Die approbierte Originalversion dieser Diplom-/Masterarbeit ist an der Hauptbibliothek der Technischen Universität Wien aufgestellt (http://www.ub.tuwien.ac.at).

The approved original version of this diploma or master thesis is available at the main library of the Vienna University of Technology (http://www.ub.tuwien.ac.at/englweb/).

MSc Program
Renewable Energy in Central and Eastern Europe

Influence of different supporting schemes on business models for PV systems in Europe

An evaluation of business models and the specific influence of the national supporting schemes in Austria, Germany, France and Great Britain.

A Master's Thesis submitted for the degree of
"Master of Science"

supervised by
Dipl. Ing. Hubert Fechner MSc, MAS

Dr.Christoph Rass

0827599

Trier, 6. November 2010

Affidavit

I, **Christoph Rass** hereby declare

1. that I am the sole author of the present Master Thesis, " Influence of different supporting schemes on business models for PV systems in Europe", 78 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
2. that I have not prior to this date submitted this Master Thesis as an examination paper in any form in Austria or abroad.

Trier, ________________ ____________________________

Date Signature

Abstract

The technology of photovoltaic has been identified in Europe as a major source of electric power generation for the future, but the still high costs of this technology require subsidies to boost photovoltaic electricity generation. In Austria, Germany, France and the United Kingdom support schemes, based on feed in tariffs, have been introduced to reach this target.

But which business models are adequate to increase the share of photovoltaic power generation and how do the national supporting schemes affect these business models? And what will happen, when supporting schemes are fading out?

To evaluate appropriate business models in the four countries, the structure of the national schemes will be identified and feasible business models will be introduced, taking size and location of the photovoltaic power plants into consideration.

In France and Austria the 100% feed into the grid business models is at the moment the best solution. In Germany partial self consumptions could offer better results and in the United Kingdom self consumption is superior to 100% feed into the grid. Nevertheless all business models are still depending on the national supporting schemes.

In the future business models under absence of supporting schemes will be possible, when the initial invest for photovoltaic power plants will decrease significantly and the lifetime of the plants could be extended to a range of 40 years.

Table of Content

List of Tables

List of Figures

Abbreviations

a	Year
BIPV	Building integrated Photovoltaic
BOS	Balance of System
DCF	Discounted Cash Flow
EEG	Erneuerbare Energien Gesetz
EEX	European Energy Exchange
EIA	Environmental Impact Assessment
EPIA	European Photovoltaic Industry Association
EU	European Union
FiT	Feed in Tariff
GWp	Gigawatt Peak
IPCC	Intergovernmental Panel on Climate Change
IRR	Internal Rate of Return
JRC	Joint Research Center of the European Union
kWh	Kilowatt Hour
kWp	Kilowatt Peak
MCS	Microgeneration Certification Scheme
MT	Master's Thesis
MWp	Megawatt Peak
NEA	Nation Energy Act USA
NOCF	Net Operation Cash Flow
NPV	Net Present Value
OFGEM	Office of the Gas and Electricity markets
OPEX	Operational Expenditure
PHPP	Passivhaus Projektierungs Paket
PURPA	Public Utility RegulatoryAct
PV	Photovoltaic
REC	Renewable Energy Credit
RES	Renewable Energy Sources
RO	Renewable Obligation
ROC	Renewable Obligation Certificate
ROI	Return of Investment
RPS	Renewable Portfolio Standards
SREC	Solar RenewableEnergyCredit
StrEG	Strom Einspeise Gesetz
TRC	Tradable RenewablesCredits
VAT	Value Added Tax

1. Introduction

1.1.Motivation

In the last decades photovoltaic has undergone a tremendous development and it is becoming more and more a major driver for future renewable electric energy generation. The uncomplicated installation of the system combined with sharply declined prices for PV components making this technology a favourable energy source for the future. It can be foreseen, that due to economies of large scale, the production costs of the PV systems will reach a competitive price level in the next decade. Especially if the hidden costs of fossil energy use are taken into account, the price for solar electricity is close to being competitive. PV technology is easy to handle, has very limited risks and the maintenance costs of the plants are the lowest in the electricity production sector. The sun, as the resource of energy for PV, is nearly infinite and it is free of charge. The input price - the main reason for economic uncertainty -is zero and it will remain zero. That makes the use of sunlight as the future source of energy for our planet the most attractive.

The first investments in PV installations were in general driven by individuals, who had a strong ecological consciousness. Small single home installations were often not connected to the grid and were used to generate energy for individual use. With the climate change report 2007of the IPCC[1], the attention of the public was attracted and the consequences of the excessive use of fossil energy sources became obvious for the common citizen. As consequence, politics reacted in supporting more actively the use of renewable energy sources and various supporting schemes have been implemented to encourage potential operators to invest in this technology. With the perception of the average citizen and the reaction of the governments by offering subsidies, the reason to invest in PV plants changed dramatically. Now the investment in PV is triggered by economics and investments in PV plants can create under certain circumstances attractive revenues. In general human beings are driven by economic - thinking that financial success will help to fulfil their emotional needs – and in this context the demand for PV plants increased tremendously in the countries offering effective supporting schemes.[2] The investments were done on one hand by many small, individual households on their

[1]IPCC 4th assessment report , climate change 2007 (AR4) http://www.ipcc.ch/publications_and_data/publications_and_data_reports.htm
[2]The average growth rate from 2003 until 2008 was in the EU27 39%, source EPIA, Set for 2020, http://www.setfor2020.eu/

single home roofs, and on the other hand by investors, who put their money in PV power plants on large roof tops or in green field projects. The sizes of the PV plants grew with the market and today PV plants with up to 80 MWp are in operation.

But the supporting schemes are very divers and the results of these schemes are showing very different results. The key factor for the effectiveness of the support system is the proper business model related to the existing scheme. In the fast changing and rapidly growing photovoltaic market, the business models will change rapidly to take advantage of the situation.

In the future even utility size PV plants are expected to come and business models will change accordingly. Nevertheless private persons in single homes, owners and tenants of apartment buildings, small, medium and large companies, communities and institutions will somehow invest in this technology. There are countless possibilities to do so and thus different business models will develop in the environment of the various supporting structures and legal environments.

The target is that PV will finally not depend on subsidies and can replace fossil energy consumption for power generation by offering competitive electricity prices and become a major, sustainable source for the future energy demand. The business models will play the major role and will determine the pace of the development of this technology. Politics have to adjust their framework carefully to this development to assure the transition from fossil energy consumption to the use of renewable energy sources with minimal costs for the citizens. This can be done by giving a stable framework where business models for the different requirements of the stakeholder can be developed.

1.2. Core questions

Fossil fuel is limited and in long term it is unavoidable to replace electricity generation based on these resources by other technologies. Nuclear power depends on Uranium as a not sustainable energy source and thermonuclear fusion power plants will not be available in the next decades and it is disputed, if the process can ever achieve industrial utilization.

But how can the change from fossil fuel to sustainable energy sources achieved with the lowest cost for the society?

In the case of photovoltaic the transition is not possible without subsidies. But long term subsidies will result in improper allocation of state funds and they will take pressure from all market participants to optimize production and services. In consequence consumers have to pay a higher price for electricity, than under perfect market conditions. The question is now, how a competitive price situation can be reached?

In the four evaluated countries policy has decided to involve market forces to reach this target. By offering different frameworks for financial support, individual investments in the different sustainable technologies should be triggered.

Through rapid growth of the market economies of large scale should be accomplished and price competition on the supplier side should be intensified.

Nevertheless all countries have chosen different schemes or at least the lay out of the support systems differ. All four have mainly decided use feed in tariffs to support the PV, but other tools like renewable obligations are applied too. The levels of the national FiT`s are different and all countries have special requirements concerning location, size and feed in methods for the eligibility to apply for FiT`s.

Concerning the feed in methods, two approaches are preferred.

- the complete energy is contributed to the grid
- or the consumption on the site of the PV generator is favored

The two concepts represent two controversial tenors. The first concept is based on a centralized grid idea, in which the PV generators should be fully integrated and the second concept is favoring the idea of decentralized local grids. But both concepts have to deal with the same attribute of PV, the discontinuous of the production and the peak production at noon. Especially in the case of self consumption critical grid conditions can be generated and smart grids to control processes to adjust electricity demand and supply are not yet available.

The core questions are now:

- What are the advantages and disadvantages of the different supporting schemes
- which business models will develop under the different national supporting schemes
- what are the effects of feeding in 100 % of the generated electricity into the grid versus self consumption
- how do nation legal aspect and ownership affect possible business models

- which size of the PV plant fits best to the different business models
- and can power generation with PV plants become competitive, when subsidies have faded out

1.3. Approach and structure of the Master`s Thesis

The target of the thesis is to find out and make appropriate proposals for well adapted business- and operator models for the different supporting schemes. The approach to reach this goal is to find out the main principles how supporting schemes are designed and how they work. With this knowledge combined with the varying applications in different locations for PV plants, compatible operator models will be identified. The thesis is divided in three main parts.

In the first part the different supporting structures used by policy to boost the utilization of renewable energy sources for power generation will be introduced and the advantages and the disadvantages of these structures will be highlighted. Direct subsidies, Green Certificates and Feed in Tariffs as the main tools will be checked and the functionality of the different approaches will be introduced.

In the second part the chosen supporting schemes of four countries will be evaluated and the effectiveness of the supporting systems will be examined. The elements of the national schemes will be demonstrated in detail. Calculations for selected examples are used to show the different results and conclusively preferred business models.

In the third part the distinct applications of PV plants and different locations of the generation with the effect on business models will be analysed. The influence of size, ownership, legislation and liabilities for the operation of PV plants in Austria, Germany, France and the United Kingdom will be examined and potentials and risks of the various business models will be compared. Combined with the results of the first two parts it will be concluded which are the most promising operator models in each of the four 4 countries.

After the evaluation of the business models under the influence of active support from the state, future development of possible business models under absence of supporting schemes will be presented and analysed.

The conclusion will summarize the findings of the thesis and give an outlook to possible future developments.

2. Supporting schemes to promote power generation by renewable energy sources

Subsidies of any kind in general are only to choose, if the free market is not able to deliver acceptable results, which are urgently needed for the security, welfare, sustainable use of natural resource and environment of a society. Especially economic processes in the free market, concerning limited natural resources and environmental aspects, could deliver not satisfactory results. In general this happens due to the fact, that short term profit maximization is today the common goal, driven by shareholder value aspects, what is closely related to the daily price of the shares traded in the stock exchanges. In this situation the targets of long term, sustainable use of natural resources related with this environmental aspects are in contradiction with short term profit maximization. In this case, regulatory framework provided by the government is needed. In times of globalization, in absence of global aligned political targets and framework, it is hard to establish such a global framework to reach worldwide sustainable use of natural resources and environmental protection. Nevertheless more and more individual countries have started to create such frameworks by national - or like in the EU - by supra national plans.

To achieve the goal of sustainability two main directions can be chosen:

- Obligations to fulfil certain standards
- Subsidies to promote investments in technologies which provide sustainable use of the resources.

In the case of renewable energy both alternatives have been taken, but it has shown that supporting investments in new technologies have a greater effect than legal obligations and cause lesser cost for the society. The next chapter will be focused only on subsidies and the different forms provided in the PV sector.

2.1. Direct subsidies

Direct subsidies are very common and have been used all over the world to achieve common goals by supporting investment in facilities or in offering help to sectors in crisis. The funds for these direct subsidies have their source in the public budget raised by taxes. Direct subsidies are transferring money to the potential investor, but there are different ways to do so. Several options can be chosen by the government to distribute the funds to the investors:

- Direct money transfer by grants
- Bails
- Loans
- Equity
- Tax credits
- Exemption of duty and taxes[5]

The advantage of direct money transfer by grants, bails, loans and equity is the immediate accessibility of the funds for. They can be spend directly to reduce the total cost of investment with a direct effect to the return of investment and profitability.

Tax credits, the exemption of duty and taxes are closely related to the economic results of the investment or to the income of the investor, but the benefits of this kind of subsidies are in the future and more difficult to calculate. A higher risk for the investor is involved with this kind of support.

But the main problem with direct subsidies and especially with actual paid grants is the financing of these grants out of the public budget. The public budgets in most western industrial countries are showing huge deficits, and additional spending is difficult to finance. To raise taxes to gather the needed funds are not popular and the public will oppose the additional tax burden and the supported technology responsible for the higher taxes. This is counterproductive to the political goal to support the desired technology. In addition it contributes the decision which project should be subsidised and which not directly to the state and market forces are having no possibility to regulate the efficiency of the support.

Positive features of the direct subsidies are the obvious costs of the support. Especially grants can be determined clearly and are hard to hide. Tax credits, bails and exemptions of taxes as well as duties are more difficult to identify and quantify, but they are obviously and directly related to the specific receiver of the benefit.

[5]Handbook of Photovoltaic and engineering ,Antonia Luque, ,Steven Hegedus, 2005,page 1094ff

2.2.Green Certificates and Renewable Obligation Standards

Green certificates are having many different denominations. They are known under the name renewable energy certificates (REC's), renewable energy credits, renewable electricity certificates, tradable renewable credits (TRC's), renewable obligation certificates (ROC's), green tags and green certificates.

A green certificate is in general the proof, that one Megawatt/hour of electricity is produced with a renewable energy generator. For this production one green certificate is issued by authorized institutions, in general from the state administration. These certificates are eligible for trade and not related directly to the supply of the electrical energy used by the customer. The motivation to buy green certificates was in the beginning of the system connected to green thinking and a voluntary support for the renewable industry.

To use the certificates as a tool for political set targets, a second component was needed to make the system work. This second component is the obligation to have a specified quote of renewable energy used for electricity generation. This quote is raised during time to the designated target. The United States have established in many states renewable portfolio standard (RPS). In the UK[6] the renewable obligation (RO) are used as tools in the policy to boost the use of renewable energy sources (RES). Especially utilities are affected by this system. If they are not willing or able to build renewable energy generators themselves, they have to buy certificates from the producers using renewable energy[7]. In this case a market for green certificates will develop. The prices for the green certificates in the ideal case shall develop on this free market.

The idea of the green certificates related to a quota system seems to be an adequate tool to support the enhanced use of renewable energy and it is spread widely. But it has been found out that this system has major disadvantages against - for example - feed in tariffs. The main principle of the green certificate system is to create a market for the certificates by setting obligations for the share of use of RES. This market will trade the certificates and a market price will develop. But how all

[6] In the UK feed in tariffs were added to the system of RO's, because the FiT's seem to be more effective for micro and small renewable electricity generation. Renewable obligations,Guidance for generators,1st April 2010,http://www.ofgem.gov.uk/Sustainability/Environment/RenewablObl/Documents1/2010%20RO%20generator%20guidance%20final%20for%20publication.pdf

[7] In the US the certificates used in the case of solar energy,are known as solar renewable energy certificates (SREC's)

processes controlled by markets the price is not fixed, what adds uncertainty to investments. In the case of the renewable energy market it could happen, that the increase of the use of RES grows faster than expected. In this case the prices for the green certificates will drop. In general the income from selling the green certificates to utilities, which have not fulfilled their renewable obligations, is part of the business model and effects significantly the ROI. As consequence the investor in a renewable energy power plant will price this uncertainty in, what will slow down the growth of the use of RES.

All countries with green certificate systems have lower growth rates in the renewable energy market than countries where the support system is based on FiT's. In addition it has been found out, that these systems cause higher costs for the society to promote the use of the RES[8]

This leads to the last, most effective supporting schemes introduced in this study, the Feed-in Tariffs System.

2.3.Feed-in Tariffs

Feed in tariffs were used for the first time in the United States in 1978 under the NEA and PURPA[9] which focused on a turnaround of the American energy policy. The breakthrough of this policy instrument though was achieved with the German "law on feeding electricity into the grid" or in German "Stromeinspeisegesetz" (StrEG). The StrEG was replaced later on by the "Law for the priority use of renewable energies" the "Gesetz für den Vorrang ErneuerbarerEnergien" (EEG). This law developed Germany, especially in the field of photovoltaic, to the lead market in the world with over 15 GWp installed capacity at the end of September 2010[10], what is three times more than the next biggest user Spain has installed. Spain itself has the Feed-In Tariff system enabled to encourage the use of RES. The success in these countries leads to the conclusion that the FiT System seems

[8] Carbon trust and LEK consulting, Policy frameworks for renewables, 2006, p.2. (http://www.cleanenergystates.org/international/downloads/Policy_Frameworks_for_Renewables_Carbon_Trust_July2006.pdf)

[9] NEA the national energy act and the PURPA public utilities regulatory policy act were inaugurated by Jimy Carter, to prevent the energy crisis of the future, by encouraging energy conservation and use of RES, http://en.wikipedia.org/wiki/Feed-in_tariffs#History

[10] 14,341 GWpstatus 31.08.2010 http://www.bundesnetzagentur.de/cln_1912/DE/Sachgebiete/ElektrizitaetGas/ErneuerbareEnergienGesetz/VerguetungssaetzePhotovoltaik_Basepage.html

to be the most effective. To understand why this support scheme works best, the structure of the FiT's System will be highlighted

Feed-in Tariffs have some key components to encourage the use of RES and minimize the cost for the general public[11].

- Priority access to the grid
- Fixed prices and obligation to buy electricity produced by RES for a determined time
- Differentiated tariffs based on the different costs of the technologies
- Stepped tariffs
- Intermittent adjustment to the changing prices of the technology.

Without the priority access to the grid FiT's system could not work, because the renewable electricity production supported by FiT's is in direct competition with the traditional electricity production of the utilities. Only the legal obligation to give priority access to the grid forces the utilities to allow this competition. Otherwise they could just block this competition by refusing to connect the renewable energy suppliers to the grid.

The fixed prices are vital to secure the investment in these new technologies and provide the possibility to get financing for the projects. The period of price guarantee should be long enough to secure the investment. The obligation not only to connect but although to buy the electricity for the fixed tariffs is the key component of the system. Differentiation between the technologies helps to find the right tariff for the specific technology. At the beginning of a technology, the initial invest will be high and the related support has to be adapted. By increasing numbers of installations the prices for the technology will decrease and adjustment of the tariffs will be necessary.

Stepped tariffs can level the tariffs to the decreasing technology prices and they should be revised regularly to keep pace with the market development.

---

[11] Paul Gipe; Evolution of Feed in tariffs, October 6th 2010 ; http://www.wind-works.org/FeedLaws/EvolutionofFeed-inTariffs.html

3. The supporting schemes in the Austria, Germany, France and UK

3.1. Austria

Austria is well known for a strong use of renewable energy from large and small hydro power plants, biomass and solar thermal applications. But today the use of PV in Austria is very limited due to limited funds offered by the Austrian supporting scheme. The Austrian supporting system is regulated in two acts,

- the ecological electricity act "Ökostromverordnung"[12]
- the climate and energy fund act "Klima und Energiefondsgesetz"[13]

and in regional supporting schemes, offering some subsidies for PV.

The Ökostromverordnung came into action in 2002 and has undergone several amendments. The latest version is from February 2nd 2010 and it offers feed in tariffs for photovoltaic installations >5kWp . The feed in tariffs are guaranteed for 13 years and two classes are defined:

- PV - installations > 5kWp ≤ 20 kWp
- PV - installations > 20 kWp

The tariffs for the different classes are:

- \> 5 kWp≤ 20 kWp   38 Eurocents
- \> 20 kWp   32 Eurocents

if installed on a roof or at buildings or on noise barriers and :

- \>5 kWp≤20 kWp   35 Eurocents
- ≥ 20 kWp   25 Eurocents

when not installed on a roof or at a building or on a noise barrier. In addition the maximum support may not exceed 500,000. €/a.

What is obvious as well as at first disturbing, all PV plants < 5 kWp are not eligible for feed in tariffs in Austria. To support this class, the climate and energy fund act

[12] Bundesgestzblatt für die Republik Östereich,Jahrgang 2010, 2.Februar 2010,Teil 2, 42 Verordnung, Ökostromverordnung 2010-ÖSVO 2010; www.ris.bka.gv.at
[13] http://www.ris.bka.gv.at/Dokument.wxe?Abfrage=RegV&Dokumentnummer =REGV_COO_2026_100_2_337401

offers direct subsidies for PV installations with a peak power of ≤5 kWp. The Climate and Energy fund regulates the subsidies by issuing guidelines for the support of photovoltaic facilities. These subsidies are defined in two guidelines active at the moment.

- “guidelines of the climate and energy fund for the support of photovoltaic facilities in 2010”[14]
- “guidelines of the climate and energy fund for the support of building integrated photovoltaic in prefabricated houses 2009”

Eligible to apply for the subsidies in both guidelines are only individuals and private households who will consume the electricity on site and the electricity is mainly for personal and not commercial use. For both guidelines the maximum allowed peak power is limited to ≤ 5 kWp.

