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MASTER THESIS

NAMŲ ŪKIŲ INVESTICIJŲ Į SAULĖS FOTOELEKTROS SISTEMAS PARAMOS MODELIŲ EKONOMINIO POVEIKIO VERTINIMAS	EVALUATION OF THE ECONOMIC IMPACTS OF SUPPORT SCHEMES ON INVESTMENT IN RESIDENTIAL PHOTOVOLTAIC SYSTEM

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

DPP - discounted payback period

EU - European Union

FiT - feed-in tariff

GDP - gross domestic product

GHG - green house gas

IRR - internal rate of return

NAS - net accounting system

NBS - net billing system

NCC - National Commission for Energy Control and Prices

NMS - net metering systems

NPV- net present value

PI - profitability index

PP - payback period

PV - photovoltaic

RES - renewable energy sources

SDGs 2030 - Sustainable Development Goals 2030

INTRODUCTION

Relevance of the topic. In the 21st century the world is facing serious challenges due to global warming. As the major resource of greenhouse gases, the consumption of fossil fuels must be reduced, yet the rapid development of the global economy requires extensive supply of energy. Thereby, the need for cleaner renewable energy is created. Among several renewable energies, including solar energy, wind energy, biomass energy and so on, the year 2019 witnessed the fastest growth in solar energy since 2010, with solar overtaking other power generation technologies. Solar energy has become the most popular power generation source in Europe thanks to its versatility, relative easiness and quickness of installation, as well as the low cost. Therefore more and more investments are being made into solar by European citizens, and at the same time governments are increasingly embracing solar in their climate strategies.

However, even though solar is popular and has a great potential in Europe, it is still only the initial stage for the solar energy production in the EU, with its total share reaching just 5%. Massive investments will be needed to transit to a low carbon economy. Only to achieve the EU's 2030 energy and climate targets, the financing gap is estimated at EUR 180 billion per year. Public funding is vital for the transition but it will not be enough. A substantial part of the financial flows will have to come from the private investors.

Small-scale PV projects can make a significant contribution to financing the development of power systems. However, this can only happen if the investment pays off within some acceptable period. The payback period depends on a number of factors and specific conditions of use. In the case of using solar energy, the most important influencing factors include the level of solar irradiance, the amount of investment required, the rules for selling and buying energy, and the availability and amount of support for green energy. The support scheme and the rules of energy trading are chosen by government agencies based on the economic capabilities of each country.

It's necessary to note that there is a very large difference in the terms of installed capacity and electricity generation between European countries and even between the three Baltic States. Examining solar power, countries are ranked according to the average annual solar irradiance they receive. However, the Baltic States have comparable solar irradiation levels, equivalent PV technology equipment prices, all three countries operate on a single power exchange (Nord Pool), so the differences cannot be explained by the variations in solar irradiation or electricity prices. It is clear that different capabilities and government support schemes for renewable energy sources play a major role in the development of a PV technology market. Thus careful analysis is required to assess whether solar PV is a suitable technology that will justify public support schemes in the lower solar irradiation countries, such as Lithuania.

The overall **goal** of this work is to pre-evaluate the impact of different schemes of public support on the economic efficiency of residential PV systems, as well as to compare the cost-effectiveness of different financing options and to develop proposals for improving support framework with the intension to avoid the mistakes when designing policy support and pricing mechanisms based on the experience of other countries. This work focuses on the assessment of financial performance of micro residential rooftop solar PV systems, affected by various options of remuneration schemes, grant and financing mechanisms.

To achieve the goal the following **tasks** are implemented:

- Examine existing global support mechanisms and legal support frameworks for residential solar PV systems in the EU and Lithuania, in particular;
- Describe current infrastructural and economic conditions on solar PV market and determine the intensity of utilization of the PV panels in the EU and the Baltics states in order to identify the reasons of difference in these levels;
- Identify the most suitable criteria for PV project efficiency evaluation;
- Develop a model to estimate the generation of solar electricity, household electricity demand and net export volume of electricity;
- Model a range of scenarios of various remuneration and financing strategies;
- Apply empirical analysis to examine the impact of remuneration and financing strategies on the financial performance of residential PV system;
- Using economic efficiency criteria, compare the economical effects of policy mechanisms and financing options and make a conclusion for the best opportunity to deliver a sustainable residential renewable electricity system.

The novelty of the research lies in the fact that the results of solving the above tasks can be useful both for potential residential PV prosumers (consumers with their own production) and for decision-makers at the legislative level in the development of green energy. This study uses smart metering data collected in Lithuania, Vilnius city; however, it is possible to utilize the results and conclusions in other, primarily, Northern European countries with low solar irradiation and similar economic conditions.

In order to solve the main purpose and to compete the above-mentioned objectives, the following **methods** are applied:

- Systematization of scientific literature and its comparative analysis;
- Statistical, dynamic and structural analysis;
- Correlation analysis;
- Capital budgeting methods;
- Sensitivity analysis.

The structure of this thesis is presented as follows:

In the first section, the classification of existing legal support mechanisms in the sphere of PV activities is outlined in order to show which support schemes and policies potential individual prosumer can find currently in Lithuania and which of them can be implemented subsequently.

Also in the first part the theoretical basis of the research is presented as the preferred capital budgeting methods, which include the net present value, internal rate of return, profitability index, the payback period and discounted payback period evaluating methods. Then, additional background - current infrastructural and economic conditions of solar PV market and analysis of the intensity of utilization of PV panels in the EU and in the Baltic states are performed. Practical studies in this thesis related to the investment analysis, evaluation methodologies (in solar PV industry in particular) and various support mechanisms, are based on the sources of the theoretical and practical researches published by authors all over the world, such as de Boeck et al., 2016; Petrichenko L. et al., 2018, Zemite L. et al., 2010, Talavera D.L., 2017, Sauhats A., Couture and Gagnon, 2010; Sarasa-Maestro C. et al., 2013; Campoccia et al., 2014; Dusonchet and Telaretti, 2015; Lacchini and Ruther, 2015, Raszkowski A. et al., 2018, Ameli, Kammen, 2014; Antonelli, Desideri, 2014; Frondel et al., 2010; Hass et al., 2011; Laleman, Albrecht 2014, Lee M. et al., 2016, and others.

The second part is represented as a research design that begins with the development of a model to estimate the monthly generation of solar electricity and household electricity demand. The cost figures used are based on data collection from active market practitioners from Vilnius city. Then scenarios of various remuneration and financing strategies are modeled.

In the third part, impacts of different support strategies and financing options on the financial performance of residential solar installation are examined, using the discounted cash flow methods adapted to analysis of PV system investment. Furthermore, sensitivity analysis is held to determine the effects of the retail rate change on the economic performance of a system.

The conclusions section will reveal the authorship input and present the key research results.

1. SUPPORTING POLICIES FOR PHOTOVOLTAIC PROSUMERS AND POSSIBILITIES FOR THEIR IMPLEMENTATION IN LITHUANIA

1.1. Supporting policies for photovoltaic prosumers in the European Union

Solar photovoltaic (PV) technology witnessed a noticeable decrease in installation costs over the last few years, the costs went down by 85% since 2008. The technology is developing fast and becoming more competitive compared to traditional energy sources, increasing the deployment dramatically and reaching 627 GW total installed capacity in 2019 all over the world. The biggest proportion of deployment is situated in locations where solar resources are combined with governmental support policies. In some cases, policy incentives for commercial and utility-scale installations have created windfall benefits for asset owners at high public cost, ultimately leading to unstable, boom-and-bust market dynamics (De Boeck, Van Asch, De Bruecker, Audenaert, 2016).

As costs of PV installations continue to decrease, countries with low irradiation and solar PV adoption rates, such as Lithuania, are also becoming increasingly interested in policy support for solar PV, focusing on remuneration schemes for residents, though prosumer electricity demand and solar generation profiles are often mismatched. As mentioned by Zemite, Gorobetz, Gerhards, Ribickis, and Levchenkov, 2010, the existing energy market rules alone cannot deliver the desired levels of RES utilisation in the European Union, therefore support schemes are needed to overcome this market failure and increase investments in renewable energy (RE). Policy makers have to take into consideration a number of factors, such as the system value of growing the share of solar PV on the electricity system, the current and future economics of solar PV for various customers (utility-scale, commercial, and residential), as well as the environmental, social and other impacts of increased solar PV electricity generation.

Governments used to finance renewable energy sources (RES) development programs using a feed-in tariff (FiT), however, this has recently been replaced with other instruments that apply the incentives to producers, namely, tax incentives, tradable green certificates, investment support, net metering systems (NMS), auction/tendering systems and others.

A feed-in-tariff (FiT) scheme provides a premium price and obliges the grid operators to purchase the generated electricity output. Tax incentives provide the best relationship between the cost of capital and through the use of tax credits. The production tax credit and the investment tax credit are both given to eligible companies who either start certain renewable energy projects or invest in renewable energy equipment. Eligible companies with insufficient profit to utilise these credits can sell them as tax equity to investors in order to finance their projects. In the tendering/ auction system, the government announces tenders for the purchase of a certain capacity or production of energy based on renewable sources. Project developers wishing to participate in the auction submit an application with the price per unit of electricity at which they expect to implement the project. The auctioning institution evaluates the offers according to price and other criteria and signs a power purchase agreement with the successful bidder (Petrichenko L., Zemite L., Sauhats A., Klementavicius A., Grickevics K. 2019). FiTs are not currently applied for supporting solar PV installations in Lithuania at all.

The NMS is an electricity policy, which allows energy prosumers to balance their electricity usage with electricity produced by themselves. The variability and inconsistency of the energy generation and consumption schedules lead to a need for energy exchange between the consumer and the electric grid (Poullikkas A., Kourtis, G., Hadjipaschalis, J, 2013). The NMS system establishes rules for the exchange of energy between the electric grid and the consumer and the formation of payments for using it. Diverse methods of paying for the energy given or taken are used in the formation of bills. A common feature for different systems is that they each ensure the possibility of supplying energy from the consumer to the grid at times when generation exceeds consumption and returning it in the opposite case. The methods used by the NMS are distinguished based on the way of paying for the energy given or taken in the formation of bills. In European countries, two main groups of NMS variants are used (Sauhats A., Zemite L., Petrichenko L., Moshkin I., Jasevics A., 2018).

The first group is based on taking into account the energy exchange between the electric grid and the prosumer (net accounting system (NAS)). The NAS does not respect the production/consumption time and market value of the energy produced or consumed (Petrichenko *et al.*, 2019). The NAS, which is currently in place in many countries (in particular, in Lithuania), disregards the prices of the submitted and received energy. The energy surplus is measured in units of energy (kWh), and when electricity production exceeds consumption, it is submitted to the network; otherwise, it can be returned from the network.

The second group takes into account not only the amount of energy but also its cost (a net billing system (NBS)). In this case, a new, more sophisticated payment scheme should be used. This is based on the treatment of the variable cost of energy depending on the actual wholesale market price of electricity. The cost of energy forms the basis for mutual settlements between the electric grid and the prosumer. In the NBS case of grid debt, the market price of the submitted and received energy is considered. The grid's debt is expressed in monetary terms. The prosumer is motivated to submit energy at time periods when the prices are high and to consume it when the prices are as low as possible, receiving an energy amount that is larger than the submitted amount. Such an NBS system has significant advantages; however, it not only requires more complex measurements but also is more complex from the point of view of its effectiveness analysis, since it is strongly influenced by three random processes: the generation of energy, energy consumption, and energy market price (Sauhats *et al.*, 2018).

Another support mechanism is providing subsidies, which are based on capacity-based incentives. The capacity-based incentives are solar incentives where the incentive rate is offered based on the installed capacity of the solar PV system (Euro per kW), and are generally paid as up-front incentives. With the capacity-based incentives, the budget is generally limited, and the incentives are offered on a first-come, first-served basis; thus, it is not guaranteed for all customers to receive such incentives. Additionally, the capacity-based incentives decline over time as the statewide installed capacity of the solar PV system increases. Therefore, the more delayed the installation of the solar PV system, the more difficult it comes to receive a higher amount of incentives (Lee *et al.*, 2018).

Table 1 reviews the countries of the European Union and indicates the support schemes in place for the installation of solar panels (data available on June 2020).

Table 1

Supporting mechanisms for solar PV installations in the European Union

EU country (28)	Feed-in tariff	Loans	Net metering	Premium tariff (Tenders)	Tax regulation	Subsidies
Austria	✓					✓
Belgium	✓		✓			✓
Bulgaria	✓					✓
Turkey	✓		✓			✓
Czech Republic	✓			✓		
Denmark			✓	✓		
Estonia				✓		
Finland						✓
France	✓				✓	✓
Germany	✓	✓		✓		
Greece	✓		✓	✓	✓	✓
Hungary	✓		✓	✓		
Ireland						✓
Italy			✓	✓	✓	✓
Latvia			✓			
Lithuania		✓	✓	✓	✓	✓
Luxembourg	✓				✓	✓
Malta	✓					✓
The Netherlands		✓	✓	✓	✓	✓
Poland		✓			✓	✓
Croatia		✓				
Portugal	✓					
Romania						✓
Slovakia					✓	✓
Slovenia		✓				✓
Spain						
Sweden					✓	✓
United Kingdom	✓				✓	✓

Source: gathered by author using Legal sources for Renewable energies.

Recent studies present the comparative analysis of financial performance which use different support mechanisms in various countries with different costs, irradiance profiles, and other market conditions (for example: Couture and Gagnon, 2010; Sarasa-Maestro *et al*., 2013; Campoccia *et al*., 2014; Dusonchet and Telaretti, 2015; de Boeck *et al.,* 2016; Lacchini and Ruther, 2015).

Some studies show that FiTs "consistently delivered new renewable energy supply more effectively, and at lower cost, than alternative policy mechanisms" (Couture and Gagnon, 2010), however, other research comments on the disadvantages for governments and taxpayers of overly generous FitTs. (Sarasa-Maestro *et al.,* 2013). Whereas, Lacchini and Ruther (2015) state that the policies should be aimed at decreasing upfront investment costs instead of issuing generation-based remuneration. The application of FiTs and investment support schemes has aided the distribution of a large number of RES installations across the Europe, but has ultimately lead to an increase in the cost of the bills for end users (approximately 35% is included in the bill), causing discontent among the public, which means that it is impossible to further increase the FiTs (Sauhats A., *et al*, 2018). In the situation, where there is no consensus on the question of the most efficient policy for solar PV, the optimal policy can be created based on the solar resource and market characteristics of each individual country. Given the lack of consensus on the type of policy most efficient and effective for solar PV systems, it is clear that optimal design should be based on solar resources and other market characteristics in a particular country.

What is more, when drawing up a proposal in the solar PV sphere, it is necessary to keep in mind the negative effect of distributed solar PV on supplier revenues. In many countries, the costs of distribution, transmission and generation of electricity are recovered through retail tariffs levied on a volumetric basis (Darghouth *et al.,* 2016). This can lead to PV customers with lower electricity demands avoiding paying for electricity system costs.

This effect is particularly obvious with net metering policies, under which PV customers pay the retail rate for the net amount of electricity they generate, and therefore such policies implicitly subsidize customers for distribution, transmission and generation of services that they do not provide (Kirsch and Morey, 2015). In a world with higher shares of distributed renewable generation, a different tariff will be necessary to make up for the fixed costs of grid services (Sioshansi, 2016). One option is a two-part tariff that has a fixed charge for grid services and a volumetric electricity charge (Darghouth et al., 2011). Nevertheless, a tariff is likely to influence the financial performance of PV systems. Therefore, in case of feasibility evaluation for solar PV policies both the on-going and potential retail tariff sctuctures should be taken into account.

Some studies have conducted an economic analysis of the solar PV system in the EU, taking into account the incentives for solar energy use. (Ameli, Kammen, 2014; Antonelli, Desideri, 2014; Frondel *et al.,* 2010; Hass *et al.,* 2011; Laleman, Albrecht 2014). Ameli and Kammen (2014) developed a financing tool based on a pollution abatement methodology in order to examine options to bridge the cost gap between solar PV and other energy generation technologies in Italy. The results showed that a well-designed Property Assessed Clean Energy (PACE) loan program, as an alternative to subsidy programs (i.e. feed-in tariff), would be an effective tool to achieve solar grid parity without burdening public budgets. Hass *et al.* (2011) evaluated the performance of various promotion strategies for electricity from renewable energy sources within the EU member states. The study concluded that technology-specific financial support measures were more effective than other strategies, implying that how promotion strategies are designed and implemented for each technology is the key solution, not what kind of support instrument is selected and implemented. These studies evaluated the economic aspects of various solar incentives and proposed effective solutions, but failed to apply these lessons to low-GDP and low-solar irradiance regions (i.e. Lithuania, etc.).

Financing can also have a major impact on the economics of solar PV projects (Ongrajek *et al.* 2015; Tao and Finenko, 2016). Obviously, governments that offer financial incentives have increased rates of PV deployment, as shown by Crago and Chernyakhovskiy (2017), Sarzynski *et al.* (2012) and Jacobsson and Lauber (2006). Financing, which is available to residential prosumers is different from the one commercial investors can receive, e.g. households might possess savings in cash and pay in cash to install a PV system, while commercial investors are more likely to apply for a loan, and then lending rates would reflect on the cost of servicing the debt. Moreover, households take a different approach to decision making compared with commercial investors. The financing conditions and options for residential prosumers are different from those used by commercial investors. Households may have significant savings and choose to pay for a PV installation in cash, mainly in case of low deposit interest rates. Commercial investors are more likely to use loans and then interest rates will determine the cost of servicing that debt. It is also crucial to take into consideration the fact that households take a different approach to capital budgeting compared with commercial investors, so their financial performance should also be evaluated differently.

1.2. Decision-making criteria in evaluation of photovoltaic system investment

The results of many studies, such as: Raszkowski A. *et al.* "Towards Sustainable Regional Development: Economy, Society, Environment, Good Governance Based on the Example of Polish Regions" (2018), Dalevska N. *et al.* "A model for estimating social and economic indicators of sustainable development"(2019), Dabyltayeva N. *et al.* "The green economy development path: Overview of economic policy priorities" (2019), Brożyna J. *et al.* "Renewable energy and economic development in the European Union (2017), Matuszewska-Janica A. *et al.* "Evaluation of Short-Term Relationships between Selected Investment Funds and the Capital Market in Poland" (2019) indicate that one of the main drivers which provide the financial base for sustainable growth is green investment.

The most important component of developing sustainable progress either of a company or a household is the identification, selection, and drawing up of worthwhile investment projects, comprising a detailed analysis of all assumptions underlying its implementation, correct calculation of expected cash flows and in-depth assessment of risks. The decision to proceed with or abandon the project will have a noticeable effect not only on the short term economic profile of a given investor, but also influence long-term profitability.

In an economic sense, an investment is the purchase of goods that are not consumed today but are used in the future to create wealth. An investment always concerns the outlay of some asset today (time, money, effort, etc.) in hopes of a greater payoff in the future than what was originally put in. From this point of view, installation of the residential solar PV system can be seen as a private investment.

Before analyzing the impact of different support policies and financing schemes on the investment projects in residential PV systems and developing a model for the evaluation of economic efficiency of investment projects, which can allow households to make optimal investment decisions, it is necessary to understand the types of analysis of investment projects. Project analysis is one of the main types of work performed by the initiator of the project at the pre-investment stage that is used to determine the socio-economic efficiency of the project, the complex risks, the feasibility of the project and the organization of its funding.

The main types of project analysis are:

- Analysis of the technical feasibility and innovation capacity;
- Environmental analysis of the project;
- Strategic analysis of the project;
- Project Risk Management;
- Rapid analysis.

Project analysis deals with three different areas. The first stage involves collecting and evaluating project-related data. Particularly, predicted costs (construction costs, costs of technical components), subsidies, outputs (value of net produced electricity), and calculated benefits must be analyzed carefully, because this analysis will influence the criteria that will be used later to evaluate the project. Next is the evaluation stage, which involves assessment of project benefits that will contribute for the value of an investor. Finally, there is a third stage that deals with the risk analysis, which will also check the evaluation results.

The evaluation of an investment project is started upon completion of the cash flow calculation. The majority of the methods of evaluating the economic efficiency of investment project is based on the discounted cash flows, i.e. the cash flows of a project must be discounted to the present value, with a relevant discount rate corresponding to the level of investment.

Nowadays, economists have a variety of methods and criteria for evaluating the efficiency of investments, but the most transparent, comprehensible and widely used are the following: 1) net present value (NPV) method; 2) internal rate of return (IRR) method; and 3) simple and discounted payback period (PP, DPP) method; 4) profitability index (PI) method.

NPV method is widely used as the best single screening criteria to reject or accept a project because it takes into consideration the time value of money concept. Its value reflects an expected change in shareholders' value caused by a project. The equation of NPV is as follows:

$$NPV = -Outlay + \sum_{i=1}^{T} \frac{C_i}{(1+r)^i}, \text{ where} \quad (1)$$

$-Outlay = Initial\ Investment$

$C \quad = Cash\ Flow$

$r \quad = Discount\ Rate$

$T \quad = Period\ of\ time$

It is important to remember that the discount rate takes into consideration not only the time value of money concept but also the risk of uncertainty of expected cash flows. That is the reason why the project's weighted average cost of capital (WACC) should be used as the discount rate. In other words, a project's WACC is the required rate of return on capital invested in the project. Accordingly, the greater the risk of uncertainty of expected cash flows, the higher the discount rate, and vice versa.

$$WACC = r_e \, {}^{E}/_{(E+D)} + r_d \, (1-t) \, {}^{D}/_{(E+D)}, \text{ where} \quad (2)$$

E / (E +D) = proportion of equity used to finance the project;

r_e = cost of equity;

D / (E +D) = proportion of debt used to finance the project;

r_d = cost of debt;

t = company's tax rate.

The decision rule in using the NPV method is rather straightforward. The threshold value of zero indicates that cash flows of a project exactly cover the cost of invested capital and provide the required rate of return on invested capital. A stand-alone project should be accepted if its NPV is positive, rejected in case it is negative, and stay indifferent if zero. Among several mutually exclusive projects, the one with the highest positive net present value should be accepted.

Like NPV method, *IRR method* also takes into account the time value of money. It analyzes an investment project by comparing the IRR to the minimum required rate of return of the company, which is normally set by management. Most of the time, it is the cost of capital of an investor.

The IRR is the discount rate at which the present value of a project's net cash inflows becomes equal to the present value of its net cash outflows. In other words, it is the discount rate at which a project's net present value becomes equal to zero.

$$NPV = -Outlay + \sum_{i=1}^{T} \frac{C_i}{(1+r)^i} = 0, \text{ where} \quad (3)$$

$-Outlay = Initial\ Investment$

$C = Cash\ Flow$

$r = Discount\ Rate$

$T = Period\ of\ time$

According to this method, if the IRR provided by the investment project is greater than or equal to the minimum required rate of return, the project is considered acceptable, otherwise the project is rejected.

The *payback period* refers to the amount of time it takes to recover the cost of an investment. Simply put, the payback period is the length of time an investment needs to reach a break-even point. The desirability of an investment is directly related to its payback period. Shorter paybacks mean more attractive investments. The main calculation principle is that cumulative cash flow (which is initial investment minus inflows) is equal to zero. The payback period method does not discount cash flows at the project's required rate of return and ignores the time value of money. In addition, this method does not calculate cash flow at the end of the payback period and does not consider the overall return on investment. Many managers and investors thus prefer to use NPV as a tool for making investment decisions.

While calculating the payback period is useful in financial and capital budgeting, this metric can be applied in other industries. As the most basic and the simplest evaluation method, it can be used by households and small business units to calculate the return on energy-efficient technologies such as solar PV panels, including maintenance and other incremental costs.

Discounted payback period is a capital budgeting method used to calculate the time period a project will take to break even and recover the initial investments. It is an appropriate method to determine the viability of a project as the calculation is done after considering the time value of money and discounting the future cash flows. A general rule to consider when using the discounted payback period is to accept projects that have a payback period that is shorter than the target timeframe. An investor can compare its required break-even date for a project to the point at which the project will break even according to the discounted cash flows used in the discounted payback period analysis, to approve or reject the project. One of the drawbacks of the discounted payback period method is that flows coming in after break-even point are not considered. What is more, this method notes only the time needed to recover the initial cost of a project. Therefore, it can clash with NPV and bring about wrong results. So, choosing the project based only on the payback criterion is not an optimal decision.

The *profitability index (PI)* describes an index that represents the rate between the costs and benefits of a considered project, using the following ratio:

$$PI = \frac{PV\ of\ future\ cash\ flows}{Initial\ investment} = 1 + \frac{NPV}{Outlay} \tag{4}$$

The PI is helpful in ranking various projects because it lets investors quantify the value created per each investment unit. A profitability index of 1.0 is the lowest possible measure of the index, because any value lower than that number would specify that the project's present value (PV) is less than the initial investment. The higher the value of the profitability index, the better the financial prospects of a project.

The utility of any analytical instrument always depends on the specific application. Two observations by Brounen, De Jong, and Koedijk (2004) and Graham and Harvey (2001) outline the commonness of their use by European and American and corporations, using a scale ranging from 0 (never) to 4 (always). Mean responses about frequency of use of capital budgeting techniques are presented in Table 2 (Clayman *et al.*, 2012).

Table 2

Mean responses about frequency of use of capital budgeting techniques

Criteria	United States	United Kingdom	Netherlands	Germany	France
Internal rate of return	3.09	2.31	2.36	2.15	2.27
Net present value	3.08	2.32	2.76	2.26	1.86
Payback period	2.53	2.77	2.53	2.29	2.46
Discounted payback period	1.56	1.49	1.25	1.59	0.87
Profitability index	0.85	1.00	0.78	1.04	1.64

Source: Graham and Harvey (2001) and Brounen, De Jong, and Koedijk (2004), Clayman *et al.*, 2012.

The research shows that despite traditional books praising the NPV and IRR techniques, a few other methods are also widely used. In the European countries, for example, the payback period method is used as often as, or more often than, the NPV and IRR. In general, larger companies usually choose the NPV and IRR over the payback period. Private businesses and individual investors preferred using the payback period compared with public corporations.

According to Bernard Chabot, (1999), “From costs to prices: economic analysis of photovoltaic energy and services”, the criteria used for profitability analysis of PV projects were reviewed through net present value, internal rate of return, and profitability index. A simple method with associated equations and graphic tools was used in order to assess the profitability of PV projects from the PI. According to the article, despite the dramatic reduction in the cost of PV projects, such projects need incentives either in the form of subsidies on the initial outlay or rate-based incentives.

Photovoltaic applications are very different, but in each case their economic analysis can give relevant information, which parameters are of importance for a sufficient profitability of PV projects. Soft conditions for project financing and fair prices and tariffs for PV kWh and services are of paramount importance for achieving economic profitability of PV projects. The methodology and the tools, presented by the author, to calculate the overall discounted cost of PV kWh and PV energy services and to quantify the profitability of PV projects can contribute to facilitating discussions between PV developers and regulators fixing tariffs of such kWh or services.

In the work, Dusonchet Luigi, Telaretti Enrico, “Economic analysis of different supporting policies for the production of electrical energy by solar photovoltaics in western European Union countries” (2010) analyze national support policies and support mechanisms in PV technology in western European countries, based on the calculation of the cash flow, the NPV and the IRR indices. Their study indicates that in some situations support policies can create difficulties for development of the PV-based generation system, moreover, the differences in the implementation of the same support policy in different countries, can lead to distinctly dissimilar results.

In the research paper, Setiawan, Agus, *et al.* (2018) "Determination of Optimal PV Locations and Capacity in Radial Distribution System to Reduce Power Losses” and Qashtalani Haramaini, Agus Setiawan *et al.*, (2019), ”Economic Analysis Of PV Distributed Generation Investment based on Optimum Capacity for Power losses Reduction”, describe an analysis for choosing the most beneficial investment of photovoltaic distributed generation based on technical calculations of optimum PV location and capacity to reduce power losses. The optimal location that has been calculated is used as a base location to find out the optimum PV capacity to be installed by using some economical parameter.

To evaluate the benefits and cost of the PV investment, the annual savings, the revenue, the initial capital investment, the operating and maintenance costs are taken into account, and analysis is made using NPV, IRR and PP methods. According to Setiawan and Agus, if the NPV-based decision is used, the most beneficial of PV investment is based on optimum PV capacity, because it reduces power losses.

