Market analysis of how to promote the spread of photovoltaics in Hungary

Alex Frenkel

CAH Vilentum University of Applied Sciences

Market analysis of how to promote the spread of photovoltaics in Hungary

Alex Frenkel

European Structural Funds Management

Thesis coach:

Kees Schipper

Lambertus Vogelzang

20.06.2016

Dronten

Preface

The purpose of this research is to identify the bottlenecks of the Hungarian photovoltaic (PV) market and to provide feasible and proper solutions in order to overcome the barriers.

Solar panels have come a long way since their world-wide inception in the 20th century. Efficiency, size and cost have improved dramatically and the technology will keep improving as research and development move forward. As a result, the global photovoltaic market is increasing rapidly and Europe is no exception from this. The European Union supports the spread of photovoltaics in the Member States, by providing directives, regulations and financial assistance in the form of the European Investment and Structural Funds.

Despite the efforts, the Hungarian photovoltaic market is not developing according to expectations and it lags behind its regional neighbors and several other European countries. A reason for this can be the inefficient distribution of EU funds and the fact, that call for applications for residents willing to invest in photovoltaics are not realized. Besides the residential sector, the commercial sector is also handicapped by administrative measures. These measures are decreasing the competitiveness of SMEs and as a result the market’s. Moreover, Hungary’s outdated Energy Policy is not supporting the spread of renewable energy sources, including the spread of photovoltaics. In contrast it does support nuclear, as the country is planning to start the construction of its second nuclear reactor in 2018. It can be determined that the government does not want to support the Renewable Energy Sector (RES) due to several reasons.

The thesis aims to identify the measures needed to be taken to strengthen the spread of photovoltaic electricity in Hungary. For this reason, the Hungarian PV market will be analyzed, its characteristics, investments cost, together with the supply and demand side will be presented. Based on the analyses proper recommendations are given in order to overcome that market barriers and to achieve market growth on the Hungarian photovoltaic market.

Contents

Summary

The topic of this thesis is the identification of the bottlenecks on the Hungarian photovoltaic market. The need for the research is based on the fact that while Europe's renewable market is developing on a rapid pace, the Hungarian market lags behind. For this reason, this research takes place in order to answer the following main research question: *What measures need to be taken to strengthen the spread of photovoltaic electricity in Hungary.*

The research focuses on analyzing the Hungarian photovoltaic market conditions in terms of applicability of photovoltaics in Hungary, market characteristics (investment, price evolution, market growth), the use of EU funds, competitiveness of SMEs and the role of photovoltaic electricity can play in the Hungarian electricity portfolio. The framework of the research is based on secondary research and primary research. Secondary research gives the literature review, the theoretical framework of the thesis, while primary, qualitative research provides up to date inside information on the market. As part of this, an in-depth interview was conducted with Mr. Ernő Kiss, head of the Hungarian Photovoltaic Association. He provided several useful information and point of views about the country's photovoltaic market. These data were essential in order to carry out a throughout and transparent research on the market.

The thesis starts with the introduction of the topic, followed by a review of photovoltaics. During these chapters the reader gets acquainted with photovoltaics, their benefits and applicability in Hungary. Next the Hungarian photovoltaic market characteristics are analyzed, including price evolution, feed-in tariff and investment costs for residents. A separate chapter discusses the Hungarian bottlenecks, like the discrimination of SMEs and the inefficient use of the European Structural and Investment Funds meant to support the spread of renewable energy sources like photovoltaics. A comparative to compare the investment cost of the planned PAKS II Nuclear Power Plant with a Photovoltaic Power Plant is also part of the research.

Based on the findings of the analyses the bottlenecks of the Hungarian photovoltaic market were promptly identified and demarcated. The inefficient distribution of European Structural and Investment Funds within Thematic Objective 4, the lack of call for applications to support the residential sector with their photovoltaic investments, the discrimination of photovoltaic SMEs, the lack of a Renewable Energy Act and the country's outdated Energy Policy are all contributing to the poor performance of the renewable energy sector, including photovoltaics.

Following the analyses of the bottlenecks, six recommendations had been given. The recommendations aim to solve the bottlenecks. The most important measure to implement on the Hungarian photovoltaic market would be to update the outdated Hungarian Energy Policy and in the same time to implement a proper and supportive Renewable Energy Act. These measures would greatly reduce the discrimination of Hungarian photovoltaic SMEs, since in this way their market development would be supported by the government itself. In case these measures would be applied by the target group of this thesis, the competitiveness of the Hungarian photovoltaic market would greatly improve.

1. Introduction

As the global population is increasing together with the living standards of the third world countries, it is becoming an even greater challenge to satisfy the electricity demand. The trend of the past decades shows that the demand for electricity is increasing twice as fast as overall energy use. Between 2000 and 2010 the electricity demand grew by 26%, and to 2035 it is likely to rise by more than 2/3 (World Nuclear Association, 2015).

Today most electricity of the world is generated with fossil fuels. The demand for it is increasing by every year. Due to this, the growth of CO2 concentration in the atmosphere is increasing rapidly as well, causing significant damage to the environment and the economy. Currently the most environmental benign way of producing electricity on a large scale is nuclear power. Recent years however have shown that despite having a low carbon footprint, in case of a disaster it can cause great and lasting damage to the surrounding. Handling nuclear waste can also be problematic and costly.

To meet the demand for electricity in an environmental friendly and sustainable way, governments and civil societies should act collectively. An efficient alternative are the renewable energy sources. There are many type of renewable energy, however in this report only the solar energy, harnessed by photovoltaics (PV) is going to be disused. I chose this topic as for a long time I am highly interested in sustainable energy sources – especially in photovoltaics – and in how the transition from fossil to renewable is happening. In order to have a specific thesis topic choosing an exact sustainable energy source is important. I chose photovoltaics, as for Hungary it would be the most obvious choice: the country does not have the proper conditions for hydro power, wind is unpredictable but the total annual sunshine hours at the Southern Great Plain is above 2000 hours (Dr. Horváth & Dr. Domokos, 2011, p. 61). A photovoltaic (PV) system employs solar panels composed of a number of solar cells to supply usable solar power: it is the direct conversion of light into electricity. Mostly this is the reason why people often refer to photovoltaics as solar panels.

The thesis is going to concentrate on the challenges the Hungarian solar market is facing. Currently the country's solar market in terms of cumulative photovoltaic capacity is among the least developed ones in the European Union, ranking 16 out of the 28 Member States (MSs) in 2015. When looking at the photovoltaic capacity per inhabitants, the country performs poorly, ranking 20 out of 28 MSs. (EuroObserv'ER, 2016). One reason for this is that unlike other Member States like Italy, Germany, Spain, Slovakia, etc., Hungary does not have a Renewable Energy Act what could create a favorable environment to support the spread of renewable energy sources (RES). As a consequence, no tax discount or governmental support exist for residents willing to install photovoltaics or for companies operating in the sector. Without these a stable and supporting renewable policy, there is essentially no governmental backup behind photovoltaics. In this manner the real problem owners are the innovators and early adopters of the technology – individuals of the residential and commercial sector – who receive no incentives to support their investment. In Hungary not only the residential sector, but companies dealing with the manufacture, distribution and installation of photovoltaic systems are also discriminated by several legislative measures, like a high product fee on solar modules and the lack of proper tender calls.

As the use of photovoltaic generated electricity is a relatively new technology in the residential sector, it need governmental support during its adoption period. Without the help, the PV adoption lifecycle takes place in a much slower pace. A side effect of the current situation is that on the long term the Hungarian photovoltaic opportunities might fall behind other countries' market. By not supporting the development of the photovoltaic market during its growing phase, policy makers risk to lose the chance to be competitive on an EU level.

The primary target group of this research are policy makers, researchers and economist, who do have a direct or indirect influence on the shaping of the legislations affecting the competitiveness of the Hungarian photovoltaic market. More likely they are Hungarians, however since the country is a member of the European Union, members of the European Commission – again policy makers, researchers and economists – are also within the boundaries of the primary target group.

As the research contains a moderate amount of economic expressions, public policy actions and energy industry specific details and descriptions, it is also written to people curious about the Whys and Hows of this area. They are considered the secondary target group, which members wants to get a clear and full picture of the current state of the Hungarian photovoltaic market. Members of the secondary target group are characterized by the fact, that they are willing to put pressure on the legislation system in order to improve and/or change market conditions, however first they need to be informed about current bottleneck and state of the photovoltaic market.

The creation of the secondary target group is based on the Dutch example, where an NGO called Urgenda together with several residents sued the Dutch government for not taking enough responsibilities for supporting the spread of renewable energy sources. The suitors demanded the government to increase its 2020 goals in terms of share of renewable energy in total energy consumption from 15% to 25%. In the end the suiters won and the government restructured its residential call for application system and its monetary assist system for renewable energy sources, including photovoltaics. (HVG. 2015) This case shows that as a bottom-up approach, ordinary residents if well informed can bring change and progress into the system. For this reason, the creation of the secondary target group is legitimate and can be important.

With the conclusion of this research the target group might get a clear picture of the bottlenecks of the Hungarian photovoltaic market, while the recommendations provide transparent and realistic improvement measures about what should be changed on a legislative level in order to overcome the barriers and make the market competitive. Keep in mind that since this research is a Bachelor thesis, the level of information and depth of analyses are executed according BSc requirements and knowledge. Consequently, the result of this thesis can form the basics of further studies/researches, like Master thesis or Ph.D. work.

1.1 Problem description and demarcation

Currently the Hungarian electricity generation depends heavily on primary energy sources like fossil fuels. As shown in Figure 1, in 2014 53% of the electricity was generated by nuclear. Despite being CO2 emission free, the management of radioactive waste generated during the process can be problematic and risky.

Following nuclear, natural gas and coal combined are responsible for 43% of the generated electricity. Moreover, recent events have shown that being energy independent is an advantage to countries in the region. By the burning of gas and coal in in 2013 Hungary released 53.7 million tonnes of CO2 is to the air. (KSH). This number could be drastically cut back if even one-third of the production would be replaced with renewable. The renewables were represented by 11% in 2014, however within it the actual share of photovoltaics are only 1.8% (Hungarian Energy and Public Utility Regulatory Authority, 2016).

The Hungarian solar energy industry is among the least developed ones in the European Union. It not only ranks below the average, but the capacity installed is also way behind. In 2013 the total photovoltaic capacity installed was 17.95MW. Compared to its neighbor's, Slovakia installed 45 MWP, Austria 208.8 MWP while Romania 972.7 MWP in the same year (EuroObserv'ER, 2015).

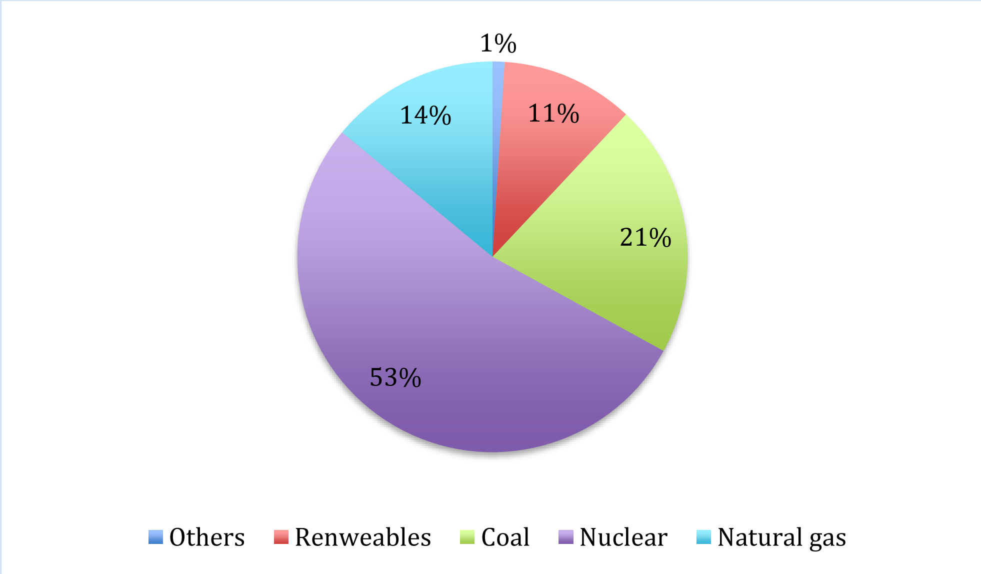


Figure 1: Primary energy sources of electricity production
Source: Hungarian Energy and Public Utility Regulatory Authority, 2016

To great surprise in 2014, the installed capacity was even lower, only 3.3 MWP, while Hungary's neighbors all continued to increase their photovoltaics capacity. Despite Hungary's competitive advantage, the solar energy potential available in the country is not utilized properly. The way how the grid works today is this: most countries have coal, natural gas, nuclear, hydro, wind and solar. But not enough wind and solar, especially solar in those place where every aspect is given to invest in it. It would be an obvious solution to do, since there is this handy fusion reactor in the sky called the sun. After setting up a photovoltaic system, with little effort and investment nothing has to be done, it just works. The sun shows up every day and produces huge amount of free energy.

The research topic of this thesis has a link with EU funds as in Hungary little to no funds are provided to support the photovoltaic market. Since 2011 there has been no proper call for applications for the residential sector, while photovoltaic SMEs also lack the opportunities to apply for call for tenders and proposals. Due to the lack of calls, the European Structural and Investment Funds are not able to support the market growth of photovoltaics. It is important to mention that during the last 4 years there has been an ongoing governmental program – called Otthon Melege Program (Warmth of Home Program) – what provides non-refundable governmental support for civilians willing to increase the energy efficiency of their home. However, there are minor problems with the program, which together results in its inefficiency and the missing of target group:

- In order to apply the applicant has to meet illogical requirements/specifications;
- It offers financial support to a mix of energy efficiency improvements for family homes;
- The program is not specifically tailored for photovoltaics. PVs are only part of the package, so those interested only in installing solar panels are not applicable.

The main problem with the program is its complexity. It offers a mix of energy efficiency support for family homes, including installation of solar modules. It cannot be used simply for PV installation, moreover there are too much criterion that need to be met. As a result, it is only a drop in the ocean and does not contribute to the market development.

As part of the Partnership Agreement (PA) between the European Union and Hungary, the country must meet specific targets by 2020 in terms of renewable energy sources. The Partnership Agreement focuses on five main national development priorities from which the 3rd priority covers the topic of “Enhancing energy and resource efficiency”. To achieve the objective of the 3rd priority, the European Structural & Investment Funds (ESIF) provides financial support for achieving the target of 14.65% share of renewable energy in total energy consumption by 2020 (9.6% in 2012).

According to the PA, Hungary has 11 Thematic Objectives (TO). The 4th TO – called TO4 – is aimed for supporting the shift towards a low-carbon economy in all sectors. Within the TO4 the country will spend 13.25% of the European and Regional Development Funds (ERDF) to promote low carbon economy further and another 845 million EUR dedicated from the Cohesion Fund (CF). As a consequence, Hungary has 1 034 million EUR (13.25% of 1,425,387,797 EUR ERDF plus 845,000,000 EUR CF provided by the European Union to invest in energy efficiency and renewable.

We can see that plenty of funds are available, but for some reason these – again provided by the EU – are not distributed efficiently. The government does not make the ERDF and CF funds available for the residential and commercial sector. It is important to unveil the bottlenecks in the system and to try to offer a corresponding solution how could the market become more competitive. It is also important to clarify in the beginning, that Small Scale Photovoltaic Power Plants are being installed in Hungary, but only by the government and in small scale compared to other countries. The latest power plant – Mátra Solar Power Plant – was opened this year February. It has a capacity of 16 MWh and can provide electricity to approximately 4.000 houses – assuming that an average house consumes 4 kWh. Still the main problem remains, that no incentives exist for the residential sector to support their PV investment.

The absence of support represents a threat to the spread of the technology, especially when the bottom-up approach could be applied. In the photovoltaic case the bottom-up approach refers to the fact, that solar panels can be installed just as easily by residents and companies as the government. This presents a problem, as investing in a photovoltaic system can be costly even for wealthier countries' citizens.

Following the short introduction of the Hungarian photovoltaics situation, it raises the main question of *"What measures need to be taken to strengthen the spread of photovoltaic electricity in Hungary?"* The aim of this research is to find the answer for this primary question. The focus of the research is on analyzing the Hungarian photovoltaic market conditions in terms of:

- Applicability of photovoltaics in Hungary;
- Market characteristics (investment, price evolution, market growth);
- The use of EU funds;
- Competitiveness of SMEs;
- Future prospects.

Following the main question and the focus of the research, the relevant sub-questions are the followings:

- How did the Hungarian photovoltaic market perform over the past few years?
- What role European Structural and Investment Funds play in the Hungarian photovoltaic market performance?
- How are photovoltaic SMEs discriminated in Hungary?
- What measures need to be introduced/removed in order to support photovoltaic investments in the residential sector?
- What role can photovoltaics play in the country's electricity portfolio?

By analyzing the market, its bottlenecks can be detected, especially in terms of not using the available funds efficiently. With proper data it can be concluded whether it is possible and by what measures to improve market conditions in the foreseeable future, or for now simply it is not.

Photovoltaics are not the only renewable energy sources, there are alternative solutions in terms of renewables. Options include biomass power plants and wind turbines as well, however governmental investments in these fields are also insignificant. A clear explanation for the low governmental investment in renewables are the fact, that the current government committed itself in investing in nuclear power generation. Hungary’s only nuclear power plant generating 2GW of electricity provides electricity for half the country. The Nuclear Reactor has 4 cores, each capable of producing 500MWh. The plant was constructed during the 1980s and is expected to be decommissioned between 2032 – 2037. The government committed itself to build two more reactors to the existing 4, 1,200MWh capacity per each. The expected grid date is 2025 – 2027. By this the old cores could be replaced with new ones, operating for the following 40 years at least. (MVM PAKS II. 2016)

It would be an illogical decision from the government’s side to provide monetary support for renewables, since by that it would be basically financially supporting a competition (renewables) for its own investment.

On the other hand, the question remains to be answered whether nuclear or photovoltaic electricity is more cost efficient on the long term. The world’s leading economies are committing themselves on renewable, most of them on photovoltaics. As later in this research will be analyzed, the total price of a PVs system fell drastically in the last 30 years due to technological development, mass production and economies of scales. Forecast indicates that PVs in the next years will be even less costly and will become one of the most competitive energy source available on the market. (Chaudhry, Nadim. 2016)

1.2 Research objectives

Based on the previous questions, the research objectives of this thesis is to analyze the Hungarian photovoltaic market and uncover its bottlenecks. By analyzing the current governmental and market conditions, proper answers can be given in regard to why EU funds are not used efficiently and why the market lacks behind. Based on these data, realistic recommendations can be given at the end of the thesis in regard to what should be done differently in order to boost photovoltaic investment in the residential sector.

The primary objective of this thesis is to resolve the research questions properly. In order to determine what measure need to be taken to promote the use of solar energy in Hungary, first the structure of the solar market need to be unfold and analyzed. To promote the installation of photovoltaics in the residential sector, the government need to support the investment by tax relief, by call for applications and other incentives. For example, Germany and the USA are both implemented heavy tax reductions, so the cost of photovoltaics is more consumer friendly. As a result, both countries are ranking highest in terms of photovoltaics per capita purchases. Moreover, photovoltaic SMEs are supported by appropriate market conditions and they also benefit from increased investments in the residential sector. Without these governmental measures the spread of solar panels can drastically slow down.

As part of the thesis a comparative analysis will be drawn between the procurement, installation and maintenance cost of – the planned – Paks II Nuclear Power Plant and a photovoltaic plant with the same capacity. This is one of the main applicability if the research. The aim of the comparison is to find out whether from the total project cost of Paks II a solar plant could be built, capable of generating the same amount of electricity.

Obviously the only disadvantage of photovoltaics is that when the sun is not shining, it does not produce electricity. On the other hand, when it does, a properly sized photovoltaic power plant is producing more electricity than is needed. Obviously the solution is to store that electricity surplus in batteries for the night.

So far batteries have not been widespread in photovoltaic systems, mostly because there was no need for that: a Home Scale Photovoltaic System (HPVS) is always connected to the grid, meaning that during daytime it uses PV electricity, and after sunset the house can use electricity provided by the electrical utility. However, in case the house has its own battery storage unit, it would not require electricity from the utility, as it already stored up the electricity needed for the night. In this case it does not really matter whether a Large Scale Photovoltaic Power Plant can store the electricity for the night or not, because there would be no demand for it from households.

Moreover, since photovoltaics would be part of the electricity portfolio, after sunset other electricity sources – like wind, wood, coal, electricity generated from waste incineration – can supply electricity for those in need.

The objective is to determine which power generation model is more competitive on the short and long term, and what role photovoltaics can play in the electricity portfolio of Hungary. It is important to note, that the two way of generating energy do not necessarily exclude each other and in the end it is up to the reader to decide which model is better to apply: invest in photovoltaics as the Germans do or continue to ignore it and invest in nuclear and other non-renewables.

