RESOURCE MANAGEMENT IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT: THE USAGE OF SOLAR PHOTOVOLTAIC SOURCES

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ABSTRACT: In the paper [8] from the bibliography, the authors presented a case study about photovoltaic cells embedded in curtain wall structures. The conclusions of the authors were that the investment, therefore, turns out to be profitable only for emerging organization rather than for the existing ones. The use of alternative energy for this purpose would be a profitable investment and consequently lead to the sustainable development of the organization. The costs entailed by an energetic capitalization of solar radiation are still very high. A profitable investment might be accomplished, though, running parallel to the classical system, by mounting photovoltaic panels in order to cover the necessary energy for the operation of small energophagous consumers: illumination, household hot water, office systems (computers, printers, etc.); therefore the preservation of the classical system for the highly energophagous technology. It is a prerequisite for the economic situation of any country to evince a strong connection with sustainable development. Profit can only be obtained under decent circumstances, given the connection among the three components of sustainable development, i.e. economic, social and environmental. The strategies aimed at environmental protection and resource management are considered as a major objective for any manager. The aim of this paper is to set forth a theoretical approach to environmental protection strategies by means of promoting investment in photovoltaic panels, as well as provinding a statistic analysis in SPSS 16.
Key words: sustainable development, renewable resources, solar energy

1. INTRODUCTION

In spite of the fact that scientists have warned well in advance of the serious consequences brought about on the planet by pollution, any decision meant to prevent this has been either postponed or dismissed. Lately, though, people have become aware that the environment has been in a state of continuous degradation. People have noticed the complexity of the concept of sustainable development thus no longer an environmental issue, but also a matter related to technology, economy, international trade, human rights, health, etc.

Sustainability should be more than a mere project undertaken by various specialists in the intelligent administration of resources and more than a mere term, frequently used in certain contexts. It is a paradigm where the future is envisaged as a balance of its three components (economic, social and environmental) in view for developing and improving the quality of life. Sustainable development is a hard-to-define concept, since it continuously evolves and adds new meanings which makes it even more difficult to define.

There are a number of available methods for energy preservation and effective technologies for using feedstock [1]. The key for an efficient functioning of all activities in any organization relies on the availability of alternate solutions to energetic resources. An organization will potentially obtain long-term, sustainable results and accomplish its objectives by any means of any action undertaken by the organization in this respect.

Solar energy might ensure the entire amount of energy required globally by the modern society for an indefinite future. Solar energy is available in huge amounts, as it is unending and ecological. Tapping into solar energy does not case pollution or negative consequences on the atmosphere, considering that the Earth`s pollution has reached alarming rates, and consequently this issue has been taken into account by an increasing number of industrial organizations.

Research in the field of photovoltaic cells have recorded outstanding progress lately. Given the crisis of feedstock and the high relevance of sustainable development, an increasing number of organizations have chosen to target their activity undertaken by the research-development and innovation departments towards the development of new technologies for the conversion of renewable, non-conventional energy into electrical energy. Photovoltaic cells represent an alternative, since they are systems able to transform solar energy into electrical energy.

The solution of curtain walls represents an innovation in this field [11, 12]. Curtain walls structures represent a method of building envelope by means of a protective outer shell. These elements are sometimes called special coating structures considering their twofold functioning, i.e. both aesthet aesthetically and for enhanced performance of indoor climate control.

Alternative energy produced over a year depends on the placement of photovoltaic elements, however the influence of shadowing other building in close proximity represents a significant element.

The modules incorporated in the curtain wall structures of buildings enable designers to combine functionality with aesthetics in view of obtaining optimal effects: glass surfaces integrated in the facade may create special architectural effects. Thus, solar panels become a multifunctional construction material.

As a result of the effective combination of economic and environmental protection effects, the energy obtained by means of photovoltaic cells integrated in the solar panels may be regarded as a technology of the future [8].

Global warming and increasing prizes of fossil fuels have drawn more attention towards the usage of renewable energy sources particularly solar energy because of its well known advantages. A great deal of research has been conducted in this field over the last few decades. Solar PV panel is a power source having non linear internal resistance. A major challenge in using a SPV source containing a number of cells in series is to deal with its non-linear internal resistance [9, 10].

