**Czech University of Life Sciences Prague**

**Faculty of Economics and Management**

**Department of Economics**

**Diploma Thesis**

# Analysis of the Return on Investment in Photovoltaics in Selected EU Countries

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# CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Department of Economics

Faculty of Economics and Management

# DIPLOMA THESIS ASSIGNMENT

Ondřej Průša

Economics and Management

Thesis title

**Analysis of the Return on Investment in Photovoltaics in Selected EU Countries**

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**Objectives of thesis**

The objective of this Thesis is to analyse return on investment in photovoltaic businesses over time in the context of legislation of selected EU markets. The Thesis is taking into regard type of financing of the solar business, as well as a wide range of parameters of the power plants.

**Methodology**

1. Analysis of the legislation related to solar businesses in selected EU countries, namely in Germany, France, and Romania and record of the development of the policies since 2008.

2. Development of a model estimating financial flows of solar businesses based on identified parameters as well as a way of financing of the business. Computation of predictions of return on investment of solar businesses using the model.

**The proposed extent of the thesis**

50-60 pages

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**Recommended information sources**

COUTURE D, T., CORY, K., KREYCIK, C., WILLIAMS, E., 2010. A Policymaker's Guide to Feed-in Tariff Policy Design, Washington, D.C., USA: U.S. Department of Energy, National Renewable Energy Laboratory,

McENVOY, A., MARKVART, T., CASTANER, L., 2011. Practical Handbook of Photovoltaics: Fundamentals and Applications. 2nd edition. Academic Press, 1268 pp., ISBN 9780123859341

POULEK, V., LIBRA, M., 2010. Photovoltaics: Theory and Practice of Solar Energy Utilization. 1st edition. ILSA, Prague, 169 pp. ISBN 978-80-904311-2-6

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Dean

Prague on 27. 03. 2015

Statutory Declaration

I declare that I have worked out my Diploma Thesis "Analysis of the Return on Investment in Photovoltaics in Selected EU Countries" by myself under the supervision of the supervisor using literature and other information resources, which are cited in the Thesis and mentioned at the end of the Thesis. As the Author of the Thesis I further declare that I did not breach copyright of third parties in connection with its creation.

Prague, 31st March 2015

Ondřej Průša

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# Analysis of the Return on Investment in Photovoltaics in Selected EU Countries

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# Analýza návratnosti investic do fotovoltaiky ve vybraných zemích EU

**Summary**

The Thesis provides an analysis of attractiveness of investment in large-scale photovoltaic installations in Germany and France. After discussing theoretical background of economy of photovoltaic technology, of renewable energy policy tools and of types of financing of solar businesses, a thorough study of relevant pieces of both national and supranational legislation follows. Types of existing support and their implications are examined alongside with an analysis of appropriate business structures and tax consequences.

A financial model of a photovoltaic power plant is then developed for each of the countries, based on findings from the study of legislation and literature review. This model contains a wide range of controllable input parameters including type of financing of the project. It is slightly modified for each of the countries in order to be adjusted for the most advantageous business structure available for the given type of project. Based on the model output, solar projects in both countries are evaluated using methods of capital budgeting.

Results of the analysis suggest that large-scale photovoltaic facilities do not achieve satisfactory internal rate of return under existing legislation in neither of the countries. Especially the model facility in Germany has not proved to be profitable, unless major adjustments of the input variables are made. However, in France, findings suggest that the project should be undertaken when using equity finance and a low internal rate of return, or when benefiting from a low-interest debt. Final recommendations discuss implications of the research for investors, policymakers and photovoltaic supply chain.

**Keywords:** photovoltaics, photovoltaics in the EU, regulation of photovoltaics, regulatory policy, renewable energy sources policy, investment in photovoltaics

**Souhrn**

Diplomová práce analyzuje atraktivitu investování do velkých fotovoltaických elektráren v Německu a ve Francii. Po poskytnutí teoretického přehledu ekonomiky fotovoltaiky, politik ve vztahu k obnovitelným zdrojům a typů financování solárního podnikání následuje zevrubná studie relevantní legislativy, a to jak národní, tak nadnárodní. Specifika stávajících typů podpory fotovoltaiky jsou zkoumána spolu s analýzou adekvátních obchodních struktur a jejich daňových implikací.

Následně je na základě výsledků studia teoretických konceptů a legislativy pro každou ze zemí vypracován finanční model fotovoltaické elektrárny. Tento obsahuje širokou škálu nastavitelných vstupních parametrů včetně typu financování projektu. Model je adaptován pro každou ze zkoumaných zemí tak, aby co nejefektivněji reflektoval nejvýhodnější obchodní strukturu, v jejímž rámci je hypotetický projekt realizován. Na základě výstupů z modelu jsou pak fotovoltaické projekty posouzeny pro každou ze zemí za použití metod hodnocení investic.

Výsledky analýzy indikují, že velké fotovoltaické instalace při platné legislativě nedosahují dostatečného vnitřního výnosového procenta v žádné z daných zemí. Zejména investice do modelové elektrárny v Německu byla vyhodnocena jako velmi nevýhodná. Pro model elektrárny ve Francii lze nicméně implikovat výhodnost investice za předpokladu nízké diskontní míry vlastního kapitálu, respektive dostatečně nízkého úroku při dluhovém financování. Závěrem jsou vyvozena z výzkumu plynoucí doporučení pro investory, zákonodárce a pro dodavatelský řetězec fotovoltaického průmyslu.

**Klíčová slova:** fotovoltaika, fotovoltaika v EU, regulace fotovoltaiky, regulační politika, politika obnovitelných zdrojů energie, investice do fotovoltaiky

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## List of Used Acronyms

CF – Cash Flow

CSP - Concentrated solar power

EC – European Commission (also referred to as "the Commission")

EEG – Erneuerbare-Energien-Gesetz, German Renewable Energy Act

EPBT - Energy Pay-Back Time

EROI - Energy Return on Energy Investment

EU – European Union

FIT – feed-in tariff

GC – Green Certificates

IC – Installed capacity

IRR – Internal rate of return

LCOE - Levelized Cost of Electricity (€/kWh)

NPV – Net Present Value

NREAP – National Renewable Energy Action Plan

p.a. – per annum, annually

PP – Purchase price

PV – Photovoltaics, photovoltaic

PVPP – Photovoltaic power plant

RE – Renewable energy

RES – Renewable energy source(s)

UG – Unternehmergesellschaft, Entrepreneurial Company with Limited Liability

VAT – Value Added Tax

Wp – Watt-peak

# 1 Introduction

A few, if any, energy sectors experienced such a dramatic boom in the last decade, as did photovoltaics (PV). On global level, the installed capacity (IC) of PV facilities rocketed almost exponentially from close to nothing to almost 200 GWp. In the last nine years, the industry saw start-up costs of PV systems falling by an average of 13% p.a..[1] Hand in hand with the falling costs and rising demand came increased efficiency of the solar cells, as well as other technology improvements.

Roughly a half of global PV IC is located in Europe. Why? In 2008, the European Union set forth a pathway towards a more efficient and more environmentally friendly energy sector. The so-called "20-20-20" goal set out a bundle of binding targets for EU Member States energy sectors to be achieved by 2020. Among others, the EU aims to cover at least 20% of its total energy consumption by renewable energy sources (RES). This EU initiative inevitably shaped national energy policies, which started to integrate renewable energy (RE) support schemes.

Considering the falling costs and increased efficiency of the PV installations and the illustrated EU energy policy trend, PV sounds like a very attractive field to be in. Indeed, growth of this industry gave rise to many highly specialized European companies. For example, German PV sector provided approximately 56,000 jobs in 2013 and global market share of German PV suppliers amounted to 46% in 2011.[2]

Simultaneously, PV also became an attractive investment opportunity in the EU. The boom of PV installations itself is a proof – numerous individuals, companies and investment funds alike grasped their chance and undertook projects in this field.

However, costs of RE support are usually transferred onto energy consumers. Therefore, after a solar boom in many countries, energy policymakers were forced to tighten the conditions of RE investment incentives.

So, is PV still an excellent investment in 2015? This Thesis will try to provide the answer.

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[1] Fthenakis, V. M., and Kim, H. C. **Photovoltaics: Life-cycle Analyses.**

[2] Wirth, H., comp. **Recent Facts about Photovoltaics in Germany**, p. 32

# 2 Objectives of the Thesis

The objective of this Thesis is to analyse attractiveness of investment in PV installations in the context of legislation of two major EU markets: Germany and France. The Thesis seeks to conduct this analysis while taking into regard legislative implications of each of the markets, as well as a way of financing of the project and a range of specific parameters of the power plants.

An integral part of the objectives therefore is to provide a detailed summary of relevant pieces of recent **legislation** of each of the countries and of the EU as a whole. The analysis consequently focuses on an overview of RE policy and its outlook in the given country. Subsequently, types of support for electricity from RES are examined with an emphasis on implications for solar businesses. Last but not least, business structures appropriate for PV installations and corresponding taxation issues are discussed.

The findings from the preceding document study are then used in developing **financial models** of a hypothetical PVPP launched in January 2015. The models are adjusted to reflect the specifics of each of the countries. Furthermore, the models distinguish between debt and equity financing or a combination of both. Finally, PV projects in both countries are evaluated using methods of capital budgeting and recommendations are proposed.

The Analysis puts special focus on large-scale investments aimed at generating PV electricity and selling it to the power grid. Even if the regulation overview covers all types of PV installations, the Thesis analyses investment in large-scale PV installations (of installed capacity of 1MWp) and thus is mostly designed to serve large investors.

This Thesis does not aim and claim to be an exhaustive manual for PV investors. Details on regulatory requirements, taxation, legislation and other formal requirements may not always be thoroughly discussed, especially if not directly related to developing of the model PVPP. Nevertheless, this Thesis seeks to provide a fair overview of a wide range of specifics associated with PV investment in each of the analysed countries and to give a potential investor an image about the attractiveness of such investment.

# 3 Literature Review

## 3.1 Photovoltaics – Background

In order to facilitate understanding of the specifics of the technology, which represents the keystone of the financial models developed further in this Thesis, this Chapter offers an overview of theory of solar power, photovoltaics and its economy.

### 3.1.1 Solar Power

The radiation eradiated by the Sun, i.e. solar energy, is a major source of energy that is freely available to mankind. The Earth receives about $1.8\times10^{17}$ W of solar radiation every year.[3] Within only six hours of daylight, World's deserts receive more solar energy than the humankind consumes in the whole year.[4] A fraction of this vast amount of energy is utilised by living organisms; yet most of it remains unused.

Solar radiation occupies a specific category of renewable energy sources (RES). Together with wind, geothermal heat and tidal energy, solar energy is a **flow resource**. As such, it does not need regeneration and its supply is virtually unlimited.[5] This property makes it an ideal energy resource, provided that relatively cheap methods of conversion of solar energy into other types of energy, such as electricity, exist.

Solar energy has been exploited by the society for centuries, especially in architecture and agriculture, as well as in water heating. In the recent decades, the technology has progressed at a dramatic pace which finally enabled a relatively wide-scale use of solar radiation for production of electricity. Indeed, as is apparent from the previous paragraphs, energy from the sun has a huge potential in generating **solar power** (i.e. electricity made from solar energy). Yet, challenges connected with it, mainly power storage issues and photovoltaic panels efficiency are still to be overcome before humanity can universally enjoy the comfort of this widely available, unlimited and environmentally friendly power source.

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[3] Poulek V., Libra M., **Photovoltaics: Theory and Practice of Solar Energy Utilization**, p. 8

[4] DESERTEC Foundation: Concept

[5] Šindelář J., **Natural Resources Management: First Lecture**

### 3.1.2 Photovoltaics

*Photovoltaics* (PV) is a process of production of electricity from insolation using solar (PV) panels made of semiconducting materials (known as solar cells) that are capable of the photovoltaic effect. [6] **Photovoltaic power plant** (PVPP) is a system of solar panels, transformers and converters that together generate solar power. A major advantage of PV is that solar panels may be used in locations with limited direct sunlight as they do not require direct sunlight for electricity production. Furthermore, low weight allows for their placement on rooftops or integration into buildings. The maximal nominal power output of the PVPP achievable under ideal conditions (sunlight spectrum, light intensity 1000 W/m$^2$, panel temperature 25 ºC), is known as its installed capacity (IC) and is measured in Watt-peaks (Wp).

Apart from PVPPs, solar power may be generated from **concentrated solar power plants**. These plants incorporate a set of mirrors that continuously reflect the sunbeams to a receiver and thus heat a medium that subsequently generates power in a steam generator.[7] It follows that this type of solar power plants are only suitable for sunny regions. Presently, there are roughly 4 GWp of total IC of concentrated solar power (CSP) plants in the EU[8]; yet this is still just a fraction compared to the IC of PVPPs. Due to their limitations, CSP plants will probably not massively penetrate European market with solar power, unless they are able to quickly gain cost-competitiveness with PV technologies, grow and achieve significant economies of scale[9]. Yet a certain growth of CSP can be expected in the long run, especially in the sunny regions of Southern Europe. While there were no CSP plants in the EU in 2005, in 2010 they accounted for 2.4% of all installed capacity (IC) of solar electricity and projections estimate that CSP plants will account for almost 8% of the total solar IC in the EU in 2020.[10]

[6] Goetzberger, A., Hebling, C., and Schock, H. W., **Photovoltaic Materials, History, Status and Outlook.**

[7] Poulek V., Libra M., **Photovoltaics: Theory and Practice of Solar Energy Utilization**, p. 32, 33

[8] European Comission, **Technical Background of CSP.**

[9] Jäger-Waldau, A. **PV Status Report 2014**, p. 31

[10] Beurskens, L.W.M., and Hekkenberg, M. **Renewable Energy Projections as Published in the National Renewable Energy Action Plans of the European Member States**, p. 90

A PV installation is usually **on-grid**, i.e. connected to the power grid, and it supplies all or a part of its electricity production to the grid. Yet many systems are so-called **off-grid**, meaning that they operate independently on the grid and are not connected to it. An off-grid system usually includes a storage battery and the produced electricity is consumed by the owner of the system. These installations are particularly useful in places where power consumption is not very high and connection to the grid involves considerable cost. Off-grid systems generally do not require any kind of licensing by regulatory bodies and are therefore not involved (or only in form of estimates) in the PV statistics. These systems are usually not a subject of regulatory policies or subsidy schemes, although with grid parity of PV systems being achieved, some policymakers (such as the German ones) try to control this kind of power self-consumption too.

### 3.1.3 Types of PV cells

A PV cell is a basic unit of any solar panel. Two types of the cells are currently predominant in the market: crystalline and thin-film. The former prevail commercially, occupying almost 90% of the market in 2013.[11, 12]

**Crystalline** (also known as wafer-based) **silicon cells** are made from silicon ingots of different crystal structure. Polycrystalline silicon is the commercially predominant type, accounting for about 55% of total production[12]; it is less expensive than monocrystalline silicon cells, yet less efficient, with efficiency ranging from 12% to 18%, while monocrystalline silicon achieves efficiencies between 14 and 21%.[13]

**Thin-film** technology allows for reduction of the layer of active material, thus achieving lower environmental impact. However, its efficiencies are generally comparatively lower (around 13%)[14] as opposed to crystalline silicon cells. The materials used for thin-film cells production differ. While a majority of them are silicon-based, some use cadmium telluride or copper indium gallium selenide. Cadmium telluride cells are on the one hand cost-efficient in terms of cost per watt of electricity produced, yet on the

[11] Jäger-Waldau, A. **PV Status Report 2014**, p. 30

[12] Philipps, S., and Warmuth, W. **Photovoltaics Report**, p. 4

[13] Jäger-Waldau, A. **PV Status Report 2013**, p. 35

[14] Philipps, S., and Warmuth, W. **Photovoltaics Report**, p. 6

other hand contain a small amount of poisonous cadmium. Nevertheless, study proves that cadmium in these cells is in a stable form and its amount is relatively small.[15] Copper indium gallium selenide cells achieve highest efficiency among thin-film cells of up to 20% but further development of the technology is needed to allow for more favourable costs.[16]

### 3.1.4 Economy of PV

PV has been associated with several misconceptions that distort its public image. Some still believe PV to be a costly, economically uncompetitive technology that could not exist without support schemes or subsidies. The author of this Thesis therefore considers enlightening to address several issues related to the economy of PV.

**Energy Return on Energy Investment** (EROI) is an indicator relating the amount of energy gained from an energy production process to the amount of energy required to generate a new unit of energy. It is a ratio of the generated energy to the total primary energy required to produce it (energy directly and indirectly used to extract and deliver the fuel).[17] Sufficiently high EROI is crucial for an energy production process to remain viable in the long run. EROI (when electricity output is converted to primary energy) of PV ranges between 19 (polycrystalline silicon panels) and 38 (cadmium telluride panels), thus outmatching oil (EROI between 10 and 30) and approaching the EORI of coal (40 – 80), which is, however, a more polluting energy carrier.[18]

It is worth noting that EROI does not take into account the origin of the primary energy and so does not make a difference between renewable and non-renewable nature of the energy inputs.[18] Therefore EROI does not clearly indicate the sustainability of an energy production system if used independently. Had EROI considered for example a need to employ carbon capture and storage technologies with coal, PV would have been

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[15] Fthenakis, V. M. **Life Cycle Impact Analysis of Cadmium in CdTe PV Production.**

[16] Osborne, M. **ZSW Achieves Record Lab CIGS Cell Efficiency of 20.8%.**

[17] Constanza, R., **Energy Return on Investment (EROI)**

[18] Raugei, M., Fullana-I-Palmer, P., and Fthenakis, V. **The Energy Return on Energy Investment (EROI) of Photovoltaics: Methodology and Comparisons with Fossil Fuel Life Cycles.**

performing even better relative to coal and other greenhouse gas emissions-intensive energy resources.

**Energy Pay-Back Time** (EPBT) is another indicator of the energy performance of a PV system. It is a ratio of the energy used for building and later decommission of a plant expressed in terms of primary energy to the net yearly output expressed as an electricity equivalent to primary energy.[19] In other words, EPBT denotes the number of years necessary for the system to produce enough energy to outweigh the primary energy used for its construction and decommission.

