Integration of PV & Simulated DC Sources for the DC House

Senior Project

ELECTRICAL ENGINEERING DEPARTMENT

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Abstract

The DC House, an ever improving project, uses only pure DC power which most renewable energy sources generate, from solar to wind power. The DC House and this project expect a donation of photovoltaic modules to supply a constant source of DC power. At the moment, the DC House desperately needs power sources because not only does the house have various loads unaccounted for, but the distribution system to determine proper power flow needs a redesign. The project chose to account for these issues by implementing a solar panel onto the DC House and a power distribution module to have the power available where it is needed. Several loads will be applied after the installation of the panel to test whether or not the desired amount of power supplies the appropriate load. This project converts solar power and various other DC Sources into DC electrical power and delivers power efficiently across several DC loads within the DC House.

1. Introduction

Energy is not always affordable and accessible to all people. Society today has become so dependent on energy that many things are taken for granted. Upon examining rural areas of third world countries, power which has been regarded as one of the commodities for many, is a luxury for the individuals who live in these areas. Modern day power generation is transitioning to renewable sources of energy to help alleviate problems such as power generation in third world countries, and to mitigate the environmental damage that can result from power generation.

In a rural setting it is more expensive and complicated to use standard power generation methods. Rural areas in places like Indonesia for example are home to people who live in poverty and generally experience a lower standard of living. The common thread between all these areas is access to renewable sources of power generation at little to no cost to the inhabitants. Sources such as solar, wind and hydro are all readily available and must just be utilized correctly to provide a great benefit to the people that live in these areas. Additionally, energy can be harvested from simple activities done by people on a daily basis such as swinging or playing on a merry-go-round.

The DC House is an affordable and efficient solution to solve the power dilemma faced by so many who live in rural areas. The DC House is a large scale project that aims to fill the void by utilizing renewable sources that include: micro-hydro, wind, solar and human power generation. The target audience for the DC house includes low-income families in third world countries as well as green enthusiasts or hobbyists who would prefer to be off the grid. This project has the potential to improve the lives of many individuals who are living in unfortunate circumstances around the world by providing power to their homes.

The benefits included when a DC House is installed in an area without access to modern power utility structures are vast. The initial push it takes for a neighborhood to become modernized and begin its route onto more technologically advanced area is what the DC House provides. It allows any area of any reasonable weather access to electric power. Electricity is used for many beneficial purposes, whether it is as simple as lighting, cooking and storing food. Many areas today will benefit greatly from the DC House, furthering their use of modern technology while continuing to have some of the basic necessities taken care for.

Affordability and feasibility are two key attributes that are vital when it comes to the hardware required for the DC House. With the generation of DC power, the efficiency lost from the conversion of DC to AC has no effect because this house purely consists of DC. In addition, many more advantages using DC power over AC power in short distance transmission exist. Comparing AC and DC, DC systems do not introduce any reactance in the line, thus reducing power losses. Also DC systems have no frequency, thus requiring no frequency monitors, such as synchronization. With all of these benefits, DC power for the unfortunate seems to be a feasible option available through renewable energy sources.

2. Background

Ever since Tesla and Edison, there has been a debate between AC and DC. At the time, it was decided that AC was the better candidate. Due to Westinghouse's invention of the transformer, AC power sent over long distances with minimal losses was possible [1]. Today, with current power electronic technologies, DC has the capability to step-up or step-down voltage and should be considered as a solution to improve distribution efficiency [2]. Not only does DC have the capability to improve efficiency and reduce power loss between the source and load, but it can also be used in a variety of locations; anywhere with any natural renewable energy sources could harness electricity and a shelter for humans.

There are many disadvantages surrounding the use of AC. For example, the capacity to transmit power in an AC transmission line is limited to 70.7% of the peak value. AC is affected by the "Skin Effect" which decreases the amount of power that can be transmitted through a conductor. Also, AC systems have to account for reactance and frequency, both of which can affect power flow efficiency. Unfortunately, with AC infrastructure being built over the past century, it is impossible to switch over completely to DC but it is possible to have a DC distribution system locally.

The DC House project aims to promote Edison's belief and to solve the problems of accessibility and affordability of electricity for people living in rural areas. Moreover, the specific targets of this project are people living in remote secluded areas in third world countries [3]. Since the target population is expected to be from third world countries it is essential that the design of the DC House include affordability as an important factor.

"A DC House is a house, whose electricity is provided by DC power, rather than the traditionally used AC power" [3]. Renewable forms of energy will be used, rather than the traditional gasoline, coal, biomass or animal waste, to sustain daily energy necessities. As seen in Figure 2-1, there has been a dramatic rise in fossil fuels in the past few decades and a slight increase in renewables. Hopefully, this project will help curb the reliance of fossil fuels and promote renewable energy. The DC House will use renewable sources, specifically wind, solar, hydro and human powered sources .The power generated will provide basic living necessities, such as room lighting, electric stove, heating, and refrigeration.

