RENEWABLE ENERGY ‑ OPPORTUNITIES FOR PRODUCTION AND USE OF ELECTRICAL POWER FOR FARMERS UNDER CONDITIONS OF THE RENEWABLE ENERGY ACT IN GERMANY

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Abstract

In Germany, the production of electricity from Renewables is grant-aided by the government for different reasons. As a consequence of this expensive way of energy production the prices for energy have increased respectable in the last ten years. To become more independent from increasing energy prices, this paper examines the opportunity for a farmer with feeder piglet production in Germany to use the energy from his own photovoltaic systems (PV). Therefore data from an exemplary farm were collected and in an economic model the quantities and costs for electrical supply were calculated regarding production, consumption, storage, and load management. In summary, farmers could reduce costs for the energy supply, if they used the energy directly without installing a storage system. Due to currently high costs for batteries an electrical storage system is still too expensive. Further it would be an opportunity to increase the rate of self-sufficiency and the rate of own consumption using load shifting. That means, farmers should use power consuming equipment, like for example a grist mill, which are flexible in their times of use, in the times of a high electricity production of the PV-plant.

Keywords: Renewable Energies, Renewable Energy Act, Production and Usage and Storage of Solar Energy, 'Prosumer', load shifting

1. Introduction

Worldwide limited resources of fossil fuels and the threat of global climate change due to global warming caused by rising greenhouse gases, such as carbon dioxide, require increased use of renewable energies. Further the government in Germany decided the closure of nuclear power plants after the catastrophe of Fukushima, Japan in 2011. Instead of nuclear power plants Germany needs substitutes for the energy production.

For more than a decade in Germany, the renewable energies from wind, solar and biogas etc., have been promoted by for example a minimum remuneration for renewable electricity (Germany's Renewable Energy Act (EEG), 2004). The reallocation of this "renewable energy fee" comes from the electricity power customers, currently amounting to 6.24 €-cents/kWh [2], which considerably increased electricity prices. The electricity prices for German consumers are relatively high compared to those in other European countries (Figure 1).

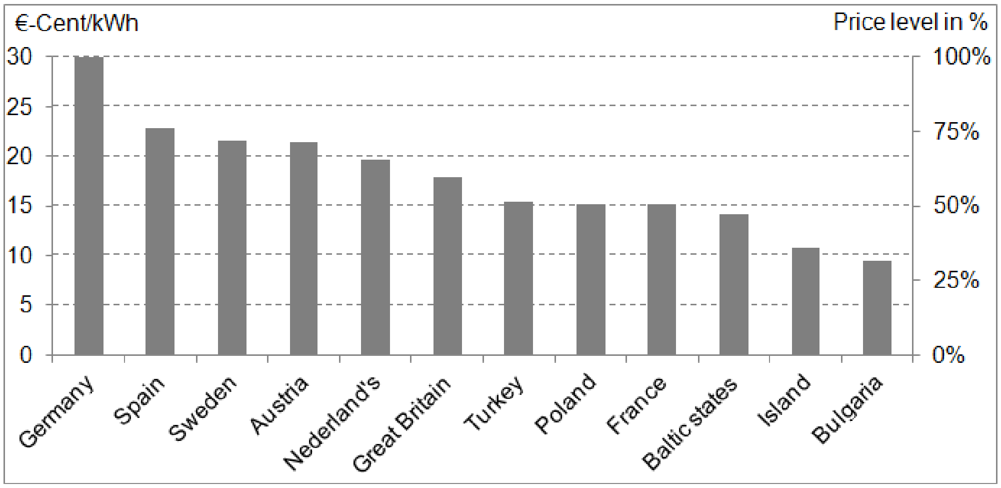

Figure 1: Average electricity prices for private households in selected European countries in €-Cent/kWh (1. half of 2013); Source: Anondi GmbH Website (Last accessed 03/09/2015)

This paper will focus only on electrical power production and use, not mentioning the renewable heat section. In short the tendencies are the following: The production of renewable electrical power has increased enormously over the last decade, therefore on some sunny and windy days the electrical power production from wind and photovoltaic power plants is sufficient to provide the entire German country with electrical power. Due to increasing mass production of photovoltaic cells, investment costs decreased [3]. To avoid overcompensation the renewable energy act was adopted in 2004, 2009, 2012, and lately in 2014 with the announcement of further reduction of the minimum remuneration price for renewable electricity.

Farmers participated a lot in the development of Renewables. The roofs of agricultural buildings are predestined for installation of photovoltaic systems (PV) and large energy-consuming operations like feeder pig production offer the opportunity of self-consumption of cheaper self-produced electricity. So for example the farmers are able to become independent from increasing commodity prices. Using renewable electrical power from PV implies that usually the electricity cannot be stored to cover demand during peak demand periods or during the night. Therefore in addition to own electrical power production the purchase of electricity has to be considered. To increase the own consumption two measures are possible, first the use of flexible power consumers like grist mills or agitators and liquid manure pumps could be moved in time periods with sunshine, and second, batteries could store excess energy.

