A Design with Implementation of Solar and Thermal Hybrid Power

Satyam Gupta[1] Deena Lodwal Yadav[2] Dr. K T Chaturvedi[3]
[1]ME Scholar [2,3]Assistant Professor
[1,2,3]Department of Electrical and Electronics Engineering
[1,2,3]UIT RGPV, Bhopal, India

Abstract— In this master thesis a hybrid photovoltaic / solar thermal power plant was modeled for a high irradiance location. The selected location was Chile's northern region. For the evaluation the software greenius was used, a program being continuously developed at DLR since 1999. This program did not possess a storage function for PV simulations. Therefore one of the aims of this thesis was firstly to analyze the accuracy of the PV model and subsequently develop and implement a battery model to evaluate the financial viability of standalone PV systems. For this reason the greenius model was compared with PVWatts and PVSyst photovoltaic models. Additionally, an electric storage element based on a charge balance model was implemented in the system. This model proved to accurately depict the performance of batteries without the need for many parameters. The second aim of this thesis was to optimize and evaluate the financial feasibility of hybrid power plants with a high capacity factor (> 90%).

Keywords: Hybrid Solar, CSP, PV, Battery Model, PV Model, Greenius

I. INTRODUCTION

A. Introduction of Various Type of Thermal with solar Hybrid systems:

Solar thermal energy is a ground-breaking technology for harnessing solar energy to produce heat energy. Solar thermal collectors can be classified as low or high-temperature collectors. Low-temperature collectors are flat plates typically used to warm swimming pools, heating water or heating air for residential and industrial use.

High-temperature collectors center sunlight using mirrors or lenses and is usually used for electricity power production. Solar Thermal Energy for electricity generation is totally different from the popular P.V, which converts solar power directly into electricity. Solar thermal power plants convert the sunlight's energy to heat first and then to electricity through a series of processes. They are also referred to as concentrating solar power plants (CSPs). Solar tower, which is also a form of CSP captures and focus the sun's thermal energy with numerous tracking mirrors placed in a very large field. A tower is placed at the center of the heliostat field. The heliostats then focus concentrated sunlight onto the receiver which sits on prime of the tall tower. Within the receiver, the focused sunlight heats molten salt to above temperatures of 1,000°F (Kumar & Kumawat ,2013). The intense heated molten salt will then flow into a thermal storage vessel where it's then stored, sustaining 98 percent thermal potency, and then it's finally pumped to a steam generator. The steam spins a typical rotary engine to get electric power.

