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THE ECONOMICS OF SMALL DECENTRALIZED PV-SYSTEMS

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CONTENT

1. ABSTRACT

The aim of this work is to expand on the different economic conditions in Czech Republic and Austria regarding the usage of small-scale decentralized PV systems with nominal power of less than 10kWp.

The pros and cons of different types of installations, like using of batteries or not, connection to the grid or not will be taken into account.

The usage of this technology seems be helpful to fulfil the Paris agreement and increase of the amount of renewable energy in the energy mix.

2. COMPARATION OF SOLAR CONDITIONS IN CZECH REPUBLIC AND AUSTRIA

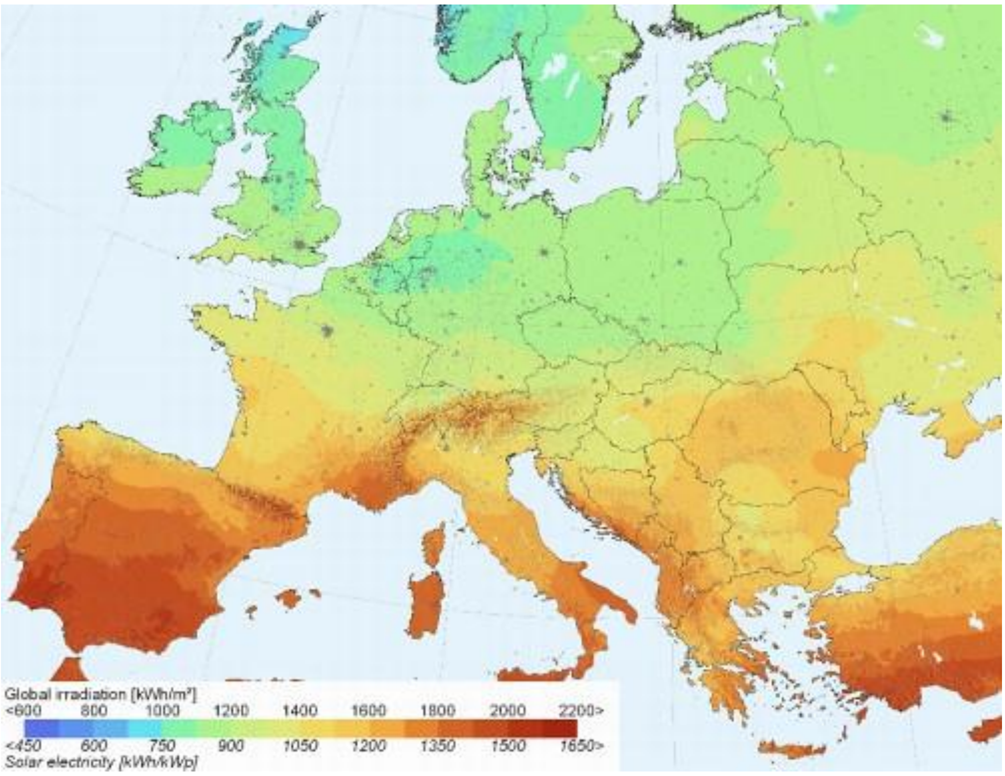

Figure 1 [1]

If we'll look on a Global irradiation map above, we can clearly see that conditions for solar systems in Czech Republic are worse than in Austria. Basically, best conditions in Czech Republic are the worst in Austria. But the solar irradiance isn't the only thing which decide success rate of solar systems in the country. So far solar systems especially the small ones need for economical function some form of government subsidies. That is why we are going to compare subsidies in Czech Republic and Austria.

3. SUBSIDIES IN CZECH REPUBLIC

In Czech Republic since 2013 works program which is called Nová zelená úsporám. Thru this program support government chosen types of small solar systems. Table with subsidies is below.

Type of system	Subsidy Kč
Solar termic system for preparation of hot water	35 000
Solar termic system for preparation of hot water and additional heating	50 000
Photovoltaic system for preparation of hot water with direct heating	35 000
Photovoltaic system without accumulation of electric energy and with thermal use of surpluses and total usable amount of electric energy ≥ 1700 kWh/year	55 000
Photovoltaic system with accumulation of electric energy and with thermal use of surpluses and total usable amount of electric energy ≥ 1700 kWh/year	70 000
Photovoltaic system with accumulation of electric energy and with thermal use of surpluses and total usable amount of electric energy ≥ 3000 kWh/year	100 000
Photovoltaic system with accumulation of electric energy and with thermal use of surpluses and total usable amount of electric energy ≥ 4000 kWh/year	150 000

Table 1

Additional rules for getting a subsidy are that is needed to consume 70 % of generated electricity right in the place of generation and the subsidy can cover only 50 % of all expenses. It is also possible to get additional 5000 Kč subsidy for preparation of documentation and administrative stuff.

4. TERMS OF DISTRIBUTORS COMPANIES IN CZECH REPUBLIC

One of the disadvantages of PV systems is that it don´t generate electricity continuously.