In the work, Nofuentes G., *et al.* "Tools for the Profitability Analysis of Grid-Connected Photovoltaics" (2002) reviewed some parameters and criteria involved in PV grid-connected systems profitability analysis: net present value, modified profitability index, payback period, internal rate of return and break-even turnkey cost. The article also presents charts and tables intended to assess the profitability of such PV systems in terms of some of the economic measures of attractive financial support programmes, promoting the use of grid-connected PV in the EU.

Gua Yaxiu *et al.*, in their research work "Techno-economic analysis of a solar photovoltaic/thermal (PV/T) concentrator for building application in Sweden using Monte Carlo method" (2018) developed the analytical model for economic evaluation of a PV concentrator. In the model, sensitivities of 11 key input variables (including average daily solar irradiance, electrical efficiency, prices of electricity, operation & management cost, PV capital cost, debt to equity ratio, interest rate, discount rate, and inflation rate) to 3 economic-performance metrics (levelized cost of energy (LCOE), NPV, and payback period) are analyzed. Essential influencing variables are optimized for recommendations of PV investment in a particular country.

In their work, D.L. Talavera *et al.*, "A worldwide assessment of economic feasibility of HCPV power plants: Profitability and competitiveness" (2017) presented an analysis of the required IRR of high concentrator PV power plants in over 133 countries, together with required tariffs which fulfill profitability requirements for owners or investors in the high concentrator PV power plants in those countries. Besides, investor's required tariff has been compared to wholesale electricity prices in order to determine the competitiveness of the HCPV power plant by means of the concept "generation parity" within the analysed countries, for a scenario in 2015 and a mid-term scenario in 2020.

The results, obtained by Talavera, D. L. *et al.* in their research paper "Sensitivity Analysis on Some Profitability Indices for Photovoltaic Grid–Connected Systems on Buildings: The Case of Two Top Photovoltaic European Areas", (2013) provide clear evidence that factors such as initial investment subsidy, dividends on own capital, taxes, annual loan interest exert a relatively small and similar influence on the net internal rate of return, the net present value and the discounted payback time. However, other factors such as the initial investment, the annual PV electricity yield and the PV electricity unitary price have a bigger influence on these profitability indices.

Faiers and Neame (2006) note that that payback period is the most important criterion for homeowners who decide to invest in rooftop PV. Lee *et al.* (2016) also refer to the payback period, citing Rai and McAndrews (2012) and indicating that households require a payback period of seven to ten years in order to proceed with rooftop PV investment. Scarpa and Willis (2010) state the period must be shorter and name a timeframe of between three and five years. However, a ten-year maximum might be more appropriate for the Lithuanian residential PV market, which is still an immature market.

By incorporating the NPV, IRR and PP methods, the investors can arrive at a right decision and know the exact risk involved in a project. Equally important that these methods are appropriate for investment estimation of a solar PV project, as cash flows and discount rate can be correctly determined. If the guaranteed tariff rate and relatively low operating costs are used, the future cash flows of the project can be estimated more precisely. Initial costs are based on current prices and thus can also be considered reliable.

The risk and uncertainty analysis are also very important phases in the decision-making process. *Sensitivity analysis* researches the differences in objective function in case of variations in the key inputs of a model with the goal of finding the most important risk factors that might have an effect on the output (and as a result influence the decision about investment), and then ranks them.

The fundamental purpose of the sensitivity analysis is twofold: insight into the impact of critical model-based parameters and the sensitivity of model-produced profitability to those parameters. Sensitivity analysis reveals the effects on the output criteria (NPV, IRR, PP) of changes in one input variable at a time. So, using the information obtained from the sensitivity analysis, various scenarios for variables that are critical in the model can be devised.

In contrast, scenario analysis draws up scenarios that consist of changes in several of the input variables and calculates the output criteria for each scenario. Relative financial performance of a residential PV system will be estimated in various scenarios (combinations of different support schemes and financing structures), using traditional discounted cash flow metrics (net present value and internal rate of return) but with a special emphasis on discounted payback period.

1.3. Overview of investment possibilities in solar photovoltaic market in the European Union

1.3.1. Background: current infrastructural conditions of solar photovoltaic market in the European Union

European Union enjoyed one of the best years ever for solar energy in 2019. Solar energy will take a key role in enforcing the European Green Deal: the most progressive set of procedures aiming at benefitting both citizens and businesses from the use of sustainable green energy; its other goal is to make Europe the first climate-neutral continent by 2050.

There are a lot of reasons why solar power was the source that created more energy than any other electricity generation technology in the European Union in 2019, and there are many reasons why solar power is likely to remain in the leading position in the future. In contrast to the period from 2008 to 2012, when high green tariffs in a very small number of member countries of the system led to distinct but rather short-term growth of solar energy.

First of all, the most important factor of solar energy deployment in the EU and beyond is its competitiveness. Solar power is often cheaper than any other power generation source today, so its economic viability experiences an increase faster than that of any other technology. Another important factor ensuring the growth of solar power in the EU countries, is the fact that many member states have already started to prepare for their compliance with the Clean Energy Package's 32% renewables target by 2030. Solar power is the most popular power generation source among EU citizens, it also provides a way for the governments to expand the share of renewables.

Nowadays, there are lots of tools and technologies backing solar, e.g. tenders that show utility-scale solar is able to win technology-neutral tenders against all other power generation technologies; self-consumption and storage opportunities that attract prosumers; new business models made possible by digitalisation (peer-to-peer electricity supply). The latest trend promoting the rise of solar is corporate renewable power sourcing, which has become an essential part of the energy and sustainability strategy for many leading corporations (SolarPower Outlook, 2019).

Moreover, the EU's "Clean Energy for All Europeans" legislation creates positive conditions for solar energy storage. The legislation has set a higher-than-expected 32% renewables target by 2030, providing the right to self-consumption, and giving priority to small-scale solar installations, among many other pro-solar provisions. Finally, it has addressed the need for a flexible, renewable energy system by creating a new electricity market design framework and implementing new tools.

What's more, European Green Deal which is aimed at making Europe the world's first carbon-neutral continent by 2050 and assessment of the European Commission in 2020 might result in stricter 2030 targets with a commitment to reduce CO_2 reductions by 55% (rising from a current target of 40%), these developments will have a beneficial effect on promotion of solar power.

From the capacity point of view, it is clear that in 2019 in the EU region 16.7 GW were installed, which signifies a 104% increase over the 8.2 GW added the year before. Furthermore, the year 2019 also showed the strongest solar growth since 2010, when the EU PV market increased by 104% during the first European solar boom, although to a lower level, reaching 13.4 GW (SolarPower Outlook, 2019).

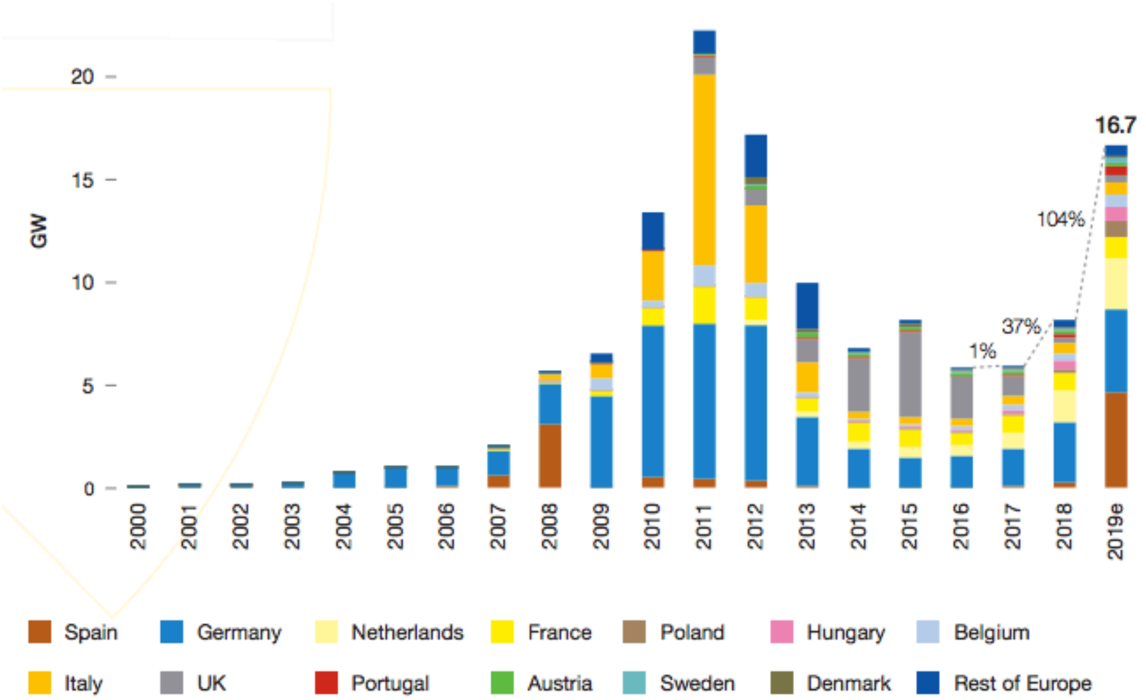


Figure 1. EU28 Annual solar PV installed capacity 2000 – 2019.

Source: SolarPower Outlook, 2019.

Spain (with an added 4.7 GW in 2019) was both the EU's and Europe's biggest solar market, returning to the continent's top solar spot, 11 years after it last held the position. The remain top 5 EU solar markets include Germany (4 GW), the Netherlands (2.5 GW), France (1.1 GW), and Poland, which nearly quadrupled its installed capacities in 2019 and reached 784 MW.

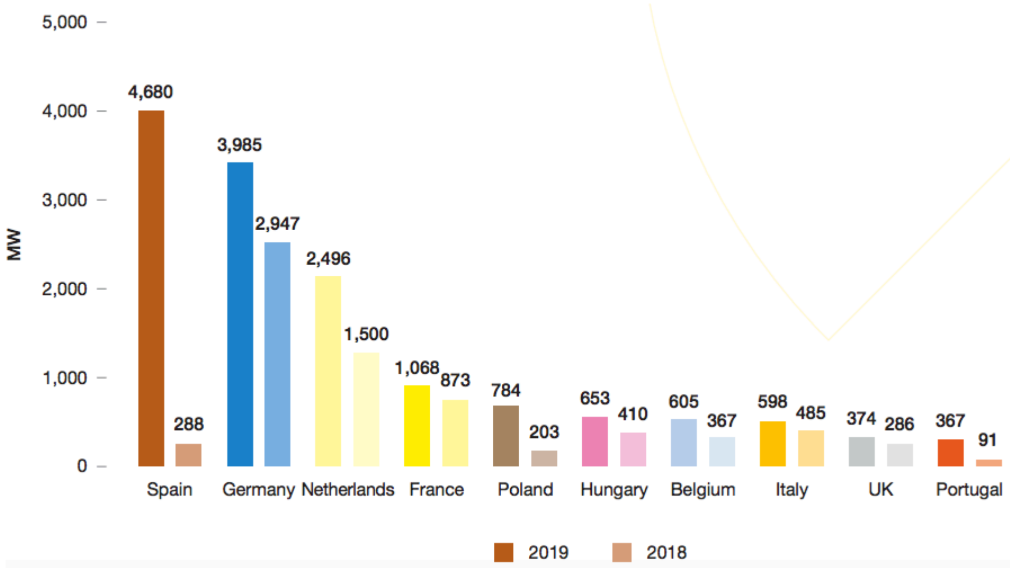


Figure 2. EU28 TOP 10 solar PV markets, 2018 – 2019.

Source: SolarPower Outlook, 2019.

Collectively, the Top 5 solar markets were responsible for over 75% of the installed capacity in the EU in 2019.

Growth in solar support in the European Union resulted in a total of 131.9 GW by the end of 2019, up 14% from 115.2 GW a year earlier.

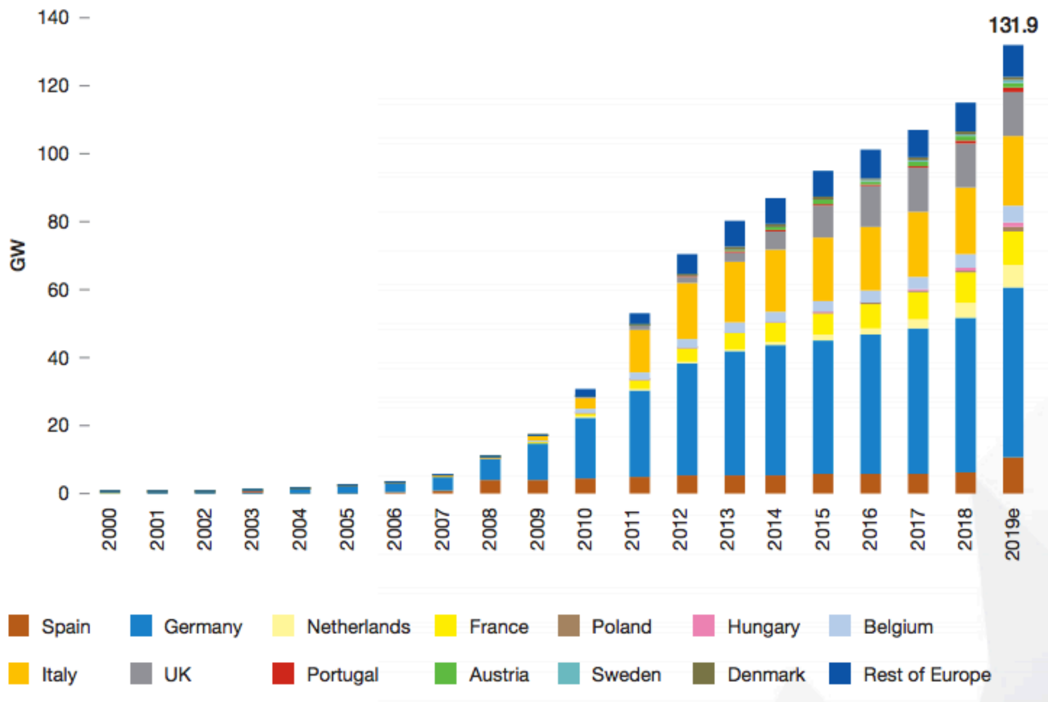


Figure 3. EU28 Total solar PV installed capacity 2000 – 2019.

Source: SolarPower Outlook, 2019.

The pattern of EU-28 total solar installed capacities in 2019 is similar to 2018 (see Figure 3). Like in the past, Germany continues to be the biggest solar power plant operator by far - with

49.9 GW of total installed capacity – followed by Italy, which has now exceeded the 20 GW mark, reaching 20.5 GW. Again, Germany (38%) and Italy (16%) are owners to over half of the EU's solar power generation capacities. Nevertheless, their collective share slightly reduced again; 53% vs. 57% in the previous year. In 2018, only one other European market – the UK – had more than 10 GW of solar PV installed, now at 13.3 GW equal to a 10% share. In 2019, Spain also became in the two-digit GW solar market class with 10.6 GW, after grid-feeding around 4.7 GW. If round up, France is now also a 10 GW solar giant after adding about 1.1 GW, bringing total capacity to 9.97 GW by the end of 2019.

Along with the four double-digit solar giants in the EU, 12 EU countries had solar capacities in the single-digit GW class, two of which are in the mid-range – the Netherlands with 6.7 GW and Belgium with 4.7 GW – while most EU countries fall into the 1-2 GW class (Austria, Bulgaria, Czech Republic, Denmark, Hungary, Greece, Poland, Portugal, Romania). Notably, in 2019, three countries exceeded the established aggregate level of 1 GW for the first time, Denmark, Hungary and Poland, and turned the tide to the majority of European states having more than 1 GW of solar installed. (SolarPower Outlook, 2019).

Despite the relatively small contribution of the other EU member states, it seems that the vast majority are now heading in the right direction, even if this is happening at a much lower level. In 2019, 26 of the 28 EU markets had more solar capacity installed than a year earlier.

1.3.2. Intensity of utilisation of photovoltaic panels in the European Union and the Baltics countries

The current tendency of greening the economic development contributes to analysing the most significant drivers that boost this process. All EU countries signed the agreement on achieving Sustainable Development Goals 2030 (SDGs 2030). According to this agreement, the EU countries, on a voluntary basis, try to reduce their negative impact on the environment and harmonise their economic, social, and environmental development. The results of many studies indicate that one of the main drivers, which provide the financial base for sustainable growth, is green investment. Green investment can help in achieving important sustainable development goals: GDP per capita, increase of renewable energy utilization and greenhouse gas (GHG) emission reduction. The findings show that green investment could provoke the growth of GDP per capita by 6.4%, the decline of GHG by 3.8%, and the increase of renewable energy in the final energy consumption by 5.6% (Lyeonov *et al.,* 2019).

The majority of the sources, such as García-Álvarez *et al.,* 2018; Popovic *et al.,* 2018, show the leading countries in the utilisation of PV technologies in terms of installed capacity, which does not provide an opportunity to compare the intensity of the utilisation of PV technologies, taking into account the population numbers of the countries and their economic situation. To evaluate the situation regarding the utilisation of PV technologies, Jasevics *et al.,* 2018, in their research paper introduce the PV technology utilisation evaluation scale: installed capacity of PV technologies per one inhabitant and installed capacity of PV technologies in relation to the GDP of the country with the aim to offset the influence of the number of population and the economic situation on the utilisation of PV technologies.

The analysis of PV system installed capacity per one inhabitant makes it possible to evaluate the intensity of the utilisation of PV panels and installation activity in each country.

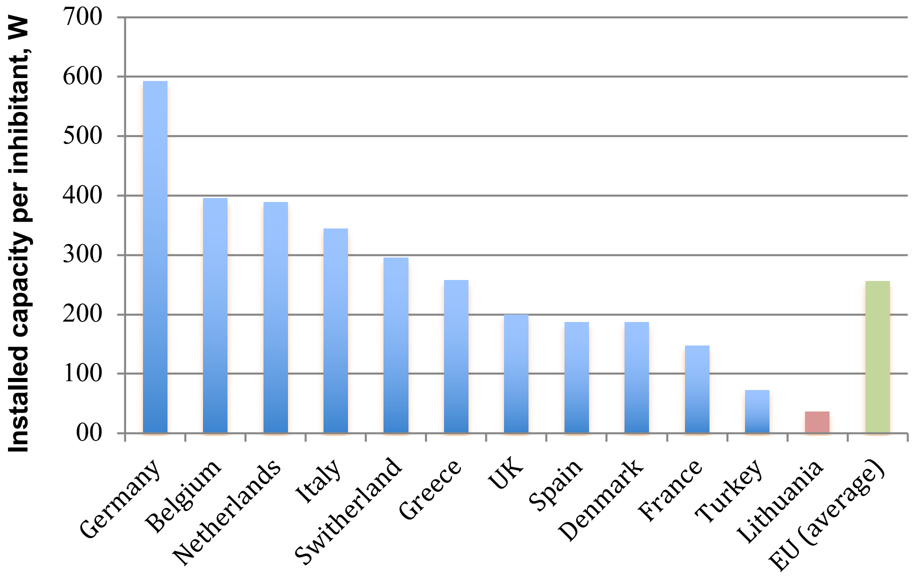


Figure 4. The installed capacity of PV technologies per capita in the EU in 2019.
Source: Eurostat, gathered by author.

Figure 4 shows that Germany has the largest installed capacity per one inhabitant (approx. 600 W/inhabitant), followed by Belgium and the Netherlands (approx. 400 W/inhabitant). The EU average PV panel installed capacity per inhabitant is 257 W/inhabitant. Noteworthy, that in comparison of Northern low-irradiance European countries with a maximum irradiance of 1000 kWh/kW per year, a high indicator is also observed in Denmark: 187 W/inhabitant. In the remaining Northern European countries, this indicator is approx. 30 W/inhabitant, while Lithuania has level of 37 W/inhabitant. So, it can be concluded, that the level of radiation is not the most influential factor on the intensity of the utilisation of PV energy. To be able to analyze the impact and share of the installed capacity of additional PV panels in Lithuania, it is also necessary to evaluate how the GDP of the countries influences utilisation of PV technologies (Figure 5).

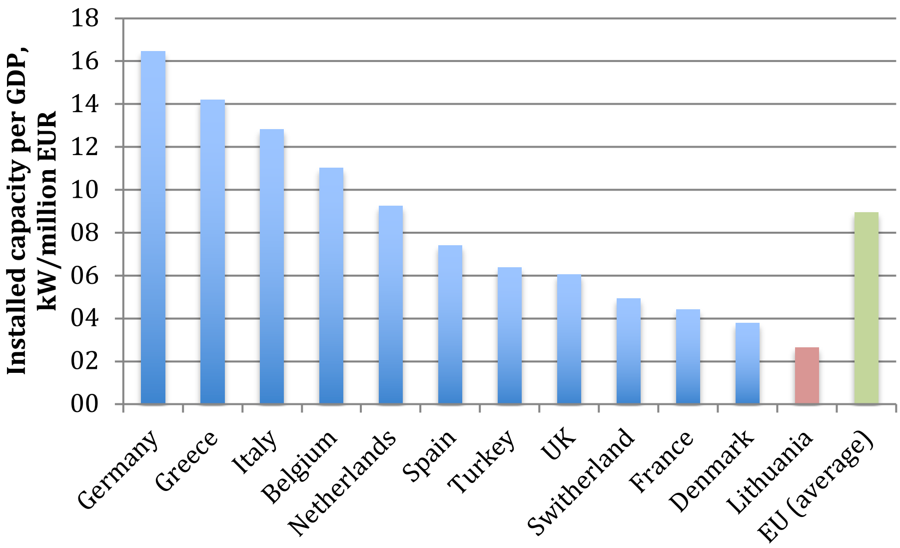


Figure 5. The installed capacity of PV technologies per GDP in the EU in 2019.

Source: Eurostat, gathered by author.

From the data obtained (Figure 5), a tendency can be observed: countries with a higher GDP per capita have a higher installed capacity of solar panels, which can be mainly explained by more available state support for the use of PV technologies. Countries with a higher GDP have the possibility to introduce additional state support systems to facilitate the introduction of PV technologies.

The experts have created the Sustainable development goal index to demonstrate countries' success on the way to achieving SDGs 2030. According to the official report (Sachs *et al.,* 2019), in 2019, the first five places were occupied by Denmark, Sweden, Finland, Austria and Germany with the index of 79.8-75.3. For these high-income countries, allocation of additional capital for achieving SDGs is not a serious challenge. Unfortunately, for such upper-middle-income countries like Lithuania (its rating is 23 with an index 62.6), Latvia and Estonia, allocation of additional financial resources for increasing the share of affordable clean renewable energy (SDG7) is a big issue due to their unstable economic situation.

Notwithstanding the similarities in the climatic conditions and natural resources, there are differences in how renewable-source-based equipment is used in the Baltic States. For example, the largest amount of hydropower is available in Latvia, utilisation of solar power is most active in Lithuania and utilisation of wind power is most widely used in Estonia. In 2018, in Lithuania approx. 24.4% of the total electricity consumption was produced from renewable energy sources. In Estonia in 2018, the share of renewable-source-based electricity made up approx. 30% of the total electricity consumption. In Latvia, the share of renewable-source-based electricity was approx. 40.3% in 2018 (Eurostat, 2019).

A comparison of the Baltic countries shows that Lithuania is in the lead and has the highest installed PV capacity — 103 MW, followed by Estonia with approx. 13.8 MW and Latvia with approx. 1.9 MW. It can be concluded that applying a particular type of support scheme for PV prosumers in countries with a low average solar irradiance and a low GDP plays a crucial role in the development of the PV solar market and can explain such uneven use of PV technologies. In such countries it is necessary to make well-informed and economically substantiated decisions for the PV technology utilisation levels to reach the level of Germany or at least the EU average.

In the conclusion of the theoretical and market overview of the support policies and their influence on residential PV utilization, it's important to note that many scientists made major contributions to the retrospective assessment of customer economics in a variety of PV support policies. Economists have indicated that electricity is a heterogeneous product in time, space, and lead-time dimensions (Hirth et al., 2016; Borenstein, 2012; Joskow, 2011). The prices on electricity and the availability of solar PV generation can differ over time, thus leading to inconsistencies in case of applying average values to economic efficiency evaluation. This may be especially relevant for locations with low solar irradiation, big variations between the duration of a day in winter and summer, and a mismatch between the timing of electricity usage and solar production, for example in Lithuania.

A residential PV may be seen as a potential receiver of support, so it is important to examine the economic value available to homeowners who might consider installing solar, and how their financial gains can be influenced by different policy schemes. It is important to understand the financial options available to households as they choose from the variety of energy-saving technologies available, and to evaluate the metrics of the PV financial performance, using the most appropriate decision-making criteria.

2. METHODOLOGY FOR EVALUATION OF THE IMPACT OF SUPPORT SCHEMES ON ECONOMIC EFFICIENCY OF RESIDENTIAL PHOTOVOLTAIC SYSTEM

2.1. Description of net metering model

The use of a solar power plant in a household can be divided into four phases: 1) solar energy harvesting; 2) electricity usage; 3) excess energy delivery to the grid and its storage; 4) energy return. With the help of special equipment (inverter), solar energy is converted into electrical energy that can be used by a household. In Lithuania, like in many other countries, the amount of energy generated by a solar power plant fluctuates depending on the season and the period of a day. Because of this, there is either a deficit or an excess of energy generated. To account for these fluctuations, a net metering system is used in collaboration with the local electricity supplier. When the household doesn't need all the amount of the energy being produced, the surplus is transferred to the grid for storage. In winter, when the days are often less sunny, solar power plants do not collect enough energy to meet the needs of households. Returning the previously obtained electricity surplus from the grid solves this problem.

The net metering is a measurement procedure that allows homeowners to use a bi-directional meter that measure current flow of electricity in two directions (Figure 6).

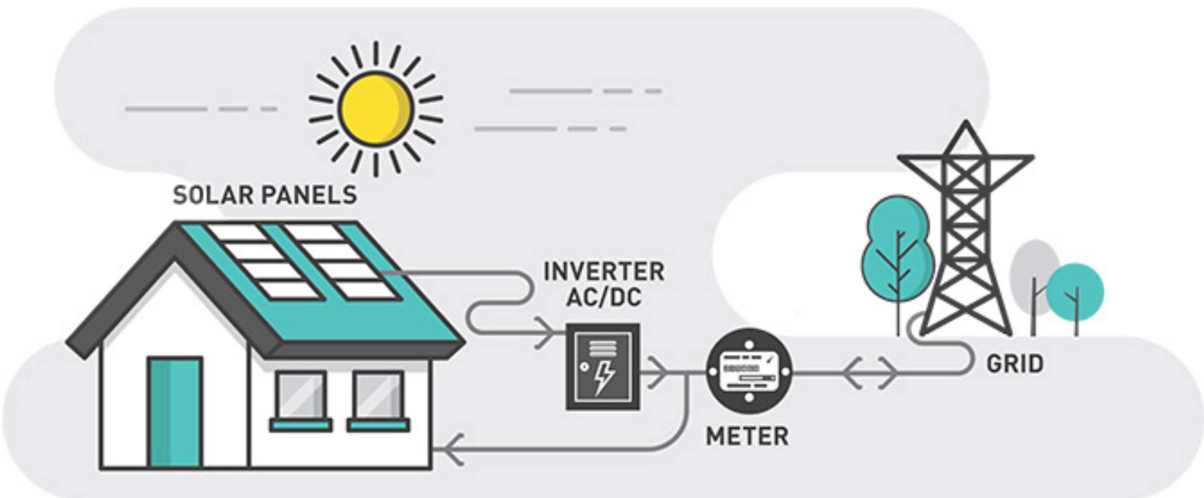


Figure 6. Net metering scheme.

In Lithuania, where is a net accounting system (NAS) currently, the net metering procedure is follows:

The electricity generated by the prosumers is billed in accordance with the electric meters that record the generation and consumption of electricity. Electric meters record:

1) the net volume of the self-consumed electricity and excess electricity exported into the grid per calendar month, and

2) the net volume of the self-consumed electricity and excess electricity exported into the

grid from 1 April of the current year until 31 March of the following year ("accumulation period").

