# Solar Systems for Manufacturers: Evidence from Northern Cyprus

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# ABSTRACT

From the past few decades, the use of fossil fuels has observed a significant increase, causing a serious threat to future resources. Countries have started relying on non-renewable resources for energy generation, which has led to the world's pollution, severe climate changes, and high carbon emissions. This is important and vital in the process of achieving sustainable development. Cyprus, the third-largest island in the Mediterranean, is also facing this issue. Researchers have conducted various studies to determine the financial and operational viability of solar energy and wind for producing energy. The market of solar panels production is constantly growing, owing to increased demand for energy generation sources from renewable resources. Literature analyses showed that fossil fuels have significantly damaged the environment and therefore, many other energy resources are considered to produce electricity for achieving sustainable development. Electricity is argued to be a costly input for the industry in North Cyprus which has negative impacts on the productivity and competitiveness of especially manufacturers. In this thesis we argue that if manufacturers use solar systems to generate electricity, it will help them to reduce one of their input costs. In this respect, feasibility analyses are made for two different projects which are for 2,5 and10 MW capacity of solar power systems. Findings reflect that NPV for 2,5 MW of solar system is positive being 1.280.396 Euros and an IRR higher than discount rate, as 27%. We also carry out a feasibility analysis for 10 MW as well and find that NPV is 5.418.014 Euros and IRR of 28%. These results show that both project are feasible and a profitable investments. As for risk, sensitivity analysis shows that in 2,5 MW project, only when the production of solar systems fall by 40% and more, the NPV will turn to negative. There is no risk for the project in relation to price and other variables. We also find that 10 MW capacity of solar power project has relatively lower risk in relation to production and price. As a whole, the results of the financial analysis for the solar systems show that the non-renewable energy sources do have positive financial implications along with a reduction in the carbon footprints for the corporate world. As for the manufacturers in North Cyprus who consumes around 83.000 MWh yearly, we show with this study that they these projects can supply 5% and 21% of this consumption respectively and can reduce their energy costs significantly. The implications of these findings call for the policy makers and the governments to support and encourage manufacturers to build solar farms. This can be done by providing more convenient financial means and by giving permits to manufacturers.

**Keywords:** Electricity, Solar Systems, Renewable Energy, Manufacturers, Net Present Value, Internal Rate of Return, Sensitivity Analysis.

# ÖZ

Son yıllardaki fosil yakıt kullanımı kayda değer bir şekilde artmış olup, dünyanın gelecekteki kaynakları için ciddi bir tehlike yaratmıştır. Ülkelerin enerji üretimi için yenilenebilir olmayan kaynaklarına yönelmesi, dünyada hava kirliliğine, şiddetli iklim değişikliklerine ve yüksek karbon emisyonlarına yol açmaktadır. Akdeniz'de üçüncü en büyük ada olan Kıbrıs da bu sorunlarla yüzleşmektedir. Araştırmacılar güneş ve rüzgar ile elektrik enerji üretiminin finansal ve uygulanabilirliklerini belirlemek için çeşitli araştırmalar yapmıştır. Yenilenebilir kaynaklardan enerji üretimine olan ilgi arttığından dolayı güneş panelleri ile enerji üretimi sürekli şekilde artış göstermektedir. Yenilenebilir enerji üretimleri sürdürülebilir kalkınmaya da destek vermektedir. Kuzey Kıbrıs'ta elektrik üretimi maliyetlidir. Bu durum özellikle sanayi sektörünün verimliliğini ve rekabet edebilirliğini olumsuz etkilemektedir. Bu tezde, sanayi sektöründeki imalatçıların ihtiyaç duydukları elektrik enerjisini güneş enerji sistemleri kullanarak üretmelerinin girdi maliyetlerini azaltmalarına yardımcı olabileceği savunulmaktadır. Bu kapsamda 2.5 ve 10 MW kapasiteli iki farklı güneş enerji sistemleri projelerinin fizibilite analizleri yapılmıştır. Sonuçlar, 2.5 MW'lık solar sistemi için Net Bugünkü Değer'in (NPV) 1.280.396 Avro ve İç Verim Oranının (IRR) yüzde 27 olup paranın maliyetini gösteren iskonto değerinden daha fazla olduğunu göstermektedir. Ayrıca, 10 MW'lık sistemin Net Bugünkü Değer'in 5.418.014 Avro ve İç Verim Oranının %28 olduğu hesaplanmıştır. Bu sonuçlar, her iki projenin de uygulanabilir ve karlı olduğunu göstermektedir. Projelerin riskini belirlemek için yapılan duyarlılık analizi, solar enerji üretiminin yüzde 40 ve daha düşük seviyede olması durumunda, 2.5 MW'lık projenin negatif Net Bugünkü Değer ile karşı karşıya kalacağını göstermektedir. Bu da projenin üretim miktarına duyarlı olduğunu göstermektedir. Üretilecek enerjinin satış fiyatı ve diğer değişkenlerin her iki sistemdeki proje için herhangi bir risk taşımadığı ve bunlara duyarlı olmadığı tespit edilmiştir. Ölçek olarak daha büyük olan 10 MW'lık sistemde riskin çok daha düşük olduğu tespit edilmiştir. KKTC'deki imalatçıların 2018 yılında enerji tüketiminin yıllık 83.000 MWh civarında olduğu dikkate alınırsa, 2.5 MW ve 10 MW sistemlerinin hayata geçmesi ile tüketimlerinin sırasıyla yüzde 5 ve yüzde 20'sini karşılayabilecektir. Sonuç olarak, yenilenebilir enerji kaynakları finansal açıdan karlı olup, iş dünyasında büyük şirketlerin karbon salımının azalmasını sağlaması yanında maliyetlerini de azaltacaktır. Özellikle imalatçıların solar sistemlerini kullanmaları enerji maliyetlerinin azaltılmasına ve rekabet edebilirliklerinin artmasını sağlayacaktır. Bu tespitlerle politika geliştiricileri ve hükümetlerin bu tür projeleri desteklemesi ve teşvik etmesi gerektiğini göstermektedir. Bu destekler imalatçılara daha uygun finansman kaynakları sağlayarak ve solar enerji üretimi için daha çok izin vermeleri ile gerçekleştirilebilecektir.

**Anahtar Kelimeler:** Elektrik, Solar Sistemleri, Yenilebilir Enerji, İmalatçılar, Net Bugünkü Değer, İç Getiri Oranı, Duyarlılık Analizi.

I dedicate this work to all my family and friends

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# INTRODUCTION

## 1.1 Background Study

In recent decades, the use of fossil fuels has increased at an alarming rate, which has not only strained the future resources but also added to the world population. In fact, the effects of over dependency on the use of fossil fuels for energy generation have started appearing in world (WHO,2020). The increased global warming, severe climate changes, large carbon footprints, and decreasing fossil fuels resources are some of the glaring effects. In addition, the human emissions of greenhouse gases have caused the depletion of ozone layer, which has also caused serious environment impact. As per Statistical Review of World Energy, around 35% of the total energy was produced by oil in the year of 2018, which is a major contributor to greenhouse emissions and climate change (BP, 2019).

Owing to such growing environmental concerns and rising fossil fuels prices, both developed and developing countries have given great importance to discover sources of renewable energy and implement infrastructure systems that harness them. As Agacbicer (2010) stated in his study, energy policy in the almost all of the countries have given emphasis and priority on renewable energy sources. The idea of replacing fossil fuels with the environmental friendly and sustainable energy policies became a top goal for the authorities (Gielen, Boshell, Saygin, Bazilian, Wagner & Gorini, 2019). Among all renewable energy sources, it is obvious that the most widely available and abundant source is the sun. Some regions are fortunate in this regard due to favourable climatic conditions, like Mediterranean. Countries located in Mediterranean possess large solar resources that are suitable for producing solar energy. Some of the countries are Turkey, France, Morocco, Israel, Lebanon, Greece, Turkey, Turkish Republic of Northern Cyprus, Greek Cypriot Administration of Southern Cyprus and Tunisia.

Cyprus is the third largest island in the Mediterranean, located at 33ºE of Greenwich and 35ºN of the Equator. The climate conditions are mostly dry and sunny, with mild winters. The island has no gas or oil resources, so the entire population of around 200,000 people rely on the fossil fuels energy. The oils and petroleum products are imported from other countries to produce electricity (Ilkan & Erdil, 2005). Currently, the Cyprus government is not paying any attention on determining environmental friendly ways to produce energy. In recent years, the demand for electricity in winters reaches to its peak; therefore some private companies are being called in Cyprus to install fuel oil fired diesel power plants to solve the problem. The Cyprus Electricity Authority (KIB-TEK) only focuses on the supply of electricity to fulfil the consumer's demand. Having control only on the supply side and frequent increases in demand has caused several problems for the KIB-TEK. Moreover, the increasing petroleum products cost, lower return on investments, and high rate load growth have adversely affected the electric utilities in the developing countries, like Cyprus (Ogbeba & Hoskara, 2019).

Northern Cyprus has an enormous amount of solar energy with an average global solar radiation being 5.4 $kW/m^2$ daily. Some studies also reflected that it has great potential of producing wind energy, along with solar energy. In Northern Cyprus, around 32 % of the produced energy is consumed by buildings and around 8% of this energy consumed by industries. The industrial consumption of electricity is quite low in Cyprus, therefore most of the energy is used for household purposes, such as air-conditions, heaters, electronic devices, etc. Therefore, the use of renewable energy sources, such as solar, for power generation, pumping, water heating, and space heating can reduce the need for capacity expansion, improve the load capabilities, raise the system load factor, and increase electrical reserves margins. In addition to household uses, use of renewable energy by firms in different sectors will not only help them reduce one of the main cost of production which can help them to be more competitive.

## 1.2 Problem Description

No doubt, the energy availability and environmental concerns are the significant issues that humanity is facing currently. The main reason of this problem is the over dependency on the fossil fuels, as around 85% of total energy consumed by world comes from the non-renewable sources, in which the heat generation and electricity generation sectors hold the lion share. A massive amount of carbon dioxide ($CO_2$), Nitrous Oxide ($N_2O$), and Sulphur Oxide ($SO_x$) are emitted through the combustion of the fossil fuels, which is the primary reason of global warming effects. Population is increasing with each passing day and similarly the use of fossil fuels in producing electricity is also increasing. Like any other country, North Cyprus is also mostly relying on the fossil fuels, such as oils and petroleum products to produce energy. Moreover, the industry finds the energy as a costly and expensive input. It is defined as one of the main problems for production (YAGA, 2017). It is also worth noting that very few researches have been made on the potential use of solar energy for resolving these issues, especially in North Cyprus.

## 1.3 Aim of the Study

This research aims to get an overview of the current renewable energy prospects, especially solar, in the case of North Cyprus. The main focus will be on determining on how financially feasible solar systems are for manufacturers in North Cyprus. Therefore, this study will involve the financial feasibility study on the use of solar energy for manufacturing companies whose are the member of Chamber of Industry in Northern Cyprus, by considering the costs and benefits taken from established solar energy systems of some other countries. Moreover, different investment analysis tools, including Net Present Value (NPV), payback period, and Internal Required Rate of Return (IRRR) will be used for better financial projections, and sensitivity tests will be carried out.

## 1.4 Objectives of the Study

In order to fulfil the research aims described above, the following are the objectives of the study:

- Give an overview of the current energy system of North Cyprus considering the existing generation, distribution, and usages.
- Conduct a feasibility study of using solar energy to produce electricity in North Cyprus by using various financial investment techniques.
- Carry out sensitivity analysis to determine the risks involved in producing solar energy in North Cyprus.

## 1.5 Significance of the Study

This thesis tries to address what is missing in the previously available literature and to present a financial analysis of a solar system envisaged to be established by the chambers in North Cyprus. The thesis is also expected to present a better overview about solar energy system in North Cyprus. The outcomes of this study will contribute to the existing knowledge on the financial and practical feasibility of solar energy and the energy use practices in manufacturing companies in North Cyprus. Furthermore, this research will also help to the researchers by shedding light on the areas in the field which needs a further research. This study will also guide stakeholders in the North Cyprus energy sector and authorities in the country to find out the aspects that need improvement in the region in order to be provide infrastructure for the solar energy systems and to observe to what extent the solar energy is feasible and viable in the island.

# Chapter 2

# LITERATURE REVIEW

## 2.1 Renewable Energy Sources

Pictures of starving polar bears circulating around the social media, breaking news of island simply vanishing due to the on-going increase in sea levels, videos of glaciers in the Arctic melting, and unwanted new Guinness book records being broken due to unprecedented high temperatures being witnessed all over the globe serve as a warning that Climate change is truly here and its impacts are no longer subtle. Carbon Dioxide, a greenhouse gas is regarded by most experts to be the major contributor to the on-going problem of global warming and climate change, is mainly the resultant of combustion where 60% of CO2 emissions are caused by the power and industry sector (IPCC, 2011).

The scale of the problem is too big to an extent that these unanimous agreements that action should to be taken in order to save of what is left of mother earth. Kyoto Protocol, Paris agreement which aims at reducing greenhouse gas emissions by at least 40% by the year 2030 compared to the levels recorded in 1990, and other agreements are the fruit of universal efforts to take serious and ambitious efforts to combat the pressing issue of global warming and climate change (Rogelj et al, 2016). The Energy sector being the major contributor of the carbon footprint as seen in the graph below coupled with the report of the international Energy Agency in 2019 that has shown that the need for energy has grown by 2.3 %, a new high in the past decade. An increase mainly attributed to the industrial prosperity and bigger need for heating and cooling, has made the shift toward renewable energy a must.

