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RETURN ON SOLAR CELL INVESTMENTS BASED ON A HUNGARIAN EXAMPLE[1]

Key words: solar energy, solar cells, savings, return on investment, payback period

ABSTRACT. Solar cells are not only environmentally friendly, but save considerable electricity costs as well (namely, in this case, only maintenance costs have to be paid, the value of which is significantly lower than the price of electricity). The long term aim is for these energy sources to be applied and used by all macroeconomic actors (companies, households, the government and other institutions). Such cells can be introduced by applying for a considerable amount of investment subsidies at an EU level and in Hungary, as well. However, the ROI of this kind of undertaking is long term. The aim of this study is to examine whether a non-profit public institution would find it worthwhile to invest in this type of venture in the long term. Thus, the ROI of a solar cell investment was examined at a well-known environmentally public institution, at an abbey in Hungary. Data were provided by the abbey. From available data, ROI calculations were carried out and the approximate payback period was estimated. Calculations were carried out taking into account different scenarios. One part of the research focused on the inflation rate (there was a case where the inflation rate was ignored), in the other part, the cost of investment was taking into account in different ways. The payback period of solar cell investment is relatively short (11-13 years) in the case of EU or government subsidies, otherwise it is quite long (25-30 years).

INTRODUCTION

According to Tamás Kocsis [2008], in order to stop harmful environmental processes and achieve sustainability, Earth's energy management needs to be based on new foundations. The solution is primarily to reduce energy consumption in developed countries. However, environmental pollution is not exclusively due to an enormous increase in energy use, though it contributes to it significantly. Therefore, air pollution could be reduced by using environmentally friendly energy, which would significantly reduce energy waste. This is mainly possible by choosing a renewable energy source. Currently, the following renewable energy sources are available: solar energy, wind energy, hydropower, geothermal energy, biomass, biodiesel, and heat pumps [Szecsei, Kacz 2011]

Solar energy is one of the most popular sources of renewable energy and is relatively easy to access. Solar energy is the energy released during solar fusion processes. Currently,

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this type of energy source is hardly used by society, although it offers many benefits, such as easy access; it is a clean and environmentally friendly energy source; it is available for millions of years; it has a positive impact on the local economy; there is no need to deliver it, etc.

Solar energy may be utilized in an active and passive way. Passive utilization mainly concerns buildings and their orientation. This is an energy use where building design allows the use of sunlight and solar radiation. In this case, determining factors are building materials and the orientation of the building. Active use includes the use of solar cells and solar collectors. Both methods are a good way to use solar energy for the benefit of society. An important difference is that the solar cell provides electricity and the solar collector provides thermal energy. That is, a solar cell converts solar energy into electricity by means of a so-called photovoltaic system. Solar energy is transformed directly into electricity by means of solar cells. The low DC voltage obtained can be used to operate different devices (e.g., lighting, ventilation, etc.). If necessary, 230V AC consumers can also be operated by the use of an inverter unit. The energy collected is stored chemically in batteries or in other ways, for example, as local energy for water, and is used as required. In many cases (for instance at farmsteads), it is necessary to provide energy in a place where no installed energy supply network is available. However, it is usually not possible to build a power supply network because of the high costs involved. This energy-saving device has no harmful effect on the environment and does not pollute the atmosphere, as no harmful substances are released during operation. In contrast, a solar collector utilizes solar energy to heat air or water, so heat energy is at the centre instead of electricity. Solar collectors are as energy efficient and environmentally friendly as solar cells and have a long service life. This system is more like auxiliary heating and is best used in spring or autumn. With this it is not possible to become a stand-alone energy provider as opposed to solar cells [Horváth 2006, Bartholy et al. 2013, Swami 2012, IEA 2011, EC 2009].

The analysis of Fraunhoffer ISE (2015) shows that solar power will soon be the cheapest form of electricity in many regions of the world. IRENA (2012) stated that the total installed cost of PV systems can vary widely within individual countries, and between countries and regions. These variations reflect the maturity of domestic markets, local labour and manufacturing costs, incentive levels and structures, and a range of other factors.