If in a current calendar month, the volume of electricity generated and transferred into the grid exceeds the volume of electricity used, the unused volume of energy from the previous month is transferred into to the following month, as an amount, which is accumulated in the accumulation period. If in a current calendar month, a prosumer generates less electricity than consumes, the difference between energy amount consumed and transferred into the grid resulting in a current calendar month is subtracted from the accumulated amount of the electricity fed into the grid over the accumulation period. If at the end of a calendar month a prosumer consumed more electricity than generated and fed into the grid, for this difference he pays the electricity price agreed with the electricity supplier in the electricity purchase and sale agreement. The surplus of the previous year of electricity produced by a prosumer is not transferred to the following year and he is not paid for it (Chapter III Art. 20[1] Par. 3 and 4 Law on Energy from Renewable Sources) (Legal sources on renewable energy, 2020).

For small customers, energy costs refer only to net electricity consumption, defined as the difference between electricity received from the grid and supplied to the grid. With regard to the amount of electricity produced and self-consumed, the prosumer is exempt from paying mandatory procurement components to support renewable energy sources and cogeneration. Prosumers are exempt from payment of utility charges - a public service obligation (PSO) levy in terms of the amount of electricity produced and self-consumed. Moreover, they have to pay a fee for using the power grid set by the National Commission for Energy Control and Prices, which is 0,039 € per kWh.

To find out whether that usage of solar power plants is economically beneficial for households, a model of the investment project must be developed and its economic efficiency evaluated.

The modeling process for assessing the economic efficiency of the investment project consists of 4 stages:

- Collection of input data, presenting project operation activity information using initial data;
- Creation of the project's financial model, including choice of the budget structure, calculation cash inflows and outflows;
- Selection and application of the method for evaluating the project's efficiency in accordance with appropriate discount rate, scenario and risk analysis;
- Analysis and interpretation of results and presentation of conclusions.

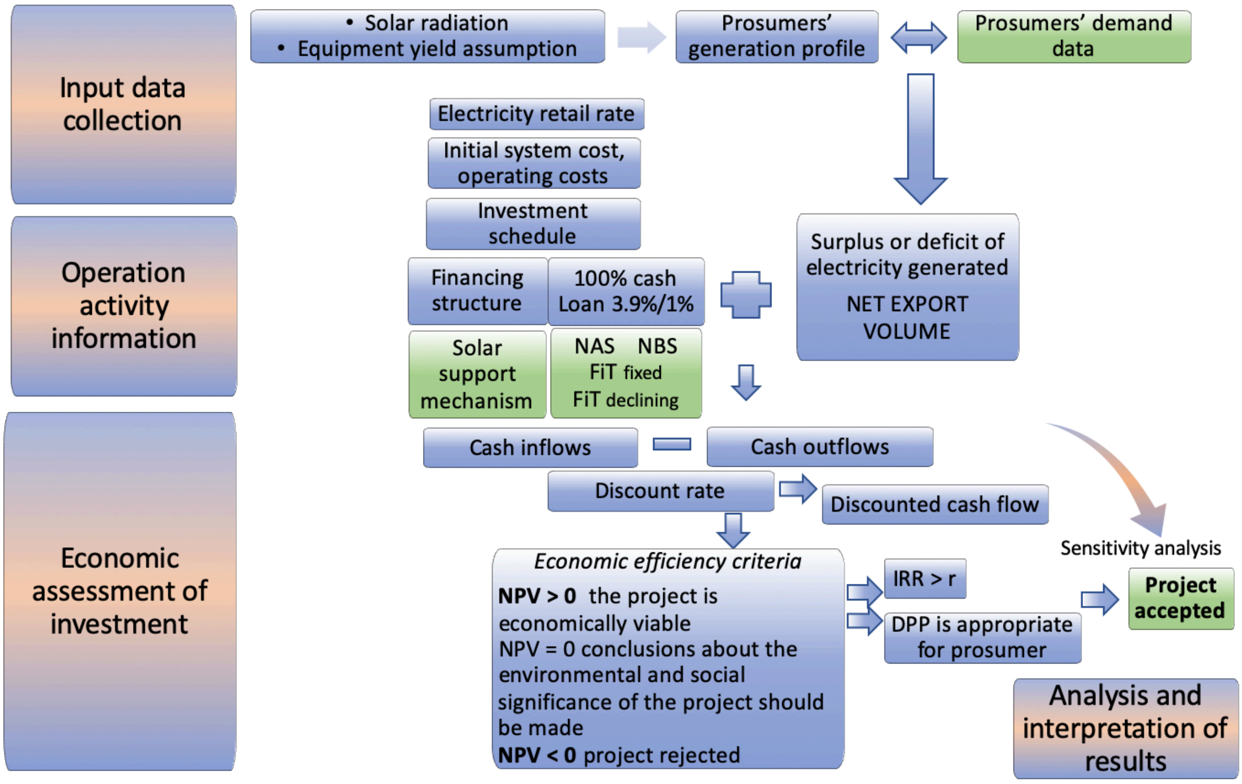


Figure 7. The modeling process for assessing the economic efficiency of the investment project in residential PV installation.

Source: gathered by the author.

The analysis starts with building a model that estimates the monthly output of solar electricity and the household demand for electricity (the resident photovoltaic net production model). The value numbers used are based on data, given by "Smart Energy Fund" powered by Ignitis Group, Lithuanian electricity supplier, and interviews with active market players. By combining them, the scenarios of various remuneration and financing strategies are modeled and their impact on financial performance is estimated.

2.2. Resident photovoltaic net production model

In this research the detailed production time series data were used to model the generation occurring in a residential photovoltaic installation in Lithuania and then compared with monthly household demand data to provide an accurate estimate of self-consumption and net export potential. Ignitis Innovation Hub provided the data of generation. Using special equipment and tools, generation data was collected during 2019 in Vilnius, Kaunas and Panevėžys, Lithuania.

The capital city of Vilnius was chosen to model the generation, based on the population criterion (nearly one fifth of Lithuanian households are located here), moreover, there is relatively low variation in irradiance within the country, making Vilnius an appropriate choice.

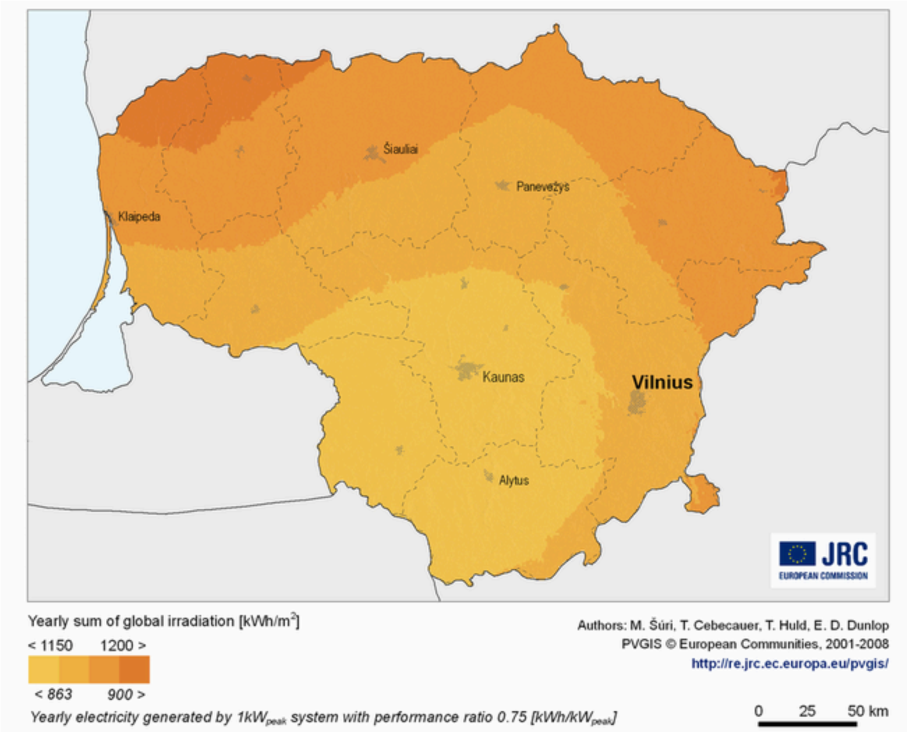


Figure 8. Photovoltaic electricity potential (Lithuania).

Source: the E.U. Joint Research Council (JRC).

The E.U. Joint Research Council (JRC) have created PVGIS maps, according to which the radiation level in Lithuania is between 900 kWh/m2 and 1100 kWh/m2 per year. Average radiation level in the major cities of Lithuania (kWh/m2/year): Vilnius – 998, Kaunas – 1058, Klaipėda – 1062, Šiauliai – 974, Nida – 1073. Nevertheless, unlike utility-scale solar, which can be installed in the most commercially fit locations, rooftop PV is likely to be installed by households across the country, not necessarily in the best locations. Therefore, a representative, non-optimised locational selection was chosen for this work.

The aim of this research is to examine the typical economics of household PV systems in different supporting and financial structures, it does not focus on the results that are specific to the technology, so it is not necessary to adjust the technical specifications, and automated settings provided by Ignitis professionals can be used. It can be seen from the model that annual energy yield from solar PV panels in Vilnius is 865 kWh/kWp.

The model tool that was applied produces an hourly generation profile for the year, indicating the generation value in each of 8760 hours. For economic research purposes it's convenient to accumulate the hourly data in the monthly generation profile.

Three probable size scenarios are developed using generation profiles based on discussions with photovoltaic system installation specialists who are working in the market of residential photovoltaic systems nowadays. Sizes vary from a relatively small system with a power of 3 kW, to a medium-sized system with a power of 5 kW, to the maximum size of 8 kW (larger installations are associated with additional costs).

Demand data used in the analysis was obtained from prosumers profiles, provided by Ignitis Innovation Hub as well as generation data. Amounts of energy consumed from the electricity grid and energy delivered to the electricity grid were measured every hour during the 2019 year and then combined to monthly data.

Low, medium, and high annual household consumption scenarios from national average values were completed for this study, as indicated by the National Energy Regulatory Council (VERT) and are presented in Table 3.

Table 3

Annual household electricity demand scenarios

Low usage	Medium usage	High usage
3100 kWh	5300 kWh	8100 kWh

Source: National Energy Regulatory Council (VERT).

These values serve as the total household electricity consumption before taking PV generation into account.

But residential buildings consume more energy in the morning and in the evening when solar irradiation is low. Therefore when the solar PV plant is used, and load consumption is not synchronized with the photovoltaic power production profile, it is extremely necessary to take into consideration the self-consumption rate in later calculating the amount of electricity demanded from the grid by retail price as well as from accumulated amount.

According to self-consumption rate, the amount of electricity required from and delivered to the grid, consumed from accumulated energy balance, and net exports can be determined for Year 1.

These data can be extrapolated to subsequent periods, taking into account the degradation rate of a system. The cash outflows and cash inflows can be enumerated for every year for each combination of system size/household electricity demand in accordance with the costs and benefits, associated with PV system installation.

Further research represents the estimation of economic efficiency criteria, such as net present value, discounted payback period and internal rate of return, for various combinations of system size/household electricity demand under different remuneration mechanisms. Then these criteria will be evaluated for debt/grant scenarios and conclusions can be made about the level of significance of the impact of a particular support scheme, funding structure and grant amount.

2.3. Benefits associated with photovoltaic system installation

The electricity that households obtain using solar PV energy can be used for their own consumption, which decreases payments to the electricity supplier. So, a prosumer's self-consumption is his financial interest, and leads to savings on electricity bills. To estimate the savings of PV usage and the net PV export volume, monthly consumption data were compared with the monthly PV production data. To make certain that each next year represents the precise share of the PV energy production taking into account the degradation of the module, the PV energy generation is estimated for each month in Year 1 and then annual productivity is diminished by 0.70% for each of the next 24 years of the system's lifespan.

The volume of PV energy self-consumed by the prosumer in month *i* (*SCi*) is estimated as either the full volume of generation in a month, if electricity production is less than demand, or the total volume of demand in a month if electricity production is higher than demand, as in Equation 5.

$$For\ G_i \leq Dt_i,\ SC_i = G_i;$$
$$For\ G_i \geq Dt_i,\ SC_i = Dt_i \tag{5}$$

Where Dt_i - Monthly Household Electricity Demand;

G_i - Monthly PV Generation.

i – month of a year, starting from April 1st.

For every year total annual demand from the network less PV generation (*Dpv*) is then calculated as the sum of monthly kWh volume of electricity, consumed by retail price (net of electricity volume, accumulated earlier and received back from the grid - *ACi*) according to Equation 6:

$$Dpv_n = \sum_{i=1}^{12} Dti \; - \; \sum_{i=1}^{12} SCi \; - \sum_{i=1}^{12} ACi \tag{6}$$

For every year total on-bill savings (S_n) are estimated as the difference between the annual prosumer's electricity bill with PV usage and the annual bill without PV usage (which, in turn, is calculated as total monthly grid demand multiplied by the retail rate) minus costs for using the electricity grid:

$$S_n = (Dt_n - Dpv_n) \times r_n \ - Un \ , \tag{7}$$

Where Dt_n – cumulative household's demand for electricity (before using PV system);

Dpv_n – household's demand for electricity from the grid net of PV self-consumption;

r_n — retail rate for electricity;

$Un = \sum_{i=1}^{12} Ui$ - cost for using electricity grid.

Although according to current Law on Energy from Renewable Sources, the surplus of the preceding year of electricity produced by a prosumer is not transferred to the following year and he is not paid for it, net export for every year n (NE_n) of any surplus PV generation not self-consumed is necessary for estimating cash inflows in scenarios with remuneration for excess electricity production. It can be estimated by deducting the number of kWh-s self-consumed from the total generation, as in Equation 8:

$$NE_n = \sum_{i=1}^{12} Gi \; - \; \sum_{i=1}^{12} SCi \qquad (8)$$

2.4. Remuneration and financing scenarios

In order to find out what effect different support schemes and financing structures have on the economic performance of household PV installation, several scenarios should be defined.

A base case shows a photovoltaic system purchased at full cost, funded by cash of the homeowner, that is 100% equity financing. It also reflects current policies and regulatory conditions, incorporated in NAS, which allow self-consumption to compensate for volumetric costs, but do not provide additional remuneration for exported generation volume. Stimulation can be done using different support mechanisms, however, this analysis studies the effects of remuneration schemes (feed-in tariff (FiT) and net billing system (NBS)) and profitable financing options on the prosumer economics.

The FiT scheme offers a set price for the generation of solar PV energy, either on a net basis, setting a fixed tariff for excess generation, or on a gross basis, setting a fixed tariff for each kWh produced. Households are allowed to consume PV for their own needs, so the first type is used. The fixed FiT case offers a remuneration for excess generation during the entire project lifespan at a fixed tariff of 0.04204 €/kWh, which reflects the tariff previously available in accordance with the latest renewable energy auctions in Lithuania. The tariff used here was applied to big generators according to the REFiT scheme. Even though it might not be suitable for a residential PV system, it can be a useful starting mark for potential FiTs. The declining FiT case begins with remuneration at approximately the retail rate, with a decline of 0.05€/kWh every five years. This scheme provides an initial incentive, while restraining government spending in the long-term perspective. Under the NBS scenario, prosumers are allowed to sell surplus kWh produced back to the network and get remuneration at retail tariff rate.

Table 4

Remuneration policy model scenarios

Scenario	*Remuneration Scheme*
Base Case	No remuneration for excess generation, funded through 100% equity finance
NBS Metering	Remunerates excess generation at the retail rate of €0.137/kWh
FiT-fixed	Remunerates excess generation at a fixed tariff of €0.04204/kWh
FiT-declining	Year 1-5: €0.137/kWh Year 6-10: €0.087/kWh Year 11-15: €0.037/kWh Year 15+: none

Source: gathered by author.

Supplementary financing scenarios are drawn up to evaluate the impact of financing options on PV system financial performance. Under full equity financing, it's assumed that the resident purchases the PV installation for cash and pays the full initial cost from savings. Then a financing case is simulated in which half of the cost of the system is financed by debt at a rate of 3.9%, and the remaining expenses are paid in cash. Although capital costs vary considerably across jurisdictions and countries, there is a real-world example with observable commercial rates nowadays in Lithuania. A potential prosumer can apply for financial support for a solar power plant from joint project InBank and APVA with an annual interest rate of 3.9%. This scenario is also done with an interest rate of 1% to evaluate the impact of a promising lending program that can propose extraordinary low financing rates.

In the end, all financing scenarios are designed along with capacity-based grants, which diminish the initial cost of residential PV system in increments of 10%, in the range from 0 to 50% of the total cost of the investment project. There is already a capacity based incentive for solar PV energy in Lithuania (i.e., approximately 30-40% of the cost per kW, which decreases as system capacity increases). But the budget is generally limited, and the incentives are offered on a first-come, first-served basis; thus, it is not guaranteed for all customers to receive the solar incentives. Additionally, the capacity-based incentives decline over time as the statewide installed capacity of the solar PV system increases. Therefore, the more delayed the installation of the solar PV system, the more difficult it becomes to receive a higher amount of incentives. Therefore, this grant should not be taken into account in a long-term perspective as an axiom. Scenarios with different financing schemes are presented in Table 5.

Table 5

Financing model scenarios

Scenario	*Financing assumptions*
100% Equity	100% equity finance
3.9% Interest Rate	50% equity (from savings), 50% debt at an interest rate of 3.9%; debt tenor is 60 months plus contact fee 1.5%
1% Interest Rate	50% equity (from savings), 50% debt at an interest rate of 1%; debt tenor is 60 months plus contact fee 1.5%
Capacity-based grant	Grant funding in 10% increments from 0-50% of project cost

Source: gathered by author.

All scenarios are based on the assumption that Lithuanian and other governments will continue to provide their solar support, a likely situation if current solar activities and new policy frameworks in the EU are taken into account. Also scenarios presume that there are no import taxes for solar products, no prohibitive taxes or fees on self-consumption/storage volumes, or any other barriers. Moreover, all scenarios anticipate no major macroeconomic issues in the EU countries.

2.5. Financial model for estimation photovoltaic performance

In order to estimate the economic performance of household PV installation under different support mechanisms and financing structures, NPV for each system size/demand scenario should be calculated. Therefore, it is necessary to create a cash flow model that uses the upfront initial costs and net cash flows for each combination of system size (3 kWp, 5 kWp, and 8 kWp) and annual household electricity usage (low, medium, and high).

$$NPV = \sum_{n=1}^{25} \frac{Sn - Cn + (NEn \times t)}{(1+d)^n} \quad (9)$$

Where S_n – the savings occurred in Year n and calculated by Formula 7;

C_n – cost of the system in Year n, including initial costs in Year 1, maintenance and etc. expenses and inverter substitute, excluding capacity-based incentive, where it's applicable;

NE_n – the net export, or volume of surplus kWh produced for which the prosumer is remunerated;

t – the rate at which net export is remunerated;

d – the discount rate.

When excess and exported generation volume is compensated, it is supposed at rate t. It is determined to be equal to the retail electricity price r, in the case of NBS metering; equal to the FiT rate in the case of a FiT; and equal to zero in the case where NAS metering is considered. It is assumed that prosumers take decision either to invest in solar energy installation or not, and, importantly, do not consider other investment opportunities, so cash flows should be discounted at the current available deposit rate of 1.32% (for deposits from euro area households with agreed maturity of over 2 years according statistics of Bank of Lithuania on November 2020).

Residents do not usually make decisions regarding capital budgeting based on NPV, so it is sensible to calculate the internal rate of return (IRR), showing the returns that residents can achieve during the lifetime of the project and the discounted payback period (DPP) that indicates the year in which the total savings from the project will exceed the initial cost of the PV installation and subsequent costs. In some cases, however, collective savings can be positive in one year, but negative in the next because of the need to install a new inverter, which happens in Year 12. Thus, payback is the number of years in which collective savings are positive, e.g. a payback of 14 years may mean that collective savings were positive in Year 11, then decreased sharply due to an inverter substitute in Year 12, and then recovered in Year 15.

Summing up the methodological part of the study, it can be concluded that the evaluation of the economic efficiency of the investment project is a multi-stage process, all phases of which are closely interrelated. When assessing the economic efficiency of investment in residential PV system, at the initial step of collecting the input data (solar radiation, PV system costs, electricity retail rates, currents support incentives, etc.), it is also necessary to make some assumptions regarding equipment performance, household's self-consumption rate in PV electricity generation, appropriate discount rate and forecasted macro-economic variables. Using all this information discounted cash flows can be calculated, which, in turn allow computing the parameters of economic efficiency: NPV, IRR and DPP. When comparing and interpreting the values of these criteria for various combinations of system size/ household electricity demand and different support schemes and financing structures, conclusions can be drawn about the economic feasibility of carrying out the project from potential prosumer perspective, as well for decision making at the legislative level in the development of PV energy.

3. EMPIRICAL RESEARCH OF THE IMPACT OF SUPPORT SCHEMES ON ECONOMIC EFFICIENCY OF RESIDENTIAL PHOTOVOLTAIC SYSTEM

3.1. Prosumer's generation and consumption profile for Year 1

In the previous section, a methodology was developed to assess the impact of various support schemes on the economic performance of a residential PV system.

First of all, the monthly and yearly volumes of electricity produced by residential PV installations of different capacities (3kWp, 5kWp, 8kWp) were calculated for Year 1, using level of radiation in Vilnius and productivity of a PV plant. They are presented in Table 6.

Table 6

Amount of electricity generated by a system, kWh

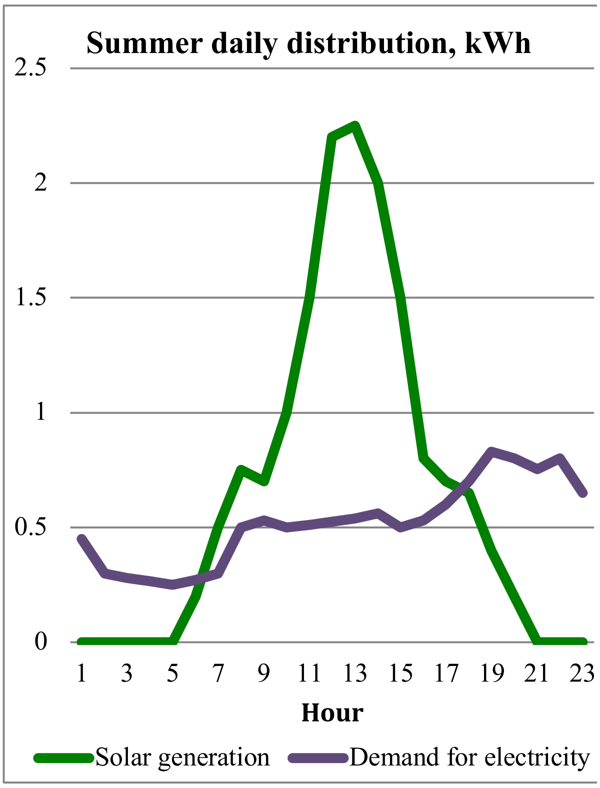
System size, kWp	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	*Year*
Radiation kWh/m2	119	177	157	135	139	90	51	11	6	11	31	71	*998*
3kWp	309	460	408	351	361	234	133	29	16	29	81	185	*2595*
5kWp	516	767	680	585	602	390	221	48	26	48	134	308	*4325*
8kWp	825	1227	1089	936	964	624	354	76	42	76	215	492	*6920*

Source: gathered by author.

Daily and annual distribution of household electricity demand in Vilnius can be projected, using data obtained from Ignitis Innovation Hub, and compared with the distribution of solar PV production.

In accordance with the data, there is a relatively weak correlation between seasonal PV production and household energy consumption each year, when more solar energy is generated in summer and demand is higher in winter because of heating and longer lighting hours. This is different from the situation in hot climates, where peak demand is in the summer because of the need for air conditioning, which coincides with high solar energy generation.

Figure 9 shows that the daily peak of electricity consumption in households also does not correspond with the timing of peak PV generation in both winter and summer. Therefore it is necessary to take into consideration the self-consumption rate in calculating the amount of electricity demanded from the grid by retail price as well as from accumulated amount.



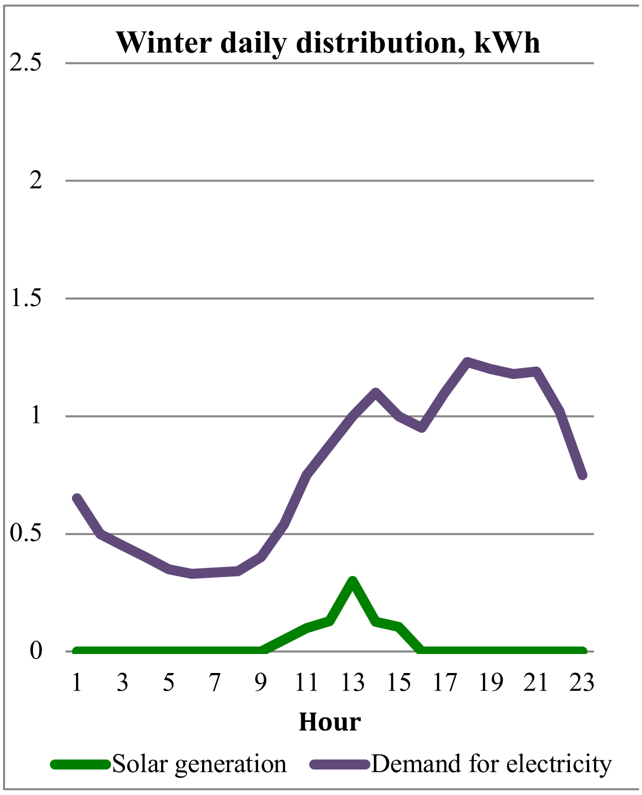


Figure 9. Daily distribution of PV generation and electricity demand (Vilnius city).
Source: gathered by author.

In a self-consumption PV economic model (in which a household uses PV electricity for its own electrical needs), the PV-generated energy is consumed instantaneously as it is being produced. A self-consumption ratio of less than 100% means that some PV production is not locally consumed at that moment. In such cases, the PV excess is injected into the grid, where it may be stored (at cost of 0,039 € per kWh) or valorized under different economic schemes.

Table 7 presents the gap between household's demand from the grid with PV (*Dpv*) and without PV (*Dt*), and a household self-consumption rate in Year 1. More detailed monthly calculations are presented in Annex 1.

Table 7

Annual household grid demand and self-consumption rate of electricity for Year 1

System size, kWp	*3*	*3*	*3*	*5*	*5*	*5*	*8*	*8*	*8*
Demand	*Low*	*Medium*	*High*	*Low*	*Medium*	*High*	*Low*	*Medium*	*High*
Dt_1 (kWh)	3100	5300	8100	3100	5300	8100	3100	5300	8100
G_1 (kWh)	2595	2595	2595	4325	4325	4325	6920	6920	6920
SC rate, %	46%	67%	84%	33%	51%	68%	23%	36%	49%
Dpv_1 (kWh)	605	87	70	2766	1126	144	5535	3873	1431

Source: gathered by the author.

To calculate the savings of PV usage and the net PV export volume, monthly consumption data were compared with the monthly generation data. According to self-consumption rate, the amount of electricity required from and delivered to the grid, consumed from accumulated energy balance, and net exports were determined for Year 1. Their calculations are also presented in Annex 1.

These data can be extrapolated to subsequent periods, taking into account the degradation rate of a system. The cash outflows and cash inflows can be enumerated for every year in accordance with the assumptions indicated in the next paragraph.

3.2. Key assumptions of the analysis

According to commercial proposals of residential solar installers currently active in the Lithuanian market (i.e. UAB "Saulės Grąža"), the estimated cost-per-kilowatt for a completely installed rooftop PV system on a representative residential house is between €800-€1067 (decreasing with an increase of solar plant capacity). Table 8 shows the total installation cost for each system size (including VAT).

Table 8

Total installation cost for PV plant, € (VAT including)

Scenario assumptions	3kWp	5kWp	8kWp
Total installation cost, € (VAT including)	3200	4200	6400

Source: UAB "Saulės Grąža", 2020.

A 25-year lifespan for the total PV system is expected, with a panel module lifespan of 25 years and an inverter substitute is needed in Year 12 at a cost of €1045 (current price for the most popular model Fronius Symo 3.0-3-M), adjusted for inflation. Cost of maintenance and insurance is assumed for Year 1 of €50, this amount increases annually at the rate of inflation.

