Cost of current and alternative support schemes to grid parity in target countries

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PVPARITY

1 INTRODUCTION TO THE PV PARITY PROJECT

The PV PARITY project aims at defining grid parity, i.e. achieving a stage of development of the PV technology, at which it is competitive with conventional electricity sources. It will also provide relevant policy makers in the EU Member States with a clear understanding of the necessary measures to support solar PV technology in achieving grid parity. The project will also develop strategies for supporting the PV sector after grid parity is reached. As a result, an increased PV penetration in EU electricity markets and grid will be accomplished at the lowest possible price for the community.

The consortium is made up of knowledgeable partners from the research and academic sector, from the industry and from the energy production sector. The project focuses on 11 EU countries, namely Austria, Belgium, Czech Republic, France, Germany, Greece, Italy, The Netherlands, Portugal, Spain and United Kingdom. The country selection aims to cover a large proportion of the EU electricity market and to be representative of various country configurations in terms of electricity prices, maturity of the national PV market and growth potential in the coming years. Some MENA countries will also be considered, in view of their high PV market potential.

The project starts from the assumption that the goal of existing support schemes is to help the PV technology become competitive with conventional electricity sources in the coming years. However, the support to PV from policy makers is under heavy pressure and some countries are already experiencing signs of a downturn in the level of support from policy makers as well as from the public opinion.

1.1 Project strategic objectives

The strategic objective in the long-term of the PV Parity project is to ensure an appropriate policy framework for photovoltaics in order to achieve up to 12% of the EU electricity demand by 2020. This target for 2020 will imply reaching a total installed capacity of about 390 GWp according to the EPIA, SET For 2020 study. In order to achieve this aim, in the first part of the project, the steps necessary to define grid parity will be carried out. This implies to identify the parameters which may influence the grid parity:

- PV generation costs - projections;
- electricity prices, especially in the coming decade – projections;
- the impact of PV generation on base, medium and peak-load generation in terms of technical and economic challenges and opportunities;
- the role of technologies that can be used to minimise the cost or maximise the benefits of PV such as storage, demand response).
- electricity transmission and distribution costs

In Figure 1 the parameters influencing the PV parity are shown.

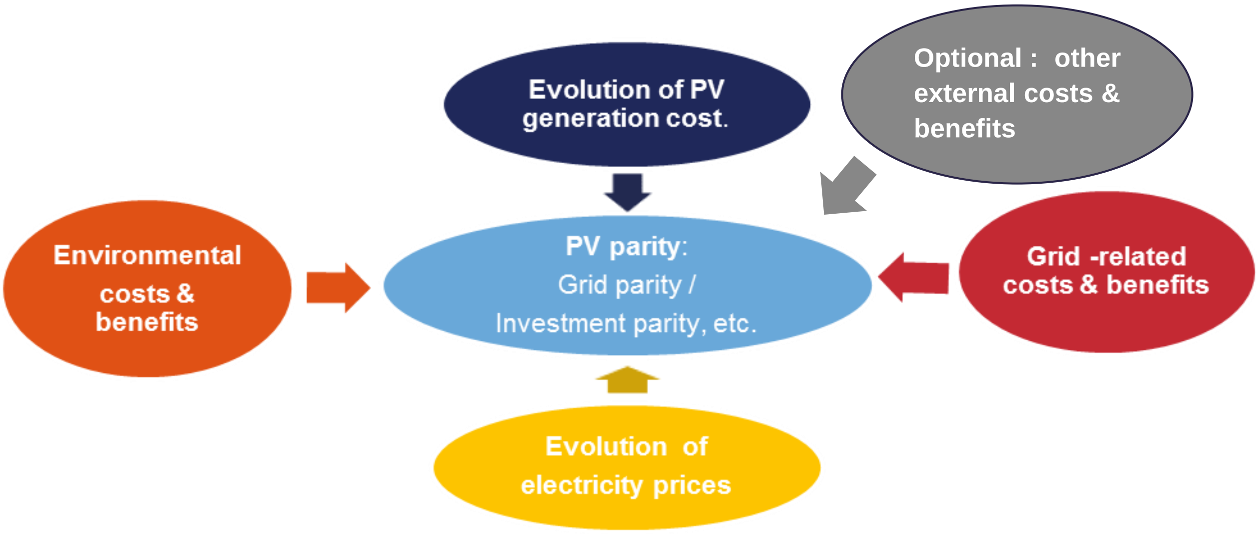

Figure 1: Parameters influencing PV parity: the classical, limited approaches, which only look at PV generation and electricity prices, and the more sophisticated approaches used in the project. Source: ECN, Wim Sinke.

The project will also present information which is needed to identify support schemes most appropriate to reach grid parity and also include information on PV market developments and regulations in several European and MENA countries.

The PV Parity project starts in June 2011 and will end in November 2013. The PV Parity project will be co-financed by the European Commission in the framework of the Intelligent Energy Europe (IEE) Program (Contract No. IEE/10/307 / SI2.592205).

1.2 Project partners

The list of the partners cooperating in this project are shown below. More information about them and the project is available under www.pvparity.eu.

WIP	www.wip-munich.de	
EPIA	www.epia.org	
ECN	www.ecn.nl	
TUC	www.enveng.tuc.gr	
SUER	www.stiftung-umweltenergierecht.de	
GSE	www.gse.it	
EGP	www.enelgreenpower.com	
ICON	www.imperial-consultants.co.uk	
TUW	www.tuwien.ac.at	
IDAE	www.idae.es	
EDF EN	www.edf-energies-nouvelles.com	

2 Cost analysis of current support schemes

To implement uncompetitive power generation technologies in a first step into the energy system, financial support schemes are necessary to encourage these technologies to their future market maturity. In the last years the implementation of PV to the energy system was mainly driven by different national support schemes like Feed in Tariffs (FiT), Green-Certificates, Net-Metering and/or investment grants. The PV market is growing very fast and the cost reduction was significant, thus PV becomes more and more competitive in different European countries and market segments [1][2].

PV competitiveness in the rooftop segments can be measured through an economic comparison with the current retail electricity price (= generation costs & grid costs & taxes). The conditions for the competitiveness of PV generation are then savings on end-users electricity bill by self-consumption and revenues through feeding PV generation into the grid. A calculation over the lifetime of a PV generation plant can then be performed considering the dynamic development of different parameters, such as self-consumption, grid exports and price development to derive the net present values (NPV) of revenues and cost of PV generation.

The roadmap of PV grid parity in the residential and commercial sector shows that some target countries achieved PV competitiveness in 2012 [1][2]. However, there are still support schemes in most of the target countries to foster the growth of PV capacities. An overview of the current support schemes is shown in Table 1[3].

Table 1 Overview of current support schemes in the target countries

	FiT and/or Green Certificates	Net-Metering	Investment Grants
Austria	Yes	No	Yes
Belgium	Yes	Yes	Regional
Czech Republic	Yes	No	No
France	Yes	No	No
Germany	Yes	No	Yes
Greece	Yes	No	No
Italy	Yes	No	Yes
Portugal	Yes	No	Yes
Spain	moratorium	No	Yes
The Netherlands	No	Yes	No
United Kingdom	Yes/Yes	No	Yes

In order to analyse the cost of current support schemes from a PV owner's economical point of view , the gap between self-consumption option (dynamic grid parity approach) and the use of support schemes is quantified for residential and commercial sector, considering different shares of self-consumption. The analysis is done for the selected target countries Germany, Italy, the Netherlands and Austria, to show the effects of different kind of support schemes for distinguished initial situation of PV competitiveness.

3 Cost of support schemes in the residential sector

It is assumed that the parameters of annual demand, Weighted Average Cost of Capital (WACC), Operational and Maintenance (O&M), costs inflation rate and the increase of retail prices are equal for all selected target countries within the residential sector. These parameters are set as follows:

- Demand: 3500 kWh/year
- WACC: 4%
- O&M: 25 EUR/kWp
- Inflation: 2.5%/year
- Increase of retail prices: 3%/year
- Decrease of Module Efficiency: 0.5%/year
- Plant Lifetime: 25 years

The used energy market (EM) price in the calculation need not reflect an average wholesale price. The assumed EM prices could be a contract with an utility or other energy market participants, which provides the customers with green electricity and perhaps who are willing to pay more than average wholesale prices, such as the example in Austria.

The indicated shares of self-consumption for different PV system sizes are calculated within the MITHRAS model itself. The MITHRAS model used standardized load profiles and irradiation profiles. The time resolution of the profiles is 15 minutes, for each time step the value of procurement from the grid, self-consumption and feeding into the grid is calculated and summarized over the whole year.

In general it is mentioned, that the following analysis is only a snapshot of a current or past energy market environmental. Due to the continuous changes of PV systems costs, retail prices, Feed in Tariff (FiT) and investment grants, the calculated absolute values can be changed. Nevertheless, these snapshots should show the trend and influence of the share of self-consumption to the costs of different support schemes. The holistic results and conclusions will not change fundamentally.

3.1 Germany - FiT

Germany's PV support scheme is based on a FiT for 20 years. The PV system costs in Germany are one of the lowest in Europe due to the highly mature PV market and the PV boom driven by the FiT support scheme. The assumed PV system costs are:

- 2 kWp: 1800 EUR/kWp
- 3.5 kWp: 1750 EUR/kWp
- 5 kWp: 1700 EUR/kWp
- 10kWp: 1600 EUR/kWp

The limit of 10 kWp for households can be explained due to the average maximum roof size of households and the maximum FiT of 166.4 EUR/MWh[1] for systems up to 10 kWp. If no FiT support scheme in Germany is assumed, the PV generation which is fed into the grid is remunerated with an energy EM price of 50 EUR/MWh. The electricity retail price in Germany for households is assumed at 255 EUR/MWh[2].

The result of the sensitivity analyses for different shares of self-consumption and a comparison between FiT and EM price based results is shown in Figure 2. This figure shows the cumulated NPV of costs of a household without PV and with PV for different PV systems. If a household with PV has lower costs as a household without PV, the yellow bars show the savings of the household with PV compared to a household without PV. In case, a household with PV has higher costs as a household without PV the blue bars are higher as the black dashed line. The results for to 5 kWp highly correlate with the results of the Monte Carlo simulation within the roadmap [1], certainly because 5

[1] FiT for February 2013 [4]
[2] https://www.bdew.de/, February 2013

kWp PV system size is the maximum size in the roadmap analysis for the residential sector. The 10 kWp system size is not economical with EM price as of the low share of self-consumption, with a FiT it also a 10 kWp PV system sizes are economic.

In order to analyse the costs of PV support for a household with different PV system sizes, these specific cumulated NPV are compared to specific costs of a household without a PV system. These values are referred to the overall electricity generation of the PV plants over the lifetime. The results in Figure 3 show similar findings as in Figure 2, meaning for up to 5 kWp PV system size and a possible self-consumption the specific costs are negative even if only an EM price is paid for feeding into the grid. Negative specific costs imply revenues for the PV owner and PV competitiveness is reached. As shown on the right hand side of Figure 3, all analysed PV system sizes with a FiT support scheme are economical, even without any self-consumption. In this case the revenues of the FiT support scheme in Germany compared with a household without PV are between 7 EUR/MWh and 14 EUR/MWh (see green triangles).

