TECHNISCHE UNIVERSITÄT WIEN

Energy Economics Group

Institute of Energy Systems and Electrical Drives
Energy Economics Group (EEG)

VU Selected Topic in Energy Economics and Environment

28.10.2024

Homework 2

Submission date: 11.11.2024 13:00

Profitability of a single PV system; Decline of revenues of a distribution system grid due to increased PV self-generation

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In the following, the profitability of a PV system over the entire technical service life of 25 years is examined. The costs of pure electricity purchase (electricity supply contract and grid tariff) are to be used as a comparison. The following data are to be used as a basis for the profitability calculation.

1. Data of the PV system:

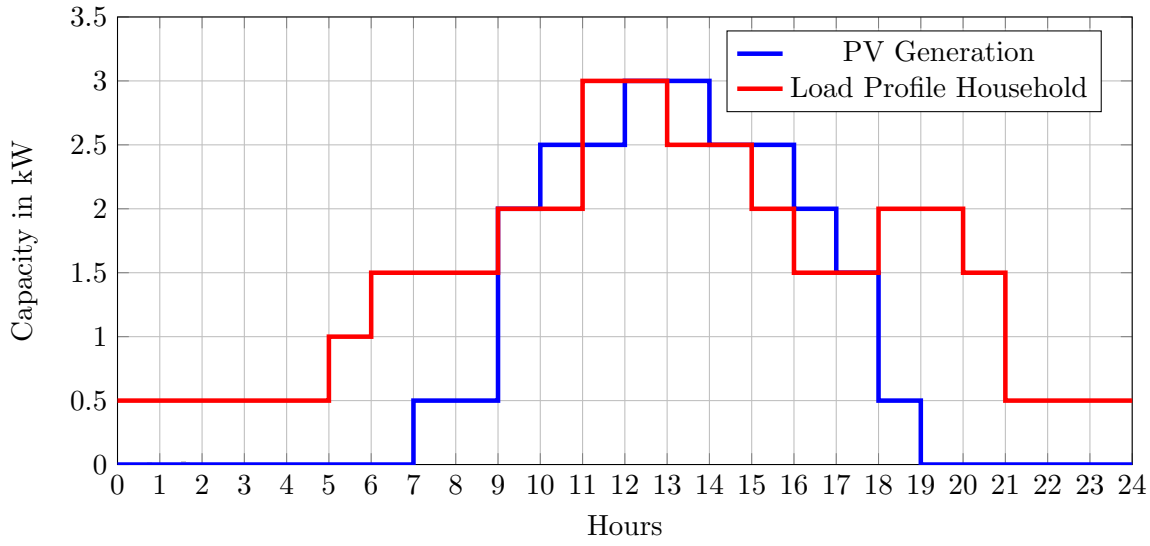
- Installed capacity: 3 kWp
- Specific investment cost: 800 EUR/kWp
- Technical lifetime: 25 Years
- Degradation (efficiency losses) of the PV panels can be neglected

2. Electricity purchase (electricity supply contract and grid tariff) is composed as follows:

- Electricity supply contract: 20 cent/kWh
- Grid tariff: 100 EUR annual fixed grid tariff component, 5 cent/kWh variable grid tariff component

3. Remuneration of sales for surplus electricity fed into the grid: 10 cent/kWh.

Daily profiles below (household load profile, PV generation profile) represent an average day of the year (for simplicity, no seasonal effects are assumed). For annual considerations of the calculations below, assume that the year can be represented by 365 average daily profiles.



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a) Assuming the investment and operation of the PV system in accordance with the data and parameters specified above, carry out a profitability analysis using the Net Present Value (NPV) method

$$NPV = -I - \sum_{t=1}^{T} \frac{P_t}{(1+i)^t} + \sum_{t=1}^{T} \frac{R_t}{(1+i)^t}$$

with the investment I, interest rate i, payments A_t, revenues E_t and the time period t. The annuity factor respectively its reciprocal value (annuity present value factor) can be found in the following table:

		Kalkulationszinssatz									
		0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.1
Laufzeit	1	1.010	1.020	1.030	1.040	1.050	1.060	1.070	1.080	1.090	1.100
	2	0.508	0.515	0.523	0.530	0.538	0.545	0.553	0.561	0.568	0.576
	3	0.340	0.347	0.354	0.360	0.367	0.374	0.381	0.388	0.395	0.402
	4	0.256	0.263	0.269	0.275	0.282	0.289	0.295	0.302	0.309	0.315
	5	0.206	0.212	0.218	0.225	0.231	0.237	0.244	0.250	0.257	0.264
	6	0.173	0.179	0.185	0.191	0.197	0.203	0.210	0.216	0.223	0.230
	7	0.149	0.155	0.161	0.167	0.173	0.179	0.186	0.192	0.199	0.205
	8	0.131	0.137	0.142	0.149	0.155	0.161	0.167	0.174	0.181	0.187
	9	0.117	0.123	0.128	0.134	0.141	0.147	0.153	0.160	0.167	0.174
	10	0.106	0.111	0.117	0.123	0.130	0.136	0.142	0.149	0.156	0.163
	11	0.096	0.102	0.108	0.114	0.120	0.127	0.133	0.140	0.147	0.154
	12	0.089	0.095	0.100	0.107	0.113	0.119	0.126	0.133	0.140	0.147
	13	0.082	0.088	0.094	0.100	0.106	0.113	0.120	0.127	0.134	0.141
	14	0.077	0.083	0.089	0.095	0.101	0.108	0.114	0.121	0.128	0.136
	15	0.072	0.078	0.084	0.090	0.096	0.103	0.110	0.117	0.124	0.131
	16	0.068	0.074	0.080	0.086	0.092	0.099	0.106	0.113	0.120	0.128
	17	0.064	0.070	0.076	0.082	0.089	0.095	0.102	0.110	0.117	0.125
	18	0.061	0.067	0.073	0.079	0.086	0.092	0.099	0.107	0.114	0.122
	19	0.058	0.064	0.070	0.076	0.083	0.090	0.097	0.104	0.112	0.120
	20	0.055	0.061	0.067	0.074	0.080	0.087	0.094	0.102	0.110	0.117
	21	0.053	0.059	0.065	0.071	0.078	0.085	0.092	0.100	0.108	0.116
	22	0.051	0.057	0.063	0.069	0.076	0.083	0.090	0.098	0.106	0.114
	23	0.049	0.055	0.061	0.067	0.074	0.081	0.089	0.096	0.104	0.113
	24	0.047	0.053	0.059	0.066	0.072	0.080	0.087	0.095	0.103	0.111
	25	0.045	0.051	0.057	0.064	0.070	0.078	0.086	0.094	0.102	0.110

