Czech-Austrian Winter and Summer School (Achievement of energy efficiency in the households by using PV)

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CONTENT

ABSTRACT

In Europe, the household sector is one of the largest consumers of electricity. (Energiebilanzen, 2013). Therefore, during the last years, the usage of energy from PV cells is becoming more important. One of the main reason, is the decreasing price for PV. The production of solar electricity from PV is starting therefore to penetrate the energy market in many European countries.

Gradually, the constantly increase of prices of the energy leads households to find accessible ways for cost-efficient energy usage. This paper makes an effort to find out if nowadays is still budget – wise for households to use PV. It analyses the production- and consumption profiles of energy in the households, studies the issue of storage of the energy and gives some suggests how the households can obtain the most benefit by using PV. Furthermore it takes into account of the political aspects as and prices of the energy by PV. A comparison of those factors in Czech Republic and Austria will be listed as result.

1. INTRODUCTION

Because of the rising shortage of fossil fuels, deep interest of people in the environment in whole Europe, geopolitical pressures and also raising prices of the energy, the question of the renewables gets the significant relevance. One of them is energy produced by PV cells. The costs for purchasing the PV cells are continual decreasing. The market price of PV cells is nowadays as low as even the small stand – alone objects like the households are can place the cells on the roof without subsidy and gain the eco - friendly energy for their own houses. The demand for the energy is growing worldwide as the technology goes ahead. Every day the new electric appliance comes into existence. The solar energy appears to be a good solution how to deal with the problems above. However the quantity of produced solar energy is changing depending on season, day, hour etc. We need to save the surplus of energy so we can use it another time. For this transfer the suitable storage is needed. The purpose of this work is to find some kind of balance between the production and consumption of energy in the households by using the storage. The main aim of this paper is also to find out if there is a hypothetical possibility for households being more or less independent from energy from the grid by elimination of fluctuation of produced energy in certain time horizon. At the first part of paper we will analyses the production and consumption of energy from PV in households in general. On the basis of the previous information the suitable storage of the energy will be determined. At the last part the economic and political aspects determining the background in Austria and Czech Republic will be compared. Finally the results will be summarized and the evaluation of the total efficiency of PV will be discussed.

2. ELECTRICITY STORAGE

The design of classical electricity storage for PV panels was mainly designed for stand-alone purposes. In this paper, we concentrate on storage of part of the solar power for near-term consumption within a day or subsequent days. This leads house owners to become more independent from the grid and does pay only for the congestion of his energy. This kind of storage can be used also to bridge the power loss periods caused by electric utility companies. Furthermore, households are more satisfied as they can fulfill part of their own energy need by themselves. The electricity grid is used as a help achieve the balance between solar energy production and the electricity consumption of the household. The grid is used as a virtual storage, which means the overproduction during the day is supplied into the grid and a demand in the evening is covered by the electricity network. (Grietus Mulder, Fjo De Ridder, Daan Six, 2010)

Since some years, the usage of self-consumption of PV is publicly encouraged in some European countries (e.g. Germany, Austria …) and it can be realized by electric storage. The owners are remunerated for feeding their electricity into the grid. (Ministery of Environment (Bundesumweltministerium), 2009)

As mentioned above, classically storage for PV panels is mainly designed for stand-alone purposes therefore the amount of stored energy must be suffice at least the production gap of a couple days of clouded weather. This can vary between 3 and 20 days. The more days we have to store the more expensive is the storage. In this paper only on near-term consumption within a day or subsequent days will be concentrated. Therefore charge and discharge of a daily cycle on the total storage vary between 2% and 30%. (Häberlin, 2007) (T. Markvart, L. Castaner, 2003)

2.1 Production and consumption

This chapter gives a characterization of production and consumption for households with PV panels. This is needed to understand the impact of production and consumption on the small-scale battery systems and their dimension. Furthermore it shows how the households can obtain the most benefit by using PV.

