

**SOLAR POWER PLANT INVESTMENT STRATEGY ASSESSMENT WITH
COST BENEFIT ANALYSIS: A CASE OF RETAIL COMPANY IN TURKEY**

(FAYDA MALİYET ANALİZİ İLE GÜNEŞ ENERJİSİ SANTRALİ YATIRIM
STRATEJİSİNİN DEĞERLENDİRİLMESİ: TÜRKİYE’DE BİR PERAKENDE
FİRMASI ÖRNEĞİ)

by

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Thesis

Submitted in Partial Fulfillment
of the Requirements
for the Degree of

MASTER OF SCIENCE

in

INDUSTRIAL ENGINEERING

in the

GRADUATE SCHOOL OF SCIENCE AND ENGINEERING

of

GALATASARAY UNIVERSITY

Supervisor: Dr. İlke Bereketli

Feb 2024

ACKNOWLEDGEMENTS

I would like to express my endless gratitude to my mother, father, and Hazal Erdil for their unwavering support in writing this thesis.

Also, the contributions of my thesis advisor, Dr. İlke Bereketli, in completing this thesis are invaluable, thanks to her always supportive attitude and logical approaches.

I hope that this thesis will prove to be a correct source for those who will conduct research in this field in the future.

With gratitude,

Feb 2024

Semih AVŞAR

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LIST OF SYMBOLS

CBA	: Cost Benefit Analysis
NPV	: Net Present Value
IRR	: Internal Rate of Return
WACC	: Weighted Average Cost of Capital
MWp	: Megawatt Pick
MWh	: Megawatt hour
KWh	: Kilowatt hour
GW	: Gigawatt
USD	: United States Dollar
TRY	: Turkish Lira

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ABSTRACT

In Turkey and around the world, increasing energy prices and the problems of climate change brought by carbon emissions are driving countries towards investments in renewable energy sources. Especially after the Covid-19 pandemic and the Russia-Ukraine war, the increase in energy prices has made the shift to renewable energy sources more important than ever. Among renewable energy investments, solar and wind energy lead compared to other types of clean energy. However, even if long-term returns are obtained, investment costs have still not fallen below expectations worldwide. The efforts to zero out carbon emissions and reduce the costs created by energy prices through these investments continue with incentives provided by governments. Turkey is among the countries that have started significant efforts in this area. Especially, the incentives that cover up to 50% of the investments and Turkey being one of the leading countries in the world in terms of wind and solar energy potential are the main reasons that pave the way for these investments in Turkey. The strategy of offsetting with clean energy power plants that retail companies in Turkey, which have started to focus on renewable energy investments due to both the reduction in dependence on external energy and other factors, can establish for the electricity used in their many stores spread across the country, is another factor that encourages investments in this area. In this thesis, a study has been conducted on how to proceed with the cost benefit analysis method for the investment strategies to be determined by a retail company in Turkey with more than 3000 stores and an annual energy consumption of more than 700,000 MWh for a solar power plant investment. By examining the data on which option is the best for a solar power plant that can be established entirely with equity, with credit, or through an energy company, a conclusion has been reached through cost benefit analysis, and the differences between the options have been evaluated and opened for discussion.

ÖZET

Türkiye’de ve Dünyada artan enerji fiyatları ve karbon emisyonlarının getirdiği iklim değişikliği problemleri ülkeleri yenilenebilir enerji kaynağı yatırımlarına yöneltmektedir. Özellikle Covid-19 pandemisi ve Rusya-Ukrayna savaşı sonrası artan enerji fiyatları yenilenebilir enerji kaynaklarına yönelimi her zamankinden önemli hale getirmiştir. Yenilenebilir enerji yatırımlarında ise güneş enerjisi ve rüzgar enerjisi diğer temiz enerji türlerine göre başı çekmektedir. Ancak uzun vadede geri dönüşleri alınsa dahi yatırım maliyetleri hala dünyada beklentilerin altına düşmemiştir. Bu yatırımların göze alınarak uzun vadede yenilenebilir enerji sayesinde karbon emisyonunu sıfırlamaya ve de enerji fiyatlarının oluşturduğu maliyetleri düşürmeye yönelik çalışmalar hükümetlerin sağladığı teşviklerle devam etmektedir. Türkiye de bu konuda önemli çalışmalara başlamış ülkelerden biridir. Özellikle yapılan yatırımların %50 oranına kadar sağladığı teşvikler ve rüzgar ile güneş enerjisi potansiyeli konusunda dünyanın önde gelen ülkelerinden biri olması, Türkiye’de bu yatırımların önünü açan başlıca sebeplerdir. Hem enerjide dışa bağımlılığın azalması hem de diğer faktörler gereği yenilenebilir enerji yatırımlarına önem vermeye başlayan Türkiye’de perakende firmalarının ülke geneline yayılan bir çok mağazasının kullandığı elektrik için kurabilecekleri temiz enerji santralleriyle mahsuplaşma stratejisi, bu konudaki yatırımları teşvik edici diğer unsurlardan biridir. Bu tezde Türkiye’de 3000’den fazla mağazası ve yılda 700.000 MWh’dan fazla enerji tüketimi olan bir perakende firmasının güneş enerjisi santrali yatırımı için belirleyeceği yatırım stratejileri maliyet-fayda analizi yöntemiyle masaya yatırılarak nasıl adım atılması gerektiğine dair bir çalışma yapılmıştır. Tamamen özkaynak, kredili ya da enerji firması aracılığıyla kurulabilecek bir güneş enerjisi santrali için en iyi opsiyonun hangisi olduğuna dair veriler incelenerek maliyet fayda analizi sayesinde bir çıktıya ulaşılmış ve buna göre opsiyonlar arasındaki farklılıklar değerlendirilerek tartışmaya açılmıştır.

1 INTRODUCTION

This thesis aims to thoroughly examine the importance and effectiveness of renewable energy sources in today's world, where energy consumption is increasing, especially in the retail sector in Turkey, and includes an analysis of investments to be made in this direction. Turkey has a significant potential, especially in solar and wind energy, and this study will investigate and examine how a retail chain with more than 3000 stores and an annual energy consumption of over 700,000 MWh can utilize this potential. The thesis evaluates investments in renewable energy sources in terms of energy policies, economic sustainability, environmental impacts, and business strategies. The research includes a cost benefit analysis (CBA) of solar alternatives, aiming to highlight economic efficiency in the selection of investment types.

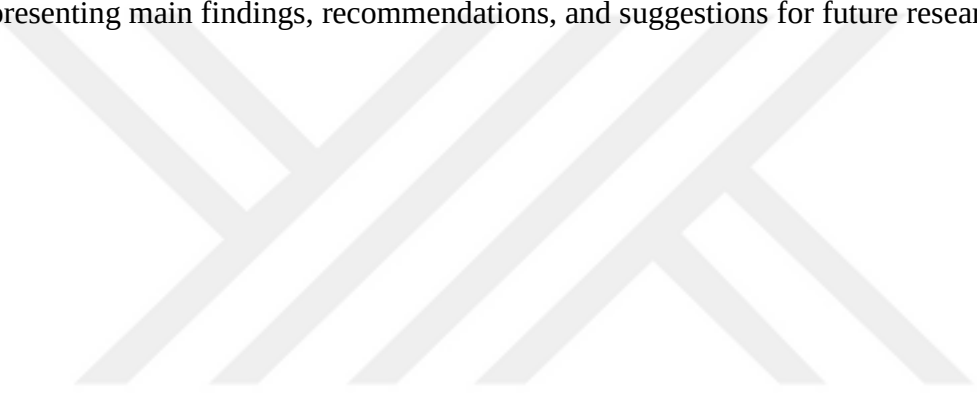
This thesis comprehensively analyses the process of a major retail chain in Turkey investing in renewable energy sources and to assess the cost-effectiveness and environmental sustainability of this process. A CBA of solar energy alternatives will help determine the efficiency of these energy investment types and their suitability for the retail sector. This analysis will reveal the balance between environmental and economic sustainability in the choice of investment types. The thesis also offers recommendations for strategic planning and policy-making in energy investments. The outcome of the study aims to provide valuable insights into the challenges and opportunities that retail companies in Turkey will face when investing in renewable energy sources. This information will be a guide not only for Turkey's retail sector but also for energy policies and sustainable development strategies in general.

The primary motivation of this study is to understand how renewable energy sources can be effectively utilized in the retail sector in Turkey, and to assess the economic and environmental impacts of this usage. In the fight against global warming and climate change, managing energy consumption through sustainable methods have vital importance. Turkey is taking serious steps towards reducing its dependency on fossil fuels and meeting its increasing energy demand. This thesis aims to offer sustainable solutions, both environmentally and economically, by deeply examining the role the retail sector can play in energy efficiency and sustainability. In particular, Turkey's geographical location and climatic features enhance the potential of renewable energy sources like solar energy. Assessing the cost-effectiveness and environmental impacts of these resources aims to guide decision-makers in the sector. The diversification of energy sources and the transition to renewable energy are also have great importance in terms of Turkey's energy security and sustainable development goals.

The original contributions of this study to the literature vary in the areas of energy and environmental policies, economic analyses, and strategic planning. On one hand, it offers a comprehensive analysis of Turkey's energy use and the current policies regarding renewable energy sources, while on the other hand, it specifically addresses the energy needs of the retail sector and the potential for renewable energy usage. This analysis explores the balance between environmental sustainability and economic efficiency in the selection of energy sources, contributing to policymaking in this field. Additionally, considering Turkey's geographical and climatic features, it presents a cost benefit analysis of investments in solar energy. This expands the current literature focused on general energy consumption and provides a detailed case study on the energy consumption of the retail sector and the process of investing in renewable energy sources.

Following the introduction, the thesis continues with a section titled 'Background' This part discusses renewable energy sources, fossil fuels and global transition to renewables while investigating investment effects. This section also examines the trends of energy consumption at the global and national levels, Turkey's access to energy resources, and the economic, environmental, and political impacts of these factors. The 'Literature Review' section of the research thoroughly examines the existing literature on renewable energy, energy policies, and the energy usage of the retail sector, laying the groundwork

for the thesis's methodology and analysis sections. The 'Analysis of Sectoral Renewable Energy Investments by Retail Companies' section discusses the energy consumption profile of the retail sector and the potential for renewable energy usage in this sector, enriched with examples of energy usage in retail sectors in Turkey and worldwide. The 'Methodology and Modeling' section details the research methods, datasets used, and analysis techniques of the thesis. The 'Problem Assessment' and 'Application' sections examine the energy strategy of the selected retail company, modeling of investment decisions, and the feasibility of these decisions. Finally, the 'Results and Discussion' section evaluates the modeling and analysis results and their impact on the retail sector and renewable energy policies. The thesis concludes with the 'Conclusion' section, presenting main findings, recommendations, and suggestions for future research.



2 BACKGROUND

2.1 Fossil Fuels and Renewable Resources

2.1.1 Fossil Fuels

Fossil fuels are energy sources formed hundreds of millions of years ago from the decay of organic material underground. There are three main types: Coal, oil, and natural gas. Coal has been used for energy production for a long time. It is burned in power plants to generate electricity. However, burning coal produces a large amount of greenhouse gas emissions and air pollution. Oil is a fundamental resource for transportation, energy production, and the chemical industry. It is used as fuel for vehicles like cars, airplanes, and ships. However, being a limited resource, oil causes price fluctuations. Natural gas is used for heating, electricity production, and industrial processes. It is a cleaner energy source compared to other fossil fuels, but natural gas reserves are also limited¹. Worldwide, fossil fuels are still the most commonly used energy sources. As of 2022, 61% of the world's energy production comes from fossil fuels (<https://ourworldindata.org/fossil-fuels>, Accessed: November 2023). In Turkey, fossil fuel usage amounted to 1580 TWh in 2022, accounting for 81% of total energy use (<https://ourworldindata.org/fossil-fuels>, Accessed: November 2023), with particularly high consumption of coal and natural gas.

Fossil fuel consumptions have dramatically increased because of the global development (Azni et al., 2023). As Ritchie and Rosado (2017) included in their article that the consumption levels and statistics of fossil fuels worldwide in 2022 can be seen in Figure 2.1:

¹ <https://www.energy.gov/fossil>

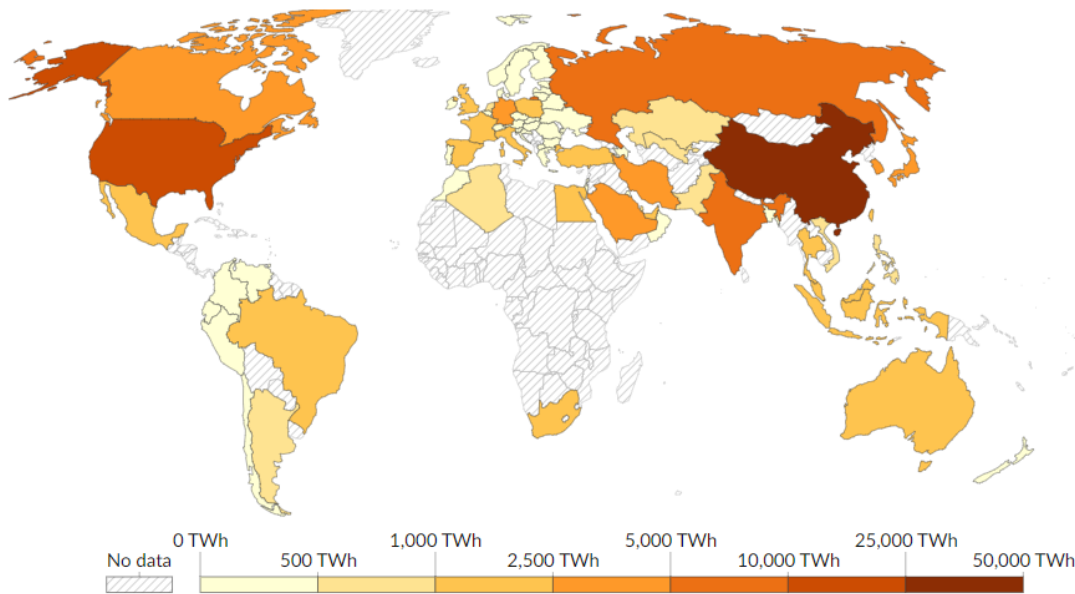


Figure 2.1: Levels of fossil fuel consumption by country in 2022

The advantages of fossil fuels include their abundant reserves, the ease with which they can be integrated into existing energy infrastructure, and their relative economic affordability². However, the disadvantages of fossil fuels include their contribution to greenhouse gas emissions, which leads to climate change, the creation of air and water pollution, and their status as a limited resource, which could lead to supply issues in the future. As Ajide and Mesagan mentioned in their article the problems related to climate change and environmental pollution mostly occur from fossil fuel consumption of human being that causing high amount of carbon emissions (2022).

2.1.2 Renewable Energy Resources

Renewable energy sources are derived from nature and are continuously replenished. It can be gathered from wide range of sources by different methods and transmit into different form of energy (Desmukh et al., 2023). The main types are solar energy, wind energy, hydroelectric energy, geothermal energy, and biomass energy.

Solar energy is obtained through solar panels and used for electricity generation and heating. Solar energy is versatile, powering everything from small household systems to large solar farms and even providing heat for industrial processes. Wind energy is

² <https://www.eesi.org/topics/fossil-fuels/description>

produced with wind turbines and is widely used for electricity generation. Wind farms, both onshore and offshore, are becoming increasingly common and contribute significantly to the global energy mix. Solar and wind energy production have been proved to be the most logical and easy to obtain payback option among the all renewable options (Islam et al. 2023). Hydroelectric energy uses water resources to generate electricity, employing dams and water turbines. While large-scale hydroelectric plants are effective, they sometimes raise environmental and social concerns. Geothermal energy is produced by utilizing the heat from beneath the earth's surface and is used for heating and electricity generation. While its application depends on geographical conditions, it provides a reliable and constant energy source. Biomass energy is produced using organic matter, plant, and animal residues. Biomass can be converted into biofuels like ethanol and biodiesel or burned directly to produce heat and electricity³.

2.1.3 Usage and Potentials of Renewable Energy Sources

The information collected from “United Nations” web site explains the details of renewable sources as below:

Solar Energy: Commonly used in areas with abundant sunlight, especially through panels installed on rooftops. Large-scale solar power plants can be established in deserts and wide-open spaces.

Wind Energy: Coastal regions and open lands are ideal for wind energy. Large wind farms can generate significant energy.

Hydropower: Dams built on large rivers are primarily used for energy production. Small-scale hydroelectric systems can be installed on small rivers.

Biomass Energy: Used for waste management and energy production in areas with intense agricultural activities.

³ <https://www.un.org/en/climatechange/what-is-renewable-energy>

Geothermal Energy: Volcanic areas with high geothermal activity are suitable for this energy.

Renewable energy sources are increasingly being used today. They are preferred for their sustainability, environmental benefits, and increasing efficiency. The utilization of fossil fuels have big portion in emerging countries which is an important concern all around the world in terms of environmental and climate consequences (Naimoglu, 2023). Because of this, the share of renewable energy sources is growing every year. Their most significant advantages include reducing greenhouse gas emissions since they are clean energy sources, their unlimited and continuous renewability, and long-term cost savings. Disadvantages include high initial investment costs, storage and transmission challenges, and the risk of some renewable sources causing local environmental damage.

2.2 Global Energy Transition

In the future, it is expected that fossil fuels will be gradually reduced and replaced with increased renewable energy sources. This is important for combating climate change and ensuring energy security. Moreover, the development of energy storage technologies will make renewable energy even more effective (Elkadeem et al. 2019). From an environmental standpoint, the use of fossil fuels leads to climate change and environmental pollution. Renewable energy sources, on the other hand, reduce or eliminate these negative impacts. Consequently, in the future, there will be a need to shift away from fossil fuels and focus more on renewable energy sources for energy production and consumption. This transition can provide many benefits from economic, environmental, and social perspectives. However, it also involves challenges and requires investment as part of the transition process. Policy, economic, and technological factors can influence the speed of this transformation. International agreements like the Paris Agreement aim to reduce greenhouse gas emissions and support carbon-neutral goals, creating a factor that influences the speed of this transformation. As Osman et al. (2023) mentioned in their article that renewable energy sources play a crucial role to meet the Paris Agreement 2°C target. Additionally, the development of energy storage technologies and strengthening of grid connections can enable more effective use of renewable energy.

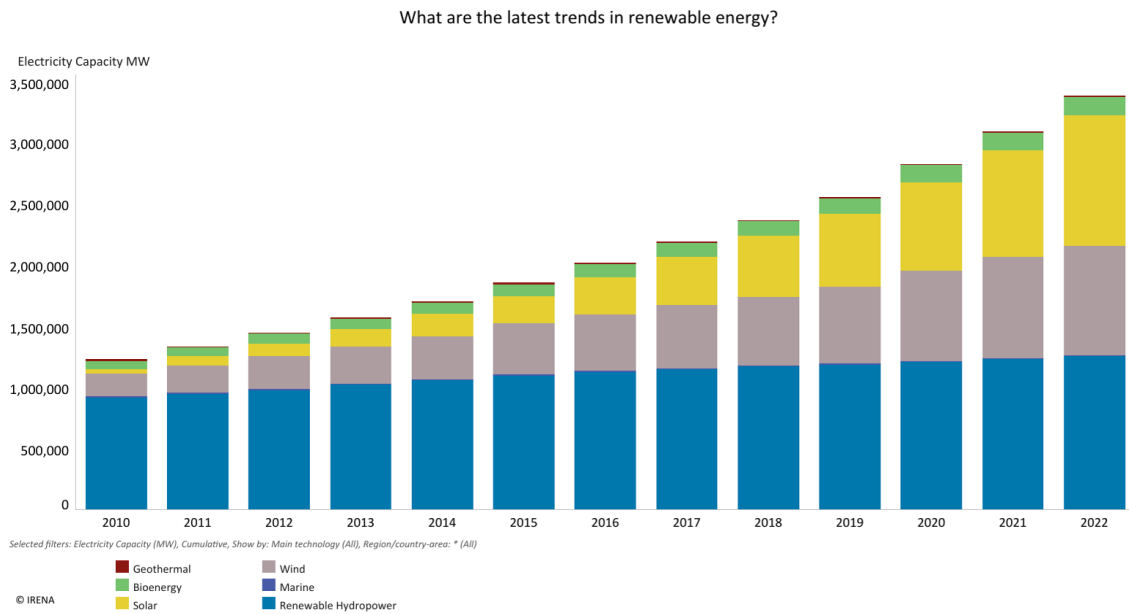


Figure 2.2: The world's total renewable energy capacity, changes over the years

According to the information obtained from “International Renewable Energy Agency” (<https://www.irena.org/> website as of November 2023), as seen in Figure 2.2, as of 2022, the global renewable energy capacity has reached a total of 3.4 terawatts (TW). This includes 898 GW from wind, 1.06 TW from solar, 1.25 TW from hydroelectric, 150 GW from bioenergy, and 14 GW from geothermal energy.

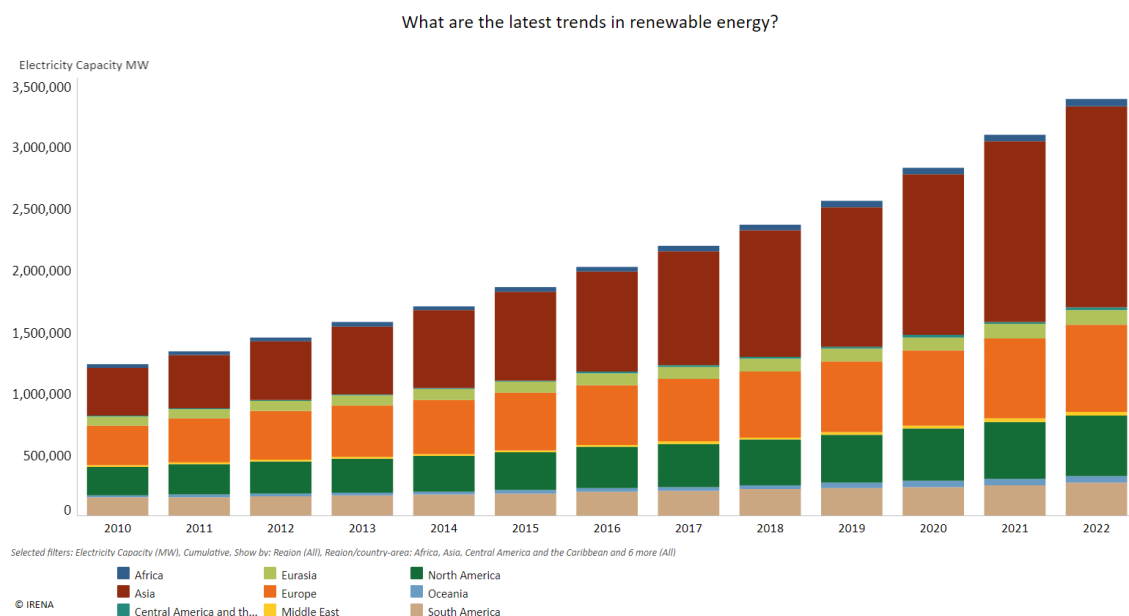


Figure 2.3: Distribution of total renewable energy capacities across continents

In Figure 2.3 which is captured from international renewable agency as well, it can be seen that 1.6 terawatts (TW) of the total renewable energy capacity are located in Asia, 705 gigawatts (GW) in Europe, 490 GW in North America, and the remaining 267 GW is spread across other continents.

As can be seen in Figure 2.4, in 2022, a total of 189 GW of solar and 73 GW of wind energy capacity were added worldwide, while in 2011, the additions were 32 GW for solar and 39 GW for wind (IRENA, access: November 2023).