EVALUATION OF ENERGY INVESTMENTS

In assessing the future return on investment, both the expected costs and revenues of the investment should be taken into account. In addition to the initial cost of construction, expenditures include future operating (operating, maintenance, depreciation) costs as well, while revenues represent future positive cash flow. Investment – based facilities are generally long-lived, therefore their revenue and expenses related to their operation are also long-term [Kovács et al. 2015].

There are several methods available for evaluating energy efficiency investments. On the one hand, general evaluation methods used for other investments may be used. One of these groups is the so-called static investment-economy calculations (e.g., a comparison of costs or profit, the determination of the payback period and the average profitability of the investment), which do not take into account the time value of money, while the so-called dynamic investment-economy calculations (e.g., net present value calculation (NPV), internal rate of return (IRR), profitability index (PI)) are based on the time value of money [Brealey et al. 2003]. The disadvantage of the latter is that it ignores the rate of inflation and that it may only be used for calculations where net cash flows can be predicted for the entire expected lifetime of the investment.

Another evaluation opportunity is the so-called Life Cycle Cost Analysis (LCC), which takes into account the costs and revenue at each stage of a project, so it can predict the cost-effectiveness and success of implementation. Knowing the full life-cycle cost, it calculates an annual cost ratio that can help to determine the payback period of resources for energy efficiency, renewable energies, and other savings, which is longer than the expected life cycle of the investment. Similarly to the previous – dynamic investment-economics -calculations, LCC also takes into account the time factor and discounts the individual costs for the same period. The disadvantage of this method is that, in the calculation of costs, the analysis period is also a predetermined time interval (e.g., 30 years). Thus, if the expected lifetime of the investment or the expected payback period is not known, expected return may be determined by using an approximate method [Csermák 2017]. In the research of Károly Csermák [2017], it was stated that the passive thermal insulation of buildings and the replacement of doors and windows, as well as the placement of solar cells on high rooves could be an optimal solution, which would significantly reduce the cost of electricity for households. However, the latter only offers a ROI with significant government support.

The aim of the research is to investigate the solar cell investment of the abbey and the amount of electricity generated by solar cells. Developing energy efficiency tools is a special investment that is significantly different from the expansion of other fixed assets, as their construction and commissioning costs are very high, with a long payback period (up to several decades) for their establishment and no profit in cash. As this is not a revenue-generating investment, there is no income flow in this case, so instead the alternative income will be the value of unused and unpaid electricity, i.e., savings. As a result, a further feature of these investments is that the income flow is not balanced. Taking into account these conditions, the purpose of this analysis is to apply a calculation method that can be used to estimate the return on investment that is particularly energy-efficient. A further condition for a suitable method is to comply with the principles outlined in the accounting of the cash flows of investments, with particular regard to inflation.

RESEARCH MATERIAL AND METHODS

Primary data was provided by the abbey. Using the data, the return of the realized project was analyzed with financial calculations (inflation-adjusted payback period (PB) calculation). According to Szilveszter Farkas [2006] the payback period may be calculated as follows:

$$t + \frac{b - c}{d - c}$$

where:

t = the last full year in which the cumulative income is less than the amount of the initial investment, b = the amount of the initial investment, c = cumulative income for t years, d = cumulative income for $t + 1$ years.

The initial amount of investment (initial cash flow) is considered to be self-contribution. In the study, it was examined whether or not, from the point of view of the abbey, it is worth implementing the project. The initial cash flow is the cost of the investment, which, in this case, includes installation costs as well. The working cash flow is made up of 'revenue', which is considered to be the inflation-adjusted value of the electricity saved each year. In calculating inflation, "revenue" is adjusted by the annual average change in the price level of electricity, while the cost is adjusted by the annual average change in the general consumer price level. Since the price of electricity in Hungary is centrally regulated, it is very difficult to determine in advance how the price will develop in the future. For this calculation, there was a further obstacle in determining the period that is relevant for determining the annual average rate of inflation. To solve this, calculations were made for three periods: the period under review (from 2009 to 2016), a period of ten years (from 2006 to 2016), and from the millennium to present (2000 to 2016). The average annual growth rate of consumer price indices was calculated using the weighted geometric mean of the Consumer Price Index data of the Central Statistical Office, which are as follows: 96.13% (2009-2016), 101.42% (2006-2016), 104.06% (2000-2016).

