THE ENERGETIC UTILIZATION OF SOLAR PHOTOVOLTAIC SYSTEMS FOR INDIVIDUALS, PRICE CHANGES IN HUNGARY

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ABSTRACT
The energy consumption has an important role in Human life and one of the biggest challenges is the continuously growing energy demand of the world.
The aim of present study is to review the determination of the characteristics of the Hungarian energy supply, the introduction of renewable energy utilization and the economic determination of the return of crystalline solar systems in Hungary. This study shows us the effect of the changing investment cost to the payback period. This calculation can be important for a household to decide by or against a solar (PV) system.
The main direction of our recent research is the utilization of photovoltaic (PV) solar energy. The studies were performed with crystalline solar systems. The research was carried out in solar-electric power plants extended from 3 kWp to 12 kWp. The study is about the investment of crystalline solar cell systems. The payback period is studied due to the help of static and dynamic indices.

Keywords: renewable energy for individuals, solar energy utilization, static indices, dynamic indices

INTRODUCTION

The PV technology generates direct current (DC) electrical power measured in watts (W) or kilowatts (kW) from semiconductors when they are illuminated by photons. The solar cell generates electrical power. When the light stops, the electricity stops. Solar cells never need recharging like a battery (LUQUE ET AL., 2011).
The solar energy is popular because of it is available for almost every consumer. The solar energy could increase the energy independence of countries or companies. Solar systems do not need transport of row materials, because the solar energy comes to the place of utilization. Solar energy can be planned ahead in a limited way, which is available in the largest quantities in summer. To build a PV system needs significant investment, but they do not contain moving parts (except for the inverter) and ideally it has to be maintained between 10 and 15 years.

MATERIAL AND METHOD

Hungarian energy supply

The energy consumption of Hungary was 1162.4 PJ in 2011, 39.17% was domestic production and 60.83% was import. An average Hungarian family needs 2500-5000 kWh of electricity/year. In our country, the oil, the coal and the gas consumption were almost 76%. The nuclear energy use in 2011 was 14.72% (electricity import ~2%) and the share of renewable energy was more than 7.85% (www.mavir.hu) (*Figures 1, 2*).

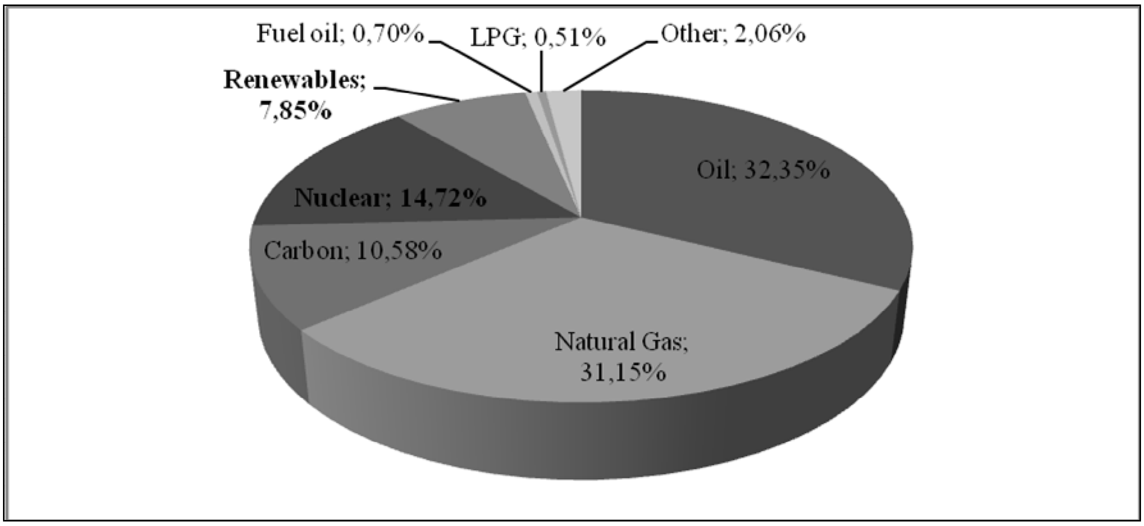

Figure 1. Composition of energy consumption in Hungary (2011)
Source: own work based on www.mavir.hu, 2011