1.3 Research design and methodology

On the nature of this thesis, both literature review and qualitative research methods are used to gather a part of the necessary information. As in most cases, there is a knowledge gap about the subject. To fill this gap secondary and primary data will be used.

Secondary data from companies, governmental and non-governmental organizations and from previous studies are used just as data from different type of field-related publications. For example, the introduction part of the thesis is followed by the Review of photovoltaics chapter. This chapter is completely based on secondary data gathered by desk research from different sources.

The next two chapters (The Hungarian photovoltaic market and the Hungarian bottleneck) however is mostly based on primary and secondary research. These parts of the research require up-to-date sector related data what is not always available online or in articles. In order to fill the knowledge gap, an interview is made with Mr. Ernő Kiss, the head of the Hungarian Photovoltaic Association. As being an association, it collects data from its members and among its members are most of the countries photovoltaics firms. Besides being the head of the association, he is also the head of Greentechnic LTD – a Hungarian PV firm with significant market share and experience –, meaning that he has the necessary professional skills and knowledge to provide valuable information, like fresh data about the market, what are the growth prospects of the PVs sector in Hungary and what are its barriers, what should be changed. Greentechnic trades with, distribute and install PV systems for both the residential and commercial sector as well. This qualitative research can be considered as the foundation of this thesis, as it gives an insight view of the challenges photovoltaic companies face in the current legislative environment.

Besides providing more valuable information about the market, during the interview personal point of views are shared about the Hungarian photovoltaic market condition, the absence of funds, how they perform within current situation, what change would benefit the market etc. These valuable data are used starting from Chapter 3 until the end of the thesis.

The primary and secondary research provides the theoretical framework of the study. It is important to mention that as the research is about the Hungarian photovoltaic market, most of the data are provided by Hungarian sources and by numerous international organizations like EurObserv'ER and the European Commission.

Throughout the thesis comparisons are drawn, so the characteristics of the country's photovoltaic market can be compared to other countries' market. Based on the result of the analysis, it is expected to uncover the whys of the market's bottlenecks and barriers. Based on the findings conclusions are drawn on what should be done differently in order to make the market more competitive not only on a national but on an EU level as well. Moreover, the thesis contains costs and prices. In most some cases they are expressed in USD, but mostly they are shown in EUR. Those cost that are specific for the Hungarian market are converted from HUF to EUR. HUF is the country's official currency and exchange rate used throughout the thesis is the rate available on 15.05.2016. The exact exchange rates can be found in Appendix 1: Calculations. **[1]**

1.4 Outline of the thesis

The thesis consists of seven chapters, each covering a specific area of the research topic. The introductory chapter familiarized the reader with the research problem and the questions for what the research aims to find answers.

Chapter II provides the literature review of photovoltaics. Beside their history, the type and structure of the photovoltaic systems are introduced. The applicability of solar modules in Hungary are discussed: geographical requirements, advantages and disadvantages are mentioned.

Chapter III introduces and explores the evolution and current state of the Hungarian photovoltaics market. Cost evolution, market characteristics and investments cost of a regular Home Scale Photovoltaic System (HPVS) are analyzed. The chapter ends with describing the producer and customer side of the photovoltaic market, aka the supply and demand side.

Following the exposition of the Hungarian photovoltaic market, Chapter IV introduced and analyses the bottleneck of the market. The importance of the European Structural and Investment Funds for the photovoltaic market are discussed. It is important to find out how the residential sector – demand side – and the commercial sector – supply side – are benefiting from the EU funds. The Partnership Agreement's relevant part to the research topic are also discussed in order to get a full picture of the total budget Hungary accepted to spend to support the spread of Renewable Energy Sources (RES), like photovoltaics. Moreover, the disadvantageous position of Hungarian SMEs is analyzed. Throughout the chapter recommendations are given about what administrative measures should be changes in order to improve the competitiveness of the photovoltaic market.

Chapter V consists of a comparative analysis. The aim is to compare which project is more beneficial from a financial point of view on the long term: the planned PAKS II Nuclear Power Plant or a Photovoltaic Power Plant. The simulated photovoltaic power plant has the same capacity as PAKS II is planned to have. With the result of this comparative analyses the competitiveness of photovoltaic electricity can be measured. The chapter discuses Hungary's electricity portfolio to determine the proper role of photovoltaic electricity. Due to the fact, that photovoltaic power plants do not generate electricity after sunset – neither they store it –, the electricity portfolio and the supply chain has to be modified in order to have a balanced system and to always meet the electricity demand.

Chapter VI concludes the results of the analysis of this research by answering the research question and relevant sub-questions.

The thesis ends with Chapter VII, where feasible and proper recommendations are given to make the market competitive and to support the spread of photovoltaics in Hungary.

2. Review of photovoltaics

Before going on with the analyses of the Hungarian PV market, first let's have a literature review on photovoltaics. In this chapter the origins of solar modules and their evolution are presented. Their system structure and use in Hungary is also part of the chapter as these topics provide the relevant literature review to understand further chapters. This chapter, just like future ones do not mention complex technical terms, as the research does not concentrate on the technical side of photovoltaic systems.

Humans have been using the energy of the sun since the early ages. In the 7th century B.C people used magnifying glass to concentrate the sun's rays to make fire and to burn ants. Later in 300 B.C. the Greeks and Romans used burning mirrors to light torches for religious purposes. Legend has it that even Archimedes the Greek scientist used the reflective properties of bronze shields to focus sunlight and to set fire to wooden ships from the Roman Empire which were besieging Syracuse. (Although no proof of the result exists, the Greek navy recreated the experiment in 1973 and successfully set a wooden boat on fire at a distance of 50 meters.) (Josh Clark, 2008) Apparently the use of the sun's energy is not a new idea. Its history spans from 700 B.C. to today. People started out concentrating the sun's heat with glass and mirrors to set objects on fire. In the last few decades the use of solar energy has diversificated: technology can offer everything from solar-powered buildings to solar powered vehicles.

As mentioned in the introduction chapter, photovoltaics (PV) are devices that can generate electricity from sunlight by the help of an electronic process occurring naturally in certain type of materials like crystalline silicon. Today we refer to electricity produced directly from light as the photovoltaic effect. This effect was observed as early as 1839 by Alexandre Edmund Becquerel, and was the subject of scientific interest through the early 20th century. (Williams, 1960, p. 1509). Following the initial observation more than 100 years passed until the first fully functioning solar panel was made.

In 1954 the US based Bell Labs introduced the first photovoltaic device that was able to produce usable electricity with an efficiency of 4%. However, the high procurement and production cost of PVs kept the technology out of the electrical power market. During the following years technical development of silicon solar cells continued to rise, but commercial success eluded the technology. The main reason for this was that a one-watt cell cost almost 300 USD/watt in 1956, while a traditional coal-based power plant cost 0.5USD/watt to build at the time. Luckily during the early 1960s, the National Aeronautics and Space Administration (NASA) was searching for a power source to supply its ambitious space ventures. Photovoltaics proved to be a reliable choice, since during the previous decade the technology has advanced and solar panels were able to meet the increased power demand of satellites at an affordable price. (Perlin, 1999, p. 4)

While photovoltaics was widely used in space from the beginning of 1970s, back on Earth it was still too costly for the average citizen and companies. On the market the primary criteria for energy sources are price per kilowatt hour (kWh). It was not until 1980 when the price of one watt was down under 30 USD. With a significantly lower price, solar cells could compete with other primary energy sources, however only on places that were too far away from the grid. Ironically the first beneficiary was the oil industry. (Perlin, John, 1999, p. 7) For example, off-shore oil rigs required horns and warning lights to prevent collision with ships. These were powered by batteries which other than toxic, had to be replaced frequently. Inland gas and oil fields also required electricity but were too far away from the grid. Compared to their installation, maintenance and replacement, solar modules proved a bargain. As a result, significant purchases of solar modules by the gas and oil industry gave the solar cell industry the needed capital to persevere and later develop.

2.1 Type of photovoltaics and system structure

Throughout the decades two type of solar cells have gained wide spread popularity: monocrystalline and polycrystalline silicon solar cells. Monocrystalline cells are cut from a single crystal of silicon, what is cylindrical in shape. In appearance, it has a smooth texture and the thickness of the slice is noticeable. These are the most efficient but also the most expensive solar cells to produce. They are also rigid so in order to protect them they must be mounted in a rigid frame. Monocrystalline cells have been in mass production since 1954. The other type of solar cells, the polycrystalline silicon based panels were introduced to the market in 1981. These cells are basically a slice cut from a block of silicon, consisting a large number of crystals. These cells are slightly less efficient and slightly less expensive than monocrystalline cells and again need to be mounted in a rigid frame. Despite these benefits, polycrystalline cells have lower heat tolerance than monocrystalline cells and with the lower efficiency also comes with the lower space efficiency. In term of efficiency the mass-marketed polycrystalline-based solar panels are typically 13 – 16% while monocrystalline cells are typically 15 – 20%. (Energy Informative, 2015)

There is a third type of solar cells, the so called thin-film solar cells (TFSC). The technology is relatively new and it consists of depositing one or more thin layers of photovoltaic material onto a substrate. Depending on the material, current prototypes have reached an efficiency of 13%, while current production modules operate at a level of 9%. TFSCs have several main advantage over crystalline based ones. Their mass production is simple, resources are cheap and widely available. They are potentially cheaper to manufacture than other type of cells. They can also be made flexible, opening up new ways of applicability. Las but not least, they perform better under high temperature and shading. Mostly due to these facts, in the USA the market for thin-film PV grew at a 60% annual rate from 2002 to 2007. In 2011, close to 5% of U.S. photovoltaic module shipments were based on thin-film. (Energy Informative, 2015) Due to its several advantages, TFSC are likely to replace crystalline silicone in the coming decades. However currently the crystalline silicone solar panels dominate the market: in 2011 it supplied 95% of the market.

In the aspect of PV system structure, a PV system consist of several parts. The solar panels are where the electricity gets generated, but they are only one of the numerous parts in a complete photovoltaic system. In order for the generated electricity to be useful for the end-customer, a number of other parts must be in place like mounting structure, inverter, metering system, connectors and wires. A system can include other parts as well, however in this research only the most basics will be covered. A simple schematic scheme of a solar system is presented in Figure 2.

The solar modules must be mounted on a rooftop or – in case of a utility scale system – on the ground. In any case a stable and durable mounting structure is needed that is able to withstand rain, hail, wind and corrosion. If the modules are installed on a regular slanted roof, basic mounting structure will do the work. On the other hand, when the roof is flat the mounting structure must be set in angle with the sun. This applies to ground installations as well. Moreover, for modules mounted on the ground, a tracking mechanism moving the panels automatically to follow the sun on the sky can also be mounted. These measure can affect the cost of the mounting structure, but still it remains a small percentage of the total system cost. The wires and connectors are also a minor part of the total cost.

The most crucial part of a PV system is definitely the inverter. The role of an inverter is to convert the direct current – DC – electricity generated by the PV modules into altering current – AC – electricity. Since AC electricity is used by most of our appliances in our homes, without an inverter the electricity generated by the solar modules would be useless. An important characteristic of inverters – what also heavily influences its price – is the maximum power output in kW. This defines how much electricity it can provide to the devices connected to the grid. Let's say a house requires 4kWh of electricity and the owner wants to cover that energy need by only using solar panels. If he decides to purchase 260W modules – 1 module can produce 260Wh –, then he will need to buy 16 modules in order to safely get 4kWh (4000W/260W=15.38). In order to convert the 4kW DC electricity produced by the solar modules into AC electricity, the a 4kW inverter need to be integrated to the system.

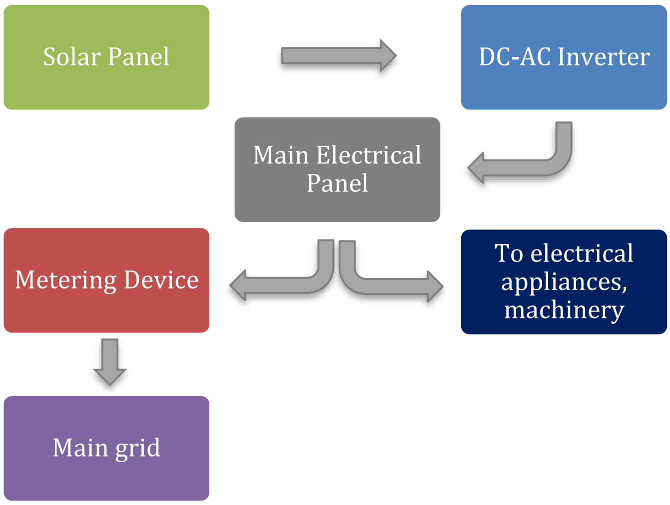


Figure 2: Photovoltaic System Scheme
Source: Author (2016)

Metering devices are also part of the system. In the 1980s the photovoltaic technology was mostly used off-grid. Today more than 95% of solar installation are on-grid or "grid-tied" so the electricity can be sent back to the grid. The metering device's role is to monitor how much electricity generated by PVs is sent back to the main electrical grid. In Hungary if the proprietor has an electricity surplus, it is sent back automatically to the main grid. When a house generates more electricity from PV than it consumes, the energy that gets put back on the wires will likely get used by the neighbors. The amount of this surplus is monitored by the metering device. Based on its data, the owner of the PV system is paid by a utility for the electricity their system generates. In Hungary's case it is the Hungarian Energy and Public Utility Regulatory Authority that sets the feed-in price for PV electricity. In 2016 it is 0.08 EUR/W. (Hungarian Energy and Public Utility Regulatory Authority, 2016)

2.2 Application area of photovoltaic systems in Hungary

Hungary is situated in the northern temperate zone extending between the latitude of 45.8° and 48.6°. Due to its geographical characteristic, in terms of solar radiation Hungary is among the medium favored countries. The annual solar radiation hitting the country is about 3.5kWh/m^2 per day on a horizontal surface. When compared to the best spots at the Tropic of Cancer and Capricorn where the annual radiation is about 5-7kWh/m^2/day, the country receives around 50 – 60% less amount of energy. Still it is more than enough to utilize Hungary's solar energy potential. A good European example for this is Germany and Austria, where the annual radiation is even less what Hungary receives. Despite their comparative disadvantage both realized more photovoltaic projects during the previous years and supporting heavily residential and non-residential installations.

By taking a look at Hungary's EU member neighbors in Table 1, 4 out of 5 have higher electricity production from solar photovoltaic power. Since 2014 Romania is the absolute leader in term of size, despite the fact that it has the lowest GDP per capita - 21,916 USD – from the six countries in the list. In comparison Croatia's GDP in the year of 2015 was 21,791 USD, Hungary's 26,941 USD, Slovakia's 29,209 USD, Slovenia's 31,720 USD and Austria's 47,188 USD. On the other hand the electricity production from photovoltaics grew by 4.3 times bigger between 2013 and 2015 (25GWh $\rightarrow$ 108GWh).

As the PV capacity of Hungary increased, so does the PV capacity per inhabitant. When taking a look at the photovoltaic capacity per inhabitant for these countries in the year 2015, Hungary takes the same position as in in the previous table. The first place is occupied by Slovenia. Keep in mind that Slovenia has a population of only 2 million – while Hungary has 9.8 million inhabitants – but with higher GDP per capita. Also by looking at the growth rate, in 2013 it was only 3.27W/inhabitant while by 2015 it increased to 14Watt/inhabitant, it can be said that a 4.28 growth rate characterizes the photovoltaic electricity per inhabitant. When comparing Hungary's growth rate both in Table 1 and 2, the country ranks the first.

Table 1: Cumulated photovoltaic capacity in MWh, 2013 – 2015

Country name	2013	2014	2015
Romania	1022	1,292.6	1,325
Austria	690.4	770.5	935.3
Slovakia	537.1	590.1	591
Slovenia	254.8	256	257.4
Hungary	*32.1*	*69.08*	*137*
Croatia	21.7	34.2	44.8

Source: EurObserv'ER, 2016; Hungarian Energy and Public Utility Regulatory Authority, 2016

Table 2: Photovoltaic capacity per inhabitant (Watt/inhabitant) between 2013 – 2015

Country name	2013	2014	2015
Slovenia	123.8	124.2	128.4
Slovakia	99.3	109	109
Austria	81.7	90.6	108.9
Romania	51.1	64.8	66.7
Hungary	*3.27*	*7.04*	*14*
Croatia	5.1	8.1	10.6

Source: EurObserv'ER, 2016; Hungarian Energy and Public Utility Regulatory Authority, 2016

Regional neighbors performing well on the photovoltaic market prove that electricity generated from photovoltaics can work in practice, even in those places where the solar radiation is lesser compared to what Hungary receives. PVs can be a working alternative to traditional primary energy sources when it comes to electricity generation. Another convincing fact is that the country receives 3,000 times more energy by solar radiation than the total energy consumption of the country. Even at less favored places, a horizontal surface receives annually about 1.1 – 1.2MWh/m^2 of energy from the sun. Taking into consideration that Hungary is 93,030km^2, the country receives a total of 116,287,500,000MWh annually. The total energy consumption of the country is 38,544,000MWh annually. By dividing the two value it becomes visible just how much free energy Hungary receives.

By having a closer look at the geography, the best places for setting up PV systems are the central and southeast part, the worst are the western and northern parts. In fact, after examining the differences between various parts of the country it is safe to say that the difference between the "best" and "worst" favored places is less than 5 – 8%. (Greentechnic Hungary, 2012, p. 15) Due to the small difference, the actual location of a photovoltaic system in Hungary does not necessarily affect the performance of solar modules. Therefor the whole territory is suitable for PVs installations.

The solar radiation at the sunniest southern parts is about 1.325kWh/m^2/year, at the worst favored northern part it is about 1.120kWh/m^2/year. These data refer to flat surfaces. They can be easily improved if solar panels are properly oriented: facing south and tilted toward the sun's "average" elevation (30-45° in Hungary). With proper setup, PV modules can perform best, by gaining a 15% increase of efficiency compared to flat surfaces. Translated into kWh, 1.288 – 1.493kWh/m^2/year can be achieved. This amount of energy can also be examined from a financial point of view. Assuming that the Sun – just like electricity suppliers – submits the bill for each kWh provided, then 1.288 kWh/m^2/year would cost 144.5 EUR (45,505 HUF)*****. Thus the Sun radiates to every well oriented m2 tens of thousands of forint (HUF) worth of energy per year. With proper measures it could be easily utilized, especially by family homes, where the rooftop is available for installing solar modules. (Országos Meteorológiai Szolgálat. 2016)

Conclusion

To conclude Chapter II, it is clear that photovoltaics have all the chances to play an important role in Hungary's electricity portfolio. The technology is already introduced to the residential sector and is spreading, while new technological developments are on the way with the thin-film solar cells (TFSC). Hungary's geographical characteristics are favorable, so the potential for photovoltaics are given. Countries with less favorable solar radiation, like Germany and Slovakia, are investing heavily into photovoltaics. Table 1 and 2 prove that investments in Hungary are also taking place (which is a good sign) but the growth rate could be easily boosted, since the country could easily meet part of its electricity demand by photovoltaic generated electricity.

* For the calculation basic daytime electricity tariff, valid from 01.01.2015 was used, provided by the Hungarian National Electricity Utility (Source http://goo.gl/Byjb0r). The result was converted into EUR.
1,288 kWh/m2/year x 35,33t/kWh = 45,505Ft/m2/year
48,377Ft/m2/year x 0.00317465 EUR= 153.58004305 EUR

3. The Hungarian photovoltaic market

Following the technological advancement achieved in the photovoltaic technology, it did not take much time for solar panels to appear in Hungary. In the beginning they were mostly used in really small amounts, mostly by research institutions: in the 1970s some were placed on top of buildings to measure their efficiency and to experiment with them. They were capable of producing only a couple of watts, they were also big and heavy. However, this was not the time when the so called Hungarian photovoltaic market began to develop.

3.1 Price per Watt evolution of solar modules

Before going on into analysing the Hungarian PVs market, first let's have a global outlook. Today the global photovoltaic industry is gaining more and more space. Due to the past's technological advancements on the field, there are two trends moving in parallel. First of all, the production costs are decreasing, resulting in lower consumer prices.

