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Performance Analysis and Modelling of 1kWp grid Connected Photovoltaic System using TRNSYS 17

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***Abstract*—The depletion of fossil fuel resources on a worldwide basis has necessitated an urgent search for alternative energy sources to meet up the present day demands. Grid-connected photovoltaic (PV) is one of the most promising applications of PV systems. The amount of incident solar radiation significantly determines the electricity produced by photovoltaic (PV) systems. The paper examines the performance as well as economic feasibility of 1kWp grid-connected PV systems installed at kovilpatti. Further, possible plant capacity is estimated for an arbitrarily chosen area. The modelling and simulation has been done using TRNSYS 17 which helps for an accurate prediction of long term performance. Results obtained from the field test and simulation results from TRNSYS 17 are to be correlated aimed to attain maximum performance of the system.**

***Keywords*— TRNSYS, PV systems, grid connection**

I. Introduction

Solar energy is clean, inexhaustible, environment friendly and a potential resource among the various renewable energy options. Photovoltaics (PV) are the direct conversion of sunlight to electricity. It is an attractive alternative to conventional sources of electricity for many reasons: it is silent, non-polluting, and renewable; it is reasonably reliable; requires simple maintenance; and it can be installed anywhere. In addition, anything that requires electricity can be powered with PV. With the widespread commercialization of PV and other renewable energy resources, our society will become less dependent on conventional central-station generation. In return it will maintain our environment as being healthy and clean.

1.1. TYPES OF PHOTOVOLTAIC SYSTEM

PV systems for buildings can be either stand-alone or grid connected. In a standalone system, the building has no connection to the utility grid and often relies on a set of batteries to store power for use at night and during periods of limited sun light. In a grid-connected or utility-interactive system, the building receives electricity from both the PV array and the utility grid. Some PV systems are capable of both stand-alone and utility-interactive modes of operation. PV electricity is produced by an array of individual PV modules electrically connected in series and parallel to deliver the desired voltage and current. Each PV module, in turn, is constructed of individual solar cells also connected in series and parallel.

1.2 ADVANTAGES OF PV SYSTEMS

The PV benefits are: system costs can be largely reduced; power is produced at the point of end use; so that transmission and distribution costs are significantly reduced; and maximizing the value of electricity generated. However, grid-connected PV systems will not be attractive unless power production is large and the cost of electrical energy produced by it is comparable to other conventional energy sources

1.3 SIMULATION TOOL –TRNSYS

TRNSYS (pronounced 'tran-sis') is an extremely flexible graphically based software environment used to simulate the behavior of transient systems. TRNSYS is a complete and extensible simulation environment for the transient simulation of systems, including multi-zone buildings. It is used by engineers and researchers around the world to validate new energy concepts, from simple domestic hot water systems to the design and simulation of buildings and their equipment, including control strategies, occupant behavior, alternative energy systems (wind, solar, photovoltaic, hydrogen systems), etc. The DLL-based architecture allows users and third-party developers to easily add custom component models, using all common programming languages (C, C++, PASCAL, FORTRAN, etc.). In addition, TRNSYS can be easily connected to many other applications, for pre- or post-processing or through interactive calls during the simulation (e.g. Microsoft Excel, Matlab, COMIS, etc.). TRNSYS applications include:

- Solar systems (solar thermal and PV)
- Low energy buildings and HVAC systems with advanced design features (natural ventilation, slab heating/cooling, double façade, etc.)
- Renewable energy systems
- Cogeneration, fuel cells

TRNSYS is made up of two parts.

- Engine (called kernel)
- Library of components

After 35 years of commercial availability, TRNSYS continues to be a flexible, component-based software package that accommodates the ever-changing needs of both researchers and practitioners in the energy simulation community

The five-parameter PV model is used to enable simulation of amorphous modules as well as polycrystalline modules. The input to the program is the weather data for India.