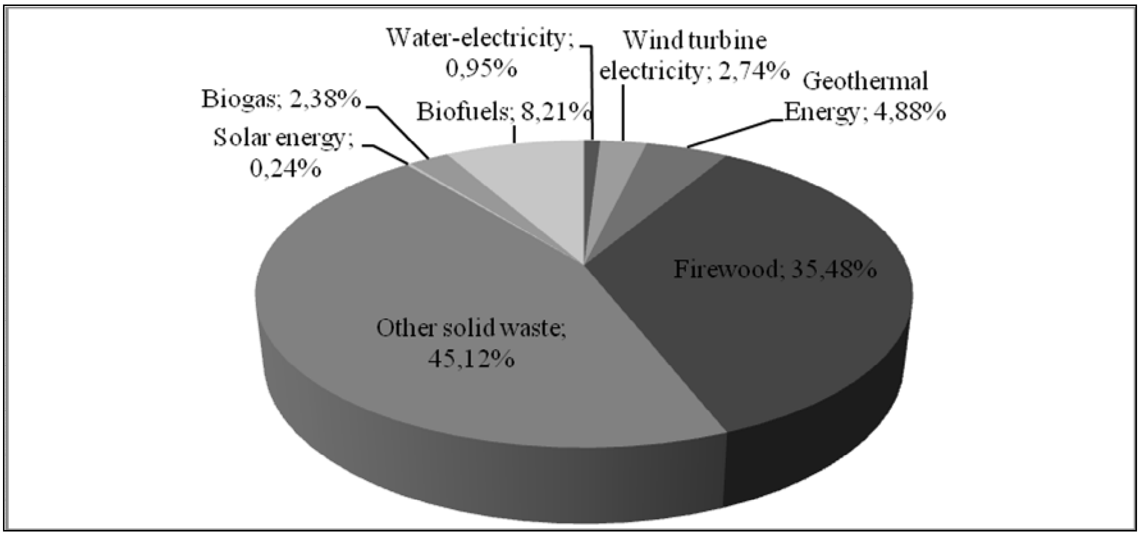

Figure 2. The use of renewable energy resources in Hungary (2011)
Source: own work based on www.mavir.hu, 2011

Solar energy and solar PV systems
Solar power of 1200 kWh/m^2 – 1360 kWh/m^2 comes to Hungary every year. We calculated with 1280 kWh solar energy / year in Hungary based on Photovoltaic Geographical Information System (including losses) (www.www.solargis.info, www.re.jrc.ec.europa.eu). The price/Watt relationship of 6 different solar systems of different performance was compared in February 2014 and in August 2014 (types produced for network, fixed onto slanted roof, finished systems, without any unexpected network development) (www.napelemdepo.hu, www.bacs-napkollektor.hu).
The type of solar panels are Renesola, SolarWorld and ET Solar. The brands of inverters are Kaco Powador, SMA and Fronius.

Static indicators

Their feature is that they do not take the money value of time into account (NÁBRÁDI ET AL., 2008).

Average profitability of the investment

It expresses the efficiency of the investment and the relationship of expenditure and profit in its simplest form (NÁBRÁDI ET AL., 2008).

Br =(E /B)*100

Br the profitability of investment (%)
E the average annual return of investment (EUR)
B one-time investment cost (EUR)

Payback time period

It expresses how many years it takes the investment to return from average surplus (NÁBRÁDI ET AL., 2008).

Bm = B/E

Bm the payback period of investment (years)
E the average annual return of investment (EUR)
B a one-time investment cost (EUR)

Dynamic indicators

Dynamic calculation methods take the time factor into account.

Net present value (NPV)

In finance, the Net Present Value (NPV) or Net Present Worth (NPW) of a time series of cash flows, both incoming and outgoing, is defined as the sum of the present values (PVs) of the individual cash flows of the same entity (Net Present Value).

$$\mathbf{NPV} = \sum_{i=1}^{n} \frac{Ri - Ii - Ci}{(1+r)^{i}}$$

NPV Net Present Value (EUR)
n time of use (years)
Ri receipts in i year (EUR)
Ii investment cost of the i year (EUR)
Ci operating costs in i year (EUR)
r discount rate (%/100)

Internal Rate of Return (IRR)

The internal rate of return on an investment or project is the "annualized effective compounded return rate" or "rate of return" that makes the net present value (NPV as NET*1/(1+IRR)^year) of all cash flows (both positive and negative) from a particular investment equal to zero. It can also be defined as the discount rate at which the present value of all future cash flow is equal to the initial investment or in other words the rate at which an investment breaks even (www.investopedia.com).