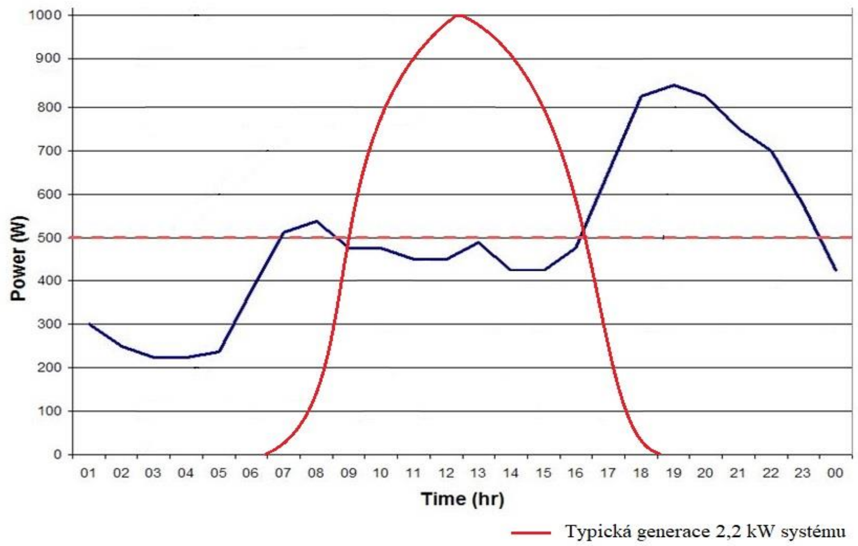

Figure 2

As you can see from the model graph, the maximum generation takes place between 11 am and 1 pm. Of course, this distribution is dependent on the season, weather and customer behaviour, as will be shown in the following chapters. For this case without accumulation, about 50% of the generated energy would flow into the distribution network, for which the PV system operator receives the price agreed with his distributor. Conditions for different distributors are different between countries.

Czech Republic

In Czech Republic there are 3 main distributors. In Prague and surroundings company PRE a.s. In south Bohemia and Moravia company E.ON a.s. and in the rest of the republic ČEZ a.s. There are no fees charged to the network in the capital city of Prague, but the purchase price is zero, so it can be said that the operator of the PVP donates this energy to the system. ČEZ offers 40% of the price of electricity as part of the agreed tariff in the “Electricity for Solar” program, and E.ON provides a virtual battery service that I will discuss later.

In general, it could be said that price which owner of small photovoltaic system will get for electricity send to the system is quite negligible. That is why the most economic way of operation PV system is to use maximum amount of generated electricity directly in the house where is PV system build. But that assumes some kind of accumulation system. According type and size of accumulation system will be different cost of the system. In the next chapter I´ll do Czech market research to determine input costs for PV system in Czech Republic.

5. OFFER OF SMALL PV SYSTEMS ON CZECH MARKET

On the beginning it is necessary to decide whether I will design a self-built system or choose a turnkey solution. Given that to obtain the Nová zelená úsporám subsidy, it is necessary to provide project documentation, the building's energy assessment, expert opinion, cover sheet of technical parameters, audit report and execution of the network connection agreement with the distributor. Unfortunately it is possible to receive a subsidy only after completion of the construction and any failure to deliver any of the documents or noncompliance with the energy specifications could lead to the rejection of the subsidy application. Which would make the system almost twice as expensive in most cases. In view of these facts, I will not consider this work by myself and all the solutions mentioned will be turnkey. In the following tables I will give a brief overview of suppliers on the Czech market. Although the complete table of these companies does not exist, I have found more than 50 of them by simply searching the Internet. The following tables offer the largest companies on the Czech market.

The first is a table with systems with hot water accumulation. To these systems it is necessary to install a boiler, which in most cases is not part of the offered system. Since most of the customers in question for these PV plants do not have a sufficient hot water tank installed, I was counting on the purchase of a new electric hot water heater from ELIZ together with the acquisition of PVP [2].

Suppliers of PV systems	Installed Power	Capacity of boiler	Price of boiler without VAT	Total price without VAT	Total price with VAT	Total price calculated on one kWp
	kWp	l	Kč	Kč	Kč	Kč/kWp
www.termsenergy.cz	2.1	200	10 271	118 880	137 328	65 394
www.termsenergy.cz	3.12	300	14 167	150 448	173 865	55 726
www.iqenergy.cz	1.62	160	6 508	83 503	96 419	59 518
www.iqenergy.cz	2.16	200	10 271	109 016	125 985	58 326
www.iqenergy.cz	3.24	300	14 167	138 040	159 596	49 258
www.elektroma.cz	2.16	200	10 271	106 775	123 408	57 133
www.elektroma.cz	2.5	200	10 271	115 271	133 178	53 271
www.elektroma.cz	3	300	14 167	134 158	155 132	51 711
www.sollaris.cz	1.5	160	6 508	78 261	90 390	60 260
www.sollaris.cz	2	200	10 271	93 913	108 616	54 308

Table 2

These prices are without subsidy which is currently 35 000 CZK plus 5000 CZK for documentation, if it is a direct PV system with hot water heating and 55 000 CZK plus 5000 CZK, if there is an inverter in the system and I only store surpluses in water. For comparability of different system sizes I converted prices to 1 kWp. As can be seen in the larger systems, it is possible to get the price even below 50 000 CZK / kWp. After including the subsidy, the prices are around CZK 34,000 / kWp. However the main question is selection of the system size, because the usability of such a quantity of hot water (160 litre) needs to be considered.

