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REVIEW ARTICLE

A Comparative Evaluation of Photovoltaic Electricity Production Assessment Software (PVGIS, PVWatts and RETScreen)

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Abstract The production and installation of PV systems is now one of the world's fastest growing industries. This paper presents the primary differences in the usage and results of three major free software packages, Photovoltaic Geographical Information System (PVGIS), PVWatts and RETScreen, used for quick estimations and calculations relevant to photovoltaic (PV) electricity production. This work spots the differences between these three software packages when used to estimate the ins and outs of variously sized theoretical PV arrays. Real measurements of existing PV parks installed in Greece (i.e., a real roof integrated PV array of 9.6 kWp, a PV plant of approximately 105.6 kWp, and a 98.4 kWp installation featuring a 2-axis tracking mechanism), provided data compiled over 24 months and allowed the assessment of the theoretical calculation results of the major software.

Keywords Simulation · Methodology · Roof-integrated systems · Photovoltaic software

1 Introduction

The European Commission (2014) has set a new policy for 2030 energy systems to make them more competitive, secure and sustainable. Since we are in the middle of achieving the 2020 targets (European Commission 2014) an integrated policy framework was introduced to ensure regulatory certainty for investors and a coordinated approach among Member States. This framework was introduced in January 2014 in order to drive investors towards a low-carbon economy. The main target of this framework is to reduce GHG emissions by 40 % below the

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level they were in 1990. Among other targets, Renewable Energy Sources (RES) could not be excepted as they are estimated to increase their share by at least 27 %. The current incentive law on RES (Maroulis 2012) is considered a drawback towards many renewable technologies but the Government seeks to implement new incentives such as net metering to boost photovoltaic parks after the current negative turn events by electricity cuts by the Public Power Corporation (PPC) (Tsagas 2013). Investors will be seeking the least expensive projects. This opinion is enhanced by Lagogiannis (2012), who also confirmed that investors risk capital enterprises, especially civilians which do not have the expertise of the available renewable energy options. They could refer to established PV construction companies instead of individual engineers. In the field of Solar PV system, if a standalone Photovoltaic (PV) system is to be designed, then there will be separate simulation software for corresponding task as per the requirement of the users (Lalwani et al. 2010). Construction companies spend an amount of money to purchase software for simulation and computation to complete their proposals or reports without knowing how accurate the results they get are or if they get almost similar results if not the same by the software that someone can find for free on the web. This would be a useful knowledge because many freelance engineers do not have the budget to purchase expensive computation tools, and so, in developing countries, free software are commonly used (Elliott 2011).

In a competitive market where many software companies have created their own computation tools to accurately simulate the energy production of renewable energy sources, the European Commission and the National Renewable Energy Laboratory (NREL) of the USA have developed PVGIS and PVWatts, respectively. While most software are expensive and require engineering knowledge, PVGIS and PVWatts are free, relatively simple to operate, accurate and flexible with a number of options available. For many years, Europe has been eager to promote and put into practice multiple renewable energy technologies, whilst the USA is relatively new to the RES implementation and have been investing in alternative energy sources more intensively since the California electricity crisis of the 90's (EPIA 2012; Cheyney 2010; Lalwani et al. 2010).

The RETScreen Clean Energy Project Analysis Software (RETScreen)is the world's leading clean energy decision-making software. It is provided completely free-of-charge by the Government of Canada as part of Canada's recognition of the need to take an integrated approach in addressing climate change and reducing pollution.

In this paper, a comparative evaluation of three major free software packages, Photovoltaic Geographical Information System (PVGIS), PVWatts and RETScreen, has been attempted. The criteria for this choice were: the flexibility of the tool containing wide range applications; the public availability of a reasonable amount of documentation for the software; the usefulness of the tool for analysis of energy systems in context of sustainable development. The energy produced by existing photovoltaic installations has been computed and compared using the previously mentioned software.

2 Basic features of PVGIS

PVGIS is an online free solar photovoltaic energy calculator for stand alone or connected to the grid PV systems and plants, providing a large and accurate solar radiation free database for Europe, Africa, the Mediterranean Basin and South-West Asia. PVGIS is the ideal free online tool to estimate the solar electricity production of a photovoltaic system. As a photovoltaic