In the guideline for the BIPV in prefabricated houses 2009, only houses which offer certain standards like:

- Passive houses standards according to Passivhaus-Projektierungs-Paket PHPP[15]
- Active houses standards according to “AktivHaus”[16] standards
- Meet the following requirements:
    - are possessing the “energy passport” with a maximum of heat demand of 30 kWh/m^2 per year ***and***
    - the heating system is fuelled by biomass, solar thermal energy, heat pumps or is connected to district heating system or uses high efficiency gas or oil burners ***and***
    - a ventilation system is installed

are eligible for the grant and in this case the maximum subsidies can reach 2,600 Euro per installed kWp and the total value of all allocations may not exceed 60% of the total investment.

In the guideline for photovoltaic facilities 2010 the grant is limited to 1,300 Euros for stand-alone and roof top installations, 1,700 Euros for building integrated PV and

---

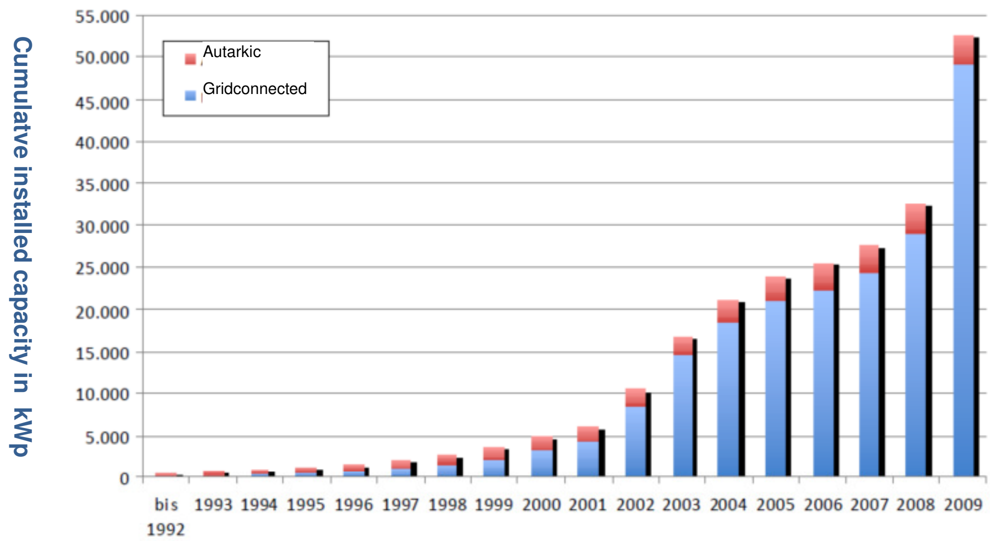
[14] In Germanlanguage “ Richtline des Klima- und Energiefonds für die Förderung von Photovoltaik- Anlagen in 2010“ § 7 Abs. 5 Klima und Energiefons Gesetz , Bundesgesetzblatt 40/2007 idgF.
[15] www.igpassivhaus.at
[16] www.haus.klimaaktiv.at

may not exceed 30% of the total investment costs. The total amount of all subsidies, including regional supports, may not exceed 2,400 Euros and 50% of the total cost of the PV installation.

For both schemes an application has to be made, and the approval is given by order of the date of application in combination with a regional distribution factor.

On the first impression the Austrian supporting scheme seems to be adequate to bring forward the use of PV in Austria. But as seen in figure 1 the total installed PV capacity in Austria is with 53MWp marginal. In 2009 the growth of 20.2MWp is significant, but if compared with Germany, which installed in the same year about 3.8 GWp,it is still not very strong. The additional installed capacity in Austria in 2009 was about 2.4 watt/capita and in Germany it was 46.3 Watt/capita, which is nearly 20 times more.

Figure 1: **Austrian development of installed PV-capacity 1992-2009**, Source: Innovative Energietechnologien in Östereich,Marktentwicklung 2009,Peter Biermayr, Rita Ehrig, Christoph Strasser,ManfredWörgetter, Natalie Prüggler, Hubert Fechner,MarkusNurschinger, Werner Weiss, Manuela Eberl,Berichte aus Energie und Umweltforschung 15/2010



The reason for this underperformance in the system can be found in the very limited funds, allocated by the Austrian government. The amount offered for the different schemes in 2010 are:

- FiT system 2.1 Million Euro/year[18]
- Guideline PV 35 Million Euro
- Guideline BIPV prefab. houses 1 Million Euro

All federal grants together are summing up to 38.1 million Euros[19].

The regions supported PV installations in 2009 with another 21.65 million Euros, whereof Niederösterreich contributed the predominant part with 20.1 million Euros. The amount of 60 million Euros seems not to be able to significantly develop a market.

If considered, that the price for 1 kWp in 2010 in average could reach the level of about 3,000 Euro/kWp and the average support of a PV installation would be 30% of the total investment, the maximum amount spent for PV would be 180 Million Euro. This represents an additional installed capacity of 60 MWp/year under the chosen assumptions. This would triple the 2009 growth of the PV market and seems the maximum, what can be achieved with these funds. The choice to support PV installations with direct, state funded subsidies makes higher values more difficult to realize. The solution for this problem seems that the needed funds for the support have to be raised directly at the consumer of electricity. The costs of PV assistance than could be distributed to all customers, which is easier to communicate, as to introduce new taxes or raise taxes. The German market has shown that this system works. Therefore the next chapter will analyse the German Feed in tariffs practice.

[18] 2.Ökostromgesetznovelle 2008 § 21
bhttp://www.pvaustria.at/upload/1321_Abaenderungsantrag-OSG-07-2008.pdf
[19] http://www.pvaustria.at/content/page.asp?id=70

3.2.Germany

Germany is at the moment the leading market for photovoltaic. It is estimated, that in 2010 over 7 GWp[20] will be installed additionally. The success of the German model is based on the EEG, the law for the priority use of renewable energy sources. The history of the EEG started in 1990 with the very basic “feed in law”, which promoted first small PV and wind projects[21]. During the 1990's the system was redefined several times until in 2000 the first EEG was launched. The main difference to the precedent law was that the system now introduced divers tariffs for the specific renewable energy sources, while taking size and location in consideration, and offering a fixed time of the guaranteed tariffs. The EEG discriminates the following types of PV installation:

- By capacity:
    - <30 kWP
    - 30-100 kWp
    - 100-1000 kWp
    - >1000 kWp
- By location:
    - Roof top and building integrated PV
    - Ground mounted PV plants on conversional area[22]
    - Ground mounted systems in a 110 m corridor from highways and railways
    - Ground mounted systems on commercial and designated areas

The costs of the elevated prices for electricity are distributed to all customers by the EEG premium on the electricity bills of each electricity customer. The FiT’s are directly paid by the utilities to the operator of the PV plant. In the EEG, in addition to the yearly reduction of the FiT’s, a second tool for adjusting the FiT’s to the growth of the PV electricity production has been embedded.

[20]Bundesnetzagentur; 4.88 GWp has already been registered until August 2010http://www.bundesnetzagentur.de/cln1912/DESachgebiete/ElektrizitaetGas/ErneuerbareEnergienGesetz/VerguetungssaetzePhotovoltaik_Basepage.html
[21]Feed-in tariffs, Acceleration the development of renewable energy, MiguelMendonça,World future Council,2007, page 25 ff.
[22]Conversional areas are for example old military airfields, old waste dumps etc.

This tool has been introduced to limit the amount of subsidies distributes to the operator of the PV plants by the FiT's. For this reason a target zone for the yearly growth of the market has been defined. Depending to this target the yearly reduction can be increased or reduced.

The latest version of the EEG was introduced 2009 with a significant adjustment of the tariffs for PV on July, 1st 2010[23]. These tariffs for PV were changed because of the tremendous increase of PV installations in 2009 and the first half of 2010,triggered by the declining prices of PV modules. The tariffs for PV are the highest in the EEG system and due to that the cut for the FiT's is coherent. The scheme worked so effectively that the returns of investment for the operator of the PV plants were extremely attractive. The EEG is built to support the preferred use of the RES, but nevertheless it should be done with the lowest cost for the consumers. The FiT's allowed in 2009 and the first half of 2010 margins that high for the investors that policy could not accept any longer the fact that the consumers subsidized by elevated electricity prices the profits of the investors in PV. These high profits could be realized, because the prices for the PV modules and the BOS have decreased significantly. Here the weak side of the FiT's system can be recognized. If no frequent tariff's adjustments are made, the system tends to offer too high profits for the operators of PV plants. Through the distribution of the costs to all consumers, they have to carry the burden of these profits. Short intervals of revising the FiT's are crucial to keep the cost of the support as low as possible. This short excurse demonstrates the mode of action of the EEG and how it works.

Investors are attracted with above average margins and well predictable turnovers allowing rapid market growth. While the market is growing, the suppliers start to invest in new production facilities for all supplies. The higher output will cause cost reduction by economies of large scale. Mostly the increase in production overshoots the demand and then price competition will increase and prices for the system components for the PV plants will decrease. This will create new demand and accelerate the growth. The German market has shown that this system has proven. To avoid overheating of the market and to keep pressure on the system prices, the EEG FiT's will be lowered each year. The percentage of the reduction is depending of the additional installed capacity of the preceding year. This shall compensate potential over support. The annual reduction of the tariffs is set to 9% if the target

[23]Bundestags Drucksachen; 17/1147, 17/1604, 17/1950 17/2402
http://www.bundestag.de/dokumente/drucksachen/index.html

corridor of 2.500 MWp and 3.500 MWp is kept. If the growth is higher than the 3.500 MWp per year the reduction rate is increased in four steps by 1% for each 1000 MWp exceeding the target in 2011 and 3% in 2012 and the proceeding years. That means that in the worst case the reduction rate can reach 13% in 2011 and from 2012 on 21%.

If the target corridor is not reached, the reduction rate is cut in three steps by 1% for each 500 MWp below the lower target corridor of 2.500 MWp in 2011and in steps of 2.5% in 2012 and the proceeding years. In this case the reduction rate can be lowered in 2011 in the maximum to 6% and in 2012 to 1.5% .

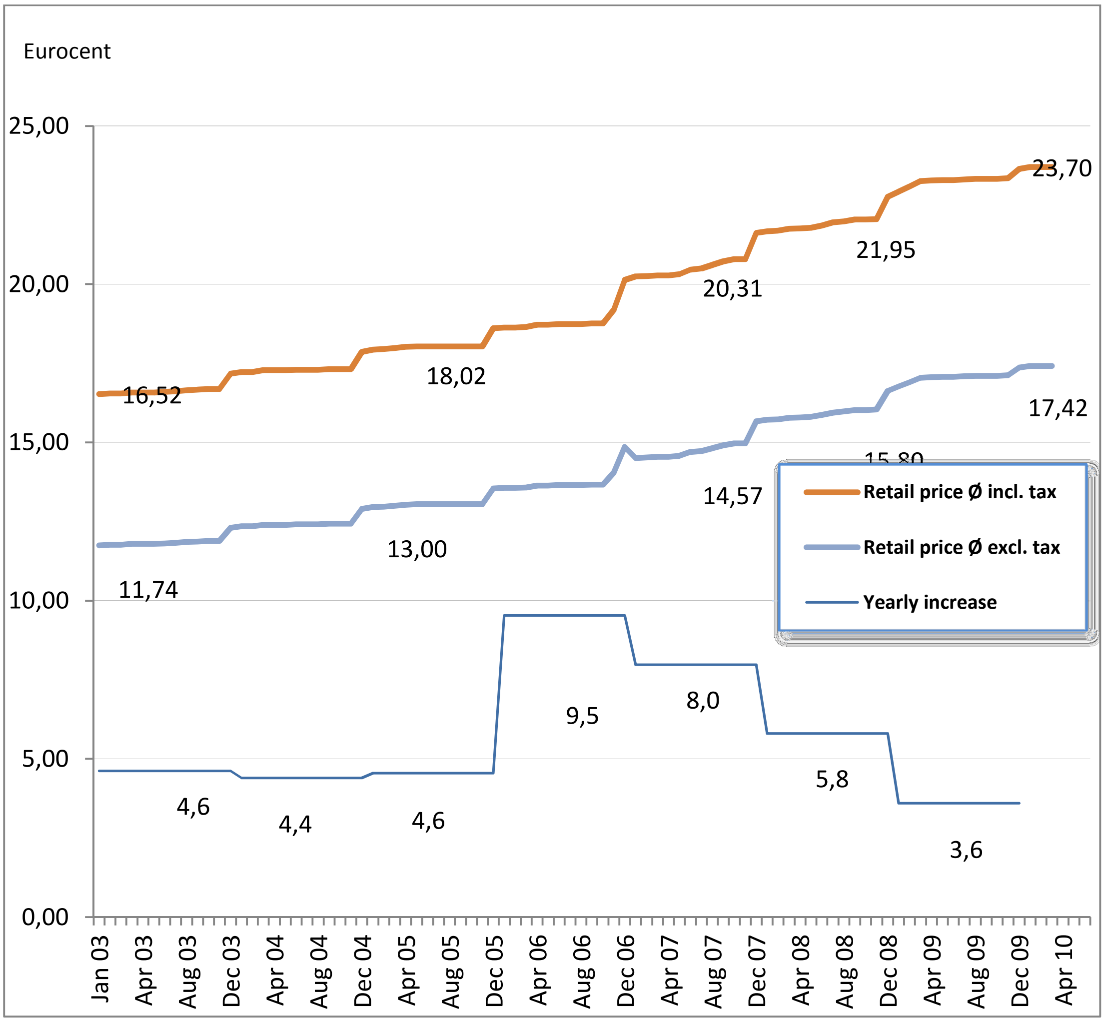
In real it has to be appraised that the growth will hit or overshot the corridor in the next two or three years. Nevertheless this scheme shows that grid parity will be reached in the near future. Grid parity is reached when the costs of electricity from PV systems matches the price paid by consumers for retail electricity[25].Assumed that the PV growth will hit the target corridor in the next years and taken into consideration that the retail price excluded VAT and electricity tax[26] is at the moment 17.42 Eurocent, latest in 2014 grid parity is realized for PV plants > 1000 kWp, even if the prices for electricity would stagnate at the current level. If assumed that the prices will increase with the some rate of 5.8 % in average, one kWh will cost in:

- 2011 18.42 Eurocent
- 2012 19.48 Eurocent
- 2013 20.61 Eurocent
- 2014 21,80 Eurocent

excluded VAT and electricity tax.

[25]H.Fechner; the concept of grid parity from the PV perspective;http://www.iea-pvps.org/workshops/0809valencia/presentations/2_Hubert_Pr-344sentation4%20%5BKompatibilit-344tsmodus%5D.pdf
[26]The electricity tax has to be paid by the producers and it is € 20,50 per MWh (Aug/2010)

Figure 2, **Retail price development Germany 2003-2010**, database; Bund der Energie- verbraucher.www.energienetz.de/files_db /1277202249_7707__12.xls



To compare the current price situation with the FiT the actual level of the FiTs has to be checked as well as the development in the next years. This development in comparison with the development of the retail prices will influence the possible operator models significantly.

Tabl 1.gives an overview of the FiT's for PV in Germany[27]

[27]FiT'scorresponding the changes made to the EEG on July, 1st 2010. Source: Bundestags Drucksachen; 17/1147, 17/1604, 17/1950 17/2402 http://www.bundestag.de/dokumente/drucksachen/index.html

Table 1: **:FiT’s Germany 2010-2015,** Source: Bundestagsdrucksachen; 17/1147, 17/1604, 17/1950 17/2402

FIT`s Germany related to added capacity 2010-2015

	2010	2011	2012	2013	2014	2015
Added capacity	6.500 MWp	3.000 MWp	3.000 MWp	3.000 MWp	3.000 MWp	
Roof top or BIPV						
< 30 kwp	33,03	28,74	28,20	25,66	23,35	21,25
30-100 kwp	31,42	27,34	26,80	24,38	22,19	20,19
100-1000kWp	29,73	25,87	25,33	23,05	20,97	19,08
>1000 kWp	24,79	21,57	21,03	19,13	17,41	15,85
Free range conversion area	25,38	22,08	21,54	19,60	17,84	16,23
Free range	24,26	21,11	20,57	18,72	17,03	15,50
Self consumption <30 %						
< 30 kwp	16,65	12,3561	na	na	na	na
30-100 kwp	15,04	10,9554	na	na	na	na
100-50kWp	13,35	9,4851	na	na	na	na
Self consumption >30%						
< 30 kwp	21,03	16,7361	na	na	na	na
30-100 kwp	19,42	15,3354	na	na	na	na
100-50kWp	17,73	13,8651	na	na	na	na

Self consumption will be revised in 2011
na: not available

If figure 2 is compared with table 1 it can be seen that the reduction of the FiTs will lead PV to grid parity on roof top or BIPV in 2013 with installations > 1000 kWp and on ground mounted system on conversion and commercial areas and in 2014 all the PV installations >30 kWp will reach grid parity. This will for sure increase the range for operator models dramatically.

The German EEG grants a 20 year guarantee for the FiT, but does not offer inflation compensation.

In addition to the FiTs offered for 100% feed into the grid the EEG offers a second scheme to support consumption of the PV electricity on site. This scheme discriminates PV plants by the percentage of consumption realized on the site of production and it takes the discrimination between the plants regarding the size into account.

To calculate the de facto tariff offered by the grant, the actual price paid for the electricity to the utilities is needed, because the scheme deducts for plants < 30% of self consumption 16.38 Eurocents from the FiT and for plants with a self consumption over 30% for the part exceeding the 30%, the FiT is reduced by 12

Eurocents [28]. That means that the actual electricity prices determine the economic benefits of the system. For consumers paying high prices to the utilities, the scheme can offer advantages compared with the 100 % feed into the grid.

Up to July 1st 2010 this scheme was limited to plants up to 30 kWp. From now on the scheme is eligible for PV plants up to 500 kWp. The raise of the upper limit to 500 kWp shows the political target to support on site consumption. In reality it has to proof, if the system especially for the larger installations will work. In reality larger plants need a consumer -who will be in general the operator of the plant - with high consumption, in ideal case 100% of the production. In this case 70% of the production can benefit from the elevated tariff offered in this special scheme, because only 12 Eurocents instead of 16.38 Eurocents will be deducted from the base FiT's. A problem in the particular case of large installations for self consumption up to 500 kWp will be the electricity price offered by the utilities. For consumers with installed capacity of 550 KWp[29] the price will be significantly below the prices for the private households. The critical value for the price of electricity is below 13.31 Eurocents, assumed that 100% of the produce electricity from the PV generator is consumed on site. This theoretical value will not be reached in reality. Values between 30-60% are realistic and with this rate of self consumption the critical price will raise to 16.38 Eurocents at 30% and 14.19 Eurocents at 60% of self consumption.

The complexity of the system makes the decision for the self consumption complicated. A calculation example should make the working principle of the scheme obvious. The average price for 1 kWh[30] is for the moment 23.7 Eurocents with 19% VAT and without it is 19.92 Eurocents. Because the FiT will again be reduced on October 1st 2010, both tariffs will appear in the chart below. The calculation is done for commissioning after October 1st 2010.

[28] All prices excluding VAT
[29] This is an example to compare the system with a 500 kWp PV plant
[30] Typical for households with consumption of 2500-5000kWh/a, source: StatistischesBundesamt

***Table 2:* Comparison self consumption versus 100% feed into the grid I**

Calculation self consumption						
			brutto			Added capacity 2010 (MwP)
Actual electricity price per kWh		19,92 cent	23,70 cent	Commissioning	2010	>6.500
% self consumption		60,00%		Reduction to 2010	13,00%	
Plant size		100,00 kWp				
% of self consumption/ Plant size in kWp	<30 % < 30 kWp	<30 % >30kWp < 100 kWp	<30 % 100kWp-500 kWp	> 30 % <30 kWp	> 30% > 30 kWp < 100 kWp	>30 % 100kWp-500 kWp
Reduction from FIT	16,38 cent	16,38 cent	16,38 cent	12,00 cent	12,00 cent	12,00 cent
Energy price	19,92 cent	19,92 cent	19,92 cent	19,92 cent	19,92 cent	19,92 cent
FIT						
01.07.2010	34,05 cent	32,39 cent	30,65 cent	34,05 cent	32,39 cent	30,65 cent
01.10.2010	33,03 cent	31,42 cent	29,73 cent	33,03 cent	31,42 cent	29,73 cent
01.01.2011	28,74 cent	27,33 cent	25,87 cent	28,74 cent	27,33 cent	25,87 cent
FIT with energy savings						
01.07.2010	37,59 cent	35,93 cent	34,19 cent	41,97 cent	40,31 cent	38,57 cent
01.10.2010	36,57 cent	34,96 cent	33,27 cent	40,95 cent	39,34 cent	37,65 cent
01.01.2011	32,28 cent	30,87 cent	29,41 cent	36,66 cent	35,25 cent	33,79 cent
FIT withour energy savings						
01.07.2010	17,67 cent	16,01 cent	14,27 cent	22,05 cent	20,39 cent	18,65 cent
01.10.2010	16,65 cent	15,04 cent	13,35 cent	21,03 cent	19,42 cent	17,73 cent
01.01.2011	12,36 cent	10,95 cent	9,49 cent	16,74 cent	15,33 cent	13,87 cent
FIT for specified plant	Comissioning	Self consumption < 30%		Self consumption > 30%	Feed in	
<30	2010	36,57 cent		40,95 cent	33,03 cent	
> 30 < 100	2010	34,96 cent		39,34 cent	31,42 cent	
> 100 -500	2010	33,27 cent		37,65 cent	29,73 cent	
Specified plant size	Classes	kWp in classes	% in classes	<30 %	> 30 %	Feed into grid
100,00 kWp	< 30kwP	30,00 kWp	30,00%	10,97 cent	12,29 cent	9,91 cent
	>30kWp < 100kWp	70,00 kWp	70,00%	24,47 cent	27,54 cent	21,99 cent
	100kWp-500kWp	0,00 kWp	0,00%	0,00 cent	0,00 cent	0,00 cent
			Average FIT	35,44 cent	39,82 cent	31,90 cent
% of different FIT's	30,00%	10,63 cent				
	30,00%	11,95 cent				
	40,00%	12,76 cent				
		35,34 cent	31,90 cent	3,44 cent	10,78%	
		With self consumption	100 % Feed In	Advantag / disadvantage		

In the above case a plant size of 100 kWp was chosen as well as a self consumption rate of 60% and the average household price of 19.92 Eurocents net for electricity. In this scenario the use of the self consumption offers an additional benefit of 3.44 Eurocents what equals 10,78% of the additional income. But taking a closer look to the scheme it can be recognized that the benefit depends heavily on the actual electricity price and the rate of self consumption. To demonstrate this coherence the same calculation with an electricity price of 14 Eurocents net[31] and a rate of self consumption of 30% will be executed.

