Goran Pichler dipl. oec
Moje Sunce Ltd.
Franje Krežme 20, 32000 Osijek
Phone: 00385915547396
E-mail address: obnovljivi.izvori.ee@gmail.com

Vladimir Grebenar univ. spec. oec; mag. oec
Periska Ltd.
H. D. Genschera 14, 32100 Vinkovci
Phone: 0038532638404
E-mail address: vladimir.grebenar@gmail.com

Boris Banović univ. spec. oec; mag. oec
S. Podhorskog 28, 10000 Zagreb
Phone: 00385997887352
E-mail address: boris.banovic@gmail.com

THE APPROACH OF CONDUCTING A COST & BENFIT ANALYSIS OF A RENEWABLE ENERGY INVESTMENT PROJECT

PRISTUP IZRADI COST & BENEFIT ANALIZE INVESTICIJSKOG PROJEKTA ZA OBNOVLJIVE IZVORE ENERGIJE

ABSTRACT

Compared to other investment projects whose dynamic cost-effectiveness is being measured in cash inflows generated from the commercialization of the project, investment into a solar power facility for own use is rather specific since its dynamic cost-effectiveness is being measured in savings generated over the useful life of the project. This is why a cost and benefit analysis is the most suitable technique to be applied to calculate dynamic cost-effectiveness of such a project. Another specificity of such a project is that the unit of measure used to measure generated savings cannot be unambiguously determined, and that such a price has to be corrected. Such corrected prices are another reason why the financial analysis of this investment project is based on a cost-and-benefit-analysis approach. This paper illustrates a methodological approach of a calculation of costs and benefits of an investment project. This paper proves that in case of constant electricity consumption during 24 hours a day, an investment into a solar power facility in Eastern Slavonia can create economic potential which makes such an investment profitable and cost-effective.

Key words*: cost & benefit, solar power plant, dynamic profitability, electricity, methodological approach.*

ABSTRACT

Investicijski projekt sunčane elektrane za vlastite potrebe specifičan je po tome što se njegova dinamička rentabilnost mjeri u uštedama ostvarenim tijekom korisnog vijeka projekta, za razliku od drugih investicijskih projekata koji svoju dinamičku rentabilnost ostvaruju u novčanim primicima od komercijalizacije investicije. Iz tog je razloga tehnika izračuna dinamičke rentabilnosti investicijskog projekta cost & benefit analiza. Investicijski projekt poseban je i po tome što jedinicu mjere po kojoj se mjeri ušteda nije moguće jednoznačno *utvrditi, već je tu cijenu potrebno ispraviti. Ispravljene cijene drugi su razlog zašto je u financijskoj analizi investicijskog projekta riječ o cost & benefit analizi. U radu se daje metodološki postupak izračuna troškova i koristi investicijskog projekta. Radom se dokazuje da u slučaju cjelodnevne potrošnje električne energije ovakva investicija u istočnoj Slavoniji može imati ekonomski potencijal koji investiciju čini rentabilnom.*

Ključne riječi: *cost & benefit, sunčane elektrane, dinamička rentabilnost, električna energija, metodološki pristup*

1. Introduction

This paper comprises a conceptual framework for an investment study of a renewable energy facility for an investor (entrepreneur) who has a business which consumes electrical energy permanently on a daily basis. The investor (entrepreneur) either plans or really consumes electrical energy continuously during 24 hours a day, 7 days a week and 12 months a year. Dependent on the geographical location, the roof pitch as well as the roof position relative to the sun, the entrepreneur might generate an investment idea for a private solar power facility producing electrical energy. When contemplating such an idea, the fundamental question is whether benefits of such an investment project (i.e. installation of a solar power facility) will exceed long-term investment costs. This is particularly important when an investment project produces benefits primarily through savings and perhaps to some marginal degree through additional revenues of solar energy sales. In such a scenario and for the purpose of this paper, we assume that the entrepreneur will sell all excess electrical energy which is produced by the installed solar power facility, but not consumed by the entrepreneur. In another scenario, it is also possible that all excess electrical energy will be lost and thus such an investment will be less cost-effective. In both scenarios, the applied conceptual framework is equal in its essence.

