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REC

STUDY ON THE PROFITABILITY OF COMMERCIAL SELF-CONSUMPTION SOLAR INSTALLATIONS IN GERMANY

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Heineken Wieckse Brewery, Netherlands – 3,683 REC solar panels – 921 kW solar installation for commercial self consumption

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Study on commercial self-consumption

Main findings

- The electricity purchase price for the retail and manufacturing market segments is set to fall slightly over the next 20 years. This is because the EEG levy will drop significantly as the generous feed-in tariffs of legacy solar and wind installations expire. The costs for the heavy-duty production industry, on the other hand, will increase because the taxes and duties are currently so low that they will not offset the rising market electricity price.

- A solar installation with self consumption is most attractive for the retail segment, followed closely by manufacturing. The financial benefits for the heavy-duty industry are very minimal. Depending on location, the payback period for retail is 7.4 to 9 years, for manufacturing 8.1 to 10.1 years, and for the heavy-duty industry, 12 to 15.5 years. Commercial self consumption of solar electricity is attractive because of the high taxes and duties imposed when purchasing from conventional sources.

- An east-west-facing solar installation with self consumption has three benefits:
    1. Shorter payback period: In the retail segment, the payback period is one to two years shorter than for a south-facing installation.
    2. The lower investment costs improve the cost effectiveness of an east-west-facing solar installation.
    3. The self-consumption ratio is higher because the output matches the load profile more closely; for the retail segment, this is up to five percent more compared to a south-facing installation.

- The higher the taxes and duties on the purchased electricity, the greater the net present value (NPV), which is the profitability of the installation once all the investment costs have been paid and taking account the cost of capital. Conversely, lower taxes and duties will cause the net present value to fall. The reason is that the profitability of the solar installation is dependent upon the avoided electricity purchase price. The higher the taxes and duties in the electricity purchase price, the more money is saved by the installation owner through solar self consumption.

- If the self-consumption of solar energy were ever made subject to the EEG levy, a solar installation would become less financially attractive for the retail segment. If a 70 percent EEG levy of 4.36 cents/kWh is imposed on self-consumption, the net present value of a solar installation in retail falls by 33 percent.

- The impact of an EEG levy on the manufacturing segment would be so serious that all investment in solar installations by companies in this segment would probably come to an end. Even if the EEG levy is reduced by 50 percent to 3.12 cents/kWh, the net present value falls by more than 80 percent. If a EEG levy of 70 percent (4.36 cents/kWh) is applied to self-consumption, the installation is no longer viable (NPV of -17 EUR/kWp). The payback period is extended by approximately 4 years.

1. Introduction

Solar markets have undergone substantial changes recently. For many years, solar energy was expensive compared to other sources of renewable or fossil energy. It is now becoming affordable because the total costs are declining steadily, although regional differences remain. For example, in Germany, by the end of 2012, costs had fallen by more than 70 percent from 4.8 EUR/watt to 1.3 EUR/watt. This cost reduction is the result of rapid technical advancements, global competition and oversupply of solar panels. With declining investment costs, solar energy becomes a competitive source of energy. The levelized cost of solar electricity is below the residential electricity rates in a number of European markets. Also for small and medium sized companies, which mainly need energy during the day, commercial grid parity is already achievable at current cost levels. This is especially relevant because solar energy provides companies with planning certainty as electricity prices increase. The higher the electricity price, the greater the financial benefit for the owner of the solar installation. In Germany, a small retail business pays on average around 20 cents/kWh, whereas manufacturing clients only pay 12 cents/kWh. At which point the investment in solar pays off depends on the electricity price and how closely the solar installation matches the particular requirement. This is the context in which new business models are flourishing. Self-generation of solar electricity with little or no government subsidies is changing the ground rules. As a way of understanding the issues and contributing to the current debate about system design and possible levies on self consumption, REC has joined forces with BET Aachen to conduct a study on the profitability of commercial self-consumption installations in Germany.

2. Issues and methodology

The study is primarily concerned with the conditions under which self consumption is attractive for commercial customers. REC carried out a comparative case study to determine the profitability of self consumption installations in different market segments. Companies in Germany were first subdivided into three segments – retail, manufacturing and heavy-duty production industries – on the basis of the taxes and duties they pay on electricity. The profitability of self-consumption installations was then examined for each group. To do this, REC used actual load profiles from a supermarket (retail), an upholstered furniture manufacturer (manufacturer), and heavy-duty production company, and calculated the key financial metrics for each segment (including payback period, net present value and internal rate of return). The calculations took account of the installation size, the investment costs, the construction and maintenance costs, the feed-in tariff and changes to electricity prices (market price and taxes and duties) over 20 years. The modeling was done on an hourly basis over a period of 20 years – i.e. an hour-by-hour comparison was carried out to determine whether it is more cost-effective to feed in the electricity to the grid or to consume the electricity directly themselves, thereby avoiding the electricity purchase price. The analysis used three locations in Germany (Hamburg, Bonn and Nuremberg) in order to take account of the varying irradiation. For the retail segment, the typical south orientation was analyzed alongside a simulated east-west orientation for comparison.

2.1. Definition of self consumption and self-consumption ratio

In the context of this study, self consumption is defined as electricity that is generated and consumed at the same location. The self-consumption ratios indicated for each segment are percentages of the self-generated solar electricity. The supermarket, for example, has an electricity requirement of 254 MWh per year, and its solar installation replaces about 30 percent of the purchased electricity ("self-sufficiency ratio"). It achieves a self-consumption ratio of around 80 percent depending on the location; in other words just 20 percent of the solar electricity is fed into the grid.

3. Changes to electricity prices for companies in Germany over 20 years

The electricity price in Germany is composed of three different elements:

a) Generation, procurement and marketing costs

b) Grid charges (coordinated by the Bundesnetzagentur)

c) Taxes, duties and levies (EEG levy to support renewable energy sources, the levy under Section 19 of the StromNEV levy, the KWK-G levy to support combined heat and power systems, the offshore liability levy, electricity tax, concession duties and VAT).

The taxes, duties and levies payable by companies in Germany vary according to electricity consumption. Our analysis considers three segments – retail, manufacturing and heavy-duty production industries – because each of them is subject to different duties. The table below shows the different composition of the electricity prices for each segment:

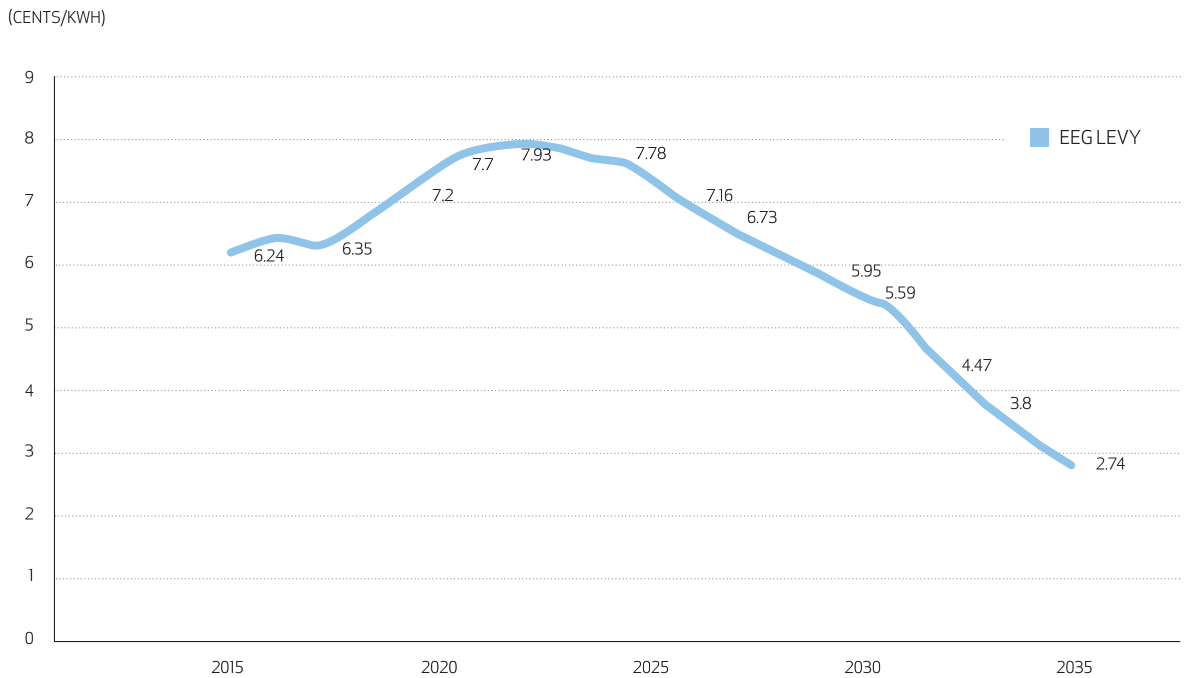
	Retail	Manufacturing	Heavy-duty industry
EEG levy The national EEG levy is a component of the electricity price, payable by the final consumer to support renewable energy sources.	Full EEG levy (6.24 cents/kWh)	Gradual: • 10 percent for consumption < 1 GWh ≤ 10 GWh • 1 percent for consumption < 10 GWh ≤ 100 GWh • 0.05 cents/kWh for consumption > 100 GWh	Exemption for consumption > 100 GWh/year and if the share of gross value added taken up by electricity costs is greater than 20 percent
KWK-G levy The KWK-G levy is used to subsidize combined heat and power generation. It is a national levy payable by the final consumer.	Full amount 0.126 cents/kWh for the first 100 MWh	Full amount 0.126 cents/kWh for the first 100 MWh, then 0.05 cents/kWh	Reduced to 0.025 cents/kWh for consumption > 100 MWh/year and if the share of gross value added taken up by electricity costs is greater than 4 percent
Electricity tax The electricity tax is a tax on final energy consumption.	Full amount 2.05 cents/kWh	25 percent reduction	Up to 90 percent reduction
Special customer supplement under Section 19 (2) The StromNEV levy (under the Electricity Grid Charges Ordinance) is used to finance the full or partial exemption of major electricity users from grid charges. It is a national levy payable by the final consumer.	Full amount (0.187 cents/kWh for the first 1,000 MWh)	Full amount (0.187 cents/kWh for the first 1,000 MWh, then 0.05 cents/kWh)	Reduced to 0.025 cents/kWh for consumption > 100 MWh/year and if the share of income taken up by electricity costs is greater than 4 percent
Offshore liability levy The offshore liability levy (Offshore-Haftungsumlage) is used to hedge the risks associated with connecting offshore wind farms to the grid.	Full amount (0.25 cents/kWh for the first 1,000 MWh)	Full amount (0.25 cents/kWh for the first 1,000 MWh, then 0.05 cents/kWh)	Reduced to 0.025 cents/kWh for consumption > 100 MWh/year and if the share of income taken up by electricity costs is greater than 4 percent
Utility concession duties Utility concession duties (Konzessionsabgabe) are the charges payable to the local authorities for sharing the use of public highways for utilities.	Capped at 0.11 cents/kWh	Capped at 0.11 cents/kWh	Capped at 0.11 cents/kWh