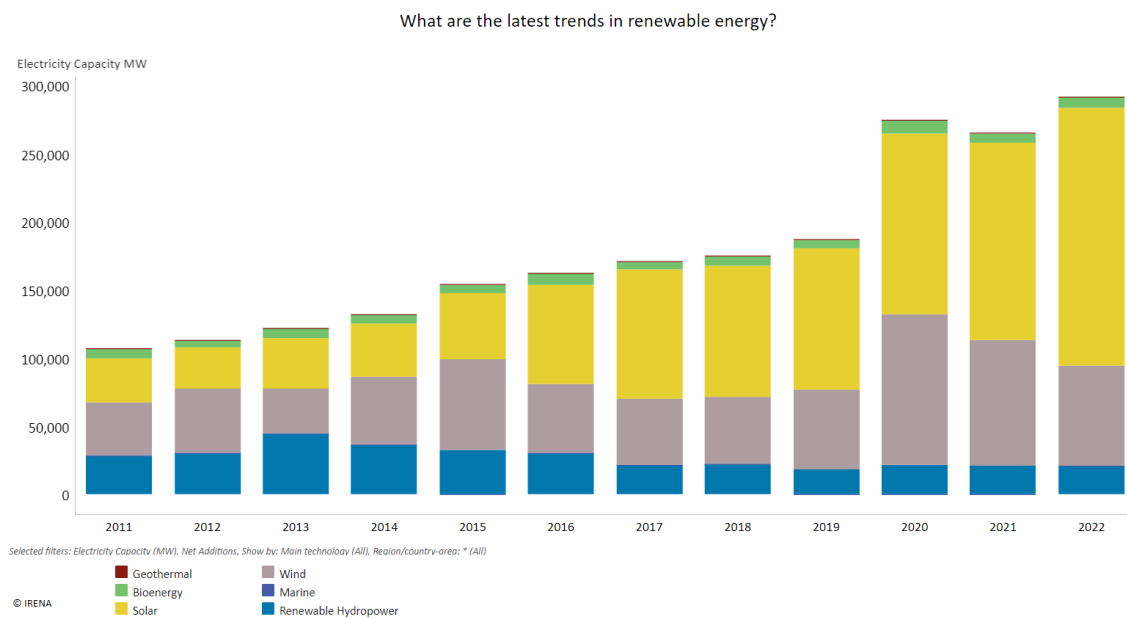


Figure 2.4: Increase in renewable energy capacity over the years

From this, it can be concluded that the rate of increase in renewable energy capacities is rising each year globally. Especially, solar energy capacities are experiencing a higher rate of increase over the years, and the impact of the economic uncertainties following the global Covid pandemic starting in 2020 can be observed with the relatively lower capacity increases in the years before 2020.

The world's advanced economies are achieving renewable energy transition faster than other countries. One of the main reasons for this is that countries with higher financial power can make the transition more easily due to the high cost of investments. As can be seen in Figure 2.5 (IRENA, access November 2023), as of the end of 2021, China is the country with the highest solar energy capacity in the world, with 393 GW. It is followed

by the USA with 113 GW, Japan with 83 GW, Germany with 66 GW, India with 63 GW, Australia with 30 GW, Italy with 25 GW, Spain with 24 GW, South Korea with 24 GW, and Spain again with a capacity of 20 GW.

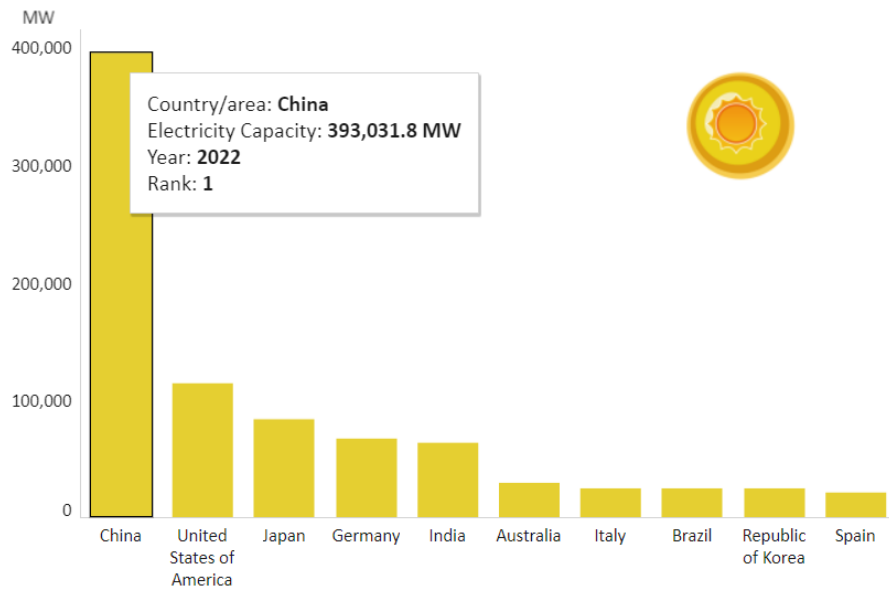


Figure 2.5: Countries by solar energy capacity size in 2022

When countries are examined based on their wind energy capacities, similar rankings can be observed, although Germany shares the third position in this category, unlike in solar energy, where it is ranked fourth. Additionally, Japan does not appear on this list.

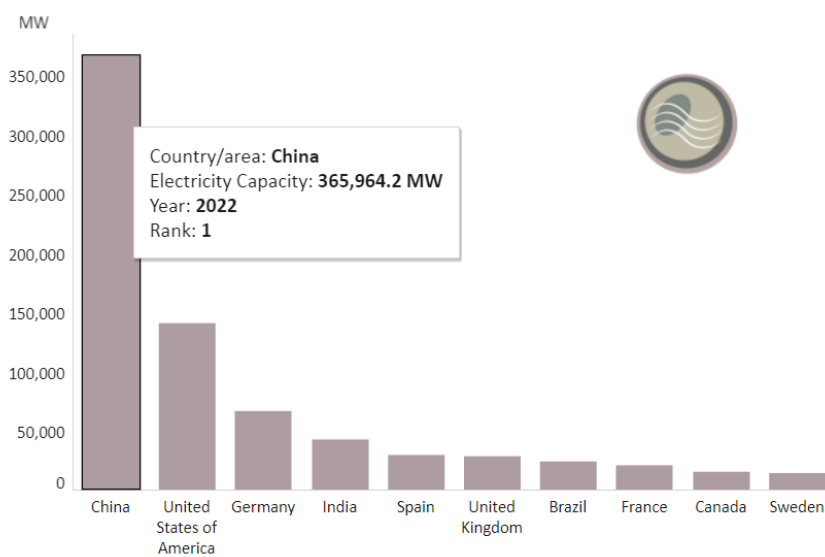


Figure 2.6: Countries by wind energy capacity size in 2022

As of the end of 2022, the countries' leading in terms of wind energy capacities are as follows: China with 365 GW, the USA with 140 GW, Germany with 66 GW, India with 42 GW, Spain with 29 GW, the United Kingdom with 28 GW, Brazil with 24 GW, France with 21 GW, Canada with 15 GW, and Sweden with 14 GW (IRENA, access: November 2023).

When countries are examined based on their solar and wind energy capacities, factors such as development level, population density, and geographical suitability are found to be as important as economic factors. For example, despite not being an advanced economy, India has made it to this list with its population of 1.4 billion. Countries like Japan and South Korea, located on major fault lines and constantly at risk of earthquakes, have turned more towards solar energy investments due to the risk of turbine destruction. In Australia, where the desert climate is predominant, solar energy capacity is among the top ranks.

Energy production and consumption vary from country to country and region to region worldwide. China, despite being the world's largest greenhouse gas emitter, is making significant investments in renewable energy and is the global leader in solar and wind energy as of 2023. The United States stands out as a major consumer in fossil fuel-based energy production. However, recent years have seen an increase in investments in renewable energy, indicating a rise in the adoption of wind and solar energy. European Union countries are making serious efforts to promote renewable energy and reduce dependence on fossil fuels, highlighted by their green energy policies and targets. Particularly, Germany, Spain, and the Scandinavian countries have made significant advancements in wind and solar energy. India, which meets a large part of its energy needs with coal, is trying to reduce this ratio by investing in renewable sources like solar and wind energy. Besides of all countries, Turkey also aims to increase the share of renewable energy in production by 2030 to reduce carbon emissions in energy production. Globally, energy agreements and plans are being developed to accelerate the transition to renewable energy sources, and countries are formulating policies based on these agreements and plans. The Green New Deal in the USA is one such plan, aimed at reducing fossil fuels and achieving net-zero carbon emissions by 2030. This plan aims to invest in renewable energy projects and increase energy efficiency. The European Green

Deal, created by the European Union, aims to achieve a carbon-neutral economy by 2050 by reducing fossil fuels. It includes comprehensive measures to promote renewable energy and increase energy efficiency. India's plan, known as the National Solar Mission, is a comprehensive plan aimed at increasing solar energy capacity and the share of renewable energy.

2.2.1 Barriers and Solutions to the Transition to Renewable Energy

Renewable energy projects can have high initial costs and require infrastructure investments. Overcoming these challenges is critical, and government incentives, financial supports, and international collaborations play a crucial role. Advances in energy storage and transmission technologies are important for the effective use of renewable energy. Innovations in smart grid systems and battery storage technologies are among the biggest developments in this area. Additionally, the implementation of renewable energy projects can sometimes encounter resistance among local communities and political decision-makers. Overcoming these barriers requires public awareness, political stability, and long-term policies.

Some experts predict that the world could transition to 100% renewable energy by 2050. For this transition to occur, government policies, technological innovations, and international collaborations are vital.

The shift to renewable energy is not just an environmental necessity but also a critical step for economic and social sustainability. This transformation requires coordinated efforts on a global scale and political determination. In the coming years, developments in this field will play a significant role in shaping our future.

2.3 Budget Impact of Energy Usage

Energy is one of the most important inputs in the modern business world. For companies, energy costs often constitute a significant budget item. However, transitioning to renewable energy sources has the potential to reduce these costs and positively affect budget balance.

The use of traditional energy sources such as coal, natural gas, and oil creates a significant financial burden for companies. Fluctuations in energy prices, especially in energy-intensive sectors (manufacturing, transportation, mining, supermarket chains, etc.), complicate budget planning. Energy costs can directly affect operational efficiency and profit margins.

Renewable energy sources like solar, wind, hydroelectric, and biomass offer long-term cost-effectiveness. The initial investment costs for renewable energy systems may be higher compared to traditional energy sources, but their operational and maintenance costs are much lower. And as Osman et al (2023) mentioned in their article renewable energy investment costs have been falling dramatically since 2010. Additionally, renewable energy sources are independent of fluctuations in energy prices, providing a significant stability factor in budget planning.

Increasing regulations and taxes on carbon emissions are raising the cost of using fossil fuel-based energy. Transitioning to renewable energy sources avoids such additional costs, enhances energy efficiency, and reduces the environmental footprint of businesses. This leads to both cost savings and strengthening of the company's sustainability image. Sustainability is becoming an increasingly important factor for today's consumers and investors, positively influencing companies' market positioning and competitive strength. Companies can also capture additional financial advantages such as government incentives and tax deductions with renewable energy projects. Considering all this information, transitioning to renewable energy sources should be considered not only an environmental responsibility but also a financially wise decision for companies. This change provides a positive contribution to long-term budget balance by ensuring stability and reduction in energy costs, increasing operational efficiency, and improving the overall sustainability performance of companies.

2.4 Renewable Energy Plant Investments

Solar power plant investments are increasing rapidly. In 2022, the total installed solar energy capacity worldwide reached approximately 1.06 TW (Our world in data, 2023). The cost of large-scale solar energy projects varies depending on the quality of solar

panels and the geographical location of the project. Typically, these costs can range from tens of millions of dollars to hundreds of millions of dollars.

Hydroelectric power plants have a long history worldwide. As of 2022, the total installed hydroelectric capacity globally is approximately 1.2 terawatts (TW) (Our world in data, 2023). Large hydroelectric plants typically require investments ranging from hundreds of millions of dollars to billions of dollars. Particularly, the costs of large dam projects are high.

2.4.1 Renewable Energy Plant Investments in Turkey

According to the information obtained from the website <https://www.irena.org/>, as can be seen in Figure 2.7, Turkey's renewable energy capacities have been increasing over the years (<https://www.irena.org/>, accessed: November 2023).

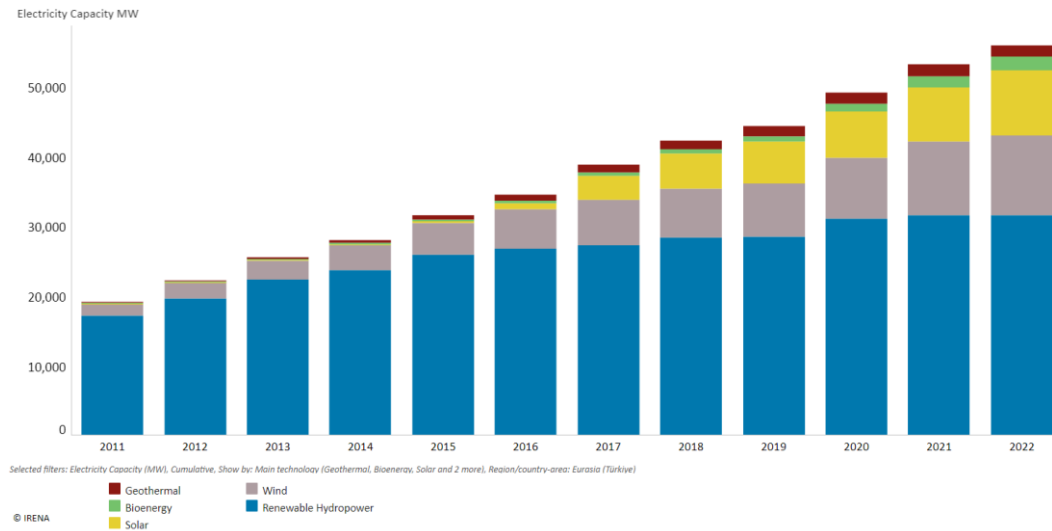


Figure 2.7: Changes in Turkey's renewable energy capacities over the years

This figure shows that as of the end of 2022, Turkey's solar energy capacity is 9.4 GW, wind energy capacity is 11.3 GW, and hydroelectric capacity is 31.5 GW, while the remaining part is shared by bioenergy with 1.8 GW and geothermal energy with 1.7 GW. Turkey aims to diversify its energy production and reduce environmental impacts by focusing on renewable energy plant investments. The size of these investments can vary based on various factors such as the development of technologies, geographical factors,

and energy demand. However, renewable energy investments are considered significant due to their long-term potential for reducing energy costs, increasing energy independence, and providing environmental sustainability.

The costs required for a renewable energy plant can vary depending on the type of project, its size, geographic location, and the technology used. Generally, the factors and cost items that need to be considered for setting up a renewable energy plant are as follows:

Land and Permits: The first step involves selecting suitable land and obtaining the necessary permits. Good land selection can increase energy production efficiency. Permits, due to local government and environmental regulations, can require a long process and affect the cost.

Equipment and Technology: Essential equipment like turbines for wind energy plants and solar panels and inverters for solar energy plants are required. The quality and efficiency of this equipment are important factors affecting the cost.

Construction and Installation: Expenditures for equipment installation, labor costs, and construction materials are required. The installation process can vary depending on the project's size and technical difficulties.

Infrastructure and Connection: Infrastructure investments for the energy plant's power transmission lines and connection points may be required. These costs can vary depending on the project's distance to the transformer station and the energy grid.

Maintenance and Operation: A long-term plan for the maintenance and operation of the renewable energy plant should be made. Routine maintenance and operational costs are important to maintain the plant's efficiency and reliability.

Financing and Return on Investment: Securing the necessary financing for the renewable energy plant investment is important. This can be done through loans, investors, or government incentives. The investment's payback period shows how long it will take for

the costs and revenues from energy production to be amortized. This period can vary depending on the type and conditions of the project.

Geographic Location: The most advantageous regions for setting up renewable energy plants might be areas with high wind speeds or abundant sunlight. This can increase energy production and reduce costs.

The costs required to set up a renewable energy plant can show significant variations depending on the project's characteristics and geographical location. However, such investments are important in terms of long-term energy production, financial benefits, and environmental sustainability. The payback periods of the investments can vary depending on the size of the investment, energy production, and energy prices, but investments in sustainable energy sources typically have a long-term return.

There are significant factors in the investments of solar energy plants. These include variables like materials, labor, land, and installation. We can compile how the average investment amounts vary according to global and local economic and political conjunctures with the following information.

2.4.2 Solar Energy Plant (1MW) Cost Shares

The information gained from www.statista.com simply shows the statistical cost shares of solar power plants for 1 MWp as follows:

Solar Panels: The cost of solar panels required for a 1 MW solar energy plant can constitute approximately 40% to 50% of the total cost.

Inverters and Other Equipment: Inverters, used to convert DC electricity from solar panels into AC electricity, can make up about 10% to 15% of the total cost.

Infrastructure and Foundation Construction: The cost of basic infrastructure and construction for mounting and securing solar panels can constitute about 5% to 10% of the total cost.

Electrical Connection and Transmission Line: The costs for the electrical connection and transmission line necessary to transmit the energy produced by the plant can make up about 10% to 15% of the total cost.

Labor and Assembly: The assembly and labor costs for solar panels can constitute about 5% to 10% of the total cost.

Land and Permits: The cost of land leasing, permits, and environmental assessments can also constitute a small portion of the cost.

These costs can vary depending on the project's characteristics, geographical location, and market conditions. Additionally, factors such as the state of the energy market, local incentives, and energy production efficiency can also affect the cost. However, these estimated cost items are helpful in better understanding the installation of 1 MW capacity wind and solar energy plants.

2.5 Global and Turkey's Energy Consumption and Trends

In 2023, the energy sector is expected to receive an estimated investment of \$2.8 trillion. A large portion of this investment, exceeding \$1.7 trillion, is directed towards clean energy, while the remaining amount over \$1 trillion is allocated for fossil fuel supply and energy production. Renewable energy and electric vehicles (EVs) lead the increase in clean energy investment. Particularly, solar energy stands out as it surpasses oil investments for the first time with annual investments of \$382 billion (<https://www.iea.org/reports/>, accessed: November 2023).

Worldwide energy demand is expected to increase by 2050. This increase is proportional to population and income growth. However, the increase is expected to be limited due to a decrease in energy intensity, meaning less energy use per economic activity, and widespread use of renewable energy sources. Global energy-related CO₂ emissions are also projected to increase in all scenarios by 2050. The primary reason is expected to be the increased energy consumption due to population growth, regional economic changes, and improved living standards. In parallel, global electricity production is expected to

increase by 40% from 2015 to 2050, with the increase largely met by zero-carbon technologies (Irena, 2018).

Since 2021, most of the increase in clean energy investments has occurred in advanced economies and China (Bhutada, 2022). Although there are dynamic markets such as solar investments in India and renewable energy use in Brazil, factors like high interest rates and uncertain policy frameworks restrict investment in many countries. Investments in energy efficiency are also on the rise but are not sufficient to meet more ambitious climate scenarios. Similarly, investment in low-emission fuels is increasing due to new policy measures, but it starts from a low base. In 2023, fossil fuel investment of \$1.05 trillion indicates potential risks related to continued fossil fuel dependency, especially for lower demand scenarios such as the NZE scenario (<https://www.iea.org/reports>, accessed: November 2023).

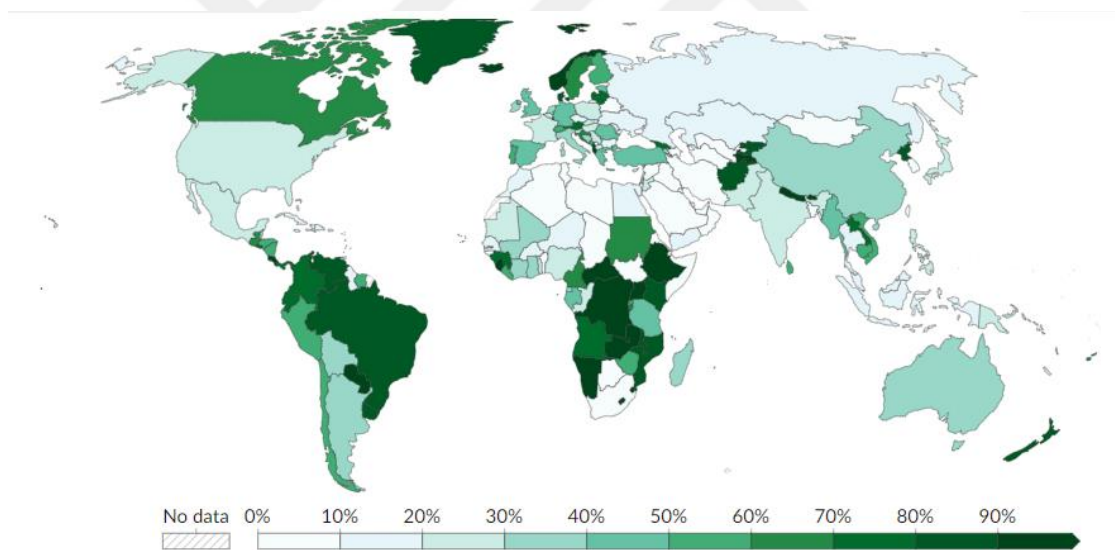


Figure 2.8: Share of renewable energy production by countries as of 2022

Due to Russia's invasion of Ukraine and the assumption that exports to Western markets will be limited, the supply, consumption, and trade of natural gas and crude oil are expected to evolve, with an increase in renewable energy supplies in regions lacking these resources. In 2022, global solar energy capacity increased by 192 GW compared to 2021, with solar energy concentrated in regions such as Asia, the U.S., and Europe, reaching a total renewable energy capacity of 1.63 TW (<https://ourworldindata.org/>, accessed: November 2023). Solar energy is close to catching up with hydroelectric energy, which

constitutes the largest share of total renewable energy capacity. Wind energy, by the end of 2022, reached a global capacity of 900 GW (<https://ourworldindata.org/>, accessed: November 2023).

2.5.1 Renewable Energy Trends in Turkey

The Turkish renewable energy market is expected to grow at a Compound Annual Growth Rate (CAGR) of approximately 4.9% between 2023 and 2028 (<https://www.mordorintelligence.com/>, Accessed: November 2023). This growth is primarily supported by government initiatives aimed at reducing dependence on fossil fuels and adopting sustainable energy sources. A significant component of Turkey's renewable energy market is hydropower, which has more than 31 GW of installed capacity. As of 2022, it accounts for about 20.3% of total energy production (<https://enerji.gov.tr/infobank-energy-electricity>, Accessed: November 2023). There have been substantial investments in large-scale hydropower-based production, and it is expected to dominate the market for many years. In terms of wind energy, according to the year-end report published by EPDK (Turkey Energy Market Audit Commission), Turkey had an installed capacity of 11.3 GW by the end of 2022. The Aegean and Marmara regions are particularly notable for their wind energy potential. According to another report published by EPDK, as of the end of 2022, Turkey has a solar energy installed capacity of 9.4 GW. Turkey, with high solar energy potential, has average irradiation values between 1400 and 2000 kwh/kwp as seen in Figure 2.9, and this potential raise panel efficiency to around 20%

In Turkey, the share of renewable energy in total energy production was 10.7% in 2000, 12.3% in 2010, and 19.1% in 2020 (<https://ourworldindata.org/renewable-energy>, Accessed: November 2023). Among OECD countries, Turkey has been ranked first since 2002 with an annual energy demand increase of 5.5% (<https://www.invest.gov.tr/>, Accessed: November 2023). Government initiatives such as the National Renewable Energy Action Plan and the Renewable Energy Support Scheme (YEKDEM) have played a significant role in this change.