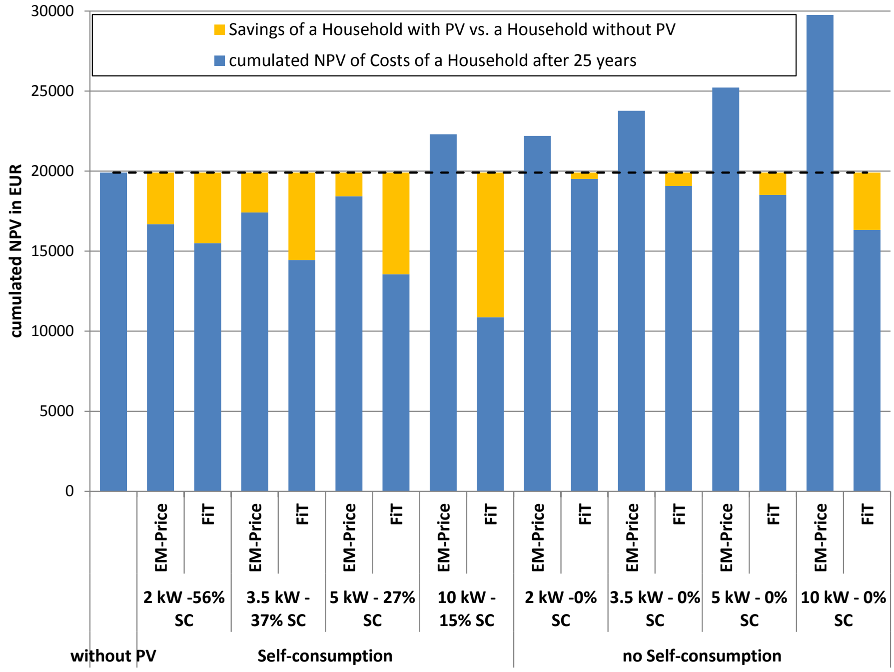

Figure 2 Comparison of cumulated NPV of Costs of a Household with and without a PV system after 25 years in Germany

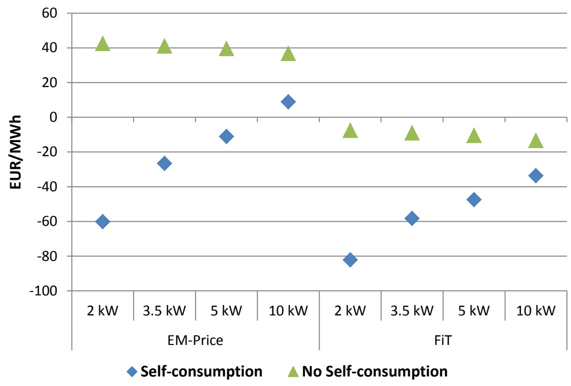

Figure 3 Differences of cumulated NPV of costs of generated PV energy of a Household with or without a PV system after 25 years in Germany

Figure 4 compares the additional cost of a FiT to the self-consumption and EM price driven approach. At the current level of FIT the specific NPV of costs are around 50 EUR/MWh. This cost decrease with a higher share of self-consumption to 22 EUR/MWh.

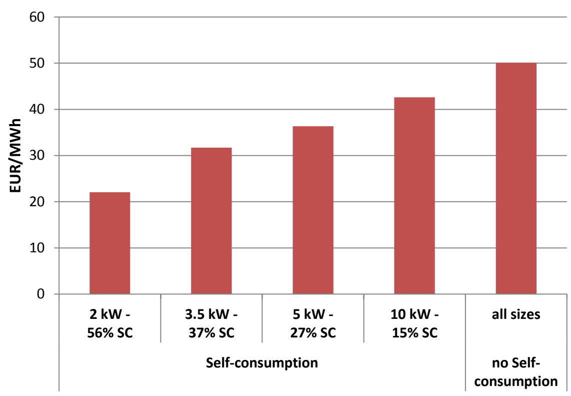

Figure 4 Differences of cumulated NPV of costs of generated PV energy of a Household with energy market price versus FiT after 25 years in Germany

3.2 Italy - FiT

Italy's support scheme was based until recently on a FiT for 20 years, the main difference to Germany's support scheme is, that on the one hand a PV owner could be supported with a FiT and on the other hand with a self-consumption bonus (lower as FiT). In this analysis the FiT is 182 EUR/MWh for PV system sizes lower 3 kWp and 171 EUR/MWh up to 10 KWp [5]. The self-consumption bonus is 100 EUR/MWh for lower 3 kWp and 89 EUR/MWh up to 10 kWp [5]. The assumed PV system costs are

- 2 kWp: 2600 EUR/kWp
- 3.5 kWp: 2450 EUR/kWp
- 5 kWp: 2300 EUR/kWp
- 10kWp: 2200 EUR/kWp

If no FiT support scheme in Italy is assumed, the PV generation which is fed into the grid is remunerated with an energy market (EM) price of 60 EUR/MWh. The electricity retail price in Italy for households is assumed to be 201 EUR/MWh.

The result of the sensitivity analyses for different shares of self-consumption and a comparison between FiT and EM price based results is shown Figure 6. This figure shows the cumulated NPV of costs of a household without PV and with PV for different PV systems. If a household with PV has lower costs as a household without PV, the yellow bars show the savings of the household with PV compared to a household without PV. In case, a household with PV has higher costs as a household without PV the blue bars are higher as the black dashed line. The results for to 5 kWp highly correlate with the results of the Monte Carlo simulation within the roadmap [1], certainly because 5 kWp PV system size is the maximum size in the roadmap analysis for the residential sector. The 10 kWp system size is not economical with EM price as of the low share of self-consumption, with a FiT it also a 10 kWp PV system sizes are economic.

In order to analyse the costs of PV support for a household with different PV system sizes, these specific cumulated NPV are compared to specific costs of a household without a PV system These values are referred to the overall electricity generation of the PV plants over the lifetime. The results in Figure 5 show similar findings as in Figure 6, meaning for up to 5 kWp PV system size and a possible self-consumption the specific costs are negative even if only an EM price is paid for feeding into the grid. Negative specific costs imply revenues for the PV owner and PV competitiveness is reached. As shown on the right hand side of Figure 5, all analysed PV system sizes with a FiT support scheme are economical, even without any self-consumption. In this case the revenues of the FiT support scheme in Italy compared with a household without PV are between 21 EUR/MWh and 27 EUR/MWh (see green triangles).

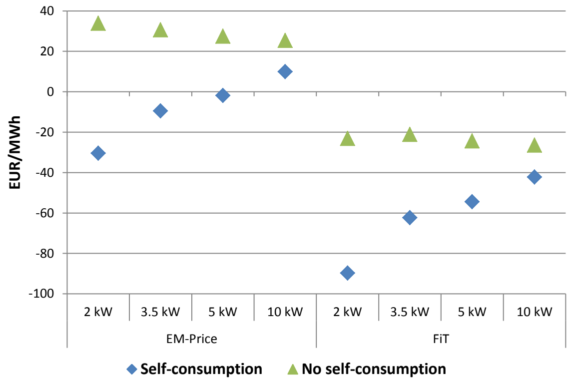

Figure 5 Differences of cumulated NPV of costs of generated PV energy of a Household with or without a PV system after 25 years in Italy

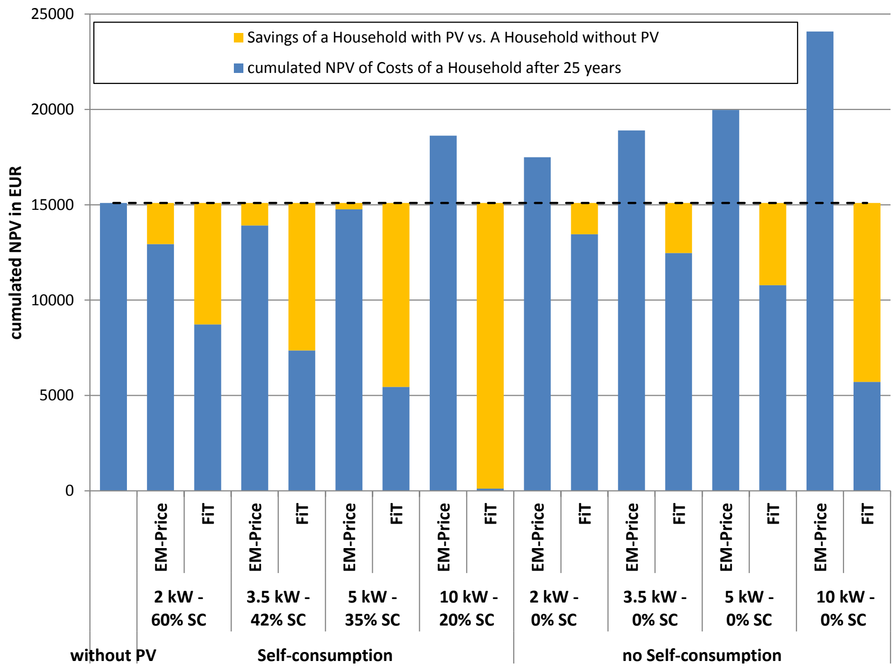

Figure 6 Comparison of cumulated NPV of Costs of a Household with and without a PV system after 25 years in Italy

Figure 7 compares the additional cost of a FiT to the self-consumption and EM price driven approach. At the current level of FIT the specific NPV of costs are around 52 EUR/MWh. This cost increase with a higher share of self-consumption to 59 EUR/MWh, due to the higher FiT for PV system sizes lower 3 kWp.

Results show that the situation in Italy is almost the same as in Germany, even with higher costs of support scheme with self-consumption in Italy. This means that a FiT promotes larger PV capacities for single PV owners, which in turn may cause problems to the grid infrastructure and overall increases the cost of the support scheme.

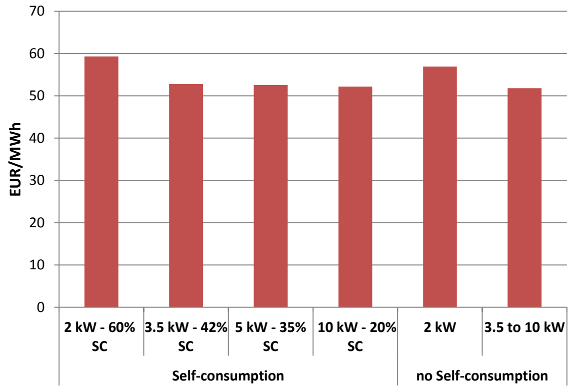

Figure 7 Differences of cumulated NPV of costs of generated PV energy of a Household with energy market price versus FiT after 25 years in Italy

3.3 The Netherlands – Net-Metering

The Netherland's PV support scheme is based on a Net-metering approach for 15 years and maximum limitation of 5 MWh per year. The PV system costs in the Netherlands are one of the lowest in Europe, probably due to neighbourhood to PV market in Germany and the Net-metering incentives. Therefore the assumed PV system costs are the same like in Germany:

- 2 kWp: 1800 EUR/kWp
- 3.5 kWp: 1750 EUR/kWp
- 5 kWp: 1700 EUR/kWp
- 10kWp: 1600 EUR/KWp

The limit of 10 kWp for households can be explained due to the average maximum roof size of households and the past limitation to use the Net-metering for maximum 5 MWh/year. If no Net-metering support scheme in the Netherlands is assumed, the PV generation which is fed into the grid is remunerated with an energy market (EM) price of 50 EUR/MWh. The electricity retail price in the Netherlands for households is assumed to be 210 EUR/MWh.

The result of the sensitivity analyses for different shares of self-consumption and a comparison between Net-metering approach and self-consumption with feeding the generated energy surplus into the grid to an energy market price (EM Prices) is shown in Figure 9. This figure shows the cumulated NPV of costs of a household without PV and with PV for different PV systems. If a household with PV has lower costs as a household without PV, the yellow bars show the savings of the household with PV compared to a household without PV. In case, a household with PV has higher costs as a household without PV the blue bars are higher as the black dashed line. The results for to 5 kWp highly correlate with the results of the Monte Carlo simulation within the roadmap [1], certainly because 5 kWp PV system size is the maximum size in the roadmap analysis for the residential sector. The 10 kWp system size is not economical with EM price as of the low share of self-consumption. With a Net-metering approach the 10 kWp PV system sizes are more or less economical.