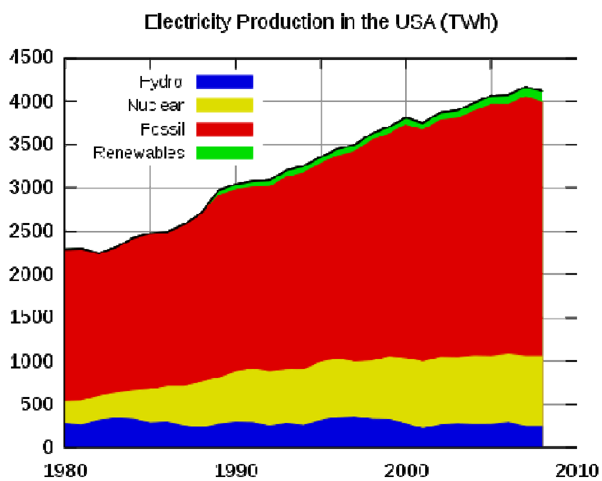

Figure 2-1: Electricity Production in the USA in the past 30 years (TWh) [2]

Previous efforts to design and sustain a DC House have propelled this project into its final stages. Prior projects that help complete the DC House as whole are in their final stages of rebuilding or improving efficiency. Each source, whether it be wind, solar, hydro, or human generated each plays a part in the completion and integration of the DC House. Even if these sources are being simulated for the purposes of design, they still serve a purpose; producing results when they are replaced with actual DC sources. Each source plays a major part in the integration into the MISO transformer [4]. In addition to these sources that supply power to the DC House, there was a full scale model of the DC House which was built. This served as a temporary feature as a proof of design for the project as a whole. Through the assistance of the previous projects, the DC House is in its final stages of production.

In our contributing portion of the final phase of the DC House project, an entire summation of all past and current projects become integrated into one structure. The previous temporary full scale model of the DC House has been torn down, rebuilt, and remodeled. The living space in the remodeled structure will be separated into portions, mainly to keep some sort of separation within the house allowing the designers to plan appropriately for electric power needs in specific living spaces. To one side is the kitchen area, where a high capacity line will be placed, and on the other, a more livable situation where two smaller capacity lines are run. To determine the capacity on each of these lines, a load distribution system will be designed, and will be integrated onto the DC House. Out of the panel, conduit will be placed around the house, concealing any open wires. The house’s power will be supplied by actual DC sources instead of the simulated ones that were used in the previous model. The photovoltaic system will be placed upon the roof of the house, integrating with the MISO. Much attention will be paid to the safety precautions of the house, ensuring if any hazards did occur, they will result in the least amount of damage. Through the integration of completed projects and the design of the electrical system, the DC House excels within the final phase.

3. Design Requirements

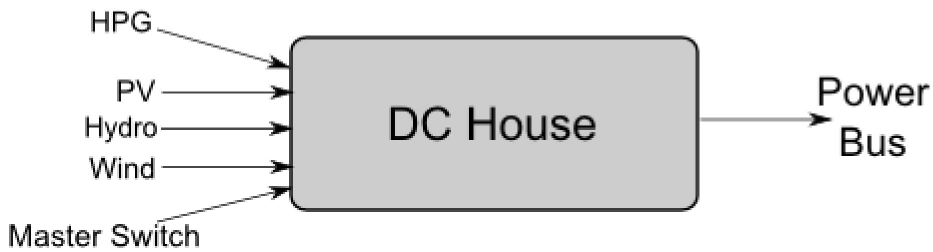

Figure 3-1: Level 0 Block Diagram of the DC House

The level 0 block diagram demonstrates a foundation for future system architectures (level 1). This basis is created by using simulated sources to provide an accurate account for how the actual DC sources function together. Unifying these four sources is imperative as they are all channeled to a common single output which serves as the main system line for the DC house and several loads associated with the house.

Table 3-1: Specifications of Level 0 Block Diagram

Module	DC House
Inputs	DC Sources: · Human Powered Generation (HPG) · Photovoltaic (PV) · Simulated Hydro · Simulated Wind
Outputs	Power Bus
Functionality	To unify four DC Sources onto one power bus while controlling the output power through a master switch.