[31]This price could be realized for customers with a constant demand for electricity. Mediums size production facilities and craftsmen's companies are able to get these prices.

Table 3: **Comparison self consumption versus 100% feed into the grid II**

Calculation self consumption						
			brutto			Added capacity 2010 (MwP)
Actual electricity price per kWh		14,00 cent	16,66 cent	Commissioning	2010	>6.500
% self consumption		30,00%		Reduction to 2010	13,00%	
Plant size		100,00 kWp				
% of self consumption/ Plant size in kWp	<30 % < 30 kWp	<30 % >30kWp < 100 kWp	<30 % 100kWp-500 kWp	> 30 % <30 kWp	> 30% > 30 kWp < 100 kWp	>30 % 100kWp-500 kWp
Reduction from FIT	16,38 cent	16,38 cent	16,38 cent	12,00 cent	12,00 cent	12,00 cent
Energy price	14,00 cent	14,00 cent	14,00 cent	14,00 cent	14,00 cent	14,00 cent
FIT						
01.07.2010	34,05 cent	32,39 cent	30,65 cent	34,05 cent	32,39 cent	30,65 cent
01.10.2010	33,03 cent	31,42 cent	29,73 cent	33,03 cent	31,42 cent	29,73 cent
01.01.2011	28,74 cent	27,33 cent	25,87 cent	28,74 cent	27,33 cent	25,87 cent
FIT with energy savings						
01.07.2010	31,67 cent	30,01 cent	28,27 cent	36,05 cent	34,39 cent	32,65 cent
01.10.2010	30,65 cent	29,04 cent	27,35 cent	35,03 cent	33,42 cent	31,73 cent
01.01.2011	26,36 cent	24,95 cent	23,49 cent	30,74 cent	29,33 cent	27,87 cent
FIT withour energy savings						
01.07.2010	17,67 cent	16,01 cent	14,27 cent	22,05 cent	20,39 cent	18,65 cent
01.10.2010	16,65 cent	15,04 cent	13,35 cent	21,03 cent	19,42 cent	17,73 cent
01.01.2011	12,36 cent	10,95 cent	9,49 cent	16,74 cent	15,33 cent	13,87 cent
FIT for specified plant	Comissioning	Self consumption < 30%		Self consumption > 30%	Feed in	
<30	2010	30,65 cent		35,03 cent	33,03 cent	
> 30 < 100	2010	29,04 cent		33,42 cent	31,42 cent	
> 100 -500	2010	27,35 cent		31,73 cent	29,73 cent	
Specified plant size	Classes	kWp in classes	% in classes	<30 %	> 30 %	Feed into grid
100,00 kWp	< 30kwP	30,00 kWp	30,00%	9,20 cent	10,51 cent	9,91 cent
	>30kWp < 100kWp	70,00 kWp	70,00%	20,33 cent	23,39 cent	21,99 cent
	100kWp-500kWp	0,00 kWp	0,00%	0,00 cent	0,00 cent	0,00 cent
			Average FIT	29,52 cent	33,90 cent	31,90 cent
% of different FIT's	30,00%	8,86 cent				
	0,00%	0,00 cent				
	70,00%	22,33 cent				
		31,19 cent	31,90 cent	-0,71 cent	-2,24%	
		With self consumption	100 % Feed In	Advantag / disadvantage		

It is obvious that the benefit turned into a disadvantage. Under these circumstances a 100% feed into the grid would be preferable. This mechanism is implemented in the EEG to promote the self consumption only under the precondition that a high rate is consumed on site. To incorporate the possibility of changes in the demand for energy on site, the EEG offers the opportunity to change on a monthly base the FiT from self consumption to 100% feed in. The FiT for self consumption is valid until 31.12.2011. If it will be continued is not clear yet. In the second quarter of 2011 this part of the scheme will undergo a critical evaluation by the government, and then it will be decided, if it will be continues or not.

The benefits of self consumption are discussed controversially. The supporter of the self consumption predict that the self consumption,

- minimizes transportation cost
- discharges the grid.
- encourages the operators of PV plants to use smart appliances to use as much PV electricity as possible
- decreases peak loads at noon

In contradiction the opponents of the extra support for self consumption argue that it is counterproductive and it leads to:

- an unfair distribution of the costs of the support
- electricity demand which will be optimized only by individual advantages without consideration of potential grid needs
- the usage of state funds to support the self consumption

The support scheme for self consumption in Germany follows the arguments of the supporters.

But the arguments of the opponents are plausible. If self consumption of the PV electricity is used, the operator of the plant will obtain less electricity from the utilities and as consequence, he pays only on this part of his consumption the distributed charges of the FiT's system. This seems to be an inequitable privilege for operators using self consumption tariffs. In addition the state and the municipalities have to waive the related taxes. In this case the supporting system is no longer financed 100% by the distribution to the electricity customers, now state and municipal budgets are involved[32].

The individual optimization will encourage the operator of the plants to use as much of the self-generated electricity as possible. This will lead to operate all high electricity consuming appliances at the time of highest generation of the PV plant at noon. Because at noon already peak loads occur, this behaviour could even intensify the load and destabilize the grid. Especially if appliances are switched on with non-smart time switches, what is very likely at the moment, self consumption can generate critical noon peak loads on days with low solar radiation.

[32]Photon,Issue 2010-03, page 3

The German FiT system has proven itself as a very reliable and effective tool to generate enormous growth of the PV market. Germany is by far the biggest market for photovoltaic right now. The success of the German EEG has been an example for many countries and it has been copied many times. France has a feed in tariff system and the UK just transformed on April, 1st their support system and offers now FiT's too. Only Austria is mainly supporting the PV by direct subsidies and only 2.1 million Euros are put into their feed in tariff system. In consequence the PV market in Austria is very limited.

Nevertheless FiT's can be accompanied with critical effects, especially if the system has generated a significant number of installations. From the technical side the varying radiation of the sun forces the grid to handle this variation. In consequence, it has to offer backup solutions for days with low radiation and it must be able to react on intensive input on sunny days. In extreme cases it can happen that the grid is not able to absorb the complete generation and the PV plants have to be limited or even disconnected from the grid to avoid a major failure of the grid.

From the market side the price for electricity can decrease on sunny days. In extreme situations the price can become negative, what happened in 2009 already for 71 hours, triggered by high volumes provided by wind energy[33]. In this case the costs of the support are increasing significant, because the spread between electricity price and paid FiT's is bigger.

3.3.France

The French market for photovoltaic is growing very fast since the FiT's have been improved in 2009. In mainland France and in all its overseas departments the FiT's are in force. Nevertheless the French Feed in tariffs system is even more complex than the German EEG. Many different tariffs apply for different installation types, building types, regions, and plant capacities.

The different criteria are defined:

[33]Negative electricity prices and the priority of renewable energy sources ;Mark Andor Kai Flinkerbusch, korrespondierender Author.1Matthias Janssen BjörnLiebau,MagnusWobbenhttp://www.wiwi.uni-muenster.de/vwt/organisation/veroeffentlichungen/AFJLW-2010-Negative-Strompreise-und-der-Vorrang-Erneuerbarer-Energien-ZfE_final.pdf

- by capacity
    - < 3 kWp
    - Up to 250 kWp
    - > 250 kWp

- by installation types
    - Building integrated PV and
        - Made of flexible material and replacing the components offering the leak proof protection of the roof
        - Rigid modules which are installed roof parallel and replacing the components offering the leak proof protection of the roof
        - Comply at least with one of the following criteria
            - are balustrades
            - are part of the facade
            - are offering sun protection
            - are screens
            - or are shutters on windows, balconies or terraces.
- by location
    - Dwellings
    - Educational or health care buildings at least two years from completion
    - Buildings at least two years from completion
    - Buildings less than two years from completion

- by regions
    - For installations > 250 kWp the FiTs are indexed with the base South France. The FiTs can be raised up to up to 20% in the northerly departments[34].

The maximum allowed annual volume to be eligible for FiT's is 1,500 kWh/kwp in mainland France and 1,800 kWh/kWp in the overseas departments. If these values

[34]Annex 8.1. shows the assessment rate of the departments

are exceeded, 5 Eurocents will be paid for each excessive kWh. For PV installations equipped with a tracking system, the maximum amount is limited to 2,200 kWh in mainland France and 2,600 kWh in the overseas area. In addition the FiT's are inflated by 20% related to the consumer price index and is adapted on a yearly base. The FiT's are guaranteed by the state for 20 years. From 2012 the tariffs are subject to a yearly degression of 10%.

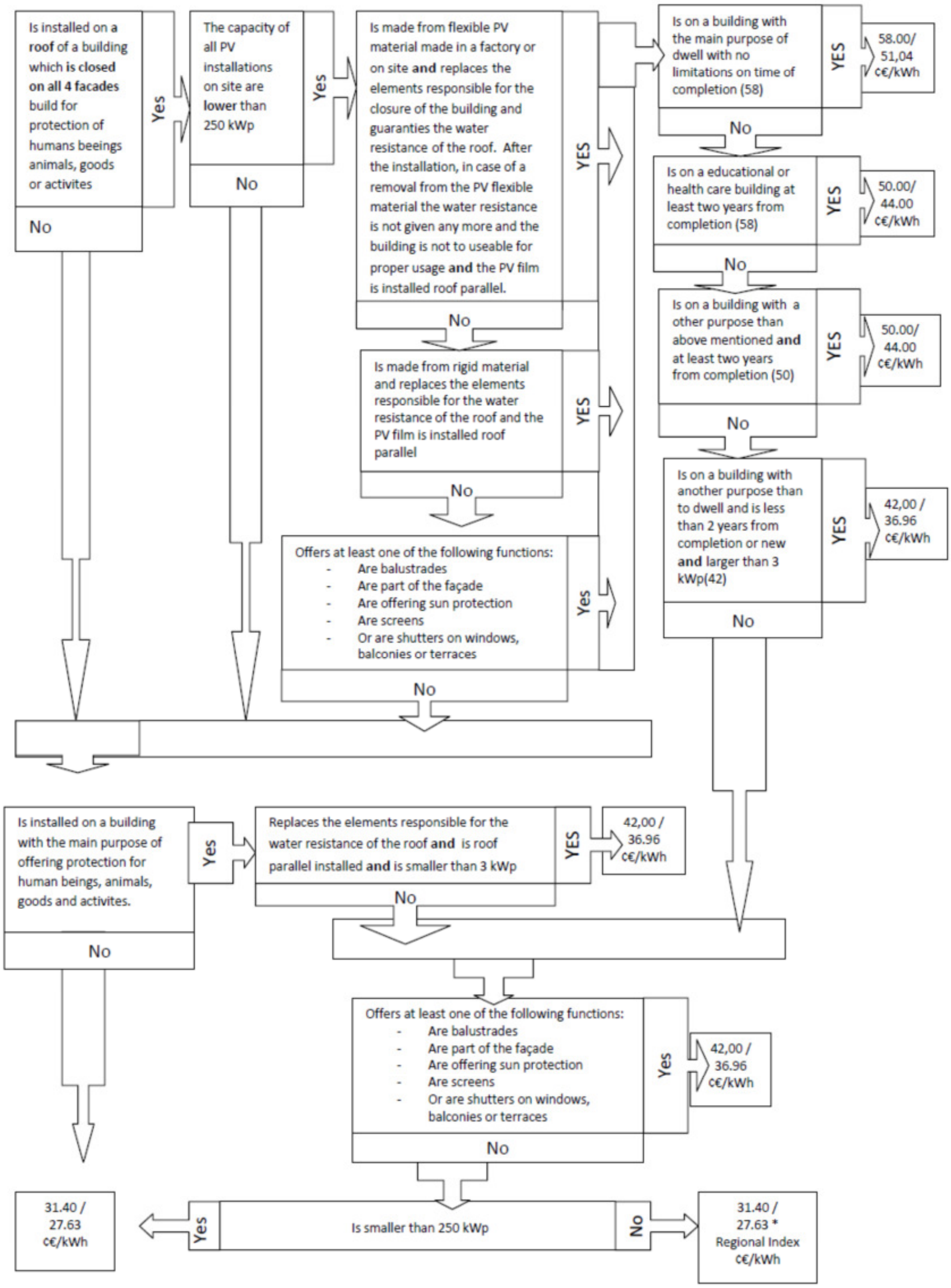
In August 2010 the French government changed the tariffs due to high number of applications. The FiTs are reduced by 12%.

Table 4: **French FiT's,** source:http://www.photovoltaique.info/Le-tarif-d-achat.html

Up to August 2010	Later than August 2010
0.58 €	0.5104 €
0.50 €	0.44 €
0.42 €	0.3696 €
0.314 €	0.2763 €
0.314 € + regional index	0.2763 € + regional index

A flow diagram will help to find out which FiT's are corresponding with the various situation.

Table 5: **Systematic of the French FiT's system**; source: http://www. Photovoltaique. info/IMG/pdf/ Logigrammev7_13Sept2010.pdf



3.4.UK

The United Kingdom's supporting structure to reach the 2020 EU target of 20% electric energy production out of renewable energy source has been changed on April 1st 2010.

Up to this date the UK favourites the green certificates to promote the use of renewable energy, but the result have been quite poor. As shown in chapter 2.2. the UK is a good example that green certificates are inferior to the feed in tariff system.

To enhance the effectiveness of the support, the UK decided to change their strategy by implementing a feed in tariff system. But it shows major differences from the German and the French system. As the German and the French systems are in general designed for feeding in 100% of the produced electricity into the grid[35], the UK system is designed to promote electricity production for consumption on site of generation.

A closer view to the UK FiT system is important to understand and evaluate the effects based on this system to locate appropriate operator models for the UK market.

Eligible for FiT in the UK are all individual, cooperate and public bodies. The maximum size for PV plants entitled to apply for the FiT's is 5 MWp. In contradiction to Germany and France there is no difference, if the PV plant is located on a roof, is building integrated or a stand-alone plant.

For the roof installation and the building integrated solutions in general no building permit is required[36]. For stand-alone solutions the permit is only deemed, when the size is smaller than 9 $m^{2.}$ In reality that means, that for a substantial PV plant a building permit with the related problems like EIA will occur.

The scheme is based on three effects:

- The generation tariff: The generation tariff is a set rate that energy supplier will pay to the owner of the PV generator. This set rate

[35] in Germany only self consumption can generate a little higher profit for the operator, but with a lot of limitations in terms of plant sizes and other restrictions

[36] Some restrictions are required especially on historical buildings, Merton rule. On roof tops the PV must not protrude more than 200mm over the roof surface;Jackie Jones; http://www.renewableenergyworld.com/rea/news/article/2010/07/new-uk-fit-spurring-pv-market-growth

will change every year for new entrants[37] but after joining the scheme the tariff will stay the same for 25 years.

- The export tariff:
    - The export tariff is paid in addition to the generation tariff for all electricity, what is not consumed on site. The tariff for each exported kWh is 3 pence/ kWh .

- Energy savings
    - The energy savings consist of all electricity, what is consumed on site. That means that all produced energy from the PV generator is free of charge, what can produce significant benefits when the demand on site is high. The maximum saving can be achieved, when the demand on site in peak hours is higher than the production of the PV plant. This effect is evident due to the fact that the price of one kWh bought from the utility companies is more expensive than 3 pence and so every kWh consumed on site has a positive outcome to the return of investment.

Table 6 shows the FiT's for the different technologies, plant sizes and the degression planned for the next years[38]. The highlighted areas show the tariffs for the photovoltaic.

[37] Only the first two years 2010 and 2011the rate will stay at the same level
[38]Table of generation tariffs;http://www.renew-reuse-recycle.com/attach.pl/2227/167/

Table 6: **UK FiT's**; source:http://www.ofgem.gov.uk/Media/FactSheets Documents1/fitfs_energy%20prices%20update%20FS.pdf

Table of generation tariffs to 2020

Technology	Scale / Scheme Year	Tariff level for new installations in period (p/kWh) [NB tariffs will be inflated annually] 1/4/10 – 31/3/11	to 31/3/12	to 31/3/13	to 31/3/14	to 31/3/15	to 31/3/16	to 31/3/17	to 31/3/18	to 31/3/19	to 31/3/20	to 31/3/21
Anaerobic digestion	≤500kW	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5
Anaerobic digestion	>500kW	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PV	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table 6 shows that feed in tariffs between 36.1 pence/kWh (0.4162 €) and 29.3 pence/kWh (0.3377€)[39] are paid to the operator of the PV plant.

The UK Feed in tariff system will in addition inflate the tariffs based on the UK-inflation index. This adds security for the investment. For home owners the feed in payments are non-taxable. The feed in tariffs are guaranteed for 25 years. This is the longest period in all European feed in systems. The idea behind this very long period of guaranteed FiT's is to minimize the disadvantages of the relatively low solar radiation in the UK[40].

To apply for the feed in tariffs, the UK scheme separates the PV generator in two classes:

- PV installations up to 50 kWp

---

[39] Exchange rate November 6th 2010

[40] For example in the southern EU countries the solar radiation allows yearly productions of up to 1300-1400 kWh/kW$_p$ whereas the UK production is only an estimated 850-950 kWh/kW$_p$

- eligible bodies to apply for the feed in tariffs have to proof that the PV plant has be constructed by an accredited installation company for micro generation (MSC certificate)[41]. The MSC shall provide proper installations for the so called micro generation plants and shall prevent negative effects to the grid by improper micro generators. It should protect the private homeowners from fraudulent contractors of renewable micro generation facilities.

- PV installations from 50 kWp to 5 MWp
- To apply for feed in tariffs in this case, the so called ROO-FiT accreditation process has to be passed. This process of accreditation is done by OFGEM[42] . In the first step a preliminary accreditation is issued. If now significant changes in the layout of the plant and in the used equipment has been made the final accreditation will be issued. With this accreditation the renewable power plants in the mentioned power range are eligible for the feed in tariff.. The small generators can choose in addition to apply for the ROC's.[43]

The cost of the elevated FiT's is transferred, like in Germany and France, to all consumers, by distribution the extra cost to the monthly electricity bill.

Summed up it can be stated that the UK feed in tariff system is a very attractive supporting scheme. The long lasting guarantee on the tariffs of 25 years, the inflated tariffs itself and the three component model of generation tariff, export tariff and energy savings are supposed to boost the UK renewable energy market for micro and small generation in the near future. The three component model is adequate to offer many different business models to operate PV plants and the possibility of choosing between FiT's and ROC's are offering even more flexibility. The substantially changed UK supporting scheme is the newest issue in the EU and has

[41]http://www.microgenerationcertification.org/

[42]The office of Gas and Electric Markets is the official body of the UK government for the deregulation of these markets and it is entitled to enforce the obligations for the usage of renewable energy sources required by the EU order.

[43] The differences in the North Ireland scheme (NROC's) and some differences in the Scottish scheme (SROC's) will disregarded in this analysis, because especially the PV installation of the future will be realized manly in England due to the better radiation situation in central and southern England

adapted to the newest perceptions for effective supporting schemes. Nevertheless the effect of the new system has to proof its effectiveness.

After having introduced the different supporting schemes for the promotion of renewable energy generation and especially the PV electricity generation in the chosen countries, a closer look to the PV plants itself and the different locations of the installation related with the possible impacts on operator models will be introduce and analysed in the next chapter.

4. Evaluation of business models and supporting schemes in the different countries

Business models can be based on various motivations, but in general the target to realize economic advantages will be the major reason to create business models and invest capital in PV plants. For sure, at the dawn of the PV technology ecological thinking was the dominant driver to operate a PV plant, but to widely spread this technology, only economic aspects will assure the mass use of PV, nevertheless the ecological spirit can and will help to promote the usage of PV. For this reason the economic impact of business models to the operation of PV plants will be the main focus of the following analysis.