EPBT and EROI relate in the following manner:[20]

$EROI_{PE\text{-}eq} = T / EPBT$, where T = lifespan of the system.

In other words, EROI in terms of its primary energy equivalent is equal to the ratio of the lifetime of the system to its EPBT. An energy producing system with EROI > T would therefore produce more energy every year than the amount of energy that was necessary for its construction and decommission. Assuming that the lifespan of PVPP is 20 years,[21] most of contemporary PVPPs achieve or exceed this condition, based on the EROI figures estimated by a study from 2012[22]. This means that a PVPP generates more energy in one year, than is required to make it and dispose of it.

**Levelized Cost of Electricity** (LCOE, €/kWh) is a figure quantifying the price of electricity generated by an energy source by relating total costs of the energy source to total electricity produced by it over its lifespan. This indicator allows for comparison of power plants with different generation technologies and cost structures.[23] The costs in the case of PVPPs include all costs of building and operating it throughout its lifetime, as well

[19] Fthenakis, V. M., and Kim, H. C. **Photovoltaics: Life-cycle Analyses.**

[20] Lloyd, B., and Forest, A. S. **The Transition to Renewables: Can PV Provide an Answer to the Peak Oil and Climate Change Challenges?**

[21] Wirth, H., comp. **Recent Facts about Photovoltaics in Germany.**

[22] Raugei, M., Fullana-I-Palmer, P., and Fthenakis, V. **The Energy Return on Energy Investment (EROI) of Photovoltaics: Methodology and Comparisons with Fossil Fuel Life Cycles.**

[23] Kost, C. **Levelized Cost of Electricity - Renewable Energy Technologies**, p. 36

as costs of capital. LCOE of PV is also determined by the amount of solar irradiance, lifespan of the plant and its annual degradation.[24]

Investment costs of solar installations have been falling by an average of 13% annually since 2006, thanks to economies of scale and technological advances.[24] Prices of PV modules have dropped by two thirds to three quarters between 2010 and 2014. As start-up costs constitute a major portion of costs of a PV system, this development helped decrease LCOE of PVPPs – in the same period, average LCOE of utility-scale PV installations has fallen by around a half.[25] Moreover, further decline can be expected. By 2030, LCOE of even small rooftop PVPPs is forecasted to outperform LCOE of coal, combined cycle power plants and to fall well below average LCOE of all fossil fuel power plants and some of the nuclear power plants.[26, 27]

Finally, **grid parity** is a point in time at which a RES becomes price-competitive with conventional energy sources without any government support or subsidies. Grid parity occurs when a RES generate power at a LCOE that is less than or equal to the price of electricity purchased from the grid.[28] As of January 2014, PV systems have achieved grid parity in at least 19 countries including Germany, Italy, Spain and Greece and more markets are expected to have reached this point since then.[29]

### 3.2 PV in Recent Years

PV has experienced a rapid growth in the last decade. After the temporary shortage of silicon in the years 2004 – 2008, the costs of crystalline silicon panels decreased dramatically. Simultaneously, RES-favourable policies employed in many EU countries and China contributed to increased demand for PV systems and thus allowed the producers to achieve economies of scale and cut the costs even further.

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[24] Wirth, H., comp. **Recent Facts about Photovoltaics in Germany**, p. 7

[25] IRENA. **Renewable Power Generation Costs in 2014**, p. 31

[26] Kost, C. **Levelized Cost of Electricity - Renewable Energy Technologies**, p. 3

[27] Wirth, H., comp. **Recent Facts about Photovoltaics in Germany**, p. 9

[28] Breyer, C., and Gerlach, A. **Global Overview on Grid-parity**, p. 1

[29] Shah, V., Booream-Phelps, J., and Min, S. **2014 Outlook: Let the Second Gold Rush Begin**, p. 2

Globally, the installed capacity of PVPPs grew almost exponentially. International Energy Agency saw cumulative PV capacity growing on average at 49% p.a. since 2003.[30] European Photovoltaic Industry Association estimates that between 2003 and 2013, cumulative installed capacity increased more than 52 times from 2.6 GW to 139 GW. A great deal of this rocket growth is attributed to Europe where cumulative installed performance of PVPPs grew in the same period from 601 MW to 81,464 MW,[31] i.e. 135 times. Figure 1 and Figure 2 represent a comprehensive visual image of the rate of global PV growth in the last decade.

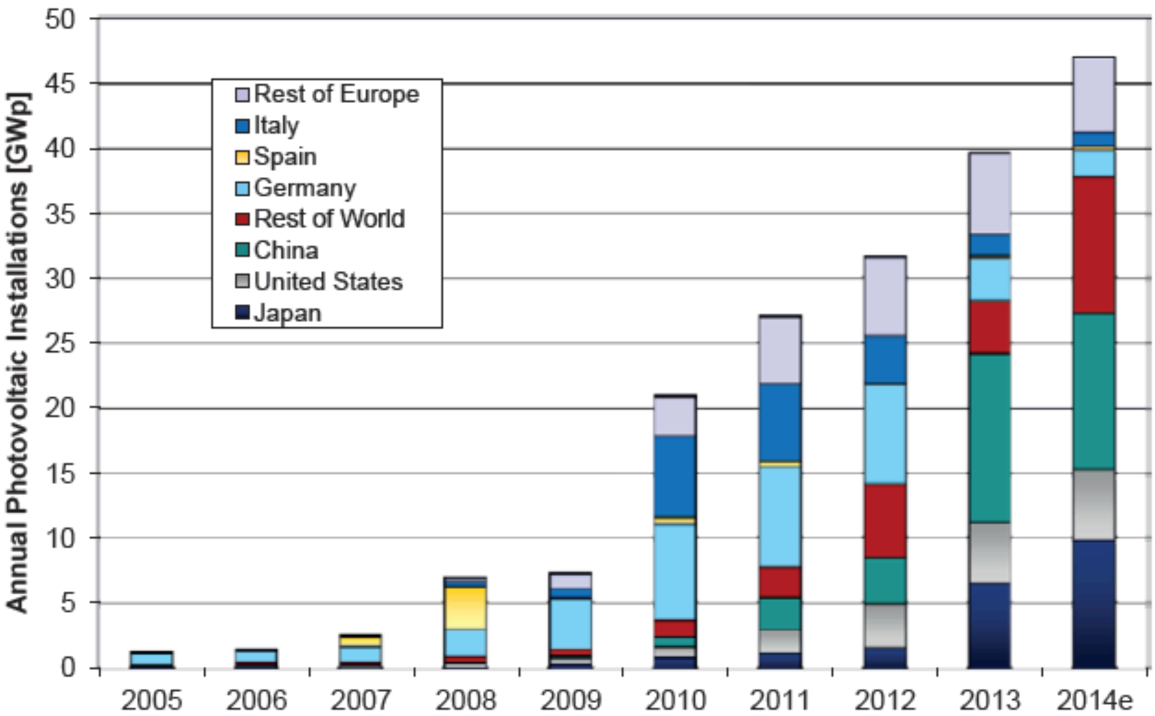


**Figure 1: Annual PV installations from 2005 to 2014.** Source: Jäger-Waldau, A.

[30] International Energy Agency, **Technology Roadmap: Solar Photovoltaic Energy - 2014 Edition.**

[31] Masson, G., Orlandi, S., and Rekinger, M. **Global Market Outlook for Photovoltaics 2014-2018.**

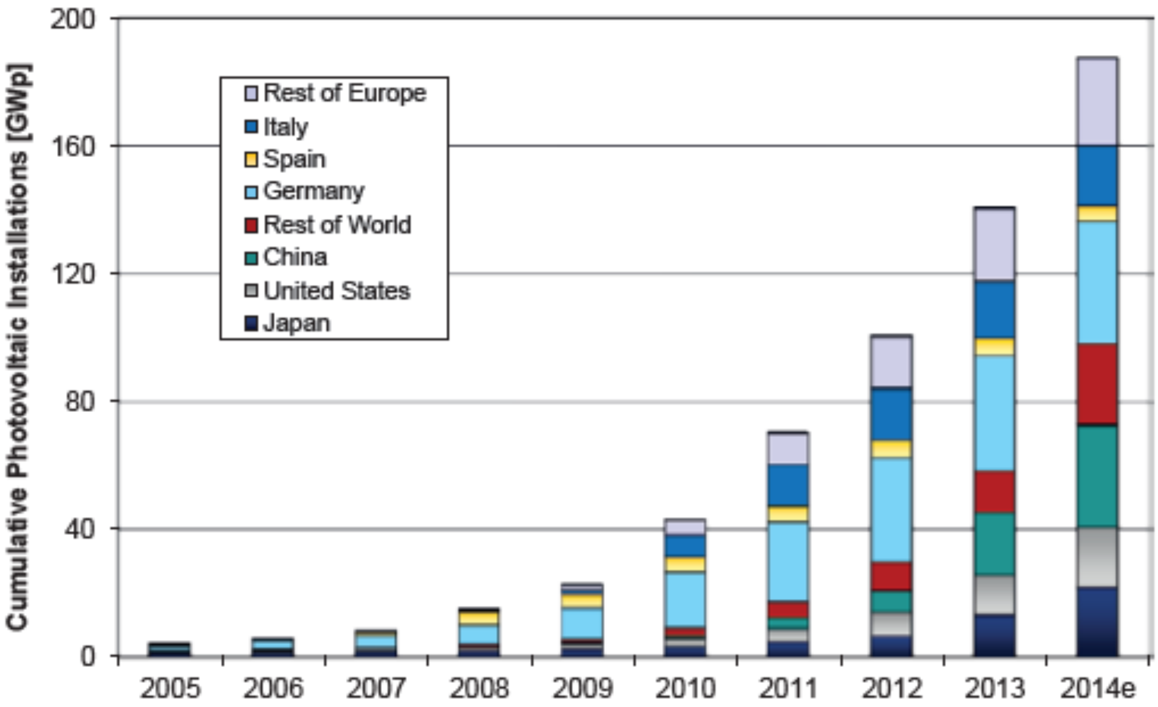


**Figure 2: Cumulative PV installations from 2005 to 2014.** Source: Jäger-Waldau, A.

### 3.3 Policy Tools

In spite of the fact that PV has already reached grid parity even in some parts of central Europe a few years ago,[32] massive growth of PVPPs is still mostly artificially induced and supported. Policy tools have driven the boom of solar installations and although achievement of grid parity is often discussed, this will probably remain unchanged. Market research firm HIS estimates that out of 53 GW of IC of PVPPs installed globally in 2015, only a little bit more than 1 GW will be operating without any incentives and even in 2018, only 6% of all global PV installations will be truly uninfluenced by policies and subsidy schemes.[33] This subchapter aims to provide an overview of the variety of tools available to policy makers who aim to stimulate (or control) growth of PV.

[32] Wirth, H., **Recent Facts about Photovoltaics in Germany**, p. 11

[33] Sharma, A., **Top Solar Power Industry Trends for 2015**, p. 3

### 3.3.1 Supportive tools

Supportive instruments for promoting RES are designed so as to increase the volume of IC of PV installations of various sizes and specifications in a given country. These tools intend to motivate investors, let them be households or companies, to buy and employ solar systems.

The main supportive instruments for RES are feed-in tariffs and systems of quota obligations. These are often accompanied by tax incentives such as tax allowances or exemptions from energy taxes, soft loans, subsidy programmes and tenders. Countries usually employ one of the tools, although some use them in a combination. In some federalised states, the policy scheme differs region from region.[34] The instruments may (and usually do) reflect type and size of the PV project. For example, supportive policies often favour small rooftop systems over large, investment-motivated PV installations by guaranteeing them higher FIT or greater tax deductions.

**Feed-in tariff** (FIT) is a prevailing RE supportive policy tool. FIT "*is an energy supply policy focused on supporting the development of new renewable energy projects by offering long-term purchase agreements for the sale of RE electricity.*"[35] These purchase agreements usually take the form of a premium or bonus above the market price of electricity for every kilowatt-hour and are guaranteed for periods of time ranging from 10 to 25 years. It has been demonstrated in countries such as Germany that FITs can constitute an effective policy tool to stimulate growth of RE and enable accomplishment of RE policy and emissions reductions objectives.[36] FIT shall not be viewed as a form of subsidy; while a true subsidy means involvement of public funds, FIT is a legally guaranteed surcharge (compulsory contribution on RES) to the price of electricity that is paid by the consumers directly to their electricity supplier.[37]

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[34] Reiche, D., and Bechberger, M. **Policy Differences in the Promotion of Renewable Energies in the EU Member States**, p. 846

[35] Couture, T. D., Cory, K., Kreycik, C., and Williams, E. **A Policymaker's Guide to Feed-in Tariff Policy Design**, p. 6

[36] Couture, T. D., Cory, K., Kreycik, C., and Williams, E. **A Policymaker's Guide to Feed-in Tariff Policy Design**, p. V

[37] Wirth, H., comp. **Recent Facts about Photovoltaics in Germany**, p. 22

**Quota obligations** are present in some of the EU Member States (Poland, Sweden, the UK, Italy, Romania, Belgium) in the form of tradable *"Green certificates"* (GC). Tradable GCs are considered to be *"an instrument capable of achieving the specified RE goal while at the same time ensuring cost-efficient development of RE in a liberalised energy market"*.[38] GCs are issued for electricity from RES and they basically prove that a certain amount of electricity has been generated using RES.

Electricity is uniform and it cannot be separated, meaning that once it is in the grid, it cannot be determined which comes from RES and which does not.[39] The Quota scheme in a way counterbalances this fact: The GC can be seen as a claim that the consumer owning it used a portion of renewable energy from the whole amount of energy available in the grid. The scheme ensures supply of the tradable certificates by giving them to producers of RE for each unit of RE produced (usually at a rate of one certificate for one MWh, although the amount may vary for different types of RES). Consequently, RE producers sell produced energy on the electricity market for regular price and then trade their GCs in order to get compensation for additional costs of RE production. Demand for GCs is then induced by requiring electricity producers, or consumers, or distributors to present a given amount of GCs. Thus, the national target for RE share is virtually transferred onto the consumers who are required to prove that they consume at least the share of RE that is specified by the policy makers. Just like FITs, GCs pass the burden onto the electricity consumers and so are financed neither by public funds, nor by the RE producers. Therefore, they are in accordance with the desirable Polluter Pays Principle.[40]

### 3.3.2 Restrictive tools

In some countries such as in the Czech Republic, Spain, Slovakia and Bulgaria, inadequate supportive policies of PV resulted in uncontrolled boom of solar installations. This development resulted in policy makers taking measures, which penalised existing PVPPs by reducing their revenues through introduction of additional taxes or increasing

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[38] Nielsen, L., and Jeppesen, T. **Tradable Green Certificates in Selected European Countries—overview and Assessment**, p. 3, 4, 5

[39] KOUBA S., **Taxation of Electricity from Solar Power Plants**

[40] Nielsen, L., and Jeppesen, T. **Tradable Green Certificates in Selected European Countries—overview and Assessment**, p. 3, 4, 5

grid costs for PV systems.[41] Author of the Thesis is of the opinion that investors should be aware of possible risks of policy makers exercising these tools. Therefore, practical examples of the forms of these measures follow in this Chapter.

Policy makers might introduce **administrative barriers** to setting up PVPPs. This is the case in Portugal for large installations. Number of **green certificates** that otherwise secure profits for PV systems may also be reduced contrary to previous plans, which is just happening in Romania. A hostile PV policy could also involve introduction of additional **grid connection tariffs** for PVPPs, as was the case in Belgium and Bulgaria.[42] In an attempt to mitigate consequences of a solar boom, the Czech Republic had introduced a special temporary **levy** of 26% on income from electricity produced by PVPPs launched in 2009 and 2010 and a tax of 32% was imposed on emission permits granted to PV electricity producers.[43]

Most of these tools negatively affect existing PV projects by worsening their cash flow and reducing returns against investor’s expectations. The listed measures clearly demonstrate that stability of the political environment (in the sense of consistency of policy) of a country towards PV investments and RES in general is a key element to reducing investor’s risk. Consequently, unexpected changes in PV support schemes harm the country’s image in the eyes of the investors. Indeed, no country that underwent a PV boom followed by harsh mitigation measures has so far been able to restore market confidence.[44] Policy makers should therefore try to avoid employing such restrictive tools.

Generally, it seems to hold that a restrictive policy follows after a PV market has overheated due to an overly generous state support. It thus seems advisable for investors to resist the temptation of “easy money” and avoid such markets.

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[41] Masson, G., Orlandi, S., and Rekinger, M., **Global Market Outlook for Photovoltaics 2014-2018**, p. 25, 31

[42] Masson, G., Orlandi, S., and Rekinger, M., **Global Market Outlook for Photovoltaics 2014-2018**, p. 27

[43] Prusa, O., **The Economy of Solar Energy in the Czech Republic**, p. 20

[44] Masson, G., Orlandi, S., and Rekinger, M., **Global Market Outlook for Photovoltaics 2014-2018**, p. 31

## 3.4 Ways of financing a Solar Business

Capital for PV projects, as well as for other RES, may be obtained in two elementary ways. The projects are financed by equity, or debt, or a combination of both. A brief overview of the key features of each type of financing follows.

### 3.4.1 Equity Financing

The principle of equity financing is that the investor or investors finance the project from their own funds. Equity may be provided from internal funds of the entrepreneur or the company that is developing the project, or by a wide range of financial investors. These typically involve infrastructure funds, pension funds, private equity funds and venture capital funds or venture capitalists.

While venture capital funds and private equity funds expect high internal rate of return (IRR) and short- to medium-term investment, infrastructure and pension funds exhibit a low risk appetite (IRR of approximately 10% or below) and so are rather conservative. While infrastructure funds generally prefer medium-term investment of 7 to 10 years, pension funds seek long-term investments that generate cash on a regular basis.[45] These characteristics make pension funds ideal potential investors in PV projects.

Equity financing obviously does not burden cash flow with expenses such as credit instalments. Nevertheless, capital budgeting rule says that the revenue streams must generate such internal rate of return that exceeds investor's opportunity cost of capital in order for the investor to carry out an investment.[46] In other words, an investor would not put his funds into a project that yields lower cash flow (discounted to its present value) than an alternative project would.