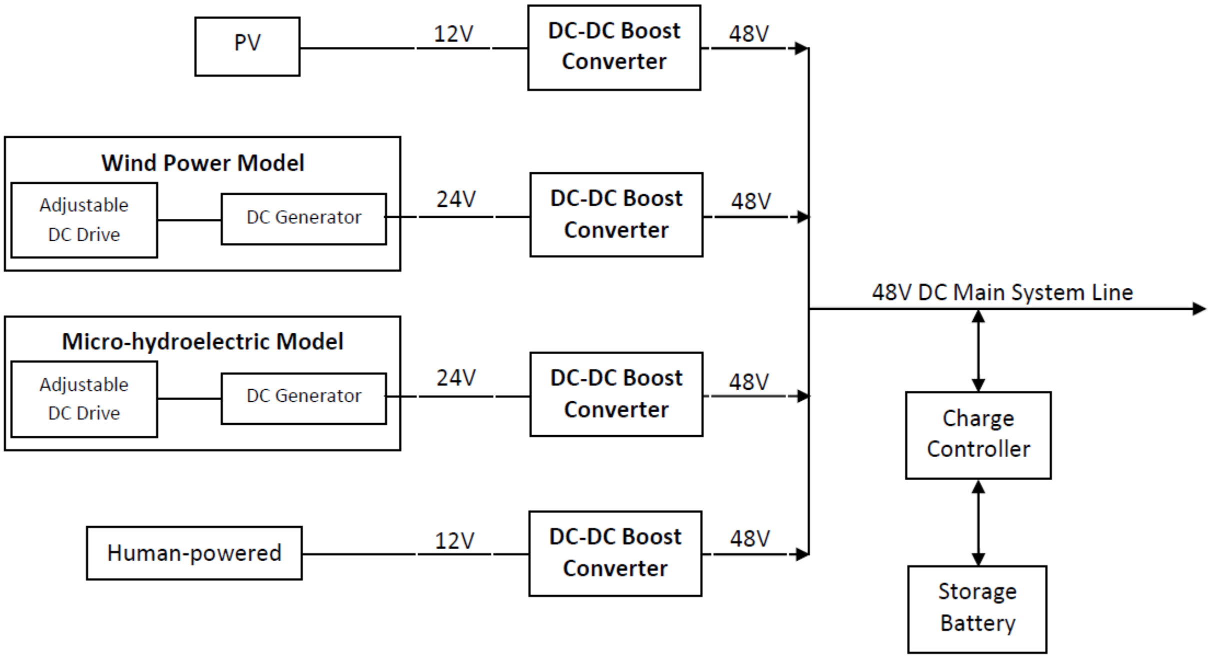

Figure 3-2: Level 1 Block Diagram of DC House

The level 1 block diagram [2] builds on the previous level 0 block diagram by incorporating the actual Wind and Hydroelectric models rather than simulated sources. In this portion of the system architecture we utilize DC-DC boost converters to achieve a uniform 48V DC output which represents the main system line for the DC house. This overall high level view of the MISO (Multiple Input Single Output) is utilized in powering the house and several loads associated with the house.

The final phase of the DC House project strives to meet several different design requirements. The table below summarizes these requirements as well as the reasoning behind each requirement.

Table 3-2: Requirements and Specifications for DC House

Requirement	Justification
Withstand different environmental conditions	The DC House needs to be able to withstand the elements as its primary area of use will be in exposed areas in third world countries. Additionally the primary source of power will be through renewable sources meaning the house will always be exposed to the elements in order to constantly be generating power.
Produce power via various renewable sources	This is one of the biggest design requirements as the house must successfully be able to utilize solar, wind, hydro and human powered sources. This is crucial because these sources directly affect the affordability of the house and serve as proof of concept for the DC House as a whole.
Connect to the MISO	All sources must be integrated into the MISO (Multiple Input Single Output) so that there can be a unified power supply line for the house. This will be done using various step-up and step-down methods. Output voltage will be 48V.
Load Distribution	Within the house, a load distribution network must be created in order to allow the house to successfully handle various different DC loads that are necessities of daily life.
Living Space	The interior of the house must feature a space that is comfortable to live in and contains all the basic needs for daily living.

4. Design

When incorporating all the components of the DC house in this final phase, the house itself became a big factor to consider. Therefore, it was decided early on in this phase that the house should be reconstructed. After generating the bill of materials shown below, and considering the time and quality of building, the decision was made to order a pre-built house:

Table 4-1: Bill of Materials to refurbish existing house

Item	Unit Cost	Quantity	Price
Insulation	$12.79	4	$51.16
Inside Walling	$10.75	8	$86.00
Primer	$39.97	1	$39.97
Screws	$50.00	1	$50.00
Windows	$85.00	3	$255.00
Interior Paint	$44.87	1	$44.87
Painting Supplies	$40.00	1	$40.00
10 Gauge Wire (100ft)	$34.97	1	$34.97
4 Gauge Wire (1ft)	$0.97	10	$9.70
Conduit	$36.98	2	$73.96
Fuses	$50.00	1	$50.00
Exterior Container	$68.00	2	$136.00
Carpet/Flooring	$150.00	1	$150.00
Putty	$20.00	1	$20.00
Drill	$100.00	1	$100.00
Outside Wall Wood	$37.97	9	$341.73
Roof Plywood	$10.47	2	$20.94
Roof Support	$2.78	8	$22.24
Door Frame	$230.00	1	$230.00
Exterior Paint	$85.37	1	$85.37
Felt	$21.50	1	$21.50
Shingles	$29.25	1	$29.25
Roof Supplies	$30.00	1	$30.00
Total			**$1227.25**

Based on the above information, a pre-manufactured 8X10' shed was ordered. This guaranteed that the house would be presentable and also structurally sound in order to safely integrate other projects. The house, shown below in Figure 4-1 was chosen according to a few different factors. The first major consideration was affordability. This is due in large part to the overall final destination of the DC House project which is primarily third world countries. Second, the concept of space was analyzed. A house that is too small would not be sufficient enough to comfortably house the various DC loads necessary to sustain and improve the quality of life. The house chosen provided a good balance between affordability and space which made it a prime candidate for the DC House.