For the example of a hog farm with 500 sows for feeder piglet production the costs of electrical power is calculated considering different scenarios from purchasing 100% of used electricity to the production of renewable electrical power with PV systems to shifting operation of electrical devices according to the PV production to storage of excess energy using batteries. The time horizon for the simulations should cover the period after the EEG, when these distortions are overcome.

This paper shows if a pig breeder could reduce his electricity costs by using his own produced electricity and installing storage capacities. As a reference situation the calculation shows the current situation of the farmer. The calculations are based on the current prices the farmer gets for his produced energy or pays for his demand. The calculations considered no price changes for possible changes in EEG in the future.

2. Proceeding

For the calculations data from an exemplary farm which installed a PV-system with 87 kWp in 2012 on the roof of the sow stable was collected. In 2012 the costs for PV cells were around 1751 €/kWp [3]. The farmer is using his self-produced electricity from this PV-plant and sells the overproduction to an external energy supplier for an average price of 14,50 ct/kWh [7] (so in reference the prices for selling electricity out of EEG 2012 are used). The farmer has to buy his energy for 24,00 ct/kWh [6] during the periods of insufficient PV production. In Germany, the consumers have to pay different fees in For the calculations data from an exemplary farm which installed a PV-system with 87 kWp in 2012 on the roof of the sow stable was collected. In 2012 the costs for PV cells were around 1751 €/kWp [3]. The farmer is using his self-produced electricity from this PV-plant and sells the overproduction to an external energy supplier for an average price of 14,50 ct/kWh [7] (so in reference the prices for selling electricity out of EEG 2012 are used). The farmer has to buy his energy for 24,00 ct/kWh [6] during the periods of insufficient PV production. In Germany, the consumers have to pay different fees in addition to the price for energy supply (for example EEG apportionment and tax on electricity [2]).

The farmer has 500 sows for feeder piglet production. As mentioned above, there is a grist mill with a rated power of 12 kW, which can be used according to the PV production, since it has no fixed time period for milling. The only constraint is that the filling level of the associated storage silo has to be kept above 25%. There are also non-shiftable electrical consumers such as lighting, electrical heating of piglet nests, or the ventilation system. The latter has a high demand during the summer months and needs less energy during the colder times [4].

The developed decision based method uses input data for PV-production for the year 2014 with a simulation period of 15 minutes, all together a time series with 35.040 observations. If there is excess energy after the demand of immovable consumers was covered, the variable consumer could start in each simulation step provided that the produced or stored energy in this 15 minutes would satisfy the needs of the - in this case - grist mill. For the different consumers there are different energy needs [5]. For example the ventilation system needs 84 kWh per year per animal.

This paper considers the following scenarios:

a) Case 1: The first reference scenario shows how high the imputed costs would be if the farmer had no photovoltaic plant and no storage system. He has to buy all energy from an energy supplier.

b) Case 2: The second reference scenario shows the imputed costs in case of installation of a photovoltaic plant. The farmer is acting as a “prosumer” – that means, he becomes an energy producer and an energy user at the same time. The farmer sells all produced energy and buys all energy he needs from an external energy supplier.

c) Case 3: The farmer is able to use electricity from the PV-plant directly in the moment of production. During periods of insufficient production he has to buy the additional energy. In the case of overproduction the farmer could sell the energy. The case 3a shows all imputed figures regarding load shifting.

d) Case 4: Additional to directly using the produced energy the farmer has the opportunity to install a storage system (in this considerations a lead acid battery) and to increase his proportion of own consumption. Therefore this paper considers different storage capacities and compares the related costs.

In all cases the rate of self-sufficiency and the rate of the own consumption will be calculated. The rate of self-sufficiency shows the proportion between own produced energy used directly and the total energy used.

The rate of the own consumption shows the proportion between the produced PV-electricity and the direct used energy.

3. Results

As mentioned above we compared different cases regarding the PV-production, self-consumption and storage of self-produced energy for a farm with 500 sows for feeder piglet production.

