DEPARTMENT OF
ELECTRICAL & COMPUTER ENGINEERING

UNIVERSITY OF CENTRAL FLO RIDA

EEL 4914
Senior Design I
Green Smart Grid

Green Energy Smart Grid (GESG)

The team consists of four members:

- Andrea Solano: Electrical Engineer
- Juan Valera: Electrical Engineer
- Manuel Keesee: Electrical Engineer
- Randall Lay: Electrical Engineer

This project will be coordinated by the UCF Burnett Honors College's Dean, Dr Alvin Wang. Our main sponsor on this project will be Progress Energy which is a contributor on projects engaging Renewable and Sustainable Energy.

Saeed Lotfifard is a professor at UCF; he will be a significant contributor to provide assistance on this project due to his interest and knowledge on the power systems and controls engineering field.

Motivation

Nowadays, the energy efficiency industry has increase due to higher concerns on environmental and global warming issues. Every day, the world is striving on creating a superior and more reliable source of energy that not only will benefit the society, but will protect our surroundings. Hence, the market of solar, wind, hydro and geothermal power is rapidly growing and potentially becoming the main source of energy in the world.

Since the United States is a powerful and strong country, citizens underestimate the advantages and comfort of technology due the ease of affordability. Every time there is a concern or a claim; entities are willing to respond efficiently to bring solutions that will surplus customer's needs, making them more a luxury than a priority. With that being said, not to belittle the great benefits that our country provides, but for people to fall into account that there are still many places in the world that besides not being aware on the green energy matter, they lack of any energy source due to economical and environmental disadvantages.

In addition, the primary motivation of this project is the idea of giving back to our community and working on a project that will give support, and provide several benefits to a group of people. Before having the sponsor presenting the purpose of this project, our group had taken a decision to design a smart grid energy system that will give more efficient, low cost and more reliable solution that can be integrated, and deliver power to any sort of electrical device or machine. Nevertheless, listening to the intentions for which this project is heading, gave us even more desire to work toward a green energy solution.

Lastly, being aware of the challenges we will encounter, it gives us more incentive to work hard, and subsequently design a system to offer a solution that will improve many aspects of this small community in South Africa.

Goals and Objectives:

The main purpose of this project is to introduce the integration and control of renewable energy in an electric power system. Integrating a Photovoltaic (PV) panel and a small wind turbine, a green renewable energy model will be used to develop control methods to control the dynamic process and the efficiency of the system. In addition it is required to provide sufficient power to a community center located in Southern Africa. As mentioned above, all of the members in this project are electrical engineering students who have a strong interest in the power and control systems field. With that being said, we have centered our attention on a project that encompasses the design and integration of a renewable energy system to benefit a community in great need of energy source.

The method of implementation consists of bringing the two renewable power generation devices into a single integrated hybrid energy system. We will use a series of DC and AC bus to mitigate power circulation thus minimize thermal power dissipation. In addition components such as inverters and rectifiers will be used to convert DC power to AC and vice versa. A storage system will be used to distribute power when the output power of our sources are not significant. In addition a charge controller will be added to regulate this power. Most importantly a grid controller will be implemented and designed to monitor and distribute efficiently the power generated by the sources

As a result, the optimal goal we are striving to achieve is the design of a robust power source integration that it includes low cost, sustainable and reliable components, which will be installed in a small community in Southern Africa. Since this community has not source of power, they cannot take any technological advantage that it might be available to them. Having no source of power, they find it difficult to acquire new skills and knowledge as compare to most civilized cities; limiting them to continue their learning at a slower and antique pace.

Finally, we will develop this project so that it can generate enough electricity, at the lowest possible cost, to power a projector and a computer at the South Africa community center which could be used for educational and recreational purposes for the people in this small community.. If there are enough teams working towards this community, the power attained will be greater and therefore, a greater diversity of devices could be powered to assist the people in the village.

Specifications and requirements:

Our project will consist in designing a green and renewable power grid distributed generation (DG) system consisting of a small wind turbine, a photovoltaic (PV) panel, and a storage system (Battery). The solar power outputs are low-voltage DC that are steps up to a higher-level DC power for processing using a DC/DC converter (boost converter) to boost the voltage level higher. However, the output power of wind turbines is variable-frequency AC power. For this source, the AC/DC or AC/AC converters will be used. In the architecture of our design, the DG sources are connected to a uniform DC bus voltage including the storage system. This will facilitate plug-and-play capability by being able to store the DC power and use DC/AC converters to generate AC power. This so called AC/DC converter is a rectifier, DC/AC converter is an Inverter and AC/AC would be an step up transformer in the case of long distance supply. we will integrate these components with a MPPT controller to efficiently distribute the energy and protect are grid from unstable and high power surge.

