

# Low Power Photovoltaic System-Grid Connection, Self Consumption

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**Abstract:** - This paper deals with problematic of grid connection of photovoltaic sources according to current valid legislative from source holder point of view.

Basic possible situations of photovoltaic source holders are listed. Furthermore influence of current valid legislative into expected return of renewable source is shown. Finally real measured data from particular photovoltaic system are published and possible solutions for optimization of self consumption of photovoltaic source are listed.

**Key-Words:** - Self consumption, Photovoltaic Installation, Photovoltaic power plants, Green mode, Renewable source, Open field application.

## 1 Introduction

Nowadays there is a market growing up with photovoltaic power plants in the Czech Republic. On the market take place both application open field located and on building located.

On building located applications have usually nominal power in the range of 1 kWp to 10 kWp. Open field applications are designed with nominal power in the range of hundred kWp to MWp units.

## 2 Current state of photovoltaic system in Czech Republic

Photovoltaic power plants installation trend from 1.1.2002 till now in the Czech republic is shown see Fig.1 [1].

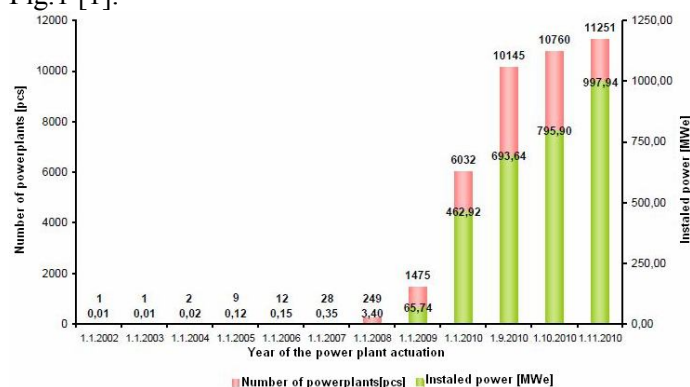


Fig. 1 Photovoltaic power plants; state: 1.3.2010 [1]

It is evident that significant increase of installed and connected to grid photovoltaic power plants application were performed during the year 2009. This situation was caused due to decreased investment costs for 1MWp of photovoltaic installations in the year 2009 according to year 2008.

Moreover there is valid the law Nr.180/2005, which guarantee a redemption price for electricity produced by means of renewable sources. Particular for electricity which is produced by means of solar energy (photovoltaic panels) is set up currently at highest value in the Czech Republic comparing the redemption prices for electricity produced by means of renewable sources with member states of EU (European Union); see Fig. 2 [3].

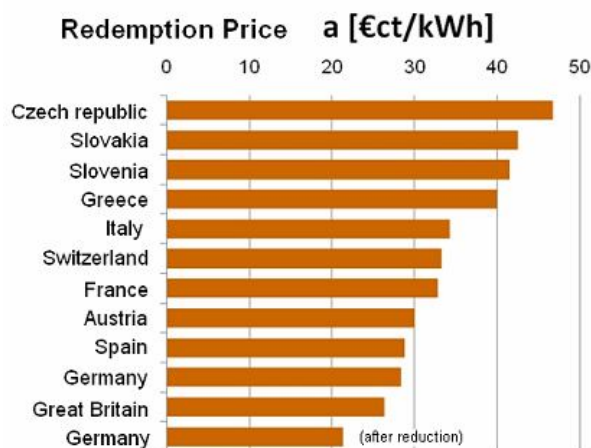


Fig. 2 Comparison of redemption price in EU [3]

Temporarily there are no more given authorizations to appliers who want to design new photovoltaic sources from local distribution companies with regard to possible instability of electrical grid during summer period.

### 2.1 Investment into photovoltaic installation

There are many approaches how to invest into photovoltaic installation. It was mentioned above that there are two basic possibilities:

- open field installation, see Fig.3;

- building located installation, see Fig.4.



Fig. 3 Open field installation [2]

According to law Nr.180/2005, producer is allowed to choose mode of redemption price for its installation. Modes are called:

- Redemption mode;
- Green mode.

“Redemption mode” guarantee to producer slightly higher redemption price for 1kWh generated in solar installation comparing it with the redemption price in “Green mode”.