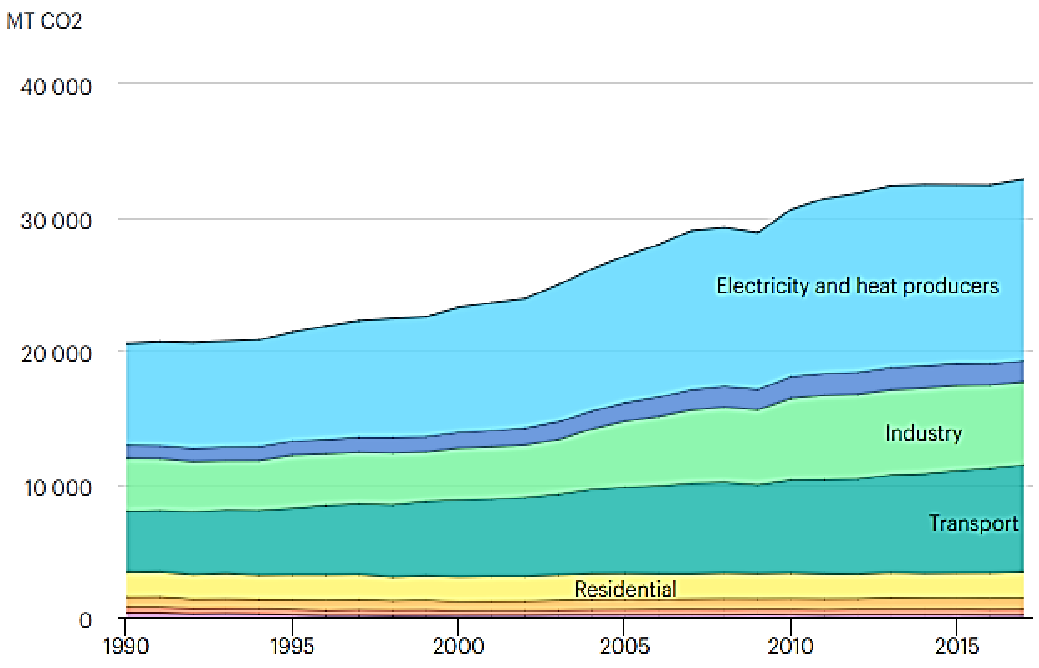


Figure 2.1: CO2 emissions by sector, world 1990-2017 IEA

The US Energy Information Administration, defines renewable energy as "energy from sources that are naturally replenishing but flow-limited". The types of renewable energy are solar energy, wind energy, biomass energy, hydroelectric energy, and geothermal energy. The main aspects to look at when considering a source of energy are availability, cost, and environmental impact. The first importance of renewable energy can be easily derived from the definition itself. Unlike Fossil Fuels which will eventually deplete, renewable energy is infinite. So, for renewable energy, availability is not an issue.

Now, looking into costs or the financial aspects of renewable energy is important as it is the aspect where in the past traditional sources of energy such as coal and natural gas has had an edge. That is no longer the case. According to Eckhouse in 2020 in his article published on Bloomberg Platform, solar and onshore wind power are now the cheapest new sources of electricity in at least two-thirds of the world's population. This shows that research and development in the field of renewable energy has come a long way reducing the cost of the technology itself and maintenance costs.

As for environmental impact for renewable energy, it is clear to expert around the world that the main benefit of renewable energy are the environmental advantages, including lower carbon emissions and reduced air pollution have been widely known for decades.

## 2.2 Photovoltaic Energy Systems

Solar Energy and Wind Energy are among the fastest growing renewable energy sectors. Indeed, over the past decade, solar photovoltaic systems have witnessed dramatic deployment growth coupled with substantial decreases in system prices (Comello & Reichelsetin & Sahoo, 2018).

The harvesting technology has been around for decades now and involves the usage of semi-conductor panels with solar cells that convert the sun energy that comes in the form of photons to power or electricity. The market of solar panels production is mainly dominated by People's Republic of China as it has managed to attain a manufacturing cost of below 1$ per W.  The efficiency of the solar panels available in the market is around 20%. Despite being around for a long time, researchers believe that there are a lot of opportunities for improvement up for grab. Scientists in April 2020 proved that to be right by coming up with a six-junction solar cell that recorded a 39.2% efficiency under one sun illumination beating the current market efficiency by a big margin.

A simple comparison between traditional sources of energy and solar panels in terms of costs, shows that the technology has become really competitive. The cost of developing new power plants that run on fossil fuels such as gas and oil, typically range between $0.05/kWh to $0.15/kWh. IRENA or International Renewable Energy Agency reports that “Solar PV projects in countries such as Chile, Mexico, Peru, Saudi Arabia and the UAE have seen a levelized cost of electricity of as low as $0.03/kW”.

## 2.3 Other Renewable Sources

### 2.3.1 Wind Energy

Saidur, Rahim, Islam & Solangi (2011) defined wind energy as the electricity produced by using wind turbines to harness the kinetic energy of the wind.

The idea of using the kinetic energy of wind dates back to the year 644 A.D. There is reliable information that gives information or description of windmills from the Persian-Afghan border region of Seistan (Friedrich & Lukas, 2017).

Recently, Wind power or wind energy has become a major supplier to the modern energy needs. Denmark is a great example to look at to grasp the potential of wind energy. Ever since 2013, Denmark has recorded times where wind power production exceeds the country’s national energy consumption (Morris, 2014).

The achievements and the growth of wind energy are mainly attributed to the improvement in the electronics and blade’s material used in the turbines. This has led to a dramatic increase in the size and the power rating of wind turbines as seen in the figure below.

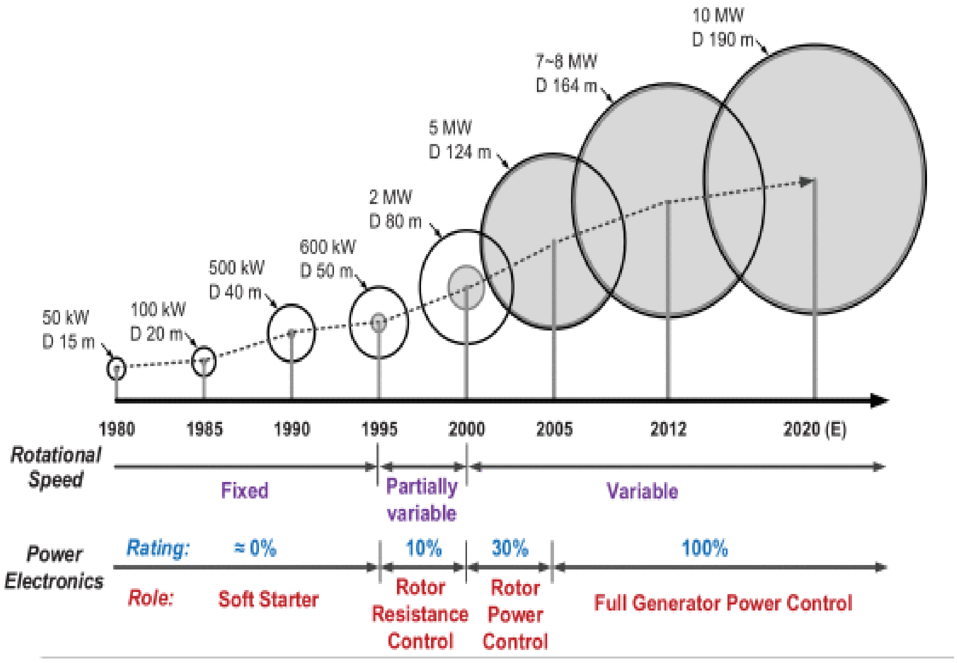



Figure 2.2: Evolution of wind turbine size and power electronics seen from 1980 to 2018 (Blaabjerg,Yang &Ma,2013)

### 2.3.2 Hydropower

Hydropower has been the major technology source of renewable energy due to the surge in the building of large dams in North America and Europe during the 1900s (Moran et al, 2018). Compared to other forms of renewable energy, the hydropower sector has reached high levels of technological maturity, or in other words there exist few opportunities to implement radical changes to the existing hydropower technologies (Kougias et al, 2019).

However, since the 1960s developed nations have halted the building of dams due to the fact that the best sites for dams were already developed, the cost of dams became too high and the growing environmental concern surrounding dams (Moran et al, 2018). On the other hand, developing countries have continued their pursuit of hydropower, thus endangering the most biodiverse river basins in the world such as the Amazon, the Congo and the Mekong (Lees et al, 2016).

**2.3.3 Biomass Energy**

In their research, Hoornweg and Bhada-Tata (2012) claim that waste can be treated through aerobic composting and anaerobic digestion that directly involves organic waste will lead to the release of methane that can be used to generate electricity, if there is enough organic waste provided.

Biomass is counted as a clean energy source since it recycles carbon dioxide through photosynthesis during biomass growth. Biomass can be used to produce electricity, thermal energy, and various chemicals. Zuberi et al. (2013) depicted the diverse advantageous aspects of the biomass resources in developing countries such as Pakistan including economic, environmental and employment benefits.

**2.3.4 Geothermal Energy**

The International Renewable Energy Agency or IRENA defines geothermal energy to be the heat extracted from within the sub-surface of the earth. According to the National Geographic, this thermal energy is contained in rocks and fluids underneath the Earth's crust. Geothermal Energy is mainly used for heating or cooling processes directly and can also be used to generate clean and eco-friendly electricity. The concept of generating electricity has potential and continues to be under study and research.

The graph below mentioned by IRENA shows the increase in the adoption of the Geothermal Energy worldwide.

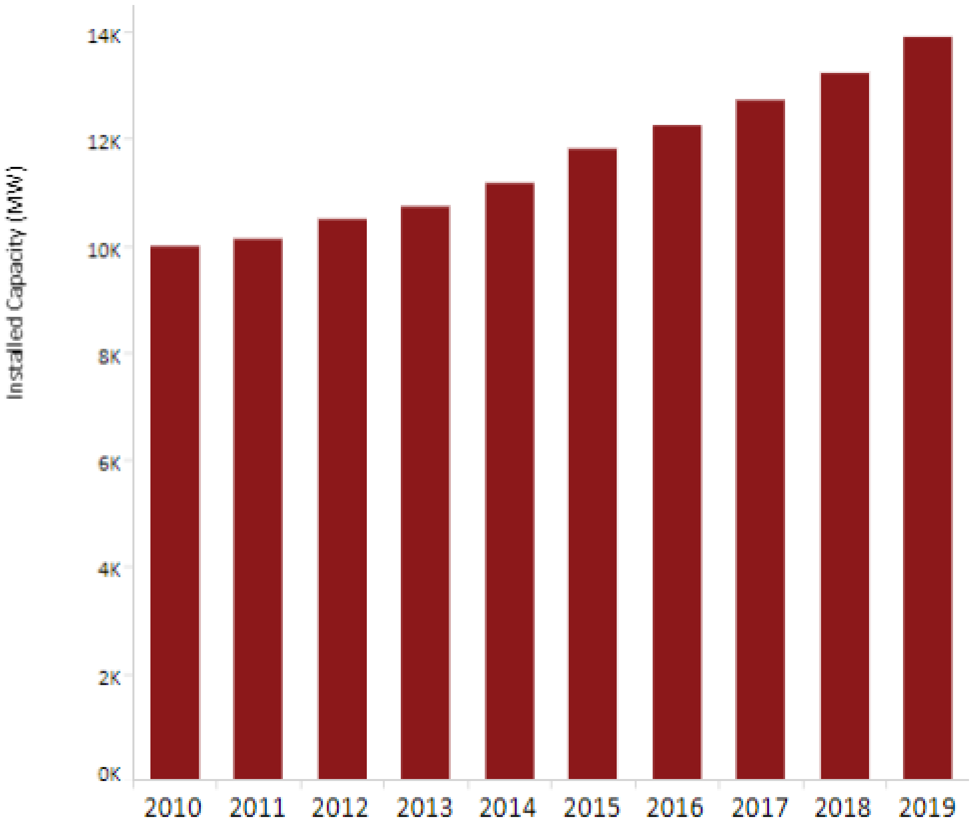


Figure 2.3: Adoption of the geothermal energy worldwide

## 2.4 Solar Energy

### 2.4.1 Photovoltaic Energy Cells

Photovoltaics are simply electronic devices that convert solar energy into electricity. Based on the material used and the level of commercial maturity, PV cell technologies have been divided into 3 generations.

The First Generation uses wafer-based crystalline silicon. Silicon is one of the most abundant elements on earth. This technology of solar PV is the one that most abundant and accounted for around 87% of global PV sales in 2010 (Schott Solar, 2011). The efficiency of crystalline silicon modules ranges from 14% to 19%.

The second generation uses thin film PV technologies. The thin film technology has been under R&D for more than 20 years now. The cost of production of this technology is lower than that of the first generation since this technology is simply comprised of successive thin layers (1 to 4 μm thick) solar cells deposited into a casing and thus they require a lot less semiconductor material when compared to the first generation. The thin film solar cells commercially are Amorphous silicon, Cadmium Telluride, and Copper-Indium-Selenide (CIS) and Copper-IndiumGallium-Diselenide (CIGS).

The third generation include technologies that are novel and under research and development. Like the technology of CPV or concentrating PV and organic PV cells. The CPV system utilizes optical devices such as lenses or mirrors to concentrate direct solar radiation onto the solar cells. CPV technology based on multi—junction solar cells has managed to hit a laboratory efficiency of more than 40 %.