In order to analyse the costs of PV support for a household with different PV system sizes, these specific cumulated NPV are compared to specific costs of a household without a PV system These values are referred to the overall electricity generation of the PV plants over the lifetime. The results in Figure 8 show similar findings as in Figure 9, meaning for up to 5 kWp PV system size with self-consumption the specific costs are negative even if only an EM price is paid for feeding into the grid. Negative specific costs imply revenues for the PV owner and PV competitiveness is reached. As shown on the right hand side in Figure 8, all analysed PV system sizes with a Net-metering support scheme are economical. In this case the revenues of the Net-metering support scheme in the Netherlands compared with a household without PV up to 5 kWp PV system size are between 54 EUR/MWh and 64 EUR/MWh and due to the limitation of 5 MWh/year for Net-metering around 2 EUR/MWh for 10 kWp (see green triangles).

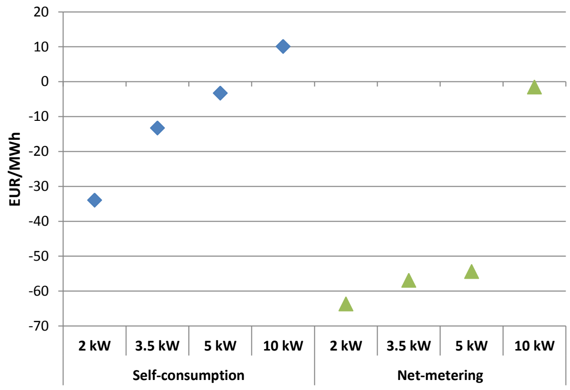

Figure 8 Differences of cumulated NPV of costs of generated PV energy of a Household with or without a PV system after 25 years in the Netherlands

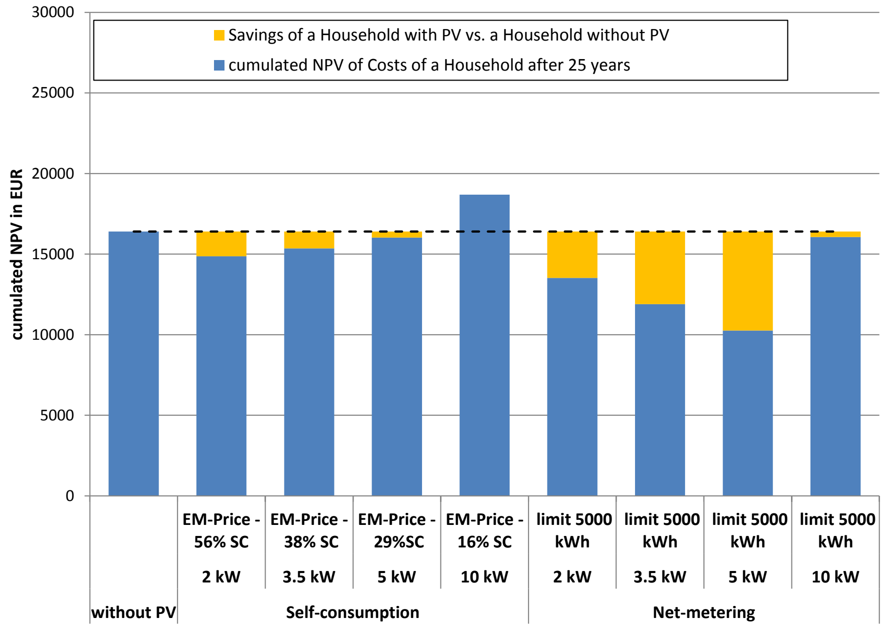

Figure 9 Comparison of cumulated NPV of Costs of a Household with and without a PV system after 25 years in the Netherlands

Figure 10 compares the additional cost of a Net-metering approach compared to the EM price driven approach. At the current Net-metering support scheme the specific NPV of costs up to 5 kWp are between 30 EUR/MWh and 51 EUR/MWh depends on PV system size, for 10 kWp around 10 EUR/MWh.

Results show that the limitation of 5 MWh per year Net-metering approach supports more small scale PV system sizes up to 5 kWp opposite to a FiT, as the cases in Germany and Italy show. Nevertheless, even with Net-metering limitation PV system becomes more economic with higher PV system sizes.

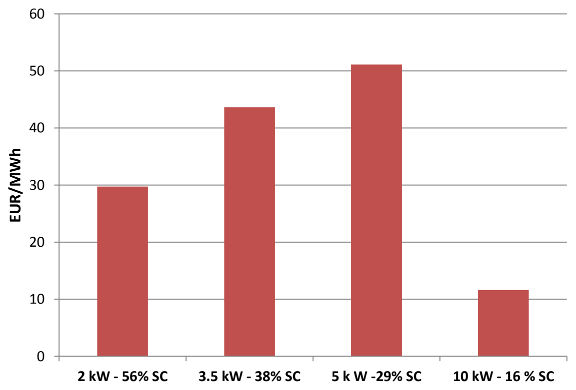

Figure 10 Differences of cumulated NPV of costs of generated PV energy of a Household with energy market price versus Net-metering after 25 years in the Netherlands

3.4 Austria – Investment Grants

In Austria the PV support scheme for the residential sector for systems up to 5 kWp is based on an investment grants. In this analysis the investment grants is 800 EUR/kWp [6][3]. Related to this investment grants the assumed PV system costs are:

- 2 kWp: 2600 EUR/kWp
- 3.5 kWp: 2450 EUR/kWp
- 5 kWp: 2300 EUR/kWp

In Austria there is the possibility of self-consumption and you can sell your PV generation surplus (feed into the grid) to the execution office for green electricity it is called "OeMAG" for around 50 EUR/MWh or to a local utility at an assumed 80 EUR/MWh rate (fixed for 10 years and afterwards also to the OeMAG-Tariff for 50 EUR/MWh). Therefore the PV generation which is fed into the grid is remunerated with an energy market (EM) price of 50 EUR/MWh. The electricity retail price in Austria for households is assumed at 200 EUR/MWh.

The result of the sensitivity analyses for different shares of self-consumption and a comparison between with and without investment grants and with an energy market price (EM Prices) or with an utility tariff for 10 years is shown in Figure 13. The results correlate with the results of the Monte Carlo simulation within the roadmap.

In order to analyse the costs of PV support for a household with different PV system sizes, these specific cumulated NPV are compared to specific costs of a household without a PV system These values are referred to the overall electricity generation of the PV plants. The results in Figure 11 show similar findings as in Figure 13, meaning for up to 5 kWp PV system size the specific costs are positive even if only an energy market price or utility tariff is paid for feeding into the grid. Therefore, in this case PV without any support scheme is not economical. With investment grants costs are

[3] Value in 2012

negative. Negative specific costs imply revenues for the PV owner. As shown on the right hand in Figure 11, all analysed PV system sizes with investments grants are economical. In this case the revenues of an investment grants support scheme in Austria compared with a household without PV are between 0 EUR/MWh and 30 EUR/MWh.

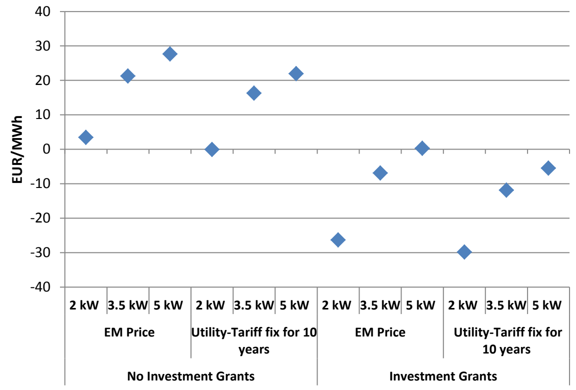

Figure 11 Differences of cumulated NPV of costs of generated PV energy of a Household with or without a PV system after 25 years in Austria

Figure 12 compares the additional cost of investment grants compared without investment grants. The specific NPV of costs are between 27 EUR/MWh and 30 EUR/MWh depends on PV system size.

Investment grants and the possibility of self-consumption lead to similar specific NPV of costs for different PV system sizes and depend on the specific PV system costs in EUR/kW. Therefore a cap for the PV system size is necessary to use the economic benefit of self-consumption.

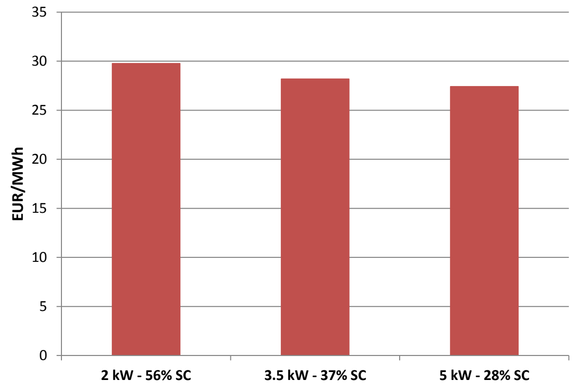

Figure 12 Differences of cumulated NPV of costs of generated PV energy of a Household with energy market price versus investment grants after 25 years in Austria

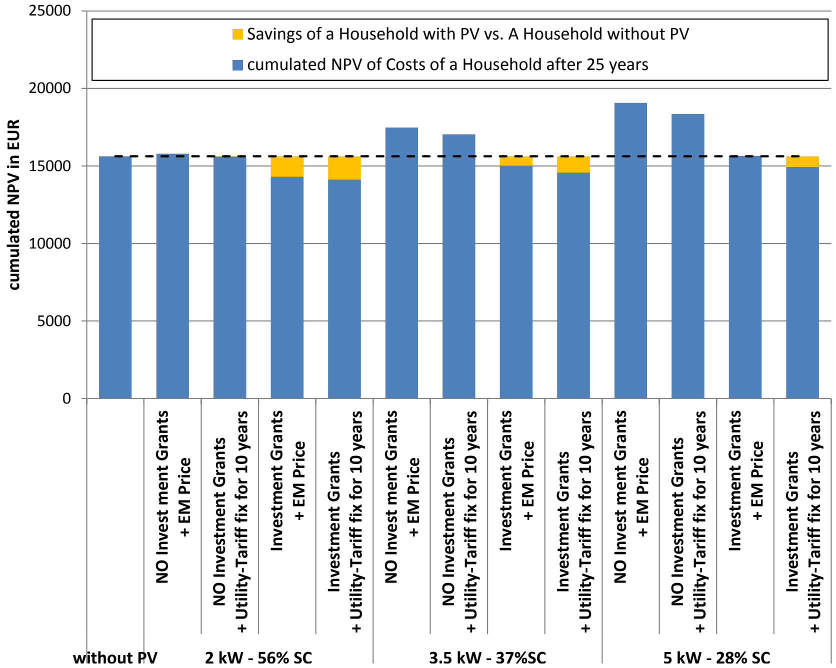

Figure 13 Comparison of cumulated NPV of Costs of a Household with and without a PV system after 25 years in Austria

4 Cost of support schemes in the commercial sector

It is assumed that the parameters of annual demand, Weighted Average Cost of Capital (WACC), Operational and Maintenance costs (O&M), inflation rate and the increase of retail prices are equal for all selected target countries within the commercial sector. These parameters are set as follows:

- Demand: 20 MWh/year
- WACC: 6%
- O&M: 25 EUR/kWp
- Inflation: 2.5%/year
- Increase of retail prices: 3%/year
- Decrease of Module Efficiency: 0.5%/year
- Plant Lifetime: 25 years

The analyses are done for Small and Medium-sized Enterprises (SME) considering "only" 20 MWh demand per year since small commercial industries have a relatively high retail price due to the low voltage grid connection.