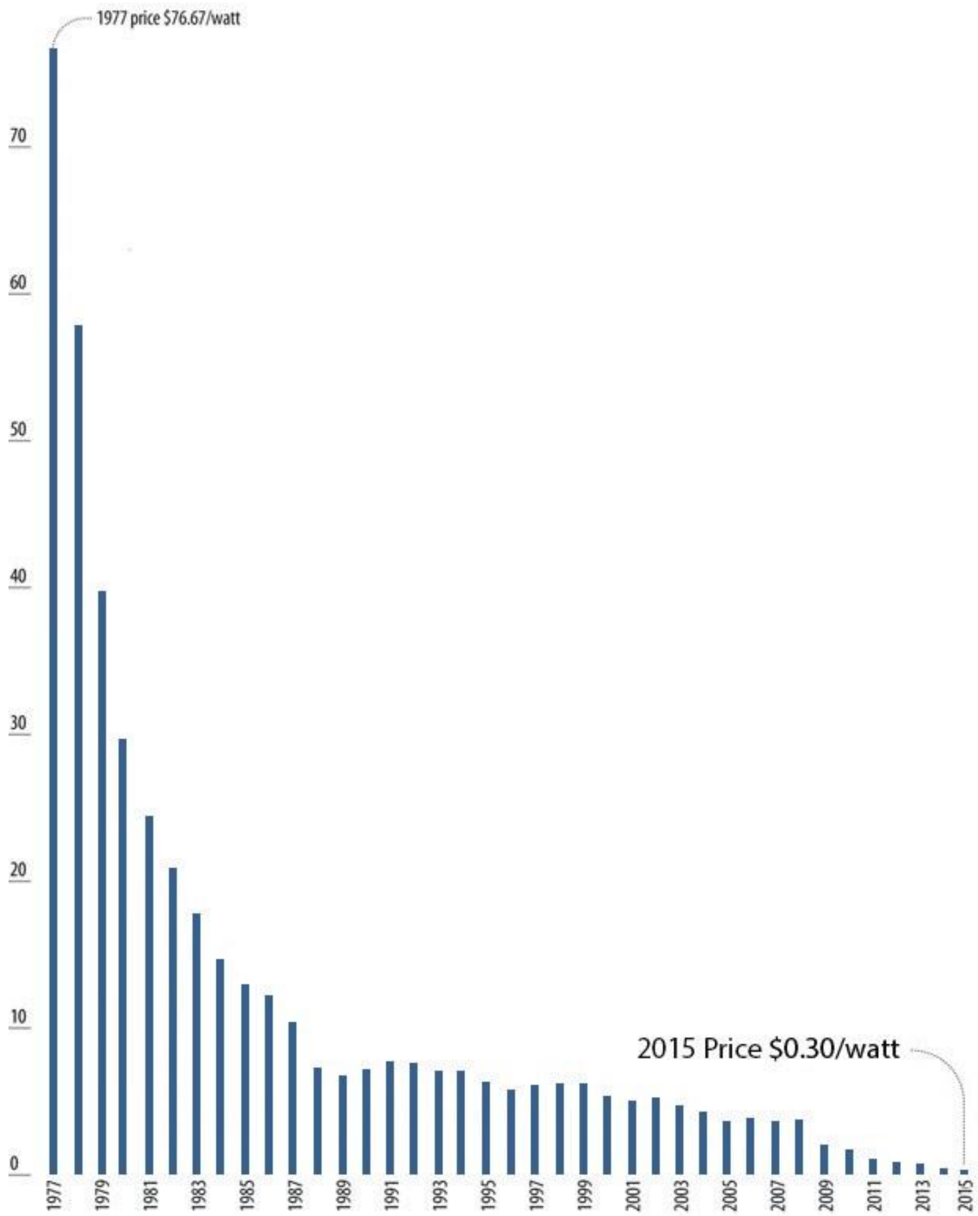


Figure 3: Change of solar cells' price over 1977 - 2015 in USD
Source: Bloomberg, New Energy Finance

Secondly, the efficiency of solar cells is increasing. Figure 3 shows the price evolution of solar cell/watt starting from the end of 1970s until 2015. It is important to point out that a photovoltaic module is a package of cells: connected assembly of typically 6×10 solar cells. So when the price/watt and efficiency of cells is discussed, it is meant for one individual cell, not for a whole solar panel/module. While in 1977 one watt cost almost 78 USD, the price reduced significantly over the years. A 2015 study shows that price/kWh dropping by 10% per year since 1980. (Farmer & Lafond, 2015, p. 652-653).

By the time of the global financial crisis, the 3USD/W was already achieved. However, there were two occurrences that helped the market to further develop and lower the price. Before 2005 silicon – the basic of crystalline silicon cells – were mostly used in big quantity only by the semiconductor industry. When the PVs market started to grow, a constant and growing demand for silicon appeared. Supplier just could not meet the demand and a shortage of silicon began. The market and its suppliers needed time to begin silicon production and to keep up the phase with PVs demand. While in 2005 only 15,000 tons of silicon were available for use in solar cells, by 2010, this number grew to 123,000 tons. (MIT Technological Review, 2010). Since then, shortage of materials needed for production is not at risk. After this bottleneck in the supply chain was solved, production capacity started to grow with promising future prospect, especially on the Chinese market. However, then the financial crisis hit and suddenly the previously existing high demand for solar panels disappeared. An excess of supply occurred in the photovoltaics market where the amount of solar panels provided exceeded the amount required or demanded by the market. The oversupply on the Chinese market gave a significant boost for the global market, but further lowering their price.

While the price of solar cells was decreasing over the years, their efficiency was increasing. In 1953 the first cells had an efficiency of 4.5%. A solar panel converted 4.5% of available energy to electricity. A 230 Watts panel had a size of 541x330cm and it costed 1,785USD/Watt. In 2012 a 230 Watts panel was 162x99cm with an efficiency of 15% and costed1.3 USD/Watt. Today the most advanced panels available on the market are 114x63cm, they have an efficiency of 23% and cost 0.70USD/Watt. (CleanTechnica, 2014) However, these high efficiency panels are not widespread yet, mostly because of their cost. Today the most widespread panels – the mono- and polycrystalline – have an efficiency of 14-18% and cost around 0.30USD/Watt. As it can be seen over the decades solar panels became smaller in size, their efficiency grew and they cost much more less than decades ago.

3.2 Market characteristics in numbers

In a legislative sense the Hungarian photovoltaic market started off in 2007, when the Act on Electric Energy (Act No. LXXXVI of 2007) was modified due to the spread of photovoltaics. The act was modified to support the development of the growing market: it introduced into the Hungarian legislation a feed-in tariff for photovoltaic electricity generated by homeowners and companies. Since then, solar electricity producers are able to send electricity generated by PV back to the grid. Due to globalisation throughout the years the price of solar cells in the country followed the global trends. However, it can be said that in terms of capacity and market development the Hungarian PV market lags 10 years behind global market, but according to Mr. Ernő Kiss, the head of the Hungarian Photovoltaic Association, the gap is closing. A good sign of the catching up process is that every year the photovoltaic capacity is doubled.

To start with, let’s have a look at the amount of Home Scale PV Systems (HPVS) installed over the years 2008 – 2014. (For your information a Home PV System has a maximum capacity of 50kW. The next category is the Small Scale PV System with a capacity between 51 – 500kW.) Figure 4 shows just how low the amount of HPVSs were in 2008, one year after the change of the Electricity Act. Big scale investments did not happen until 2010, when for the first time the marked was doubled compared to previous years. Since then in each year the amount of HPVSs is doubled. In Table 3 besides HPVSs, the Small Scale PV Systems are also indicated.

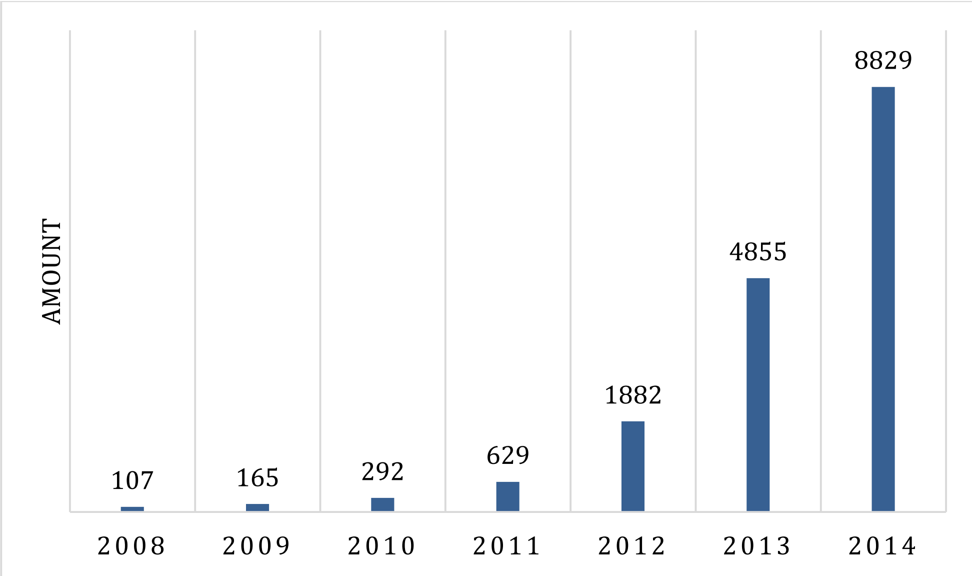


Figure 4: The amount of Home PV Systems installed between 2008 – 2014

Source: Hungarian Energy and Public Utility Regulatory Authority, 2016

The first was installed in 2011, and this segment is also subject to growth. The total PV capacity is shown in Figure 5 and is expected to further grow in the year 2016 as well, however chances to another doubling are low. The reason for this is that in the first half of 2016 only one utility scale project has been realized: The Pécsi solar power plant.

Table 3: The amount of HPVSs and Small Scale PV Systems installed between 2008 – 2014

	2008	2009	2010	2011	2012	2013	2014
HPVS	107	165	292	629	1882	4855	8829
Small Scale PV System	0	0	0	2	5	13	33
All	107	165	292	631	1887	4868	8862

Source: Hungarian Energy and Public Utility Regulatory Authority, 2016

The Pécsi Solar Power Plant is situated in the south-west part of the country. It was realized by the MVM Magyar Villamos Művek Zrt.'s subsidiary (Hungarian Power Companies Ltd.) called MVM Hungarowind and was a 100% EU funded project. The project cost 16 million EUR (5 billion HUF) and has a total capacity of 10MW. The investment was purely supported by the European Union as part of the Partnership Agreement's Thematic Objective 4. As mentioned in chapter 1.1, TO4 is aimed for supporting the shift towards a low-carbon economy in all sectors. The plant was finished and put into work at the end of April, 2016. When the Pécsi Solar Power Plant project was announced back in 2014 it was set to be the biggest photovoltaic plant in terms of capacity to date. The initial pay-off period is 10 years, meaning that after 2025 it will be basically producing free electricity for the citizens of Pécs. (HVG, 2016)

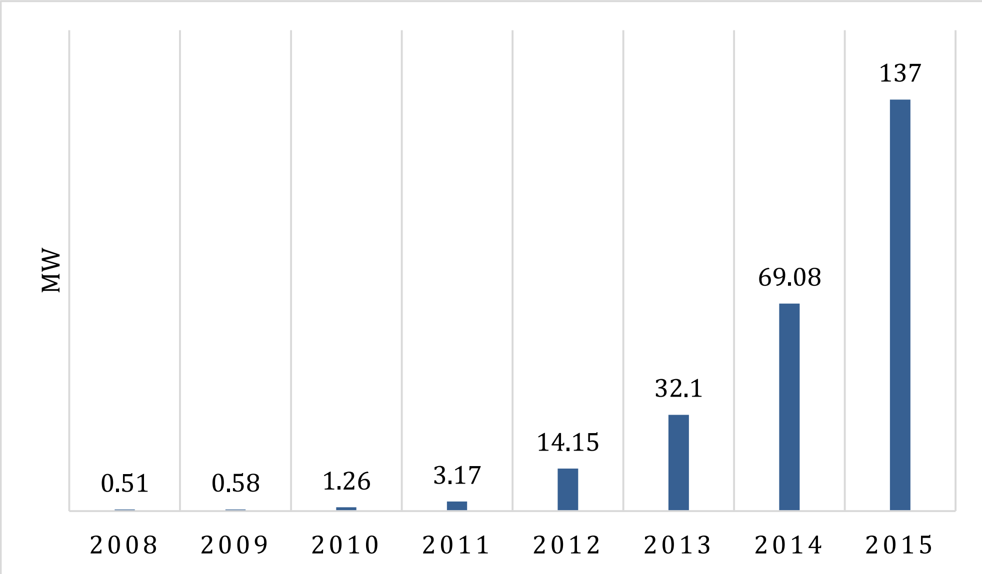


Figure 5: Total PV capacity between 2008 – 2014
Source: Hungarian Energy and Public Utility Regulatory Authority, 2016

Although the Pécsi Solar Power Plant was meant to be the biggest in terms of capacity in 2016, in the end it was preceded by the Mátra Solar Power Plant. The preparations of this project began in 2013 and construction was finalized by October, 2015. It was realized by the German owned Mátra Power Plant. The 950MW capacity Mátra Power Plant is a traditional coal-fired power plant equipped with modern CO2 filters. As part of its strict environmental policy the Plant decided to invest in renewables as well, and ended up with a PV project. The new solar power plant was 100% self-financed, meaning that the expenses of the investment were fully covered by the Plant's own income, however development tax relief were provided by the government. The total investment cost of the project was 20.5 million EUR (6.5 billion HUF) and the total capacity is 16.5MW. (Mátrai Erőmű Zrt., 2015)

Figure 6 and 7 show the amount and total capacity of HPVSs in three capacity category. As mentioned earlier a HPVS has a capacity of maximum 50kW. This category is further divided into three subcategories: below 5kW, 5-10kW and 10-50kW. A below 5kW system characterizes the residential sector: they are the civilians, families who are installing solar panels on their rooftops for different reasons like lowering the electricity bill, becoming independent or simply supporting the shift towards a low-carbon economy. The 5-10kW are represented both by the residential and the commercial sector. They are the group of people who are installing a system that can power more than one average family house, but less than a farm or a firm's headquarter. For example, farms or companies' smaller warehouses what requires a lot of power for lighting and ventilation, it can be a good choice in order to reduce their electricity bill. The third subcategory is represented by the investors willing to completely secede from electric utilities. They are typically bigger SMEs that possess significant capital to invest in a photovoltaic system that big, but institutions and governmental buildings are also among investors. It is important to remember that SMEs are charged with higher electricity prices than residents. In Hungary in 2016 residents typically pay 0.112 EUR/kWh, while companies pay 0.12 EUR/kWh. (Hungarian Energy and Public Utility Regulatory Authority, 2016) From a financial point of view, it can be a logical choice to install photovoltaics, especially since after the pay-off period, the system basically generates free electricity for the firm. IN case that firm does not have a night shift, it can meet most of its electricity demand by photovoltaics.

Interestingly Figure 6 and 7 are reciprocally proportional. Although from the residential 5kW systems are installed more in quantity than form commercial systems, the latest have more total capacity than the residential systems. The reason for this is that families, although place more orders, firms purchase more capacity output, ergo more solar panels. In Hungary the price/kWh is the lowest in the European Union. To compare with in Germany 1kWh of electricity for residents cost 0.295 EUR, in Italy 0.245 EUR and in Austria 0.2, while in Hungary since 2015 it cost only 0.112 EUR/kWh (Online-kalkulátor, 2016). According to Mr. Kiss Ernő, lately more and more realized that despite having the lowest electricity fee in the EU, it is still profitable to invest in photovoltaics. It is not only individuals who are increasingly likely to embrace photovoltaics these days. More and more commercial enterprises are making the leap to power their buildings with electricity created via the free energy received from the sun. Not only does making the switch save money, but such companies are hoping they will be viewed more favorably if their commitment to more environmentally-friendly energy sources is seen.

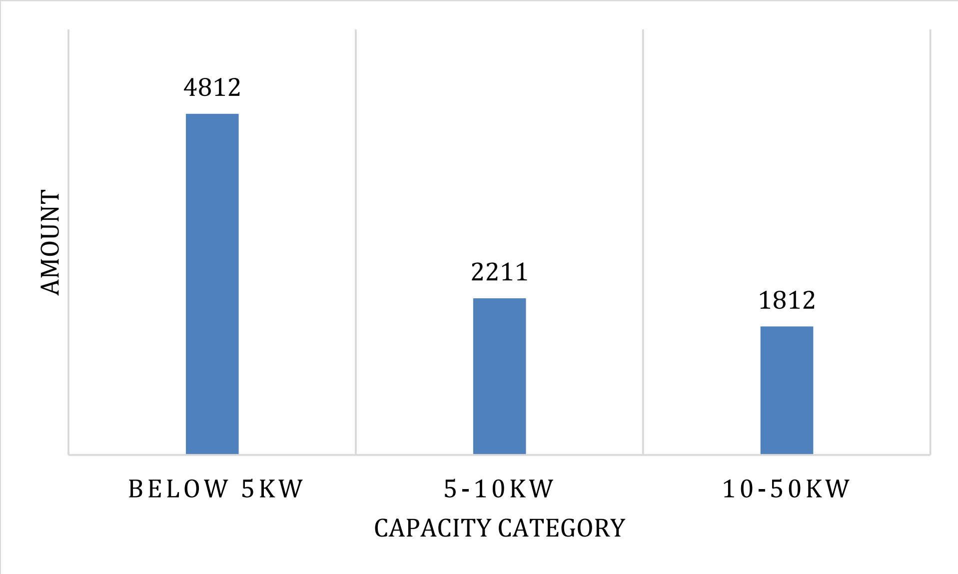


Figure 6: The amount of HPVSs in three capacity category in 2014
Source: Hungarian Energy and Public Utility Regulatory Authority, 2016

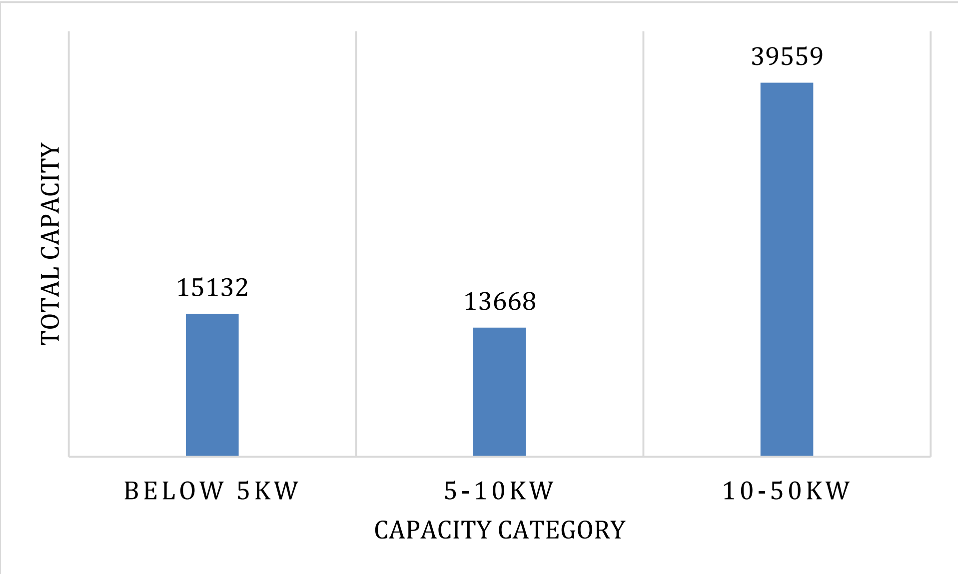


Figure 7: The total capacity of HPVSs in three capacity category in 2014
Source: Hungarian Energy and Public Utility Regulatory Authority, 2016

3.3 Feed-in tariff and investment cost

Homeowners and companies who invest in solar power systems receives numerous benefits like lower electricity bills, lower carbon footprint and higher home values. However, to get these benefits, first a significant investment has to be made. The magnitude of benefits can vary widely from one investor to another.

Let’s start with the price of solar panels, as the panels represent the largest and most capital sensitive single component of the overall expenses. The price of a solar module depends on its technology and efficiency and is mostly expressed in price/watt. For example, let’s take a 260W capacity solar panel. If one watt cost 0.717 EUR, then 260W capacity panel will cost 186 EUR.

In Hungary the price of the panels used to follow the global trend, however due to past events, the price/watt cannot be less than 0.53 EUR in the European Union. The reason for this is that the European SolarWorld company indicted an anti-dumping process against Chinese solar module importers as their cheap products were flooding the EU’s market. In order to protect the European solar module manufacturers, the EU adopted a 0.53 EUR/watt threshold price. It is an artificial price and under it no Chinese or US or any modules can enter the EU market. On the other hand, parts of solar modules imported from China has no threshold price, they are not regulated and can enter on market price without any artificial barriers. These parts can be purchased by EU photovoltaic manufacturers and are assembled in their factories across the Union. Due to these measure, in the EU photovoltaic manufacturers are protected, however they did not lower the price/watt. On the contrary, manufacturer increased their price and today the EU has one of the highest price/watt in the world. In Hungary the price/watt did increase as well especially for recent governmental measure. These measure will be discussed later in Chapter 4.2.

The other main equipment required by the system is the inverter. As discussed in previous chapters it converts the direct current generated by the solar modules into alternating current used by household appliances. The price of inverters is continually decreasing worldwide and Hungary is no exception. Moreover, they are becoming more reliable. Global brands available on world market are also purchasable in Hungary, like ABB, SME, Fronius and Huawei.

Other parts of a photovoltaic system include a metering equipment (if it is necessary to see how much power is produced), and various housing components along with cables and wiring gear. The Hungarian government made the PV Fireman Switch a mandatory part of every PV system. This device is integrated between the solar modules and the inverter. In the event of a fire, the fire-fighters are exposed to a very serious source of danger namely the electricity generated by the solar modules. If you think about it, a solar module cannot be switched of, as its power source, the Sun cannot be turned off. The Firemen Switch basically cuts the circuit, disconnects the cable between the modules and the inverter, so the firemen cannot be electrified during fire-fighting. A 5kWh system typically requires one Fireman Switch.