### 3.4.2 Debt Financing

The essence of debt financing is that a part of the project or the whole project is paid for by a loan from a financial institution. The loan and relevant interest charged on it is then gradually repaid. In general, financial institutions provide debt finance to secure

[45] Justice, S. **Private Financing of Renewable Energy: A Guide for Policymakers**, p. 7

[46] Welch, I.. **Corporate Finance: An Introduction**, p. 77

projects with low level of risk involved.[47] In other words, debt financing should be relatively accessible for PV projects in markets with stable regulatory and market environment.

Cost of debt financing is the interest that the debtor repays in addition to the principal amount. Banks either charge the borrower interest on the remaining principal amount only, i.e. use simple interest method, or calculate the interest for every period both from the principal and the interest remaining to be paid – i.e. use compound interest. Interest rate may also be calculated on a discount basis – if a borrower borrows a €100 payable in a year at a discount interest rate of 12%, he actually gets €88 and repays €100 after 12 months, thus paying an effective interest rate of 13.64%.[48] However, compound interest and simple interest are prevalent.

With debt financing, the entrepreneur reduces the amount of own funds needed to finance the project. Moreover, principal and interest payments are usually tax-deductible items, which results in a lower effective interest rate, provided that the taxes are derived from real costs. On the other hand, regular principal and interest repayment is apparently negatively projected to the cash flow and sufficient cash inflows are required to cover these. Last but not least, debt must be repaid, no matter what the result of the project is[49] - so when an equity investor "only" loses his money in case of project failure, a debt financed project might result into the company going bankrupt and losing its assets.

Equity financing and debt financing can be used in combination and the financial model developed further in this Thesis allows for this case. However, the Thesis does not deal with projects that would involve, or combine, other types of business financing such as mezzanine finance (subordinated debt).

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[47] Hussain, M. Z. **Financing Renewable Energy Options for Developing Financing Instruments Using Public Funds**, p. 14, 15

[48] Brealey, R. A., Myers, S. C., Marcus, A. J.. **Fundamentals of Corporate Finance**, p. 35, 188

[49] Richards, D. **Debt Financing - Pros and Cons.**

# 4 Methodology of the Thesis

The research section of this Thesis consists of two main parts. The first analysed legislative framework and regulatory policies related to solar installations and businesses in Germany and France in both national and international context. The second then extracted relevant pieces of information from the legislation overview for each state and utilized them in developing a model of a PV investment in line with legislation of the given state.

The first part of the analysis involved a thorough study of **documents and legislation** on national level, as well as on the level of the EU. Not only did the research focus on RE supportive policy tools available in the countries, it also analysed EU Directives and National Renewable Energy Action Plans of each country, which de facto shape both current and future RE-related legislation. Furthermore, a review of business structures adequate for running a PV project under was created, including taxation and financing implications.

Second part of the analysis applied findings from the first part onto development of a **financial model of a sample PVPP** for each of the countries. Technical parameters of both model PVPPs were held constant, while country-specific parameters such as purchase prices, depreciation methods or profit taxation differed for each of the analysed countries. For each country, the Author employed such business structure and depreciation method that he considered the most advantageous available. Consequently, a revenue and cash flow model was developed, based on all of the aforementioned parameters. Furthermore, the model was designed so as to be able to distinguish between the types of financing used in the PV project, i.e. between debt and equity financing or a combination of both. Finally, methods of capital budgeting were employed in order to evaluate the PV investment in each of the countries and using each of the ways of financing and recommendations resulting therefrom were proposed.

Technical parameters of the model PVPP, as well as data on insolation and resulting electricity yields, were discussed and optimized in cooperation with an existing company that offers complex solutions for monitoring of the performance of PVPPs. Thanks to this fact, the model accuracy was rather significant.

The **Cash Flows** projections of the financial models of PVPPs were constructed on a monthly basis in the following manner: Cash inflows consisted of net income[50] plus depreciation expenses and cash outflows involved loan instalments (when using debt finance) and, for the first ten years, a regular contribution to the repair fund for accumulation of funds needed for replacement of the inverter with a 10-year lifespan.

Subsequently, the resulting cash flows were discounted at a discount rate specified in the model and **Net Present Value** (NPV) of the investment was calculated. NPV rule says that all projects with a positive NPV earn more than they cost and should therefore be accepted.[51] NPV is considered to be the most important benchmark for decision making in capital budgeting [52] and as such represented the main factor in consequent recommendations on the projects.

Furthermore, for equity and partial equity financing, **Internal Rate of Return** (IRR) was estimated. IRR is closely related to NPV – it is such a discount rate of return of a project expected cash flows at which the NPV of the project equals zero. In other words, a project with IRR equal to or exceeding the opportunity cost of capital should be taken.[53] Theory argues that methodological challenge arises with projects incorporating several negative and positive cash flows, which results into several IRRs for one project.[54] The models designed in this Thesis controlled for this by summing up monthly cash flows into a table of annual cash flows, which were usually all positive. In case that several negative and positive cash flows still occurred (e.g. in case of a combination of debt and equity financing), IRR was not computed.

The models include several other capital budgeting tools of lesser importance. First, **payback period** of the projects, i.e. period of recovery of the investment, was assessed. The payback rule states that a project shall not be realized if its payback period is longer

[50] Net Income comprised revenues minus maintenance costs minus depreciation expenses minus appropriate income tax minus loan instalment (when applicable).

[51] Brealey, R. A., Myers, S. C., Marcus, A. J.. **Fundamentals of Corporate Finance**, p. 344

[52] Welch, I.. **Corporate Finance: An Introduction**, p. 68

[53] Brealey, R. A., Myers, S. C., Marcus, A. J.. **Fundamentals of Corporate Finance**, p. 349

[54] Welch, I.. **Corporate Finance: An Introduction**, p. 78

than the duration of the project.[55] However, payback period does not reflect time value of money, nor does it consider cash flows after recovery of investment.[56] Therefore, its use in capital budgeting is rather limited and it was used in the model only for informative reasons. Second, **profitability index** was quantified. This index compares the present value of future cash flows to initial investment. Inherently, profitability index is only meaningful when the undertaken project involves some initial investment.[57] The nature of a PVPP is consistent with this requirement. Shall this basic condition be met, the profitability index can be used interchangeably with NPV: A profitability index greater than one means the same as a NPV greater than zero – that the project should be implemented. Third, **return on investment** was calculated as a ratio of future cumulative cash flows minus initial investment to the initial investment. This metric measures rate of return per period (in this case the lifespan of the project) on money invested. The project with a higher return on investment should be realized. However, this indicator does not reflect time value of money and is therefore rather irrelevant for decision making in this context. It is involved in the model merely to provide a broader idea about the investment.

To sum up, recommendations on investment in the model PVPPs were mainly based on **NPV and IRR**. Other tools of capital budgeting were computed in order to provide more detailed information about the projects. However, as Methodology explains, they suffer from certain shortcomings and are not ideal tools for making investment decisions.

All the modelling and computations were performed using MS Excel. The model is a downloadable electronic Appendix of this Thesis (see Appendix 10).

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[55] Brealey, R. A., Myers, S. C., Marcus, A. J.. **Fundamentals of Corporate Finance**, p. 354

[56] Welch, I.. **Corporate Finance: An Introduction**, p. 83

[57] Welch, I.. **Corporate Finance: An Introduction**, p. 81

# 5 Results of the Analyses

## 5.1 *Analysis of the Legislation and Regulatory Policies*

### 5.1.1 National and Supranational Policies

National policies for the promotion of RES have been widely influenced and fuelled by international obligations. Not only had the policies been shaped by international commitments, as was the Kyoto Protocol (ratified in 1997, expired in 2012); policy makers of the Member States of the European Union are bound by EU Directives that set even higher goals and demands.

#### *5.1.1.1 EU Setting Out the Trend: 20-20-20*

In 2006, the European Commission (EC) adopted an **Action Plan** aimed at reducing energy demand and undertaking efficiency measures that would altogether enable a 20% reduction in consumption of energy in 2020 in the EU Member States compared to the consumption forecasts for 2020. The six-year Action Plan (January 2007 – December 2012) set out a number of short and medium-term steps in order to achieve this objective. These measures were aimed at improving energy performance and transformation, limiting the transportation costs, facilitating investments designed to boost energy efficiency and changing public behaviour. The EU Member States were required to transpose and adopt most of these steps.[58] By this Action Plan, the EU outlined the frame of its energy policy and developed it in the following measures.

In the beginning of 2007, the European Council approved a series of measures proposed by the EC that set out a target to reduce EU domestic emissions of greenhouse gases by at least 20% by 2020 (compared to 1990 levels).[59] This was in line with the EC Action Plan. Subsequently, the **European Union Climate and Energy Package** (further referred to as the Package) was adopted by the European Council and voted by the European Parliament in December 2008. This directive is a set of binding legislative

[58] EUROPA.EU. **Action Plan for Energy Efficiency (2007-12)**

[59] Commission of the European Communities, **Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions**, p. 5

measures with the purpose for the EU to meet its climate and energy targets for 2020, also known as the "**20-20-20**" goals. These objectives are:[60]

- Reduction of **greenhouse gases emissions** by 20% by 2020 (where reference values are 1990 emissions)
- Improvement in **energy efficiency** by 20% by 2020 (compared to projections)
- Reaching a total **share of RE in the total consumption** of the EU Member States of 20% by 2020, including 10% of renewables in the transport sector (i.e. mostly biofuels and electricity from RES)

The most relevant objective for the purpose of this Thesis apparently is the third one. The Package allowed for cooperation between the EU Member States and enabled them to achieve the target for renewable energy share jointly. In other words, it permitted "statistical" transfer of the renewable energy between the states.[60] This was important, because while some states have already been well above the 20% target in 2005, others only consumed a tiny fraction of renewable energy then.[61] These would have to adjust to the 20% goal with considerable difficulties, while reaching lower levels was more realistic for them. As *consumed*, not *produced* energy was the concern, the Package even permitted obtaining RE from a third country, as long as the electricity met certain conditions.[62]

The directive gave the EU Member States 18 months for bringing into force the laws and regulations necessary to comply with it.[63]

#### 5.1.1.2 2009/28/EC - Renewables Directive

The most relevant directive that currently affects and shapes national policies for RES of the EU Member States is the EU Directive 2009/28/EC, also known as the Renewables Directive. It has entered into force on June 25, 2009 and it was created under the Action Plan explained in the Chapter 5.1.1.1 as a part of the Package of energy and

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[60] EUROPA.EU, **EP Seals Climate Change Package.**

[61] RE-Shaping. **Renewable Energy Policy Country Profiles 2011**, p. 8

[62] EUROPA.EU. **Promotion of the Use of Energy from Renewable Sources.**

[63] EUROPA.EU, **EP Seals Climate Change Package.**

climate change legislation.[64] It amended and repealed the Directive 2001/77/EC (Directive on Electricity Production from Renewable Energy Sources), which set out national indicative targets for 2010 for the share of RE production in Member States. The Renewables Directive mandates levels of consumption of RE for the year 2020 for each of the EU Member States[65] and thus more specifically elaborates on one of the "20-20-20" goals set out by the Package (reaching a total share of RE in the total consumption of the EU Member States of 20% by 2020). Furthermore, the Directive institutes a common framework for production and promotion of energy from RES.[66]

Article 4 of the Renewables Directive required EU Member States to develop **National Renewable Energy Action Plans** (NREAPs) and to notify them to the EC by July 30, 2009. NREAPs should describe the Member States' plans for envisaging the Directive implementation and for reaching 2020 targets. Specifically, the states had been required to come up with national 2020 targets for the share of energy from RES (consumed in electricity, transport and heating and cooling) and to set out adequate measures in order to achieve these targets.[67] NREAPs should set forth expected technology mix, sectoral targets and measures to remove barriers to RE development.[68] The Plans were supposed to reflect the effects of other efficiency measures on final energy consumption and to set up steps of the reform of pricing and planning schemes and facilitate access to the power grid, promoting energy from RES.[69]

The Renewables Directive required that each EU Member State implements in its legislation a National Target for RES for 2020, calculated according to the share of energy from RE in its gross final consumption in 2005. For example, Belgium has a National Target of 13% of RES in 2020, compared to its 2.2% in 2005; Sweden, which had already been covering 39.8% of its consumption in 2005 by RES (making it the most

[64] EUROPA.EU. **Promotion of the Use of Energy from Renewable Sources.**

[65] **Directive No. 2009/28/EC (Renewables Directive)**, ANNEX I

[66] EUROPA.EU. **Promotion of the Use of Energy from Renewable Sources.**

[67] **Directive No. 2009/28/EC (Renewables Directive)**, Article 4

[68] RE-Shaping. **Renewable Energy Policy Country Profiles 2011**, p. 4

[69] EUROPA.EU. **Promotion of the Use of Energy from Renewable Sources.**

environmentally-friendly EU Member State), has the National Target set to 49%.[70] Furthermore, Member States were required to be able to guarantee the origin of energy and to ensure priority access of RES to the infrastructure (power grid).[71]

#### ***5.1.1.3 Future Outlook: 2030***

In October 2014, the European Council adopted the 2030 EU Climate and Energy Package which adjusted the "20-20-20" targets for the year 2030 in the following manner:[72]

- Reduction of **greenhouse gases emission** by 40% by 2030 (compared to 1990 emissions)
- Improvement in **energy efficiency** by 27% by 2030 (compared to projections)
- Reaching a total **share of RE in the total consumption** of the EU Member States of 27% by 2030, including higher level of interconnections of the electricity markets of EU Member States (10% by 2020, 15% by 2030)

While the energy efficiency target is indicative (non-mandatory), the other two are binding. The RE target will again be delivered collectively by all EU Member States together.[73] The 2030 Package proves the determination of the EU states to move further towards the low-carbon economy. As it builds on the 2020 Package and develops its aims further, it also ensures important regulatory certainty for investors. It can be expected that this new 2030 Package will soon be reflected in future EU directives, as was the case with the 2020 Package and with the Renewables Directive. Subsequently, measures leading to completion of its goals will have to be implemented in the legislations of the EU Member States. So, in other words: RE support will definitely continue and it will even most likely be intensified.

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[70] RE-Shaping. **Renewable Energy Policy Country Profiles 2011**, p. 8

[71] EUROPA.EU. **Promotion of the Use of Energy from Renewable Sources.**

[72] European Commission. **Outcome of the October 2014 European Council.**

[73] European Council. **European Council 23/24 October 2014 – Conclusions**

### 5.1.2 Legislation in Germany

#### *5.1.2.1 Country Overview*

Germany has been tending to support RES for more than a decade. A trend of energy transition is noticeable since the early 2000s. Within this so-called *"Energiewende"*, German energy industry transforms towards wider deployment of RES, promotion of sustainable development and energy efficiency. The first official sign of the transition was adoption of the Renewable Energy Act (*"Erneuerbare-Energien-Gesetz, EEG"*) that entered into force in 2000. Latest revision of the EEG came into force on August 1, 2014. The EEG pledges support to RES through a system of FITs that are gradually decreased in order to develop pressure on producers of RE technologies and thus promote innovation. It shall be pointed out that under this support scheme, the costs of RE promotion are passed on to energy consumers.

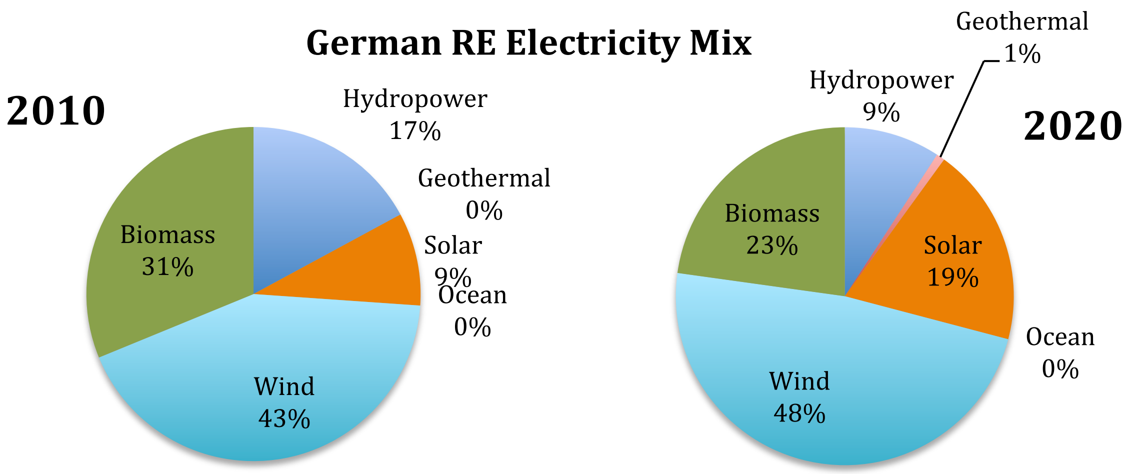


**Figure 3: German RE Electricity Mix in 2010 and 2020.** Own Elaboration.
**Data Source**: **Beurskens, L.W.M., and Hekkenberg, M.**

In its National Renewable Energy Action Plan, Germany commits itself to cover 19.6% of its energy consumption in 2020 by RES. Compared to other countries, this seems to be a rather mediocre figure; nevertheless, we must realize that its starting point is 10% in 2010. Germany is especially ambitious in employing RES in electricity generation. The country met 17.4% of its electricity needs by RE in 2010 and it seeks to more than double this figure by 2020: Germany aims to cover at least 38.6% of its electricity consumption by RES in 2020. 48% of this "green" electricity should come from wind power and 19% from

PV. In other words, 7.4% of German final gross electricity consumption should be covered by a total of 41.4 GWh of solar energy.[74] Detailed composition of share of each type of RE technology on the total RE electricity consumption in Germany in 2010 and 2020 is visually depicted in Figure 3. Some sources estimate that in 2013, roughly 24% of electricity was of RES origin[75] and so was 28.5% in 2014,[76] whereas the running goal for 2015 was 26.8%[77] - so the country obviously is on the right track to meeting its objectives. The EEG 2014 goals provide an even more ambitious perspective: The country aims to cover up to 40-45% of its electricity consumption by electricity from RES by 2025, 55-60% by 2035 and finally, by 2050, "green" electricity should account for 80% of gross electricity consumption.[78]

The aforementioned 2020 goals mean that in 2020, total installed capacity (IC) of PV in Germany should constitute 57% of the IC of PV of the EU Member States and the country should produce 40% of all solar electricity generated within the EU[79]. Average annual growth for PV capacity in Germany then should be almost 13%.[80] Hand in hand with RE deployment goes energy efficiency, which, according to German energy strategy, efficiency represents a key factor to retain competitiveness.[81]

Presented figures clearly demonstrate that Germany seems to be an ideal country for both PV investors and PV supply chain businesses.

