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CONSIDERATIONS REGARDING THE DEVELOPMENT OF A PHOTOVOLTAIC PARK LOCATED IN DEFILEUL JIULUI AREA

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ABSTRACT

The paper presents the simulation results for a photovoltaic park in terms of its energy production capability and environmental impact. The energy generated by the photovoltaic system would be used for household purposes, for the nearby villages.

In order to accurately simulate the energy production of this renewable energy source there were performed two types of calculation sets and a comparative evaluation between them.

INTRODUCTION

The paper presents a case study regarding the development of a photovoltaic park located in DefileulJiului area, between Vulcan city located in Hunedoara county and Bumbesti-Jiu city located in Gorj county, as is presented in figure 1.

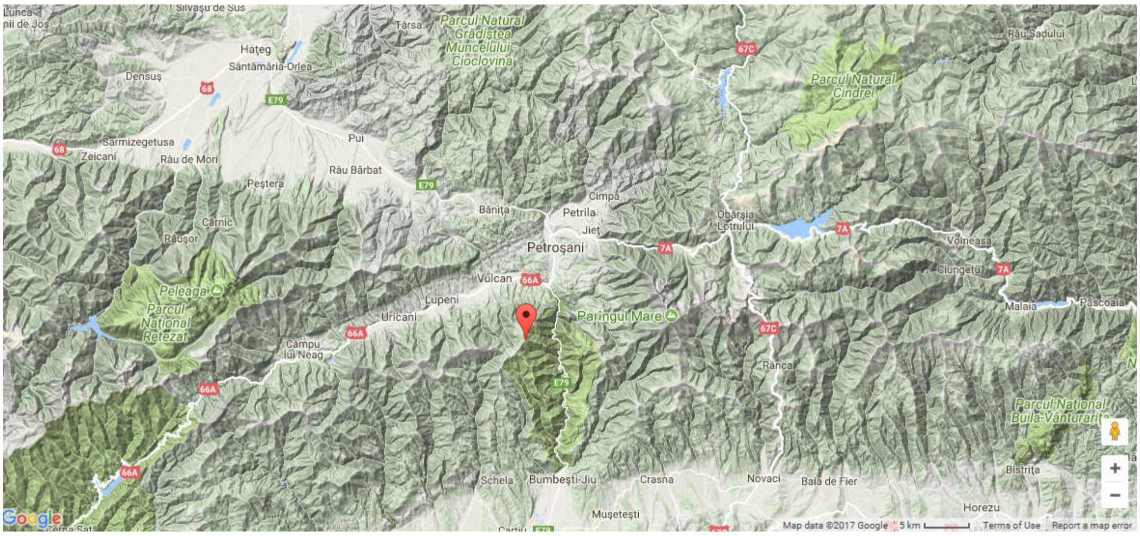

Figure 1Photovoltaic parklocation overview [8]

The study analyzes the energy production of the photovoltaic system during a whole year taking into account the specific topographyfor the proposed area.

The area affected by the photovoltaic park is a rectangular surface with a length of 310 meters and a width of 110 meters, totalizing 34100 square meters, the area being located at a latitude of 45.314, longitude of 23.333 and an altitude of 1664 meters.

The panels are polycrystalline silicon type, having a length of 1.636 mm, width of 992 mm, depth of 50 mm and a weight of 19.3 Kg.

The topography of the considered area was simulated [8] in order to establish accurate results and it is presented in figure 2.