4.1 Germany - FiT

Germany's PV support scheme is based on a Feed in Tariff (FiT) for 20 years. The PV system costs in Germany are one of the lowest in Europe due to the highly developed PV market and the PV boom driven by the FiT support scheme. The assumed PV system costs are:

- 20 kWp: 1400 EUR/kWp
- 50 kWp: 1200 EUR/kWp

The FiT for PV system sizes between 10 and 40 kWp is 157.4 EUR/MWh[4] and between 40 and 1000 kWp 140.4 EUR/MWh[5]. If no FiT support scheme in Germany is assumed, the PV generation which is fed into the grid is remunerated with an energy EM price of 50 EUR/MWh. The electricity retail price in Germany for SME is assumed at 160 EUR/MWh.

The result of the sensitivity analyses for different shares of self-consumption and a comparison between FiT and EM price based results is shown in Figure 14. This figure shows the cumulated NPV of costs of a SME without PV and with PV for different PV systems. If a SME with PV has lower costs as a SME without PV, the yellow bars show the savings of the SME with PV compared to a SME without PV. In case, a SME with PV has higher costs as a SME without PV the blue bars are higher as the black dashed line. With a high share of self-consumption a PV system is more or less economic with only an EM price. If the share of self-consumption is too low a FiT is necessary for an economic PV system.

In order to analyse the costs of PV support for a SME with different PV system sizes, these specific cumulated NPV are compared to specific costs of a SME without a PV system. These values are referred to the overall electricity generation of the PV plants over the lifetime. The results in Figure 15 show similar findings as in Figure 14. Negative specific costs imply revenues for the PV owner. As shown in Figure 15, all analysed PV system sizes with a FiT support scheme are economical, even without any self-consumption. In this case the revenues of the FiT support scheme in Italy compared with a SME without PV are around 7 EUR/MWh (see green triangles).

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4 FiT for February 2013 [4]
5 FiT for February 2013 [4

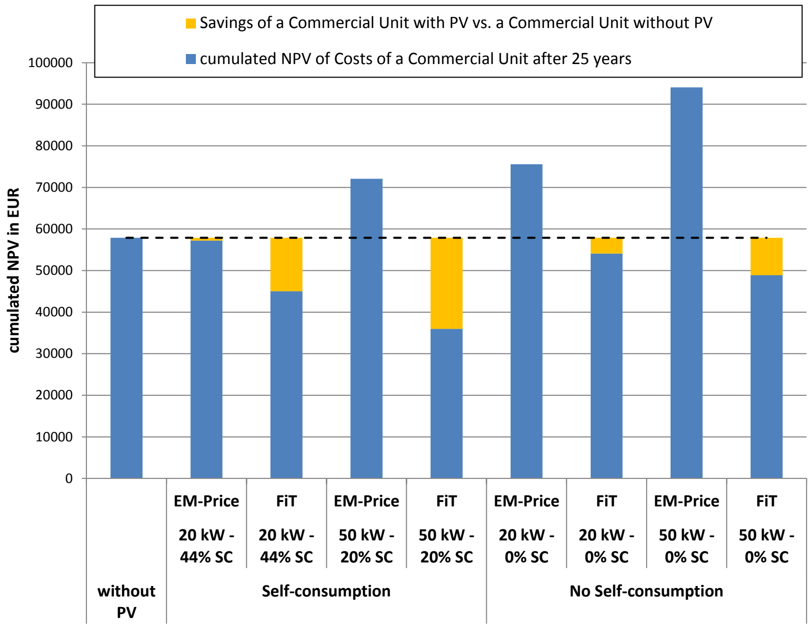

Figure 14 Comparison of cumulated NPV of Costs of a SME with and without a PV system after 25 years in Germany

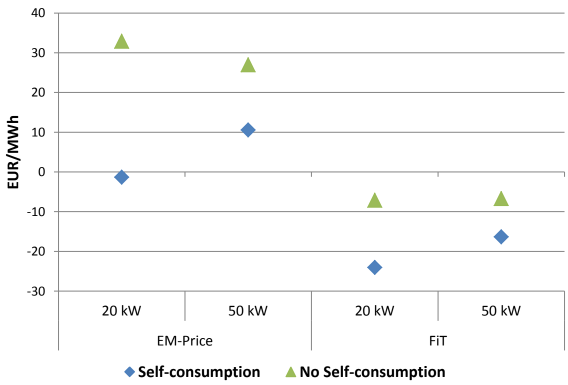

Figure 15 Differences of cumulated NPV of costs of generated PV energy of a SME with or without a PV system after 25 years in Germany

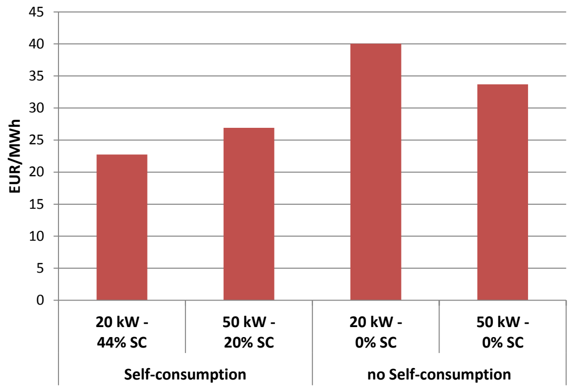

Figure 16 Differences of cumulated NPV of costs of generated PV energy of a SME with energy market price versus FiT after 25 years in Germany

Figure 16 compares the additional cost of a FiT compared to the self-consumption and EM price driven approach. At the current FIT with no self-consumption the specific NPV of costs are between 33 EUR/MWh and 40 EUR/MWh, depends on the PV system size and the associated FiT. This cost decrease with a higher share of self-consumption to 22 EUR/MWh.

With a FiT the PV system becomes more economic with higher PV system sizes, if there is no or less self-consumption.

4.2 Italy - FiT

Italy's support scheme was based until recently on a FiT for 20 years, the main difference to Germany's support scheme is, that on the one hand a PV owner could be supported with a FiT and on the other hand with a self-consumption bonus (lower as FiT). In this analysis the FiT is 157 EUR/MWh for system sizes between 20 kWp and 200 kWp [5]. The self-consumption bonus is 75 between 20 kWp and 200 kWp [5].The assumed PV system costs are

- 20 kWp: 2000 EUR/kWp
- 50 kWp: 1800 EUR/kWp

If no FiT support scheme in Italy is assumed, the PV generation which is fed into the grid is remunerated with an energy market (EM) price of 60 EUR/MWh. The electricity retail price in Italy for SMEs is assumed to be 155 EUR/MWh.

The result of the sensitivity analyses for different shares of self-consumption and a comparison between FiT and EM price based results is shown in Figure 18. This figure shows the cumulated NPV of costs of a SME without PV and with PV for different PV systems. If a SME with PV has lower costs as a SME without PV, the yellow bars show the savings of the SME with PV compared to a SME without PV. In case, a SME with PV has higher costs as a SME without PV the blue bars are higher as the black dashed line. With a high share of self-consumption a PV system is more or less economic with only an EM price. If the share of self-consumption is too low a FiT is necessary for an economic PV system.

In order to analyse the costs of PV support for a SME with different PV system sizes, these specific cumulated NPV are compared to specific costs of a SME without a PV system. These values are referred to the overall electricity generation of the PV plants over the lifetime. The results in Figure 17 show similar findings as in Figure 18. Negative specific costs imply revenues for the PV owner. As shown in Figure 17, all analysed PV system sizes with a FiT support scheme are economical, even without any self-consumption. In this case the revenues of the FiT support scheme in Italy compared with a SME without PV and without self-consumption are between 12 EUR/MWh and 1 EUR/MWh (see green triangles). For using the generated PV electricity the revenues are between 26 EUR/MWh and 36 EUR/MWh (see blue squars).

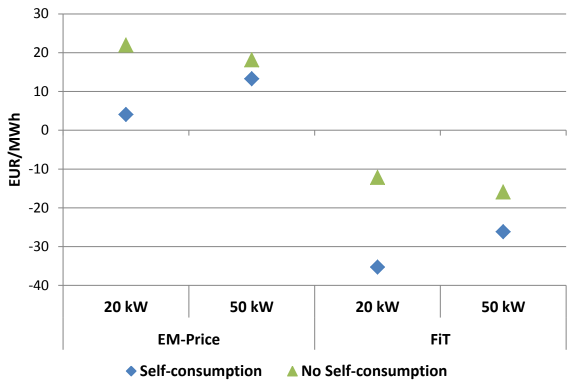

Figure 17 Differences of cumulated NPV of costs of generated PV energy of a SME with or without a PV system after 25 years in Italy

Figure 19Figure 16 compares the additional cost of a FiT compared to the self-consumption and EM price driven approach. At the current FIT with no self-consumption the specific NPV of costs are around 34 EUR/MWh. With self-consumption FiT and bonus the specific NPV of costs are around 39 EUR/MWh

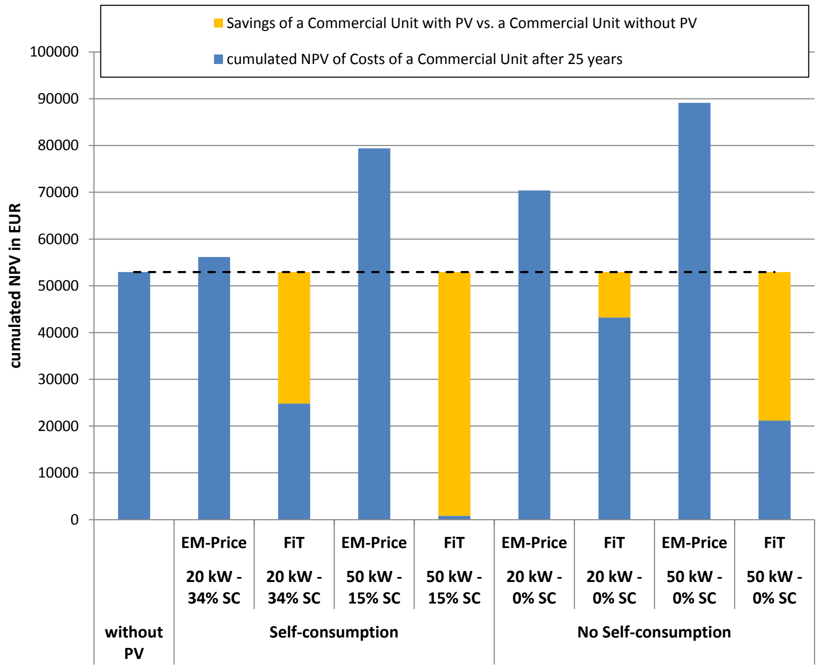

Figure 18 Comparison of cumulated NPV of Costs of a SME and without a PV system after 25 years in Italy

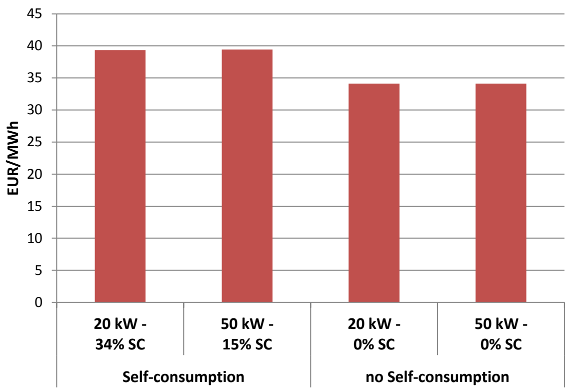

Figure 19 Differences of cumulated NPV of costs of generated PV energy of a SME with or without a PV system after 25 years in Italy

With a FiT the PV system becomes more economic with higher PV system sizes, if there is no or less self-consumption.