3.1. Changes to the EEG levy between 2014 and 2033

The main components of the electricity price were modeled for the 20-year analysis. Of particular interest are the changes to the EEG levy, which will start at 6.24 cents/kWh on January 1, 2014, increase to 7.93 cents/kWh by 2021, and then steadily fall. In 2033 the levy will only be 2.74 cents/kWh. The reason for the fall is that the high subsidies for solar and wind installations only expire after 20 years. This means that the start-up financing of these new technologies has to be subsidized for another eight years before consumers start to enjoy the benefits of solar electricity in terms of lower bills. The EEG levy is one of the main components of electricity prices, which means that prices will fall slightly for non-exempt final consumers.

Changes to the EEG levy between 2014 and 2033

The EEG levy rises to 7.93 cents/kWh in 2020 and then falls steadily until it reaches 2.74 cents/kWh in 2033.



3.2. Changes to taxes and duties for electricity over 20 years

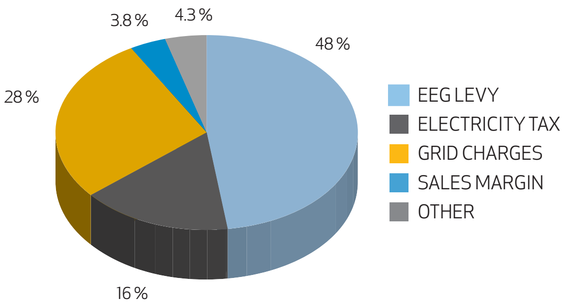
3.2.1. Taxes and duties for retail

The taxes and duties for the retail segment are 13.08 cents/kWh in 2014 – higher than the two other segments. The EEG levy is 6.24 cents/kWh, accounting for almost half the total, followed by the grid charges of 3.7 cents/kWh (28 percent) and electricity tax of 2.05 cents/kWh (16 percent). The other duties such as the offshore liability levy, the concession duties, the special levy tax (Sonderabgabensteuer) and the KWK-G levy together account for 4.3 percent. An additional sales margin of 3.8 percent (0.5 cents/kWh) is also included.

The reduced EEG levy means than in 2033, the duties for retail will only be 9.71 cents/kWh. The EEG levy will fall to 2.74 cents/kWh, making up almost a third of the duties. By then, the grid charges will be the biggest component, at 42 percent (4.1 cents/kWh), followed by electricity tax of 21 percent (2.05 cents/kWh). The other costs (concession duties, special levy tax, etc.) will amount to 3 percent, assuming that the offshore liability levy will expire in 2026. The sales margin will be 5 percent.

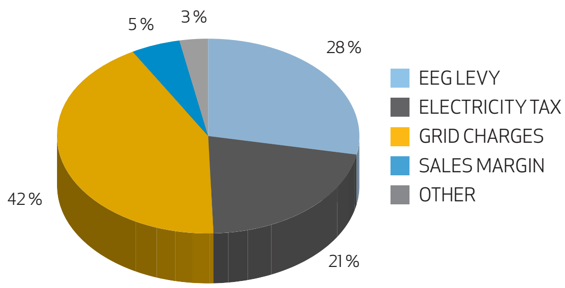
Taxes and duties for retail 2014

The EEG levy is the biggest chunk, with almost 50%



Taxes and duties for retail 2033

The lower EEG levy means that the grid charges become the biggest cost component



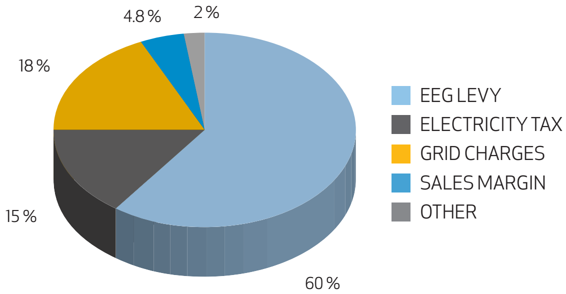
3.2.2. Taxes and duties for manufacturing

The taxes and duties for manufacturing amount to 10.41 cents/kWh in 2014. The EEG levy of 6.24 cents/kWh accounts for two thirds of the total taxes and duties, followed by the grid charges of 18 percent (1.91 cents/kWh) and electricity tax of 15 percent (1.53 cents/kWh). The other duties (offshore liability levy, concession duties, special levy tax, etc.) together account for 2 percent. The sales margin is just under 5 percent.

By 2033, the taxes and duties will fall by around 30 percent to 7.05 cents/kWh because the EEG levy will fall sharply as in the retail segment. It will be just 2.7 cents/kWh, making up around 40 percent of the taxes and duties. The second component will be the grid charges of 30 percent (2.1 cents/kWh), with electricity tax in third place at 22 percent (1.5 cents/kWh). The sales margin will amount to 7 percent (0.5cents/kWh) and the other costs (offshore liability levy, concession duties, special levy tax, etc.) will together account for 2 percent (0.16 cents/kWh).

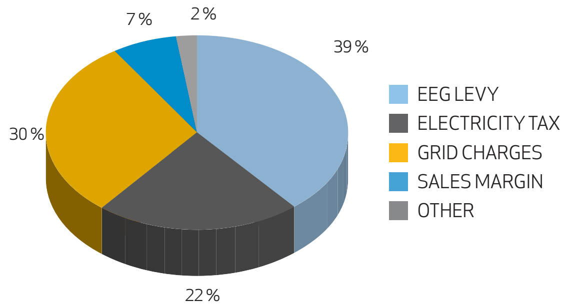
Taxes and duties for manufacturing 2014

The EEG accounts for two-thirds of the costs



Taxes and duties for manufacturing 2033

The lower EEG levy means that the grid charges become the biggest cost component



3.2.3. Taxes and duties for heavy-duty industry

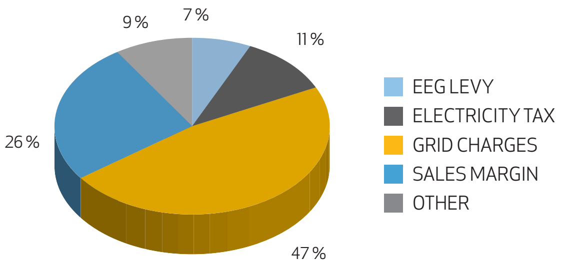
The duties payable by heavy-duty industry amount to 1.89 cents/kWh, the lowest of the three segments. The grid charges make up around half of the taxes and duties (0.89 cents/kWh), followed by the sales margin of 26 percent (0.5 cents/kWh) and electricity tax of 11 percent (0.2 cents/kWh). The EEG levy of 0.108 cents/kWh is much lower for the heavy-duty industry, so it only accounts for 7 percent of the total costs. The remaining 9 percent consists of the other duties such as the offshore liability levy, concession duties, special levy tax, etc.