In this research the most common tariff plan is used. Around 80% of residential use "Standard" tariff plan, which is up to 2.3 billion kWh of energy used per year. According to a contract, user pays energy component of one-time zone at 0.137 € per kWh. It is assumed that retail prices will rise by 2.8% each year, according to the historical average of Lithuania indicated in the National Energy Regulatory Council report (2020). It is difficult to forecast retail tariffs for electricity, especially in the current situation on the global fuel market and the consequences of COVID-19. It's a high probability that tariffs, on the contrary, will decline. And therefore a sensitivity analysis for expected changes in retail rates to PV installation economic performance is of great importance. Key assumptions are presented in Table 9:

Table 9

Key assumptions for analysis

Starting year point	November 2020	Source
Maintenance and insurance, € per year	50	Average-market price
Inverter Replacement Cost, €	1045	Average-market price
Degradation rate of the system	0,7%	Bazilian *et al.* (2013)
Retail electricity price, € per kWh	0,137	State Energy Regulatory Council
Retail electricity price annual increase, average (%)	2,8%	State Energy Regulatory Council
Fee for using electricity grid, € per kWh	0,039	State Energy Regulatory Council
Inflation rate (%)	2,2%	Eurostat
Discount rate for households (%)	1,32%	Bank of Lithuania
Capacity-based incentive, € per kW of installed capacity	323	State Energy Regulatory Council

Source: gathered by author.

Lithuania's Ministry of Energy has signed an order to back the installation of small residential solar power systems with a budget of EUR 4.5 million for 2020. Individual homeowners will be eligible for financial support after installing solar arrays with capacities of up to 10 kW. Each kilowatt will receive €323. Overall, Lithuania intends to invest more than EUR 16 million of EU funds in this field by 2023. This amount of €323 per kW of installed capacity can be deducted from the initial installation costs. Lithuania is currently reforming its self-consumption framework, and from October 2019 the net metering scheme have been extended to include a "virtual" net metering option. This is means that a single consumer could link a behind-the-meter self-consumption system at one location with a consumption point elsewhere within the same grid voltage level.

Further research represents the estimation of economic efficiency criteria, such as net present value, discounted payback period and internal rate of return, for various combinations of system size/household electricity demand under different remuneration mechanisms. Then these criteria will be evaluated for debt/grant scenarios and conclusions can be made about the level of significance of the impact of a particular support scheme, funding structure and grant amount. Sensitivity analysis for expected changes in retail rates to PV installation economic performance as an important integral part of the research concludes the study.

3.3. Financial performance results for resident photovoltaic system under support schemes

Table 10 indicates the results of the remuneration policy model, which compares Net accounting system (NAS) incorporated in the Base Case, in which produced solar energy can be used only to replace prosumer's demand with no remuneration for excess generation but excess generation can be delivered to the grid and consumed later, with the three different types of remuneration: net billing system (NBS) and two types of Feed-in-Tariffs (the details are described in Section 2.4.). These results show the net present value (NPV), internal rate of return (IRR), and discounted payback period (DPP) for each combination of installation size and annual prosumer demand for electricity, and assume that system is purchased with full equity financing, i.e. cash paid by the resident. More detailed calculations are attached in Annex 2.

Table 10

Financial performance results for all combinations System size/Demand under support schemes

a. Base case (Net accounting system)

System size	*3 kWp*	*3 kWp*	*3 kWp*	*5 kWp*	*5 kWp*	*5 kWp*	*8 kWp*	*8 kWp*	*8 kWp*
Demand	*Low*	*Medium*	*High*	*Low*	*Medium*	*High*	*Low*	*Medium*	*High*
NPV, €	€3 397	€950	-€2 500	€4 912	€8 729	€5 732	€1 889	€11 002	€22 328
DPP, years	13.4	16.1	never	12.2	5.9	5.7	19.8	7.5	4.4
IRR, %	10%	5%	-	11%	18%	16%	4%	15%	25%

b. Net billing system

System size	*3 kWp*	*3 kWp*	*3 kWp*	*5 kWp*	*5 kWp*	*5 kWp*	*8 kWp*	*8 kWp*	*8 kWp*
Demand	*Low*	*Medium*	*High*	*Low*	*Medium*	*High*	*Low*	*Medium*	*High*
NPV, €	€3 756	€1 170	-€2 393	€9 637	€9 272	€6 086	€15 894	€17 354	€23 232
DPP, years	12.8	15.2	never	5.9	5.6	5.5	5.5	5.2	4.2
IRR, %	11%	6%	-	18%	19%	17%	20%	21%	26%

c. Feed-in tariff (fixed)

System size	*3 kWp*	*3 kWp*	*3 kWp*	*5 kWp*	*5 kWp*	*5 kWp*	*8 kWp*	*8 kWp*	*8 kWp*
Demand	*Low*	*Medium*	*High*	*Low*	*Medium*	*High*	*Low*	*Medium*	*High*
NPV, €	€3 477	€999	-€2 476	€5 965	€8 850	€5 811	€5 009	€12 417	€22 529
DPP, years	13.2	15.9	never	8.1	5.8	5.7	13.5	6.7	4.3
IRR, %	10%	6%	-	13%	18%	17%	9%	16%	26%

d. Feed-in tariff (declining)

System size	*3 kWp*	*3 kWp*	*3 kWp*	*5 kWp*	*5 kWp*	*5 kWp*	*8 kWp*	*8 kWp*	*8 kWp*
Demand	*Low*	*Medium*	*High*	*Low*	*Medium*	*High*	*Low*	*Medium*	*High*
NPV, €	€3 512	€1 020	-€2 466	€7 450	€8 902	€5 845	€6 356	€13 028	€22 616
DPP, years	13.0	15.6	never	6.2	5.7	5.6	6.0	5.3	4.2
IRR, %	10%	6%	-	16%	18%	16%	14%	19%	25%

Considering the PV installation as an investment project, the most appropriate choice nowadays is the correspondence between electricity demand and installed capacity of a system. Obviously, PV installation with minimal capacity is not economically efficient with either medium or high electricity demand (because of low savings, provided by small generated value of electricity and relatively high initial cost), especially in the last case, where NPV is negative. Also the case with non-sufficient NPV occurs where low electricity demand diminishes the value to be gained from self-consumption (Low/8kWp). As the NPV is positive (except of a case Low demand/8kWp) and IRR is more than the required rate of return, the conclusion can be made that PV installation is a good investment opportunity to a household.

For all scenarios one rule is obvious: the more the installed capacity of a PV system, the more economic benefits a household has (the best matches are High demand/8kWp with NPV €22328, DPP 4.4 years and Middle demand/8kWp with NPV €11 002, DPP 7.5 years, also quite good options are Middle or High demand/5kWp). Meanwhile, for low household electricity demand it will be not so beneficial to install a bigger than 3kWp system according to low NPV and long DPP (for capacity of 3kWp NPV is €3 797, DPP is calculated to occur only in Year 13.4). It's a long time to get payback on any investment, but from the household's perspective this scenario can be realized.

Examining the scenarios in which PV owners are compensated for excess generation, a conclusion can be made that introducing supporting mechanisms (NBS as well as FiTs) has a noticeable effect on the economic efficiency of a project only for cases with sufficient mismatch between energy demand and generation level: in NBS case Low demand/8kWp NPV raised from €1 889 to €15 884, DPP decreased from 19.8 years to 5.5. In the majority of options there is no big difference in the economic efficiency indicators, NPV as well DPP and IRR. But if the remuneration mechanisms are introduced, a net billing case offers the best performance of other scenarios studied. In case a household can invest only a limited amount of money, a good option is to install a system with bigger system capacity than household demand (for example, Low demand/5kWp – in case of NBS: NPV and IRR increased from €4 912 to €9 637, 11% to 18% respectively, DPP decreased from 12.2 years to 5.9 years). Nonetheless, the shortest discounted payback period possible under the modeled scenarios is under Net billing system, equal 4.2 years for case High demand/8kWp capacity.

Remarkably, there is not much difference between the NBS metering and the declining FiT results. This indicates that net billing system, which provides ongoing remuneration throughout the life of the project, has about the same financial impact as the declining FiT, where remuneration is high at first, but becomes equal to 0 since Year 16. In the same time, in NBS case, rules in the energy market can be changed, and a household will have no opportunity to sell excess electricity to the market, unlike in a FiT system, where a prosumer, who had won an auction, has a priority to sell all of excess generated electricity at auction price.

Generally, initial results indicate that while residential PV panels are a smart investment in many cases from a classic NPV perspective, in some cases the payback period is far beyond what households might require. Most of all, this investment project is worth considering for households with a high level of electricity consumption, and only if they have enough funds to purchase a plant with a large capacity. In terms of policy support, a net metering scheme, in which households are remunerated at retail tariffs for surplus generation not consumed, as well feed-in tariff remuneration, has no significant impact on financial performance for big installations with high prosumer electricity demand. However, from the point of view of a household with low level of electricity consumption, the introduction of a support system (especially NBS) may serve as a reason for purchasing a PV system with installed capacity not less than 5 kWp.

3.4. Debt and grant scenario analysis

In the previous paragraph it was revealed that the option with the highest performance indicators is the case of High demand/8kWp. Also it was found that when support mechanisms are put in place, the most significant change in efficiency criteria occurs in the case of the medium-size system with low electricity demand (Low demand/5kWp). Further research will be conducted for analyzing these two alternatives, as well for the case with the lowest initial cost of a project with a corresponding low level of energy consumption (Low demand/3kWp). A combination of three parameters to examine the impact on NPV and on the discounted payback period is included in the further analysis:

- Grant level: from 0% to 50% with increments of 10%;
- Financing structure: 100% equity, 50% debt finance with 3.9% and 1% annual interest rates;
- Remuneration scheme: Base case and Net billing system.

Tables 11-13 present the results of application grant and debt parameters, which can influence the economic attractiveness of solar PV installation. More detailed calculations of some cases are attached in Annex 3.

Table 11

Financial performance results for Debt-Grant scenarios for combination Low usage/5kWp

a. Base case (Net accounting system)

100% equity	NPV, €	DPP, years	Loan with 3.9% interest	NPV, €	DPP, years	Loan with 1% interest	NPV, €	DPP, years
Current grant (323/kWp)	4912	12.2	Current grant (323/kWp)	4759	12.7	Current grant (323/kWp)	4910	12.3
0% grant	3297	16.8	0% grant	3144	17.3	0% grant	3295	16.8
10% grant	3717	15.7	10% grant	3564	16.1	10% grant	3715	15.7
20% grant	4137	14.5	20% grant	3984	14.9	20% grant	4135	14.5
30% grant	4557	13.3	30% grant	4404	13.7	30% grant	4555	13.3
40% grant	4977	12.1	40% grant	4824	12.5	40% grant	4975	12.1
50% grant	5397	7.9	50% grant	5244	8.4	50% grant	5395	7.9

b. Net billing system

100% equity	NPV, €	DPP, years	Loan with 3.9% interest	NPV, €	DPP, years	Loan with 1% interest	NPV, €	DPP, years
Current grant (323/kWp)	9637	5.9	Current grant (323/kWp)	9484	6.2	Current grant (323/kWp)	9635	5.9
0% grant	8022	9.3	0% grant	7869	9.6	0% grant	8020	9.3
10% grant	8442	8.4	10% grant	8289	8.7	10% grant	8440	8.4
20% grant	8862	7.5	20% grant	8709	7.9	20% grant	8860	7.6
30% grant	9282	6.7	30% grant	9129	7.0	30% grant	9280	6.7
40% grant	9702	5.8	40% grant	9549	6.1	40% grant	9700	5.8
50% grant	10122	4.8	50% grant	9969	5.2	50% grant	10120	3.7

Source: gathered by author.

The results of the Table 11 show that the use of a loan (in both base case and NBS case), even at 3.9% annum, does not greatly affect the economic efficiency of the project for option Low usage/5kWp: DPP has increased only for a half of a year. For those prosumers who do not have the opportunity to pay for the system in cash, this is an excellent possibility to distribute costs over time. The introduction and use of a grant has more significant impact on the discounted payback period: with an increase of every 10% of the initial cost of the installation, the DPP of the investment is reduced by 1.2 year in a base case (and a little less than a year in NBS case). Moreover, in a base case with a grant equal 50%, the replacement of an inverter in the year 12 is already possible due to the accumulated cash savings, and the DPP is sharply reduced to about 8 years from 17 years without grant. It is also noteworthy that in the NBS case of a 50% grant and use of a purpose loan at 1%, the discounted payback period was reduced to less than 3.7 years, which is extremely fast from the household's perspective.

Table 12

Financial performance results for Debt-Grant scenarios for combination High usage/8kWp

a. Base case (Net accounting system)

100% equity	NPV, €	DPP, years	Loan with 3.9% interest	NPV, €	DPP, years	Loan with 1% interest	NPV, €	DPP, years
Current grant (323/kWp)	22328	4.4	Current grant (323/kWp)	22094	3.8	Current grant (323/kWp)	22324	3.1
0% grant	19744	7.1	0% grant	19510	7.3	0% grant	19740	7.1
10% grant	20384	6.4	10% grant	20150	6.7	10% grant	20380	6.4
20% grant	21024	5.8	20% grant	20790	6.0	20% grant	21020	5.8
30% grant	21664	5.1	30% grant	21430	5.3	30% grant	21660	5.1
40% grant	22304	4.4	40% grant	22070	3.9	40% grant	22300	3.2
50% grant	22944	3.7	50% grant	22710	0.5	50% grant	22940	0.3

b. Net billing system

100% equity	NPV, €	DPP, years	Loan with 3.9% interest	NPV, €	DPP, years	Loan with 1% interest	NPV, €	DPP, years
Current grant (323/kWp)	23232	4.2	Current grant (323/kWp)	22998	3.4	Current grant (323/kWp)	23228	2.7
0% grant	20648	6.9	0% grant	20414	7.1	0% grant	20644	6.9
10% grant	21288	6.2	10% grant	21054	6.5	10% grant	21284	6.2
20% grant	21928	5.6	20% grant	21694	5.8	20% grant	21924	5.6
30% grant	22568	4.9	30% grant	22334	5.1	30% grant	22564	4.8
40% grant	23208	4.2	40% grant	22974	3.5	40% grant	23204	2.8
50% grant	23848	3.6	50% grant	23614	0.4	50% grant	23844	0.2

Source: gathered by author.

The analysis of the results in Table 12 also indicates that in a case High demand/8 kWp capacity the use of a loan has no significant impact on the economic efficiency of the project (in the Base case, as well in NBS case NPV does not decrease and DPP does not increase substantially). Due to the fact that not all consumers are in a position to pay for a PV system with 100% equity, debt financing of installation is a key factor in the implementation of the project. Granting, as in the previous case, has an extremely beneficial effect on the performance of the project, reducing the payback period by 0.7 years with every additional 10% grant of initial cost. It's interesting to note that a combination of grant not less than 40% and loan use dramatically shorten the payback period, and the project begins to bring economical benefits within the first year of high usage 8kWp capacity system.

Table 13

Financial performance results for Debt-Grant scenarios for combination Low usage/3kWp

a. Base case (Net accounting system)

100% equity	NPV, €	DPP, years	Loan with 3.9% interest	NPV, €	DPP, years	Loan with 1% interest	NPV, €	DPP, years
Current grant (323/kWp)	3397	13.4	Current grant (323/kWp)	3280	13.8	Current grant (323/kWp)	3395	13.4
0% grant	2428	16.9	0% grant	2311	17.3	0% grant	2426	16.9
10% grant	2748	15.7	10% grant	2631	16.1	10% grant	2746	15.7
20% grant	3068	14.6	20% grant	2951	15.0	20% grant	3066	14.6
30% grant	3388	13.4	30% grant	3271	13.9	30% grant	3386	13.4
40% grant	3708	12.3	40% grant	3591	12.7	40% grant	3706	12.3
50% grant	4028	6.6	50% grant	3911	7.1	50% grant	4026	6.6

b. Net billing system

100% equity	NPV, €	DPP, years	Loan with 3.9% interest	NPV, €	DPP, years	Loan with 1% interest	NPV, €	DPP, years
Current grant (323/kWp)	3756	12.8	Current grant (323/kWp)	3639	13.2	Current grant (323/kWp)	3754	12.8
0% grant	2787	16.1	0% grant	2670	16.5	0% grant	2785	16.1
10% grant	3107	15.0	10% grant	2990	15.4	10% grant	3105	15.0
20% grant	3427	13.9	20% grant	3310	14.3	20% grant	3425	13.9
30% grant	3747	12.8	30% grant	3630	13.2	30% grant	3745	12.8
40% grant	4067	7.5	40% grant	3950	12.1	40% grant	4065	7.5
50% grant	4387	6.3	50% grant	4270	6.7	50% grant	4385	6.3

Source: gathered by author.

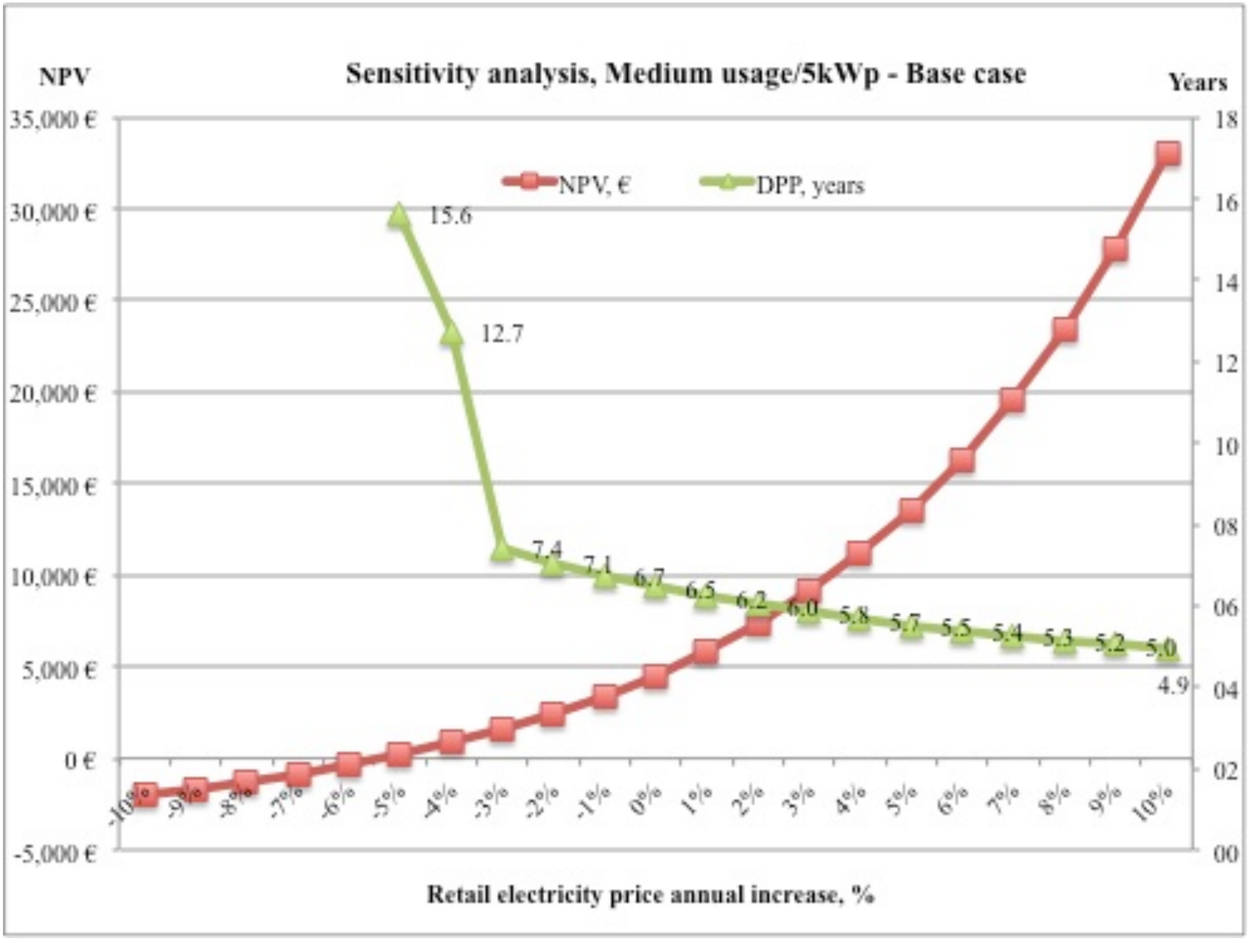
Table 13 shows the results of applying the combination of debt and grant options for the system with the lowest initial investments and low level of energy consumption respectively (Low demand/3kWp – the case with sufficient NPV level). Comparison of NPV and DPP indicators makes it possible to conclude that the use of a targeted loan for a half of initial cost is still economically viable option for installing 3kWp system for households with a low level of cash savings (in both Net accounting system and Net billing system scenarios) (NPV decrease and DPP increase are insignificant). At the same time a shorter payback period with an increase of funding from the government shows the importance of impact of this support mechanism for the residential PV deployment (reducing the payback period by 1.1-1.2 years with every additional 10% of grant). In a Net billing system scenario a grant of 40% provides an opportunity to dramatically shorten the payback period to about 7 years in options of 100% equity and 1% loan for a half of upfront cost, and 50% grant – for the option 3.9% loan in NBS and for all financing options in NAS.

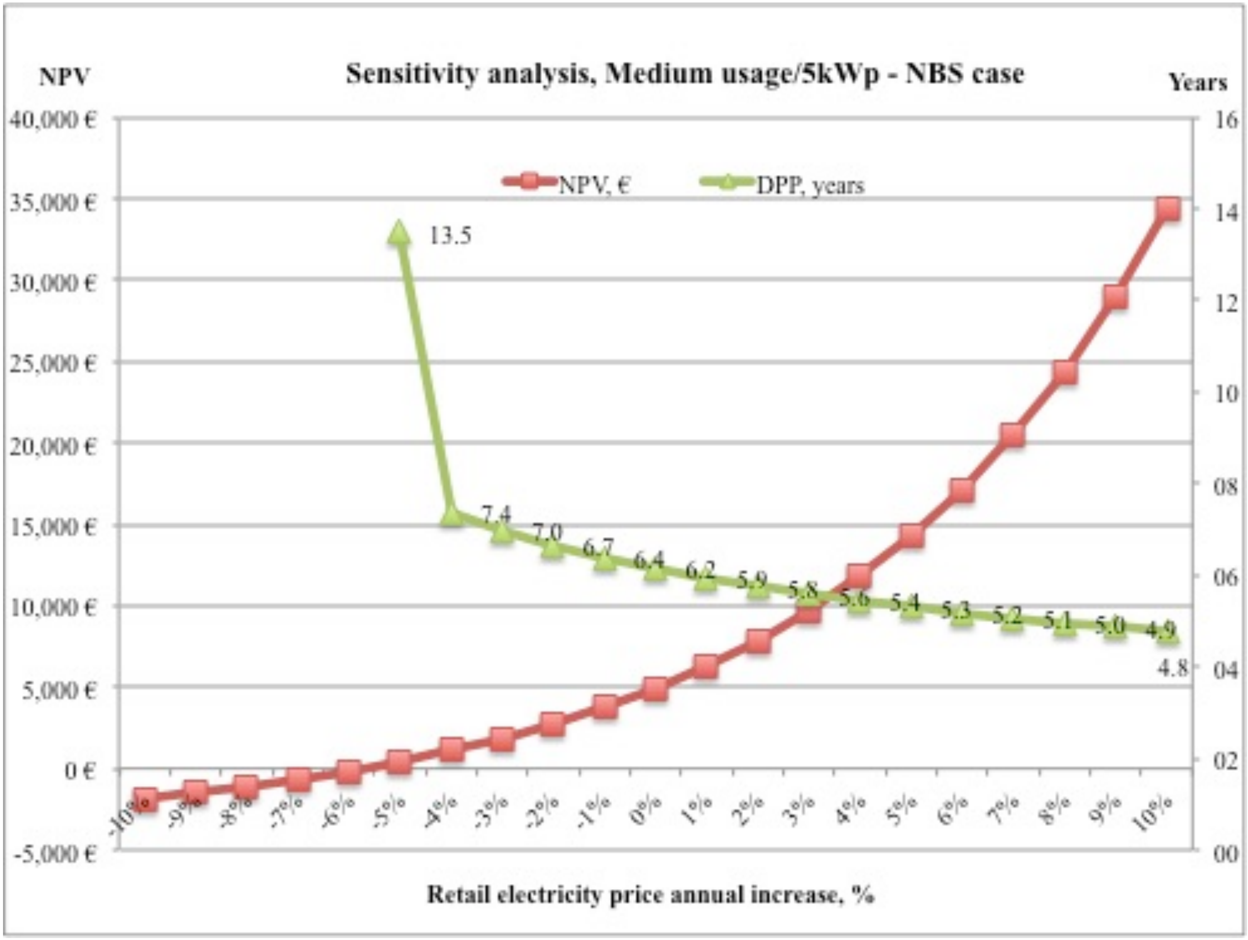
3.5. Sensitivity analysis for retail electricity price annual change

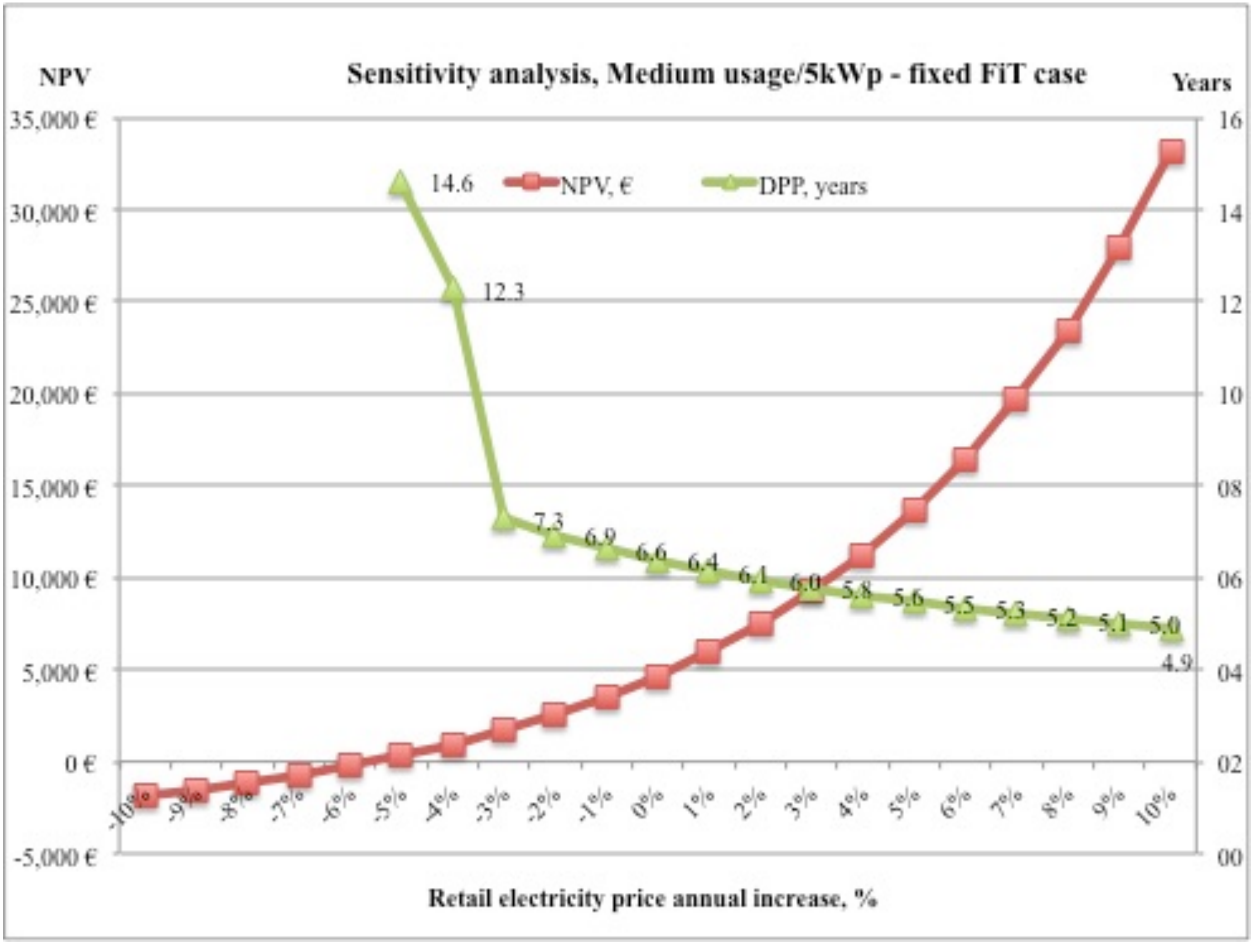
It's quite difficult to forecast retail tariffs for electricity, especially in the current situation on the global fuel market and the consequences of COVID-19, therefore a sensitivity analysis for expected changes in retail rates to PV installation economic performance is of great importance.