Business models will vary, depending of the size of the plants, the ownership of the property where it is erected and the entity operating the plant. This will make it necessary to take a closer look to the different situations. The first situation, which will be analysed, is the private household sector. This sector is still providing the biggest number of installed PV plants, even in total capacity.

4.1.Small and medium size plants

4.1.1. Dwellings with single ownership

Today the most common use of photovoltaic is on roofs of single homes[44] using feed in tariff systems with 100% of the electricity feed into the grid. The typical size of PV plants on a single home is below 10 kWp and the owners of the houses are investing themselves, to have an additional income as well as for ecological reasons. As higher the FiT's are, the more individuals will invest in PV system, but as already found out, with additional costs for all end-users of electricity. The business model in this case is very simple and just driven by the direct economic advantages of the owner of the PV plant. The 100% feed into the grid by FiT's systems are a fast way to boost the usage of PV but it did not encourage the user to change the way of consuming electricity. PV is producing the most electricity around noon, what is on one hand suitable in most countries, because peakloads are occurring at noon. In addition the transmission of the electricity causes extra expenses. The target is now to use the PV generated electricity at the location of

[44] Durchschnittliche Größe 23,3 kWp. 91% der Anlagen sind kleiner als 5 kWp. http://www.sonnenseite.com/index.php?pageID=6&article:oid=a16362

production. This is a more and more discussed issue and the industry is starting to offer smart household appliances which use the electricity, when it is produced. The politics in the different countries offering supporting schemes to enhance the use of the onsite generated electricity by adding an incentive.

In this case the business model is shifting from a very simple system into a more complex system. To change as an operator of a PV plant to a system with more complexity an additional profit must be realized or administrative regulations have to force the operator to do so.

In the four countries that are observed the tools to achieve this goal are different and it make sense to compare possible business models and their restrictions in the different countries. But first, possible business models for single homes should be introduced:

- 100% feed into the grid
- Partial self consumption combined with feed into the grid
- Stand-alone systems with 100% self consumption and storage
- Pooling of PV installations with 100% feed into the grid
- Polling of PV installations with self consumption and feed into the grid
- Self operated, decentralized grid for housing areas
- Renting out of the roof to investors
- Renting out the PV installation

The easiest and most common business model for single homes is the 100% feed into the grid system with feed in tariffs. For this model the owner of the house just has to calculate the turnover determined by the solar radiation and the FiT's, the initial investment, financing cost and operational cost to come to a result. The house owner will invest and operate the PV plant, if the return of investment meets his expectations. Problems with ownership, contracts, guarantees, servitudes and liabilities are easier to solve, than in cases of multiple ownership.

It is very likely that single homes are financed for a very long period, and it happens that the owner is failing to pay the redemption of his debt. In this case the financing bank will auction the house. This can cause problems concerning the liabilities. This matter will be analysed in chapter 4.3. - 4.6. for each country.

Partial self consumption with feed into the grid is gaining more and more importance. The target to boost self consumption is caused by minimizing distribution cost and building up local grids. It is mentioned that local distribution could help to abate investment into the long distance grid and in the control systems for the grid. The unstable production of PV makes the stabilization of the grid more and more complicated, as more PV is installed. A consensus, if self consumption is able to reach this target, did not exist, but policy seems to accept self consumption as an adequate method to solve this problem.

For the moment the self consumption gets in the UK and in Germany extra support, but in different schemes. In the UK the self consumption makes any time economically sense, due to the generation tariffs. Each kWh what is consumed on site will have a positive effect to the economic result of the operation of the PV plant. As example table 7 shows the difference between 100% feed into the grid and self consumption in Germany with the UK. It can be seen that the UK system reacts very strongly to self consumption compared to Germany. Nevertheless the German system offers a significant incentive to use self consumption, when the part of self consumption is higher than 30%.

Tabel 7: **Comparison FiT Germany, self consumption Germany, self consumption UK**

Comparision FIT Germany, self consumption Germany and self consumption UK

Considered self consumption rate			0,00%
Plant size			5 kWp
kwH/kWp			1.000 kWh
Fit Germany			0,3303 €
FiT Geermany self consumption			0,1623 €
FiT UK generation tariff			0,4058 €
FiT UK export tariff			0,0337 €
Retail price electricity Germany			0,17 €
Retail price electricity UK			0,16 €
Yearly consumption household			5.000 kWh
Exchange rate 1GBP			1,12 €

Germany					UK				
FiT 100%	FiT self consumption		energy savings	sum self cons.	Fit 100%	generation tariff	export tariff	energy savings	sum
	0,00%	100,00%	0,00%			100,00%	100,00%	0,00%	
	self cons.	feed in							
0,3303 €	0,1623 €	0,3303 €	0,17 €		0,4395 €	0,4058 €	0,0337 €	0,16 €	
1.651,50 €	0,00 €	1.651,50 €	0,00 €	1.651,50 €	2.197,50 €	2.029,00 €	168,50 €	0,00 €	2.197,50 €
	difference to 100% feed in			0,00%		difference to 100% feed in			0,00%

Considered self consumption rate			25,00%

Germany					UK				
FiT 100%	FiT self consumption		energy savings	sum self cons.	Fit 100%	generation tariff	export tariff	energy savings	sum
	25,00%	75,00%	25,00%			100,00%	75,00%	25,00%	
	self cons.	feed in							
0,3303 €	0,1623 €	0,3303 €	0,17 €		0,4395 €	0,4058 €	0,0337 €	0,16 €	
1.651,50 €	202,88 €	1.238,63 €	212,50 €	1.654,00 €	2.197,50 €	2.029,00 €	126,38 €	200,00 €	2.355,38 €
	difference to 100% feed in			0,15%		difference to 100% feed in			7,18%

Considered self consumption rate			60,00%

Germany					UK				
FiT 100%	FiT self consumption		energy savings	sum self cons.	Fit 100%	generation tariff	export tariff	energy savings	sum
	60,00%	40,00%	60,00%			100,00%	40,00%	60,00%	
	self cons.	feed in							
0,3303 €	0,2103 €	0,3303 €	0,17 €		0,4395 €	0,4058 €	0,0337 €	0,16 €	
1.651,50 €	630,90 €	660,60 €	510,00 €	1.801,50 €	2.197,50 €	2.029,00 €	67,40 €	480,00 €	2.576,40 €
	difference to 100% feed in			9,08%		difference to 100% feed in			17,24%

Considered self consumption rate			100,00%

Germany					UK				
FiT 100%	FiT self consumption		energy savings	sum self cons.	Fit 100%	generation tariff	export tariff	energy savings	sum
	100,00%	0,00%	100,00%			100,00%	0,00%	100,00%	
	self cons.	feed in							
0,3303 €	0,2103 €	0,3303 €	0,17 €		0,4395 €	0,4058 €	0,0337 €	0,16 €	
1.651,50 €	1.051,50 €	0,00 €	850,00 €	1.901,50 €	2.197,50 €	2.029,00 €	0,00 €	800,00 €	2.829,00 €
	difference to 100% feed in			15,14%		difference to 100% feed in			28,74%

In Germany an extra premium can be realized under certain conditions. But it is strongly related to the standard electricity tariff paid by the owner of the PV plant and the percentage of self consumption of the PV produced electricity. In many cases it makes more sense to feed 100% of the production into the grid. Because the absence of FiT's for PV installations < 4 kWp the self consumption is in Austria the only alternative to use PV. In France the self consumption gets no extra grant.

Stand-alone system with 100% self consumption and storage solutions do not play a significant role in Europe as a business model. It is used for some applications in traffic control systems and on remote dwellings, but it will not gain significant importance. The absence of affordable storage solutions make the use in developed areas uneconomic.

Pooling of roofs and 100% feed into the grid could be a business model of the future. If some home owners decide to pool their roof areas to build a PV plant together, more competitive prices for the installation can be achieved and the profit for each partner of the pool would rise. Especially under existing FiT's this business model can create higher yields than single plants on one home. But as all models with multiple partners the closing of the needed contracts will be the main obstacle. In these contracts the obligation for all owners to register servitudes has to be agreed, the amount for the reserve funds has to be defined as well as the use of the profit, etc.. In the likely case that financing is required the forming of a company or any other association can not be avoided. Nevertheless the cooperative operation of PV plants can be an attractive business model.

Pooling roofs with partial self consumption offer in general the same advantages than the business models with 100% feed into the grid. In countries offering extra support for self consumption this model can create even bigger advantages. In the chapters analysing business models for the each country a closer look will be taken to this model.

Self operated grids in single home areas with multiple PV plants on or at the buildings can offer business models. The problem will be the investment in a new grid or the acquisition of an existing grid. If a new local grid has to be integrated in an existing housing area, the investment will be very high, and if profits can be realized at all, a very long period of operation will be needed. For companies or associations with the home owners as partners, the realization of an own grid will be hardly to achieve. To acquire the existing grid will be even more difficult. The local grid is in general owned and operated by the utilities what gives them a very strong position. If they would sell the local grid to the home owners, respectively their association, the utilities would give up their strong position and would lose many clients for selling traditional electricity.

The only realistic scenario for a self operated grid is the erection of a local grid in a new development for a housing area with the obligation to build a PV plant on the house and to feed this electricity in the local grid. With the purchase of the property a partnership in the association operating and owning the grid should be combined and the use of smart appliances should be a requirement in this development.

Renting out the roof to an investor is a widely used business model in the PV sector, but for single homes it is not very common. Due to the small sizes of the PV plants, the rent for the roof is very small[45] and possible long term damages to the house like a leaky roof will prevent this business model.

To build a PV plant and to rent out the complete installation is an alternative. At first sight it looks strange to rent out the plant and not to produce and sell the electricity. But under the condition that a single home owner, who is not willing to take the risk of selling the electricity after the end of existing supporting schemes, can invest in the plant an rent it for a fixed price. The operator of the PV plant, who calculates with high prices in the future, can operate a plant and realize profits without doing an initial investment. Especially if the time for the supporting schemes is short, this model has a chance for realisation. Later on, it will be analysed in a special scenario for Austria. Nevertheless for single homes the relatively high cost for negations, contracts and registration of servitudes will prevent this model to be widely used.

4.1.2. Multiple dwellings with single or multiple ownership

Apartment houses represent the major form of dwellings in urban areas and the density of the electricity consumption in the urban areas is very high. Finding appropriate business models for this area could help to solve the upcoming energy problems of the future. The trend to urbanization is getting stronger and stronger and therefore business models for PV plants on apartment houses and office buildings are needed urgently.

Various configurations of the ownership of apartment houses require different solutions for successful operations of PV installations. The most common modes of ownerships are:

- Ownership by a single person
- Ownership by an association
- Part ownership
- Ownership of municipalities

[45] In Germanyfor example, 2.5%-5% per year - related to the solar radiation- of the turnover can be offered as rent for an area suitable for a PV plant. For a 5 kWp single home installation the turnover is about € 1,650.-,/a, accordingly the maximum rent € 82.50/a

For office building the same structure applies and therefore the analysis is limited to apartment houses.

For apartment houses with a single person as the owner, this person has to evaluate, if a PV installation makes sense or not. In this evaluation it is intended, that the single owner is operating only a small number of apartments houses. With FiT`s the 100% feed in, is the most common way to operate the PV installation. If an additional incentive for self consumption exists a new problem to solve is added. In the apartment houses are living many tenants, who are using the PV electricity produced on site. In this case, some aspects have to be evaluated.

- Agreement with the tenant to deliver PV electricity
- Agreement about potential distribution of the extra profit out of the incentive forself consumption

The tenants in an apartment house will have their own metering system and own contracts with the utilities. If self consumption should be used, it becomes more complex. Due to the fact that the tenants are having their individual contracts with the utilities, the owner of the house has to establish delivery contracts with the tenants, and they have to switch their contracts to the owner. That means that the owner of the PV plant becomes an electricity producer with certain standards, he has to obtain. Because PV electricity is not available all the time, he will be forced to close contracts with utilities, to deliver electricity in the time of absence of PV electricity. This gives a first idea that this scheme will only work, when the PV plant has a significant capacity. A plant with 10 or 20 kWp will not be able to bear the burden of the complex negotiations and contracts to be done for such a project. And even in projects with bigger volume, the tenants have to be convinced, that it makes sense to switch from the utility to the operator of the PV plant. In reality it has been shown that for example in Germany less than 10% of the consumers are changing to other suppliers of electricity, even if they offer better prices[46].

This leads to the question of the distribution of the profits that can be realized out of the self consumption scenario. To remind, the extra profit that can be shared is only the one, what is realized on top of the profits of the 100% feed model. As more electricity is consumed on site, as higher the extra profits are. If the distribution of extra profits should be done, the percentage of each tenant has to be determined to guarantee a fair distribution. The one who is adapting his energy consumption to the

[46] http://www.eon.com/de/responsibility/29285.jsp

availability of the PV electricity should get the extra accordingly. The one who is not able or willing to adapt to the energy production pattern of the PV plant will get less. A must for such a calculation is a metering system, which is able to count the different supplies of electricity from the utility and the PV plant.

This description shows already the complexity of PV plants on apartment houses with many tenants and a single owner. The owner will face severe problems to realize a PV plant using self consumption. In times of feed in tariff systems, he will prefer the 100% feed in system. It can be assumed that only a significant reduction of the electricity price can motivate tenants to change. Ecological reasons as a marketing instrument can support the willingness to change, but the price will stay the major influence for a possible change.

Nevertheless in future times, this model can become attractive, when the price for the PV systems continues to decline and the prices for the energy from fossil fuels rise. The creation of standard contracts, affordable intelligent metering systems and automated billing systems has to accompany this model to use it in smaller scale projects with single ownership of apartment houses

When the owner of the apartment houses is an association, the main problem remains the same. If a FiT's system is in force, they will in general utilize this very simple business model. If they want to use the self consumption regulation an attractive business model is only to create, if the majority of the tenants will switch their energy supply to the operator of the PV plant.

Associations operating apartment's buildings with a significant number of houses, will have the advantage to have already existing back office facilities for managing the negotiations and contracts with the clients and the utilities. Although they could realize lower investment cost for PV plants by combining multiple PV plants to one project or by closing master agreements. In contradiction to the single owner, they can have already the status of energy suppliers for their own dwellings and have negotiated special delivery contracts with the utilities, with prices below the standard retail price for the tenants. In this case the calculation of the PV plant will become even more difficult, because the gap between the retail price and the PV price is lower.

Part ownership of an apartment house is very common and it exists mainly in two versions.

- All owners are living in their own apartments
- A part of the apartments are rented out.

In the first case, the probability to convince all owners to build a PV plant on the house and to use the feed in tariff model is likely. Nevertheless the decision to use parts of the house for installing a PV plant will require very often a concordant decision of all owners, because the wall and the roof of the house are common properties, fixed in the declaration of condominium. This shows the weak part of this model. Only one person can obstruct the installation of the PV plant. That argument is valid for the case with all owners living in the apartment house and in the likely case that apartments are partly rented out. If self consumption is taken into account, the difficulties already described will be added and the realization of a PV installation will become very improbably.

Local communities often own apartment houses for offering affordable housing for households with low income. The community can establish the same business models already described, with the same opportunities and burdens, but it can in addition set easier standards to their houses. Setting standards for the obligation to use PV is critical, because it affects directly the economical result of the owner of an apartment house and can create competition disadvantages. In that case the owner and operator of the apartment house is a community itself, setting standards is uncritical. Together with this standards, the tenants of apartments offered in social aid programs, can be supplied with the PV energy for a reduced price to give support. On the other hand the community can get benefits from feed in tariffs to subsidies the reduced electricity price and they can make it mandatory, to use electricity provided by the community.

4.2.Utility size plants

The utility size plants are in general stand-alone system on large arrays or roof mounted PV plants on industrial or commercial buildings. These PV power plants have been multiple realized in Germany, Spain, Czech Republic and all countries offering high FiT’s. It is not a big challenge to realize these plants with FiT’s, but with declining FiT’s and limitations for available properties, new business models have to come. At the moment mainly private investors owning and operating large scale PV plants from 200 kWp to 80MWp, feeding in the complete energy into the grid, but in the future utilities will play a more and more vital role in the development of large scale plants. On one hand they have already existing distribution channels and direct access to the customers and on the other hand they have financial resources to do the initial investment. Nevertheless at the moment there is no way to produce competitive electricity out of PV without some support schemes, even with very big plants. In the near future, under the assumption of increasing prices for electricity out of fossil fuels and decreasing prices of PV electricity the generation and storage of electricity can become a profitable business model for utilities. Because the PV is producing in the peak load hours at noon, the utilities can trade this electricity intraday, if the peak price is suitable. In the countries with a high share of PV, the peak hours at noon will disappear due to high production of the PV plants at noon during sunny days. In this case the price for electricity in the noon hours will decrease. Utilities can respond to this situation with storage -for example in pumped storage hydroelectricity plants - and resell the electricity in hours of high demand.

The main problem discussed concerning big plants - especially for stand-alone systems - is the excessive land use of these plants. More and more resistance against these types of plants is coming up. As a consequence they will only be accepted, in remote areas or on conversion areas like old industry sites or landfill areas.

The above introduced possibilities for PV plants could have different impacts to business models in each country. To evaluate the influence of the existing support schemes on possible business models in the four chosen countries, each country has to be analysed.

4.3.Austria

In this chapter the different business models will be explored in general and for the specific situation in Austria. The general models will be compared in the chapters for Germany, UK and France to show the different results, caused by national supporting schemes and legal aspects.

As shown in chapter 3.1.the Austrian support systems for small size plants ≤ 5 kWp, is limited to direct subsidies given by the climate and energy act with no FiT's. Even if the budget for this scheme is very limited and it is already spent for 2010 a business model based on this scheme should be investigated.

In this case the owner of the PV plant will create an economic extra value only by consuming the electricity on site and buying less electricity from the utilities. The economic feasibility of the project is determined by the solar radiation at the designated location, the height of the subsides, the retail price for the electricity, the consumption, the fraction of the produced PV energy that can be used, the interest rates, the time of the redemption for an potential debt and the estimated lifetime of the plant. The last factor is in general underestimated but it is one of the key factors for the profit that can be created by a PV plant. In case of subsidies the question for the planed lifetime is obvious, because there is no regulatory framework related to the lifetime of the plant. The individual setting of this factor will rule the decision to invest or not to invest.

In case of FiT’s the lifetime of the PV plant is set in general equal with the period of guaranteed tariffs. The calculations for the bank financing are based on this guaranteed price period, to guarantee a business plan with no risk from price variation. The remaining risk is limited to changes in solar radiation, what is a very unlikely[47] and to the only relevant risk, the failure of main components, like modules or inverters. This kind of calculation will lead to results, which require either very low investment cost per kWp or gradually high tariffs for the electricity. This matter will be highlighted later and will become one of the critical parameters of future business models under absence of supporting schemes.

If a detached house owner in Austria thinks about investing in a PV plant ≤ 5 kWp, the first decision to make is the size of the plant. The positive effect of the PV plant will be higher, as more of the produced electricity is used in the house. The average household in Austria has a yearly demand of about 4,417 kWh/year[48]. With an estimated production of 1000 kWh/kWp in Austria[49]a PV generator with a peak capacity of 4.2 kWp could theoretically supply enough electricity to cover the needs of the household. But the disadvantage of the technology is the varying radiation of the sun. For delivering electric lighting in the night, PV is obviously not the adequate technology. The only way to consume the maximum of the produced electricity is the additional installation of a storage solution. These solutions are expensive and sophisticated solutions are not yet available. The overproduction can be feed into

[47] Variation from 1975 until 2005 was between 1365 and 1367 W/m2; Source:http://en.wikipedia.org/wiki/File:Solar-cycle-data.png

[48]Satisitk AustriaStatus 2008http://www.statistik.at/web_de/dynamic/statistiken/energie_und_umwelt/035453

[49] JRC European Commission, Photovoltaic geographical information system,http://re.jrc.ec.europa.eu/pvgis/apps3/pvest.php

the grid, but there is no state regulation that determines the price per kWh. The possibility to sell the electricity to the base load tariff exists, but with an average base load price of 4,834 Eurocent in the last 5 years[50] it did not offer an economic alternative. Some utilities are offering contracts to buy the access production, but there is no legal obligation to do so and therefore it is difficult to create business models for the future on this base.

The FiT's for installations ≥ 5 kWp ≤20 kWp in Austria is 38 Eurocents, what can make an investment in PV attractive. The duration of the FiT's of only 13 years make it for sure more difficult to get financing for the plant. A IRR of 5.43% is lower than the general requested IRR >7% [51], but it is still a better return of investment as a savings account with the actual low interest rates.

In Austria the operation by the owner of the house and feed into the grid with or without self consumption is most common.

