Hybrid Wind/Solar Generator

PROJECT PLAN

May1727
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Revised: 10/13/16

1 Introduction

1.1 Project statement

The overall goal of this design project is the development of a hybrid wind and solar power generation system. We will accomplish this by first building simulations of a wind energy system, as well as a solar PV array system in Simulink to gain a better understanding of what to expect when we are interacting with the project hardware. When we are certain that these simulations are working on an individual level, we will integrate the two systems and document the outcome to accomplish our deliverable of a hybrid wind and solar energy lab document for EE 452.

An underlying goal of this project is to benefit the electrical engineering (power) department by leaving a usable lab document, as well as the hardware that goes along with it upon project completion. This means we will aim to have the solar panel hardware functioning on a level deemed reasonable for the usage of the 452 lab. We will also look into building a meaningful relationship with WESO to gain access to a functioning wind turbine that will be accessible to 452 students for a week of a semester. The turbine will likely need modifications to make an arrangement work to the order of making it waterproof, adding extra safety precautions, and attaching the necessary sensors to get accurate readings for the 452 lab.

1.2 purpose

The purpose of this project is to benefit the EE department through the creation of a hybrid solar and wind energy generation system and lab documentation for the usage of EE 452. The secondary purpose of this project is to create and maintain a relationship with WESO in order to not only gain access to a functioning wind turbine for this project, but for future students of EE 452 to use in lab.

Importance: As “Green” energy is a growing industry, implications are developing on the supporting architecture of the power grid. Building this hybrid power generation device will allow us to test the role renewable energy will have on peak loads and the necessary supporting architecture.

1.3 Goals

- Design the hybrid system using software simulation in order to better understand its inner workings.
- Purchase and set up a wind turbine.
    - Secondary: Work with WESO to gain access to a usable wind turbine for a portion of a semester.
- If possible or needed, upgrade the existing solar panel array with more efficient panels.
- Combine the newly purchased wind turbine and the already existing solar panels so that their generated powers combine together.

- Create labs for EE 452 centered around the hybrid system so future ISU students can use the hybrid system as a learning tool.

2 Deliverables

2.1 Deliverables Description

With the main goal of this project being to create a hybrid power generating system, there are multiple deliverables that will need to be realized. This involves understanding wind and solar energy systems at all levels such as simulation, component and system levels. The group will be broken up into Wind and Solar teams, respectively.

Each team will need to do research on their respective topics and build a simulation model that accurately reflects what the system should accomplish. The simulations will be modelled using MatLab Simulink and will be handmade as much as possible. Specifically, Solar team will need to study and verify the photovoltaic effects through varying temperature and irradiance on the system, as well as by studying the effects of the absence and presence of the maximum power point tracking, a battery bank, and finally a load. Wind team will need to develop a similar model that can monitor the output of a system with changing variables such as wind speed, turbine position, blade angle, efficiency, rotor area, and power coefficient.

From there, we will move onto the hardware component of the project in order to verify our results from software and gain an overall understanding of how the system works in everyday weather conditions. Once we implement the hardware, we will need to make sure to include equipment to monitor wind speed, voltage, and power flow so we can compare our system to the simulation.

Once both the wind and solar components are working individually, we will need to combine them in simulation and combine the hardware. We will need to verify that the systems are working together and then develop reproducible lab experiments to be used in EE 452.

Along the way there will need to be a lot documentation developed to maintain a record of our results and provide justifications for our design. This will include but not be limited to: Project Plans, Design Documents, final presentation, poster, lab documents and rubrics, WESO agreements and terms of use contracts, etc.