List of Parts:

- 1) 1 Photovoltaic (PV) Panel
- 2) 1 Small Wind turbine
- 3) Smart Grid Controller (DESIGN)
- 4) 1 Battery & Charge Controller
- 5) 1 Inverter
- 6) 1 Rectifier

1_PV Panel:

Table 1.1 255W Monocrystalline Solar Panel (Width X Length X Thickness) 40' X 65' X 1'

Maximum power at STC (Pmpp)	255
MPP voltage (Vmpp)	30.0
MPP current (Impp)	8.50
Open circuit voltage (Voc)	37.7
Short circuit current (Isc)	9.10
Module efficiency (%)	15.5
Operating temperature (°C)	-40 ~ +90
Maximum system voltage (V)	1000 (IEC), 600 (UL)
Maximum series fuse rating (A)	15
Power tolerance (%)	0 ~ +3

* STC (Standard Test Condition): Irradiance 1000 W/m^2, module temperature 25 °C, AM 1.5

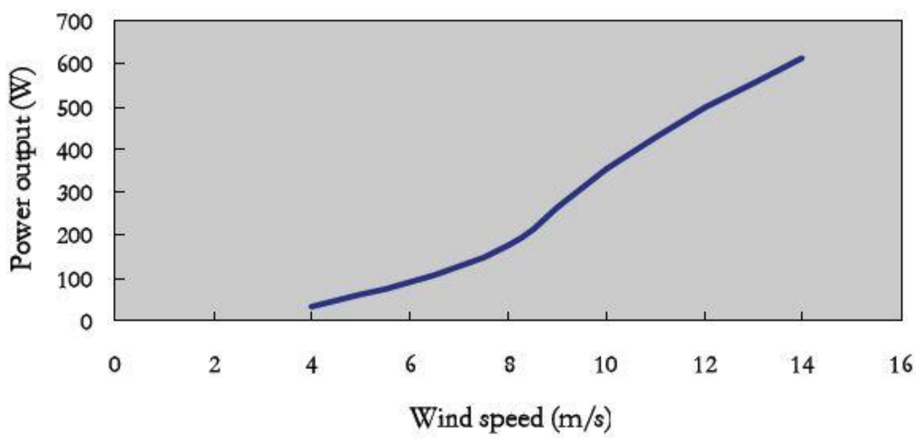
* The nameplate power output is measured and determined by LG Electronics at its sole and absolute discretion.

Related Speed	12.5m/s or 5.5 MPH
Related Power	600W
Voltage with MPPT	12/24 Volts
Rotor diameter	0.65 m (2.1 ft)
Cut-in wind speed	4.5 MPH
Survival wind speed	157 MPH
Number of Blades	3 Blades
Blade material Fiber glass	Fiber glass
Suggested battery capacity	> 100 A/H

2_Small Wind Turbine:

Table 2.1 Data Sheet Average 600W Small wind Turbine

Table 2.2 Performance of wind turbine. Power = (Voltage)x(Amps)

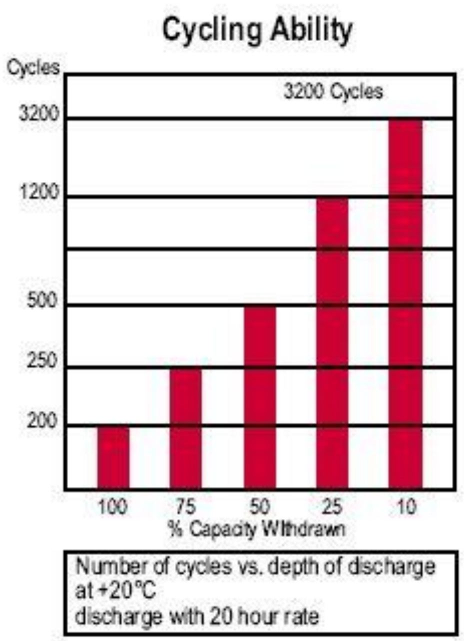


3_Small Grid Controller: This component of the smart grid will be designed and implemented by the students. with the objective of looking at the output of the wind generator and PV panel, and comparing it against the battery voltage. It will then use an algorithm to calculate the absolute best power that the wind turbine and PV panel can put out. it would be similar to a MPPT controller which will then convert its findings to the best possible voltage in order to allow for maximum AMPS running in to the battery bank. Most MPPT controllers are at 92-97% efficient in the conversion meaning that our design controller has to be within the range. This controller will track the maximum power point, which will vary from the STC (Standard Test Conditions) rating under almost all situations. However, it is important to note that if we do not have a way of tracking the power point, we are going to lose power. Hence our controller will contain multiple features such as temperature sensors and an integrated Multimeter for better power tracking.