Due to the fact that no data were available from later years for full return, the payback period of investment and all the data needed could only be estimated under the following conditions: under constant conditions (no new building expansion, no increase in heating), the average of the amount of annual electricity savings is used. Thus, the value of the savings was calculated for each year. The annual costs were adjusted with the annual growth rate of the inflation rate for the period 2009-2016 (each year). Net savings are equal to the value of the electricity actually saved. From the cumulative amount of these, it can be seen how much of the total value of the investment is covered by savings in a given year. The investment will be returned in the year when this number turns positive.

In this study, several possible outcomes (scenarios) were set up along two dimensions. One aspect is the consideration of inflation. In addition to possible annual growth, inflation was ignored in the fourth case. On the other hand, when determining the initial cash flow of the investment, two cases were distinguished: in the first, only the self-contribution provided by the abbey was considered as a cost of the investment, while in the second case the total cost of the investment was taken into account.

RESEARCH RESULTS

The abbey realized the solar cell investment within a government supported project. The total cost of the project is HUF 70,881,405, the subsidy rate is 60%, which means a total of HUF 42,528,843. Construction work was completed in June 2011 with a successful trial run. Solar panels were installed at two locations of the abbey. Two solar power plants were built in the abbey. On the roof of the 12 × 39 meter structured biomass heating plant, 141 pieces of 1.0 x 1.5 meters were installed at a 30° inclination, totaling 212 m^2. At the other venue, on the top of the Viator Restaurant and Wine Bar with a 9.5 x 46.5 floor, 126 pieces of 1.0 x 1.5 meters were located at an angle of 12° on an 189 m^2 surface. The solar cells were made by Kyocera, their type: KD210GH-2PU; rated power: 210 W (1,000 W/m^2 sunlight), total rated power of the system: 29.61 kW; and expected annual output: 55,500 kWh. The installed solar system can cover 10% of the annual electricity demand of the abbey with an expected annual output of 103,600 kWh.

Figure 1 shows the amount of electricity generated by solar cells at two locations in the abbey. The aggregate data on energy production at these two locations are different. The reason is that different numbers of solar cells were installed.

The output of solar cells varies from year to year, as the efficiency of a solar cell depends on the number of sunny hours. The power recovered from solar cells depends on the angle of incidence of light, the intensity of illumination, and the load attached to the solar cell. In Hungary, sunshine over 2,000 hours is typical in the southern and south-eastern part of the country, while the least sunny areas are in the northern, north-eastern parts of the country with the amount of sunshine constituting less than 1,800 hours a year. Figure 2 shows the amount of electricity generated by the solar panel and purchased from the energy supplier.

