MOAS Project: Wind Energy Demonstration

Spring Proposal

Wind Energy Systems Inc.

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December 2, 2004
EML 4551

1.0 Introduction

The Mary Brogan Museum of Art and Science has endeavored to develop a series of energy-themed exhibits to educate the public on alternative fuel sources and renewable energy. As an educational museum, this facility focuses mainly on family entertainment; thus the exhibits need to be appealing to all ages. The Florida A&M and Florida State College of Engineering has offered work with the museum in a joint venture that can benefit both organizations. The FAMU/FSU mechanical engineering curriculum incorporates a senior design project, which provides the students with a yearlong, career based, design application utilizing the needs and resources of several companies around the area. The FSU/FAMU Mechanical Engineering department has deemed it a worthy cause to design and fabricate an exhibit for the energy conversion demonstration for the Mary Brogan Museum, while using the project to help educate and prepare the senior mechanical engineering students for the transition into the career world. Five senior mechanical engineering students, together with the Mary Brogan Museum, will design and fabricate a sub-scale wind energy demonstration to be displayed in the energy-themed exhibit. The following document proposes the planned exhibit, all of its components, and the budget needed in order to fabricate a working wind energy demonstration.

1.1 Specifications from the Museum

The Mary Brogan Museum had several needs and specifications for the wind energy demonstration. The museum attracts guests of all ages including the youth that attend the local school systems. The Brogan Museum has made it a priority that these future thinkers of America are the main target audience. With this in mind, the design needs to concentrate on attracting and keeping the interest of the younger visitors as well as being educational enough to teach something new to the adult visitors. The key to keeping the younger museum visitors interest is to make the exhibit interactive this means giving the children the chance to make something happen within the exhibit and visualize the effects. The design needs to be able to be viewed from more than one side, enabling a group of visitors to interact and learn from the exhibit at the simultaneously. As well as multiple viewing angles, the design should provide visibility for all of the important moving parts. Since children are the main audience the science and engineering aspects of the design need to be explained in simple terms, and should appeal to several different learning styles. The wind energy exhibit will be in use for several years; therefore the design should be durable and require very little maintenance. However, the most important specification is safety due to the amount of visitors that will come in contact with the exhibit. These specifications need to be met and an attractive professional looking museum exhibit will be produced.

1.2 Engineering Concepts From the Sponsor

Other considerations and specifications arose after meeting with the team sponsor, Dr. Chiang Shih. These engineering-based ideas and components need to be implemented into the design in order to help demonstrate what is actually happening. A device to monitor and display the wind velocity would help depict the amount of wind required to generate power from a turbine. The application of a mesh screen or honeycomb to regulate the flow of the wind will also be needed in the design to insure a laminar flow of air. A power output device needs to be installed to inform the audience of the power that can be produced using wind energy. The idea of comparing two different types of wind turbines has been implemented into the design. A pulley system will be used to rotate the wind turbines and will aid in the understanding the effects of the wind's angle of attack on both a horizontal and vertical axis turbine. Although these components and ideas are not necessary, they will make the exhibit more interactive and help convey the information displayed in the design.

1.3 Main Features of the Design

The final design has incorporated the previous constraints and specifications deemed important by the Mary Brogan Museum and sponsor Dr. Chiang Shih. First, the exhibit needs to attract and keep the attention of both children and adult visitors; to ensure this, interaction is the key. Therefore, the wind speed and angle of attack are variable and controlled by museum visitors. These two variables will result in different amounts of power produced by each wind turbine, and will be displayed via light towers wired to display the power output. These power meters will give the visitors the opportunity to visualize a cause and effect demonstration for each controlled variable.

The visibility of the exhibit and all moving parts is the next main area of concern. The designed exhibit will maximize the area of visibility, giving the exhibit the ability to entertain a group of museum visitors at one time. The wind turbines will be constructed as open-air turbines giving visibility to the DC generators and other internal components. The design must be durable and require very little maintenance due to the long lifespan of the exhibit. To ensure this specification, the casing will be constructed of aluminum with acrylic, plastic inserts that will be bolted onto the aluminum casing. These plastic inserts will thusly enclose the exhibit. With safety in mind, the electronics, all moving parts, and the entire exhibit will be enclosed inside the plastic casing. To create airflow in and out of the exhibit, as desired by the customer, vents will be placed on the sides of the exhibit, but only large enough for air to enter and exit the casing.

On the engineering side several components have been added to aid in the understanding of what is actually happening in the exhibit. A major goal of the exhibit was to utilize a comparison of two types of wind turbines. In order to create this comparison, both a horizontal axis and a vertical axis wind turbine will be constructed. The two designs will be compared by the power that each turbine will produce at various wind speeds and different angles of attack. A pulley system was designed to rotate both turbines to create these varying angles of attack, enabling the comparison of which turbine design is more applicable, more efficient in the real world. A Heavy Duty Mini-Vane CFM Thermo-Anemometer will be implanted in the exhibit in order to monitor and display the velocity of the generated wind. The idea of a diffuser to accelerate the wind's velocity and the application of a mesh screen or honeycomb to regulate the flow of the wind were also considered in the design process to ensure laminar flow of the air. Laminar airflow will help to make the controlled parameters of the experiment more accurate and consistent for each cycle that the exhibit demonstrates the energy conversion. A diffuser will not be used; however, the honeycomb screen will be a component of the exhibit in order to regulate and create the desired laminar wind flow. To display the power output of the two wind turbines, two light towers will be used. These light towers will be wired so that the number of lights that are illuminated is directly proportional to the power being created.

