Legislative and economic tools of photovoltaic power support in Slovakia

***Katarína Čulková*[1], *Lucia Domaracká*[2] and *Mária Muchová*[3]**

At present, the photovoltaic power is subject to a number of discussions in domestic, as well as foreign studies and expert publications. Despite the conditions of the sunshine in the Slovak Republic, which are better than in the Czech Republic or Germany, Slovakia keeps relatively behind current trends in the construction of photovoltaic power plants. The goal of the contribution is, therefore, to present methods and tools that can present support for economic evaluation of photovoltaic power plants. We used mainly the Monte Carlo simulation for the analysis of investment risk with the aim to increase the quality of the decision. In applying the Monte Carlo method for the amount of produced energy and inflation, the cumulative balance of production and current estimated exceeds expectations in the future were predicted.

Key words: *solar energy, economic analysis, photovoltaic power plant, simulation Monte Carlo, Slovakia*

Introduction

At present, renewable energy sources and their effectiveness are subject to a number of discussions in domestic, as well as foreign studies and expert publications. Using the energy from RES has its big perspective for the future, but energy from RES is still rather financially demanded, comparing with conventional energy sources. There is much effort to search possible photovoltaic power use by analyzing the effectiveness of investment to this chosen RES. Using of photovoltaic power achieves more and more importance. Such source brings a real alternative to conventional sources, which stocks are limited and gradually spending. Photovoltaic power has the minimal influence to the climax, but despite some conveniences, development of photovoltaic power plants is still rather slow and limited.

Despite the fact that conditions of the sunshine in the Slovak Republic are better than in the Czech Republic or Germany, Slovakia keeps relatively behind current trends in the construction of photovoltaic power plants. It is because the legislation to promote renewable energy sources (RES) in Slovakia was adopted recently.

There are still presuppositions that photovoltaic installing and their development are exceedingly not effective and costly since we have available rather cheaper conventional sources. However, the problem of photovoltaic development is also the legislation and economic system, acting according to the principle „cheaper production, faster achievement of high profit". Photovoltaic development, its financial and environmental return, last for some period, it means that results cannot be expected immediately. Therefore, it is necessary to invest in photovoltaic with the aim to achieve broader space and time for technologies and innovation improving, and consequently it will lead to higher effectiveness of energy transmitting as well as shorter payback period.

Present state of photovoltaic power using in EU and Slovakia

The European Union as a whole is dependent on the import of primary energy sources – around 50 %. Member state in the EU had agreed on increasing energy production from RES in 2009. Its goal is to achieve a 20 % rate of RES till 2020. In 2011, its rate was estimated at the level of 13,4 % that presented a growth of about 0.9 %. Europe is investing considerably in renewable energies for a sustainable future, with both Iberian countries (Portugal and Spain) significantly promoting new hydropower, wind, and solar plants. (Jerez, et.al, 2013) The potential of solar energy is higher than another renewable source, although several limits exist (Aste, et.al, 2013). For example, the effect of technological evolution on the overall performance of photovoltaic power generation or establishing performance benchmarks for much larger variety types of photovoltaic power plants and technologies.

On the other hand, developed countries are going from darkness to darkness in the field of electricity power sector, which presents one of the chronic problems, and they encounter a huge and serious problem. Therefore, for example in Yemen, renewable energy sources are considered as one of optimal solutions for the power sector, mainly solar energies. (Alkholidi, 2013) Some studies prove that solar photovoltaic power plants have great potential and high-cost effectiveness for meeting the energy demand. (Chandel, et.al, 2014). It was also

[1] *doc. Ing. Katarína Čulková, PhD.*, TU Košice, Faculty BERG, Letná 9, 040 01 Košice, Slovak Republic, katarina.culkova@tuke.sk
[2] *doc. Ing. Lucia Domaracká, PhD.*, TU Košice, Faculty BERG, Letná 9, 040 01 Košice, Slovak Republic, lucia.domaracka@tuke.sk
[3] *Ing. Mária Muchová, PhD.*, TU Košice, Faculty BERG, Letná 9, 040 01 Košice, Slovak Republic, maria.muchova@tuke.sk

confirmed by studies of Zhang et.al, (2014) that Europe has the potential of photovoltaic energy, where ongoing photovoltaic development increases the contribution of solar energy exponentially. Within this significant potential, it is important for investors, operators, and scientists alike to provide answers to the mechanism, advantages and evolution of photovoltaic technologies.