4.1_Battery: The battery for this project will consist of a deep cycle battery with a capacity of 100 (Ah).

Nominal Voltage	Capacity (Ah)	Weight ≈	Dimension (WxLxH*)
12 V	100 (Ah)	20/25 lb	12.75" x 6.88" x 9.88"
			(324 mm x 175 mm x 251 mm)

Figure4.1-Average deep cycle battery efficiency



4.2_Charge controller: Is basically a voltage and/or current regulator to keep batteries from overcharging. It regulates the voltage and current coming from the DC bus system going to the battery. so if there is no regulation the batteries will be damaged from overcharging. Most batteries need around 14 to 14.5 volts to get fully charged.

5_Inverter: The power inverter will convert the DC power from the DC bus or battery into pure sine wave AC household power, allowing us to run loads up to 1000 watts.

Table5.1 US 1000Watts Inverter

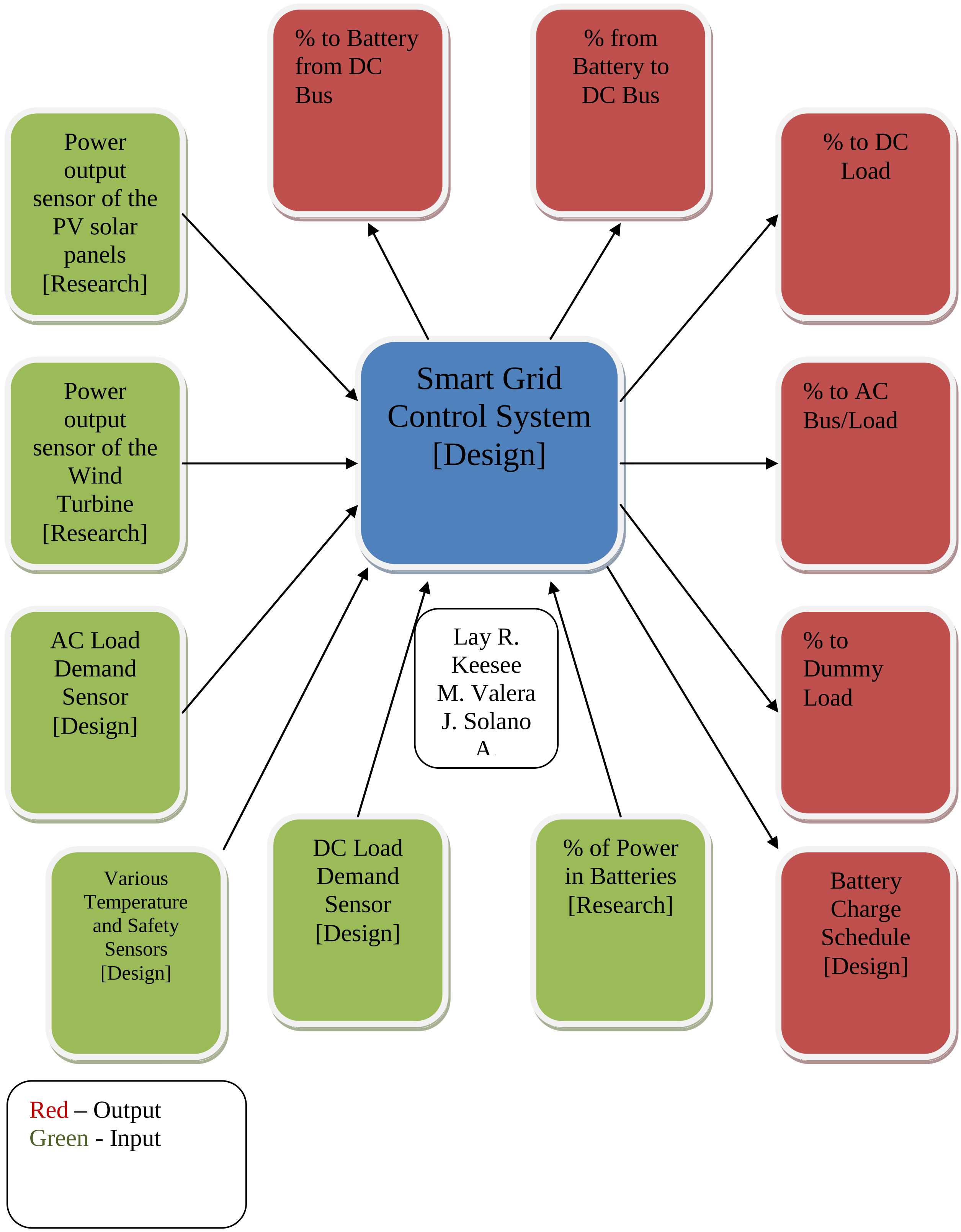
Continuous power	1,000 watts
AC output voltage	120 VAC
AC output current	5/8 AAC
AC output frequency	60 Hz
AC output wave form	True sine wave