Geographical Information System, it proposes a Google Map application that makes it easy to use. This application calculates the monthly and yearly potential electricity generation E [kWh] of a Photovoltaic system with defined modules tilt and orientation. Also, it is possible to download free maps of radiation for different countries and regions: Europe, Europe Mediterranean region, Europe Alpine region, etc. The basis for the European part of PVGIS is a dataset with 10 years of data from 566 ground stations in Europe measuring global horizontal radiation and in some cases diffuse radiation. The station data were collected and processed as a part of the European Solar Radiation Atlas (ESRA) and published as monthly averages of daily irradiation sums (Pavlović et al. 2011, 2012, 2013a, b; Šuri 2007; Pagola et al. 2010; Angelis-Dimakis et al. 2011). The computational approach is based on a solar radiation model, and the spline interpolation that are implemented within the open-source GIS software GRASS. The solar radiation model algorithm uses the equations published in the ESRA. This is certainly a powerful tool that can be used for the development of new solar power plants that will obviate climate change and promote sustainable development through poverty alleviation (Pagola et al. 2010; Dike et al. 2012; Hofierka and Kanuk 2009). Other details of the PVGIS methodology and development can be found in some key reference papers (Carrion et al. 2008; Chineke 2008; Šúri et al. 2005, 2008; Kenny et al. 2006).

PVGIS is a web-based calculation tool implemented by European Commission available in five languages with English as the primary. It uses a large database and maps of every European country available, with an adequate number of forms. The maps represent an annual sum of solar irradiation on both inclined and flat surfaces. The data appears to be recent for the majority of territories relevant to this paper (up to 2011), while countries with low solar irradiance (above 58°N) use a 10 year average of the years 1981–1990. The parameters and data used for the calculations are all available on the website. The PVGIS webpage looks poor and the design appears to be rather simple and unorganized (Joint Research Centre 2014).

Entering the PVGIS platform, a map of Europe is clearly visible on the left half of the page (which has recently been updated to Google Maps v3) while there are also options available for Africa. It is noticeable that while the Google Maps functionality has been updated, it still does not allow the user to navigate to other continents. Normal map is the default setting but the user is also able to choose other features such as hybrid mode etc. Maps are available according to solar radiation levels and a temperature database. On the right side, the data interface for the calculations is displayed in a simple grey environment. The first tab allows the user to calculate the production of a photovoltaic installation by filling in the required boxes. It also allows the user to export the results to a pdf file or a simple web page (Fig. 1). PVGIS also allows the user to predict monthly and daily radiation via the user uploading hourly consumption files, in order to estimate the output of stand-alone photovoltaic installations (Joint Research 2014).

Three search boxes on top of the map allow the user to manually enter the location and country, latitude and longitude or navigate by just hovering and clicking. In general, PVGIS is simple and has a large and detailed database promoting it more as a calculation than an estimation tool. A big weakness of this software is that it is not applicable for countries outside of Europe and Africa. It would be particularly useful for customers in Asia, since China is presently the leading force in photovoltaic production. PVGIS is portable and can be used even on a smartphone, hence no need for installation. Although PVGIS provides a large amount of data over a period of time, it does not indicate any financial projections of the energy produced by the photovoltaic installation. However, 12 month graphs of solar irradiance and energy production can be produced via the data entered by the user (EPIA 2012; Šúri et al. 2007; Huld et al. 2010).