Open field installation are 100% operated in the mode which is called “Redemption mode” considering slightly higher redemption price for 1 kWh generated in solar installation. Selling electricity in this mode means that entire amount of produced electricity from solar installation is delivered to a local electricity distribution company. Electricity is used for covering of losses in distribution grid but is not necessarily consumed in the place of production. Thus could be caused problems with regulating of an electrical grid during sunny days in summer time.

“Green mode” guarantee to a producer slightly lower price for entire production from photovoltaic system as was mentioned. Advantage for a producer is possibility to consume electricity in its own household and thereby to lower its electricity demand required from local distribution company. In that way a distribution grid is less loaded and thus can profit from these solar installations distribution companies.

## 2.2 Return of Investment

Let us focus on building located installation, see Fig.3. As investor one can get an offer from photovoltaic system supplier.

Case offer for complete photovoltaic system with power 4,24 kWp which consists of basic components (photovoltaic panels, wiring, inverter, protective components, support construction, electricity meter, switchboard, mounting work, consulting service, etc.) can costs about 93 000,-CZK including 10% Value Added Tax (VAT).



Fig. 4 Building located installation (illustrative)

With summary budget investor usually obtain economic return of investment using “Redemption mode” or “Green mode”, see Fig.5. Only this simple economic return of investment doesn’t take into account all necessary legislative requirements resulting from Czech valid laws. It is possible to increase self consumption of photovoltaic source by means of control unit and thus to improve economic return. Possible technical solutions of such control unit are described in chapter 3. and 4. of this article.

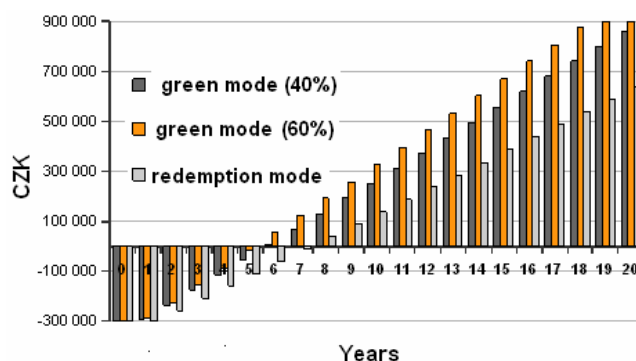


Fig. 5 Simple economic return of investment

## 2.3 Legislative requirements

Different legislative requirements for owner and operator of building located installation of photovoltaic system can occur.

Owner and operator of photovoltaic system can be:

- Employee;
- Trust Company Limited (Ltd);
- Self-employed, with double-entry accounting;
- Self-employed, with analytical accounts.

According to law Nr.458/2000 (Energetic law) each holder of License for producing of electricity is becoming accounting entity [4]. Thus has to follow law Nr.563/1991 (Accounting law). Based on law

Nr.563/1991 is every accounting entity obliged to conduct double-entry accounting. [5] This is not fatal for an employee who can start with no complication to conduct double-entry accounting. However this legislative requirements consequent upon law Nr.458/2000 might be fatal for self-employed who were conducting analytical accounts.

Next legislative requirement is to pay health insurance according to law Nr.592/1992 (Law about payment for general health insurance) and .social insurance according to law Nr. 589/1992 (Law about payment for social insurance) [6],[7].

These legislative requirements might cause some problems for owners and operators of small building located operations.

Paradoxically owners who operate large open field solar systems don't have to pay health and social insurance except for their own employee.

All owners of solar systems have to pay taxis according to Law Nr.586/1992 (Law about income assessment) [8].

### **3 Technical solutions for control of self consumption of low power photovoltaic system**

Self consumption of low power photovoltaic system which works in the "green mode" typically consist of standard household appliances. These appliances are devices for freezing and chilling of food products, table and portable computers and other. Electrical device with biggest power input is an electrical heater for preparing of heat water for household if the household is with such a device equipped. Seasonal appliance might be device for electrical heating. Disadvantage of time distribution of electricity generated using photovoltaic system is well known. During winter months low amount of electricity and during summer months big amount of electricity generated using photovoltaic system is available (See Fig.6). To increase amount of self consumption is possible to use above all the heater for the hot water and during winter time electrical heating. Control of self consumption might be realized using different technical means with different financial costs and different efficiency.