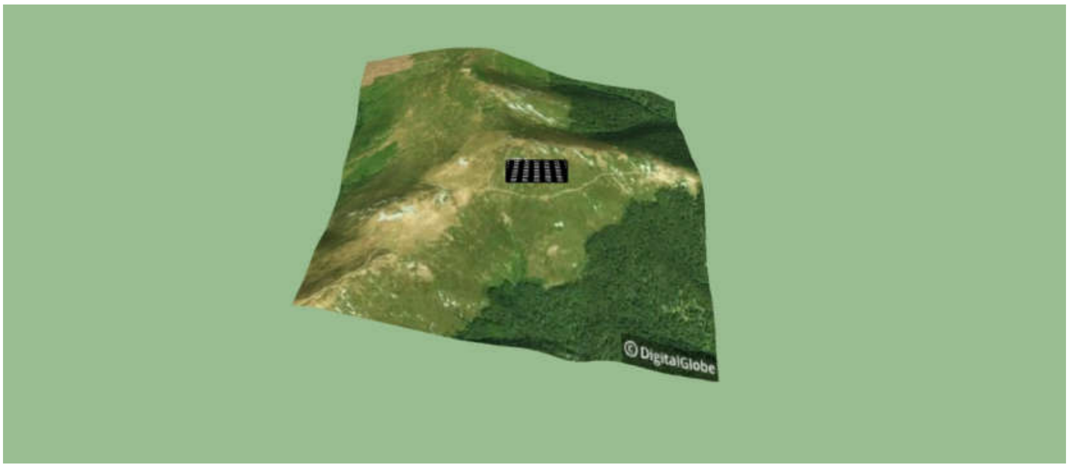

Figure 2 Photovoltaic park location topography [8]

The system is composed by 6952 photovoltaic panels, each one of them developing 230 W in standard conditions. Each panel is considered to have a peak efficiency of 14.17%, 60 cells, I_{mp}=7.82 A, V_{mp}=29.4 A.

MATERIALS AND METHODS

Numerical simulations were performed in two variants [6,9] referred below as S1 respectively S2. First option is based on PVWATTS software developed by National Renewable Energy Laboratory (NREL) of the USA[6] and second option is based on PVGIS software developed by European Commission[9].

The sun path chart was considered the same for both cases, being presented on figure 3.

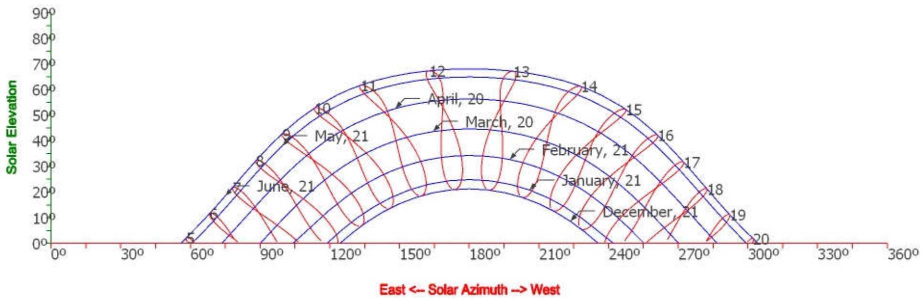

Figure 3Sun path chart[8]

As it is shown in the table 1 the total energy production for S1over a period of one year is 1964538 kWh.

Table 1

Global results - PVWATTS

Solar panels	NºP.	P. power (Wp)	P.weight (kg)	DC r. (kWp)	Energy (kWh)	Yield (kWh/kWp)
Aide Solar:XZST-230W (M)	6952	230	18	1598.96	1964538	1228.63

Where: NºP. - Number of panels, P.power - Power of the solar panel (Wp), DC r. - DC rating (kWp),Energy ($\sum E_m$) - Electricity production from the given system in one year (AC energy) (kWh),
Yield - Ratio between power and energy (kWh/kWp).

The average daily electricity production for S1is presented in table 2, having a peak in July and a minimum in December, depending on global irradiation per square meter received by the modules of the given system.

Table 2

Average daily electricity production from the given system(E_d) – PVWATTS

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
E_d (kWh/day)	2676	4681	5321	6238	7056	7566	7991	7460	6318	4090	2560	2595

The average monthly electricity production for S1 is presented in table 3,following the same trend as daily electricity production.

Table 3

Average monthly electricity production from the given system(E_m) – PVWATTS

	Jan	Feb	Mar	Apr	May	Jun
E_m(kWh/month)	82967	131087	164979	187148	218735	226989
	Jul	Aug	Sep	Oct	Nov	Dec
E_m (kWh/mont)	247721	231269	189541	126805	76828	80462

The average daily and monthly sum for S1 of global irradiation per square meter received by the modules of the given system are presented below in table 4 respectively table 5.