II. SOLAR HYBRID POWER PLANT

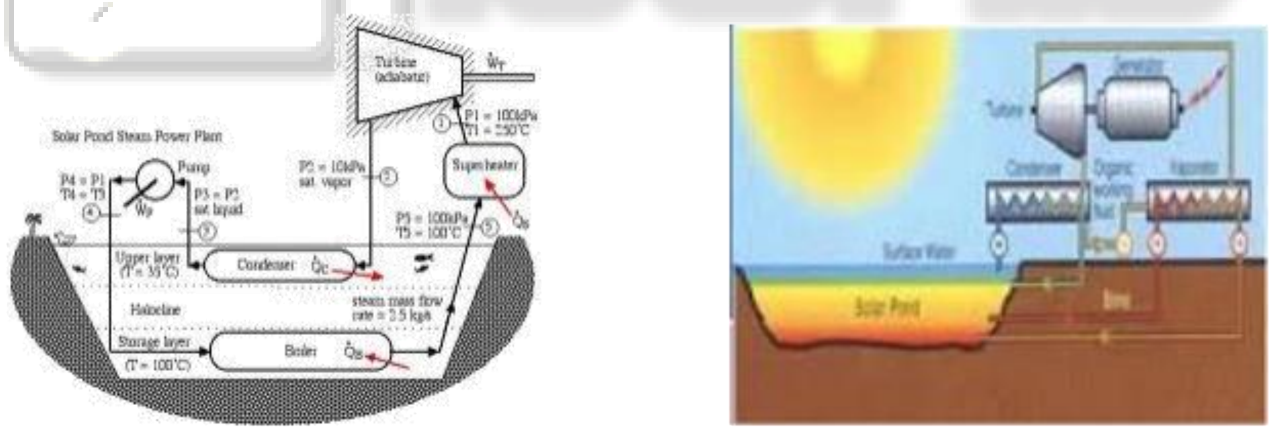

Fig. 1.2: Solar Hybrid Power Plant

A solar pond is a pool of saltwater which acts as a large-scale solar thermal energy collector with integral heat storage for supplying thermal energy. A solar pond can be used for various applications, such as process heating, desalination, refrigeration, drying and solar power generation. Concept of hybrid power plants: Hybrid technology is the phenomenon of retrofitting two different plants by virtue of which we can obtain improved utilization of the turbines and thus optimal operation of the entire power plant block, a more cost-effective buffering of fluctuations in the solar radiation by using of auxiliary heating with fossil fuels. The construction of hybrid power plants is possible: for example, they can be integrated with ease in the relatively clean natural-gas-fired combined-cycle power plants of the latest generation. It is also possible to install existing conventional steam power plants with parabolic trough solar fields as an additional solar steam generator. Hybrid technology leads to a great improvement in competitiveness against conventional power plants.

III. Result and Simulation

A. Data Mentioned in Simulink Input plant:

Parameters	Values
Set point of Fuels	70
Avg Outdoor temperature	50
Maximum Cost	30

B. Data Mentioned in Hybrid plant Simulink Input plant:

Parameters	Values
Electrical Efficiency	88.86%
All system cost	191492.187

PV(KWH)	9867
Fuel Consumed	6588
Total cost of fuel	2.365×10^4
CO2 generation	6.407×10^4
Nox Generation	1426
PM factor	57.32
Total power(A)	3933
PID response time	0.5s

C. Simulink Modelling of Thermal Analysis:

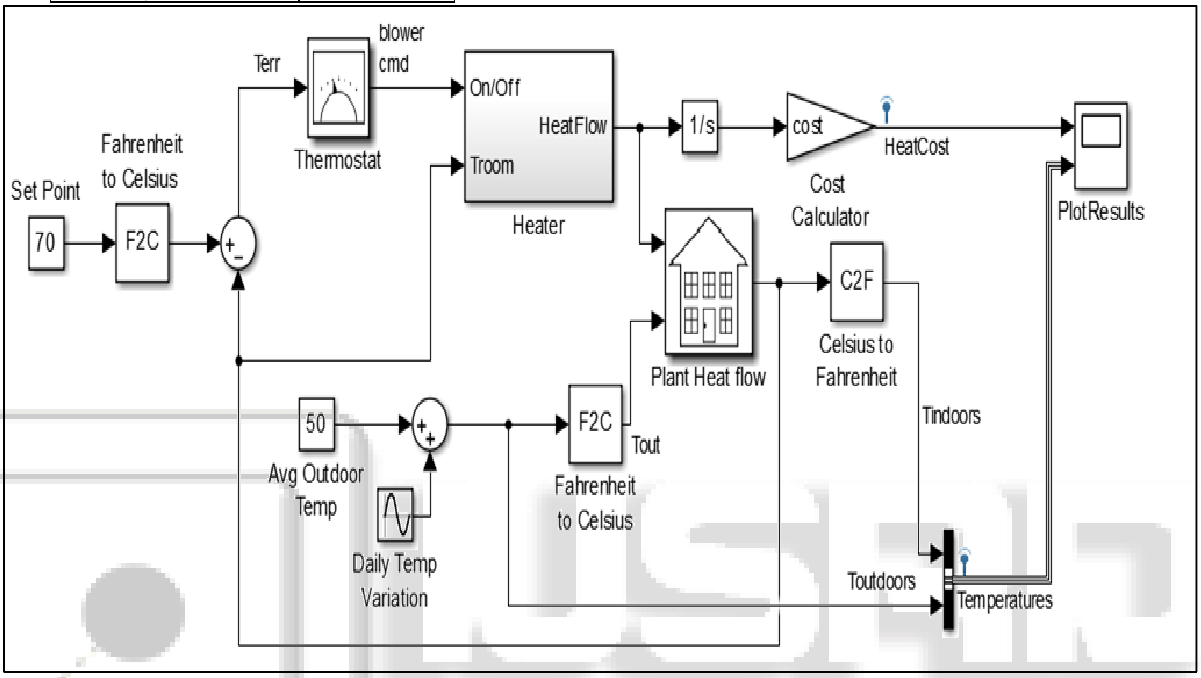

Fig. 3.1: Simulink Modelling Fuel insert and Heat Flow.