Solar modules produced in Hungary are also subject to product fee, which is the highest product fee in European Union: it is 0.36 EUR/kg. This fee is almost 6 times higher than the second highest product fee in the EU: in Belgium the fee of solar modules is 0.07 EUR/kg. In Hungary this represent almost 3% of the total cost of a single solar module.

Now let’s see feed-in tariff for Hungary. Hungary’s electricity use per household is below the world’s average. In 2014 an average Hungarian household was using 2,717kWh. To compare with, in the Netherlands this value is 3,291kWh, Spain 3,944 kWh, France 5,036 kWh and the USA 12,305 kWh. (Energy Efficiency Indicators, 2015) 2,717kWh means that in one month a household consumes on average 226kWh. For the sake of simplicity and since it is an average lets calculate with 250kWh/household. 250kWh/household means that throughout one year that household consumes 3,000kWh. If the owner of the house – let’s call him Fábián – decides to install photovoltaics to get rid of the electricity bills and become independent, he has to choose a 2kWh system to meet his household’s electricity demand. Assuming that the sun shines on an average of 6 hours a day throughout the year, a 2kWh PV system can generate 4,380kWh/year. (2kWh*6h/day*365day/year) Now Fábián generates enough electricity to meet his own house demand, but as everybody knows during the night solar modules do not generate electricity. Let’s see how an actual system would work in practice:

- During daytime Fábián’s PV system generates electricity;

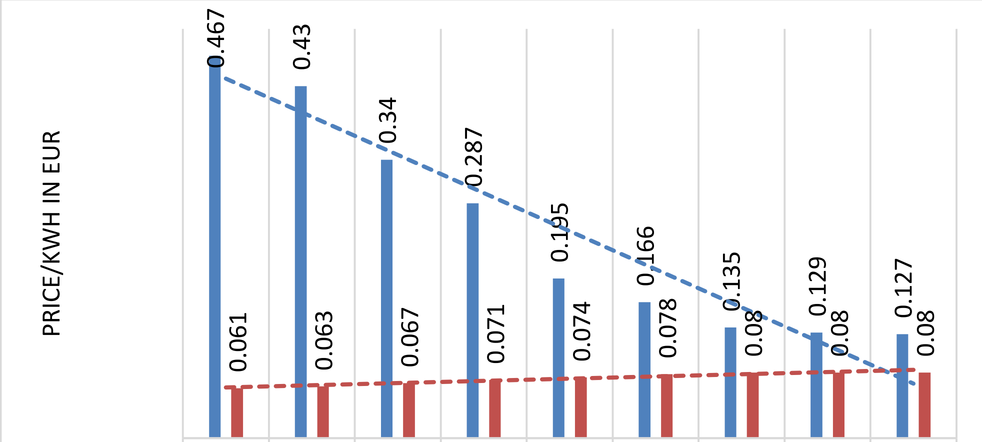
- This electricity however is used only in small amount by Fábián's household, as he and his family is at work/school;
- However, if the generated electricity could be stored in batteries, it could successfully satisfy the Fábián family energy demand throughout the whole afternoon and evening, when the sun is not shining;
- Next morning when the sun rises, the solar modules can start generating electricity again and charging the batteries and the whole cycle starts again.

Based on people's behaviour, they are not keen on installing batteries and only a fraction of customers buys batteries to store PV electricity (Kiss, 2016). This tendency makes sense, since in most EU countries there is a feed-in tariff for renewable energy: basically if a household generate PV electricity but it is not consumed by the household, the surplus electricity can be sold to the electrical utility.

As previously mentioned the HPVS transfers the electricity to the main grid through a metering device. The metering device measures how much electricity generated by Fábián is sent to the main grid and how much grid electricity is used by Fábián when the sun does not shine during cloudy days, short winter days and night. With this net metering method, the electrical utility basically works as a battery station: the unused electricity is "stored" in the electrical grid, but when it is needed a household can use the electrical grid to meet its own energy demand. The device is usually checked monthly or yearly. If there is a surplus, then the Electrical Utility pays for Fábián.

As mentioned previously with a proper PV system you are able to generate an income on your PV system thank to the feed-in tariff. The feed-in tariff differs for each EU member state. In Table 6 the price/kWh is shown, that electrical utilities in Hungary and Germany pay for residents transferring PV electricity to the main grid.

The two countries feed-in tariff is reciprocally proportional throughout the years: while Germany had an initial high price for PV electricity back in 2008, Hungary had a relatively low price. The tendency is that Germany slowly reduces the price/kWh its electrical utilities have to pay for HPVS electricity. The reason for this is that when a technology is new, it needs some sort of governmental support in order to make it popular and convince people to invest in it. Eight years ago solar panels used to have a much higher price, so incentives were needed. However, during the last decade, PV price dropped significantly, PVs became popular widespread and affordable for the masses in Germany. As a result, the incentives were no longer needed they were lowered and today the feed-in tariff is 0.127 EUR/kWh instead of the 2008 price of 0.467 EUR/kW. Bear in mind that in 2015, Germany's PV capacity amounted to 37GWh, while Hungary's PV capacity amounted only to 0.137GWh. (37,000MWh vs. 137MWh) Moreover Germany had 1.5 million PV system installed in 2015, while Hungary had 8,862 PV system as shown in Table 3. (Tillmann, 2015, p. 948). Since the modification of the Act on Electrical Energy in 2007, the feed-in tariff in Hungary is continually increasing, a good sign of the market development. Although in the last three years the price/kWh of PV generated electricity stagnates, it is still a competitive price on a European level.



	2008	2009	2010	2011	2012	2013	2014	2015	2016
Germany	0.467	0.43	0.34	0.287	0.195	0.166	0.135	0.129	0.127
Hungary	0.061	0.063	0.067	0.071	0.074	0.078	0.08	0.08	0.08

Figure 8: Feed-in tariff for PV electricity in DE&HU between 2008-2016
Source: Hungarian Energy and Public Utility Regulatory Authority, 2016; Bundesnetzagentur, 2016

3.3.1 Investment cost and Rate of Return of a 2kWh HPVS

In this subchapter the previous Fábián example is continued. In term of cost, if Fábián electricity demand for a year is exactly 3,000kWh and he generates exactly 3,000kWh, then his system balance at the end of the year is even. This means that throughout the year Fábián generated and sold to the electrical utility exactly as much electricity as he had been using when PV output was down. It is like a Barter system, where person A sells 1kg of apple he does not need to person B, and later person B sells back 1kg of apple to person A, when he needs it. The metering device records the electricity exchange between Fábián and the utility. With the help of the metering device, this exchange system frees utilities from the administrative burden that comes with the invoicing and payment. In another scenario where Fábián generates less, let's say 2,500kWh, he has to pay for 500kWh electricity, as he used this 500kWh from the main electrical grid provided by the electrical utility. However, in our example Fábián managed to generate 4,380kWh a year, despite using only 3,000kWh. The 1,380kWh electricity surplus is sent to the main grid through the metering device. Based on Table 6 data Fábián generates 110 EUR throughout the year. 110 EUR might not seem a significant income for a whole year, but keep in mind that beside the 110 EUR, Fábián did not have to pay the electricity bills since its PV system was installed. Moreover, the 6 hours of sunshine/day is a minimum value, the average is above this.

Now Fábián generates about 110 EUR/year by selling PV electricity to the utility. It is time to calculate the costs of a photovoltaic system in Hungary using prices available from one of the main Hungarian photovoltaic contractor called ManituSolar. The price of the different parts of the PV system are from ManituSolar's webpage. As always the prices are converted into EUR using the given exchange rate. Table 4 shows Fábián's 2 kWh capacity PV system, its component together with their cost. Below in bullet points the calculations are explained.

- In order to generate 2kWh PV electricity it was decided to purchase 8 piece of 260W solar modules, resulting in a capacity of 2,060W. One module gross cost is 237 EUR, so 8 pieces cost 1,896 EUR.
- As mentioned earlier the product fee for solar modules in Hungary is 0.36 EUR/kg. One solar module weights 17.2kg, so 8 pieces weight 137.6, costing 50 EUR.
- The Firemen Switch is mandatory for every PV system and for each 5kWh capacity one has to be integrated to the system. In this case one Firemen Switch is needed, costing 635 EUR.

- For Fábián's system a 2.5kWh capacity inverter was chosen mainly for two reason: the solar modules gross capacity is above 2kWh (2,060W), and if Fábián decides to purchase more solar modules in the future, no additional investment in inverters will be needed.
- The *Other* section represents the cost of the cables, connectors, mounting frames and installation fees. These usually represent about 10 – 12% of the total investment of a 2kWh system (Kiss, 2016).

Table 4: Home Scale Photovoltaic System components' cost in EUR

PV modules	**Product fee**	**Firemen Switch**	**Inverter**	**Other**	**Total**
1,896	50	635	1,067	500	**4,148**

Source: Author, 2016

Figure 9 shows the distribution of cost. It is clear that almost 50% of the investment is spent on the purchasing of the solar modules., meaning that they are the most expensive part of the system. The inverter represents the second largest slice from the pie, 26%. The Firemen Switch and Others (like cables, frames, project management fee) are around the same amount. In chapter 3.2 it was pointed out that product fee for solar modules in Hungary is the highest in the world: it is 0.36 EUR/kg. Although it represents 3% of a solar module's cost, looking at the total system investments it represents only 1%. As a consequence, since cost after installation is minimal for photovoltaic systems, the relevant costs are only the purchase cost, installation costs and the cost of land, where the modules are situated. In this case however we are talking about a rooftop photovoltaic system so land cost does not exist.

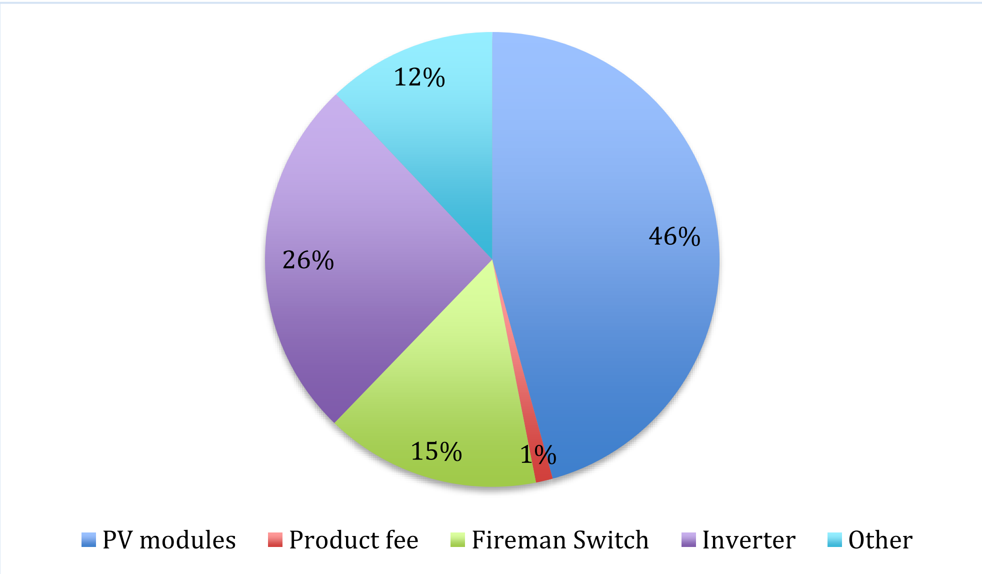


Figure 9: Home Scale Photovoltaic System components' cost distribution
Source: Author, 2016

The lifespan of solar panels are minimum 25 years. This is reinforced by the fact, that the majority of manufacturers offer the 25-year standard solar panel warranty, which means that power output should not be less than 80% of rated power after 25 years. In other words, a 260W panel after 24 years should be producing not less than 208W (80% of 260W). In case it fails to do so, it can be returned and changed. The reason behind this long warranty is that solar modules contains no moving parts and they are well protected against the weather conditions. Actually there are many solar panels installed decades ago, which are still working and generating electricity. For example, in 1984, Sweden's first grid-connected photovoltaic system was built in Stockholm. Since its installation, the 2.1kWh system has been continuously and reliably providing the residents of an apartment building with environmentally-friendly electricity. The modules' average annual power generation performance is still reliable — with no significant change since the system was installed 32 years ago. The Technical University of Berlin also has solar panels on its rooftop for 36 years and still in good conditions. (CleanTechnica. 2011) Bear in mind that technology has improved, solar panels have become more durable: if early solar panels produce electricity for far more than 30 years, what to expect of today's solar panels?!

The maintaining cost is minimal, operation cost basically does not exist. However, the inverters are advised to change in every 15 years. The average lifespan of a regular inverter is 11 to 14 years, and the warranties seem to reinforce this. Modern inverters however are believed to have 20 to 25 years, since more solid-state electronics are integrated in the inverters, meaning that they have less physically moving parts to worn-out. (HomePower. 2015) For the simplicity of the calculation, we will not calculate with the replacement of the inverter.

Let's see the numbers to calculate the ROR:

- The total cost of Fábián's HPVS is 4,148 EUR;
- We assume that Fábián's PV system continues to generate 4,380kWh/year, but his household continues to use only 3,000kWh/year;
- Assuming that Fábián generates 1.380kWh surplus in each year and the price/kWh of PV electricity paid by the utility – 0.08 EUR/kWh – does not change, he gains an income of 110 EUR/year;
- In case Fábián did not install a PV system and would be still buying the electricity from the electrical utility, he would pay annually 336 EUR for 3,000kWh; (0.112 EUR/kWh*3,000kWh)
- The 336 EUR is the amount of money Fábián saves every year, by not buying electricity from the utility. It can be listed as an annual income in our case together with the 110 EUR/year.

Now that the expenditure and the incomes are listed the rate of return (ROR) can be calculated:

$$\frac{4{,}148\ EUR}{336\ EUR + 110\ EUR} = 9.3\ years$$

As shown above Fábián's investment will pay-off in roughly 9 years. It means that basically from the 9th year it is generating free electricity with a profit of 110 EUR/year for at least for the next 16 years. Moreover, it saves the 336 EUR electricity bill for Fábián. The ROR is 10.7%, meaning that for 9.3 years 10.7% of the total investment is payed off annually.

To conclude this chapter, it is obvious that a Home Scale Photovoltaic System has a long term pay-off period in Hungary, however not that long that it could not be realized. To compare with in Germany, the pay-off period is even shorter for PV systems, mainly for three simple reasons: the price/kWh paid for electricity is higher than in Hungary, but the feed-in tariff is also higher, while the investment of a similar 2kWh system is about the same cost as in Hungary. Investing in photovoltaic system becomes profitable in the 9th year and remains so for many years, even decades.

3.4 Producers and customers

This subchapter centers around the solar module producers and their customers in Hungary. The production and/or assembly of solar modules and systems is mainly done by PV companies in the country. As the market is small, most of the companies are Hungarian-owned. The customers are coming from the residential, commercial and public sector as well.

In chapter 3.1 Figure 6 was presented, where the amount of HPVS was shown in three different capacity category. It was clear that there are plenty of costumers in all three HPVS category size.

On the other hand, Figure 7 showed that despite having fewer customers in the 10 – 50kWh category, when looking at the total capacity, this category has the most installed capacity. This means, that throughout the year customers ordering a PV system between the size of 10 – 50kWH might be fewer, but they pay more, since their ordered PV system contains more solar modules, materials, more firemen switch and bigger inverters. Clearly they spend more on PV systems than families. Basically these "big fish" investors are the main target group of photovoltaic companies in Hungary, as they represent more income per job for the company.

The previous situation is the result of the fact that in Hungary residents willing to invest in photovoltaics can expect no governmental support, incentives or tax reduction. Without these measure the investment is simply too costly for regular citizens. In fact, the residential – and also the commercial – sector have been supported only by the European Union, but the financial support the country receives from the EU is mainly handled by the government. The current and previous governments did not have the policy – or simply was not their interest – to support the renewable market and as a result it never made the funds – provided by the EU – available for the residential and commercial sector. The last call for applications for photovoltaic installation available for residents was in 201. Withal, the provided financial resources were evanescent and the application was open for only 36 hours.

While the European Union's financial support might not reach the residential and commercial sector's individuals willing to invest in photovoltaics, it reaches the public sector. As pointed out in chapter 1.1, the Partnership Agreement signed between the European Commission and Hungary back in 2013 contains a target in terms of renewable energy: by 2020 14.65% of the total energy consumption of Hungary has to be provided by renewables. The current government aims to reach this target by providing financial support only to the public sector. This policy has two contradictory results.

First of all, more and more public institutions, schools, hospitals, governmental building are being equipped with solar panels. According to Mr. Ernő Kiss, this contributes to the overall market growth, but only slightly since it is the private sector where most of the capital is located. These projects are financed by EU funds and are spent to meet the 2020 renewable target, which is a good sign after all.

Secondly, not making available the EU funds meant to promote renewable energy is hurtful not only to Hungary but to the EU's long term goals as well: the Union's 2020 target of total renewable energy is 20%. In fact, the annual report from the European Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of Regions on renewable energy progress found that Hungary might face difficulties in achieving its 2020 renewable energy targets (European Commission, 2015, p. 5). It is only under optimistic assumptions related to the future development of energy demand and specific financing conditions that the 2020 renewable energy targets appear achievable. (European Commission, 2015)

Hungary's goal is 14.65% of renewable energy from total energy consumption. When the Partnership Agreement was signed in 2013, Hungary's share of renewables was 9.5%, but by the end of the year it rose to 10.2, as shown in Figure 10. Since then it has been constantly but slowly growing. By taking a closer look on the year 2016 and 2020, the figure makes it visible, just how much the country would need to invest in renewable energy sources on order to reach its target and to contribute the EU 20% target. An exponential growth should be required to be back on track.

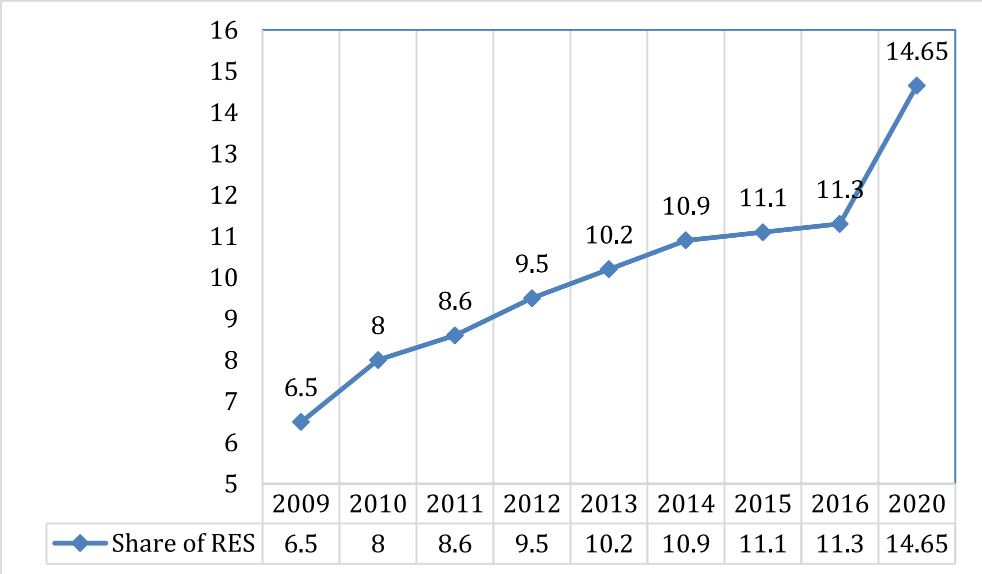


Figure 10: Share of renewable energy from total energy capacity in Hungary with the 2020 target (%)
Source: EurObserv'ER Report, 2015

As mentioned in chapter 1, there is a planned tender – called Otthon Melege Program (Warmth of Home Program) – what provides non-refundable governmental co-funding for civilians willing to increase the energy efficiency of their home. The program is planned to be available at the end of summer and is targeting the residential sector. Civilians can apply for EU funds, managed by Hungary to improve the energy efficiency of their home. The program is focusing not only on photovoltaics, but it is meant mainly for installation of solar collectors, replacement of doors and windows, modernization of heating and water system. The idea of the program would be adequate, however there are some controversies with the eligibility of the applicants.

- First of all, in order to apply you have to meet illogical requirements/specifications. One of these is that the specific house wished to be renovated has to be built no later than 1996, meaning that if your house was built around 2000 and you want to use this application to renovate your house in order to save on utilities' bill and be more efficient, you are not eligible to apply;
- Secondly, the more renovation you plan on your house, the more non-refundable financial support you receive. There is a minimum limit of three in terms of renovated items: you either choose to modernize the heating system, replace the windows and doors, or replace the windows, install solar panels and buy a new, energy efficient washing machine, etc. This might sound good at first hearing, however taking into consideration that in this year this is the only announced governmental program on energy efficiency, it should be more flexible and customer friendly: it is not likely that there will be many residents willing to invest more just to get more funds. Also, the less renovation you do, the less financial support you receive;
- The third controversy is that the available financial framework is 16 million EUR, what is enough for approximately 2,000 – 2,200 renovation of family houses (Kiss, 2016).