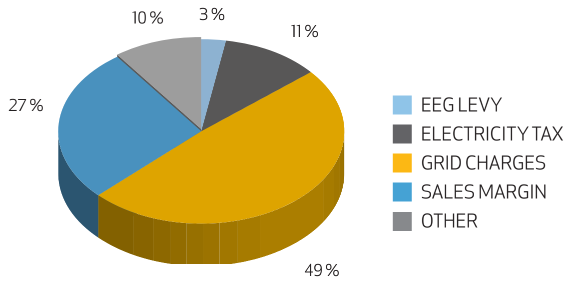
By 2033, the taxes and duties will scarcely change, remaining at 1.82 cents/kWh. The EEG levy will fall slightly to 0.06 cents/kWh, making up 3 percent of the duties. The grid charges remain the largest cost component with 49 percent (0.89 cents/kWh), followed by the sales margin of

27 percent (0.5 cents/kWh) and electricity tax of 11 percent (0.20 cents/kWh). The other costs fall slightly because of the expiring offshore liability levy, accounting for 10 percent of the overall costs (0.16 cents/kWh).

Comparison of taxes and duties for heavy-duty industry in 2014 and 2033

Because the EEG levy is already low in 2014 (subsidized final consumers), the taxes and duties will minimally change between 2014 and 2033





3.3. Changes to the electricity price

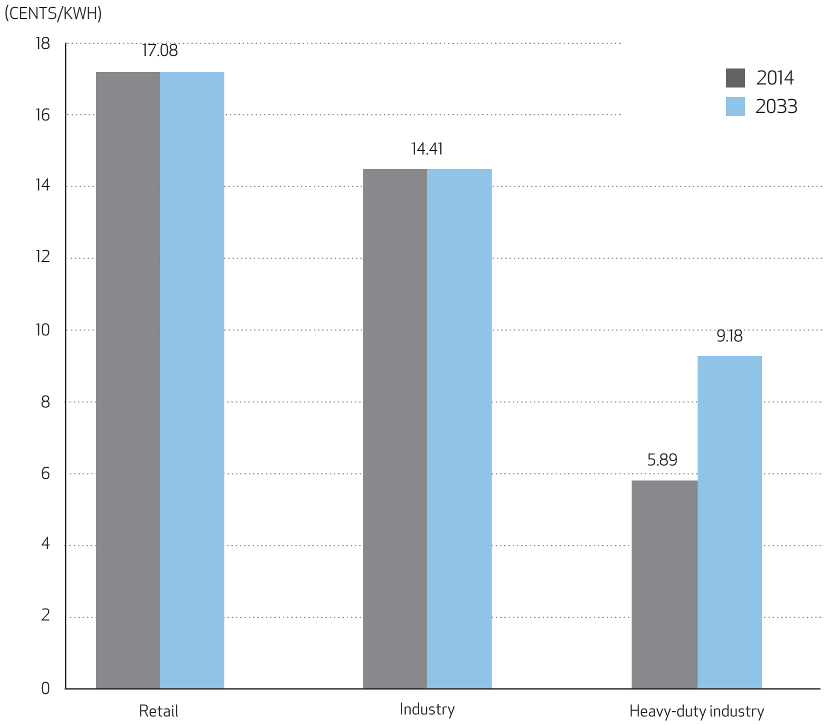
In 2014, the average market electricity price is 4 cents/kWh. The modeling of the electricity price between 2013 and 2017 is based on the energate hourly price forward curve (HPFC). For 2018, the arithmetic average of offers between June 1, 2013 and July 15, 2013 was calculated. For 2019 to 2033 the HPFC curve was increased by 5 percent to reflect the expected annual price increase, ending in an average electricity price of 7.36 cents/kWh in 2033.

3.4. Conclusion

Let us now consider the total electricity purchase costs (taxes, duties and market electricity price). In the retail and manufacturing segments, the total electricity costs remain virtually the same up to 2033 (14.41 cents/kWh for retail and 17.07 cents/kWh for manufacturing). This means that the falling taxes and duties are offset by the rising market electricity price. In both segments, the electricity price will initially increase for about 10 years before the falling EEG levy starts taking the pressure off companies by reducing the overall electricity costs. In heavy-duty industry, on the other hand, the discounted EEG levy and special arrangements mean that the taxes and duties are already so low in 2014 that by 2033 the rising market electricity price will have increased the total costs by 35 percent.

Changes in total electricity purchase costs (taxes, duties and market electricity price) from 2014 to 2033

The total costs remain stable for retail and manufacturing, whereas they increase for heavy-duty industry.



4. Results of the study for companies in Germany

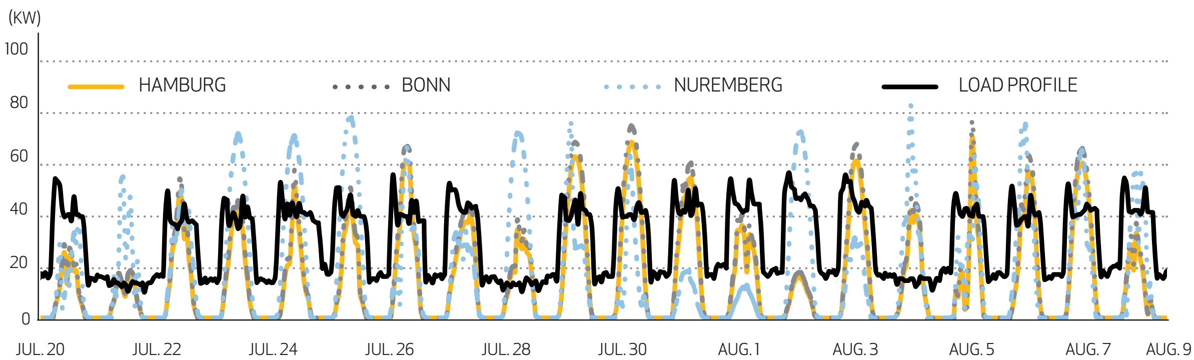
4.1. Retail segment

For the retail segment, the study investigated south-facing self-consumption installations at three locations – Hamburg, Bonn and Nuremberg – plus an east-west-facing installation at the Bonn location. The calculation was based on the actual load profile of a supermarket. The installation size of 95 kWp was determined by the supermarket's available roof surface area. Comparing the load profile with the generation profile shows that on sunny days, the installation generates slightly more solar electricity than can be used, allowing the excess electricity to be fed into the grid.

In addition, electricity generation regularly exceeds consumption on Sundays. In total, supermarkets were found to be able to consume about 80 to 84 percent of the generated electricity themselves.

Retail			
(high taxes and duties) South-facing solar installation			
Energy requirement [MWh/year]	254		
Installation size [kWp]	95		
Solar installation investment costs [EUR]	114,000		
Solar installation investment costs [EUR/kWp]	1,200		
Locations	Hamburg	Bonn	Nuremberg
Self-consumption ratio [%]	83.7	80.5	79.6
Net present value of self-consumption [EUR]	40,429	57,795	76,492
Net present value of self-consumption [EUR/kWp]	426	609	806
Internal rate of return [%]	8.95	10.49	12.09
Payback period [years]	9.0	8.2	7.4
Return on equity	20.01	24.42	28.98

Solar electricity generation – summer



4.1.1. Payback period

The investment costs of the installation were estimated at EUR 114,000, which corresponds to 1,200 EUR/kWp. Depending on the location, a 95 kWp south-facing self-consumption installation takes between 7.4 and 9 years to repay the invested capital from the profits.

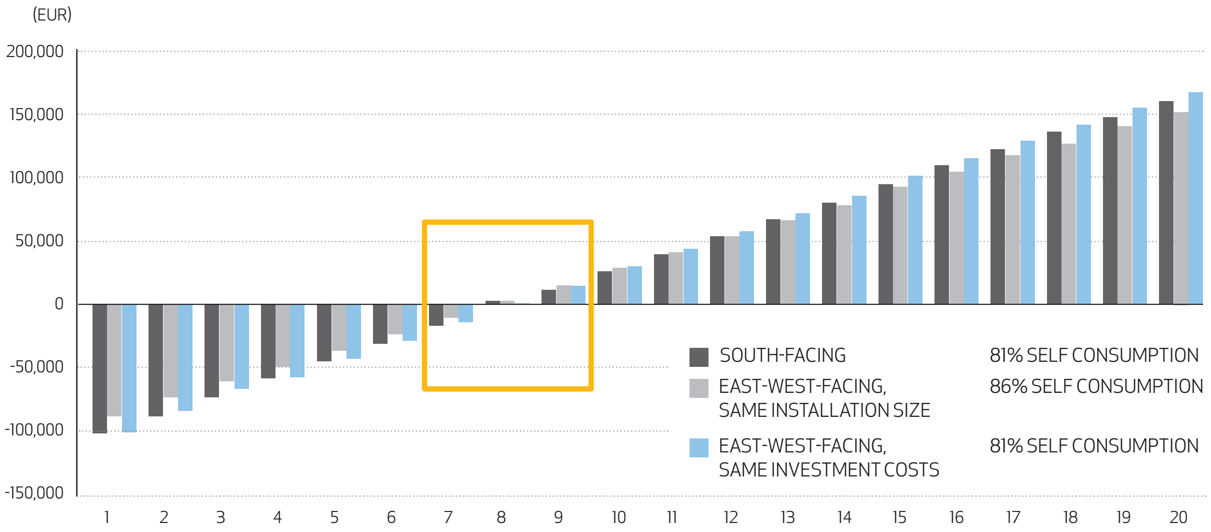
The analysis of the east-west-facing installation shows that this orientation is somewhat more profitable. Two alternatives were investigated. Either the same installation size is used or the investment costs are kept constant (i.e. a slightly greater capacity is installed).