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II. RELATED WORK

To analyze the performance of a grid connected PV system, certain parameters are important; they are yields (reference, array and final), losses (array capture and system losses), PV and inverter efficiencies and performance ratio. Anand Joshi et al (2009) discussed a thorough review of photovoltaic and photovoltaic thermal systems on the basis of their performance, based on electrical as well as thermal output. An outdoor experimental laboratory that has been developed to estimate the performance of photovoltaic (PV) plants in operating conditions as described by Alessio et al(2012) which includes ten different plants and a data acquisition system that has been specifically conceived to monitor the actual behaviour of the plants. Loredana Cristald et al(2012) was analysed a model of PV panel, suitable for the aforementioned applications, presented together with a simple procedure for the identification of its parameters. Quesada et al (2010) studied the 7.2 kWp monocrystalline installation. In this paper the experimental results from January 2001 to March 2003 have been analyzed, and have been compared with a five parameter PV model.These aspects are analyzed thoroughly in this paper, as well as the problems inherent to the PV power injection into the grid. The model was sequentially coupled with a radiation model and an electrical model to calculate the electrical performance of the PV panels. Using the developed model, various studies were performed to evaluate the electrical and thermal performance of the module under different environmental, operating conditions with and without cooling .as described by Usama siddiqui et al (2012). Janyanta Deb Mondol et al(2006) analyzed the different combinations of the tilted surface, radiation model, global-diffuse correlation model and PV module temperature equation and compared the performance of grid connected photovoltaic system were used in the simulations. The in plane insolation predicted by an isotropic sky model was 4.8% lower than the measured in plane insolation and 0.2% lower to 1.7% higher for three anisotropic sky model over the whole simulation period.The power plant was operating within 2.1% of the long-term prediction, which was well within the expected error bars. Improvements in measurement techniques will lower the error. Improvements in the thermal model could result in increased accuracy. Panchula et al(2012) analyzed and compared the first year measured performance of the 20MW power plant with both long term energy prediction and the expected energy for the operating year. Díez-Mediavilla et al (2011) studied the real PV production from two 100 kWp grid-connected installations located in the same area, both of which experience the same fluctuations in temperature and radiation. Data sets on production were collected over an entire year and both installations were compared under various levels of radiation. PV panels production differs by more than 8% and this signifies the main contribution to the differences in production between both facilities. Mahendra Lalwani et al(2010) investigated the scenario of the available Photovoltaic simulation softwares till date. Some programs are specifically designed for photovoltaic applications and some include additional renewable energy simulation features. Major softwares available for PV simulations are shown in table 1.

TABLE1 SIMULATION SOFTWARES FOR PV SYSTEMS

Software Name	Manufacturer/ Developing Institution	Cost/ License	Website
RETScreen	Natural Resources Canada	Free of Charge	www.retscreen.net
TRNSYS	University of Wisconsin, Madison, US	$2100 for educational Use	http://sel.me.wisc.edu/trnsys/
HOMER	National Renewable Energy Laboratory, USA	Free of Charge	www.nrel.gov/homer
INSEL	Insel Company, Germany	1700 Euro for full version; 85 Euro for full version for students	http://www.insel.eu
PV F-Chart	University of Wisconsin, Madison, US	$400 for single user, $600 for educational site	http://www.fchart.com/
NREL Solar Advisor Model(SAM	National Renewable Energy Laboratory, Washington	Free	https://www.nrel.gov/analysis/sam/background.html
PVsyst	Institute of Environmental Sciences (ISE),University	900 CHF for one machine license;150CHFfor additional machines	http://www.pvsyst.com/5.2/index.php
SolarDesignTool	Verdiseno, Inc, Santa Cruz, USA	Free version available and an expert version with a monthly fee	http://www.solardesigntool.com/
ESP-r 11.5	University of Strathclyde, Scotland	Free	http://www.esru.strath.ac.uk/Programs/ESPr.htm

III. PROPOSED APPROACH

The problem is to compare the field-tested measured performance of PV systems with the software tested estimated performance of the PV systems by simulation. Also some variable parameters such as azimuth angle, array slopes are included to improve the performance of the system.

3.1 THEORETICAL MODELLING

To observe the overall effect of meteorological conditions on their operation characteristics by field test, the monitoring system has been measuring and analyzing the performance of PV system using TRNSYS. The results will indicate that it is highly imperative to develop evaluation, analysis and application technology for PV systems. A dynamic model has been implemented in TRNSYS following the scheme as shown in figure 2. TRNSYS has a weather database to predict the behaviour of PV installations at particular location. In this work, two different approaches have been used. In case (a), the PV power output is calculated using the METEORONORM weather data as inputs for the PV module (Type 194). The approach (b) is similar, but the meteorological inputs are in-field monitored data. These two models allow for an a priori and a posteriori analysis of the results. This approach has helped to quantify the uncertainties which are involved in the modeling of a PV field, such as the choice of the weather data and the radiation or temperature models.

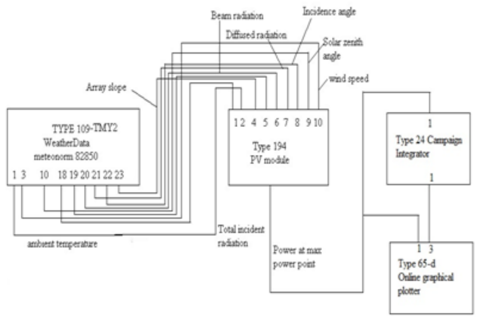

Figure 1 Schematic representation of PV model with TRNSYS 15

Modelling of 1kWp PV system is shown in the figure 2.The model is based on the same five-parameter model and differ only in the meteorological data file (meteorological data) and

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a posteriori studies (measured weather data) respectively. Type 194-b ‘‘photovoltaic arrays with inverter’’ determines the maximum power point from I–V curves in the operating conditions which are given by the meteorological inputs. Type 194-b requires the following inputs: total incident radiation on tilted surface (1), ambient temperature (2), array slope (4), beam, sky diffuse and ground diffuse radiation on tilted surface (5–7), incidence angle on tilted surface (8) and wind speed (9). The radiation inputs (5–7) are calculated internally in Type 109 by means of a radiation processor which calculates inplane irradiances from the total horizontal irradiances. Type 194-b can calculate only energetic losses such as angular, spectral and temperature losses.