Please answer the following questions:

- What is the Net Present Value (NPV) over the entire technical life time of the PV system? (25 years, 5% interest rate)?
- What NPV would result over 25 years from pure electricity purchase at an interest rate of 5
- What is the NPV over the technical life time of the PV system if there is no remuneration at all for the surplus feed-in to the grid?
- Compare the options: (i) Does investing in a PV system make economic sense from the household point-of-view? (ii) How does profitability change if there is no remuneration for surplus electricity fed into the grid?

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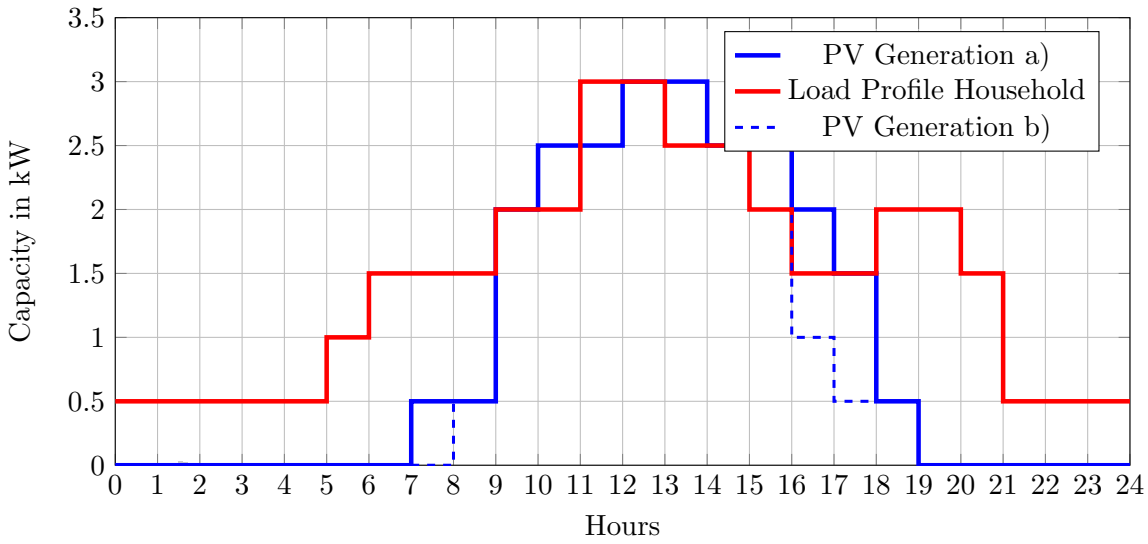
b) Based on the original situation under question a), the following changed situation now arises. On the neighboring property, a property developer is building a larger building, which leads to partial shading of the PV system between 7 a.m. and 8 a.m. (reduction of PV power by 0.5 kW) and 4-6 p.m. (reduction of PV power by 0.5 kW) according to the following figure. The building authority only approves the construction of the residential developer's building on the condition that the PV system operator on the neighboring property must exit cost-neutrally due to the partial shading caused. Therefore, the question arises: What financial compensation does the property developer have to give the PV system operator so that the PV system operator is held harmless over the entire technical life of the PV system of 25 years?



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c) Now assume that a distribution grid operator has 1,000 PV system operators in its distribution grid as described in point a). Due to its own generation with the PV systems of household customers, the distribution grid operator distributes less electricity and thus achieves lower revenues compared to the original situation, where none of the household customers had a PV system yet. Surplus feed-in is not taken into account here.

What is the decline in revenues of the distribution grid operator for 1,000 households with PV systems?

Furthermore, if it is assumed that this loss of revenue of the distribution grid operator is fully compensated by an increase in the fixed cost component in the grid tariff of all household customers (i.e. both those with and without a PV system):

By what amount must the fixed cost component of the grid tariff per household customer be increased if it is assumed that the distribution grid operator supplies a total of 10,000 household customers?

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d) Now the situation shown in the following figure occurs on 10 days a year (the remaining days of the year the situation from a)). Due to the amount of PV systems in the distribution grid, this has a negative impact on the operation of the distribution grid. Therefore, a penalty of by 5 EUR/kWh for grid feed-ins will be introduced if it is by 2.0 kW or more. This is intended to promote grid-friendly behavior (keyword: load-shifting).

How does this change the profitability of the PV system for a household over the entire life time? Discuss qualitatively what measures can be taken by the household to counteract the penalties?