PV (R) Present Value of Output (EUR)
PV (I) Present Value of Investment (EUR)
PV (C) Present Value of Costs (EUR)

Profitability index (PI)

Profitability index (PI), also known as profit investment ratio (PIR) and value investment ratio (VIR), is the ratio of payoff to investment of a proposed project. It is a useful tool for ranking projects because it allows you to quantify the amount of value created per unit of investment (www.absoluteastronomy.com).

PI = PV(R)/PV(C)

If PI > 1 then accept the project

If PI < 1 then reject the project

Discounted payback period

It indicates how many years of discounted income is needed to return the sum of the initial investment (NÁBRÁDI ET AL., 2008).

RESULTS

PV systems cost in Hungary in 2014

In the last few years the prices of the PV systems have decreased. The decline in the price of the finished system is not completely in accordance with capacity of the installed power. Up to 5 kWp decrease can be experienced, over 5 kWp there is a smaller price increase and decrease.

The cheapest system regarding the watt / price connection was the 12 kWp in February 2014 and in August 2014 (three-phases, one inverter) (*Figure 3*).

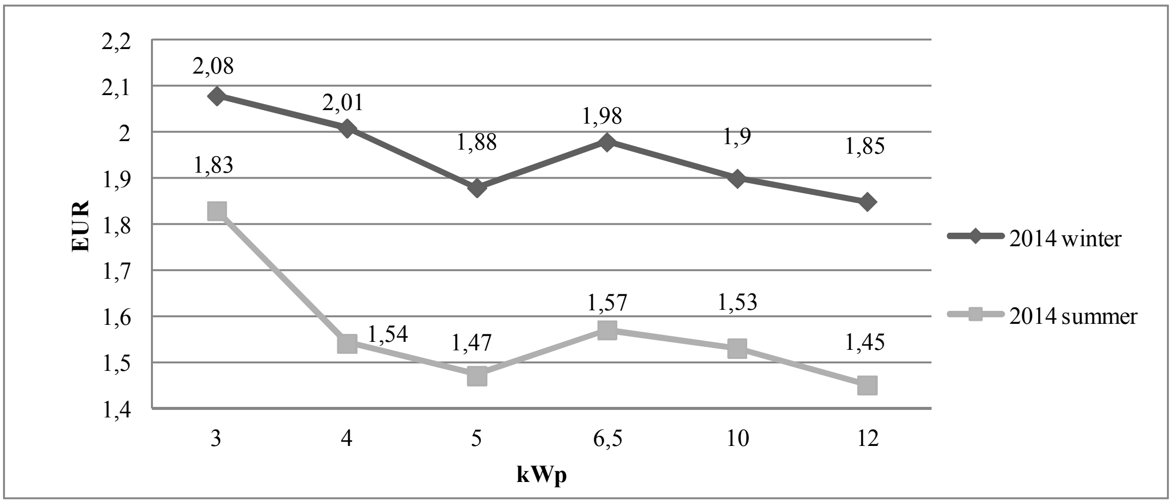

Figure 3. Investment costs of PV systems in 2014 winter and summer (EUR/Watt)
Source: own work

The payback period of domestic small PV systems

Statistic and dynamic indicators have used to examine the payback period. We calculated 305 HUF/EUR exchange rate. The SolarGIS data were used to the planning process, which provides high-resolution climate data, maps, software and services for on-line access to solar energy. A theoretical 1kW solar power plant can utilize 1200 kWh –1360 kWh energy (including losses).

An individual customer can have a saving of 0.1228 EUR/kWh in 2014. Energy measurement is carried out with a two-way measuring device. Excess energy (or all