Next I compared the offer of systems supplied with a physical battery.

Suppliers of PV systems	Installed Power	Capacity of battery	Total price without VAT	Total price with VAT
	kWp	kWh	Kč	Kč
ČEZ a.s. (Battery Box)	4.41	7.2	252 058	304 990
ČEZ a.s.	3.12	4	303 205	348 686
ČEZ a.s.	2.6	4	218 407	251 168
ČEZ a.s.	5.2	7.5	459 655	528 603
www.elektrinazeslunce.cz	3.575	4.8	227 082	261 144
www.elektrinazeslunce.cz	4.95	7.2	420 310	483 357
www.s-power.cz	1.89	2.4	147 826	170 000
www.sollaris.cz	3.12	7.2	299 703	344 659
www.sollaris.cz	3.64	7.2	315 652	363 000
www.sollaris.cz	4	7.2	339 977	390 973
www.sollaris.cz	6.5	11.6	473 838	544 914
www.neosolar.cz	1.71	6	102 438	123 950
www.neosolar.cz	2.52	6.8	183 174	210 650
www.neosolar.cz	3.36	6.8	215 739	248 100
www.iqenergy.cz	2.43	4.32	162 250	186 588
www.iqenergy.cz	2.7	5.04	170 777	196 394
www.iqenergy.cz	3.24	4.8	223 998	257 598

www.iqenergy.cz	3.78	6	317 443	365 059
www.iqenergy.cz	5.4	7.5	369 916	425 403
EON a.s.	3	4.5	340 870	392 000
EON a.s.	5	7.5	426 087	490 000

Table 3

These prices are again without subsidy, which in this case is 75 000 or 105 000 CZK. If, as in the previous case, I recalculated the systems to a price of 1 kWp, I would get to the number of about 90 000 CZK, but since in this case the capacity of battery is different between considered systems it cannot be compared as in systems with accumulation in water.

Quite interesting is the offer from ČEZ, which in a limited series offers a 4.41 kWp system with a smart Battery box for the first 100 customers at a price of CZK 199,990 minus subsidies [3]. Compared to other offers of similar systems, it is definitely the cheapest and shows where the Czech solar system market may move in the near future.

6. Economical calculation for small photovoltaic systems in Czech Republic

As I mentioned before there is a big problem in disproportion between times of generation PV system and time of consumption of a consumer. That's why some kind of storage system is needed. But for determination of size of that storage system we need to know how the graph of consumption will look not only thru the day but also thru the whole year. Because consumption in summer and in winter will look really differently.

In Czech Republic operator of the market provides typical daily diagrams of consumption TDD in Czech so for calculation of economical effectivity I´ll use these diagrams. Difference between typical diagram and real diagram from one random day in a year is on next graph.

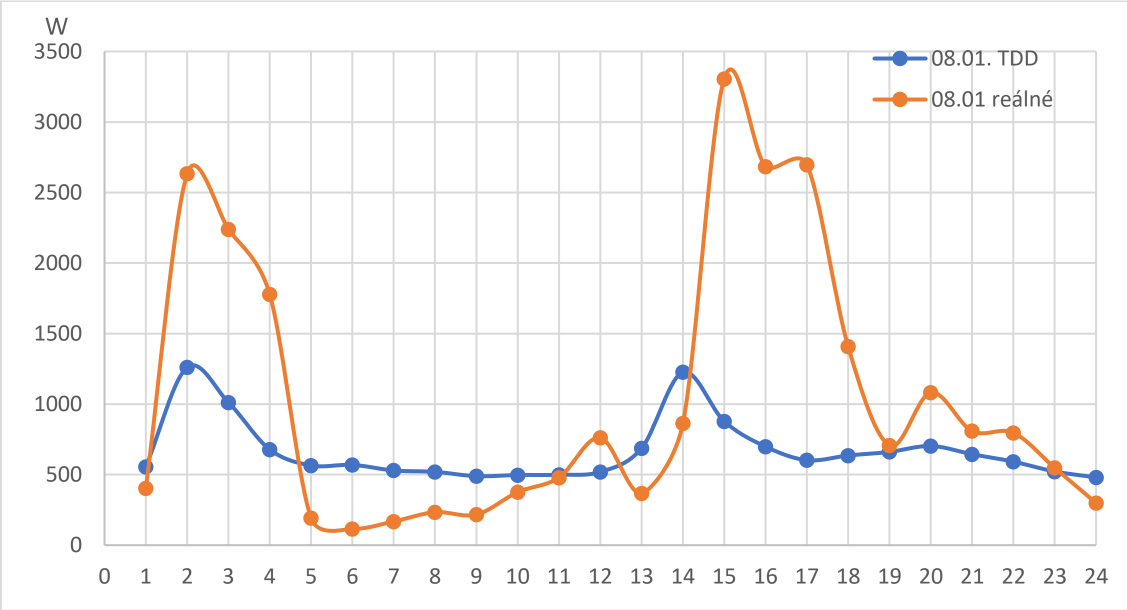

Figure 3

As it visible from this graph TDD are typically smoother and the pikes aren´t that big as in case of real data. Also baseload of TDD is higher than in case of real data. Both of these facts talks in favour of design of small PV systems.