Different models, where the owner is not operating the plant himself could be:

- Rent out of the roof
- Rent out of the PV plant

On single homes the rent out of the roof seems to be quite unrealistic. Due to the fact that the size of the plant is in general small, the achievable rent will be very limited. For a 10 kWp plant in Austria a yearly turnover of about € 3,800.- by feeding into the grid is realistic. After depreciation and taxes of € 2,500.-[52] only € 1,300.- will remain for a potential investor. Even if he would be willing to pay 10% of his turnover to the owner of the roof, only € 130.-/a could be paid. This is for sure an unattractive rent and the risk of any damage of the roof or any other risk will prevent the owner of renting out the roof of his home.

The renting out of the entire PV plant on a single home is currently not realized in lack of any investor. Nevertheless it could be a business model and should be analysed.

The advantage for the operator to rent an entire PV installation is the absences of the initial investment. This investment is made by the owner of the plant, and the operator has only to pay a rent for using the installation.

[50] Source EEX.http://www.eex.com/en/Download,Quarterly Prices According to CHP Law
[51] Appendix8.2.1,
[52] Price for PV plant € 2,900.-, depreciation 13 years according to FiT duration, tax 25%

For the owner of the plant it could be attractive, because the operator is taking over the risk of future development for the price of electricity, and he has a not varying, regular income combined with a fixed interest rate on his investment. This is in countries like Austria, where the FiT system is limited to only 13 years an issue. If the operator of the PV installation is a large entity like utilities and the owner of the single home and the PV plant is judging the risk of a breakdown of this entity low and the risk of negative future electricity price development high, this model could be interesting.

On the other side the operator has to solve some particular problems, what makes this type of business models until today, especially in the single house environment, very uncommon.

First of all, the operator has to proof to the owner that he has the financial potential to pay the rent for a very long period. In general the period will be longer than the FiT's period. If the rent would only be limited on the time of the FiT's, no advantage for both sides could be created. If the operator is able to proof the ability to guarantee the long term renting contract, it is very likely that this potential operator will be an entity with sufficient capital resources and in general this entity will be able to invest itself. Nevertheless it could be possible that the existing capital is needed for other investments and the renting of PV installations could offer advantages. Difficulties will occur, when the operator is making long term contracts to sell the produced electricity. In the case of bankruptcy of the owner of the PV plant, the access to the plant could be limited or totally lost. Regarding small installations the administrative cost of doing the contracts, managing many small plants and so on are preventing this business model from being used currently. To initialize this type of business models, standardized contracts automated back office solutions and controlling tools must be developed to minimize the costs of this model. For larger installations this models could be already an alternative.

The calculations in Appendix 8.2.2.are showing positive business results for the operator and the owner of the plant. The owner will realize out of his € 29,000.- investment a yearly rent of € 2,000.- for 25 years, and the operator will create positive cash flows over the whole period, without any capital invested[53].

Legal aspects which have to be taken into consideration are the liabilities of the PV plant in alliance with the financing of the PV plant and the financing of the single

[53]Appendix8.2.2.

home itself. In the single home case this question will not cause bigger problems, but in contradiction for of multiple dwellings, this aspect can have significant impact on the business model. For this reason the possible situations, which can cause difficulties in case of disposition or auction due to fail paying back the debt for the single home, have to be to analysed:

- Single home and PV-plant are financed, both debts are given by the same bank
- Single home and PV-plant are financed by different bank
- Single home is still financed and the PV plant is already paid

The first case is easy to handle for the bank, because the house and the PV plant will be liable for the financing and therefore the house can be sold or auctioned including the PV plant without any hindrance.

In the second case problems can occur. It can be assumed that the PV plant is able to bear the financing of the PV plant itself. The turnover of the PV plant is in general ceded to the bank and so the financing bank of the PV plant does not have a problem. In the case of the insolvency of the house and PV plant owner, the right to open the foreclosure will be transferred to the two banks. This particular case raises the question of the liabilities. Areal estate in Austria is including the house itself, the property, and all parts of the property and the house which are fixed to the house. These parts cannot be separated to serve as single liabilities. That means, if the PV plant is fixed to the house it becomes a substantial part of it and cannot be separated to be a liability for the PV financing. Now the definition of the word fixed is crucial for the financing bank and possible business models. If a PV plant would be a fixed object on the house, business models with different ownership are practical impossible, if the house is still financed. Under these circumstances, the PV plant would be liable for the financing of the house too and the investor in the PV plant would partly take over liabilities for the financing of the house. In Austria the word fixed is specifies as "ground bonded, riveted or nailed".[54] Most PV plants are fixed with screws to the roof or the building. In this case the PV plant is not a substantial part and can be used as a proper liability for the financing. In the case of the foreclosure sale of the house, the question of the future operation of the PV plant has to be determined. If servitude has been registered in the cadastral register, the financing bank of the PV plant can operate or sell the PV plant. In this case the

[54] http://de.wikipedia.org/wiki/Grundst%C3%BCck

new owner has to tolerate the PV plant on his house, but a rent for the roof has to be negotiated, what can ruin the profitability of the PV project and the PV plant has to be removed from the roof. In consequence the entitlement for the FiT will expire, because it is associated to the location of the plant. The only remaining value of the PV plant than consist in the used parts like modules, inverters etc., what will not present a significant value, considering the falling prices of PV components in the future.

In addition it is very unlikely that servitude is registered in the cadastral register, if the owner of the house and the owner of the PV plant are identical.

The third possible case can cause the same trouble than case number two. The difference between the two cases is that after the bankruptcy of the house owner, a liquidator will be appointed, who can operate the PV plant on the house. He will be in the same situation as the financing bank of the PV plant with the same scenarios.

For multiple dwellings like apartment houses the same schemes than for single homes apply in Austria.

Due to very limited funds in Austria, a practical absence of any support for PV can be stated. Utility size plants are not feasible. Business models have to work in a free market environment, which is at the moment not possible. Consecutively the PV market in Austria has developed very slowly and shows no significant production of PV electricity.

To find business models in Austria for single houses, multiple dwellings and utility size plants business models without subsidies have to be designed. These models will not be significantly influenced by the national characteristics and developed in chapter 5.

4.4.Germany

In Germany the market for single home PV installations is very developed. Many single home owners, especially in the south of Germany, have taken advantage of the attractive FiT's to build and operate PV plants. Due to the latest reduction of the FiT's in Germany combined with the increase in the maximum allowed capacity for self consumption up to 500 kWp, self consumptions has become a more and more attractive way to operate a PV plant. In contradiction to Austria the funds for financing the use of PV are not limited. Due to the allocation of the support scheme costs to all consumers of electricity, the state budget is not significantly touched. The operation of a typical PV installation of 5 kWpwith 100% feed into the grid will produce a IRR 7.02% [55]. If self consumption of 50% is taken into consideration the virtual FiT increases by 1.19 Eurocent and the IRR raises to 7.46%[56]. For single home owners, paying the regular retail price, it makes always sense to use self consumption and the advantage increase with the percentage consumed on site.

For the apartment houses case, self consumption faces the same problems as described in the case of Austria.

The issue of the liabilities during the financing are the same as in Austria too, especially the aspect of the PV plant as a substantial part of the building is handled in Germany the same way than in Austria.

The increase of the maximum capacity eligible for self consumption from 30 kWp to 500 kWp could make this business model used more widely.

A very common business model in Germany for larger PV plant is to do long term rental agreements with owners of buildings or real estates, to erect and operate PV plants on the rented sites. The rental cost and duration of the contract are crucial parameters in the IRR calculation. To have the flexibility to operate more than 20 years, these contracts often have options for a prolongation of 5-10 years. For long term rental agreements the registration of servitudes is mandatory. It has to be secured that a change in the ownership of the rented location will not obstruct the operation. In the case of financing, it is a requirement from the financing institutes to have servitudes registered in the cadastral register. With the PV installation as a not substantial part of the building, the operator and the financing institute have the security of plant operation during the planed lifetime. Only with building integrated solutions like PV-foils as roofing material or PV facades, this system does not work, because the PV plant becomes a substantial part of the building and cannot be separated. Therefore the use of BIPV is only suitable for business models where the ownership of the PV plant and the building is identically.

Self consumption in the rent model pretends that operator of the plant and the consumers of the electricity are different entities. Regarding the definition of self

[55] Appendix 8.2.3
[56] Appendix 8.2.4

consumption it seems to be impossible to apply for the self consumption tariff when the consumer is a different entity than the operator of the PV plant. On one hand this seems to make sense, but on the other hand it has to be questioned, what the law was trying to achieve. The target of the preferred support of the self consumption is the consumption of the produced electricity on site. Why should it be a hindrance when operator and consumer are different entities? Who is eligible for the extra profit out of the self consumption?

The law is using the definition that the operator has to consume the energy, but the consumption at the location of the plant by third parties is seen as self consumption too[57]. Assumption for the eligibility of the self consumption tariff in this case is that the transmission grid of the utility is not used and the grid, transmitting the self consumed energy, is owned by the operator of the plant. If the PV plant is operated on a rented roof on a commercial building, the local grid will be in general in the possession of the owner of the building and not of the operator and owner of the PV plant. Direct trading of the electricity is a different situation and the self consumption tariff could not be claimed. That prevents selling the electricity to third party consumers and claiming self consumption. At the moment the legal interpretation is not finally determined and accordingly the self consumption tariff is not used under these circumstances.

As already demonstrated, for bigger PV plants on apartment houses or industry sites the price for the regular electricity is critical, when using the self consumption tariff option. Due to the fact that entities with a high consumption will have lower prices than the household retail price, the self consumption will be used less. For example the critical price for the regular electricity for an operation of a plant with 50% self consumption is 14.63 Eurocents. Considering a 200 kWp plant, a base load of 100 kW is required to reach the 50% self consumption. Companies with such consumption will have reduced tariffs for regular electricity what affects the generation of extra profits from self consumption negatively.

Utility size plants have been realized in Germany very often. The biggest plant is located near Leipzig and has an installed capacity of 40 MWp. But with the changes of the EEG on July 1st 2010, it has become more difficult to invest in large scale ground mounted PV plants. In the new EEG the conditions to claim FiT's and the tariffs themselves have changed considerably. In the version of 2009 it was possible

[57] http://www.etagreen.com/archive/107,715380/Sonne/Eigenverbrauch-von-Solarstrom.html

to erect plants on agricultural areas, commercial areas and conversion areas. In the new version the agricultural land, the most common used location for large scale PV plants, has been excluded. As consequence new plants have to be erected at commercial or conversion areas. The commercial areas are more expensive to lease or to buy and with the decreased FiT's the realization of plants in the megawatt class have significantly decreased.

For Germany it can be summarized that the 100% feed into the grid business model is widely used, but the possibility to claim an extra bonus by using the self consumption opportunity is offering an attractive alternative. The decrease of 13% on July 1st, 3% on October 1st and another 13% on January 1st 2011 will impact the business models of the next years. For sure the prices for the components will follow somehow, but the pressure to create business models without subsidies will grow.

4.5.France

France is offering at the moment the highest FiT's of the four analysed countries. The main difference is the demonstrated complexity of the criteria for eligibility by the location and construction type of the plant. Especially the building integrated solutions are offering very attractive FiT's, but have to deal with high initial investments. The average price surplus for building integrated PV is about 28%[58]. As shown the maximum size of the BIPV plant eligible for the highest FiT is 250 kWp. The calculation[59] for a 50 kWp BIPV plant shows a IRR of 8.90% and will make the investment in this type of plants attractive. But the BIPV plant business model is only possible for the owner of the building, because the same argumentation as for all the other countries is valid. The plant will become a substantial part of the building. In addition the requirement of the French legislation to replace the roofing material and offer the function of weather protection adds potential risk to the project. Long term experiences for these types of plants do not exist. The interpretation of the legal expressions defining the eligibility to apply for the elevated FiT is adding risk as well.

A disadvantage of the French system is the long period, required for receiving permission to build. This will generate extra expenses which can be lost in the case

[58] http://www.solarserver.de/solar-magazin/solar-report/gebaeudeintegrierte-photovoltaik-auf-dem-weg-zum-massenprodukt.html

[59] Appendix 8.2.5.

of denial of the application. In Germany and Austria for small and medium size projects it takes very short time to obtain the permission or it isn't required at all.

All other business models based on the FiT's are not showing different results and problems than for Germany and Austria.

4.6. UK

The UK FiT's system allows all business models already described, but due to the different layout of the FiT's system in the UK some extra business models are possible. The main difference to the Austrian, German and French system is the generation tariff, which is paid without obligation to feed the produced electricity into the grid. That makes self consumption or trading with the produced electricity more attractive. In contradiction to the other countries the following business models are easier to establish and offering sound earnings.

- Rent of a location and offering the produced electricity
- Self consumption for high volume electricity consumers

If an investor would like to rent for example a roof, the generation tariff offers the possibility to pay the rent by delivering electricity to the owner of the building. The average electricity price in the UK is 13.58 pence/kWh[60] and the export tariff for the PV plant operator is 3 pence/kWh. This gap can be used to pay for the rent of the location. The average electricity bill in the UK is 448.-GBP for a household consuming 3,300kWh/a. For a detached house, suitable of carrying a PV plant, an average consumption of 5,000 kWh/a and the related bill of to 679.- GBP can be assumed. If the operator of the PV plant would offer the produced electricity for free and the household could consume 50% or 2,500 kWh/a of the produce electricity, a saving of 389.50 GBP could be achieved. The costs for the operator to offer these electricity is the not realized export tariff of 3 pence/kwh, what equals a value of 75.- GBP. In Austria, France and Germany this model in general does not work, because the operator can pay only a limited price for the rent[61] and the disadvantages of the possible defects on the house are bigger than the extra income. In the UK this extra income for the household, with saving in the illustrated

[60] http://www.decc.gov.uk/assets/decc/Statistics/publications/prices/566-qepsep10.pdf
[61] See page 50. In Austria only € 130/a

example of 50% of the electricity bill, is significant and the costs for the operator are bearable.

Obviously this model gets more and more attractive, as bigger the plants are and as higher the percentage of the consumed electricity is on site. In the UK this model is possible up to the maximum supported size of 5 MWp. The ideal model is a big volume electricity consumer with a base load greater than the maximum capacity of the PV plant. This implicates that all generated electricity can be offered and used on site. For example a factory with extreme high electricity consumption and the average price of extra-large consumers of 5.078 pence[62] could save up to 215,850.-GBP/a by offering the operator the needed space for a 5 MWp PV plant. With rising electricity prices this effect will generate more and more savings. Even under the condition of stable electricity prices in the 25 years of the granted FiT's, the savings would be 5,396,250 GBP. For a stand-alone or an inclined roof top PV system the space for the assumed 5 MWp plant is about 15 ha and a related rent of 14,390.-GBP/ha will be realized.

All the arguments above will apply as well, when the PV plant is operated by the owner of the property himself. These very high figures will boost the UK PV market in the next years significantly.

The UK feed in tariffs system has the advantage over the systems of Austria, France and Germany that especially in the apartment house sector it is considerably easier to operate and deliver electricity to the tenants of the apartments. Due to the generation tariff it is more expedient to deliver the electricity to the local consumers, than to the grid, because the retail price is higher than the export tariff. If the owner of the building is operating the PV plant, he can sell the PV-generated electricity for a reduced price what is beneficial for the tenant, who has as more advantage of the reduced price as more he consumes from the PV electricity.

If the operator of the PV plant is different from the owner of the building, a possible business model is to give the produced electricity to the owner for free as a compensation for the given space for the PV installation, and the owner himself can sell the electricity to the tenants. With an installed net metering system the difference between the supplied energy by the utility and the consumed electricity by the tenants represents the profit of the owner of the property. The owner can offer a

[62]http://www.decc.gov.uk/assets/decc/Statistics/publications/prices/566-qepsep10.pdf; page 33

competitive PV electricity price for the tenants to motivate them to use it, when the PV plant produces.

In the urban areas a speciality of the UK has to be taken into consideration, when operating a PV plant. Different to the other examined countries in the UK the apartment buildings, the majority of the buildings in the cities, are divided in leasehold and freehold buildings[63]. The leasehold is a long term lease with up to 999 years duration and in general not shorter than 40 years, when agreed. The freehold is a not limited ownership of the property.

Most buildings and apartments in the UK are leaseholds and therefore it is vital to check the residual term of the existing leasehold agreement. It has to be at least as long as the FiT's are granted, that means at least 25 years, but it should exceed the expected lifetime of the plant of 35-40 years.

It can be seen that the business models of the UK and all other countries are depending on the support system. Although all system have mechanisms to decrease the FiT's over time and this will lead compulsory to new business models, which do not rely on supporting schemes.

Table 8 gives an overview of the differentbusiness models and their economic feasibility.

[63] http://www.justlanded.com/deutsch/Grossbritannien/Artikel/Immobilien/Britisches-Grundstuecksrecht

Table 8 : Economic feasibility of different business models

Economic feasibility of business models

	stand alone	100% feed in	self consumption	pooling 100% feed in	pooling self consumption	rent out space	rent out PV plant	self operated grids
Austria								
singel homes	+	-	+	-	+	-	-	+
multiple dwellings single ownership rented out	-	+	-	na	na	+	+	+
multiple dwellings multiple ownerership rented out	-	+	-	na	na	+	+	+
multiple dwellings multipe ownership self used	-	+	-	na	na	+	+	+
multiple dwellings owned by associations	-	+	-	+	-	+	+	+
multiple dwellings municipality owned	-	+	-	+	-	+	+	+
utility size	-	-	-	-	-	na	-	-
Germany								
singel homes	--	++	++	++	++	-	-	+
multiple dwellings single ownership rented out	--	++	-	na	na	+	+	+
multiple dwellings multiple ownerership rented out	--	+	-	na	na	-	-	+
multiple dwellings multipe ownership self used	--	++	++	na	na	+	+	+
multiple dwellings owned by associations	--	++	+	+	+	++	+	+
multiple dwellings municipality owned	--	++	++	++	++	+	+	+
utility size	--	++	--	+	--	na	+	+
France								
singel homes	--	++	--	++	--	+	-	+
multiple dwellings single ownership rented out	--	++	--	na	na	+	+	+
multiple dwellings multiple ownerership rented out	--	+	--	na	na	-	-	+
multiple dwellings multipe ownership self used	--	++	--	na	na	+	+	+
multiple dwellings owned by associations	--	++	--	+	--	++	+	+
multiple dwellings municipality owned	--	++	--	++	--	+	+	+
utility size	--	++	--	+	--	na	+	+
UK								
singel homes	+	+	++	+	++	+	+	+
multiple dwellings single ownership rented out	+	+	++	na	na	+	+	+
multiple dwellings multiple ownerership rented out	+	+	+	na	na	+	+	+
multiple dwellings multipe ownership self used	+	+	++	na	na	+	+	+
multiple dwellings owned by associations	+	+	++	+	++	+	+	+
multiple dwellings municipality owned	+	+	++	+	++	+	+	+
utility size	+	+	++	+	-	na	+	+

5. Business models of the future under absence of supporting schemes

The time limited support schemes in all countries make it necessary to look for other business models working in absence of subsidies. But how can alternative business models look like and compete with the traditional energy supply out of fossil fuels?

The easiest way to reach this goal is to extend the period under consideration. Assumed that at PV plant will generate electricity for 25 years, already today a not subsidized plant will offer an IRR of 3.59% based on the current electricity retail price[64]. This determines that the electricity can be sold for the retail price or can be consumed a 100%. For a single house this target is very unrealistic, but on locations with high volume demand the 100% self consumption seems possible, but as already shown those consumers will have lower electricity prices.

A more realistic scenario for a future operation of PV plants are even longer periods of operation with replacement of the inverters and modules after a given period. A calculation with 40 year of operation and a replacement of the inverters after 20 years and the modules after 25 years, based on a price of the initial investment of 1000.-Euro per kWp and a sales price of 10 Eurocents per kWh offers already a IRR of 7.01%.[65]

But the above introduced business model needs still a price of 10 Eurocents to deliver an acceptable IRR. At the moment even the average peak load price traded in the EEX is in average lower[66]. It is very likely that the price for regular electricity will rise and influence this case positively. Anyway it will be critical to get this price. To achieve the best price for the PV generated electricity in the future, storage will be mandatory. If a change in the peak load pattern occurs storage is needed to adapt and to sell, when the prices are high, but storage solutions like hydroelectric pump stations are expensive and a single PV operator will not be able to realize such projects. The formation of cooperatives of many PV operators on the other hand could manage such projects.

Cooperatives are a sophisticated solution to establish direct sales to customers, acquiring and operating local grids and offering back office solutions for the PV

---

[64] Appendix8,2,6,
[65] Appendix8.2.7.
[66] http://www.eex.com/de/Marktdaten/Handelsdaten/Strom/Intraday%20|%20Spotmarkt/Intraday%20Chart%20|%20Spotmarkt/spot-intra-chart/2010-10-11/1y

operators like meter control and invoicing. After feed in tariffs have been vanished the operators will be highly motivated to find solutions to sell the electricity of the already depreciated PV plants. Most calculation models for PV installations are based on 20 years and the depreciation is adjusted to these 20 years, but the technical lifetime of PV plants is estimated between 30-40 years. That implies that the plant can produce another 10 and 20 years and only operational costs will apply. A typical amount of the operating cost is about 30 € per kWp/a and with a yearly production of 1,000 kWh/kWp the cost for 1 kWh is only 3 Eurocents. If a 2% inflation is taken into account, the production cost of 1 kWh will be 4.37 Eurocents in 20 years, 5.32 Eurocents in 30 years and 6.49 Eurocent in 40 years. Obviously this will be competitive prices in the future.