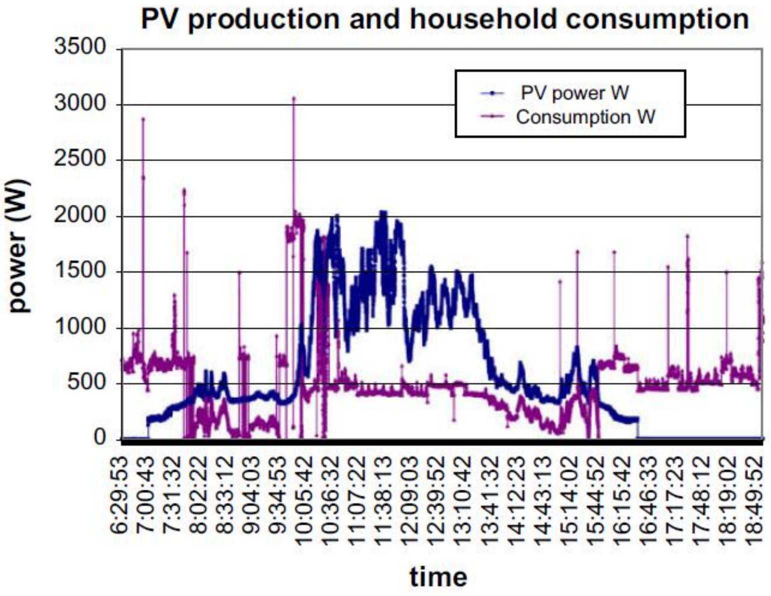

Figure 1 production and consumption profile on a day in October (Grietus Mulder, Fjo De Ridder, Daan Six, 2010)

The figure above shows a production profile of solar panels on a day in October and the consumption profile of the household on the same day. The simultaneous consumption of the household is included, as well. It can be identified, that the production is not sufficient the whole day long. Intra-day storage could solve this problem.

Following two criteria are important for storage systems:

1) Power need for charge and discharge current
   The power change occurs within some seconds. As shown in the figure, the power can decrease and be at full power again some seconds later. Therefore the system must respond drastically.
2) Storage capacity
   This criteria need not to be precise as the first criteria. According the figure, the consumption can be nearly zero. Therefore the system must absorb the full power of the PV panel.

The next figure (*Figure 2 Production and grid dependence during a week*) shows measurements of power fluxes in seven houses with PV panels. Those houses have been measured mainly during a complete year, some at first half and some on the second half of the same year.

Following data have been considered to calculate the dwellings consumption:

a. measured AC power out of the inverter
b. power to the grid
c. power drawn from the grid

The measurements have been carried out in 5 min intervals. From this figure, it can be derived, that production cannot cover household's consumption for every time step.

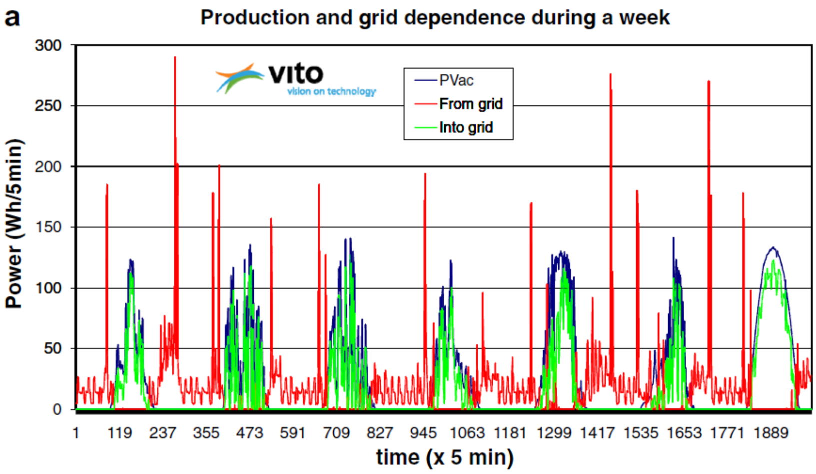

Figure 2 Production and grid dependence during a week (Grietus Mulder, Fjo De Ridder, Daan Six, 2010)

In the *Figure 3 Monthly production and consumption* a typical consumption and production profile on monthly base during a year is shown. The decrease of energy production and the increase of the consumption in the winter months can be seen easily