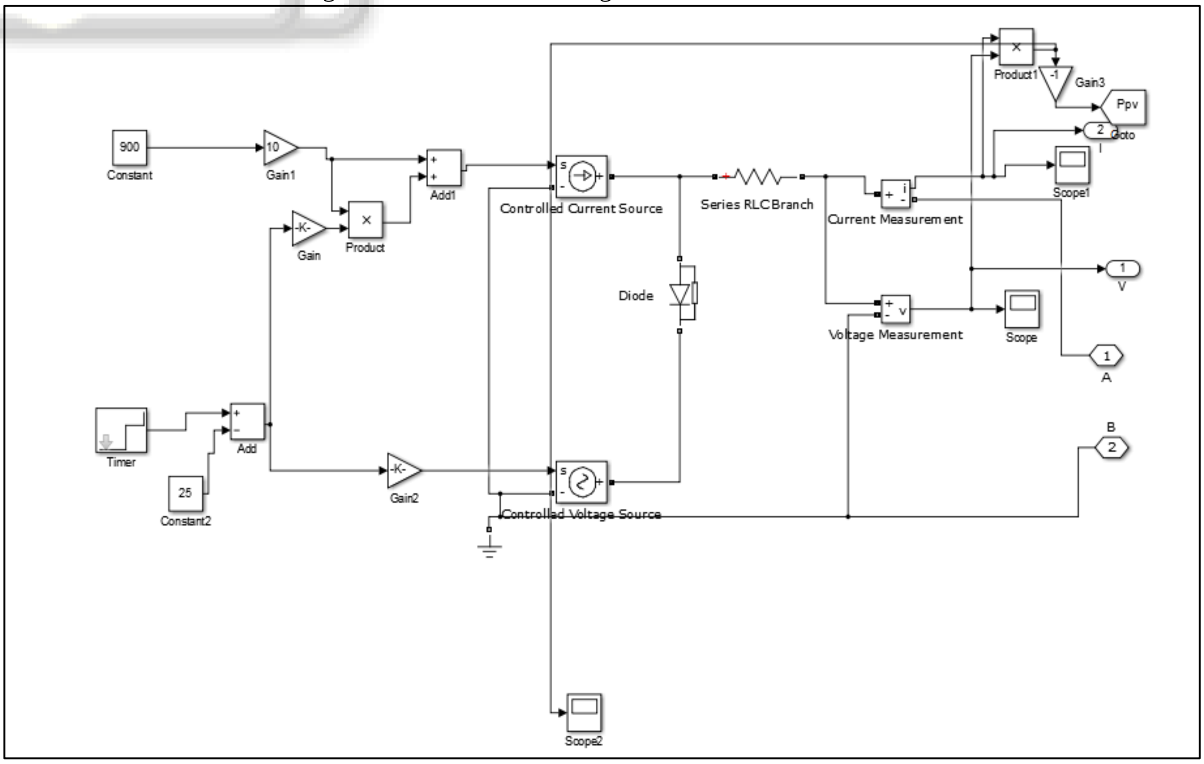

Fig. 3.2: Simulink Modelling of Solar system.