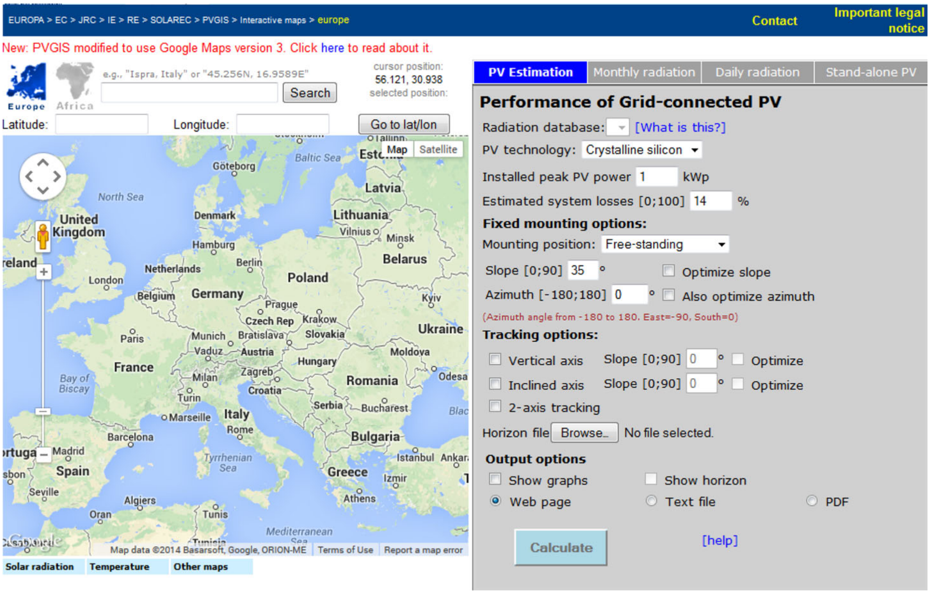

Fig. 1 PVGIS Interface

3 Basic features of PVWatts

This tool has been designed by the NREL, and two versions of the software exist. Version 1 allows users to select a location in the US from a map; it also allows choosing countries around the world. The available cities are all predetermined, i.e., Athens is the only city in Greece. The second version is no longer available, although according to the latest update (January 2014) PVWatts Beta release calculator is based on PVWatts v1, PVWatts v2 and IMBY (In MyBackYard) (NREL 2014).

PVWatts calculator is a well-designed website, embedding social network feedback, with a pleasant modern design. Unlike PVWatts Version 1, the last version guides the user easily, with simple steps to estimate the energy produced by the photovoltaic installation. A user can easily learn the ins and outs of this software by simply clicking the 'help' button on the welcome page. For a system located in the United States, PVWatts reads Typical Meteorological Year 3 (TMY3) and Typical Meteorological Year 2 (TMY2) solar resource data from the National Solar Radiation Database (NSRDB) of the NREL, and a 10 k gridded dataset from SolarAnywhere for locations within the United States. It does not include the older 40 k gridded data from PVWatts Version 2 as the other datasets are superior. By default, PVWatts chooses the TMY3 data site nearest the system location, but one can change it to the nearest TMY2 data site (NREL 2014). PVWatts comments that for a system location outside the United States, the software reads solar resource data from one of the following databases, depending on location:

a) Solar and Wind Energy Resource Assessment Program (SWERA)
b) The ASHRAE International Weather for Energy Calculations Version 1.1 (IWEC)
c) Canadian Weather for Energy Calculations (CWEC)

Using typical meteorological year weather data for the selected location, PVWatts calculator determines the solar radiation incident of the PV array and the PV cell temperature for each hour of the year. The DC energy for each hour is calculated from the PV system DC rating and the incident solar radiation, and then corrected for the PV cell temperature. The AC energy for each hour is calculated by multiplying the DC energy by the overall DC-to-AC derate factor and adjusting for inverter efficiency as a function of load. Hourly values of AC energy are then summed to calculate monthly and annual AC energy production. Default system parameters are used, but users have the option to change the following: DC rating, DC to AC derate factor, type of PV array (fixed or tracking), PV array tilt angle, PV array azimuth angle and local electric costs. Users cannot change the following system parameters: installed nominal operating cell temperature (INOCT) of 45 °C, power degradation due to temperature of 0.5 %/°C, angle-of-incidence (reflection) losses for a glass PV module cover, photovoltaic cell technology: crystalline silicon (mono, poly) (Marion and Anderberg 2000; Marion et al. 2001; Marion 2010).

PVWatts notes that if the user does not want to use the data above, he can import his own or use a different database. Typical meteorological years (TMY) are used for the NREL's database of a typical year of solar resource data. It represents the solar radiation and meteorological data that has been collected during a number of years in the past. This database allows PVWatts to provide an economic 25-year life cycle analysis. TMY2 is available for 230 locations within USA using a 30-year collection of data for the period from 1961 to 1990. TMY3 includes more recent files, where the years 1991–2005 are included. The manual of the software provides enough details of every aspect of the data and algorithm used, making it easy for the user to understand what to fill in the form. In the main page there is a Get Started box where you may enter your Postal Code or the name of a city you wish. As it was mentioned above, PVWatts does not provide full data on other countries, however, the primary cities of countries worldwide are available.

In Fig. 2, the form which the user has to fill in is shown. DC system size in kW, array type, DC-AC derate factor, arrays tilt and azimuth are required. Also, in PVWatts the direction to south is considered to be 180° while in PVGIS is 0°. A fancy but helpful tool that PVWatts provides is "draw your system".

This tool forwards the user in a new window tab to Google Maps, where the user may draw with as much precision as the zoom allows the area of the photovoltaic system. Although calculations are unrelated to the location which is chosen to draw (e.g., if the location is Athens, GRC and you draw in Morocco, PVWatts calculates for Athens), it is helpful for a random user to see the estimated capacity of his roof, or open field.