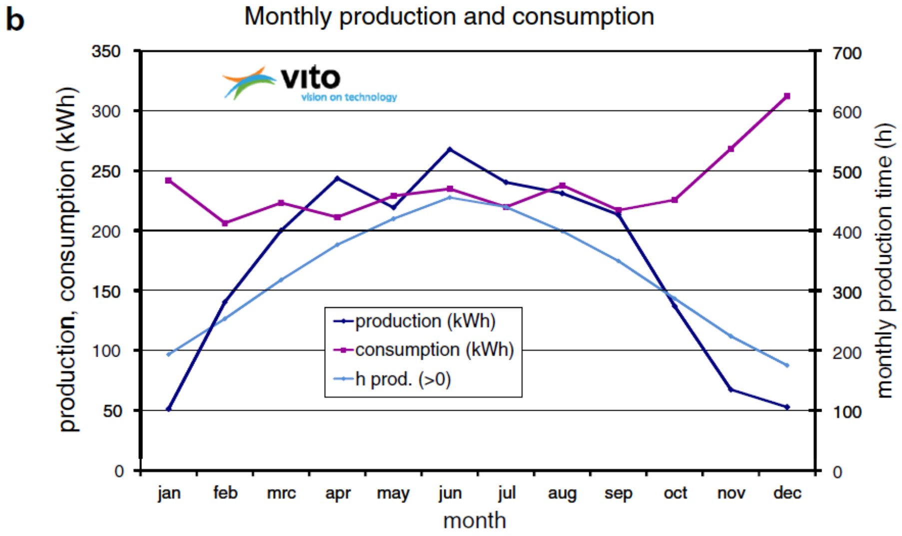

Figure 3 Monthly production and consumption (Grietus Mulder, Fjo De Ridder, Daan Six, 2010)

2.2 Storage

According to the Figure 3 Monthly production and consumption and measurements, it can be noticed, that production for none of the houses is sufficent for the consumption for every time step or even mont. (M. Suri, T.A. Hulda, E.D. Dunlopa, H.A. Ossenbrinka, 2007). The production-consumption ratio can vary between 30% and 80% on a monthly base. e.g. in the month december, appr. 50 kWh is produced but more than 300 kWh consumed.

The exact amount of the produced and consumed energy will be handled in a later chapter for calculating of return on investment of PV and savings.

Since the measured houses do not include any storage systems, the following figure 4 shows the influence of storage. As a basis, the *Figure 2 Production and grid dependence during a week* is used.

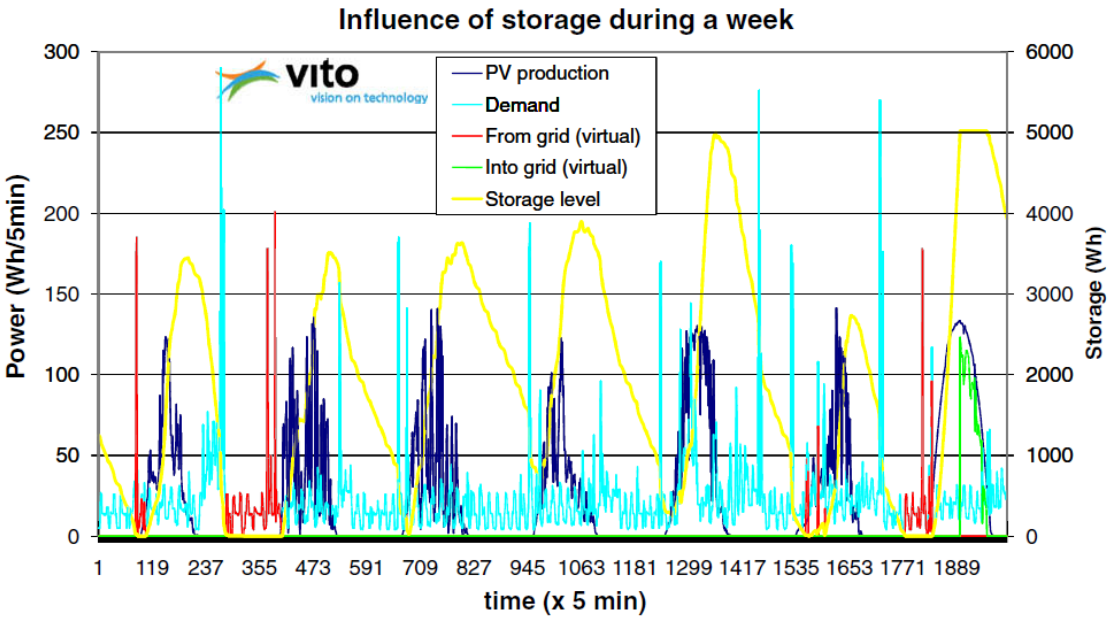

Figure 4 Influence of storage during a week (Grietus Mulder, Fjo De Ridder, Daan Six, 2010)