As a final remark on the program, it would be a good and important governmental initiative, if there were other applications separately and specific for PV systems, solar collectors, modernization of heating system and so on. Providing subsidies in a package with strict eligibility criteria only divides the target group into smaller parts and the ones who would be willing to invest in these technologies are left out.

Despite the fact that the Warmth of Home Program does not support the installations of PV system separately, it might have a negative consequence to residents who are thinking about investing in a PV system: they might have been waiting around for a governmental program like the current one, however realizing that they are not eligible, they might simply continue to wait one or two more years, hoping that a better suited program will come. However, based on recent events it is very unlikely that there will be any, in fact chances are that this is the last call for applications for residents in the coming years. In the next chapter the reasons behind this prediction will be explored.

Conclusion

The price of solar modules has decreased drastically over the past four decades, while their efficiency increased. There are plenty of manufacturers of solar modules, especially from Asia. The distribution channels are already developed and due to mass production it is very unlikely that suppliers could not meet the increasing demand for photovoltaics.

Solar module and inverter prices in Hungary more or less follow the global trends and it was only a matter of time until photovoltaics appear in Hungary. In 2007 the Act on Electric Energy was modified, making it possible for individuals to sell their photovoltaic generated electricity. By this mean, the Hungarian photovoltaic market took off on its controversial journey.

The example in Chapter 3.3.1 gave an idea about how much a regular HPVS in Hungary does cost, what is the pay-off period and rate of return. The result shows that despite having a longer pay-off period compared to Austria or Germany, it is still profitable on the long term to invest in a Home Scale Photovoltaic System. With the feed-in tariff, after the investment's pay-off period, it is generating pure profit, even in the case of smaller capacity systems. This gave a boost for investments and the photovoltaic market was doubling in size for several years. However, achieving these doublings was more or less easy, as during the beginning of a technology lifecycle, the early adopters prefer to try out and purchase the technology. This is the case with photovoltaics as well. In order to further support the spread of photovoltaics and its market development, it is essential to make it attractive for the early majority.

In case Hungary wants to achieve its 2020 goal, namely to have 14.65% of renewable energy from total energy consumption, an exponential growth should be required according to the report from the European Commission. Figure 10 showed how much the country need to grow in terms of renewable energy sources. Whether it will be achieved or not, it is not sure for now. In any case, chances are low, because as mentioned in Chapter 3.4 currently there is only one ongoing governmental program supporting the spread of photovoltaics. As concluded, this program is meant primarily for energy efficiency investments targeting the residential sector, but according to Mr. Ernő Kiss and based on the analyses of this research, it has several minor controversies, especially with the eligibility of the applicants. Moreover, it is not primarily focusing on the installation of photovoltaics, but they are only part of the program.

4. The Hungarian bottleneck

In the previous chapter the Hungarian photovoltaic market was discussed in terms of numbers: the different costs and rate of return of a HPVS were introduced together with a planned governmental program to boost the investments of home building's energy efficiency together with photovoltaics. Based on those data this chapter is going to concentrate on identifying the existing bottlenecks of the country's PV market.

There are two type of measures holding back the market development: administrative measures and governmental policies. Even with existing burdens, the market is growing, however it cannot be defined as a competitive one. There are several factors what make investing in photovoltaic systems in Hungary unattractive and risky. To start with, the relevant points of the Partnership Agreement is introduced, and how Hungary is handling the available funds meant to support the shift towards a low carbon economy. As a continuation of this subchapter the need – or needlessness – of EU funds for the residential and commercial sector will be discussed. Than the discrimination of Hungarian SMEs is introduced, followed by a nuclear power plant versus a PV power plant comparative analyses. The last subchapter focuses on the energy portfolio of the country in order to determine what role photovoltaics can play in the overall energy mix.

4.1 The Partnership Agreement between Hungary and the European Commission

The Partnership Agreement (PA) is set between Hungary and the European Commission on using European Structural and Investment Funds (ESIF) for growth and jobs in 2014-2020. It sets down the strategy for the optimal use of ESIF throughout the country. The PA covers five funds, forming together the European Structural and Investment Funds:

- The European Regional Development Fund (ERDF)
- The European Social Fund (ESF)
- The Cohesion Fund (CF)
- The European Agricultural Fund for Rural Development (EAFRD)
- The European Maritime and Fisheries Fund (EMFF)

The PA paves the way for investing 21.9 billion EUR in total for Cohesion Policy funding over 2014-2020, but Hungary also receives 3.45 billion EUR for rural development and 39 million EUR for fisheries and the maritime sector. The investments are meant to tackle unemployment and boost competitiveness and economic growth through support to innovation, training and education in cities, towns and rural areas. They also promote entrepreneurship, fight social exclusion and help to develop an environmentally friendly and a resource-efficient economy.

The PA focuses on the following five main national development priorities:

1. Improving the competitiveness and global performance of the business sector
2. Promoting employment through economic development, employment, education and social inclusion policies, taking account territorial disparities
3. Enhancing energy and resource efficiency
4. Tackling social inclusion and demographic challenges
5. Implementation of local and territorial development aimed at promoting economic growth

The 3rd priority is important for our topic, as it supports the increasing share of renewable energy sources in the overall energy structure (like biomass, wind and solar). The three main priorities are realized in 11 Thematic Objectives (TO). The 4th TO concentrates on supporting the shift towards a low carbon economy in all sectors and uses the European Structural and Investment Funds to tackle the challenge. Table 4 shows how much ESI Funds are meant to support the TO4 goals. The budget is separated in the five funding programmes. The 2.8 billion EUR is meant for supporting the TO4's objectives in all sector, including energy and resource efficiency measures and investment in renewable sources as well. On the other hand, the overall financial contribution purely to renewable sources are 1 billion EUR. This is divided between wind, solar and biomass, and supports the investments in the residential, commercial and public sector as well. (European Commission, 2014, p. 4)

Table 5: TO4 budget structure and contribution to the growth of renewable energy sources in EUR

	ERDF	ESF	CF	EAFRD	EMFF	Total
TO4 Budget Structure	1,425,387,797	0	845,597,151	532,278,345	5,000,000	2,808,263,293
Contribution to RES	188,863,883	0	845,597,151	0	0	1,034,461,034

Source: European Commission, 2014

We can see that plenty of funds are available, however they are used in an inefficient way. The funds provided by the EU are entrusted to the Member States, and it is up to the state how it distributes it. Of course, in the PA it has to be specified on what projects, how and when the EU funds will be spent. The expected outcomes are also mandatory to mention. In the case of Hungary, the biggest issue is with the distribution itself, since the funds are often not made available for the residential and commercial sector.

As mentioned in Chapter 3.3, the last invitation for photovoltaic program/application targeting residents was in 2011. The offered financial resources were evanescent and the call for applications was open for only 36 hours. Since then, no tender was available purely for PV system installation. Although the Warmth of Home Program is planned to open at the end of summer, it supports mostly energy efficiency investment, like modernization of the heating system, replacement of doors and windows. Solar panels are also part of the tender, but they are not in the focus. Moreover, it is very unlikely that any photovoltaic tender will be available in the foreseeable future (Kiss, 2016).

At the end of 2015 the Hungarian government announced that it will change the structure of Thematic Objective 4. TO4 basically provides EU funds for supporting the shift towards a low-carbon economy. EU Member States use these type of funds in three ways:

- To financially support the residential sector – through governmental programs using EU funds – with their investments in energy efficiency measures, renovation of existing buildings and installing renewable energy sources;
- To financially support the public sector by publishing call for tenders in order to find a service provider for a specific mission. The mission can be the same as in the residential sector case: investing in energy efficiency measures, renovating existing buildings and installing renewable energy sources. The main difference is that the buildings are owned by the government and the government is the customer.
- Investing in other cases, like maritime and agriculture related issues. This is however not the topic of this thesis, as a consequence it will not be discussed.

The new plan is to relocate a part of the TO4's EU funds meant for the call for applications, tenders and proposals of the renewable sector for the 2014 – 2020 period. The relocated funds would be used to achieve other policy goals of the government on other fields, like the development of ICT and road infrastructure. The government has already separated 480 million EUR from TO4 to continue the financial support of the public sector. This means that call for tenders will continue in the future and public institutions like hospitals, schools, municipalities will be renovated and equipped with photovoltaic systems.

In the same time the government has submitted a structural change request for TO4: it sent a petition to the European Commission asking for the relocation almost half of the TO4 budget. To start with, the government asked for the approval of relocating 508 million EUR from TO4, however it was denied by Brussels due to not being in harmony with the 2020 energy efficiency goals (Kiss, 2016). In 2016 as a second try it tries to enforce the relocation of only 289 million

EUR. In this case no decision has been made so far. (NRG Report. 2016) This act shows the governmental policy aim clearly, namely that it has no intention to make the TO4 budget available for the support of the renewable sector or for energy efficiency projects.

As a result, financial support for the residential sector would be relocated and the Warmth of Home Programme could be the last EU funded residential program supporting energy efficiency investments. Although this change sounds worrisome, if you think about it more, it does not really worsen the Hungarian photovoltaic market, as in the financial framework 2014 – 2020 there have been no EU funded residential programs supporting photovoltaics. As mentioned in Chapter 3.3, the program was 5 years ago in 2011 and even back then it was not residential-friendly: the provided financial resources were evanescent and the application was open for only 36 hours.

The fact that there has not been and will not be proper programs using EU funds to support not only energy efficiency measures but the spread of renewable energy sources like photovoltaics show that the TO4's objectives are not part of the government's current policies. From a market point of view, not supporting the spread of renewables is an absolutely logical decision, since Hungary in 2014 – 2015 decided to expand its current nuclear reactor. If the project is executed, the country's current 2MWh nuclear capacity will be expanded with an additional 2.4MWh. As a result, the PAKS Nuclear Power Plant would have a total 4.4MWh capacity for at least two decades. Taking into consideration that Hungary's electricity demand is about 4.7 – 5.2GWh, the 5.5GWh capacity is enough to meet the country's average electricity demand. (MAVIR. 2016) In case the government were to support the spread of photovoltaics – and other renewables as well, it would create a competition to its own nuclear power plant project.

Currently it seems that only EU funds meant to support the spread of photovoltaics in the public sector will be used. The funds meant for the residential and commercial sector will be suspended and relocated. As a consequence, the residential and commercial sector have to finance their photovoltaic investments on their own, since no tax reduction and EU funds managed by Hungary are and will be available. For companies this might not be a serious issue, as they represent a greater purchasing power than residents, but the withdrawal of EU funds can still set back the photovoltaic market development.

4.2 The need – or needlessness – of EU funds for photovoltaic investments

The European Union provides funding for various projects and programmes in areas like regional and urban development, agriculture, rural development, research and innovation, etc. Since the introduction of these financial aids provided by the EU, funds are managed according to strict rules in order to ensure a transparent and accountable manner over how funds are managed and spent.

The European Commission has the ultimate responsibility for ensuring that the funds provided by the EU are managed properly by the national governments. On the other hand, responsibility for conducting checks and annual audits lies with the Member States. In the previous chapter the European Structural and Investments Funds (ESIF) was already introduced: it combines the 5 big funds meant to implement the Europe 2020 strategy. (European Union. 2015) With the help of this financial aid Hungary is meant to fall into line with other more developed Member States.

The European Union funds are the foundation of growth. The need and positive effects of the funds in Hungary – and in other less developed MSs – are unquestionable: they contribute to the increase of the national gross domestic product, without them several important projects meant to develop the ICT and transport infrastructure could not be realized. They support investments in education and training, promote social inclusion, etc. Without these external development resources there would be little to no growth and public investments in Hungary. However, when part of the funds meant to support the development of a specific sector are not used in an efficient way, it raises the question (besides several other important question) how can that sector survive and stay competitive on the long term.

In the previous chapter we already covered why EU funds meant to support the spread of renewable energy sources do not reach the residential and commercial sector. For the commercial sector the absence of funds supporting their PV investments is definitely a drawback. While a HPVS is not as costly as it used to be 10 years ago, it is still a capital sensitive investment. As GDP per capita and living standards in Hungary are below the EU average, only a small segment of the population is able to finance a HPVS investment. According to Mr. Ernő Kiss, the average age of the investors coming from the residential sector are 35 – 50 years, mostly representing a stable and well-doing financial background. This segment is able to invest without any monetary assist or call for applications. In the commercial sector the situation is similar. During the previous years no funds have been made available, as there is no call for proposal or proper tenders for what photovoltaic companies would be in the running or simply eligible (Kiss, 2016).

The EU funds are the foundation of growth, however too little from them is bad, but too much is just as bad. In Hungary most of the EU projects are overpriced and the distribution of EU funds is not efficient. It is not the interest of the authorities to tightly control the spending, so overpricing is basically hard-wired in the system. The usual topic surrounding the funds is whether the country can spend them entirely. On the other hand, the efficiency of the spending and the developments are pushed into the background (Transparency International, 2015, p. 15).

In Hungary the efficiency of development programmes is usually low. A good example for this is the area of governmental aids to enterprises. In the last 10 years, the country spent 2.7 times the EU average on grants to enterprises to enhance their competitiveness, however their competitiveness level remained far below the EU average. Moreover, the legislative environment and the administrative system is overcentralized. The distribution of funds for the residential, commercial and public sector are under the dominant coordination of the central power without any national supervisory body (Transparency International, 2015, p. 22). As a consequence, funds allocated to the development of specific sectors are used with very low efficiency, on the other hand they have a high exposure for corruption and they favour overpriced EU projects.

Knowing all this, it is no surprise that funds are not allocated efficiently and the photovoltaic sector does not receive proper support. EU funds if not handled properly can have a market distortion characteristic. According to Mr. Ernő Kiss what we can see in Hungary today is the absolute discrimination of photovoltaic companies and people willing to invest in HPVS. Based on past experience, even if there are call for tenders, without having the proper connection winning the tender call is little to no chance. The only effects EU funds have on PV companies in the sector is that those knowing the shortcuts and having the connections gain a dishonest competitive advantage. With these conditions it is a challenge so compete on the market and to stay profitable. Moreover, in most of the cases these companies do not own the required professional knowledge to execute a PV project in a time and resource efficient manner (Kiss, 2016).

To conclude this subchapter, it would be important to lower the corruption risks of EU funds in Hungary. In case there were absolutely no funds provided for the photovoltaic sector, it would have two results:

- The market would grow in a much slower pace, compared to other Member State’s PV market;
- But everybody would be more or less equal, as without unfairly distributed EU funds gaining a competitive advantage would require market knowledge and skills.

As Hungary’s PV market is not supported by EU funds properly, it already lacks behind other MS’s PV market. As the last sentence of this subchapter it is important to point out that the EU funds are not responsible for current market state, but their inefficient use at the MS level is.

4.3 The discrimination of SMEs

While photovoltaics are on the rise in the rest of the world, in Hungary the government are bottlenecking its spread with the relocation of EU funds from the Thematic Objective 4, with administrative means and with different fees and measures. Although the government's behaviour is understandable from its planned nuclear investment's point of view, the direct consequences of the bottleneck are placing the sector in a disadvantageous market position on the EU level.

In order to accelerate the spread of photovoltaics both the residential and commercial sector need to be supported. The residential sector should be supported by governmental incentives and/or call for application, aiming to support financially their investments. During previous chapters it has been concluded that no such incentives and/or call for applications really exist in Hungary. Despite this, the residential sector is still installing photovoltaics on their rooftops, but in a much slower pace compared to regional neighbours where incentives are available.

The commercial sector can install photovoltaic systems, but can also be the installer. In Hungary there are numerous SMEs on the market providing HPVSs from manufacturing the solar modules through designing the system parameters until the actual installation. These companies contribute mostly to the growth of the Home Scale Photovoltaic Systems. They rarely participate in projects consisting of Small Scale or bigger photovoltaic systems, as these projects are mostly aiming public institutions (Kiss, 2016). Due to this, these projects are mostly managed by the government, starting from the tender announcement and contract notice until contract awarding and the contract signature.

The Hungarian photovoltaic companies are dealing mostly with HPVSs, however according to Mr. Kiss companies are discriminated by the governmental measures and policies, as they are completely put into a disadvantageous market position. There are six factors what contribute to the discrimination of SMEs in Hungary: (24.hu. 2016)

- Solar module product fee
- Firemen Switch
- Lack of call for applications for the residential sector
- Lack of financial support for renewable energy sources (RES)
- Lack of Renewable Energy Act
- High VAT

Below these factors are discussed more in details, however bear in mind the some of them have been already mentioned in previous chapters.

Solar module product fee

In chapter 3.2 it was already mentioned that in Hungary solar modules produced in Hungary are equipped with a product fee. This product fee is the highest product fee in the European Union: it is 0.36 EUR/kg. This fee is almost 6 times higher than the second highest product fee in the EU: in Belgium the fee of solar modules is 0.07 EUR/kg. An ordinary solar module weights around 17kg., meaning that for a solar module it is 6 EUR. In Hungary this represent almost 3% of the total cost of a single solar module.

Although from the total investment cost of a 2kWh HPVS the product fee represents only 1% of the total investment, it is still inexplicably high fee. For example, batteries have a product fee of only 0.18 EUR/kg. Moreover, while solar modules contain no chemicals or have toxic parts, batteries are made from a variety of chemicals to power their reactions. Some of these chemicals, such as nickel and cadmium, are extremely toxic and can cause damage to humans and the environment. In particular, they can cause soil and water pollution and endanger wildlife. (Forbes. 2016) Knowing these, it would be logical to tax batteries with a higher product fee, rather than do it with solar modules.

It is important to stress, that solar modules manufactured and completed in other countries and shipped to Hungary are not subject of the product fee, but only solar modules manufactured in Hungary.

Firemen Switch

The Firemen Switch basically cuts the circuit, disconnects the cable between the modules and the inverter, so the firemen cannot be electrified during fire-fighting. The installation of a Firemen Switch in Hungary is mandatory. It cost 635 EUR and it represents the 15% of the total investments. The deal with the Firemen Switch is that for each 5kWh capacity photovoltaic system one switch is needed. Ergo the more the capacity the more is needed.

At first hearing it sounds as an important part of a PV system. It can be. However, according to Mr. Kiss if proper technical solutions are applied to the PV system, the Firemen Switch can be substituted and as a result taken out of the system. In many countries around the world, including USA and Austria, the use of a Firemen Switch is not even mandatory. In fact, is some cases it can be the cause of the fire: in Australia the Firemen Switches were held responsible for home fires in so many cases, that the government banned the use of them in photovoltaic systems (Kiss, 2016).

Going back to the example of Fábián's 2 kWh HPVS, if the Firemen Switch would not be mandatory to install, then the total cost of the investment would be 3,513 EUR instead of the 4,148 EUR. The pay of period would be 7.9 years instead of 9.3 years with 12.6% ROR instead of 10.7%. Therefore, removing the Firemen Switch as a mandatory part of the photovoltaic systems could boost the investments significantly in Hungary.

Lack of call for applications for the residential sector and financial support for RESs

Basically the EU funds meant to support the spread of renewable energy sources, including photovoltaics. Due to governmental policies and other priority areas, these funds are not made available to the residential and commercial sector, there are no applications and tenders, however if there are any, then the funds are distributed inefficiently.

Without proper financial support for the residential sector, individuals will not invest in photovoltaic system. If there are no investments, the SMEs do not get orders and hence their income goes down. Not making the funds available for the residential sector can be considered as an indirect discrimination of photovoltaic companies in Hungary. As a result, the competitiveness of the sector is at stake, since other SMEs in the region's countries do not face similar barriers.

Lack of Renewable Energy Act

In most EU countries there is a feed-in tariff for renewable electricity: basically if a household generate PV electricity but it is not consumed by the household, the surplus electricity can be sold to the electrical utility.

In Hungary the feed-in tariff for photovoltaic electricity is specified at an annual basis. While most of the Member States have a Renewable Energy Act, in what the feed-in tariff is set for a specific period of time, Hungary does not have one. Since 2010 it is planned to enact the Act, however so far it has not been realized. The role of the Renewable Energy Act would be, that it guarantees a minimum feed-in tariff for electricity generated from renewable energy sources, and sets up a subsidiary scheme with incentives for several years ahead. The first Renewable Energy Act was ratified by Germany and soon other member States followed its example, including Bulgaria and Slovakia (Kiss, 2016).

Without a Renewable Energy Act the feed-in tariff is set on an annual basis and it can change drastically if circumstances require that. The absence of a proper legal framework, investments in the photovoltaic sector cannot be considered as a safe investment on the long term, since there is no legal environment protecting them on the long term. Remember that a photovoltaic system can produce electricity for at last three decades. Today in countries with proper Renewable Energy Act, it is a safe and profitable choice to invest in photovoltaic systems. Residents can install HPVS, but companies can decide to install a Small Scale PV system, like 2MWh to sell electricity for the surrounding buildings.