General calculation assumptions

I will count the system life time for 20 years, but the components will not work for 20 years with the same efficiency. That is why I decreased the annual generation of PV panels by 0.07% per year. In addition, I will assume the replacement of the inverter and batteries after the system's half-life. Since I have no idea how much the batteries and the inverters will cost in 10 years I will consider changing them at their current price. Especially the batteries could be cheaper in the future, but if I include the inflation effect and I think that with sufficient price reduction the demand for batteries will rise so much that there will be a lack of cobalt needed for Li-On batteries, and the price will rise again. The assumption of the same purchase price is a fairly suitable alternative to avoid speculation and potential errors arising therefrom.

The PV power plant also has an annual operating cost. There are PV power planes owners who wash the panels, and then this work can be counted as an expense, but according to various studies, the impact of pollution on PV module production is not noticeable [4]. Another cost a PV system can have is insurance. After all, it is a system worth hundreds of thousands of crowns. Annual insurance is very individual. It will depend on the size of the system, location and type of insurance that I will want (against fire, explosion, lightning strike, aircraft crash, storm, hail, earthquake, tree fall, etc. In general, however, the practice in the Czech Republic is that it does not insure FV system directly, but the house insurance is increased by the PVP price. The PVP insurance itself is then issued in hundreds of crowns per year [5]. Once every few years, it will also be necessary to inspect the system by an inspection technician, repair the structure on which the system is built, or replace faulty solar panels.

For these reasons, I will count the annual operating costs of 1000 CZK.

To determine the most economically advantageous option, I will use the Net Present Value (NPV) calculation.

$$NPV = \sum_0^t \frac{CF_t}{(1+i)^t} \quad \textbf{(1)}$$

However, this method considers a discount or a price for money. Since I design a system for an ordinary customer and not a company, the discount will be in the range of 2% (which is approximately the inflation level) up to 4%.

Due to the fact that the system is purchased by a regular customer, all prices will be calculated with VAT. If I would calculate PV system for the company, I would have to deduct VAT from the prices. Furthermore, I would have to reckon with depreciation that I do not consider in the household.

Total customer consumption has changed little over the years. Although more and more electrical appliances are being used, on the other hand, these appliances are becoming more and more efficient, so I am not counting the increase in consumption between years.

It is clear that even with some energy storage system I won´t use 100 % of generated electricity. So I have to calculate on the beginning the coefficient of total usable amount of electricity for every type of system. For this calculation I´ll use special software DEKSOFT FVE, where I will set the TDD consumption profile. But because TDD is only an assumption I´ll calculate with several variants of total consumption coefficient and the calculated value I´ll use only as a starting point.

The last assumption, significantly affecting the result of the calculation, will be an increase in the price of electricity. Over the past few years, electricity price growth has been quite dramatic, with stock prices rising almost 100% over the next two years [3], but this is not a long-term sustainability, and I am primarily interested in end prices for customers, not stock prices. Therefore, I will set a linear increase in electricity prices to start at 3% per year (slightly above current inflation level).

Speciality in Czech tariff structure

In Czech Republic there exist two tariff stricture which means that a customer when fulfil certain conditions can have a tariff rate with two different distribution fees during a day. As an example, I´ll explain the most common two tariff rate in Czech Republic

Rate D 25d

Two-tariff rate with operative management of low rate for at least 8 hours. However, a distributor will decide when will be which tariff. Distributor may divide the duration of low tariff and high tariff up to three intervals, none of which will be less than one hour. A necessary condition for obtaining this tariff is that an electric storage appliance for heating the building or an electric storage appliance for domestic water heating must be installed at the place of consumption. In addition, the distributor may block the use of these storage appliances during the high tariff period. [6]

Tariff Rate D 25d			
Price for 1 MWh in Kč	E.ON	ČEZ	PRE
High tariff	5388,65	4994,55	4767,97
Low tariff	2301,20	2244,91	2126,83

Table 4

As it visible the distribution fee in duration of Low tariff is more than two times cheaper. But distribution fee isn't the only one which customer has to pay except fee for electricity.

7. Tariff structure in Czech Republic

As first I´ll show distribution of payments for customer with two tariff structure D 25d. According real bill which I was able to get from random house this customer will pay in my case 16 554 Kč per year for 4,51 MWh taken from the grid.