6_Rectifier: The purpose of this component is to convert alternating current (AC) to direct current (DC). This will be used to convert AC power coming out of the wind turbine to DC so that the energy can be integrated to the DC bus. Below are the components of our rectifier.

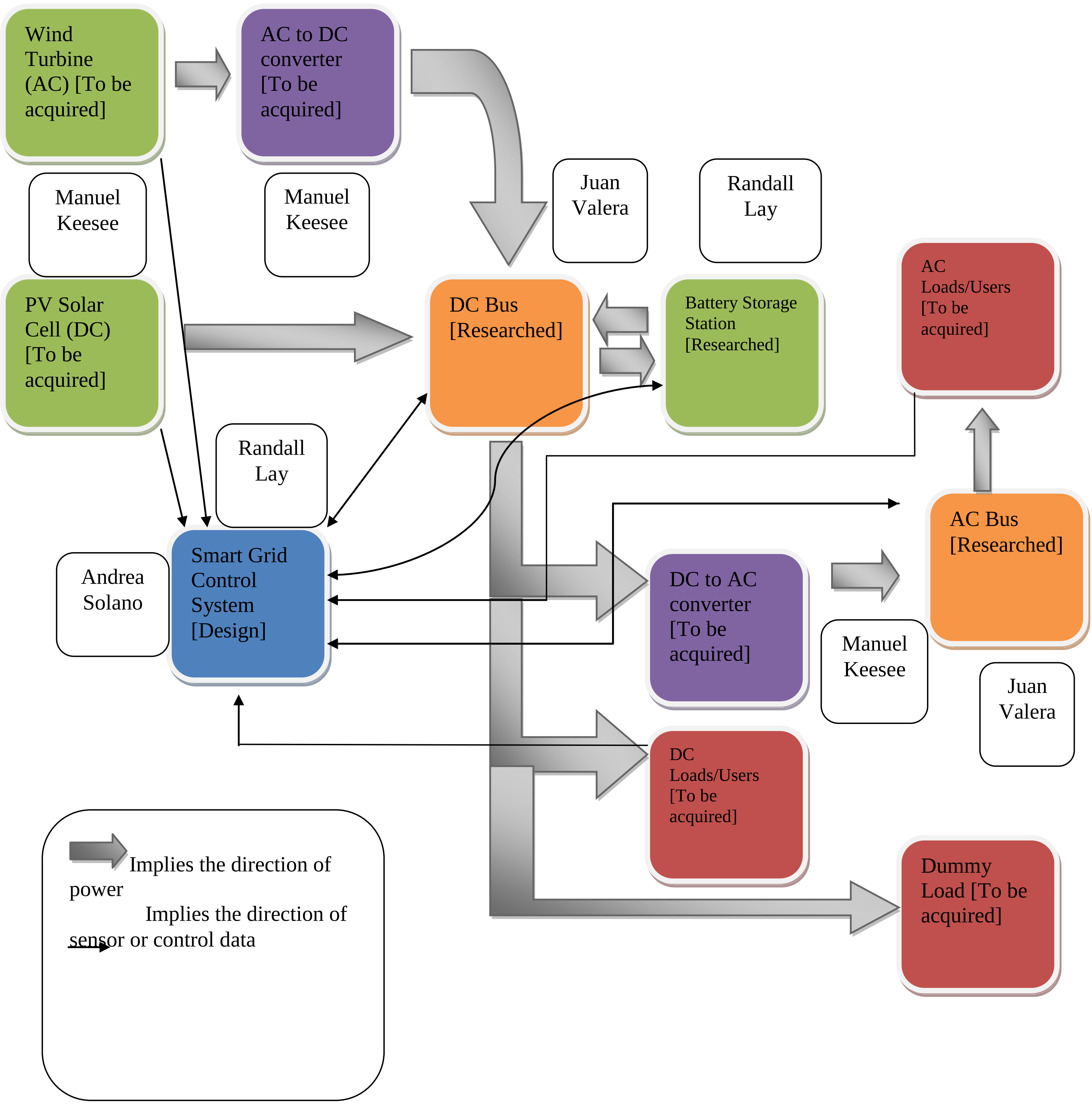
Table6.1 Components of rectifier

3	Full wave rectifiers (Min 35 amp rating)
1	Aluminum heat sink
4	Terminal blocks
2 FL OZ	Silicone heat sink compund
12	Spade connectors for 10 gage wire
3'	10 gage wire
10 to 24	tpi screws
1	Kill Switch
1	Ammenter

Overview of Smart Grid Control System:
Input and Outputs



Hardware Block Diagram:



5. Project budget and financing.

In order to minimize the impact this project will cause in the budget of the group we will look for external financing options such as Progress Energy since we are working on a renewable and sustainable energy- related project. Also, this project is expected to be financed in part by the UCF Burnett College Dean's Dr. Alvin Wang whom proposed the idea of developing a smart power generation system for an isolated community in South Africa. Moreover, we will do extensive research in order to ensure we use components that will allow us to get the performance we expect at the lowest possible cost as long as the integrity of the system is unaffected. In this way, not only we will need a lower budget but also will reduce future maintenance and repairs cost for the South Africa community.

The total cost corresponding to the design, building and implementation of our smart grid energy system has been estimated to be 1,525$, based on observed prices as of September 2012. In order to create this estimate we studied the prices of the different resources we are going to need during the development of this project which consists of equipment/parts, tools and software.

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The following table shows with more detail the expected cost we will face during the different phases of this project.

Item	Finance	Approximate Cost
PV Panel	Group/Sponsor PE	400$
Wind Turbine	Group/Sponsor PE	500$
Inverter	Group/Sponsor	150$
Rectifier	Group/Sponsor	25$
Charge Controller	Group/Sponsor	50$