The user may either directly enter the capacity desired or use the drawing feature, which allows the user to pick a desired PV efficiency for the calculations. By the time the drawing is complete, the cumulative capacity is calculated. The results represent the sum of each month but also a file can be downloaded for an hourly or monthly fully detailed report. The software warns that for its calculations many assumptions are made and the results may vary from actual photovoltaic installations. Better performance PV modules are not differentiated within PVWatts from lower efficiency modules. The economic results are also commented to be rough estimations and not accurate analysis.

At the bottom of the form, the user may enter economic details for the software to estimate the energy produced annually in USD (Fig. 2).

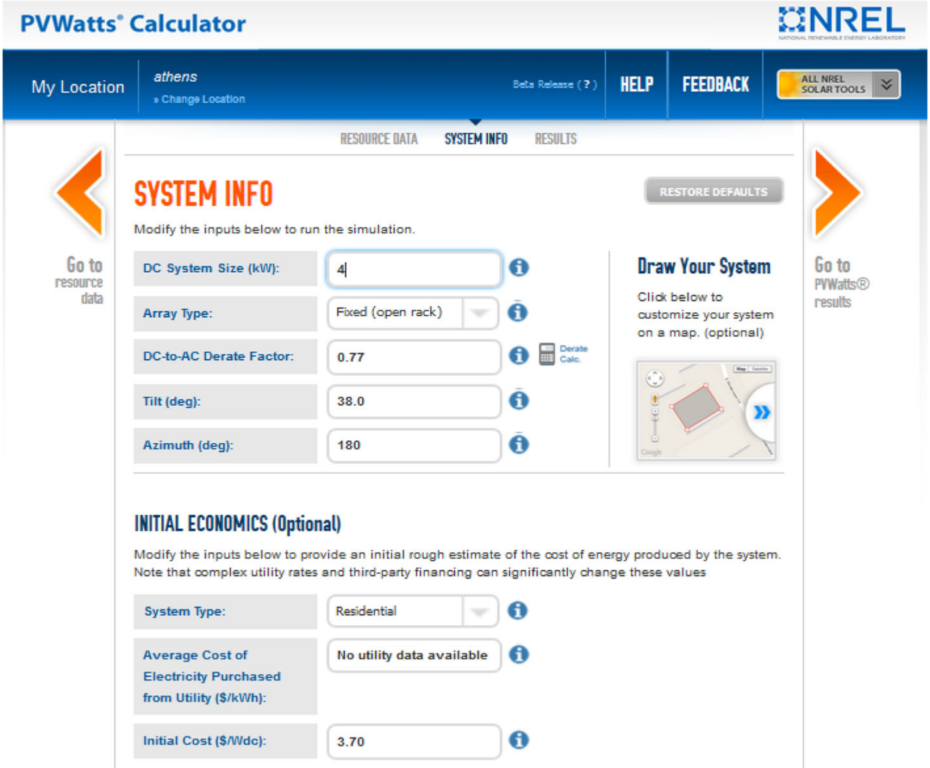

Fig. 2 PVWatts Interface

4 Basic features of RETScreen

The RETScreen clean energy project analysis software is a decision support tool developed with the contribution from government, industry, and academia. It was originally developed in 1996 by the Natural Resources Canada (NRCan) CANMET Energy Technology Centre for renewable energy technologies analysis. The software, is provided free-of-charge from http://www.nrel.gov/ and http://www.retscreen.net/, and can be used worldwide to evaluate the energy production and savings, costs, emission reductions, financial viability and risk for various types of renewable energy and energy efficient technologies. The RETScreen software is available in multiple languages and also includes product, project, hydrology and climate databases, a detailed user manual, and a case study based college/university-level training course, including an engineering e-textbook.

Once the type of the project is entered, the next tab allows the user to select out of a variety of options the technology and grid type of his choice. The RETScreen software provides users' access to climatic data from ground monitoring stations, or as an alternative, from the NASA Space Environments and Effects (SEE) satellite-derived data sets. For example, with regards to Greece, many locations around the country, and not just Athens, are included. The second tab includes an energy model of financial analysis, emission analysis and case power system depending on the choice that has previously been made.

Ground-based meteorological data includes averages of ground-based observations for over 6500 sites around the world, compiled from over 50 different sources for the period 1982 to 2006. NASA's satellite-derived meteorological data for any location on earth is provided for use with the RETScreen software via the NASA prediction of worldwide energy resource (POWER) project. The current NASA data set is formulated from data gathered for a 20-year period starting in July 1983, using a 1-degree cell. At mid-latitudes (45°), the cell size is approximately 80,110 km. Solar irradiance values are inferred using satellite observations of the atmosphere and Earth's surface. The other meteorological parameters (e.g., temperature, humidity, etc.) are adapted from the NASA's Global Modeling and Analysis Office (GMAO), Goddard Earth observing system (GEOS v. 4.0.3) meteorological analysis (Markovi et al. 2011; Šuri 2007).