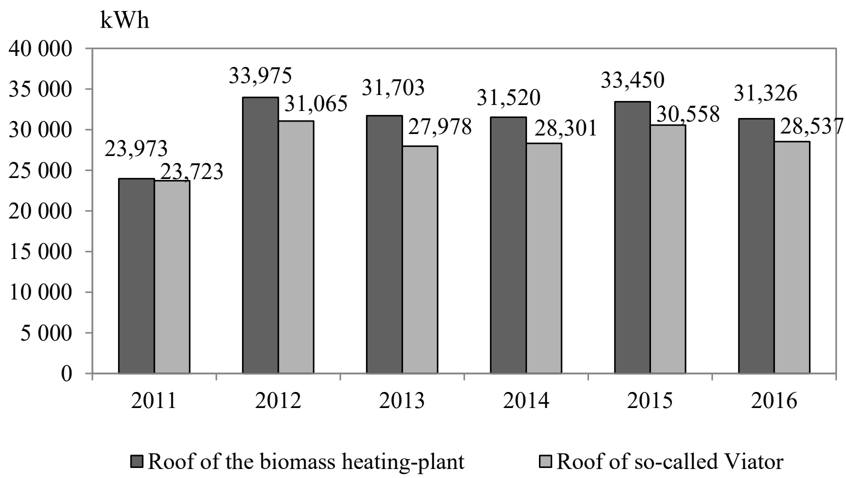

Figure 1. Electricity generated by solar cells at the abbey between 2011 and 2016
Source: own elaboration based on the data of the abbey

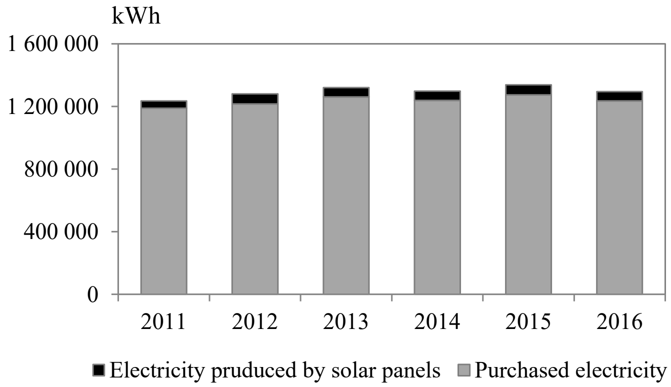

Figure 2. Purchased and produced electricity at the abbey

Source: own elaboration based on data of the abbey

It can be seen that the amount of purchased electricity did not decrease, but increased despite the solar cells. The reason is that the number of abbey buildings increased and new facilities were launched. In 2015, a total of 1,274,112 kWh of energy was purchased, while in the same year, 64,007 kWh of energy was generated from solar cells. This is 4.7% of total consumption. Thus, the electricity consumption of the buildings of the abbey is almost 5% covered by renewable energy sources.

In Table 1 the annual amount of electricity saved in the energy supply and the amount of money saved can be seen from the year 2011 (taking into account the annual average price of electricity), which is caused by the project (the average price for electricity was calculated with an annual average).

The return on the solar cell investment can be seen in Table 2. The total cost of the investment was HUF 70,881.405 of which the subsidy rate was 60%, giving a total of HUF 42,528,843, and self-contribution was at a level of HUF 28,352,562. Thanks to the electricity generated by solar cells over six years, the amount of savings equals approximately HUF 12,609,000. This constitutes 44.47% of the total investment cost.

In the case of ROI of the solar cells, the cost of investment was considered to be the self-contribution paid by the abbey. The summary of net savings shows that the rate of

Table 1. The amount and value of energy saved by solar cells at the abbey

Year	Electricity produced by solar panels [kWh]	Average consumption price of electricity [Ft/kWh]	Value of saved electricity [HUF]
2011	47,696	46.8	2,232,173
2012	65,039	48.5	3,154,392
2013	59,681	43.7	2,608,060
2014	59,821	38.3	2,291,144
2015	64,007	36.6	2,342,656
2016	59,249	36.6	2,168,506
Total	-	-	14,796,931

Source: own calculations based on data of the abbey and the Central Statitistical Office return here is relatively quick. The reason for this is that there is no maintenance or operation cost for solar cells, that is the cost of energy can be reduced by 100% on solar cells. In terms of payback time, only a future estimate could be made, which is presented in Table 3.

On the basis of estimation, it can be stated that the payback time of the solar cells is relatively short. The payback time of solar cells is significantly reduced with the help of government subsidies. Without this, it would only be able to make a ROI in 23-31 years, compared to the original 11-13 years. In terms of growth rate of the price index, the separation of the periods 2000-2016 and 2006-2016 is not relevant in this case either. However, the 2009-2016 period is not relevant here, as evaluable data was not received because the rate of change in the price level of electricity in this period showed a decreasing trend. If the price change really follows this trend, the price of electricity would decrease to zero year by year.