2. Methodology

Firstly, an analysis of the electrical energy market has to be conducted. The general aim of such an analysis is to examine the market price and its structure. There are two main components of the price of electrical energy which are constant and basic: the cost of the high tariff per unit and the cost of the network tariff per unit. Other components of the price are charges per unit which largely depend on contractual conditions. A quality market research also requires to take into consideration a time horizon of at least three years as well as to compute a weighted average price. In the long-term period assumed in a feasibility study, the weighted average price has to be constant. A final output of such an approach is a weighted average of corrected relevant market prices. Such an average price is actually a benefit per saving unit and that is the main reason why this investment study is based on a cost-and-benefit-analysis approach.

Secondly, a technological and technical analysis has to be conducted. The major activity in this step is to determine consumption of electrical energy (in kWh) in previous years. A time horizon of at least three years is repeatedly the most suitable time period to be used. When analysing a time period of three years, a consumption trend can be determined and future forecast can be computed. It is also necessary to determine a daily consumption curve and the average consumption per hour ratio for the past three years. Information related to electrical energy consumption will be gathered from a supplier of electrical energy. Subsequently, a daily time period which is the most representative throughout the year has to be determined – namely a period in which the solar power facility can produce the highest amount of electrical energy (e.g. between 10:00 AM and 4:00 PM) during the period of 365 days without interruptions. It is also necessary to determine the hourly average solar irradiance during the period of a day (in Wh/m²). Data related to hourly average solar irradiance for a specific geographical location are provided by the State Hydro-meteorological Institute. The institute also provides exact data on the time of sunrise/sunset for a period of a full calendar year. Finally, the percentage of solar irradiation in a previously determined period relative to a day is to be computed. The purpose of this activity is to compute the excess amount of produced electrical energy in a period with the highest electrical-energy production level. The excess amount is a quantity which is constant if expected production decreases in line with expected consumption. If it is realistic to expect that a surplus of electrical energy will be generated, then the total quantity of electrical energy produced by the solar power facility will be reduced by the surplus which is produced.

Thirdly, a decision considering capacity of the solar power facility has to be made. Capacity primarily depends on the surface of the roof and/or on the area which is chosen for facility installation, but it also depends on businesses needs for electrical energy. The most important factors influencing capacity are costs relative to benefits, but in this step of our approach capacity has to be assumed. Optimal capacity can be computed by conducting a sensitivity analysis. For that purpose, it is important to compute an equal cost value per installed unit. Considering the capacity of a solar power facility, investment costs can be estimated.

Fourthly, expected production of electrical energy is to be calculated and then it should be compared with expected consumption, particularly for the determined period of the day. The process of computing of expected energy production is quite simple and can be conducted with on-line calculators. Several factors are needed to conduct such a calculation: inclination, orientation, type of a system (fixed vs. cycle) and precise data on location.

Finally, a financial analysis including both the static and the dynamic approach should be conducted including a sensitivity analysis and a risk analysis, thus optimising capacity of the solar power facility relative to expected benefits and investment costs.

3. Research

Our business case relates to a swimming-pool facility located in eastern Croatia which has a suitable roof pitch and a suitable roof position relative to the sun. Consumption of electrical energy in the respective object is constant, 24 hours a day and without any interruptions. Approximately, electrical energy consumption is 75 – 105 kW per hour.
Table 1 illustrates the price structure and the calculating approach used in determining of the constant price for the purpose of a feasibility study as described in the previous chapter. A time horizon of three years is used and inflation is not taken into account.