1.4 Overview

In the following sections, a description of the project and its significance will be defined. The project parameters have been outlined in order to comply with the customers desires, while the group generated the more specific exhibit components and design generations. The following sections will help to create a clearer picture of the proposed idea, the necessary components of the project, as well as the various design specifications that have been described.

2.0 Final Design Specifications

2.1 Casing

The overall dimensions of the exhibit were specified by the director of the MOAS. These dimensions were five feet long, four and one half feet tall and three feet deep. As a group, sketches were made and after consulting with the customer, a frame was designed. A CAD drawing of the frame can be seen below in Figure 2.1.

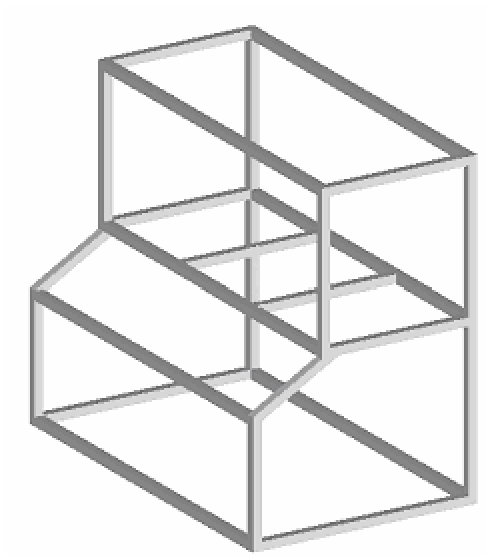


Figure 2.1 – A CAD drawing of the frame for our exhibit.

In order to construct the frame, a welder was contacted in order to consult the idea of have a frame built of welded steel. The engineering drawings were presented to the welder and a quote was requested. After the welder reviewed the design, he suggested a company that makes modular aluminum, known as 8020. After doing some research about the products of the company and looking at examples of aluminum pieces, engineering drawings, as well as a parts list, were sent off to 8020 for a quote on building the pieces for the frame. Recently, a quote was received from 8020 as well as a CAD drawing for the construction of the previously designed frame. An expanded quote can be seen in Appendix A and the CAD drawing can be seen in Figure 2.2.

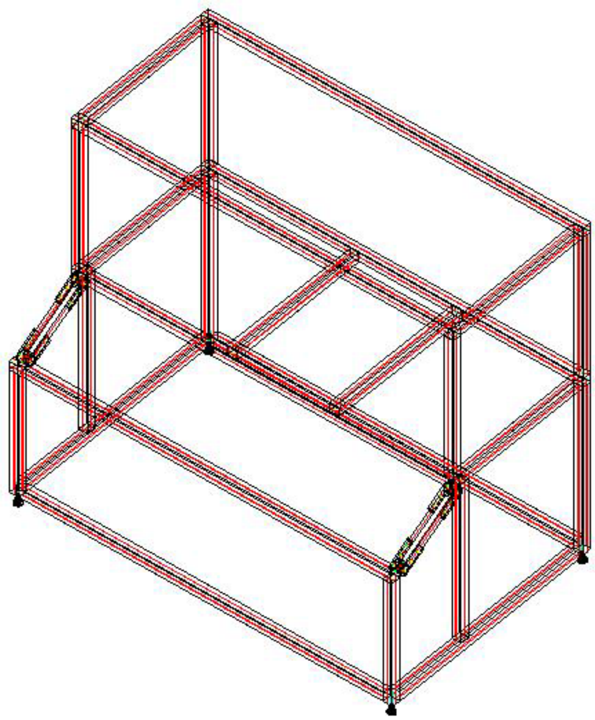


Figure 2.2 – The CAD drawing sent to us by 8020 for the construction of the frame for the exhibit.

The frame will not be assembled when it is shipped, only the individual aluminum pieces will be shipped. This is one main advantage that was realized when considering 8020 because shipping, transportation, and construction of the frame will be much easier with just the individual aluminum pieces. Once the aluminum pieces have been received, the frame can be constructed using Allen wrenches because of the fact that the pieces will be precut and ready to be assembled.

Per request of the museum, the bottom of the exhibit needs to be closed using laminated wood. This wood will match the base of the other existing exhibits to create a more uniform effect throughout the museum. The wooden laminate panels would be bolted to the frame in order to enclose the base of the exhibit. The director of the museum suggested a carpenter to assist in making these wooden laminate panels. The suggested carpenter was willing to assist in the project and plans have already been made to meet and discuss the future work of the project.