4.3 Austria – FiT + Investment Grants

In Austria the PV support scheme for systems above 5 kWp up to 500 kWp is based on FiT for 13 years with additional investment grants. The assumed PV system costs are:

- 20 kWp: 2000 EUR/kWp
- 50 kWp: 1800 EUR/kWp

The FiT for PV system sizes between 5 and 500 kWp is 181.2 EUR/MWh and the additional investment grants is 200 EUR/kWp [6]. If no FiT support scheme in Austria is assumed, you can sell your PV generation surplus (feed into the grid) to the execution office for green electricity it is called "OeMAG" for around 50 EUR/MWh or to a local utility at an assumed 80 EUR/MWh rate (fixed for 10 years and afterwards also to the OeMAG-Tariff for 50 EUR/MWh). Therefore the PV generation which is fed into the grid is remunerated with an energy market (EM) price of 50 EUR/MWh. The electricity retail price in Austria for SME is assumed at 169 EUR/MWh.

The result of the sensitivity analyses for different shares of self-consumption and a comparison between with and without investment grants and with an energy market price (EM Prices) or with a utility tariff for 10 years is shown in Figure 21.
In order to analyse the costs of PV support for a SME with different PV system sizes, these specific cumulated NPV are compared to specific costs of a SME without a PV system. These values are referred to the overall electricity generation of the PV plants. The results in Figure 20 show similar findings as in Figure 21, which means the specific costs are positive even if only an energy market price or utility tariff is paid for feeding into the grid. Therefore, in this case PV without any support scheme is not economical. With FiT and investment grants costs are negative. Negative specific costs imply revenues for the PV owner. As shown on the right hand in Figure 20, all analysed PV system sizes with FiT and investments grants are economical. In this case the revenues of an investment grants support scheme in Austria compared with a SME without PV are between 2 EUR/MWh and 5 EUR/MWh.

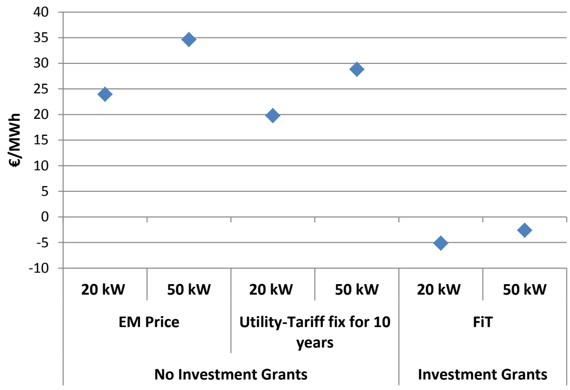

Figure 20 Differences of cumulated NPV of costs of generated PV energy of a SME with or without a PV system after 25 years in Austria

Figure 22 compares the additional cost of FiT plus investment grants compared without investment grants. The specific NPV of costs with an EM price are between 29 EUR/MWh and 37 EUR/MWh and with a utility tariff between 25 EUR/MWh and 31 EUR/MWh, depends on PV system size.

A FiT for 13 years and additional investment grants and after 13 years the possibility of self-consumption lead to similar specific NPV of costs for different PV system sizes and depends on the specific PV system costs in EUR/kW. Nevertheless, the FiT promotes larger PV capacities for single PV owners without considering self-consumption. However, the FiT period of 13 years limits the non-consideration.

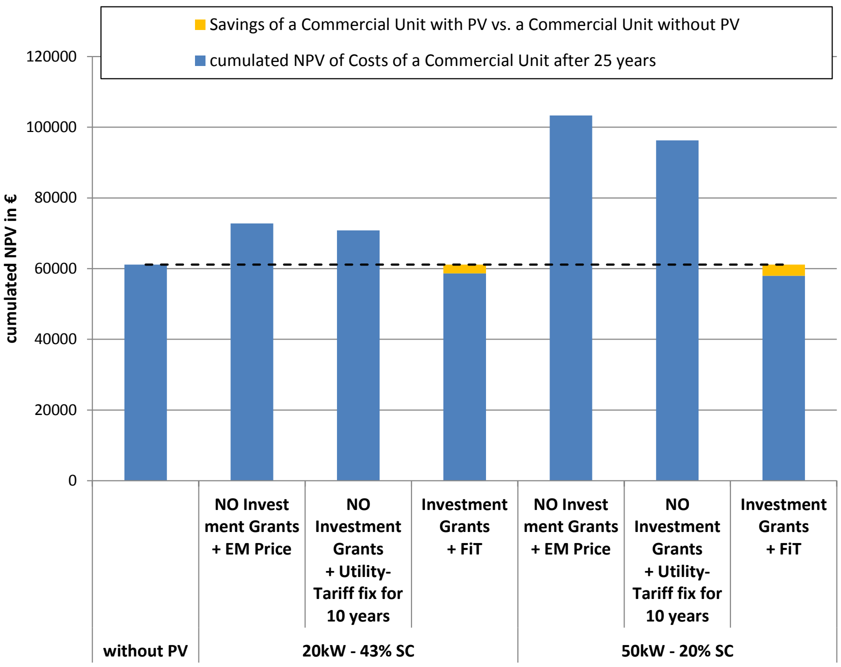

Figure 21 Comparison of cumulated NPV of Costs of a SME with and without a PV system after 25 years in Austria

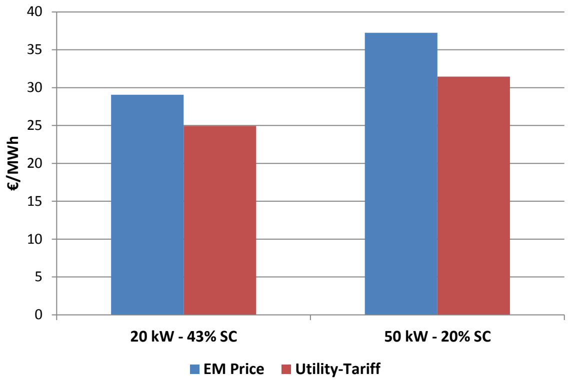

Figure 22 Differences of cumulated NPV of costs of generated PV energy of a SME with energy market price or utility tariff versus FiT and investment grants after 25 years in Austria

5 Business cases of alternative support schemes

The purpose of the following two chapters is showing the PV competitiveness of households when their PV systems require grid charges and taxes for the share of self-consumption. The most important parameter to reach PV competitiveness for prosumers is the share of self-consumption [1],[2]. The share of self-consumption depends on the load and irradiation profiles as well as the PV system size. Meaning that PV generation (partially) replaces the current consumption and, thus, reduces the external procurement from the grid. For the external procurement from the grid the end-user has to pay a retail electricity price (= procurement costs + grid costs + taxes) which means that self-consumed kilowatt-hours are direct savings for end-users via their electricity bills.

The reduction of the end-users electricity bill leads to lower revenues for grid operators and municipalities. With a high penetration of PV in the energy system and the possibility of self-consumption in the current market design, the financial problems of grid operators and municipalities due to decreasing revenues will grow. However, if self-consumption could only be accounted for the procurement cost part of the electricity bill, PV grid parity is likely to not be reached yet and would consequently postpone the PV competitiveness significantly [7].

The next chapter provides an economic sensitivity analysis of different business cases for PV, when PV self-consumption contributes to current grid costs and taxes and additional reinforcement costs of the grid caused by PV.

In order to analyse the cost of alternative support schemes from an economic point of view for a PV owner, the gap between the self-consumption option (dynamic grid parity approach) and different kind of cost contributions with and without a PV system is discussed.

5.1 Business Case 1

In the first analysed business case it is assumed that self-consumption revenues include the current share of grid costs and all taxes with and without fees for renewable energy. Furthermore additional grid reinforcement costs and capacity costs for different PV penetration levels are added to the cost analysis of the PV systems.

Therefore in Business Case 1, five different scenarios for the sensitivity analysis are developed:

A. Current market design for self-consumption and no additional contribution to grid costs and taxes.
B. The shares for grid costs and taxes within the retail prices (without fees for renewables) have to be covered even for self-consumption.
C. The shares for grid costs and all taxes within the retail prices (incl. fees for renewables) have to be covered even for self-consumption.
D. The share of current grid costs and extra costs for grid reinforcement for different PV penetration levels (2% and 18 %) and all taxes have to be covered even for self-consumption.
E. The share of current grid costs and extra costs for grid reinforcement for different PV penetration levels (2% and 18 %) plus all taxes have to be covered even for self-consumption. Additional capacity costs of PV have to be covered according to total annual PV generation.

5.2 Business Case 2

In the second business case it is assumed that self-consumption revenues include all taxes without fees for renewable energy. Grid reinforcement costs have to be covered at once through grid connection fees of the PV systems (depending on the PV penetration rate). Capacity costs for different PV penetration levels are added according to the share of PV generation.

Therefore, in Business Case 2, five different scenarios for the sensitivity analysis are developed:

A. Current market design for self-consumption and no additional contribution to grid costs and taxes.
B. The shares for grid costs and taxes without fees for renewables within the retail prices have to be covered even for self-consumption.
C. The shares for grid costs and taxes without fees for renewables within the retail prices have to be covered even for self-consumption. Additional reinforcement costs are covered with costs for feed into the grid and connection costs for different PV penetration levels
D. The shares for grid costs and taxes without fees for renewables within the retail prices have to be covered even for self-consumption. For different PV penetration levels (2% and 18 %), additional reinforcement costs are covered with costs for feed into the grid and connection costs. Additional capacity costs of PV are covered by 10% of total annual PV generation.
E. The shares for grid costs and taxes without fees for renewables within the retail prices have to be covered even for self-consumption. For different PV penetration levels (2% and 18 %), additional reinforcement costs are covered with costs for feed into the grid and connection costs. Additional capacity costs of PV are covered by 50% of total annual PV generation.

6 Cost of alternative support schemes and sensitivity analysis

For all selected target countries within the residential sector, it is assumed that the parameters of annual demand, Weighted Average Cost of Capital (WACC), Operational and Maintenance (O&M), costs inflation rate and the increase of retail prices are equal for all selected target countries within the residential sector. These parameters are set as follows:

- Demand: 3500 kWh/year
- WACC: 4%
- O&M: 25 €/kWp
- Inflation: 2.5%/year
- Increase of retail prices: 3%/year
- Decrease of Module Efficiency: 0.5%/year
- Plant Lifetime: 25 years

6.1 Germany

The PV system costs in Germany are one of the lowest in Europe due to the highly developed PV market and the PV boom driven by the FiT support scheme. The assumed PV system costs are[6]:

- 2 kWp: 1600 €/kWp
- 3.5 kWp: 1500 €/kWp
- 5 kWp: 1400 €/kWp

The PV generation which is fed into the grid is remunerated with an EM price of 50 €/MWh. The electricity retail price in Germany for households is assumed at 287 €/MWh.

The retail price in Germany is divided in following parts incl. VAT:

- Energy: 121.6 €/MWh
- Grid: 87.2 €/MWh
- Taxes w/o RES fees: 24.2 €/MWh
- RES fees: 54 €/MWh

Figure 23 shows the shares of the German retail price as percentage incl. VAT [8].