Cooperatives can merge the interest of the operators and especially in urban areas with many small or medium size plants they could add value to the operators.

Utilities and other large entities with long term strategies can benefit from the same effect and they can already start to secure their future interests. A possible business model for these companies, if they are not willing to invest directly, is to act as guarantors for investors and operators of PV plants. As return service they could agree to take over the PV plant after the FiT has faded out for free or a very low price. This gives investors, who have not the financial power, the opportunity to realize their projects, and the guarantors would have the benefit of taking over a depreciated plant with very competitive production costs.

The development of future prices for initial investment will certainly determine the development of the use of PV. In general all business models depend on the relationship between investments, turn over and time of operation of the plant. It is not possible to find out where the prices for PV installation will be in the future, but if the development of the prices in this sector will follow the development of other technologies it can be estimated that prices for PV will decrease dramatically. Production facilities for thin film modules will be able to produce 1 Watt peak for 44 Eurocents in 2011.[67] So it can be estimated that compete installations will be available below 1 Euro/Wp in the very near future and prices reaching 50 Eurocents/Wp are conceivable. With these initial investment PV plant based on 30

[67] http://www.photon.de/photon/pd-2008-05.pdf

years of operation could initially generate 1 kWh for 6.5 Eurocents, what constitutes a competitive price while offering an IRR of 8,88%[68].

The above introduced business models have demonstrated that even under absence of FiT'sa profitable operation of PV plants is possible.

[68]Appendix 8.2.8.

6. Conclusion

The analysis of the different supporting schemes in the four chosen countries have proven that at the moment all business models are based on subsidies and operation of the plants is not profitable without support. But the rapid growth of the PV market has already decreased the prices of installations significantly and the prices for the initial invest will drop dramatically in the near future. With low installation costs and new business models like cooperatives of PV plant operators, extended operation of the plants with revamping after a certain time of operation and generation of PV electricity with depreciated plants, the use of PV will grow after the supporting schemes have faded out.

Reality has shown for the four countries Austria, France, UK and Germany that the FiT's are the best solution, to support the development of PV. But all countries have differences in their FiT's systems. Germany as the leading market in the world has triggered with its FiT's investments representing today an installed capacity of 14.68 GWp[69]. Due to this growth the FiT's have been reduced in the revision of the EEG in July 2010 and the tariffs will be decreased further on, to reach grid parity in 2013-2014.

The Austrian supporting scheme of today is characterized by the very limited funds, which do not allow significant use of PV in Austria. For the operators receiving a part of the limited subsidies profitable business models are feasible. Otherwise with the existing initial investment costs, business models are not profitable. Only scenarios in absence of subsidies will work in the future.

France has redesigned its FiT's system and increased the FiT's in January 2010 but has already cut the tariffs in August 2010 because the government was worried, that the market would grow too fast. The French system still offers the highest FiT's of the four countries. The preferred support of BIPV makes business models for this type of installation the most attractive, but as substantial parts of the buildings, only business models where ownership and operation is in one hand can work properly.

The structure of the UK FiT's system is different than in the other three countries. The use of a generation tariffs, export tariffs and energy savings combined with 25

[69] Bundesnetzagentur: Status 31.08.2010

years of guaranteed prices for PV will boost the UK market to one of the major markets in Europe. This system makes business models based on a high percentage of self consumption favourable. The generation tariff offers the opportunity to sell the produced PV electricity for a competitive price and establish decentralized electricity production. The limitation to claim FiT's for installations ≤5 MWp will help to keep the market structure decentralized.

For the future the development of PV electricity production will depend on the development of the prices for the PV components. To offer attractive business models a price level for turnkey power plants between 500.- and 1000.- Euro per kWp installed capacity has to be achieved depending on the price level for electricity out of fossil fuels. Alternatively the production with depreciated plants and extended use of up to 40 years will help to bridge the time until the prices for PV systems have reached competitive price levels.

7. References

2. Ökostromgesetznovelle 2008 § 21 b. (2008). Retrieved from Bundesgesetzblatt 1 Nr.114/2008: http://www.pvaustria.at/upload/1321_Abaenderungsantrag-OSG-07-2008.pdf

A.T. Kearney. (2010, June 22). *SET for 2020.* Retrieved from http://www.setfor2020.eu/

Alr, F. (2010, July 11). *Sonnenseite.* Retrieved from Photovoltaikzubau in Deutschland: http://www.sonnenseite.com/index.php?pageID=6&article:oid=a16362

Andor, M., Flinkerbusch, K., Janssen, M., Liebau, B., & Wobben, M. (2010). *Negative electricity prices and the priority of renewable energy sources.*Retrieved from Lehrstuhl für Volkswirtschaftstheorie, Westfälische Wilhems-Universität Münster,: http://www.wiwi.uni-muenster.de/vwt/organisation/veroeffentlichungen/AFJLW-2010-Negative-Strompreise-und-der-Vorrang-Erneuerbarer-Energien-ZfE_final.pdf

Austrian Energy Agency. (2009). *Annual Report 2008.*Wien: Austrian Energy Agency.

Biermayr, P., Ehrig, R., Strasser, C., Wörgetter, M., Prüggler, N., Fechner, H., et al. (2010). Innovative Energietechnologien in Östereich, Entwicklung 2009. *Berichte aus Enerie und Umweltforschung 15/ 2010*. Bundesministerium für Verkehr, Innovation und Technologie.

Bund der Energieverbraucher. (2010). *Energy prices.*Retrieved from www.energienetz.de/files_db/1277202249_7707__12.xls

Bundesgesetzblatt 40/2007 idgF. (2010). Richtline des Klima- und Energiefonds für die Förderung von Photovoltaik- Anlagen in 2010.

Bundesgestzblatt für die Republik Östereich. (2010, Februar 2). *Ökostromverordnung 2010-ÖSVO 2010.* Retrieved from http://www.ris.bka.gv.at/Dokument.wxe?Abfrage=RegV&Dokumentnummer=REGV_COO_2026_100_2_337401

Bundesnetzagentur. (n.d.). *Datenmeldung vom 1 .Oktober 2009 bis 30 September 2010.*Retrieved from http://www.bundesnetzagentur.de/cae/servlet/contentblob/160398/publicationFile/8921/MeldungenJuniSept2010xls.xls

Bundesnetzagentur Deutschland. (2010, August). *Feed inTariffs 2010.*Retrieved from http://www.bundesnetzagentur.de/cae/servlet/contentblob/135486/publicationFile/8928/DegressionsVerguetungssaetze2010_pdf.pdf

Bundestagsdrucksache. (2010). *17/1147, 17/1604, 17/1950 17/2402.* Retrieved from http://www.bundestag.de/ dokumente/drucksachen/index.html

Carbon trust and LEK consulting. (2006, July). *Policy Framework for Renewables.* Retrieved from http://www.cleanenergystates.org/international/downloads/Policy_Frameworks_for_Renewables_Carbon_Trust_July2006.pdf

Department of Energy and Climate chnage UK. (2010, September). *Quarterly Energy Prices 2010.* Retrieved from http://www.decc.gov.uk/assets/decc/Statistics/publications/prices/566-qepsep10.pdf

EEX European Energy Exchange. (2010, October). *Quarterly Prices According to CHP Law.* Retrieved from http://www.eex.com/en/Download

E-ON. (2010). *Kundenbindung statt Abhängigkeit.* Retrieved from http://www.eon.com/de/responsibility/29285.jsp

Fechner, H. (2008, September 4). *The concept of grid parity from the PV perspective.* Retrieved from IAEA PVPS Workshop, Valencia ,Spain: http://www.iea-pvps.org/workshops/0809valencia/presentations/2_Hubert_Pr-344sentation4%20%5BKompatibilit-344tsmodus%5D.pdf

Gipe, P. (2010, October 6). *Evolution of Feed in tariffs, October 6th 2010.* Retrieved from http://www.wind-works.org/FeedLaws/EvolutionofFeed-inTariffs.html

Halwart Schrader. (2005). *Leben und Arbeiten in England.*Retrieved from Britisches Grundstücksrecht; Freehold und Leasehold:

http://www.justlanded.com/deutsch/Grossbritannien/Artikel/Immobilien/Britisches-Grundstuecksrecht

IPCC Intergovernmental Panel of climate change. (2007). *IPCC 4th assessment report , climate change 2007 (AR4) .* Retrieved from http://www.ipcc.ch/publications_and_data/publications_and_data_reports.htm

Jones, J. (2010, July 14). *New UK FIT Spurring PV Market Growth .* Retrieved from http://www.renewableenergyworld.com/rea/news/article/2010/07/new-uk-fit-spurring-pv-market-growth

JRC European Commission. (2010). *Photovoltaic Geographical Information System.* Retrieved from http://re.jrc.ec. europa.eu/ pvgis/apps3/pvest.php

Karweder, A. (2010, April 22). *Gebäudeintegrierte Photovoltaik auf dem Weg zum Massenprodukt.*Retrieved from Economic Forum LTD, London - München - Bozen: http://www.solarserver.de/solar-magazin/solar-report/gebaeudeintegrierte-photovoltaik-auf-dem-weg-zum-massenprodukt.html

Kreutzmann, A. (2010, March). Grid parity ist eine Fata Morgana, die Eigenverbrauchsförderung ein Irrweg. *Photon*, p. 3.

Luque, A., & Hegedus, S. (2005). *Handbookk of Photovoltaic and engineering.*Wiley & Sons.

Masloton, M. (2010, August). *Eigenverbrauch von Solarstrom.* Retrieved from ήgrenn: http://www.etagreen.com/archive/107,715380/Sonne/Eigenverbrauch-von-Solarstrom.html

Mendonça, M. (2007). *Feed -In Tariffs, Accelerating the deployent of Renewable Energy.* London-Sterling,VA: Earthscan.

Microgeneration Certificate Scheme. (2010). Retrieved from http://www.microgenerationcertification.org

OFGEM. (2010, April 1). *Renewable obligations, Guidance for generators.* Retrieved from http://www.ofgem.gov.uk/Sustainability/ Environ ment/RenewablObl/Documents1/2010%20RO%20generator%20guidance%20final%20for%20publication.pdf

Photovoltaique.info. (2010). *Structure du tarif d'achat.*Retrieved from http://www.photovoltaique.info/Le-tarif-d-achat.html#Structuredutarifdachat

Rohde, R. (2008, February 1). *Solar Cycle Variations.* Retrieved from http://en.wikipedia.org/wiki/File:Solar-cycle-data.png

Sargent, J. (2008, May). Grid parity bis 2010. (PHOTON, O. Papathanasiou, & C. Podewils, Interviewers)

Wikipedia.org. (2010). *Grundstücke / Rechtbegriffe.* Retrieved from http://de.wikipedia.org/wiki/Grundst%C3%BCck

8. Appendix

8.1. Index list of French departments[70]

List of coeffficents for the French départments to compensate different radiation in the départments for inclined roof top and ground mounted PV installations > 250kWp

DÉPARTEMENT	NUMBER OF DÉPARTEMENT	REGION	COEFFICIENT R	FIT (Eurocents)	FIT after Reduction
				31,40	27,63
Ain	1	Rhône-Alpes	1,09	34,23	30,12
Aisne	2	Picardie	1,15	36,11	31,78
Allier	3	Auvergne	1,09	34,23	30,12
Alpes-de-Haute-Provence	4	Provence-Alpes-Côte	1	31,40	27,63
Hautes-Alpes	5	Provence-Alpes-Côte	1	31,40	27,63
Alpes-Maritimes	6	Provence-Alpes-Côte	1	31,40	27,63
Ardèche	7	Rhône-Alpes	1,03	32,34	28,46
Ardennes	8	Champagne-Ardenne	1,16	36,42	32,05
Ariège	9	Midi-Pyrénées	1,05	32,97	29,01
Aube	10	Champagne-Ardenne	1,13	35,48	31,22
Aude	11	Languedoc-Roussillon	1,03	32,34	28,46
Aveyron	12	Midi-Pyrénées	1,02	32,03	28,18
Bouches-du-Rhône	13	Provence-Alpes-Côte	1	31,40	27,63
Calvados	14	Basse-Normandie	1,17	36,74	32,33
Cantal	15	Auvergne	1,08	33,91	29,84
Charente	16	Poitou-Charentes	1,08	33,91	29,84
Charente-Maritime	17	Poitou-Charentes	1,05	32,97	29,01
Cher	18	Centre	1,09	34,23	30,12
Corrèze	19	Limousin	1,07	33,60	29,57
Côte-d'Or	21	Bourgogne	1,13	35,48	31,22
Côtes-d'Armor	22	Bretagne	1,18	37,05	32,61
Creuse	23	Limousin	1,09	34,23	30,12
Dordogne	24	Aquitaine	1,06	33,28	29,29
Doubs	25	Franche-Comté	1,13	35,48	31,22
Drôme	26	Rhône-Alpes	1,01	31,71	27,91
Eure	27	Haute-Normandie	1,15	36,11	31,78
Eure-et-Loir	28	Centre	1,12	35,17	30,95
Finistère	29	Bretagne	1,15	36,11	31,78
Gard	30	Languedoc-Roussillon	1	31,40	27,63
Haute-Garonne	31	Midi-Pyrénées	1,05	32,97	29,01
Gers	32	Midi-Pyrénées	1,04	32,66	28,74
Gironde	33	Aquitaine	1,05	32,97	29,01
Hérault	34	Languedoc-Roussillon	1	31,40	27,63
Ille-et-Vilaine	35	Bretagne	1,13	35,48	31,22
Indre	36	Centre	1,06	33,28	29,29
Indre-et-Loire	37	Centre	1,1	34,54	30,40
Isère	38	Rhône-Alpes	1,06	33,28	29,29
Jura	39	Franche-Comté	1,1	34,54	30,40
Landes	40	Aquitaine	1,06	33,28	29,29
Loir-et-Cher	41	Centre	1,11	34,85	30,67
Loire	42	Rhône-Alpes	1,09	34,23	30,12
Haute-Loire	43	Auvergne	1,08	33,91	29,84
Loire-Atlantique	44	Pays de la Loire	1,08	33,91	29,84
Loiret	45	Centre	1,11	34,85	30,67
Lot	46	Midi-Pyrénées	1,05	32,97	29,01
Lot-et-Garonne	47	Aquitaine	1,04	32,66	28,74
Lozère	48	Languedoc-Roussillon	1,05	32,97	29,01
Maine-et-Loire	49	Pays de la Loire	1,1	34,54	30,40
Manche	50	Basse-Normandie	1,17	36,74	32,33
Marne	51	Champagne-Ardenne	1,13	35,48	31,22
Haute-Marne	52	Champagne-Ardenne	1,11	34,85	30,67
Mayenne	53	Pays de la Loire	1,12	35,17	30,95

70 http://www.legifrance.gouv.fr/affichTexte.do;jsessionid=71AAD6A66076A4FC0517629885A6044B.tpdjo03v_3?cidTexte=LEGITEXT000021706627&dateTexte=20100828

DÉPARTEMENT	NUMBER OF DÉPARTEMENT	REGION	COEFFICIENT R	FIT (Eurocents)	FIT after Reduction
Meuse	55	Lorraine	1,2	37,68	33,16
Morbihan	56	Bretagne	1,11	34,85	30,67
Moselle	57	Lorraine	1,19	37,37	32,88
Nièvre	58	Bourgogne	1,12	35,17	30,95
Nord	59	Nord - Pas-de-Calais	1,2	37,68	33,16
Oise	60	Picardie	1,16	36,42	32,05
Orne	61	Basse-Normandie	1,14	35,80	31,50
Pas-de-Calais	62	Nord - Pas-de-Calais	1,2	37,68	33,16
Puy-de-Dôme	63	Auvergne	1,09	34,23	30,12
Pyrénées-Atlantiques	64	Aquitaine	1,08	33,91	29,84
Hautes-Pyrénées	65	Midi-Pyrénées	1,08	33,91	29,84
Pyrénées-Orientales	66	Languedoc-Roussillon	1,03	32,34	28,46
Bas-Rhin	67	Alsace	1,14	35,80	31,50
Haut-Rhin	68	Alsace	1,13	35,48	31,22
Rhône	69	Rhône-Alpes	1,08	33,91	29,84
Haute-Saône	70	Franche-Comté	1,12	35,17	30,95
Saône-et-Loire	71	Bourgogne	1,09	34,23	30,12
Sarthe	72	Pays de la Loire	1,11	34,85	30,67
Savoie	73	Rhône-Alpes	1,08	33,91	29,84
Haute-Savoie	74	Rhône-Alpes	1,08	33,91	29,84
Paris	75	Ile-de-France	1,14	35,80	31,50
Seine-Maritime	76	Haute-Normandie	1,19	37,37	32,88
Seine-et-Marne	77	Ile-de-France	1,13	35,48	31,22
Yvelines	78	Ile-de-France	1,14	35,80	31,50
Deux-Sèvres	79	Poitou-Charentes	1,08	33,91	29,84
Somme	80	Picardie	1,2	37,68	33,16
Tarn	81	Midi-Pyrénées	1,03	32,34	28,46
Tarn-et-Garonne	82	Midi-Pyrénées	1,03	32,34	28,46
Var	83	Provence-Alpes-Côte	1	31,40	27,63
Vaucluse	84	Provence-Alpes-Côte	1	31,40	27,63
Vendée	85	Pays de la Loire	1,06	33,28	29,29
Vienne	86	Poitou-Charentes	1,09	34,23	30,12
Haute-Vienne	87	Limousin	1,09	34,23	30,12
Vosges	88	Lorraine	1,15	36,11	31,78
Yonne	89	Bourgogne	1,12	35,17	30,95
Territoire de Belfort	90	Franche-Comté	1,12	35,17	30,95
Essonne	91	Ile-de-France	1,12	35,17	30,95
Hauts-de-Seine	92	Ile-de-France	1,14	35,80	31,50
Seine-Saint-Denis	93	Ile-de-France	1,14	35,80	31,50
Val-de-Marne	94	Ile-de-France	1,14	35,80	31,50
Val-d'Oise	95	Ile-de-France	1,14	35,80	31,50

8.2. Calculations

8.2.1. Austria, life time 13 years, FiT's 13 years

Austria, lifetime = FiT period:13 years

Initial invest	29.000,00 €	€/kWp	2.900,00 €	€/kwH FIT	0,38 €	PV rental	0,00
IRR	5,43%	kWp	10,00	Retail price kW/h	0,17 €	Inflation rent	0,00%
NPV	0,00	kWh/kWp/a	1.000,00	Inflation retail price kW/h	3,00%		
Lifetime	13	OPEX/a	200,00 €	Degredation	0,50%		
Fit Time	13	Inflation opex	2,00%	Taxes	25,00%		

Year	Depreciation	Opex	Rent	Generation (kWh/a)	FiT	Retail price	Revenues	Taxes	NOCF		DCF
										Kontrollwert	-29.000,00
1	2.230,77 €	200,00 €	0,00 €	10.000 kWh/a	0,38 €	0,17 €	3.800,00 €	342,31 €	3.257,69 €	3.257,69 €	3.090,01 €
2	2.230,77 €	204,00 €	0,00 €	9.950 kWh/a	0,38 €	0,18 €	3.781,00 €	336,56 €	3.240,44 €	3.240,44 €	2.915,45 €
3	2.230,77 €	208,08 €	0,00 €	9.900 kWh/a	0,38 €	0,18 €	3.762,10 €	330,81 €	3.223,20 €	3.223,20 €	2.750,67 €
4	2.230,77 €	212,24 €	0,00 €	9.851 kWh/a	0,38 €	0,19 €	3.743,28 €	325,07 €	3.205,97 €	3.205,97 €	2.595,14 €
5	2.230,77 €	216,49 €	0,00 €	9.801 kWh/a	0,38 €	0,19 €	3.724,57 €	319,33 €	3.188,75 €	3.188,75 €	2.448,35 €
6	2.230,77 €	220,82 €	0,00 €	9.752 kWh/a	0,38 €	0,20 €	3.705,95 €	313,59 €	3.171,54 €	3.171,54 €	2.309,79 €
7	2.230,77 €	225,23 €	0,00 €	9.704 kWh/a	0,38 €	0,20 €	3.687,42 €	307,85 €	3.154,33 €	3.154,33 €	2.179,01 €
8	2.230,77 €	229,74 €	0,00 €	9.655 kWh/a	0,38 €	0,21 €	3.668,98 €	302,12 €	3.137,12 €	3.137,12 €	2.055,58 €
9	2.230,77 €	234,33 €	0,00 €	9.607 kWh/a	0,38 €	0,22 €	3.650,63 €	296,38 €	3.119,92 €	3.119,92 €	1.939,08 €
10	2.230,77 €	239,02 €	0,00 €	9.559 kWh/a	0,38 €	0,22 €	3.632,38 €	290,65 €	3.102,71 €	3.102,71 €	1.829,13 €
11	2.230,77 €	243,80 €	0,00 €	9.511 kWh/a	0,38 €	0,23 €	3.614,22 €	284,91 €	3.085,51 €	3.085,51 €	1.725,36 €
12	2.230,77 €	248,67 €	0,00 €	9.464 kWh/a	0,38 €	0,24 €	3.596,15 €	279,18 €	3.068,30 €	3.068,30 €	1.627,43 €
13	2.230,77 €	253,65 €	0,00 €	9.416 kWh/a	0,38 €	0,24 €	3.578,17 €	273,44 €	3.051,08 €	3.051,08 €	1.535,00 €
		2.936,07 €	0,00 €	126.171 kWh			47.944,83 €	4.002,19 €	41.006,58 €		29.000,00 €