2.2 Wind Generation

The goal of the exhibit is to show wind energy as an alternative energy source; therefore, in order to generate wind inside the exhibit chamber, a fan needs to be purchased. Before selecting the fan, a few specifications had to be considered. Because this exhibit needs to be as interactive as possible, varying the wind speed is one way to accomplish that goal. Consequently, the fan had to have a variable speed control with a still relatively high flow rate. In addition to have a varying wind velocity, the fan also needs to be small enough to be mounted into the exhibit's frame. After researching various types of fans, a commercial pedestal type fan was found that fit the previously described qualifications. In order mount the fan inside of the exhibit casing, the base of the fan, which consists of a pole and a tri-support, will be removed. The remaining fan component will then be placed in the exhibit. The commercial fan chosen was the Qmark LDC20 Light Duty Commercial Fan available at a price of $215.25, which is well within the project's budget. A picture of the fan can be seen in Figure 2.3.

Figure 2.3 - The Qmark LDC20 Light Duty Commercial Fan

2.3 Wind Turbines

The main objective of the exhibit is to educate viewers about how wind can be used to produce power by using a generator and a turbine. To accomplish this goal, small-scale wind turbines were needed for the exhibit. Research concluded that no companies build wind turbines on such a small scale. This realization led to the conclusion that the small-scale turbines would have to be constructed locally. After careful consideration and research in ways to produce power, it was decided that the easiest way to create electricity was to obtain a DC motor and run the motor in reverse in order to generate power. Before actual construction of the exhibit's turbines and generators, testing was first required. Small DC motors, along with propellers that are normally used for model aircraft, were purchased at Hobby Town USA to perform this initial testing. From this experimentation, the best fit between propeller, turbine and generator was selected.

Another idea that was generated to enhance the exhibit was in incorporate two different types of wind turbines in order to show how different wind turbines have different efficiencies. The variance between the wind turbines will be that one turbine rotates about a horizontal axis, while the other rotates about a vertical axis. After several design generations, a horizontal axis design and a vertical axis design were concocted in order to show the efficiency difference. The two different turbines can be seen below in CAD drawings in Figure 2.4.

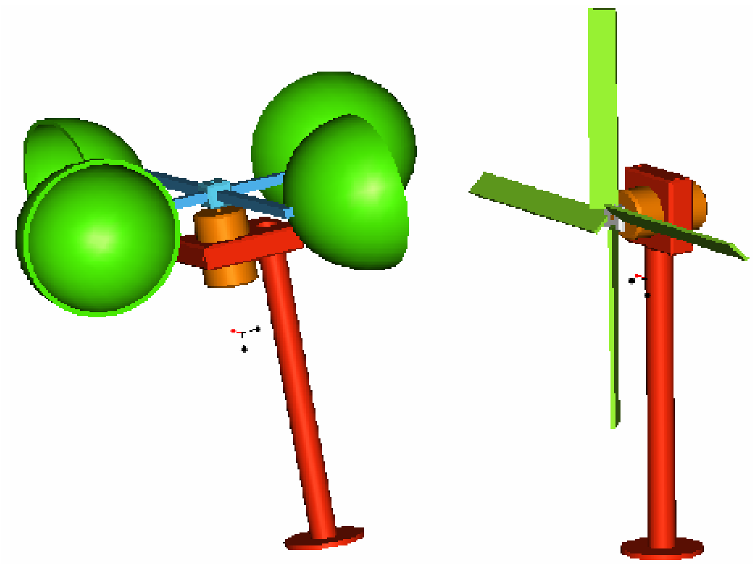
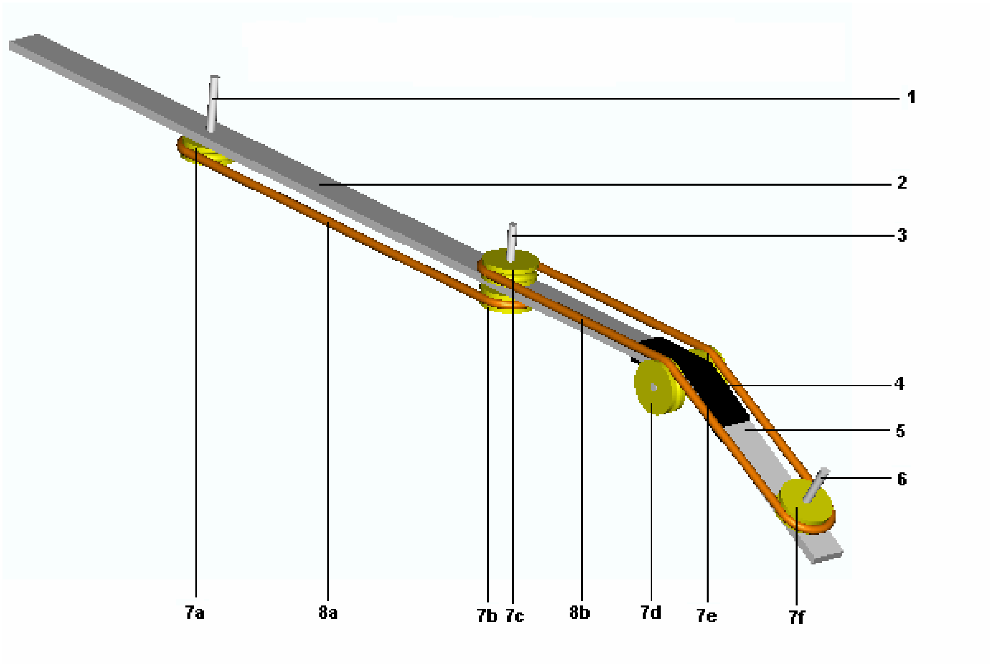


Figure 2.4 – CAD drawings of the vertical and horizontal axis wind turbines

2.4 Pulley Design

During the spring semester the turbines will be constructed. The bases for the wind turbines will be constructed by the FAMU/FSU College of Engineering machine shop using engineering drawings. The DC motors and the propeller blades will be assembled and mounted at this time as well.