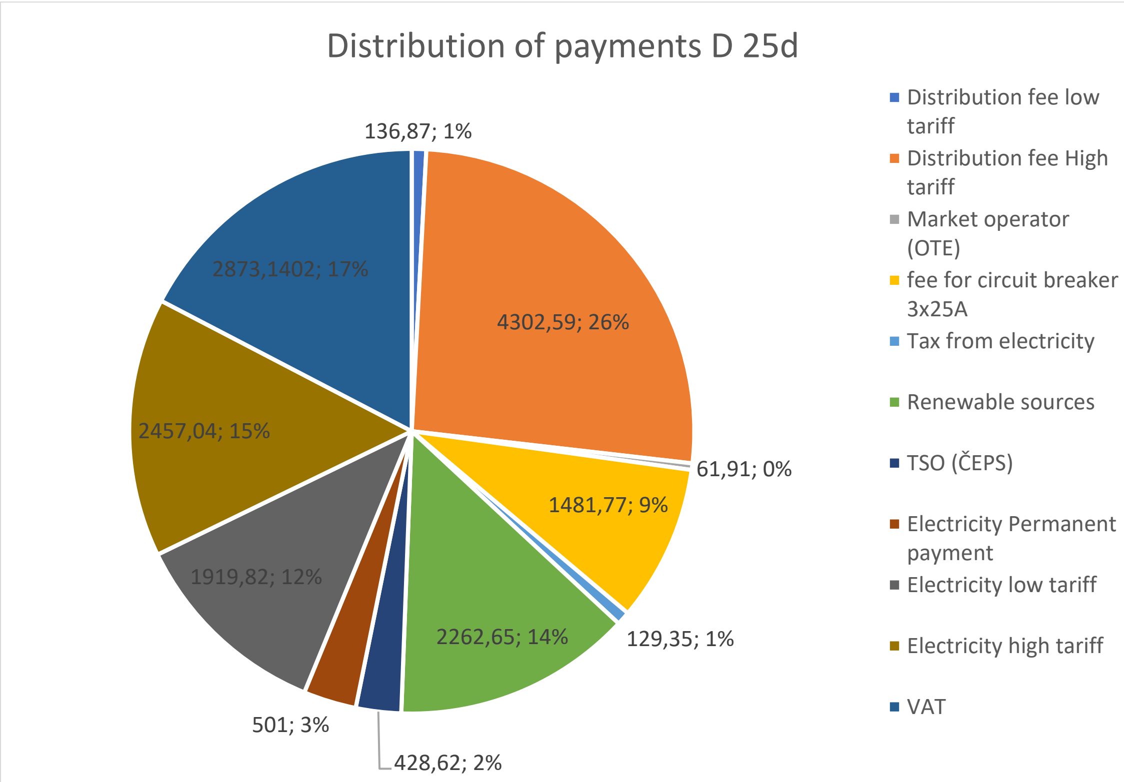

Figure 4

It is clear that small PV system cannot save the whole amount 16 554 Kč because OTE's fees and circuit breaker fees will not change. Depending on the system customer will have, save payments for electricity in low and high tariff. Also distribution payments and all payments per MWh will be decreased for amount of MWh which PV system will produce in a year and customer will be able to consume or store. Thus, it is possible to save up to 87% of total electricity payments by building PV system.

But when the customer will have single tariff structure as for example tariff D 02d the distribution will look slightly different. I´ll assume a customer which will consume 3 MWh of electricity per year for which he has to pay 13 504 Kč