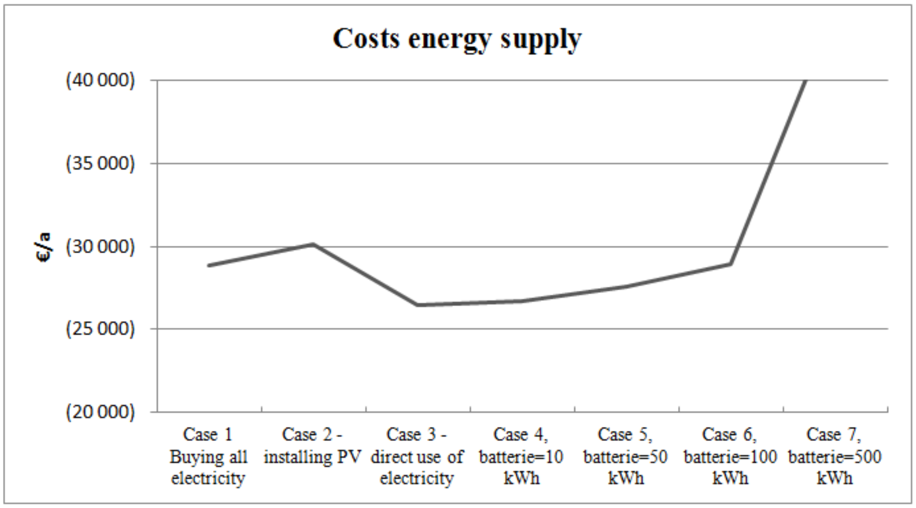

Figure 2: Costs for energy supply in different cases/scenarios; Source: Own calculations

In case 1 the costs for electricity for the farmer is 28.820 €/year. As figure 2 shows the lowest costs are the ones shown in case 3. For the famer it is the most profitable way to install a PV-plant and use the energy directly in his stable. The installation of a storage system would be an unnecessary expense, because the costs increase by minimum 7% in the next step (for installing a battery with 10 kWh). In this case the rate of own consumption is 47% and the rate of self-sufficiency is 32%. If the farmer used shiftable loads in times when the sun is shining, he could increase both up to 49% and 33% (see table 2). But if the farmer did load shifting and build a storage system with a capacity of 10 kWh, he would have the same costs for his energy supply as without load shifting.

Table 1: Comparison between Case 3 and Case 4 – with and without load shifting; Source: Own calculations

	without load shifting	with load shifting
	Case 3 - without battery	Case 4 - with 10 kWh battery
Costs energy supply	- 26.476,05	- 26.427,57
Own Consumption in kWh	38.327,52	43.893,09
rate of own consumption	47%	54%
rate of self-sufficiency	32%	37%

As table 1 shows in this case it would make sense to install a battery of 10 kWh to increase the rate of own consumption and self-sufficiency to become more independent from rising electricity prices.

The uses of flexible consumers are profitable in every case because costs of own use are less than buying electricity. It is possible to increase the direct consumption without installing a storage system and so the farmer could note less costs for his energy supply, if he used his flexible consumers in times of sunshine.

Table 2: Costs and amount of energy in different cases with load shifting; Source: Own calculations

	Case 3 a	Case 4	Case 5	Case 6	Case 7
Costs energy supply	- 26.207,29	- 26.427,57	- 27.416,03	- 28.775,60	- 44.375,75
Profit selling energy in €	5.643,80	5.225,04	3.875,75	2.471,42	753,64
Costs buying energy in €	- 18.741,50	- 18.132,33	- 16.128,78	- 14.030,62	- 11.485,78
Internal Consumption in kWh	39.332,52	43.893,09	52.327,61	61.042,90	72.051,58
Purchase in kWh	- 78.089,57	- 75.551,38	- 67.203,25	- 58.460,90	- 47.857,40
Costs PV-Installation per year in €	- 13.073,78	- 13.073,78	- 13.073,78	- 13.073,78	- 13.073,78
rate of own consumption with load shifting	49%	54%	65%	75%	89%
rate of self-sufficiency with load shifting	33%	37%	44%	51%	60%

As table 2 shows with doing load shifting still Case 3a is the best alternative with fewest costs. So in comparison for the farmer it would be the best way to install a PV-plant, use his flexible power consuming equipment mainly in times of sunshine and use the energy from the PV-plant directly without investing in a battery.

For the calculation in this paper the times series of 2014 were used. As mentioned above, as a flexible consumer the grist mill was considered. It has got a connected load of 12 kW. The conditions of using the grist mill are explained in chapter 2 (page 5 of 10). If there was no load management, the grist mill would only start to work when its level is under 25%. This would be the case mainly two times a week. If the farmer used the grain mill in times when the PV-plant is producing at least the amount of energy the mill needs in this 15 minutes, the flexible consumer would work more often, but not over such long periods. This happens because the mill even starts to work when the level is over 25%, but fewer than 60%. As figure 3 shows the grist mill mainly starts to work in times of PV-production (except the level would be under 25%). Once the grist mill has started to work, is has to be filled up to a level of 100%.