### 2.4.2 Solar Panel Mechanism

What started as technology used in space only to power satellites electrical systems of satellites as they roam outer space, has become a major supplier of residential and commercial electricity. The major improvements that the field of solar panels witnessed in terms of technical efficiency and manufacturing quality has allowed for the wide spread of the technology among the public. The big question here is “How do solar panels work? ”

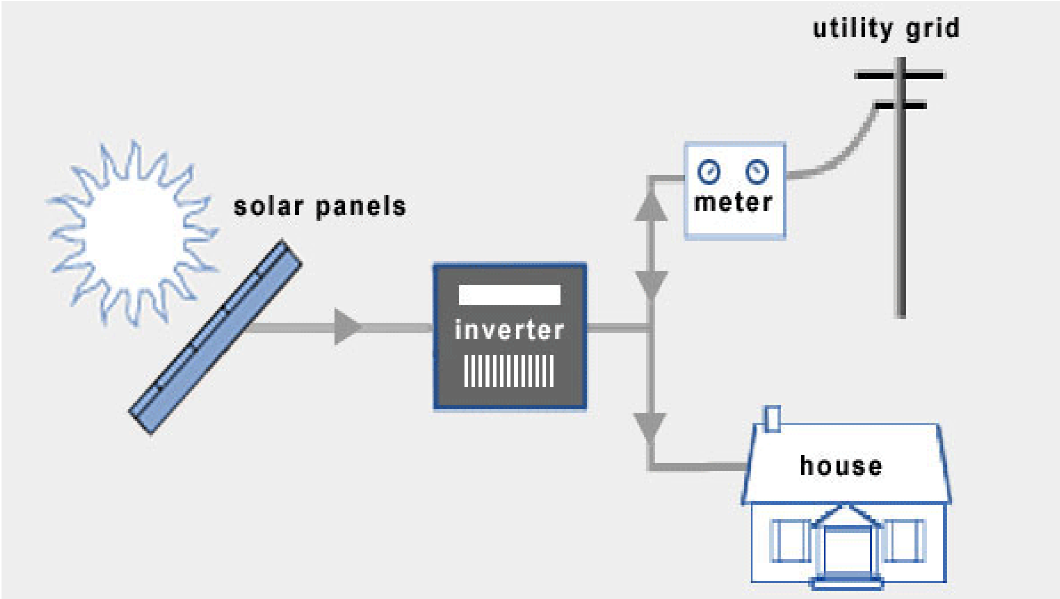


Figure 2.4: Solar panel system

The main steps of the conversion of solar energy into electricity are:

1- Photovoltaic cells absorb the solar energy and convert it to DC electricity,
2- The solar inverter installed converts the DC electricity to AC electricity which is needed for appliances to run.
3- Excess Electricity produced by the solar grid is fed to the electric gird. This step is only available if a smart meter system is added by the user of solar grid. Net Metering allows both residentials and commercial users of different types of renewable energy to sell the electricity they aren't using to the grid (Darghouth, Barbose, & Wiser, 2011). This system has been adopted by different countries in order to encourage users to produce their own electricity by reducing their electricity bills (Darghouth, Barbose, & Wiser, 2011).

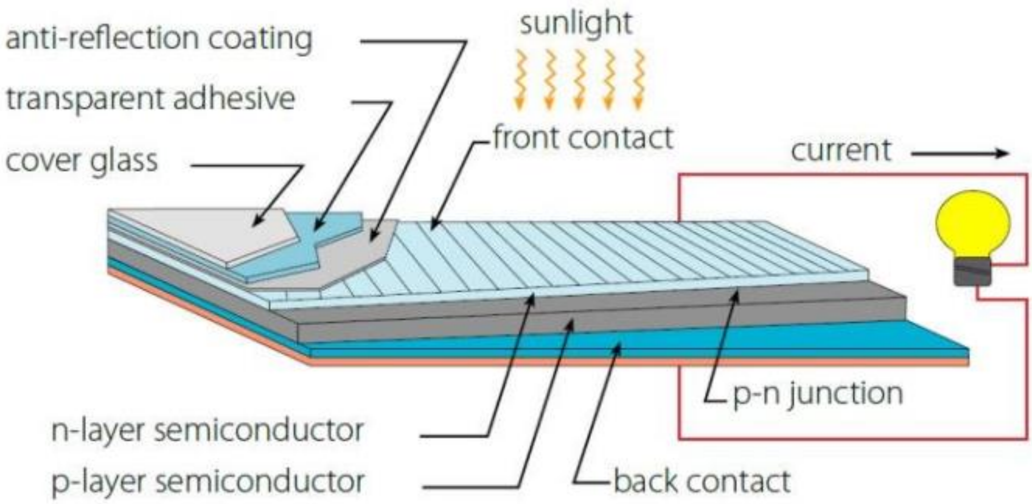


Figure 2.5: Photovoltaic cells mechanism

So how do photovoltaic cells convert solar energy into electricity? As seen in the figure above, photovoltaics are made of special types of material labelled as semiconductors such as silicon. When the light strikes cell, a portion of this light's energy actually gets trapped in the semiconductor material or silicon itself.

The atom of silicon consists of 14 electrons arranged across 3 shells. The first two shells house 2 electrons and 8 electrons respectively. Thus, they are said to be full and stable. However the outer shell isn't completely full and thus the atom is on the lookout to gain electrons it .Thus the silicon atom looks to share electrons with 4 nearby atoms, forming what is known as the crystalline structure.

However given the fact that silicon is a poor conductor of electricity, certain impurities are added to it to improve its characteristics. The process of adding impurities is called doping. When silicon is doped with phosphorous, the resulting silicon has free electrons and is thus is called N-type semiconductor.

As for P-type semiconductor, it is silicon doped with boron. The P type has free openings and carries a positive charge. When the two semiconductors are put into contact, an electric field forms at the junction between the two allowing electrons to only pass from the P side to the N side and not the other way around.

When light in the form of photons hits the solar panel, each photon striking the solar cell results in one free electron and one free hole as well. The electric field sends the electron to the N side and the hole to the P side (Inganäs & Sundström, 2016). The electrons would like to go back to the holes and with their movement create current (Inganäs & Sundström, 2016). The electric field of the semiconductors creates **voltage**. With both current and voltage produced, we now have power.

Since silicon is highly reflective material, a property that might cause the photons to come bouncing off the solar panel and thus preventing the production of electricity, an antireflective coating is added. The glass cover plate added to simply protect the elements housed in the solar panel.

However, the electricity produced by the solar grid is in the form of direct current, and thus before putting it to use with any of the electric appliances it has to be converted to alternating current (Mallwitz & Engel, 2010). The inverter technology has advanced significantly, as modern-day inverters provide data monitoring and advanced utility controls.

## 2.5 Electricity Market in Northern Cyprus

The electricity market in North Cyprus is facing issues to get to its complete potential due to some of management and operations issues. The biggest issue remains of non-optimization of electricity needs to transmissions lines and electricity distribution systems. The commercial customers are not provided with reactive systems even though their consumption is much higher (Feridum & Shahbaz, 2015). Line losses are another major factor that contribute to the damp electricity market in Cyprus. The usual limit of line losses is around 5% in most of the countries. While in North Cyprus it is around 20%. This means that transmission lines should be upgraded. Furthermore, the issue of low voltage is also felt at consumer side. Customers are not happy with the quality of electricity being provided to them. KIBTEK (Cyprus – Turkish Electricity Authority) has started working on increasing the number of transmission lines so the issue of low voltage can be solved. There is also a need for reactive power system to compliment the active power. The transmission of active power results in more power losses in and wrong quality for consumer use. KIBTEK needs to work on this issue. There is also a strict need for regulations by KIBTEK as uneven distribution is keeping consumers at a lower side o receiving energy. It is important that balance must be kept between and industrial and domestic users (Baricik, 2010).

In Turkish Republic of Northern Cyprus, electricity production and producing electricity from its own resources in order to meet the country’s needs has 19 years past. Until the year 1994, the little portion of the electricity needs was produced from gas turbine power plants from 1970s that were generated by motorine oils, and the remaining large portion of electricity needs supplied by South Cyprus. In 1990 with the support of Turkey, huge step been made about electricity production in North Cyprus. With the total of 125 million dollars investment from Turkey, steam turbine power plant built with the modern day conditions in Teknecik region of North Cyprus. The first cell of the power plant was started operating in 1995 and the other part started operating in 1996. The power plant consists of 2 cells, each cell has 60 Megawatt (MW) power, in total power plant has 120 Megawatt(MW) power. In power plants the number 6 fuel oil used as a fuel. After steam turbine power plant started operating, on March 1996 South Cyprus cut off the electricity that is provided to Turkish Republic of Northern Cyprus. After this date till the year 2003, this power plant produced most of the electric energy North Cyprus needs. Thus, within this timeline both in terms of time and in terms of production, this power plant has made efficient production of more than 95 per cent which is at command power.

In the beginnings of 2000s, the two units of cells in Teknecik Power Plant was not able to produce the electricity needed, the construction of new power plant with the approach of lease-option- to-purchase model. With the private investment, the state-controlled Kalecik Power Plant started electricity production, with 2 cells and total of 35-Megawatt power.

Kıbrıs Türk Elektrik Kurumu a.k.a. KIB-TEK (Cyprus – Turkish Electricity Authority) is conducting for country's electricity production, generation and distribution. From 1995 until the year 2015 the annual electricity production and peak demand rose by 5.7 per cent. The energy demand of the growing population of Northern Cyprus does not fulfilled due to inadequate natural resources (KIBTEK, 2015).

Rising costs, high rate load growth and low electricity rates are some factors adversely affecting electric utilities of developing countries. KIB-TEK needs future estimations of power requirements for effective and efficient planning. For long term planning (i.e., 10–30 years) utilities need to develop electrical demand and consumption models, which directly account for the impact of economic variables upon energy consumption. In 2014 the total installed electricity generation capacity in North Cyprus was 376 MW (Kıb-Tek management, Personal communication).Supplementing the generation capacity of Kıb-Tek is a private generator, Aksa Enerji, that has a power purchase agreement (PPA) to supply electricity using six diesel plants (Aksa Enerji, 2014). KIB-TEK has been charging different energy rates only to different customer classes such as residential, commercial, agricultural and industrial. Considering the fact that electricity sources are limited and energy prices in North Cyprus is one of the most expensive compared to other European Union nations and it is state owned, it is imperative that the policy makers provide better infrastructure at affordable prices. The energy transmission in North Cyprus almost covers whole geographical location. Basically, there are three levels of transmission. The highest level has 132 and 66 KV lines. 11 and 22 KV as medium while 240 and 415 V lines are found at low transmission levels. Total length of transmission lines is more than 550 km (Baricik, 2010).

The development and infrastructure in North Cyprus are progressing rapidly. So, the energy consumption would also increase. It is estimated that by the time of 2025 the total consumption need of North Cyprus will cross the figure of 1GWh. In this regard it is necessary that appropriate steps must be taken to ensure that energy production should be increased with more focus on sustainable energy sources. Also, the energy losses should be minimized (Ozerdam & Baricik, 2009).

North Cyprus is working on developing new sources of energy. Recently, it signed and agreement with European Union about Solar Energy. Through this agreement, the EU will invest in providing Photovoltaic cells to North Cyprus. A total capacity of 1.3 MW has been aimed to achieve through this project and EU has invested 3.5 million euros. More than 6000 solar panels will be installed in a separate land and this project would be handed over to KIB-TEK (Al-Ghentawi, 2018).

In other plans of expanding its energy potential, North Cyprus intends to utilize its wind energy potential as well. It is estimated that more than 50 MW electricity can be produced solely from the wind potential. Meanwhile North Cyprus also has an agreement with Turkey. Under that agreement HVDC line will connect Turkey with North Cyprus and a maximum of 300 MW electricity will be transmitted from Turkey. However, this project will take 5-10 years to complete (Sengul, 2015).

## 2.6 Other Feasibility Studies for Industry Sector

Lots of researches done that prove that use of solar system for energy production feasible and good investment for households, however there is no major studies for industry sector for manufacturers.

A study done for industry sector in Uganda resulted with grid-tied rooftop solar photovoltaic systems about 25,5 MWh capacity of project with a possible profit margin. The study showed that a solar PV system can be installed on all positions for rooftops in Uganda, while the East as the best side  for optimal solar PV energy generation for Kampala, Uganda. Observations on solar PV application on Visa

Plastic industry building indicates that solar PV can supply about 60,34%, 62,97% and 122% of total annual energy demands of Visa Plastics Ltd for the installation on the roof slope area due South West, North East and on both angle areas, respectively, considering an evaluated annual energy demand of 188.027,38 kWh.. On average, the sampled buildings were appropriate for installation of about 25,4 MWp capacity of rooftop solar PV system. The economic analysis of the system indicated project feasibility with a 5,75 US cent/kWh, internal rate of return of 7% and a possible profit margin of 5,29 US cent/kWh for every energy fed to the grid system.

Another research has done with 5kW solar power plant for a residential consumer in North Cyprus in the year of 2012. The study has found that the project will have a positive NPV of 4,986 Euros in case 25% of initial investment cost is subsidized by the government and if the current feed-in-policies are applied.

To sum up, climate change and global warming phenomenons as certified by many scientific publications which are related to the extensive use of fossil fuels are likely to get worse at a much faster rate with further increasing usage of fossil fuels. These when combined with the public opposition regarding the use of nuclear energy made it necessary to consider more environmental-friendly and sustainable technologies that will not have undesired effects on the environment and world`s climate. Many other energy resources are considered to produce electricity for achieving sustainable development. This thesis is also an example of those investments. The project has done for manufacturers to provide them establish a 2,5 MW and/or 10 MW solar farms because of an increase in energy cost, damage to environment of other non-renewable sources and for a sustainable economic development.

# Chapter 3

# PROJECT DATA AND METHODOLOGY

## 3.1 Project Description

One of the most serious rates of input costs in manufacturing companies are energy input costs which is 0,92 TL/kW. Currently, there is a government incentive of 0,10 TL/kW for manufacturers and commercial enterprises. In order to benefit from this incentive, the firms must be a member of the Chamber of Industry, TRNC (KTSO). However, the persistence of this incentive for industrial firms is in uncertainty because of economy in the country. As a precaution to that and in case of if the incentives remain, a solar power plant project is considered which the output costs of the manufacturers would be reduced by 5% or 10%.