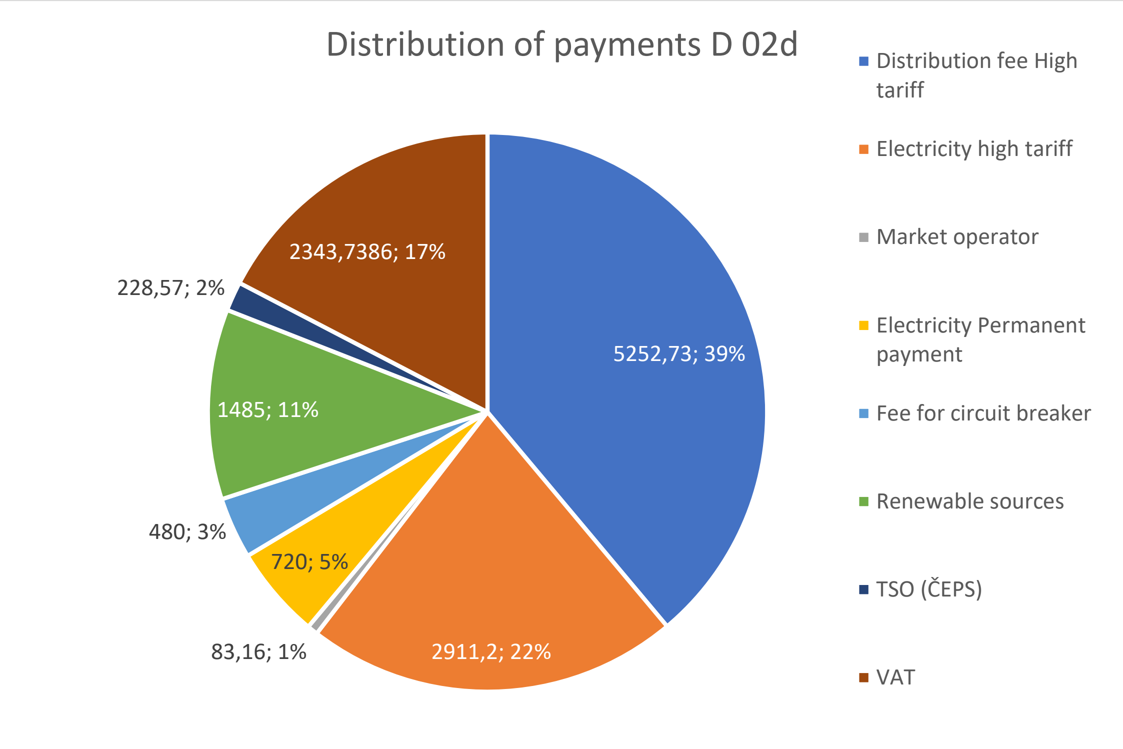

Figure 5

It is clear from the graph that the customer with the D 02d tariff will pay only about CZK 3,000 per year less for 3 MWh than the customer with the D 25d tariff for 4.5 MWh. In addition, permanent payments account for only 8% of the total, compared to 13% for D 25d. Which means that PV can save more, and photovoltaic system should be more profitable.

8. METHODOLOGY FOR A PHOTOVOLTAIC SYSTEM WITH THERMAL USE OF SURPLUSES

For a customer with a two-tariff rate, when the PVP is generating electricity, the generated electricity will first be consumed in the house (and thus reduce the price of electricity taken from the grid, potentially even at high tariffs), and in the event of overproduction of electricity, the surpluses will warm up water in the boiler, which would otherwise be heated primarily during the low tariff period. From the above, it follows that the status of such a PV system will mainly reduce the charges for distribution fee in a low tariff and partly in the high tariff. However, the distribution of these savings will be crucial for the correct calculation of the customer's economic efficiency with a two-tariff rate.

When the system will be designed for someone with normal single tariff rate, calculations of savings will be much easier. In Czech Republic is the most widespread single tariff rate D 02d tariff, where due to the lack of a low tariff, only a high tariff will be pushed out.

Another factor significantly affecting design efficiency will be the percentage of generated electricity consumed directly at the point of consumption, because if the generated electricity is not consumed in the house and the boiler is fully heated, electricity will go into the grid. In the case of the capital city of Prague, where PRE a.s. is distributor, the conditions are such that the customer does not pay anything for overflowing electricity, but also does not receive anything. It is therefore ideal to design the system to minimize overflows, if possible. Also another limitation is to consume 70 % of generated electricity in place of generation.

9. Methodology for a photovoltaic system with accumulation of electric energy

In case of a system with accumulation into a physical battery there is the biggest variability in size of a system, size of a battery or saving an energy in low or high tariff. The coefficient of saved energy in high and low tariff will be the opposite here than in the case of accumulation in water. Most of the electricity from the battery will be taken in the evening (approximately between 6 pm and 11 pm) that´s mean in high tariff duration. Most of the time when PVP is producing, it is also high tariff, but it can be low tariff duration between about 4 pm and 4 pm (depends how the distributor will divide periods of high and low tariff). In addition, if the customer has a classic electric boiler in the house (and rate D 25d expects it), I can consume electricity from the battery to heat the water in the boiler, ie. again, pushing the low tariff. For this reason, I expect this system to displace 20% low tariff and 80% high tariff, essentially without much consideration for the installed PV power.

I can vary the amount of installed capacity up to 10 kWp just by increasing of size of a battery, with the condition that 70% of the energy at the place of production will be used. If it will be economically advantageous to increase the installed capacity along with the battery capacity, I will try it in the calculation part.

10. Calculation of economical effectivity for photovoltaic system with thermal use of surpluses in Czech Republic

Because the design of a PV system will be totally different for different customers I´ll calculate economical effectivity for two different types of households. For tariff D 25d and D 02d. Because customers with tariff D 25d have usually bigger consumption I´ll count that D 25d will consume 4,5 MWh/year and D 02d 3 MWh/year.

As I already mentioned, on the beginning I´ll calculate total coefficient of consumption in a specialized software and after that I´ll change it as I´ll change another inputs for calculations.