A small storage system enable house dwellings almost independent from the grid. It could use his own solar electricity and shift it over the day. Therefore the purpose in this paper is not the classical approach of week shifts. From this idea, in the summer a limitation on battery size can be derived from the energy that is still consumed from the grid, as the storage of too much solar energy which cannot be consumed is not useful, too.

By using the monthly consumption pattern, the maximum storage size of solar energy on monthly base, can be optimized. (Grietus Mulder, Fjo De Ridder, Daan Six, 2010)

3. COMPARISON OF RES POLICY IN AUSTRIA AND THE CZECH REPUBLIC

3.1. Support policy for residential PV in the Czech Republic

The Czech elektricity market is fully liberalized since 2006. There are two possible schemes for using elektricity from PV in the Czech Republic. The first one - *Feed-in tariff* - is classic mode used in the most Europien countries. A FIT scheme was introduced in 2002 in the Czech Republic reflecting the EU legislativ (Directive 2001/77/EC). (Support schemes for elektricity produced from RES Issue Paper, 2011). In Feed-in tariff scheme all produced energy is send back to the grid for the price seted by ERO (Energy regulation organisation in the Czech Republic). The FIT policies can be provided by two approaches. The FIT price can be dependent or independent on the market price. The second system is so called *Feed-in premium*, which offers premium on top of the spot market elektricity price. In this system is produced energy consumed by the producer and the rest of non-consumed energy is sold to the grid for the prearranged market price. Moreover the producer gains a payment (bonus) for each produced kWh in accordance with the current price statement published by ERO. This system is used also in Spain and Slovenia. In the FIT system the price is increasing of inflation (from 2% up to 4%) but never can be decreased. (Renewable Energy Policy Country Profiles, 2011*)* The prices in each scheme differs - in Feed-in premium ERO also considers the higher market risk. The prices are guaranteed for 20 years. It is possible to use only one from these two models, it can´t be combined. Act 180/2005 on Renewable Energy Support introduced a system with a mix consisting of a these two schemes. Since that the PV capacities has rapidly increased. In 2010, 1500 MWp were installed, placing the country in the 4th position in EU in cumulative capacity (totally 2000 MWp) (EurObserv'ER, 2011).

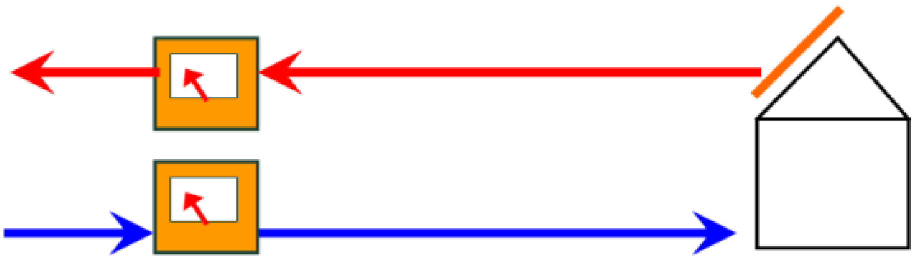

Figure 5 Scheme of operation of solar power station in the mode of Feed-in tariff

(*CENTRUM PRO OBNOVITELNÉ ZDROJE A ÚSPORY ENERGIE* [online].