The investment costs for an east-west-facing installation are lower than for a south-facing installation for several reasons. First, the available space is used more efficiently, reducing construction and cabling costs. And second, the wind load is lower, reducing the cost of the mounting system. An east-west-facing installation has a lower maximum output per kWp, meaning that more solar panels can be connected to each of the inverters, which are utilized more effectively. This reduces investment costs because fewer inverters are required. The payback period for an east-west-facing solar installation of the same size at the Bonn location is one to two years shorter, so this is the best choice. Here, the investment costs of 99,750 EUR are about 12.5 percent lower than a comparable south-facing installation.

An east-west-facing installation with the same investment costs as a south-facing installation (covering the entire roof surface area) will also have a shorter payback period. However, the payback period (0.2 years) is longer than the period for a smaller east-west-facing installation of the same size as the south-facing installation.

	Same installation size		Same investment costs	
	South facing	East-west facing	South facing	East-west facing
Location	Bonn		Bonn	
Energy requirement [MWh/year]	254		254	
Installation size [kWp]	95		95	108
Solar installation investment costs [EUR]	114,000	99,750	114,000	114,000
Solar installation investment costs [EUR/kWp]	1,200	1,050	1,200	1,050
Self-consumption ratio [%]	80.5	86.0	80.5	81.0
Net present value of self-consumption [EUR]	57,795	57,248	57,795	61,661
Net present value of self-consumption [EUR/kWp]	609	605	609	570
Internal rate of return [%]	10.49	11.17	10.49	10.84
Payback period [years]	8.2	7.8	8.2	8.0
Return on equity	24.42	26.35	24.42	25.42

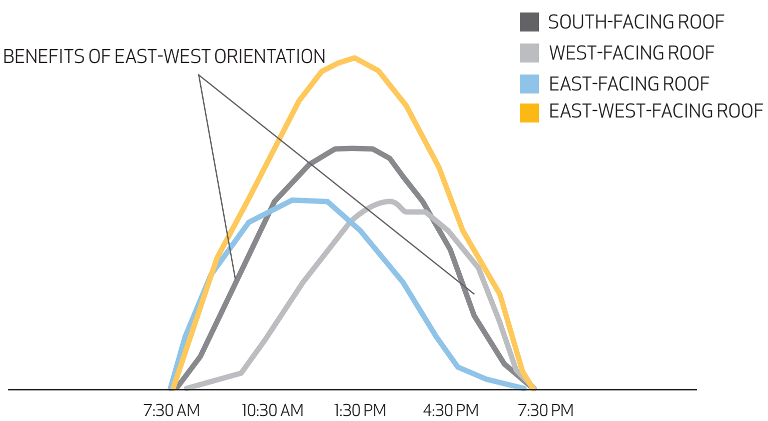
Cumulative cash flow analysis for retail at the Bonn location



* An east-west-facing installation will be repaid after just 7.8 years.

4.1.2. Self-consumption ratio

A supermarket uses electricity all day, including on Saturdays and Sundays to power the refrigerators – making for an ideal scenario for a solar installation. This helps the supermarket achieve a high self-consumption ratio at all three locations. Like the payback period, the self-consumption ratio varies according to the irradiation (location) and the orientation of the installation. The self-consumption ratio is between 80 and 84 percent for a south facing solar installation, and up to five percent higher for an east-west-facing installation of the same size. This is because the output of an east-west-facing installation matches the load profile more closely, producing more electricity in the mornings and evenings with a lower midday peak. The solar panels in an east-west-facing installation are not used to their full capacity, but this is outweighed by the lower investment costs and the greater self consumption.

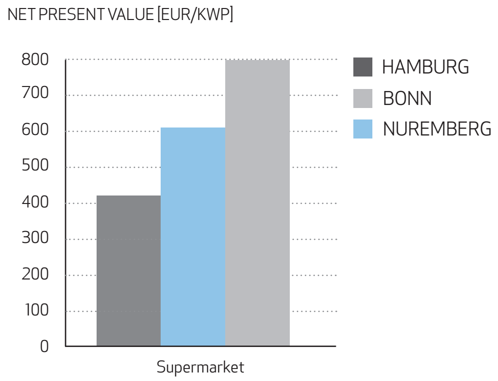


* With an east-west-facing roof, electricity is generated for more hours in the day.

4.1.3. Net present value

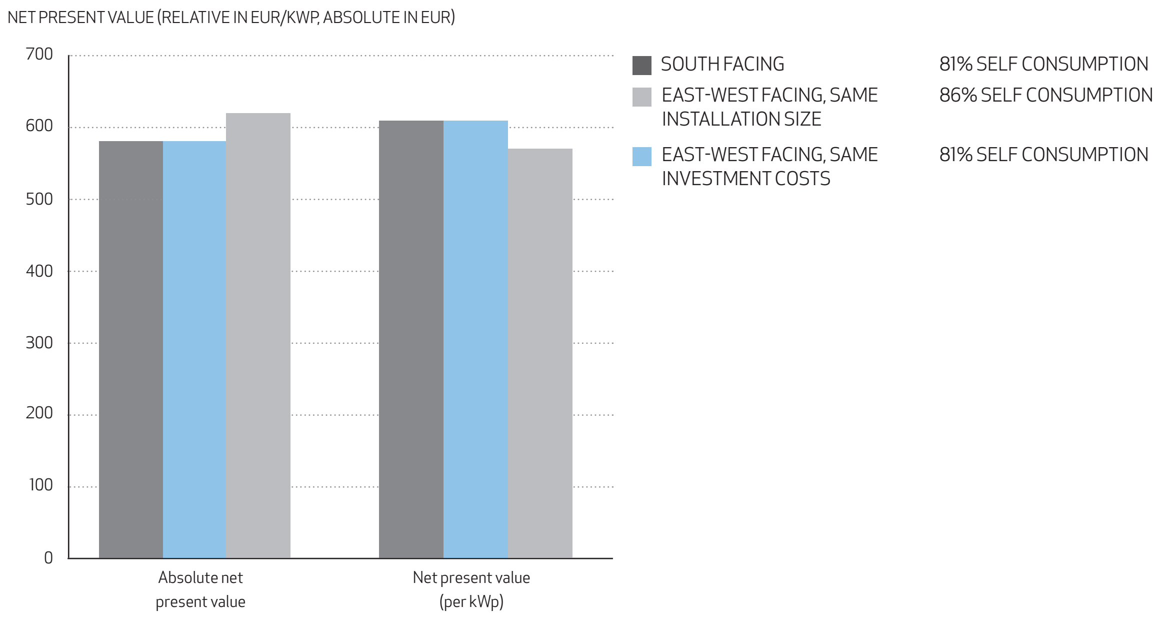
The net present value (NPV) is an important factor in determining the profitability of a self-consumption installation because it represents the profit of an installation once all the investment costs have been paid back. At the Nuremberg location, the retail segment achieves the highest net present value per kWp – 800 EUR/kWp (south-facing installation). The NPV is 200 EUR/kWp lower at the Bonn location, whereas the installation in the Hamburg location can only manage 400 EUR/kWp, making it half as profitable as the installation in Nuremberg.

Profitability of solar installations for the retail segment



Net present value also depends on the orientation of the installation. For example, at the Bonn location, an east-west-facing installation with the same investment costs is more profitable than a south-facing 95 kWp installation or an east-west-facing installation of the same system size and lower investment costs. On the other hand, the relative net present value (per kWp) for the east-west-facing installation with the same investment costs is slightly lower.

Profitability of south Vs. east-west orientation



*In absolute terms, the east-west orientation may achieve a higher net present value, although it is slightly lower per kWp.