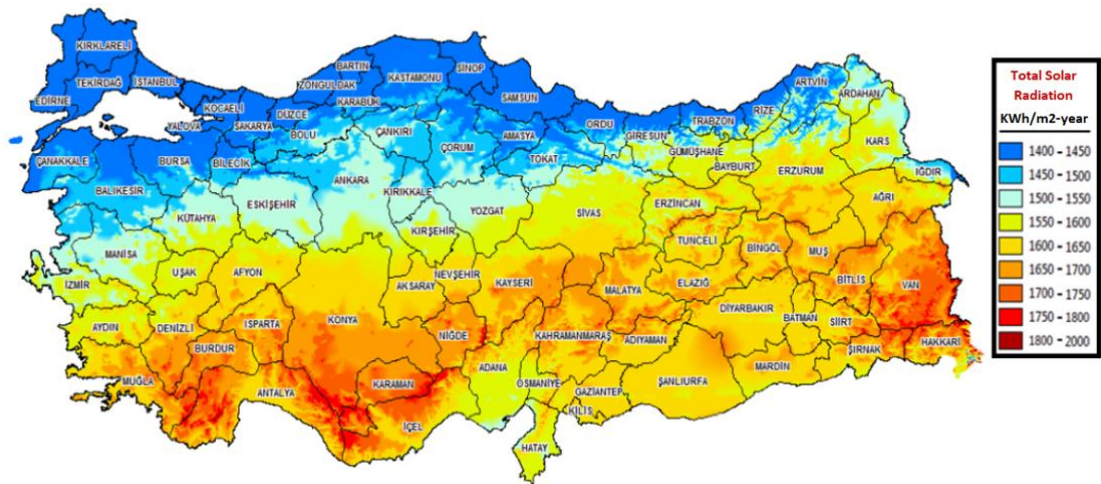


Figure 2.9: Turkey's solar radiation map

In summary, both globally and in Turkey, there is a notable increasing trend in renewable energy investments, especially in solar and wind energy. However, challenges related to costs, policy frameworks, and infrastructure continue. The transition from fossil fuels to renewable energy is a critical component worldwide in combating climate change and ensuring energy security.

3 LITERATURE REVIEW

Numerous articles in the literature conduct renewable energy investments using cost benefit analysis and similar economic investment analyses.

In according with investment analysis types and investigating economic feasibility of renewable investments following studies can be shown as examples. In their article, Gudlaugsson and others (2023) have examined the economic feasibility of integrating renewable energy and smart technologies into existing energy systems, as well as the social and environmental impacts of this transition. They have demonstrated through cost benefit analysis in St-Jean, France, and Barcelona, Spain, that such a transition is financially viable with low payback periods. Their research highlights that the shift to renewable energy not only reduces environmental impacts due to carbon emissions and other factors but also offers economic and social advantages. Al Afif and others (2023) evaluated the feasibility of both grid-connected and off-grid hybrid renewable energy systems for the Al-Karak region in Jordan. Using Homer Pro analysis, they aimed to optimize the economic costs and carbon dioxide emissions of systems involving wind turbines, PV panels, and batteries while maximizing integration. The study revealed that hybrid operation of PV and wind energy, in conjunction with storage systems connected to the grid, presented the most optimal solution. Pastore (2018) emphasized the importance of financial analysis in the feasibility of photovoltaic (PV) systems. By providing an example of how factors such as investment costs, incentives, energy costs, and system integration should be used in financial analysis, he presented a case study on how to properly evaluate proposals. Ahmad and others (2021) examined the efficiencies of grid-connected and off-grid renewable energy sources in meeting urban and rural requirements. Their study, highlighting the technical and economic feasibility of renewable energies, observed the impact of financial, technical, and operational

feasibility on integration with and without a grid. Optimization, simulation, and sensitivity analysis were conducted in the study, using parameters such as capital, maintenance, operation, and fuel costs. Atanasoaea and others (2019) assessed the economic feasibility of renewable energy sources below 1 MW, independently from those supported by European Union standards over 1 MW, using cost benefit analysis. Otsuki (2017) systematically addressed the significant contributions Mongolia could make by using its rich wind and solar resources for large-scale renewable energy investments, which could be exported to other countries if connected to the grid. However, the study, which discussed the need for high investments in transmission lines, emphasized that these projects would bring significant environmental and economic benefits if carried out with international collaboration Kozlova and Collan (2020) investigated the economic impacts of geography on renewable energy investments. Presenting different investment scenarios in four different geographical regions in Russia, the research helps investors in similar situations with decision-making methods.

Also, some studies show the investment barriers of renewable energy sources as Bachner and others (2019) evaluated the macroeconomic effects of the widespread use of wind and solar energy in Europe through modeling. Considering integration costs, the study mentioned that while the expansion of wind and PV would increase societal welfare, high integration costs could have negative effects in some regions. The study emphasized the high capital requirements for renewable energy investments and mentioned how high input costs could make production costs uncompetitive. Hu and Others (2018) detailed the barriers that renewable energy investments could face in combating climate change on both micro and macro scales. The research stressed that not only superficial barriers should be considered and that if fundamental barriers are not eliminated through monetary and fiscal policies, but negative effects on investments would also increase. İlbarhar and others (2022) presented research contributing to the correct assessment of investment risks in renewable energy investments, considering the high investment costs required. The research proposed an effective risk assessment system that overcomes factors such as experts' uncertainties and cognitive biases by using the Expectancy Theory and AHP-developed FMEA method, avoiding risk assessment processes based on expert judgments. Almulhim and Al Yousif (2023) analyzed renewable energy investment scenarios and the criteria affecting the selection of these scenarios. Proposing a hybrid

framework for decision-making, the study included a multidisciplinary approach that combined macroeconomic assumptions, historical data, and expert judgments as qualitative data. The study also dealt with uncertainties about the future direction of renewable energy investments using Fuzzy Set theory and presented a 3-scenario application of the proposed hybrid framework for a case in Saudi Arabia. Mattha and Mehling (2020) proposed a global guaranteed mechanism aimed at reducing risk premiums and increasing market efficiency to support renewable electricity generation, especially in financially challenging regions globally. The researched scenario projected net savings of \$15 trillion by 2030, with the most significant savings in Sub-Saharan Africa and the Maghreb. The study, which foresees reducing carbon reduction costs in high-risk countries, emphasizes that a more constructive outcome in the fight against global climate change can be achieved.

While considering investment analysis and risks there are also different types of studies about renewable energy investments to show other effects. Appiah-Otoo and others (2023) investigated the impact of renewable energy investments on global carbon dioxide emissions. The research, examining the effects of all renewable energy sources on carbon dioxide emissions from 2004 to 2018, found that investments initially reduced carbon dioxide emissions but after crossing a certain threshold in solar and wind energy investments, they decreased carbon dioxide emissions. The study found threshold values of \$1.64 trillion for solar energy investments and \$266.3 billion for wind energy investments, concluding that biofuel energy had a reverse effect on carbon dioxide emissions. The study concluded that wind and solar energy investments should be encouraged to reduce carbon dioxide emissions. Ofori and others (2021) discussed the complementary effect of private sector renewable energy investments to government efforts and addressed the challenges faced. Emphasizing the importance of investment timing and risk considerations in high initial capital renewable energy projects, the research examined the optimal investment timing for government-supported renewable energy projects in Ghana using real option analysis, binomial trees, and Monte Carlo simulations. According to the results, investments should be delayed until uncertainties are reduced and maximum benefits are obtained, and policies such as high system capacities and appropriate tariff applications are necessary to promote these projects. Freitas and others (2020) emphasized the necessity of increasing renewable energy

capacities in Brazil to meet the growing electricity demand. Addressing production variability, market uncertainties, and investors' risk aversion, they presented a stochastic decision support model that maximizes expected returns. According to the study's results, asset diversification and complementary combinations of production resources by investing firms reduced financial risks, and more conservative solutions were reflected in the results as risk aversion increased.

In literature, there are different overviews and studies about renewable energy investments including cost benefit analysis and other economic feasibilities as explained above. In this thesis, another contribution has been made about analyzing different types of solar energy investments for a specific place about financial point of view. The specification about the thesis is considering different investment options for solar energy powerplant in Turkey and aiming to help logical decision-making process for different options.

4 RETAIL COMPANIES AND RENEWABLE INVESTMENTS

4.1 About the Retail Sector

The retail sector is constantly evolving with changing consumer expectations and technological innovations. Supermarket chains, as a significant branch of the retail sector, stand out from other retail chains due to their high electricity consumption for refrigeration systems and extensive lighting needs.

In Turkey, the leading supermarket chains include BİM, A101, Migros, and Carrefoursa. This sector has experienced rapid growth since the 2000s, diversified with investments from local and international companies. There has been a significant shift from traditional markets to modern supermarkets.

As the retail sector enters a significant race to offer more personalized and convenient shopping experiences for their customers, a seamless transition between physical stores, online platforms, and mobile applications, known as omnichannel shopping experience, is gaining importance.

Retail companies need to adopt innovative approaches to stay afloat. This means both strengthening technological infrastructure and adapting to customer expectations. Additionally, investing in sustainable and eco-friendly practices helps companies gain a competitive advantage.

The retail sector, both globally and in Turkey, has a constantly changing structure. Technological advancements, customer expectations, and sustainability are the main

factors shaping the future of this sector. Companies need to adapt to these changes and adopt innovative approaches to be successful.

4.2 Energy Usage in the Retail Sector

The retail sector, especially supermarket chains, is a significant sector in terms of energy consumption. Leading supermarket chains in the world such as Walmart, Tesco, Carrefour stand out for their high energy consumption due to factors such as heating, cooling, and lighting, brought about by their global store network.

Store lighting is a major component of energy consumption in supermarkets due to their large area. Additionally, refrigeration systems necessary for keeping food products fresh also constitute a significant part of energy consumption. Air conditioning systems, essential for customer comfort and food safety, especially in warm regions or seasons, lead to high energy consumption. Technological equipment such as cash register systems, IT infrastructure, and security systems are other energy-consuming devices.

4.3 Energy Transition in the Retail Sector

Many major retail chains are investing in innovations that will increase energy efficiency, such as the use of LED lighting, energy-efficient cooling systems, and automatic climate control. Companies like Walmart, Tesco, and Carrefour are not only using efficient devices that reduce consumption but are also making significant investments to ensure that the electricity they use comes from renewable energy sources instead of fossil fuels. This approach aims to reduce the unit cost of consumed electricity and to lessen significant environmental factors like carbon emissions. Especially with the economic problems emerging after the pandemic and the resultant global inflationary environments, as well as the Ukraine-Russia war and instabilities in the Middle East, which have led to serious increases in energy prices, companies with such high energy consumption have been compelled to shift towards renewable energy to reduce energy costs, increase environmentally friendly investments, and respond to the growing sensitivity of customers.

Although the energy transition in the retail sector continues to achieve significant successes, there are still major challenges to this transformation. The most important of these is the still high cost of transitioning to energy-efficient technologies and renewable energy investments. Moreover, integrating these new systems into existing conditions requires significant planning and management. Energy management in retail involves continuous innovation and keeping up with new technologies.

4.4 Global News and Plans

Globally and in Turkey, several supermarket chains are starting to make strides in renewable energy transformation, with the following information about their news and plans:

Hannaford Supermarkets aims to operate its operations with 100% renewable energy by 2024. Currently, in Maine, Massachusetts, and New York, they have embarked on over 30 solar energy collaboration projects, achieving 30% renewable energy usage. They are also implementing various projects such as LED lighting, night curtains, modern refrigeration systems, and rooftop solar panels to increase energy efficiency in their stores. They have committed to becoming a net-zero carbon operation by 2040⁴.

Sainsbury's has opened a new and pioneering energy-efficient flagship store in Hook. This store consumes only half the energy of similar-sized stores and operates with 100% renewable electricity. The chain plans to obtain 40% of its total electricity consumption from new wind and solar energy projects by the end of 2023, with a goal to become carbon neutral by 2035⁵.

Walmart has committed to using 100% renewable energy in its operations by 2035. Through a partnership with ENGIE North America, they have launched a 500-Megawatt renewable energy production facility to annually provide renewable energy to their stores, clubs, and distribution centers in Texas, South Dakota, and Oklahoma. These projects help reduce approximately 1.3 million metric tons of CO₂ equivalent in greenhouse gas

⁴ www.supermarketnews.com

⁵ www.retailgazette.co.uk

emissions per year. In 2020, about 36% of Walmart's global electricity needs were met from renewable energy sources. The company has also launched the Gigaton Project, aiming to prevent one gigaton of greenhouse gas emissions from its global supply chain by 2030⁶.

Tesco aims to invest more than 50 billion pounds in low-carbon technologies in the UK by 2035. This amount includes 12 GW of wind, nuclear, and solar energy, covering a fifth of the country's total demand⁷. Committed to sourcing 100% of its electricity from renewable sources by 2030, the company has invested over 700 million pounds since initiating its energy transformation in 2007⁸

Carrefour has set a goal to reduce its greenhouse gas emissions by 30% by 2030 and 55% by 2040 compared to 2019 levels⁹. The company plans to source 100% of the electricity used in its stores and warehouses from renewable sources and reduce energy consumption by 2030¹⁰.

Aldi ranks 14th in the US in terms of total installed solar energy capacity and 5th in terms of total solar energy plant installation¹¹. Aiming to reduce greenhouse gas emissions by 26% by 2025¹², it became the first supermarket chain in Australia to provide 100% renewable energy, achieving this goal 6 months ahead of its schedule¹³.

⁶ <https://corporate.walmart.com>

⁷ <https://www.edie.net>

⁸ <https://www.tescopl.com>

⁹ <https://www.carrefour.com>

¹⁰ <https://www.carrefour.com>

¹¹ <https://corporate.aldi.us>

¹² <https://www.retailgazette.com>

¹³ <https://reneweconomy.com.au/>

5 METHODOLOGY

For the thesis work, an analysis will be conducted to decide how a retail chain in Turkey should proceed if it invests in a solar power plant. This decision-making step will be developed using a CBA. The firm will determine the most advantageous step for itself in terms of where and how to invest for a solar power plant with a 25-year lifespan, with detailed research being conducted to contribute to the literature on this subject.

5.1 Cost Benefit Analysis

Cost benefit analysis is a systematic approach used in the investment process that accounts for future projections and identifies the benefits and costs involved. This helps in understanding whether the proposed project is worth implementing, thus aiding decision-making processes. CBA, commonly utilized in engineering, is a standard method vital for maximizing ideas and options across various industries. From large corporations to start-ups, this technique helps in making informed and relevant decisions by identifying the highest potential value of a system or design (Sanusi & Yusufi, 2023). CBA is a commonly used method for assessing and quantifying the effects of an investment choice, aiming to evaluate the project's expenses and advantages (Siciliano et al, 2016). By compiling these results, one can draw conclusions about the project's viability and the merit of carrying it out (Gustafsson et al., 2004). CBA is the predominant method for evaluating infrastructure investments (Beria et al., 2012). CBA is commonly used in business and public policy decision-making mechanisms. CBA evaluates the social impact (social costs and benefits) for the public in a specific country or area by weighing various costs and benefits, which may encompass elements outside the market (like externalities) and benefits that can't be quantified, all of

which are shared by the community (Siciliano et al., 2016) CBA systematically lists impacts as pros (benefits) and cons (costs), assigns monetary values and weights, and then evaluates a proposal against the current situation based on net benefits (benefits minus costs) or the benefit-cost ratio (Boardman et al. 2011). The aim of CBA is to assist in social decision-making and to better distribute limited resources (Hanley & Barbier, 2009). By 2020, CBA has been extensively utilized in various research fields worldwide (Jiang & Marggra, 2021).

Essentially, the total benefits of a project or decision should outweigh its total costs; this leads to the conclusion that the decision will be advantageous. CBA fundamentally compares trade-offs, requiring total benefits to surpass the overall opportunity cost (labor, time, financial expenses, etc.) for a project to be viable. If social costs exceed benefits, the project should be reconsidered (Beria et al., 2012). In business, it can also be used to analyze the return on a new investment by comparing the benefits it offers against other alternatives. This way, an investor can choose the option that promises the highest return (risk factors can also be analyzed). Alternatively, if the costs of a desired project outweigh the benefits, the process can be halted despite all motivation, and the investor can benefit by not proceeding with the project. Here, benefits and costs are expressed in monetary values. CBA relies on monetization and temporal discounting, using money as a universal unit to convert all associated investment or policy costs and benefits (Beria et al., 2012). However, the changing value of money over time is also considered, displaying the present value of benefits and costs that change over time, so a common ground for discussion can be established. These analyses help in understanding critical aspects like the investment's return on investment and value chain.

CBA can determine which option is more advantageous by calculating and subtracting the costs from the benefits of a project. It can also be used to compare multiple projects, where the analysis of costs and benefits of each project determines which offers the higher return, aiding in decision-making.

In CBA, it is impossible to achieve 100% accuracy in future assessments of benefits and costs, so it cannot be considered a perfect evaluation. The closest estimation of benefits and costs in qualitative terms is critical for the accuracy of the analysis, but achieving this

in the real world is impossible. The time horizon should align with the economic lifespan of the key assets. While investment horizons are generally open-ended, for project analysis, it's useful to envisage a future point where all assets and liabilities are essentially settled at once. (Siciliano et al., 2016)

Costs and Benefits: CBA commonly refers to any decision-making analysis that weighs the anticipated costs and benefits (in monetary terms) of an investment (Park et al., 2018). Costs include direct costs (e.g., materials, labor), indirect costs (e.g., electricity expenses, overheads), and intangible costs (e.g., social harm, decrease in motivation), and other costs may arise. Benefits can be divided into tangible and intangible benefits. Tangible benefits include the monetary gains provided to the investor when the project is realized, while intangible benefits might include increased employee satisfaction or environmental contributions.

CBA quantifies in monetary terms all outcomes associated with governmental policies (like setting environmental standards) or investment projects (such as reforestation in floodplains) for the entire society (Jiang & Marggra, 2021). So, all tangible and intangible benefits must be quantified in monetary terms. While tangible items can be more easily valued, assigning a monetary value to intangible concepts is challenging and requires certain assumptions.

For CBA to be applicable, the analysis must be as accurate as possible, and its limitations should be defined accordingly. This also means clarifying the goal and all alternatives. When setting boundaries, the currency in which the costs and benefits will be analyzed is heavily dependent on the relationship of that element with its currency, and past data can be reviewed if available. This is a metric, and for the measure to be accurate, the metric must closely resemble reality. Of course, both costs and benefits must be evaluated in the same currency for comparison.

The next step is identifying the costs and benefits. Listing all possible costs and benefits will increase the accuracy of the analysis. When classifying costs, direct costs that directly affect the job can be started. All expenses that directly affect the job fall into this category. Indirect costs can be shown as fixed or variable costs that contribute to general expenses

during the job but do not directly affect it. For example, direct costs for an investment in a production facility could include labor costs, production costs, material costs, and inventory costs, while indirect costs could be electricity bills, water bills, rental fees, etc. Examining intangible costs is important for the accuracy of the analysis, as even if the estimates for direct and indirect costs are accurate, unexpected intangible situations such as environmental impacts and human effects can arise during business. An example of a hard-to-measure intangible cost in the investment in a production facility could be a decrease in sales due to an unexpected competitive factor, affecting productivity and preventing production capacities from being filled as desired. Intangible costs can also be valued using methods such as surveys, where feedback from experts related to the job is obtained. This provides an opportunity for parallel evaluation with other costs.

It is equally important to determine the benefits along with the costs. Benefits, like costs, can be considered as direct, indirect, and intangible benefits. Continuing with the same example, the direct benefit of an investment in a production facility could be the income generated by selling the produced products. An indirect benefit could be the increase in customer interest as a result of increased brand awareness. An intangible benefit could be the social benefits brought about by the employment created in the region where the production facility is located. Estimated returns of these benefits can be considered.

The next step is to assign monetary values to all identified costs and benefits. Direct costs and benefits are easier to value because they have direct impacts on the investment. However, various methods must be used to assign monetary values to indirect and intangible costs and benefits. Incorrect valuation can lead to significant deviations in the outcome of the analysis. When using a valuation method, it is beneficial for the currency to have a direct correlation with the relevant investment. This is because the lesser the deviation in the monetary change of the investment's costs and benefits over time in a particular currency, the lesser the impact will be. Also, considering the change in the value of money over time, moving in a currency with a lower risk of fluctuation will bring the analysis closer to reality.

The final step is to sum up and compare the costs and benefits, where various calculation methods can be used. The net present value (NPV) sums up all revenues and expenses

over the estimated life of the investment in today's money, after adjusting for the time value of money. NPV must exceed zero to make a project economically appealing (Siciliano et al. 2016). By other means, when calculating the NPV, it is expected that the benefits will exceed the costs. When this situation arises, other perspectives come into play. That is, even though the benefits exceed the costs, how much do they meet expectations, and is this investment worth it? These questions are explored through metric calculations. Formulas such as the payback period of the investment and the internal rate of return (IRR) of the investment help in these perspectives. However, if the costs exceed the benefits, the details of the analysis should be refocused to check whether the costs and benefits have been correctly valued. Costs exceeding benefits mean the investment is negative and has no return. In this case, different alternatives may have to be sought for the project to proceed, or the money may be used in another option with a return on investment. This is where the critical point of CBA lies: to show the decision-maker the path to take - whether to make the investment, and if so, to observe the return of this investment compared to different alternatives and decide whether to stop or take the risk.

5.1.1 Advantages of Cost Benefit Analysis

The most significant advantage of CBA is that it bases costs and benefits on numerical data, removing intuitive metrics and paving the way for more objective decision-making. This allows entities such as businesses, entrepreneurs, and policymakers who are going to make investments to make more rational decisions and take action.

One of the benefits of this analysis is that it considers all the details of the benefits and costs of a project, eliminating hidden costs and benefits and helping to address the topic holistically.

Another advantage is that it allows for the evaluation and comparison of multiple options, contributing to the determination of the most optimum choice. Thus, it assists in identifying the most beneficial option among different alternatives.

Another advantage of CBA can be said to be its ability to assess the long-term effects of projects. With the analysis of changing costs and benefits over time, what kinds of

changes are anticipated in the future, and how these will contribute to or harm the project, can be calculated using metric methods.

5.1.2 Disadvantages of Cost Benefit Analysis

The most significant disadvantage of CBA is the difficulty in measuring the monetary value of future costs and benefits. Especially, the monetary valuation of indirect and intangible factors lacks clarity, and inaccurate measurements can lead to different results, thereby causing deviations in the analysis.

It can be very challenging to predict variables like inflation over the long term, so the estimated values in the CBA of long-term projects can be significantly different from the actual values. For example, unexpected factors that significantly affect society, such as wars and natural disasters, will lead to greater deviations from these forecasts. In this context, short and medium-term projects carry less risk compared to long-term ones.

Choosing the correct rates for discounting future costs and benefits to present value is crucial. These rates are determined using various formulation methods, which can include risk factors, risks of countries, or geopolitical risks of the investment area. However, incorrectly estimated rates can result in different values that are detached from reality.

Another important disadvantage of CBA is that it leads to the elimination of certain values or ethical considerations, as businesses or public investments are naturally measured in terms of monetary value. In other words, it overlooks the importance of an investment from a non-monetary value perspective, even if the investment may not yield financial benefits.