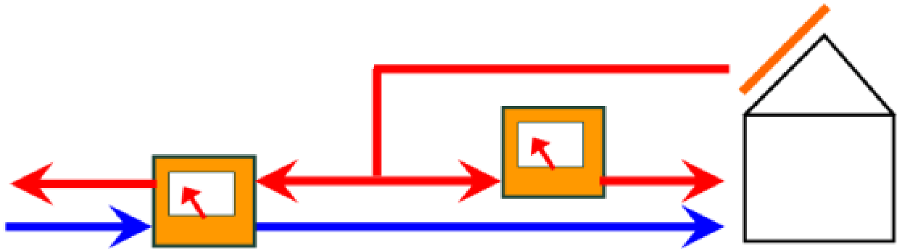

Figure 6 Scheme of operation of solar power station in the mode of Feed-in premium (*CENTRUM PRO OBNOVITELNÉ ZDROJE A ÚSPORY ENERGIE* [online].

3. 2. Future Outlook for PV in the Czech Republic

After great expansion of PV in previous years, the significant decrease in 2011 has been come. Only 6 MW on new systems were connected to the grid. The main reason is fall on support of about 45%, limiting it only for small rooftop systems (Global market outlook for photovoltaics until 2016, 2012). The yellow curve in Figure 7 represents feed-in tariff for small device with capacity up to 30 in the Czech Republic. The significant decline from the year 2010 can be seen. The green curve represents the time development of Feed-in tariff in Germany and the violet one is the market price of electricity for regular households in the Czech Republic.

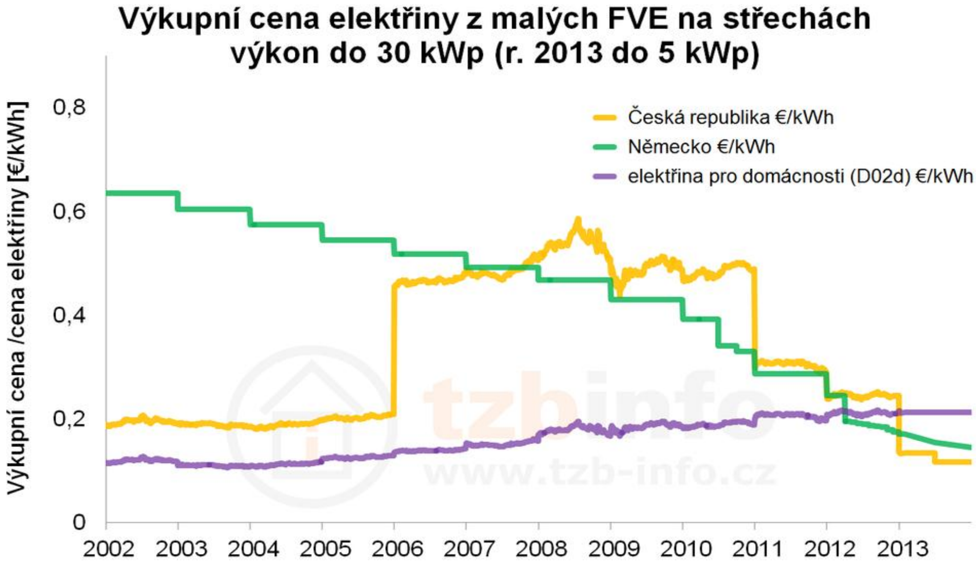

Figure 7 Development of Feed-in tariff in the Czech Republic (Technická zařízení budov. *TZB-info* [online].

3.3. The Support Policy for residential in Austria

The federal support policy for electricity from RES is regulated by the Austrian Green Electricity Act (Ökostromgesetz).The RES policy instrument in Austria is in general Austrian Electricity Green Act (adopted in 2002). The support instrument in Austria is Feed-in tariff system. From one part managed by centre OeMAG (Abwicklungsstelle für Ökostrom Österreich) and partly dependent on providers buing elektricity. The prices by OeMAG are sett only for devices with capacity over 5kWp.The guaranteed duration of the feed in tariff here is currently 13 years. (The price in FIT is currently 18,12 eurocent, which is by 30% less than in year 2012.) For that devices also works the principle of subsidy in Austria. The grants for PV projects are available, it can be investment subsidy or low cost loan. But when the producer use this grants, he can not use the FIT. Therefore subsidies are using by large stand – alone power plants. Producers with capacity up to 5kWp are referend to some provider. There is several of them in Austria, all of them are not available in all regions. Depending on the provider, there are also some restrictions and contract condicions. The price is varying between 6 - 12 cent/kWh. Recently (April 2013) was new subsidy scheme adopted which will be financed by the *Climate Energy Fund*. This system offers budget of 36 milion euros to photovoltaic systems with capacity up to 5 kW. For rooftop systems can gain subsidy 300€/kWp (the building integrated even 400€/kWp). The condition is to make a registration and finish plant till 12 weeks after the registration. The registrations is possible to make until 30th November 2013. The new capacity of 115 MW is expected to come into existence.