It had been previously agreed that both of the wind turbines would be placed on rotating platforms so that they would be able to turn with respect to the direction of the incoming wind. To accomplish this, it was decided that a turntable and pulley system would be used. A Pro/E model of the setup, with its important components labeled, is shown in Figure 2.5 below. Note well that the entire setup will be concealed from view, within the exhibit.



1	Vertical axis mounting shaft
2	Supporting cross bar 1
3	Horizontal axis mounting shaft
4	Cross bar connecting bracket
5	Supporting cross bar 2
6	Control dial mounting shaft
7a	Horizontal axis pulley wheels
7b	Transfer pulley wheel
7c	Vertical axis pulley wheel
7d&7e	Idler pulley wheels
7f	Input pulley wheel
8	Round drive belts

Figure 2.5: Pro E picture of pulley system with all major components labeled in the chart.

2.5 Power Meters

To show the power generation from the wind turbines, the museum asked that the power output display be easily visible. The best way to show power output visually is to have a light display that has an amount of light showing which corresponds to amount of electricity that is being generated. To do this, a light tower with light bulbs of different color will show the power generation from the DC motor. As more power is generated, the light bulbs will light up sequentially as more power is generated.

After testing the light towers data from the testing of the power output of the DC motor was taken to Dr. Dave Cartes of the Mechanical Engineering Department. Dr. Cartes assisted the project by drawing for a simple circuit that would light up the bulbs sequentially. Dr. Hui Li of the Electrical Engineering Department has also offered assistance with this project. Dr. Li will help to actually construct the circuit and ensure that the wiring is correct. Parts for this part of the exhibit will be purchased from McMaster and assembled by GT Electric, an electrician referred to by the MOAS.

2.6 Start Button

The museum expressed an interest in a having start button to initiate the fan to produce airflow. This button will be located on the front display panel of the exhibit, so that when pushed, this button will start up the exhibit by giving power to the fan and thus creating wind. The start button was provided by the museum and will cost very little to wire into the exhibit. The Electrical Engineering Department, especially Dr. Hui Li, will aid in the design and wiring of this circuit.

2.7 Kill Switch

Energy conservation was in mind for the next electrical component. Like every business, the museum has customers that come in waves, meaning that some hours or days are not as busy as others. With this thought in mind, it was decided to incorporate a kill switch, which will shut off power being supplied to the exhibit. With no movement of the wind speed dial, this kill switch will cut power to the wind generation system after a programmed amount of time. The length of this time can be altered by the museum depending on utility and usage requirements. The kill switch will be wired to the start button in order to coordinate the airflow and power supplied to the fan. The kill switch that was selected will be purchased from Grainger, a local electronics supply distributor. The off delay octal base timer is designed by Dayton and will have a delay time range from 0.1 minute to 10 minutes. The price of this electrical component is $54.70 before tax. However, since Grainger is a local establishment, there will be no extra shipping or handling charges.

2.8 Wind Velocity Measurement

A hot wire anemometer will be used to determine the wind velocity moving through the exhibit as a result of the fan motion. The hot wire anemometer will protrude into the airflow of the exhibit with a digital display of the wind velocity mounted onto the front display panel. The digital readout of the wind velocity in the exhibit was a request of the museum in order to create more interaction with the exhibit. The hot wire anemometer will be a costly part of the project. After doing budget analysis on the anemometer, it is estimated that the cost for the instrument will reach upward bounds of $500 to purchase. Therefore, if budget concerns arise, this part of the project may be eliminated so that other parts of the project that have been deemed more important will not have to be eliminated.

2.9 Honeycomb

In a real world application the wind impinging on an actual wind turbine will not be perfectly parallel. In order to create a more parallel flow, a honeycomb will be purchased to fulfll this objective. Conveniently, the honeycomb will be relatively inexpensive, so this will not be a large concern when calculating the budget. The surface area for the honeycomb will be two square feet, while the depth of the honeycomb will be one inch. The openings of the honeycomb will be one quarter of an inch in area in order to allow enough airflow through the cavity of the exhibit. This will add more control and consistency to the wind energy experiment.

3.0 Cost/Budget Analysis

The design and fabrication of an exhibit of this magnitude can be quite expensive. However, the cost of designing the exhibit and the initial consultation for the exhibit was performed by the senior design group; thus, there will be no charge. The only cost that the museum will incur is the cost of the materials and the professional fabrication that will be required for the exhibit. After researching the materials necessary to build the exhibit and professional help needed to fabricate the exhibit, a budget was created to determine the cost of the exhibit. Table 3.1 below shows a basic outline of how the budget will be allocated, which components are the most expensive, and how much of the budget will be left for excess expenses. Table 3.1 shows a 20% margin of error. This 20% pertains to 20% of the total budget and will serve as a cushion to account for the unexpected expenses that will arise when constructing the project. If at the end of the project there is money that is left over, then that extra money will be reallocated back to the museum. Because it is a better business practice to overshoot the expected budget, this will be done in order to avoid running out of capital for the project.