Due to the lack of a proper Renewable Energy Act in Hungary, investments from the commercial sector (companies installing 500kWh and bigger PV systems) are not realized. This has a negative effect on photovoltaic SMEs as without the Act, bigger investments are not happening. The relocation of TO4 funds is a sinister sign, showing that a Renewable Energy Act is not on the government's schedule.

High VAT

Hungary has the highest VAT in the European Union, 27%. The second highest Denmark and Sweden have with 25%. The lowest Luxemburg has with 17%, the second lowest Germany with 19% (European Commission, 2016, p. 3).

Due to the high VAT it is already a challenge to stay competitive on the Hungarian market, not to talk about when a company plans to export its product or service to other markets. Without receiving any funds or tax relief residents have to pay a high price for their photovoltaic system. Photovoltaic companies are also subject of the 27% VAT. According to Mr. Kiss, many photovoltaic SMEs in Hungary choose to avoid taxes by not doing black work. This way the customer and the implementer company benefits as well, since they both can avoid part of the 27% tax. On the other hand, this behaviour does not favour companies that are operating legally by obeying the law and paying the taxes, as they are put in a disadvantageous position on the market.

It is important to stress, that solar modules manufactured and completed in other countries and shipped to Hungary are not subject of the product fee, but only solar modules manufactured in Hungary.

The existence of the high product fee and the high VAT are convincing enough to a customer in Hungary to order a complete photovoltaic system from another country, then only purchase the assembly of the system from a local company. Recently more and more of the 10kWh and above capacity photovoltaic systems are being purchased from Austria. In this was the customer pays the local 20% VAT and the 0.05 EUR/kg product fee (Kiss, 2016).

It is obvious that there are many barriers, holding back the development of the Hungarian photovoltaic market. One of those is that the government's outdated electricity generation policy does not take into consideration international tendencies and as a consequence Hungarian companies cannot compete efficiently with neighbouring countries' companies. Moreover, as pointed out in previous chapters, the governmental policy does not support renewable energy sources mainly because it is investing in nuclear. The next chapter is going to analyse whether it is a good decision to invest in nuclear from a financial point of view.

Conclusion

Throughout this chapter the bottlenecks of the Hungarian photovoltaic market were analysed. It can be concluded that several of them exist and together are held responsible for not only the discriminations of SMEs, but for the inefficient distribution of EU funds.

The Partnership Agreement between Hungary and the European Union provides the country with the necessary financial means to develop its market. The PA consists of 11 Thematic Objectives, each with different objectives. TO4 is set to support the shift towards a low carbon economy. Part of the funds provided by TO4 are meant to pave the way for the spread of renewable energy sources. However, in Hungary these funds do not reach their target group: residents and companies. The most serious bottleneck of the market is that the government does not make these funds available for the residential sector: there are no call for applications, there are no ongoing governmental programmes targeting the photovoltaic market. Basically the installations of HPVSs are financially not supported. In case residents in Hungary decide to invest in a photovoltaic system, they can expect no tax reduction, no financial support or governmental incentives. In fact, the Hungarian government has submitted a structural change request for TO4: it sent a petition to the European Commission asking for the relocation half of TO4's budget. The

European Commission denied the relocation of 508 million EUR. However, this simple act shows the governmental policy aim clearly, namely that it has no intention to make the TO4 budget available for the support of the renewable sector or for energy efficiency projects.

Besides not making the European Structural and Investments Funds meant for the renewable energy sources available, players of the commercial sectors, the SMEs are also discriminated. First of all, if homeowners from the residential sector are not supported in their investments by incentives, then it is very unlikely that photovoltaic companies are going to have lots of work. If companies do not get orders, they lose income and their operations become unsustainable on the long term. Secondly, there are several administrative measures that make the efficient functioning of photovoltaic companies cumbersome, like the high product fee, the need of Firemen Switch and mostly the high VAT. Another issue SMEs faces in Hungary is the high corruption. Hungary has one of the most overpriced EU projects, but generates on of the lowest efficiencies. The renewable energy sector is no exception of this: funds are not allocated efficiently, applicants for tender calls are not on the same playing field. This raises the question whether inefficiently distributed EU funds are needed for the Hungarian photovoltaic market or not due to the fact, that in their current state they do create inequality among photovoltaic companies

5. Paks II Nuclear Power Plant versus Photovoltaic Power Plant

This chapter is structured around a comparative analysis to compare the investment cost of the planned PAKS II Nuclear Power Plant with a Photovoltaic Power Plant. With the outcomes of this comparative analysis it can be determined which project would be a logical decision in terms of investment cost to invest for 40 plus more decades.

Before going into the details, it is important to mention that the costs used during the analyses are estimated costs, meaning that in reality they might differ, however the disparity are not significantly large. The goal of this comparative analysis is not to calculate the exact investments cost of the two projects, but to try to roughly estimate them. By getting the estimated investment costs an intuitive decision making can be done to determine which project would be more beneficial on the long term. In this case *long term* means 40 and more years.

The structure of this chapter is as follows:

- First the two separate projects are introduced with the relevant background information;
- Secondly the investments cost of the two projects are calculated, then compared with each other;
- Thirdly a conclusion is given based on previous results. In this phase other parameters are also taken into consideration, because simply calculating the investment costs cannot be the decisive parameter. Other factors like lifespan, electricity storage, environmental effects should also be considered when concluding this chapter.

5.1 PAKS II Nuclear Power Plant

First of all, let's review what is already known of PAKS II. The reason for building, or more precisely expanding the current nuclear reactor is that its cores are planned to be decommissioned between 2032 – 2037. Currently PAKS has 4 core, each capable of producing 500MWh electricity. Twenty years later, when these 2,000MW cores will be shut down, Hungary will have to replace the 2,000MWh capacity with something in order to meet electricity demand. It was decided that it will be replaced with two nuclear core, each capable of producing 1,200MWh. This project is called PAKS II

Construction of PAKS II is expected to start in 2018 – 2019 and commissioning is expected in 2025 – 2026. Even if delays occur – what often happens in nuclear projects – it is safe to say that by 2032 the power plant would be operational. The PAKS II project received many criticisms from associations, national and international NGOs and the European Union. The reason for this is that as a result of the 2011 Fukushima nuclear disaster, many countries around the world, including most of the EU Member States decided to support the spread of renewable energy sources as an attempt to replace nuclear. The most radical shift is taking place in Germany, where the government not long after Fukushima decided to shut down most of its nuclear reactors (10 exactly). In fact, Germany managed to change its power supply scheme and electricity portfolio in such a short time, that on good days like 11th of May, 2016, renewables supplied 90% of the country's electricity need. On less good, average day it is a minimum 26%. (The Guardian. 2016)

Germany is not the only example: Austria, Denmark, Spain, France, Romania and Slovakia also invested heavily into the renewable sector and are on the way to change their power supply scheme and electricity portfolio. Among Member States it is only the UK and Hungary who are planning to build new nuclear power plants. Due to the previously presented facts, it is obvious why the PAKS II nuclear project – together with UK's Hinkley Point project – receives so many criticisms from so many.

The advantage of PAKS II is that it could be generating electricity for at least 40 years, but probably for 60 with proper maintenance and upgrade. (MVM PAKS II. 2016) The disadvantage is that it is costly: the project cost 12.5 billion EUR. The high investment cost means that the electricity it produces will also be costly. However, most probably the produced electricity by PAKS II will be supported by tax reduction and monetary assistance in order to have a competitive electricity price. It would not be a new phenomenon, since until today the oil industry is still subsidized by governments worldwide. (Oilprice.com. 2015)

Besides the investment cost, significant maintenance costs are also expected, since the control rods – responsible for the controlled nuclear reaction – are needed to be changed regularly. Moreover, following the decommissioning of the reactor, the nuclear waste need to be handled: they are usually buried deep under the ground, from where the radiation cannot reach the living habitats. The nuclear waste management can be costly and dangerous; however nuclear power is the only large-scale energy-producing technology which takes full responsibility for all its wastes. (World Nuclear. 2015)

In any cases the project is costly: not only the initial investment cost is high, but throughout its lifespan and following its decommissioning it requires financial support and measures.

5.2 Photovoltaic Power Plant

Following the introduction of PAKS II let's have a look at the opponent, a Photovoltaic Power Plant. Conducting this comparative analysis is not an easy challenge due to the fact, that PV electricity generation is more flexible compared to other electricity generation methods. Under the word *flexible* is meant, that there are two choices:

- Build several PV plants which together add up 2,400MWh;
- Or simply support the residential sector so they will build Home Scale Photovoltaic Systems for themselves.

What is known for sure is that by 2030 the latest, 2,400MWh of electricity should be generated from photovoltaics. PAKS is decommissioned, PAKS II never happened. As a result, at least 2,000MWh electricity is missing from the national electricity portfolio. It was decided to meet the demand by photovoltaics.

To keep things simple, the first option is chosen: to build several PV plants with a total capacity of 2,400MWh.

The disadvantage – if not the only one – of photovoltaics is that after sunset, they do not generate electricity. Although there are advanced batteries to store electricity on a large scale, their technology need another 10 years before it can be competitive on the market and affordable for large scale investments. (Alternative Energy News. 2016)

The solution for this matter is to structure the country's electricity portfolio according to the best use of photovoltaics. Based on this scenario, during the day when the sun is up, solar modules are generating around 2,000 – 2,400MWh of electricity, while after sunset coal-fired power plants, wind turbines, natural gas -, incineration- and biomass plants would supply the electricity until the sun rises again. In case the PV power plants could not generate enough electricity (2,000 – 2,400MWh) during daytime, these power plants would kick in to help.

With this scenario half of the country's daytime electricity need would be met by photovoltaics. The other half of the electricity demand would be met by coal, natural gas, incineration plants, biomass and wind. In fact, in Hungary the situation is similar today. Figure 11 shows how the electricity portfolio was structured in 2015. It shows that half of the electricity is generated by fossil fuels, like coal and gas. In fact, even in Germany the share of fossil fuels is 74.6%, while renewables are 25%. (Bundesministerium für Wirtschaft und Energie. 2015) Germany also restructured its electricity portfolio in order to adopt its enormous 40GWh (40,000MWh photovoltaic capacity compared to Hungary's 137MWh) capacity photovoltaic market: during daytime photovoltaic power plants supply electricity, while after sunset fossil fuel based, incineration and biomass power plants take over to make up the supply lost.

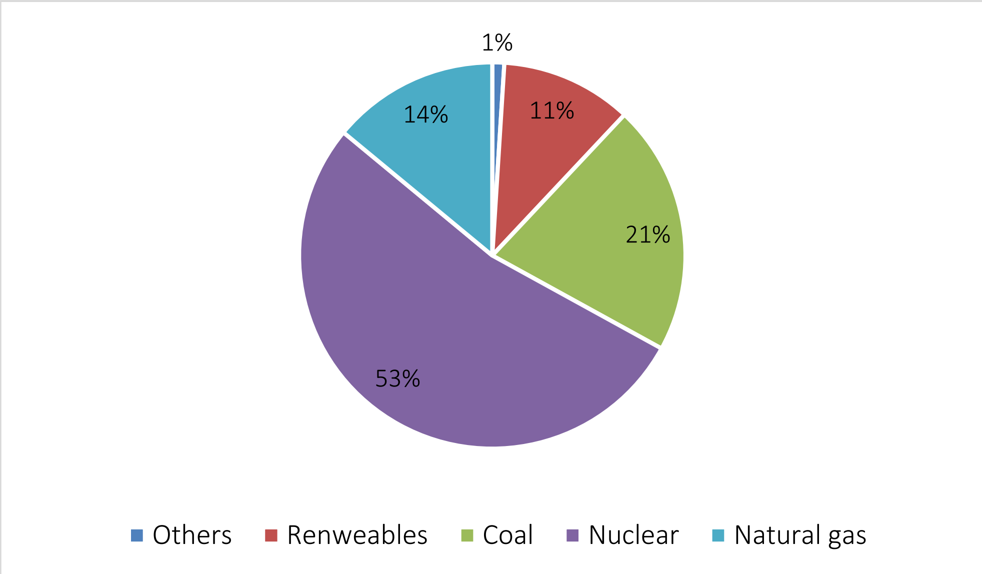


Figure 31: Primary energy sources of electricity production
Source: Hungarian Energy and Public Utility Regulatory Authority, 2016

As mentioned previously, Germany closed and decommissioned 10 nuclear power plants right after Fukushima and managed to replace half of them with renewable sources, mostly with photovoltaics and biomass. Hungary is planning to decommission only one nuclear power plant, but only in mid-2030. By 2030 the photovoltaic technology will most likely become more developed and the PV market more mature, meaning that in the foreseeable future solar modules will become even more cheaper and efficient. However, in the current case the PAKS II project is expected to start around 2018, meaning that existing costs for photovoltaics have to be used to calculate the project's financial need.

5.3 Comparative analysis

In chapter 5.1 the investment cost of PAKS II was already mentioned. As of 2016, the project costs 12.5 billion EUR. This information is clearly given, since the project exist in the real world in Hungary. The costs are also calculated in according to the Hungarian market conditions.

On the other hand, the 2.4GWh Photovoltaic Power Plant project does not exist. As a result, no clear investment cost for a project like that exist, nor is calculated, especially not according to the country's market conditions. In order to overcome this barrier, an estimated project cost will be calculated based on a previous photovoltaic power plant project realized in Hungary.

In chapter 3.2 two PV power plants, built in the last two years were mentioned: the Pécs and Mátra Power Plant. It was discussed that the Pécs Power Plant was subsidized in 100% by EU funds. However, in chapter 4.2 it was also mentioned that a report on *The Corruption Risks of EU Funds in Hungary* found that in Hungary most of the EU projects are overpriced. The reasons were also mentioned, mostly that the government's structure is overcentralized and it lacks a proper supervisory body when it comes to the efficient distribution of EU funds. On the other hand, the Mátra Power Plant project was realized by a German company operating in Hungary, and it was 100% privately funded. This means that in the Mátra project the cost of the project was based on market prices and there was no reason to overprice it as in an EU funded project.

To verify whether the Mátra project was more cost efficient or the Pécs project, in Table 6 it was calculated which project was able to install 1kWh of electricity on a more competitive cost. The calculations were made based on the Rule of Threes. The result shows that in Pécs' case 1kWh costed 1,600 EUR, while in Mátra's case it costed only 1,242 EUR. Therefore, the project cost of the Mátra Power Plant will be used in the comparative analysis.

Table 6: Competitiveness of project pricing

Pécs Photovoltaic Power Plant		Mátra Photovoltaic Power Plant	
16 million EUR	10,000kWh	20.5 million EUR	16,500kWh
1,600 EUR	1kWh	1,242 EUR	1kWh

Source: Author, 2016

In Table 7 – again with the help of the Rule of Threes – it was calculated how much a 2.4MWh PV power plant costs based on the project cost of the Mátra Photovoltaic Power Plant. The result shows that a 2.4MWh capacity PV power plant investment cost inHungary is 3 billion EUR. Again, this number is a rough estimation based on Mátra project's cost. In reality chances are that the cost would be even lower due to economies of scale. Economies of scale is the cost advantage that arises with increased production volume. In this case it means, that the bigger the investment is, the lower the price is.

Table 7: Assumed investment cost of a 2.4MWh photovoltaic power plant based on the Mátra Photovoltaic Power Plant project cost

Mátra Photovoltaic Power Plant	
20.5 million EUR	16.5MWh
3 billion EUR	**2.4MWh**

Source: Author, 2016

Table 8 includes the two project's relevant characteristics: their capacity, investment cost and cost efficiency, and expected lifetime. The capacity is the same. By looking at the investment cost it can be concluded that PAKS II costs four times more than the equivalent Photovoltaic Power Plant does. It is no surprise, especially since a nuclear reactor requires refined uranium, huge amount of water and building construction (steel, concrete), not to even mention the several safety measures its operation requires. On the other hand, a Photovoltaic Power Plant requires simple frames to hold the modules, cables, several inverters and huge amount of solar modules. None of these represent a danger to their surroundings. In case of an earthquake or any type of attack a PV plant cannot cause any damage to the environment. The structure of a photovoltaic plant is simple and easy to construct. Moreover, while the construction of a nuclear plan can last for several years, most of the PV plants until the 250MWh capacity are constructed in less than a year (International Finance Corporation, 2015, p. 11).

Due to the differences in the investment costs, the price/kWh also differs: in case of the nuclear project 1 kWh cost 5,208 EUR to build, while in case of the PV project it cost 1,736 EUR. This significant difference affects heavily the electricity price the power plants will be charging on their customers: while the photovoltaic electricity will have a low tariff without any monetary assistance from the government, nuclear electricity will require financial support to stay competitive. This raises concerns with the competitiveness of the nuclear electricity on the long term, since photovoltaics are becoming more and more competitive. Based on the US Energy Information Administration's analysis and projections, by 2020 PV electricity will be less expensive then newly constructed nuclear power plant's electricity. By 2020 it is forecasted that 1kWh PV generated electricity will cost 0.062 EUR, while newly constructed nuclear plants will be generating 1kWh for 0.113 EUR (International Finance Corporation, 2015, p. 177)

Table 8: PAKS II vs. its assumed equivalent Photovoltaic Power Plant

	PAKS II Nuclear Power Plant	Photovoltaic Power Plant
Capacity	2,400MWh	2,400MWh
Investment cost	12.5 billion EUR	3 billion EUR
Price/kWh	5,208 EUR/kWh	1,736 EUR/kWh
Expected lifetime	60 years	25 years

Source: Author, 2016

In case the photovoltaic electricity can successfully be integrated to Hungary's electricity portfolio, the Photovoltaic Power Plant is a preferable choice, both from a financial and environmental impact point of view. On the other hand, Table 8 also mentions the expected lifetime of the power plants. PAKS II has its unquestionable advantage, namely the 60-year lifespan. It means that with proper maintenance the power plant can generate electricity for six decades. On the other hand, at photovoltaic power plants the source of the electricity generation – the solar modules – have a shorter lifespan.

Today the majority of manufacturers offer a 25-year standard solar panel warranty. This is not a 100% warranty for 25 years, because the manufacturer only guaranties that the power output of a single module should not be less than 80% of rated power after 25 years. Basically after 25 years, the photovoltaic power plant's efficiency will decrease by 20%. According to Mr. Ernő Kiss this does not necessarily mean that it will be producing 20% less electricity, since a power plant generates electricity based on the hours of sunshine.

Most importantly the question raises: what will happen to solar modules after 25 years? Truth is it is not really known so far. There are not enough corresponding data available, since the technology is relatively new and it is still developing rapidly (Kiss, 2016). Moreover, the vast majority of the photovoltaic plants were installed during the last 10 years.

However, from what is seen far, there is reason to be excited:

- The world`s first modern solar panel still works after 60 years;
- A 33W solar panel (Arco Solar 16-2000) actually outperformed its original factory specifications 30 years after it was manufactured (remember that today's standards for solar panels are 260W);
- Kyocera – a Japanese world leading manufacturer of innovative solar power solutions – has reported several solar power installations that continue to operate reliably and generate electricity even though they are nearly 30 years old. (Energy Informative. 2014)

The previously presented data show that even if the efficiency of solar modules decreases on the long term, they will probably still outperform the manufacturer's original expectations even after 30 years. The technology is continually improving, meaning that more durable panels are being manufactured. Last but not least, due to the differences of the investment costs, after 30 or 40 years the Photovoltaic Power Plant's old solar modules can be replaced with new, more efficient one. Due to the fact, that today's PV power plants do not require monetary assist from the government during their lifespan – only during the lifespan –, a Power Plant during its lifespan can create the financial reserves needed to upgrade its solar modules by time.

Conclusion

Throughout the chapter the advantages and disadvantages of the planned PAKS II Nuclear Power Plant and an equivalent capacity Photovoltaic Power Plant were introduced. They were analyzed in terms of investment cost, cost efficiency, environmental impact and longevity.

The main result of the chapter is that on the short and even on long term, photovoltaic have the clear advantage over nuclear. A photovoltaic power plant does not require monetary assist from governments in order to stay competitive on the electricity market. On the other hand, nuclear power generation requires and PAKS II would certainly do, due to the fact that its price/kWh is three times higher than the analyzed photovoltaic electricity price in this chapter.

Moreover, based on market forecast, it is expected that photovoltaic price/kWh will have a stable 0.062 EUR/kWh by 2020, while nuclear electricity is expected to have 0.113 EUR/kWh. The difference is significant, but it is already visible even on the level a simple comparative analyses as the previous was. The maintenance cost of the two plants were not taken into consideration, but since photovoltaics do not require any additional fuel after construction, probably it has a lower maintenance cost compared to nuclear. Remember nuclear require control rods to control the core's nuclear reaction. These rods are changed regularly and are classified as nuclear waste due to their high radiation. A solar module at the end of its lifespan do not face similar problem.

To conclude Chapter V, it can be said that from a financial and environmental point of view replacing PAKS' 2,000MW would be better to do with a photovoltaic capacity, rather than to invest in an aged and costly technology, like nuclear. Beside the cost analysis, it is not a personal conclusion, since several developed countries – like Germany, Austria, Spain, France, USA – are doing the same (EurObserv'ER, 2016, p. 72).