4. THE CALCULATION OF RETURN ON INVESTMENT OF PV AND SAVINGS

Because there is many factors influencing the final height of cost on PV like used sort of material or different prices of complementary services, we use the annual current final cost of the investment in this calculation. The development of cost is illustrated in the Figure below. In 2009 typical PV system cost were in the range 2950€/kW_{el} to 4750€/kW_{el}. (Financing Renewable Energy in the European Energy market, Final report, 2011) These cost levels were reached after strong cost declines in the year 2008 and 2009. This reduction in investment cost marks an important departure from the trend of the year 2005-2007, during which cost remained flat, as rapidly expanding global PV markets and a shortage of silicon feedstock put upward pressure on both module prices and non-module costs.

The new dynamic began to shift in 2008, as expansit on the supply-side coupled with the financial crisis led to a relaxation of the PV markets and cost reduction achieved on the leasing curve in the meantime factored in again. Furthermore, the cost decrease has been stimulated by the increasing globalization of the PV market, especially the stronger market appearance of Asian manufacturers.

Figure 8 Current annual cost on complete installation of PV for households (Bundesverband Solarwirtschaft Preiseindex 1301, 2013)

Following Calculation will analyse the return on investment allowing for the conditions adjusted in the Czech Republic for the following period of the year 2013.

The data used for our calculation comes from the case study (Grietus Mulder, Fjo De Ridder, Daan Six, 2010) which analyses production and consumption of seven representative houses in Belgium. For our purpose we need only first one – house „Lummen". The measured values from that study will be applied on the price´s parametres beeing in the Czech Republic and Austria. This way we will find out what amount of money can be saved and how long takes returning the investment on PV.

Table 1 Characterisation of the house under study, showing the PV panel data and the electric production and consumption data

	Lummen
Panel surface (m2)	16.7
Installed power (kWp)	2.2
Relative annual yield (kWh/kWp)	975
Annual solar production (kWh)	2107
Annual consumption (kWh)	2890
Production–consumption ratio (À)	0.7

In this study the consumption is in excess of production. It is due to lower power installed. There will be the relevant approaches to both countries analysed. The Feed-in tariff and the Feed- in premium in Czech Republic and The Feed-in tariff in Austria.

4.1. Calculation in terms of the Czech Republic

For knowing the Payback period are following information needed.

- Annual complete cost on investment……………….. 1684 €[1]/kWp
- Current Feed in tariff premium……………………………... 0,11€2/kWh
- Current Feed-in tariff…………………………….………….. 0,13 €[2]/kWh
- The price of elektricity from the distributor (€/kWh,annual)... 0,1487€[3]/kWh

Further we consider depreciation of about 1% per year expressed by a coefficient 0,887.[1]

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[1] Source - see Figure 8

[2] ENERGY REGULATORY OFFICE. *Energetický regulační věstník*. Available at: http://www.eru.cz/dias-browse_articles.php?parentId=338

3 Annual elektricity for end – user in Czech Republic, [online], Available at: http://www.energy.eu/#renewable

Payback period in the Feed-in premium scheme:

Investment/((((Production * elektricity price) + (production * premium price) – ((consumption - production) * electricity price)) * depreciation coefficient)

Case study - Lummen

- Investment = 2,2 kWp * 1684€ = 3705€

PT = 3705/((2107 * 0,1487) + (2107 * 0,11)-(783 * 0,1487)) * 0,887 = 9,7

Payback time value is 9,7, which means it takes about 10 years for returning the investment. After that the unit will generate the net profit. The lifetime of PV is about 20 years so the net profit will be:

10 years *(2107kWh * 0,11€) + (2107kWh * 0,1487€) - (783kWh * 0,1487€) = 4287€.