Results for D 25d

System 2.1 kWp					
Coeff. of consumption	Coeff. of usage in high tariff	Coeff. of usage in low tariff	Electricity price grow	Discount	**NPV**
0.92	0.2	0.8	0.03	0.02	**-22 031 Kč**
0.92	0.3	0.7	0.03	0.02	**-12 899 Kč**
0.92	0.2	0.8	0.03	0.03	**-27 637 Kč**
0.92	0.3	0.7	0.03	0.03	**-19 421 Kč**
0.92	0.3	0.7	0.04	0.03	**-15 696 Kč**
0.92	0.3	0.7	0.04	0.02	**-8 642 Kč**
0.85	0.3	0.7	0.03	0.02	**-19 519 Kč**
0.85	0.3	0.7	0.04	0.02	**-15 586 Kč**
0.85	0.3	0.7	0.04	0.03	**-21 991 Kč**

Table 5

As it clear from a table on a beginning was coefficient of total consumption 92% so 8% went to the grid for free. From these 92 % was 20 % replacing electricity in high tariff and 80 % in low tariff. With grow of electricity price of 3 % and discount 2 % was Net Present Value of such a project 22 thousand crowns in minus. Which means that this PV system is really not profitable. In other variants which I calculated, is value slightly worse or better, but NPV never went into positive numbers.

When I tried to increase installed capacity, the results are below

System 3.24 kWp					
Coeff. of consumption	Coeff. of usage in high tariff	Coeff. of usage in low tariff	Electricity price grow	Discount	**NPV**
0.8	0.2	0.8	0.03	0.02	**-36 899 Kč**
0.8	0.3	0.7	0.03	0.02	**-25 043 Kč**

0.8	0.3	0.7	0.04	0.02	**-19 516 Kč**
0.8	0.3	0.7	0.04	0.03	**-29 114 Kč**
0.75	0.2	0.8	0.03	0.02	**-43 218 Kč**
0.75	0.3	0.7	0.04	0.02	**-26 922 Kč**
0.75	0.3	0.7	0.03	0.02	**-32 103 Kč**
0.75	0.3	0.7	0.03	0.03	**-40 361 Kč**

Table 6

Because of higher purchase price of a system and lower coefficient of total consumption are results worse.

Results for D 02d

System 2.1 kWp				
Coeff. of consumption	Electricity price grow	Discount	**NPV**	Return rate [years]
0.8	0.03	0.02	**37 981 Kč**	13.2
0.8	0.03	0.03	**26 116 Kč**	13.2
0.8	0.04	0.02	**53 076 Kč**	12.5
0.7	0.03	0.02	**20 745 Kč**	15
0.7	0.03	0.03	**10 547 Kč**	15
0.7	0.04	0.03	**33 953 Kč**	14

Table 7

The system achieves positive NPV under all assumptions. However, a return of over 12 years is still not entirely interesting for most customers. The big disadvantage of this system however is, that with the use of approximately 200 litres of hot water per day, which this system assumes, will be much more convenient for the customer to change his tariff to D 25d and not to build a PV power plant. So the numbers look promising, but the system with the surplus water storage is from principal nonsense for the customer with the D 02d tariff. Unfortunately, this type of calculation (tariff D 02d plus PV system with thermal use of surpluses) is used as an advertisement how profitable PV systems are. Under certain assumptions may return rate be even between 6 and 8 years. [7]

11. CALCULATION OF ECONOMICAL EFFECTIVITY FOR PHOTOVOLTAIC SYSTEM WITH ACCUMULATION OF ELECTRIC ENERGY

The PV system with batteries delivers the greatest variability and independence from the distribution network. If certain conditions are met, it can function in island operation for a short time, which is in the event of a network failure benefit, which cannot be properly financially evaluated in my calculations. Results are below.

Results for D 25d

System 1.89 kWp						
Coeff. of consumption	Coeff. of usage in high tariff	Coeff. of usage in low tariff	Electricity price grow	Discount	**NPV**	Return rate [years]
0.85	0.8	0.2	0.03	0.02	**-33 684 Kč**	-
0.85	0.8	0.2	0.03	0.03	**-44 328 Kč**	-
0.85	0.8	0.2	0.04	0.02	**-19 971 Kč**	-
0.85	0.8	0.2	0.04	0.03	**-32 335 Kč**	-
0.9	0.8	0.2	0.04	0.02	**-11 796 Kč**	-

Table 8

As first variant I chose small system with 1,89 kWp installed power. The system with the classic battery has largest variability. I can always buy more PV panels and more batteries, but the question is how much it will be effective due to the high cost of the batteries and their limited life. As in the previous cases, I was counting on the replacement of the inverter once for the life of the system, here I will also count with the replacement of batteries.

Net present value is in all cases negative, which means that I´ll try to add few panels and batteries and by that increase installed capacity. Results are below.

System 3.6 kWp						
Coeff. of consumption	Coeff. of usage in high tariff	Coeff. of usage in low tariff	Electricity price grow	Discount	**NPV**	Return rate [years]
0.7	0.8	0.2	0.03	0.02	**-35 250 Kč**	-
0.7	0.8	0.2	0.04	0.02	**-14 856 Kč**	-
0.7	0.7	0.3	0.03	0.02	**-45 458 Kč**	-
0.7	0.8	0.2	0.04	0.03	**-33 962 Kč**	-
0.75	0.7	0.3	0.03	0.02	**-32 880 Kč**	-
0.75	0.8	0.2	0.03	0.02	**-21 943 Kč**	-
0.75	0.8	0.2	0.04	0.02	**-92 Kč**	-
0.75	0.8	0.2	0.04	0.03	**-20 668 Kč**	-

Table 9

As can be seen from the results, this option is in some cases better. Higher investment will somewhat mitigate the impact of fixed PVP costs and, with an optimistic option using 75% of generated energy in the building and 4 % grow per annum of electricity prices (which is optimistic in terms of PVP's economic return, less for the customer), the NPV gets almost zero. Nevertheless, it is still below zero which means that even bigger system isn't profitable for customer with tariff D 25d.