The profitability is further influenced by the size of the installation. The relative net present value increases as the self-consumption ratio rises. This means that an installation larger than 95 kWp is less profitable than a smaller installation – but the absolute NPV increases as the installation size grows. The optimum installation size can therefore only be calculated on a case-by-case basis, and always depends on the particular roof surface area, the load profile and the location (irradiation). The analysis also shows that depending on the installation size, the relative net present value can be up to 1,000 EUR/kWp for each installed kWp – it is 939 EUR/kWp at the Nuremberg location, which has an installation size of 57 kWp .

Relative net present value [EUR/kWp] - retail		Hamburg	Bonn	Nuremberg
Baseline	95 kWp	426	609	806
Case 1 (+20 % of installation size)	114 kWp	376	550	736
Case 2 (+40 % of installation size)	133 kWp	330	497	675
Case 3 (-20 % of installation size)	76 kWp	475	672	879
Case 4 (-40 % of installation size)	57 kWp	508	721	939

4.1.4. Conclusion

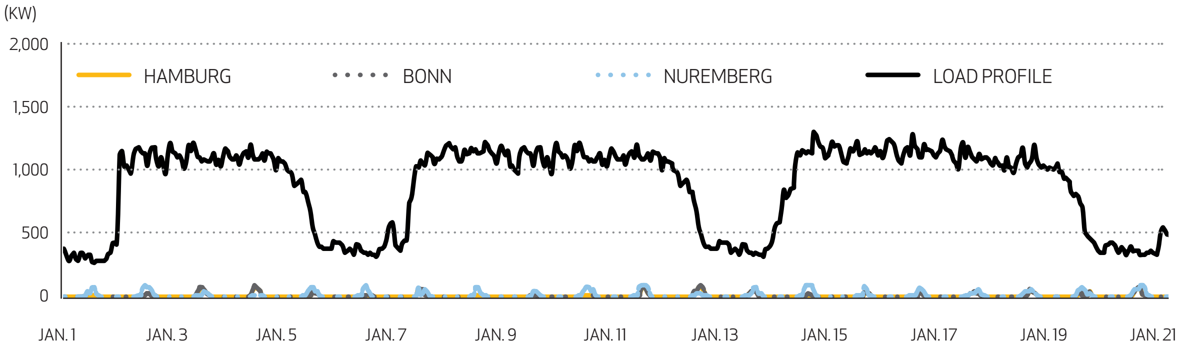
At sunny locations, the installation in the retail segment achieves a very good return on equity of almost 30 percent. The target return on equity is just 20 percent. For the retail segment, it is generally cheaper to generate solar electricity than to purchase electricity. The guaranteed feed-in tariff also makes a self-consumption installation a relatively low-risk investment, although profitability falls when electricity is fed into the grid. In principle, the analysis shows that a solar self-consumption installation is a good investment for the retail segment, and that an east-west orientation is better than a south-facing installation in terms of payback period, self-consumption ratio and net present value.

4.2. Manufacturing

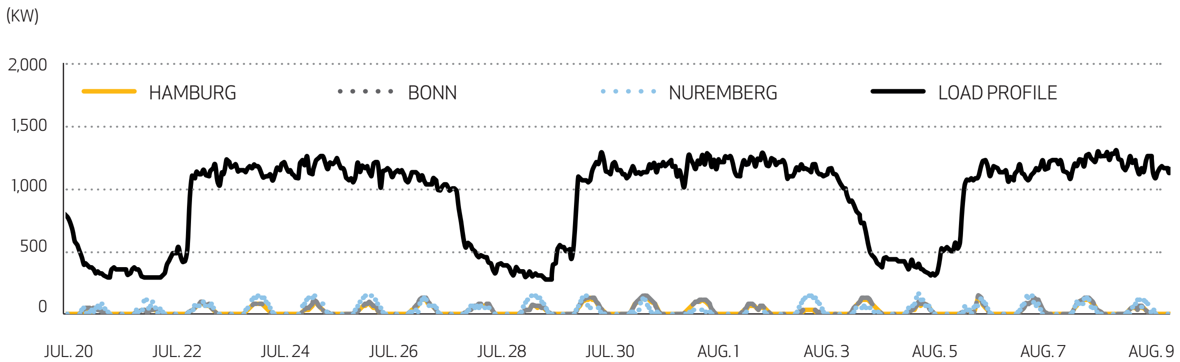
The calculations for the manufacturing segment were based on the example of a load profile for an upholstered furniture manufacturer. This sector uses about 30 times as much electricity as a supermarket, and generally has significantly more roof surface area available. The analysis is based on an installation size of 190 kWp, but the results are reliably applicable to larger installations. In this case, no east-west analysis was carried out. However, the very high self-consumption ratio means that an east-west orientation with the largest possible installation size would improve profitability even more. The load profile confirms that solar energy production is well below the load curve.

Manufacturing			
(moderate burden from taxes and duties) South-facing solar installation			
Energy requirement [MWh/year]	7,956		
Installation size [kWp]	190		
Solar installation investment costs [EUR]	228,000		
Solar installation investment costs [EUR/kWp]	1,200		
Locations	Hamburg	Bonn	Nuremberg
Self-consumption ratio [%]	99.6	99.6	99.6
Net present value of self-consumption [EUR]	100,536	177,233	254,096
Net present value of self-consumption [EUR/kWp]	251	443	635
Internal rate of return [%]	7.4	9.08	10.69
Payback period [years]	10.1	8.9	8.1
Return on equity	15.59	20.42	24.99

Solar electricity generation and load profile – winter



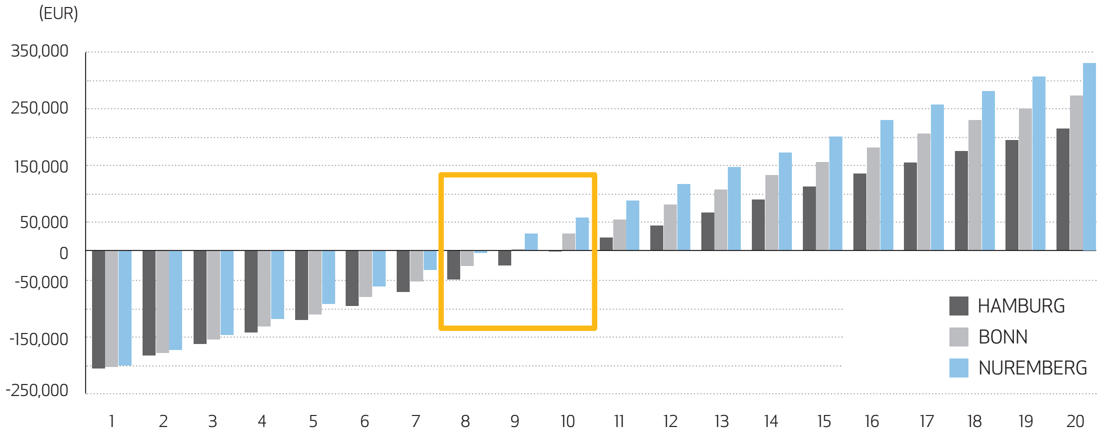
Solar electricity generation – summer



4.2.1. Payback period and self-consumption ratio

The assumed investment costs per kWp are the same as for the supermarket, totaling EUR 228,000 for an installation size of 190 kWp. The payback period is slightly longer than for the supermarket – between 8.1 and 10.1 years depending on the location.

Profitability analysis – payback period (manufacturing)

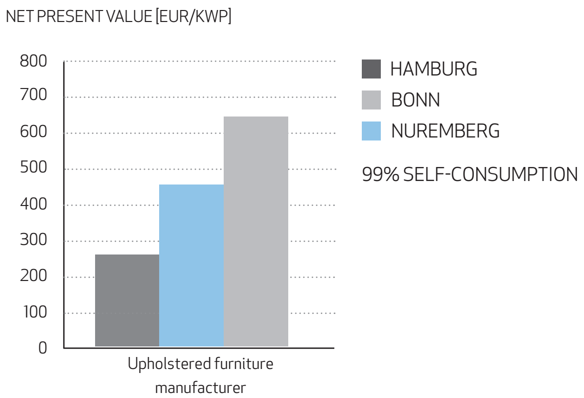


The installation size of 190 kWp is relatively small in comparison with the overall electricity consumption needs, so the self-consumption ratio is almost 100 percent regardless of location.

4.2.2. Profitability

The profitability of a solar self-consumption installation is slightly lower than in the retail segment because of the lower electricity purchase costs. However, a net present value of more than 600 EUR/kWp certainly makes the investment attractive at the Nuremberg location. The other two locations also achieve a positive net present value – 400 EUR/kWp in Bonn and 200 EUR/kWp in Hamburg.

Profitability of solar installations for the manufacturing segment



The net present value per kWp is the same in a larger installation because virtually all the generated electricity can be used directly. Therefore, the ideal installation size should be so large that the generated solar electricity is just below the load profile curve. In this particular case, this would be about 400 kWp.