Figure 4-1: DC House (prior to installation of solar panel)

Additionally the turbine air vent shown below in Figure 4-2 was installed on the roof. In the future, the turbine will be replaced with a new turbine that features solar panels in order to provide another source for generating power.

Figure 4-2: Wind Turbine to serve as another potential source in the future

The solar panel was donated by San Diego Gas and Electric and has the following specs shown in Table 4-2 below:

Table 4-2: Solar Panel Specifications

Model Number	STP210-18/Ub-1
Rated Max Power	210W
Current at P_{max}	7.95A
Voltage at P_{max}	26.4V
Short-Circuit Current	8.33A
Open-Circuit Voltage	33.6V

Using a solar pathfinder, shading analysis was conducted on the roof to determine the amount of shading a particular spot would get annually. Although the south facing side of the roof had the ideal tilt angle for the solar panel, there was a large tree obstructing the sunlight. Therefore, the decision was made to place the panel on the north facing side of the roof, where there would be more sunlight annually but with a less than ideal tilt angle. The panel itself was mounted onto two 5’ steel bars which are screwed in through the roof and the rafters of the house to insure that they are secure. The mounted solar panel is shown below in Figure 4-3.

Figure 4-3: Solar Panel Mounted on the roof of the DC House

The simulated micro-hydro and wind power supplies have a separate enclosure in order to protect them from the elements. These simulated sources provide a way to test the wind and hydro sources prior to their completion. The simulated sources can be seen below in Figures 4-4 and 4-5.

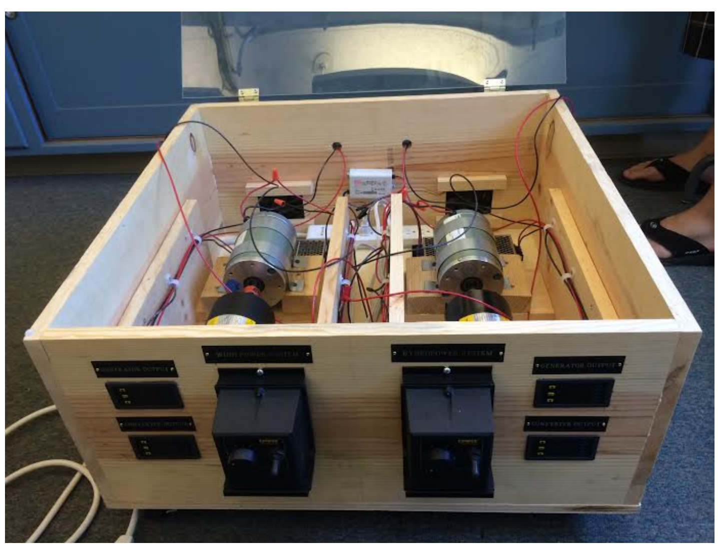

Figure 4-4: Simulated Sources (Front Panel View)

Figure 4-5: Simulated Sources (Overhead View)

The enclosure to house the simulated sources and battery bank is shown below in Figure 4-6 and has been constructed using plywood and 2x4's.

Figure 4-6: Enclosure for the Simulated Sources

To help with the limited space within the house, the enclosure will be placed outside behind the house. All the sources are connected to a breaker box, attached on the back wall of the interior of the house as shown in Figure 4-7 below.