When the energy model screen with the PV as an energy source is selected, RETScreen allows the user to apply two methods which do not differ from each other. In this paper, the second method will be selected to perform all the calculations. It requires the details of the panel like: power capacity, manufacturer and model type, and by using NASA climate database in each location, it calculates the electricity produced to grid on a monthly and annual basis as well (Figs. 3 and 4).

5 A comparative evaluation: case studies

Three different types of photovoltaic installations are used in order to spot the differences in the calculations among the three software packages presented above:

- A roof mounted photovoltaic installation of 9.6 kWp in the area of Athens,
- A 105.6 kWp open field array in Asopos, Lakonia (Southwest Greece), and finally,
- A 98.4 kWp array in Amyntaio, Florina (Northwest Greece) using a 2-axis tracker.

Fig. 3 RETScreen interface

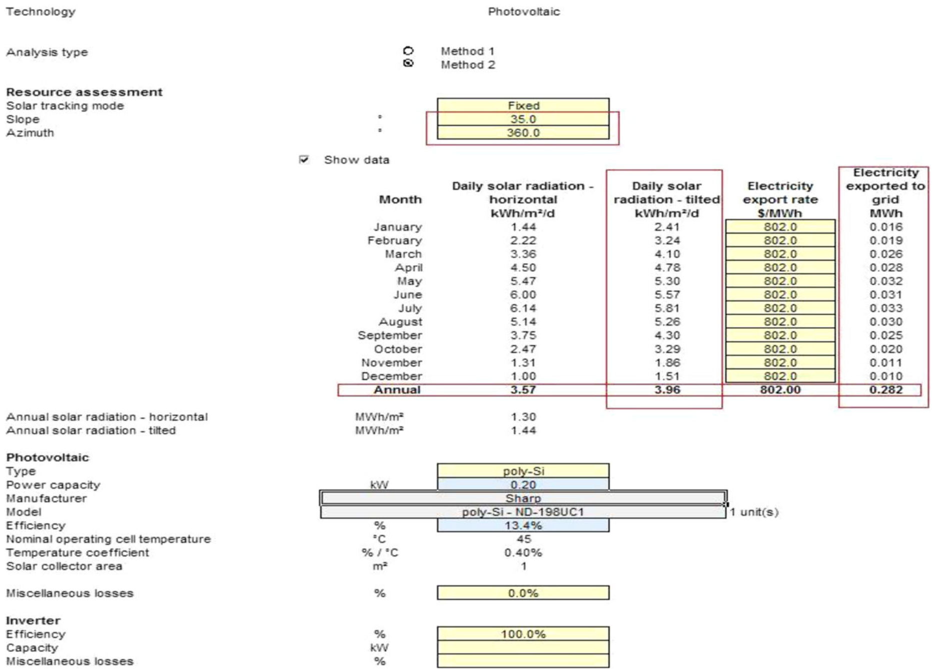

Fig. 4 RETScreen interface

In Table 1, the characteristics of the roof mounted photovoltaic installation of 9.6 kWp in the area of Athens are presented. Measurements and simulation results using the three free simulation software packages are also presented in Table 2. Specifically, monthly energy production of the actual installation, simulated energy production results and their deviation from the measurements (real data) for the summer, winter and annual periods are explicitly shown. The real data were collected from SMA's Sunny Portal database (an average of the years 2012 and 2013) and inserted into the software data forms to obtain the calculation results.

The above mentioned results are presented graphically in Fig. 5. PVGIS was able to calculate the energy produced from the exact location while PVWatts used the location of Athens. RETScreen used the stored climate data from the station of Ellinikon (close to Athens).

From Table 2 and Fig. 5, it is shown that the annual real energy produced by the array is underestimated by all software packages, but PVGIS gave closer results to the actual measurements. Especially for the summer period, PVGIS is more accurate than the other two software packages (−5.9 % deviation from the measurements compared to the −7.6 and

Table 1 Small scale photovoltaic installation characteristics

Location:	Athens - Egaleo (38.000271, 23.669375)	Size:	9.6 kWp
Type:	Roof-mounted	Module:	SunPower E19 320 EU
Inverter:	Sunny Boy 3300–11, efficiency: 94.50 %	Losses:	16.5 %
Slope:	30°	Azimuth:	0°

Table 2 Small scale photovoltaic installation measured data and simulation results