Moreover, for example in Greece, the law of photovoltaic was provided for the first time in 2006, appealing feed-in tariff incentives for photovoltaic. Two subsequent laws formed an even more attractive investment and licensing context, both for photovoltaic installation. Photovoltaic capacities exceeded the national target for 2020 and caused continuously tremendous delays. The effectiveness of this legislative framework cannot be judged solely by the response of prospective investors, but also effective provisions as well as techno-economic assessment. (Karteris, Papadopoulos, 2013). There is necessary to assess also market characteristics (e.g. electricity price and production cost) that influence photovoltaic policy strength. There was proved the interaction of photovoltaic policy design, electricity price, and electricity production cost that is a more important determinant of photovoltaic development than policy enactment alone. (Jenner, et.al, 2013) Also Knez and Jereb (2013) proved the use of alternative renewable energy sources and registered successful investments in the field of solar power plants in Slovenia. However, whether or not such projects present a profitable investment - individuals, as well as companies, have to deal with it. (Knez, Jereb, 2013)

In Slovakia, the electrical energy is provided mainly by nuclear and heat power stations, with the remainder being produced in hydroelectric power stations. In this sector, renewable energy sources (RES) still represent a minimal share in Slovakia. (Rybár, et.al, 2012) Nonetheless, the years 2009 and 2010 specifically represented a turning point in legislation promoting RES, with the introduction of a guaranteed repurchase period for buying electricity produced by photovoltaic power. This resulted in a greater interest of investor in the building of energy sources for the production of heat and electricity including those derived from photovoltaic. (Tauš, Taušová, 2009)

As a member state of the EU, Slovakia is bound by Directive 2009/28/EC on the promotion of the use of energy from renewable sources to increase the share of used RES to 14 percent of the final gross energy consumption and 10 % in transport. The National Action Plan for Energy from RES anticipates that the proportion of RES used in gross energy consumption will, in fact, be 15.3 percent. (Decree No. 225/2011).

The present trend in Slovakia in the searched area is the so-called G-component that has a negative influence on the economic result of the company with the retrospective effect (www.sapi.sk). It presents payment for reservation of performance of energy producer with the effect from 1st January 2014. G-component influences mostly and mainly producers, producing energy from solar energy. In the frame of RES support of equipment for solar energy production, connected to the distribution net in 2010 and 2011, obtained claim of rather generous support. Act about RES support supports energy producers by an additional payment for 15 years. Through G-component, there is possibly real decreasing of higher mentioned support, which has a negative influence on the profitability of investment for construction of equipment for electricity production.

Methods of economic evaluation

Decisions, whether to invest to RES, are made according to a number of economic indicators. These indicators evaluate the yield (return) of the resources invested. Several methods are used in the theory and practice of investment evaluation with the aim to increase the efficiency of investment projects. Also, a cost-effectiveness analysis can be used for photovoltaic systems by households (Burtt, Dargusch, 2015), with an annual payback period calculation and regression of these against the actual uptake of the present value of associated emission reductions, creating a relationship by sensitivity analysis. At the whole solar power plant, multi-criteria decision-making methods are very important, where the risk of investment is one of the factors.