Table 3.1: Basic Budget Break Down

• Wind Generation	$ 415.25
• Power Generation	352.64
• Electrical Systems	1502.37
• Flow Management	100.00
• Pulley System	148.53
• Exhibit Casing	1500.00
• 20% margin of error	803.76
Total Cost	**$4822.55**

4.0 Schedule of Future Work

Before the actual start of this project, one of the first duties outlined was a timeline projecting the completion of this exhibit. The main outline, as decided by the professor of the course, Dr. Luongo, was to have the design and planning completed by December 3, 2004. The spring semester is dedicated to the actual building and construction of the project, which is to be finished in April of 2005. The project has been progressing along as planned; however, the scheduling of the museum's launch of the entire energy display falls earlier than the expected completion of this project. The energy conversion section of the museum with which this project is associated with is scheduled to be unveiled on January 28, 2005. The museum has been informed of this scheduling difference, and has approved the later completion of the project. Because the other energy exhibits will be displayed before this project is complete, it is desired by the museum to have something in the space where the wind energy exhibit will eventually be displayed. This will help to give the presence of the wind energy exhibit before its actual completion. To do this, there will be a pictorial display of what the exhibit will look like in the space where the exhibit will eventually be showcased. This display will be the first steps to explaining what viewers can expect in the near future.

In order to portray the exhibit, the display will have several pictures and descriptions of the design. The main section of the display will contain the final design as well as a detailed description of the design and how it will work. Pictures of the various components for the final design will be shown to give a better understanding of what the finished exhibit will eventually look like. Similar to the descriptions given for the final design, there will be a description for each components and any other necessary information. Lastly, there will be a timeline in order to let the people who view the exhibit know how long until this wind energy exhibit will be amongst the other exhibits. The display will also be updated periodically during the construction of the exhibit to show the progress made during the spring semester until it is completed. By compiling these figures and descriptions there will hopefully be a spark of curiosity lit in the public that will prod each person to come back to the museum to experience the completed exhibit.

Because this project will initially be absent from the other energy exhibits, it is apparent that there will be a large hole in this section of the museum that is concentrating on energy conversion. By creating this display it will help to fill this void and create the project's presence and potential to show how it will enhance and compliment the other energy demonstrations. This energy exhibit is one that will be displayed in the museum for years to come, so that absence of this project for a few months is somewhat insignificant in the long term due to the durability and quality that is promised with this project. Although the projected completion date of the exhibit is next April, there is a possibility that the project will be completed earlier. If this scenario happens to occur, and if approval is received from the Dr. Loungo, Dr. Shih, and the museum, the exhibit may be able to be displayed before this deadline. However, even taking into account various conflicts and roadblocks that may occur when constructing the exhibit, it is most definite that the exhibit will be completed by no later than April. In the meantime the proper unveiling of the exhibit will be preceded by this display, which will help to create a clear picture of just exactly what the museum patrons can expect in the near future.

4.1 Plans for Spring Semester

Before the end of the fall semester most, if not all of the parts needed to fabricate the wind energy exhibit will be ordered. At the start of the spring semester more extensive testing will take place using the horizontal and vertical axis wind turbines. At first there will be testing of the electrical output of the horizontal and vertical axis wind turbines using the wind tunnel to determine the exact output of the DC motors at various velocities and angle of attack. This information will then be given to Dr. Li to determine the necessary zener diodes and driver op amps to create the control circuit. Once the control circuit design is completed it will be sent to the GT Electric to fabricate so that it can be installed into the exhibit. As the parts arrive from the various vendors, construction of the exhibit will commence.

The first part of building the exhibit will be the construction of the 8020 frame. Once the 8020 frame is constructed, the carpenter can take the necessary measurements to fabricate the necessary wooden panels that will be attached to the exhibit. While the carpenter is fabricating the wood panels, the support rods and support blocks will be constructed for the wind turbines. The pulley system for the wind turbines will also be constructed and installed onto the 8020 frame while the wooden panels are being made. After the wooden panels are completed, they will be attached to the frame and outer casing of the exhibit will be completed.

Once the outer casing of the exhibit is completed the interior of the exhibit can be installed. First the wind turbines will be installed into the casing and attached to the pulley system. The next components to be installed will be the fan and the light towers and then the electrician will come and do the wiring. The electrician will install the start button, kill switch, control dial for the fan, control circuit, and the anemometer. After the electrician is done installing the electrical components, the exhibit will be completed and final testing can begin. The final testing will test the completed exhibit to make sure everything is in working order before the unveiling of the exhibit at the museum. A schedule of this general outline is shown in Appendix B.