In order to reduce energy costs with the renewable energy project, a 2,5-Megawatt (MW) project was planned to be built on a 22000 m2 land and with a 6 years repayment loan from the development bank. Furthermore, in the second scenario same estimations would be done for 10-Megawatt project.

## 3.2 Financial Sustainability of Solar Projects in Cyprus

Any commercial project is incomplete without analysing its financial sustainability. Among many methods, we have assessed the financial viability by calculating Internal Rate of Return (IRR), Net Present Value (NPV) and Payback Period of a typical solar power generation project.

A comprehensive financial appraisal was conducted for the solar power projects worth two capacities namely 2,5 MW and 10 MW. The data was obtained from the competent institutions available in the country of implementation (Northern Cyprus) and suited to its energy sector. Well-designed sets of tables of parameters covering the Cost structure of implementing the project are framed at first followed by results with financial implications accompanied by necessary calculations to reach the cash flow statements.

Another important part of the financial analysis is the sensitivity analysis that highlights the impact of several variables on the financial outcome. The variables considered for this analysis are as follows:

- Total energy produced
- Selling price of energy per kWH
- Change in the portion of energy lost KTSO institutions which include service procurement for panel cleaning, malfunction maintenance repair, security camera systems etc.
- Investment cost overrun
- Salary costs and
- Inflation rate.

## 3.3 Data

We have tried assessing the financial stability with two scenarios namely with capacities of 2.5MW and 10MW. As a first step, we have developed detailed cost estimates of each PV field with details on each of the system components necessary for building the solar plant irrespective of the capacity. These system cost components include:

incurred in the beginning of the project, other costs are annual expenses to be incurred for daily operations. Power annual deterioration factor refers to the expected fall in power generation capacity of a typical solar power panel per year; Benjamin Mow (2018).

Details and assumptions involved in arriving at these costs are tabulated below:

Table 3.1: High level assumptions

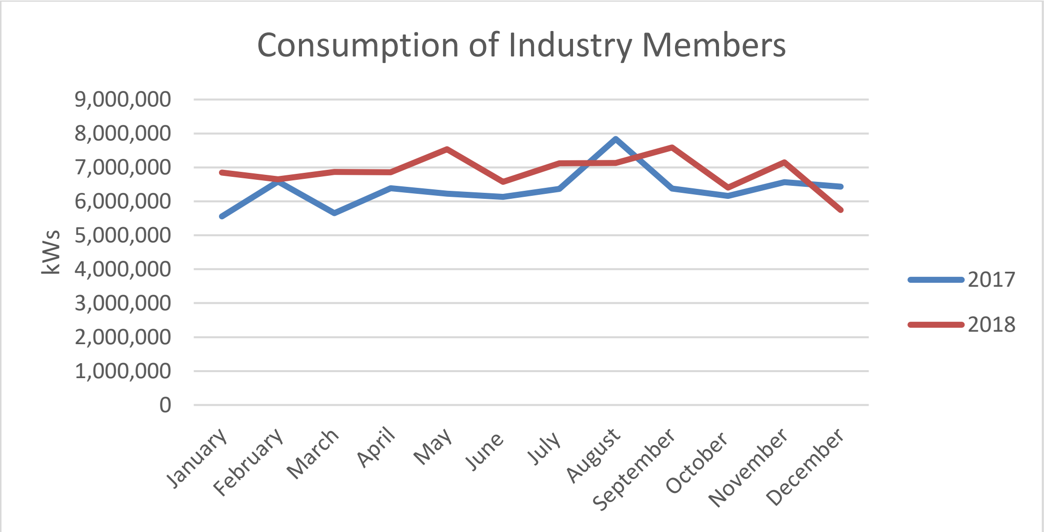
| | |
|---|---|
| **Macro and project specific assumptions** | |
| Total years of the project | 25 |
| Inflation rate (EUR) | 1,4% |
| EUR to TL forex conversion rate (1 EUR = X TL) | 8,72 |
| Power annual deterioration factor (if any) | 1,0% |
| Power Load Factor | 20% |
| **Other assumptions with financial implications** | |
| Selling price per kWh-Rounded to 2 decimal places (EUR) | 0,11 |
| Total land required to generate 1MW power (in sq.m) | 8.800 |
| Approximate average cost of land per sq.m (in EUR) | 5 |
| Cost of inverter (100kW Geo series in EUR) | 2.200 |
| Maintenance cost per year (in EUR per MW) | 8.000 |
| Infrastructure costs per MW (Panels and inverters in EUR) | 700.000 |
| Debt equity structure assumed | 75:25 |
| **Other arbitrary assumptions (subject to user/ market movements)** | |
| Bank interest rate of debt | 4% |
| Discount rate used for calculating NPV | 10% |
| KIBTEK distribution expense (% of revenue) | 10% |
| KTSO Power Plant Operating Expenses (% of revenue) | 2% |

### 3.3.1 Power Production vs Consumption

We have tried assessing the financial stability with two projects namely - power generation capacities of 2,5MW and 10MW.

Power load factor accounts for any power losses from transmission and impact of days with less intense sun light. The power produced by such plants (2,5 MW and 10MW) assuming a 20% Power Load Factor is approx. 4,380MWh and 17.520 MWh respectively.

The official numbers from the Chamber of Commerce and Industry Members, TRNC, the total power consumption for 2018 by commercial establishments was around 82.487MWh  and 76.274.519 in the year of 2017 (Chamber of Commerce and Industry Members Consumptions in 2017-2018) as shown in Figure 3.1. While the plants under our consideration produce just 5,31% of total consumption (4.380MWh for 2,5MW plant) and 21% of consumption (17.520MWh for 10MW plant), we have considered this to be a Proof of Concept. The financial viability results arrived here can then be used as a claim to expand the scale in future.



## 3.4 Cost

### 3.4.1 Land Cost

Focus group discussions and interviews with Solar power plant commissioning agencies revealed that about 8.800 sq.m of land will be required to commission a solar field of 1MW capacity in Northern Cyprus. These figures translate to a total land required of about 22.000 sq.m for setting up a 2,5MW capacity power plant and 88.000 sq.m for a 10MW capacity power plant.

Regarding cost, our discussions with realtors in Northern Cyprus revealed that 1 square metre of land in Northern Cyprus costs about EUR 5. Thus, we anticipate a total investment of about EUR 110.575 and EUR 442.304 for 2,5MW capacity and 10MW capacity power plants respectively.

Table 3.2: Land acquisition investment

| **Component** | **Total cost in EUR** | |
|---|---|---|
| | **2,5MW** | **10MW** |
| Total capacity of the solar field (MW) | 2,5 | 10,00 |
| Total land required (in metre square) | 22.000 | 88.000 |
| **Total amount required for land (in EUR)** | **110.575** | |

The land required for commissioning the solar plant is assumed to be completely bought before commencing operations. This decision to buy the complete parcel of land will impact the net present value of the project as we incur significant cash outflow in the early years of the project. Other options could be to lease the land or to buy it in tranches or pockets.

Another key assumption here is that the land acquired is sold at the end of the project (in year 26 from commencement) for any the then market price. This is assumed as revenue for the firm and recognized as a cash inflow in cash flow statement. This also drives the financial parameters like NPV, IRR and payback period ahead of earlier estimates when we liquidate the land.

### 3.4.2 Other Infrastructure Costs

Literature review of existing power plants across the world and interviews with solar power plant commissioning agencies put the total infrastructure cost to procure, setup and commission Photovoltaic panels and inverters at EUR 700.000 per MW worth of production. This puts the total cost at EUR 1,75 million and EUR 7 million for the 2,5MW and 10MW capacity power plants. The other materials utilized in commissioning the power plant like the Photo Voltaic cells, inverters, etc. are assumed to not fetch any value and hence we don't associate any value here.

Furthermore, we are expected to incur one-time installation costs of about EUR 48.000 per MW worth of production for purchasing transformers, cables, setting up a system control center and other components. Thus the total procurement and infrastructure costs stand at EUR 1,98 million for the 2,5MW capacity power plant and EUR 7,92 million for the 10MW capacity power plant.

Table 3.3: Total infrastructure investment

| Component | Total cost in EUR | |
|---|---|---|
| | **2,5MW** | **10MW** |
| Total capacity of the solar field (MW) | 2,5 | 10,00 |
| Total land required (in metre square) | 22.000 | 88.000 |
| **Total amount required for land (in EUR)** | **110.575** | |

| | | |
|---|---|---|
| Panel & Inverter | 1.750.000 | 7.000.000 |
| Power transmission equipment, cables | 20.000 | 80.000 |
| System control centre | 100.000 | 400.000 |
| **Total investment** | **1.980.575** | |

### 3.4.3 Staff and Staff Costs

We assume a total number of 15 and 24 employees employed across different stages of the project with varying responsibilities for 2,5 MW and 10 MW capacities of project. They are split into the following groups based on their responsibilities.

Table 3.4: Staff costs

| **Type of staff** | **No of staff** | | **Pay-per emp in EUR** | **Staff costs (in EUR)** | |
|---|---|---|---|---|---|
| | **2.5MW** | **10MW** | | **2.5MW** | **10MW** |
| Project manager | 1 | 2 | 2.083 | 2.083 | 4.116 |
| Engineers and technicians | 2 | 4 | 1.667 | 3.334 | 6.668 |
| Financial Analysts/Economists | 2 | 3 | 1.042 | 2.084 | 3.126 |
| Maintenance specialist/Workers | 10 | 15 | 625 | 6250 | 9.375 |
| Total | 15 | 24 | 5,147 | 13,750 | 23.333 |

The above numbers on total employees and responsibilities are arbitrarily assumed and can be changed per the existing average salary of a typical worker in the area in which the project is commissioned. We have also assumed a 2% hike in salary per year for all employees across designations. This was also arbitrarily assumed in a way that the salary hike figure beats the inflation.

### 3.4.4 Other Operating Costs

Apart from the staff costs mentioned above, it was assumed the costs related to day-to-day operations.

- Inverter replacement costs

Interviews with engineers in Solar power plant management revealed that typical inverters would be replaced once in every 10 years and it has been accounted in the model as well.

- Other maintenance costs

The additional maintenance costs are incurred to account for daily operational activities (if any) in the solar field and this will be incurred in addition to the salary paid to the maintenance workers identified as part of the staff.

- Distribution costs incurred to KIBTEK and KTSO Power plant operating costs

These are costs incurred to the electricity distribution firms in Northern Cyprus to distribute power generated from the power field. Secondary research revealed that these costs are typically 10% and 2% of the total revenues realized from the energy sales.

## 3.5 Financial Analysis

The aim of this study is to do a thorough financial analysis for commissioning a solar power plant. In order to assess this, we have modelled the profit and loss and the cash flow originating from the project. The cash flow was split into two sections as:

- Cash inflow and the
- Cash outflow

The initial investment is the main cash outflow. As mentioned in the beginning of this chapter the initial investment mainly accounts for the land and the other material expenses. 75% of this is assumed to be funded by bank loans at an interest rate of about 4%, while the rest will be equity funded. The loans are assumed to be repaid in about 6 years or less.

Table 3.5: Loan schedule-2,5 MW

| ***Years*** | | ***1*** | ***2*** | ***3*** | ***4*** | ***5*** | ***6*** |
|---|---|---|---|---|---|---|---|
| Interest rate | 4.0% | 4.0% | 4.0% | 4.0% | 4.0% | 4.0% | 4.0% |
| Cash outstanding at the beginning of year | 1.485.432 | 1.485.432 | 1.237.860 | 990.288 | 742.716 | 495.144 | 247.572 |
| Interest accrued | 59.417 | 59.417 | 49.514 | 39.612 | 29.709 | 19.806 | 9.903 |
| Repayment | 59.417 | 306.989 | 297.086 | 287.184 | 277.281 | 267.378 | 257.475 |
| Interest | 59,417 | 59.417 | 49.514 | 39,612 | 29,709 | 19,806 | 9,903 |
| Principal | 0 | 47.572 | 247.572 | 247.572 | 247.572 | 247.572 | 247.572 |
| Outstanding at the end of the year | 1.485.432 | 1,237.860 | 990.288 | 742.716 | 495.144 | 247,572 | 0 |

Table 3.6: Loan schedule-10 MW

| ***Years*** | | ***1*** | ***2*** | ***3*** | ***4*** | ***5*** | ***6*** |
|---|---|---|---|---|---|---|---|
| Interest rate | 4.0% | 4.0% | 4.0% | 4.0% | 4.0% | 4.0% | 4.0% |
| Cash outstanding at the beginning of year | 5.941.728 | 5.941.728 | 4.951.440 | 3.961.152 | 2.970.864 | 1.980.576 | 990.288 |
| Interest accrued | 237.669 | 237.669 | 198.058 | 158.446 | 118.835 | 79.223 | 39.612 |
| Repayment | 237.669 | 1.227.957 | 1.188.346 | 1.148.734 | 1.109.123 | 1.069.511 | 1.029.899 |
| Interest | 237.669 | 237.669 | 198.058 | 158,446 | 118,835 | 79,223 | 39,612 |
| Principal | 0 | 990.288 | 990.288 | 990.288 | 990.288 | 990.288 | 990.288 |
| Outstanding at the end of the year | 5.941.728 | 4.951.440 | 3.961.152 | 2.970.864 | 1.980.576 | 990.288 | 0 |

The chief cash inflow is the profit realized by selling energy produced in the solar field which is the revenues netting after accounting for all the costs incurred. The domestic inflation index was used to grow the revenue and the costs incurred every year. The cash inflows and outflows are calculated in real and in nominal terms.