The example of the upholstered furniture manufacturer with an installation size of 950 kWp shows that the relative net present value at the Nuremberg location falls slightly from the original 635.24 EUR/kWp to 620.27 EUR/kWp. In most cases, however, the entire surface area of the roof should be used in order to achieve the highest possible absolute NPV.

The return on equity for the upholstered furniture manufacturer is between 15.6 and 25.0 percent depending on the irradiation.

4.3. Heavy-duty industry

On the basis of the example installation size of 190 kWp, the analysis shows that for the heavy-duty industry, a solar self-consumption installation is not economically viable. This is because the electricity purchase price is extremely low compared to the other two segments and almost always below the feed-in tariff. This means that an investment in a solar installation for self-consumption is unattractive even if the energy requirements are much higher than the generated energy at all times. In this segment, more than 95 percent of self-generated energy will be fed into the grid, regardless of location. The rare times when the electricity purchase price is higher than the generation costs are not enough to make the investment in the solar self-consumption installation pay off. A larger installation does not improve cost-effectiveness.

Heavy-duty industry			
(low taxes and duties) South facing solar installation			
Energy requirement [MWh/year]	215,388		
Installation size [kWp]	190		
Solar installation investment costs [EUR]	228,000		
Solar installation investment costs [EUR/kWp]	1,200		
Locations	Hamburg	Bonn	Nuremberg
Self-consumption ratio [%]	2.4	2.4	2.4
Net present value of self-consumption [EUR]	-45,519	-19,650	5,567
Net present value of self-consumption [EUR/kWp]	-240	-104	29
Internal rate of return [%]	2.49	3.97	5.32
Payback period [years]	15.5	13.5	12.0
Return on equity	1.55	5.78	9.65

This shows that the feed-in tariff alone is not usually sufficient to justify an investment in a solar installation. It is only possible to achieve a positive net present value at sunny locations like Nuremberg.

Location	Electricity generation costs [cents/kWh]	Feed-in tariff [cents/kWh]
Hamburg	13.53	11.23
Bonn	12.18	
Nuremberg	11.07	

Changes to taxes and duties might improve profitability in this segment. Many major consumers now operate other self-consumption systems such as combined heat and power installations, which are more financially attractive and offer greater certainty on electricity prices.

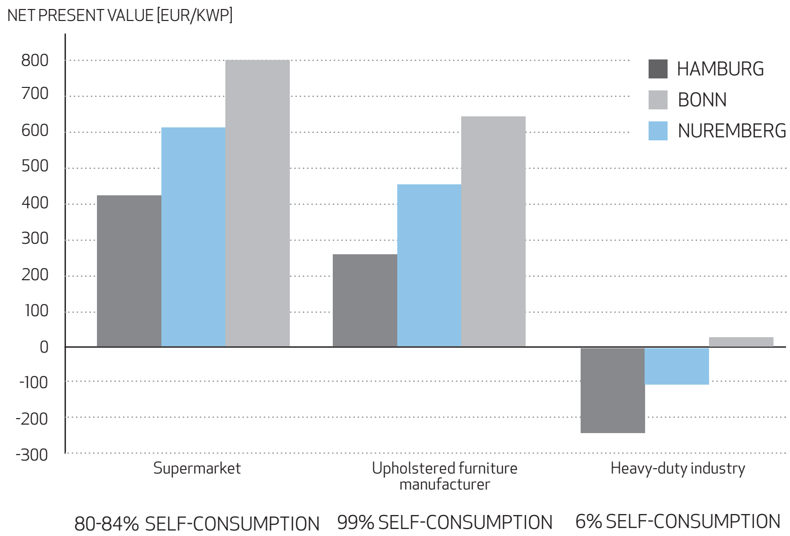
5. Discussion of results

5.1. The profitability of the installation is related to the electricity purchase price

The analysis shows that an investment in a solar self-consumption installation is most profitable for the retail segment and is also attractive for manufacturing. It is clear from the composition of electricity costs that in this segment, changing the taxes and duties would have a much bigger impact on the net present value than changing the wholesale electricity prices.

Self-consumption in the heavy-duty industry, on the other hand, is not profitable due to the low electricity purchase price – this segment will therefore not be considered further.

Profitability of solar installations for the three segments



The supermarket achieves a peak net present value of 800 EUR/kWp at Nuremberg, the sunniest location of all three. This means that the installation makes 800 EUR/kWp once all investment and capital costs have been paid back. The corresponding figures for Bonn and Hamburg are 600 EUR/kWp and 400 EUR/kWp respectively.

The solar installation for the second segment, manufacturing, makes 200 EUR/kWp less on average, so the figures are 600 EUR/kWp for Nuremberg, 400 EUR/kWp for Bonn and 200 EUR/kWp for Hamburg. Although this makes the installation less profitable than for the supermarket, it is still a very attractive proposition. The main reason for the varying profitability is the different electricity purchase costs of the three segments.

The supermarket pays all taxes and duties (EEG levy, electricity tax, KWK-G levy, special customer supplement, etc.) so its electricity purchase price is higher than the manufacturing and heavy-duty industry segments. Until 2020 (when the EEG levy starts to fall), a supermarket will save the most per kWh of solar energy it generates. The installation remains attractive even as the EEG payment falls, thereby reducing the electricity purchase price, especially as the investment costs are repaid over the years.

The manufacturing segment pays a lower electricity tax and lower grid charges, so the electricity it uses costs 3 cents/kWh less than for retail.

The financial benefits of a self-consumption solar installation are primarily dependent on the electricity purchase price – other factors such as irradiation or orientation (east-west facing or south facing) are less important.

5.1.1. Influence of electricity costs on the "self-consumption business model"

One central issue for the "self-consumption business model" is how taxes and duties will change in future. The costs of extending the network are bound to increase while the energy system is being remodeled, but it is difficult to estimate how much the regulator will increase charges and who will be affected. We can therefore only cover a small number of scenarios here.

Three different scenarios were analyzed: 10 percent higher taxes and duties, 10 percent lower taxes and duties, and 50 percent lower taxes and duties.

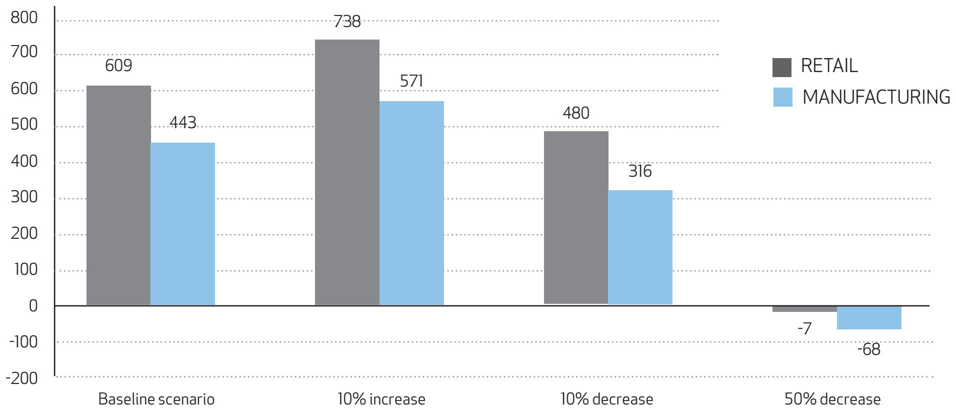
The net present value (EUR/kWp) will always increase if the taxes and duties increase – in other words, the profitability of the installation increases once all the investment costs have been repaid. Conversely, lower taxes and duties will cause the net present value to reduce. This means that the greater the increase in taxes and duties, the more money is saved by the installation owner through solar self-consumption.

If the taxes and duties increase by 10 percent, the net present value increases for the retail segment by 21 percent to 738 EUR/kWp and for the manufacturing segment by 29 percent to 571 EUR/kWp. If the taxes and duties fall by 10 percent, the net present value decreases for retail by 21 percent to 480 EUR/kWp and for manufacturing by 28 percent to 316 EUR/kWp.

If the taxes and duties fall by 50 percent, the self-consumption installation would no longer be financially attractive for manufacturing or for retail. The net present value in both cases would be negative (for retail -7 EUR/kWp and for manufacturing -68 EUR/kWp).

Change of net present value in EUR/kWp with different taxes and duties

THE NET PRESENT VALUE (EUR/KWP) INCREASES WITH HIGHER TAXES AND DUTIES AND REDUCES WITH LOWER TAXES AND DUTIES, BONN LOCATION



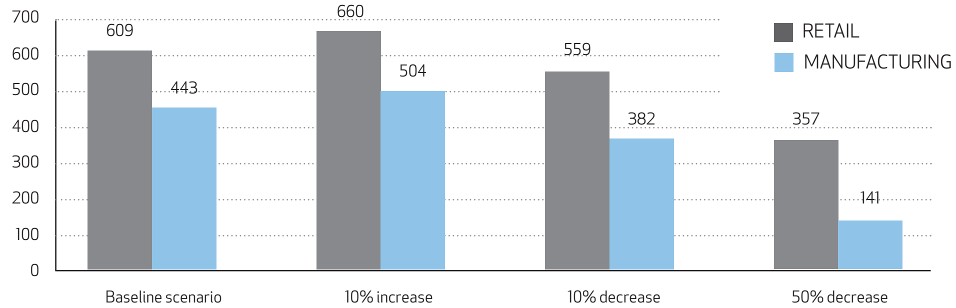
In the second step, the analysis considers the same scenarios for the market electricity price: a 10 percent increase, a 10 percent reduction and a 50 percent reduction in the market electricity price.