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[74] Beurskens, L.W.M., and Hekkenberg, M. **Renewable Energy Projections as Published in the National Renewable Energy Action Plans of the European Member States**, p. 193

[75] Philipps, S., and Warmuth, W. **Photovoltaics Report**, p. 6

[76] Lang, M. **BDEW: Renewables Account for Record 28.5% of Gross German Electricity Consumption in First Half of 2014.**

[77] Beurskens, L.W.M., and Hekkenberg, M. **Renewable Energy Projections as Published in the National Renewable Energy Action Plans of the European Member States**, p. 193

[78] Germany. **EEG - Renewable Energy Act 2014 (in German),** Section 1, Par. 2

[79] The difference is caused by the fact that a significant portion of PVPPs will be in Spain, Italy and France, where higher insolation ensures higher yields per each Wp of IC.

[80] Beurskens, L.W.M., and Hekkenberg, M. **Renewable Energy Projections as Published in the National Renewable Energy Action Plans of the European Member States**, p. 88, 89

[81] **National Energy Efficiency Action Plan** (EEAP) of the Federal Republic of Germany, p. 4

#### *5.1.2.2 Types of Support of PV*

| PV in Germany: Key Points | |
|---|---|
| **Type of Support** | Feed-in Tariffs, Market premium |
| **FIT Adjusted** | Monthly |
| **Support granted** | 20 years |
| **FIT Indexation** | None (FIT remains constant) |

**Table 1: PV in Germany – Key Points.**
Source: Author's Work

In Germany, PV installations of IC up to 10 MWp are mainly supported by **feed-in tariffs** (*"Einspeisevergütung"*) and newly (under the EEG 2014) by FIT-related **market premiums** (*"Marktprämie"*). These may be under certain conditions accompanied by low interest loans provided for promotion of RE production. Under EEG 2014 Revision, financial support is guaranteed to remain **constant** for a period of **20 years** plus the remaining months of the year when the PVPP was launched. Beginning with April 1, 2012, FITs that apply to newly launched PV installations are adjusted on a **monthly basis** and fall by 0.25% (in 2015 and Q4 2014) to 1% (first half of 2014) per month.[82] The purchase prices reflect IC and type of the installation (rooftop installations and ground mounted installations) and they are regularly set and announced in advance by the Federal Network Agency (*"Bundesnetzagentur"*). In line with EU legislation, RES are granted priority connection to the power grid. Moreover, electricity from RES shall be given priority for purchase and transmission by the grid operator.[83]

Since EEG 2014 Revision, **FITs** in Germany differ depending on the following **characteristics of PV installations**:[84]

- Rooftop installations (*"Dachanlagen"*) with IC **up to 10 kWp**.
- Rooftop installations (*"Dachanlagen"*) with IC **up to 40 kWp**
- Rooftop installations (*"Dachanlagen"*) with IC **up to 500 kWp**
- Ground mounted and other installations with IC **up to 500 kWp**

Please note that the building on rooftop of which the rooftop installation is made must be a residential building, or a building authorised and used for permanent stabling of animals, or a farmstead built after March 31, 2012. Furthermore, PV installations fixed to a

[82] German Federal Network Agency. **Archived Data Reports.**

[83] Lang, M., and Lang, A. **Overview Renewable Energy Sources Act**, Chapter 6

[84] Germany. **EEG - Renewable Energy Act 2014 (in German),** Section 51

noise barrier also fall under this category.[85] PV system built on rooftops of buildings that do not meet the aforementioned specifications falls to the category of "other installations". The land on which ground mounted installations are built must also meet certain criteria – for details see Appendix 3.

FITs are adjusted on a monthly basis pursuant to the running fulfilment of the target corridor for increase of PV installations.[86] The coefficient of change of the FIT is announced quarterly. The more significantly the target corridor is exceeded by the actual PV installations, the higher the rate of decrease of FIT for future periods. This holds vice versa – if the target corridor is not met, rate of decrease of FIT shrinks, falls to zero or the FIT is even increased.[87] For example, if the actual IC of newly launched PVPPs in the last quarter of 2014 is less than the target corridor, the rate of monthly decrease in FITs can be set to 0.25% for the first quarter of 2015. If the IC of new PV installations then increases and meets the target corridor, the rate of monthly decrease in FITs will be readjusted to 0.5% for the second quarter of 2015.

Table 2 summarizes the most recent FITs. For a complete overview of FIT development since January 2013 see Appendix 1.

| FIT (€ cents/kWh) | **Rooftop Installation up to 10 kWp** | **Rooftop Installation up to 40 kWp** | **Rooftop Installation up to 500 kWp** | **Other Installation up to 500 kWp** |
|---|---|---|---|---|
| **January 2015** | 12.56 | 12.22 | 10.92 | 8.70 |
| **February 2015** | 12.53 | 12.18 | 10.90 | 8.68 |
| **March 2013** | 12.50 | 12.15 | 10.87 | 8.65 |

**Table 2: FITs guaranteed to PVPPs launched in 2015.**
**Source: German Federal Network Agency.**

**Market premium** is, as a type of support, related to FIT in its principle. Under the regime of market premiums, the producer of electricity is required to market the electricity he produces directly by himself at the spot market of power exchange of EPEX SPOT SE

[85] Germany. **EEG - Renewable Energy Act 2014 (in German),** Section 51, Par. 3

[86] According to Section 31 Par. 1 of the EEG 2014 Revision, this target corridor is 2.4 to 2.6 GWh of IC of PV installations per year.

[87] Germany. **EEG - Renewable Energy Act 2014 (in German),** Section 31

in Paris.[88] Grid operator then pays the producer an extra "market premium" in addition to the price of electricity that the producer achieved. Market premium is the difference between the FIT plus a "management bonus" and the monthly average amount of the market price of electricity at the power exchange for the region of Germany/Austria. Management bonus shall remunerate transactional costs connected to trading and those resulting from errors in forecasting of amounts of energy supplied to the grid.[89] It is set together with FITs (actually being derived from them) by the Federal Network Agency and in 2015, it is between 0.3-0.5 cents €/kWh. Market premium is from its nature determined and paid retroactively on a monthly basis. In essence, producers who are able to sell their electricity above the average market price are better off with a market premium than with FITs. Also producers with real management costs of direct marketing of electricity lower than the "management bonus" will on average benefit from the market premium scheme.

Market premium was first mentioned in EEG 2012 Revision. In EEG 2014 Revision, direct marketing of electricity and consequent support of RE producers through market premium became a rule for larger producers. Market premium regime is **obligatory** for PVPPs launched between August 1, 2014 and December 31, 2015 with IC **exceeding 500 kWp** and for PVPPs launched after December 31, 2015 with IC exceeding 100 kWp.[90] Other PVPPs can choose between market premium and FITs and even switch between them later.[91] As mentioned above, basis for determining market premium levels equals FIT plus management bonus and is therefore bound to FIT level. This should only remain so until December 31, 2016.[92]

Since EEG 2014 Revision, Market premium levels differ depending on the following characteristics of a PV installation:

- Rooftop installations (*"Dachanlagen"*) with IC **up to 10 kWp**
- Rooftop installations (*"Dachanlagen"*) with IC **up to 40 kWp**

[88] Germany. **EEG - Renewable Energy Act 2014 (in German),** Section 34

[89] Lang, M. **VIK: Energy Costs for Industrial and Commercial Consumers Will Rise.**

[90] Germany. **EEG - Renewable Energy Act 2014 (in German),** Section 37, Par. 2

[91] Germany. **EEG - Renewable Energy Act 2014 (in German),** Section 20, Par. 1

[92] Lang, M., and Lang, A. **Overview Renewable Energy Sources Act**, Chapter 7

- Rooftop installations (*"Dachanlagen"*) with IC **up to 1 MWp**
- Ground mounted and other installations with IC **up to 10 MWp**

Detailed specifications of each type of installation have been mentioned in relation to FITs earlier in this Chapter. The same specifications hold in this case. Table 2 presents a summary of bases for determining Market Premium for 2015. For a complete overview of Market Premium bases see Appendix 2.

| Basis for Market Premium (€ cents/kWh) | **Rooftop Installation up to 10 kWp** | **Rooftop Installation up to 40 kWp** | **Rooftop Installation up to 1 MWp** | **Other Installation up to 10 MWp** |
|---|---|---|---|---|
| **January 2015** | 12.95 | 12.61 | 11.32 | 9.09 |
| **February 2015** | 12.92 | 12.58 | 11.29 | 9.07 |
| **March 2013** | 12.89 | 12.55 | 11.26 | 9.05 |

**Table 3: Bases for determining Market Premium that are guaranteed to PVPPs launched in 2015. Source: German Federal Network Agency.**

As mentioned in the beginning of this Chapter, RES investors in Germany can benefit from **low interest loans**. These loans are offered by German government-owned development bank, KfW, under several programmes. Two of these enable financing of projects which use solar technologies: KfW Energy Turnaround Financing Initiative and KfW Renewable Energies Programme – Standard. The former is focused on large enterprises with annual turnover between €500 and 3,000 M and provides loans worth €25M - €100M that cover up to 50% of the investment costs.[93] The latter aims on RE investments made by private individuals, farmers, non-profit organizations, investment funds or domestic and foreign enterprises majority-owned by private individuals. This type of loan may cover up to 100% of investment costs and must not exceed €25M. Annual effective interest rate varies between 1.31% and 7.56% and it is fixed for entire period of technical and economic duration of the project,[94] which makes it a very favourable financial product.

German legislation also allows for (and regulates) **self-consumption** of RE. This was especially beneficial for producers before the EEG 2014 Revision came into force. At that time, self-generated electricity used to be exempt from paying the RES contribution

[93] KfW. **Energy Efficiency, Corporate Environmental Protection and Renewable Energies.**

[94] Bozsoki, I. **Loan (KfW Renewable Energy Programme – Standard).**

surcharge (EEG surcharge), which amounts to roughly 50 % of the final electricity price paid by consumers[95]. However, this has been modified in EEG 2014 Revision and currently it holds for new power plants that self-consumers do have to pay a certain EEG surcharge. It is determined depending on type of technology used in the power plant in order to favour RE or very efficient conventional power plants.[96] However, this will not be discussed in detail in this Thesis, as it is not close enough to its Objectives.

Finally, it shall be noted that EEG 2014 Revision aims to introduce support to RES through auctions (**tender calls**) by 2017. This should apply in particular to projects with large IC exceeding 100 kWp.[97] As a transition to this system, auctions of several pilot projects with purchase price determined outside the FIT scheme should be organised and evaluated in 2015. An updated EEG revision employing tenders at large scale should be in force by autumn 2016.[98]

#### 5.1.2.3 Taxation and Business Structures

German law differentiates between several types of businesses depending on their annual turnover and other factors. Consequently, taxation scheme differs for each of these.

Small-scale businesses can be run under the regulation of "**small business**" (*"Kleinunternehmer"*), provided that their annual turnover (excluding fixed assets sale) did not exceed € 17,500 in the preceding calendar year and is not expected to exceed € 50,000 in the current year. These businesses are not registered as VAT payers and therefore cannot claim VAT refund.[99] This can be seen as a drawback in relation to investments into PV that involve high start-up costs, however, considering the amount of regulation and bureaucratic burden that "small businesses" avoid, this scheme appears like a reasonable choice for households and small entrepreneurs. In relation to PV, this business regime is suitable for small installations up to 10 kWp. Nevertheless, should the PV project involve

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[95] Eurostat. **Electricity and Natural Gas Price Statistics.**

[96] Lang, M., and Lang, A. **Overview Renewable Energy Sources Act**, Chapter 10

[97] Germany. **EEG - Renewable Energy Act 2014 (in German),** Section 2, Par. 5

[98] Lang, M., and Lang, A. **Overview Renewable Energy Sources Act**, Chapter 14

[99] Germany. **Value Added Tax Act (in German)**, Par. 19

debt financing with tax-deductible interest payments, a different scheme might be worth considering.

Being a German resident, a PV investor could also decide to run a PVPP as a **sole proprietor** (*"Einzelunternehmen"*) or under the regime of "**civil law partnership**" (*"Gesellschaft bürgerlichen Rechts"*). The tax and business law consequences arising from these types of businesses are derived from annual turnover and/or profit.[100] Individuals (including sole proprietors) are taxed on their income at a progressive rate starting from 15% for income exceeding €8,004 and going up to 45% for income over €250,000.[101] These schemes might fit the needs and expectations of small individual investors as they are more simple to run then an actual company and do not involve high establishment costs. Furthermore, under these schemes, the business owners are not limited by the turnover boundaries that apply for "small business" regime and so they can be used for operating larger PVPPs. However, it shall be considered that a sole proprietor is liable to his debts up to the level of his personal property. Therefore, if he started a PV facility using debt finance and then would not be able to meet his obligations, he would risk losing own private assets. In case of PV, which is dependent on state support, a sole proprietor is hence highly dependent on the stability of political environment of the country where he is doing business.

Finally, a PV system can be run under a **corporation**. German law differentiates between several types of corporations: a public limited company (*"Aktiengesellschaft, AG"*), a partnership limited by shares (*"Kommanditgesellschaft auf Aktien, KGaA"*), a limited liability company (*"Gesellschaft mit beschränkter Haftung, GmbH"*) and "entrepreneurial company with limited liability" (*"Unternehmergesellschaft – haftungsbeschränkt, UG"*), also known as "mini GmbH". These types of corporations differ in a number of factors such as capital or ownership structure.[102] However, taxation of income that shall be applied on yields from a PVPP is similar for all.

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[100] IHK Köln. **Types of businesses that are not registered in the commercial register (in German).**

[101] White, O.. **What type of business pays what taxes? (in German)**

[102] JuraForum.de. **Explanation of the Concept of Corporations (in German).**

First, the corporations are **VAT** (*"Umsatzsteuer"*) payers. This implies that they can deduct VAT from their expenses and they deduct real expenses including depreciation and interest payments from the revenue. Second, corporations pay **corporate tax** (*"Körperschaftsteuer"*) on their taxable income. Since 2008, this tax amounts to **15.825%** including a solidarity surcharge.[103] Third, the corporations are subject to local trade tax (*"Gewerbesteuer"*). This tax is derived from taxable income and it is paid to the municipality where the company operates. Its levels differ across Germany. The tax rate for each municipality is calculated as a basic tax rate of 3.5% which is common for the whole Germany, times a multiplier set by the municipality. The latest data available from German Federal Statistical Office indicate that in 2013, an average rate of the multiplier throughout Germany was 390 %,[104] which makes the overall **local trade tax rate 13.825%.** In order for the overview of corporate taxes to be complete, it shall be mentioned that the corporations are obliged to pay payroll tax (*"Lohnsteuer"*). This is however not directly related to corporate income and so it is not discussed in detail. In the model, all employee-related costs including this tax fall under maintenance costs.

A note at the end: A PV business in Germany might often incorporate **self-consumption**, which implies a whole set of special regulatory, accounting and taxation rules. Although self-consumption is an attractive incentive for those who wish to run a PV installation in Germany, this possibility will not be discussed in detail in this Thesis. This Thesis aims to compare investment in PV facilities that generate electricity and sell it to the power grid. Therefore, a system where the investor consumes the electricity by himself is not a subject of analysis in this Thesis, no matter how advantageous it may be under certain circumstances.