After creating the cash flow statements, the next step was to calculate the Annual Debt Service Coverage Ratio. ADSCR is a measurement that demonstrates whether a company has the cash for paying its debt. It is also used by lenders to see whether there is enough cash flow to service their debt.

Table 3.7: ADSCR-2,5 MW

| ***Years*** | | ***1*** | ***2*** | ***3*** | ***4*** | ***5*** | ***6*** |
|---|---|---|---|---|---|---|---|
| Debt Repayment Period | 0.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Net CASH FLOW | -1.980.575,92 | 326.240,21 | 326.321,58 | 326.380,91 | 326.417,70 | 326.431,43 | 326.421,55 |
| Debt Repayment Schedule | 0.00 | 306.989,27 | 297.086,39 | 287.183,51 | 277.280,63 | 267.377,75 | 257.474,87 |
| ADSCR | 0.00 | **1,06** | **1,10** | **1,14** | **1,18** | **1,22** | **1,27** |

Table 3.8: ADSCR-10 MW

| ***Years*** | | ***1*** | ***2*** | ***3*** | ***4*** | ***5*** | ***6*** |
|---|---|---|---|---|---|---|---|
| Debt Repayment Period | 0,00 | 1,00 | 1,00 | 1,00 | 1,000 | 1,00 | 1,00 |
| Net CASH FLOW | -7.922.303,66 | 1.441419,19 | 1.444.473,81 | 1.447.494,89 | 1.450.481,49 | 1.453.432,60 | 1.456.347,22 |
| Debt Repayment Schedule | 0.00 | 1.227.957,07 | 1.188.345,55 | 1,148,734.03 | 1.109.122,51 | 1.069.510,99 | 1.029.899,48 |
| ADSCR | 0.00 | **1,17** | **1,22** | **1,26** | **1,31** | **1,36** | **1,41** |

Following the ADSCR, the Loan Life Coverage Ratio was calculated. LLCR is similar to ADSCR, in which they both are financial ratios that measure the ability of a firm to pay back its debt. Unlike ADSCR, LLCR is used more commonly in financing projects because it has a long term nature. LLCR covers the entire span of the debt.

Table 3.9: LLCR-2,5 MW

| Years | | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| Net Cash Flow Available for Debt Service | 0,00 | 326.240,21 | 326.321,58 | 326.380,91 | 326.417,70 | 326.431,43 | 326.421,55 |
| Debt Repayment Scheduled | 0,00 | 306.989,27 | 297.086,39 | 287.183,51 | 277.280,63 | 267.377,75 | 257.474,87 |
| PV of NCF Available for Debt Service-Nominal | 0,00 | 1.779.282,28 | 1.511.163,75 | 1.232.235,86 | 942.089,15 | 640.298,30 | 326.421,55 |
| PV of Loan Repayment | 0,00 | 1.544.849,21 | 1.287.374,35 | 1.029.899,48 | 772.424,61 | 514.949,74 | 257.474,87 |
| LLCR | 0 | **1,15** | **1,17** | **1,19** | **1,21** | **1,24** | **1,26** |

Table 3.10: LLCR-10 MW

| ***Years*** | | ***1*** | ***2*** | ***3*** | ***4*** | ***5*** | ***6*** |
|---|---|---|---|---|---|---|---|
| Net Cash Flow Available for Debt Service | 0,00 | 1.441.419,19 | 1.444.473,81 | 1.447.494,89 | 1.450.481,49 | 1.453.432,60 | 1.456.347,22 |
| Debt Repayment Scheduled | 0,00 | 1.227.957,07 | 1.188.345,55 | 1.148.734,03 | 1.109.122,51 | 1.069.510,99 | 1.029.899,48 |
| PV of NCF Available for Debt Service-Nominal | 0,00 | 7.897.511,00 | 6.714.335,48 | 5.480.656,15 | 4.194.487,70 | 2.853.766,46 | 1.456.347,22 |
| PV of Loan Repayment | 0,00 | 6.179.396,86 | 5.149.497,38 | 4.119.597,91 | 3.089.698,43 | 2.059.798,95 | 1.029.899,48 |
| **LLCR** | 0 | 1,27 | 1,30 | 1,33 | 1,35 | 1,38 | 1,41 |

## 3.6 Analysis Tools For Measuring the Worthiness of the Project

### 3.6.1 Net Present Value

Literature review revealed that Net Present Value to be a widely used decision making tool in commencing an infrastructure project. According to this method, a project is worthy of initiating, if it reports a positive NPV over its lifetime considered. In cases with more than one mutually exclusive project, the NPV should be calculated for each project and choose the one with biggest NPV. In order to arrive at the NPV value, we use a subjective discount rate which is usually a hurdle rate that should be satisfied. For this project we have assumed that to be 10%. In order to ensure the financial feasibility of the project, we have also carried out sensitivity analysis across different discount rates.

In 2014, Amy Gallo wrote a research to explain NPV. According to the research, NPV uses time value of money concept to translate all the money realized from the project to the current dollar value which in turn is used to determine if a project's investment is worthwhile.

$$Net\ Present\ Value = \sum_{n}^{1} \frac{Year\ n\ Total\ Cash\ Flow}{(1 + Discount\ Rate)^{n}}$$

However, the project manager should be careful in framing the assumptions used in calculating NPV. Assumptions considered to arrive at the NPV values should be supported by a financial or empirical theory. Assumptions on especially the initial investment value and discount rate can have adverse impacts on the final NPV value

### 3.6.2 Discounted Payback Period

In 1985, Shyam Bhandari in his study, suggested the Discounted Payback period method as another viable choice to assess the financial feasibility of a project. The method helps to arrive at the number of years (from the commencement of the project) needed to get the investment money back.

According to the research study, the discounted payback period takes into consideration the time value of money, retains the useful properties of payback period, and eliminates some of the payback period drawbacks such as lack of consideration of time value of money, ignoring the cash inflows after the payback period of the project.

As an inference, the discounted payback period should be less than or equal to the pre-specified period of the project in order to go ahead with the project. For mutually exclusive projects, the project with the shortest discounted payback period should be chosen. According to Bhandari, projects that are selected by discounted payback period are guaranteed to be profitable, since the method takes into consideration the time value of money and discounting cash flows at the required rate of return.

### 3.6.3 Internal Rate of Return

Hartman and Schafrick (2004) stated in their study that the Internal Rate of Return (IRR) is the rate at which the Net Present Value equals zero. The project is worthy of going ahead, if the IRR is greater than the discount rate. In this project, in addition to using NPV and the Payback Period, we are also using the IRR as a decision maker tool.

# Chapter 4

# RESULTS AND FINDINGS

In this chapter, the results of financial analysis used in the study will released. Also, it will include interpretations and discussions for each result of analysis.

## 4.1 Net Present Value (NPV) and Internal Rate of Return (IRR)

Our analysis shows that a typical solar power plant with a total capacity of 2.5MW will have a positive nominal NPV of about EUR 1.583.032 across a period of 25 years at a discount rate of 10%. The IRR stood at approx. 29% for the project. The payback period is about 6 years in this scenario assuming the project starts functioning from 2021. At inflation adjusted levels, the NPV falls to EUR 1.280.396 at an IRR of 27%.

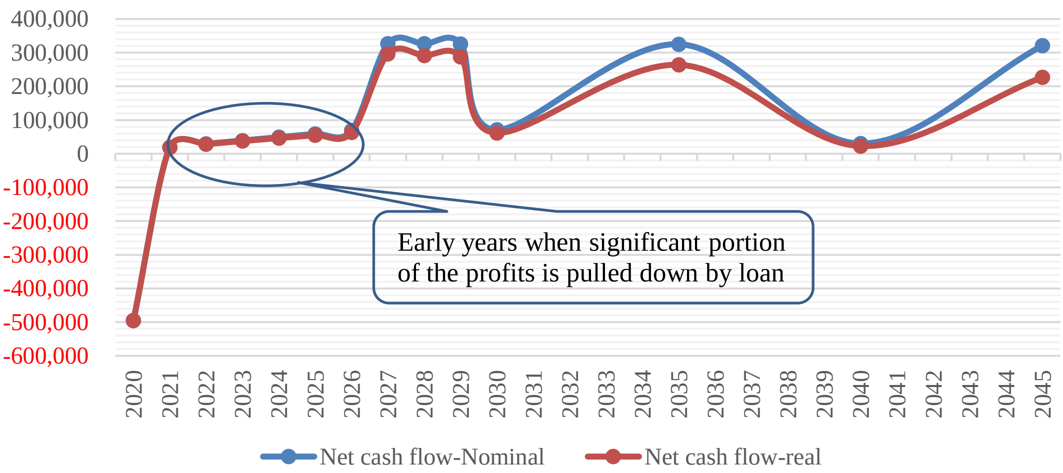



Figure 4.1: Trend in net cash flow (in EUR) for 2.5 MW capacity plant across years

The returns for the 10MW project stood at EUR 6.666.026 worth Net Present Value at an IRR of 30% with the same payback period of about 6 years. At inflation adjusted levels, the NPV falls to EUR 5.418.014 at an IRR of 28%.

Kindly note that the NPV will be relatively higher if the project owner were to lease the required land for the whole period of the project or buy the land in parcels across years.

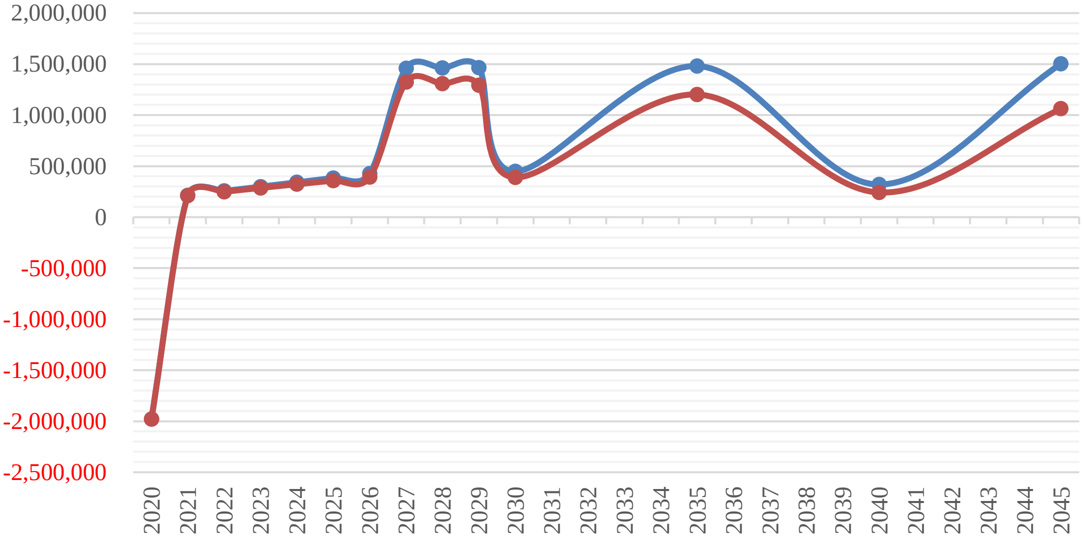


Figure 4.2: Trend in net cash inflow (in EUR) for 10MW capacity plant across years

In both two scenarios, the projects gave a positive NPV which indicates the projects are profitable and worth to be undertaken. Although, the net cash flow is negative in first year and the significant portion of the profits pulled down by loan for 5-6 years, the project has an ability to elevate and covers its expenditures. This shows us that the money invest in these two projects will be paid back and more.

For this study, the discount rate used was 10%. The IRR of the project is 28% for 10 MW and 27% for 2,5 MW. This is a positive indication since IRR is greater than the discount rate used in both projects

Table 4.1: Cash flow statement- 2,5 MW

| **Year** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **15** | **20** | **25** | **26** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Cash inflow** | | | | | | | | | | | | | | | |
| Total Revenues | 0 | 462.110 | 463.894 | 465.684 | 467.482 | 469.286 | 471.098 | 472.916 | 474.742 | 476.574 | 478.414 | 487.719 | 497.205 | 617.451 | 110.576 |
| **Cash outflow** | | | | | | | | | | | | | | | |
| Investment cost | -1.980.576 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Annual Operating Cost | 0 | -89.203 | -89.972 | -90.752 | -91.541 | -92.342 | -93.153 | -93.975 | -94.808 | -95.652 | -351.621 | -100.967 | -398.907 | -110.863 | 0 |
| Total Costs | -1.980.576 | -89.203 | -89.972 | -90.752 | -91.541 | -92.342 | -93.153 | -93.975 | -94.808 | -95.652 | -351.621 | -100.967 | -398.907 | -110.863 | 0 |
| **Net Cash flow Before Financing** | **-1.980.576** | 372.907 | 373.922 | 374.933 | 375.941 | 376.945 | 377.945 | 378.942 | 379.934 | 380.922 | 126.793 | 386.752 | 98.297 | 493.319 | 110.576 |
| Loan Distribution | 1.485.432 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Annual Loan Repayment | | 306.989 | 297.086 | 287.184 | 277.281 | 267.378 | 257.475 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Net Cash flow After Financing** | **-495.144** | 65.918 | 76.835 | 87.749 | 98.660 | 109.567 | 120.470 | 378.942 | 379.934 | 380.922 | 126.793 | 386.752 | 98.297 | 493.319 | 110.576 |
| Income Taxes Paid | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Net Cash Flow Nominal** | **-495.144** | 65.918 | 76.835 | 87.749 | 98.660 | 109.567 | 120.470 | 378.942 | 379.934 | 380.922 | 126.793 | 386.752 | 98.297 | 493.317 | 110.576 |
| **Net cash flow real in 2020 prices** | **-495.144** | **65.008** | **74.728** | **84.165** | **93.323** | **102.209** | **110.829** | **343.801** | **339.942** | **336.120** | **110.336** | **313.952** | **74.436** | **348.481** | **77.013** |