Table 1: *The cost structure of the electrical energy price*

The price structure of electrical energy during the time period of the highest tariff				
Total consumption 1.1.2011.-30.9.2014			kWh	2.724.904
Number of monthly invoices (2011-2014)				45
Average monthly consumption (2011-2014)			kWh	60.553
ID	COST STRUCTURE 2011	SUPPLIER	UNIT	PRICE
* * *				
ID	COST STRUCTURE 2012	SUPPLIER	UNIT	PRICE
* * *				
ID	COST STRUCTURE 2013	SUPPLIER	UNIT	PRICE
* * *				
ID	COST STRUCTURE 2014	SUPPLIER	UNIT	PRICE

The price structure of electrical energy during the time period of the highest tariff				
1	Electrical energy – high tariff	XY Ltd.	kWh	0,41960
2	Charge 1	XY Ltd.	kWh	0,00468
3	Charge 2	XY Ltd.	kWh	0,03500
4	Charge 3	XY Ltd.	kWh	0,00375
5	Network tariffs	Z Ltd.	kWh	0,25000
6	Price of electricity		kWh	0,71303
	Average price of electricity (kn / kWh) 2011-2014		kWh	0,71936

Source: http://www.hep.hr/ods/kupci/poduzetnistvo.aspx

According to the previously outlined methodological approach, a technological and technical analysis has to be conducted and a decision about the capacity of the solar power facility has to be made. In a day period from sunrise to sunset, the annual average energy consumption is 52% relative to 24 hours. The highest irradiation and thus the highest expected electrical energy production is between 10:00 AM and 4:00 PM. Between March and September, irradiation and expected electrical energy production are higher than 58% relative to a period from sunrise to sunset.

Table 2 illustrates technical estimates of production as well as consumption of a solar power facility. Installed capacity is 321,2 kW. Inclination is 6°. Orientation is 15°. Assumed capacity relates to the total roof surface.

***Table 2:** Technical estimates of production and consumption of electrical energy*

Month	E_d	E_m	H_d	H_m	*Irradiation*[1]	*Production*	*Consumption*	*Difference*
	kWh/plant	*kWh/plant*	*Wh/plant*	*Wh/plant*	*%*	*kWh*	*kWh*	*kWh*
Jan	334	10.280	2.551	78.507	80,7%	8.299	15.259	-6.960
Feb	549	15.416	4.181	117.374	75,1%	11.576	14.409	-2.832
Mar	1.002	31.057	7.819	242.348	69,2%	21.487	16.241	5.246
Apr	1.294	38.861	10.412	312.612	64,1%	24.928	16.325	8.603
May	1.458	45.284	12.022	373.360	60,1%	27.238	17.501	9.737
Jun	1.587	47.532	13.339	399.624	58,4%	27.780	17.540	10.239
Jul	1.619	50.102	13.694	423.869	59,3%	29.705	18.483	11.222
Aug	1.461	45.284	12.335	382.257	62,3%	28.191	18.594	9.597
Sep	1.066	31.956	8.697	260.660	67,1%	21.451	9.406	12.045
Oct	774	23.766	6.168	189.379	73,3%	17.431	17.913	-482
Nov	437	13.136	3.429	103.116	78,6%	10.326	17.089	-6.763
Dec	260	8.093	2.007	62.443	82,5%	6.678	15.907	-9.228
Surplus of produced electrical energy (difference between production and consumption) = 66.689 kWh per year								

Source: http://www.fer.unizg.hr/_download/repository/ZR09MJurkovic.pdf

As previously outlined, we have also calculated expected production of electrical energy and then compared it with the needed long-term consumption. The assumed solar power facility has a reliable long-term efficiency of at least 25 years, with effectiveness weakness of at most 0,5% per year relative to the previous year. In this respective business case, the investor (entrepreneur) expects the solar power facility to produce a surplus of electrical energy which then will be sold on the market.

Table 3 illustrates a short version of dynamic estimates of electrical energy production.