Table 2. ROI of the solar panels at the abbey

Year	Net saving [HUF]	Cumulated net saving [HUF]
2011	2,232,173	-26,120,389
2012	3,154,392	-22,965,998
2013	2,608,060	-20,357,938
2014	2,291,144	-18,066,794
2015	2,342,656	-15,743,340
2016	2,168,506	-13,589,432

Source: own calculations based on data of the abbety and the Central Statitistical Office

Table 3. Payback time of investment of solar cells under different conditions (years)

Initial cash flow	Ignoring inflation	Annual growth rate of price level between		
		2009 and 2016	2006 and 2016	2000 and 2016
Self-financed part of the total cost of the investment	12	13	11	11
Total cost of the investment	31	not relevant	27	23

Source: own calculations based on the data provided by the abbey and the Central Statitistical Office

SUMMARY AND CONCLUSIONS

Use of renewable energy sources is not only environmentally beneficial, but can also save significant energy costs. Thanks to the installed solar cells, the examined abbey can cover 5% of its electricity consumption, thus saving nearly HUF 2.2 million a year. However, installing these alternative energy sources requires very high investment costs. Although, most of these projects are realized with significant EU and government support, it is worth considering whether it there will be a ROI within the time frame expected before undertaking such an investment.

If so-called predictable and balanced inflation is present in the economy, the number of years necessary to achieve ROI can be estimated with a relatively high degree of accuracy. However, choosing the right method to calculate the return is an important consideration in the calculation of the return, which can provide a realistic estimate for the future. There are a number of realistic and reliable methods of calculating return on investment in the literature, but not specifically for investments to improve energy efficiency. These are different from other investments (high installation costs, the opportunity of using a large amount of government support, long payback period, alternative income generation), so special considerations should be taken into account in their return calculations – in addition to the generally expected principles of investments.

Examining the energy investment (solar cell installation) data of the abbey in several scenarios, it was found that, in the case of ignoring the impact of inflation, the payback time of the investment may be several times higher than the inflation-adjusted payback time, and if the annual rate of growth of the electricity price index is lower than the rate of growth of all products, then there is no ROI. This is especially true for the period 2009-2016, when utility tariffs decreased. For the previous period, a single annual rate of inflation can be expected.

In the case of the energy investments of the abbey based on these calculations, it was found that the investment amount of the solar cell installation will make a ROI in 11-13 years. If the total investment amount is also taken into account (i.e., the part of the self-contribution supplemented by government subsidies), the ROIs increases to 23-31 years. So, it can be seen that in the case of the solar cell a more accurate estimate will be achieved with the chosen method. It can therefore be concluded that in a public institution of this size, energy-efficient investments can be installed in a relatively short period of time with the help of government subsidies. However, one of the reasons for this is that these investments, especially solar installations, do not fit the size of the institution in terms of their size, and installed much smaller units than desired. (In accordance with the foregoing this is reflected in the fact that the abbey still buys a significant amount of electricity.) For the efficient operation of the abbey, it would be worthwhile installing solar cells for additional roof structures, which are now and will continue to be available in many further EU and government subsidies.

BIBLIOGRAPHY

Bartholy Judit, Hajnalka Breuer, Ildikó Pieczka, Rita Pongrácz, Kornélia Radics. 2013. *Megújuló energiaforrások* (Renewable energy sources). Electronic book. Eötvös Lóránd University, http://elte.prompt.hu/sites/default/files/tananyagok/MegujuloEnergiaforrasok/book.pdf, access: 27.05.2017.

Brealy Richard, Stewart C. Myers, Franklin Allen. 2003. *Principles of corporate finance*. New York: McGraw-Hill Irwin.

Csermák Károly. 2017. *Lakóépületek korszerűsítő felújításának költségelemzési és finanszírozási kérdései* (Cost analysis and financing issues for the modernization of residential buildings). *Polg*ári *Szemle* 12: 4-6.