Table 4.2: Cash flow statement- 10 MW

| **Year** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **15** | **20** | **25** | **26** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Cash inflow** | | | | | | | | | | | | | | | |
| Total Revenues | 0 | 1.848.440 | 1.855.575 | 1.862.738 | 1.869.928 | 1.877.146 | 1.884.392 | 1.891.665 | 1.898.967 | 1.906.297 | 1.913.656 | 1.950.875 | 1.988.819 | 2.469.804 | 442.308 |
| **Cash outflow** | | | | | | | | | | | | | | | |
| Investment cost | -7.922.304 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Annual Operating Cost | 0 | -325.146 | -327.589 | -330.060 | -332.560 | -335.089 | -337.648 | -340.237 | -342.856 | -345.506 | -1.368.639 | -362.083 | -1.549.497 | -392.517 | 0 |
| Total Costs | -7.922.304 | -325.146 | -327.589 | -330.060 | -332.560 | -335.089 | -337.648 | -340.237 | -342.856 | -345.506 | -1.368.639 | -362.083 | -1.549.497 | -392.517 | 0 |
| **Net Cash flow Before Financing** | -7.922.304 | 1.523.294 | 1.527.986 | 1.532.678 | 1.537.368 | 1.542.057 | 1.546.744 | 1.551.429 | 1.556.112 | 1.560.791 | 545.016 | 1.588.793 | 439.322 | 2.024.211 | 442.308 |
| Loan Distribution | 5.941.728 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Annual Loan Repayment | 0 | 1.227.957 | 1.188.346 | 1.148.734 | 1.109.123 | 1.069.511 | 1.029.899 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Net Cash flow After Financing** | -1.980.576 | 295.337 | 339.641 | 383.944 | 428.245 | 472.546 | 516.844 | 1.551.429 | 1.556.112 | 1.560.791 | 545.016 | 1.588.793 | 439.322 | 2.024.211 | 442.308 |
| Income Taxes Paid | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Net Cash Flow Nominal** | -1.980.576 | 295.337 | 339.641 | 383.944 | 428.245 | 472.546 | 516.844 | 1.551.429 | 1.556.112 | 1.560.791 | 545.016 | 1.588.793 | 439.322 | 2.014.211 | 442.308 |
| **Net cash flow real in 2020 prices** | **-1.980.576** | **330.327** | **368.259** | **405.080** | **440.813** | **475.480** | **1.407.558** | **1.392.314** | **1.377.220** | **474.275** | **291.259** | **1.289.727** | **332.678** | **1.429.904** | **308.133** |

Table 4.3: Financial results

| Parameter | 2.5MW capacity | | 10MW capacity | |
|---|---|---|---|---|
| | Nominal | Real | Nominal | Real |
| NPV (in EUR) | 1.5823.032 | 1.280.396 | 6.668.026 | 5.418.014 |
| IRR (in %) | 29% | 27% | 30% | 28% |
| Payback period (in years) | 6 | 6 | 6 | 6 |

The Net Present Value for 2.5MW is 1.280.396 ad for 10MW is 5.418.014 and with IRR of 27% and 28%. The results show us that both projects are a good investment since their Net Present Value (NPV) is positive and Internal Rate of Return (IRR) higher than discount rate.

## 4.2 Discounted Payback Period

Discounted payback period is a metric decision making used in capital budgeting. It is integrated from the simple method of payback period. The discounted payback period give the period, in years, at which the project will breakeven from the investment expenditures. The difference between the payback period and the discounted payback period is that the lateral takes into consideration the time value of money. For this project, the discounted payback period is done once on the net cash flow after financing and resulted with 6 years for 2.5MW and for 10MW, as shown in table, below. Usually, companies set a desired payback period to determine whether to take the project or not. However, in this study no period was specified. The discounted payback period was used to give an idea at which point will the project breakeven. The discounted payback period is still being developed. However, it is not considered a very precise and accurate decision criterion. In this case it was used as a support to the NPV and IRR. Since all three criterion gave a positive result, the project is displayed a good investment.

Table 4.4: Discussed payback period

| | |
|---|---|
| **Discount rate** | 10% |
| **Discounted Payback Period** | 6 yrs |

## 4.3 Ability to Service Debt

Another important factor to analyse is the ability to service bank debt until the repayment period. The variables analysed to determine the servicing capability were Average Debt Service Coverage Ratio (ADSCR) and the Loan Life coverage Ratios (LLCR) for the first six years since commissioning the project. Though the project yields negative net cash flow in the early stages of the project, the operating profit is sufficient enough in both 2.5MW and 10MW capacity scenarios to service the interest and principal payments for the whole planned repayment period.

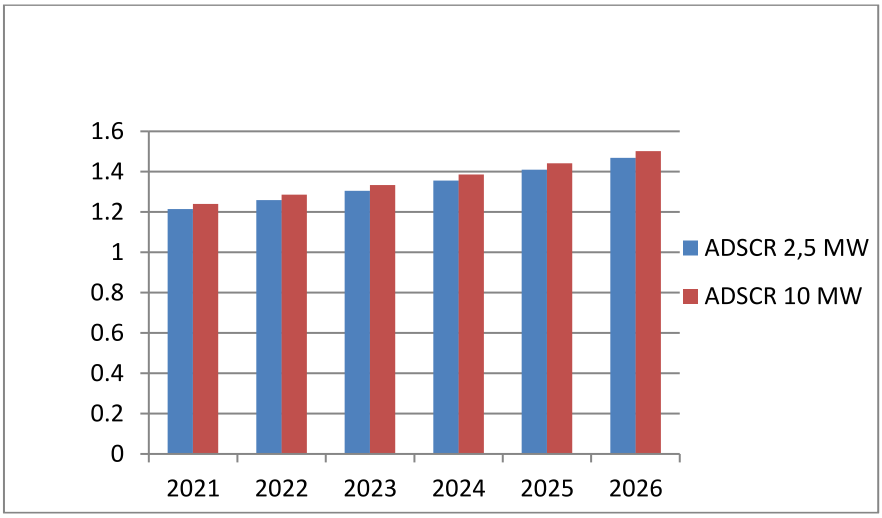


Figure 4.3: Trend in average debt service coverage ratio (ADCRS)

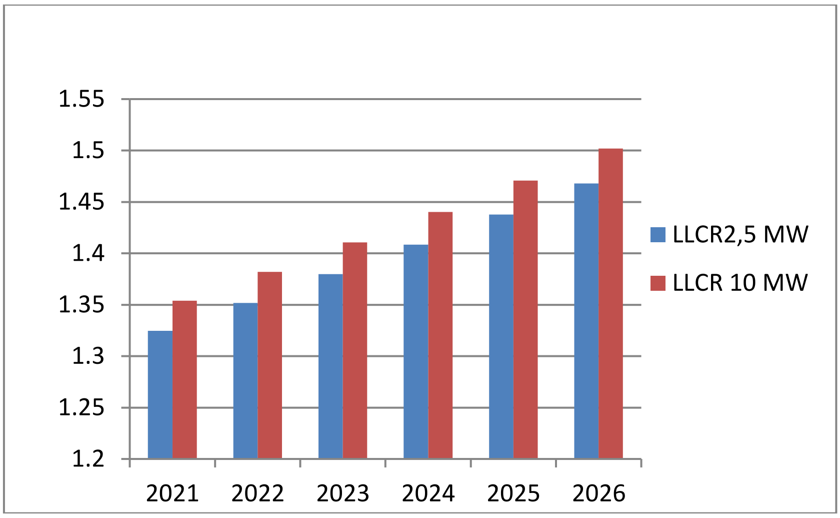


Figure 4.4: Trend in loan life coverage ratio (LLCR)

## 4.4 Sensitivity Analysis

The sensitivity analysis tests the investment under different conditions. It is required because the future is not guaranteed, and no matter how precise the financial analysis is, there are always unpredictable events that can take place. For this project, the sensitivity analysis was done on parameters that could have the highest impact on the success or failure of the project namely ;

- Change in energy production
- Change in energy price
- Overrun cost
- KTSO Operating share
- Salary and
- Inflation rate

### 4.4.1 Change in Energy Production

We assume the energy produced from the solar power plant can change from various factors like change in Load Factor, effectiveness of Photo Voltaic cells, delay in installation, etc. We assume a worst cases scenario of a fall in total energy produced by 40%.

Table 4.5: Sensitivity analysis: change in energy production- 2,5 MW

| Change in Energy Production | NPV (Nominal in Euro) | NPV (REAL in Euro) | IRR (Nominal) | IRR (REAL) |
|---|---|---|---|---|
| -40% | 63.043,63 | -73.246,08 | 11% | 9% |
| -30% | 443.040,85 | 265.164,41 | 15% | 13% |
| -20% | 823.038,07 | 603.574,91 | 19% | 17% |
| -10% | 1.203.035,28 | 941.985,40 | 24% | 22% |
| -5% | 1.393.033,89 | 1.111.190,65 | 26% | 25% |
| 0% | 1.583.032,50 | 1.280.395,89 | 29% | 27% |
| 5% | 1.773.031,11 | 1.449.601,14 | 32% | 30% |
| 10% | 1.963.029,71 | 1.618.806,39 | 34% | 33% |
| 15% | 2.153.028,32 | 1.788.011,63 | 37% | 36% |

Table 4.6: Sensitivity analysis: change in energy production-10 MW

| Change in Energy Production | NPV (Nominal in Euro) | NPV (REAL in Euro) | IRR (Nominal) | IRR (REAL) |
|---|---|---|---|---|
| -40% | 588.071 | 3.446 | 12% | 10% |
| -30% | 2.108.059 | 1.357.088 | 16% | 14% |
| -20% | 3.628.048 | 2.710.730 | 20% | 18% |
| -10% | 5.148.037 | 4.064.372 | 25% | 23% |
| -5% | 5.908.032 | 4.741.193 | 27% | 26% |
| 0% | 6.668.026 | 5.418.014 | 30% | 28% |
| 5% | 7.428.020 | 6.094.835 | 33% | 31% |
| 10% | 8.188.015 | 6.771.656 | 36% | 34% |
| 15% | 8.948.009 | 7.448.477 | 39% | 37% |

The tables above confirm the fact that the increase in energy production increases NPV and IRR. For 2,5 MW, if the energy production decreases at 40% we would have negative NPV and IRR would be less than discount rate. However, for 10 MW capacity NPV and IRR would never be negative in worst case of energy production.

### 4.4.2 Change in Energy Price

The second parameter is the assumed change in the price nominated for selling a kWH worth of energy. This could change due to two main reasons namely the prevailing economic conditions and the government policies.

Table 4.7: Sensitivity analysis: change in energy price-2,5 MW

| Change in Energy Price | NPV (Nominal in Euro) | NPV (REAL in Euro) | IRR (Nominal) | IRR (REAL) |
|---|---|---|---|---|
| -30% | 444.726 | 266.665 | 15% | 13% |
| -20% | 822.906 | 603.457 | 19% | 17% |
| -10% | 1.204.687 | 943.457 | 24% | 22% |
| -5% | 1.391.977 | 1.110.249 | 26% | 25% |
| 0% | 1.583.032 | 1.280.396 | 29% | 27% |
| 5% | 1.773.758 | 1.450.249 | 32% | 30% |
| 10% | 1.964.649 | 1.620.248 | 34% | 33% |
| 20% | 2.342.829 | 1.957.040 | 40% | 39% |

Table 4.8: Sensitivity analysis: change in energy price-10 MW

| Change in Energy Price | NPV (Nominal in Euro) | NPV (REAL in Euro) | IRR (Nominal) | IRR (REAL) |
|---|---|---|---|---|
| -30% | 2.114.800 | 1.363.091 | 16% | 14% |
| -20% | 3.627.520 | 2.710.260 | 20% | 18% |
| -10% | 5.154.646 | 4.070.258 | 25% | 23% |
| -5% | 5.903.802 | 4.737.427 | 27% | 26% |
| 0% | 6.668.026 | 5.418.014 | 30% | 28% |
| 5% | 7.430.928 | 6.097.425 | 33% | 31% |
| 10% | 8.194.491 | 6.777.424 | 36% | 34% |
| 20% | 9.707.211 | 8.124.592 | 42% | 40% |

As energy price increases the outputs of both models are increasing. Since we are not expecting that energy price would be 30% less , we can see that the NPV and IRR affected but not in serious rates in both models.

### 4.4.3 Overrun Cost

Another key factor determining the financial success of a power project is the estimated cost required to run the project and any possible deviation from the projected cost. We model the possible change in costs and estimate the change in final results.

Table 4.9: Sensitivity analysis: change in overrun costs – 2.5 MW

| Change in Overrun costs | NPV (Nominal in Euro) | NPV (REAL in Euro) | IRR (Nominal) | IRR (REAL) |
|---|---|---|---|---|
| -15% | 1.880.119 | 1.577.482 | 52% | 50% |
| -10% | 1.781.090 | 1.478.453 | 40% | 38% |
| -5% | 1.682.061 | 1.379.425 | 33% | 31% |
| 0% | 1.583.032 | 1.280.396 | 29% | 27% |
| 10% | 1.384.975 | 1.082.338 | 23% | 22% |
| 20% | 1.186.917 | 884.281 | 20% | 18% |
| 30% | 988.860 | 686.223 | 17% | 15% |
| 40% | 790.802 | 488.166 | 15% | 13% |

Table 4.10: Sensitivity analysis: change in overrun costs-10MW

| Change in Overrun costs | NPV (Nominal in Euro) | NPV (REAL in Euro) | IRR (Nominal) | IRR (REAL) |
|---|---|---|---|---|
| -15% | 7.856.372 | 6.606.360 | 55% | 53% |
| -10% | 7.460.256 | 6.210.245 | 42% | 40% |
| -5% | 7.064.141 | 5.814.129 | 35% | 33% |
| 0% | 6.668.026 | 5.418.014 | 30% | 28% |
| 10% | 5.875.796 | 4.625.784 | 24% | 22% |
| 20% | 5.083.565 | 3.833.554 | 20% | 19% |
| 30% | 4.291.335 | 3.041.323 | 18% | 16% |
| 40% | 3.499.105 | 2.249.093 | 16% | 14% |

In our both models, the NPV stay with positive. If the investment cost increases the NPV and IRR output would decrease since they have an inverse relationship. If the investment cost increase by 40%, in both scenarios NPV real keep as positive by

488.176 and 2.249.093. So the cost overrun variable would not affect the output results in all cases.