Table 4

Average daily sum of global irradiation per square meter received by the modules of the given system (H_d) – PVWATTS

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
H_d (kWh/m^2/day)	1.95	3.5	4.03	4.93	5.71	6.31	6.77	6.3	5.16	3.24	1.9	1.92

Table 5

Average monthly sum of global irradiation per square meter received by the modules of the given system(H_m) – PVWATTS

	Jan	Feb	Mar	Apr	May	Jun
H_m (kWh/m^2/month)	60.35	97.88	124.88	147.99	176.93	189.3
	Jul	Aug	Sep	Oct	Nov	Dec
H_m(kWh/m^2/month)	209.9	195.29	154.94	100.55	57.09	59.48

Yearly average ondaily and monthly electricity production for S1 as well as global irradiation data is presented in table 6.

Table 6

Yearly average – PVWATTS

	E_{dy}(kWh/day)	E_{my}(kWh/month)	H_{dy}(kWh/m^2/day)	H_{my}(kWh/m^2/month)
Yearly average	5382.3	163711.5	4.31	131.1

The total energy production for S2 over a period of one year is 1816600 kWh, presented in table 7.

Table 7

Global results - PVGIS

Solar panels	NºP.	P. power (Wp)	P.weight (kg)	Power (kWp)	Energy (kWh)	Yield (kWh/kWp)
Aide Solar:XZST-230W (M)	6952	230	18	1598.96	1816600	1136.11

The average daily electricity production for S2is presented in table 8.

Table 8

Average daily electricity production from the given system(E_d) – PVGIS

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
E_d (kWh/day)	2600	3330	4980	6210	6160	6860	7460	7270	5490	3930	2880	2460

The average monthly electricity production for S2is presented in table 9.

Table 9

Average monthly electricity production from the given system(E_m) – PVGIS

	Jan	Feb	Mar	Apr	May	Jun
E_m (kWh/month)	80700	93200	154000	186000	191000	206000
	Jul	Aug	Sep	Oct	Nov	Dec
E_m (kWh/month)	231000	225000	165000	122000	86300	76400

The average daily and monthly sum for S2of global irradiation per square meter received by the modules of the given system are presented below in table 10 respectively table 11.

Table 10

Average daily sum of global irradiation per square meter received by the modules of the given system(H_d) – PVGIS

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
H_d (kWh/m^2/day)	1.86	2.38	3.63	4.69	4.77	5.4	5.95	5.77	4.25	2.97	2.12	1.77

Table 11

Average monthly sum of global irradiation per square meter received by the modules of the given system(H_m) – PVGIS

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
H_m (kWh/m^2/month)	57.6	66.7	113	141	148	162	184	179	128	92.1	63.5	54.9

Yearly average of daily and monthly for S2electricity production is presented in table 6 listed below.

Table 12

Yearly average – PVGIS

	E_{dy}(kWh/day)	E_{my}(kWh/month)	H_{dy}(kWh/m^2/day)	H_{my}(kWh/m^2/month)
Yearly average	4980	151000	3.81	116

RESEARCH RESULTS

In terms of the impact on local biodiversity, this territory investigated is part of the protected area **ROSCI0063 Defileul Jiului and also ,,Defileul Jiului National Park,,**

In this area we found these types Natura 2000 habitats:

A. Forest habitats represented byfollowing types: habitat **9110 –** *Luzulo-Fagetum*beech forests; CLAS. PAL.41.11; RO habitat type code: R4102, R4105-4107, R4110; habitat **9130-** *Asperulo-Fagetum* beech forests; CLAS. PAL.: 41.13; RO habitat type code: R4118, R4119, R4120; **91V0 -** Dacian beech forests (*Symphyto-Fagion*); CLAS. PAL.: 41.1D2; RO habitat type code R4101, R4103, R4104, R4108, R4109, R4116; habitat **9410 -** Acidophilus spruce forests (*Picea*) of the montane to the alpine levels (*Vaccinio-Piceetea*);CLAS. PAL.: 42.21 to 42.23, 42.25- Eastern Carpathian arolla forests; EUNIS cod - G3.1B62 -Eastern Carpathian subalpine spruce forest; RO habitat type code: R4203, R4205, R4206, R4207, R4208, R4209; habitat **91Y0** - Dacian oak-hornbeam forests; CLAS. PAL.: 41.2C; RO habitat type code: R4124, R4125, R4126, R4143, R4147; habitat **9150** - Medio-European limestone beech forests of the *Cephalanthero-Fagion* CLAS. PAL.: 41.16; habitat **9180***-*Tilio-Acerion* forests of slopes, screes and ravines CLAS. PAL.: 41.4; RO habitat type code: R4117; habitat **91E0***-Alluvial forests with *Alnusglutinosa*and *Fraxinusexcelsior* (*Alno-Padion, Alnionincanae, Salicionalbae*; CLAS. PAL.: 44.3, 44.2 and 44.13 RO habitat type code: R4401, R4402, R4405, R4407, R4408; (Gafta and Mountford., coord., 2008)

B. Rock and screes habitats. The most important debris habitat in this area is the habitat **8210** is found in nthis territory - Calcareous rocky slopes with chasmophytic vegetation; CLAS. PAL.: 62.1;RO habitat type code:R6202, R6204, R6206, R6207, 6208, R6209, R6211 p.p., R6212,R6213, R6214, R6216, R6217, R6218, R6222, R6223**;** (Gafta and Mountford., coord., 2008). This habitat is characteristic to rocky, steep and shady walls, calcareous rocks, growing on superficial rendzinic soils. Out of the vegetal communities characteristic to the habitat in this area the most frequently found are the following: *Asplenio- Cystopteridetumfragilis*Oberd. (1936) 1949; *Thymopulcherrimi-Poëtumrehmanii*Coldea (1986) 1990; *Asplenietumtrichomano-rutae-murariae*Kuhn 1937, Tx. 1937 (Syn: *Tortulo-Asplenietum*Tx. 1937); *Asplenioquadrivalenti-Poëtumnemoralis*Sooex Gergelyet al. 1966.

C. Tall-herb habitats. From this types we found the habitat**6430 -** Hydrophilous tall-herb fringe communities of plains and of the montane to alpine levels; CLAS. PAL.: 37.7 şi 37.8; RO habitat type code:R3701, 3702, 3703, 3706, 3707, 3708, R3714 (Gafta and Mountford., coord., 2008).Hydrophilous weeds in this habitat grow in shady places with high humidity of the montane level on colluvium alluvial soils.

D. Heath habitats. From this category the most important habitat is: **4060** - Alpine and Boreal heathsCLAS. PAL.31.4;RO habitat type code:R3101, R3104, R3107-3109, R3111, R3115, R3617. It includes dwarf, sometimes crawling heaths, characteristic to the higher montane levels, mainly dominated by *Ericaceae s*pecies (Gafta and Mountford., coord., 2008).

E.Waters flowing. In this area from this type habitats we found : habitat **3220** – Alpine rivers and the herbaceous vegetation along their banks; CLAS. PAL.: 24.221 şi 24.222; RO habitat type code: R5416, R5418, R5420, R5423;habitat **3230** -Alpine rivers and their ligneous vegetation with *Myricariagermanica*; CLAS. PAL.: 24.223 x 44.111; RO habitat type code: R4415; **3240** -Alpine rivers and their ligneous vegetation with *Salix elaeagnos*; CLAS. PAL.: 24.224 x 44.112;RO habitat type code:R4417
Human impact, current pressure and future threats
In the investigated area this habitats is characterized by the following data on the conservation status and human impact.

Conservation status: from favorable up to unfavorably-inappropriate;
Development trend of habitat: from stable up to decreasing;
Human impact and current pressures: G05.07-missing or wrongly directed conservation measures; H05.01- garbage and solid waste; F04.02.02- hand collection;E03.01- disposal of household/recreational facility waste; A.06.01.02- non- intensive annual crops for food production; D.06- Other forms of transportation and communication; H05.01- garbage and solid waste; A04.01- intensive grazing; H01.09- diffuse pollution to surface waters due to other sources not listed; B01 - forest planting on open ground; D01.02-roads, motorways; E01-Urbanized areas, human habitation;E02-Industrial or commercial areas.