The problem gets all the more complex when the array receives non-uniform insolation. Cells under shade absorb a large amount of electric power generated by cells receiving high insolation and convert it into heat. This heat may damage the low illuminated cells under certain conditions. To relieve the stress on shaded cells, bypass diodes are added across the modules. In such a case multiple peaks in power-voltage characteristics are observed under non uniform illumination. Classical Maximum Power Point Tracking methods are not effective due to their inability to discriminate between local and global maxima [2, 7]. Nevertheless, it is very important to understand the characteristics of SPV under partial shaded conditions to use photovoltaic installations effectively under all conditions. Analog models of solar photovoltaic sources at varying temperature, insolation and partial shaded conditions were presented in the literature [3]. Also, the paper [8] presents the improved model of solar photovoltaic array which takes care about the dependence of all the parameters in the model with respect to insolation and temperature [4, 5, 6, 11]. The model was simulated using Matlab software. The developed model was validated with experimental results. To capture the characteristics under constant insolation and temperature conditions, the experimental characteristics were obtained using linear MOSFET as an electronic load [8, 11].

The equivalent circuit model of a solar cell consists of a current generator and a diode plus series and parallel resistance [9]. The mathematical equation expressing the output current of single cell is given by equation (1):

$$I_{PV} = I_{ph} - I_r \left[exp\left\{ \frac{V_{PV} \mp I_{PV} R_{se}}{V_t} \right\} - 1 \right] - \frac{V_{PV} \mp I_{PV} R_{se}}{R_{sh}} \quad (1)$$

where: I_{PV}, V_{PV} - Solar PV module Current (A) and Voltage (V) respectively

I_{ph} - Photo current SPV module (A)

I_r - Diode reverse saturation current in the equivalent circuit (μA)

R_{se} - Series resistance in the equivalent circuit of the module (mΩ)

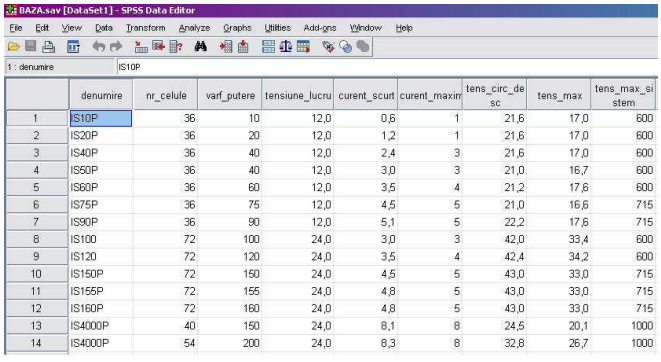
R_{sh} - Parallel resistance in the equivalent circuit of the module (Ω)

V_t - Thermal voltage (= nkT/q)

2. APPLICATION IN SPSS 16.0 FOR WINDOWS

Let us present the steps to be taken into account in the SPSS in view of analyzing the output of photovoltaic cells.

In this respect, statistical data will be stored in the BAZA.sav file.


BAZA.sav [DataSet1] - SPSS Data Editor

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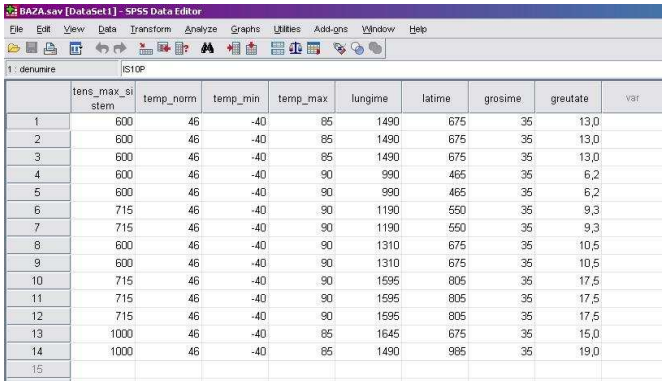
1 : denumire | IS10P

	denumire	nr_celule	varf_putere	tensiune_lucru	curent_scurt	curent_maxim	tens_circ_desc	tens_max	tens_max_sistem
1	IS10P	36	10	12,0	0,6	1	21,6	17,0	600
2	IS20P	36	20	12,0	1,2	1	21,6	17,0	600
3	IS40P	36	40	12,0	2,4	3	21,6	17,0	600
4	IS50P	36	40	12,0	3,0	3	21,0	16,7	600
5	IS60P	36	60	12,0	3,5	4	21,2	17,6	600
6	IS75P	36	75	12,0	4,5	5	21,0	16,6	715
7	IS90P	36	90	12,0	5,1	5	22,2	17,6	715
8	IS100	72	100	24,0	3,0	3	42,0	33,4	600
9	IS120	72	120	24,0	3,5	4	42,4	34,2	600
10	IS150P	72	150	24,0	4,5	5	43,0	33,0	715
11	IS155P	72	155	24,0	4,8	5	43,0	33,0	715
12	IS160P	72	160	24,0	4,8	5	43,0	33,0	715
13	IS4000P	40	150	24,0	8,1	8	24,5	20,1	1000
14	IS4000P	54	200	24,0	8,3	8	32,8	26,7	1000