[1] Irradiation (10:00 AM – 4:00 PM) / irradiation (5:00 AM – 9:00 PM)

Table 3: *Technical estimates of electricity production for 25 years*

0,5%	***2016***	***2017***	***2018***	***2019-2037***	***2038***	***2039***	***2040***
Month	Total production of electricity during 25 years in kWh						
Jan	10.280	10.229	10.178		9.150	9.098	9.047
Feb	15.416	15.339	15.262		13.720	13.643	13.566
Mar	31.057	30.901	30.746		27.640	27.485	27.330
Apr	38.861	38.667	38.472		34.586	34.392	34.198
May	45.284	45.058	44.831		40.303	40.077	39.850
Jun	47.532	47.295	47.057	*	42.304	42.066	41.829
Jul	50.102	49.851	49.601	*	44.591	44.340	44.090
Aug	45.284	45.058	44.831	*	40.303	40.077	39.850
Sep	31.956	31.796	31.636		28.441	28.281	28.121
Oct	23.766	23.647	23.529		21.152	21.033	20.914
Nov	13.136	13.070	13.004		11.691	11.625	11.559
Dec	8.093	8.053	8.012		7.203	7.163	7.122
Total	360.768	358.964	357.160		321.083	319.280	317.476
	Surplus of electricity during 25 years in kWh						
	2016	***2017***	***2018***	***2019-2037***	***2038***	***2039***	***2040***
Mar	*5.246*	*5.139*	*5.031*		*2.883*	*2.775*	*2.668*
Apr	*8.603*	*8.478*	*8.353*		*5.861*	*5.736*	*5.611*
May	*9.737*	*9.601*	*9.464*		*6.741*	*6.604*	*6.468*
Jun	*10.239*	*10.100*	*9.962*	*	*7.184*	*7.045*	*6.906*
Jul	*11.222*	*11.073*	*10.925*	*	*7.954*	*7.806*	*7.657*
Aug	*9.597*	*9.456*	*9.315*	*	*6.496*	*6.355*	*6.214*
Sep	*12.045*	*11.938*	*11.830*		*9.685*	*9.578*	*9.471*
Total	*66.689*	*65.785*	*64.881*		*46.803*	*45.899*	*44.995*

Source: http://re.jrc.ec.europa.eu/pvgis & converted data

The final part of in our methodological approach relates to preparing of a static and dynamic financial analysis based on a cost-and-benefit-analysis approach. Major benefits of this investment project are savings during the expected useful life of the solar power facility, but also revenues generated from sales of electrical energy.

Table 4 illustrates a static financial analysis for all years of the expected useful life of the investment project (i.e. the solar power facility). The most relevant financial indicator here is the net profitability ratio. The highest net profitability ratio is at the end of the expected useful life, mostly due to the estimated residual value. The expected useful life is actually 30 years, but for the purpose of this paper, it is reduced by 5 years. During the period of the expected useful life, net profitability is constantly positive.

Table 4: *Static financial analysis 2016-2040*

0,5%	*2016*	*2017*	*2018*	*2019-2037*	*2038*	*2039*	*2040*
Month	Savings during the period of the expected useful life (kn)						
Jan	7.395	7.358	7.321	*	6.582	6.545	6.508
Feb	11.090	11.034	10.979	*	9.870	9.814	9.759
Mar	18.567	18.532	18.498	*	17.810	17.775	17.741
Apr	21.767	21.716	21.666		20.664	20.614	20.564
May	25.571	25.506	25.441		24.143	24.078	24.013
Jun	26.827	26.756	26.685		25.264	25.193	25.122
Jul	27.969	27.895	27.822		26.354	26.281	26.208
Aug	25.672	25.611	25.549		24.319	24.258	24.196
Sep	14.323	14.285	14.248		13.492	13.454	13.416
Oct	17.096	17.011	16.925		15.216	15.130	15.045