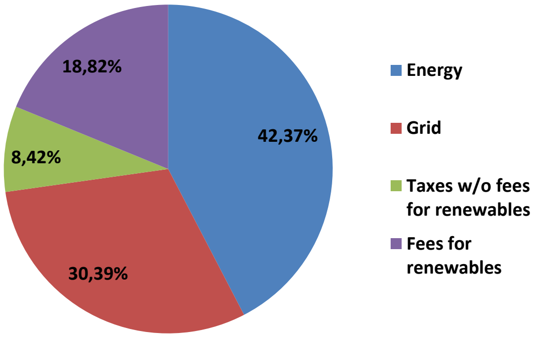

Figure 23 Composition of the German retail price

The additional capacity and grid costs of PV depending on different PV penetration levels in Germany are shown in Table 2 [9].

Table 2 Additional capacity and grid costs of PV for Germany

Germany (€/MWh)			
Additional Cost for		Capacity	Grid
PV Penetration level	2%	11,81	1,98
	4%	11,81	0,99
	6%	12,24	0,66
	8%	12,46	0,53
	10%	12,59	0,75
	12%	12,68	0,98
	14%	12,74	3,88
	16%	12,79	6,35
	18%	12,83	8,10

The result of the sensitivity analyses for business case 1 and 2 is shown in Figure 24 and Figure 25. Thereby, selected scenarios of cost contribution at different shares of self-consumption are considered and a comparison between a household with without PV is depicted.

The cost of alternative PV support for a household with different PV system sizes and different scenarios of cost contribution of self-consumption shares have been analysed. To perform this analysis the specific cumulated NPV of costs of a household for a PV system is compared to specific costs of a household without PV system. These values are referred to the overall electricity generation of the PV plants. Negative specific costs do not only imply revenues for the PV owner but also that PV competitiveness is reached.

[6] October 2013

6.1.1 Business Case 1

Scenario A shows that the dynamic grid parity approach wherein all analysed PV system sizes are economical.

For Scenario B without contribution to renewable fees, with a high share of self-consumption PV systems are also economical feasible.

In scenario C, where the self-consumption does include the share of grid fees and taxes of the retail price, the possible cost for supporting PV systems are between 7 €/MWh and 18 €/MWh, depending on the PV system size.

For all other scenarios the cost for future support schemes rise up to 35 €/MWh.

6.1.2 Business Case 2

In business case 2 Figure 23 shows that all scenarios have negative specific costs.

This is due to the fact, that PV self-consumption in this scenario does not include the grid share of the retail price. However the shares of taxes of the retail price (excl. extra fees for renewables) are covered with self-consumption. Even if extra grid connection cost of 100 €/kWp for the PV system and capacity costs according to Table 2 are considered, still negative cost were calculated.

Thus, it is evident that no alternative support schemes are necessary within business case 2.

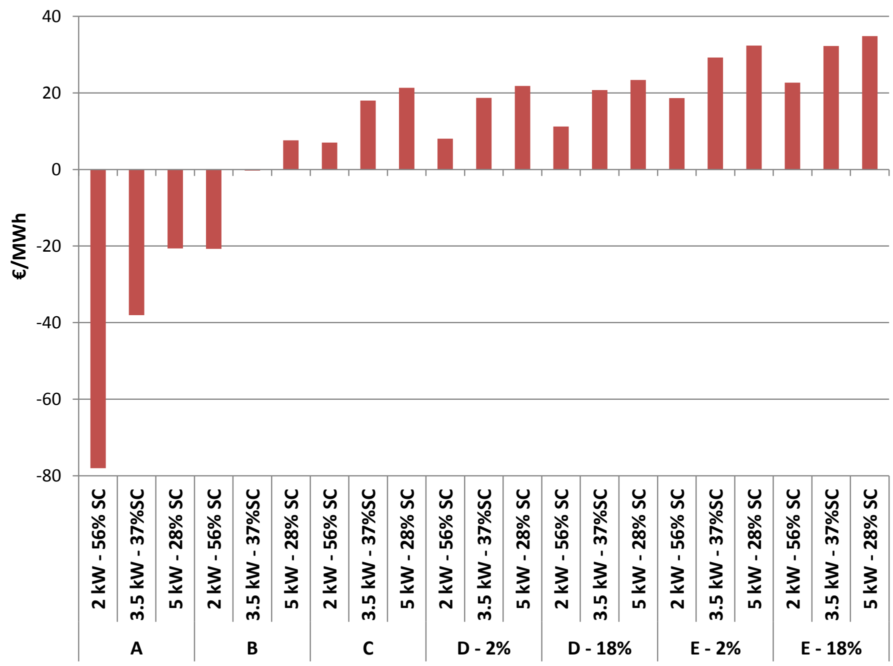

Figure 24 Business Case 1 - Differences of cumulated NPV of costs of generated PV energy of a Household with PV versus without PV after 25 years in Germany

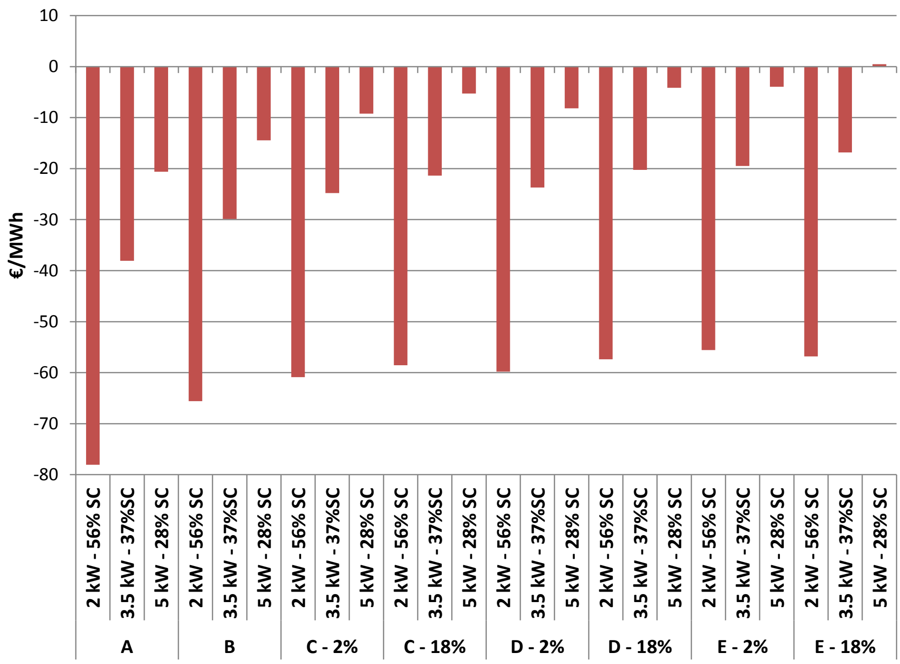

Figure 25 Business Case 2 - Differences of cumulated NPV of costs of generated PV energy of a Household with PV versus without PV after 25 years in Germany

6.2 Italy

The assumed PV system costs in Italy are

- 2 kWp:2200 €/kWp
- 3.5 kWp: 2000 €/kWp
- 5 kWp:1800 €/kWp

The PV generation which is fed into the grid is remunerated with an EM price of 60 €/MWh. The electricity retail price in Italy for households is assumed at 201 €/MWh.

The retail price in Italy is divided in following parts incl. VAT:

- Energy: 137.5 €/MWh
- Grid: 50.3 €/MWh
- Taxes w/o RES fees: 15.5 €/MWh
- RES fees: 15.9 €/MWh

Figure 26 shows the shares of the Italian retail price as percentage incl. VAT [10].

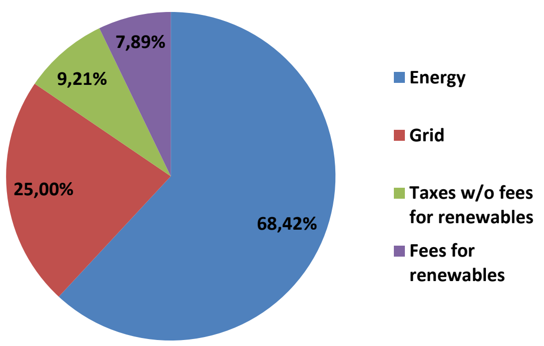

Figure 26 Composition of the Italian retail price

The additional capacity and grid costs of PV depending on different PV penetration levels in Germany are shown in The cost of alternative PV support for a household with different PV system sizes and different scenarios of cost contribution of self-consumption shares have been analysed. To perform this analysis the specific cumulated NPV of costs of a household for a PV system is compared to specific costs of a household without PV system. These values are referred to the overall electricity generation of the PV plants. Negative specific costs do not only imply revenues for the PV owner but also that PV competitiveness is reached.

Table 3 [9].

The result of the sensitivity analyses for business case 1 and 2 is shown in Figure 27 and Figure 28. Thereby, selected scenarios of cost contribution at different shares of self-consumption are considered and a comparison between a household with without PV is depicted.

The cost of alternative PV support for a household with different PV system sizes and different scenarios of cost contribution of self-consumption shares have been analysed. To perform this analysis the specific cumulated NPV of costs of a household for a PV system is compared to specific costs of a household without PV system. These values are referred to the overall electricity generation of the PV plants. Negative specific costs do not only imply revenues for the PV owner but also that PV competitiveness is reached.

Table 3 Additional capacity and grid costs of PV for Italy

Italy (€/MWh)			
Additional Cost for		Capacity	Grid
PV Penetration level	2%	9,60	0,00
	4%	11,73	0,92
	6%	12,43	0,61
	8%	12,79	0,46
	10%	13,00	0,37
	12%	13,14	0,31
	14%	13,24	0,26
	16%	13,32	0,25
	18%	13,38	0,35

6.2.1 Business Case 1

Scenario A shows that the dynamic grid parity approach wherein all analysed PV system sizes are economical.

For Scenario B without contribution to renewable fees, with a high share of self-consumption PV systems are also economical feasible.

In scenario C, where the self-consumption does include the share of grid and taxes of the retail price, the possible cost for supporting PV systems are between 2 €/MWh and 8 €/MWh, depending on the PV system size.

For all other scenarios the cost for future support schemes rise up to 20 €/MWh.

6.2.2 Business Case 2

In business case 2 Figure 28 shows that all scenarios, except scenario E with low share of self-consumption, have negative specific costs.

This is due to the fact, that PV self-consumption in this scenario does not include the grid share of the retail price. However the shares of taxes of the retail price (excl. extra fees for renewables) are covered with self-consumption. Even if extra grid connection cost of 100 €/kWp for the PV system and capacity costs according to The cost of alternative PV support for a household with different PV system sizes and different scenarios of cost contribution of self-consumption shares have been analysed. To perform this analysis the specific cumulated NPV of costs of a household for a PV system is compared to specific costs of a household without PV system. These values are referred to the overall electricity generation of the PV plants. Negative specific costs do not only imply revenues for the PV owner but also that PV competitiveness is reached.

Table 3 are considered, mostly negative cost were calculated. For scenario E and a low share of self-consumption the cost for future support schemes can rise up to 5 €/MWh.

Thus, it is evident that no alternative support schemes are necessary within business case 2.

