ISSN 0543-5846
METABK 51(3) 365-368 (2012)
UDC – UDK 669.188:669.041:628:515:622.81=111

EVALUATION AND COMPARISON OF RETURN OF INVESTMENT FOR PROPOSED USE OF SOLAR SYSTEMS IN THE CZECH AND SLOVAK REPUBLIC

Received – Prispjelo: 2011-09-21
Accepted – Prihvaćeno: 2011-12-20
Review Paper – Pregledni rad

The aim of the paper is to evaluate return of investment (ROI) and cost savings from proposed use of solar systems for residents funded by government grants. The paper deals with proposals for solar energy systems for various use, simple calculations of payback periods of solar systems financed with subsidy and without subsidy. Apart from climatic conditions, chemical composition the of the absorber and structural elements that are made of copper, respectively aluminum and Al-Mg alloy play an important role in assessing the payback period of the investment in solar panels.

Key words: renewable energy, solar energy, Czech and Slovak Republic, payback period, cost savings.

Procjena i usporedba povratka ulaganja predloženog rabljenja solarnih sustava u Češkoj i Slovačkoj. Cilj članka je procjena povratka ulaganja (PU) i ušteda troškova za predloženo rabljenje solarnih sustava stanovanja utemeljenih pod pokroviteljstvom vlade. Članak daje prijedloge za solarne energetske sisteme za različite upotrebe, jednostavni izračun termina povratka ulaganja sa i bez subvencioniranja. Dijelovi za klimatske uvjete, kemijski sastav absorbera i strukturalnih elemenata napravljeni od bakra, odnosno aluminija i Al-Mg legura igraju veliku ulogu u procjeni termina povratka investicije za solarne panele.

Ključne riječi: obnovljiva energija, solarna energija, Češka i Slovačka, termin povratka ulaganja, uštede troškova.

INTRODUCTION

Solar Energy-situation abroad

South Africa is on its way to becoming a leader in the green energy revolution with a giant solar park which, once fully built, will be the largest in the world [1].

The world´s largest photovoltaic solar plant wa s opened in Southern Spain with an installed peak power of 23 MW [2].

The largest share of solar energy per inhabitant is currently in Cyprus, where up to 90 % of residential buildings have solar collectors installed. In Israel more than 700 000 households are equipped with simple solar collectors in the price of about $ 500 [3].

Possibilities for financing solar systems in Slovakia

Funding from the state budget is in the form of government grants under the Program of the Ministry of Economy established by Resolution No. 383/2007 on the draft Strategy for greater use of renewable energy in Slovakia.

The amount of subsidies for solar energy is:

a) € 100 per 1 m^2 of installed solar collectors in the range of maximally 8 m^2 area, including the family home,
b) € 50 per 1 m^2 of installed solar collectors in the range of more than 8 m^2 area in the family house,
c) € 100 per 1 m^2 of solar collectors installed in an apartment building, the maximum subsidy is not more than 3 m^2 for each apartment in the apartment building [4].

Possibilities for financing solar systems in the Czech Republic

State support for domestic water heating and heating is currently very simple. This is a Program of the Ministry of the Environment which aims to implement measures that lead to energy savings and usage of renewable sources in family and residential buildings.

Determination of payback period will be calculated for single-family house with four residents, thus the area of Renewable energy sources for heating and hot water preparation will be used. If we continue to consider solar thermal heat exchanger in our discretion, then the condition for the grant is to achieve calculated annual solar gain in real use at least 350 kWh/m^2 area aperture collector (in the case of only for hot water preparation system)

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or 280 kWh/m^2 area aperture collector (in the case of domestic hot water preparation system and heating) and a total of 1 100 kWh for installation on a family house, or a total of 750 kWh per residential unit, which is connected to the system, for installation on a residential building. By installation which also serves the heating, the required calculated values of annual solar gain for the entire installation increase 1,3 times.

As shown in Table 1 the state supports domestic hot water preparation system and heating in different ways [5].

Table 1 **State aid in following sections**

Supported aid measurements	Subsidy CZK/€*
Solar system for hot water preparation	55 000/2200
Support for project to check the correctness of the implemented measures	5 000/200
The total subsidy for domestic water heating	60 000/2400

* 1 € = 25 CZK

The proposal of solar system for a house

The following section will focus on solar system design for a natural person that is owner or co-owner of the house / 4 person household / for domestic hot water heating and heating support. We suggest to use the most often used flat solar collector TS 300 [6].

In the production of solar collectors as the most efficient method for quality control seems to be modified Failure Mode and Effect Analysis (FMEA), which is possible to eliminate defects before products are approved for production [7].

In terms of design solutions to manufacturers of specific products resulting from concepts, high thermal conductivity of metal elements plays an important role, which can be negatively reflected in increased rates of energy losses of body collector due to the possibility of unwanted thermal bridges existence, which is immediately reflected in the nature of heat balance of the collector and then in the economic efficiency of whole solar equipment operation as a comprehensive energy system.