Results for D 02d

Systém 1.89 kWp				
Coeff. of consumption	Electricity price grow	Discount	**NPV**	Return rate [years]
0.75	0.03	0.02	**-36 283 Kč**	-
0.75	0.03	0.03	**-46 676 Kč**	-

0.75	0.04	0.02	**-22 855 Kč**	-
0.8	0.03	0.02	**-28 105 Kč**	-
0.8	0.03	0.03	**-39 289 Kč**	-
0.8	0.04	0.02	**-13 782 Kč**	-

Table 10

As you can see, the NPV is once again negative in all variations. This time a little more than for an customer with a different tariff and higher consumption. If I wanted to increase the use coefficient, I would have to add a larger battery at the same system size, but that would be again disproportionately increase the of investment. So, I have to build a larger system that, once again, is able to spread some of the fixed costs with greater savings. It would be ideal to get just a little bigger system, about 2 kWp, to avoid a big battery while meeting the 70% power requirement in the building. Looking at the Czech market, however, I find that a power plant with an output of slightly over 2 kWp with accumulation in the battery does not exist. The reason for this is that a capacity of 1.25 kWh per 1 kWp of installed capacity is required to obtain a subsidy in category C3.5. This means that for a 2 kWp power plant, a battery greater than 2.5 kWh is required, but the batteries are normally supplied in 2.4 kWp or multiples of this value. I could add one additional panel after granting the subsidy, slightly overloading the inverter and increasing the amount of power generated, but with the battery unchanged, the coefficient of consumption would decrease anyway, so the design doesn't help much, in addition, one panel doesn't make any major change. Apart from the fact that this would mean a violation of the subsidy conditions.

Another option is to increase the system quite significantly to a value of about 3 kWp with a significantly larger battery, thus maintaining the utilization coefficient, but also increasing the savings.

System 3.12 kWp				
Coeff. of consumption	Electricity price grow	Discount	**NPV**	Return rate [years]
0.7	0.04	0.02	**-110 240 Kč**	-

Table 11

As you can see, the cost of the battery is totally disproportionate to its economic benefit to this installation. Other changes of parameters will not change the fact that the system designed in this way is just too big and mainly expensive for the customer with a consumption of 3 MWh / year.

12. Conclusion

As can be seen from previous calculations, none of these configurations are currently cost-effective. It should be noted that I calculated renew the inverter and battery for the current market price. This assumption may be relatively conservative due to falling battery prices. Furthermore, I count on constant fixed costs regardless of the installed system performance. This is because I assume that the failure rate is similar for all systems and the system revision will also cost roughly the same, whether it is a 1 kWp or 3 kWp system.

What should be advantage for the economic efficiency of photovoltaic power plants is my assumption of an ideal rotation to the south and an ideal slope, which may not be a condition for all customers.

Looking at the results, I must say that it is currently unprofitable to build any photovoltaic system for the vast majority of potential households represented by the D 02d and D 25d tariffs. This is quite bad news for our environment, because PV systems should be one of main renewable power sources in the future. But if there won't be any dramatic change in the near future, small PV systems will be negligible power source as well as today. That at very least means, that we won't be able to fulfil Paris agreement goals.

References

[1] P. D. Ing. Bechník Bronislav, “Fotovoltaika - podpora v různých zemích Evropy,” 1917. [Online]. Available: https://oze.tzb-info.cz/fotovoltaika/6421-fotovoltaika-podpora-v-ruznych-zemich-evropy. [Accessed: 23-Jun-2019].

[2] “Elektrické bojlery a ohřívače vody l Domintex.” [Online]. Available: https://www.domintex.cz/elektricke-ohrivace-vody/. [Accessed: 02-Mar-2019].

[3] “ČEZ Battery Box.” [Online]. Available: https://www.cez.cz/cs/sluzby-pro-zakazniky/cez-battery-box/.

[4] Ekowatt, “Vliv znečištění na FV panel.” [Online]. Available: http://fotovoltaika.ekowatt.cz/vliv-znecisteni.php.

[5] Ing. Jiří Chlupáček, “Pojištění fotovoltaické elektrárny - SVP Solar.” [Online]. Available: https://www.svp-solar.cz/pojisteni-fotovoltaicke-elektrarny/.

[6] “Energetický regulační VĚSTNÍK ENERGETICKÝ REGULAČNÍ ÚŘAD.”

[7] “Fotovoltaická elektrárna 2,6 kWp na klíč | Solární Experti.” [Online]. Available: https://www.solarniexperti.cz/solarni-systemy/fotovoltaika/fotovoltaicka-elektrarna-fve-o-vykonu-26-kwp-na-klic/.