Type 99 “Data Reader and Radiation processer” This component reads weather data in a user format at regular time intervals from a data file, converting it to a desired system of units and processing the solar radiation data to obtain tilted surface radiation and angle of incidence for an arbitrary number of surfaces.

Type 24 ‘‘Quantity Integrator” integrates series of quantities not more than 500 inputs over a period of time.

Type 65-d ‘‘Online Graphical Plotter’’ is used to plot the maximum PV power point (1) and the energy PV output (3).

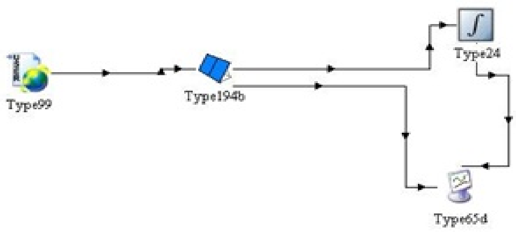

Figure 2 Modelling of 1kWp PV system using TRNSYS 17

IV.METHODOLOGY

The problem is to compare the field-tested measured performance of PV systems with the software tested estimated performance of the PV systems by simulation. Along with comparison of performance, a variation in azimuth angle and array slopes are also to be applied to the simulation system and the performance is to be estimated. The various design steps are as shown in Figure 3 for the performance analysis of PV systems with TRNSYS 17.

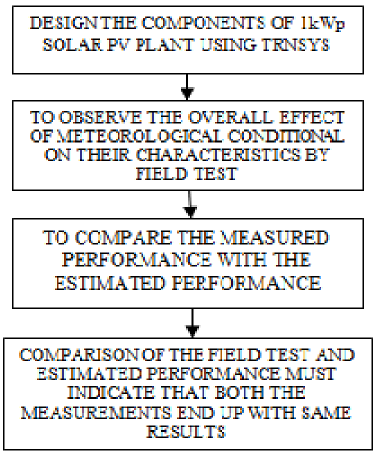

Figure 3 Flow chart for performance analysis of PV systems

The technical characteristics of a typical PV panel and an inverter are listed below.

A.TECHNICAL CHARACTERISTICS OF THE PV PANEL

I_{mp}	= 8.2Amps
V_{mp}	= 30.5Volts
V_{oc}	= 37.7Volts
I_{sc}	= 8.68Amps
T_{noct}	= 47ºC
Module area	= (1645*992*42) ± 2mm

B.TECHNICAL CHARACTERISTICS OF INVERTER

Rating	=1000W
Input voltage	=180-260
Output voltage on Mains mode	= same input
Output voltage on inverter mode	= 220 ± 5 %
Inverter Overload	=120%
Inverter short circuit	=300%

IV. SIMULATION RESULTS

Simulations were carried out for a period of 7 days and the characteristics of the system were analysed. The simulation results of the PV system for one day and seven days are shown in Figure 4 and Figure 5 respectively.

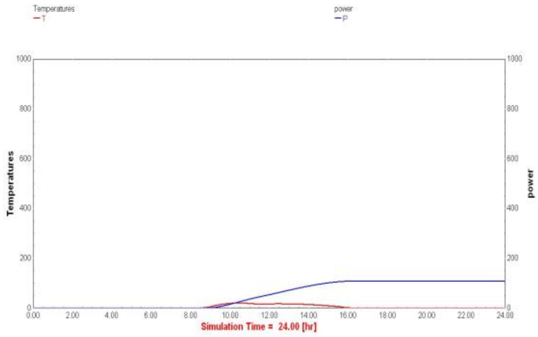

Figure 4 Result for PV system for 1 day

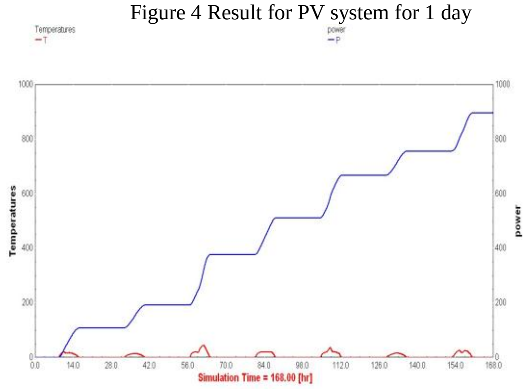

Figure 5 Result for PV system for 7 days

V. CONCLUSION AND FUTURE WORK

The study is being extended by undergoing field work as per the schematic (Figure no. 2).A comparison between standalone and grid connected PV system is to be laid in future to examine the performance using TRNSYS 17.To observe the overall effect of meteorological conditions on their operation characteristics by field test, the monitoring system has been measuring and analyzing the performance of PV system using TRNSYS 17. Designing, cost analysis and

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efficiency calculations of this solar photovoltaic power plant now need to be done once the capacity is estimated which can be carried out in future publications. Environmental impact of this photovoltaic plant can be taken up as one the important issue in near future.

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