BAZA.sav [DataSet1] - SPSS Data Editor

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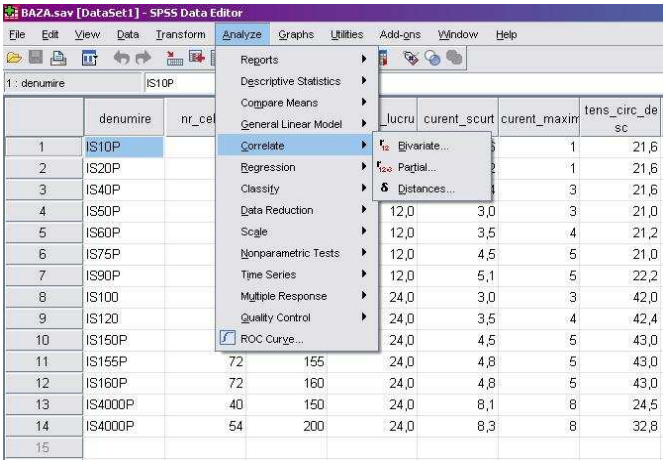
1 : denumire | IS10P

	tens_max_sistem	temp_norm	temp_min	temp_max	lungime	latime	grosime	greutate	var
1	600	46	-40	85	1490	675	35	13,0	
2	600	46	-40	85	1490	675	35	13,0	
3	600	46	-40	85	1490	675	35	13,0	
4	600	46	-40	90	990	465	35	6,2	
5	600	46	-40	90	990	465	35	6,2	
6	715	46	-40	90	1190	550	35	9,3	
7	715	46	-40	90	1190	550	35	9,3	
8	600	46	-40	90	1310	675	35	10,5	
9	600	46	-40	90	1310	675	35	10,5	
10	715	46	-40	90	1595	805	35	17,5	
11	715	46	-40	90	1595	805	35	17,5	
12	715	46	-40	90	1595	805	35	17,5	
13	1000	46	-40	85	1645	675	35	15,0	
14	1000	46	-40	85	1490	985	35	19,0	
15									

The SPSS helps draw some remarks on the influence of the number of cells in a panel upon the value of a specific technical characteristic or the other way round.

This information is useful for the identification of the connection intensity between the two statistical variables (correlation). In the present situation, we calculate the correlation between the number of cells in a panel and the short circuit current.

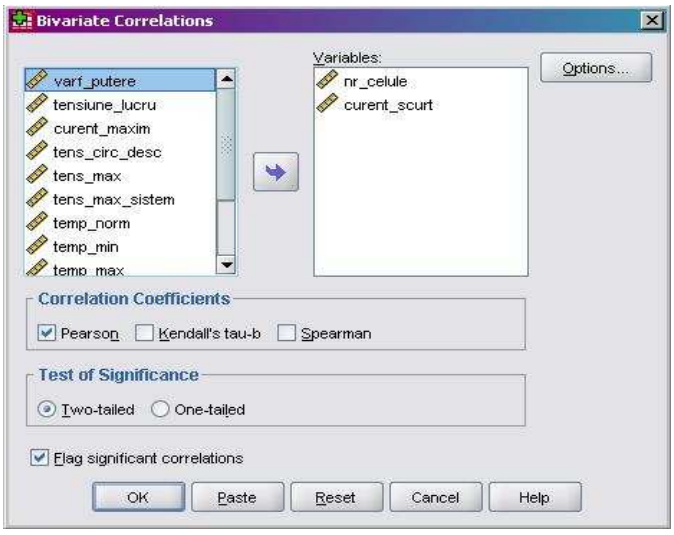
In order to launch the correlation analysis, the Analyze-Correlate-Bivariate... shall be selected from the menu:



	denumire	nr_cel		_lucru	curent_scurt	curent_maxim	tens_circ_de sc
1	IS10P					1	21,6
2	IS20P					1	21,6
3	IS40P					3	21,6
4	IS50P			12,0	3,0	3	21,0
5	IS60P			12,0	3,5	4	21,2
6	IS75P			12,0	4,5	5	21,0
7	IS90P			12,0	5,1	5	22,2
8	IS100			24,0	3,0	3	42,0
9	IS120			24,0	3,5	4	42,4
10	IS150P			24,0	4,5	5	43,0
11	IS155P	72	155	24,0	4,8	5	43,0
12	IS160P	72	160	24,0	4,8	5	43,0
13	IS4000P	40	150	24,0	8,1	8	24,5
14	IS4000P	54	200	24,0	8,3	8	32,8
15							

The variables used in the analysis shall be selected from teh dialogue box: i.e. the number of cells in a panel and the short circuit current.

Click OK button



This will accomplish the correlation matrix for the number of cells in a panel and the short circuit current.

Correlations

		nr_celule	curent_scurt
nr_celule	Pearson Correlation	1,000	,195
	Sig. (2-tailed)		,503
	N	14,000	14
curent_scurt	Pearson Correlation	,195	1,000
	Sig. (2-tailed)	,503	
	N	14	14,000

Pearson`s correlation coefficient indicates a linear correlation between the two discreet quantitative characteristics. The correlation identified in the table is positive and there is no significant change from 0, which suggests that the manufacturers of photovoltaic panels should not be concerned with the number of cells, when the goal is effectiveness, since it has no significant effect on the short circuit current.

However, the calculation of Pearson`s correlation coefficient will yield optimal results when the variables are (approximately) evenly distributed and there are no abnormal values. A scatterplot graphic representation may highlight these potential problems.

Also, in SPSS we can calculate the statistic indicators, using the commands Analyse→Descriptive Statistics→Frequencies. For example:

Statistics

		curent maxim	tensiune maxima
N	Valid	14	13
	Missing	0	1
Mean		4,2857	23,5538
Median		4,5000	17,6000
Mode		5,00	17,00[a]
Std. Deviation		2,09132	8,08802
Variance		4,374	65,416
Skewness		,264	,507
Std. Error of Skewness		,597	,616
Kurtosis		,147	-2,031
Std. Error of Kurtosis		1,154	1,191
Range		7,00	17,60
Minimum		1,00	16,60
Maximum		8,00	34,20
Percentiles	25	3,0000	17,0000
	50	4,5000	17,6000
	75	5,0000	33,0000

In SPSS can be realised regressions, using the commands: Analyse→Regression→Curve Estimation. For example:

Model Description

Model Name	MOD_1

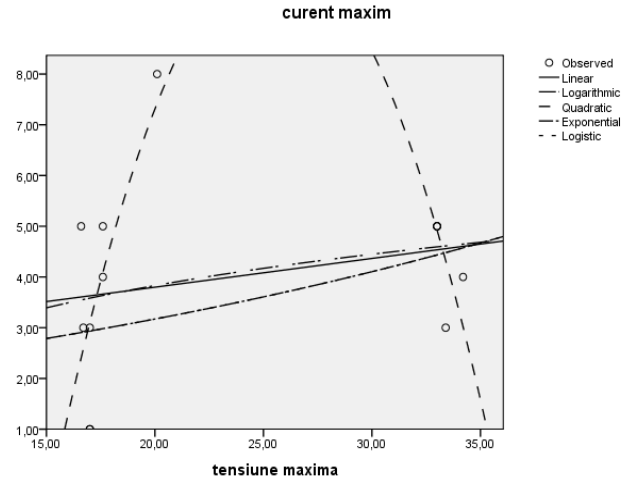
Dependent Variable	1	curent maxim
Equation	1	Linear
	2	Logarithmic
	3	Quadratic
	4	Exponential[a]
	5	Logistic[a]
Independent Variable		tensiune maxima
Constant		Included
Variable Whose Values Label Observations in Plots		Unspecified
Tolerance for Entering Terms in Equations		1.0E-4