5.0 Conclusion

The future work for the spring entails the actual construction of the wind energy exhibit. The main components of the exhibit will be the fan, nozzle, honeycomb, wind turbines, generator, and power display. In addition to these components, the exhibit also includes the plastic casing, wooden laminate, aluminum frame, anemometer, varying wind speed dial, start button and kill switch. The various components have all undergone extensive research and cost analysis in order to make the most accurate and effective wind energy exhibit possible. The fan, frame, plastic casing, anemometer, kill switch, speed dial, and start button are all pre-fabricated and will be purchased from each components respective vendor. Although the frame will be pre-fabricated, actual assembly of the frame will be done in house. The wind turbines, wooden laminate panels, and electrical wiring will be professionally fabricated specifically for this project. Various professionals throughout the community will aid in the production and construction of these materials, so this in turn helps to reduce on the cost and uncertainty of shipping the materials. The project was first generated on engineering drawings, and these drawings will aide in construction by giving the vendors and craftsmen the correct dimensions and orientations of the components that are being purchased.

After a complete cost analysis of all of the components, the entire exhibit will cost approximately $4822.55. Because the anticipated budget is $5000, these projected expenses leave a margin for error and uncertainty when constructing the exhibit. The entire design and each component has been approved by the customer, so with future supervision and cooperation, the Mary Brogan Museum of Arts and Sciences and the FAMU/FSU student engineering group will be able to construct a wind energy exhibit that is effective, educational, and an overall improvement to the entire energy exhibit with which this exhibit will be associated.

Appendix A – Budget Analysis

Table A1: Cost Breakdown for Wind Generation

Part Description	Part Number	Manufacturer	Distributor	Cost
Variable Speed Fan	Qmark LDC20	Qmark	HeatersPlus.com	$215.25
Shipping	N/A	N/A	N/A	50.00
Labor	N/A	COE Machine Shop	N/A	150.00
			Total	**$415.25**

Table A2: Cost Breakdown for Power Generation

Part Description	Part Number	Manufacturer	Distributor	Cost
Vertical Axis Turbine				
DC Motor	CRE-RE280	Aristo-Craft	Hobby Town USA	$ 5.00
Cup Rotor	Vortex Pro 1200	InSpeed.com	InSpeed.com	0.00
Base structure of Turbine				13.82
Horizontal Axis Turbine				
DC Motor	CRE-RE280	Aristo-Craft	Hobby Town USA	15.00
Propeller	11 x 7	Top Flite	Hobby Town USA	5.00
Base structure of Turbine				13.82
Labor	N/A	COE Machine Shop	N/A	300.00
			Total	**$352.64**

Table A3: Cost Breakdown for Exhibit Casing

Description	Part Number	Quantity	Distributor	Cost Per Item	Total
T-slotted extrusion	1515	27	8020	$17.05	$ 460.32
Black PVC Coated Wire Mesh	2474	2	8020	$18.44	36.88
Clear Polycarbonate	2609	3	8020	$98.31	294.93
Deluxe Leveling Foot	2190	4	8020	$12.25	49.00
Hole Inside Corner Bracket	4301	36	8020	$4.05	145.80
90° Degree Pivot Nub	4388	4	8020	$4.55	18.20
Straight Arm	4396	8	8020	$5.25	42.00
Economy T-Nut	3320	168	8020	$0.57	95.76
Flanged BHSCS	3330	8	8020	$0.34	2.72
Parts Cut to Length/ Labor	7010	36	8020	$3.55	127.95
Wood	N/A	1	Wood Concepts	$226.44	226.44
				Total	**$1,500.00**

Table A3: Cost Breakdown for Parts and Costs from the 8020 Company

Part Number	***Quantity***	***Length (in)***	***Description***	***Cost Per Item***	***Total***
1515	5	63.00	T-slotted extrusion	$31.50	$157.50
1515	2	60.00	T-slotted extrusion	$30.00	$60.00
1515	2	36.00	T-slotted extrusion	$18.00	$36.00
1515	2	28.50	T-slotted extrusion	$14.25	$28.50
1515	2	27.00	T-slotted extrusion	$13.50	$27.00
1515	10	27.84	T-slotted extrusion	$12.00	$120.00
1515	2	20.938	T-slotted extrusion	$10.47	$20.94
1515	2	10.375	T-slotted extrusion	$5.19	$10.38
2474	2	6.250 SQ ft	Black PVC Coated Wire Mesh	$18.44	$36.88
2609	3	13.750 SQ ft	Clear Polycarbonate	$98.31	$294.93
7010	27	N/A	Parts Cut to Length	$1.850	$49.95
7025	4	N/A	Tap Extrusion Ends	$2.25	$9.00
7095	2	N/A	Shearing Expanded Metal	$9.75	$19.50
7155	3	N/A	Cut Polycarbonate Panels	$16.50	$49.50
2190	4	N/A	Deluxe Leveling Foot	$12.25	$49.00
4301	36	N/A	Hole Inside Corner Bracket	$4.05	$145.80
4388	4	N/A	90° Degree Pivot Nub	$4.55	$18.20
4396	8	N/A	Straight Arm	$5.25	$42.00
3320	168	N/A	Economy T-Nut	$0.57	$95.76
3330	8	N/A	Flanged BHSCS	$0.34	$2.72
				Total	**$1,273.56**