Climatic conditions have a strong influence on the economics of solar thermal panels. Fundamental and technical parameters of the solar panel are the absorption surface: 1,76 m^2 and optical efficiency: 80 % that is one panel can use 700 – 930 kWh of energy per year. Other technical parameters such as weight, max. operating temperature etc. are not important for calculating the return in the assumption that they will not cause additional costs.

Solar collectors for domestic hot water heating

When sizing the solar system for domestic hot water heating, it is necessary to comply with these rules and conditions:

- Per one habitant of house area of 1,2 to 1,5 square meters of solar collectors is needed for the preparation of 50 l of hot water a day with temperatures from 50 to 60° C a day,
- Ability to cover 58-65 % of annual energy for domestic hot water heating,
- One square meter collector area should have a reservoir (boiler) 45 to 65 liters.

For housing construction (detached houses) consumption of hot water is calculated to 0,082 m^3/person day. For four people it is volume V = 0,328 m3/day. We also assume that the average temperature of cold water throughout the year is 10° C. Temperature needed for common use of domestic hot water is 55° C.

While respecting these rules and conditions, we can propose the following household solar system :

$$Q_{TUV,den} = (1+z)\cdot\frac{\rho\cdot c\cdot(t_2-t_1)}{3600} = 21{,}5\,kWh$$

Z - loss of heating system (assumption for domestic hot water heating by electric boiler 0,25)
ρ - water density (1 000 kg/m^3)
C - measurable heat capacity of water (4 186 J / Kg K)
t1 - running water temperature (55° C)
t2 - running water temperature (10° C)

By simple assumption of needed function throughout the year we get to the number of energy needed for domestic water heating:

21,5kWh· 365 days = 7,84 MWh/year

if we neglect the difference in temperature t1 during the year and amount of solar radiation. From the knowledge of annual energy consumption and intensity of solar radiation we will now define how large area and how many solar-thermal heat will be needed [8].

The intensity of solar radiation for Prague is 3 801 – 3 900 MJ / m^2 per year, i.e. approximately 1,07 MWh / m^2 per year.

The resulting absorbent surface is given by:

Sa = 7,84 MWh / year / 1,07 MWh / year per m^2 = 7,32 m^2

and the number of solar panels

7,32 m^2 / 1,76 m^2/piece = 4,15 pc.

Here it is needed to calculate with the effectiveness of the selected solar thermal heat exchanger of 80 %. This means that only 80 % of incident solar energy will be used.

Sa = 7,32 m^2 / (1,07 MWh/year/m^2· 0,8) = 7,32 / 0,856 = 8,55 m^2

and the resulting number of pieces

8,55 m^2 / 1,76 m^2/piece = 4,8 pc, this means 5 pcs.

If we assume the use of solar collectors to cover the hot water of 60 %, let's assume 60 % coverage of needed energy

Sa = (7,84 MWh / year · 0,6)/(1,07 MWh/year/m^2 · 0,8)) = 4,7 / 0,856 = 5,5 m^2

and consequently the number of pieces

5,5 m^2 / 1,76 m^2/piece = 3,12 pcs

We will use the same calculation for Slovakia just the incident of energy will be different according to the selected location. If you choose this energy in the size of 1 275 kWh, we analogously get to 2,6 piece of solar panel that is 3 pieces.

Empirical experience of constructors of thermal insulation is a need from 1,2 to 1,5 square meters per person. For 4 people there will probably be a need 4·1,35 m^2 = 5,4 m^2 and then the number of collectors 5,4 / 1,76 = 3,06 this means 3 pieces again.

For further calculation of return we will therefore continue using 3 pieces of solar thermal collectors.

Table 2 **Real budget proposal for domestic hot water heating systems in Slovakia [9]**

	Price with VAT in €
Collectors (3 pcs)	1 302,34
Other material	2 215,59
Work	558,11
Technical-organizational arrangements (transport)	119,00
TOTAL PRICE	4 195,04
PRICE including a government subsidy of 200 € per m^2 net absorption area (1 068 €)	3 127,04

The initial investment of selected collector TS 300 is its purchase. Its price in the Czech Republic is set at 1 2300 CZK. Initial investment is therefore a purchase worth of 12 300 · 3 = 36 900 CZK. We will use percentage of other materials used, transport and work related to the price of collectors from the budget table in the Slovak Republic.

Table 3 **Real budget proposal for domestic hot water heating systems in Czech republic [10]**

	Price with VAT (CZK/€)
Collectors (3 pcs)	36 900/1476
Other material	62 776 /2511
Work	15 813 /632,5
Technical-organizational arrangements (transport)	3 372/134,9
TOTAL PRICE	118 861/4754,5
PRICE with the state subsidy (60 000 CZK/2400€)	58 861/2354

The state subsidy in Czech Republic in this case is 60 000 CZK and therefore after the subsidy the total investment is 58 861 CZK.