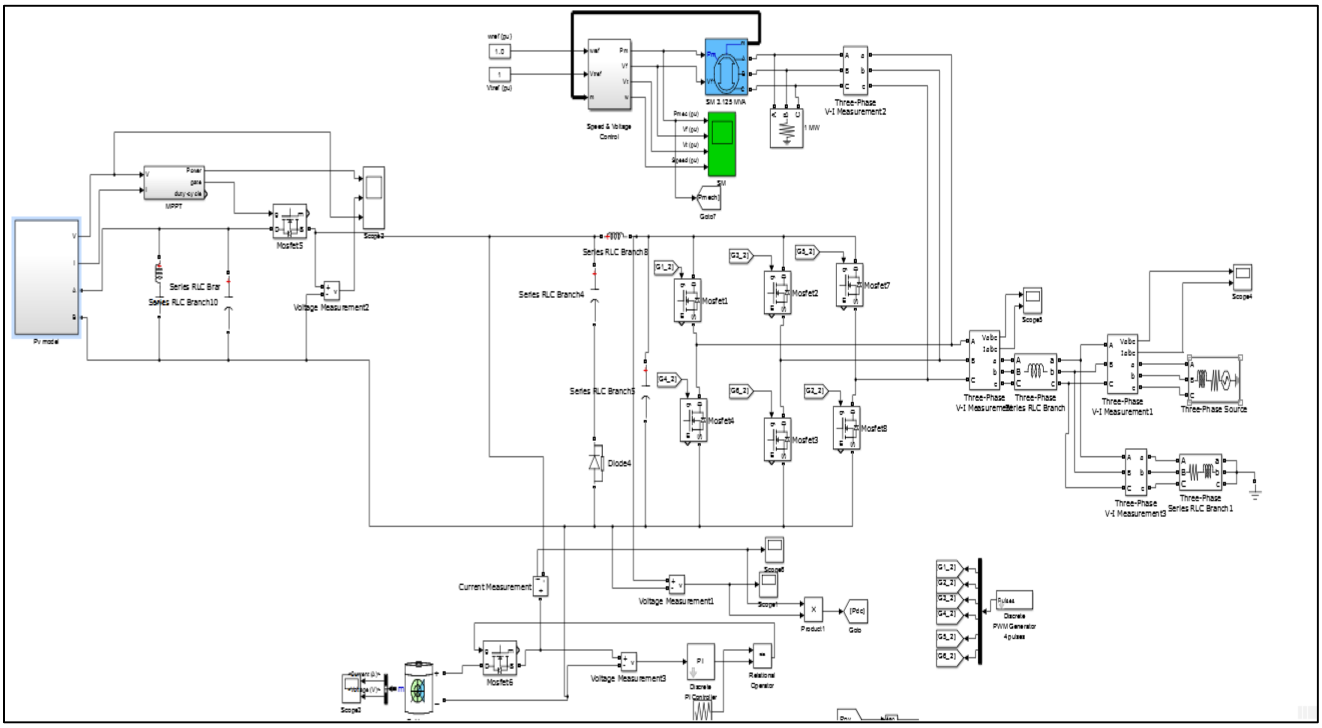

Fig. 3.3: Simulink Modelling of All system.

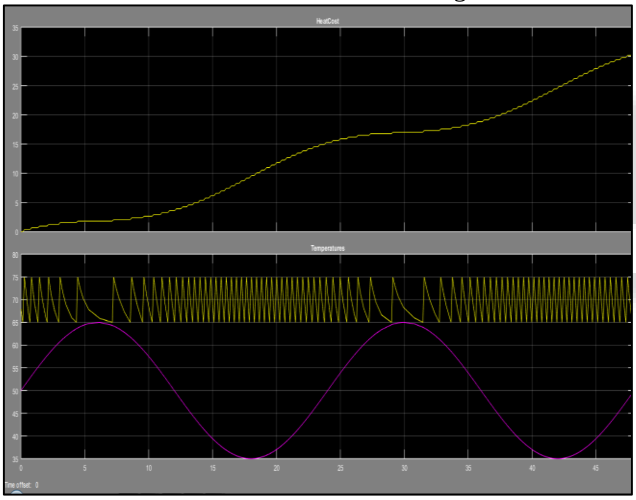

Fig. 3.4: Thermal plant Cost variation.

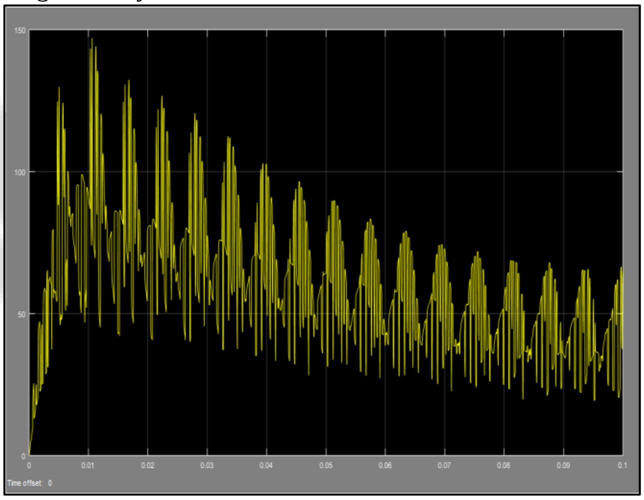

Fig. 3.6: Solar Across Power Generation.