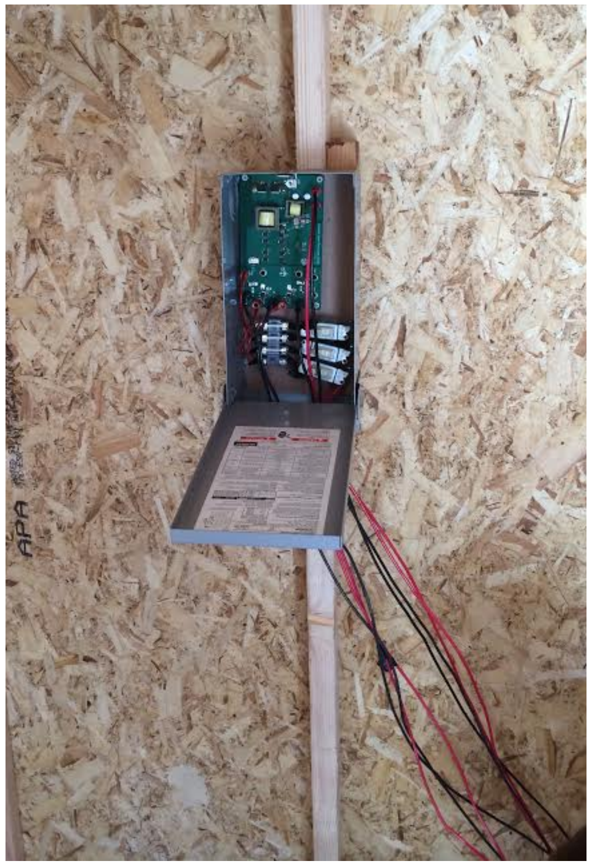

Figure 4-7: Breaker Box on the inside of the House

The overall system design can be seen below in Figure 4-8. This wiring diagram details the connections between the sources and loads. On the source side, each source is connected to the MISO which feeds a battery bank and in turn powers the various loads within the DC House. The loads are divided into three separate branches including: a heavy load branch, a light load branch, and a branch dedicated to lighting. Fuses are implemented throughout the system in order to protect it from current overloads.

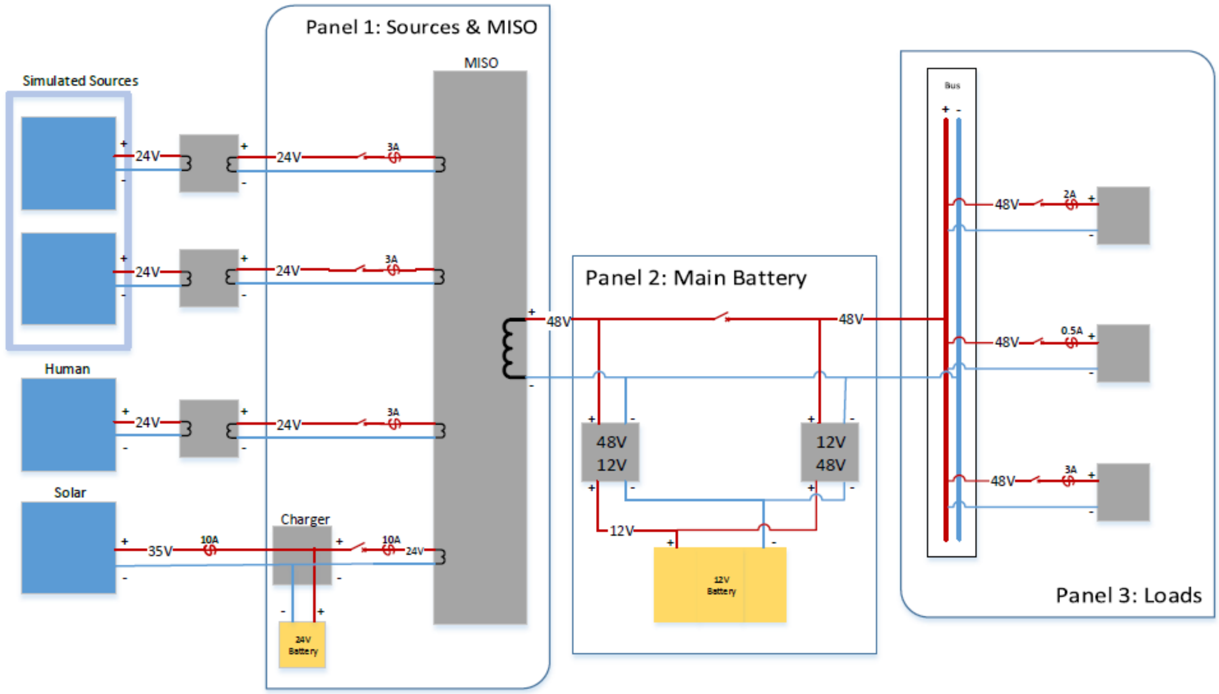

Figure 4-8: Wiring Diagram and Source-Load Connections

In the proposed wiring diagram for the DC House shown above, the 48V to 12V and the 12V to 48V converters were not used. This is due to the possibility of feedback for the 12V to 48V converter. The actual wiring has the output of the MISO connected directly to the load panel board. There is still the switch between the source panel board and the load panel board. To turn on a load, three switches must be turned on. The switch connecting the source to the MISO, the switch between the panel boards and the switch for the load branch correlating to the load the user wants to turn on.

5. Testing and Results

After implementing the wiring diagram shown in Figure 4-8, the DC House was ready for a test phase. With the exception of the 48V to 12V converter, second 12V battery and 12V to 48V converter the house was connected and tested. The first test involved connecting the photovoltaic module to the solar charger to examine the voltage. Since the solar panel is capable of a high output, it was covered for safety purposes. The initial reading from the solar panel was 26.7V. As portions of the panel were uncovered, the voltage steadily rose to around 28V.