Comparison of solar collectors use for domestic water heating in terms of cost savings and payback periods in the Slovak Republic and the Czech Republic

In our case, we calculated with a simple payback period, which is sometimes called a simple repayment period. When calculating a simple payback period it is necessary to calculate the cost of savings over conventional electric domestic hot water heating way. Input data for calculation on the basis of obtained documents are summarized in the table below, while the cost savings is calculated as:

Cost Savings = annual energy production by collectors times average price for 1 kWh of electricity.

Simple repayment period, respectively simple return is considered as a simple economic criterion. The basic calculation is:

Simple payback period = investment cost / cost savings.

With state support we can use solar energy to heat water for another approximately 17 years at low operating costs. With this subsidy, we will reduce the payback period in 4,5 year compared to the system financed without subsidy. If we consider a 2 % increase in electricity prices, the investment will be paid back in about 11,5 year, while we don´t take inflation and possible introduction of reduced value added tax (VAT) rate on the solar system into account. If we compare payback period of investments into solar technology with thermal energy from biomass from the perspective of the finances they are approximately the same (after including subsidies) but in terms of technological intensity, solar energy is more environmentally friendly [12].

Table 4 **Input data and calculated cost savings – Slovak Republic [11]**

	DWH
Number of collectors	3
Operating costs	13,28 €
Energy gain from collectors	820 kWh
Annual production of energy	2460 kWh (820kWh x 3)
Average price for 1 kWh of electricity in the year 2010	0,0957 €/kWh
Savings €/year	235,42 €

Table 5 **Simple payback period of solar domestic hot water systems – Slovak Republic [11]**

	Without subsidy	With subsidy
Investment costs	4 195,04 €	3 127,04 €
Simple payback period	17,81 year	13,28 year

To calculate payback periods in the Czech Republic it is important to set the price of electricity for 1 kWh. Our selected geographical location corresponds to the supplier who offers the low rate ‘Komfort Kombi 16 “ price for 1 kWh = 1,59 CZK with VAT.

Operation of the collector is essentially maintenance free and therefore additional annual maintenance costs will be assumed zero. Furthermore it is possible to assume gain of solar energy 820 kWh/year from one collector, the same as it was in Slovakia, therefore three collectors:

820 kWh · 3 = 2,460 kWh / year.

Annual savings in cost per kWh is therefore

2 460 · 1,59 = 3 911,4 CZK

Payback period will equal the share of investment and annual savings

Tr = 58 861 / 3911,4 = 15,04 year

Table 6 **Input data and calculated cost savings – Czech Republic [13]**

Number of collectors	3
Energy gain from collectors	820 kWh
Annual production of energy	2460 kWh (820kWh x 3)
Average price for 1 kWh of electricity in the year 2010 *	1,59CZK /kWh
Savings CZK/€ year	3 911,4 CZK/156€

* “Komfort kombi 16“ - price for 1 kWh = 1,59/0,0636 CZK/€ with VAT

The assumption of the energy prices increase is not considered in this comparison, but we can assume that the return will be less than 15 years and also that the lifetime of collectors will be at least 25 years. The col-

Table 7 **Simple payback period of solar domestic hot water systems – Czech Republic [13]**

	Without subsidy	With subsidy
Investment costs	118 861 CZK/4554,5€	58 861 CZK CZK/2354€
Simple payback period	30,3 year	15,04 year

lector may record revenues throughout 10 years, although its effectiveness will gradually decrease.

Table 8 **Comparison of basic indicators in the Czech Republic and Slovak Republic [13]**

	Czech Republic	Slovak Republic
Investment costs	118 861 CZK/ 4 755 €	4 195 €
State subsidy	60 000 CZK/ 2 400 €	1 068 €
% of total investment subsidy	50,5 %	25,45 %
Price for 1kWh	1,59 CZK/ 0,063 € /kWh	0,0751 €/kWh

The table summarizes and compares the basic parameters that affect the return on investments in solar systems for domestic hot water heating in both countries.

CONCLUSION

Currently the most widespread and how it is possible to see from the calculations, effective way of solar systems use is domestic hot water heating. This system is a very effective method of converting sunlight into energy. While solar cells achieve efficiency to produce electricity according to the performed analysis about 10-15 %, solar collectors have efficiency from 50 to 90 % for hot water preparation. The assumption for achieving a higher degree of energy coverage needs and also a higher economic efficiency is installation of solar collectors in new buildings, the construction of low-energy house. The state can contribute to interest increase of the equipment using solar energy by providing state subsidies and tax advantages.

Acknowledgment

The paper was written within the project SEE/A/037/2.4/X - „ENER SUPPLY - Energy Efficiency and Renewables - Supporting Policies in Local level for Energy and the project VEGA 1/0339/10 „Economic growth and it´s limits factors."

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Note: The responsible translator for English language is Viera Nemčoková CSc. from TU Košice, Slovakia.