Future threats: E03.01- disposal of household / recreational facility waste;E01.01-continuous urbanization;D.06- Other forms of transportation and communication; F.03.02.09 - other forms of taking animals; H05.01- garbage and solid waste; H01.09-diffuse pollution to surface waters due to other sources not listed; B01-forest planting on open ground; D01.02-roads, motorways.

In terms of energy production, yearly average of monthly energy production for S1 is 8% higherthanS2, the results being presented in figure 3.

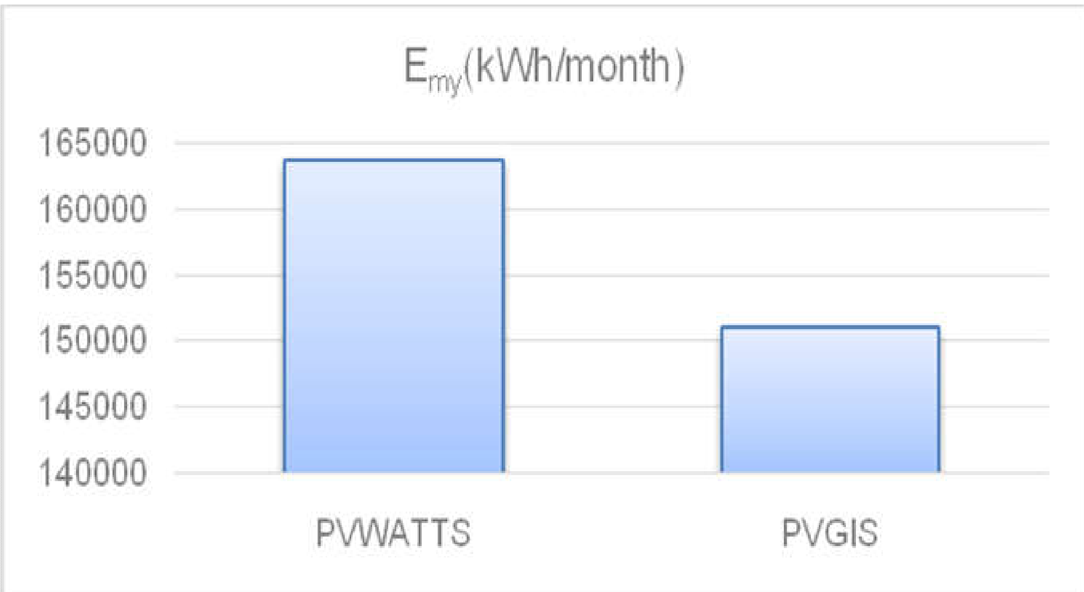

Figure 3 - Yearly average of monthly energy production

The total energy production of the photovoltaic system keeps the same trend as the monthly energy production, the results being presented in figure 4.