energy) can be sold at 0.0506 EUR/kWh, so in the current situation solar power plants should be designed, that they do not produce more energy than the yearly used (www.solargis.info/, www.eon.hu).
We have studied the following systems: 3 kWp and 5 kWp (these are the most common categories) solar PVs. Only own capital investments are studied because in Hungary individuals have no financial support. One inverter is necessary to these systems and they do not require any maintenance for 10-15 years. We calculated according to the following method: 1 kWp solar PV system can produce 1280 kWh (the average of 1200 kWh and 1360 kWh). The average annual amortization was 0.3%/year based on practical experience, the returns were examined for 15 years (www.solargis.info/; www.napelemdepo.hu; JORDAN AND KURTZ, 2012).
The life expectancy of inverters is between 10-15 years. The replacement is assumed in 15 years' time. The electricity prices increased about 7%/year between 2000 and 2010. We calculated with a better value because the current market conditions, difficult to calculate the current price increase (artificial price reduction) (MEKH, 2014).
The price of electricity has been considered with 4% annual price increase (Starting from 2014 0.1228 EUR/kWh), assuming 100% consumption of energy. Different kinds of natural damage (lightning, hail) were not taken into account.
A financial discount rate of 8% was calculated because 8% financial discount rate should be applied to the cash flows discounting in Hungary (NFÜ, 2008, www.vati.hu) (*Table 1*).

Table 1. 1kWp solar PV system savings in one year in Hungary for individuals in 2014

Source: own work

1kW solar PV system energy produced (kWh)	1280
Electricity supply retail selling price of electricity in 2014 (Euro Cent / kWh)	12.28
Overcapacity purchase price (Euro Cent / kWh)	5.06
Savings at 100% utilization (EUR)	**157.2**
Savings at 0% utilization (EUR)	**64.8**

The results of our study

Static indicators

The data clearly show that the profitability of a 3 kWp system was 9.8% in winter, while this value was in summer 1.4% better. The 5 kWp system was 3.1 % better in summer than in winter. The payback period by solar power plants is can be made among 7 and 9 years in summer (*Table 2*).

Table 2. Analysis of the profitability of investment and the investment payback

Source: own work

Year	**2014 February**	**2014 August**	**2014 February**	**2014 August**
The size of the system (kWp)	3		5	
E (EUR)	615	615	1026	1026
B (EUR)	6 255	5 496	9 409	7 370
Br=E/B*100 (%)	9.8	11.2	10.9	14
Bm=B/E (Years)	**10.2**	**8.9**	**9.2**	**7.1**

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Dynamic indicators

The examined 3 kWp plants are not recommended to be implemented in 15 years but the payback period is 2.3 years better in summer than in winter (*Table 3*).

Table 3. Dynamic indicators analysis in 15 years, 3 kWp system

Source: own work

Year	2014 February	2014 August
System size (kWp)	3	
Investment costs (EUR)	6 255	5 496
Maintenance costs (EUR)	0	
Electricity charge savings, at the same price (EUR)	9 230	9 230
r = interest (%)	8	
Present value savings (EUR)	5 002	5 002
NPV (EUR)	-1 252	- 493
IRR (%)	4.84	6.63
PI	0.80	0.91
Discounted payback period (Year)	**(18.8)**	**(16.5)**

NPV, PI, IRR:

The examined 5 kWp plant (2014 winter) is not recommended to be implemented in 15 years. In this form the payback period is about 17 years.

The examined 5 kWp system (2014 summer) is recommended to be realized and the payback period is about 13 years. The return of investment is 3.6 years better in summer than in winter (*Table 4*).

Table 4. Dynamic indicators analysis in 15 year, 5 kWp system

Source: own work

Year	2014 February	2014 August
System size (kWp)	5	
Investment costs (EUR)	9 409	7 370
Maintenance costs (EUR)	0	
Electricity charge savings, at the same price (EUR)	15 384	15 384
r = interest (%)	8	
Present value savings (EUR)	8 338	8 338
NPV (EUR)	-1 071	968
IRR (%)	6.25	9.9
PI	0.89	1.13
Discounted payback period (Year)	**(16.9)**	**13.3**

CONCLUSIONS

A PV system of 3 or 5 kWp can be enough for an average Hungarian family, which uses 2500-5000 kWh or more electricity. The cost of a 3 kWp system is slightly more expensive (also in winter and in summer) regarding watts / price, than the 5 kWp solar power plant. The counted payback period shows us the same result: it is higher at the 3 kWp system than at the 5 kWp system.
It would be important to rationalize the transfer price of the extra energy. This amount is in the size of domestic small power stations 0.0506 EUR net (for individuals).
With an interest rate of 8% has been calculated in the article but the bank rates in Hungary were around 1-2%. Thus the net present value of these investments could be better if the individuals compare the rate with a bank rate and not with a long term stocks.
Our final results show us that the 3 kWp system is too small for a real savings: the investment cost of it is bigger than the net price of the energy saving but at the 5 kWp system the present value of the energy saving is bigger than the investment cost.

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