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ePV-Trainer: Software for dimensioning stand-alone and grid-connected photovoltaic systems for educational purposes

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ABSTRACT

ePV-Trainer is a user-friendly desktop application that allows users to dimension stand-alone and grid-connected photovoltaic systems. In addition, data on any geographic location in the world can be uploaded to the platform. The aim of this paper is to describe and assess the operation of the software developed in LabVIEW™. The study concludes with practical examples to verify that data delivered by the program match the one executed on manual calculations. The result is an intuitive software, which also allows to estimate the electricity generation of photovoltaic systems, based on real parameters of solar radiation and temperature. The software has been developed for educational purposes.

1. Introduction

Nowadays, there are many governments and energy companies around the globe have increased their interest on solar photovoltaic systems, based on the environmental benefits, technology availability and system modularity. During the past decades, there has been a great effort in the development to improve solar modules efficiency to be able to provide electricity on urban and rural areas [1,2].

It can be found different tools that permits users to dimension photovoltaic systems based on their energy requirements. This wide set of options eases the task of selecting the most suitable components for each case. However, user interface of many of them is complex, while others represent a cost and require an Internet connection. Some of these softwares are improved or updated versions of PSyst PRO30 and PVSyst PREMIUM, with prices oscillating from 569 to 727 USD [3].

On the other hand, license-free softwares commonly found on the internet such as Censolar software, which does not allow the design of photovoltaic systems connected to the grid. In the case of RETScreen, it does not provide an intuitive interface [4].

It is interesting to mention that equipment manufacturers in solar photovoltaic technology, such is the case of the german company, Solar Technology AG (SMA), which is the largest manufacturer of solar inverters worldwide, have already designed a software that it is included only in its products. The software does not work as a desision tool, which is what someone would expect from a simulator.

In 2015, the Energy Research Group (GRINEN for its acronym in Spanish) of Universidad de Medellin decided to create a free software, focused only on education purposes, called ePV-Trainer. The software, which can be used either in Spanish or English, allows users to dimension photovoltaic systems. From the above explained arguments, the aim of this article is to explain in detail, how users can interact with the software.

2. Software/data availability

Name of software: ePV-Trainer
Developer: Universidad de Medellin
Contact address: Carrera 87 N° 30–65
Telephone: +57 (4) 3405555
E-mail: caarredondo@udem.edu.co
Year first available: 2016
Hardware required: Processor Speed Pentium 4–2.5 GHZ or higher processor. Memory 2 gigabyte (GB) of RAM required minimum. Hard Disk 500 MB or higher of available hard-disk space. Operating System Windows
Software required: Windows PC
Availability: Internet
Cost: Free
Program language: LabVIEW™
Program size: 200 MB

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0263-2241/

3. Software description

ePV-Trainer was developed using LabVIEW™ (Laboratory Virtual Instrument Engineering Workbench), a graphical programming language capable to build user interfaces for data acquisition systems, instrumentation and control, by creating block diagrams containing its operating principles. To define the most suitable equations to include in the algorithm, different bibliographical sources were consulted and taken into consideration to validate fundamental criteria such solar photovoltaic systems and installations [1,5], photovoltaics devices and solar radiation [6–8], temperature profiles on solar photovoltaic systems [9,10], and economical implications of solar systems [11,12].

On the other hand, as mentioned above, ePV-Trainer 2.0 does not require an internet connection, which means that all the information that may be needed to operate it, it's stored in databases. For that, solar radiation records published on the official website of NASA "*Insolation incident on a horizontal surface*" have been collected [13]. At the same time, for the particular case of Colombia, some of these data were compared with those presented on the Interactive Solar Radiation Atlas of Colombia and also with on-site measurements performed with meteorological stations located across the Valley of Aburrá (Medellin, Colombia). After completing the above tasks, the software development was finished.

4. Software interface

The following is a description of each of the functionalities included in the tabs that the software contains:

4.1. Home

It is the welcome screen. In this tab, users can select the geographical location of the site where the PV system is placed and the type of PV system to be dimensioned using the software.

A, B and C. The user must select one out of three eligible countries (Colombia, Mexico or other), state or province, and the town in which the system will be installed.

D. In this section, the user defines whether if it is a grid-connected photovoltaic system to the electrical grid or isolated (see Fig. 1).

E. Clear: The user can restart the program and start a new case of PV sizing.

4.2. Consumption

Once completed the first tab, users can click on *Consumption*. This tab allows the user to calculate the total daily energy demand in kW h. With this data, the software will dimension the energy requirements of the PV systems. In Fig. 2, it is shown the parameters considered for PV systems dimensioning, followed by a detail description of each one of them.

F. Quantity: Users submit the number of devices of a single type that exist where the photovoltaic system is located.

G. Electric device: A list of 27 different devices, including the most common home appliances is offered. Nevertheless, users can only select up to 10 different devices.

H. Power (W): Users must add the energy that each device demands to operate. This information can be found attached to the device on a data plate.

I. Daily consumption (time): Users must specify the average daily hours of use for each device.

J. Default: This button has been placed if for any reason the user cannot provide values for unitary power nor hours of daily use. When clicked, average values appear by default, depending on the selected device.

K and L. Add and Erase: The tab *Consumption* only shows a bar of added devices, if users want to add a different device, it can be done by pressing the button *Add*, making a new bar appear in the list. On the other hand, users can also delete devices by pressing the button *Erase*.

M. Extra energy consumption per day (Wh): In the case users exceed the maximum 10 available devices (illustrated as rows) and need to add more devices which exceed power consumption per day.

N. Total daily energy to supply (kW h): This indicator shows the energy consumption of the installation.

Fig. 1. Home screen of the software *ePV-Trainer*. Source: Authors.