Payback time in the Feed-in tariff scheme

Table 2 Payback period in the Feed-in tarrif scheme

Year	**Feed-in tarif (€)**	**Takings per year (€)**	**Financial balance (€)**	**Year**	**Feed-in tarif (€)**	**Takings per year (€)**	**Financial balance (€)**
2013	0,1316	277,28	-3427,72	2024	0,1636	344,76	13,92
2014	0,1342	282,83	-3144,89	2025	0,1669	351,66	365,58
2015	0,1369	288,48	-2856,41	2026	0,1702	358,69	724,27
2016	0,1397	294,25	-2562,16	2027	0,1736	365,87	1090,14
2017	0,1424	300,14	-2262,02	2028	0,1771	373,18	1463,32
2018	0,1453	306,14	-1955,88	2029	0,1807	380,65	1843,97
2019	0,1482	312,26	-1643,61	2030	0,1843	388,26	2232,23
2020	0,1512	318,51	-1325,10	2031	0,1880	396,03	2628,26
2021	0,1542	324,88	-1000,22	2032	0,1917	403,95	3032,20
2022	0,1573	331,38	-668,85	2033	0,1956	412,03	3444,23
2023	0,1604	338,00	-330,84	2034	0,1995	420,27	**3864,49**

In calculation is assumed the current the Feed-in tariff 0,1316 € set by ERO. The price in Feed-in tariff scheme is guaranteed for 20 years and yearly increased by the price index of industrial producer´s which is 2 %. We also have to deduct the own need of electricity for consumption from the income. So the result is *3864,5€ - (2890kWh * 0,1487€/kWh) = 3298 €.* From the table is evident that the unit starts to earn money from the twelfth year of operation. The disadvantage of the Feed-in premium scheme is a fact, that the bonuses are declared every half of the year in the Czech Republic by ERO and they have been decreased recently. The operator can decide to change the scheme as he finds out it is not budget-wise anymore. It can be done ones a year. In this case the operator has a claim for the Feed-in tariff price valid in the year of starting the power plant, increased by year – on – year index of industrial producers.

4.2. Calculation in terms of Austria

For knowing the Payback period are following information needed.

1) Tarrif provider: OeMAG

- Annual complete cost on investment……………….. 1684 €[1]/kWp
- Subsidy from new Climate Energy Fund program…………………- 300€/kWp
- *Current Feed in tariff premium*……………………………….. *not offered*
- Current Feed-in tariff (OeMAG)………………………………….. 0,0452 €/kWh
- The price of elektricity from the distributor (€/kWh,annual)... 0,20103€[3]/kWh

Table 3 Payback time in the Feed-in tarrif scheme - Tarrif OeMAG, no fixed period, the cost on investment decreased by 300€/kWp

Year	Feed-in tarrif	Takings per year	Financial balance	Year	Feed-in tarrif	Takings per year	Financial balance
2013	0,0452	95,24	-2949,76	2024	0,0562	118,41	-1767,68
2014	0,0461	97,14	-2852,62	2025	0,0573	120,78	-1646,90
2015	0,0470	99,08	-2753,54	2026	0,0585	123,20	-1523,70
2016	0,0480	101,07	-2652,47	2027	0,0596	125,66	-1398,04
2017	0,0489	103,09	-2549,39	2028	0,0608	128,18	-1269,86
2018	0,0499	105,15	-2444,24	2029	0,0620	130,74	-1139,12
2019	0,0509	107,25	-2336,99	2030	0,0633	133,35	-1005,77
2020	0,0519	109,40	-2227,59	2031	0,0646	136,02	-869,75
2021	0,0530	111,58	-2116,00	2032	0,0658	138,74	-731,01
2022	0,0540	113,82	-2002,19	2033	0,0672	141,52	-589,49
2023	0,0551	116,09	-1886,10	2034	0,0685	144,35	**-445,14**

In the table 3 is clear that the same producer with the same investment costs reaches the negative values in tariff provided by OeMAG. This tariff doesn´t offer fixed time period and the price is the lowest, but is equalized four times a year. It can be considered as the advantage and it gives some certainty. But in our case it is not budget – wise even if we cut the cost by 660 euro as we apply new program provided by *Climate Energy Fund.*