0,5%	2016	2017	2018	2019-2037	2038	2039	2040
Nov	9.449	9.402	9.355		8.410	8.363	8.315
Dec	5.822	5.793	5.764		5.182	5.152	5.123
SAVINGS	211.548	210.901	210.253		197.306	196.658	196.011
Selling price: 0,40 kn/kWh	Income during the period of the expected useful life (kn)						
	2016	*2017*	*2018*	*2019-2037*	*2038*	*2039*	*2040*
Mar	*2.099*	*2.056*	*2.013*		*1.153*	*1.110*	*1.067*
Apr	*3.441*	*3.391*	*3.341*		*2.344*	*2.294*	*2.245*
May	*3.895*	*3.840*	*3.786*		*2.696*	*2.642*	*2.587*
Jun	*4.096*	*4.040*	*3.985*	*	*2.873*	*2.818*	*2.762*
Jul	*4.489*	*4.429*	*4.370*	*	*3.182*	*3.122*	*3.063*
Aug	*3.839*	*3.782*	*3.726*	*	*2.598*	*2.542*	*2.486*
Sep	*4.818*	*4.775*	*4.732*		*3.874*	*3.831*	*3.788*
INCOME	*26.675*	*26.314*	*25.952*		*18.721*	*18.360*	*17.998*
RESIDUAL V.							*464.119*
BENEFITS	***238.223***	***237.215***	***236.206***		***216.027***	***215.018***	***678.128***
	Costs during the period of the expected useful life (kn)						
	2016	*2017*	*2018*		*2038*	*2039*	*2040*
MAINTENANCE	*7000*	*7.035*	*7.105*		*15.855*	*16.660*	*17.500*
TERMOGR. SCANNING		*7.570*				*7.570*	
INSOURANCE	*7.000*	*7.000*	*7.000*		*7.000*	*7.000*	*7.000*
DISPOSAL OF WASTE							*100.000*
INTEREST							
DEPRECIATION	*128.773*	*128.773*	*128.773*		*128.773*	*128.773*	*128.773*
COSTS	***142.773***	***150.378***	***142.878***		***151.628***	***160.003***	***253.273***
	Long-term profits (kn)						
EBT	***95.451***	***86.837***	***93.328***		***64.399***	***55.015***	***424.855***
RETAINED ERNINGS	***95.451***	***182.287***	***275.615***		***1.785.992***	***1.841.007***	***2.265.862***
Net profitability	*40,1%*	*36,6%*	*39,5%*		*29,8%*	*25,6%*	*62,7%*

Source: Feasibility study; Swimming pool "Lenije", eastern Croatia

The static performance indicators are positive. A static financial analysis is an analysis which does not include the risk impact as well as the time value of money. On the other side, the dynamic financial analysis considers both, the risk impact and the time value of money. Table 5 illustrates the dynamic financial analysis and the financial flow. The financial flow represents also the economic flow of the assumed investment as well as the economic potential of the investment. It is assumed that the investment project is fully financed by the investor.

Table 5: *Dynamic financial analysis 2016-2040*

Dr = 2,7 %	***2016***	***2017***	***2018***	***2019-2037***	***2038***	***2039***	***2040***	NPV	IRR
Inflows (cash)	**238.223**	**237.215**	**236.206**		**216.027**	**215.018**	**678.128**		
Income	26.675	26.314	25.952		18.721	18.360	17.998		
Savings	211.548	210.901	210.253		197.306	196.658	196.011		
Residual v.							464.119		
Outflows	**3.233.322**	**21.605**	**14.105**		**49.350**	**57.725**	**150.995**		
Investment	3.219.322							509.280	4,24%
Maintenance	7.000	7.035	7.105		15.855	16.660	17.500		

Dr = 2,7 %	*2016*	*2017*	*2018*	*2019-2037*	*2038*	*2039*	*2040*	NPV	IRR
Insurance	7.000	7.000	7.000		7.000	7.000	7.000		
Term. scanning		7.570				7.570			
Inverters					26.495	26.495	26.495		
Disposal of waste							100.000		
Positive cash flow	-2.995.099	215.610	222.101		166.677	157.293	527.133		

Source: Feasibility study; Swimming pool "Lenije", eastern Croatia

The discount rate is a long-term interest rate on loans at the moment of writing this paper. Possible risks are eliminated with the included insurance costs. In another scenario, where investment is co-financed with a grant in the value of 50% of total investment costs, the NPV is 2.076.000 kn and the IRR is 14,22%.