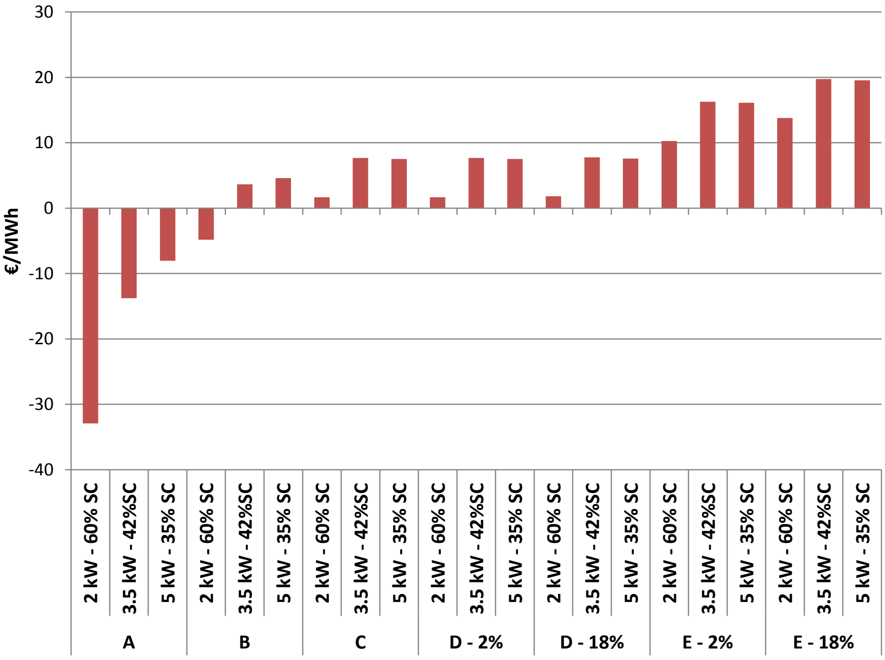

Figure 27 Business Case 1 - Differences of cumulated NPV of costs of generated PV energy of a Household with PV versus without PV after 25 years in Italy

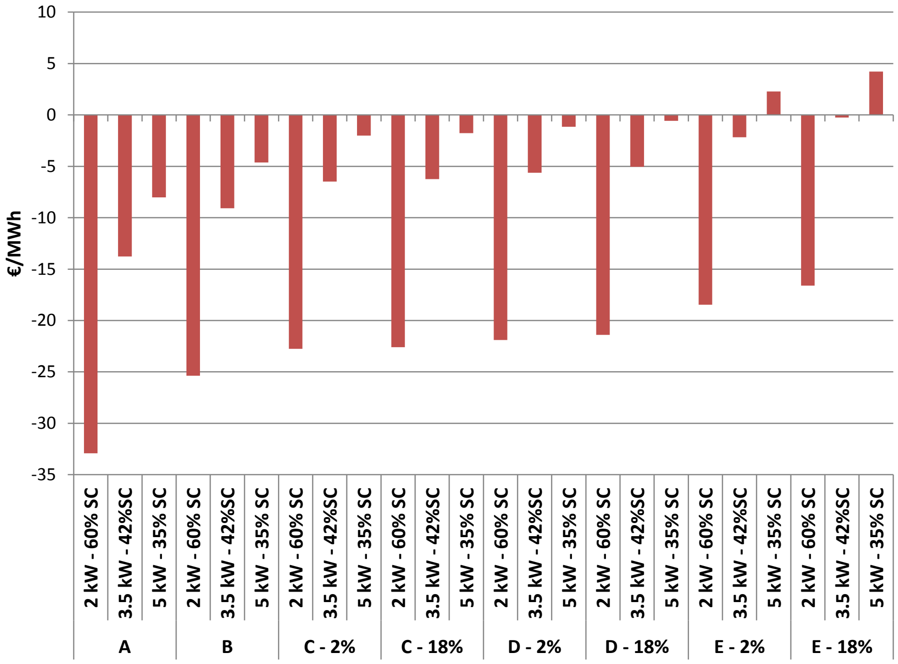

Figure 28 Business Case 2 - Differences of cumulated NPV of costs of generated PV energy of a Household with PV versus without PV after 25 years in Italy

6.3 The Netherlands

The assumed PV system costs in the Netherlands are:

- 2 kWp: 1600 €/kWp
- 3.5 kWp: 1500 €/kWp
- 5 kWp: 1400 €/kWp

The PV generation which is fed into the grid is remunerated with an EM price of 50 €/MWh. The electricity retail price in the Netherlands for households is assumed at 210 €/MWh.

The retail price in the Netherlands is divided in following parts incl. VAT:

- Energy: 82.9 €/MWh
- Grid: 44.2 €/MWh
- Taxes w/o RES fees: 72.7 €/MWh
- RES fees: 27.6 €/MWh

Figure 29 shows the shares of the Dutch retail price as percentage incl. VAT [10].

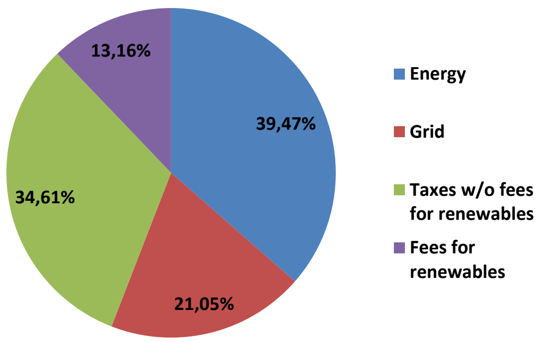

Figure 29 Composition of the Dutch retail price

The additional capacity and grid costs of PV depending on different PV penetration levels in Germany are shown in The result of the sensitivity analyses for business case 1 and 2 is shown in Figure 30 and Figure 31. Thereby, selected scenarios of cost contribution at different shares of self-consumption are considered and a comparison between a household with without PV is depicted.

The cost of alternative PV support for a household with different PV system sizes and different scenarios of cost contribution of self-consumption shares have been analysed. To perform this analysis the specific cumulated

NPV of costs of a household for a PV system is compared to specific costs of a household without PV system. These values are referred to the overall electricity generation of the PV plants. Negative specific costs do not only imply revenues for the PV owner but also that PV competitiveness is reached.

Table 4 [9].

The result of the sensitivity analyses for business case 1 and 2 is shown in Figure 30 and Figure 31. Thereby, selected scenarios of cost contribution at different shares of self-consumption are considered and a comparison between a household with without PV is depicted.

The cost of alternative PV support for a household with different PV system sizes and different scenarios of cost contribution of self-consumption shares have been analysed. To perform this analysis the specific cumulated NPV of costs of a household for a PV system is compared to specific costs of a household without PV system. These values are referred to the overall electricity generation of the PV plants. Negative specific costs do not only imply revenues for the PV owner but also that PV competitiveness is reached.

Table 4 Additional capacity and grid costs of PV for the Netherlands

The Netherlands (€/MWh)			
Additional Cost for		Capacity	Grid
PV Penetration level	2%	10,42	2,11
	4%	10,42	1,05
	6%	11,66	0,70
	8%	12,28	0,57
	10%	12,65	0,58
	12%	12,90	0,74
	14%	13,07	1,83
	16%	13,21	4,42
	18%	13,31	6,77

6.3.1 Business Case 1

Scenario A shows that the dynamic grid parity approach for a high share of self-consumption is economical. Due to the high shares for grid costs and taxes within the retail prices.

For all other scenarios the cost for future support schemes rise up to 65 €/MWh. In business case 1 in the Netherlands the share of self-consumption has less influence of the possible costs of the support scheme.

6.3.2 Business Case 2

In business case 2 Figure 31 shows mostly the same results as in Figure 30 but with lower costs for the support scheme.

This is due to the fact, that PV self-consumption in this scenario does not include the grid share of the retail price. However the shares of taxes of the retail price (excl. extra fees for renewables) are covered with self-consumption. Even if extra grid connection cost of 100 €/kWp for the PV system and capacity costs according to The result of the sensitivity analyses for business case 1 and 2 is shown in Figure 30 and Figure 31. Thereby, selected scenarios of cost contribution at different shares of self-consumption are considered and a comparison between a household with without PV is depicted.

The cost of alternative PV support for a household with different PV system sizes and different scenarios of cost contribution of self-consumption shares have been analysed. To perform this analysis the specific cumulated NPV of costs of a household for a PV system is compared to specific costs of a household without PV system. These values are referred to the overall electricity generation of the PV plants. Negative specific costs do not only imply revenues for the PV owner but also that PV competitiveness is reached.

Table 4 are considered. In business case 2 the share of self-consumption has a high influence to the costs of support schemes. For scenario E and a low share of self-consumption the cost for future support schemes can rise up to 43 €/MWh.

Thus, it is evident that an alternative support schemes are necessary within business case 1 and 2.

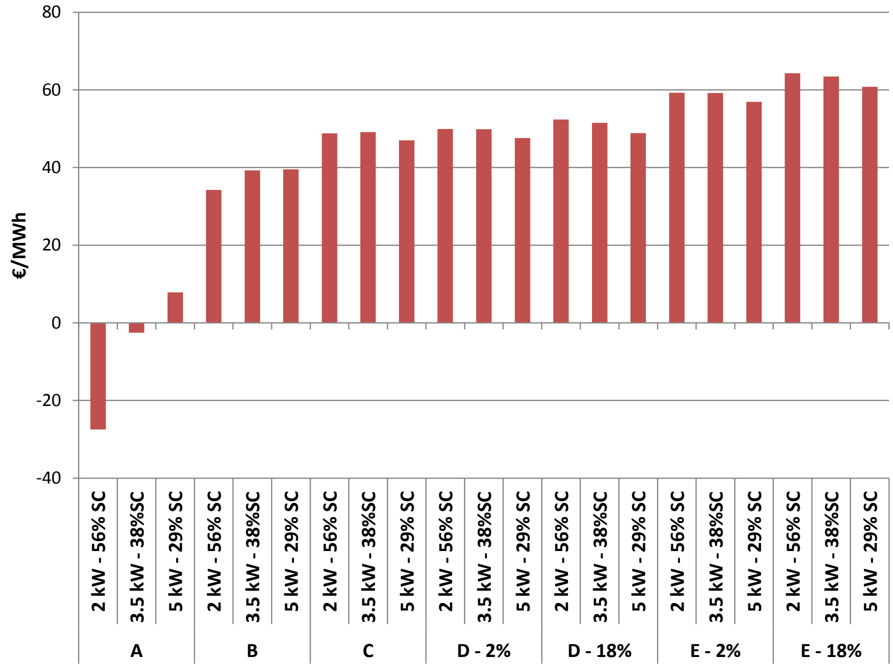

Figure 30 Business Case 1 - Differences of cumulated NPV of costs of generated PV energy of a Household with PV versus without PV after 25 years in the Netherlands

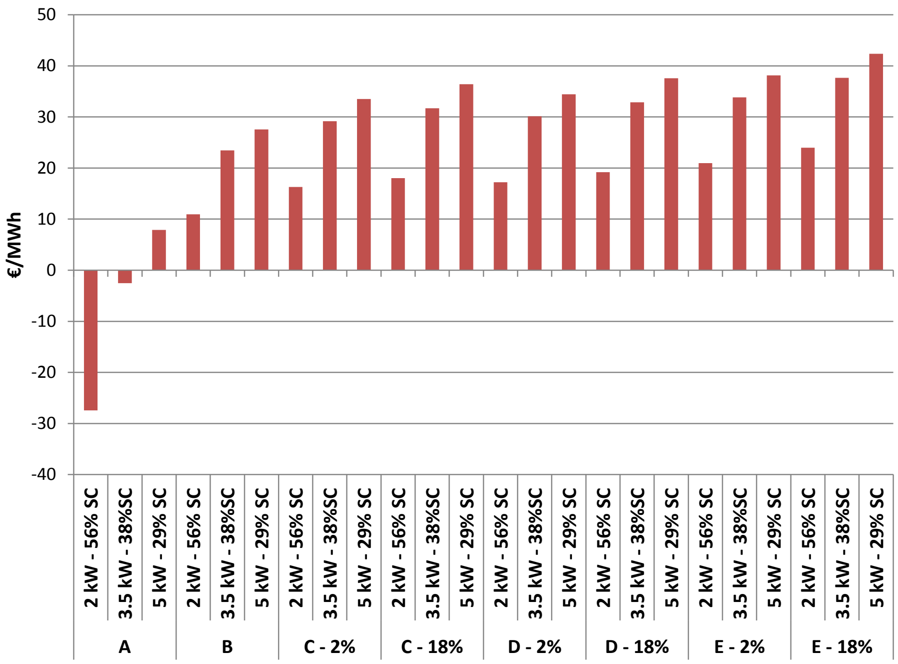

Figure 31 Business Case 2 - Differences of cumulated NPV of costs of generated PV energy of a Household with PV versus without PV after 25 years in the Netherlands

6.4 Austria

The assumed PV system costs in Austria are

- 2 kWp: 2200 €/kWp
- 3.5 kWp: 2000 €/kWp
- 5 kWp: 1800 €/kWp

The PV generation which is fed into the grid is remunerated with an EM price of 50

€/MWh. The electricity retail price in Austria for households is assumed at 210 €/MWh.