Risk analysis is part of all investment projects where the factor of risk and uncertainty plays a key role. One of the tools of risk analysis for providing an increased quality of decision making is a Monte Carlo simulation. The principle of Monte Carlo simulation consists of generating an extensive file containing scenarios, for which the recalculation of monitored financial indicators of the investment project is made. The output provides the obtaining of statistical characteristics and metrics that serve as the basis for the decision to adopt respectively refuse the investment project or for optimizing and control of the process. The benefits and costs of increasing solar electricity generation depend on the scale of the increase and on the time frame over which it occurs. (Baker, et.al, 2013)

Financial analysis, as an element of technical and economic study, presents an essential tool for investors' decisions. It means, first of all, the decision about which project to invest in (investment decision), as well as the decision about the amount of resources (financial decision). The basis for the realization of actual investment and financing decisions present criteria of economic efficiency, which measures the return on invested capital. They can be divided to traditional criteria, such as average profitability and payback period. The second group of criteria consists of criteria based on discounting: net present value, internal rate of return and profitability index. However, the Monte Carlo simulation presents a further tool for analysis of investment risk with the aim to increase the quality of the decision. The Monte Carlo simulation consists of following steps:

1. Creation of mathematical model

The model is presented concerning the calculation of the cumulative balance after 15 years of investment project service. 15 year period is chosen due to the fixed repurchase prices of electric power that are guaranteed during the given period.

2. Determination of risk factors

Risk factors present variables that enter into the calculation of the cumulative balance according to calculation in the first step. The real value of factors is not known in present time. The volume of the influence of risk factor changes to the change of monitored factor – mainly the cumulative balance in a certain year, and determines the sensitivity of the model. Key factors are changed through analysis of sensitivity, and their uncertainty is regarded in the Monte Carlo simulation. The choice of division type of risk factors and setting up of their parameters depends on expert evaluation, or knowledge, obtained from historical data. Commonly, normal and triangle division are used. The normal division is defined by an average value and a standard deviation. Triangle division obtains defined lower and upper level, except the most probable value of risk factor, and this level should be overstepped by pessimistic or optimistic scenario. Casual choice presents a common way for the choice of values from specified division during simulation.

3. Determination of statistical dependence of factors

Risk factors used in the model can be dependent on each other. Linear relations can be detected by correlation. Theoretically, there are infinitely many possible forms of dependence. The problem of mutual interdependence is reflected in the multiplication of random variables, where also covariance, respectively correlation, between the factors is taken into consideration. In addition to dependence on factors, there is necessary to identify dependence of one variable in a time sequence. If there is such dependence, it is not possible to ignore it in the simulation.

4. Monte Carlo simulation

During 4th step, there are determined factors – indexes, by which the simulation will be carried out, and there is also determined the number of scenarios that will be generated by the simulation. The single simulation creates a set of combinations of defined values according to given parameters of the distribution and choice. For each combination representing one scenario, an analysed variable – indicator that is the subject of searching is calculated. In our case, it represents the cumulative balance. In this step, the computer support has its use, and it provides realization of simulation with a range of one million observations lasting a few seconds.

5. Results of simulation

Simulation output presents the probability of cumulative balance division for the given year and the statistical characteristics determining the average, variance, minimum, maximum and selected percentiles. When determining the payback period, a 2.5-percentile or a minimum value of cumulative balance is considered, which is compared to a zero instead of comparing the mean value to zero. The calculated expected value of the cumulative balance in a given year can be determined by an interval of probable values.

Results of analysis of legislative tools and economic support of photovoltaic energy using

Act No. 309/2009 Coll. about the support of RES was adopted on 1st September 2009, and it specifies that the distributor has an obligation to connect the source to the network and guarantee the purchase price of produced electric power for 15 years from the time of power plant establishment. The price is determined by the Regulatory Office for Network Industries (RONI) and for specific years, it is determined by RONI Decree No. 7/2009.

The price of electricity for the equipment of producer reconstructed or upgraded before 1st January 2010, entered into service before 1st January 2010 or put into service in 2010, is engaged in §8 Decree in the Act No. 225/2011. The price of electricity produced from photovoltaic power for equipment of its producer, installed to operation in 2010 is determined by direct determination of the fixed price in euros per megawatt hour of solar power with a total installed capacity of the producer of electricity (see Table 1).