5.1.3 Net Present Value

In cost and benefit analysis, since the costs and benefits are placed according to their future period time values, they must be compared within a common time period. This is done by discounting all future cost and benefit values to their present value using a

discount rate (r), and the resulting values are known as the NPV. NPV must exceed zero to make a project economically appealing (Siciliano et al. 2016).

The formula for NPV is as follows:

$$NPV = \sum_{t=0}^{\infty} \frac{B_t - C_t}{(1 + r)^t} \quad (1)$$

NPV : Net Present Value

t : term

B_t : Benefits of related term

C_t : Costs of related term

r : discount rate

Here, as the discount rate (r) decreases, it helps to value future costs and benefits closer to their current equivalents, while a higher discount rate results in a lower valuation of future costs and benefits compared to their present values.

The determination of the discount rate can vary depending on the risk level of the investment and the expected return. Some commonly used models for determining this rate include:

5.1.3.1 Weighted Average Cost of Capital

This model takes into account both the cost of debt and equity of a company. It represents the cost of capital that a company uses for its investment projects. The formula is as follows:

$$WACC = \left(\frac{E}{V} \times Re \right) + \left(\frac{D}{V} \times Rd \times (1 - Tc) \right) \quad (2)$$

E = Value of the company's equity in market value

V = Total capital (equity + debt)

Re = Cost of equity

D = Value of the company's debt in market value

Rd = Cost of debt

Tc = Corporate tax rate

The value of a company's equity in the market (E): This is known as the market value of the company. For public companies, it can be calculated by multiplying the number of shares in circulation with the current share price. For private companies, the equity value is estimated based on the analysis of similar companies.

The value of a company's debt in the market (D): This can be estimated using the total debts listed in the company's recent balance sheet statements.

Cost of Equity (Re): This is the rate representing the minimum return demanded by the company's shareholders.

Cost of Debt (Rd): The interest rates on the company's current debts are the cost of those debts. However, the same interest rates may not be applied for future periods. Therefore, the cost of debt can be estimated using the company's credit rating, or for long-term debts, by calculating an average maturity and considering it as the return of a bond until this average maturity is reached.

Company tax rate (Tc): Since interest payments can be deducted from taxes, this tax rate is included in the calculation. The tax rate of companies varies depending on the country and region in which they operate.

5.1.3.2 Adjusted Risk Premium

This method, which does not have a standard formula, is found by adding a risk premium to the risk-free interest rate (usually the yield on 10-year government bonds).

5.1.3.3 Internal Rate of Return

It is the rate that makes the NPV equal to zero. In other words, it can also be described as the rate that equates costs to benefits. Instead of calculating directly with a formula, it can be found using trial and error or financial calculation tools.

The IRR formula can be represented as follows:

$$NPV = \sum_{n=0}^N \frac{C_n}{(1+r)^n} \quad (3)$$

NPV : Net Present Value

N : Total number of periods

n : non-negative integer

C_n : cash flow

r : internal rate of return

5.1.3.4 Specific Company or Industry Risk Premiums

There is no standard formula. It is a risk indicator put forth considering the specific risks of individual companies.

In conclusion, when conducting a CBA, the NPV holds critical importance. The discount rate used in calculating the NPV is also important. Formulas and calculations that

incorporate various factors, such as the country where the investment will be made, the industry of the investment, geopolitical factors, etc., can be created to calculate this rate. The examples mentioned above are some of these.

The uncertainty in the parameters of CBA can also be evaluated by conducting a sensitivity analysis. That is, different outputs obtained with different parameters can be assessed among the options, and the decision-making process can become clearer depending on whether to take risks or not. Sensitivity analysis can measure how sensitive the results are to the parameters and how they respond.

5.2 CBA Usage for Renewable Investments

Conducting a CBA for investing in a renewable energy plant can be an effective method in the decision-making process. There are 2 main goals behind wanting to establish a renewable energy plant. These are contributing to sustainability policies by producing clean energy, thereby reducing carbon emissions, and benefitting the budget by eliminating electricity costs through fossil fuels. Apart from these, there can be many factors such as the environmental impact, job creation, contributions to the country's economy and business economy of a renewable energy plant, but unexpected results may also emerge in terms of costs. Especially states that have signed international agreements on climate policies help investors overcome the high input costs due to technological infrastructure by providing tax deductions to encourage investments in renewable energy plants.

When considering the cost factors directly affecting the establishment of renewable energy plants, especially solar power plants, we have:

Equipment costs: These are the costs of the equipment necessary for the establishment of the facility. In the establishment of solar power plants, solar panels, inverters, mounting systems, transformer costs, monitoring systems are included in these costs.

Construction and installation costs: These are the costs related to the physical construction of the renewable energy plant. Labor and material costs fall into this category. Activities

that ensure the installation of the equipment and the connection of the plant to the electrical grid with power lines are included in this class.

Land costs: The primary need for establishing a renewable energy plant is to find suitable land. A land that has received positive results from environmental impact assessment is needed. The most important condition is that it should not be agricultural land. The purchase or lease of this land falls directly into the cost category.

Operating and maintenance costs: Regular maintenance is necessary for the renewable energy plant to demonstrate the expected performance during energy production after its establishment. The labor expenses for these maintenances fall into direct costs. Additionally, the operation of the plant is another item of labor expense. The items created by consumables and spare parts during maintenance and operation also fall under direct costs.

Energy storage systems: Although not in every renewable energy plant, some plants operate with storage systems. Batteries and other energy storage equipment for storage systems set up for use as needed rather than directly supplying to the grid fall into this category.

Transport and logistics: Includes all logistics costs necessary for the transportation of equipment to the site in the installation of the renewable energy plant.

Legal and consultancy fees: Technical and financial consultancy fees required for the installation of the renewable energy plant, and all fees necessary to follow the legal processes of the plant fall into the direct costs' category.

Indirect cost items that impact the costs of renewable energy plant investments can be listed as follows:

Financial costs: In the case of the investor using credit instruments for the establishment of the renewable energy plant, the interest payments of these credits or other expense items necessary to finance the related project are among the indirect costs.

Land acquisition and preparation: Project development costs during the process of making the land ready for renewable energy plant installation after the purchase and lease of the land fall under this item. Costs such as building cadastral roads, expenses for zoning approvals, and expenses paid to consulting firms monitoring this process.

Permit acquisition and regulatory compliance: The environmental impact assessment required by the state for project approval of the renewable energy plant and the necessary permits and fee payments for these permits are among the indirect costs. Additionally, expenses related to compliance with local, regional, and national regulations are also included in these items.

Grid connection: The costs of power line adjustments necessary for the renewable energy plant to supply electricity to the grid, transformer connection costs, and costs related to power upgrades if there is no capacity fall under this item.

Research and development: Some renewable energy plant installations may require initiatives to develop technological infrastructure. Research and development expenses for this are shown as indirect costs.

Insurance costs: Costs of general liability, property, and other insurance types related to the operation of energy facilities fall under this category.

In addition to the direct and indirect costs of renewable energy plant investments, there are also abstract factors that impact the investment. Some of these can be listed as follows:

Environmental impact: Although renewable energy plant investments are a more environmentally friendly investment method compared to fossil fuel consumption, they can cause some negative situations affecting the environment. For example, the disruption of habitats due to solar power plants or bird deaths caused by wind turbines can be listed among these.

Visual and aesthetic impact: The appearance of large-scale renewable energy plants can be perceived as visual discomfort by some communities.

Noise and other disturbing factors: Some renewable energy plants can create disturbing noise in the environment. For instance, people living near wind turbines may be disturbed by the sounds they make.

Cultural and heritage impact: If some renewable energy plants are located on points important for cultural heritage, they can lead to the loss and damage of these areas, or they can create a situation that hinders the richness of mine sites or other underground resources.

Impact on wildlife and biodiversity: Renewable energy plants can have negative effects on species living in sensitive ecological areas in the region they are located. Disruptive effects on wildlife and biodiversity constitute an abstract cost.

Opportunity cost: The cost spent on investments in renewable energy can create a reason for preventing potential uses that would provide more beneficial returns in the short term. This is also an abstract cost.

Long-term commitment and flexibility: Even if a renewable energy plant is established with the most innovative form according to current technological infrastructure, there is a risk of limiting new technological developments due to its long operating life. For example, even if more efficient versions of the solar panels used in a solar plant are found after the plant investment, equipping the plant with these new type panels will be quite difficult.

After listing all possible cost items of renewable energy investments, it is necessary to mention the benefits they provide. Like the cost items, let's consider the direct, indirect, and abstract benefits.

Direct benefits can be listed as follows:

Reduction in greenhouse gas emissions: Although the greenhouse gas emissions caused by fossil fuels in electricity production reveal one of the most important problems humanities has faced, such as the climate crisis, the energy produced by renewable energy plants does not emit carbon, that is, it is clean energy, therefore it contributes to the climate. States seeking to combat the climate crisis through international agreements have started to pave the way for renewable energy initiatives by implementing tax policies for greenhouse carbon emissions in public and private initiatives.

Energy production: The most important benefit of a renewable energy plant is energy production. These plants, which contribute to clean and sustainable energy production instead of energy produced from fossil fuels, also help to get rid of the costs of electricity obtained through fossil fuels.

Energy independence and security: Renewable energy allows countries and businesses to easily produce their own electricity through the increase of both private ventures and national renewable energy investments, thereby reducing dependence on imported fuels. Thus, the risk of external dependence is eliminated. Measures are taken against situations such as shortages that will occur in cases of war and natural disasters. Especially the natural gas crisis that emerged with the Russia-Ukraine war is the most important example of this and has increased the orientation of European countries dependent on Russia for natural gas imports towards renewable energy investments.

Stabilization of energy prices: Countries and private businesses dependent on imported energy affected by price fluctuations created by fossil fuel exporters, with renewable energy investments, take steps towards a more stable energy price strategy by preventing these fluctuations.

Economic benefits and job creation: The establishment of renewable energy facilities contributes to the local and regional economy, creating employment.

Support for the local industry: The supply of materials used in the installation of renewable energy plants from the local industry provides economic contribution and helps the development of the industry.

Technological innovation and leadership: Investments in renewable energy encourage technological developments. With the reduction of energy costs, the orientation towards research and development activities increases, leading businesses and countries to innovation leadership.

Environmental benefits: Investments in renewable energy plants contribute to preventing air pollution by reducing air pollution related to fossil fuels.

Indirect (indirect) benefits of renewable energy investments can be listed as follows:

Revitalization of local and global economies: In addition to direct plant expenditures, investments in renewable energy can stimulate economic activity in terms of sectors. It contributes to the economy by creating local and regional employment and revitalizes economic activities by reducing the energy costs of countries and businesses.

Improvement in public health: Renewable energy investments contribute to improvements in public health at the local and regional level by preventing air pollution caused by fossil fuels.

Environmental protection: Investments in renewable energy ensure the development of perspectives from an environmental awareness and sustainability framework and increase incentives in this direction.

Promotion of rural development: Renewable energy investments are generally made in rural areas. This can lead to infrastructure and economic developments in rural areas.

Combating climate change: By reducing greenhouse gas emissions, it plays a leading role in the fight against climate change, not only reducing air pollution but also contributing to the reduction of factors such as sea level rise and extreme weather events.

Positive impact on biodiversity: Renewable energy plants can eliminate the negative impact on ecosystems and biodiversity that would occur due to the extraction and combustion of fossil fuels.

Intangible benefits of renewable energy investments can be listed as follows: Leadership in sustainable practices: Making investments in renewable energy positions businesses or countries as leaders in terms of sustainable practices and environmental protection and has a credibility-enhancing effect. The increase in the trust index contributes to both countries and businesses in terms of having a say in this matter.

Public health and quality of life: The reductions in air pollution achieved with renewable energy investments provide an effect that increases the quality of life and results in better public health.

Cultural and social values: Playing an encouraging role in sustainability and respect for the environment with renewable energy investments can strengthen the cultural and social ties of communities that prioritize ecological welfare as a priority.

Awareness of climate change: Renewable energy projects help raise social awareness about climate change and provide carbon footprint-reducing effects, contributing to the formation of environmentally conscious environments.

Climate Change Awareness: Renewable energy projects help raise social awareness about climate change and provide effects that reduce carbon footprints, contributing to the formation of environmentally conscious communities.

Benefits for Future Generations: Renewable energy investments contribute to future generations inheriting a healthier planet, thereby building a more sustainable future.

Psychological Benefits: Both countries and businesses, by participating in renewable energy projects or being involved in the business processes created through these projects, develop an awareness of contributing to a sustainable future, which positively impacts human psychology. It creates a motivating effect.

All possible costs and benefits are placed in Figure 5.1.

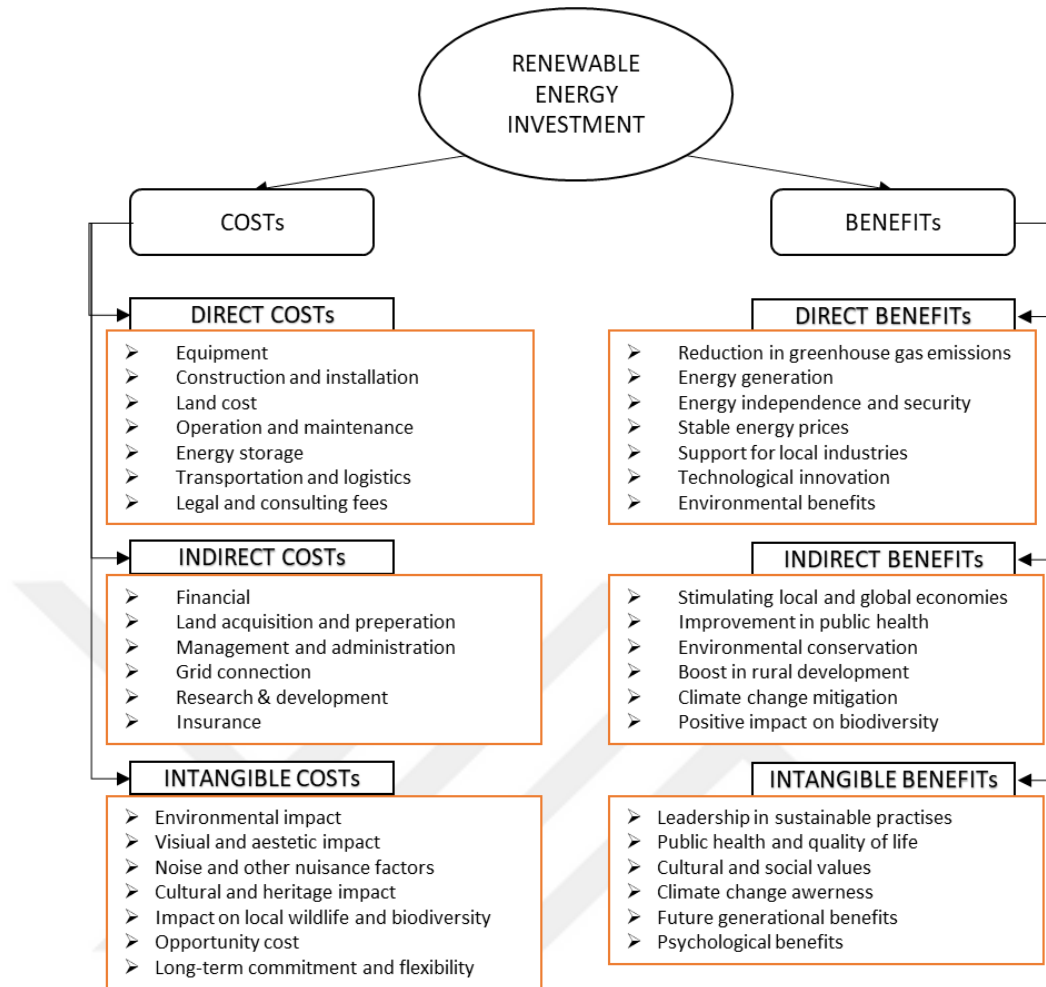


Figure 5.1: All possible costs and benefits of renewable energy powerplant investments

6 PROBLEM ASSESSMENT

In this thesis, the problem of how a retail chain in Turkey, with more than 3,000 stores and over 30 distribution centers, and an annual total energy consumption of 700,000 MWh, should implement an investment in a solar power plant will be examined. This will involve making certain decisions, and an effort will be made to solve this problem through a CBA. First, it will be clarified which cost and benefit items should be used as monetary values in the CBA, and then the steps on how to proceed with the investment will be outlined one by one.

6.1 Explanation of The Strategy for The Retail Company

The retail chain looking to make an investment has two primary objectives. The first is to reduce electricity consumption focused on fossil fuels by producing clean energy in line with its goal of achieving zero carbon emissions. The second is to relieve the burden on the budget balance caused by rising energy prices, especially due to the global increase in natural gas and oil prices due to the Covid pandemic and the Russia-Ukraine war. The Republic of Turkey, through a decision published in the Official Gazette on October 1, 2022, has issued a regulation approving the consumption of electricity produced in one location under the responsibility of any of the 21 different electricity distribution companies responsible for electricity distribution in Turkey, to be consumed in different electricity distribution areas. This regulation has thus provided an opportunity for large-scale companies, like retail chains, to benefit from clean energy produced through investments anywhere in the country for the electricity consumed in their stores (Official Gazette of Turkey Republic, 2022).



Figure 6.1: Electricity distribution companies in Turkey¹⁴

The retail company, which has a significant annual electricity consumption of 700,000 MWh across all its stores, has concluded that investing in renewable energy is indispensable due to the rise in energy prices making electricity consumption one of its most significant cost items. This new regulation should be perceived as an incentive for making investments in clean energy, allowing for the offsetting of electricity consumed by their own subscriptions anywhere in the country with the facility established anywhere in Turkey.

The 'Data on energy price trends' article for the year 2023, published by the Statistisches Bundesamt (Destatis), shows the change in the price per kilowatt-hour of industrial electricity consumption in Euro cents from the first half of 2008 to the first half of 2022, on a country-by-country basis, as seen in Table 6.1. The price statistics per kilowatt-hour for European countries, including Turkey, indicate a trend of increasing electricity prices, especially in the first half of 2020, which was exacerbated by the global impact of the Covid-19 pandemic. Prices reached their highest level in the first half of 2022 with the onset of the Russia-Ukraine war. Turkey, like other countries, has been affected by these price increases and has been driven into a tighter squeeze, already being in an inflationary trend. The decision of Turkey's energy market regulatory authority, published on October 1, 2022, regarding the offsetting of unlicensed electricity produced in a different distribution area anywhere in the country, is highly related to these price increases. Like

¹⁴ <https://www.myenerjisolar.com/elektrik-dagitim-sirketleri>

every country aiming to accelerate its steps towards zero carbon goals, Turkey has announced this decision, which encourages private enterprises to invest in renewable energy, thus opening another door for businesses hesitant about high investment costs.

Table 6.1: Energy price change of European countries between 2008 and 2022

Reference Period	Germany	France	Italy	Netherlands	Spain	Finland	Greece	Austria	Sweden	Czechia	Türkiye
1st half 2008	9.59	5.84	12.48	9.03	8.38	6.10	7.37	9.26	6.20	9.25	6.43
2nd half 2008	9.57	5.61	14.21	9.15	8.91	6.42	7.98	9.65	6.86	9.39	7.96
1st half 2009	10.02	6.86	13.33	9.88	9.53	6.57	8.29	10.86	5.91	9.40	7.24
2nd half 2009	10.07	6.12	12.24	9.73	9.34	6.64	8.11	10.81	6.01	9.78	7.21
1st half 2010	9.93	6.96	12.09	8.90	9.27	6.79	8.25	10.32	7.18	9.40	8.24
2nd half 2010	10.58	6.26	12.98	8.91	8.97	6.68	8.95	10.32	7.36	9.69	8.44
1st half 2011	11.21	7.42	12.95	8.68	9.16	7.33	8.85	10.12	7.89	9.96	6.99
2nd half 2011	11.39	7.00	13.93	8.72	9.37	7.23	9.20	10.14	7.08	9.67	6.80
1st half 2012	11.45	8.11	16.29	8.49	10.15	7.20	10.22	9.83	7.13	9.69	7.68
2nd half 2012	11.69	7.00	16.78	8.67	10.03	7.18	10.59	9.85	6.73	9.72	8.71
1st half 2013	12.78	8.34	15.37	8.83	10.46	7.12	10.68	9.84	6.90	9.72	8.86
2nd half 2013	12.73	7.43	15.91	8.65	10.80	7.17	10.70	9.80	6.72	9.55	7.59
1st half 2014	13.76	8.45	15.23	8.44	10.39	6.97	10.88	9.60	6.35	7.85	6.89
2nd half 2014	13.26	8.07	15.91	8.22	10.29	7.01	10.64	9.37	5.98	7.71	7.26
1st half 2015	13.16	8.95	14.89	8.17	9.68	6.63	10.02	8.97	5.45	7.18	7.88
2nd half 2015	13.00	8.47	14.85	7.97	9.55	6.81	8.97	9.09	5.15	7.20	6.96
1st half 2016	12.85	7.90	14.06	7.74	9.02	6.50	9.29	8.57	5.31	6.39	6.68
2nd half 2016	12.62	7.56	14.35	7.66	8.63	6.67	8.62	7.95	5.57	6.29	6.58
1st half 2017	12.68	7.84	13.44	7.74	8.81	6.38	9.02	8.14	5.53	6.20	5.85
2nd half 2017	12.70	7.41	13.24	7.58	8.59	6.51	9.99	8.43	5.56	6.30	5.68
1st half 2018	12.20	7.73	11.90	7.79	9.92	6.50	8.73	8.46	5.66	6.38	5.51
2nd half 2018	12.44	7.24	12.16	7.97	9.50	6.79	8.85	8.84	6.16	6.36	5.98
1st half 2019	13.10	8.35	14.17	8.67	9.67	6.74	9.26	9.48	6.64	7.30	6.61
2nd half 2019	13.61	7.89	13.99	8.59	9.28	6.76	9.50	9.58	5.96	7.55	8.01
1st half 2020	15.09	8.51	12.80	9.76	8.41	6.51	9.39	9.64	5.63	8.12	7.17
2nd half 2020	15.34	8.07	13.09	9.84	8.40	7.21	9.01	10.32	5.42	8.17	5.84
1st half 2021	15.01	8.70	13.40	10.58	8.77	6.37	10.29	10.79	6.05	8.82	6.15
2nd half 2021	16.42	8.82	16.07	12.74	15.28	7.82	19.27	11.95	8.84	9.92	7.40
1st half 2022	19.25	12.58	23.44	17.38	19.02	8.70	27.13	17.40	9.78	16.48	11.46

In light of all this information, companies with stores and, consequently, an electricity consumption network across many parts of Turkey, like the company in question, have turned towards unlicensed renewable energy investments. However, the critical point in this orientation is how to make the right decision. The new decision that the relevant retail chain company needs to make is where to establish the solar power plant. The most crucial supporting point for this decision is the opportunity to benefit from investment incentives provided separately by the Government of the Republic of Turkey for each province. The Government of the Republic of Turkey, with the aim of encouraging investments by private enterprises, has provided advantages such as tax exemptions for a certain percentage of the amount invested in each province, through the 'Decision on State Aids in Investments' numbered 2012/3305, published in the Official Gazette on 19.06.2012, and the implementation circular numbered 2012/1, published on 20.06.2012. In the investment incentive systems presentation published on the website of the Ministry of Industry (accessed: November 2023), the provinces listed in the Table 6.2 below are divided into incentive regions, and investments made in these regions are entitled to tax

reductions according to the advantages offered for each region. Investments in the 6th region receive a 50% tax deduction incentive, those in the 5th region receive 40%, and investments in other regions receive a 30% tax deduction incentive. Therefore, it is expected that a company investing in a renewable energy plant will make an investment in the 6th region.