For the next portion of testing the solar panel was connected to a 24V battery and therefore the connection to the MISO within the DC House was completed. Two 12V batteries were connected in series order to create a 24V battery with a feasible Amp Hour rating. The switch for the PV source was verified to be in the "OFF" position as shown in Figure 5-2 below to ensure that there was no feedback current through the system. After the connection was made, the voltage was measured at the PV switch and shown below in Figure 5-3. As expected with the switch in the OFF position, we observed the same voltage as the two batteries connected in series.

After verifying prior connections, the MISO was connected and turned on by switching the PV source switch to the "ON" position as shown in Figure 5-4 below. A voltage reading taken at the output of the MISO showed 48V as we expected. The final test to verify the system was indeed working involved turning on a load. The load panel shown in Figure 5-6 houses three separate load branches: two heavy load branches and one branch designated for lighting. The lighting circuit was switched to the "ON" position and the light bulb turned on as shown in

Figure 5-7. The two heavy load circuits are connected to Smart DC Wall Plugs which were later tested and verified to be functioning correctly.

Figure 5-1: Source Panel

Figure 5-1 shows the source panel board which is located on the back wall in the interior of the DC House. This contains the MISO, fuses and switches that are connected to the sources. There are currently three sources connected to the MISO: the PV panel, simulated hydro and simulated wind. The human powered generation was left open, but there is room for an additional switch and fuse. The MISO is connected to the panel board with hot glue and the switches and fuses with industrial strength velcro tape. The switches are labeled on the inner side of the panel board. The wires are also labeled individually inside of the house to avoid any confusion.

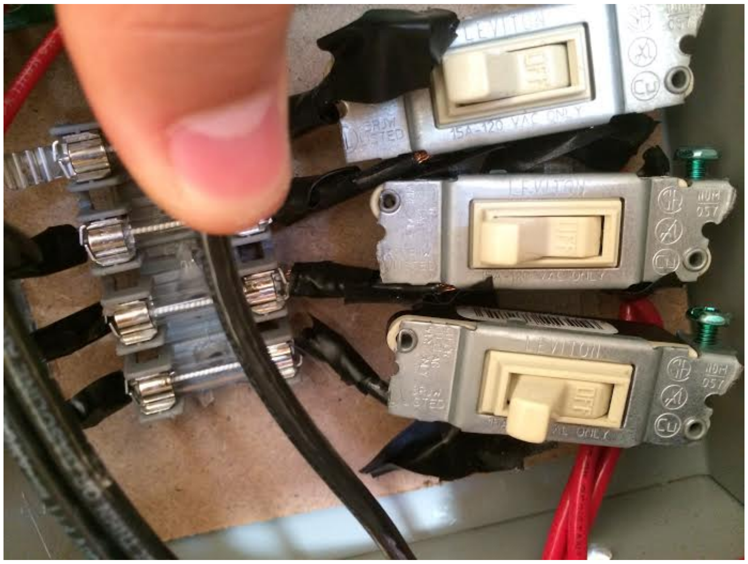

Figure 5-2: Source Switches in the OFF position (Hydro, Wind, PV)

Figure 5-2, shows the source switches on the off position. The top switch is the simulated hydro, middle switch is the simulated wind and the bottom switch is the PV panel.

Figure 5-3: Voltage Reading from the PV source with the switch in the OFF position

Figure 5-3, shows the output voltage of the PV source. Even though switch for the PV panel is in the off position the panel is constantly outputting approximately 26V and charging the two 12V batteries which are connected in series.

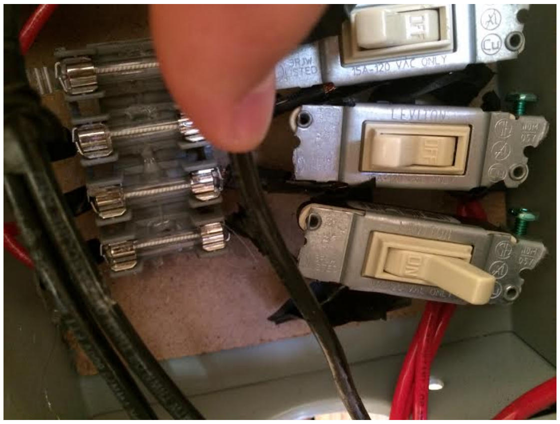

Figure 5-4: PV Source switch in the ON position

Figure 5-5: Output Voltage Reading of the MISO (PV Source ON)

Figure 5-4 shows the switch for the PV source in the on position. This energizes the MISO and the resulting output of the MISO is shown in Figure 5-5 which is approximately 48.1V.