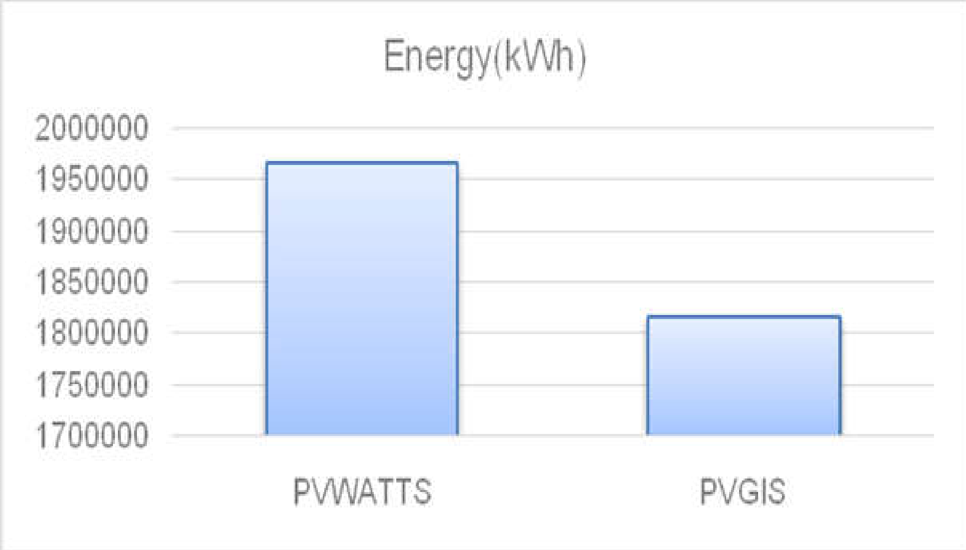

Figure 4 - Total energy production of the PV system

The study results reveal that the optimistic scenario for electricity generation is represented by the S1 simulation software but on a practical approach the difference between the two are not so far removed.

CONCLUSIONS

The analyzed system has a maximum of 1964538 kWh total energy production for S1 and 1816600 kWh for S2.

The study reveals the capabilities of a photovoltaic system over a period of one year, the impact of the system on local biodiversity and the differences between the two simulation software utilized.

Since the production of energy using photovoltaic panels does not generate greenhouse gases, this technology is a viable option for the future, despite the fact that the considered zone is in a protected area.

BIBLIOGRAPHY

1. **GAFTA, D., MOUNTFORD, O. Coord.**, 2008 - *Romanian Manual for interpretation of Eu habitats*, ED. Risoprint, Cluj-Napoca, pp. 101

2. **MOUNTFORD O., GAFTA D., ANASTASIU Paulina, BĂRBOS M., NICOLIN Alma, NICULESCU Mariana & OPREA Ad.**, 2008 - *Natura 2000 in Romania. Habitat Fact Sheets*. Available on: http://www.anpm.ro

3. **NICULESCU, MARIANA, GRECU, FLORINA, NUŢĂ, I. S., IOVU, I.**- *Researches on the meadows from Cynosurioncristatibr.-bl. et tx. 1943 in the Bistriţa-Văratec Valley (Gorj County, Romania),* AnaleleUniversităţii din Craiova, seriaAgricultură – Montanologie – Cadastru Vol. XLII/2/2012, http://agronomie.administrativ.ucv.ro/aamc/index.php/aamc, p.188-193

4. **NICULESCU, MARIANA, FĂGĂRAȘ, M. M.**- *The grassland Natura 2000 habitats found in Lespezi Quarry and the surroundings, Dambovita County* -15th International Multidisciplinary Scientific GeoConference SGEM 2015,www.sgem.org, SGEM2015 Conference Proceedings, ISBN 978-619-7105-39-1 / ISSN 1314-2704, June 18-24, 2015, Book5 Vol. 1, 877-882 pp, DOI:

10.5593/SGEM2015/B51/S20.116,http://www.sgem.org/sgemlib/spip.php?article6369&lang=en
5. **TRIF, C. R., FĂGĂRAȘ, M. M., HÎRJEU, N. C., NICULESCU, M**.-2015. *Ghidsintetic de monitorizarepentruhabitate de interescomunitar (sărături, dune continentale, pajiști, apadulce)* din Romania, Ed. Bolda, Constanța
6. NREL (2017) PVWatts Calculator. National Renewable Energy Laboratory, http://pvwatts.nrel.gov, Accessed November 2017
7. Psomopoulos, C.S., Ioannidis, G.C., Kaminaris, S.D. et al. Environ. Process. (2015) 2(Suppl 1): 175. https://doi.org/10.1007/s40710-015-0092-4
8. SketchupSkelion solar design plugin renewable energy, http://out.easycounter.com/external/skelion.com, Accessed November 2017
9. European Commission. PVGIS: PV Potential Estimation Utility, Photovoltaic Geographical Information System, http://re.jrc.ec.europa.eu/pvgis/apps4/pvest.php, Accessed November 2017
10.*** *Council Directive 92/43/EEC* of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora, Annex I (Habitats Directive)
11.****List Threats, Pressures and Activities* (final version) http://bd.eionet.europa.eu/activities/Reporting/Article_17/reference_portal