Figure 6.2: Regional incentive map of Turkey

The creation of tax benefits at a rate of 50% for a large-scale renewable energy investment is certainly a situation that cannot be overlooked. Therefore, it is expected that this retail company will make an investment in the 6th region. According to the Turkey Solar Energy Potential Atlas published by the Ministry of Energy and Natural Resources of the Republic of Turkey (accessed: November 2023), among the provinces in the 6th region, Van has the highest solar radiation. Hence, it has emerged that Van is the most suitable province for the solar energy investment of the retail chain in question. After deciding to establish a solar power plant in Van, the main discussion topic, which is also the primary subject of the thesis, arises. Here, a CBA will be conducted to decide whether the investment should be made by the company using 100% equity, through a loan, or via a Build-Transfer-Operate model with an energy production company. The Build-Transfer-Operate method is a form of energy plant production provided by energy producer companies, where after the construction of the solar power plant, the plant is transferred to the owning company against a letter of bank guarantee, and the constructing firm takes

over the operation, charging the owner company for each unit of electricity produced. This way, the retail company avoids the financial burden of establishment and instead passes it to the energy company. The energy company, in turn, sells the electricity produced by the plant to the retail company, seeking to make a long-term profit from this venture. The operation of this system can be understood more clearly in the Figure 6.3.

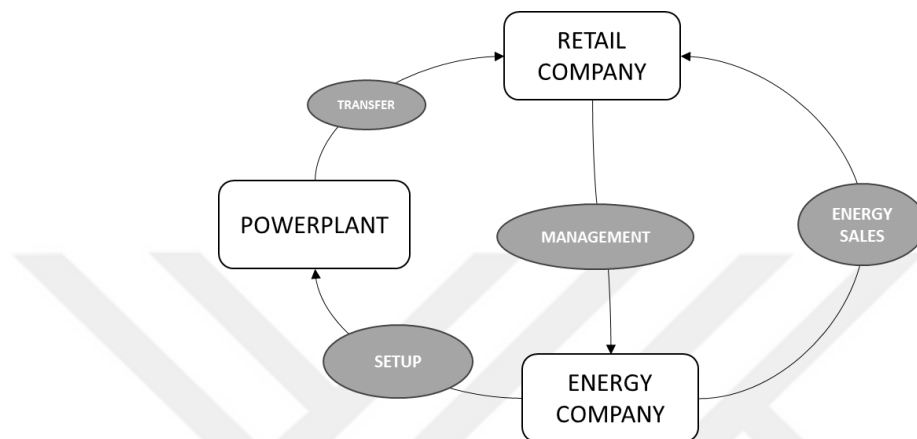


Figure 6.3: Build-Transfer-Operate method

In this context, we have mentioned two different methods for the retail company to set up its own power plant: investment through equity or through a loan. The third option is the Build-Transfer-Operate method with an energy company. In all three methods, the retail company needs to decide which will provide more NPV benefit through a CBA. When performing the CBA for the Build-Transfer-Operate method with an energy company, the most crucial variable is how much the retail chain will pay per unit of electricity to the energy company. An IRR approach will also be conducted in the CBA to determine how much this unit price should be.

The most significant factor influencing the decision during the CBA is the IRR method. With the IRR method, the annual average expected returns of the investment will be compared, and actions will be taken accordingly. At the same time, determining the Weighted Average Cost of Capital (WACC) rate is another critical aspect when calculating the NPV. Finally, the savings from the electricity to be used from the grid will be considered as a benefit. The forecasts for future electricity prices will also play a critical role in the decision-making stages of the model, as these prices will be evaluated as benefits.

6.2 Model Type and Structure

The detailed explanation of the CBA was provided earlier. The previous section also discussed the three options available to the retail company deciding to establish a solar power plant. For the application of the CBA, it is first necessary to determine the costs and benefits. Specifically, the costs and benefits associated with renewable energy investments were explained. These items will be used to describe the general structure of our model.

Our proposed model, which will apply the CBA, will separately analyze whether the investment by the retail company in the province of Van will be made through equity, credit, or the Build-Transfer-Operate model. The structure of the following proposed model can be seen below.

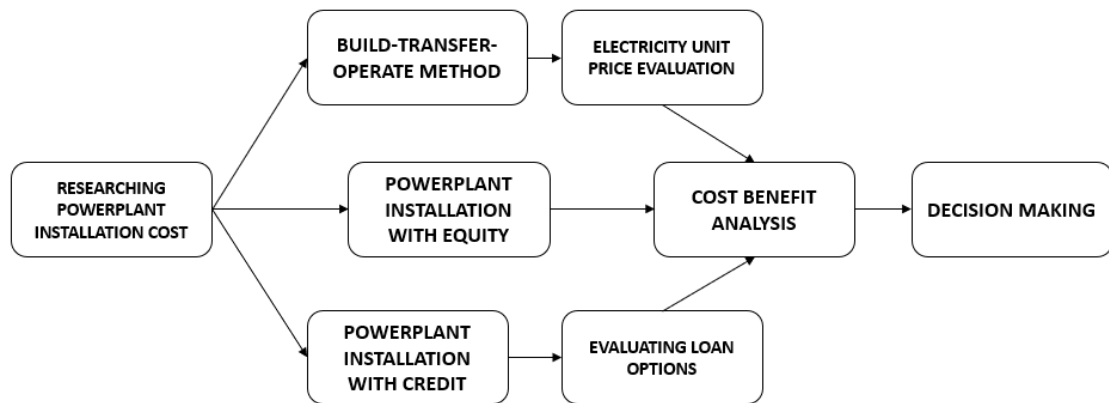


Figure 6.4: Investment decision-making model

According to this model, if the retail company proceeds with the Build-Transfer-Operate method for its investment in the province of Van, it will need to determine at what price per unit of electricity in the agreement would be mutually beneficial for both the retail company and the energy company.

The CBA will proceed with the model shown in Figure 6.5 below. In this decision-making step, if the retail chain decides to build the power plant itself, it will need to clarify which would be more beneficial: using equity or a loan. In addition, if the company works with

an energy firm using the Build-Transfer-Operate model, the suitable unit price for this collaboration will be determined.

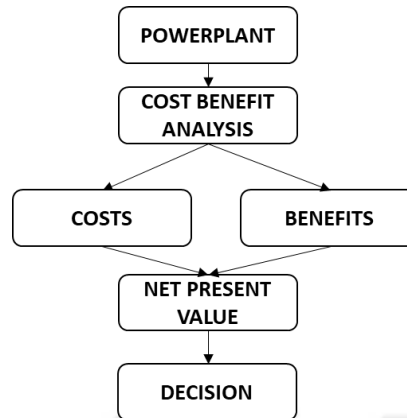


Figure 6.5: Decision-making steps of powerplant investment

Even though it is expected that the Build-Transfer-Operate arrangement with an energy company might provide less financial benefit compared to the retail company doing it by itself, the potential advantages of this method will also be discussed separately.

6.3 Data for Cost & Benefits

It was mentioned that a CBA would be conducted for 3 different options. Determining the parameters for the time value of money for these 3 different options constitutes one of the most important stages. As the time value of money, the costs and benefits need to be detailed, and relevant future period estimates must be entered into the cash flow.

Firstly, research shows that the lifespan of a solar power plant is 25 years. After 25 years, technological renewal works must be carried out to continue using the plant. This could be considered as an investment in a new plant, or it could be thought of as completely disposing of the plant along with the land.

Despite there being many tangible and intangible factors that could be considered as inputs and outputs during this 25-year period for the CBA, some will be ignored, and the study will be conducted with this in mind. The parameters to be considered in the CBA during this period will be:

- Land cost
- Land development cost
- Plant installation cost
- Energy transmission line (connection to the grid) installation
- Annual operation, maintenance, repair, and security costs
- Distribution fee for feeding electricity into the grid after production
- Distribution fee for drawing electricity from the grid
- Depreciation (to be added first for measuring tax benefit and then subtracted)

Global solar panel prices, valuations of power producers for plant installations, and energy unit prices in countries in Europe, America, or any other continent, progress indexed to the US dollar currency. One of the main reasons for this is that the US dollar is accepted as a valid currency in global markets. Another important reason is that inflation rates of the dollar over the years are lower and more stable compared to other currencies.

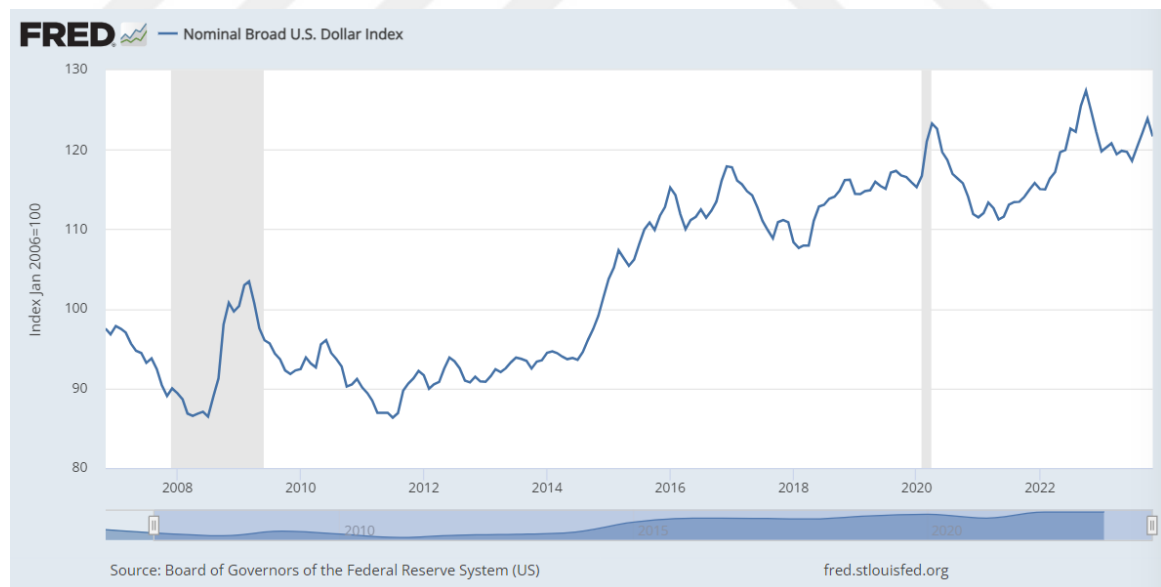


Figure 6.6: Historical US Dollar index of previous years

The Figure 6.6 shows the annual change in the US dollar according to the world currency index based on data from the official website of the US Federal Reserve (fred.stlouisfed.org, Access: November 2023).

As can be seen from the figure, since 2007, the currency has depreciated by approximately 20%. This corresponds to an annual depreciation of about 1%, which is quite low considering the currencies used in today's markets. In this context, the US dollar currency will be used for all cost items mentioned above as well as other parameters that constitute the benefits and costs.

Firstly, to determine the cost of land, it must be clarified how many MWp of power a retail company is going to install in its energy plant. For a retail company with an annual total energy consumption of more than 700,000 MWh, a plant in the province of Van must be 423 MWp in size to meet all its electricity consumption, based on the average annual radiation value of 1652 kwh/kwp. However, considering that a 1 MWp plant covers an average area of 13,000 square meters, a plant of this size would correspond to an area of 5.5 square kilometers, which is quite challenging to develop in one go. Given the reality that a land containing a solar power plant of this size will not be on a single parcel, both the consolidation of all parcels and the conditions of not being agricultural land, as well as passing all environmental impact values positively, are quite challenging. Moreover, considering that it is nearly impossible for the land's topography to be uniformly flat and at the desired slopes, it will be assumed that the example plant investment in our case will be 10 MWp in size. The average required area for a 10 MWp size land is 130,000 square meters, and developing land of this size can be relatively easier.

Market research shows that as of November 2023, the price per square meter for a non-agricultural land of 130,000 square meters in the province of Van suitable for plant installation is approximately 3 USD/square meter. Additionally, according to market research, the average cost per MWp for all official procedures and project development activities carried out until the zoning approval for the plant installation is obtained is identified as 40,000 USD.

After determining the land and land development costs, the next step is to research the installation prices of the plant to be built on the land. It was mentioned in previous sections that the most significant cost item affecting the installation of a solar energy plant

is photovoltaic panels. Approximately 80% of the world's solar energy panels are imported from China. Especially in 2023, it is known that the prices of the latest technology 550-Watt monocrystalline solar panels, which the retail company also wants to use in its own plant, have started to decrease globally due to cost reductions in the cell technology used in the raw material of this panel.

According to data published on its own web address by PVXvhange, one of the world's largest panel distributors based in the UK, photovoltaic panel prices worldwide have shown a downward trend as seen in the Figure 6.7. Accordingly, the high-efficiency solar panel index, which was 0.40 Euro/Watt in November 2022, has experienced a significant drop by November 2023, falling to 0.25 Euro/Watt.

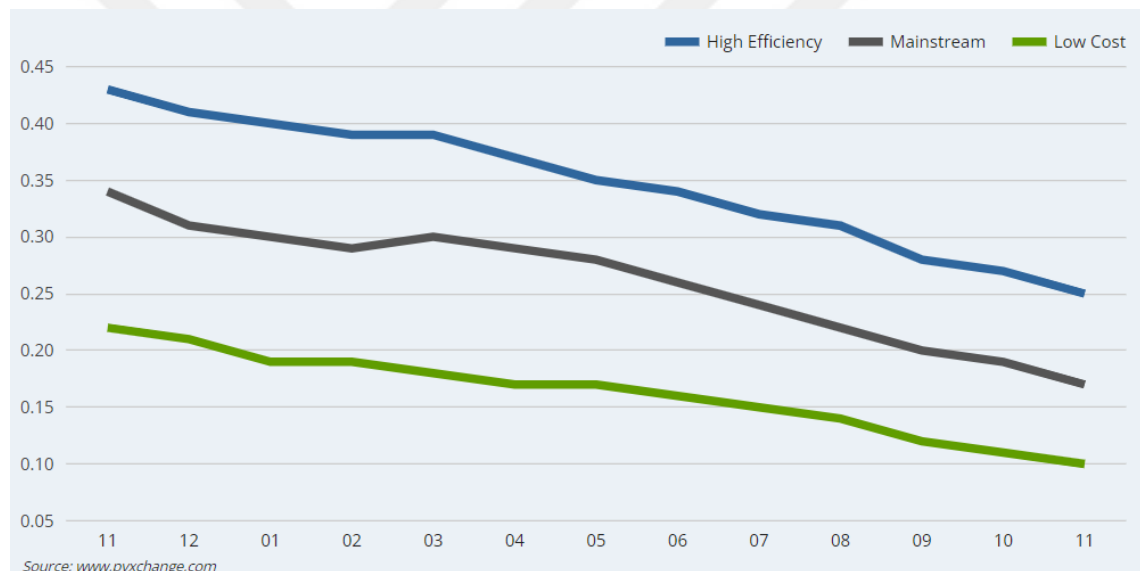


Figure 6.7: Panel price change graph from November 2022 to November 2023

As of November 2023, taking into account that the Euro-Dollar exchange rate is approximately 1.1, the equivalent price of 0.25 Euro/Watt corresponds to about 0.23 USD/Watt. Based on the information in earlier sections that panel prices constitute 40-50% of the cost of a solar energy plant, it can be assumed that the cost per MWp of the solar energy plant will be 575,000 USD in a worst-case scenario.

After estimating the approximate cost of the plant installation, the next item to consider is the cost of installing the Energy Transmission Line. Market research indicates that the

cost of installing an energy transmission line is approximately 110,000 USD per kilometer between the power plant and the connecting transformer. Assuming a generally accepted notion that the distance to the transformer is 1 km per MWp, it is accepted that this will be 10 km for the plant to be installed. This means that the total cost of installing the energy transmission line would be 1,100,000 USD.

After determining the investment costs, it will be necessary to determine the annual maintenance, repair, operation, and security costs for the relevant solar energy plant. As of November 2023, market research has found that this cost averages 15,000 USD per MWp. This value is determined by the area covered by the solar energy plant, as costs for operations, maintenance, repair, and security increase with area. An annual cost of 15,000 USD per 13,000 square kilometers has been identified as a generally accepted market value.

After the solar energy plant is installed, there is a distribution fee set by the EPDK for feeding each kWh of electricity produced into the grid. This fee is published regularly by the EPDK within certain time intervals. In 2023, EPDK, which publishes electricity price tariffs every three months, set the fees for this at 3.5 USD cents per kWh for January-March, 3.2 USD cents for April-June, 2.8 USD cents for July-September, and 2.7 USD cents for October-December. While these values were below 2 USD cents in previous years, they have shifted to higher tariffs to the benefit of distribution companies according to market managers. Assuming this policy will continue in the future, the 2023 average of 3.02 USD cents per kWh will be used in our CBA.

To utilize the electricity supplied by the energy plant in the retail company's stores, i.e., to reconcile with the distribution network, it must also be drawn from the grid. Every place, whether it has a solar energy plant or not, and operating under normal commercial status, applies a distribution fee to the distribution company in addition to using electricity at the tariff set by the EPDK. After the installation of the solar energy plant, this fee will still apply and has increased compared to the old distribution fees with new updates in 2023, closing the year with an average of 3.6 USD cents per kWh. Therefore, it is appropriate to use a grid draw fee of 3.6 cents per kWh in our CBA for the following years.

Amortization costs will be determined based on the equipment installed with the plant's setup and will be appropriately distributed over the solar energy plant's total lifespan of 25 years. Accordingly, the amortization cost will be calculated by dividing the total equipment cost incurred during plant installation equally over 25 years. Assuming the total plant installation cost is $575,000 \text{ USD/MWp} \times 10 \text{ MWp} = 5,575,000 \text{ USD}$, the annual amortization cost is expected to be 223,000 USD/year.

All the above-mentioned costs for the installation and continued operation of the plant reflect current cost values, but it is also necessary to include the inflation predictions of the currency to be used, namely the US dollar, in the calculations.

After determining the costs and the currency to be used for our 25-year CBA, estimating future inflation rates for the currency is another important parameter.

The Figure 6.8, taken from the official website of the U.S. Bureau of Labor Statistics, shows the 12-month inflation rates of the US Dollar for the past 20 years (data.bls.gov, Access: November: 2023) :

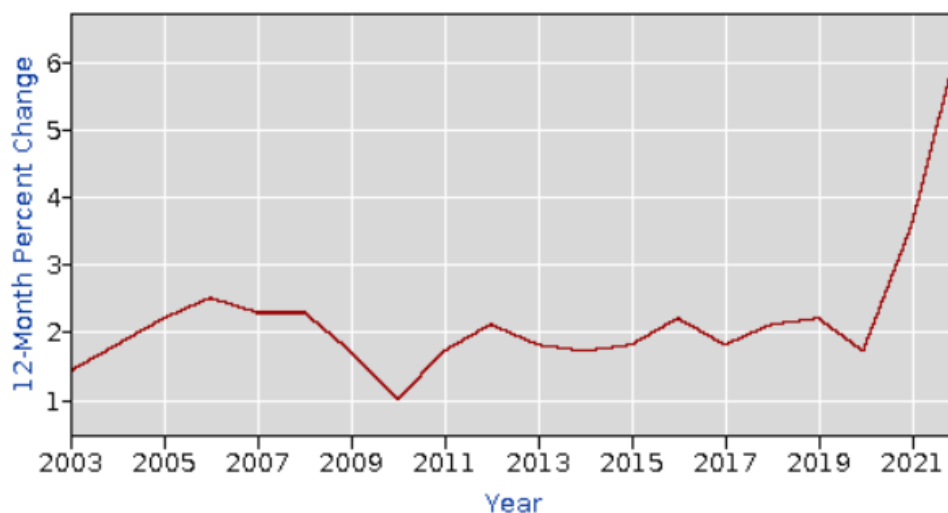


Figure 6.8: Annual inflation of the US Dollar in past years

An examination of the past 20 years reveals that the annual inflation rate, which hovered around an average of 2% until 2020, began to rise after 2020, reaching levels around 6%.

The primary reason for this is the impact of the Covid-19 pandemic that began in 2020, which led to supply chain issues in global markets and an increase in demand inflation. In response to this inflation, the Federal Reserve (the central bank of the United States) attempted to take measures by increasing interest rates and tried to keep the upward trajectory of inflation under control.

For the coming years, while the CBA we will apply is based on these inflation expectations, it is evident that a long-term average inflation rate of 2% can be assumed from past averages. However, for the initial years of the solar energy plant investment, particularly in 2024, it would not be accurate to assume a 2% dollar inflation rate. Financial experts suggest that after attempts to stabilize inflation with interest rate hikes, it will take some time for the inflation rate to decrease and settle at the 2% mark.

In the relevant application, assuming the increasing trend of U.S. dollar inflation from 2020 to 2022 as a basis, it is assumed that it will decrease at the same rate after 2023. It is projected that the annual inflation rate will be 4% in 2024, 3% in 2025, and 2% in 2026. For the years following 2026, the monetary values of costs or benefits will be adjusted with these inflation rates, using the historical average annual rate of 2%. For this, if we take the index value of 2024 as 1, the rates to be charged in the following years will be as shown in the Table 6.2 below. Here, 2024 is considered the year of the plant's construction, with operation anticipated in 2025, and it has been deemed appropriate not to enter any inflation value for 2024.

Table 6.2: Inflation index to be used in cost benefit analysis

Period	0	1	2	3	...	25
Year	2024	2025	2026	2027	...	2049
Inflation Rate		3%	2%	2%	...	2%
Inflation Index	1	1.03	1.05	1.07	...	1.66

Two other important considerations for future periods in the CBA are the changes in electricity tariffs due to the replacement of grid electricity with electricity produced by the plant, and the carbon taxes implemented by governments to maintain their carbon zero policies, both of which will be shown as benefits.

The electricity used in the stores of the retail company planning to install the solar energy plant is classified as commercial tariff electricity. Including the future estimated values of this electricity, which is priced according to tariffs set by the electricity market regulatory board, in our CBA cash flow is another key factor. For this purpose, it is necessary to examine the annual average prices of the commercial electricity tariff rates.

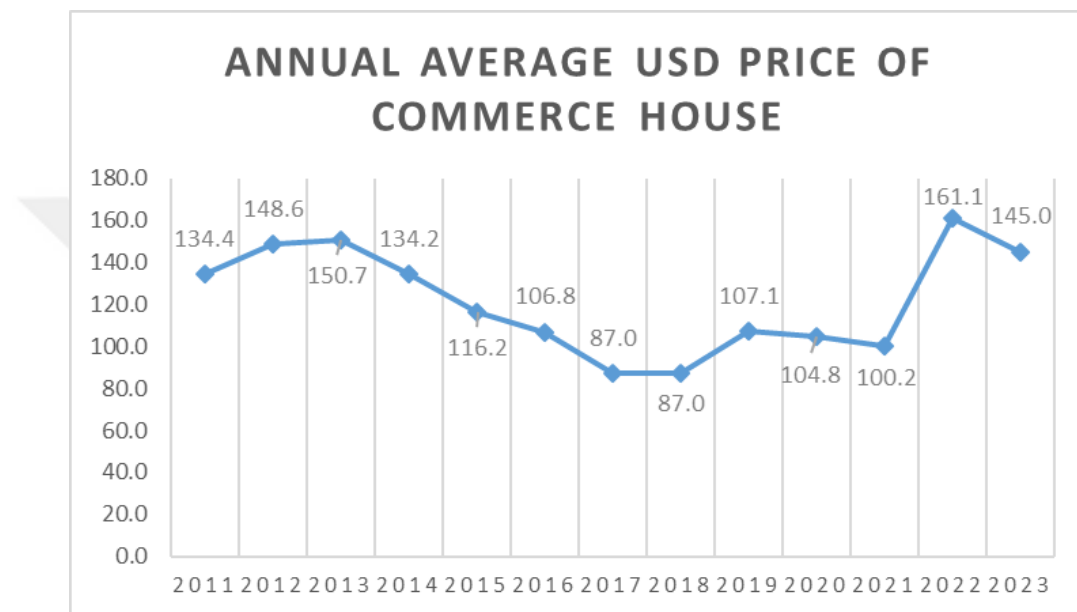


Figure 6.9: Turkey's past years' commercial electricity tariff prices

As can be seen in the Figure 6.9, since 2011, the average annual price per MWh for commercial electricity in Turkey, including tax and other fees, has been 121.77 USD. Consequently, in the CBA we will create, the uninflated energy prices will also be the average value of 121.77 dollars.