2.2 Itemized Deliverables

Item	Due Date	Item	Due Date
Project Plan	Varies, 28 November	Perform Feasibility Studies	20 January
Design Document	Varies, 28 November	Hybrid Simulation Verification	20 January
Preliminary Research	1 October	Hardware Testing	10 March
WESO Proposition, WESO Agreement	14 November, 6 December	EE 452 Lab Write Up/Testing	31 March
Solar Simulation Verification	18 November	WESO Agreement, Turbine Work	31 March
Wind Simulation Verification	18 November	Project Plan	21 April
Existing Hardware Verification	2 December	Design Document	21 April
New Hardware Acquisition	2 December	Project Poster, Misc. Documents	21 April
Final Presentation	6 December	Final Presentation	28 April

Table 1

3 Design

3.1 Previous work/literature

The previous group utilized a photovoltaic array and a simulated wind turbine via wind controlled motor that was linked to a generator. Our current solar team was provided two Kyocera Solar KD135GX-LPU solar panels, a MPPT, a battery bank, a rectifier, boost converter, and an inverter. See figures 2-5 in the appendix. We were also given a great deal of literature pertaining to both Solar and Wind energy by Ankit Singhal [9] , our project TA. Some of the items from papers by Bhuvaneswari/Annamalai [1] & Mishra/Kar [4] was used in developing the MATLAB model for our system along with simulation techniques discussed by DenHerder [2]. Further modeling was aided in understanding PV systems by Hansen/Sorensen/Hansen/Bindner [3]. When we were considering the Solar aspects of our system, literature by Yu/Lin [6] was instrumental because of the role a MPPT would play in our system to make it much more efficient. Then for the Wind aspect we used literature by Youssef/Abdel-Rahim/Shaltout [5] to

gain a better understanding for indirect elements that need to be considered into our design, such as turbine blade length and wind fluctuance.

3.2 Proposed System Block diagram

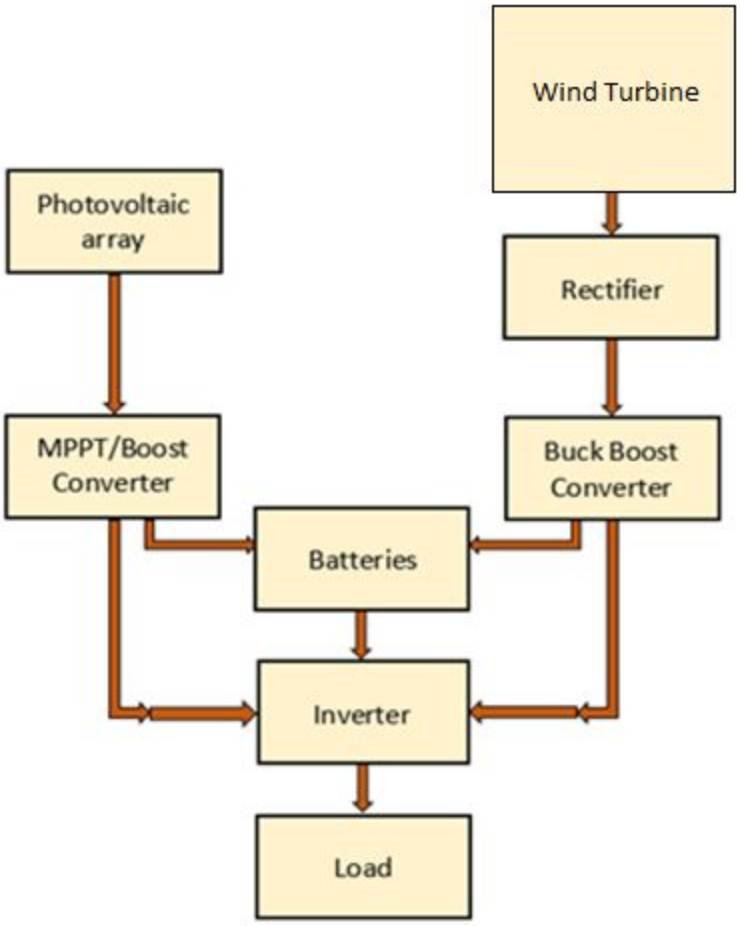


Figure 1

3.3 Assessment of Proposed methods

The approach we would prefer to take is to research and simulate the solar and wind systems separately before integrating them into one system. As we are doing this, we are looking into purchasing and installing a wind turbine, as well as getting familiar with the solar panels and system the previous senior design group left us. Once all simulations are complete with suitable results, we would like to look into integrating the hardware and equipment to verify the results of the simulations and construct a lab for EE 452.