6. Conclusion

This research took place in order to answer the main research question of "What measures need to be taken to strengthen the spread of photovoltaic electricity in Hungary". The research question was formulated due to the fact that the Hungarian photovoltaic market lags behind not only on an EU level, but on a global level. The lagging on normal circumstances would not occur, since the country's geographical position is favorable for photovoltaic electricity generation. Moreover, Members States with similar economic capabilities and performance are progressing with the market development on more a satisfactory level. Meanwhile the Hungarian photovoltaic market is bottlenecked by several administrative measures in order to prevent the spread of not only photovoltaics, but generally speaking the renewable energy sources in Hungary.

In order to introduce the reader into the topic of photovoltaics and its market, the research work concentrated on analyzing the applicability of photovoltaics in Hungary, the market characteristics, use of EU funds and competitiveness of photovoltaic SMEs. Based on these focus areas, the following sub-questions were formulated:

- How did the Hungarian photovoltaic market perform over the past few years?
- What role European Structural and Investment Funds play in the Hungarian photovoltaic market performance?
- How are photovoltaic SMEs discriminated in Hungary?
- What measures need to be introduced/removed in order to support photovoltaic investments in the residential sector?
- What role can photovoltaics play in the country's electricity portfolio?

Below the findings of these sub-questions are presented.

As mentioned in Chapter III, the Hungarian photovoltaic market exists since 2007, when the Act on Electric Energy was modified due to the spread of photovoltaics on a global level. The price/Watt has dropped significantly throughout the year, resulting in the exponential growth of the global photovoltaic market. Since 2008, the Hungarian PV market experienced significant growth, mostly doubling in size each year. However, when compared to other countries market like Romania, Slovakia and Austria, the growth rate is low: the market is not growing in a proper pace. Chapter 3.2 presented up-to-date data about the HPVSs growth and even in that early stage of the research it could be suspected that the residential sector is not supported in their photovoltaic investments.

Although governmental incentives in Hungary do not exist, those who ultimately decide to invest in this costly way of electricity generation, can expect a competitive feed-in tariff for their produced surplus electricity. However, do to the low electricity prices in Hungary, the pay-off period of a regular HPVS is 10 years. Compared to this, in Germany a PV system pays off in 5-6 years. The bright side is, that after the initial pay-off period, electricity bills are the past and a profit – considerably low – can be gained by each years.

The controversial nature of the unbacked residential photovoltaic investments in Hungary is that the Partnership Agreement between the European Commission and Hungary for 2014 – 2020 distributes EU funds for the support of the Hungarian renewable energy sector, including photovoltaics. The PA's Thematic Objective 4 utilizes European Structural and Investment Funds in order to distribute a part of 1.03 billion EUR via call for applications, call for proposals and call for tenders. However, as presented in chapter 4.1, these calls are not realized, instead the government plans to relocate the funds to support the growth of other sector, like ICT and development of road network. In case the European Commission approves the relocation of funds, the Hungarian residential and commercial sector cannot expect any call for application supporting photovoltaic investments in the foreseeable future. The commercial sector is likely to suffer similar fate.

While the residential and commercial sector cannot expect EU funds to support their photovoltaic investments, projects in the public sector are likely to follow. The reason for this is that Hungary has to achieve its 2020 goal in terms of share of renewable energy in total energy consumption, 14.65%.

Chapter V covered in short the topic of corruption in Hungary. Based in International Transparency Hungary, EU projects are heavily overpriced in Hungary, while their efficiency is among the lowest. As a result of the uneven level playing field, the commercial sector is heavily discriminated when it comes to call for tenders and proposal. The discrimination of SMEs reveals itself not only by the fact, that photovoltaic companies receive no financial assist or incentive to spread the technology, but they also face several administrative barriers. The two most serious administrative barriers are the extremely high VAT and the seemingly low, but illogically high product fee for solar modules. Due to the 27% VAT and 0.36 EUR/kg product fee, Hungarian photovoltaic companies cannot compete with neighboring countries PV companies. In fact, there are already project which are being realized in Hungary by Austrian PV companies due to their more favorable VAT and product fees. The difference in the project cost are enough motivation for Hungarian individuals to order their PV system from abroad. The Firemen Switch, as a mandatory part of the PV systems in Hungary are also bottlenecking the system, since in most countries the use of is optional. In fact, Australia just banned the device, since it was responsible for several fire cases. As Mr. Ernő Kiss mentioned, the role of the Firemen Switch can be easily substituted by proper technical solutions in the PV system.

It is not modest to assume that photovoltaics can play a relevant and important role in Hungary's electricity portfolio. In fact, Germany, Austria, Spain and France have all restructured their electricity portfolio and supply chain in order to adopt their growing photovoltaic capacity to the electricity requirements. Basically during daytime photovoltaic power plants supply the electricity need, while after sunset fossil fuel based, incineration and biomass power plants take over to make up the supply lost.

This was important to mention, since Hungary in the foreseeable future is planning to build a new nuclear reactor, PAKS II, to replace its current one when it will be decommissioned in mid-2030. A comparative analysis was conducted to compare the investment cost of the planned PAKS II Nuclear Power Plant with a Photovoltaic Power Plant. The aim was to determine which investments would be more logical in terms of investment cost. The result showed that from the project cost of PAKS II, 4 Photovoltaic Power Plant could be built each with the same capacity if PAKS II. Despite the fact, that the PV Power Plant's efficient lifespan is only the half PAKS II lifespan, it would be still a more reasonable choice to invest in: the PV plant can produce electricity on a much competitive level – on a lower price – without any governmental monetary assist, while on the other hand PAKS II's electricity will be generated with high cost, even with monetary support. Due to the fact that the photovoltaic technology is still developing and modules are becoming even more efficient and durable, it can be already considered as a more competitive electricity generation method than the aging and outdated nuclear technology. To further support the relevant role photovoltaics can play in the foreseeable future, it is a notable tendency, that developed countries – like USA, Germany, France, Spain – are all investing in renewable energy sources, mostly in photovoltaic power plant to meet their increasing electricity need.

As a result of the conclusions it can be said, that the Hungarian photovoltaic market is severely bottleneck by different administrative measures and by the relocation of EU funds meant to support the growth of the sector. Despite these measure, the market is still growing, but on a slow pace and it lags 10 years behind its neighbor's photovoltaic market. Moreover, the government's commitment in investing in nuclear energy instead of renewables shows that in the foreseeable future conditions are unlikely to change for the better.

7. Recommendations

Following the conclusion of the research on the Hungarian photovoltaic market's barriers, feasible and proper recommendations are given tailored for the bottlenecks identified during the analyses of the country's photovoltaic market. The recommendations of this research are the followings:

- The European Structural and Investment Funds of the Thematic Objective 4 should be used according to the Partnership Agreement signed in 2013;

Relocation of the ESI Funds from TO4 for other policy areas should be denied by the European Commission. When the PA was created, it set up a financial assistance plan for each policy areas in Hungary for the 2014 – 2020 period. The aim of the EU funds are to support economic cohesion and the growth of several economic sector, including the renewable energy sources (RES).

- Call for applications, call for tenders and call for proposals should be guaranteed;

The withdrawal of ESI Funds' direct consequence is the lasting termination of call for applications for the residential sector; call for tenders and call for proposals for the commercial sector. By the denial of the relocation of ESI Funds from TO4, the financial measures meant to support the photovoltaic sector would remain still and available for proper and efficient distribution. Calls should be announced in order to use the available budget for supporting market participants with their photovoltaic investment (residents and companies).

- Monetary assist for the residential sector should be guaranteed;

Besides the calls, the residential sector should receive governmental incentives in the forms of tax reduction and subsidized photovoltaic products. The subsidization and tax reduction are recommended until the photovoltaic market is mature enough to sustain itself on its own, by becoming widespread, competitive and attractive for small and large scale investments. Subsidized photovoltaic product might benefit SMEs as well.

- The discrimination of photovoltaic SMEs should be tackled and ceased;

Administrative measures like the need of the Firemen Switch in every PV system in Hungary should be abolished; the high product fee of solar modules should be lowered to a reasonable level; and the withdrawal of EU funds from call for tenders and proposals should be undid. VAT for photovoltaic product should also be reduced to increase the market's competitiveness. These corrections would make photovoltaic companies more competitive on a national and regional level as well. Moreover, the decreased investment cost of PV systems would boost the residential sector's appetite to invest in renewable energy sources, like photovoltaics.

- A Renewable Energy Act should be enacted;

Hungary is among the few Member States that does not have a Renewable Energy Act. In order to support the RES, including photovoltaics, one should be taken into effect with three main principles: 1.) Investment protection through guaranteed feed-in tariffs; 2.) Long term subsidization system for RES, including photovoltaics; 3.) Embedment of electricity generated by RES, including photovoltaics, to the Hungarian electricity portfolio.

- Update the outdated Hungarian Energy Policy.

Hungary's Energy Policy is based on fossil fuels and nuclear. Its aging nuclear reactor should be replaced with a more cost efficient and environmental friendly Photovoltaic Power Plant, rather than with another nuclear plant. In order to achieve this, the country's outdated Energy Policy should be updated together with its electricity portfolio.

Appendix 1: EUR – HUF exchange rate

The exchange rates used throughout the thesis:

1 HUF = 0.00317465 EUR

1 EUR = 314.995 HUF

Appendix 2: The script of the interview with Mr. Ernő Kiss, Head of the Hungarian Photovoltaic Association, 24.05.2016

1. Mikor telepítették/telepíthették az első napelemet Magyarországon?

70-es években telepíthették az elsőket, kísérleti jelleggel szerelték őket egyetemek, kutatóintézetek tetejére. Néhány wattosok voltak.

A magyar napelemes piac 2007-ben indult el. 2007-ben módosították a villamos energia törvényt és azóta van lehetőség arra, hogy hálózat-visszatáplálós napelemeket telepítsünk magyarba. Onnantól datáljuk a m. napelemes piacot. Nem volt számottevő kapacitás, mennyiség, de a jogszabályi háttér megteremtődött, azért hogy ezek a napelemes rendszerek működhessenek.

2. Hogyan alakult a napelem rendszerek hazai beszerzési ára az utóbbi években? – magánszemélyek és cégek részére egyaránt. Más országokhoz viszonyítva? Várható az inverterek árának a csökkenése?

Solarworld kezdeményezésére antidömping eljárás indult az EUba a kínaiak ellen. Emiatt az EUba a világon a legmagasabb a modulár. 53euro centben van a küszöbár, ami alatt nem jöhet be Kínából napelemes termék. Kérdés értelmében a gyártási költség folyamatosan csökken, ennek ellenére az eus gyárak inkább emelték mintsem csökkentették az árakat. Jellemzően az antidömping ár fölött forgalmazzák a termékeiket. USA vagy Ázsia más területein jelentősen olcsóbbak a napelemek, mint EUba. Magyarba a napeleme beszerzési ára viszonylag stagnál, nem csökken, sőt emelkedet.

Több oka van ennek. Tavaly bevezettek egy napelemes termékdíjat – brutális mértékű -, 1kg napelemre 114 forint a termékdíj. Világon az egyik legmagasabb termékdíj. EUba a legmagasabb a belga termékdíj, annak 6x-sa a magyar. (Nézz utána mennyi belgiumba pontosan). Nonszensz: akksikra 57ft/kg, ami sokkal környezetpusztítóbb tud lenni, mint napelem. Törvényalkotó ennyire veszélyesebbnek gondolja. Az ára jelentősen emelkedett, kb 5%.

Inverterek ára foly. Csökken. Egyre olcsóbbak és hatékonyabbak. Ami előfordul nemzetközi piacon, az itthon is megkapható: SME, Huawei, ABB, stb.. Elterjedését nehezíti némileg, hogy HÁLÓZATI ENGEDÉLYESEK. Egynél azonban minosítenek egy típust, a többiek autom. Átveszik. Nem kell mind a háromnál külön regisztrálni, bevizsgálni. Mindenesetre jelentős költség.

3. Hazai napelem gyártás hogyan boldogul a globális piacon? - Jüllich Glass kérdezd meg a cég kapacitásást.

Jüllich glass – jól prosperáló üveggyártó cég, napelem gyártása nem jelentős, de nézz utána - az egyik legnagyobb. KTL elektronik, Korax kisebb regionális összeszerelők, néhány megawattnyi kapacitás. Jellemzően Kínából importálják az alapanyagokat és magyarba laminálják, szerelik azt össze. Igaziból összeszerelés.

Csornán új gyár, vékonyréteg napelem gyártó cég. Svájci befektető csoport által egy újfejlesztésű vékonyrétegű napelemet készít állítólag. Export valószínű. Jellemzően viszont hazai gyárak belső piacra termelnek.

4. Hazai téren mennyire figyelhető meg a napelemes technológia térnyerése?

Jól jelzi, hogy minden évben megduplázódik a kapacitás ….ábra….eu viszonylatba viszont csekély mértékű, de mindenképpen növekszik. Lakossági részről is jelentős, de igazából az intézményi, közintézményi hálózatban a legjelentősebb, köszönhetően az EUs támogatásoknak, illetve annak, hogy a kormányzat az uniós megújuló energiára/épületenergiai rekonstrukcióra fordított összegeket teljes egészében átcsoportosítja a közintézményeknek a fejlesztésére. Ezrét az önkormányzatok, sulik terén jelentősek a fejlesztések és valóban épülnek is a cuccok…korházaknál is. Egyre jobban terjednek.

5. Mit gondol a magyar napelem piac helyzetéről? Más országokhoz viszonyítva? Jól/rosszul teljesít vagy épp, hogy csak tartja a lépést.

Egy évtizedes lemaradásban vagyunk, de próbáljuk behozni. Sajnos azonban a folyamatos adminisztratív intézkedések nehezítik a napelemes technológiák elterjedését…pl termékdíj. Nehézséget okoz.

Másik admin. Intézkedés az országos tűzvédelmi szabályzat, ami kötelezettséget ró a napelem telepitokre. Éspedig egy olyan tűzeseti leválasztó kapcsolót kell beépíteni kötelezően minden napelemes rendszerhez, ami egy további 10%-al megdrágítja a napelemes rendszer. Kiss szerint ez szintén arra jó, hogy nehezebben lehessen ezeket eladni. Tehát ez is egy akadály. A kapcsoló a rendszerhez illeszkedik: Van egy háztartási méretű napelemes erőmű, egy tűzeseti leválasztó kapcsoló 200e ft-ba kerül és ez 20 ampert tud lekapcsolni, azaz 2 „string"et. PL.: 50kW rendszer 10 string – 5 tuzv. Leválasztó kapcsoló kell. Lineárisan ennyivel drágítja meg.

A valóságban viszont elkerülhető ezeknek az alkalmazása néhány egyszerű műszaki megoldása. Ausztráliában nemrég tiltották be ezeket a kapcsolókat, mert épp hogy több tűzesetet is okoztak. Tehát ez nem tűzvédelmi kapcsoló, hanem TŰZESETI LEVÁLASZTÓ KAPCSOLÓ. Ég az épület, leválasszák a napelemeket, hogy nehogy megrázza a tűzoltót a házba, mivel a napelemet nem lehet lekapcsolni. ..csak leválasztani.

Otthon Melege Program elindult, ami gyakorlatilag a teljes magyar piacot megállította. Mert most mindenki azt gondolja, hogy 3 évig nem volt semmiféle pályázat, de – 3 évvel ezelőtt volt egy nagyon rövid ideig tartó, mindössze néhány óráig tartó pályázat, amikor ehetett kapni egy viszonylag jelentős összeget , fél éves magyar átlag fizetéssel egyenlő összeget épületenergetikai célokra. – na és most azt gondolják, hogy ezek megint jönnek és mindenkiben éltetik a reményt, hogy egy ilyet lehet majd kapni. Ez pedig megakadályozza minden más embernek a beruházási kedvét, mondván, hogy „hát látod akkor mégis érdemes várni, mer hátha csak lesz egyszer egy ilyen beruházási támogatás". A Pályázatot lényegében egyáltalán nem tudja senki felhasználni, mert a p. feltételek alapján minden épületenergetikai követelményeknek meg kell felelni – a pályázónak – pl. épület szigetelés, nyílászáróknak a hőátadási tényező. Igaziból napelemre nem annyira kedvező ez a pályázat.

6. A napenergiával előállított áramot az áramszolgáltató jelenleg milyen áron köteles átvenni? Mindig fizet érte az ELMŰ vagy csak mikor többletre van szükség? Mi a véleményük erről az árról?

FEE-IN TARIFF: Ma magyarba a villamos energia törvény a házt,méretű napelemes kiserőművekre – max 50kWig érthető – úgyn. szaldóelszámolást biztosít. EZ más országokban nincs így. Lényegében a villamos áram vételára az általam biztosított áram eladási ára is. Év végén, ha a különbözett mondjuk 500kW, akkor jelenleg 40ft-t- kapott kW.ként.

Ha többet termelek, mint amennyit fogyasztok, tehát többet táplálok vissza a hálózatba, ebben az esetben csak a hálózati használati díjjal csökkentett villamos energia költségét fizeti meg a szolgáltató. Ezt még adózni is kell, vállalkozói engedélyt is ki kell váltani, igazából elég bonyolult és a valóságban nem használja senki. Jelenleg bruttó 22ft adnak többlettermelésért.

Ha valaki kereskedelmi célú napelemes rendszert szeretne, arra érdemes egy kiserőművet építeni, 50-500kW közötti. Ezzel kötelező átvételi támogatási áron – KÁT – tudja értékesíteni az áramot az áramszolgáltatónak, aki ezt átveszi szerződés alapján. Ennek mértéke január elsejétől 31.77 fillér + ÁFA. Excelből csinálj táblázatot az árakról. Számolj kicsit a költségekkel, mennyire térülne meg. Ez magasabb, mint a lakossági fogyasztói ára a villamos energiának, tehát ez egy elég vonzó ár. Euba is magasnak számít. Veszélye, hogy nálunk nincsen még MEGUJÚLÓ ENERGIA TÖRVÉNY, így ez az ár évenként kerül meghatározásra. Hosszútávon nem lehet tudni, mennyire kiszámítható, kormány határozza meg. Magyar energetikai és Közmű-szabályozási hivatal hirdeti meg évente.

7. Igénybe vesznek – vagy épp vettek – Önök bármilyen állami támogatást? Ha igen mikor, milyen gyakran és milyen mértékben?

Egyik sem kapott semmilyen támogatást. A szövetség egyszer részt vett egy norvég pályázatban. Norvég civil pályázat, de nem lényeges. Állami támogatást sosem kapott.

Nem tud semmire sem pályázni, mert középmagyarországi régióba van, az fejlett, EUs átlag felett van és kevés eus pénzt kap. – fejlettségi szint. Csekély pályázati lehetőség számukra.

8. Véleményük szerint a jelenlegi állami támogatás – vagy épp annak hiánya – hogyan hat a hazai piacra?

Olyan, hogy állami támogatás nincs, csak eus támogatás/források. Ezek alapvetően torzítják a piacot. Mindenkit arra ösztökél, hogy ezeket a projekteket próbálják meg kihasználni, emiatt jelentősen túlárazott projektek jönnek létre a hazai piacon. Aki pedig saját forrásukból valósítanak meg beruházásokát hátrányba sodorják és kedvét szegik sajnos.

9. Mit gondolnak a jelenlegi állami ösztönző rendszerről?

Nincs ilyen napelemes rendszerekre vonatkozóan. Otthon Melege Programra 5 milliárd forint jut összesen, pályázat támogatási keretre ez csekély. Kb. 2-2200 lakás komplett energetikai rekonstrukciójára ad támogatást, de olyan p. feltételek vannak, hogy valószínűleg elég kevesen tudnak majd ezzel élni. Ez inkább hátrányos, mintsem előnyös. Pl. azok a személyek, akik megvalósítottak volna, napelemes projektet azt mondják majd, haha úgyis lesz majd napelemes pályázatra jövőre. Ő még akkor egy kicsit kivár. Holott lehet tudni, a jelen ciklusba már nem lesz többet ilyen, mert a kormányzat az erre megítélt támogatásokat más forrásokra elvonta.

Ezek folyamatban vannak. A kormány múlt héten adott be az EUnak egy módosítási kérelmet, hogy 80 milliárd ft a lakossági pályázati keretből közintézmény fejlesztésre fordítsanak. Ezt nem engedélyezte ez EU. Az EU 160 milliárdot ítélt oda erre a célra tavaly januárban, a kormány ezt előbb megpróbálta teljesen átcsoportosítani, majd második körben megpróbálnak ebből 80-t elvonni. Különböző kormányzati nyilatkozatokból azt lehet tudni, hogy nem kívánják a lakosság számára adni ezt a pénzt különböző indokokkal. Keress forrást, újságcikkeket. Két hete jelent meg egy cikkben két érv az állam részéről. 1.: A lakosságnak erre nincs szüksége. 2.: Bonyolult lenne a lakossági pályáztatási rendszer, senki nem élne vele, nincs erre megfelelő állam apparátus, nem képesek kezelni. Ezt nyilatkozta Lázár János.