Locations:	Egaleo	Egaleo	Athens	Ellinikon
Available Module:	SunPower E19 320 EU	–	–	Canadian Solar CS6X-300P
Power:	9.6 kWp	9.6 kWp	9.6 kWp	9.6 kWp
	Measurements (Real Data)	PVGIS	PVWatts	RETScreen
	kWh/kWp	kWh/kWp	kWh/kWp	kWh/kWp
January	81.0	86.6	76.1	77.3
February	84.2	95.5	83.1	82.6
March	136.7	128.1	116.4	110.6
April	152.5	141.7	128.1	127.0
May	163.2	155.2	144.4	141.0
June	173.0	159.4	158.5	147.9
July	174.7	167.7	166.7	151.4
August	172.8	164.6	158.9	147.0
September	151.3	140.6	144.0	127.7
October	120.2	119.8	108.5	100.2
November	82.9	91.7	68.0	70.9
December	70.0	80.3	65.6	62.4
Annual	1562.4	1531.1	1418.3	1346.0
	Winter deviation	+10.4 %	−4.6 %	−5.8 %
	Summer deviation	−5.9 %	−7.6 %	−16.6 %
	Annual deviation	−2.0 %	−9.2 %	−13.8 %

−16.6 % for the PVWatts and RETScreen, respectively) while the opposite is true for the winter period (+10.4 % deviation from the measurements compared to the −4.6 and −5.8 % for the PVWatts and RETScreen, respectively). These findings most likely occur due to the weakness of all of the programs in forecasting the real, current climatic conditions of each location as they both use historical data. PVGIS is the most favorite among the rest packages on an annual basis, as the annual deviation from the measurements is only −2 %, while it is

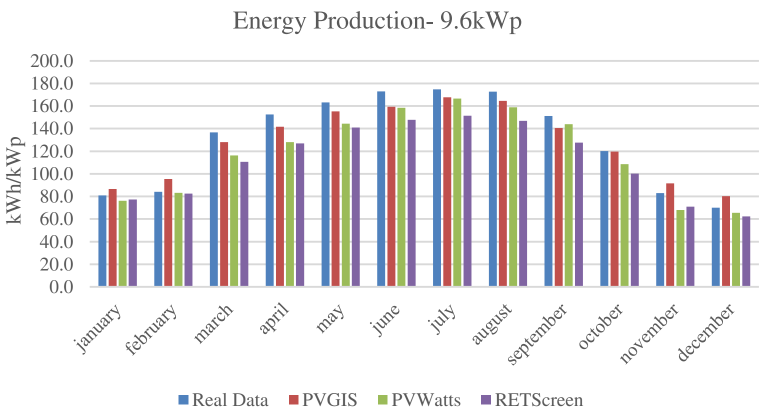

Fig. 5 Energy production measurements and calculations by PVGIS, PVWatts and RETScreen for the 9.6 kWp roof mounted PV installation in the area of Athens, Greece

−9.2 % and −13.8 % for the PVWatts and RETScreen, respectively. Most probably PVGIS uses more accurate databases for the specified location.

On a larger scale and for a 105.6 kWp open field array in Asopos, Lakonia, the results (measurements and software calculations) are presented in Tables 3 and 4, and graphically in Fig. 6. Specifically, in Table 3, the basic characteristics of the open field photovoltaic array are presented. Next, measurements and simulation results using the three free simulation software packages are also presented in Table 3. Again, monthly energy production of the actual installation, simulated energy production results and their deviation from the measurements (real data) for the summer, winter and annual periods are shown. From Table 4 and Fig. 6, it is shown that the annual real energy produced by the array is underestimated by PVWatts and RETScreen while PVGIS overestimates them. PVGIS predictions are closer to the actual measurements. Especially for the summer period, all software packages estimate accurately the produced energy (|deviation| ≤1.5 %) while for the winter period, RETScreen is more accurate (−3.4 % winter deviation) and then comes PVGIS and PVWatts with +8.3 %, −12.6 % deviations from measurements, respectively. On an annual basis, both PVGIS and RETScreen appear to be relatively accurate, a finding which is justified by the fact that in both cases the climatic data used by the packages are coming from location near the actual location of the array. On the other hand, PVWatts appears to be less accurate mainly because of the rather long distance between software array location and real array location (200 km northeast to Athens). In other words, the different azimuth angle used by the software, most probably has caused this deviation.

