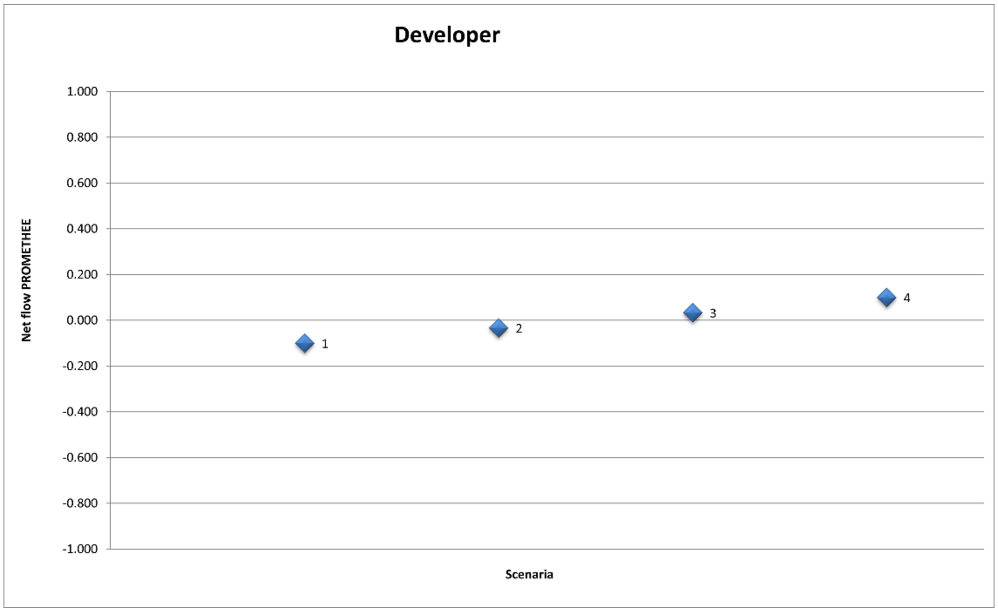

Figure 14. Developer's preference (sensitivity analysis-2)

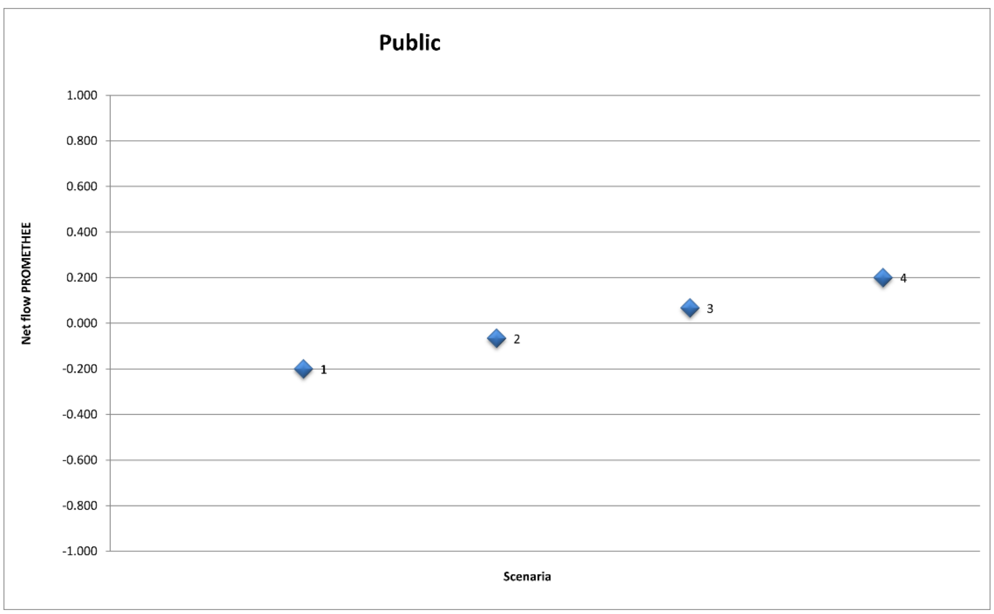

Figure 15. Public's preference (sensitivity analysis-2)

CHAPTER 6. CONCLUSIONS

The study's primary aim was to conduct an analysis of the different scenarios for wind energy development in the Karabakh region of the Republic of Azerbaijan. The MCDA method PROMETHEE II was used to rank the scenarios. To achieve this goal, the author first identified four critical criteria based on which various scenarios were created, primarily dependent on the installed capacity of the assumed wind energy projects. The study sought to gather valuable inputs from a number of diverse stakeholders, such as a renewable energy expert, a developer, a member of a governmental body, and the general public. To accomplish this, the author adopted a two-round interview process that involved a comprehensive discussion of the criteria, ranking of the scenarios based on their overall performance, and gathering feedback from the real stakeholders. In the first round, criteria were weighted and scenarios were ranked. The second round involved presenting the results to stakeholders and soliciting opinions and feedback on the ranking. Based on the findings of the initial interviews, stakeholders reviewed and modified their initial preferences in the second round of interviews. The second interviews offered more information and viewpoints, which helped to clarify their priorities with reference to wind energy scenarios. This iterative procedure enabled more accurate scenario evaluation and better-informed comments. In addition, author conducted a sensitivity analysis to make sure the results of the stakeholder interviews were accurate. To examine the effects on the rankings and spot prospective adjustments, author adjusted the weights given to the criteria used to evaluate wind energy scenarios. This revealed details about the various stakeholder preferences and how they affect rankings.

Findings of this study revealed that stakeholders' preferences and priorities had a significant impact on scenario ranking. It was noted during the second round of interviews that some stakeholders changed their initial weightings in light of the outcomes. This shows that the PROMETHEE II method is flexible to accommodate changings for assisting decision-making among stakeholders. It is vital to recognize that the altered weightings could have also been influenced by other external factors or new information. This highlights the value of maintaining ongoing stakeholder interaction and the need for a flexible approach in decision-making processes. The author also discovered that changing criteria weight significantly impacted scenario rankings as well. This study provides valuable insights for policymakers and stakeholders in developing sustainable energy strategies for Azerbaijan. It enhances our understanding of the potential for wind energy in the region.

It is important to note that study's findings may not represent all relevant stakeholders' views due to the limited number of participants interviewed. Moreover, author focused only on wind energy development and did not consider Karabakh's other renewable energy sources potential or their integration into the energy system. In addition to the criteria that were evaluated, it is possible that there are other influential criteria that were not taken into account. Also, due to time constraints, it wasn't possible to conduct a more in-depth analysis of the scenarios or gather a larger sample size for the stakeholder interviews. These unconsidered factors could have a substantial impact on the decision-making process. It is crucial to recognize the potential limitations of any future research could delve into these areas in more detail.

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