The methodology section mentions that the financial performance of residential PV (in case a household purchases and runs the PV system) is derived from the savings coming from decreased usage of grid electricity. In other words, prosumer's savings are a direct outcome of self-consuming PV energy and off-set the cost of kilowatt hours at retail tariff rate. Therefore, changes in the retail rate may have a significant effect on the amount of those savings. That's why sensitivity analysis should reflect the effects of changes in the retail tariff rate.

To carry out this analysis, combinations of a demand level and a system capacity, which are the most popular among the Lithuanian residents nowadays and which have the highest indicators of economic efficiency (medium demand/5kWp capacity and High demand/8kWp capacity), were selected. The graphs in Figure 10 illustrate the sensitivity of economic efficiency criteria (NPV and DPP) to changes in the annual level of electricity retail rates for most popular Medium demand/5kWp capacity combination in the context of all support mechanisms.




NPV
Sensitivity analysis, Medium usage/5kWp - NBS case
Years
NPV, €
DPP, years
13.5
7.4
7.0
6.7
6.4
6.2
5.9
5.8
5.6
5.4
5.3
5.2
5.1
5.0
4.9
4.8
Retail electricity price annual increase, %


NPV
Sensitivity analysis, Medium usage/5kWp - fixed FiT case
Years
14.6
NPV, €
DPP, years
12.3
7.3
6.9
6.6
6.4
6.1
6.0
5.8
5.6
5.5
5.3
5.2
5.1
5.0
4.9
Retail electricity price annual increase, %

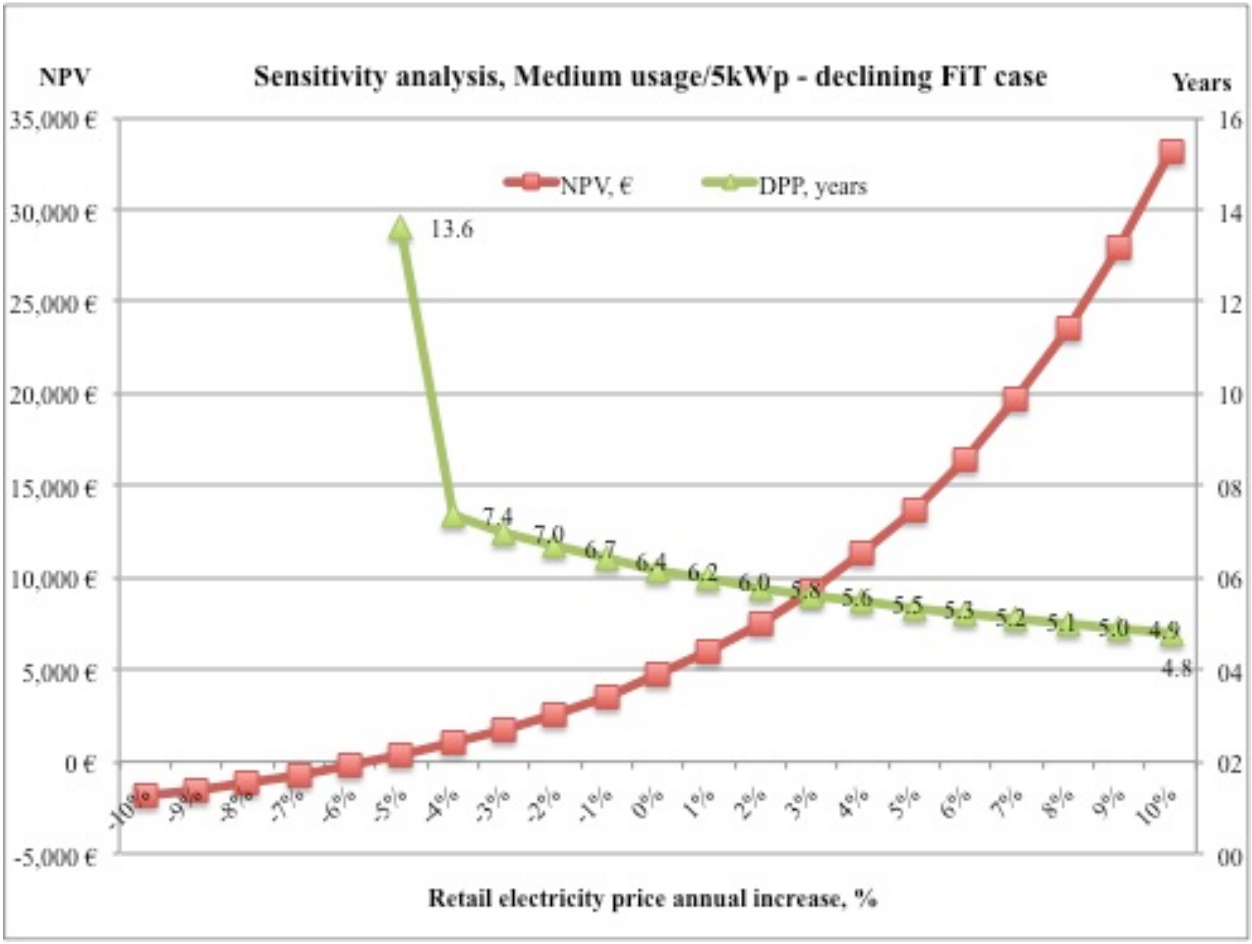


Figure 10 – Impact of retail electricity annual price change to NPV and DPP, Medium demand/5kWp capacity, all support schemes.
Source: gathered by author.

As can be seen from the graphs, the use of a PV system becomes economically viable even with a reduction in electricity tariff rate. Starting from the annual change of -5% (5% decrease in the retail rate from the current value of 0.137€/kWh), the NPV criterion for combination Medium demand/5kWp capacity crosses the zero line and becomes positive for all support mechanisms. In the modern realities of the world energy market, a reduction in the price of traditional energy resources is quite likely, but it is improbable that the decline will be significant (more than 5% less annually on a constant basis) in the nearest future. At the same time, the discounted payback period ranges from 13.5 years (for Net billing system case) to 15.6 years (for current Net accounting system), which is acceptable, but quite a long period for households.

However, the outlook is extremely favorable: even with a 4% (for NBS and FiT declining scenarios) and a 3% (for NAS and FiT fixed scenarios) annual retail rate reduction, the discounted payback period drops to 7.4 years, which is really satisfactory for residents. It is worthy to note that the pattern for all support mechanisms is the same: with further changes in retail rates (from -3/-4% to +10%), the NPV criterion increases rapidly in absolute terms with change in electricity prices by each additional 1% and reaches the value of 34 419€ for NBS scenario, 33 189€ for FiT declining, 33 137€ for FiT fixed and 33 016€ for NAS base case scenario with 10% annual increase in electricity retail rates. While in percentage terms, although the NPV growth remains significant, it slows down dramatically with annual change in electricity price at point -5%/-4% and then gradually reaches the stable level of 19%. In contrast to the NPV criterion, the discounted payback period is not so sensitive to the annual percentage change in electricity tariff. As already mentioned, for the most popular combination Medium demand/5kWp system capacity the key points are 3%/4% annual decrease in retail rates, where DPP falls down markedly. In particular, DPP is sharply reduced by 42% and 41% at 3%- retail rate decrease in NAS case and in FiT Fixed case respectively, and by 45% and 46% at 4%-retail rate decrease in NBS case and in FiT Declining case respectively. But with further changes in retail rates (from -3/-4% to +10%), the DPP criterion decreases only for 0.4-0.1 of a year with change in electricity prices by each additional 1%, which corresponds to 2%-reduction, and gradually reaches the value of 4.8/4.9 years with 10% annual increase in electricity retail rates in all scenarios.

Table 14 represents the changes in the NPV and DPP criteria in percentage terms with change in electricity retail rates by each additional 1% for combination Medium demand/5kWp capacity for all support schemes.

Table 14

Sensitivity analysis for the NPV and DPP criteria for annual change in electricity retail rate, Medium usage/5kWp

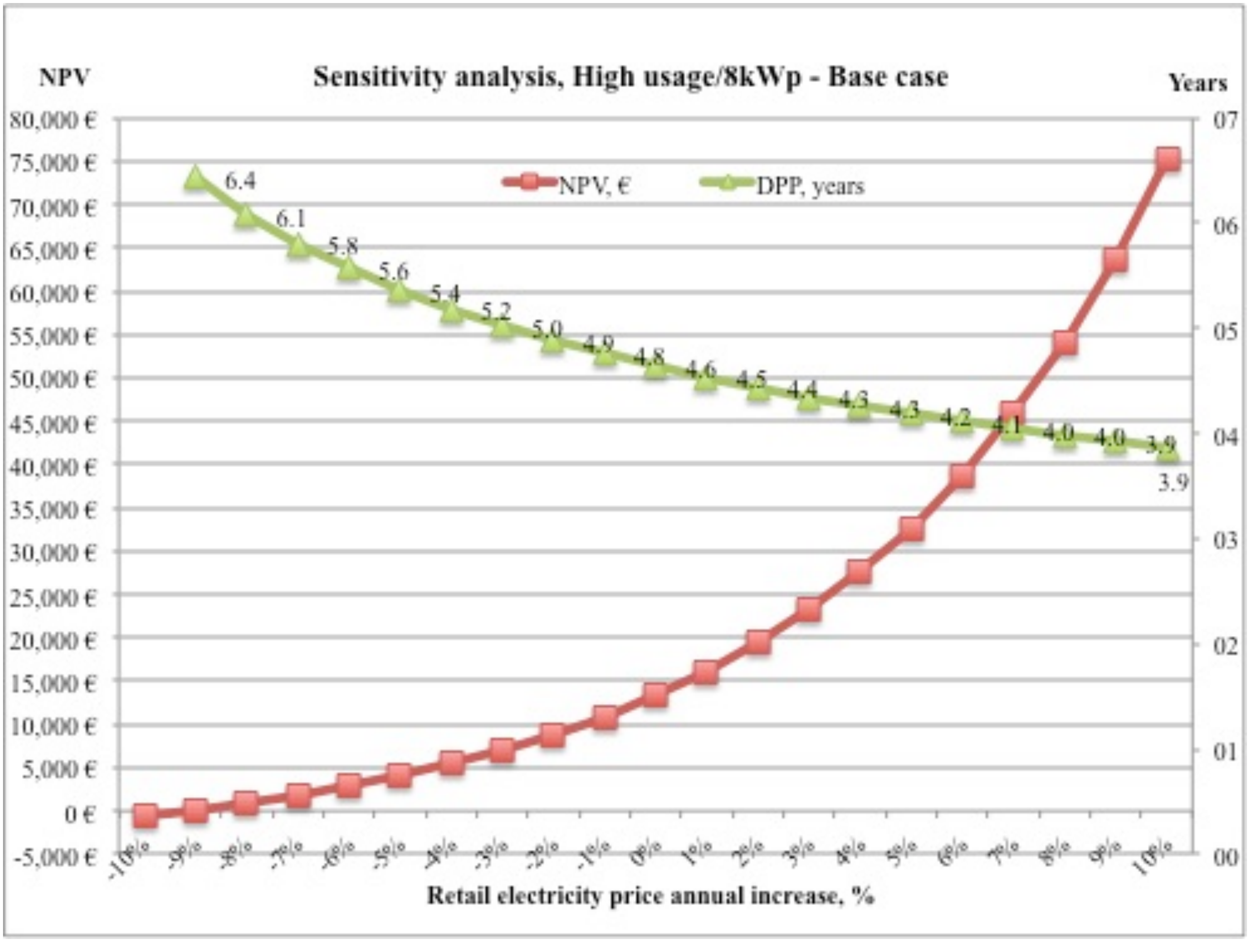
Retail electricity price annual increase, (%)	NAS case		NBS case		FiT Fixed case		FiT Declining case	
	NPV growth, %	DPP change, %	NPV growth, %	DPP change, %	NPV growth, %	DPP change, %	NPV growth, %	DPP change, %
-10%	-	-	-	-	-	-	-	-
-9%	17%	-	19%	-	18%	-	18%	-
-8%	23%	-	26%	-	25%	-	26%	-
-7%	34%	-	41%	-	37%	-	39%	-
-6%	58%	-	78%	-	67%	-	72%	-
-5%	155%	-	408%	-	232%	-	295%	-
-4%	324%	-19%	151%	-45%	201%	-16%	173%	-46%
-3%	88%	-42%	69%	-5%	77%	-41%	73%	-5%
-2%	54%	-5%	47%	-4%	50%	-5%	48%	-4%
-1%	40%	-4%	37%	-4%	38%	-4%	38%	-4%
0%	33%	-4%	31%	-4%	32%	-4%	32%	-4%
1%	29%	-4%	27%	-3%	28%	-4%	28%	-3%

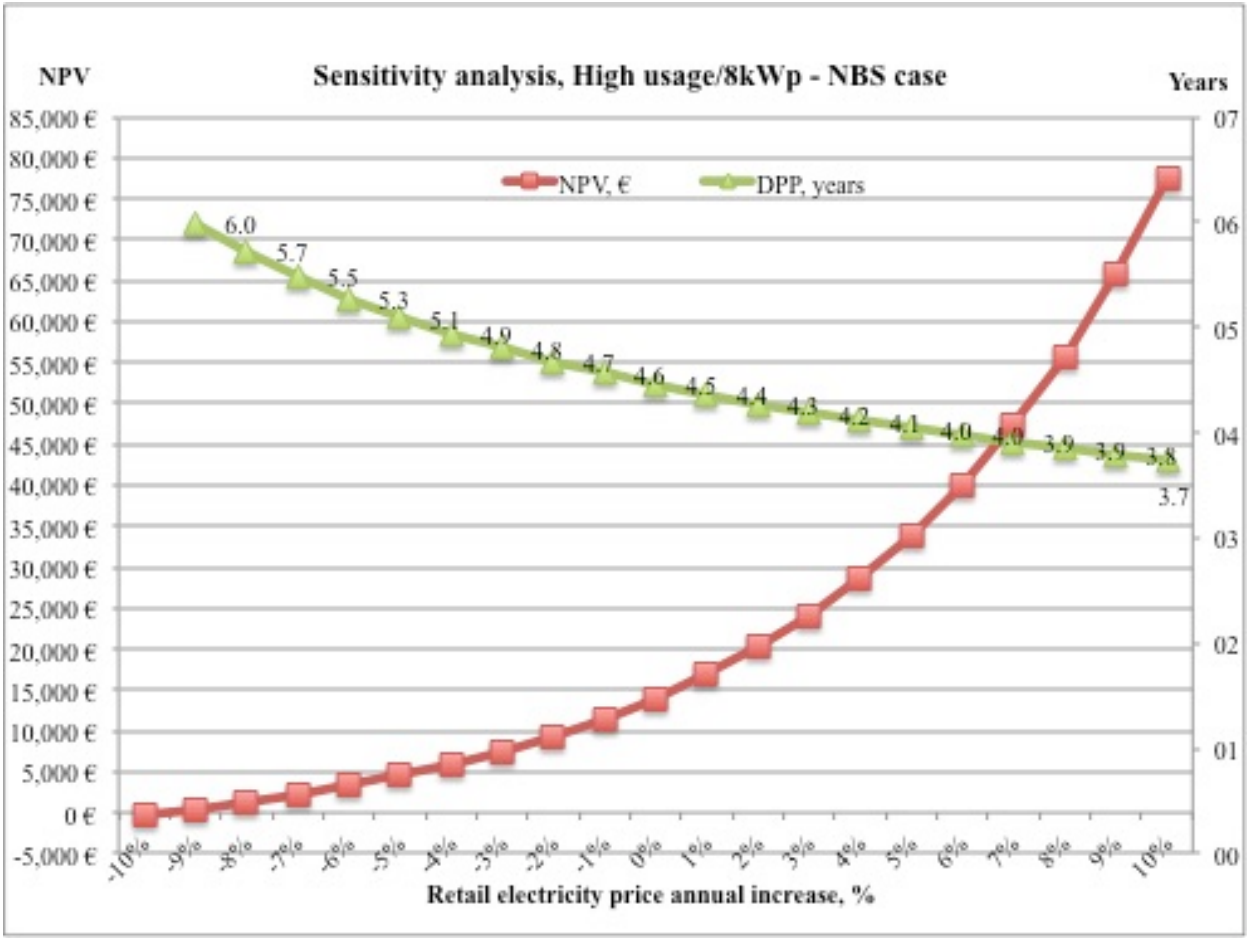
Continuation of Table 14

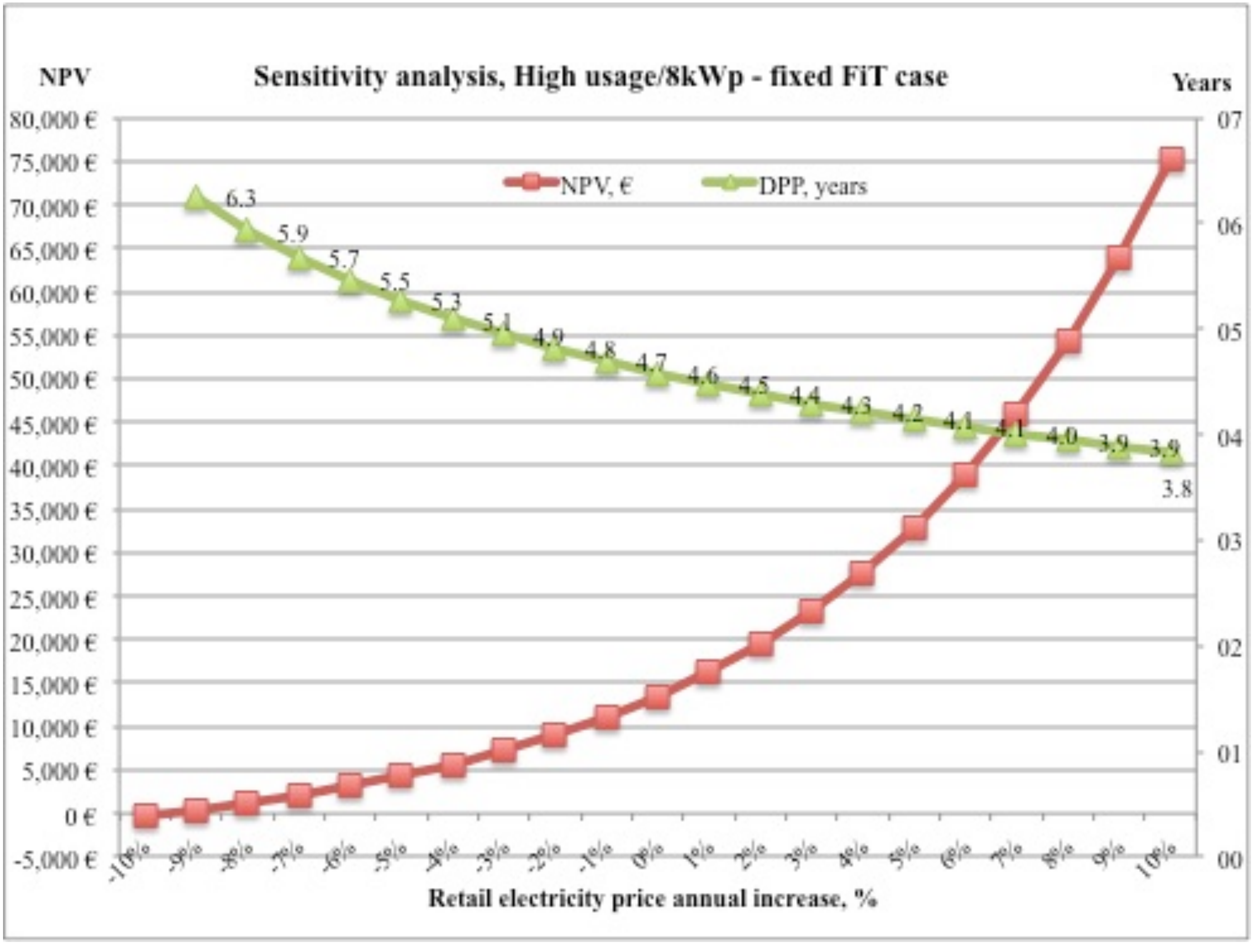
Retail electricity price annual increase, (%)	NAS case		NBS case		FiT Fixed case		FiT Declining case	
	NPV growth, %	DPP change, %	NPV growth, %	DPP change, %	NPV growth, %	DPP change, %	NPV growth, %	DPP change, %
2%	26%	-3%	25%	-3%	25%	-3%	25%	-3%
3%	24%	-3%	23%	-3%	24%	-3%	23%	-3%
4%	22%	-3%	22%	-3%	22%	-3%	22%	-3%
5%	21%	-3%	21%	-3%	21%	-3%	21%	-2%
6%	21%	-2%	20%	-2%	20%	-2%	20%	-2%
7%	20%	-2%	20%	-2%	20%	-2%	20%	-2%
8%	19%	-2%	19%	-2%	19%	-2%	19%	-2%
9%	19%	-2%	19%	-2%	19%	-2%	19%	-2%
10%	19%	-2%	19%	-2%	19%	-2%	19%	-2%

Source: gathered by author.

The graphs on the Figure 11 illustrate the sensitivity of economic efficiency criteria (NPV and DPP) to changes in the annual level of electricity retail rates for High demand/8kWp capacity combination, which have the highest indicators of economic efficiency, in the context of all support mechanisms.




Sensitivity analysis, High usage/8kWp - NBS case
NPV
Years
NPV, €
DPP, years
Retail electricity price annual increase, %


Sensitivity analysis, High usage/8kWp - fixed FiT case
NPV
Years
NPV, €
DPP, years
Retail electricity price annual increase, %

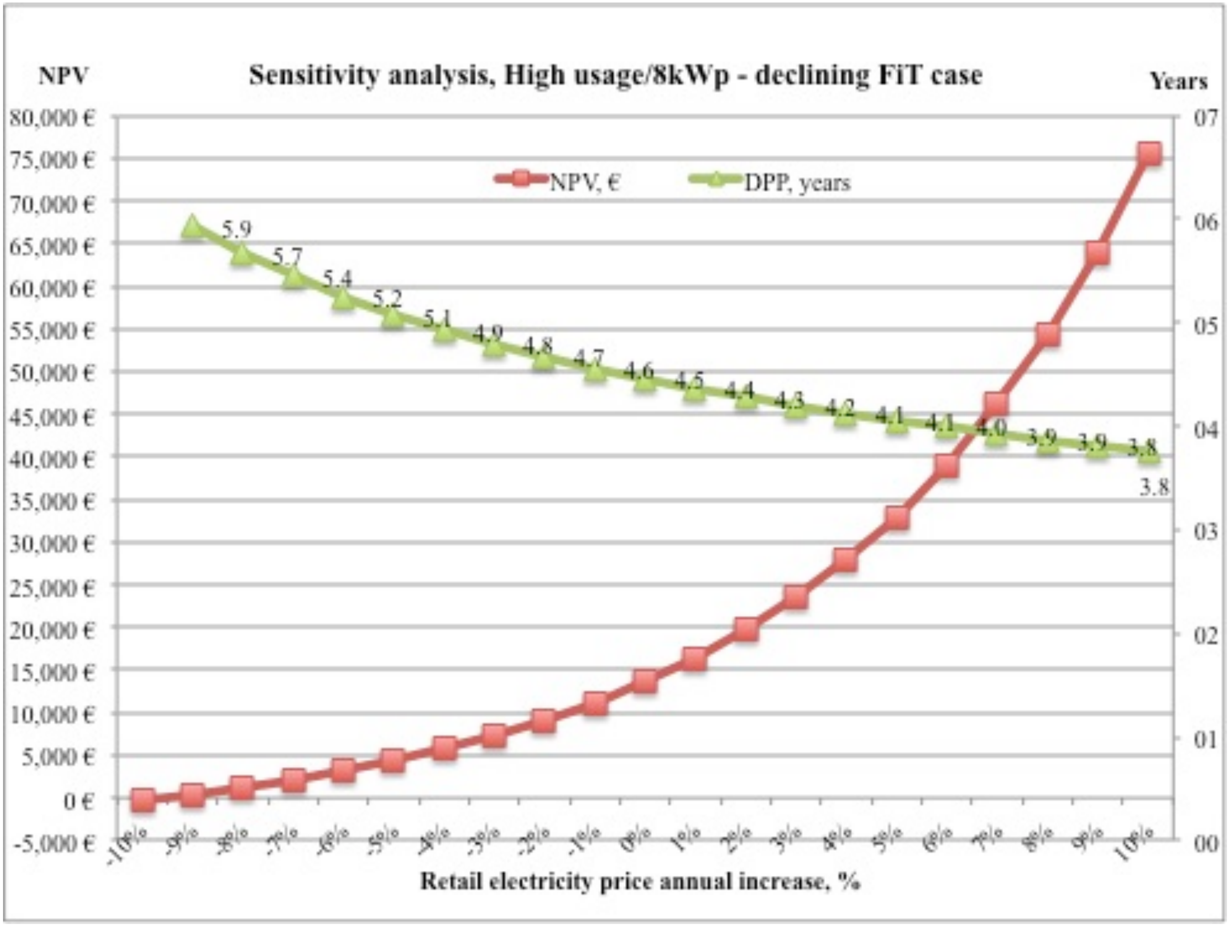


Figure 11 – Impact of retail electricity annual price change to NPV and DPP, High demand/8kWp, all support schemes.

Source: gathered by author.

The graphs above show the interesting fact that the use of a PV system becomes economically viable even with a strong reduction in electricity tariff rate. Starting from the annual change of -9% (9% decrease in the retail rate from the current value of 0.137€/kWh), the NPV criterion for combination High demand/8kWp capacity crosses the zero line and becomes positive for all support mechanisms. The discounted payback period, even with such significant annual reduction in retail electricity rates, equals about 6 years for all cases, which is a satisfactory period from a household's perspective.

It is important to note that the pattern for all support mechanisms is the same: with a significant reduction in annual retail rates (from -10% to -3%), the NPV criterion increases rapidly (starting from more than twice annual increase at -10% to one third at -3% change for all remuneration schemes). With further increase in electricity prices (from -3% to +10%), even if the NPV growth remains significant, it slows down and gradually reaches a 18% stable level. In absolute terms the NPV criterion rises remarkably and reaches the value of 77 477€ for NBS scenario, 74 430€ for FiT declining, 75 343€ for FiT fixed and 75 141€ for NAS base case scenario with 10% annual increase in electricity retail rates.

Table 15 represents the changes in the NPV and DPP criteria in percentage terms with change in annual electricity retail rates by each additional 1% for combination High demand/8kWp capacity for all support schemes.

Table 15

Sensitivity analysis for the NPV and DPP criteria for annual change in electricity retail rate, High usage/8kWp

Retail electricity price annual increase, (%)	NAS case		NBS case		FiT Fixed case		FiT Declining case	
	NPV growth, %	DPP change, %	NPV growth, %	DPP change, %	NPV growth, %	DPP change, %	NPV growth, %	DPP change, %
-10%	-	-	-	-	-	-	-	-
-9%	129%	-	261%	-	203%	-	271%	-
-8%	509%	-6%	184%	-4%	223%	-5%	180%	-4%
-7%	95%	-5%	74%	-4%	78%	-4%	73%	-4%
-6%	56%	-4%	48%	-4%	50%	-4%	48%	-4%
-5%	41%	-4%	37%	-3%	38%	-4%	37%	-3%
-4%	33%	-3%	31%	-3%	32%	-3%	31%	-3%
-3%	29%	-3%	27%	-3%	28%	-3%	27%	-3%
-2%	26%	-3%	25%	-3%	25%	-3%	25%	-3%
-1%	24%	-3%	23%	-2%	23%	-3%	23%	-2%
0%	22%	-2%	22%	-2%	22%	-2%	22%	-2%
1%	21%	-2%	21%	-2%	21%	-2%	21%	-2%
2%	20%	-2%	20%	-2%	20%	-2%	20%	-2%
3%	20%	-2%	19%	-2%	19%	-2%	19%	-2%
4%	19%	-2%	19%	-2%	19%	-2%	19%	-2%
5%	19%	-2%	19%	-2%	19%	-2%	19%	-2%
6%	18%	-2%	18%	-2%	18%	-2%	18%	-1%
7%	18%	-2%	18%	-2%	18%	-2%	18%	-2%
8%	18%	-2%	18%	-2%	18%	-2%	18%	-2%
9%	18%	-2%	18%	-1%	18%	-2%	18%	-1%
10%	18%	-2%	18%	-1%	18%	-1%	18%	-1%

Source: gathered by author.