#### **3.1 Current relay**

One of the solutions how to control self consumption is to use current relay on the wiring of the photovoltaic system output. According to actual amount of generated electricity from the photovoltaic system is switched on particular electrical device. Thus is self consumption controlled in power levels corresponding to switching current of current relay and voltage of appliance.

Advantage of this solution is its simplicity and financial accessibility. Disadvantage of this solution is possible increase of entire consumption of producer site in a high tariff during coincidentally switched on another electrical appliance of the household. Current relays are available on the market.

#### **3.2 Programmable relay with current sensors**

It is possible to use for control of self consumption programmable relay, which enable to set priorities to particular appliances and to control these appliances depending on actual state of generated electricity from photovoltaic system with better accuracy comparing with current relay. For proper function of programmable relay it is necessary to bay current sensors for measuring of immediate values of current.

Advantage of this solution is better optimization of self consumption in the place of electricity generation. Disadvantage is bigger demand on financial costs. Necessary technical equipment for control of self consumption is available on the market.

#### **3.3 Special device for self consumption control of photovoltaic system**

For maximal optimization o self consumption of production site is possible to use special device for control of self consumption.

The device is based on programmable chip, which allows control electrical devices according to immediate production of electricity from photovoltaic system taking into account other electrical appliances in household which can be switched on (in any time). Such function of control device is provided by measuring of immediate current and voltage in all three phases in electrical installation of production site. Switching on and off of electrical appliances is based on priorities and on measured values. Measured monthly values of self consumption without control device for self consumption (See Fig.6) and with a prototype of device for control of self consumption of production site (See Fig.7).

Advantage of this solution is better optimization of self consumption compared with solutions mentioned. Disadvantage is that such a control unit is not yet available on the market.

### **4 Measured values of self consumption of Photovoltaic system**

In the next diagrams are given measured values of electricity production and self consumption of production site.

### 4.1 Production site 2,1kWp-typical household without control of self consumption

In the Table 1 are given values of generated electricity using photovoltaic system with installed power 2,1 kWp [9]. Hereafter are in the table 1 given values of entire electricity taken from electrical grid, amount of electricity given from photovoltaic system to the grid, entire consumption of electricity in production site and percentage usage of electricity generated using photovoltaic system as a self consumption. Measured values are given in Figure 6. Particular household has installed gas heating and hot water is prepared using electrical heater. Entire consumption of household consists of consumption in high tariff (HT) and low tariff (LT, 8h per day).

Table 1 Measured values, production site 2,1 kWp.

2010	Power take of from grid-[kWh]	Delivery to the grid-[kWh]	Photovoltaic production-[kWh]	Self consumption [%]	Total consumption [kWh]
prosinec	262	9	25,0	64,00%	278,0
leden	267	4	18,0	77,78%	281,0
unor	213	29	56,0	48,21%	240,0
brezen	219	114	179,0	36,31%	284,0
duben	179	181	271,0	33,21%	269,0
kveten	151	138	204,0	32,35%	212,0
cenen	127	214	239,0	28,43%	212,0
cenenac	116	257	314,0	18,15%	173,0
srpen	119	164	225,0	27,11%	180,0
zari	160	127	195,0	34,87%	228,0
njen					
listopad					
prosinec					

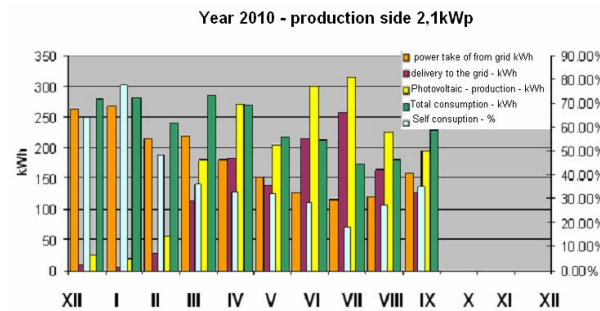


Fig. 6 Measured values, production site (2,1 kWp)

From the figure 6 it is evident, that in the time period when the biggest power from photovoltaic system is available, rate of self consumption is decreasing to lowest value. Rate of self consumption rely on electrical appliances equipment of given household. It is possible to increase self consumption of production site using control unit for self consumption as is mentioned below.