8.2.2. Austria, life time 25 years, FiT's 13 years, PV installation rent out

Austria, life time 25 years, FiT's 13 years, PV installation rent out

Initial invest	29.000,00 €	€/kWp	2.900,00 €	€/kwH FIT	0,38 €	PV rental	2.000,00
IRR		kWp	10,00	Retail price kW/h	0,17 €	Inflation rent	0,00%
NPV		kWh/kWp/a	1.000,00	Inflation retail price kW/h	3,00%		
Lifetime	25	OPEX/a	200,00 €	Degredation	0,50%		
Fit Time	13	Inflation opex	2,00%	Taxes	25,00%		

Year	Depreciation	Opex	Rent	Generation (kWh/a)	FiT	Retail price	Revenues	Taxes	NOCF		DCF
										Kontrollwert	-29.000,00
1	1.160,00 €	200,00 €	2.000,00 €	10.000 kWh/a	0,38 €	0,17 €	3.800,00 €	400,00 €	1.490,00 €	1.200,00 €	1.215,94 €
2	1.160,00 €	204,00 €	2.000,00 €	9.950 kWh/a	0,38 €	0,18 €	3.781,00 €	394,25 €	1.472,75 €	1.182,75 €	1.214,39 €
3	1.160,00 €	208,08 €	2.000,00 €	9.900 kWh/a	0,38 €	0,18 €	3.762,10 €	388,50 €	1.455,51 €	1.165,51 €	1.212,59 €
4	1.160,00 €	212,24 €	2.000,00 €	9.851 kWh/a	0,38 €	0,19 €	3.743,28 €	382,76 €	1.438,28 €	1.148,28 €	1.210,54 €
5	1.160,00 €	216,49 €	2.000,00 €	9.801 kWh/a	0,38 €	0,19 €	3.724,57 €	377,02 €	1.421,06 €	1.131,06 €	1.208,23 €
6	1.160,00 €	220,82 €	2.000,00 €	9.752 kWh/a	0,38 €	0,20 €	3.705,95 €	371,28 €	1.403,85 €	1.113,85 €	1.205,65 €
7	1.160,00 €	225,23 €	2.000,00 €	9.704 kWh/a	0,38 €	0,20 €	3.687,42 €	365,55 €	1.386,64 €	1.096,64 €	1.202,79 €
8	1.160,00 €	229,74 €	2.000,00 €	9.655 kWh/a	0,38 €	0,21 €	3.668,98 €	359,81 €	1.369,43 €	1.079,43 €	1.199,65 €
9	1.160,00 €	234,33 €	2.000,00 €	9.607 kWh/a	0,38 €	0,22 €	3.650,63 €	354,08 €	1.352,23 €	1.062,23 €	1.196,22 €
10	1.160,00 €	239,02 €	2.000,00 €	9.559 kWh/a	0,38 €	0,22 €	3.632,38 €	348,34 €	1.335,02 €	1.045,02 €	1.192,48 €
11	1.160,00 €	243,80 €	2.000,00 €	9.511 kWh/a	0,38 €	0,23 €	3.614,22 €	342,60 €	1.317,81 €	1.027,81 €	1.188,43 €
12	1.160,00 €	248,67 €	2.000,00 €	9.464 kWh/a	0,38 €	0,24 €	3.596,15 €	336,87 €	1.300,60 €	1.010,60 €	1.184,06 €
13	1.160,00 €	253,65 €	2.000,00 €	9.416 kWh/a	0,38 €	0,24 €	3.578,17 €	331,13 €	1.283,39 €	993,39 €	1.179,35 €
14	1.160,00 €	258,72 €	2.000,00 €	9.369 kWh/a	0,00 €	0,25 €	2.339,01 €	20,07 €	350,22 €	60,22 €	72,44 €
15	1.160,00 €	263,90 €	2.000,00 €	9.322 kWh/a	0,00 €	0,26 €	2.397,14 €	33,31 €	389,93 €	99,93 €	121,81 €
16	1.160,00 €	269,17 €	2.000,00 €	9.276 kWh/a	0,00 €	0,26 €	2.456,71 €	46,88 €	430,65 €	140,65 €	173,73 €
17	1.160,00 €	274,56 €	2.000,00 €	9.229 kWh/a	0,00 €	0,27 €	2.517,76 €	60,80 €	472,40 €	182,40 €	228,29 €
18	1.160,00 €	280,05 €	2.000,00 €	9.183 kWh/a	0,00 €	0,28 €	2.580,32 €	75,07 €	515,21 €	225,21 €	285,61 €
19	1.160,00 €	285,65 €	2.000,00 €	9.137 kWh/a	0,00 €	0,29 €	2.644,44 €	89,70 €	559,10 €	269,10 €	345,80 €
20	1.160,00 €	291,36 €	2.000,00 €	9.092 kWh/a	0,00 €	0,30 €	2.710,16 €	104,70 €	604,10 €	314,10 €	408,99 €
21	1.160,00 €	297,19 €	2.000,00 €	9.046 kWh/a	0,00 €	0,31 €	2.777,51 €	120,08 €	650,24 €	360,24 €	475,31 €
22	1.160,00 €	303,13 €	2.000,00 €	9.001 kWh/a	0,00 €	0,32 €	2.846,53 €	135,85 €	697,55 €	407,55 €	544,87 €
23	1.160,00 €	309,20 €	2.000,00 €	8.956 kWh/a	0,00 €	0,33 €	2.917,26 €	152,02 €	746,05 €	456,05 €	617,82 €
24	1.160,00 €	315,38 €	2.000,00 €	8.911 kWh/a	0,00 €	0,34 €	2.989,76 €	168,59 €	795,78 €	505,78 €	694,30 €
25	1.160,00 €	321,69 €	2.000,00 €	8.867 kWh/a	0,00 €	0,35 €	3.064,05 €	185,59 €	846,77 €	556,77 €	774,45 €
		6.406,06 €	50.000,00 €	235.560 kWh			80.185,48 €	5.944,86 €	25.084,57 €		20.353,75 €

8.2.3. Germany, life time 20 years, FiT’s 20 years

Germany, life time 20 years, FiT's 20 years

Initial invest	13.500,00 €	€/kWp	2.700,00 €	€/kwH FIT	0,3303 €	PV rental	0,00
IRR	7,02%	kWp	5,00	Retail price kW/h	0,1700 €	Inflation rent	0,00%
NPV	0,00	kWh/kWp/a	1.000,00	Inflation retail price kW/h	3,00%		
Lifetime	20	OPEX/a	100,00 €	Degredation	0,50%		
Fit Time	20	Inflation opex	2,00%	Taxes	25,00%		

Year	Depreciation	Opex	Rent	Generation (kWh/a)	FiT	Retail price	Revenues	Taxes	NOCF		DCF
1	675,00 €	100,00 €	0,00 €	5.000 kWh/a	0,3303 €	0,1700 €	1.651,50 €	219,13 €	1.332,38 €	1.332,38 €	1.245,01 €
2	675,00 €	102,00 €	0,00 €	4.975 kWh/a	0,3303 €	0,1751 €	1.643,24 €	216,56 €	1.324,68 €	1.324,68 €	1.156,65 €
3	675,00 €	104,04 €	0,00 €	4.950 kWh/a	0,3303 €	0,1804 €	1.635,03 €	214,00 €	1.316,99 €	1.316,99 €	1.074,53 €
4	675,00 €	106,12 €	0,00 €	4.925 kWh/a	0,3303 €	0,1858 €	1.626,85 €	211,43 €	1.309,30 €	1.309,30 €	998,20 €
5	675,00 €	108,24 €	0,00 €	4.901 kWh/a	0,3303 €	0,1913 €	1.618,72 €	208,87 €	1.301,61 €	1.301,61 €	927,26 €
6	675,00 €	110,41 €	0,00 €	4.876 kWh/a	0,3303 €	0,1971 €	1.610,62 €	206,30 €	1.293,91 €	1.293,91 €	861,34 €
7	675,00 €	112,62 €	0,00 €	4.852 kWh/a	0,3303 €	0,2030 €	1.602,57 €	203,74 €	1.286,22 €	1.286,22 €	800,07 €
8	675,00 €	114,87 €	0,00 €	4.828 kWh/a	0,3303 €	0,2091 €	1.594,56 €	201,17 €	1.278,52 €	1.278,52 €	743,13 €
9	675,00 €	117,17 €	0,00 €	4.803 kWh/a	0,3303 €	0,2154 €	1.586,58 €	198,60 €	1.270,81 €	1.270,81 €	690,22 €
10	675,00 €	119,51 €	0,00 €	4.779 kWh/a	0,3303 €	0,2218 €	1.578,65 €	196,04 €	1.263,11 €	1.263,11 €	641,05 €
11	675,00 €	121,90 €	0,00 €	4.756 kWh/a	0,3303 €	0,2285 €	1.570,76 €	193,46 €	1.255,39 €	1.255,39 €	595,35 €
12	675,00 €	124,34 €	0,00 €	4.732 kWh/a	0,3303 €	0,2353 €	1.562,90 €	190,89 €	1.247,68 €	1.247,68 €	552,89 €
13	675,00 €	126,82 €	0,00 €	4.708 kWh/a	0,3303 €	0,2424 €	1.555,09 €	188,32 €	1.239,95 €	1.239,95 €	513,44 €
14	675,00 €	129,36 €	0,00 €	4.685 kWh/a	0,3303 €	0,2497 €	1.547,31 €	185,74 €	1.232,22 €	1.232,22 €	476,78 €
15	675,00 €	131,95 €	0,00 €	4.661 kWh/a	0,3303 €	0,2571 €	1.539,58 €	183,16 €	1.224,47 €	1.224,47 €	442,71 €
16	675,00 €	134,59 €	0,00 €	4.638 kWh/a	0,3303 €	0,2649 €	1.531,88 €	180,57 €	1.216,72 €	1.216,72 €	411,06 €
17	675,00 €	137,28 €	0,00 €	4.615 kWh/a	0,3303 €	0,2728 €	1.524,22 €	177,99 €	1.208,96 €	1.208,96 €	381,66 €
18	675,00 €	140,02 €	0,00 €	4.592 kWh/a	0,3303 €	0,2810 €	1.516,60 €	175,39 €	1.201,18 €	1.201,18 €	354,34 €
19	675,00 €	142,82 €	0,00 €	4.569 kWh/a	0,3303 €	0,2894 €	1.509,02 €	172,80 €	1.193,39 €	1.193,39 €	328,95 €
20	675,00 €	145,68 €	0,00 €	4.546 kWh/a	0,3303 €	0,2981 €	1.501,47 €	170,20 €	1.185,59 €	1.185,59 €	305,37 €
		2.429,74 €	0,00 €	95.390 kWh			31.507,16 €	3.894,36 €	25.183,07 €		13.500,00 €

8.2.4. Germany, life time 20 years, FiT's 20 years, 50% self consumption, virtual FiT € 0.3303 + € 0.0119

Germany, life time 20 years, FiT's 20 years, 50% self consumption virtuel FiT € 0.3303 + € 0.0119

Initial invest	13.500,00 €	€/kWp	2.700,00 €	€/kwH FIT	0,3422 €	PV rental	0,00
IRR	7,46%	kWp	5,00	Retail price kW/h	0,1700 €	Inflation rent	0,00%
NPV	0,00	kWh/kWp/a	1.000,00	Inflation retail price kW/h	3,00%		
Lifetime	20	OPEX/a	100,00 €	Degredation	0,50%		
Fit Time	20	Inflation opex	2,00%	Taxes	25,00%		

Year	Depreciation	Opex	Rent	Generation (kWh/a)	FiT	Retail price	Revenues	Taxes	NOCF		DCF
1	675,00 €	100,00 €	0,00 €	5.000 kWh/a	0,3422 €	0,1700 €	1.711,00 €	234,00 €	1.377,00 €	1.377,00 €	1.281,42 €
2	675,00 €	102,00 €	0,00 €	4.975 kWh/a	0,3422 €	0,1751 €	1.702,45 €	231,36 €	1.369,08 €	1.369,08 €	1.185,63 €
3	675,00 €	104,04 €	0,00 €	4.950 kWh/a	0,3422 €	0,1804 €	1.693,93 €	228,72 €	1.361,17 €	1.361,17 €	1.096,96 €
4	675,00 €	106,12 €	0,00 €	4.925 kWh/a	0,3422 €	0,1858 €	1.685,46 €	226,09 €	1.353,26 €	1.353,26 €	1.014,89 €
5	675,00 €	108,24 €	0,00 €	4.901 kWh/a	0,3422 €	0,1913 €	1.677,04 €	223,45 €	1.345,34 €	1.345,34 €	938,92 €
6	675,00 €	110,41 €	0,00 €	4.876 kWh/a	0,3422 €	0,1971 €	1.668,65 €	220,81 €	1.337,43 €	1.337,43 €	868,61 €
7	675,00 €	112,62 €	0,00 €	4.852 kWh/a	0,3422 €	0,2030 €	1.660,31 €	218,17 €	1.329,52 €	1.329,52 €	803,54 €
8	675,00 €	114,87 €	0,00 €	4.828 kWh/a	0,3422 €	0,2091 €	1.652,01 €	215,53 €	1.321,60 €	1.321,60 €	743,32 €
9	675,00 €	117,17 €	0,00 €	4.803 kWh/a	0,3422 €	0,2154 €	1.643,75 €	212,89 €	1.313,68 €	1.313,68 €	687,58 €
10	675,00 €	119,51 €	0,00 €	4.779 kWh/a	0,3422 €	0,2218 €	1.635,53 €	210,25 €	1.305,76 €	1.305,76 €	636,00 €
11	675,00 €	121,90 €	0,00 €	4.756 kWh/a	0,3422 €	0,2285 €	1.627,35 €	207,61 €	1.297,84 €	1.297,84 €	588,26 €
12	675,00 €	124,34 €	0,00 €	4.732 kWh/a	0,3422 €	0,2353 €	1.619,21 €	204,97 €	1.289,91 €	1.289,91 €	544,09 €
13	675,00 €	126,82 €	0,00 €	4.708 kWh/a	0,3422 €	0,2424 €	1.611,12 €	202,32 €	1.281,97 €	1.281,97 €	503,21 €
14	675,00 €	129,36 €	0,00 €	4.685 kWh/a	0,3422 €	0,2497 €	1.603,06 €	199,68 €	1.274,03 €	1.274,03 €	465,38 €
15	675,00 €	131,95 €	0,00 €	4.661 kWh/a	0,3422 €	0,2571 €	1.595,05 €	197,02 €	1.266,07 €	1.266,07 €	430,38 €
16	675,00 €	134,59 €	0,00 €	4.638 kWh/a	0,3422 €	0,2649 €	1.587,07 €	194,37 €	1.258,11 €	1.258,11 €	397,99 €
17	675,00 €	137,28 €	0,00 €	4.615 kWh/a	0,3422 €	0,2728 €	1.579,14 €	191,71 €	1.250,14 €	1.250,14 €	368,02 €
18	675,00 €	140,02 €	0,00 €	4.592 kWh/a	0,3422 €	0,2810 €	1.571,24 €	189,05 €	1.242,16 €	1.242,16 €	340,29 €
19	675,00 €	142,82 €	0,00 €	4.569 kWh/a	0,3422 €	0,2894 €	1.563,38 €	186,39 €	1.234,17 €	1.234,17 €	314,63 €
20	675,00 €	145,68 €	0,00 €	4.546 kWh/a	0,3422 €	0,2981 €	1.555,57 €	183,72 €	1.226,16 €	1.226,16 €	290,89 €
		2.429,74 €	0,00 €	95.390 kWh			32.642,29 €	4.178,14 €	26.034,42 €		13.500,00 €

8.2.5. France, 20 years life time, 20 years FiT's, BIPV

France, 20 years life time, 20 years FiT's, BIPV

Initial invest	179.500,00 €
IRR	8,90%
NPV	0,00
Lifetime	20
Fit Time	20

€/kWp	3.590,00 €
kWp	50,00
kWh/kWp/a	1.000,00
OPEX/a	2.000,00 €
Inflation opex	2,00%

€/kwH FIT	0,5104 €
Retail price kW/h	0,17000 €
Inflation retail price kW/h	3,00%
Degredation	0,50%
Taxes	25,00%

Rent location	0,00
Inflation rent	2,00%

Year	Depreciation	Opex	Rent	Generation (kWh/a)	FiT	Retail price	Revenues	Taxes	NOCF		DCF
1	8.975,00 €	2.000,00 €	0,00 €	50.000 kWh/a	0,5104 €	0,1700 €	25.520,00 €	3.636,25 €	19.883,75 €	19.883,75 €	18.258,46 €
2	8.975,00 €	2.040,00 €	0,00 €	49.750 kWh/a	0,5124 €	0,1751 €	25.493,97 €	3.619,74 €	19.834,23 €	19.834,23 €	16.724,27 €
3	8.975,00 €	2.080,80 €	0,00 €	49.501 kWh/a	0,5145 €	0,1804 €	25.467,97 €	3.603,04 €	19.784,12 €	19.784,12 €	15.318,44 €
4	8.975,00 €	2.122,42 €	0,00 €	49.254 kWh/a	0,5165 €	0,1858 €	25.441,99 €	3.586,14 €	19.733,43 €	19.733,43 €	14.030,27 €
5	8.975,00 €	2.164,86 €	0,00 €	49.007 kWh/a	0,5186 €	0,1913 €	25.416,04 €	3.569,04 €	19.682,13 €	19.682,13 €	12.849,95 €
6	8.975,00 €	2.208,16 €	0,00 €	48.762 kWh/a	0,5207 €	0,1971 €	25.390,11 €	3.551,74 €	19.630,21 €	19.630,21 €	11.768,48 €
7	8.975,00 €	2.252,32 €	0,00 €	48.519 kWh/a	0,5228 €	0,2030 €	25.364,22 €	3.534,22 €	19.577,67 €	19.577,67 €	10.777,60 €
8	8.975,00 €	2.297,37 €	0,00 €	48.276 kWh/a	0,5249 €	0,2091 €	25.338,34 €	3.516,49 €	19.524,48 €	19.524,48 €	9.869,76 €
9	8.975,00 €	2.343,32 €	0,00 €	48.035 kWh/a	0,5270 €	0,2154 €	25.312,50 €	3.498,54 €	19.470,63 €	19.470,63 €	9.038,02 €
10	8.975,00 €	2.390,19 €	0,00 €	47.794 kWh/a	0,5291 €	0,2218 €	25.286,68 €	3.480,37 €	19.416,12 €	19.416,12 €	8.276,02 €
11	8.975,00 €	2.437,99 €	0,00 €	47.556 kWh/a	0,5312 €	0,2285 €	25.260,89 €	3.461,97 €	19.360,92 €	19.360,92 €	7.577,93 €
12	8.975,00 €	2.486,75 €	0,00 €	47.318 kWh/a	0,5333 €	0,2353 €	25.235,12 €	3.443,34 €	19.305,03 €	19.305,03 €	6.938,43 €
13	8.975,00 €	2.536,48 €	0,00 €	47.081 kWh/a	0,5354 €	0,2424 €	25.209,38 €	3.424,47 €	19.248,42 €	19.248,42 €	6.352,60 €
14	8.975,00 €	2.587,21 €	0,00 €	46.846 kWh/a	0,5376 €	0,2497 €	25.183,67 €	3.405,36 €	19.191,09 €	19.191,09 €	5.815,97 €
15	8.975,00 €	2.638,96 €	0,00 €	46.612 kWh/a	0,5397 €	0,2571 €	25.157,98 €	3.386,01 €	19.133,02 €	19.133,02 €	5.324,41 €
16	8.975,00 €	2.691,74 €	0,00 €	46.378 kWh/a	0,5419 €	0,2649 €	25.132,32 €	3.366,40 €	19.074,19 €	19.074,19 €	4.874,16 €
17	8.975,00 €	2.745,57 €	0,00 €	46.147 kWh/a	0,5441 €	0,2728 €	25.106,68 €	3.346,53 €	19.014,58 €	19.014,58 €	4.461,77 €
18	8.975,00 €	2.800,48 €	0,00 €	45.916 kWh/a	0,5462 €	0,2810 €	25.081,08 €	3.326,40 €	18.954,19 €	18.954,19 €	4.084,05 €
19	8.975,00 €	2.856,49 €	0,00 €	45.686 kWh/a	0,5484 €	0,2894 €	25.055,49 €	3.306,00 €	18.893,00 €	18.893,00 €	3.738,12 €
20	8.975,00 €	2.913,62 €	0,00 €	45.458 kWh/a	0,5506 €	0,2981 €	25.029,94 €	3.285,33 €	18.830,99 €	18.830,99 €	3.421,30 €
		48.594,74 €	0,00 €	953.895 kWh			505.484,36 €	69.347,41 €	387.542,22 €		179.500,00 €