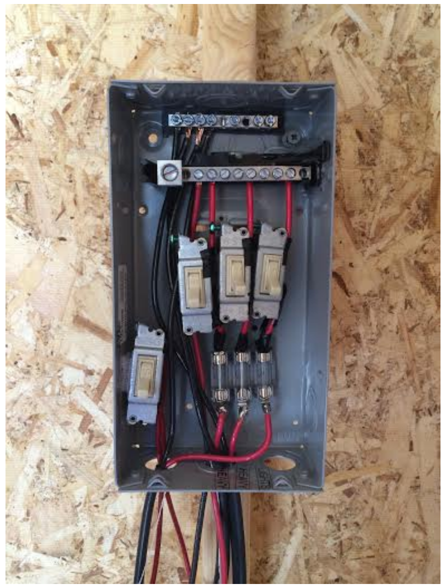

Figure 5-6: Load Panel

The load panel shown in Figure 5-6 allows for easy control over the three load branches within the DC House. The switch on the bottom left corner of the load panel controls the output of the MISO. When switched to the ON position, the bus seen on the load panel rises to 48V. Attached to this bus are three switches. The two switches on the left control two branches of loads within the house referred to as “heavy loads”. The switch on the right controls the lighting within the DC House.

Figure 5-7: Lighting Circuit Powered ON

6. Conclusions and Future Work

At this point in the project, the DC House is in its "prototype" phase. This means that elements of the house have been designed to show functionality and not as an end result. For example, the batteries chosen for the MISO and the Solar Panel have been chosen in order to have a run time of 6 hours as opposed to the end goal of 12. This is simply because at this stage, the DC House is a proof of concept idea which will be refined further before we have a final working prototype.

One of the areas that can be improved in future iterations of the DC House is the addition of more realistic loads. More diverse loads can be incorporated and the battery bank sizing can be adjusted accordingly in order to sufficiently power new loads. Additionally, the actual human powered sources (merry-go-round and swing) can be tested in conjunction with the DC House in order to replace the simulated sources with the actual sources. This will provide an even more accurate model of the DC House in its intended final form.

Functionally, the house needs a new solution for the section of Figure 4-8 that involves the 48V to 12V and 12V to 48V converters and the second battery. As of now, the converters are disconnected because the system would be trying to force two outputs that are not exactly equal which would lead to feedback current on the converter. Once a solution is in place, the converters can be reconnected to the system and the second battery can be incorporated to complete the battery bank.

Additionally, the interior of the house can also undergo some cosmetic changes to make it more habitable for the final product. Insulation and dry wall can be fitted in the interior to make it more similar to a modern home and thus making it more feasible for people to live in. Carpet can be installed and the light bulb fixtures can undergo a more permanent attachment method to the rafters of the house. Overall, this project accomplished its goal by rebuilding the DC House and creating a safe and successful distribution system that involved multiple sources and the dynamic loads which are associated with the developing DC House.

References

[1] A. Ma, "Modling and Analysis Of a Photovoltaic System with a Distributed Energy Storage System,"
California Polytechnic State University,, San Luis Obispo, 2012.

[2] Shenai, Krishna, and Rajendra Singh. "DC Microgrids and the Virtues of Local Electricity." - *IEEE Spectrum*. IEEE, 6 Feb. 2014. Web. 19 Feb. 2014. Available: http://spectrum.ieee.org/green-tech/buildings/dc-microgrids-and-the-virtues-of-local-electricity/?utm_source=energywise&utm_medium=email&utm_campaign=021214

[3] Taufik. “The DC House Project.” Available: http://www.calpoly.edu/~taufik/dchouse/index.html
[Accessed Feb. 17, 2014].

[4] “International Energy Statistics – Electricity.” *US Energy Information Administration*. Web. 2011.
www.eia.doe.gov/

[5] Jong, Owen. (2012). *Multiple Input Single Output (MISO) DC-DC Converter for the DC House Project* [Online]. Available FTP: http://digitalcommons.calpoly.edu/cgi/viewcontent.cgi?article=1164&context=eesp

Appendix C – Analysis of Senior Project Design

Summary of Functional Requirements

The DC House aims to utilize the DC energy directly from renewable energy sources without the need of DC to AC conversion. Various types of DC power generation include: wind power, micro-hydroelectric and human power generation. Each source includes their own DC-DC converter and feeds into a Multiple Input Single Output (MISO) converter that has an input power rating of 300W and outputs 48V. The output of the MISO outputs to a load panel, that serves as a control center for various loads, and a battery bank system.

Primary Constraints

There were several constraints associated with the implementation of this project. Many of the required components were not complete until late into the spring quarter, such as the MISO and the DC wall plugs. Prior to their completion, much planning had been taken into consideration to account for these components. However, soon after these portions were complete, hardware production began to take place.

Economic

Those in developing countries and also those who may be out of reach of the utility grid now have the opportunity to use renewable energy sources. Bringing the traditional electrical grid to remote areas of the world is expensive for power companies and is generally not cost-effective. This creates an opportunity for engineers to apply new technologies to and address basic humanitarian needs that improve the quality of life. This also gives less fortunate people the freedom to use their own generated power. As an open source project, if the DC House became mass produced, it would exclusively be for humanitarian cause, not for profit. The estimated costs at the beginning of the project are shown in Table C-1 below.