As with the taxes and duties, the net present value increases with a higher market electricity price and reduces with a lower market electricity price.

Overall, however, the influence on the net present value is smaller because the market electricity price only accounts for 30 percent of the total electricity purchase costs for retail, and 38 percent for manufacturing. If the market electricity price increases by 10 percent, the net present value only increases by 8 percent to 660 EUR/kWp for retail and by 14 percent for manufacturing to 504 EUR/kWp. If the market price falls by 10 percent, the net present value falls by 8 percent for retail and 14 percent for manufacturing. If the market electricity price were to fall by half, the self-consumption installations in both segments would still just be profitable – 357 EUR/kWp (-41 percent) for retail and 141 EUR/kWp (-68 percent) for manufacturing.

Change of net present value in EUR/kWp with different market electricity prices

THE NET PRESENT VALUE (EUR/KWP) INCREASES WITH A HIGHER MARKET ELECTRICITY PRICE AND REDUCES WITH A LOWER MARKET ELECTRICITY PRICE, BONN LOCATION



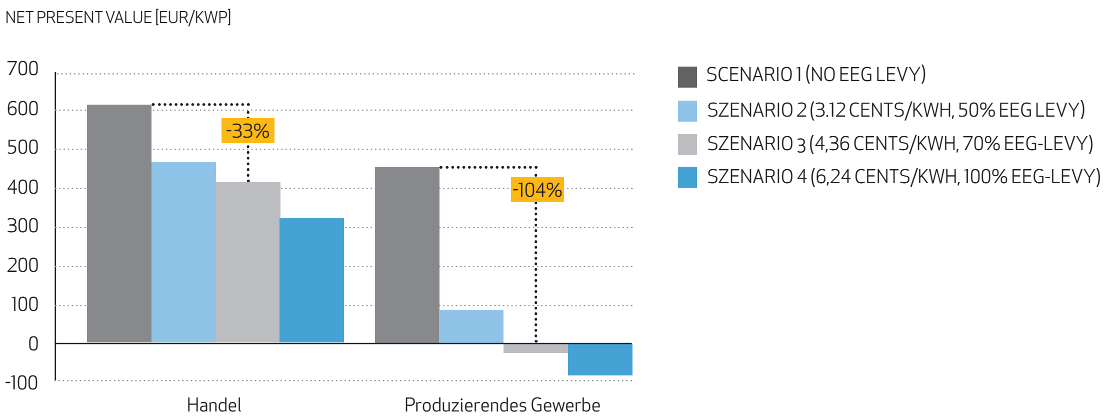
5.1.2. Impact of making self consumption subject to the EEG levy

At present, self consumption of energy from one's own solar installation is not subject to any levies. If this changes and self consumption is made subject to the EEG levy, the profitability for the retail segment would fall. If a reduced EEG levy of 3.12 cents/kWh is imposed on self consumption, the net present value of a solar installation in retail falls by 23 percent. If the full EEG levy is imposed, profitability collapses by up to 50 percent. The profit of the installation declines by 33 percent, should the EEG levy of 70 percent been applied. The impact of an EEG levy on the manufacturing segment in particular would be so serious that all investment in solar installations by companies in this segment would probably come to an end. Even if the EEG levy is reduced by 50 percent, giving 3.12 cents/kWh, the net present value falls by more than 80 percent. If the full EEG levy is applied to self consumption, the installation is no longer viable (NPV of -91 EUR/kWp).

The impact of an EEG levy on the manufacturing segment would be so serious that all investment in solar installations by companies in this segment would probably come to an end. Even if the EEG levy is reduced by 50 percent to 3.12 cents/kWh, the net present value falls by more than 80 percent to 86 EUR/kWp. If a EEG levy of 70 percent (4.36 cents/kWh) is applied to self-consumption, the installation is no longer viable (NPV of -17 EUR/kWp). Additionally, the payback period is extended; for example, from 10.1 to 14.3 years at the location in Hamburg.

The example of the EEG levy can be directly transferred to other charges such as the network connection fee, etc. The important thing is that the profitability of solar self-consumption installations is impacted much more by political factors than by electricity prices over the next 10 to 15 years. As the government sets about reforming the taxes and duties applicable to solar self consumption, it must therefore take great care not to impose a burden that could destroy this emerging business model.

Influence of levies to self consumption on the net present value at the Bonn location



Feed-in tariffs are currently falling, so the solar market is transforming itself from a market based solely on yields – based on fixed earnings over 20 years – to a market with alternative financial models for solar electricity. One possible business model, with new refinancing opportunities, is self consumption for retail and manufacturing industries. Installation costs have already fallen so much that the old self-consumption bonus for solar electricity is no longer needed, indicating that this new business area is financially attractive without government subsidies. Considerable investment will be needed in order to meet the political targets concerning the development of renewable energies, and retail and manufacturing businesses could be major drivers. The government must ensure that it remains attractive for retail and manufacturing to replace a small portion of purchased electricity with self-produced solar energy. Any duties payable on self consumption must not make this young business area unprofitable. Instead, the government must ensure that solar installations remain attractive for investors.

In Germany, there is a lot of concern about the erosion of the principle of solidarity thought to be caused by self consumption. This study shows that the manufacturing segment, which would be the most affected by the EEG levy, can only meet a very small portion of its energy needs (2.4 percent) with a self-consumption installation. Taxes and duties will still be payable on the remaining 97.6 percent of electricity (purchased). And in retail, a good 70 percent of the electricity used will remain subject to taxes and duties.

	Retail	Manufacturing
Average self-consumption ratio (in %)	81.3	99.6
Average coverage of total electricity needs (in %)	30.3	2.4

Crucially, there is no erosion of the principle of solidarity among solar operators because the solar installation is not the main source of electricity for major consumers.

The rules governing the electricity markets in future should take account of the effects of imposing an EEG levy on self consumption. In terms of the wider economy, solar installations for self-consumption are a very cost-effective way of supporting the Energy Transition and decentralizing energy supplies. The analysis shows that they do not cause an increase to the EEG levy and do not bring about any erosion of the principle of solidarity as currently feared. In the manufacturing segment, much less than 10 percent of the electricity requirement is covered, which means that these systems will help to cover much of the costs from legacy installations.

5.2. Investment decisions by companies

In both scenarios (retail and manufacturing), the payback period is between 7 and 10 years, which is usually too long to prompt a company to invest. Executives often make investment decisions for a period of three to five years. One important way of encouraging small and medium-sized companies to invest is to use a baseline feed-in tariff as a support payment. The actual amount is not critical here; the important thing to note is that bank loans need to be secured against guaranteed returns over 20 years.

The example of the east-west facing solar installation for the supermarket at the Bonn location demonstrates that altering the orientation can certainly improve profitability. In the current debate about network capacity problems, some people have suggested increasing the subsidy for east-west-facing installations, thereby mitigating the midday solar feed-in peak. Where self consumption is being used to refinance an installation, a higher subsidy would not necessarily be required as the installation is more profitable because of lower investment costs and a more efficient interplay of irradiation and the load profile. The trend of recent years is also expected to continue, whereby the market electricity price experiences a trough at midday. This would act as a market-based incentive to build east-west-facing installations.

Businesses such as supermarkets do not always own the property they operate from. This can present a problem; if the property owner invests in a self-consumption installation, the electricity would have to be supplied to the supermarket operator, turning the property owner into an energy supplier. Depending on the circumstances, the property owner may be subject to the notification requirements stated in Section 5 of the Energy Management Act (EnWG) unless the installation is a customer installation as defined in Section 3, 24 a, b of the Energy Management Act (EnWG) or has been classified by the authorities as a closed distribution network in accordance with Section 110 of the Energy Management Act (EnWG). Examples of other relevant issues include whether and what duties are payable on the supplied electricity, what the notification and disclosure requirements are, and what needs to be included in the electricity supply contract.

Innovative business models – such as the sale of generated solar electricity to third parties, or rental models (e.g. partial rentals) for solar installations – are young business areas that will develop in the years to come. The regulatory framework will also certainly require some adjustment in order to encourage innovative business models like local electricity supply.