3.4 Validation

Pre-Confirmation of the system is done with combined simulation of both solar and wind aspects with supporting devices and simulated load. We will be able to measure wind speed and replicate it in the simulation. We are also currently looking into ways to measure the irradiance. Ideas we've had are: buying a device that directly measures irradiance, approximate irradiance from temperature, or use an infrared light sensor and arduino to approximate irradiance. True confirmation of the system is achieved by powering a fully resistive load that will vary based on peak and nonpeak times.

4 Project Requirements/Specifications

4.1 functional

Working simulations in simulink will be achieved before hardware decisions and experimentation occurs, except the wind turbine emplacement. We will have a fully operating simulated system using a generic wind turbine before we purchase a wind turbine, but we won't be able to include its specific attributes until we receive and test our specific wind turbine.

Our solar panels will utilize MPPT control for efficient power output and then to a boost converter. The wind turbine will produce AC power that is rectified and then sent to a Buck/Boost converter. Both systems meet to charge the battery and from the battery go through the inverter to power the load.

4.2 Non-functional

Analysis of solar and wind emplacement for maximum power generation. MPPT logic improved to maximize power more effectively and understanding the role of external factors such as temperature on solar panels.

5 Challenges

Challenges for this project range anywhere between being able to meet as a group, to get work done, to getting approval to purchase and install a wind turbine on the Coover Hall premises. The solar team has been researching the photovoltaic effect in terms of temperature and irradiance, as well as effects of having an MPPT and battery in the system. However, we are using models that were built by previous groups, and are not well documented making it difficult to move onto the hardware portion of the project.

The process of purchasing and installing the turbine will likely come in over the current budget. With help from Professor Ajjarapu, we may be able to overcome this obstacle, however we are still faced with system constraints based on possible placement of the wind system. We are currently trying to choose between putting the turbine in either

the courtyard, which may not receive the minimum amount of wind necessary to generate power, or putting it in a Northwest corner of the Coover property, which costs extra because of the landscaping and aesthetic work that would need to be done.

6 Timeline

6.1 First Semester

The timeline, shown in table 2, can be generalized to three different stages. The first stage ranging between August to September regarded formalizing the administrational side of things. Second stage ranging between September to October has Solar and Wind groups working on their respective simulations and research. The last stage of this semester ranging from November to December have the simulations being combined and the wind group installing the hardware for the new wind turbine.

	August	September	October	November	December
Whole Team					
	Pick teammates				
	Assign Project				
				Combine Simulink models	
Wind Team					
		Research Wind Energy			
		Create Simulink model			
		Research Wind Turbines			
				Install Hardware	
Solar Team					
		Research Solar Energy			
		Create Simulink model			

Table 2

6.2 Second Semester

The second semester timeline in table 3 will have the entire group working together. Hardware testing and continued combined simulink models will be the beginning tasks that will turn out the entire combined system by March. Midway through the system's construction is when formalized documentation and labs will begin development before presentation and our graduation.

	January	February	March	April	May
Whole Team					
	Test and Validate Hardware				
	Combine Systems				
	Combine Simulink models				
		Create Documentation			
			Create Labs		
					Presentation
					Graduation

Table 3

7 Conclusions

In conclusion, after completion of our project according to the aforementioned plan, our Senior Design Team will have created a simulated wind turbine, simulated solar array, a simulated hybrid (wind and solar) system and physical hybrid system that will be able to operate completely off-grid. In addition to the power generating components of the wind turbine and solar panels, our design will also include a system to ensure maximum power efficiency (Maximum Power Point Tracking system), a system to store unused power and a system to simulate a load or a demand for power. Once the system has been implemented lesson plans will need to be developed so that the hybrid generation station can be included as part of the course curriculum for EE 456.

Some of our other short term goals include working with the Wind Energy Student Organization (WESO) to potentially provide funding for our wind turbine and long-term support even after our group has graduated. Coordination with Facilities Planning & Management is also necessary in order to mount a wind turbine in the Coover courtyard or on the roof. The process to achieve our goals is already underway and our team is making sound progress to finish our project.

8 References

[1] Bhuvaneswari, G., and R. Annamalai. "Development of a Solar Cell Model in MATLAB for PV Based Generation System." 2011 Annual IEEE India Conference (2011): 1-5. Web.