### 4.2 Production site 2 kWp-holiday property-since August 2010 installed control unit

In the Table 2 are given values of generated electricity using photovoltaic system with installed power 2,0 kWp [10]. Hereafter are in the table given values of entire electricity taken from electrical grid, amount of electricity given from photovoltaic system to the grid, entire consumption of electricity in production site and percentage usage of electricity generated using photovoltaic system as a self consumption. Measured

values are given in Figure 7. Particular production site is used as holiday property and has installed electrical heater for hot water preparation. Entire consumption of holiday property consists of consumption in high tariff (HT) and low tariff (LT, 8h per day). Distribution of consumption in high tariff, low tariff, self consumption and amount of electricity transmitted to distribution grid [kWh] are given in Figure 8

Table 2 Measured values, production site 2,0 kWp

2010	Power take of from grid-[kWh]	Delivery to the grid-[kWh]	Photovoltaic production-[kWh]	Self consumption [%]	Total consumption [kWh]
XII	262	9	25,0	64,00%	278,0
I	162	32	35,0	8,57%	155,0
II	129	79	90,1	12,32%	140,1
III	131	186	204,8	9,18%	149,8
IV	140	241	269,2	10,48%	168,2
V	126	195	215,4	9,47%	146,4
VI	135	251	279,1	10,07%	163,1
VII	84	273	311,4	12,33%	122,4
VIII	25	98	232,0	57,76%	159,0
IX	34	42	188,0	77,66%	180,0
X	40	30	146	79,45%	156,0
XI					
XII					

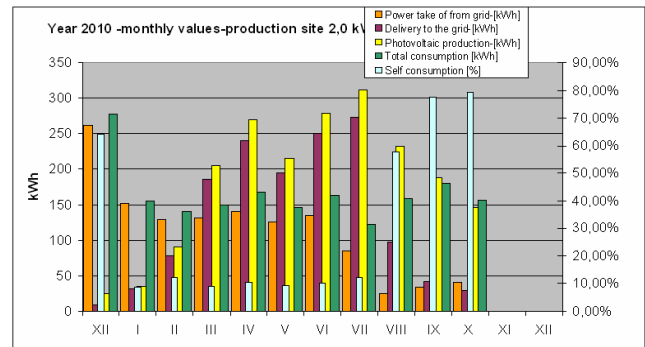


Fig. 7 Measured values, production site (2,0 kWp)

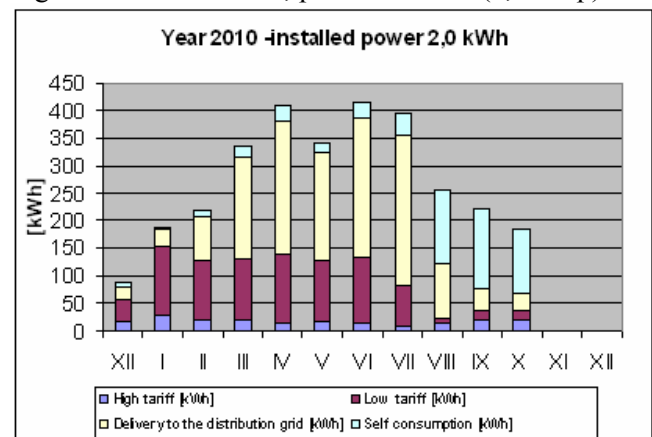


Fig. 8 Distribution of consumption and production (2,0 kWp)

From the Figure 7 and Figure 8 it is evident, that it is possible significantly increase self consumption of production site using control device for self consumption. Control device is in operation since August 2010. At this time the control unit is a prototype, which is not available on the market. One can suppose that using appropriate configuration of electrical appliances it is possible to increase self production of current state.

Case offer from supplier for investor who wants to invest into building located installation with power 4,24 kWp was demonstrated.

Legislative requirements according to Czech law were pointed out and possible situations for photovoltaic installation holder as well. Negative influence of legislative requirements to an economic return of investments is evident.

## 5 Conclusion

The aim of the article was to show current situation with photovoltaic systems in the Czech Republic.

Case offer from supplier for investor who wants to invest into building located installation with power 4,24 kWp was demonstrated.

Legislative requirements according to Czech law were pointed out and possible situations for photovoltaic installation holder as well. Negative influence of legislative requirements to an economic return of investments is evident.

Finally measured values from real production sites were published and possible solutions for optimization of self consumption were mentioned. Function of control unit for self consumption was showed by means of measured values.

## ACKNOWLEDGMENT

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