Table A4: Cost Breakdown for Electronics

Part Description	Part Number	Manufacturer	Distributor	Price	Quantity	Cost
Power Meters						
Light Towers	8654T7	Undetermined	McMaster-Carr	$142.06	2	$ 284.12
Control Circuit	N/A	N/A		$150.00	2	300.00
Energy Conservation						
Kill Switch	6X154	Dayton	Grainger	$54.70	1	54.70
Start Button	N/A	Unknown	Supplied by Museum	$0.00	1	$0.00
Additional Wiring	N/A	N/A	Radio Shack	$50.00	1	50.00
Wind Speed						
Anemometer	407117	Extech	Test equipment depot	$459.00	1	459.00
AC adapter	156221	Extech	Test equipment depot	$25.00	1	25.00
Labor	N/A	GT Electric	N/A			300.00
Shipping						29.55
					Total	**$1,502.37**

Table A5: Cost Breakdown for the Pulley System

Part Description	Part number	Distributor	Unit price	Quantity	Cost
Connecting bracket	33125T44	McMaster-Carr	$1.98	2	$ 3.96
Pulley	6284K51	McMaster-Carr	$6.34	6	38.04
Round drive belt	1835T412	McMaster-Carr	$7.20	4	28.80
Supporting cross bar	89215K421	McMaster-Carr	$17.10	1	17.10
Shafts	9061K131	McMaster-Carr	$10.63	1	10.63
Labor					50.00
				Total	**$148.53**

Table A6: Cost Breakdown for the Flow Management System

Product Description	Part Number	Manufacturer	Distributor	Cost
Honeycomb	9635K73	Undetermined	McMaster-Carr	$ 44.55
Front Wire Mesh (see Casing)	2474	80/20	80/20	N/A
Back Wire Mesh (see Casing)	2474	80/20	80/20	N/A
Labor				50.00
Shipping				5.45
			Total	**$100.00**

Table A7: Budget Break Down Summary

Wind Generation	$ 415.25
Power Generation	352.64
Electrical Systems	1502.37
Flow Management	100.00
Pulley System	148.53
Exhibit Casing	1500.00
20% margin of error	803.76
Total Cost	**$4822.55**

Appendix B – Schedule

Resources and Assignments	Start	Finish
Contact With Dr. Shih	September 2, 2004	September 2, 2004
Team Building	September 6, 2004	September 6, 2004
Meeting With MOAS	September 9, 2004	September 9, 2004
Prepare Code of Conduct	September 6, 2004	September 9, 2004
Submit Code of Conduct	September 9, 2004	September 9, 2004
First Tuesday group meeting	September 14, 2004	September 14, 2004
Prepare Project Scope	September 14, 2004	September 16, 2004
Submit Project Scope	September 16, 2004	September 16, 2004
1st Fall Progress Presentation (Victor)	September 23, 2004	September 23, 2004
2nd Meeting with Dr. Shih	September 27, 2004	September 27, 2004
Begin work on Website (Suzanne)	September 28, 2004	September 28, 2004
Prepare Needs Assesment and Product Specifictaion	September 28, 2004	September 30, 2004
Submit Needs Assemsment and Product Specification	September 30, 2004	September 30, 2004
Prepare Project Schedule & Delgate of tasks	October 10, 2004	October 14, 2004
Submit project schedule	October 14, 2004	October 14, 2004
Tuesday group meeting	October 12, 2004	October 12, 2004
2nd Meeting with MOAS	October 7, 2004	October 7, 2004
3rd Meeting with Dr. Shih	October 8, 2004	October 8, 2004
Tuesday group meeting	October 12, 2004	October 12, 2004
First Sunday Group Meeting	October 10, 2004	October 10, 2004
Prepare Concept Generation and Selection	October 10, 2004	October 14, 2004
Submit concept generation and selection	October 10, 2004	October 10, 2004
Calculations	October 18, 2004	October 20, 2004
Budget Analysis	October 20, 2004	October 22, 2004
Pro/E Design	October 19, 2004	October 25, 2004
Tuesday Group meeting (Budget, Concept, Pro E, etc)	October 19, 2004	October 19, 2004
Staff Meeting	October 14, 2004	October 14, 2004
Prepare 2nd Fall Progress Presentation	October 17, 2004	October 21, 2004
Tuesday group Meeting	October 19, 2004	October 19, 2004
2nd Fall Progress Presentation (Nicholas)	October 21, 2004	October 21, 2004
Sunday group meeting	October 10, 2004	October 10, 2004
Tuesday Group meeting	October 12, 2004	October 12, 2004
Meeting with Keith Larson (Victor)	October 13, 2004	October 13, 2004
First trip to Hobbytown USA (Mike & Victor)	October 16, 2004	October 16, 2004
Sunday group meeting	October 17, 2004	October 17, 2004
Bi-weekly Meeting With MOAS	October 19, 2004	October 19, 2004
Tuesday group meeting	October 19, 2004	October 19, 2004
Sunday group meeting	October 24, 2004	October 24, 2004
Meeting with Dr Dave (Brad)	October 25, 2004	October 25, 2004
Bi-weekly meeting with MOAS	October 26, 2004	October 26, 2004
Trips to Grainger & Radioshack (Brad & Victor)	October 26, 2004	October 26, 2004
Tuesday Group meeting	October 26, 2004	October 26, 2004
Sunday group meeting	October 31, 2004	October 31, 2004
Tuesday group meeting	November 2, 2004	November 2, 2004