In Table 5, the characteristics of a 2-axis 98.4 kWp installation in Amyntaio, Florina are presented. Measurements and simulation results (for this site) using the three free simulation software packages are presented in Table 6. Monthly energy production of the actual installation, simulated energy production results and their deviation from the measurements (real data) for the summer, winter and annual periods are also explicitly shown in Table 6 and graphically on Fig. 7. Once again the real data (measurements) were collected from SMA's Sunny Portal database (an average of the years 2012 and 2013) and inserted into the software data forms to obtain the calculation results.

In this case, all software packages appear to underestimate the production energy by the array. Both PVGIS and PVWatts seem to predict relatively accurately the produced energy with annual deviation −4 and −6.5 %, respectively. The prediction of the produced energy during winter and summer worsens with deviations around 7 to 8 %. In this case, RETScreen seems to present the highest deviation from the measurements (−12.6 %) although the software array location is rather close to the actual one (35 km South of Kozani) and it is closer than the respective one that PVWatts uses (500 km South East to Athens). Obviously, the difference in climate date (irradiance levels) among the different locations used by the software packages, seriously affect the simulation results, sometimes in favor and others against simulation precision.

Table 3 Medium scale photovoltaic installation characteristics

Location:	Asopos-Lakonia, (36.734955, 22.841202)	Size:	105.6 kWp
Type:	Free standing	Module:	Yingli Solar YL 245 P-32b EU
Inverter:	Sunny tripower 17000TL-10, efficiency: 98.00 %	Losses:	11.9 %
Slope:	28°	Azimuth:	0°

Table 4 Medium scale photovoltaic installation measured data and simulation results

Locations:	Asopos-Lakonia	Asopos-Lakonia	Athens (200 km NE)	Yithion (20 km W)
Available Module:	Yingli Solar YL 245 P-32b	–	–	Yingli Solar YL 245 P-32b
Power:	105.6 kWp	105.6 kWp	105.6 kWp	105.6 kWp
	Measurements (Real Data)	PVGIS	PVWatts	RETScreen
	kWh/kWp	kWh/kWp	kWh/kWp	kWh/kWp
January	88.1	94.7	79.3	88.0
February	95.7	106.1	87.1	96.0
March	136.8	143.9	122.6	132.9
April	156.2	155.3	135.7	152.0
May	161.6	170.5	153.7	164.7
June	168.2	172.3	169.2	172.7
July	174.4	179.9	177.5	177.1
August	177.5	176.1	168.3	171.1
September	154.8	152.5	151.4	148.0
October	135.1	131.6	113.7	123.5
November	94.2	103.2	71.1	86.6
December	84.9	90.2	68.4	75.6
Annual	1627.6	1676.4	1498.0	1588.0
	Winter deviation	+8.3 %	−12.6 %	−3.4 %
	Summer deviation	+1.6 %	−1 %	+0.2 %
	Annual deviation	+3.0 %	−8.0 %	−2.4 %

6 Conclusions

In this paper, a comparative evaluation of three well-known freeware software (PVGIS, PVWatts and RETScreen) for energy production from PV has been attempted. A comparison

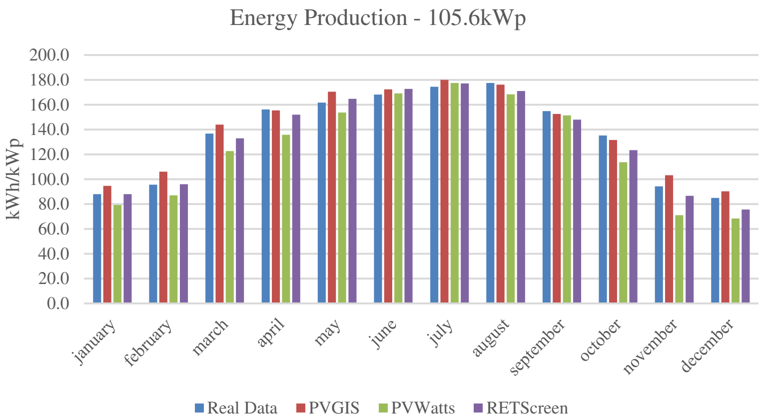

Fig. 6 Energy production measurements and calculations by PVGIS, PVWatts and RETScreen for the 105.6 kWp free-standing PV installation in Asopos-Lakonia, Peloponnese

Table 5 Medium scale, 2-axis photovoltaic installation characteristics

Location:	Amyntaio-Florina (40.665363, 21.626712)	Size:	98.4 kWp
Type:	2 axis tracker	Module:	Solarworld, sunmodule SW 230 poly
Inverter:	Sunny tripower 15000TL, efficiency: 97.70 %	Losses:	12.1 %
Slope:	–	Azimuth:	–

between each software package and their deviation from the real energy produced of existing photovoltaic parks was performed. The weaknesses and strengths of each platform for three case-type of installations were presented in Tables 1, 2, 3, 4, 5 and 6, illustrated in Figs. 5, 6 and 7 and discussed in section 5. All these software packages can be used only as estimation tools and not as accurate calculation tools, neither as scientific simulators.