In contrast to the NPV criterion, the discounted payback period is not so sensitive to the annual percentage change in electricity tariff. The DPP criterion decreases only for 0.3-0.1 of a year with annual change in electricity prices by each additional 1%, which corresponds to 5-1%-reduction, and gradually reaches the value of about 3.8 years with 10% annual increase in electricity retail rates in all scenarios.

In the modern realities of the world energy market, a reduction in the price of traditional energy resources is quite possible, so it’s important to check the economic efficiency of a PV system use even under such conditions. The PV system investment becomes economically viable even with a strong reduction in electricity tariff rate. For the most likely retail rate change from the current value of 0.137€/kWh (from range -2% to +4% annually) the NPV criterion increases by 20-30%, while the DPP decreases by 3-5% with each additional 1% change increase in rates.

CONCLUSIONS AND PROPOSALS

1. As the photovoltaic technology is developing fast and becoming more competitive with conventional generation sources, countries with low irradiation and solar PV adoption rates, such as Lithuania, are also becoming increasingly interested in policy support for solar PV. These countries focus on remuneration schemes for residents, though prosumer electricity demand and solar generation profiles are often mismatched. Governments used to finance renewable energy sources development programs using a feed-in tariff; however, now they tend to use initial capacity-based support, net metering systems (NMS), auction/tendering systems, tax incentives, tradable green certificates and others.

2. The net accounting system, which is currently in place in many countries (in particular, in Lithuania), disregards the prices of the submitted and received energy. The energy surplus is measured in units of energy (kWh), and when electricity production exceeds consumption, it is submitted to the network; otherwise, it can be returned from the network. Another support mechanism, which is applied in Lithuania nowadays, is providing subsidies, which are based on capacity-based incentives (Euro per kW), and are generally paid as up-front grant (current amount is €323/kWp).

3. After the analysis of intensity of utilisation of photovoltaic panels in the EU and the Baltics countries, it was confirmed that level of radiation is not the most influential factor on the intensity of the utilisation of PV energy. It was found that countries with a higher GDP per capita have a higher installed capacity of solar panels, which can be mainly explained by more available state support for the use of PV technologies. It was also concluded that applying a particular type of support scheme for PV prosumers in countries with a low average solar irradiance and a low GDP plays a crucial role in the development of the PV solar market and can explain uneven use of PV technologies.

4. Relative financial performance of a residential PV system was assessed in various scenarios (combinations of different support schemes and financing structures), using traditional discounted cash flow metrics (net present value and internal rate of return) but with a special emphasis on discounted payback period.

5. Generally, initial results indicate that residential PV panels are a smart investment in many cases from a classic NPV perspective. Considering the PV installation as an investment project, the most appropriate choice nowadays is the correspondence between electricity demand and installed capacity of a system. Even under current conditions of the absence of remuneration for the surplus of PV electricity generated in Lithuania, solar panels installation is a good investment opportunity from a household's perspective corresponding to positive NPV and IRR more than required rate of return (except of a significant mismatch case Low demand/8kWp),

but in some cases the payback period is much longer than might be appropriate for households. A rule is obvious: the more the installed capacity of a PV system, the more economic benefits a household has.

6. In terms of policy support, a net billing scheme, which provides ongoing remuneration throughout the life of the project at the retail rate, offers the best performance of any other scenario studied, although there is not much difference between the NBS metering and the declining FiT results. This indicates that the net billing system has about the same financial impact as the declining FiT, where remuneration is high at first, but decreases in a stepwise manner to 0. In the same time, in NBS case, rules in the energy market can be changed, and a household will have no opportunity to sell excess electricity to the market, unlike in a FiT system, where a prosumer, who has won an auction, has a priority to sell all amount of excess generated electricity at an auction price.

7. However, it should be noted that NBS as well as feed-in tariff remuneration, has no significant impact on financial performance for big installations with high prosumer electricity demand. Examining the scenarios in which PV owners are compensated for excess generation, a conclusion can be made that introducing supporting mechanisms (NBS as well as FiTs) has a great impact on the economic efficiency of a project only for cases with sufficient discrepancy between energy usage and generation level of a PV system with quite big capacity. From the point of view of a household with low level of electricity consumption, the introduction of a support mechanism (especially NBS) may serve a reason for purchasing a PV system with installed capacity not less than 5 kWp.

8. The structure of financing of the investment project, i.e. use of cash or a loan, even at 3.9% annum, does not significantly affect the economic efficiency of the project: DPP increases only for a half of a year. For those prosumers who do not have the opportunity to pay for the system in cash, using a loan is an excellent possibility to distribute costs over time. The introduction and use of a grant has a more noticeable impact on the discounted payback period: with an increase in a grant by every additional 10% of the initial system cost, the DPP of the investment is reduced by more than a year. As was discovered, combining the implementation of net billing metering with a 50% grant and a purpose loan at 1% annum sharply reduces the discounted payback period by several times, which becomes an extremely fast period from the household's perspective. Although under current circumstances, the investment in the project is not an economically viable choice (from DPP perspective) for some combinations of system size/electricity demand.

9. Conducting the sensitivity analysis for electricity retail rate is very important, since in the modern realities of the world energy market a significant change in the price of traditional

energy resources is quite possible in both positive and negative terms. It has been found that the PV system investment remains economically viable even with a strong reduction in electricity tariff rate. In contrast to the NPV criterion, the discounted payback period is not so sensitive to the annual percentage change in electricity tariff. For the most likely retail rate change from the current value (from range -2% to +4% annually) the NPV criterion increases by 20-30%, while the DPP decreases by 3-5% with each additional 1% change increase in rates.

10. Under current energy market conditions, a proposal can be given for potential residential PV prosumers: in order to avoid additional costs, a system of the capacity that will fully match the household's demand level for electricity should be installed. The more a household's electricity usage is, the more economic benefits a household will have.

The results of this research could be also valuable for decision-makers at the legislative level, who are considering further strategies for the green energy development. Implementation of the net billing metering system may be advised to encourage the deployment of residential PV systems. The remuneration rates for the excess electricity produced by a prosumer and delivered to the grid should be negotiated as a part (on the equal basis with the rest of the terms) of the long-term agreement between a resident and the grid. Continued grant funding can also make a major contribution to increasing the numbers of the resident PV systems.

Corporate renewable power sourcing and virtual net metering are other ways, which can promote the rise of solar. They have already become an essential part of the sustainability strategy for several leading corporations, and are gradually being introduced in Lithuania. Economic efficiency evaluation of residential investments in such corporate renewable power projects is a direction of the author's further research.

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EVALUATION OF THE ECONOMIC IMPACTS OF SUPPORT SCHEMES ON INVESTMENT IN RESIDENTIAL PHOTOVOLTAIC SYSTEM

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SUMMARY

67 pages, 11 figures, 15 tables, 60 references.

The goal of this master thesis is to pre-evaluate the impact of different schemes of public support on the economic efficiency of residential PV systems and to compare the cost-effectiveness of financing options. This work focuses on the assessment of financial performance of micro residential rooftop solar PV systems, affected by various options of remuneration schemes, grant and financing mechanisms. In order to solve the main purpose, the following methods are applied: systematization of scientific literature and its comparative analysis; statistical, dynamic and structural analysis; correlation analysis; capital budgeting methods; sensitivity analysis.

The work consists of 3 main parts. In the first section, the classification of existing legal support mechanisms in the sphere of PV activities is outlined, the preferred capital budgeting methods (incl. net present value, internal rate of return, and discounted payback period) are presented. Then, current infrastructural and economic conditions of solar PV market and analysis of the intensity of utilization of PV panels in the EU and in the Baltic states are performed.

The second part is represented as a research design that begins with the development of a model to estimate the monthly generation of solar electricity and household electricity demand.

In the third part, impacts of different support strategies and financing options on the financial performance of residential solar installation are examined, using the discounted cash flow methods adapted to analysis of PV system investment.

Initial results indicate, that in Lithuania even under current conditions of the absence of remuneration for the surplus of PV electricity generated, solar PV installation is a good investment opportunity for a household from a classic NPV perspective, but in some cases the payback period is much longer than might be appropriate for residents. The more the installed capacity of a PV system, the more economic benefits a household has.

The performed research revealed, that introduction of net billing scheme offers the best performance of any other scenario studied. But initiating all support mechanisms has a great impact on the economic efficiency of a project only for cases with sufficient discrepancy between energy usage and generation level of a PV system with quite big capacity.

It was discovered, that the financing structure does not significantly affect the economic efficiency of the investment project: thus using a loan is an excellent possibility for prosumer to distribute costs over time. Meanwhile the introduction and use of an upfront grant has a more noticeable impact on the discounted payback period.

Sensitivity analysis is held to determine the effects of the retail rate change on the economic performance of a system. It has been found that the PV system investment remains economically viable even with a strong reduction in electricity tariff rate.

The conclusions and proposals section reveal the authorship input and present the key research results, which can be helpful for residents-potential PV prosumers as well for decision-makers on the legislative level in low solar radiation countries.

NAMŲ ŪKIŲ INVESTICIJŲ Į SAULĖS FOTOELEKTROS SISTEMAS PARAMOS MODELIŲ EKONOMINIO POVEIKIO VERTINIMAS

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SANTRAUKA

67 puslapiai, 11 paveikslų, 15 lentelių, 60 šaltiniai.

Šio magistro baigiamojo darbo tikslas yra įvertinti skirtingų valstybinių paramos modelių poveikį fotoelektros sistemų skirtų gyvenamiesiems namams ekonominiam naudingumui ir palyginti finansavimo galimybių ekonominį efektyvumą. Šiame darbe pagrindinis dėmesys skiriamas gyvenamųjų namų stoginių fotoelektros mikro sistemų finansinės veiklos vertinimui, kuriam turi įtakos įvairios kompensavimo schemos, dotacijos, finansiniai mechanizmai. Pagrindiniam šio darbo tikslui pasiekti taikomi šie metodai: mokslinės literatūros apžvalga ir jos lyginamoji analizė; statistinė, dinaminė ir struktūrinė analizė; koreliacijos analizė; kapitalo biudžeto sudarymo metodai; jautrumo analizė.

Darbą sudaro 3 pagrindinės dalys. Pirmame skyriuje yra apibendrinama esama teisinės paramos mechanizmų klasifikacija fotoelektros srityje. Taip pat yra pateikiami pageidaujami kapitalo biudžeto sudarymo metodai (įskaitant grynąją dabartinę vertę, vidinę grąžos normą ir diskontuotą atsipirkimo laikotarpį). Tolimesniuose skyriuose yra atliekama dabartinės fotoelektros rinkos infrastruktūrinių ir ekonominių sąlygų bei fotoelektrinių plokščių panaudojimo intensyvumo ES ir Baltijos šalyse apžvalga.

Antroje darbo dalyje pateikiamas tyrimo projektas, kuriuo pradedamas kurti modelis, skirtas įvertinti mėnesinį saulės energijos ir buitinės elektros energijos poreikį.

Trečioje dalyje nagrinėjamas skirtingų paramos strategijų ir finansavimo galimybių poveikis gyvenamųjų saulės įrenginių finansiniams rezultatams, naudojant diskontuotų pinigų srautų metodus, pritaikytus fotoelektrinės sistemos investicijų analizei.

Pirminiai rezultatai rodo, kad Lietuvoje net ir esant dabartinėms sąlygoms, kai nėra kompensacijos už pagamintos saulės energijos perteklių, saulės elektrinių įrengimas yra gera investavimo galimybė namų ūkiui žvelgiant iš klasikinės NPV perspektyvos, tačiau kai kuriais atvejais atsipirkimo laikotarpis yra daug ilgesnis, nei būtų priimtinas gyventojams. Kuo didesnis įdiegtų fotoelektrinės sistemos pajėgumas, tuo didesnė ekonominė nauda yra namų ūkiui.

Atliktas tyrimas atskleidė, kad grynojo atsiskaitymo schemos įvedimas yra geriausias tarp visų kitų ištirtų scenarijų. Tačiau visų paramos mechanizmų inicijavimas daro didelę įtaką ekonominiam projekto efektyvumui tik tais atvejais, kai yra pakankamas neatitikimas tarp energijos vartojimo ir gana didelės galios fotoelektrinių sistemų gamybos lygio.

Tyrimo metu buvo nustatyta, kad finansavimo struktūra neturi reikšmingos įtakos investicinio projekto ekonominiam efektyvumui: taigi paskolos naudojimas yra puiki galimybė vartotojui paskirstyti išlaidas laikui bėgant. Tuo tarpu išankstinės dotacijos įvedimas ir naudojimas turi didesnį poveikį diskontuotam atsipirkimo laikotarpiui.

Jautrumo analizė atlikta siekiant nustatyti mažmeninės kainos pokyčio poveikį sistemos ekonominei veiklai. Nustatyta, kad fotoelektrinės sistemos investicijos išlieka ekonomiškai perspektyvios net ir labai sumažinus elektros energijos tarifo normą.

Išvadų ir rekomendacijų skyriuje pateikiamas šio darbo autoriaus indėlis ir pateikiami pagrindiniai tyrimų rezultatai, kurie gali būti naudingi potencialiems fotoelektros vartotojams, taip pat sprendimų priėmėjams įstatymų leidybos lygmenyje žemos saulės radiacijos šalyse.

ANNEXES

Annex 1
Monthly electricity usage and Net export per household for Year 1

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Year
Low usage per household per month (3100 kW per year)	*258*	*200*	*171*	*152*	*151*	*183*	*266*	*304*	*341*	*390*	*367*	*317*	*3100*
3kWp: Self-consumption, KWh	142	200	171	152	151	108	61	13	7	13	37	85	1141
From the grid:	115	0	0	0	0	76	205	291	333	377	330	232	1959
Dpv1: at retail price	115	0	0	0	0	0	0	0	0	0	301	188	*605*
from accumulated electricity	0	0	0	0	0	76	205	291	333	377	29	44	1354
Delivered to the grid, KWh	167	260	237	199	210	126	72	15	8	15	44	100	1454
Accumulated energy balance, kWh	167	427	665	863	1073	1124	991	715	390	29	44	100	
5kWp: Self-consumption, KWh	170	200	171	152	151	129	73	16	9	16	44	102	1232
From the grid:	87	0	0	0	0	55	193	289	332	374	323	215	1868
Dpv1: at retail price	87	0	0	0	0	0	0	0	0	0	0	0	*87*
from accumulated electricity	0	0	0	0	0	55	193	289	332	374	323	215	1780
Delivered to the grid, KWh	346	567	509	433	451	261	148	32	17	32	90	206	3093
Accumulated energy balance, kWh	346	913	1422	1855	2306	2512	2468	2211	1896	1554	1321	1312	
8kWp: Self-consumption, KWh	188	200	171	152	151	142	80	17	9	17	49	112	1290
From the grid:	70	0	0	0	0	41	185	287	331	373	318	205	1810
Dpv1: at retail price	70	0	0	0	0	0	0	0	0	0	0	0	*70*
from accumulated electricity	0	0	0	0	0	41	185	287	331	373	318	205	1740
Delivered to the grid, KWh	637	1027	917	784	812	482	273	59	32	59	166	380	5630
Accumulated energy balance, kWh	637	1665	2582	3366	4179	4619	4707	4479	4180	3866	3714	3890	

Continuation Annex 1

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Year
Medium usage per household per month (5300 kW per year)	*440*	*342*	*293*	*260*	*259*	*314*	*454*	*520*	*582*	*667*	*627*	*542*	*5300*
3kWp: Self-consumption, KWh	207	308	274	235	242	157	89	19	10	19	54	124	1739
From the grid:	233	33	19	25	17	157	365	501	572	648	573	418	3561
Dpv1: at retail price	233	0	0	0	0	0	0	373	562	642	564	391	*2766*
from accumulated electricity	0	33	19	25	17	157	365	128	9	5	9	27	795
Delivered to the grid, KWh	102	152	135	116	119	77	44	9	5	9	27	61	856
Accumulated energy balance, kWh	102	221	336	427	530	450	128	9	5	9	27	61	
5kWp: Self-consumption, KWh	263	342	293	260	259	199	113	24	13	24	69	157	2015
From the grid:	177	0	0	0	0	115	342	496	569	642	559	385	3285
Dpv1: at retail price	177	0	0	0	0	0	0	0	0	94	535	319	*1126*
from accumulated electricity	0	0	0	0	0	115	342	496	569	548	23	66	2159
Delivered to the grid, KWh	253	425	388	325	344	191	108	23	13	23	66	151	2310
Accumulated energy balance, kWh	253	678	1066	1391	1734	1811	1577	1104	548	23	66	151	
8kWp: Self-consumption, KWh	296	342	293	260	259	224	127	27	15	27	77	177	2124
From the grid:	144	0	0	0	0	90	327	493	567	639	550	365	3176
Dpv1: at retail price	144	0	0	0	0	0	0	0	0	0	0	0	*144*
from accumulated electricity	0	0	0	0	0	90	327	493	567	639	550	365	3032
Delivered to the grid, KWh	529	885	796	676	705	400	227	49	27	49	138	316	4796
Accumulated energy balance, kWh	529	1415	2211	2887	3592	3902	3801	3357	2816	2226	1813	1764	

Continuation Annex 1

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Year
High usage per household per month (8100 kW per year)	*673*	*522*	*447*	*398*	*396*	*479*	*694*	*795*	*890*	*1019*	*959*	*828*	*8100*
3kWp: Self-consumption, KWh	260	387	343	295	304	197	111	24	13	24	68	155	2180
From the grid:	413	136	104	103	92	283	583	771	877	995	891	673	5920
Dpv1: at retail price	413	86	31	38	36	225	546	750	872	992	886	660	*5535*
from accumulated electricity	0	50	74	65	56	58	37	21	5	2	5	13	386
Delivered to the grid, KWh	50	74	65	56	58	37	21	5	2	5	13	30	415
Accumulated energy balance, kWh	50	74	65	56	58	37	21	5	2	5	13	30	
5kWp: Self-consumption, KWh	351	522	447	398	396	265	150	32	18	32	91	209	2911
From the grid:	322	1	0	0	0	214	544	763	872	987	867	618	5189
Dpv1: at retail price	322	0	0	0	0	0	0	288	857	978	852	575	*3873*
from accumulated electricity	0	1	0	0	0	214	544	474	15	8	15	43	1315
Delivered to the grid, KWh	165	245	233	187	207	125	71	15	8	15	43	98	1414
Accumulated energy balance, kWh	165	410	643	830	1037	948	474	15	8	15	43	98	
8kWp: Self-consumption, KWh	404	522	447	398	396	306	173	37	20	37	105	241	3088
From the grid:	269	0	0	0	0	174	521	758	870	982	853	586	5012
Dpv1: at retail price	269	0	0	0	0	0	0	0	0	0	686	477	*1431*
from accumulated electricity	0	0	0	0	0	174	521	758	870	982	168	110	3581
Delivered to the grid, KWh	421	705	641	538	568	318	180	39	21	39	110	251	3832
Accumulated energy balance, kWh	421	1126	1767	2306	2874	3019	2678	1959	1110	168	110	251	

Annex 2

Financial performance calculations for base case and remuneration cases

a. Base case (Net accounting system)

Low usage/3kWp																										
Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-2231	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1420	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-3200																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1357													
Capacity-based incentive, 323€ per kW	969																									
Savings, €		285	293	301	309	317	325	334	342	351	360	369	378	387	397	407	416	426	437	447	458	469	480	491	502	514
Demand without PV Dt, kWh		3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100
Demand with PV Dpv, kWh		605	622	640	657	674	691	708	724	741	756	774	790	806	822	838	854	870	886	901	916	932	947	962	977	992
Delivered to the grid, kWh		1454	1439	1424	1410	1395	1380	1366	1352	1338	1325	1314	1302	1291	1280	1270	1261	1252	1244	1235	1226	1218	1209	1201	1192	1184
Cash flow, €	-2231	235	242	248	255	262	269	277	284	291	299	307	-1042	322	331	339	347	356	364	373	382	391	401	410	420	430
NPV		€3 397																								
Discounted CF, €	-2231	232	235	239	242	246	249	252	256	259	262	265	-891	272	275	278	281	285	288	291	294	297	300	303	307	310
Cumulated discounted CF, €	-2231	-1999	-1763	-1525	-1282	-1037	-788	-535	-280	-21	242	507	-384	-112	163	442	723	1008	1295	1586	1880	2177	2477	2781	3087	3397
Discounted payback period, years		13,4																								
IRR		9,8%																								

Continuation Annex 2

a. Base case (Net accounting system)

Low usage/5kWp

Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-2585	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1109	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-4200																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1045													
Capacity-based incentive, 323€ per kW	1615																									
Savings, €		292	305	317	330	344	357	371	386	400	415	431	446	462	479	495	512	530	548	566	585	605	625	645	666	688
Demand without PV Dt, kWh		3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100
Demand with PV Dpv, kWh		87	90	92	95	97	100	102	105	107	109	112	114	116	119	121	123	126	128	130	132	135	137	139	141	143
Delivered to the grid, kWh		3093	3061	3029	2998	2967	2936	2906	2875	2845	2819	2795	2770	2746	2722	2702	2683	2664	2645	2627	2608	2590	2572	2554	2536	2518
Cash flow, €	-2585	242	253	265	277	289	302	314	328	341	355	368	-662	397	412	428	443	459	476	492	510	528	546	564	584	603
NPV		€4 912																								
Discounted CF, €	-2585	239	247	255	263	271	279	287	295	303	311	319	-566	335	343	351	359	367	376	384	392	401	409	417	426	435
Cumulated discounted CF, €	-2585	-2346	-2099	-1844	-1581	-1311	-1032	-745	-450	-147	164	483	-83	252	595	946	1306	1673	2049	2432	2825	3225	3634	4052	4478	4912
Discounted payback period, years		12,2																								
IRR		10,7%																								

Continuation Annex 2

a. Base case (Net accounting system)

Low usage/8kWp																										
Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-3816	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1109	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-6400																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1045													
Capacity-based incentive, 323€ per kW	2584																									
Savings, €		196	209	223	237	252	267	282	297	313	329	345	362	379	396	414	432	450	469	488	508	528	549	570	592	615
Demand without PV Dt, kWh		3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100
Demand with PV Dpv, kWh		70	72	74	76	78	80	82	84	86	87	89	91	93	95	97	99	100	102	104	106	108	109	111	113	114
Delivered to the grid, kWh		5630	5572	5515	5458	5402	5346	5290	5235	5180	5132	5088	5043	4999	4955	4918	4884	4850	4816	4782	4748	4715	4682	4649	4617	4585
Cash flow, €	-3 816	146	158	171	184	197	211	225	239	254	268	283	-747	314	330	346	362	379	397	414	432	451	470	490	510	530
NPV		€1 889																								
Discounted CF, €	-3816	144	154	164	174	185	195	205	215	225	235	245	-638	265	275	284	294	303	313	323	333	342	352	362	372	382
Cumulated discounted CF, €	-3816	-3672	-3518	-3354	-3180	-2995	-2800	-2595	-2380	-2155	-1919	-1674	-2312	-2048	-1773	-1489	-1195	-891	-578	-255	77	420	772	1134	1507	1889
Discounted payback period, years		19,8																								
IRR		4,1%																								

Continuation Annex 2

a. Base case (Net accounting system)

Medium usage/3kWp																										
Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-2231	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1420	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-3200																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1357													
Capacity-based incentive, 323€ per kW	969																									
Savings, €		314	313	311	309	307	305	302	299	296	293	288	283	278	272	266	260	253	245	237	228	219	209	199	188	176
Demand without PV Dt, kWh		5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300
Demand with PV Dpv, kWh		2766	2846	2925	3004	3082	3160	3237	3314	3390	3460	3540	3615	3689	3762	3835	3907	3979	4051	4122	4192	4262	4331	4400	4469	4537
Delivered to the grid, kWh		856	848	839	830	822	813	805	796	788	781	774	767	760	754	748	743	738	732	727	722	717	712	707	702	697
Cash flow, €	-2 231	264	261	259	256	253	249	245	241	236	232	225	-1 137	213	206	198	190	182	173	163	153	142	130	118	105	91
NPV		€950																								
Discounted CF, €	-2231	260	255	249	243	237	230	224	217	210	203	195	-972	180	171	163	154	146	136	127	118	108	98	87	77	66
Cumulated discounted CF, €	-2231	-1971	-1716	-1467	-1224	-987	-757	-533	-317	-107	97	292	-680	-500	-329	-166	-11	134	270	398	515	623	720	808	884	950
Discounted payback period, years		16,1																								
IRR		5,4%																								

Continuation Annex 2

a. Base case (Net accounting system)

Medium usage/5kWp

Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-2585	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1109	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-4200																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1045													
Capacity-based incentive, 323€ per kW	1615																									
Savings, €		482	494	507	520	533	546	559	573	587	602	615	630	645	660	675	691	707	723	739	756	773	790	808	826	845
Demand without PV Dt, kWh		5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300
Demand with PV Dpv, kWh		1126	1158	1191	1223	1254	1286	1317	1349	1380	1408	1441	1471	1501	1531	1561	1590	1620	1649	1678	1706	1735	1763	1791	1819	1847
Delivered to the grid, kWh		2310	2286	2262	2239	2216	2193	2170	2147	2125	2105	2087	2069	2051	2033	2018	2003	1989	1976	1962	1948	1934	1921	1907	1894	1881
Cash flow, €	-2 585	432	443	454	466	478	490	502	515	527	541	553	-478	580	594	608	622	636	651	665	680	696	712	727	744	760
NPV		€8 729																								
Discounted CF, €	-2585	426	432	437	442	448	453	458	464	469	474	479	-409	489	494	499	504	509	514	519	523	528	533	538	543	548
Cumulated discounted CF, €	-2585	-2159	-1727	-1290	-848	-400	53	511	974	1443	1917	2396	1988	2477	2971	3470	3974	4483	4996	5515	6039	6567	7100	7638	8181	8729
Discounted payback period, years		5,9																								
IRR		17,8%																								

Continuation Annex 2

a. Base case (Net accounting system)

Medium usage/8kWp																										
Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-3816	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1109	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-6400																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1045													
Capacity-based incentive, 323€ per kW	2584																									
Savings, €		519	540	562	584	607	630	654	678	703	729	755	781	809	837	865	894	924	955	986	1 019	1 052	1 086	1 121	1 157	1 194
Demand without PV Dt, kWh		5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300
Demand with PV Dpv, kWh		144	148	153	157	161	165	169	173	177	180	185	189	192	196	200	204	208	211	215	219	222	226	229	233	237
Delivered to the grid, kWh		4796	4747	4699	4650	4602	4554	4507	4460	4413	4372	4334	4296	4259	4222	4190	4161	4131	4103	4074	4045	4017	3989	3961	3933	3906
Cash flow, €	-3 816	469	489	510	531	552	574	597	620	644	668	693	-327	744	770	797	825	853	882	912	943	975	1 007	1 040	1 074	1 109
NPV		€11002																								
Discounted CF, €	-3816	463	477	490	504	517	531	545	558	572	586	599	-280	627	641	655	669	683	697	711	726	740	755	769	784	799
Cumulated discounted CF, €	-3816	-3353	-2876	-2386	-1882	-1365	-834	-290	269	841	1427	2026	1746	2374	3015	3669	4338	5021	5718	6429	7155	7895	8649	9419	10203	11002
Discounted payback period, years		7,5																								
IRR		14,6%																								

Continuation Annex 2

a. Base case (Net accounting system)