Batteries	Group/Sponsor	100$
Max Power Point Track Controller (Design)	Group/Sponsor	300$
Funding	Dr. Wang	-1000$

6. Project milestone for both semesters

In order to monitor the project's progress we will set several tasks with assigned dates. In this way, we will be able to finish this project in a timely fashion during the following two semesters. We will use these milestones to establish reference points which will mark major accomplishments in the development of our project. These milestones will consist of the realization of required research, the completion of required paperwork and documentation, the waiting time for the acquisition of parts, the building phase, the testing phase, and presentation of the final product. We will distribute the research and work needed for this project based on the individual preferences and interests of each group member and at the same time making sure that each member be responsible for equal amounts of work.

The expected duration for each stage of our project for senior design I is depicted in the following chart which we will use as a guide to effectively track and accomplish our goals.

Date	Task
08/20/2012	Define Project • Goals and Objectives • Area of Interest
08/31/2012	Research • Smart Grids • Hybrid Energy Systems • Climate Conditions
09/05/2012	Design • Hardware Diagram • Software Diagram
09/11/2012	Finish Initial Project and Group Identification Document

10/30/2012	Acquisition of Required Hardware/Parts • PV Panels • Wind Turbine • Charge Controller • Power Inverter
11/30/2012	Finish Final Documentation
01/30/2013	Prepare Initial Presentation
02/15/2013	Building Phase • Build Rectifier • Build Max Power Point Track Controller
02/25/2013	Assembly of Prototype
01/10/2013	Programming • Charger Controller • PV Panel Controller • Wind Turbine Controller • Max Power Point Track Controller
02/30/2013	Testing Phase • Make Sure Prototype Works as Specified • Test Integrity of the System Under Several Conditions
04/15/2013	Prepare for Final Presentation

Cited Sources:

Integration of Green and Renewable Energy in Electric Power System. Ali Keyhani

Smart Power Grids. 2011 Edition. Muhammad Marwali

Smart Grid Fundamentals Design Analysis. 5th Edition. James Momoh