Table C-1: Pre-Project Cost Estimate

Item	Cost	Amount	Justification
Wires -14AWG	$100 per 100ft	200ft	Vital component for system integration. Wire will be used from source to load.
DC Connectors	$80	16	Needed to connect wires to components
DC Battery Backup System	$400	1	N+1 Redundancy for "Fall back" power
PV Roof Mounts	$300	1	PV system installation.
Wood	$200	1	Roof overhaul
DC-DC Converters	$100 each	4	Interface between sources and MISO. Needed for each source
Total Cost	**$2780**		

Upon completing the project, the final costs are shown in Table C-2 below.

Table C-2: Post Project Cost Totals

Item	Cost	Amount	Justification
Shed	$1800	1	It was more cost efficient and structurally sound to purchase a pre-built shed rather than rebuild the house from the ground up.
Batteries	$200	3	These served as the batteries for the battery bank. A 24V battery was required for the PV module and a 12V battery was required for the remainder of the system.
Building Materials	$800	1	This includes everything used to complete the wiring system within the house as well as build the enclosure for the simulated sources outside of the house.
Total Cost	**$3200**		

Commercial Basis

While the DC House addresses a specific market segment in third world countries, we do not expect many DC Houses manufactured on an annual basis. After many years of improving the DC House to eventually create a near perfect product, it is likely that several units could be sold around the world. However, a commercially viable DC House is potentially several years down the line. Each DC House's materials could cost anywhere from $5,000-$15,000, depending on the DC sources. Given the unlimited sources of available renewable power, it could take several years of the house’s usage to break even on cost and become profitable.

Environmental

The design of the DC House is as environmentally friendly as possible. While in use, no environmental impact occurs due to the fact that the house generates power through renewable energy sources. Unless an overconsumption of wind, solar, and hydro-generation impacts the environment, the power generated by the DC House remains completely environmentally safe. This reduces the pollution created by other power production sources; by having less power consumed from non-renewable sources and more consumed from renewable sources such as the DC House. The impact the DC house has on species directly correlates to the location in which it is utilized. At this time the assumption stands that the market for the DC House remains third world countries only such as Indonesia.

Manufacturability

The DC House has few limitations on its manufacturability due to the fact most components are purchased directly from a manufacturer. If a component of the DC House was designed rather than purchased, the schematics for the design are online and easily available for reproduction.

Sustainability

After production, from a maintenance stand point, the DC sources will require more maintenance that the house itself. Regular checks for normal household conditions, such as termites, leaky roof, or any mold should occur as with any other house. The electrical components of the DC House should undergo regular maintenance checks for any chance of water leaks, build-up of materials from the environment creating shorts across wires, or for damage to the wires caused by animals. Even though the DC House generates its power through renewable sources, it can over-consume the natural environmental energy sources, resulting in detrimental effects on the ecosystem.

Throughout the DC House there exist many portions and types of circuitry used (DC-DC converters). The only source of electrical loss would result from these designs. If these are improved to create a better efficiency, the overall performance of the DC House could be improved. The challenge with improving these designs is simply that most of the designs are student created with wide latitude in the design parameters.

Ethical

By having an off-the-grid house generating power, having no the use of the grid might create many ethical implications. To begin with, to complete any work on the DC House, workers must either volunteer or be paid, and if not ethical conflicts arise; one of the potential DC sources, human powered generation, could also create ethical challenges under similar conditions. If the DC House is implemented in a habitat far away from civilization, there are opportunities for criminal misconduct and illegal activities to manufacture harmful or illegals substances with the aid of renewable energy sources.

Looking at these complications from a utilitarianism framework, the greater good would benefit by the DC House. Power generation, without the need of a grid or petroleum, could be implemented anywhere having sun, wind, water, or humans willing to do work.

Health and Safety

The DC House has minimal health and safety risks. The few dangers involved with handling the electrical components in the DC House are the risks of electrical shock. Also there are potential health and safety hazards from exposed wiring and/or electrical components.

Social and Political

Even though the DC House seems as a low environmental impact, "green" DC powered house, a variety of social and political issues come included. Many power generation companies have a deep influence on social and political issues. These companies would view the DC House as a threat to their profitability, making it really difficult to implement on a large scale. The DC House does not use any sort of grid nor a single drop of petroleum to generator power.

Many indirect stakeholders become affected through the production of the DC House. These indirect stakeholders could include transportation companies assisting in moving these houses. Also, the communities sharing the DC House, not only the owner, also benefit, whether they use it for general economic profits, gaining knowledge, or just using it to improve their daily happiness.

Development

While developing this portion of the DC House, we gained more knowledge about DC-DC converters, power system design and load distribution networks. To ensure safety of the system and individuals associated with it, several safety precautions have been implemented. The system features many switches to control each individual source and branch of loads. This allows the user to have complete control of the system to avoid overloading it. Additionally, there are multiple fuses placed throughout the system that protect it from an overload of current. Each fuse has been chosen specifically to protect each component of the system from experiencing this overload in current.