4. Conclusion

This paper illustrates an investment opportunity into solar power which is potentially interesting to local governments and entrepreneurs located in eastern Croatia. The investment project analysed in this paper relates to establishing of a solar power facility producing electrical energy not only for the purpose of generating savings by covering own needs for electrical energy, but also for the purpose of generating revenues through sales of produced but not consumed electrical energy. The business case analysed in this paper is based on an assumption that there is a business which has a constant need (24 hours a day) for electricity consumption. Our analysis suggests that the economic potential of such an investment is positive, even without additional co-financing through grants. This paper also proves that an established business investing into a solar power facility with the aim of covering its own needs for electrical energy is profitable and cost-effective. The paper rejects the assumption that generating profitability by a solar power facility without additional grants and financial incentives is not possible in eastern Croatia.

REFERENCES

Andersen A., (1999): ***Strategic Cost Management. Theory of Constraints***. Institute of Management Accountants http://www.imanet.org/PDFs/Public/Research/SMA/Theory%20of%20Constraints%20TOC.pdf (accessed 12 December 2014)

Atkinson A. A., Kaplan R. S., Matsumura E. M., Young S. M. *(2012):* ***Management Accountin,*** Pearsons Education, New Jersey

Belak, V. (1995): ***Menadžersko računovodstvo,*** RRiFplus, Zagreb

Belak, V. (1994): ***Profitni centri i interna ekonomija poduzeća,*** RRiFplus, Zagreb

Belak, V. i drugi. (2009): ***Računovodstvo proizvodnje. II. dopunjeno izdanje***, RRiFplus, Zagreb

Belak, V., Brkanić, V. i dr. (2000): ***Računovodstvo poduzetnik,*** RRiF, Zagreb

Belak, V. (ur) (2011): ***Računovodstvo i menadžment. Zbornik radova, svezak I – znanstveni radovi.*** M.A.K. Golden, Zagreb

Bendeković, J. i drugi (1993): ***Planiranje investicijskih projekata,*** Ekonomski institut, Zagreb

Bendeković, J. i drugi (2007): ***Priprema i ocjena investicijskih projekata,*** Foip biblioteka, Zagreb

Čulo, K., (2010): ***Ekonomika investicijskih projekata*,** Građevinski fakultet, Osijek

Garrison, R. i Noreen, E. (2000): ***Managerial Accounting*,** McGraw-Hill Higher Education; New York

Gervais, M., Levant, Y., Ducrocq, D. (2010): ***Time-Driven Activity-Based Costing (TDABC): An Initial Appraisal through a Longitudinal Case Study,*** Jamar, http://www.cmawebline.org/joomla4/images/stories/JAMAR_2010_Summer/JAMARv8.2-TDABC.pdf (accessed 11 March 2014)

Gilbert, S. J., Kaplan, R. S. (2007**):** ***Adding Time to Activity-Based Costing,*** *Harward Business School Publishing*. http://hbswk.hbs.edu/pdf/item/5657.pdf (retreived 15.1.2014).

Grgo, R. (ur) (2010): ***Računovodstvo, financije i porezi u praksi*,** Udruga računovođa i financijskih djelatnika, Split

Goldratt E. M., Cox, J. (2012): ***The Goal. A Process of Ongoing Improvement*,** The Nort River Press Publishing Corporation, Great Barrington

Hilton, R. (2009): ***Managerial Accounting: Creating Value in a Dynamic Business Environment,*** McGraw-Hill Irwin, New York

Horngren, C. T., Harrison, W. T., Oliver, M. S. *(2012):* ***Financial & Managerial Accounting*,** Pearsons Education, New Yersey

Karić, M. (2006): ***Ekonomika poduzeća*,** Ekonomski fakultet u Osijeku, Osijek

Karić, M. (2008): ***Upravljanje troškovima,*** Ekonomski fakultet u Osijeku, Osijek

Knez-Riedl, J. (2007): ***Benchmarking and Controlling*,** Ekonomski fakultet Rijeka, Rijeka

Osmanagić, B. (1998): ***Kontroling – abeceda poslovnog uspjeha*,** Školska knjiga, Zagreb

Rayburn, L. G. (1993): ***Cost Accounting*,** Burr Ridge, Illinois, Irwin

Vidučić, Lj. (2006): ***Financijski menadžment***, RRiF – plus, Split