**4.4.4 Change in KTSO Operating Share**

Any possible change in the KTSO operating share from 2% to a new share could also impact the financial results as shown below. However, results don't change the NPV sign and IRR would be still higher than discount rate.

Table 4.11: Sensitivity analysis: change in KTSO Operating share- 2.5MW

| Change in KTSO Operating share | NPV (Nominal in Euro) | NPV (REAL in Euro) | IRR (Nominal) | IRR (REAL) |
|---|---|---|---|---|
| **1.50%** | 1.604.623 | 1.299.624 | 29% | 27% |
| **1.75%** | 1.593.828 | 1.290.010 | 29% | 27% |
| **2.00%** | 1.583.032 | 1.280.396 | 29% | 27% |
| **2.25%** | 1.572.237 | 1.270.782 | 29% | 27% |
| **2.50%** | 1.561.442 | 1.261.168 | 29% | 27% |
| **2.75%** | 1.550.646 | 1.251.554 | 29% | 27% |
| **3.00%** | 1.539.851 | 1.241.940 | 28% | 27% |
| **3.25%** | 1.529.056 | 1.232.326 | 28% | 27% |

Table 4.12: Sensitivity analysis: change in KTSO operating share-10MW

| Change in KTSO Operating share | NPV (Nominal in Euro) | NPV (REAL in Euro) | IRR (Nominal) | IRR (REAL) |
|---|---|---|---|---|
| **1.50%** | 6.754.389 | 5.494.926 | 30% | 29% |
| **1.75%** | 6.711.208 | 5.456.470 | 30% | 28% |
| **2.00%** | 6.668.026 | 5.418.014 | 30% | 28% |
| **2.25%** | 6.624.845 | 5.379.559 | 30% | 28% |
| **2.50%** | 6.581.663 | 5.341.103 | 30% | 28% |
| **2.75%** | 6.538.482 | 5.302.647 | 30% | 28% |
| **3.00%** | 6.495.300 | 5.264.191 | 29% | 28% |
| **3.25%** | 6.452.119 | 5.225.736 | 29% | 27% |

### 4.4.5 Change in Salary Costs

The next parameter under sensitivity analysis is to assess the change in salary costs. Despite modelling the cost overrun scenario, there are chances that the employee salary costs alone can deviate substantially from other costs for reasons such as change in minimum wages, faster growth in inflation driving the need for higher salary, need for more number of employees, etc.

Table 4.13: Sensitivity analysis: change in salary-2.5MW

| Change in Salary costs | NPV (Nominal in Euro) | NPV (REAL in Euro) | IRR (Nominal) | IRR (REAL) |
|---|---|---|---|---|
| -30% | 1.626.787 | 1.319.010 | 29% | 28% |
| -20% | 1.612.202 | 1.306.139 | 29% | 27% |
| -10% | 1.597.617 | 1.293.267 | 29% | 27% |
| 0% | 1.583.032 | 1.280.396 | 29% | 27% |
| 10% | 1.568.448 | 1.267.525 | 29% | 27% |
| 20% | 1.553.863 | 1.254.653 | 29% | 27% |
| 30% | 1.539.278 | 1.241.782 | 28% | 27% |
| 40% | 1.524.693 | 1.228.911 | 28% | 26% |

Table 4.14: Sensitivity analysis: change in salary-10MW

| Change in Salary costs | NPV (Nominal in Euro) | NPV (REAL in Euro) | IRR (Nominal) | IRR (REAL) |
|---|---|---|---|---|
| -30% | 6.742.277 | 5.483.541 | 30% | 28% |
| -20% | 6.717.526 | 5.461.699 | 30% | 28% |
| -10% | 6.692.776 | 5.439.857 | 30% | 28% |
| 0% | 6.668.026 | 5.418.014 | 30% | 28% |
| 10% | 6.643.276 | 5.396.172 | 30% | 28% |
| 20% | 6.618.526 | 5.374.330 | 30% | 28% |
| 30% | 6.593.775 | 5.352.488 | 30% | 28% |
| 40% | 6.569.025 | 5.330.645 | 30% | 28% |

### 4.4.6 Change in Inflation Rate

The final parameter to change is the change in inflation rate across years. The numbers vary as shown below.

Table 4.15: Sensitivity analysis: change in inflation rate-2.5MW

| Change in Inflation Rate | NPV (Nominal in Euro) | NPV (REAL in Euro) | IRR (Nominal) | IRR (REAL) |
|---|---|---|---|---|
| **0%** | **1.583.032** | **1.280.396** | **28,9%** | **27,1%** |
| 2.40% | 1.581.218 | 1.278.230 | 28,9% | 27,1% |
| 3.40% | 1.579.403 | 1.276.075 | 28,9% | 27,0% |
| 4.40% | 1.577.589 | 1.273.931 | 28,8% | 27,0% |
| 5.40% | 1.575.774 | 1.271.798 | 28,8% | 27,0% |
| 6.40% | 1.573.960 | 1.269.675 | 28,8% | 26,9% |
| 7.40% | 1.572.145 | 1.267.562 | 28,8% | 26,9% |
| 8.40% | 1.570.331 | 1.265.458 | 28,8% | 26,9% |
| 9.40% | 1.568.516 | 1.263.364 | 28,7% | 26,8% |

Table 4.16: Sensitivity analysis: change in inflation rate-10MW

| Change in Inflation Rate | NPV (Nominal in Euro) | NPV (REAL in Euro) | IRR (Nominal) | IRR (REAL) |
|---|---|---|---|---|
| **0%** | **6.668.026** | **5.418.014** | **30,0%** | **28,2%** |
| 2.40% | 6.660.768,0090 | 5.409.073,3689 | 30,0% | 28,2% |
| 3.40% | 6.653.509,9799 | 5.400.182,4592 | 30,0% | 28,1% |
| 4.40% | 6.646.251,9508 | 5.391.340,1269 | 29,9% | 28,1% |
| 5.40% | 6.638.993,9216 | 5.382.544,9893 | 29,9% | 28,0% |
| 6.40% | 6.631.735,8925 | 5.373.795,7158 | 29,9% | 28,0% |
| 7.40% | 6.624.477,8634 | 5.365.091,0253 | 29,9% | 28,0% |
| 8.40% | 6.617.219,8343 | 5.356.429,6838 | 29,9% | 27,9% |
| 9.40% | 6.609.961,8052 | 5.347.810,5027 | 29,8% | 27,9% |

# Chapter 5

# CONCLUSION

The main purpose of this study was to generate a financial analysis for 2,5 MW and 10MW power plant for the Chamber of Industry in North Cyprus. The thesis was to find out whether the project would be financially a successful investment.

The study introduced with a literature review of renewable energy resources, solar energy systems and the energy sector in North Cyprus. Table of parameters were constructed by using the data which obtained from the energy sector of the country. Cash flow and income statements were developed through the use of table of parameters. After the statements, the study went on and calculated the NPV, payback period and carried out a sensitivity analysis. While commissioning any power project is a capital-intensive exercise, it is key to derive a positive return (IRR) and Net Present Value throughout its lifetime. As we have analysed two different scenarios in this project, this project yields positive NPV and IRR in both the scenarios. We found NPV for 2.5 MW system as 1.280.396 Euros and IRR as 27%. Similarly, for 10 MW project's NPV is found to be 5.3178.014 Euros with an IRR of 28%. These analyses show us that both of the projects are feasible and profitable. The project also shows to be having financially strong capacity to service its debt. Furthermore, sensitivity analysis are tested for both projects and the results indicate that only if energy production declines by 40% and more in 2,5 MW power system, the NPV will be negative and IRR will be less than discount rate which make the project a bad investment. There are no other variables that are sensitive and are risk to the project.

According to Chamber of Industry data, the production will meet 5,31% of consumption with 2,5 MW and will meet 21% with 10 MW capacity of solar power system and we believe that consumption will raise in following years. As energy cost increases because of economic situation in the country, the commitment of such projects would help to reduce one of the important input cost. As stated in the beginning of this chapter, while this is just a proof of concept, repeating the same exercise for bigger scale and capacity also yielded positive returns and NPVs highlighting that this model can be replicated for bigger establishments.

The results of this analysis have also shown that support of the governments can be in different ways. The manufacturers are already receiving an electricity subsidy from the government which is a burden to the budget. With such analysis, policy makers can consider supporting business in different ways. Such as providing more financial means and also giving more permits for solar energy production. Supporting these kinds of renewable projects will not only reduce pollution of the air, but it can also reduce the burden on the central budget of the government.

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# APPENDIX

Table 1-Initial numbers for the projects

| **Parameters** | **2.5MW** | **10MW** |
|---|---|---|
| Total years of the project | 25 | 25 |
| Inflation rate | 1.4% | 1.4% |
| Euro to TL Forex Conversion rate (1 EUR = X TL) | 8.72 | 8.72 |
| Inflation index | 1.00 | 1.00 |
| Power annual deterioration factor (if any) | 1.0% | 1.00% |
| **Power capacity and production** | | |
| Power factor | 20% | 20% |
| Total power produced (in KWH per year) | 4,380,000 | 17,520,000.00 |
| Selling price per KWH generated (In TL) | 0.92 | 0.92 |
| Selling price per KWH generated (In EUR) | 0.11 | 0.11 |
| **Total investment (in EUR)** | | |
| Total capacity of the solar field (MW) | 2.5 | 10.00 |
| Total land required (in metre square) | 22,000 | 88,000 |
| Total amount required for land (in EUR) | **110,575** | **442,303** |
| Panel & Inverter | 1,750,000 | 7,000,000 |
| Power transmission and cables | 20,000 | 80,000 |
| System control centre | 100,000 | 400,000 |
| Total investment | 1,980,575 | 7,922,303 |
| **Other costs** | | |
| Inverter replacement time (in years) | 10 | 10 |
| No of inverters used | 100 | 400 |
| Inverter (100kW) cost (in EUR) | 2,220 | 2,220 |
| Total replacement cost (in EUR) | 222,000 | 888000 |
| Maintenance Cost (in EUR) | 20,000 | 80000 |
| KIBTEK Transmission / Distribution / Expense | 10% | 10% |
| KTSO Power Plant Operating Expenses | 2% | 2% |
| **Number of employees** | | |
| Project manager | 8 | 15 |
| Engineers and technicians | 10 | 20 |
| Economists | 4 | 6 |
| Maintenance specialist | 10 | 15 |
| Workers | 40 | 60 |
| **Salary costs (in EUR)** | | |
| Project manager | 16,667 | 31,250 |
| Engineers and technicians | 16,667 | 33,333 |
| Economists | 4,167 | 6,250 |
| Maintenance specialist | 6,250 | 9,375 |
| Workers | 16,667 | 25,000 |
| Total salary costs | 60,417 | 105,208 |

Table 2-Electricity tariff

| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 15 | 20 | 25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Electricity tariff-Adj for inflation (EUR/kWh) | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 |
| Electricity tariff-Nominal (EUR/kWh) | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 |
| Electricity tariff (TL/kWh) | 0.92 | 0.93 | 0.95 | 0.96 | 0.97 | 0.99 | 1.00 | 1.01 | 1.03 | 1.04 | 1.06 | 1.07 | 1.09 |

Table 3-Energy sales (2.5MW)

| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 15 | 20 | 25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total energy produced (MWh) | 4,380 | 4,336 | 4,292 | 4,249 | 4,207 | 4,165 | 4,123 | 4,082 | 4,041 | 4,001 | 3,805 | 3,618 | 3,441 |
| Selling price per kWh(in EUR) | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Total revenues (in EUR) | 462,110 | 463,894 | 465,684 | 467,482 | 469,286 | 471,098 | 472,916 | 474,742 | 476,574 | 478,414 | 487,719 | 497,205 | 506,875 |

Table 4-Energy sales (10 MW)

| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 15 | 20 | 25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total energy produced (MWh) | 17,520 | 17,344 | 17,171 | 16,999 | 16,829 | 16,661 | 16,494 | 16,329 | 16,166 | 16,004 | 15,220 | 14,474 | 13,765 |
| Selling price per kWh(in EUR) | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Total revenues (in EUR ‘000) | 1,848 | 1,855 | 1,862 | 1,869 | 1,877 | 1,884 | 1,891 | 1,898 | 1,906 | 1,913 | 1,950 | 1,988 | 2,027 |

Table 5-Investment schedule (2.5MW)

| Parameter | 2.5MW | 10MW |
|---|---|---|
| One-time capital investment needed | 1,980,576 | 7,922,303.66 |
| Total debt (Ratio of initial investment) | 75% | 75% |
| Total debt | 1,485,432 | 5,941,728 |
| Interest rate of debt (in %) | 4.0% | 4.0% |

| | | |
|---|---|---|
| Loan repayment period (in years) | 6 | 6 |
| Discount rate to calculate NPV | 10% | 10% |