The price of electricity for the equipment of producer, installed into operation from 1st January 2011 to 30th June 2011, is dealt in § 9 of the Decree of Act No. 225/2011. The price of electricity produced from photovoltaic power in the producer´s equipment placed into operation from 1st January 2011 to 30th June 2011 is determined by direct determination of the fixed price in euros per megawatt hour of solar power with a total installed capacity of electricity producer. The price of electricity for equipment of producer, installed into operation from 1st July 2011 to 31st December 2011 is dealt in §10 of the Decree of Act No. 225/2011. The price of electricity produced from photovoltaic source in the producer's equipment, installed into operation from 1st July 2011 to 31st December 2011, is determined by the direct determination of the fixed price in euros per megawatt hour of solar power with a total installed capacity of 100 kW, which is located on the roof or on the outer wall of a building, connected to the ground by a solid foundation, as € 259.17 / MWh.

The price of electricity for equipment of producer, installed into operation from 1st January 2012 to 30th June 2012 is dealt in §11 of the Decree of Act No. 184/2011 dated 22nd June, amending and supplementing Decree of the Regulatory Office for Network Industries No. 225/2011, establishing a price regulation in the electric-power industry, as amended by Decree No. 438/2011 from solar energy with a total installed capacity of power producer up to 100 kW, which is located on the roof or the outer wall of a building connected to the ground by a solid foundation. The price of electricity for the facility of the electricity producer installed into operation from 1st July 2012 to 31st December 2012 is dealt in §11 of the Decree of Act No. 184/2011

from solar energy with a total installed capacity of power producer up to 100 kW, which is located on the roof structure or the outer wall of a building connected to the ground by a solid foundation.

The price of electricity for the facility of the electricity producer installed into operation from 1st January 2013 is dealt in §11b of the Decree of Act No. 184/2011 of solar energy with a total installed capacity of power producer up to 100 kW, which is located on the roof structure or the outer wall of a building connected to the ground by a solid foundation.

Tab. 1. The price of electric energy, produced from RES [EUR /MWh].

Year	Period	Installed performance of equipment from producer of energy	Fixed price of electric energy per MWh
2010	1.1.2010-31.12.2013	To 100 kW including	430,72 EUR/MWh
		Over 100 kW	425,12 EUR/MWh
2011	1.1.2011-30.6.2011	To 100 kW	387,65 EUR/MWh
		Over 100 kW including	382,61 EUR/MWh
	1.7.2011-31.12.2011	To 100 kW	259,17 EUR/MWh
2012	1.1.2012-30.6.2012	To 100 kW	194,54 EUR/MWh
	1.7.2012-31.12.2012	To 100 kW	119,11 EUR/MWh
2013	Since 1.1.2013	To 100 kW	119,11 EUR/MWh

By the Monte Carlo method, a simulation in the photovoltaic plant in the chosen Slovakian quarry, which was put into operation in 2010, was realized. The analysis was based on a three-year history. Values of production corresponding to 1kWp were obtained through the share of specific production kWh / year during the period 2010-2012 and installed capacity of photovoltaic power. Specific production of the 1kWp for individual years was 1 242.936 kWh / year - 2010, 1 219.243 kWh / year - 2011, and 1 241.833 kWh / year - 2012. In the simulation, an average value of 1 234,671 kWh / year and range 23.6928 kWh / year were considered. In the determination of the distribution of specific production per 1kWp, a standard deviation – the integral part of the range was used.

Tab. 2. Resulting intervals of the cumulative balance in individual situations in the 15th year of a photovoltaic power plant lifetime.

	The 15th year of lifetime	Regarding performance degradation of photovoltaic panels (annual decrease by 1%)
Situation 1	3 812 275€	3 240 433,75 €
Situation 2	3 807 864€	3 236 684,40 €
Situation 3	3 783 562€	3 216 027,70 €
Prediction	2 709 252,67€	2 302 864,77 €

In the application of Monte Carlo method for the amount of produced energy and inflation, predicted cumulative balance after 15 years of operation will reach a value of at least 3 783,562 € (after performance degradation – 3 216 027,7 €). This value corresponds to the lower margin of the estimated range of simulations, where 10% deviation from the mean value of the energy produced during the first three years of the plant´s operation was chosen. Compared with the originally predicted yield value in 15th year - 2709 252, 67 € (after degradation – 2 302 864, 77 €), the current pessimistic estimation exceeds expectations by more than € 1 million €.