8.2.6. No FiT's, 25 years life time

No FiT's, 25 years life time

Initial invest	27.000,00 €
IRR	3,59%
NPV	0,00
Lifetime	25
Fit Time	0

€/kWp	2.700,00 €
kWp	10,00
kWh/kWp/a	1.000,00
OPEX/a	200,00 €
Inflation opex	2,00%

€/kwH FIT	0,00 €
Retail price kW/h	0,17000 €
Inflation retail price kW/h	3,00%
Degredation	0,50%
Taxes	25,00%

Rent location	100,00
Inflation rent	2,00%

Year	Depreciation	Opex	Rent	Generation (kWh/a)	FiT	Retail price	Revenues	Taxes	NOCF		DCF
1	1.080,00 €	200,00 €	100,00 €	10.000 kWh/a	0,00 €	0,1700 €	1.700,00 €	80,00 €	1.320,00 €	1.320,00 €	1.274,24 €
2	1.080,00 €	204,00 €	102,00 €	9.950 kWh/a	0,00 €	0,1751 €	1.742,25 €	89,06 €	1.347,18 €	1.347,18 €	1.255,39 €
3	1.080,00 €	208,08 €	104,04 €	9.900 kWh/a	0,00 €	0,1804 €	1.785,54 €	98,35 €	1.375,06 €	1.375,06 €	1.236,95 €
4	1.080,00 €	212,24 €	106,12 €	9.851 kWh/a	0,00 €	0,1858 €	1.829,91 €	107,89 €	1.403,66 €	1.403,66 €	1.218,90 €
5	1.080,00 €	216,49 €	108,24 €	9.801 kWh/a	0,00 €	0,1913 €	1.875,38 €	117,66 €	1.432,99 €	1.432,99 €	1.201,23 €
6	1.080,00 €	220,82 €	110,41 €	9.752 kWh/a	0,00 €	0,1971 €	1.921,99 €	127,69 €	1.463,07 €	1.463,07 €	1.183,93 €
7	1.080,00 €	225,23 €	112,62 €	9.704 kWh/a	0,00 €	0,2030 €	1.969,75 €	137,97 €	1.493,92 €	1.493,92 €	1.166,99 €
8	1.080,00 €	229,74 €	114,87 €	9.655 kWh/a	0,00 €	0,2091 €	2.018,70 €	148,52 €	1.525,57 €	1.525,57 €	1.150,39 €
9	1.080,00 €	234,33 €	117,17 €	9.607 kWh/a	0,00 €	0,2154 €	2.068,86 €	159,34 €	1.558,02 €	1.558,02 €	1.134,13 €
10	1.080,00 €	239,02 €	119,51 €	9.559 kWh/a	0,00 €	0,2218 €	2.120,27 €	170,44 €	1.591,31 €	1.591,31 €	1.118,20 €
11	1.080,00 €	243,80 €	121,90 €	9.511 kWh/a	0,00 €	0,2285 €	2.172,96 €	181,82 €	1.625,45 €	1.625,45 €	1.102,60 €
12	1.080,00 €	248,67 €	124,34 €	9.464 kWh/a	0,00 €	0,2353 €	2.226,96 €	193,49 €	1.660,46 €	1.660,46 €	1.087,30 €
13	1.080,00 €	253,65 €	126,82 €	9.416 kWh/a	0,00 €	0,2424 €	2.282,30 €	205,46 €	1.696,37 €	1.696,37 €	1.072,30 €
14	1.080,00 €	258,72 €	129,36 €	9.369 kWh/a	0,00 €	0,2497 €	2.339,01 €	217,73 €	1.733,20 €	1.733,20 €	1.057,60 €
15	1.080,00 €	263,90 €	131,95 €	9.322 kWh/a	0,00 €	0,2571 €	2.397,14 €	230,32 €	1.770,97 €	1.770,97 €	1.043,19 €
16	1.080,00 €	269,17 €	134,59 €	9.276 kWh/a	0,00 €	0,2649 €	2.456,71 €	243,24 €	1.809,71 €	1.809,71 €	1.029,05 €
17	1.080,00 €	274,56 €	137,28 €	9.229 kWh/a	0,00 €	0,2728 €	2.517,76 €	256,48 €	1.849,44 €	1.849,44 €	1.015,18 €
18	1.080,00 €	280,05 €	140,02 €	9.183 kWh/a	0,00 €	0,2810 €	2.580,32 €	270,06 €	1.890,19 €	1.890,19 €	1.001,58 €
19	1.080,00 €	285,65 €	142,82 €	9.137 kWh/a	0,00 €	0,2894 €	2.644,44 €	283,99 €	1.931,98 €	1.931,98 €	988,23 €
20	1.080,00 €	291,36 €	145,68 €	9.092 kWh/a	0,00 €	0,2981 €	2.710,16 €	298,28 €	1.974,84 €	1.974,84 €	975,13 €
21	1.080,00 €	297,19 €	148,59 €	9.046 kWh/a	0,00 €	0,3070 €	2.777,51 €	312,93 €	2.018,79 €	2.018,79 €	962,28 €
22	1.080,00 €	303,13 €	151,57 €	9.001 kWh/a	0,00 €	0,3163 €	2.846,53 €	327,96 €	2.063,87 €	2.063,87 €	949,66 €
23	1.080,00 €	309,20 €	154,60 €	8.956 kWh/a	0,00 €	0,3257 €	2.917,26 €	343,37 €	2.110,10 €	2.110,10 €	937,27 €
24	1.080,00 €	315,38 €	157,69 €	8.911 kWh/a	0,00 €	0,3355 €	2.989,76 €	359,17 €	2.157,52 €	2.157,52 €	925,11 €
25	1.080,00 €	321,69 €	160,84 €	8.867 kWh/a	0,00 €	0,3456 €	3.064,05 €	375,38 €	2.206,14 €	2.206,14 €	913,17 €
		6.406,06 €	3.203,03 €	235.560 kWh			57.955,52 €	5.336,61 €	43.009,82 €		27.000,00 €

8.2.7. No FiT's, 40 years life time, replacement inverters after 20 years, modules after 25 years

40 years operation, replacement inverters after 20 years modules after 25 years (opex + 200.- € modules/a 50.- € inverters /a)

Initial invest	10.000,00 €	€/kWp	1.000,00 €	€/kwH FIT	0,00 €	Rent location	0,00
IRR	7,01%	kWp	10,00	Retail price kW/h	0,10000 €	Inflation rent	2,00%
NPV	0,00	kWh/kWp/a	1.000,00	Inflation retail price kW/h	3,00%		
Lifetime	40	OPEX/a	350,00 €	Degredation	0,50%		
Fit Time	0	Inflation opex	2,00%	Taxes	25,00%		

Year	Depreciation	Opex	Rent	Generation (kWh/a)	FiT	Retail price	Revenues	Taxes	NOCF		DCF
										Kontrollwert	-10.000,00
1	250,00 €	350,00 €	0,00 €	10.000 kWh/a	0,00 €	0,1000 €	1.000,00 €	100,00 €	550,00 €	550,00 €	513,99 €
2	250,00 €	357,00 €	0,00 €	9.950 kWh/a	0,00 €	0,1030 €	1.024,85 €	104,46 €	563,39 €	563,39 €	492,04 €
3	250,00 €	364,14 €	0,00 €	9.900 kWh/a	0,00 €	0,1061 €	1.050,32 €	109,04 €	577,13 €	577,13 €	471,04 €
4	250,00 €	371,42 €	0,00 €	9.851 kWh/a	0,00 €	0,1093 €	1.076,42 €	113,75 €	591,25 €	591,25 €	450,97 €
5	250,00 €	378,85 €	0,00 €	9.801 kWh/a	0,00 €	0,1126 €	1.103,17 €	118,58 €	605,74 €	605,74 €	431,77 €
6	250,00 €	386,43 €	0,00 €	9.752 kWh/a	0,00 €	0,1159 €	1.130,58 €	123,54 €	620,61 €	620,61 €	413,42 €
7	250,00 €	394,16 €	0,00 €	9.704 kWh/a	0,00 €	0,1194 €	1.158,68 €	128,63 €	635,89 €	635,89 €	395,86 €
8	250,00 €	402,04 €	0,00 €	9.655 kWh/a	0,00 €	0,1230 €	1.187,47 €	133,86 €	651,57 €	651,57 €	379,07 €
9	250,00 €	410,08 €	0,00 €	9.607 kWh/a	0,00 €	0,1267 €	1.216,98 €	139,22 €	667,67 €	667,67 €	363,01 €
10	250,00 €	418,28 €	0,00 €	9.559 kWh/a	0,00 €	0,1305 €	1.247,22 €	144,73 €	684,20 €	684,20 €	347,64 €
11	250,00 €	426,65 €	0,00 €	9.511 kWh/a	0,00 €	0,1344 €	1.278,21 €	150,39 €	701,17 €	701,17 €	332,94 €
12	250,00 €	435,18 €	0,00 €	9.464 kWh/a	0,00 €	0,1384 €	1.309,98 €	156,20 €	718,60 €	718,60 €	318,88 €
13	250,00 €	443,88 €	0,00 €	9.416 kWh/a	0,00 €	0,1426 €	1.342,53 €	162,16 €	736,48 €	736,48 €	305,42 €
14	250,00 €	452,76 €	0,00 €	9.369 kWh/a	0,00 €	0,1469 €	1.375,89 €	168,28 €	754,85 €	754,85 €	292,54 €
15	250,00 €	461,82 €	0,00 €	9.322 kWh/a	0,00 €	0,1513 €	1.410,08 €	174,57 €	773,70 €	773,70 €	280,21 €
16	250,00 €	471,05 €	0,00 €	9.276 kWh/a	0,00 €	0,1558 €	1.445,12 €	181,02 €	793,05 €	793,05 €	268,42 €
17	250,00 €	480,47 €	0,00 €	9.229 kWh/a	0,00 €	0,1605 €	1.481,03 €	187,64 €	812,92 €	812,92 €	257,13 €
18	250,00 €	490,08 €	0,00 €	9.183 kWh/a	0,00 €	0,1653 €	1.517,84 €	194,44 €	833,31 €	833,31 €	246,33 €
19	250,00 €	499,89 €	0,00 €	9.137 kWh/a	0,00 €	0,1702 €	1.555,56 €	201,42 €	854,25 €	854,25 €	235,98 €
20	250,00 €	509,88 €	0,00 €	9.092 kWh/a	0,00 €	0,1754 €	1.594,21 €	208,58 €	875,75 €	875,75 €	226,08 €
21	250,00 €	520,08 €	0,00 €	9.046 kWh/a	0,00 €	0,1806 €	1.633,83 €	215,94 €	897,81 €	897,81 €	216,61 €
22	250,00 €	530,48 €	0,00 €	9.001 kWh/a	0,00 €	0,1860 €	1.674,43 €	223,49 €	920,46 €	920,46 €	207,53 €
23	250,00 €	541,09 €	0,00 €	8.956 kWh/a	0,00 €	0,1916 €	1.716,04 €	231,24 €	943,71 €	943,71 €	198,84 €
24	250,00 €	551,91 €	0,00 €	8.911 kWh/a	0,00 €	0,1974 €	1.758,68 €	239,19 €	967,57 €	967,57 €	190,53 €
25	250,00 €	562,95 €	0,00 €	8.867 kWh/a	0,00 €	0,2033 €	1.802,38 €	247,36 €	992,07 €	992,07 €	182,56 €
26	250,00 €	574,21 €	0,00 €	8.822 kWh/a	0,00 €	0,2094 €	1.847,17 €	255,74 €	1.017,22 €	1.017,22 €	174,93 €
27	250,00 €	585,70 €	0,00 €	8.778 kWh/a	0,00 €	0,2157 €	1.893,08 €	264,34 €	1.043,03 €	1.043,03 €	167,63 €
28	250,00 €	597,41 €	0,00 €	8.734 kWh/a	0,00 €	0,2221 €	1.940,12 €	273,18 €	1.069,53 €	1.069,53 €	160,64 €
29	250,00 €	609,36 €	0,00 €	8.691 kWh/a	0,00 €	0,2288 €	1.988,33 €	282,24 €	1.096,73 €	1.096,73 €	153,94 €
30	250,00 €	621,55 €	0,00 €	8.647 kWh/a	0,00 €	0,2357 €	2.037,74 €	291,55 €	1.124,65 €	1.124,65 €	147,52 €
31	250,00 €	633,98 €	0,00 €	8.604 kWh/a	0,00 €	0,2427 €	2.088,38 €	301,10 €	1.153,30 €	1.153,30 €	141,38 €
32	250,00 €	646,66 €	0,00 €	8.561 kWh/a	0,00 €	0,2500 €	2.140,27 €	310,90 €	1.182,71 €	1.182,71 €	135,49 €
33	250,00 €	659,59 €	0,00 €	8.518 kWh/a	0,00 €	0,2575 €	2.193,46 €	320,97 €	1.212,90 €	1.212,90 €	129,85 €
34	250,00 €	672,78 €	0,00 €	8.475 kWh/a	0,00 €	0,2652 €	2.247,97 €	331,30 €	1.243,89 €	1.243,89 €	124,45 €
35	250,00 €	686,24 €	0,00 €	8.433 kWh/a	0,00 €	0,2732 €	2.303,83 €	341,90 €	1.275,69 €	1.275,69 €	119,28 €
36	250,00 €	699,96 €	0,00 €	8.391 kWh/a	0,00 €	0,2814 €	2.361,08 €	352,78 €	1.308,34 €	1.308,34 €	114,32 €
37	250,00 €	713,96 €	0,00 €	8.349 kWh/a	0,00 €	0,2898 €	2.419,75 €	363,95 €	1.341,84 €	1.341,84 €	109,57 €
38	250,00 €	728,24 €	0,00 €	8.307 kWh/a	0,00 €	0,2985 €	2.479,88 €	375,41 €	1.376,23 €	1.376,23 €	105,02 €
39	250,00 €	742,80 €	0,00 €	8.266 kWh/a	0,00 €	0,3075 €	2.541,51 €	387,18 €	1.411,53 €	1.411,53 €	100,67 €
40	250,00 €	757,66 €	0,00 €	8.224 kWh/a	0,00 €	0,3167 €	2.604,67 €	399,25 €	1.447,75 €	1.447,75 €	96,49 €
		21.140,69 €	0,00 €	363.360 kWh			67.178,72 €	9.009,51 €	37.028,52 €		10.000,00 €

8.2.8. No FiT's, 30 years life time

No FiT's, 30 years life time

Initial invest	5.000,00 €	€/kWp	500,00 €	€/kwH FIT	0,00 €	Rent location	0,00
IRR	8,88%	kWp	10,00	Retail price kW/h	0,06557 €	Inflation rent	2,00%
NPV	0,00	kWh/kWp/a	1.000,00	Inflation retail price kW/h	3,00%		
Lifetime	30	OPEX/a	200,00 €	Degredation	0,50%		
Fit Time	0	Inflation opex	2,00%	Taxes	25,00%		

Year	Depreciation	Opex	Rent	Generation (kWh/a)	FiT	Retail price	Revenues	Taxes	NOCF		DCF
1	166,67 €	200,00 €	0,00 €	10.000 kWh/a	0,00 €	0,0656 €	655,74 €	72,27 €	383,47 €	383,47 €	352,20 €
2	166,67 €	204,00 €	0,00 €	9.950 kWh/a	0,00 €	0,0675 €	672,03 €	75,34 €	392,69 €	392,69 €	331,26 €
3	166,67 €	208,08 €	0,00 €	9.900 kWh/a	0,00 €	0,0696 €	688,73 €	78,50 €	402,16 €	402,16 €	311,58 €
4	166,67 €	212,24 €	0,00 €	9.851 kWh/a	0,00 €	0,0717 €	705,85 €	81,73 €	411,87 €	411,87 €	293,08 €
5	166,67 €	216,49 €	0,00 €	9.801 kWh/a	0,00 €	0,0738 €	723,39 €	85,06 €	421,84 €	421,84 €	275,70 €
6	166,67 €	220,82 €	0,00 €	9.752 kWh/a	0,00 €	0,0760 €	741,36 €	88,47 €	432,08 €	432,08 €	259,36 €
7	166,67 €	225,23 €	0,00 €	9.704 kWh/a	0,00 €	0,0783 €	759,79 €	91,97 €	442,58 €	442,58 €	244,00 €
8	166,67 €	229,74 €	0,00 €	9.655 kWh/a	0,00 €	0,0806 €	778,67 €	95,57 €	453,36 €	453,36 €	229,56 €
9	166,67 €	234,33 €	0,00 €	9.607 kWh/a	0,00 €	0,0831 €	798,02 €	99,25 €	464,43 €	464,43 €	215,99 €
10	166,67 €	239,02 €	0,00 €	9.559 kWh/a	0,00 €	0,0856 €	817,85 €	103,04 €	475,79 €	475,79 €	203,23 €
11	166,67 €	243,80 €	0,00 €	9.511 kWh/a	0,00 €	0,0881 €	838,17 €	106,93 €	487,45 €	487,45 €	191,23 €
12	166,67 €	248,67 €	0,00 €	9.464 kWh/a	0,00 €	0,0908 €	859,00 €	110,91 €	499,41 €	499,41 €	179,95 €
13	166,67 €	253,65 €	0,00 €	9.416 kWh/a	0,00 €	0,0935 €	880,35 €	115,01 €	511,69 €	511,69 €	169,34 €
14	166,67 €	258,72 €	0,00 €	9.369 kWh/a	0,00 €	0,0963 €	902,22 €	119,21 €	524,29 €	524,29 €	159,36 €
15	166,67 €	263,90 €	0,00 €	9.322 kWh/a	0,00 €	0,0992 €	924,64 €	123,52 €	537,23 €	537,23 €	149,97 €
16	166,67 €	269,17 €	0,00 €	9.276 kWh/a	0,00 €	0,1022 €	947,62 €	127,95 €	550,50 €	550,50 €	141,15 €
17	166,67 €	274,56 €	0,00 €	9.229 kWh/a	0,00 €	0,1052 €	971,17 €	132,49 €	564,13 €	564,13 €	132,84 €
18	166,67 €	280,05 €	0,00 €	9.183 kWh/a	0,00 €	0,1084 €	995,30 €	137,15 €	578,11 €	578,11 €	125,04 €
19	166,67 €	285,65 €	0,00 €	9.137 kWh/a	0,00 €	0,1116 €	1.020,04 €	141,93 €	592,46 €	592,46 €	117,69 €
20	166,67 €	291,36 €	0,00 €	9.092 kWh/a	0,00 €	0,1150 €	1.045,38 €	146,84 €	607,18 €	607,18 €	110,78 €
21	166,67 €	297,19 €	0,00 €	9.046 kWh/a	0,00 €	0,1184 €	1.071,36 €	151,88 €	622,30 €	622,30 €	104,28 €
22	166,67 €	303,13 €	0,00 €	9.001 kWh/a	0,00 €	0,1220 €	1.097,98 €	157,05 €	637,81 €	637,81 €	98,16 €
23	166,67 €	309,20 €	0,00 €	8.956 kWh/a	0,00 €	0,1256 €	1.125,27 €	162,35 €	653,72 €	653,72 €	92,41 €
24	166,67 €	315,38 €	0,00 €	8.911 kWh/a	0,00 €	0,1294 €	1.153,23 €	167,80 €	670,06 €	670,06 €	86,99 €
25	166,67 €	321,69 €	0,00 €	8.867 kWh/a	0,00 €	0,1333 €	1.181,89 €	173,38 €	686,82 €	686,82 €	81,90 €
26	166,67 €	328,12 €	0,00 €	8.822 kWh/a	0,00 €	0,1373 €	1.211,26 €	179,12 €	704,02 €	704,02 €	77,10 €
27	166,67 €	334,68 €	0,00 €	8.778 kWh/a	0,00 €	0,1414 €	1.241,36 €	185,00 €	721,67 €	721,67 €	72,59 €
28	166,67 €	341,38 €	0,00 €	8.734 kWh/a	0,00 €	0,1457 €	1.272,21 €	191,04 €	739,79 €	739,79 €	68,34 €
29	166,67 €	348,20 €	0,00 €	8.691 kWh/a	0,00 €	0,1500 €	1.303,82 €	197,24 €	758,38 €	758,38 €	64,35 €
30	166,67 €	355,17 €	0,00 €	8.647 kWh/a	0,00 €	0,1545 €	1.336,22 €	203,60 €	777,46 €	777,46 €	60,59 €
		8.113,62 €	0,00 €	279.232 kWh			28.719,92 €	3.901,58 €	16.704,73 €		5.000,00 €