### 5.1.3 Legislation in France

#### *5.1.3.1 Country Overview*

In the National Renewable Energy Action Plan, France commits itself to cover 23% of its energy consumption in 2020 by RES and 27% of its electricity consumption by RES. However, most of the RE electricity should originate from hydro power (46%) and wind

[103] Germany. **Corporate Income Tax Act (in German)**, Par. 23

[104] German Federal Statistical Office. **Average Real Tax Collection Rates (in German).**

power (37.3%). By 2020, solar power should cover at least 4.4% of RE electricity consumption and 1.3% of overall final gross electricity consumption.[105] Detailed composition of share of each type of RE technology on the total RE electricity consumption in France in 2010 and 2020 is visually depicted in Figure 4. As of April 2014, IC of PV installations in France are estimated to have amounted to nearly 4.5 GWp, representing 3.5% of the total IC of all electricity sources.[106]

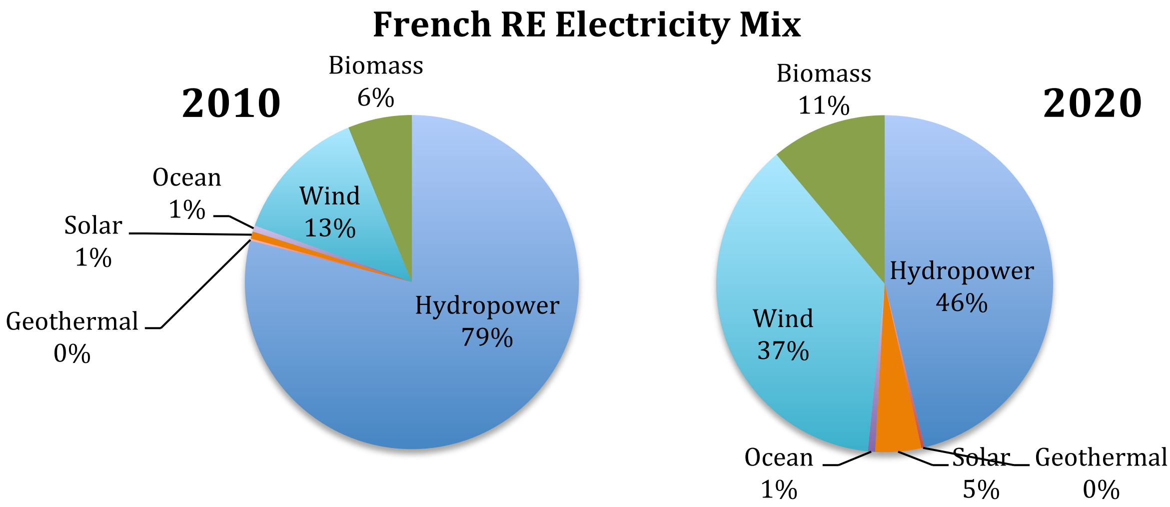


**Figure 4: French RE Electricity Mix in 2010 and 2020.** Own Elaboration.
**Data Source**: **Beurskens, L.W.M., and Hekkenberg, M.**

According to French National Renewable Energy Action Plan, France should account for production of 7% of all solar electricity generated in the EU Member States in 2020, which will make it the fourth biggest EU PV electricity producer. However, in order to reach this goal, it must be able to achieve an annual growth of almost 27% of capacity of PV electricity. The steepest growth should occur between 2010 and 2015 and then the boom is supposed to cool down.[107] Indeed, France has experienced a sign of solar boom in 2010 as a result of high fall in PV prices, which resulted in a three-month moratorium on

[105] Beurskens, L.W.M., and Hekkenberg, M. **Renewable Energy Projections as Published in the National Renewable Energy Action Plans of the European Member States**, p. 203

[106] Chabot, B. **PV Electricity in Production and Consumption of Electricity in France in April 2014 (in French).**

[107] Beurskens, L.W.M., and Hekkenberg, M. **Renewable Energy Projections as Published in the National Renewable Energy Action Plans of the European Member States**, p. 89

newly connected PV installations and a consequent considerable drop in FIT prices. However, thanks to constantly decreasing start-up costs of PVPPs, French PV market has soon recovered. As a matter of interest, the construction of what will be European largest solar park begun in November 2014 in the municipality of Cestas in France. The IC of the project should amount to 300 MWp with annual production of 350 GWh (which is equivalent to annual consumption of the city of Bordeaux) and the panels will cover nearly 300 ha of land.[108]

In general, attitude towards RES in France is ambivalent. When the 2030 EU Climate and Energy Package was being negotiated in 2014, French are reported to have worked behind the scenes against binding national targets for RE deployment.[109] The Author of this Thesis argues that the reason behind is that French power generation system depends heavily on nuclear power plants and the transformation involves significant costs. Nevertheless, will towards energy mix transformation is definitely present: nuclear power is capped by law to a maximum of 63.2 GW of absolute capacity, representing no more than 50% of the total capacity of electricity resources. Furthermore, in the new energy transformation bill which is being processed, the government sets an ambitious target of supplying 32% of overall energy consumption by RES.[110] Last but not least, United Nations Climate Change Conference (COP21) will take place in Paris in late 2015 with the main aim no less than achieving a binding and universal agreement on climate. Undoubtedly, France wants to be seen as a willing participant who is focused on low-carbon renewable energy.

##### *5.1.3.2 Types of Support of PV*

France employs two support schemes for PV RE, **feed-in tariffs** (*"des tarifs d'achat"*) and **tender calls** (*"des appels d'offres"*). Since July 1, 2011 (based on the Decree of March 4, 2011) FITs differ depending on the size and type of PV installation and are **announced quarterly** by the Ministry of Ecology, Sustainable Development and Energy. Their levels are adjusted depending on the increment of new PV installations for

[108] Menard, H. **Construction of the Largest Photovoltaic Park in Europe (in French).**

[109] Alves, R. **The 2030 EU Climate and Energy Package.**

[110] EY. **Renewable Energy Country Attractiveness Index**, p. 30

the previous period – if increment in installed performance of PV is in line with the planned path of 200 MW/year for integrated rooftop installations and 200MW/year for simplified rooftop installations, the FIT for the next period will be 2.6% lower; otherwise the decline in FIT may be smaller or even zero in order to attract more investment to the sector. FITs are guaranteed for a period of **20 years**[111] and are indexed to a rate *("coefficient L")* close to inflation.[112]

The RE electricity producer can choose between two ways of connection to the power grid. Either all the electricity produced is sold to the grid operator at a contractually given FIT, or the producer consumes a part of the generated electricity and only sells the surplus to the grid operator at the given FIT.[113]

| PV in France: Key Points | |
|---|---|
| **Type of Support** | Feed-in Tariffs, Tender Calls |
| **FIT Adjusted** | Quarterly |
| **Support Granted** | 20 years |
| **FIT Indexation** | Coefficient L (close to inflation) |

**Table 4: PV in France – Key Points.**
Source: Author's Work

French FITs reflect following **types of PV installations**:[114, 115]

- **Integrated rooftop installation** (*"L'intégration au bâti, IAB"*; **IC < 9 kWp**, applicable tariff T1) is an installation where PV panels are integrated directly to the building construction by replacing roof tiles. These small installations are ideal for residential buildings and they benefit from the highest FIT.
- **Simplified rooftop installation** (*"L'intégration simplifiée au bâti, ISB"*; **IC 0-36 kWp and 36-100 kWp**, applicable tariff T4) is an installation where PV panels are installed on a construction mounted to the existing rooftop.

[111] French Ministry of Ecology, Sustainable Development and Energy. **Purchase Prices (in French).**

[112] Alliance Solaire. **Photovoltaics - FAQ (in French).**

[113] Photovoltaïque.info. **Connected to the Network: Building-integrated Photovoltaics (in French).**

[114] Emig, M. **Types of PV Installations (in French).**

[115] Eco Infos. **Purchase Prices for PV Electricity (in French).**

The tilt of the panels must be parallel to the rooftop. Thanks to better ventilation, these systems achieve greater performance (efficiency of PV panels drops with increasing temperature); however, the FIT for these installations is lower. Simplified rooftop installations are the best for large rooftop areas and for off-grid systems where the producer cannot benefit from higher FIT.

- **Other installations** (*"Non-intégré au bâti"*, IC 0-12 MWp, applicable tariff T5), including the previous two types with IC > 100 kWp, or rooftop installations that do not meet all the requirements of the previous two types, or ground mounted installations, are subject to the lowest FIT; nevertheless, these benefit from good ventilation of the PV modules and from optimal tilt which both ensures maximal performance of the system.

Furthermore, until January 31, 2013, the FITs had also reflected type (purpose) of the building on which the PV system was installed: Systems mounted to residential buildings would have been guaranteed the highest FIT, educational and health institutions would have got an FIT of approximately one third lower and buildings with other purpose would have benefited from FIT of approximately three-fifths of the residential FIT.[116] However, for installations launched since February 1, 2013, these rules no longer apply.

The Decree of January 7, 2013 has amended the Decree of 4 March 2011 and has doubled target volumes of PV share and implemented a range of other changes for PV. Harmonization of tariffs depending on the use of the building was already mentioned in the previous paragraph. Apart for that, the Decree introduced a **bonus of 5% to 10%** of the FIT granted to PVPPs under tariffs T1 and T4 launched since February 1, 2013, components of which were made within the European Economic Area.[117] It also made significant cuts to FITs for simplified rooftop installations and at the same time **capped annual decline in FITs to 20%**.

[116] French Ministry of Ecology, Sustainable Development and Energy. **Purchase Prices in 2011 and 2012 (in French).**

[117] This bonus was also granted to PVPPs under tariff T5 launched since October 1, 2012.

The following Table 5 summarizes FITs guaranteed to PVPPs launched between January 1 and March 31, 2015. For FITs for the preceding periods see Appendix 4.

| | Integrated Rooftop Installation (IAB), 0-9 kWp | Simplified Rooftop Installation (ISB), 0-36 kWp | Simplified Rooftop Installation (ISB), 36-100 kWp | Other Installation, 0-12 MWp |
|---|---|---|---|---|
| **FIT (€ cents/kWh)** | 26.55 | 13.47 | 12.79 | 6.62 |

**Table 5: FITs guaranteed to PVPPs launched between 01/01/2015 and 31/03/2015. Source: Eco Infos.**

Considering that as of March 1, 2015, the price of electricity for household consumers in France was between 0.1378 €/kWh and 0.1641 €/kWh depending on the supplier,[118] it is obvious that the FIT for Other Installations is rather low. However, the previous table is not the only determinant of solar electricity purchase price. French Government regularly announces **tender calls** for projects of IC exceeding 100 kWp with an objective to adhere to long-term path for PV deployment. In practice this means that the Government has an annual target for volume[119] of PV installations (500 MWp in 2011 and 2012, 1000 MWp since 2013)[120] and it covers a part of this target by a tender call while leaving the remaining capacity available to FIT-granted installations.

Two tender calls have been closed so far, one for the period 2011/2012 and another one for the period 2013/2014. Presently, **third tender call** is declared with the deadline for submissions being June 1, 2015. The 2015 tender call is divided into two parts. The "simplified tender call" seeks a total of 120 MWp of IC in installations on buildings and parking shade structures between 100 - 250 kWp. The other part of the 2015 tender call aims to attract a total of 400 MWp of projects of IC exceeding 250 kWp, divided into several categories according to the size and type of installation (i.e. building mounted, ground mounted, parking shade structures, CSP technology, solar panels with trackers).[121]

The tender call defines price frame of the bids, as well as other parameters of the PVPPs. The final purchase price is then determined as a weighted average of the bidding

[118] Brandini, D. **The Price per KWh of Electricity in France in 2015. (in French)**

[119] (in terms of IC)

[120] Photovoltaïque.info. **Tender Procedures (in French).**

[121] Photovoltaïque.info. **Tender Procedures (in French).**

prices of the selected projects. The final prices are several as the projects are divided into categories based on the type of installation and technology involved. In the 2013 tender call, the average final purchase price of all the selected projects together was **14.238 € cents/kWh**,[122] i.e. nearly double compared to the price that would have been guaranteed to the projects under FIT support.

In conclusion, the Author of the Thesis argues that FITs are completely inappropriate for larger PV projects and **investors who seek large investment opportunities into PVPPs in France[123] should carry out their projects by submitting a bid to a tender call**.

#### *5.1.3.3 Taxation and Business Structures*

France provides certain types of tax benefits to PV projects, thus creating additional incentives to those mentioned in the previous subchapter. All of these benefits aim to support small-scale PV systems and direct consumption of the electricity produced. However, even larger, investment-motivated projects can benefit from taxation system in France. Although French corporate tax rate generally is 33.33%,[124] business regimes that allow for different taxations exist and are discussed further in this Chapter.

Income from PV electricity produced by individuals in small scale is exempt from the **income tax** (and any social contributions) under the following conditions. First, the PV installation must have an IC less or equal to 3kWp and second, a maximum of two such PV installations per household/owner is eligible for this exemption. An installation exceeding 3 kWp cannot however enjoy the tax exemption for the first 3 kWp of its IC. PVPP of IC greater than 3kWp can benefit from a special tax regime for **microenterprises** (*"régime de micro-entreprise"*), as long as its annual revenues do not exceed a certain level (€82,200 for 2014). Under this regime, a flat rate of tax deduction of 71% applies, in other words, the PV project run as a microenterprise will tax 29% of its income by income tax (at a progressive rate; for rates see Appendix 5) and social contributions (15.5%).[125]

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[122] Photovoltaïque.info. **Tender Procedures (in French).**

[123] Large investment meaning PV installations with IC over 100 kWp

[124] KPMG. **Corporate Tax Rates Table.**

[125] Photovoltaïque.info. **Tax System (in French).**

The PV installation can also opt for a "**simplified tax scheme**" (*"régime réel simplifié, RSI"*), which resembles a system used in corporations. This plan is obligatory for businesses with annual revenues between €82,200 and €783,000 and it reflects actual business costs, rather than using a flat tax deduction.[126] The same rates of income tax apply as in the case of microenterprises (for rates see Appendix 5). The drawback of this scheme is higher level of bureaucracy involved compared to microenterprise regime, as these businesses are required to fill out a number of forms and statements every year. However, the regime allows for deductions of actual costs and so is favourable for projects that involve high initial investment that can be gradually depreciated. Moreover, this scheme is especially beneficial to projects financed by debt, as interest paid on the loan is a tax-deductible expense.

Finally, PV installations may be run under the "**normal regime**" (*"régime réel normal, RN"*). Just like the previous tax regime, this plan determines the profit based on real costs; however, when compared, "normal regime" involves an even higher degree of paperwork. This scheme is obligatory for businesses exceeding the revenue border of the "simplified tax scheme".[127] As the border revenue is many times higher than the expected revenue of model PV projects analysed in this Thesis, this regime will not be discussed here in detail.

Apart from various tax regimes, a certain tax incentive is the reduced **VAT rate** on equipment, delivery and services related to PV installations. In order to benefit from this reduction, the solar system should be delivered and installed by one company. This reduced VAT rate is 10% since January 1, 2014 – but only small PV installations up to 3 kWp can benefit from it. For larger PVPPs, a VAT rate of 20% applies.[128]

Last but not least, expenditures in PV systems used to be eligible to tax credit (VAT would have been refunded). However, this is not the case anymore for expenses incurred after January 1, 2014.[129]

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[126] French Ministry of Finance. **Artisans and Traders – Tax Systems (in French).**

[127] French Ministry of Finance. **Artisans and Traders – Tax Systems (in French).**

[128] Eco Infos. **Taxation of Income from PV Panels in 2015 (in French).**

[129] Najdawi, C. **Tax Regulation Mechanisms I.**

## 5.2 Analysis of Investment in Photovoltaics

This Chapter aims to meet the main goal of this Thesis by providing an analysis of PVPPs in the selected countries while distinguishing between debt and equity financing. The Thesis investigates into current possibilities of large-scale investment in PV, thus serving the needs of large investors. Therefore this Chapter picks out pieces of legislation related to such big, investment-oriented PV installations and uses these pieces for construction of financial models of the investments. The models consequently estimate a wide range of capital budgeting parameters of the projects, most notably IRR and NPV. The outcomes are consequently evaluated and investment recommendations follow in Chapter 6.

For the sake of consistency and ease of comparison, some input parameters of the financial models of PVPPs are constant for all the countries. These parameters were provided to the Author of this Thesis by a Czech company operating on European PV market in the field of PVPP metering (further referred to as “the consulting company”). This company supplies complex solutions for measuring and diagnosing of the performance of PVPPs and as such has a number of data relevant to this Thesis. The **basic input parameters** used in the models in this Chapter are following:

- The IC of the model PVPP is 1 MWp
- The project is launched on January 1, 2015 and generates electricity ever since. Accounting is conducted on monthly basis.
- Initial investment is CZK 42,000,000 and is recalculated by a EUR/CZK rate of 27.49 CZK/EUR[130] to EUR 1,527,828. VAT is not considered.
- Lifespan of the PVPP is 20 years
- Performance of the PVPP drops by 1% per year
- Annual maintenance costs are 1.5% and increase at a rate of 1.03 per year
- Inverter cost is CZK 9,000,000 and is recalculated by a EUR/CZK rate of 27.49 CZK/EUR[131] to EUR 327,392.
- Inverter lifespan is 10 year[132]

[130] Exchange rate set by Czech National Bank as of March 2, 2015

[131] Exchange rate set by Czech National Bank as of March 2, 2015

- The installation is ground mounted[133]

The estimates assume purchase of all generated electricity by the grid operator.

Furthermore, the models that were used for the analysis differentiate between debt and equity financing. For **debt financing**, the assumptions were the following:

- Debt covered 100% of the initial investment
- Principal therefore equals the initial investment
- The interest rate was 5% p.a.
- The instalments were paid monthly, however, interest was counted on annual basis
- Simple interest rate was used

For analysing a **combination of debt and equity** financing, the proportion of debt finance to equity finance was 1:1, unless stated otherwise.[134]

Finally, the models use annual **discount rate** (i.e. cost of capital) **of 5%**. Apart from opportunity costs, the project cost of capital should reflect the risk factor of the project.[135] Assuming that both France and Germany constitute a stable business environment, a rather low discount rate seems to be adequate.

### 5.2.1 PV Investment in Germany

A detailed summary of German legislative framework towards PV, including types of support schemes and specifics of taxation, was presented and analysed in Chapter 5.1.2.

As Chapter 5.1.2.2 on types of support for PV under German legislation explains in detail, producers of PV electricity are either granted support in the form of a FIT, or a market premium. Market premium support scheme is currently obligatory for PVPPs with

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[132] The price of the new inverter was linearly distributed to a special fund (“inverter exchange fund”) over a period of 10 years and at that time did not generate any tax-deductible costs. After the purchase, the inverter was depreciated over a period of 10 years and thus constituted a tax-deductible item.

[133] This might have consequences on the type of purchase price to be used; some support is provided to rooftop installations only.

[134] However, the model can calculate with any proprotion of debt to equity finance.

[135] Brealey, R. A., Myers, S. C., Marcus, A. J.. **Fundamentals of Corporate Finance**, p. 423

IC exceeding 500 kWp, which makes it the type of support to be calculated with in this model. Under **market premium scheme**, the electricity producer markets and sells electricity directly by himself and gets an extra RE support retroactively at the end of each month. This support (called market premium) is determined as a difference between the remuneration basis for market premium (see Table 3 and Appendix 2), which is guaranteed to the electricity producer at the time of launch of his PVPP for 20 years to remain constant, and the average spot market price of electricity in the given month. Therefore, the actual compensation that the producer receives for the electricity he generates is dependent on the price he is able to sell his electricity for.

For the purpose of the analysis, the model PVPP is assumed to be running under the scheme of "**entrepreneurial company with limited liability**" (UG). This type of company is subject to commercial law, with all regulation and tax implications. It is safer for the investor to operate under the UG regime than under a sole proprietorship, because he eliminates the risk of losing his private assets in case of bankruptcy. The UG is only liable for its debts to the level of its capital – and contrary to other types of corporations, minimum capital for a UG is €1, which makes it accessible to establish. Furthermore, unlike sole proprietorship, UG is available to non-residents.