The mentioned development of prices of electric energy till 2013 and cumulative balance is connected to the evaluation of the specific operated power plant with the negative influence of legislative changes to the economic prognosis of business in the area of energetics. For example, Slovakia is a member of a number of double or multiple agreements that also include the protection of investments. In simple words, such agreements have to protect an international investor against later changes of laws, as well as against new taxes, which could threaten his investment. By this way, the international arbitral procedure has a completely clear expectation of success.

Conclusion

At present, there is necessary to invest to photovoltaics since such source brings a real alternative to conventional sources, which stocks are limited and gradually spending. However, the legislation of renewable energy sources (RES) in Slovakia was adopted only recently lacking proper support, and also the economical evaluation still needs an improvement. In particular, it is necessary to assess other characteristics of investment to photovoltaics (e.g. electricity price and production cost). The Monte Carlo simulation presents another tool for analysis of investment risk with the aim to increase the quality of the decision. This method consists of 5 steps, according to which investors can make a proper decision, bringing positive results in the future.

The Monte Carlo method was used for simulation in the photovoltaic plant in the chosen Slovakian quarry with the aim to provide a scheme for evaluation in similar conditions. In the simulation, average values and a standard deviation - the integral part of the range, were considered. Resulting value corresponds to the lower margin of the estimated range of simulations, which was further compared to the originally predicted value and estimated current expectations.

References

Alkholidi, A.G.: Renewable energy solution for electrical power sector in Yemen. *International Journal of Renewable Energy Research. Vol.3, No 4, 2013, p. 803-811*.

Aste, N., Del Pero, C., Leonforte, F., Manfren, M.: A simplified model for the estimation of energy production of PV systems. *Energy. Vol.59, No 15, 2013, p. 503-512*.

Baker, E., Fowlie, M., Lemoine D., Reynolds, S.S.: The economics of solar electricity. *Annual Review of Resource Economics. Vol.5, 2013, p. 387-426.*

Burtt, D., Dargusch, P.: The cost-effectiveness of household photovoltaic systems in reducing greenhouse gas emissions in Australia: Linking subsidies with emission reductions. *Applied Energy. Vol.148, 2015, p. 439-448*.

Chandel, M., Agrawal, G.D., Mathur, S., Mathur, A.: Techno-economic analysis of solar photovoltaic power plant for garment zone of Jaipur city. *Case Studies in Thermal Engineering. Vol.2, 2014, p. 1-7*.

Decree No 225/2011 of Law, Office for regulation of net branches from 11st July, 2011 about price regulation in electro energetics

Jenner, S., Groba, F., Indvik, J.: Assessing the strength and effectiveness of renewable electricity feed in tariffs in European Union countries. *Energy Policy. Vol.52, 2013, p. 385-401*.

Jerez, S., Trigo, M., Vicente, S.M., Pozo, V.D., Lorente, P.R., Lorenzo, L.J., Santos, A.F., Montávez, J.P.: Impact of the North Atlantic Oscillation on Renewable Energy Resources in Southwestern Europe. Journal of Applied Meteorology & Climatology. *Vol. 52 Issue 10, 2013, p. 2204-2225*.

Karteris, M., Papadopoulos, A.M.: Legislative framework for photovoltaics in Greece: A review of the sector´s development. *Energy policy. Vol.55, 2013, p. 296-304*.

Knez, M., Jereb, B.: Solar power plants – Alternative sustainable approach to greener environment: A case of Slovenia. *Sustainable Cities and Society. Vol.6, No 1, 2013, p. 27-32*.

Tauš, P., Taušová, M.: Ekonomická analýza fotovoltaických elektrární podľa inštalovaného výkonu (Economic analysis of photovoltaic power plants according installed performance). *Acta Montanistica Slovaca. Vol.14, No 1, 2009, p. 92-97*.

http://www.sapi.sk/projects/g-komponent/