High usage/3kWp																										
Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-2231	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1420	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-3200																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1357													
Capacity-based incentive, 323€ per kW	969																									
Savings, €		335	323	309	295	280	264	247	229	210	192	169	146	123	98	72	44	15	-15	-47	-80	-115	-152	-191	-231	-273
Demand without PV Dt, kWh		8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100
Demand with PV Dpv, kWh		5535	5694	5853	6011	6167	6323	6477	6630	6783	6923	7084	7233	7381	7528	7674	7819	7962	8105	8247	8388	8528	8667	8805	8942	9078
Delivered to the grid, kWh		415	411	407	403	398	394	390	386	382	378	375	372	369	365	363	360	358	355	353	350	348	345	343	340	338
Cash flow, €	-2 231	285	272	257	242	226	208	190	171	151	131	107	-1 274	58	32	4	-25	-55	-87	-121	-156	-193	-231	-271	-313	-357
NPV		-€2 500																								
Discounted CF, €	-2231	282	265	247	230	211	193	174	154	134	115	92	-1088	49	26	3	-20	-44	-69	-94	-120	-146	-173	-201	-229	-257
Cumulated discounted CF, €	-2231	-1949	-1685	-1438	-1208	-997	-804	-631	-477	-343	-228	-135	-1224	-1175	-1148	-1145	-1165	-1210	-1279	-1373	-1493	-1639	-1813	-2013	-2242	-2500
Discounted payback period, years		never																								
IRR		-																								

Continuation Annex 2

a. Base case (Net accounting system)

High usage/5kWp																										
Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-2585	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1109	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-4200																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1045													
Capacity-based incentive, 323€ per kW	1615																									
Savings, €		524	525	526	526	526	526	525	524	522	521	518	515	511	507	502	497	491	485	477	470	461	452	442	431	419
Demand without PV Dt, kWh		8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100
Demand with PV Dpv, kWh		3873	3985	4096	4207	4316	4425	4533	4640	4747	4845	4958	5062	5166	5268	5371	5472	5573	5673	5772	5871	5968	6066	6162	6258	6353
Delivered to the grid, kWh		1414	1399	1385	1371	1356	1342	1328	1314	1301	1289	1277	1266	1255	1244	1235	1226	1218	1209	1201	1192	1184	1176	1167	1159	1151
Cash flow, €	-2 585	474	474	473	473	471	470	468	466	463	461	455	-594	446	441	434	428	420	412	403	394	384	373	361	349	335
NPV		€5 732																								
Discounted CF, €	-2585	468	462	455	448	442	434	427	419	411	404	394	-507	376	367	357	347	336	326	315	303	291	279	267	254	241
Cumulated discounted CF, €	-2585	-2117	-1656	-1201	-752	-311	124	551	970	1381	1785	2179	1672	2048	2415	2772	3118	3455	3780	4095	4398	4689	4969	5236	5490	5732
Discounted payback period, years		5,7																								
IRR		16,4%																								

Continuation Annex 2

a. Base case (Net accounting system)

High usage/8kWp

Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-3816	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1109	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-6400																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1045													
Capacity-based incentive, 323€ per kW	2584																									
Savings, €		903	935	967	1 001	1 035	1 070	1 107	1 144	1 182	1 221	1 260	1 301	1 343	1 386	1 430	1 475	1 521	1 568	1 617	1 667	1 718	1 771	1 825	1 881	1 938
Demand without PV Dt, kWh		8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100
Demand with PV Dpv, kWh		144	148	153	157	161	165	169	173	177	180	185	189	192	196	200	204	208	211	215	219	222	226	229	233	237
Delivered to the grid, kWh		4796	4747	4699	4650	4602	4554	4507	4460	4413	4372	4334	4296	4259	4222	4190	4161	4131	4103	4074	4045	4017	3989	3961	3933	3906
Cash flow, €	-3 816	853	884	915	948	981	1 015	1 050	1 085	1 122	1 160	1 198	193	1 278	1 319	1 362	1 405	1 450	1 496	1 543	1 591	1 641	1 692	1 744	1 798	1 853
NPV		€22 328																								
Discounted CF, €	-3816	842	861	880	899	918	938	958	977	997	1017	1037	164	1078	1098	1119	1139	1160	1181	1203	1224	1246	1268	1290	1313	1335
Cumulated discounted CF, €	-3816	-2974	-2113	-1234	-335	584	1522	2479	3457	4454	5471	6509	6673	7751	8849	9968	11107	12267	13449	14651	15876	17121	18389	19680	20992	22328
Discounted payback period, years		4,4																								
IRR		25,2%																								

Continuation Annex 2

b. Net billing system

Low usage/3kWp																										
Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-2231	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1420	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-3200																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1357													
Capacity-based incentive, 323€ per kW	969																									
Savings, €		285	293	301	309	317	325	334	342	351	360	369	378	387	397	407	416	426	437	447	458	469	480	491	502	514
Demand without PV Dt, kWh		3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100
Demand with PV Dpv, kWh		605	622	640	657	674	691	708	724	741	756	774	790	806	822	838	854	870	886	901	916	932	947	962	977	992
Delivered to the grid, kWh		1454	1439	1424	1410	1395	1380	1366	1352	1338	1325	1314	1302	1291	1280	1270	1261	1252	1244	1235	1226	1218	1209	1201	1192	1184
Net Export, kWh		100	99	98	97	96	95	94	93	92	91	90	89	89	88	87	86	86	85	85	84	83	83	82	82	81
Cash flow, €	-2 231	249	256	263	270	277	284	292	299	307	315	323	-1 026	339	348	356	365	374	383	392	402	411	421	431	441	451
NPV		€3 756																								
Discounted CF, €	-2231	246	249	252	256	259	263	266	270	273	276	280	-876	286	289	293	296	299	302	306	309	312	315	319	322	325
Cumulated discounted CF, €	-2231	-1985	-1736	-1484	-1228	-969	-706	-440	-170	103	379	658	-218	68	358	650	946	1245	1548	1853	2162	2475	2790	3109	3431	3756
Discounted payback period, years		12,8																								
IRR		10,6%																								

Continuation Annex 2

b. Net billing system

Low usage/5kWp

Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-2585	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1109	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-4200																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1045													
Capacity-based incentive, € per kW	1615																									
Savings, €		292	305	317	330	344	357	371	386	400	415	431	446	462	479	495	512	530	548	566	585	605	625	645	666	688
Demand without PV Dt, kWh		3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100
Demand with PV Dpv, kWh		87	90	92	95	97	100	102	105	107	109	112	114	116	119	121	123	126	128	130	132	135	137	139	141	143
Delivered to the grid, kWh		3093	3061	3029	2998	2967	2936	2906	2875	2845	2819	2795	2770	2746	2722	2702	2683	2664	2645	2627	2608	2590	2572	2554	2536	2518
Net Export, kWh		1312	1299	1286	1272	1259	1246	1233	1220	1207	1196	1186	1176	1165	1155	1146	1138	1130	1122	1115	1107	1099	1091	1084	1076	1069
Cash flow	-2 585	422	436	451	466	482	498	514	530	547	565	583	-444	620	639	659	679	700	721	743	766	789	813	837	862	887
NPV		€9 637																								
Discounted CF	-2585	416	425	434	442	451	460	469	478	486	495	504	-379	523	532	541	551	560	570	580	589	599	609	619	629	639
Cumulated discounted CF	-2585	-2169	-1743	-1310	-867	-416	44	513	990	1476	1972	2476	2097	2619	3151	3692	4243	4803	5373	5952	6541	7141	7750	8369	8998	9637
Discounted payback period, years		5,9																								
IRR		18,2%																								

Continuation Annex 2

b. Net billing system

Low usage/8kWp

Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-3816	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1109	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-6400																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1045													
Capacity-based incentive, 323€ per kW	2584																									
Savings, €		196	209	223	237	252	267	282	297	313	329	345	362	379	396	414	432	450	469	488	508	528	549	570	592	615
Demand without PV Dt, kWh		3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100
Demand with PV Dpv, kWh		70	72	74	76	78	80	82	84	86	87	89	91	93	95	97	99	100	102	104	106	108	109	111	113	114
Delivered to the grid, kWh		5630	5572	5515	5458	5402	5346	5290	5235	5180	5132	5088	5043	4999	4955	4918	4884	4850	4816	4782	4748	4715	4682	4649	4617	4585
Net Export, kWh		3890	3850	3810	3771	3732	3693	3655	3617	3579	3546	3515	3484	3454	3424	3398	3374	3351	3327	3304	3281	3258	3235	3212	3190	3167
Cash flow, €	-3 816	678	700	722	745	768	792	816	840	865	891	918	-100	973	1 001	1 031	1 062	1 093	1 125	1 158	1 192	1 226	1 262	1 298	1 335	1372
NPV		€15894																								
Discounted CF, €	-3816	670	682	695	707	719	732	744	756	769	782	794	-85	820	834	847	861	875	889	903	917	931	945	960	974	989
Cumulated discounted CF, €	-3816	-3146	-2464	-1770	-1063	-343	389	1133	1889	2658	3439	4234	4149	4969	5803	6650	7511	8386	9274	10177	11094	12025	12971	13931	14905	15894
Discounted payback period, years		5,5																								
IRR		19,9%																								

Continuation Annex 2

b. Net billing system

Medium usage/3kWp																										
Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-2231	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1420	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-3200																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1357													
Capacity-based incentive, 323€ per kW	969																									
Savings, €		314	313	311	309	307	305	302	299	296	293	288	283	278	272	266	260	253	245	237	228	219	209	199	188	176
Demand without PV Dt, kWh		5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300
Demand with PV Dpv, kWh		2766	2846	2925	3004	3082	3160	3237	3314	3390	3460	3540	3615	3689	3762	3835	3907	3979	4051	4122	4192	4262	4331	4400	4469	4537
Delivered to the grid, kWh		856	848	839	830	822	813	805	796	788	781	774	767	760	754	748	743	738	732	727	722	717	712	707	702	697
Net Export, kWh		61	60	60	59	58	58	57	57	56	56	55	55	54	54	53	53	52	52	52	51	51	51	50	50	50
Cash flow, €	-2 231	272	270	268	265	262	258	254	250	246	242	235	-1 127	223	216	209	201	193	184	175	165	154	143	131	118	105
NPV		€1 170																								
Discounted CF, €	-2231	269	263	257	251	245	239	232	225	218	212	204	-963	188	180	172	163	154	145	136	127	117	107	97	86	75
Cumulated discounted CF, €	-2231	-1962	-1699	-1442	-1191	-946	-707	-475	-250	-31	181	385	-579	-390	-210	-38	125	279	425	561	688	805	911	1008	1094	1170
Discounted payback period, years		15,2																								
IRR		6,2%																								

Continuation Annex 2

b. Net billing system

Medium usage/5kWp

Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-2585	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1109	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-4200																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1045													
Capacity-based incentive, € per kW	1615																									
Savings, €		482	494	507	520	533	546	559	573	587	602	615	630	645	660	675	691	707	723	739	756	773	790	808	826	845
Demand without PV Dt, kWh		5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300
Demand with PV Dpv, kWh		1126	1158	1191	1223	1254	1286	1317	1349	1380	1408	1441	1471	1501	1531	1561	1590	1620	1649	1678	1706	1735	1763	1791	1819	1847
Delivered to the grid, kWh		2310	2286	2262	2239	2216	2193	2170	2147	2125	2105	2087	2069	2051	2033	2018	2003	1989	1976	1962	1948	1934	1921	1907	1894	1881
Net Export, kWh		151	149	148	146	145	143	142	140	139	137	136	135	134	133	132	131	130	129	128	127	126	125	125	124	123
Cash flow	-2 585	452	464	476	488	500	513	525	538	551	565	578	-453	606	620	634	649	664	679	694	710	726	742	759	776	793
NPV		€9 272																								
Discounted CF	-2585	447	452	458	463	468	474	479	485	490	495	500	-387	511	516	521	526	531	536	541	546	551	556	561	566	571
Cumulated discounted CF	-2585	-2138	-1686	-1229	-766	-298	176	655	1140	1630	2125	2625	2238	2749	3264	3785	4311	4842	5378	5919	6466	7017	7573	8134	8700	9272
Discounted payback period, years		5,6																								
IRR		18,7%																								

Continuation Annex 2

b. Net billing system

Medium usage/8kWp

Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-3816	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1109	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-6400																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1045													
Capacity-based incentive, 323€ per kW	2584																									
Savings, €		519	540	562	584	607	630	654	678	703	729	755	781	809	837	865	894	924	955	986	1 019	1 052	1 086	1 121	1 157	1 194
Demand without PV Dt, kWh		5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300
Demand with PV Dpv, kWh		144	148	153	157	161	165	169	173	177	180	185	189	192	196	200	204	208	211	215	219	222	226	229	233	237
Delivered to the grid, kWh		4796	4747	4699	4650	4602	4554	4507	4460	4413	4372	4334	4296	4259	4222	4190	4161	4131	4103	4074	4045	4017	3989	3961	3933	3906
Net Export, kWh		1764	1746	1728	1710	1693	1675	1658	1640	1623	1608	1594	1580	1566	1553	1541	1530	1520	1509	1498	1488	1478	1467	1457	1447	1437
Cash flow, €	-3 816	711	735	760	785	811	838	865	893	921	950	980	-34	1 043	1 075	1 108	1 142	1 177	1 213	1 250	1 288	1 326	1 366	1 407	1 448	1491
NPV		€17354																								
Discounted CF, €	-3816	702	716	731	745	760	774	789	804	819	834	849	-29	879	895	910	926	942	958	974	991	1007	1024	1040	1057	1074
Cumulated discounted CF, €	-3816	-3114	-2398	-1667	-922	-162	612	1401	2205	3023	3857	4706	4677	5556	6451	7361	8287	9229	10187	11161	12151	13158	14182	15222	16280	17354
Discounted payback period, years		5,2																								
IRR		21,1%																								

Continuation Annex 2

b. Net billing system

High usage/3kWp																										
Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-2231	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1420	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-3200																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1357													
Capacity-based incentive, 323€ per kW	969																									
Savings, €		335	323	309	295	280	264	247	229	210	192	169	146	123	98	72	44	15	-15	-47	-80	-115	-152	-191	-231	-273
Demand without PV Dt, kWh		8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100
Demand with PV Dpv, kWh		5535	5694	5853	6011	6167	6323	6477	6630	6783	6923	7084	7233	7381	7528	7674	7819	7962	8105	8247	8388	8528	8667	8805	8942	9078
Delivered to the grid, kWh		415	411	407	403	398	394	390	386	382	378	375	372	369	365	363	360	358	355	353	350	348	345	343	340	338
Net Export, kWh		30	29	29	29	28	28	28	27	27	27	27	26	26	26	26	26	25	25	25	25	25	25	24	24	24
Cash flow, €	-2 231	289	276	261	246	230	213	195	176	155	136	112	-1 269	63	37	9	-20	-50	-82	-115	-150	-187	-225	-265	-307	-351
NPV		-€2 393																								
Discounted CF, €	-2231	286	269	251	234	215	197	178	158	138	119	97	-1084	53	31	8	-16	-40	-65	-90	-116	-142	-169	-196	-224	-253
Cumulated discounted CF, €	-2231	-1945	-1677	-1425	-1192	-977	-780	-602	-444	-306	-187	-90	-1175	-1122	-1091	-1083	-1099	-1139	-1204	-1294	-1409	-1551	-1720	-1916	-2140	-2393
Discounted payback period, years		never																								
IRR		-																								

Continuation Annex 2

b. Net billing system

High usage/5kWp

Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-2585	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1109	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-4200																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1045													
Capacity-based incentive, 323€ per kW	1615																									
Savings, €		524	525	526	526	526	526	525	524	522	521	518	515	511	507	502	497	491	485	477	470	461	452	442	431	419
Demand without PV Dt, kWh		8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100
Demand with PV Dpv, kWh		3873	3985	4096	4207	4316	4425	4533	4640	4747	4845	4958	5062	5166	5268	5371	5472	5573	5673	5772	5871	5968	6066	6162	6258	6353
Delivered to the grid, kWh		1414	1399	1385	1371	1356	1342	1328	1314	1301	1289	1277	1266	1255	1244	1235	1226	1218	1209	1201	1192	1184	1176	1167	1159	1151
Net Export, kWh		98	97	96	95	94	93	93	92	91	90	89	88	87	87	86	85	85	84	84	83	82	82	81	81	80
Cash flow, €	-2 585	487	488	487	487	486	485	483	481	478	476	471	-578	463	458	452	445	438	431	422	413	403	393	382	369	356
NPV		€6 086																								
Discounted CF, €	-2585	481	475	469	462	455	448	441	433	425	418	408	-494	390	381	371	361	351	340	329	318	306	294	282	270	257
Cumulated discounted CF, €	-2585	-2104	-1629	-1160	-699	-243	204	645	1078	1503	1921	2329	1835	2226	2606	2978	3339	3689	4030	4359	4677	4983	5277	5560	5829	6086
Discounted payback period, years		5,5																								
IRR		17,1%																								

Continuation Annex 2

b. Net billing system

High usage/8kWp																										
Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-3816	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1109	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-6400																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1045													
Capacity-based incentive, 323€ per kW	2584																									
Savings, €		903	935	967	1 001	1 035	1 070	1 107	1 144	1 182	1 221	1 260	1 301	1 343	1 386	1 430	1 475	1 521	1 568	1 617	1 667	1 718	1 771	1 825	1 881	1938
Demand without PV Dt, kWh		8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100
Demand with PV Dpv, kWh		144	148	153	157	161	165	169	173	177	180	185	189	192	196	200	204	208	211	215	219	222	226	229	233	237
Delivered to the grid, kWh		4796	4747	4699	4650	4602	4554	4507	4460	4413	4372	4334	4296	4259	4222	4190	4161	4131	4103	4074	4045	4017	3989	3961	3933	3906
Net Export, kWh		251	249	246	243	241	238	236	233	231	229	227	225	223	221	219	218	216	215	213	212	210	209	207	206	204
Cash flow, €	-3 816	887	919	951	984	1 018	1 052	1 088	1 124	1 162	1 200	1 239	234	1 321	1 363	1 406	1 451	1 496	1 543	1 591	1 640	1 691	1 743	1 797	1 851	1908
NPV		€23232																								
Discounted CF, €	-3816	876	895	914	933	953	973	992	1012	1032	1052	1073	200	1114	1134	1155	1176	1197	1219	1240	1262	1284	1306	1329	1352	1375
Cumulated discounted CF, €	-3816	-2940	-2045	-1131	-198	755	1728	2720	3732	4765	5817	6890	7090	8204	9338	10493	11669	12866	14085	15325	16587	17871	19177	20506	21857	23232
Discounted payback period, years		4,2																								
IRR		26,1%																								

Continuation Annex 2

c. Feed-in tariff (Fixed)

Low usage/3kWp																										
Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-2231	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1420	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-3200																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1357													
Capacity-based incentive, 323€ per kW	969																									
Savings, €		285	293	301	309	317	325	334	342	351	360	369	378	387	397	407	416	426	437	447	458	469	480	491	502	514
Demand without PV Dt, kWh		3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100
Demand with PV Dpv, kWh		605	622	640	657	674	691	708	724	741	756	774	790	806	822	838	854	870	886	901	916	932	947	962	977	992
Delivered to the grid, kWh		1454	1439	1424	1410	1395	1380	1366	1352	1338	1325	1314	1302	1291	1280	1270	1261	1252	1244	1235	1226	1218	1209	1201	1192	1184
Net Export, kWh		100	99	98	97	96	95	94	93	92	91	90	89	89	88	87	86	86	85	85	84	83	83	82	82	81
Cash flow, €	-2 231	239	246	253	259	266	273	280	288	295	303	310	-1 039	326	334	342	351	359	368	377	386	395	404	414	423	433
NPV		€3 477																								
Discounted CF, €	-2231	236	240	243	246	249	253	256	259	262	266	269	-887	275	278	281	284	287	291	294	297	300	303	306	309	312
Cumulated discounted CF, €	-2231	-1995	-1755	-1512	-1266	-1017	-764	-508	-249	13	279	548	-340	-65	213	495	779	1066	1357	1650	1947	2247	2550	2856	3165	3477
Discounted payback period, years		13,2																								
IRR		10,0%																								

Continuation Annex 2

c. Feed-in tariff (Fixed)

Low usage/5kWp																										
Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-2585	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1109	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-4200																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1045													
Capacity-based incentive, 323€ per kW	1615																									
Savings, €		292	305	317	330	344	357	371	386	400	415	431	446	462	479	495	512	530	548	566	585	605	625	645	666	688
Demand without PV Dt, kWh		3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100
Demand with PV Dpv, kWh		87	90	92	95	97	100	102	105	107	109	112	114	116	119	121	123	126	128	130	132	135	137	139	141	143
Delivered to the grid, kWh		3093	3061	3029	2998	2967	2936	2906	2875	2845	2819	2795	2770	2746	2722	2702	2683	2664	2645	2627	2608	2590	2572	2554	2536	2518
Net Export, kWh		1312	1299	1286	1272	1259	1246	1233	1220	1207	1196	1186	1176	1165	1155	1146	1138	1130	1122	1115	1107	1099	1091	1084	1076	1069
Cash flow, €	-2 585	297	308	319	330	342	354	366	379	392	405	418	-613	446	461	476	491	507	523	539	556	574	592	610	629	648
NPV		€5 965																								
Discounted CF, €	-2585	293	300	307	314	320	327	334	341	348	355	362	-524	376	384	391	398	405	413	420	428	436	443	451	459	467
Cumulated discounted CF, €	-2585	-2292	-1991	-1685	-1371	-1051	-724	-389	-48	300	655	1017	493	870	1253	1644	2042	2448	2860	3281	3709	4144	4588	5039	5498	5965
Discounted payback period, years		8,1																								
IRR		12,7%																								

Continuation Annex 2

c. Feed-in tariff (Fixed)

Low usage/8kWp																										
Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-3816	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1109	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-6400																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1045													
Capacity-based incentive, 323€ per kW	2584																									
Savings, €		196	209	223	237	252	267	282	297	313	329	345	362	379	396	414	432	450	469	488	508	528	549	570	592	615
Demand without PV Dt, kWh		3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100
Demand with PV Dpv, kWh		70	72	74	76	78	80	82	84	86	87	89	91	93	95	97	99	100	102	104	106	108	109	111	113	114
Delivered to the grid, kWh		5630	5572	5515	5458	5402	5346	5290	5235	5180	5132	5088	5043	4999	4955	4918	4884	4850	4816	4782	4748	4715	4682	4649	4617	4585
Net Export, kWh		3890	3850	3810	3771	3732	3693	3655	3617	3579	3546	3515	3484	3454	3424	3398	3374	3351	3327	3304	3281	3258	3235	3212	3190	3167
Cash flow, €	-3 816	309	320	331	342	354	366	378	391	404	417	431	-600	459	474	489	504	520	536	553	570	588	606	625	644	664
NPV		€5 009																								
Discounted CF, €	-3816	305	312	318	325	332	338	345	352	359	366	373	-513	387	394	402	409	416	424	431	439	446	454	462	470	478
Cumulated discounted CF, €	-3816	-3511	-3199	-2881	-2556	-2225	-1886	-1541	-1189	-830	-464	-91	-604	-217	178	579	988	1404	1828	2259	2698	3144	3599	4061	4531	5009
Discounted payback period, years		13,5																								
IRR		8,5%																								

Continuation Annex 2

c. Feed-in tariff (Fixed)

Medium usage/3kWp																										
Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-2231	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1420	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-3200																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1357													
Capacity-based incentive, 323€ per kW	969																									
Savings, €		314	313	311	309	307	305	302	299	296	293	288	283	278	272	266	260	253	245	237	228	219	209	199	188	176
Demand without PV Dt, kWh		5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300
Demand with PV Dpv, kWh		2766	2846	2925	3004	3082	3160	3237	3314	3390	3460	3540	3615	3689	3762	3835	3907	3979	4051	4122	4192	4262	4331	4400	4469	4537
Delivered to the grid, kWh		856	848	839	830	822	813	805	796	788	781	774	767	760	754	748	743	738	732	727	722	717	712	707	702	697
Net Export, kWh		61	60	60	59	58	58	57	57	56	56	55	55	54	54	53	53	52	52	52	51	51	51	50	50	50
Cash flow, €	-2 231	266	264	261	258	255	252	248	243	239	234	228	-1 135	215	208	201	193	184	175	165	155	144	132	120	107	93
NPV		€999																								
Discounted CF, €	-2231	263	257	251	245	239	233	226	219	212	206	197	-970	181	173	165	156	147	138	129	119	109	99	89	78	67
Cumulated discounted CF, €	-2231	-1968	-1711	-1460	-1214	-975	-743	-517	-298	-86	120	317	-653	-472	-298	-133	23	170	308	437	556	665	765	854	932	999
Discounted payback period, years		15,9																								
IRR		5,6%																								

Continuation Annex 2

c. Feed-in tariff (Fixed)

Medium usage/5kWp

Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-2585	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1109	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-4200																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1045													
Capacity-based incentive, 323€ per kW	1615																									
Savings, €		482	494	507	520	533	546	559	573	587	602	615	630	645	660	675	691	707	723	739	756	773	790	808	826	845
Demand without PV Dt, kWh		5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300
Demand with PV Dpv, kWh		1126	1158	1191	1223	1254	1286	1317	1349	1380	1408	1441	1471	1501	1531	1561	1590	1620	1649	1678	1706	1735	1763	1791	1819	1847
Delivered to the grid, kWh		2310	2286	2262	2239	2216	2193	2170	2147	2125	2105	2087	2069	2051	2033	2018	2003	1989	1976	1962	1948	1934	1921	1907	1894	1881
Net Export, kWh		151	149	148	146	145	143	142	140	139	137	136	135	134	133	132	131	130	129	128	127	126	125	125	124	123
Cash flow, €	-2 585	438	449	461	472	484	496	508	521	533	546	559	-473	586	599	613	627	641	656	671	686	701	717	733	749	765
NPV		€8 850																								
Discounted CF, €	-2585	432	438	443	448	453	459	464	469	474	479	484	-404	494	499	504	508	513	518	523	528	532	537	542	547	551
Cumulated discounted CF, €	-2585	-2153	-1715	-1272	-824	-370	88	552	1021	1495	1974	2458	2054	2548	3046	3550	4058	4572	5090	5612	6140	6672	7210	7752	8298	8850
Discounted payback period, years		5,8																								
IRR		18,1%																								

Continuation Annex 2

c. Feed-in tariff (Fixed)

Medium usage/8kWp

Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-3816	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1109	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-6400																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1045													
Capacity-based incentive, 323€ per kW	2584																									
Savings, €		519	540	562	584	607	630	654	678	703	729	755	781	809	837	865	894	924	955	986	1 019	1 052	1 086	1 121	1 157	1194
Demand without PV Dt, kWh		5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300
Demand with PV Dpv, kWh		144	148	153	157	161	165	169	173	177	180	185	189	192	196	200	204	208	211	215	219	222	226	229	233	237
Delivered to the grid, kWh		4796	4747	4699	4650	4602	4554	4507	4460	4413	4372	4334	4296	4259	4222	4190	4161	4131	4103	4074	4045	4017	3989	3961	3933	3906
Net Export, kWh		1764	1746	1728	1710	1693	1675	1658	1640	1623	1608	1594	1580	1566	1553	1541	1530	1520	1509	1498	1488	1478	1467	1457	1447	1437
Cash flow, €	-3 816	543	563	582	603	623	645	667	689	712	736	760	-261	810	835	862	889	917	946	975	1 006	1 037	1 069	1 101	1 135	1170
NPV		€12417																								
Discounted CF, €	-3816	536	548	560	572	584	596	608	620	633	645	658	-223	683	695	708	721	734	747	760	774	787	801	815	829	843
Cumulated discounted CF, €	-3816	-3280	-2732	-2172	-1600	-1016	-420	188	809	1442	2087	2744	2521	3204	3899	4607	5328	6062	6809	7570	8343	9130	9931	10746	11574	12417
Discounted payback period, years		6,7																								
IRR		16,3%																								

Continuation Annex 2

c. Feed-in tariff (Fixed)

High usage/3kWp																										
Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-2231	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1420	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-3200																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1357													
Capacity-based incentive, 323€ per kW	969																									
Savings, €		335	323	309	295	280	264	247	229	210	192	169	146	123	98	72	44	15	-15	-47	-80	-115	-152	-191	-231	-273
Demand without PV Dt, kWh		8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100
Demand with PV Dpv, kWh		5535	5694	5853	6011	6167	6323	6477	6630	6783	6923	7084	7233	7381	7528	7674	7819	7962	8105	8247	8388	8528	8667	8805	8942	9078
Delivered to the grid, kWh		415	411	407	403	398	394	390	386	382	378	375	372	369	365	363	360	358	355	353	350	348	345	343	340	338
Net Export, kWh		30	29	29	29	28	28	28	27	27	27	27	26	26	26	26	26	25	25	25	25	25	25	24	24	24
Cash flow, €	-2 231	287	273	258	243	227	210	191	172	152	132	108	-1 273	59	33	5	-24	-54	-86	-120	-155	-192	-230	-270	-312	-356
NPV		-€2 476																								
Discounted CF, €	-2231	283	266	248	231	212	194	175	155	135	116	93	-1087	50	27	4	-19	-44	-68	-93	-119	-146	-172	-200	-228	-257
Cumulated discounted CF, €	-2231	-1948	-1682	-1434	-1203	-991	-797	-623	-468	-333	-217	-123	-1211	-1161	-1134	-1129	-1149	-1192	-1261	-1354	-1473	-1619	-1791	-1991	-2219	-2476
Discounted payback period, years		never																								
IRR		-																								