Table 6-Loan schedule (2.5MW)

| **Years** | | **1** | **2** | **3** | **4** | **5** | **6** |
|---|---|---|---|---|---|---|---|
| Interest rate | 4.0% | 4.0% | 4.0% | 4.0% | 4.0% | 4.0% | 4.0% |
| Cash outstanding at the beginning of year | 1,485,432 | 1,485,432 | 1,237,860 | 990,288 | 742,716 | 495,144 | 247,572 |
| Interest accrued | 59,417 | 59,417 | 49,514 | 39,612 | 29,709 | 19,806 | 9,903 |
| **Repayment** | **59,417** | **306,989** | **297,086** | **287,184** | **277,281** | **267,378** | **257,475** |
| Interest | 59,417 | 59,417 | 49,514 | 39,612 | 29,709 | 19,806 | 9,903 |
| Principal | 0 | 247,572 | 247,572 | 247,572 | 247,572 | 247,572 | 247,572 |
| **Outstanding at the end of the year** | **1,485,432** | **1,237,860** | **990,288** | **742,716** | **495,144** | **247,572** | **0** |

Table 7- Loan schedule (10MW)

| **Years** | | **1** | **2** | **3** | **4** | **5** | **6** |
|---|---|---|---|---|---|---|---|
| Interest rate | 4.0% | 4.0% | 4.0% | 4.0% | 4.0% | 4.0% | 4.0% |
| Cash outstanding at the beginning of year | 5,941,728 | 5,941,728 | 4,951,440 | 3,961,152 | 2,970,864 | 1,980,576 | 990,288 |
| Interest accrued | 237,669 | 237,669 | 198,058 | 158,446 | 118,835 | 79,223 | 39,612 |
| **Repayment** | **237,669** | **1,227,957** | **1,188,346** | **1,148,734** | **1,109,123** | **1,069,511** | **1,029,899** |
| Interest | 237,669 | 237,669 | 198,058 | 158,446 | 118,835 | 79,223 | 39,612 |
| Principal | 0 | 990,288 | 990,288 | 990,288 | 990,288 | 990,288 | 990,288 |
| **Outstanding at the end of the year** | **5,941,728** | **4,951,440** | **3,961,152** | **2,970,864** | **1,980,576** | **990,288** | **0** |

Table 8-Employee cost and details -2,5MW

| **Year** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **15** | **20** | **25** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total no employed | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| Hike assumed per year | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% |
| Nominal wage of 1 Project manager/year | 2,083 | 2,125 | 2,168 | 2,211 | 2,255 | 2,300 | 2,346 | 2,393 | 2,441 | 2,490 | 2,749 | 3,035 | 3,351 |
| Real wage of 1 Project manager/year | 2,083 | 2,083 | 2,083 | 2,083 | 2,083 | 2,083 | 2,083 | 2,083 | 2,083 | 2,083 | 2,083 | 2,083 | 2,083 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Engineers and technicians** | | | | | | | | | | | | | |
| Total no employed | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Hike assumed per year | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% |
| Nominal wage of 1 Engg & tech/year | 1,667 | 1,700 | 1,734 | 1,769 | 1,804 | 1,840 | 1,877 | 1,914 | 1,953 | 1,992 | 2,199 | 2,428 | 2,681 |
| Real wage of 1 Engg & tech/year | 1,667 | 1,667 | 1,667 | 1,667 | 1,667 | 1,667 | 1,667 | 1,667 | 1,667 | 1,667 | 1,667 | 1,667 | 1,667 |
| **Economists** | | | | | | | | | | | | | |
| Total no employed | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Hike assumed per year | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% |
| Nominal wage of 1 Economists/year | 1,042 | 1,063 | 1,084 | 1,105 | 1,128 | 1,150 | 1,173 | 1,197 | 1,220 | 1,245 | 1,374 | 1,518 | 1,675 |
| Real wage of 1 Economists/year | 1,042 | 1,042 | 1,042 | 1,042 | 1,042 | 1,042 | 1,042 | 1,042 | 1,042 | 1,042 | 1,042 | 1,042 | 1,042 |
| **Maintenance specialist** | | | | | | | | | | | | | |
| Total no employed | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Hike assumed per year | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% |
| Nominal wage of 1 Specialist/year | 625 | 638 | 650 | 663 | 677 | 690 | 704 | 718 | 732 | 747 | 825 | 911 | 1,005 |
| Real wage of 1 Specialist/year | 625 | 625 | 625 | 625 | 625 | 625 | 625 | 625 | 625 | 625 | 625 | 625 | 625 |
| **Worker** | | | | | | | | | | | | | |
| Total no employed | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 |
| Hike assumed per year | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% |
| Nominal wage of 1 Worker/year | 417 | 425 | 434 | 442 | 451 | 460 | 469 | 479 | 488 | 498 | 550 | 607 | 670 |
| Real wage of 1 Worker/year | 417 | 417 | 417 | 417 | 417 | 417 | 417 | 417 | 417 | 417 | 417 | 417 | 417 |
| **Total labour cost** | 60,417 | 61,625 | 62,858 | 64,115 | 65,397 | 66,705 | 68,039 | 69,400 | 70,788 | 72,204 | 79,719 | 88,016 | 97,1 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | 76 |

Table 9-Employee cost and details-10MW

| **Year** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **15** | **20** | **25** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total no employed | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| Hike assumed per year | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% |
| Nom wage of 1 Project manager/year | 2,083 | 2,125 | 2,168 | 2,211 | 2,255 | 2,300 | 2,346 | 2,393 | 2,441 | 2,490 | 2,749 | 3,035 | 3,351 |
| Real wage of 1 Project manager/year | 2,083 | 2,083 | 2,083 | 2,083 | 2,083 | 2,083 | 2,083 | 2,083 | 2,083 | 2,083 | 2,083 | 2,083 | 2,083 |
| **Engineers and technicians** | | | | | | | | | | | | | |
| Total no employed | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| Hike assumed per year | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% |
| Nominal wage of 1 Engg & tech/year | 1,667 | 1,700 | 1,734 | 1,769 | 1,804 | 1,840 | 1,877 | 1,914 | 1,953 | 1,992 | 2,199 | 2,428 | 2,681 |
| Real wage of 1 Engg & tech/year | 1,667 | 1,667 | 1,667 | 1,667 | 1,667 | 1,667 | 1,667 | 1,667 | 1,667 | 1,667 | 1,667 | 1,667 | 1,667 |
| **Economists** | | | | | | | | | | | | | |
| Total no employed | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Hike assumed per year | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% |
| Nominal wage of 1 Economists/year | 1,042 | 1,063 | 1,084 | 1,105 | 1,128 | 1,150 | 1,173 | 1,197 | 1,220 | 1,245 | 1,374 | 1,518 | 1,675 |
| Real wage of 1 Economists/year | 4,167 | 4,167 | 4,167 | 4,167 | 4,167 | 4,167 | 4,167 | 4,167 | 4,167 | 4,167 | 4,167 | 4,167 | 4,167 |
| **Maintenance specialist** | | | | | | | | | | | | | |
| Total no employed | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| Hike assumed per year | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% |
| Nominal wage of 1 Specialist/year | 625 | 638 | 650 | 663 | 677 | 690 | 704 | 718 | 732 | 747 | 825 | 911 | 1,005 |
| Real wage of 1 Specialist/year | 625 | 625 | 625 | 625 | 625 | 625 | 625 | 625 | 625 | 625 | 625 | 625 | 625 |
| **Worker** | | | | | | | | | | | | | |
| Total no employed | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| Hike assumed per year | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% | 2% |
| Nominal wage of 1 Worker/year | 417 | 425 | 434 | 442 | 451 | 460 | 469 | 479 | 488 | 498 | 550 | 607 | 670 |
| Real wage of 1 Worker/year | 417 | 417 | 417 | 417 | 417 | 417 | 417 | 417 | 417 | 417 | 417 | 417 | 417 |
| **Total labour cost** | **105,208** | **107,313** | **109,459** | **111,648** | **113,881** | **116,159** | **118,482** | **120,851** | **123,268** | **125,734** | **138,820** | **153,269** | **169,221** |

Table 10-Income statement (in EUR)-2.5MW

| **Year** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **15** | **20** | **25** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Revenues:** | | | | | | | | | | | | | |
| Deterioration factor | | 1.0% | 1.0% | 1.0% | 1.0% | 1.0% | 1.0% | 1.0% | 1.0% | 1.0% | 1.0% | 1.0% | 1.0% |
| Total MWH energy produced per annum | 4,380 | 4,336 | 4,292 | 4,249 | 4,207 | 4,165 | 4,123 | 4,082 | 4,041 | 4,001 | 3,805 | 3,618 | 3,441 |
| Amount received from selling the land | | | | | | | | | | | | | 100.576 |
| Selling price per KWH generated | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Total revenues | 462,110 | 463,894 | 465,684 | 467,482 | 469,286 | 471,098 | 472,916 | 474,742 | 476,574 | 478,414 | 487,719 | 497,205 | 617.451 |
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 15 | 20 | 25 |
| **Costs:** | | | | | | | | | | | | | |
| Inverter replacement cost | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 255,113 | 0 | 293,165 | 0 |
| Other maintenance costs | 20,000 | 20,280 | 20,564 | 20,852 | 21,144 | 21,440 | 21,740 | 22,044 | 22,353 | 22,666 | 24,297 | 26,047 | 27,922 |
| KIBTEK Txn / Distrn Expense | 46,211 | 46,389 | 46,568 | 46,748 | 46,929 | 47,110 | 47,292 | 47,474 | 47,657 | 47,841 | 48,772 | 49,720 | 50,688 |
| KTSO Power Plant Operating Expenses | 9,242 | 9,278 | 9,314 | 9,350 | 9,386 | 9,422 | 9,458 | 9,495 | 9,531 | 9,568 | 9,754 | 9,944 | 10,138 |
| leasing costs | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Salary costs | 60,417 | 61,625 | 62,858 | 64,115 | 65,397 | 66,705 | 68,039 | 69,400 | 70,788 | 72,204 | 79,719 | 88,016 | 97,176 |
| **Operating profit** | **326,240** | **326,322** | **326,381** | **326,418** | **326,431** | **326,422** | **326,388** | **326,329** | **326,245** | **71,022** | **325,177** | **30,313** | **493.319** |
| Interest cost | 306,989 | 297,086 | 287,184 | 277,281 | 267,378 | 257,475 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Depreciation | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Earnings Before Income Taxes** | **19,251** | **29,235** | **39,197** | **49,137** | **59,054** | **68,947** | **326,388** | **326,329** | **326,245** | **71,022** | **325,177** | **30,313** | **493.319** |
| Taxes | | | | | | | | | | | | | |
| **Net Income** | **19,251** | **29,235** | **39,197** | **49,137** | **59,054** | **68,947** | **326,388** | **326,329** | **326,245** | **71,022** | **325,177** | **30,313** | **493.319** |

Table 11-Income statement (in EUR) -10MW

| **Year** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **15** | **20** | **25** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Revenues:** | | | | | | | | | | | | | |
| Deterioration factor | | 1.0% | 1.0% | 1.0% | 1.0% | 1.0% | 1.0% | 1.0% | 1.0% | 1.0% | 1.0% | 1.0% | 1.0% |
| Total MWH energy produced per annum | 17,520 | 17,344 | 17,171 | 16,999 | 16,829 | 16,661 | 16,494 | 16,329 | 16,166 | 16,004 | 15,220 | 14,474 | 13,765 |
| Selling price per KWH generated | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Amount received from selling the land | | | | | | | | | | | | | 442.304 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total revenues | 1,848,440 | 1,855,575 | 1,862,738 | 1,869,928 | 1,877,146 | 1,884,392 | 1,891,665 | 1,898,967 | 1,906,297 | 1,913,656 | 1,950,875 | 1,988,819 | 2.469.804 |
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 15 | 20 | 25 |
| **Costs:** | | | | | | | | | | | | | |
| Inverter replacement cost | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,020,452 | 0 | 1,172,660 | 0 |
| Other maintenance costs | 80,000 | 81,120 | 82,256 | 83,407 | 84,575 | 85,759 | 86,960 | 88,177 | 89,412 | 90,663 | 97,190 | 104,186 | 111,687 |
| KIBTEK Txn / Distrn Expense | 184,844 | 185,558 | 186,274 | 186,993 | 187,715 | 188,439 | 189,167 | 189,897 | 190,630 | 191,366 | 195,088 | 198,882 | 202,750 |
| KTSO Power Plant Operating Expenses | 36,969 | 37,112 | 37,255 | 37,399 | 37,543 | 37,688 | 37,833 | 37,979 | 38,126 | 38,273 | 39,018 | 39,776 | 40,550 |
| leasing costs | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Salary costs | 105,208 | 107,313 | 109,459 | 111,648 | 113,881 | 116,159 | 118,482 | 120,851 | 123,268 | 125,734 | 138,820 | 153,269 | 169,221 |
| **Operating profit** | **1,441,419** | **1,444,474** | **1,447,495** | **1,450,481** | **1,453,433** | **1,456,347** | **1,459,224** | **1,462,063** | **1,464,862** | **447,168** | **1,480,760** | **320,046** | **2.024.211** |
| Interest cost | 1,227,957 | 1,188,346 | 1,148,734 | 1,109,123 | 1,069,511 | 1,029,899 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Depreciation | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Earnings Before Income Taxes** | **213,462** | **256,128** | **298,761** | **341,359** | **383,922** | **426,448** | **1,459,224** | **1,462,063** | **1,464,862** | **447,168** | **1,480,760** | **320,046** | **2.024.211** |
| Taxes | | | | | | | | | | | | | |
| **Net Income** | **213,462** | **256,128** | **298,761** | **341,359** | **383,922** | **426,448** | **1,459,224** | **1,462,063** | **1,464,862** | **447,168** | **1,480,760** | **320,046** | **2.024.211** |