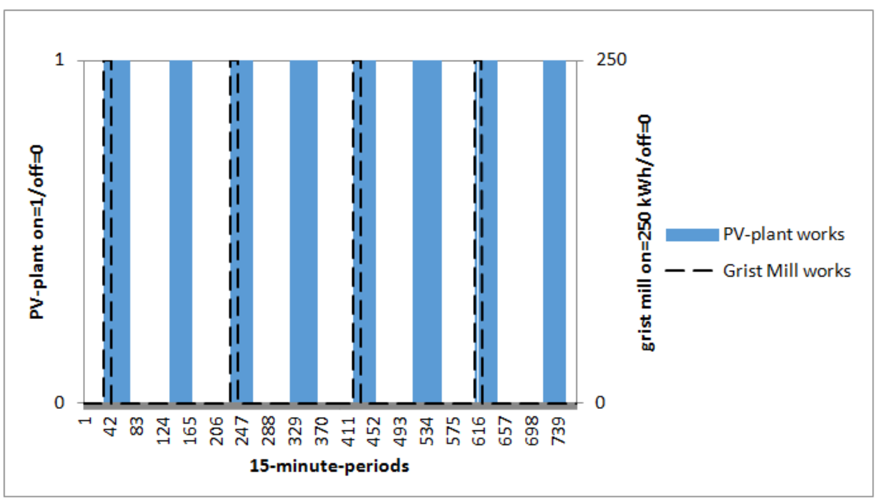

Figure 3: One week in 2014: 08.-15. May 2015 shows times of sunshine and periods the flexible consumer works; Source: Own calculations

For the installation in a storage system with lead acid batteries we calculated 265 €/kWh [1]. To calculate the break-even of the price for batteries it was set to 0 €. If the intention of the farmer was for example to reach a rate of self-sufficiency at least of 50 %, he would need a battery with a capacity of 100kWh. If there were no costs for the battery, he would have lower costs for his energy supply of 1,539 €/year compared with the reference situation in Case 3 (see table 2).

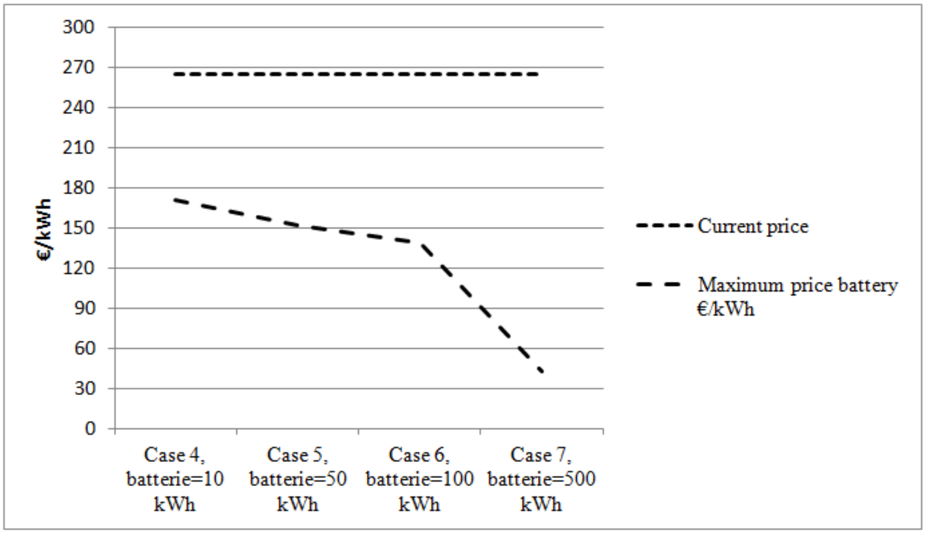

Figure 4: Difference between current costs for a lead acid battery and maximal affordable costs; Source: Own calculations

If the battery worked up to nine years [1], the farmer paid 138 €/kWh at most for this lead acid battery. Figure 4 shows: The more capacity the battery has the less the farmer could pay per kWh. [1] predicts a price for lead acid batteries in 2020 of 240 €/kWh. So it can be determined that the installation of a battery would not become profitable in the next five years.

4. Conclusion

In conclusion, the installation of a storage system of a farm with 500 sows for feeder piglet production would only make sense if the farmer had the opportunity to use flexible loads in times when the sun is shining and increased his rate of self-sufficiency and rate of own consumption. Nevertheless, the current prices for lead acid batteries are too high to reduce the costs of energy supply if batteries have a capacity bigger than 10 kWh.

The recommendation in the current situation is that the farmer should only use energy from his PV-plant directly without storage. He would pay less for his energy supply and would become a little more independent from increasing energy costs. If the prices for batteries became cheaper, he could install a storage system later.

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This calculations and this proceeding were developed within the project „Effiziente Nutzung erneuerbarer Energien durch regionale ressourcenoptimierte, intelligente‘ Versorgungs- und Verbrauchsnetze (Smart Microgrids)“ founded by the federal ministry of Education and Research (FKZ: 03ED3524 B,C and D).