The retail price in Austria is divided in following parts incl. VAT:

- Energy: 97.9€/MWh
- Grid: 61 €/MWh
- Taxes w/o RES fees: 27.9 €/MWh
- RES fees: 13.2 €/MWh

Figure 32 shows the shares of the Austrian retail price as percentage incl. VAT [10].

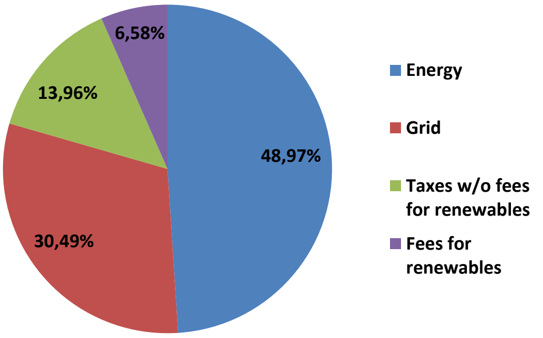

Figure 32 Composition of the Austrian retail price

The additional capacity and grid costs of PV depending on different PV penetration levels in Germany are shown in The cost of alternative PV support for a household with different PV system sizes and different scenarios of cost contribution of self-consumption shares have been analysed. To perform this analysis the specific cumulated NPV of costs of a household for a PV system is compared to specific costs of a household without PV system. These values are referred to the overall electricity generation of the PV plants. Negative specific costs do not only imply revenues for the PV owner but also that PV competitiveness is reached.

Table 5 [9].

The result of the sensitivity analyses for business case 1 and 2 is shown in Figure 33 and Figure 34. Thereby, selected scenarios of cost contribution at different shares of self-consumption are considered and a comparison between a household with without PV is depicted.

The cost of alternative PV support for a household with different PV system sizes and different scenarios of cost contribution of self-consumption shares have been analysed. To perform this analysis the specific cumulated NPV of costs of a household for a PV system is compared to specific costs of a household without PV system. These values are referred to the overall electricity generation of the PV plants. Negative specific costs do not only imply revenues for the PV owner but also that PV competitiveness is reached.

Table 5 Additional capacity and grid costs of PV for Austria

Austria (€/MWh)			
Additional Cost for		Capacity	Grid
PV Penetration level	2%	1,38	1,98
	4%	8,29	0,99
	6%	10,59	0,66
	8%	11,74	0,53
	10%	12,43	0,75
	12%	12,89	0,98
	14%	13,22	3,88
	16%	13,47	6,35
	18%	13,66	8,10

6.4.1 Business Case 1

Scenario A shows that the dynamic grid parity approach for a high share of self-consumption is economical.

For all other scenarios the cost for future support schemes rise up to 67 €/MWh. In business case 1 in Austria the share of self-consumption has less influence of the possible costs of the support scheme.

6.4.2 Business Case 2

In business case 2 Figure 34 shows mostly the same results as in Figure 33 but with lower costs for the support scheme.

This is due to the fact, that PV self-consumption in this scenario does not include the grid share of the retail price. However the shares of taxes of the retail price (excl. extra fees for renewables) are covered with self-consumption. Even if extra grid connection cost of 100 €/kWp for the PV system and capacity costs according to The cost of alternative PV support for a household with different PV system sizes and different scenarios of cost contribution of self-consumption shares have been analysed. To perform this analysis the specific cumulated NPV of costs of a household for a PV system is compared to specific costs of a household without PV system. These values are referred to the overall electricity generation of the PV plants. Negative specific costs do not only imply revenues for the PV owner but also that PV competitiveness is reached.

Table 5 are considered. In business case 2 the share of self-consumption has a high influence to the costs of support schemes. For scenario E and a low share of self-consumption the cost for future support schemes can rise up to 44 €/MWh.

Thus, it is evident that an alternative support schemes are necessary within business case 1 and 2.

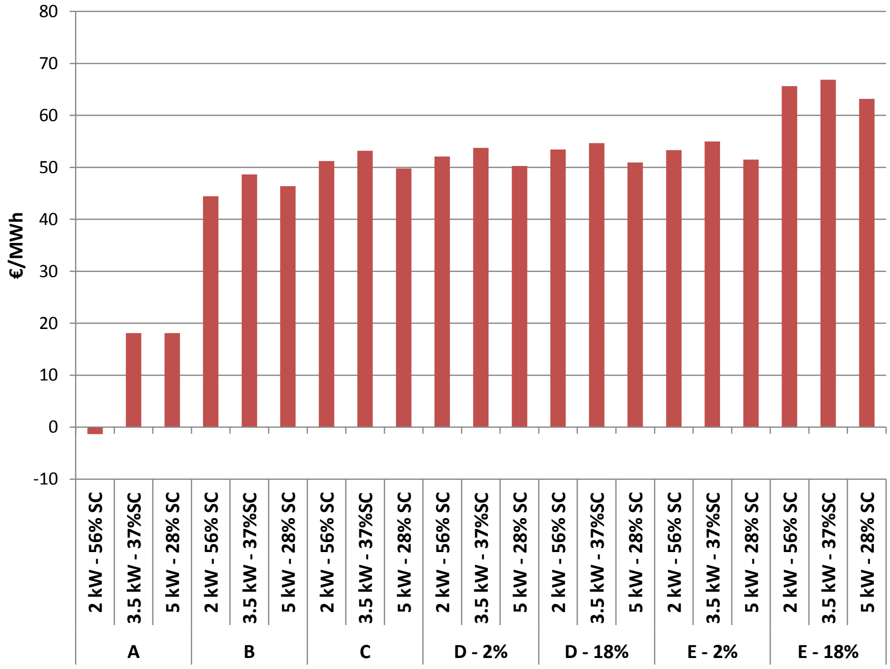

Figure 33 Business Case 1 - Differences of cumulated NPV of costs of generated PV energy of a Household with PV versus without PV after 25 years in Austria

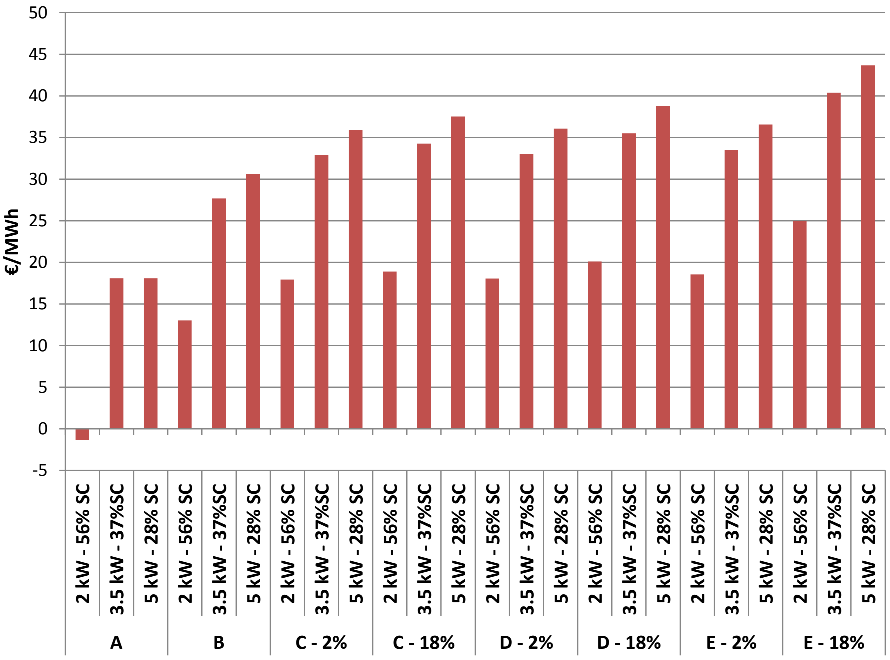

Figure 34 Business Case 2 - Differences of cumulated NPV of costs of generated PV energy of a Household with PV versus without PV after 25 years in Austria

7 Conclusions

The analysis of the costs of current support schemes shows that self-consumption can be the base for reducing the costs of support schemes in general and feed-in-tariffs support schemes in particular. Thus, well-designed measures favouring self-consumption can reduce the costs of alternative incentives compared to feed-in-tariffs.

Investment grants or tax rebates can also reduce the investment costs and bring PV closer to competitiveness. Furthermore, reduced the cost of capital enhances PV competitiveness significantly.

Net-metering could be seen as a step towards incentivizing self-consumption in an economical way: It is a compensation for the electricity fed into the grid equalling the retail price of electricity.

In order to remunerate PV electricity in a fair way, self-consumption measures must be accompanied with a fair compensation for the electricity injected into the grid. For the time being the compensation for the electricity fed into the grid needs to be higher than the market price of electricity in most countries. With decreasing PV electricity costs, this compensation will be reduced and will one day decrease to electricity market prices. Nevertheless electricity of decentralized PV generation, which is feeding into the distribution grid and distributed at the low voltage level, have not to pay additional costs for transmission and their grid losses.

Without any demand response and/or storage options, the share of self-consumption decreases with the growth of PV system sizes. An optimization of the system size and their characteristics can increase the share of self-consumption and thus increase the PV competitiveness. Optimisation of the share of self-consumption can be done on the one hand with an optimal PV system size according to the load profile and on the other hand with optimisation of the load profile with additional technologies for demand response and /or decentralised storage capacities. Additional optimization of self-consumption can foster the achievement of competitiveness.

Finally, the self-consumption business model is highly dependent on the savings on grid costs and taxes. The reduction of the end-users electricity bill through self-consumption can lead to lower revenues for grid operators and public bodies. With a high penetration of PV in the energy system and the potential of self-consumption in the current market design, these issues will grow and force to revise at least the way how grids can be financed during the energy transition.

However, if self-consumption could only be accounted for the procurement costs part of the electricity bill, PV competitiveness would likely be postponed significantly.

Not allowing the compensation of grid costs or taxes would require to be continued for a longer period of time but also alternative incentives or support schemes in order to enable some PV market development in Europe.

The currently market design do not include the contribution to grid fees and taxes of self-consumption. Anyhow, self-consumption reduces specific costs of incentives or support schemes. Furthermore, the results in this document show that an optimization of the PV system size towards a high share of self-consumption can reduce the specific costs of an alternative incentive or support scheme.

The question of alternative grid financing should be considered at system level, rather than the simple impact of PV integration. Moreover, we showed in other reports of the PV Parity project that PV can have a beneficial effect on the grid costs up to a reasonably high penetration [11]. Finally, the difference between self-consumption and energy-efficiency measures from a grid cost perspective should relativize the decrease of needed grid financing and question the need for additional grid fees for PV systems. Energy efficiency also reduces the end-users bill without discussing shares of grid costs and taxes of the retail prices.

Therefore, the development of new market designs with a fair compensation of the grid costs and taxes is necessary for the optimisation of future alternative incentives or support schemes and the further way of PV competitiveness.

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