10. Milyen változtatásokra lenne szükség, hogy elősegítsék a beruházások és a napelem piac növekedését?

EZZEL LEHETNE KEZDENI A 3.3.1-T: Leginkább a hazai vállalkozások diszkriminációját lenne szükséges megszüntetni. Egyik diszkriminatív intézkedés, hogy a napelemes termékdíj kizárólag a hazai vállalkozásokat sújtja. Ha külföldi – osztrák – idejon magyarba telepíteni napelemes rendszereket, neki pl ezt nem kell megfizetni. Ez nonszensz. Csakis kizárólag a hazai cégeknek kell termékdíjat fizetni, amikor forgalomba hozzák azokat. Tehát a forgalomba hozatalhoz kapcsolódik és nem a behozatalhoz. Pl. Egy önkormányzatnak jobban megéri Ausztriából megrendelni egy komplet napelemes rendszert az ottani ÁFA kulccsal, napelemes termékdíj nélkül bruttóban 10%al olcsóbban tudja megvenni a napelemes rendszert. NÉZZ ÁFA UTÁN Ezt követően egy hazai vállalkozással tudja azt telepíteni.

Nem állami támogatásra lenne szükség, hanem inkább az irtózatos állami terhek/kötelezettségek csökkentésére: kiemelkedően magas az ÁFA kulcs, plusz a termékdíj, plusz a tűzeseti leválasztőés egyeket NÉZZD MEGA CIKKBEN EZEKET. Ezek mind jelentősen és értelmetlenül növelik az épületenergetikai és energiatakarékossági beruházásoknak a költségét. „Igazából csak arra lenne szükség, hogy hagyjanak bennünket dolgozni" Nagyon fontos lenne.

11. Tartalmilag milyen (lakossági) pályázatra lenne szükség? Melyek lennének a fontos pontjai? Tartalmi elemek tekintetében hogyan nézne ki egy a piac növekedését támogató pályázat?

Gyakorlatilag nincsen szükség semmilyen pályázatra. Túl nagy az ÁFA költsége 27°%. Vannak angolszász és külföldön bejegyzett cégek, akik Angliából dolgoznak a magyar piacra és le is tarolják azt. Mert hogy angol adóval dolgoznak. Nem pályázat kell. hanem arra, hogy a lakossági szolgáltatási piacot ne adóztassák jelentős mértékben túl. Éppen ezért jelen pillanatban a lakossági beruházásokra jellemző, hogy nem fizetnek adót, tehát duplán veszít a költségvetés: kevés a beruházás, de az a kevés is feketén megy. Ez a tisztességes vállalkozásokat ellehetetleníti, s gyakorlatilag csak úgy tudnak életben maradni a vállalkozások, ha a helyszínen számla nélkül dolgoznak, s valamiféle adóelkerülési módot keresnek. Nagyon nehezen lehet ellenőrizni egy lakossági beruházásnál, hogy ki mikor mit csinált, s ugye eléggé egyszerű.

Németben sincs lakossági pályázat, inkább adókedvezménnyel támogatják a beruházást. Támogatják a megtermelt villamos energia átvételét is, 3x áron. FORRÁST A PDFBŐL. Németben annyival kedvezőbb a helyzet, hogy rendkívül magas a vill.áram ára, míg nálunk a világ legmagasabb ÁFA kulcsa mellett az egyik legalacsonyabb az áram ára az EUba. Éppen ezért itthon rendkívül rossz a megtérülése az ilyen beruházásoknak. Napalem beruházásnak 10 év kb. Németbe a magasabb ár miatt ez rövidebb idő, kb 5 év.

Ennek az indirekt következménye, hogy magyarba gyakorlatilag nem éri meg erőműveket üzemeltetni, már 40% fölött van a villamos energia importunk, a legmodernebb hazai erőművek állnak, mert annyira gazdaságtalan az üzemeltetés. Többe kerül a termelési költség, mint amennyiért át tudja venni az áramszolgáltató az áramot. Ez egy mesterséges, irreálisan alacsony ár. Nem piaci alapon szabályozott ár, nem fedezi a gyártási költségeket.

12. Véleményük szerint egy stabil és jól kidolgozott pályázati rendszer, vagy a napelemek által megtermelt zöld áram magasabb visszavásárlási ára lenne e kedvezőbb hatással a hazai piacra?

A p. rendszerek itthon mindenképpen a korrupció melegágyát készítik elő. Bennfentes információ, megfelelő kapcsolatok és tudnak nyerni, le tudják bonyolítani. Egyes körökhöz csoportosulnak ezek a pályázati rendszerek, ez pedig nem a gazdaság fejlődését, hanem csoportok gyarapodását szolgálja. Nyertes vállalkozás versenyelőnyt szerezz és háttérbe tudja szorítani másokat. Nem kell feltétlen híve lenni ezeknek a pályázatoknak.

Adókedvezmény jobb megoldásnak tűnik, de a hazai kormányzat úgy használja fel a EUs forrásokat ahogy azt ő gondolja, szándéka szerint, s ennek meg is van az eredménye.

13. Hány kW-t építettek eddig ki összesen? Átlagosan milyen a kiépített rendszerek hatékonysága?

Teljes magyar piac, eurobserv'er. 15-16 ezer db napelemes rendszer lett telepítve 2014-ig. Mást mond az excel. Azt írd be és tégy táblázatot is. HMKE és HMKE felletti rendszereket is említsed meg. Ezekből 33 van 2014ben.

Ezek a számok várhatóan megduplázódottak idénre. Meg nem publikusak az adatok. Két nagy erőmű lett telepítve: Visontán 16.5 MW és Tüskésréten Pécs mellett 10MW. E két erőmű jelentősen megdobta az egész beruházást. Magyarba északon leginkább polikristályosokat telepítenek, délen monokristályosokat. A hatékonyságuk igazából mindegy, az hogy a napsugárzás energiájából hogy hány %-t tudunk hasznosítani az irreleváns kérdés. Igazából a költséghatékonyság, ami igazán érdekes, Az számít, hogy mennyi megy az energiából veszendőbe. Ami a napelem által termelt energiából nem kerül felhasználásra az mind veszendőbe megy. Tehát az sokkal több. Az pedig, hogy egy napelemnek 15 vagy 18% a hatásfoka az nem degradálja sosem a napelemet. Ha összehasonlítjuk a robbanó, az Otto motorral a hatékonyságot, annak kb 20% a hatásfoka. A benzinért pedig rengeteg pénzt fizetünk ki, amit a motor mozgási energiájává alakít.

14. Jellemző az akkumulátorok telepítése?

Nem. A szigetüzemű rendszerek telepítése elenyésző.

15. A napelem a telepítés teljes költségének kb. mekkora hányadát teszi ki?

Kb. 45%-t teszi ki.

16. Kb. mennyi az ügyfélkörük átlagos életkora?

35-50. Akik már családot alapítottam, ingatlan beruházásba vannak, komolyabb beruházásba fogtak, tehát akik megalapozták az életüket.

17. Hány kW/rendszer/megrendelés a jellemző?

3 kategória van, így ezt nehéz megmondani. Nyilván a lakossági megrendelés az darabszámban több, de teljesítményben kevesebb, de egyre több a potenciális befektető, aki ilyen 500KW-s napelemes rendszer telepít. Ezekből évente több 10 darab valósul meg.

18. Az ügyfelek között mekkora a magánszemélyek, cégek és közületek megoszlása?

A közületek a jellemzőek, ők akik a legnagyobb arányban használják föl a napelemes rendszereket, mármint teljesítmény arányában. Nagyon sok vállalkozás is igyekszik megspórolni a villamos energia költségét, mert ők többet fizetnek érte, mint a magánszemélyek. Sok magánszemély felismerte, hogy annak ellenére, hogy most alacsony a villany ára, mégis megéri.

Appendix 3: Checklist Report Writing

Name: Class: Date:

Title report:

When you have checked your report using this checklist, you must add this to your report as an appendix. No form means no mark.

Items marked with an * are so-called killing points. IF there are more than five killing points ticked on the checklist, the report must be improved on all failed parts and must be handed in again together with the old version. N.B: No killing points are allowed in the thesis

ASSESSORS: Tick the box of the items which are not sufficient!

1. Use of English:

□ Does not contain more than 3 grammar errors, spelling mistakes or typos per 1000 words*
When more than 3 mistakes per 1000 words are found, the report will be marked a fail.
□ Contains correct punctuation*
□ Is attuned to the chosen target group (appropriate style)*
□ Shows a functional and business-like writing style*
□ Is not written in the "I" form*

2. The report:

□ Report is properly bound, no staples (hard copy)*
□ Is free of plagiarism* (check exam regulations)

3. The cover:

□ Displays the title
□ Author(s) is/ are mentioned

4. The title page:

□ Title is specific*
□ Author(s) is/ are mentioned in alphabetical order*
□ Date and place of publication are mentioned*
□ The sponsor/orderer of the report is mentioned*

5. The preface:

□ Contains personal reason for writing
□ Contains acknowledgement ("I" form permitted in the preface)

6. Table of contents:

□ All parts of the report are numbered*
□ The summary and appendices are included
□ Table of contents is clear
□ Page numbers are consistent

7. The summary:

□ Is a concise version of the entire report
□ Contains conclusions
□ Does not contain personal opinions

- ☐ Is well structured
- ☐ Is written business-like
- ☐ Follows the table of contents

8. The introduction:
- ☐ Is chapter 1*
- ☐ Invites the reader to read
- ☐ problem demarcation and justification are clear and specific*
- ☐ The problem context is clear and to the point*
- ☐ The aim of the research and the report is clear and specific*
- ☐ Research methods/ data collection are described *
- ☐ The function of the chapters in the report is concisely described *

9. The (construction of the) core:
- ☐ Chapters, paragraphs and subparagraphs are numbered and clearly structured (with a maximum of three levels)*
- ☐ Enumeration levels are clearly distinguishable*
- ☐ Chapters and (sub) paragraphs have a fitting title
- ☐ A chapter covers at least one page
- ☐ New chapters start on a new page
- ☐ Sentences are typed in sequence, without hard return within the paragraph
- ☐ Figures are numbered and have a fitting title, which is put below the figure.*
- ☐ Tables are numbered and have a fitting title, which is put above the table*
- ☐ Figures and tables are referred to in the text*
- ☐ Each appendix is specifically referred to in the content
- ☐ Pages are numbered*
- ☐ Pages have a functional layout

10. The discussion of results:
- ☐ Contains a review of relevant sources
- ☐ Valid argumentation is provided
- ☐ Contains a critical evaluation of own findings

11. The conclusions and recommendations:
- ☐ The conclusions are based on relevant facts and / or discussion
- ☐ The recommendations are based on relevant facts and / or discussion
- ☐ Does not contain any discussion or information that does not appear elsewhere in the report text*

12. References:
- ☐ The text is written according to the APA-rules * (check intranet)

13. The list of sources:
- ☐ Is drawn up according to the APA-rules* (check intranet)

14. The appendices:
- ☐ Are all numbered
- ☐ Each have an appropriate title

Do not contain the author's own analyses.

Sources

Internet Sources

1. World Nuclear Association (2015). World Energy Needs and Nuclear Power. Date: 23.01.2016 Retrieved from: http://www.world-nuclear.org/info/Current-and-Future-Generation/world-Energy-Needs-and-nuclear-power/
2. EurObserv'ER (2016). Photovoltaic barometer. Date: 06.06.2016 Retrieved from: http://www.eurobserv-er.org/photovoltaic-barometer-2016/
3. KSH (2016). Nemzetgazdasági ágak szén-dioxid (CO2) kibocsátása (1985–) Date: 06.06.2016 Retrieved from: https://www.ksh.hu/docs/hun/xstadat/xstadat_eves/i_ua026d.html
4. MVM PAKS II. (2016). Miért szükséges új atomerőművi blokkok építése Magyarországon? Date: 06.06.2016 Retrieved from: http://www.mvmpaks2.hu/hu/Atomenergia/IsmeretetoAlap/Lapok/AtomeromuviBlokkokEpitese.aspx
5. Nemzeti Fejlesztési Minisztérium (2009). Magyarország Megújuló Energia Hasznosítási Cselekvési Terve. Date: 23.01.2016 Retrieved from: http://www.umvp.eu/files/Meg%C3%BAjul%C3%B3%20Energia%20Hasznos%C3%ADt%C3%A1si%20Cselekv%C3%A9si%20Terv.pdf
6. Energy Informative (2015). Which Solar Panel Type is Best? Mono- vs. Polycrystalline vs. Thin Film Date: 15.05.2016 Retrieved from: http://energyinformative.org/best-solar-panel-monocrystalline-polycrystalline-thin-film/
7. Hungarian Energy and Public Utility Regulatory Authority (2016). Bruttó villamos Energia termelés. Date: 19.05.2016 Retrieved from: http://www.mekh.hu/eves-adatok
8. Magyar Napelem Napkollektor Szövetség (2015). Csökkentette a villamosenergia átvételi árakat a kormány Date: 21.05.2016 Retrieved from: http://www.mnnsz.hu/csokkentette-a-villamosenergia-atveteli-arakat-a-kormany/
9. Országos Meteorológiai Szolgálat (2016) Magyarország napsugárzás, napfénytartam és felhőzet viszonyai. Date: 06.06.2016 Retrieved from: http://www.met.hu/eghajlat/magyarorszag_eghajlata/altalanos_eghajlati_jellemzes/sugarzas/
10. MIT Technological Review (2010). A Price Drop for Solar Panels. Date: 24.05.2016 Retrieved from: https://www.technologyreview.com/s/410064/a-price-drop-for-solar-panels/
11. CleanTechnica (2014). Solar Panel Efficiency Has Come a Long Way. Date: 24.05.2016 Retrieved from: http://cleantechnica.com/2014/02/06/technological-advancements-drove-solar-panel-prices/
12. HVG (2016). Hanyatt kell-e esni a pécsi naperőműtől? Date: 26.05.2016 Retrieved from: http://hvg.hu/gazdasag/20151209_Miert_nem_kell_hanyatt_esni_a_pecsi_MVM
13. Mátrai Erőmű Zrt. (2015). Átadták Magyarország legnagyobb naperőművét Date: 26.05.2016 Retrieved from: http://www.mert.hu/atadtak-magyarorszag-legnagyobb-naperomuvet
14. Online-kalkulátor (2016). Áram Ára 2016 – A Lakossági Fogyasztók Védelmére Törekednek Date: 29.05.2016 Retrieved from: http://online-kalkulator.hu/aram-ara-2016-a-lakossagi-fogyasztok-vedelmere-torekednek/
15. Energy Efficiency Indicators (2015). Average electricity consumption per electrified household. Date: 29.05.2019 Retrieved from: https://www.wec-indicators.enerdata.eu/household-electricity-use.html
16. Bundesnetzagentur (2016). Daten-meldungen und EEG-Ver-gü-tungs-sät-ze für Pho-to-vol-taik-an-la-gen. Date: 30.05.2016 Retrieved from: http://www.bundesnetzagentur.de/DE/Sachgebiete/ElektrizitaetundGas/Unternehmen_Institutionen/ErneuerbareEnergien/Photovoltaik/DatenMeldgn_EEG-VergSaetze/DatenMeldgn_EEG-VergSaetze_node.html

17. CleanTechnica (2011). Solar Panels Creating Electricity for Much Longer than 20 Years. Date: 31.05.2016 Retrieved from: http://cleantechnica.com/2011/12/27/solar-panels-creating-electricity-for-much-longer-than-20-years/
18. HomePower (2015). ASK THE EXPERTS: Inverter Longevity. Date: 31.05.2016 Retrieved from: http://www.homepower.com/articles/solar-electricity/equipment-products/ask-experts-inverter-longevity
19. Greenfo (2016). A lakossági pályázatoknál nem lehet mutyizni - akkor ne írjuk ki. Date: 04.06.2016 Retrieved from: http://greenfo.hu/hirek/2016/04/29/a-lakossagi-palyazatoknal-nem-lehet-mutyizni-akkor-ne-irjuk-k
20. NRG Report (2016). Túl bonyolult lenne a lakosság energiahatékonysági támogatása. Date: 04.06.2016 Retrieved from: http://nrgreport.com/cikk/2016/04/27/tul-bonyolult-lenne-a-lakossag-energiahatekonysagi-tamogatasa
21. MAVIR (2016). Áttekintő ábra a magyar villamosenergia-rendszer legfontosabb adatairól. Date: 04.06.2016 Retrieved from: http://www.mavir.hu/web/mavir/home
22. European Union (2015). EU funding Date: 05.06.2016 Retrieved from: http://europa.eu/about-eu/funding-grants/
23. Forbes (2016). Are Electric Cars Really That Polluting? Date: 05.06.2016 Retrieved from: http://www.forbes.com/sites/jamesconca/2013/07/21/are-electric-cars-really-that-polluting/#12c4e65b5012
24. 24.HU (2016). Így húz el Magyarország mellett a napelemes forradalom. Date: 05.06.2016 Retrieved from: http://24.hu/fn/gazdasag/2015/05/03/igy-huz-el-a-magyarok-mellett-a-napelemes-forradalom/
25. The Guardian (2016). Germany's planned nuclear switch-off drives energy innovation. Date: 06.06.216 Retrieved from: http://www.theguardian.com/environment/2015/nov/02/germanys-planned-nuclear-switch-off-drives-energy-innovation
26. World Nuclear (2015). Radioactive Waste Management. Date: 06.06.2016 http://www.world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-wastes/radioactive-waste-management.aspx
27. Alternative Energy News (2016). Battery Technology. Date: 06.06.2016 Retrieved from: http://www.alternative-energy-news.info/technology/battery-power/
28. Bundesministerium für Wirtschaft und Energie (2015). Infografik: Aufwind für Strom aus Erneuerbaren Date: 06.06.2016 Retrieved from: http://www.bmwi-energiewende.de/EWD/Redaktion/Newsletter/2014/20/Meldung/infografik-aufwind-fuer-strom-aus-erneuerbaren.html
29. Oilprice.com (2015). Is The Oil Industry Really Subsidized? Date: 07.06.2016 Retrieved from: https://translate.google.hu/#en/hu/slump
30. Energy Informative (2014). The Real Lifespan of Solar Panels. Date: 07.06.2016 Retrieved from: http://energyinformative.org/lifespan-solar-panels/
31. HVG (2015). Hágában elmeszelték Hollandiát – túl szerény kibocsátáscsökkentést vállalt. Date: 08.06.2016 retrieved from: http://hvg.hu/gazdasag/20150625_Hagaban_elmeszeltek_Hollandiat_amiert_tul

Online articles

32. Clark, Josh (29.09.2008). What was Archimedes' death ray? HowStuffWorks.com. Date: 16.05.5016 Retrieved from: http://history.howstuffworks.com/historical-figures/archimedes-death-ray.htm
33. Chaudhry, Nadim (02.05.2016). The Solar Tsunami: it's starting in the sun belt and it will spread towards the poles. LinkedIn. Date: 19.05.2016 Retrieved from: https://goo.gl/GrsgeI

Books

34. József, Dr. Horváth & Endre, Dr. Domokos (2011). Megujúló Energia. Budapest. Page 61
35. Perlin, John (1999). From Space to Earth: The Story of Solar Electricity. Pages 4 and 7. Ann Arbor, Michigan: Aatec publication
36. Greentechnic Hungary Kft. (2012). A fotovillamos Energia ismertetése és alkalmazása kompetens partnerrel. Page 15. Budapest: Greentechnic Hungary Kft.

Journals & Articles

37. Williams, Richard (1960). Becquerel Photovoltaic Effect in Binary Compounds. The Journal of Chemical Physics, Volume 32, Issue 5, p.1505-1514
38. J. Doyne Farmer & François Lafond (2016). How predictable is technological progress? Research Policy, Volume 45, Issue 3, April 2016, Pages 652-653
39. Tillmann (2015). Don't just follow the sun – A global assessment of economic performance for residential building photovoltaics. Volume 42, February 2015, Pages 948

Reports

40. European Commission (2015). Report from the European Commission to the Parliament, the Council, the European Economic and Social Committee and the Committee of Regions: Renewable energy progress report. Page 5. Brussels: European Commission
41. Observ'ER (Fr) & Renac (DE) & Institute for Renewable Energy (IEO/EC BREC, PL) & Jožef Stefan Institute (SI) & ECN (NL) & Frankfurt School of Finance and Management (DE) (2015). The State of Renewable Energies in Europe. Page 72. Paris: EurObserv'ER
42. European Commission (2014). Summary of the Partnership Agreement for Hungary, 2014-2020. Page 4. Brussels: European Commission
43. Transparency International Hungary (2015). The Corruption Risks of EU Funds in Hungary. Pages 15 and 22. Budapest: Transparency International Hungary
44. European Commission (2016). VAT Rates Applied in the Member States of the European Union. Page 3. Brussels: European Commission
45. International Finance Corporation (2015). Utility-Scale Solar Photovoltaic Power Plants: A Project Developer's Guide. Page 11 and 177. Washington: World Bank Group