The final value stream we need to consider in the cash flow for our CBA is carbon emission taxation. States in Europe and other countries around the world have shifted to a taxation system per ton of CO₂ emissions as part of their goal to reduce carbon emissions to zero, under international agreements. This taxation, as can be seen in the Figure 6.10x” published by the World Tax Foundation, has already been implemented in some European countries but has not yet been activated in Turkey. Turkey, having signed the Paris Climate Agreement in 2015, is expected to adopt a carbon taxation system by

2025 as part of its commitment to reduce greenhouse gas emissions by 21% by 2030, in addition to the renewable energy investment incentives it has implemented.

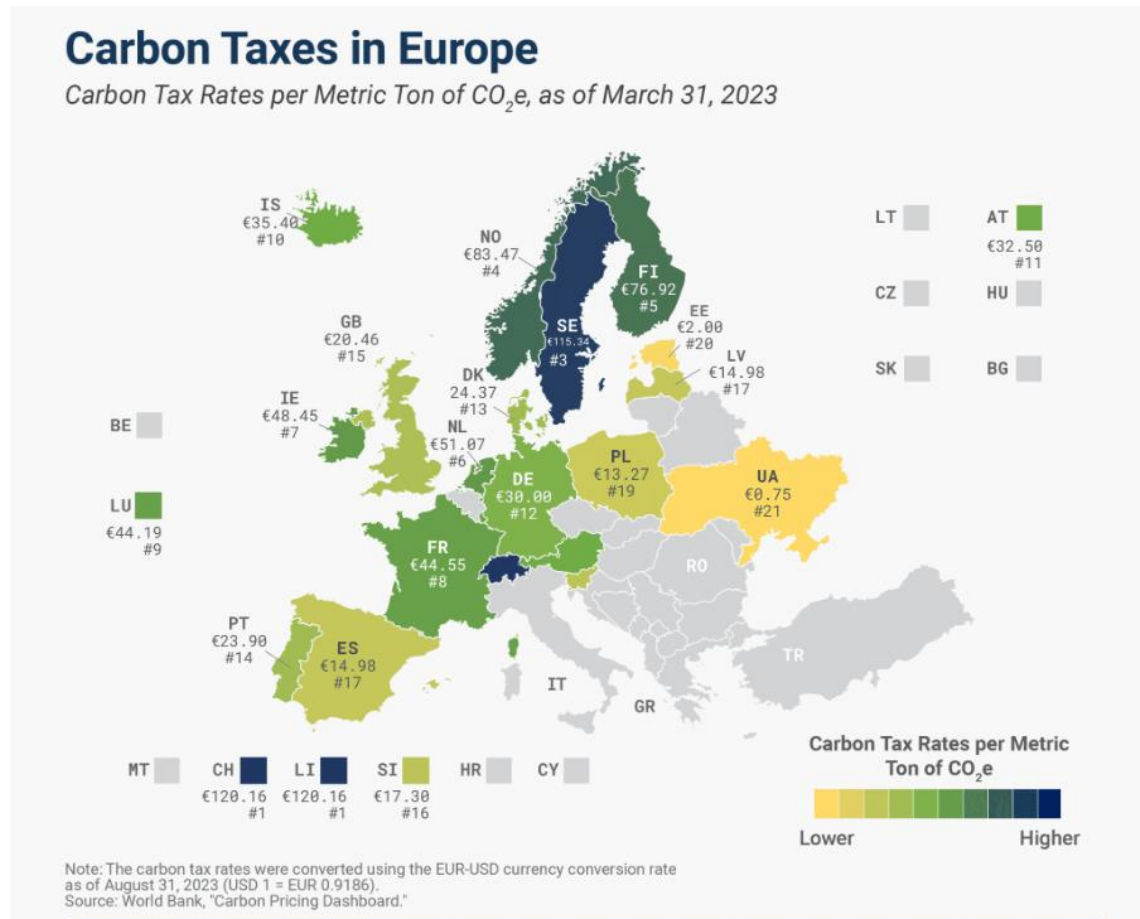


Figure 6.10: European countries with carbon tax and their tax prices

Since the carbon taxation system has not yet been implemented in Turkey, it is not yet clear how much carbon tax will be charged per ton of CO₂. For this reason, the average of the carbon taxation data from European countries will be used, and these charges will be reflected in the cash flow after 2025. The average carbon tax implemented by 21 European countries that have a carbon tax is 48.56 USD per ton of CO₂. According to data released by the United States Energy Information Administration, in the United States, the average electricity generation from natural gas, coal, and petroleum results in 1 ton of carbon emissions for every 2564 kWh (Access: November 2023). If we use this value for Turkey, it can be written in the benefit section of the cash flow that the solar energy plant investment will be exempt from a carbon tax of 48.56 USD per 2564 kWh, which corresponds to approximately 0.019 USD cents per kWh.

After determining the monetary value of the costs and benefits, it has also been explained how these costs and benefits will progress over the years. Before creating the CBA for the retail company's investment with an examination of 3 options, another point to clarify is determining the discount rate to be used in the NPV calculation. The methods for determining discount rates were discussed in Section 5.1. In the relevant case, the WACC rate will be used to find the discount rate.

The parameters necessary to calculate the critical WACC rate for calculating the NPV of money are 'company total debt,' 'company total equity,' 'cost of debt,' and 'cost of equity.' For our application involving the installation of a solar energy plant, since our retail company is a publicly traded company, multiplying its total shares in circulation by the current stock price gives a total equity of 61,558,439,220 TRY. Additionally, according to the company's 2023 Q3 balance sheets, its total long-term and short-term debts amount to 47,787,756,000 TRY.

When comparing loan offers collected from domestic and foreign banks for the company's investment in a solar energy plant, the best offer turned out to be a loan with a 7-year term, including a 1-year grace period, 20% investment down payment, and an interest rate of 9.57% in US dollars.

Furthermore, considering Turkey's market conditions in 2023, both the risk-free rate and risk premium rate indicate that the cost of equity for this particular retail company is observed to be 14.41%.

Accordingly, based on these data and applying the formula communicated in earlier sections, our calculation has determined the WACC rate to be 11.2%.

After determining the values of all parameters, it's time to move on to the implementation part of the CBA with three options. In the following section, the models and applications needed to create the relevant cash flows will be explained, and it will be discussed which is the best option or options for the retail company to construct a solar energy plant.

7 APPLICATION

In the previous section, the costs, benefits, and the time value of money, which form the critical point of the analysis, such as 'net present value' and 'internal rate of return,' were detailed for the CBA. This section will cover the modeling of cash flows necessary for the implementation of the CBA and the applications of these cash flows. All calculations for cash flow results are made by Excel program.

7.1 CBA Modelling of Photovoltaic Plant Investment for Retail Company

For implementing the cash flow of the three options for the investment to be made by the retail company – using 100% equity, 80% loan financing, or a Build-Transfer-Operate model with an energy company – it will be necessary to first use the parameters. For Option 1, which is the investment made using 100% equity, Table 7.1 assigns a letter for each parameter required in the cash flow, and Table 7.2 shows the structure of the model containing the calculations of the cash flow.

Table 7.1: Parameters to be used for cash flow

Installed Power (MWp)	a
Radiation (kwh/kwp)	b
Land Cost (USD)	c
Land Development Cost (USD)	d
Facility Installation Cost (USD)	e
Power Transmission Line Installation Cost (USD)	f
Annual Operational Cost (USD/MWp)	g
Electricity Grid Feed-in Price (USD/kwh)	h
Electricity Grid Purchase Price (USD/kwh)	i
Period	j
Inflation Index of the Year (2024 = 1)	k_j
Electricity Tariff Price (Including all other fees) (USD/kwh)	m
Annual Carbon Tax (USD/kwh)	n
WACC Rate	r
Energy Powerplant Yearly Degredation Rate	s
Year	t
Corporate Tax Rate	25%
Regional Inventive Rate	50%

According to the parameters in Table-7.1, the cash flow created over 25 years using 100% equity will be as shown in Table-7.2. Here, what each equation represents is written alongside it. The model will be calculated by placing the data over this cash flow. The 'net present value' and 'internal rate of return' calculated after the cash flow are important for comparing between options.

Table 7.2: Cash flow modeling for option 1

Period (j)	$j = \{0,1,2, \dots, 25\}$
Year (t)	$t = \{2024, 2025, \dots, 2049\}$
Period - Year Match	$j_{(0)} = 2024, j_{(1)} = 2025, \dots, j_{(25)} = 2049$
Estimated Electricity Produced (Y)	$Y_j = ab(1 - s)^j \times 1000 \quad j = \{1, 2, \dots, 25\}$
Total Investment (A)	$Z_j = -(c + d + e + f) \quad j = 0$
Total Benefits of Incentives (Z)	$A_j = (c + d + e + f) \times \frac{50}{100} \quad j = 1$
Benefit from Electricity Production (B)	$B_j = Y_j m k_j \quad j = \{1, 2, \dots, 25\}$
Benefit of Carbon Tax (C)	$C_j = Y_j n k_j \quad j = \{1, 2, \dots, 25\}$
Electricity Grid Feed-in Tariff (D)	$D_j = Y_j h k_j \quad j = \{1, 2, \dots, 25\}$
Electricity Grid Purchase Cost (E)	$E_j = Y_j i k_j \quad j = \{1, 2, \dots, 25\}$
Total Annual Savings (F)	$F_j = B_j + C_j - (D_j + E_j) \quad j = \{1, 2, \dots, 25\}$
Annual Operational Expenses (G)	$G_j = g a k_j \quad j = \{1, 2, \dots, 25\}$
Earnings Before Interest Taxes Depreciation and Amortization (EBITDA)	$H_j = F_j - G_j \quad j = \{1, 2, \dots, 25\}$
Amortization Cost (I)	$I_j = \frac{-e}{25} \quad j = \{1, 2, \dots, 25\}$
Operating Margin (K)	$K_j = H_j + I_j \quad j = \{1, 2, \dots, 25\}$
Tax Expense (L)	$L_j = K_j \times 0.25 \quad j = \{1, 2, \dots, 25\}$
Net Income after Tax (M)	$M_j = K_j - L_j \quad j = \{1, 2, \dots, 25\}$
Add Back of Amortization (N)	$N_j = -I_j \quad j = \{1, 2, \dots, 25\}$
Free Cash Flow (P)	$P_j = Z_j + A_j + M_j + N_j \quad j = \{0, 1, \dots, 25\}$
Cumulative Free Cash Flow (R)	$R_j = P_{j-1} + P_j \quad j = \{1, 2, \dots, 25\}$
Discount Rate (S)	$S_j = (1 + r)^j \quad j = \{0, 1, \dots, 25\}$
Discounted Cash Flow (T)	$T_j = \frac{P_j}{S_j} \quad j = \{0, 1, \dots, 25\}$
Cumulative Discounted Cash Flow (U)	$U_j = T_{j-1} + T_j \quad j = \{1, 2, \dots, 25\}$

$$\text{NET PRESENT VALUE: } \sum_{j=0}^{25} T_j$$

In Option 2, the loan option will be used. As mentioned in the previous section, as of November 2023, the best loan offer in the market was a 7-year term loan with a 9.32% interest rate, including a 1-year grace period. In the solar plant investment option with a loan, banks require a minimum of 20% of the investment to be financed through equity. In this context, a cash flow will be created based on using 80% loan financing.

Table 7.3 displays the parameters that will be used for the payment plan created with the use of a loan. In Table 7.4, the calculation model showing the periodic loan payment options based on these parameters is presented.

Table 7.3: Loan usage parameters

Amount to be Loaned (Z)	$Z = (c + d + e + f)x\frac{80}{100}$
Payment terms (years)	7
Grace Period (year)	1
Interest rate	r
Installment Number (number/year)	2
Credit Usage Date	1.01.2024

As can be seen in Table 7.3, the use date of the loan is estimated to be January 1, 2024. For the loan used in 2024, there will be a grace period of one year for repayment. As can be seen in the payment plan model in the following Table 7.4, payments will start on January 1, 2025, and will last for a total of 6 years, i.e., 12 periods.

Table 7.4: Loan repayment plan modeling

Payment Date	Period (t)	Principal Repayment (R)	Principal Balance (B)	Payment of Interest (P)	Total Payment (T)
1.01.2024	1	0	Z	0	0
1.07.2024	2	0	Z	0	
1.01.2025	3	$R = \frac{Z}{12}$	$B_3 = Z - R$	$P_3 = B_3 \times i \times 0.75$	$T_3 = R + P_3$
1.07.2025	4	$R = \frac{Z}{12}$	$B_4 = B_3 - R$	$P_4 = B_4 \times i \times 0.75$	$T_4 = R + P_4$
1.01.2026	5	$R = \frac{Z}{12}$	$B_5 = B_4 - R$	$P_5 = B_5 \times i \times 0.75$	$T_5 = R + P_5$
...	...	...	...	...	...
1.07.2030	14	$R = \frac{Z}{12}$	$B_{14} = B_{13} - R$	$P_{14} = B_{14} \times i \times 0.75$	$T_{14} = R + P_{14}$

For Option 2, i.e., the investment in the energy plant using a loan, the cash flow will differ from that in Option 1. Instead of taking the entire amount of the total investment, only about twenty percent will be considered, and for the remaining portion, the loan repayment cash flow as seen in Table 7.4 will be applied. Table 7.5 provides the modeling of the cash flow to be applied for Option 2. The parameters used in Table 7.5 have been taken from Table 7.1.

Table 7.5: Cash flow modeling for option 2

Period (j)	$j = \{0, 1, 2, \dots, 25\}$
Year (t)	$t = \{2024, 2025, \dots, 2049\}$
Period - Year Match	$j_{(0)} = 2024, j_{(1)} = 2025, \dots, j_{(25)} = 2049$
Estimated Electricity Produced (Y)	$Y_j = ab(1 - s)^j \times 1000 \quad j = \{1, 2, \dots, 25\}$
Total Investment (A)	$A_j = -(c + d + e + f)x \frac{20}{100} \quad j = 0$
Total Payment of Credit (V)	Shown in Table-23
Total Benefits of Incentives (Z)	$Z_j = (c + d + e + f)x \frac{50}{100} \quad j = 1$
Benefit from Electricity Production (B)	$B_j = Y_j m k_j \quad j = \{1, 2, \dots, 25\}$
Benefit of Carbon Tax (C)	$C_j = Y_j n k_j \quad j = \{1, 2, \dots, 25\}$
Electricity Grid Feed-in Tariff (D)	$D_j = Y_j h k_j \quad j = \{1, 2, \dots, 25\}$
Electricity Grid Purchase Cost (E)	$E_j = Y_j i k_j \quad j = \{1, 2, \dots, 25\}$
Total Annual Savings (F)	$F_j = B_j + C_j - (D_j + E_j) \quad j = \{1, 2, \dots, 25\}$
Annual Operational Expenses (G)	$G_j = g a k_j \quad j = \{1, 2, \dots, 25\}$
Earnings Before Interest Taxes Depreciation and Amortization (EBITDA)	$H_j = F_j - G_j \quad j = \{1, 2, \dots, 25\}$
Amortization Cost (I)	$I_j = \frac{-e}{25} \quad j = \{1, 2, \dots, 25\}$
Operating Margin (K)	$K_j = H_j + I_j \quad j = \{1, 2, \dots, 25\}$
Tax Expense (L)	$L_j = K_j \times 0.25 \quad j = \{1, 2, \dots, 25\}$
Net Income after Tax (M)	$M_j = K_j - L_j \quad j = \{1, 2, \dots, 25\}$
Add Back of Amortization (N)	$N_j = -I_j \quad j = \{1, 2, \dots, 25\}$
Free Cash Flow (P)	$P_j = V_j + Z_j + A_j + M_j + N_j \quad j = \{0, 1, \dots, 25\}$
Cumulative Free Cash Flow (R)	$R_j = P_{j-1} + P_j \quad j = \{1, 2, \dots, 25\}$
Discount Rate (S)	$S_j = (1 + r)^j \quad j = \{0, 1, \dots, 25\}$
Discounted Cash Flow (T)	$T_j = \frac{P_j}{S_j} \quad j = \{0, 1, \dots, 25\}$
Cumulative Discounted Cash Flow (U)	$U_j = T_{j-1} + T_j \quad j = \{1, 2, \dots, 25\}$

$$\text{NET PRESENT VALUE: } \sum_{j=0}^{25} T_j$$

In addition to the models created for the CBA of Option 1 and Option 2, it is also necessary to develop a separate cash flow for the plant to be established using the Build-Transfer-Operate method. However, in the cash flow to be created, the energy company will need to make sales based on a pricing per unit of electricity produced. The energy company desires to make an investment where it equates its costs to its revenues in the annual cash flow for the 10 years it will operate this plant, with an IRR of 15% (IRR = 15%). In this context, first, a unit electricity sale price that will result in an IRR of 15% for the energy company will be found, and then cash flows for both the energy and retail companies will be derived.

Table 7.6: Cash flow modeling for retail company in option 3

Period (j)	$j = \{0, 1, 2, \dots, 25\}$
Year (t)	$t = \{2024, 2025, \dots, 2049\}$
Period - Year Match	$j_{(0)} = 2024, j_{(1)} = 2025, \dots, j_{(25)} = 2049$
Estimated Electricity Produced (Y)	$Y_j = ab(1 - s)^j \quad j = \{1, 2, \dots, 25\}$
Total Benefits of Incentives (Z)	$Z_j = (c + d + e + f)x \frac{50}{100} \quad j = 1$
Payment to Energy Company (A)	$A_j = Y_j v \quad j = \{1, 2, \dots, 10\}$
Benefit from Electricity Production (B)	$B_j = Y_j m k_j \quad j = \{1, 2, \dots, 25\}$
Benefit of Carbon Tax (C)	$C_j = Y_j n k_j \quad j = \{1, 2, \dots, 25\}$
Electricity Grid Feed-in Tariff (D)	$D_j = Y_j h k_j \quad j = \{1, 2, \dots, 25\}$
Electricity Grid Purchase Cost (E)	$E_j = Y_j i k_j \quad j = \{1, 2, \dots, 25\}$
Total Annual Savings (F)	$F_j = B_j + C_j - (D_j + E_j) \quad j = \{1, 2, \dots, 25\}$
Annual Operational Expenses (G)	$G_j = g a k_j \quad j = \{1, 12, \dots, 25\}$
Earnings Before Interest Taxes Depreciation and Amortization (EBITDA)	$H_j = F_j + G_j \quad j = \{1, 2, \dots, 25\}$
Amortization Cost (I)	$I_j = \frac{-e}{25} \quad j = \{1, 2, \dots, 25\}$
Operating Margin (K)	$K_j = H_j + I_j \quad j = \{1, 2, \dots, 25\}$
Tax Expense (L)	$L_j = K_j \times 0.25 \quad j = \{1, 2, \dots, 25\}$
Net Income after Tax (M)	$M_j = K_j - L_j \quad j = \{1, 2, \dots, 25\}$
Add Back of Amortization (N)	$N_j = -I_j \quad j = \{1, 2, \dots, 25\}$
Free Cash Flow (P)	$P_j = A_j + Z_j + M_j + I_j \quad j = \{0, 1, \dots, 25\}$
Cumulative Free Cash Flow (R)	$R_j = P_{j-1} + P_j \quad j = \{1, 2, \dots, 25\}$
Discount Rate (S)	$S_j = (1 + r)^j \quad j = \{0, 1, \dots, 25\}$
Discounted Cash Flow (T)	$T_j = \frac{P_j}{S_j} \quad j = \{0, 1, \dots, 25\}$
Cumulative Discounted Cash Flow (U)	$U_j = T_{j-1} + T_j \quad j = \{1, 2, \dots, 25\}$

$$\text{NET PRESENT VALUE: } \sum_{j=0}^{25} T_j$$

Table 7.6 shows how the retail company's cash flow statement will be calculated in the case of implementing the Build-Transfer-Operate model with the energy company. The parameters in the table are based on those in Table 7.1. Unlike Options 1 and 2, the investment cost has been removed, and only the subsidy amount received has been added. Additionally, the amount to be paid for each unit of electricity produced by the energy company from the plant has also been included in this cash flow. Moreover, for the retailer, operational expenses in the cash flow will come into play from the 11th year onwards, as the plant will be operated by the energy company for 10 years.

For Option 3, in addition to the retail company's cash flow calculation model table, the energy company's cash flow statement also needs to be examined to determine the energy sales price. It is assumed here that the energy company makes the investment entirely with its own equity. In this cash flow, the energy company's investment using its own capital and its annual operational expenses will be shown as costs, and the electricity it produces and sells to the retail company will be shown as a benefit. Table 7.7 displays the parameters to be used for the energy company's cash flow.

Table 7.7: Parameters to be used for energy company cash flow in option 3

	parameter
Installed Power (MWp)	a
Radiation (kwh/kwp)	b
Land Cost (USD)	c
Land Development Cost (USD)	d
Facility Installation Cost (USD)	e
Power Transmission Line Installation Cost (USD)	f
Annual Operational Cost (USD/MWp)	g
Period	j
Inflation Index of the Year (2024 = 1)	k_j
WACC Rate	r
Energy Powerplant Yearly Degredation Rate	s
Year	t
Corporate Tax Rate	25%
Energy selling price of company	v

Table 7.8 shows the modeling that will be used for the energy company's 10-year cash flow.

Table 7.8: Cash flow modeling for energy company in option 3

Period (j)	$j = \{0,1,2, \dots, 25\}$
Year (t)	$t = \{2024, 2025, \dots, 2049\}$
Period - Year Match	$j_{(0)} = 2024, j_{(1)} = 2025, \dots, j_{(25)} = 2049$
Estimated Electricity Produced (Y)	$Y_j = ab(1 - s)^j \quad j = \{1, 2, \dots, 10\}$
Total Investment (A)	$A_j = (c + d + e + f) \quad \text{for} \quad j = \{0\}$
Income of Electricity Production (B)	$B_j = Y_j vk_j \quad j = \{1, 2, \dots, 10\}$
Total Annual Savings (F)	$F_j = B_j \quad j = \{1, 2, \dots, 10\}$
Annual Operational Expenses (G)	$G_j = g ak_j \quad j = \{1, 2, \dots, 10\}$
Earnings Before Interest Taxes Depreciation and Amortization (EBITDA)	$H_j = F_j - G_j \quad j = \{1, 2, \dots, 10\}$
Operating Margin (K)	$K_j = H_j \quad j = \{1, 2, \dots, 10\}$
Tax Expense (L)	$L_j = K_j \times 0.25 \quad j = \{1, 2, \dots, 10\}$
Net Income after Tax (M)	$M_j = K_j - L_j \quad j = \{1, 2, \dots, 10\}$
Free Cash Flow (P)	$P_j = A_j + M_j \quad j = \{0, 1, \dots, 10\}$
Cumulative Free Cash Flow (R)	$R_j = P_{j-1} + P_j \quad j = \{1, 2, \dots, 10\}$
Discount Rate (S)	$S_j = (1 + r)^j \quad j = \{0, 1, \dots, 10\}$
Discounted Cash Flow (T)	$T_j = \frac{P_j}{S_j} \quad j = \{0, 1, \dots, 10\}$
Cumulative Discounted Cash Flow (U)	$U_j = T_{j-1} + T_j \quad j = \{1, 2, \dots, 10\}$

$$\text{NET PRESENT VALUE: } \sum_{j=0}^{25} T_j$$

After the relevant costs and benefits have been established for the models shown for all options, the resulting outcomes will be examined in the next section.