#### 5.2.1.1 Project Revenues

The revenues of the model project were calculated using the basic input parameters of a model PVPP and under following assumptions:

- Monthly performance data was based on average insolation in Germany,[136] amounting to a total annual production of **950.8 kWh** of electricity.
- The producer sells his electricity at the average spot market price for electricity. Hence, the overall compensation that he receives for his production equals the remuneration basis for market premium, which currently equals the FIT plus the "management bonus".
- Remuneration basis for market premium remains constant, irrespective of inflation.
- Remuneration basis for market premium is guaranteed for 20 years.

[136] See Appendix 6

#### 5.2.1.2 Project Costs

Apart for start-up costs, maintenance costs and costs of the inverter as specified above, the model for a PV investment in Germany reflected following costs and expenses:

- According to official **depreciation** tables of the German Federal Ministry of Finance, a PV installation is depreciated over a period of 20 years. The method of linear depreciation is used, i.e. a constant amount equal to 5% of the installation costs is depreciated and deduced from the tax base every year. A combination of degressive and linear depreciation would have been more favourable to use; however, since 2011, degressive depreciation is no longer allowed in Germany.[137]
- The **costs of inverter** (which is necessary to be replaced after first 10 years of the PVPP lifespan) are projected in the model in two ways: During the first 10 years, a corresponding fraction of inverter costs is put into a special account ("inverter exchange fund") and so the resulting cash outflows are spread evenly. However, no tax-deductible costs are generated in this way; this is only negatively reflected in cash flows. After 10 years, when the inverter is actually replaced, it starts generating a tax-deductible depreciation expense. Depreciation was calculated at a linear rate of 10%.
- The revenues were taxed by a corporate income tax of **15.825%** (incl. solidarity surcharge) and by a local trade tax of **13.825%**, which equals the average local trade tax rate for the whole Germany. This means that altogether, the income tax burden was **29.65%**. For details about these taxes see Chapter 5.1.2.3.
- **Loss** of up to €1,000,000 can be (and was) carried forward for an unlimited amount of time under German law.[138]

The model does not explicitly consider other costs such as insurance costs, management costs, personnel costs or costs of connection to the grid. Nevertheless, the rate of maintenance costs of 1.5% p.a. to some extent implicitly reflects these. Should anyone using the created model wish so, these costs could be easily added to the model by

[137] ECOVIS. **Photovoltaics Guide (in German)**, p. 3

[138] Germany. **Income Tax Act (in German)**, Par. 10d

increasing maintenance costs. Furthermore, the model does not evaluate establishment costs associated with setting-up a legal structure under which the PVPP is run.

However, there is one type of costs that this model reflects, contrary to the model of the French PVPP: it is the costs that are reflected in the "management bonus" under the market premium scheme. These are essentially the costs that represent expenses related to direct marketing of produced electricity – and direct marketing is an indivisible feature of the market premium scheme. In conclusion, the Author assumes that the model PVPP receives average market purchase price for its electricity, so together with the market premium earns a price equal to the FIT and fully spends the extra contribution ("management bonus") for direct marketing of electricity. In other words, the PVPP de facto reaches a purchase price equal to the FIT level.

#### 5.2.1.3 *Project Evaluation*

The model generated the following projection of the Net Present Value of cash flows (see Figure 5).[139]

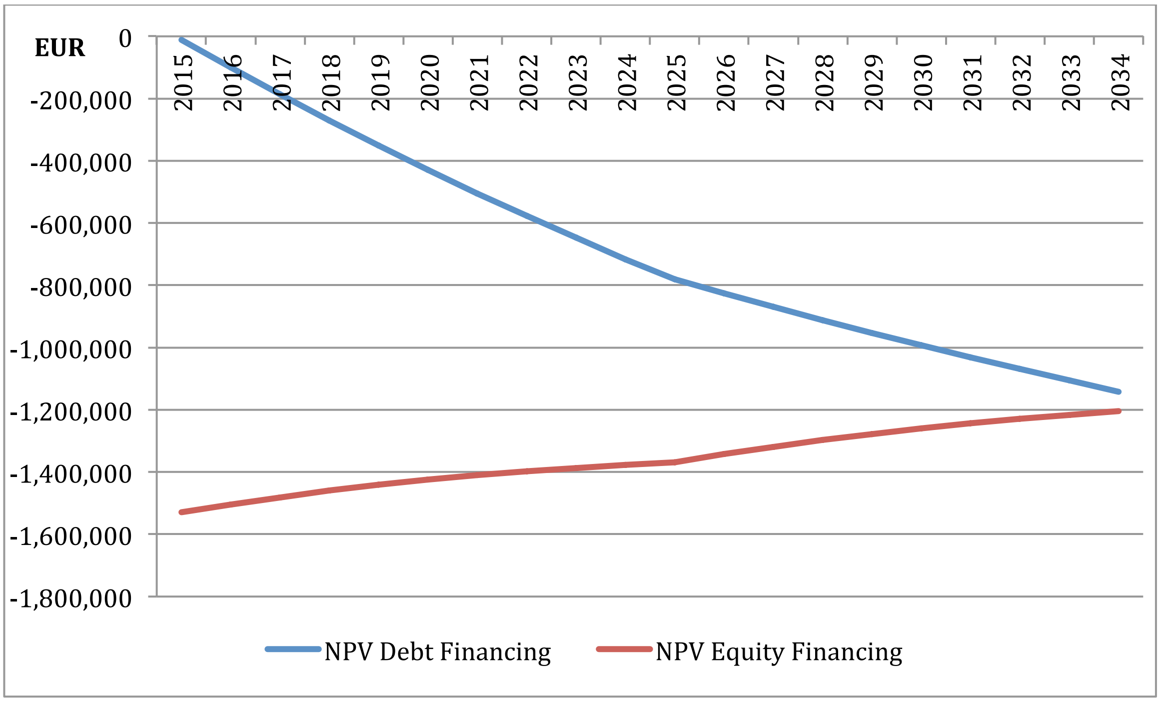


**Figure 5: NPV of Cash Flows of a German Model PVPP.** Own elaboration.

[139] The model is not capable of depicting the NPV of debt financing and a combination of debt and equity financing at the same time. For the NPV of combined financing see Appendix 7.

Furthermore, the model determined the following values of chosen capital budgeting indicators (see Table 6).

| Capital Budgeting Method | Equity Financing | Debt Financing | Combination of D+E |
|---|---|---|---|
| **Internal Rate of Return** | -7.60% | Not Applicable | N/A (negative CF) |
| **NPV At the End of the Project** | -1,192,835 | -1,172,883 | -1,182,859 |
| **Profitability Index** | 0.22 | Not Applicable | -0.55 |
| **Payback Period** | Exceeds 20 years | Not Applicable | Exceeds 20 years |
| **Return on Investment** | -63.15% | Not Applicable | -184.68% |

**Table 6: Capital Budgeting Indicators for the model PVPP in Germany**.
Own elaboration.

To graphically illustrate the Payback Period of the model PVPP, a projection of undiscounted cumulative future cash flows is depicted in Figure 6.

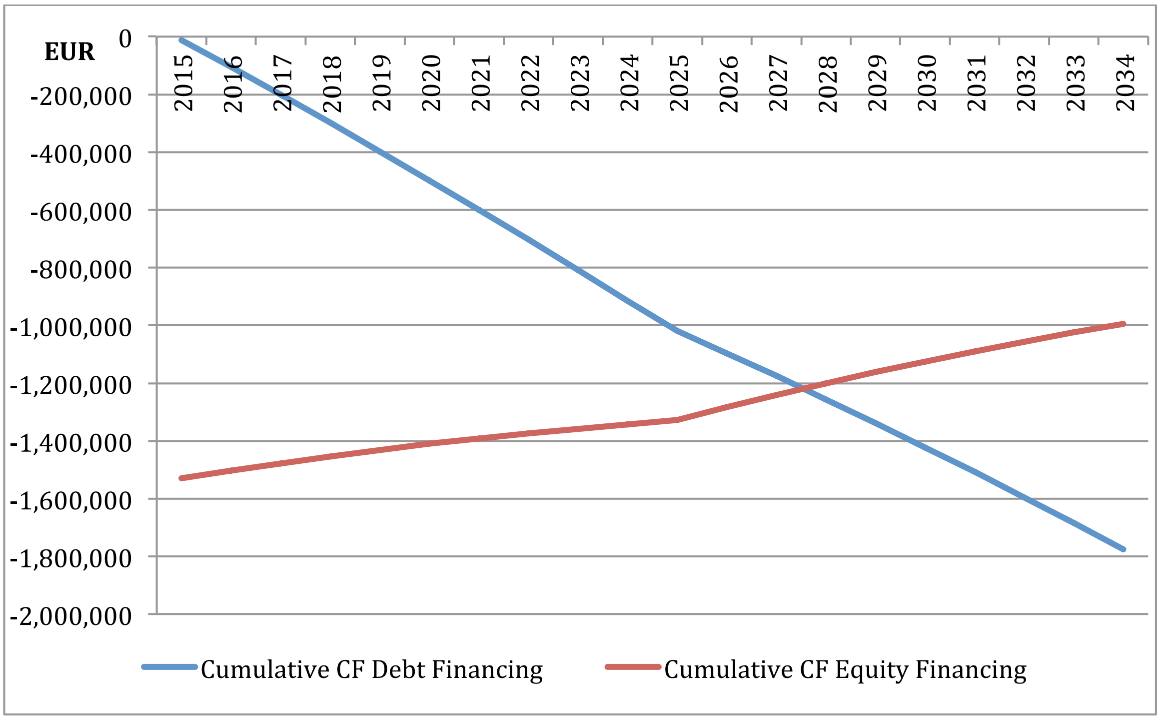


**Figure 6: Undiscounted Cumulative Cash Flows of a German Model PVPP**.
Own elaboration.

All the presented figures and values clearly illustrate that under given conditions, an investment into a PVPP of parameters identical to the ones of the model PVPP in Germany is **unprofitable, irrespective of type of financing or cost of capital** used. For both types of financing and for a combination of debt and equity alike, the Net Present Value of the investment is negative, which indicates that the project should be rejected at the given cost of capital. Moreover, the IRR is even negative with equity financing, not speaking about it being lower than the cost of capital of 5%.

Even simple capital budgeting indicators suggest that a project of these parameters should by no means be undertaken. Profitability index below one suggests turning the project down. Payback period in both cases by far exceeds the lifetime of the project. After all, a single look at the charts reveals that the cash flows resulting from this investment are not sufficient to cover the costs of debt finance and the indebtedness is continually increasing.

To sum up, judging from the model, it seems absolutely **undesirable to carry out a similar project in Germany** under current investment costs and legislation. Not even minor adjustments to the model, such as decrease in the cost of capital or the interest rate paid on the loan, can change this fact.

### 5.2.2 PV Investment in France

A thorough overview of French legislative framework towards PV, including types of support schemes and specifics of taxation, was presented and analysed in Chapter 5.1.3.

As analysed in detail in Chapter 5.1.3.2, a PVPP in France can either benefit from FITs or may be supported based on a purchase price agreement resulting from a tender call. As the aforementioned Chapter concludes, large PV projects with IC exceeding 100 kWp should be carried out under the support of tender calls in order to achieve satisfactory returns. However, the tender calls have so far been announced by French Government once in every two years. This means that large-scale PV entrepreneurs or investors must come up with their projects in the right time. One tender call is currently open, with the deadline for bids being June 1, 2015, but resulting purchase prices are not yet known. In analysis of investment of the model PVPP, this Chapter assumes that the facility has been **launched under a tender call** and as such benefits from a viable purchase price of electricity it produces.

The analysis assumes that the project is run in the "**simplified tax scheme**" regime (see Chapter 5.1.3.3). First, this scheme is available to projects of comparable expected annual revenue, unlike the regime for microenterprises, which has limits on annual turnover that would probably be exceeded by the model project. Second, the "simplified tax scheme" allows for calculation of the Income Tax based on real costs, which is necessary for the analysis to be able to compare between debt and equity financing. Subsequently, any VAT paid on expenses that are related to the PVPP is tax-deductible. Considering that the VAT rate on equipment, delivery and services related to PV installations exceeding the IC of 3kWp is 20%, this means a considerable advantage.[140]

#### *5.2.2.1 Project Revenues*

The revenues of the model project were calculated using the basic input parameters of a model PVPP and under following assumptions:

- Monthly performance data was based on average insolation in France,[141] amounting to a total annual production of **1,052.7 MWh** of electricity.
- Purchase price is assumed to be **14.24 €cents/kWh.** This is equal to the average purchase price of all types of PV projects (independent on technology used) with IC exceeding 250 kWp that resulted from the second tender call for the installations launched in the period of 2013-2014.[142] This price is also within the price range specified by the ongoing tender call.[143]
- Purchase price is assumed to be revaluated annually according to an inflation rate of 2%.
- Purchase price is guaranteed for 20 years.

#### *5.2.2.2 Project Costs*

Apart for start-up costs, maintenance costs and costs of inverter as specified above, the model of a PV investment in France reflected following costs and expenses:

- In France, PVPPs are usually depreciated over 20 years, although no specific tax rule applies. The model optimizes **depreciation** of the installation by employing a combination of degressive and linear depreciation in order to maximize tax-deductible expenses and spread them

[140] Please note that both in the model for Germany and for France, VAT is not reflected in the Initial Investment as both businesses are expected to be VAT payers.

[141] See Appendix 6

[142] Photovoltaïque.info. **Tender Procedures (in French).**

[143] Commission for Regulation of Energy. **Specifications of the tender concerning the construction and operation of PV facilities of performance greater than 250 kWp (in French)**, p. 29

to a longer period. During the first 14 years, the initial investment is being depreciated degressively at a rate of 15%. In the year 15 the model PVPP switches into linear depreciation and thus benefits from a more favourable depreciation figures for the last 6 years of its lifespan. This procedure is in line with current legislation.

- Similarly to the German PVPP model, the **costs of inverter** (which is replaced after first 10 years of the PVPP lifespan) are projected in the model in two ways: During the first 10 years, a corresponding fraction of inverter costs is put into a special account ("inverter exchange fund") and so the resulting cash outflows are spread evenly. However, no tax-deductible costs are generated in this way; this is only negatively reflected in cash flows. After 10 years, when the inverter is actually replaced, it starts generating a tax-deductible depreciation expense. This depreciation was calculated at a degressive rate of 15%. Thus, tax-deductible items are spread more equally over time.
- **Income tax rates** were determined based on Appendix 5. **Loss** was carried forward for up to 6 years, in line with French legislation.

The model does not explicitly consider other costs such as insurance costs, management costs, personnel costs or costs of connection to the grid. Nevertheless, the rate of maintenance costs of 1.5% p.a. to some extent implicitly reflects these. Should anyone using the created model wish so, these costs could be added to the model by simply increasing maintenance costs.

Finally, it shall be noted that the model does not evaluate establishment costs associated with setting-up a legal structure under which the PVPP is run.

#### 5.2.2.3 *Project Evaluation*

The model generated the projection of the Net Present Value of cash flows as shown in the Figure 7.[144]

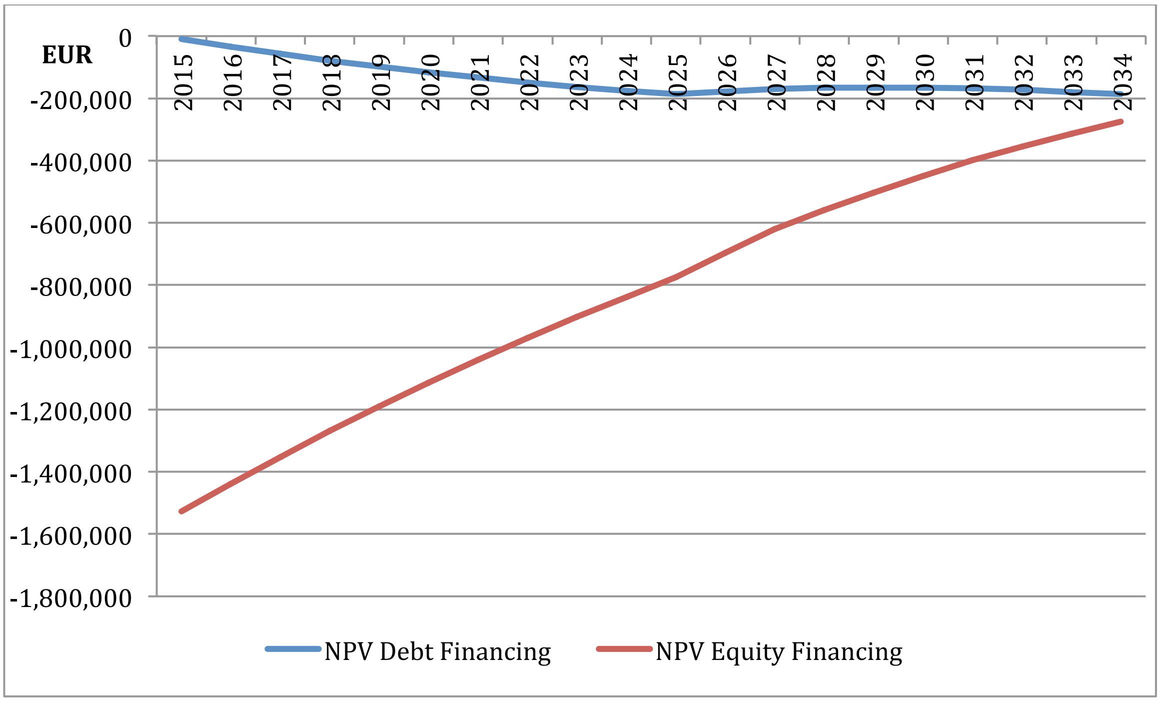


**Figure 7: NPV of Cash Flows of a French Model PVPP.** Own elaboration.

Furthermore, the model assessed the following values of chosen capital budgeting indicators (see Table 7).

| Capital Budgeting Method | Equity Financing | Debt Financing | Combination of D+E |
|---|---|---|---|
| **Internal Rate of Return** | 3.13% | Not Applicable | 0.31% |
| **NPV At the End of the Project** | -238,677 | -192,092 | -269,172 |
| **Profitability Index** | 0.84 | Not Applicable | 0.65 |
| **Payback Period** | 14.47 | Not Applicable | 18.52 |
| **Return on Investment** | 36.98% | Not Applicable | 3.18% |

**Table 7: Capital Budgeting Indicators for the model PVPP in France**.
Own elaboration.

144 The model is not capable of depicting the NPV of debt financing and a combination of debt and equity financing at the same time. For the NPV of combined financing see Appendix 8.