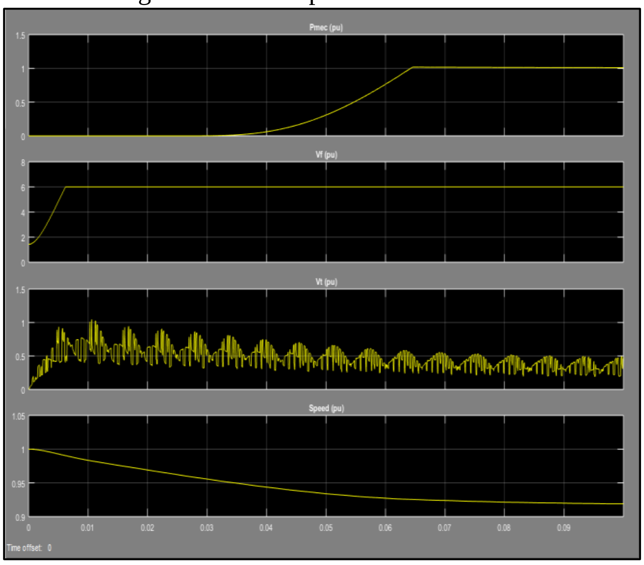

Fig. 3.5: Speed with motor control parameters.

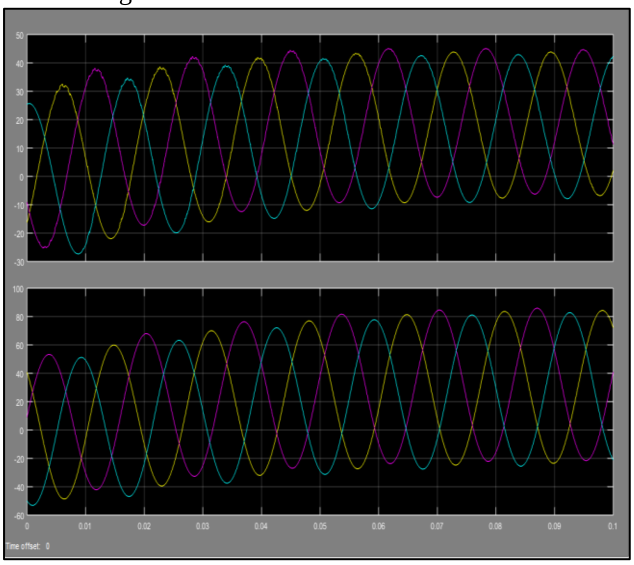

Fig. 3.7: Total Hybrid Plant outcomes.

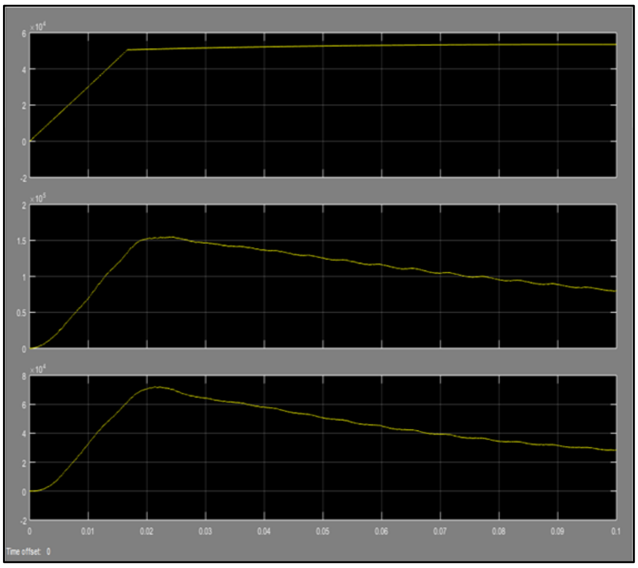

Fig. 3.8: PVdc and Total three phase power.