EC (European Commission). 2009. Photovoltaic solar energy — Development and current research, Luxemburg, Belgium.

Farkas Szilveszter. 2006. *A vállalati pénzügyek alapjai* (Corporate finance basics). Győr: Universitas-Győr Kht.

Fraunhofer ISE. 2015. *Current and Future Cost of Photovoltaics. Long-term Scenarios for Market Development, System Prices and LCOE of Utility-Scale PV Systems.* Study on behalf of Agora Energiewende. Freiburg: Fraunhofer-Institute for Solar Energy Systems (ISE).

Horváth Ákos. 2006. *A napenergia modern felhasználásai. Háztartástól naperőműig* (Modern uses of solar energy. From household to solar power). *Annex of the Fizikai Szemle* 4: 1-2.
IEA (International Energy Agency). 2011. *Renewable Energy Technologies. Solar Energy perspectives.* Paris: International Energy Agency.
IRENA 2012. *Renewable energy technologies: cost analysis series*. *Solar Photovoltaics.* IRENA Working Paper 1 (4-5).
Kocsis Tamás. 2008. A környezeti problémákról közgazdasági-természettudományos *közelítéssel.* [In] *Hogy művelje és őrizze meg* (About environmental problems with economic-natural science approach. [In] To cultivate and preserve it), eds. S. Laura Baritz, D. Fülep, 69-90. Budapest; Szent István Társulat.
Kovács Árpád Endre, Zsigmond Gábor Szalay, Éva Klárné Barta. 2015. Az időbeni pénzáramok kezelése a gazdasági számításokban (Managing time cash flows in economic calculations). *Studia Mundi. Economica* 2 (2): 93-106.
Swami Rashmi. 2012. Solar cell. *International Journal of Scientific and Research Publications* 2 (7): 1-5.
Szecsei Tímea, Károly Kacz. 2011. Possibilities of evaluation of energy plant sector in agriculture. *Acta Agronomica Óváriensis* 53 (1): 35-44.

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ZWROT Z INWESTYCJI W OGNIWA SŁONECZNE NA PRZYKŁADZIE WĘGIERSKIM

Słowa kluczowe: energia słoneczna, ogniwa słoneczne, oszczędności, zwrot z inwestycji, okres zwrotu

ABSTRAKT

Ogniwa słoneczne są nie tylko przyjazne dla środowiska, ale również pozwalają na uzyskanie znacznych oszczędności kosztów elektryczności (w tym przypadku bowiem ponoszone są jedynie koszty konserwacji, które są znacząco niższe od cen elektryczności). Celem długoterminowym jest wdrożenie i korzystanie z tych źródeł energii przez wszystkie podmioty rynkowe w ujęciu makroekonomicznym (spółki, gospodarstwa domowe, instytucje rządowe i inne). Tego rodzaju ogniwa mogą również być wprowadzane do użytku przez składanie wniosków o udzielenie znacznego dofinansowania inwestycji do UE lub do węgierskiego rządu. Celem opracowania jest ocena, czy instytucja publiczna typu *non-profit* uznałaby za godną uwagi inwestycję w ten rodzaj przedsięwzięcia w ujęciu długoterminowym. Zwrot z inwestycji w ogniwa słoneczne zbadano na przykładzie węgierskiego opactwa, instytucji publicznej znanej z zaangażowania w kwestie ochrony środowiska. Wszelkie dane zostały udostępnione przez opactwo. Na podstawie tych danych obliczono zwrot z inwestycji oraz oszacowano przybliżony okres zwrotu. Obliczeń dokonano z uwzględnieniem różnych scenariuszy. Skupiono się na stopie inflacji (istniał również przypadek, w którym stopa inflacji nie została wzięta pod uwagę), a także uwzględniono różne podejścia do kosztu inwestycji. Okres zwrotu z inwestycji w ogniwa słoneczne jest stosunkowo krótki (11-13 lat) w przypadku uzyskania unijnego lub rządowego dofinansowania. W przeciwnym razie jest on dużo dłuższy (25-30 lat).

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