5.3. Social change

In the past, solar energy has enjoyed strong growth in Germany thanks to the Renewable Energy Sources Act (EEG). Germany leads the world with more than 32 GW of installed solar capacity and a mature solar market. The process was aided by government subsidies but also by a large number of innovations in the solar industry associated with falling installation costs. At present, the solar industry is embarking upon new business models that are able to grow without government subsidies, provided that "positive regulation" allows this to happen. In other words, provided that the government does not slam the brakes on by imposing excessive duties.

The stakeholders in the solar industry – solar panel manufacturers, distributors and installers – need to reposition themselves and make the most of this opportunity to succeed in the market. If self consumption is being used to refinance solar installations, individual advice, planning and implementation are necessary in order to align the products with the company's load curve, possibly including storage solutions, etc. It will no longer simply be a matter of generating as many kWh as possible and feeding it into the grid to maximize the feed-in tariff. The winners will be those who invest in an intelligent installation. The greater complexity opens up new and exciting development opportunities for innovative companies as well as creating skilled jobs for Germany.

Appendix 1: Assumptions and notes on the calculations

Modeling of the wholesale electricity price between 2014 and 2033

The modeling of the electricity price between 2013 and 2017 is based on the energate hourly price forward curve (HPFC). For 2018, the arithmetic average of offers between June 1, 2013 and July 15, 2013 was calculated. For 2019 and 2033, the HPFC curve was calculated with an annual price increase of 5 percent. The other components of the electricity price were simulated on an annual basis.

Modeling of the EEG levy between 2014 and 2033

For the years from 2014 to 2017, the modeling of the EEG levy is based on the Agora Energiewende renewable energy levy calculator:

http://www.agora-energiewende.de/fileadmin/downloads/Software/AGORA-EEG-Calculator_mod_v1_3_3.xlsm

Between 2018 and 2033, the values were extrapolated using our own estimates and assumptions.

Calculation of the EEG levy for the individual segments (manufacturing, retail and heavy-duty) was based on Section 41 of the Renewable Energy Sources Act (EEG):

http://www.gesetze-im-internet.de/eeg_2009

- Retail: the share of gross value added taken up by electricity costs is less than 14 percent, so the full EEG levy is payable
- Manufacturing: gradual EEG levy
- Heavy-duty industry: the share of gross value added taken up by electricity costs is greater than 20 percent, resulting in a lower EEG levy of 0.05 cents/kWh.

KWK-G levy

The KWK-G levy (under the Combined Heat and Power Act) was modeled on the basis of our own estimates and expectations and assuming that the government's combined heat and power targets will be met.

The KWK-G levy was calculated for the individual segments on the basis of Section 11 of the Combined Heat and Power Act (KWK-G) and the "KWK-G 2014 supplement":

- Up to 100,000 kWh/year: standard tariff of 0.178 cents/kWh
- From 10,000 kWh/year: retail and manufacturing: 0.055 cents/kWh, heavy-duty industry: 0.025 cents/kWh

Electricity tax

The electricity tax was calculated for each segment on the basis of Sections 9 and 10 of the Electricity Tax Act (StromStG):

- Retail: 2.050 cents/kWh
- Manufacturing: 1.538 cents/kWh
- Heavy-duty industry: 0.205 cents/kWh

It is assumed that the electricity tax will stay the same for 20 years.

Special customer supplement as defined in Section 19 (2) of the Electricity Grid Charges Ordinance (StromNEV)

The special customer supplement was calculated for each segment on the basis of Section 19 (2) of the Electricity Grid Charges Ordinance (StromNEV):

- Retail: 0.187 cents/kWh
- Manufacturing: 0.05 cents/kWh
- Heavy-duty industry: 0.025 cents/kWh

Offshore liability levy

The calculation assumes that the offshore liability levy will remain payable until 2025.

It was calculated for each segment in accordance with Section 17 (f) of the Energy Management Act (EnWG):

- Retail: 0.250 cents/kWh
- Manufacturing: 0.05 cents/kWh
- Heavy-duty industry: 0.025 cents/kWh

Utility concession duties (Konzessionsabgabe)

Each segment is treated as a special contract customer in accordance with Section 2 (3) of the Concession Duties Ordinance (KAV):

- Retail: 0.110 cents/kWh
- Manufacturing: 0.110 cents/kWh
- Heavy-duty industry: 0.110 cents/kWh

It is assumed that the utility concession duties will stay the same for 20 years.

Grid charges

The grid charges were calculated on the basis of the average network costs for the different voltages and load profiles (the sum of the prices per kW and kWh). It is assumed that none of the exceptions set out in Section 19 of the Electricity Grid Charges Ordinance (StromNEV) are applicable:

- Retail: 3.731 cents/kWh, with an annual increase of 0.5 percent
- Manufacturing: 1.915 cents/kWh, with an annual increase of 0.5 percent
- Heavy-duty industry: 0.894 cents/kWh, with no increase

Installation size and self-consumption ratios (SCR)

Retail: 94.88 kWp, SCR: 81.25 percent

Manufacturing: 189.75 kWp, SCR: 99.61 percent

Heavy-duty industry: 189.75 kWp, SCR: 2.46 percent

Feed-in tariff

The feed-in tariff was calculated at 11.23 cents/kWh on the basis of the feed-in tariff of April 2014 with a monthly decrease of 1.4 percent.

Investment costs and depreciation

CAPEX: 1,200 EUR for 2013

OPEX: EUR 20 EUR / (age in years x kWp) for 2013

Depreciation: 0.5 percent / year

Conditions for raising capital

Equity ratio (ER): 35 percent

Debt ratio (BR): 65 percent

Interest rate on debt (rd): 4.25 percent

Long-term loans with fixed interest rate (rf): 2.75 percent

Return on capital (rm): 6.25 percent

Effective tax rate of company (t): 30 percent

Beta factor (ß): 0.97

Return on capital (rm): 9.00%

Cost of equity (re): 8.81%

Weighted average cost of capital (WACC): 5.03%

Appendix 2: Notes on the key financial metrics

Cash flow

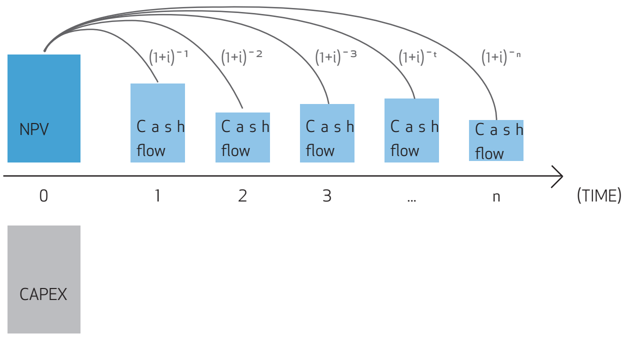
The cash flow is the movement of money in a specified period of time (e.g. per month or year; in our case, per year). The cash flow takes account of investments as well as operating costs (e.g. maintenance) and generated sales. When the purpose is to determine the profitability of a solar installation, the cash flow also considers the "avoided costs" such as savings in electricity costs. The cash flow is usually negative in the first year (when the investment is made), turning positive in subsequent years.

Net present value

This is the sum of the cash flow, which is discounted by the WACC. Because the installation sizes vary according to the segment, both the absolute net present value and the relative net present value are used, in EUR and EUR/kWp respectively.

Profitability of self-consumption

NPV FOR ELECTRICITY COSTS WITH SOLAR INSTALLATION VERSUS NPV FOR ELECTRICITY CONSUMPTION WITHOUT SOLAR INSTALLATION



Cost of capital

This is the cost incurred in obtaining the company's funds, and includes both equity and debt. The calculation uses the weighted average of the cost of each type of capital. In other words, the cost of debt is weighted with the debt ratio and the cost of equity is weighted with the equity ratio.

Internal rate of return (IRR)

The internal rate of return measures the profitability of an investment or a project as a percentage. The following applies if the investment is made in full in the first year and there is a positive cash flow in all subsequent years:

The IRR *x* percentage is the following interest rate: if the total amount is invested today at the fixed interest rate of *x*, the investor receives the same rate of return as for this project. To this extent, the IRR is the average annual return as a percentage.

Self-consumption ratio (SCR)

In the context of this study, the "self-consumption ratio" expresses the proportion of self-consumed electricity as a percentage of the total electricity generated by the solar installation. The limiting factors are the maximum hourly electricity consumption and the electricity purchase prices. Another relevant factor is the "self-sufficiency ratio" (sometimes also referred to as the self-consumption ratio), which is the proportion of self-consumed electricity as a percentage of the total electricity requirement.

Return on equity (EIRR)

Same as the IRR but only relating to the equity: a project has an IRR as above. If the installation operator is able to take on debt at an interest rate below the IRR, it is possible to increase the return on equity (leverage). Leverage also increases the risk on the equity because the interest on the debt must be paid whatever happens.

Payback period

The payback period is the period until the accumulated cash flow equals or exceeds 0 for the first time.

Notes

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