2) Tarrif provider: Stadtwerke Hartberg

- Annual complete cost on investment……………….. 1684 €[1]/kWp
- Subsidy from new Climate Energy Fund program…………………- 300€/kWp
- *Current Feed in tariff premium*……………………………….. *not offered*
- Current Feed-in tariff (OeMAG)………………………………….. 0,0925 €/kWh
- The price of elektricity from the distributor (€/kWh,annual)... 0,20103€[3]/kWh

Table 4 Payback time in the Feed-in tarrif scheme - Stadtwerke Hartberg, 13 years fixed

Year	Feed-in tarrif	Takings per year	Financial balance	Year	Feed-in tarrif	Takings per year	Financial balance
2013	0,0925	194,90	-3510,10	2024	0,0925	194,90	-1366,23
2014	0,0925	194,90	-3315,21	2025	0,0925	194,90	-1171,33
2015	0,0925	194,90	-3120,31	2026	0,0925	194,90	-976,43
2016	0,0925	194,90	-2925,41	2027	0,0925	194,90	-781,54
2017	0,0925	194,90	-2730,51	2028	0,0925	194,90	-586,64
2018	0,0925	194,90	-2535,62	2029	0,0925	194,90	-391,74
2019	0,0925	194,90	-2340,72	2030	0,0925	194,90	-196,84
2020	0,0925	194,90	-2145,82	2031	0,0925	194,90	-1,95
2021	0,0925	194,90	-1950,92	2032	0,0925	194,90	192,95
2022	0,0925	194,90	-1756,03	2033	0,0925	194,90	387,85
2023	0,0925	194,90	-1561,13	2034	0,0925	194,90	**582,75**

Table 5 Payback time in the Feed-in tarrif scheme - Stadtwerke Hartberg, 13 years fixed, the cost on investment decreased by 300€/kWp

Year	Feed-in tarrif	Takings per year	Financial balance	Year	Feed-in tarrif	Takings per year	Financial balance
2013	0,0925	194,90	-2850,10	2024	0,0925	194,90	-706,23
2014	0,0925	194,90	-2655,21	2025	0,0925	194,90	-511,33
2015	0,0925	194,90	-2460,31	2026	0,0925	194,90	-316,43
2016	0,0925	194,90	-2265,41	2027	0,0925	194,90	-121,54
2017	0,0925	194,90	-2070,51	2028	0,0925	194,90	73,36
2018	0,0925	194,90	-1875,62	2029	0,0925	194,90	268,26
2019	0,0925	194,90	-1680,72	2030	0,0925	194,90	463,16
2020	0,0925	194,90	-1485,82	2031	0,0925	194,90	658,05
2021	0,0925	194,90	-1290,92	2032	0,0925	194,90	852,95
2022	0,0925	194,90	-1096,03	2033	0,0925	194,90	1047,85
2023	0,0925	194,90	-901,13	2034	0,0925	194,90	**1242,75**

In the Table 4 we use price from tarrif of *Stadtwerke Hartberg* is fixed for thirteen years (blue colour) and even after that time the investment is not returned. Considering participation in *Climate Energy Fund program* returns the costs not much sooner. We also have to deduct the own need of electricity for consumption from the income again. So the result is *1242,75€ - (2890kWh* * 0,20103*€/kWh)* = 662€ whereas in Feed-in tarrif of the Czech Republic the amount was almost five times higher.

4. CONCLUSION

In this paper measurement data of seven households in Belgium have been taken in account to show the storage of part of the solar power for near-term consumption within a day or subsequent days for grid connected PV. Furthermore the calculation of the payback period has been analyzed.

In comparison to the classic large storage sizes, an optimal size for being less dependent from the grid can be calculated. Bridging a period of several days without sunshine was not the focus of this paper. Therefore a package which is at least five times smaller than the classical one is sufficient. Furthermore, oversized PV panels are not needed as well.

The basic principles and differences between energy systems of both countries were described. From the comparison of the results coming from the calculation is evident, that the owners of small rooftops PV in the Czech Republic have under current terms better profitability and the shorter payback period than owners in Austria. In Austria´s scheme was also considered the newest available subsidy. For Czech households is still budget – wise to install PV. In Austria depends on the provider and use of subsidy.

It can be expected the gradually reduction of differences in the energy systems and prices in the future in Europe.

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