To visually illustrate the Payback Period of the model PV project, a projection of undiscounted cumulative cash flows is presented in Figure 8.

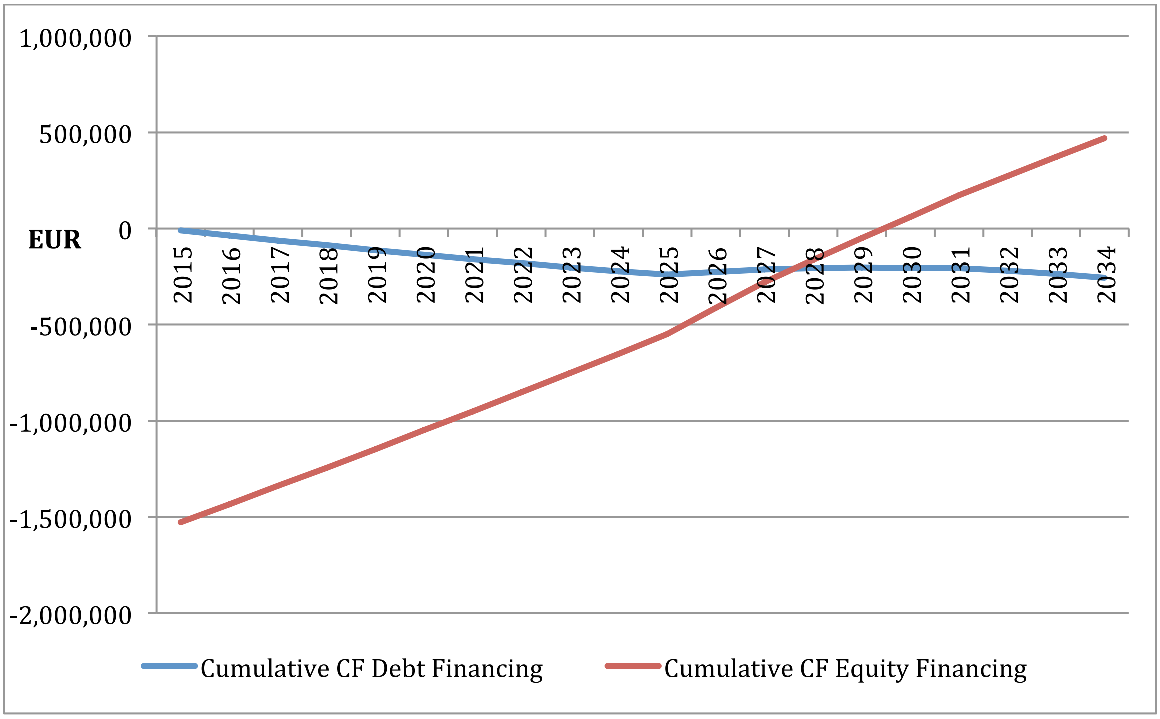


**Figure 8: Undiscounted Cumulative Cash Flows of a French Model PVPP**.
Own elaboration.

The predictions of the model of a PVPP operating in France are somewhat more optimistic than the ones for Germany. Although **NPV is negative** at the 5% cost of capital, the IRR of the project that uses equity finance is 3.13%. In other words, if it holds that the opportunity cost of capital indeed is 5%, then the project is inappropriate to be carried out. However, should the investor reconsider his cost of capital (for example based on the fact that France offers a stable, low-risk market environment) and set the discount rate below the hurdle rate (**IRR**) of **3.13%**, then he should decide **in favour of the project using 100% equity financing**.

However, debt financing of this project under the given conditions is unprofitable and should not be used. Both charts intuitively suggest that, as both discounted and undiscounted CF of the project are gradually falling, the project is not able to finance its debt and would need either more cash inflows, or a cheaper debt. NPV of the project financed 100% by debt is negative at the end of its lifespan and there is no way in improving this but to get a **more favourable interest rate** from the financial institution that provides debt financing. Matter of fact, readjusting the interest rate of approximately **3.3%** or lower resulted in positive NPV of the model project.

As for the other capital budgeting indicators, profitability index is less than one both in equity and combined financing and thus suggests not implementing the project. On the contrary, payback period of 14.5 years for equity financing and 18.5 years for combined financing implies undertaking both projects. However, as was discussed in Methodology, payback period is a simple method that exhibits several downsides, notably it does not reflect time value of money. Payback period should therefore not be the main factor for formulating the investment decision.

The interactive spreadsheet model for both countries can be found in Appendix 10.

# 6 Recommendations

Results of the conducted analysis speak clearly: Assuming the input parameters used in the model, an investor should implement the sample PV project **neither in Germany, nor in France**, no mater if he obtains the necessary funding through equity financing, debt financing or a combination of both.

Especially the model of a PVPP in **Germany is not even close** to being able to capitalize, irrespective of type of financing used – even when not considering time value of money. This is due to a set of unfavourable settings, namely low purchase price with no indexation, less advantageous depreciation methods available and lower level of insolation compared to France. In order to reach an IRR of at least 5%, the initial investment would have to fall by more than two thirds, or the purchase price for produced electricity would have to increase by almost 2.5 times, or the efficiency of the solar panels would have to be more than doubled, or a combination of these factors would have to occur.

However, the model of the PV investment in **France estimates an IRR of 3.13%** when using 100% equity finance. In other words, should the investor have cost of capital equal to or lower than 3.13%, he should undertake the project, as it would then have a nonnegative NPV. Those who like to make decisions based on simple metrics might appreciate that the Payback Period of the French project is 14.5 years with equity financing and 18.5 years with financing through 50% debt and 50% equity (while the project lifespan is 20 years). Unfortunately, Payback Period should not play a decisive role in capital budgeting decisions and is therefore relatively unimportant.

Debt financing of the PV investment in France under the given conditions is unprofitable and should not be used, as the cost of debt is higher than the cash inflows. Nevertheless, readjusting the model revealed that should the PV entrepreneur be able to get an **interest rate of 3.3% or lower**, the NPV of the project at 5% discount rate would be positive and the project should therefore be implemented.

In summary, the conducted analysis of investment in PV found out that under present conditions, **large-scale PV installations are not a very attractive field** to be in for investors. Author of the Thesis is of the opinion that this fact actually confirms

**efficiency of existing policies** towards PV in Germany and France. After all, if a country is able to cut down the profits of PV investors to the minimum and still meet the running goals for RES deployment, it can be interpreted as a great success for local policymakers. Overview of both German and French RE policy tools indicates that these countries are able to respond flexibly to the evolving PV market and tightly adjust their policies to the national targets for share of RE on energy consumption. Author sees this approach of policymakers to be rational and argues that RES and especially PV installations should not serve venture investors seeking high returns on investment. Rather, it should be households and small enterprises that should benefit from revenues guaranteed by favourable purchase prices of RE electricity.

On the other hand, another important implication for RE policymakers can be made. RE electricity support is financed through a surcharge to the electricity price and so is paid by the consumers. If a state only takes the path of guaranteeing high support to small rooftop systems, the price of RE electricity will be much higher than it would have been if legislation promoted large, more efficient PV installations that can benefit from economies of scale and generate electricity at much lower costs. Therefore, a **balanced approach** to support seems to be optimal – and that is actually what we can observe in France, where the state sets volume quotas graded by size of the PV facility.

The results of the analysis also imply an important lesson for businesses involved in the **PV supply chain**. These companies should focus on smaller PV systems designed for households and buildings, because those are the PVPPs that are the most supported by French (and to a lesser extent also by German) RE policy; and of course, higher margins can be achieved here. In addition, new business models should be developed in order for PV businesses and investors to adjust to the evolving policies and benefit from them.

## 6.1 Limitations of the model

Theory argues that the highest chance of error with calculation of IRR and other capital budgeting indicators is the use of ***promised*** **cash flows** instead of more accurate *expected* cash flows.[145] Admittedly, when using purchase prices guaranteed by the state, the model de facto operates with promised cash flows. Examples of retroactive measures

[145] Welch, I.. **Corporate Finance: An Introduction**, p. 389

carried out in some countries show that what is promised by the state does not always hold. This is a limitation of the model that is rather challenging to control. Nevertheless, it needs to be said that both France and Germany exhibit a stable political environment, and so what the state promises hopefully is close enough to what can be expected.

Both the model for France and for Germany suffers from the same drawback that reduces the rate of return: The revenue is calculated based on **average levels of insolation** for each of the countries. However, it is quite likely that a real PVPP would be built at a location with above-average insolation and its yields would be correspondingly higher.

Furthermore, the model of a PVPP in France calculates the revenues based on the price that resulted from a tender call conducted in **2013**. It could have used the regular FIT (which is much lower) but in practice, no PV installations of the size of the model PVPP would be operating under the FIT regime – and that is why the model used tender call price. However, it is likely that the price that will result from the current 2015 tender call[146] will be lower than the price used in the model and so the real revenues would be lower too.

In addition, the model calculates with a twenty-year **lifetime** of the project, which is equal to the period of guaranteed support. However, real lifespan of a PVPP is somewhere between 25 and 30 years. The question which now has no known answer is: What happens after the guaranteed support ends? At that time, market price for electricity may be well above the production costs of PV electricity and revenue streams might consequently be maintained beyond the expected period of operation. This would apparently positively affect the returns of the project and it might even result into a different investment recommendation.

Besides, some inputs of the model that affect future revenues are likely to **change during the project lifetime**: Most typically the taxes. For example, taxation of income has been changing every few years in France. However, these changes are hardly predictable and so are close to impossible to control for in the financial model.

Moreover, the model assumed a ground mounted PV installation; yet it did not explicitly consider any **land tax or land rent**. However, both can be easily added to the

[146] Unfortunately, bidding for the 2015 tender call is still in progress and so the Author could not utilize the price that would result from it in the model.

maintenance costs of the PVPP. Provided that the model calculated with slightly above-average maintenance costs, an explicit addition of land tax would probably not affect the model outcome in any significant way.

Another taxation issue exists: German corporate income tax consists of federal and local tax that is set by every municipality. The model calculates with an average local trade tax. However, a PVPP would probably be situated in the country rather than in a city. Considering that big cities usually have higher rate of the local trade tax than the surrounding municipalities, an **average local trade tax** outside the city where the PVPP would be situated would probably be somewhat lower, which would positively affect the investment cash flow and returns. Nevertheless, due to methodological and practical challenges associated with calculating something like an average local trade tax in German countryside, the model uses an average for the whole Germany. After all, the financial model for Germany always generated loss and so no taxation occurred – so this issue is mentioned only so that future users of the model are aware of it.

Finally, a weak point of the model might be the PVPP data it uses, most importantly the **start-up costs**. Although these pieces of data were provided by a company that specializes in PV, start-up costs might quite well have been somewhat obsolete, considering that Germany reviews its FITs on a monthly basis in order to reflect falling costs of PV installations. Readjustment of the initial investment might therefore lead to slightly more favourable outcome of the model. Yet, as was mentioned above, experiments with the model proved that the start-up costs of the PVPP in Germany would have to fall by more than two thirds in order for the project to achieve IRR above 5% - so a slight adjustment to the initial investment would not significantly change the overall outcome.

## 6.2 Further Research

This Thesis virtually proposed an approach to comparing investments in PV installations in various countries. Author is of the opinion that future research could definitely continue in the given direction by incorporating more EU countries and extending functionality of the developed financial model.

In addition, **self-consumption** of PV electricity constitutes a whole area with broad opportunities for analysis. In case of Germany where electricity prices by far exceed PV electricity generation costs, self-consumption seems to be the best option for PV investment, in spite of a clear tendency of the policymakers to impose the renewable energy surcharge even on self-consumed electricity. Self-consumption has not been the subject of analysis of this Thesis, yet constitutes an important stimulus for PV investments among both households and industrial electricity consumers in Germany. Average electricity price including taxes and levies in the first half of 2014 was €0.298 per kWh for households and €0.159 per kWh for industrial consumers. Considering that the electricity purchase price used in the German model was €0.087 per kWh, self-consumption leads to a very different result of the analysis.[147] Therefore, the Author argues that further research should focus on developing a financial model that is compatible with self-consumption.

Finally, in broader sense, future research in the field of PV could concentrate on developing new business models that would allow PV businesses and investors to adjust to the evolving policies and benefit from them at the maximum degree possible.

[147] For tentative projections of results of the model when it assumes sale of electricity at consumer electricity prices instead of at market premium prices, see **Appendix 9**.

# 7 Conclusions

The Thesis successfully answered the core question of the research: Presently, in 2015, investment in large-scale PV installations in Germany and France is rather unattractive. In Germany, the project was found out to be severely unprofitable and only returned positive capital budgeting indicators after massive adjustments to the input variables were made. Although limitations of the model admit that input data might not be perfectly reliable, a final investment recommendation for Germany is a clear “No”. Yet, the PV project has proved profitable in France, provided that investor’s opportunity cost of capital is low, or that a low interest debt is available. Considering that France constitutes a relatively stable market and regulatory environment, a strictly negative investment recommendation would not be adequate. Although the investment in France will be far from yielding high profits, a risk-averse investor could still benefit from it.

By all means, the financial model that was developed and employed for assessing the investment constitutes the most valuable part of the Thesis. It is easily expandable, enables control for a wide range of variables and generates a number of useful capital budgeting indicators. Comparable models are created and utilized in practice by real businesses and this one could serve professional needs as well.

Irrespective of the model outcomes, the Thesis is a significant contribution to the field of RES policy. It includes a detailed analysis of RES-related legislation of two countries that successfully manage continuous development of RE electricity generation without threatening the stability of market environment or causing an uncontrollable boom. This analysis was a rather challenging task, considering that many documents were only available in original languages. A summary of the findings is therefore certainly beneficial: The key aspects of both legislations, as well as comments on them that are presented in this Thesis, could serve as a useful source of inspiration to policymakers in other countries.

To conclude, the main findings of the Thesis indirectly indicate that investors should start investigating into more sophisticated models in RES than just building a power plant and receiving support for electricity supplied to the power grid. As grid parity is being achieved throughout Europe and electricity prices are rising, business models adapted to self-consumption might represent a good opportunity both for business consultants and future academic research.

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# 9 Appendices

**Appendix 1: Overview of German FITs from January 2013 to March 2015**

| FIT (€ cents/kWh) | **Rooftop Installation up to 10 kWp** | **Rooftop Installation up to 40 kWp** | **Rooftop Installation up to 1 MWp** | **Rooftop Installation up to 10 MWp** | **Other Installation up to 10 MWp** |
|---|---|---|---|---|---|
| **January 2013** | 17.02 | 16.14 | 14.40 | 11.78 | 11.78 |
| **February 2013** | 16.64 | 15.79 | 14.08 | 11.52 | 11.52 |
| **March 2013** | 16.28 | 15.44 | 13.77 | 11.27 | 11.27 |
| **April 2013** | 15.92 | 15.10 | 13.47 | 11.02 | 11.02 |
| **May 2013** | 15.63 | 14.83 | 13.23 | 10.82 | 10.82 |
| **June 2013** | 15.35 | 14.56 | 12.99 | 10.63 | 10.63 |
| **July 2013** | 15.07 | 14.30 | 12.75 | 10.44 | 10.44 |
| **August 2013** | 14.80 | 14.04 | 12.52 | 10.25 | 10.25 |
| **September 2013** | 14.54 | 13.79 | 12.30 | 10.06 | 10.06 |
| **October 2013** | 14.27 | 13.54 | 12.08 | 9.88 | 9.88 |
| **November 2013** | 14.07 | 13.35 | 11.91 | 9.74 | 9.74 |
| **December 2013** | 13.88 | 13.17 | 11.74 | 9.61 | 9.61 |
| **January 2014** | 13.68 | 12.98 | 11.58 | 9.47 | 9.47 |
| **February 2014** | 13.55 | 12.85 | 11.46 | 9.38 | 9.38 |
| **March 2014** | 13.41 | 12.72 | 11.35 | 9.28 | 9.28 |
| **April 2014** | 13.28 | 12.60 | 11.23 | 9.19 | 9.19 |
| **May 2014** | 13.14 | 12.47 | 11.12 | 9.10 | 9.10 |
| **June 2014** | 13.01 | 12.34 | 11.01 | 9.01 | 9.01 |
| **July 2014** | 12.88 | 12.22 | 10.90 | 8.92 | 8.92 |

| FIT (€ cents/kWh) | **Rooftop Installation up to 10 kWp** | **Rooftop Installation up to 40 kWp** | **Rooftop Installation up to 500 kWp** | **Other Installation up to 500 kWp** |
|---|---|---|---|---|
| **August 2014** | 12.75 | 12.40 | 11.09 | 8.83 |
| **September 2014** | 12.69 | 12.34 | 11.03 | 8.79 |
| **October 2014** | 12.65 | 12.31 | 11.01 | 8.76 |
| **November 2014** | 12.62 | 12.28 | 10.98 | 8.74 |
| **December 2014** | 12.59 | 12.25 | 10.95 | 8.72 |
| **January 2015** | 12.56 | 12.22 | 10.92 | 8.70 |
| **February 2015** | 12.53 | 12.18 | 10.90 | 8.68 |
| **March 2013** | 12.50 | 12.15 | 10.87 | 8.65 |

Prices are in € cents / kWh.

*Own elaboration.* ***Data source: German Federal Network Agency.***

**Appendix 2: Overview of German Market Price Bases since their introduction in August 2014 to March 2015**

| Basis for Market Premium (€ cents/kWh) | **Rooftop Installation up to 10 kWp** | **Rooftop Installation up to 40 kWp** | **Rooftop Installation up to 1 MWp** | **Other Installation up to 10 MWp** |
|---|---|---|---|---|
| **August 2014** | 13.15 | 12.80 | 11.49 | 9.23 |
| **September 2014** | 13.08 | 12.74 | 11.43 | 9.18 |
| **October 2014** | 13.05 | 12.70 | 11.40 | 9.16 |
| **November 2014** | 13.02 | 12.67 | 11.38 | 9.14 |
| **December 2014** | 12.99 | 12.64 | 11.35 | 9.12 |
| **January 2015** | 12.95 | 12.61 | 11.32 | 9.09 |
| **February 2015** | 12.92 | 12.58 | 11.29 | 9.07 |
| **March 2013** | 12.89 | 12.55 | 11.26 | 9.05 |

Prices are in € cents / kWh.