[2] DenHerder, Tyson. "Design and Simulation of Photovoltaic Super System Using Simulink." Electrical Engineering Department California Polytechnic State University San Luis Obispo (2006): n. pag. Print.

[3] Hansen, Anca D., Poul Sorensen, Lars H. Hansen, and Henrik Bindner. "Models for a Stand-Alone PV System." Riso National Laboratory, Roskilde (2000): 1-78. Print.

[4] Mishra, Bibek, and Bibhu P. Kar. "MATLAB Based Modeling of Photovoltaic Array Characteristics: A Thesis in Partial Fulfillment of Requirements for the Award of the Degree of Bachelor of Technology in Electrical Engineering." Department of Electrical Engineering National Institute of Technology (2012): 1-42. Print.

[5] Youssef, O.E.M, N.M.B Abdel-Rahim, and A. Shaltout. "Performance of Stand-alone Hybrid Wind-Photovoltaic System with Battery Storage." Proceedings of the 14th International Middle East Power Systems Conference (MEPCON'10), Cairo University, Egypt, December 19-21, 2010, Paper ID 297. (2010): 1-7. Web.

[6] Yu, Ting-Chung, and Yu-Cheng Lin. "A Study on Maximum Power Point Tracking Algorithms for Photovoltaic Systems." Department of Electrical Engineering Lunghwa University of Science and Technology (n.d.): 1-10. Print.

[7] Matt Post, *Coover Building Supervisor*

[8] Nicholas David, *Graduate Student, WESO Club Member*

[9] Ankit Singhal, *Graduate Student, 452 Teaching Assistant*

9 Appendices

Figure 1:

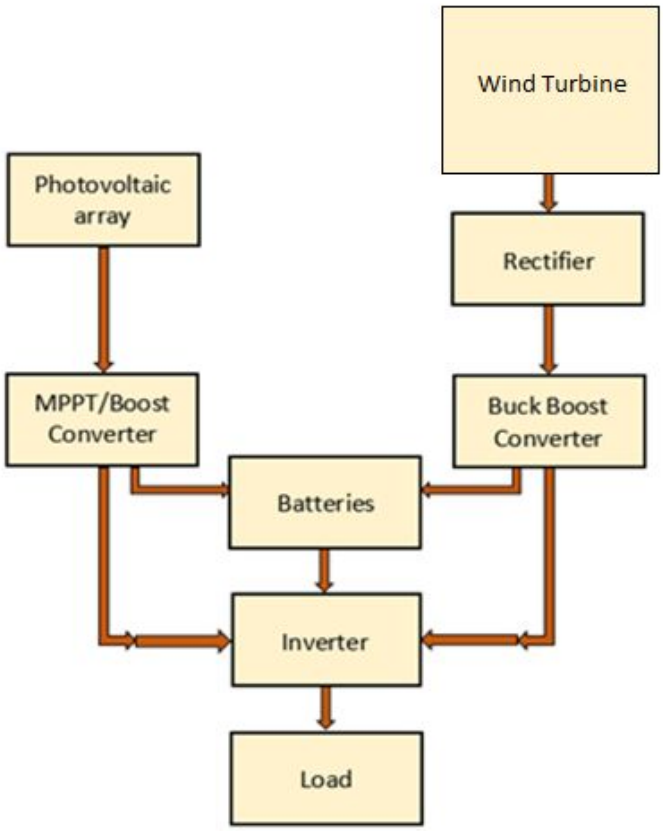


Figure 2:

Solar panels

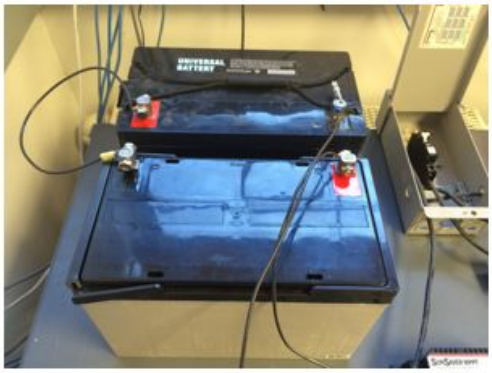
Figure 3:

Panel combiner

Figure 4:

MPPT

Figure 5:



Batteries