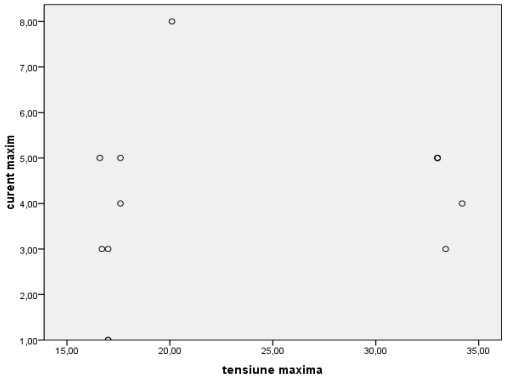
Model Summary and Parameter Estimates

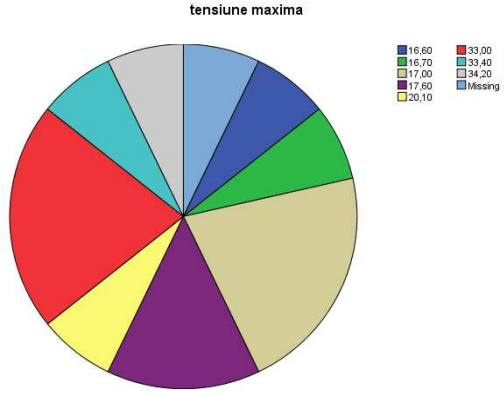
Dependent Variable:curent maxim

	Model Summary					Parameter Estimates		
Equation	R Square	F	df1	df2	Sig.	Constant	b1	b2
Linear	,060	,703	1	11	,420	2,665	,057	
Logarithmic	,073	,867	1	11	,372	-,734	1,524	
Quadratic	,532	5,683	2	10	,022	-54,490	5,074	-,099
Exponential	,114	1,421	1	11	,258	1,893	,026	
Logistic	,114	1,421	1	11	,258	,528	,975	

The independent variable is tensiune maxima.







The relations between the variables can be shown using different types of graphyics, with the commands: Graphs→Legacy Dialogs→Interactive →Bar, Dot, Line, Ribbon, Drop-Line, Area, Pie, Histogram, Scatterplot (2-D or 3-D coordinate). For example:

3. CONCLUSIONS

The statistic analysis in the SPSS program or in another program for the database processing offers a

very useful instrument for research, to analyse the necessary materials in the processing of the unconventional resources and not only for these.

BIBLIOGRAPHY

1. D. Gabor, V. Colombo, A. King, R. Galli, (1983), Să ieşim din epoca risipei, Bucureşti, Editura Politică (in romanian);
2. E. Koutroulis, K. Kalkaitzakis and N.C. Voulgaris. (2001), Development of a Microcontroller-based Photovoltaic maximum power point tracking control system, IEEE Transactions on Power Electronics, vol. 16, No.1;
3. G.Walker, (2001), Evaluating MPPT converter topologies using a MATLAB PV model, Journal of Electrical and Electronics Engineering, vol. 21, no. 1, pp. 49–56;
4. H. Kawamura, K. Naka, N. Yonekura, S. Yamanaka, H. Ohno, and K. Naito. (2003), Simulation of I–V characteristics of a PV module with shaded PV cells, Solar Energy Mater. Solar Cells, vol. 75, no. 3/4, pp. 613–621;
5. E. Karatepe, M. Boztepe and M. Colak, (2006), Neural network based solar cell model, Energy Conversion and Management: 47, pp 1159–1178;
6. M. C. Alonso-Gracia, J. M. Ruiz and F. Chenlo, (2006), Experimental study of mismatch and shading effects in the I–V characteristic of a photovoltaic module, Solar Energy Materials and Solar Cells, vol. 90, no. 3, pp. 329–340;
7. S. Jain and V. Agarwal. (2004), A new algorithm for rapid tracking of approximate maximum power point in photovoltaics systems, IEEE Power Electronics Letters, vol. 2, no. 1, pp. 16–19;
8. C. Oprean, M.A. Vanu, A. Bucur, Strategies for Enviromental Protection and Resource Management in the Context of Sustainable Development, IECS, Sibiu, 13-14 may 2010;
9. R. Ramabadran, B. Mathur, (2009), MATLAB Based Modelling and Performance Study of Series Connected SPVA under Partial Shaded Conditions, Journal of Sustainable Development, Vol.2, No.3;
10. T. Shimizu, M. Hirakata, T. Kamezawa, and H. Watanabe. (2001).Generation control circuit for photovoltaic modules, Yingying Kuai and S. Yuvarajan. (2006), An electronic load for testing photovoltaic panels, Journal of Power Sources, Elsevier, pp 308–313;
11. ***NP 102-04 (2005), „Normativ pentru proiectarea şi montajul pereţilor cortină”, Bul. Constructiilor, Vol. 7 (in romanian).