7.2 Application of The Model

Our CBA will extract the cash flows of all options by replacing all parameters with their real values in the computational methods modeled in the previous section titled 'application'. Table 7.9 shows the values corresponding to the relevant parameters that have been entered.

Table 7.9: Values to be used in cost benefit analysis

Installed Power (MWp)	10
Radiation (kwh/kwp)	1652
Land Cost (USD)	390,000
Land Development Cost (USD)	400,000
Facility Installation Cost (USD)	5,750,000
Power Transmission Line Installation Cost (USD)	1,100,000
Annual Operational Cost (USD/MWp)	150,000
Electricity Grid Feed-in Price (USD/kwh)	0.03
Electricity Grid Purchase Price (USD/kwh)	0.04
Electricity Tariff Price (Including all other fees) (USD/kwh)	0.12
Annual Carbon Tax (USD/kwh)	0.05
WACC Rate	11.20%
Energy Powerplant Yearly Degredation Rate	0.70%
Corporate Tax Rate	25%
Regional Inventive Rate	50%

The values given in Table 7.9 were initially placed in the cash flow modeling for Option 1, which is the investment for building a solar power plant using 100% equity, and the cash flow presented in Table 7.10 was generated. Table 7.10 show the main parts of cash flow, total table could be seen from Appendix A. According to this cash flow, if the retail company builds this solar power plant using only equity, an NPV of 7,054,956 USD has been created. In other words, building this plant with equity has generated this amount of intrinsic value for the company over a 25-year period, while also creating an average annual return of 28% (IRR) on the investment. Additionally, it was observed that the payback of the invested amount was achieved in the 5th year, meaning that the cash flow turned positive after five years.

Table 7.10: Cash flow generated for option 1

Period	0	1	2	3	...	25
Year	2024	2025	2026	2027	...	2049
Estimated Electricity Produced (kwh)		16,520,000	16,404,360	16,289,529	...	13,956,998
Total Investment (USD)	(7,640,000)				...	
Total Benefits of Incentives		3,820,000			...	
Benefit from Electricity Production (USD)		2,071,990	2,098,635	2,125,624	...	2,815,618
Benefit of Carbon Tax (USD)		826,278	836,903	847,666	...	1,122,825
Electricity Grid Feed-in Tariff (USD)		544,499	551,501	558,594	...	739,918
Electricity Grid Purchase Cost (USD)		612,562	620,439	628,418	...	832,407
Total Annual Savings (USD)		1,741,206	1,763,598	1,786,278	...	2,366,118
Annual Operational Expenses (USD)		154,500	157,590	160,742	...	248,504
Earnings Before Interest Taxes Depreciation and Amortization (EBITDA) (USD)		1,586,706	1,606,008	1,625,536	...	2,117,614
Amortization Cost (USD)		(230,000)	(230,000)	(230,000)	...	(230,000)
Operating Margin (USD)		1,356,706	1,376,008	1,395,536	...	1,887,614
Tax Expense (USD)		339,177	344,002	348,884	...	471,904
Net Income after Tax (USD)		1,017,530	1,032,006	1,046,652	...	1,415,711
Add Back of Amortization (USD)		230,000	230,000	230,000	...	230,000
Free Cash Flow (USD)	(7,640,000)	5,067,530	1,262,006	1,276,652	...	1,645,711
Cumulative Free Cash Flow (USD)		(2,572,470)	(1,310,464)	(33,812)	...	32,125,635
Discount Rate	100.00%	111.20%	123.65%	137.50%	...	1421.08%
Discounted Cash Flow (USD)	(7,640,000)	4,557,131	1,020,591	928,449	...	115,807
Cumulative Discounted Cash Flow (USD)		(3,082,869)	(2,062,278)	(1,133,828)	...	7,054,956

Net Present Value (USD)	7,054,956
IRR	28%
Payback Period (Year)	5

If the relevant investment had been made using the option of 20% equity and 80% financed, the parameters of the credit to be used for this would have been as shown in Table 7.12.

Table 7.11: Credit utilization parameters

Amount to be Loaned (Z)	7,640,000
Payment terms (years)	7
Grace Period (year)	1
Interest rate	9.32%
Installment Number (number/year)	2
Credit Usage Date	1.01.2024

With these parameters, that is, a 7-year term loan with 1-year grace period and an interest rate of 9.32%, the steps for credit repayment would have appeared as shown in Table 7.12.

Table 7.12: Credit payment flow

Payment Date	Period (t)	Principal Repayment (R)	Principal Balance (B)	Payment of Interest (P)	Toplam Ödeme
1.01.2024	1	0	6,112,000	0	0
1.07.2024	2	0	6,112,000	0	
1.01.2025	3	509,333	5,602,667	427,229	936,562
1.07.2025	4	509,333	5,093,333	391,626	900,960
1.01.2026	5	509,333	4,584,000	356,024	865,357
1.07.2026	6	509,333	4,074,667	320,422	829,755
1.01.2027	7	509,333	3,565,333	284,819	794,153
1.07.2027	8	509,333	3,056,000	249,217	758,550
1.01.2028	9	509,333	2,546,667	213,614	722,948
1.07.2028	10	509,333	2,037,333	178,012	687,345
1.01.2029	11	509,333	1,528,000	142,410	651,743
1.07.2029	12	509,333	1,018,667	106,807	616,141
1.01.2030	13	509,333	509,333	71,205	580,538
1.07.2030	14	509,333	0	35,602	544,936

As can be seen in Table 7.12, no payments were made during the first 1-year period following the credit drawdown date, which is considered to be 01.01.2024. However, credit payments started after the first year. This creates a payment flow of a total of 6 years and 12 periods, with the credit scheduled to be fully repaid by 01.07.2030.

In Table 7.13, the cash flow generated in the case of Option 2, which is the investment in a solar power plant with financing, is shown. This has also main parts of cash flow belongs Option-2, total cash flow can be seen from Appendix B. According to this cash flow, over a 25-year period, this plant generates a value of 6,751,171 USD in today's terms.

Since the use of credit involves payments spread over several years, IRR calculations will not give an accurate rate for such a cash flow. IRR calculations are accurate when the entire investment is made in the first year. Therefore, IRR calculations have not been added to the cash flow of Option-2. Also, there is no payback period in this cash flow. That means the investment starts to yield positive returns from the first year, especially

due to a 50% incentive, and never goes negative cumulatively due to the staggered payment plan. This is one of the key advantages of the financed option.

Table 7.13: Cash flow generated for option 2

Period	0	1	2	3	...	25
Year	2024	2025	2026	2027	...	2049
Estimated Electricity Produced (kwh)		16,520,000	16,404,360	16,289,529	...	13,956,998
Total Investment (USD)	(1,528,000)				...	
Total Benefits of Incentives		3,820,000				
Total Payment of Credit (USD)		(1,837,522)	(1,695,112)	(1,552,703)	...	-
Benefit from Electricity Production (USD)		2,071,990	2,098,635	2,125,624	...	2,815,618
Benefit of Carbon Tax (USD)		826,278	836,903	847,666	...	1,122,825
Electricity Grid Feed-in Tariff (USD)		544,499	551,501	558,594	...	739,918
Electricity Grid Purchase Cost (USD)		612,562	620,439	628,418	...	832,407
Total Annual Savings (USD)		1,741,206	1,763,598	1,786,278	...	2,366,118
Annual Operational Expenses (USD)		154,500	157,590	160,742	...	248,504
Earnings Before Interest Taxes Depreciation and Amortization (EBITDA) (USD)		1,586,706	1,606,008	1,625,536	...	2,117,614
Amortization Cost (USD)		(230,000)	(230,000)	(230,000)	...	(230,000)
Operating Margin (USD)		1,356,706	1,376,008	1,395,536	...	1,887,614
Tax Expense (USD)		339,177	344,002	348,884	...	471,904
Net Income after Tax (USD)		1,017,530	1,032,006	1,046,652	...	1,415,711
Add Back of Amortization (USD)		230,000	230,000	230,000	...	230,000
Free Cash Flow (USD)	(1,528,000)	3,230,008	(433,106)	(276,050)	...	1,645,711
Cumulative Free Cash Flow (USD)		1,702,008	1,268,902	992,851	...	29,348,648
Discount Rate	100.00%	111.20%	123.65%	137.50%	...	1421.08%
Discounted Cash Flow (USD)	(1,528,000)	2,904,683	(350,255)	(200,759)	...	115,807
Cumulative Discounted Cash Flow (USD)		1,376,683	1,026,428	825,670	...	6,751,171
Net Present Value	6,751,171					

Table 7.14 shows the main parts cash flow for Option 3 where the total version can be seen from Appendix C, where the solar power plant is undertaken and operated by an energy company for a period of 10 years, and during this time, the retail company is sold the electricity produced. If the energy company sets a unit price according to a market-compliant 15% IRR, the electricity unit price to the retail company must be sold at 0.1356 USD cents per unit. At this unit sales price, the energy company building the plant will sell the electricity produced to the retail company, thereby earning a return on its investment.

As can be seen in Table 7.14, in such a system setup, it is expected that the energy company will create a value of 1,203,030 USD for itself at the end of a 10-year period. Additionally, the company will achieve the payback of its investment in 8 years, meaning it will reach a positive value in the cumulative cash flow after 8 years.

Table 7.15 shows the main parts of 25-year cash flow where the total part can be seen from Appendix D that will occur in the retail company if the energy company sells electricity at a price of 0.1356 USD per kWh for a period of 10 years.

Table 7.14: Cash flow of the energy production company for option 3

Period	0	1	2	3	...	10
Year	2024	2025	2026	2027	...	2034
Estimated Electricity Produced (kwh)		16,520,000	16,404,360	16,289,529	...	15,507,910
Total Investment (USD)	(7,640,000)				...	
Benefit from Electricity Production (USD)		2,241,374	2,225,684	2,210,105	...	2,104,057
Total Annual Savings (USD)		2,241,374	2,225,684	2,210,105	...	2,104,057
Annual Operational Expenses (USD)		154,500	157,590	160,742	...	184,642
Earnings Before Interest Taxes Depreciation and Amortization (EBITDA) (USD)		2,086,874	2,068,094	2,049,363	...	1,919,416
Operating Margin (USD)		2,086,874	2,068,094	2,049,363	...	1,919,416
Tax Expense (USD)		521,719	517,024	512,341	...	479,854
Net Income after Tax (USD)		1,565,156	1,551,071	1,537,022	...	1,439,562
Free Cash Flow (USD)	(7,640,000)	1,565,156	1,551,071	1,537,022	...	1,439,562
Cumulative Free Cash Flow (USD)		(6,074,844)	(4,523,774)	(2,986,752)	...	7,381,746
Discount Rate	100.00%	111.20%	123.65%	137.50%	...	289.10%
Discounted Cash Flow (USD)	(7,640,000)	1,407,514	1,254,360	1,117,804	...	497,946
Cumulative Discounted Cash Flow (USD)		(6,232,486)	(4,978,126)	(3,860,322)	...	1,203,030

Net Present Value (USD)	1,203,030
IRR	15%
Payback Period (Year)	8

Table 7.15: Cash flow of the retail company for option 3

Period	0	1	2	3	...	25
Year	2024	2025	2026	2027	...	2049
Estimated Electricity Produced (kwh)		16,520,000	16,404,360	16,289,529	...	13,956,998
Total Investment (USD)		3,820,000			...	
Payment to Energy Company (USD)		(2,241,374)	(2,225,684)	(2,210,105)	...	-
Benefit from Electricity Production (USD)		2,071,990	2,098,635	2,125,624	...	2,815,618
Benefit of Carbon Tax (USD)		826,278	836,903	847,666	...	1,122,825
Electricity Grid Feed-in Tariff (USD)		544,499	551,501	558,594	...	739,918
Electricity Grid Purchase Cost (USD)		612,562	620,439	628,418	...	832,407
Total Annual Savings (USD)		1,741,206	1,763,598	1,786,278	...	2,366,118
Annual Operational Expenses (USD)					...	248,504
Earnings Before Interest Taxes Depreciation and Amortization (EBITDA) (USD)		1,741,206	1,763,598	1,786,278	...	2,117,614
Amortization Cost (USD)		(230,000)	(230,000)	(230,000)	...	(230,000)
Operating Margin (USD)		1,511,206	1,533,598	1,556,278	...	1,887,614
Tax Expense (USD)		377,802	383,400	389,070	...	471,904
Net Income after Tax (USD)		1,133,405	1,150,199	1,167,209	...	1,415,711
Add Back of Amortization (USD)		230,000	230,000	230,000	...	230,000
Free Cash Flow (USD)	-	2,942,031	(845,486)	(812,896)	...	1,645,711
Cumulative Free Cash Flow (USD)		2,942,031	2,096,545	1,283,649	...	19,313,707
Discount Rate	100.00%	111.20%	123.65%	137.50%	...	1421.08%
Discounted Cash Flow (USD)	-	2,645,711	(683,749)	(591,181)	...	115,807
Cumulative Discounted Cash Flow (USD)		2,645,711	1,961,962	1,370,781	...	2,661,438

Net Present Value	2,661,438
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In the cash flow shown in Table 7.15, the retail company will be able to directly benefit from investment incentives once the solar power plant is built and transferred to it by the

energy company. It will make payments to the energy company for the electricity produced for 10 years. At the end of the 10th year, the operation of the plant will be transferred to the retail company, and it will remain with the company until the end of the plant's 25-year lifespan. As can be seen in this table, with such an investment form, the retail company is expected to generate an NPV of 2,661,438 USD. Moreover, since it benefits from the incentive, it will continue to have a positive cash flow and, as seen in Table-34, will start to turn negative in the 7th year cumulatively and will be able to turn it positive in the 13th year.

Now that cash flows for all options have been generated, analyses regarding the retail company's investment decision will be discussed in the next section of results.

8 RESULTS & DISCUSSIONS

8.1 Decision Making Outputs of The Investment Analysis

The investment analysis, that is, the CBA with three options, was conducted in the previous section. According to this analysis, the outputs for decision-making occurred as shown in Table 7.11, Table 7.14, and Table 7.16. A summarized version of these outputs for each option can be seen in Table 8.1.

Table 8.1: Outputs of investment options

	Option-1	Option-2	Option-3
Net present value (USD)	7,054,956	6,751,171	2,661,438
Number of years with a negative budget	1	4	9
Number of years with cumulative negative	5	1	6
Total production over 25 years (kwh)	380,100,184		
CO2 emissions avoided over 25 years (tons)	148,245		

To summarize the table, for Option 1, an NPV of 7,054,956 USD was created, for Option 2, an NPV of 6,751,171 USD, and for Option 3, an NPV of 2,661,438 USD. In terms of the number of years the budget is negatively impacted, compared to the scenario of continuing to purchase electricity at the normal tariff, it is 1 year for Option 1, 4 years for Option 2, and 9 years for Option 3. The number of years the discounted cash flow is expected to be negative if the solar power plant is built is 5 years for Option 1, 1 year for Option 2, and 6 years for Option 3. In all three scenarios, the solar power plant is expected to produce a total of 380,100,184 kWh of clean energy electricity over 25 years, while preventing 148,245 tons of CO2 emissions. Additionally, in Option 3, the energy producing company will recover its investment in 8 years while

selling electricity to the retail company at 0.1356 USD/kWh. This price means that until 2029, the retail company would pay less than 0.1356 USD/kWh if it continues to buy electricity at the normal tariff, and from this year onwards, it would pay more than this price if it continues to buy at the tariff.

Figure-8 shows the path followed by the discounted cash flows of all three options over the years. All options converge to the same value line by the year 2035. However, their paths from 2024 to 2035 differ. Option 1 starts from a significantly negative position but then rises sharply due to the effect of incentives and settles into a normal flow. Option 2, having partially funded the investment with equity, starts from a negative position in 2024, then rises due to incentives, and, with credit payments spread over the years, settles its cash flow without a major shift to the negative side. Option 3, due to the effect of incentives, starts with a direct positive impact on cash flow, but continues on a negative trajectory for 10 years due to payments per unit of electricity to the energy producing company, and only turns positive at the end of the 10th year.

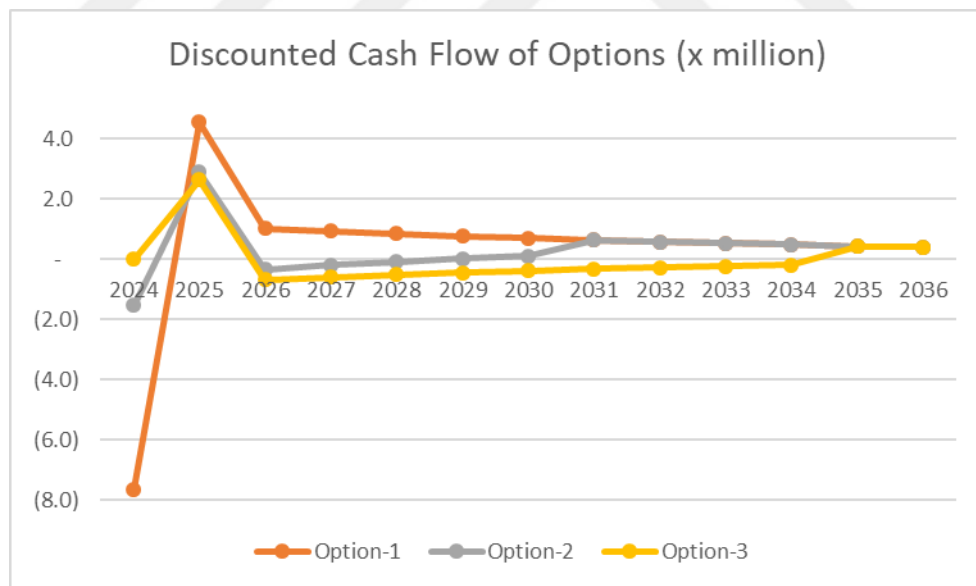


Figure 8.1: Discounted cash flow of 3 investment options

8.2 Overview of Results and Effects

Based on the results obtained, an idea has been formed on how the retail company should proceed with the solar energy investment. Although Option 1 creates the highest NPV

compared to the other two options, the fact that the budget is negative for 5 years cumulatively might incline the investor to prefer Option 2. This is because focusing only on the NPV might overlook the management logic of companies. In this case, the fact that the NPV created in Option 2 is very close to that of Option 1 and that it stays negative for only 1 year cumulatively could make the investor lean more towards the financed option. However, the more negative impact on the budget on an annual basis in Option 2 compared to Option 1 could be a factor that hinders a clear decision. In terms of NPV, the number of years the budget is negative, and the number of years the cash flow is negative cumulatively, Option 3 is observed to create the worst scenario in every aspect. However, Option 3 maintains a positive cumulative cash flow for the first 6 years due to direct incentives without any expenditure and goes negative in cumulative cash flow for 6 years starting from 2031. This indicates that the investor could create a decision-making mechanism based on the policy they want to follow in the initial years. Additionally, retail companies, due to their business nature, might prefer to invest in opening new stores to increase sales. Option 3, which allows owning a solar power plant without any out-of-pocket expenses, could free the retail company from financial debt obligations. While this option might not seem very attractive for a 10 MWp solar plant, it was mentioned earlier that the retail company would need to invest in a plant larger than 400 MWp to cover its entire energy consumption. For such a large-scale plant, the required investment would entail significant financial expenditure or financial debt risk, and a retail company not willing to take on this risk might prefer to transfer it to energy production companies and continue its core investments. In other words, they would effectively be leasing a power plant. Although this means forgoing some NPV, as a large-scale solar plant owner, the company could continue its journey with its potential for clean energy production. Moreover, in large-scale solar plant investments, retail companies and energy producers could negotiate electricity unit prices, essentially benefiting from a volume-based profit strategy. An energy production company working with this goal would not only be profit-oriented but could also guide new business fields through the brand value increase brought about by its collaboration with the retail company. Labeling such an outcome as the worst option based solely on a 10 MWp plant would be an incomplete assessment from these perspectives.

9 CONCLUSION

This thesis presents research on how a retail company interested in investing in a solar power plant can proceed with this investment by laying out various options. The thesis initially provides information about renewable energy. Renewable energy investments are gaining momentum worldwide and in Turkey. The primary reason for this is the climate crises caused by carbon emissions from fossil fuel consumption, and the targets set by international agreements. Additionally, the finite nature of fossil fuels and price fluctuations controlled by countries with these energy sources make other countries dependent on them, leading to significant cost burdens in extraordinary situations like the COVID-19 pandemic and the Russia-Ukraine war. Countries not wanting to remain dependent on these sources are announcing packages to increase investments in renewable energy. These include carbon taxation and, as seen in Turkey, incentives for investments in renewable energy sources. These incentives make the establishment of renewable energy plants with high investment costs an attractive proposition for private enterprises and public institutions. Especially in Turkey, the regulation that allows the electricity produced by a renewable energy plant to be offset in other regions, regardless of where the plant is located, has started to guide companies with a distributed structure, like retail companies, towards renewable energy sources, encouraging such companies with stores across the country to invest in renewable energy.

Companies wishing to invest in renewable energy must perform decision-making analyses to evaluate their investment options. As in this thesis, the CBA method has started to be used to create accurate decision-making systems for renewable energy investments. The thesis details the CBA, indicating the benefits it provides in investment decisions. Particularly for renewable energy plant investments,

which involve high investment inputs, CBA is a crucial method that supports investors in decision-making.

Entrepreneurs with options to make their investments using their own equity, through credit, or via energy provider companies should evaluate these options correctly, analyze them, and determine their investment decision according to their strategies.

This thesis provides significant information on how to evaluate the three-option solar power plant investment option in terms of its contribution to the literature. The cash flows created by the CBA lay out in detail the considerations that should be considered in solar power plant investments. Carbon taxation and inflation assessments, as stated in our CBA, are important elements to consider, and the correct analysis has been achieved by using these in the cash flow calculations. The thesis explains that a retail company wanting to decide based on the outcome of the three options can make clear decisions based on the results or may even choose the option that doesn't appear the best according to company policies.

Particularly, the option of establishing a solar power plant through an energy company, though it appears to create less NPV for the retail company compared to other options, is mentioned as a viable choice to avoid financial debt. Working with energy production companies for larger-scale solar power plant investments can relieve companies of the burden of debt and also lead to advantageous unit price agreements. Nevertheless, even if companies want to make solar power plant investments with their own financial resources, the option of using credit appears to be more advantageous compared to using 100% equity. The key advantages here are progressing without disrupting the budget balance over the years and following strategies that prevent negative trajectories in cumulative cash flow.