Prepare 3rd fall progress presentation	November 2, 2004	November 4, 2004
3rd Fall Progress Presentation (Mike)	November 4, 2004	November 4, 2004
1st trip to 4 Acre Electronics (Brad)	November 6, 2004	November 6, 2004
Individual member meetings w/ Dr Shih	November 8, 2004	November 12, 2004
Trip to Hobbytown	November 16, 2004	November 16, 2004
Tuesday Group meeting	November 16, 2004	November 16, 2004
Prepare 4th fall progress presentation	November 16, 2004	November 18, 2004
Fan and Motor testing (Victor)	November 16, 2004	November 17, 2004
Meeting with Keith Larson (Victor)	November 17, 2004	November 17, 2004
Meet with Dr Li (Brad)	November 18, 2004	November 18, 2004
4th Fall Progress presentation (Brad and Suzanne)	November 18, 2004	November 18, 2004
Prepare Fall Proposal & Presentation	November 16, 2004	December 1, 2004
2nd trip to 4 Acre Electronics (Brad)	November 18, 2004	November 18, 2004
Sunday group meeting (Proposal and Presentation)	November 21, 2004	November 21, 2004
Meet with Dr Li (Victor)	November 22, 2004	November 22, 2004
Fan and Motor Testing (Victor)	November 22, 2004	November 22, 2004
Tuesday Group Meeting (Proposal and Presentation)	November 23, 2004	November 23, 2004
Sunday group meeting (Proposal and Presentation)	November 28, 2004	November 28, 2004
Tuesday Group Meeting (Proposal and Presentation)	November 30, 2004	November 30, 2004
Fall Design Presentation	December 2, 2004	December 2, 2004
Submit Fall Design Report	December 2, 2004	December 2, 2004
Submit Spring Proposal to MOAS	December 3, 2004	December 3, 2004
Web site Up and Running (Suzanne)	December 3, 2004	December 3, 2004
Order Parts	December 6, 2004	December 10, 2004
End of Classes	December 10, 2004	December 10, 2004
Christmas Break	December 13, 2004	January 3, 2005
Resume Classes	January 5, 2005	January 5, 2005
First group meeting for the year	January 5, 2005	January 5, 2005
Prepare restated project scope and presentation	January 5, 2005	January 6, 2005
Submit restated project scope	January 6, 2005	January 6, 2005
Project scope Presentation (Victor)	January 6, 2005	January 6, 2005
First meeting with MOAS for the year	January 11, 2005	January 11, 2005
Testing of wind turbines in wind tunnel	January 10, 2005	January 20, 2005
Tuesday Group Meeting	January 11, 2005	January 11, 2005
Prepare restatement of work and presentation	January 11, 2005	January 13, 2005
Submit restatement of work	January 13, 2005	January 13, 2005
Restated work presentation	January 13, 2005	January 13, 2005
Sunday group meeting	January 16, 2005	January 16, 2005
Prepare exhibit poster for museum	January 18, 2005	January 28, 2005
Tuesday Group Meeting	January 18, 2005	January 18, 2005
staff meeting	January 20, 2005	January 20, 2005
Sunday group meeting	January 23, 2005	January 23, 2005
Begin receiving parts	January 10, 2005	January 20, 2005
Design of electrical system with Dr Li	January 24, 2005	February 4, 2005
Tuesday group meeting	January 25, 2005	January 25, 2005
Prepare 1st spring progress presentation	January 25, 2005	January 27, 2005
1st Fall Progress Presentation (Nicholas)	January 27, 2005	January 27, 2005
Submit exhibit poster to museum	January 28, 2005	January 28, 2005

Sunday group meeting	January 30, 2005	January 30, 2005
Assembling 80/20 Casing	January 31, 2005	February 11, 2005
Tuesday group meeting	February 1, 2005	February 1, 2005
staff meeting	February 3, 2005	February 3, 2005
Consulting with Carpenter	February 14, 2005	February 14, 2005
Carpenter fabrication of wood panel etc	February 14, 2005	February 25, 2005
Construction of support blocks and rods for turbines	February 14, 2005	February 18, 2005
Constructing Pulley system	February 14, 2005	February 25, 2005
Tuesday group meeting	February 15, 2005	February 15, 2005
Staff meeting	February 17, 2005	February 17, 2005
Sunday group meeting	February 20, 2005	February 20, 2005
Tuesday group meeting	February 22, 2005	February 22, 2005
Prepare 2nd spring progress presentation	February 22, 2005	February 24, 2005
2nd Spring Progress presentation (Mike)	February 24, 2005	February 24, 2005
Sunday group meeting	February 27, 2005	February 27, 2005
Assembly of turbines with pulley system	February 28, 2005	March 1, 2005
Tuesday group meeting	March 1, 2005	March 1, 2005
Staff meeting	March 3, 2005	March 3, 2005
Wiring by G T Electric	March 2, 2005	March 15, 2005
Final project review	March 17, 2005	March 17, 2005
Final Testing	March 16, 2005	March 22, 2005
Operations manuals due	March 24, 2005	March 24, 2005
Walk through for open house presentation	March 31, 2005	March 31, 2005
Web Page due	March 31, 2005	March 31, 2005
open house	April 7, 2005	April 7, 2005