*Own elaboration.* ***Data source: German Federal Network Agency.***

**Appendix 3: Specifications of Ground Mounted PV Installations to Be Eligible to FIT in Germany**

*"(...) the installation (...)*

*2. has been erected on an area for which a procedure pursuant to Section 38 sentence 1 of the Federal Building Code has been carried out or*

*3. has been erected in the area of an adopted local area plan within the meaning of Section 30 of the Federal Building Code and*

*a) the local area plan was produced before 1 September 2003 and was not subsequently altered for the purpose of erecting an installation to generate electricity from solar radiation energy,*

*b) the local area plan designated a commercial or industrial area within the meaning of Sections 8 and 9 of the Federal Land Utilisation Ordinance before 1 January 2010 for the area on which the installation has been erected, even if the stipulation after 1 January 2010 was altered at least partially for the purpose of erecting an installation to generate electricity from solar radiation energy, or*

*c) the local area plan was produced or altered after 1 September 2003 at least partially for the purpose of erecting an installation to generate electricity from solar radiation energy and the installation*

*aa) is located on areas which are alongside motorways or railways and the installation has been erected at a distance of up to 110 metres measured from the further edge of the paved transport route,*

*bb) is located on areas which were already sealed at the time of the decision on the establishment or alteration of the local area plan, or*

*cc) is located on conversion areas from commercial, transport-related, residential or military use and these areas had not been bindingly designated nature conservation areas within the meaning of Section 23 of the Federal Nature Conservation Act or as a national park within the meaning of Section 24 of the Federal Nature Conservation Act at the time of the establishment or alteration of the local area plan."*

***Source**: Excerpt from the **EEG - Renewable Energy Act 2014,** Section 51, Par. 1*

**Appendix 4: Overview of French FITs from February 1, 2013 to March 31, 2015**

| Tariff Type | Type of Installation and its IC | | Period of Launching of the Installation | | | |
|---|---|---|---|---|---|---|
| | | | 01/02/13 31/03/13 | 04/01/13 06/30/13 | 07/01/13 30/09/13 | 01/10/13 31/12/13 |
| T1 | Integrated Rooftop Installation (IAB) | [0-9 kWp] | 31.59 | 30.77 | 29.69 | 29,10 |
| T4 | Simplified Rooftop Installation (ISB) | [0-36 kWp] | 18.17 | 16.81 | 15.21 | 14.54 |
| | | [36-100 kWp] | 17.27 | 15.97 | 14.45 | 13.81 |
| T5 | Other Installation | [0-12 MW] | 8.18 | 7.96 | 7.76 | 7.55 |

| Tariff Type | Type of Installation and its IC | | Period of Launching of the Installation | | | | |
|---|---|---|---|---|---|---|---|
| | | | 01/01/14 31/03/14 | 01/01/14 31/03/14 | 01/07/14 09/30/14 | 01/10/14 31/12/14 | 01/01/15 03/31/15 |
| T1 | Integrated Rooftop Installation (IAB) | [0-9 kWp] | 28.91 | 27.94 | 27.38 | 26.97 | 26.55 |
| T4 | Simplified Rooftop Installation (ISB) | [0-36 kWp] | 14.54 | 14.16 | 13.95 | 13.74 | 13.47 |
| | | [36-100 kWp] | 13.81 | 13.45 | 13.25 | 13.05 | 12.79 |
| T5 | Other Installation | [0-12 MW] | 7.36 | 7.17 | 6.98 | 6.80 | 6.62 |

Prices are in € cents / kWh.

***Source****: Own elaboration of data available under the following Resources:*

*French Ministry of Ecology, Sustainable Development and Energy.* ***Purchase Prices in 2013 (in French).***

*French Ministry of Ecology, Sustainable Development and Energy.* ***Purchase Prices in 2014 (in French).***

*Eco Infos.* ***Purchase Prices for PV Electricity (in French).***

**Appendix 5: French Marginal Tax Rates in 2015**

| Taxable Income (in €) | Tax Rate |
|---|---|
| Up to 9,690 | 0% |
| From 9,690 to 26,764 | 14% |
| From 26,764 to 71,754 | 30% |
| From 71,754 to 151,956 | 41% |
| Over 151,956 | 45% |

*Source: French Ministry of Finance.* ***Marginal Tax Rates on Income Tax (in French).***

Note: These rates apply on income from 2014.

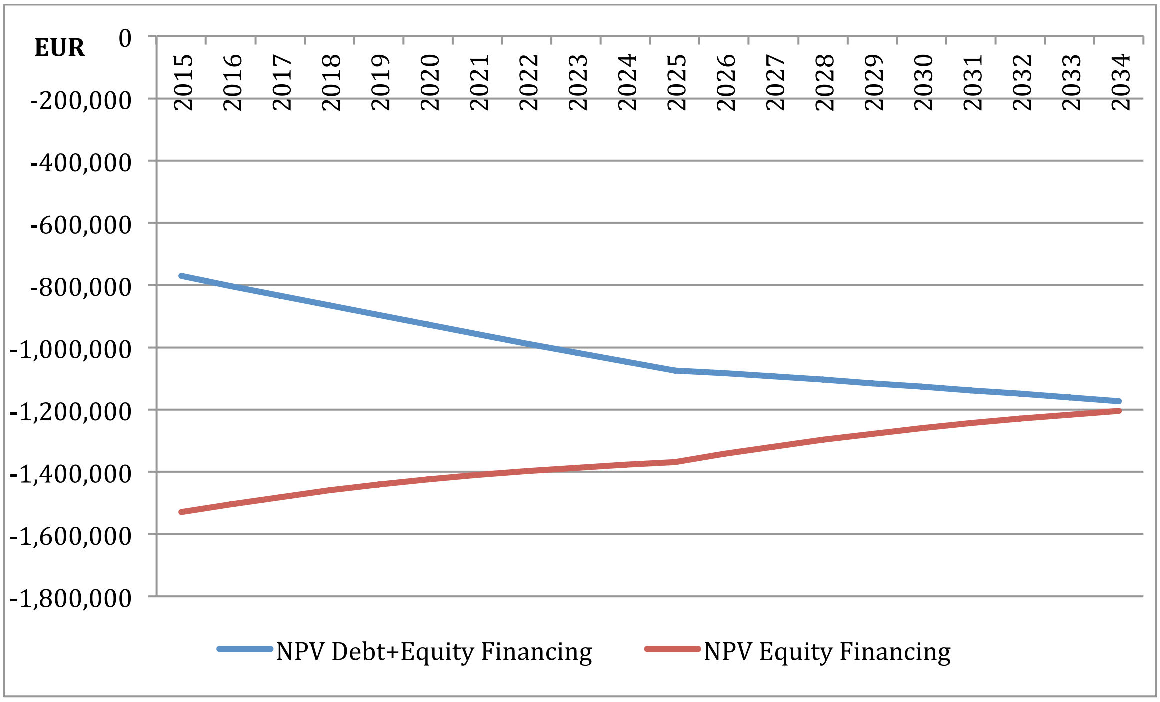
**Appendix 6: Average Monthly Performance [kWh] of a 1MWp PVPP**

| Month | **Germany** | **France** |
|---|---|---|
| **Jan** | 30,300 | 36,200 |
| **Feb** | 47,100 | 55,400 |
| **Mar** | 87,900 | 99,300 |
| **Apr** | 113,000 | 114,000 |
| **May** | 116,000 | 118,000 |
| **Jun** | 116,000 | 123,000 |
| **Jul** | 116,000 | 131,000 |
| **Aug** | 109,000 | 120,000 |
| **Sep** | 89,900 | 107,000 |
| **Oct** | 65,400 | 74,400 |
| **Nov** | 34,300 | 40,400 |
| **Dec** | 25,900 | 34,000 |

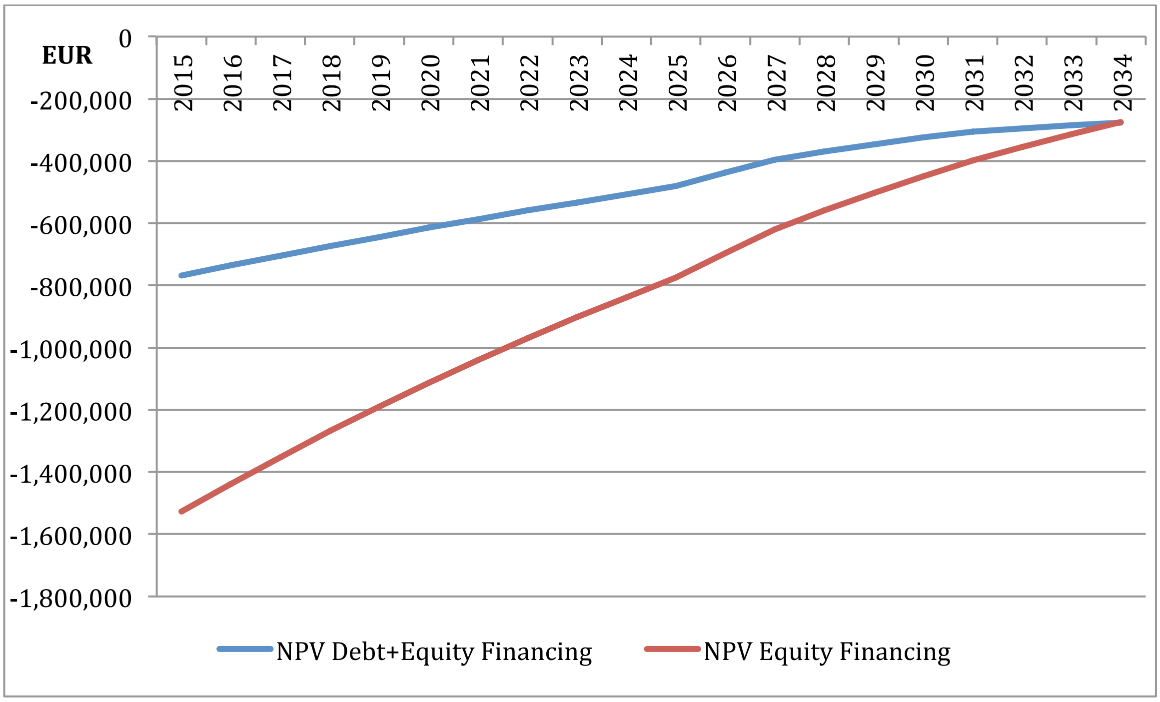
***Source: Internal data of the consulting company.***

Note: These figures assume constant efficiency of the solar cells. The difference in performance is only caused by different insolation levels.

**Appendix 7: NPV of Cash Flows of a German Model PVPP.** Own elaboration.




**Appendix 8: NPV of Cash Flows of a French Model PVPP.** Own elaboration.

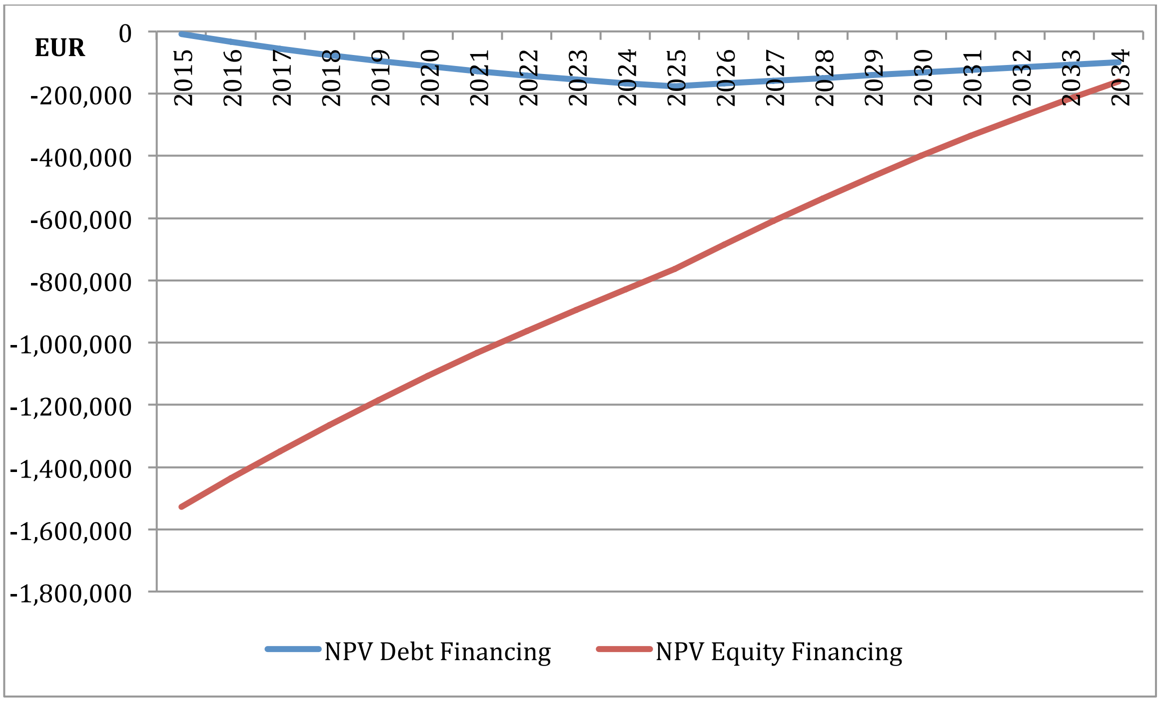


**Appendix 9: Tentative Projections of Results of the Model Using Consumer Electricity Prices Instead of RE Remuneration.** Source of Figures and Tables: Own elaboration.

*Continued on the next page.*

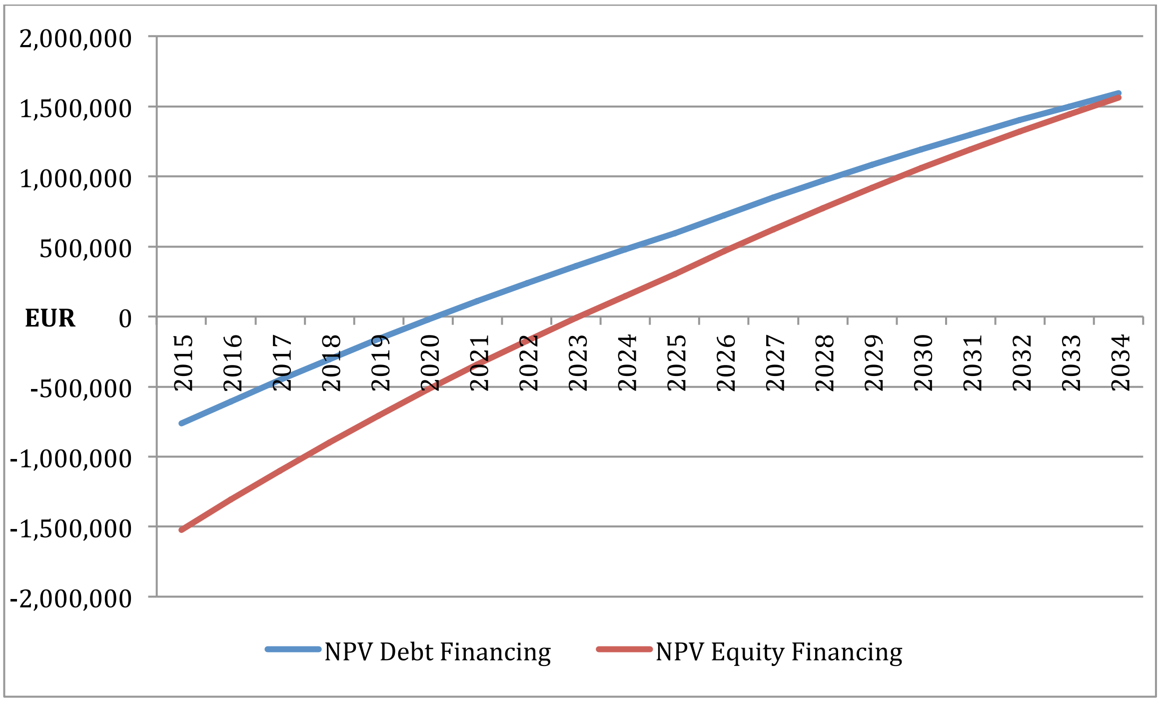
1. Capital budgeting indicators as estimated by the Model, assuming that all electricity produced is sold at an **average electricity price for industrial consumers** (i.e. initial purchase price = **€0.159/kWh**, inflation rate 2%):

| Capital Budgeting Method | Equity Financing | Debt Financing | Combination of D+E |
|---|---|---|---|
| **Internal Rate of Return** | 4.22% | Not Applicable | 3.69% |
| **NPV At the End of the Project** | -108,471 | -88,519 | -98,495 |
| **Profitability Index** | 0.93 | Not Applicable | 0.87 |
| **Payback Period** | 13.79 | Not Applicable | 14.69 |
| **Return on Investment** | 55.72% | Not Applicable | 53.05% |



2. Capital budgeting indicators as estimated by the Model, assuming that all electricity produced is sold at an **average electricity price for household consumers** (i.e. initial purchase price = **€0.298/kWh**, inflation rate 2%):

| Capital Budgeting Method | Equity Financing | Debt Financing | Combination of D+E |
|---|---|---|---|
| **Internal Rate of Return** | 15.10% | Not Applicable | 23.10% |
| **NPV At the End of the Project** | 1,673,210 | 1,693,163 | 1,683,186 |
| **Profitability Index** | 2.10 | Not Applicable | 3.20 |
| **Payback Period** | 6.50 | Not Applicable | 4.45 |
| **Return on Investment** | 245.82% | Not Applicable | 433.24% |



**Appendix 10: Financial Model of a Sample PVPP in Germany and France**

The model can be downloaded from:

**http://ondrejprusa.com/solar/model.xlsx**

Password: Olda

This model served as a basis for analyses conducted in this Thesis.