The thesis topic has been prepared based on current market prices for investment costs in solar energy investments, panel prices, land development, land prices, and electricity transmission line prices. However, these prices are subject to constant fluctuations on a global and local scale and may vary over time. Some parameters that could be taken as input for cost and benefit in investment analysis have been overlooked. In Figure 5.1, not all the costs and benefits listed have been considered; only those parameters with a

definite monetary equivalent in today's market conditions have been used. For example, abstract costs and benefits, which do not have a monetary equivalent, can be shown as such parameters. Furthermore, technological developments and environmental factors are other parameters whose monetary value cannot be determined.

This thesis clarifies the investment strategies that private enterprises with similar investment options will follow in such scenarios. In today's world, where the shift to renewable energy is accelerating and technologies related to it are increasing, making the right decisions is the most crucial aspect for companies from a financial standpoint. From this perspective, companies contributing to reducing carbon emissions and to the world by producing clean energy, as well as obtaining cheaper electricity, will make their budget balances more protective against national and international crises.

In the thesis examining strategy determination through investment options, a study could be done by further detailing the cost and benefit parameters considered in future investments. Thus, while making NPV comparisons in CBA of the investment, more accurate data closer to reality could be obtained. Moreover, when determining the monetary values of abstract costs and benefits, relative situations will arise, so monetary values can be worked on more accurately with decision-making methods in unclear situations through surveys conducted by experts. Quality analyses of technical equipment such as panels and inverters, which directly affect the investment cost of the solar energy plant, can be discussed in terms of technological differences that will affect the investment costs of the plant to be established. Additionally, investment decision options according to different city options where the solar energy plant will be established can be discussed. Thus, more accurate results can be obtained in determining strategies for renewable energy investments.

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APPENDICES

Appendix A.

Period	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
Year	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049
Estimated Electricity Produced (MWh)	16532.00	16,404.93	16,288.53	16,175.33	16,062.74	15,949.33	15,836.33	15,723.21	15,610.11	15,507.00	15,393.55	15,279.58	15,165.18	15,050.27	14,934.87	14,818.95	14,702.51	14,600.49	14,500.48	14,405.63	14,314.79	14,224.84	14,134.64	14,045.38	13,956.68	
Total Investment (USD)	(7,640.00)																									
Total Benefits of Incentives	3320.00																									
Benefit from Electricity Production (USD)	2,071,960	2,084,655	2,115,024	2,152,359	2,188,046	2,218,000	2,237,765	2,256,861	2,275,000	2,292,555	2,309,408	2,325,666	2,341,333	2,356,444	2,371,000	2,385,105	2,398,764	2,411,980	2,424,756	2,437,095	2,448,999	2,460,461	2,471,485	2,482,075	2,492,233	
Benefit of Carbon Tax (USD)	832,278	835,849	840,665	846,687	853,088	859,784	866,779	874,018	881,438	889,071	896,946	905,076	913,467	922,126	931,069	940,304	949,840	959,678	969,820	980,276	991,057	1,002,173	1,013,625	1,025,415	1,037,545	
Electricity feed-in tariff (USD)	544,465	551,501	558,594	565,777	573,053	580,423	587,897	595,477	603,163	610,965	618,894	626,950	635,137	643,462	651,934	660,562	669,355	678,313	687,445	696,761	706,261	715,945	725,813	735,865	746,101	
Electricity Grid Purchase Cost (USD)	611,562	620,438	630,438	640,648	649,865	659,078	668,279	677,468	686,645	695,810	704,963	714,105	723,236	732,356	741,465	750,563	759,650	768,726	777,791	786,845	795,888	804,920	813,941	822,952	831,953	
Total Annual Savings	1,741,265	1,763,588	1,786,778	1,809,230	1,831,277	1,852,930	1,874,302	1,895,418	1,916,280	1,936,897	1,957,269	1,977,396	1,997,278	2,016,914	2,036,303	2,055,445	2,074,340	2,093,087	2,111,686	2,130,137	2,148,440	2,166,595	2,184,603	2,202,464	2,220,178	
Annual Operational Expenses (USD)	154,500	153,590	152,742	151,957	151,236	150,578	149,982	149,449	148,977	148,565	148,214	147,924	147,694	147,524	147,413	147,361	147,367	147,431	147,553	147,734	147,974	148,273	148,631	149,048	149,525	
Earning Before Interest Taxes Depreciation and Amortization (EBITDA) (USD)	1,586,765	1,610,000	1,634,036	1,658,273	1,682,041	1,705,352	1,728,119	1,750,363	1,772,093	1,793,314	1,813,934	1,833,950	1,853,364	1,872,169	1,890,376	1,907,981	1,925,085	1,941,688	1,957,791	1,973,394	1,988,506	2,003,127	2,017,257	2,030,896	2,044,044	
Amortization Cost (USD)	(200,000)	(200,000)	(200,000)	(200,000)	(200,000)	(200,000)	(200,000)	(200,000)	(200,000)	(200,000)	(200,000)	(200,000)	(200,000)	(200,000)	(200,000)	(200,000)	(200,000)	(200,000)	(200,000)	(200,000)	(200,000)	(200,000)	(200,000)	(200,000)	(200,000)	
Operating Margin (USD)	1,386,765	1,410,000	1,434,036	1,458,273	1,482,041	1,505,352	1,528,119	1,550,363	1,572,093	1,593,314	1,613,934	1,633,950	1,653,364	1,672,169	1,690,376	1,707,981	1,725,085	1,741,688	1,757,791	1,773,394	1,788,506	1,803,127	1,817,257	1,830,896	1,844,044	
Tax Expense (USD)	338	342	346	350	354	358	362	366	370	374	378	382	386	390	394	398	402	406	410	414	418	422	426	430	434	
Net Income After Tax (USD)	1,071,590	1,030,000	1,046,651	1,061,401	1,076,461	1,091,627	1,106,927	1,122,401	1,138,051	1,153,882	1,170,133	1,186,413	1,202,628	1,218,769	1,234,836	1,250,829	1,266,758	1,282,623	1,298,434	1,314,191	1,329,894	1,345,543	1,361,138	1,376,679	1,392,166	
Add Back of Amortization (USD)	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	
Free Cash Flow (USD)	(7,640.00)	1,270,590	1,246,050	1,246,651	1,276,461	1,296,627	1,316,927	1,337,401	1,358,051	1,378,882	1,399,913	1,421,133	1,442,569	1,464,213	1,486,066	1,508,137	1,530,425	1,552,930	1,575,654	1,598,606	1,621,785	1,645,191	1,668,824	1,692,585	1,716,474	
Cumulative Free Cash Flow (USD)	(7,640.00)	(6,369.41)	(5,123.46)	(3,906.81)	-2,719.35	-1,566.73	-458.77	669.39	1,607.44	2,545.32	3,483.03	4,420.58	5,357.97	6,295.20	7,232.27	8,169.18	9,105.93	10,042.52	10,978.95	11,915.22	12,851.33	13,787.28	14,723.07	15,658.60	16,593.88	
Discount Rate	10.00%	11.26%	12.65%	13.29%	13.98%	14.70%	15.46%	16.26%	17.10%	17.98%	18.90%	19.86%	20.87%	21.93%	23.04%	24.20%	25.41%	26.67%	28.00%	29.39%	30.84%	32.35%	33.93%	35.58%	37.31%	
Discounted Cash Flow (USD)	(7,640.00)	4,557,131	4,020,596	3,588,445	3,249,747	2,988,005	2,788,005	2,638,891	2,526,603	2,438,169	2,369,620	2,316,980	2,276,370	2,244,816	2,220,344	2,201,985	2,188,772	2,180,738	2,176,921	2,176,365	2,179,103	2,184,271	2,191,825	2,200,799	2,211,214	
Cumulative Discounted Cash Flow (USD)	(7,640.00)	(3,082,869)	(2,062,273)	(1,235,828)	-686,081	-139,076	117,917	1,814,078	2,930,677	3,958,836	4,897,000	5,749,179	6,525,364	7,246,555	7,912,761	8,524,992	9,093,258	9,627,569	10,127,925	10,604,336	11,067,801	11,517,329	11,954,931	12,380,606	12,795,356	

Appendix B.

Period	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Year	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049
Estimated Electricity Produced (kwh)		16,520,000	16,404,560	16,289,529	16,175,503	16,062,274	15,949,838	15,838,189	15,727,322	15,617,231	15,507,910	15,399,355	15,291,559	15,184,518	15,078,227	14,972,679	14,867,871	14,763,795	14,660,449	14,557,826	14,455,921	14,354,729	14,254,246	14,154,467	14,055,385	13,956,998
Total Investment (USD)	(1,528,000)																									
Total Benefits of Incentives		3,820,000																								
Total Payment of Credit (USD)		(1,837,522)	(1,495,112)	(1,152,703)	(1,410,293)	(1,267,883)	(1,125,474)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benefit from Electricity Production (USD)		2,071,990	2,098,655	2,125,624	2,152,959	2,180,646	2,208,630	2,237,093	2,265,862	2,295,001	2,324,515	2,354,408	2,384,686	2,415,353	2,446,414	2,477,875	2,509,741	2,542,016	2,574,706	2,607,817	2,641,354	2,675,321	2,709,726	2,744,573	2,779,868	2,815,618
Benefit of Carbon Tax (USD)		826,278	865,903	847,566	858,557	863,608	880,791	893,118	903,591	915,211	926,981	938,302	950,976	963,206	975,592	988,139	1,000,846	1,013,717	1,026,753	1,039,957	1,053,331	1,066,877	1,080,597	1,094,494	1,108,569	1,122,825
Electricity Grid Feed-in Tariff (USD)		544,499	551,501	558,594	565,777	573,053	580,423	587,887	595,447	603,105	610,860	618,716	626,673	634,732	642,894	651,162	659,536	668,018	676,608	685,310	694,123	703,049	712,090	721,248	730,523	739,918
Electricity Grid Purchase Cost (USD)		612,562	620,439	628,418	636,499	644,685	652,975	661,373	669,878	678,493	687,218	696,056	705,007	714,073	723,256	732,557	741,978	751,520	761,194	770,973	780,888	790,930	801,102	811,404	821,838	832,407
Total Annual Savings (USD)		1,741,206	1,763,598	1,786,278	1,809,250	1,832,517	1,856,083	1,879,952	1,904,128	1,928,615	1,953,417	1,978,538	2,003,980	2,029,753	2,055,866	2,082,294	2,109,073	2,136,195	2,163,667	2,191,492	2,219,674	2,248,219	2,277,131	2,306,415	2,336,076	2,366,118
Annual Operational Expenses (USD)		154,500	157,590	160,742	163,957	167,236	170,580	173,992	177,472	181,021	184,642	188,335	192,101	195,943	199,862	203,859	207,937	212,095	216,337	220,664	225,077	229,579	234,170	238,854	243,631	248,504
Earnings Before Interest Taxes Depreciation and Amortization (EBITDA) (USD)		1,586,706	1,606,008	1,625,536	1,645,293	1,665,281	1,685,502	1,705,960	1,726,656	1,747,594	1,768,775	1,790,204	1,811,881	1,833,810	1,855,994	1,878,435	1,901,136	1,924,100	1,947,330	1,970,828	1,994,597	2,018,640	2,042,961	2,067,561	2,092,445	2,117,614
Amortization Cost (USD)		(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)
Operating Margin (USD)		1,356,706	1,376,008	1,395,536	1,415,293	1,435,281	1,455,502	1,475,960	1,496,656	1,517,594	1,538,775	1,560,204	1,581,881	1,603,810	1,625,994	1,648,435	1,671,136	1,694,100	1,717,330	1,740,828	1,764,597	1,788,640	1,812,961	1,837,561	1,862,445	1,887,614
Tax Expense (USD)		338,177	344,002	348,884	353,823	358,820	363,876	368,990	374,164	379,398	384,694	390,051	395,470	400,953	406,498	412,109	417,784	423,525	429,332	435,207	441,149	447,160	453,240	459,390	465,611	471,904
Net Income after Tax (USD)		1,017,530	1,032,006	1,046,652	1,061,470	1,076,461	1,091,627	1,106,970	1,122,492	1,138,195	1,154,082	1,170,153	1,186,411	1,202,858	1,219,495	1,236,336	1,253,352	1,270,575	1,287,997	1,305,621	1,323,448	1,341,480	1,359,721	1,378,171	1,396,834	1,415,711
Add Back of Amortization (USD)		230,000	230,000	230,000	230,000	230,000	230,000	230,000	230,000	230,000	230,000	230,000	230,000	230,000	230,000	230,000	230,000	230,000	230,000	230,000	230,000	230,000	230,000	230,000	230,000	230,000
Free Cash Flow (USD)	(1,528,000)	3,230,008	(433,106)	(776,050)	(118,823)	383,577	196,153	1,336,970	1,352,492	1,368,195	1,384,082	1,400,153	1,416,411	1,432,858	1,449,495	1,466,326	1,483,352	1,500,575	1,517,997	1,535,621	1,553,448	1,571,480	1,589,721	1,608,171	1,626,834	1,645,711
Cumulative Free Cash Flow (USD)		1,702,008	1,268,902	992,851	874,028	912,485	1,108,758	2,446,728	3,798,220	5,166,416	6,550,497	7,950,650	9,367,061	10,799,918	12,248,414	13,713,740	15,199,092	16,698,667	18,217,664	19,753,285	21,305,732	22,878,212	24,467,933	26,076,104	27,702,938	29,348,648
Discount Rate	100.00%	111.20%	123.65%	137.50%	152.90%	170.03%	189.07%	210.25%	233.80%	259.98%	289.10%	321.48%	357.40%	397.52%	442.05%	491.55%	546.61%	607.88%	675.91%	751.61%	835.79%	929.40%	1033.49%	1149.24%	1277.95%	1421.08%
Discounted Cash Flow (USD)	(1,528,000)	2,904,683	(560,255)	(200,359)	(77,711)	22,688	103,745	635,899	578,491	526,166	478,756	435,555	396,216	360,446	327,966	298,304	271,374	246,875	224,587	204,312	185,866	169,085	153,821	139,934	127,300	115,807
Cumulative Discounted Cash Flow (USD)		1,376,683	1,016,428	825,670	770,947	874,392	1,510,291	2,088,782	2,665,047	3,093,803	3,529,337	3,925,553	4,286,000	4,613,906	4,912,210	5,183,583	5,430,458	5,655,045	5,859,357	6,045,223	6,214,309	6,368,130	6,508,054	6,635,364	6,751,171	

Net Present Value 6,751,171

Appendix C

Period	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Year	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049
Estimate of Electricity Produced (kwh)	16,520,000	16,404,360	16,288,520	16,175,933	16,062,274	15,949,888	15,838,189	15,727,322	15,617,321	15,507,910	15,399,355	15,291,559	15,184,518	15,078,227	14,972,679	14,867,871	14,763,795	14,660,440	14,557,826	14,455,921	14,354,729	14,254,246	14,154,467	14,055,385	13,956,998	
Initial Investment (USD)	3,820,000																									
Payment to Energy Company (USD)	(2,241,374)	(2,215,694)	(2,190,105)	(2,164,646)	(2,139,271)	(2,114,071)	(2,088,868)	(2,063,636)	(2,038,368)	(2,013,065)	(1,987,726)	(1,962,351)	(1,936,940)	(1,911,494)	(1,886,013)	(1,860,496)	(1,834,943)	(1,809,354)	(1,783,729)	(1,758,068)	(1,732,371)	(1,706,638)	(1,680,869)	(1,655,064)	(1,629,223)	
Revenue from Electricity Production (USD)	2,071,990	2,098,635	2,125,624	2,152,959	2,180,646	2,208,690	2,237,093	2,265,862	2,295,001	2,324,515	2,354,408	2,384,686	2,415,353	2,446,404	2,477,875	2,509,741	2,542,016	2,574,706	2,607,817	2,641,354	2,675,321	2,709,726	2,744,573	2,779,868	2,815,618	
Benefit of Carbon Tax (USD)	826,278	824,903	823,565	822,267	820,999	819,761	818,552	817,381	816,248	815,151	814,091	813,066	812,075	811,117	810,191	809,297	808,434	807,601	806,797	806,022	805,275	804,556	803,864	803,200	802,563	
Electricity Grid Feed-in Tariff (USD)	544,489	551,501	558,594	565,777	573,053	580,423	587,887	595,445	603,105	610,880	618,767	626,763	634,872	643,094	651,428	659,875	668,436	677,112	685,903	694,809	703,840	713,006	722,307	731,744	739,918	
Electricity Grid Purchase Cost (USD)	612,562	620,428	628,418	636,489	644,695	652,975	661,373	669,878	678,489	687,218	696,065	705,037	714,137	723,266	732,527	741,918	751,439	761,184	770,973	780,888	790,930	801,102	811,404	821,838	832,407	
Total Annual Savings (USD)	1,341,206	1,376,598	1,398,250	1,418,250	1,437,517	1,456,083	1,473,952	1,491,128	1,507,615	1,523,417	1,538,540	1,552,985	1,566,752	1,580,841	1,594,262	1,607,017	1,619,103	1,630,529	1,641,305	1,651,441	1,660,947	1,670,834	1,680,111	1,688,788	1,696,865	
Annual Operational Expenses (USD)																										
Earnings Before Interest Taxes Depreciation and Amortization (EBITDA) (USD)	1,341,206	1,376,598	1,398,250	1,418,250	1,437,517	1,456,083	1,473,952	1,491,128	1,507,615	1,523,417	1,538,540	1,552,985	1,566,752	1,580,841	1,594,262	1,607,017	1,619,103	1,630,529	1,641,305	1,651,441	1,660,947	1,670,834	1,680,111	1,688,788	1,696,865	
Depreciation Cost (USD)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	(230,000)	
Operating Margin (USD)	1,111,206	1,146,598	1,168,250	1,188,250	1,207,517	1,226,083	1,243,952	1,261,128	1,277,615	1,293,417	1,308,540	1,322,985	1,336,752	1,350,841	1,364,262	1,377,017	1,389,103	1,400,529	1,411,305	1,421,441	1,430,947	1,439,834	1,448,111	1,455,788	1,462,865	
Corporate Income Tax Expense (USD)	377,902	383,400	388,070	394,812	400,629	406,521	412,488	418,532	424,554	430,854	390,051	395,470	400,953	406,488	412,109	417,784	423,525	429,332	435,207	441,149	447,160	453,240	459,390	465,511	471,904	
Net Income after Tax (USD)	1,133,405	1,150,199	1,167,209	1,194,437	1,207,887	1,219,562	1,227,464	1,235,596	1,243,961	1,251,563	1,170,153	1,186,411	1,200,858	1,219,495	1,236,336	1,253,953	1,270,575	1,287,997	1,305,921	1,323,448	1,340,480	1,357,721	1,375,171	1,392,834	1,410,711	
Add Back of Amortization (USD)	230,000	230,000	230,000	230,000	230,000	230,000	230,000	230,000	230,000	230,000	230,000	230,000	230,000	230,000	230,000	230,000	230,000	230,000	230,000	230,000	230,000	230,000	230,000	230,000	230,000	
Free Cash Flow (USD)	2,942,031	(845,496)	(812,894)	(700,197)	(747,384)	(714,644)	(681,404)	(648,130)	(614,928)	(581,494)	1,400,153	1,416,411	1,432,858	1,449,495	1,466,336	1,483,363	1,500,575	1,517,997	1,535,921	1,553,448	1,571,480	1,589,721	1,608,171	1,626,834	1,645,711	
Cumulative Free Cash Flow (USD)	-	2,942,031	2,096,545	1,283,649	503,462	(245,932)	(958,365)	(1,659,791)	(2,288,021)	(2,902,949)	(3,484,443)	(66,788)	764,978	2,714,473	3,680,799	5,164,151	6,664,726	8,182,723	9,718,344	11,271,791	12,843,272	14,432,992	16,041,163	17,667,997	19,313,707	
Discount Rate	100.00%	111.20%	123.65%	152.49%	170.03%	188.07%	200.25%	213.80%	259.98%	289.10%	321.48%	357.48%	397.52%	442.05%	491.55%	546.61%	607.88%	675.91%	751.61%	835.79%	929.40%	1,034.49%	1,149.24%	1,277.95%	1,421.08%	
Discounted Cash Flow (USD)	-	2,645,711	(683,749)	(591,181)	(510,623)	(430,562)	(377,073)	(324,094)	(277,262)	(236,527)	(201,140)	495,535	394,216	307,996	238,304	177,374	126,875	74,373	204,312	385,866	569,086	753,821	939,994	1,127,300	1,315,807	
Cumulative Discounted Cash Flow (USD)	2,645,711	1,961,962	1,370,781	860,259	420,967	43,094	(281,000)	(559,263)	(794,790)	(995,930)	(560,395)	(564,179)	96,267	524,173	822,477	1,093,851	1,340,725	1,565,312	1,769,824	1,955,490	2,124,577	2,278,398	2,418,331	2,546,638	2,661,438	
Present Value	2,661,438																									

Appendix D

Period	0	1	2	3	4	5	6	7	8	9	10
Year	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Estimated Electricity Produced (kwh)		16,520,000	16,404,360	16,289,529	16,175,503	16,062,274	15,949,838	15,838,189	15,727,322	15,617,231	15,507,910
Total Investment (USD)	(7,640,000)										
Benefit from Electricity Production (USD)		2,241,374	2,225,684	2,210,105	2,194,634	2,179,271	2,164,017	2,148,868	2,133,826	2,118,890	2,104,057
Total Annual Savings (USD)		2,241,374	2,225,684	2,210,105	2,194,634	2,179,271	2,164,017	2,148,868	2,133,826	2,118,890	2,104,057
Annual Operational Expenses (USD)		154,500	157,590	160,742	163,957	167,236	170,580	173,992	177,472	181,021	184,642
Earnings Before Interest Taxes Depreciation and Amortization (EBITDA) (USD)		2,086,874	2,068,094	2,049,363	2,030,677	2,012,036	1,993,436	1,974,876	1,956,354	1,937,868	1,919,416
Operating Margin (USD)		2,086,874	2,068,094	2,049,363	2,030,677	2,012,036	1,993,436	1,974,876	1,956,354	1,937,868	1,919,416
Tax Expense (USD)		521,719	517,024	512,341	507,669	503,009	498,359	493,719	489,089	484,467	479,854
Net Income after Tax (USD)		1,565,156	1,551,071	1,537,022	1,523,008	1,509,027	1,495,077	1,481,157	1,467,266	1,453,401	1,439,562
Free Cash Flow (USD)	(7,640,000)	1,565,156	1,551,071	1,537,022	1,523,008	1,509,027	1,495,077	1,481,157	1,467,266	1,453,401	1,439,562
Cumulative Free Cash Flow (USD)		(6,074,844)	(4,523,774)	(2,986,752)	(1,463,744)	45,283	1,540,360	3,021,518	4,488,783	5,942,185	7,381,746
Discount Rate	100,00%	111,20%	123,65%	137,50%	152,90%	170,03%	189,07%	210,25%	233,80%	259,98%	289,10%
Discounted Cash Flow (USD)	(7,640,000)	1,407,514	1,254,360	1,117,804	996,054	887,509	790,742	704,478	627,582	559,039	497,946
Cumulative Discounted Cash Flow (USD)		(6,232,486)	(4,978,126)	(3,860,322)	(2,864,268)	(1,976,758)	(1,186,016)	(481,538)	146,044	705,084	1,203,030

Net Present Value (USD)	1,203,030
IRR	15%
Payback Period (Year)	8

BIOGRAPHICAL SKETCH

Semih Avşar completed his high school education at Antalya Adem Tolunay Anatolian High School between 2004 and 2008. In 2008, he began his undergraduate studies in Industrial Engineering at Istanbul Technical University and completed his degree in 2013.