As far as PVGIS is concerned:

- It appears very plain and the developers have not invested time in its appearance or promotion.
- It looks very scientific and is initially difficult for the beginner to obtain information from the parameters used.
- Regarding the calculation comparison, PVGIS appears to be accurate with small variations from real data.

Table 6 Medium scale, 2-axis photovoltaic installation measured data and simulation results

Locations:	Amyntaio	Amyntaio	Athens (500 km SE)	Kozani (35 km S)
Available Module:	AleoS-19 240 W	–	–	AleoS-18 230 W
Power:	98.4 kWp	98.4 kWp	98.4 kWp	98.4 kWp
	Measurements (Real Data)	PVGIS	PVWatts	RETScreen
	kWh/kWp	kWh/kWp	kWh/kWp	kWh/kWp
January	106.0	95.3	99.6	108.6
February	95.8	114.8	103.9	110.1
March	159.1	155.5	148.1	147.4
April	170.6	172.8	168.7	152.0
May	207.3	203.3	197.8	174.3
June	249.4	224.6	228.1	203.7
July	251.8	235.8	239.2	211.1
August	233.1	226.6	212.3	196.5
September	194.2	170.7	187.0	155.8
October	163.7	140.2	134.8	122.3
November	85.8	107.7	84.0	96.0
December	102.0	91.0	84.3	85.7
Annual	2018.7	1938.3	1887.9	1763.7
	Winter deviation	−6.4 %	−7.4 %	+16.8 %
	Summer deviation	−6.9 %	−8.0 %	−20.1 %
	Annual deviation	−4.0 %	−6.5 %	−12.6 %

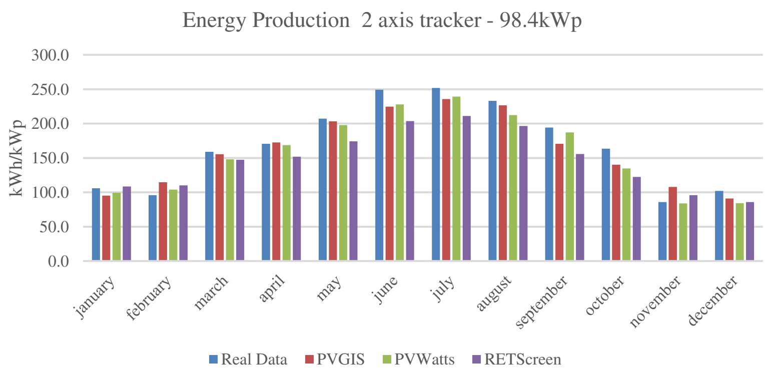

Fig. 7 Energy production measurements and calculations by PVGIS, PVWatts and RETScren for the 98.4 kWp, 2-axis tracker PV installation in Amyntaio-Florina

On the other hand, PVWatts:

- Appears to be more synchronized to new technology, allowing feedback from the most popular social media websites.
- The design is more appealing to the eye, user-friendly and is simpler to browse for details and source data.
- The drawing feature is quite enjoyable and applicable in real dimensions as it allows the user to create random shapes (from regular rectangles to more complicated geometrical drawings).
- The produced energy is corrected using the PV cell temperature.
- In general, PVWatts appears to be less accurate than PVGIS, especially when the location used by the software is far away from the real site and presents important climatic differences.

Finally, RETScreen:

- It is mostly keen to PVGIS platform, with a more serious scientific look.
- It requires PV module types, separating each manufacturer depending on module type.
- It does not contain an analytical derate factor input.
- It has a larger location database due to NASA's meteorological stations on each country.
- It is a RES calculation tool which means that it does not only include photovoltaics but also other renewables.
- Although it has a rich database, it appears to be less accurate compared to the two other software packages in winter time, summer time and on an annual basis.

Summarizing, these three software packages appear to be rather convenient tools for untrained users, with easy to fill in forms and relatively simple to obtain data results on pdf files or excel data sheets. Results are fairly accurate (on an annual basis) since both use large databases from long period of time. The strength of PVWatts is mainly confined within the U.S. borders. Nevertheless, it could also be used in other countries but with only major cities and specific locations. PVGIS is validated for Europe and Africa and it seems to estimate produced energy with relative accuracy.

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