Continuation Annex 2

c. Feed-in tariff (Fixed)

High usage/5kWp

Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-2585	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1109	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-4200																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1045													
Capacity-based incentive, 323€ per kW	1615																									
Savings, €		524	525	526	526	526	526	525	524	522	521	518	515	511	507	502	497	491	485	477	470	461	452	442	431	419
Demand without PV Dt, kWh		8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100
Demand with PV Dpv, kWh		3873	3985	4096	4207	4316	4425	4533	4640	4747	4845	4958	5062	5166	5268	5371	5472	5573	5673	5772	5871	5968	6066	6162	6258	6353
Delivered to the grid, kWh		1414	1399	1385	1371	1356	1342	1328	1314	1301	1289	1277	1266	1255	1244	1235	1226	1218	1209	1201	1192	1184	1176	1167	1159	1151
Net Export, kWh		98	97	96	95	94	93	93	92	91	90	89	88	87	87	86	85	85	84	84	83	82	82	81	81	80
Cash flow, €	-2 585	478	478	477	477	475	474	472	469	467	464	459	-590	450	444	438	431	424	416	407	398	387	376	365	352	338
NPV		€5 811																								
Discounted CF, €	-2585	472	466	459	452	445	438	430	423	415	407	397	-504	379	370	360	350	339	328	317	306	294	282	270	257	244
Cumulated discounted CF, €	-2585	-2113	-1648	-1189	-736	-291	147	577	1000	1415	1822	2219	1715	2094	2464	2824	3174	3513	3841	4158	4464	4758	5040	5310	5567	5811
Discounted payback period, years		5,7																								
IRR		16,6%																								

Continuation Annex 2

c. Feed-in tariff (Fixed)

High usage/8kWp

Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-3816	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1109	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-6400																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1045													
Capacity-based incentive, 323€ per kW	2584																									
Savings, €		903	935	967	1 001	1 035	1 070	1 107	1 144	1 182	1 221	1 260	1 301	1 343	1 386	1 430	1 475	1 521	1 568	1 617	1 667	1 718	1 771	1 825	1 881	1938
Demand without PV Dt, kWh		8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100
Demand with PV Dpv, kWh		144	148	153	157	161	165	169	173	177	180	185	189	192	196	200	204	208	211	215	219	222	226	229	233	237
Delivered to the grid, kWh		4796	4747	4699	4650	4602	4554	4507	4460	4413	4372	4334	4296	4259	4222	4190	4161	4131	4103	4074	4045	4017	3989	3961	3933	3906
Net Export, kWh		251	249	246	243	241	238	236	233	231	229	227	225	223	221	219	218	216	215	213	212	210	209	207	206	204
Cash flow, €	-3 816	863	894	926	958	991	1 025	1 060	1 095	1 132	1 169	1 208	202	1 287	1 329	1 371	1 415	1 459	1 505	1 552	1 600	1 650	1 701	1 753	1 807	1862
NPV		€22529																								
Discounted CF, €	-3816	852	871	890	909	928	947	967	986	1006	1026	1045	173	1086	1106	1126	1147	1168	1188	1210	1231	1253	1275	1297	1319	1342
Cumulated discounted CF, €	-3816	-2964	-2093	-1203	-294	634	1581	2547	3534	4540	5565	6611	6783	7869	8975	10101	11248	12415	13604	14814	16045	17297	18572	19869	21188	22529
Discounted payback period, years		4,3																								
IRR		25,5%																								

Continuation Annex 2

d. Feed-in tariff (Declining)

Low usage/3kWp																										
Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-2231	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1420	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-3200																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1357													
Capacity-based incentive, 323€ per kW	969																									
Savings, €		285	293	301	309	317	325	334	342	351	360	369	378	387	397	407	416	426	437	447	458	469	480	491	502	514
Demand without PV Dt, kWh		3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100
Demand with PV Dpv, kWh		605	622	640	657	674	691	708	724	741	756	774	790	806	822	838	854	870	886	901	916	932	947	962	977	992
Delivered to the grid, kWh		1454	1439	1424	1410	1395	1380	1366	1352	1338	1325	1314	1302	1291	1280	1270	1261	1252	1244	1235	1226	1218	1209	1201	1192	1184
Net Export, kWh		100	99	98	97	96	95	94	93	92	91	90	89	89	88	87	86	86	85	85	84	83	83	82	82	81
Cash flow, €	-2231	249	255	262	269	275	278	285	292	299	307	310	-1039	326	334	342	347	356	364	373	382	391	401	410	420	430
NPV		€3 512																								
Discounted CF, €	-2231	246	249	252	255	258	257	260	263	266	269	268	-888	275	278	281	281	285	288	291	294	297	300	303	307	310
Cumulated discounted CF, €	-2231	-1985	-1737	-1485	-1230	-972	-716	-456	-193	73	342	611	-277	-3	275	556	838	1122	1410	1701	1994	2292	2592	2895	3202	3512
Discounted payback period, years		13,0																								
IRR		10,2%																								

Continuation Annex 2

d. Feed-in tariff (Declining)

Low usage/5kWp

Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-2585	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1109	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-4200																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1045													
Capacity-based incentive, 323€ per kW	1615																									
Savings, €		292	305	317	330	344	357	371	386	400	415	431	446	462	479	495	512	530	548	566	585	605	625	645	666	688
Demand without PV Dt, kWh		3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100
Demand with PV Dpv, kWh		87	90	92	95	97	100	102	105	107	109	112	114	116	119	121	123	126	128	130	132	135	137	139	141	143
Delivered to the grid, kWh		3093	3061	3029	2998	2967	2936	2906	2875	2845	2819	2795	2770	2746	2722	2702	2683	2664	2645	2627	2608	2590	2572	2554	2536	2518
Net Export, kWh		1312	1299	1286	1272	1259	1246	1233	1220	1207	1196	1186	1176	1165	1155	1146	1138	1130	1122	1115	1107	1099	1091	1084	1076	1069
Cash flow, €	-2 585	422	431	441	451	462	410	422	434	446	459	412	-619	440	455	470	443	614	629	645	661	678	695	713	731	750
NPV		€7450																								
Discounted CF, €	-2585	416	420	424	428	432	379	385	390	396	402	357	-529	371	379	386	359	491	497	503	509	515	521	527	534	540
Cumulated discounted CF, €	-2585	-2169	-1748	-1324	-896	-464	-85	300	691	1087	1489	1846	1317	1689	2068	2454	2813	3304	3801	4304	4813	5328	5849	6376	6910	7450
Discounted payback period, years		6,2																								
IRR		16,0%																								

Continuation Annex 2

d. Feed-in tariff (Declining)

Low usage/8kWp																										
Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-3816	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1109	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-6400																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1045													
Capacity-based incentive, 323€ per kW	2584																									
Savings, €		196	209	223	237	252	267	282	297	313	329	345	362	379	396	414	432	450	469	488	508	528	549	570	592	615
Demand without PV Dt, kWh		3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100
Demand with PV Dpv, kWh		70	72	74	76	78	80	82	84	86	87	89	91	93	95	97	99	100	102	104	106	108	109	111	113	114
Delivered to the grid, kWh		5630	5572	5515	5458	5402	5346	5290	5235	5180	5132	5088	5043	4999	4955	4918	4884	4850	4816	4782	4748	4715	4682	4649	4617	4585
Net Export, kWh		3890	3850	3810	3771	3732	3693	3655	3617	3579	3546	3515	3484	3454	3424	3398	3374	3351	3327	3304	3281	3258	3235	3212	3190	3167
Cash flow, €	-3 816	678	685	693	700	708	532	543	554	565	577	413	-618	442	457	472	362	379	397	414	432	451	470	490	510	530
NPV		€6 356																								
Discounted CF, €	-3816	670	668	666	665	664	492	495	498	502	506	358	-528	372	380	388	294	303	313	323	333	342	352	362	372	382
Cumulated discounted CF, €	-3816	-3146	-2479	-1813	-1148	-484	8	503	1001	1503	2009	2367	1839	2211	2591	2979	3273	3576	3889	4212	4545	4887	5240	5602	5974	6356
Discounted payback period, years		6,0																								
IRR		14,2%																								

Continuation Annex 2

d. Feed-in tariff (Declining)

Medium usage/3kWp																										
Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-2231	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1420	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-3200																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1357													
Capacity-based incentive, 323€ per kW	969																									
Savings, €		314	313	311	309	307	305	302	299	296	293	288	283	278	272	266	260	253	245	237	228	219	209	199	188	176
Demand without PV Dt, kWh		5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300
Demand with PV Dpv, kWh		2766	2846	2925	3004	3082	3160	3237	3314	3390	3460	3540	3615	3689	3762	3835	3907	3979	4051	4122	4192	4262	4331	4400	4469	4537
Delivered to the grid, kWh		856	848	839	830	822	813	805	796	788	781	774	767	760	754	748	743	738	732	727	722	717	712	707	702	697
Net Export, kWh		61	60	60	59	58	58	57	57	56	56	55	55	54	54	53	53	52	52	52	51	51	51	50	50	50
Cash flow, €	-2 231	272	270	267	264	261	254	250	246	241	237	227	-1 135	215	208	200	190	182	173	163	153	142	130	118	105	91
NPV		€1 020																								
Discounted CF, €	-2231	269	263	257	251	244	235	228	221	214	208	197	-970	181	173	165	154	146	136	127	118	108	98	87	77	66
Cumulated discounted CF, €	-2231	-1962	-1700	-1443	-1192	-948	-713	-485	-264	-49	158	355	-615	-434	-261	-96	59	204	340	468	585	693	790	878	954	1020
Discounted payback period, years		15,6																								
IRR		5,8%																								

Continuation Annex 2

d. Feed-in tariff (Declining)

Medium usage/5kWp																										
Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-2585	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1109	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-4200																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1045													
Capacity-based incentive, 323€ per kW	1615																									
Savings, €		482	494	507	520	533	546	559	573	587	602	615	630	645	660	675	691	707	723	739	756	773	790	808	826	845
Demand without PV Dt, kWh		5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300
Demand with PV Dpv, kWh		1126	1158	1191	1223	1254	1286	1317	1349	1380	1408	1441	1471	1501	1531	1561	1590	1620	1649	1678	1706	1735	1763	1791	1819	1847
Delivered to the grid, kWh		2310	2286	2262	2239	2216	2193	2170	2147	2125	2105	2087	2069	2051	2033	2018	2003	1989	1976	1962	1948	1934	1921	1907	1894	1881
Net Export, kWh		151	149	148	146	145	143	142	140	139	137	136	135	134	133	132	131	130	129	128	127	126	125	125	124	123
Cash flow, €	-2585	452	463	475	486	498	503	515	527	540	553	558	-473	585	599	612	622	636	651	665	680	696	712	727	744	760
NPV		€8902																								
Discounted CF, €	-2585	447	451	456	461	466	464	470	475	479	485	483	-405	493	498	503	504	509	514	519	523	528	533	538	543	548
Cumulated discounted CF, €	-2585	-2138	-1687	-1231	-769	-303	161	631	1106	1585	2070	2553	2149	2642	3140	3643	4147	4656	5170	5688	6212	6740	7273	7811	8354	8902
Discounted payback period, years		5,7																								
IRR		18,4%																								

Continuation Annex 2

d. Feed-in tariff (Declining)

Medium usage/8kWp

Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-3816	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1109	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-6400																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1045													
Capacity-based incentive, 323€ per kW	2584																									
Savings, €		519	540	562	584	607	630	654	678	703	729	755	781	809	837	865	894	924	955	986	1 019	1 052	1 086	1 121	1 157	1194
Demand without PV Dt, kWh		5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300	5300
Demand with PV Dpv, kWh		144	148	153	157	161	165	169	173	177	180	185	189	192	196	200	204	208	211	215	219	222	226	229	233	237
Delivered to the grid, kWh		4796	4747	4699	4650	4602	4554	4507	4460	4413	4372	4334	4296	4259	4222	4190	4161	4131	4103	4074	4045	4017	3989	3961	3933	3906
Net Export, kWh		1764	1746	1728	1710	1693	1675	1658	1640	1623	1608	1594	1580	1566	1553	1541	1530	1520	1509	1498	1488	1478	1467	1457	1447	1437
Cash flow, €	-3816	711	729	747	765	784	720	741	763	785	808	751	-269	802	828	854	825	853	882	912	943	975	1 007	1 040	1 074	1 109
NPV, €		€13028																								
Discounted CF	-3816	702	710	718	726	734	666	676	687	698	709	651	-230	676	689	702	669	683	697	711	726	740	755	769	784	799
Cumulated discounted CF, €	-3816	-3114	-2405	-1687	-961	-226	439	1115	1802	2500	3208	3859	3629	4305	4994	5696	6365	7047	7744	8455	9181	9921	10675	11445	12229	13028
Discounted payback period, years		5,3																								
IRR		19,0%																								

Continuation Annex 2

d. Feed-in tariff (Declining)

High usage/3kWp																										
Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-2231	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1420	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-3200																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1357													
Capacity-based incentive, 323€ per kW	969																									
Savings, €		335	323	309	295	280	264	247	229	210	192	169	146	123	98	72	44	15	-15	-47	-80	-115	-152	-191	-231	-273
Demand without PV Dt, kWh		8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100
Demand with PV Dpv, kWh		5535	5694	5853	6011	6167	6323	6477	6630	6783	6923	7084	7233	7381	7528	7674	7819	7962	8105	8247	8388	8528	8667	8805	8942	9078
Delivered to the grid, kWh		415	411	407	403	398	394	390	386	382	378	375	372	369	365	363	360	358	355	353	350	348	345	343	340	338
Net Export, kWh		30	29	29	29	28	28	28	27	27	27	27	26	26	26	26	26	25	25	25	25	25	25	24	24	24
Cash flow, €	-2231	289	276	261	246	229	211	193	173	153	134	108	-1273	59	33	5	-25	-55	-87	-121	-156	-193	-231	-271	-313	-357
NPV		-€2 466																								
Discounted CF, €	-2231	286	269	251	233	215	195	176	156	136	117	93	-1088	50	27	4	-20	-44	-69	-94	-120	-146	-173	-201	-229	-257
Cumulated discounted CF, €	-2231	-1945	-1677	-1426	-1193	-978	-783	-607	-451	-315	-198	-105	-1192	-1142	-1115	-1111	-1131	-1176	-1245	-1339	-1459	-1605	-1779	-1979	-2208	-2466
Discounted payback period, years		never																								
IRR		-																								

Continuation Annex 2

d. Feed-in tariff (Declining)

High usage/5kWp

Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-2585	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1109	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-4200																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1045													
Capacity-based incentive, 323 € per kW	1615																									
Savings, €		524	525	526	526	526	526	525	524	522	521	518	515	511	507	502	497	491	485	477	470	461	452	442	431	419
Demand without PV Dt, kWh		8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100
Demand with PV Dpv, kWh		3873	3985	4096	4207	4316	4425	4533	4640	4747	4845	4958	5062	5166	5268	5371	5472	5573	5673	5772	5871	5968	6066	6162	6258	6353
Delivered to the grid, kWh		1414	1399	1385	1371	1356	1342	1328	1314	1301	1289	1277	1266	1255	1244	1235	1226	1218	1209	1201	1192	1184	1176	1167	1159	1151
Net Export, kWh		98	97	96	95	94	93	93	92	91	90	89	88	87	87	86	85	85	84	84	83	82	82	81	81	80
Cash flow, €	-2585	487	487	487	486	484	478	476	474	471	468	459	-591	449	444	438	428	420	412	403	394	384	373	361	349	335
NPV		€5 845																								
Discounted CF, €	-2585	481	475	468	461	454	442	434	426	418	411	397	-505	379	369	359	347	336	326	315	303	291	279	267	254	241
Cumulated discounted CF, €	-2585	-2104	-1629	-1162	-701	-247	195	629	1055	1474	1885	2282	1777	2156	2525	2885	3231	3568	3893	4208	4511	4802	5082	5349	5603	5845
Discounted payback period, years		5,6																								
IRR		16,8%																								

Continuation Annex 2

d. Feed-in tariff (Declining)

High usage/8kWp																										
Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-3816	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1109	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-6400																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1045													
Capacity-based incentive, 323 € per kW	2584																									
Savings, €		903	935	967	1 001	1 035	1 070	1 107	1 144	1 182	1 221	1 260	1 301	1 343	1 386	1 430	1 475	1 521	1 568	1 617	1 667	1 718	1 771	1 825	1 881	1 938
Demand without PV Dt, kWh		8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100
Demand with PV Dpv, kWh		144	148	153	157	161	165	169	173	177	180	185	189	192	196	200	204	208	211	215	219	222	226	229	233	237
Delivered to the grid, kWh		4796	4747	4699	4650	4602	4554	4507	4460	4413	4372	4334	4296	4259	4222	4190	4161	4131	4103	4074	4045	4017	3989	3961	3933	3906
Net Export, kWh		251	249	246	243	241	238	236	233	231	229	227	225	223	221	219	218	216	215	213	212	210	209	207	206	204
Cash flow, €	-3 816	887	918	949	981	1 014	1 035	1 070	1 106	1 142	1 180	1 207	201	1 286	1 328	1 370	1 405	1 450	1 496	1 543	1 591	1 641	1 692	1 744	1 798	1 853
NPV		€22 616																								
Discounted CF, €	-3816	876	894	912	931	949	957	976	996	1015	1035	1044	172	1085	1105	1125	1139	1160	1181	1203	1224	1246	1268	1290	1313	1335
Cumulated discounted CF, €	-3816	-2940	-2046	-1134	-203	746	1703	2679	3675	4690	5725	6769	6941	8026	9131	10256	11395	12556	13737	14940	16164	17410	18678	19968	21281	22616
Discounted payback period, years		4,2																								
IRR		25,9%																								

Annex 3

Financial performance calculations for Debt-Grant scenarios

a. Low usage/5kWp - Base case

Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-840	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1109	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-2100																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1045													
Grant, 0-50%, 30%, €	1260																									
Savings, €		292	305	317	330	344	357	371	386	400	415	431	446	462	479	495	512	530	548	566	585	605	625	645	666	688
Demand without PV Dt, kWh		3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100
Demand with PV Dpv, kWh		87	90	92	95	97	100	102	105	107	109	112	114	116	119	121	123	126	128	130	132	135	137	139	141	143
Delivered to the grid, kWh		3093	3061	3029	2998	2967	2936	2906	2875	2845	2819	2795	2770	2746	2722	2702	2683	2664	2645	2627	2608	2590	2572	2554	2536	2518
Loan costs: principal+ 3.9% annual+1.5% contract fee	-32	-494	-478	-462	-445	-429																				
Cash flow, €	-872	-252	-225	-197	-168	-140	302	314	328	341	355	368	-662	397	412	428	443	459	476	492	510	528	546	564	584	603
NPV		€4 404																								
Discounted CF, €	-872	-249	-219	-189	-160	-131	279	287	295	303	311	319	-566	335	343	351	359	367	376	384	392	401	409	417	426	435
Cumulated discounted CF, €	-872	-1120	-1339	-1528	-1688	-1819	-1540	-1253	-958	-655	-344	-25	-591	-256	87	438	798	1165	1541	1924	2317	2717	3126	3544	3970	4404
Discounted payback period, years		13,7																								
IRR		10,6%																								

Continuation Annex 3

Financial performance calculations for Debt-Grant scenarios

b. Low usage/5kWp – Net billing system

Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-840	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1109	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-2100																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1045													
Grant, 0-50%, 30%, €	1260																									
Savings, €		292	305	317	330	344	357	371	386	400	415	431	446	462	479	495	512	530	548	566	585	605	625	645	666	688
Demand without PV Dt, kWh		3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100
Demand with PV Dpv, kWh		87	90	92	95	97	100	102	105	107	109	112	114	116	119	121	123	126	128	130	132	135	137	139	141	143
Delivered to the grid, kWh		3093	3061	3029	2998	2967	2936	2906	2875	2845	2819	2795	2770	2746	2722	2702	2683	2664	2645	2627	2608	2590	2572	2554	2536	2518
Loan costs: principal+ 3.9% annual+1.5% contract fee	-32	-494	-478	-462	-445	-429																				
Net Export, kWh		1312	1299	1286	1272	1259	1246	1233	1220	1207	1196	1186	1176	1165	1155	1146	1138	1130	1122	1115	1107	1099	1091	1084	1076	1069
Cash flow	-872	-72	-42	-10	21	53	498	514	530	547	565	583	-444	620	639	659	679	700	721	743	766	789	813	837	862	887
NPV		€9 129																								
Discounted CF	-872	-72	-41	-10	20	50	460	469	478	486	495	504	-379	523	532	541	551	560	570	580	589	599	609	619	629	639
Cumulated discounted CF	-872	-943	-984	-994	-974	-924	-464	5	482	968	1464	1968	1589	2111	2643	3184	3735	4295	4865	5444	6033	6633	7242	7861	8490	9129
Discounted payback period, years		7,0																								
IRR		20,9%																								

Continuation Annex 3

c. High usage/8kWp - Base case

Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-1280	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1109	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-3200																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1045													
Grant, 0-50%, 30%, €	1920																									

Savings, €		903	935	967	1 001	1 035	1 070	1 107	1 144	1 182	1 221	1 260	1 301	1 343	1 386	1 430	1 475	1 521	1 568	1 617	1 667	1 718	1 771	1 825	1 881	1 938
Demand without PV Dt, kWh		8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100
Demand with PV Dpv, kWh		144	148	153	157	161	165	169	173	177	180	185	189	192	196	200	204	208	211	215	219	222	226	229	233	237
Delivered to the grid, kWh		4796	4747	4699	4650	4602	4554	4507	4460	4413	4372	4334	4296	4259	4222	4190	4161	4131	4103	4074	4045	4017	3989	3961	3933	3906

Loan costs: principal+ 3.9% annual+1.5% contract fee	-48	-753	-728	-703	-678	-654

Cash flow	-1 328	100	155	212	269	327	1 015	1 050	1 085	1 122	1 160	1 198	193	1 278	1 319	1 362	1 405	1 450	1 496	1 543	1 591	1 641	1 692	1 744	1 798	1 853
NPV		€21 430																								
Discounted CF	-1328	98	151	204	255	306	938	958	977	997	1017	1037	164	1078	1098	1119	1139	1160	1181	1203	1224	1246	1268	1290	1313	1335
Cumulated discounted CF	-1328	-1230	-1079	-875	-620	-313	625	1582	2560	3557	4574	5611	5776	6853	7952	9070	10210	11370	12551	13754	14978	16224	17492	18782	20095	21430
Discounted payback period, years		5,3																								
IRR		31,1%																								

Continuation Annex 3

d. High usage/8kWp – Net billing system

Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-1280	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1109	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-3200																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1045													
Grant, 0-50%, 30%, €	1920																									
Savings, €		903	935	967	1 001	1 035	1 070	1 107	1 144	1 182	1 221	1 260	1 301	1 343	1 386	1 430	1 475	1 521	1 568	1 617	1 667	1 718	1 771	1 825	1 881	1 938
Demand without PV Dt, kWh		8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100	8100
Demand with PV Dpv, kWh		144	148	153	157	161	165	169	173	177	180	185	189	192	196	200	204	208	211	215	219	222	226	229	233	237
Delivered to the grid, kWh		4796	4747	4699	4650	4602	4554	4507	4460	4413	4372	4334	4296	4259	4222	4190	4161	4131	4103	4074	4045	4017	3989	3961	3933	3906
Net Export, kWh		251	249	246	243	241	238	236	233	231	229	227	225	223	221	219	218	216	215	213	212	210	209	207	206	204
Loan costs: principal+ 3.9% annual+1.5% contract fee	-48	-753	-728	-703	-678	-654																				
Cash flow	-1 328	134	190	247	305	364	1 052	1 088	1 124	1 162	1 200	1 239	234	1 321	1 363	1 406	1 451	1 496	1 543	1 591	1 640	1 691	1 743	1 797	1 851	1 908
NPV		€22 334																								
Discounted CF	-1328	132	185	238	290	341	973	992	1012	1032	1052	1073	200	1114	1134	1155	1176	1197	1219	1240	1262	1284	1306	1329	1352	1375
Cumulated discounted CF	-1328	-1196	-1011	-773	-483	-142	830	1823	2835	3868	4920	5993	6193	7306	8441	9596	10772	11969	13187	14427	15689	16973	18280	19608	20960	22334
Discounted payback period, years		5,1																								
IRR		32,7%																								

Continuation Annex 3

e. Low usage/3kWp – Base case

Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-640	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1420	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-1600																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1357													
Grant, 0-50%, 30%, €	960																									
Savings, €		285	293	301	309	317	325	334	342	351	360	369	378	387	397	407	416	426	437	447	458	469	480	491	502	514
Demand without PV Dt, kWh		3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100
Demand with PV Dpv, kWh		605	622	640	657	674	691	708	724	741	756	774	790	806	822	838	854	870	886	901	916	932	947	962	977	992
Delivered to the grid, kWh		1454	1439	1424	1410	1395	1380	1366	1352	1338	1325	1314	1302	1291	1280	1270	1261	1252	1244	1235	1226	1218	1209	1201	1192	1184
Loan costs: principal+ 3.9% annual+1.5% contract fee	-24	-377	-364	-352	-339	-327																				
Cash flow	-664	-142	-122	-103	-84	-65	269	277	284	291	299	307	-1 042	322	331	339	347	356	364	373	382	391	401	410	420	430
NPV		€3 271																								
Discounted CF	-664	-140	-119	-99	-80	-60	249	252	256	259	262	265	-891	272	275	278	281	285	288	291	294	297	300	303	307	310
Cumulated discounted CF	-664	-804	-923	-1022	-1102	-1162	-913	-661	-405	-146	116	381	-509	-237	38	316	597	882	1170	1460	1754	2051	2352	2655	2962	3271
Discounted payback period, years		13,9																								
IRR		11,5%																								

Continuation Annex 3

f. Low usage/3kWp – Net billing system

Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
System cost, €	-640	-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-1420	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Initial system price, €	-1600																									
Maintenance and insurance, €		-50	-51	-52	-53	-55	-56	-57	-58	-60	-61	-62	-64	-65	-66	-68	-69	-71	-72	-74	-76	-77	-79	-81	-82	-84
Inverter Replacement Cost, €													-1357													
Grant, 0-50%, 30%, €	960																									
Savings, €		285	293	301	309	317	325	334	342	351	360	369	378	387	397	407	416	426	437	447	458	469	480	491	502	514
Demand without PV Dt, kWh		3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100	3100
Demand with PV Dpv, kWh		605	622	640	657	674	691	708	724	741	756	774	790	806	822	838	854	870	886	901	916	932	947	962	977	992
Delivered to the grid, kWh		1454	1439	1424	1410	1395	1380	1366	1352	1338	1325	1314	1302	1291	1280	1270	1261	1252	1244	1235	1226	1218	1209	1201	1192	1184
Net Export, kWh		100	99	98	97	96	95	94	93	92	91	90	89	89	88	87	86	86	85	85	84	83	83	82	82	81
Loan costs: principal+ 3.9% annual+1.5% contract fee	-24	-377	-364	-352	-339	-327																				
Cash flow	-664	-128	-109	-89	-70	-50	284	292	299	307	315	323	-1 026	339	348	356	365	374	383	392	402	411	421	431	441	451
NPV		€3 630																								
Discounted CF	-664	-126	-106	-86	-66	-47	263	266	270	273	276	280	-876	286	289	293	296	299	302	306	309	312	315	319	322	325
Cumulated discounted CF	-664	-790	-896	-982	-1048	-1094	-832	-565	-296	-23	253	533	-344	-58	232	525	821	1120	1422	1728	2037	2349	2664	2983	3305	3630
Discounted payback period, years		13,2																								
IRR		12,6%																								