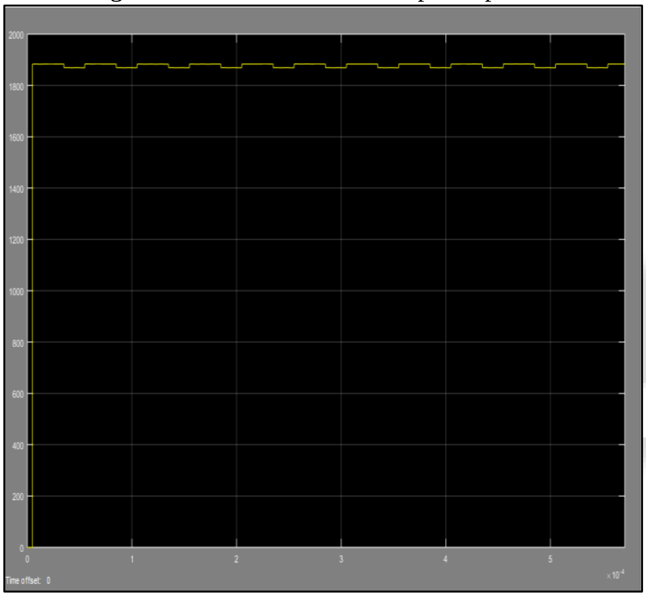

Fig. 3.9: PID response (0.5s).

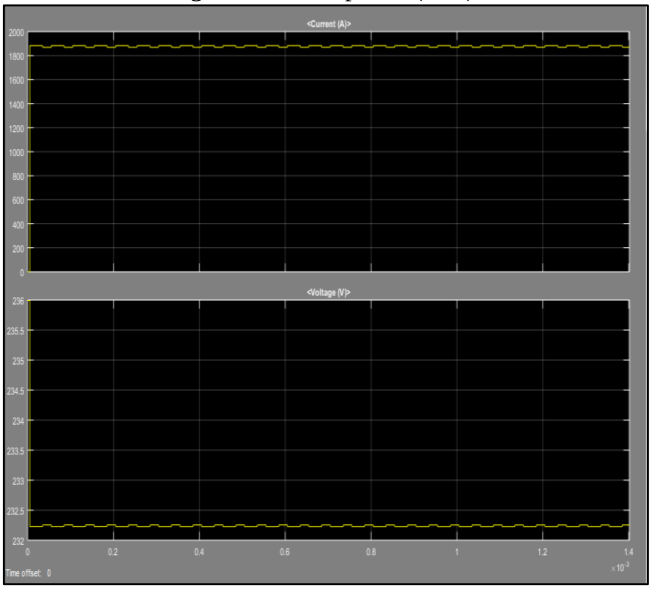

Fig. 3.10: Battery Storage voltage and current.

IV. CONCLUSIONS

The VPP can be run on standard workstations to play and simulate major power plant processes in conditions close to the real time with accuracy required for qualitative trend-based prediction and sensitivity analysis. VPPM objectives are to decrease the uncertainty during preliminary power block settings selection, better choice of the starting point in case of power block optimization, identification of the most critical physical and geometry parameters contributed to power block performance, and finally reproduction of operational scenarios contained in the measurement data. As presented in the previous sections the Virtual Power Plant Model (VPPM) structure can be easily maintained and managed, due to introduction of model variants, being model libraries updates. The available models' equations have been implemented and integrated in Matlab/Simulink. It is possible to use several modules creating a combination of simplified transfer function models and extended advanced physics-based models within the single VPPM. Such an approach is important whenever model speed and its flexibility are critical. It is possible to implement in the VPP several submodel versions to customize the model to specific needs of a modeling task, e.g. transient or steady-state. A workshop has been organized together with the involved power plant specialists and academic staff to summarize the status of the VPP and the VPPM development after the first phase of the project. Developed VPP architecture was evaluated as fulfilling the project requirements. However, it is necessary to extend the VPPM to cover broader operating range. The control system must involve more elements necessary for good reproduction of all the system events. The current project results can be divided into software infrastructure and demonstration of the model for the power plant unit. VPP project has included development of powerful software infrastructure, predominantly for data handling, processing and presentation. Further research will be performed in two directions: increase of the computational speed to achieve the real-time operation and further development of the VPPM for better accuracy, especially in transient states.

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