# RENEWABLE ENERGY EDUCATION IN ALBEMARLE COUNTY SCHOOLS

## High School Education

Global Sustainability, Fall 2011
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## ABSTRACT

Our team goals for this project were to work with Western Albemarle High School students to teach them about renewable energy sources, such as wind and solar. We were approached by the Virginia Center for Wind Energy to help increase the education of students about wind energy due to the turbine and solar energy being installed at Henley Middle School. Our main goal was to teach the students about renewable energy and to inspire them to learn more and make a push for increased implementation of these methods in the future. We also wanted to bring learning that would connect with the classroom and overlap with the Standards of Learning for the students.

We met with physics students over two days at Western Albemarle High School to teach them about renewable energy and the project at Henley. We used a wind turbine blade design activity in order to provide an interactive and thought-provoking activity. The activity also helped to grab their attention and get them invested in the rest of our course materials. Each group also had to explain their design to the class and why they thought it would produce the most energy. We did a solar panel demonstration to show how the seasons affect the energy that is transmitted by the sun. Finally, we ended the class with a PowerPoint presentation to give them some more information about wind and solar energy as well as discuss the project at Henley Middle School. We finished the class with questions and discussion about renewable energy.

We met with 144 students in two days to help introduce them to renewable energy. The students were very receptive and seemed to take a lot away from the activity and the presentation. The teacher was very happy with the activity as well, she saw many great things she could continue as well as how well the students reacted to the issues and learning process. She also saw many areas where she can relate future coursework back to our activity. We helped the students to become more interested in renewable energy and to learn more about some of the main reasons to push for these technologies in the future. We hope that we inspired some students to pursue career paths that relate to wind, solar, and other renewable energy technologies.

# INTRODUCTION

## Initial Meeting with Clients

The project was introduced through an initial meeting with Remy Luerssen from Virginia Center for Wind Energy and Lindsay Snoody from Albemarle County school system via Skype to review the background of the project and what has already been done. More importantly, we were able to learn their vision for the project, what they want us to accomplish, in what manner and during what time-frame.

## Project Definition

This project addresses education of Albemarle County students and parents about the wind turbine and solar panels that are being installed at Henley Middle School. The Middle School received a grant to install renewable energy at their school to help offset the carbon emissions from coal fired power plants. The goals are to help educate the students on the functions and working components of the turbines and solar panels, while ensuring they are meeting their instructional requirements. The overall goal is to bring more awareness of the renewable energy program, specifically wind, to the area. Also, it will help garner awareness about the harmful effects that are created by consuming fossil fuels. We are specifically going into Western Albemarle High School to instruct students. One of the major challenges is creating a curriculum that will be worthwhile and exciting for high school students. The instruction will be hands on so that they understand how the technology works and a lesson will educate them about the harmful effects of fossil fuels and the current alternative energy efforts.

Our community partners are the Albemarle County Schools as well as the Virginia Center for Wind Energy. They want to use the opportunity of installing the wind turbine and solar panels at Henley Middle School as a learning experience and to also encourage young minds to start thinking about the future of renewable energy. The overall project started last year as one group went into Henley Middle School to begin teaching students about wind turbines. The education of the students will help bring more attention to renewable energy as the students will spread their knowledge and inspire them to become leaders in renewable energy technology. The main stakeholders in the project are the students, Western Albemarle High School, Virginia Center for Wind Energy, and the sustainability program at U.Va. Though everyone shares a stake in this project as lowering global carbon emissions through renewable resources becomes more paramount as we move towards global climate change. Also, including more real life examples of up-and-coming technologies into science classes can help bring classroom learning alive. This will allow the students to be more prepared for and knowledgeable about the world, while still meeting their instructional requirements. In this way we are thinking globally about reducing carbon emissions as we switch to renewable energies, but are acting locally to inspire more young people to see how the world must move forward.

# INITIAL APPROACH

## Research

First, we researched wind turbines and solar panels. In order to effectively teach the students about these technologies, we needed to ensure that we had a foundation of knowledge ourselves. As they are highly popular, emerging technologies, information was readily available. Some of the most helpful sites for information and videos are listed in the references section at the end of the report.

As we delved into the project our first goal was to research ways in which we could challenge high school students while teaching them about renewable energy from solar panels and wind turbines. We researched the Internet to find activities and ensure that we were meeting instructional objectives. This gave us some ideas about possible activities and helped us to understand the technology of wind turbines and solar panels.

To ensure that the instruction the students would receive aligned with education requirements we referenced the Virginia Standards of Learning (SOL). We chose to concentrate on physics because it is the subject most closely related to the renewable energy technologies. These devices use the principle of the conservation of energy in order to turn solar and wind energy in electricity. Looking through the physics SOLs we found the following: "PH.4 The student will investigate and understand how applications of physics affect the world. Key concepts include a) examples from the real world; and b) exploration of the roles and contributions of science and technology." We found that this SOL left a lot of room to explore wind and solar renewable energies, since it includes the concept of conservation of energy as well as allowing the students to explore the contributions of science and technology. Also, it allows students to see how many of the principles they will study in class could help one day change the world. Since wind turbines operate using the concept of energy conservation the following SOL also applies, "PH.6 The student will investigate and understand that quantities including mass, energy, momentum, and charge are conserved. Key concepts include a) kinetic and potential energy; b) elastic and inelastic collisions; and c) electric power." Not adding to the curriculum but merely using wind energy to replace other real-world examples was an important provision from our community partners. With these two SOL being so closely connected to our project, it was easy to connect these renewable forms of energy with the physics curriculum.

Once we decided upon reaching out to physics classes, we started brainstorming activities that could bring about the information to the students in a meaningful and interactive way. As high school students, we could give them challenging ideas and describe more technically how the wind turbines and solar panels operate. We continued by looking for ideas of lesson plans and activities; however, many of these projects were a lower level than we wanted and they required a larger budget. We looked into some model turbine kits and assessed the costs in the event that we would have to purchase one for an activity we would like to do. Many good sources are included in the references with a quick overview of the items they provide.

We did some research on the school itself, Western Albemarle High School. We looked at their schedule to see how long classes were so we could have an idea of how long our lessons/interaction with the students could be. We looked up clubs that existed that we could also share resources with so that they could continue to spread news and ideas about renewable energy to their classmates. We found the school uses block scheduling with 85 minute classes on Tuesday-Friday while every class meets for 40 minutes on Mondays. The school also has a Green Club, which could be paramount in helping continue our mission of providing continued education and more renewable energy in the future. They could continue to instruct students even after we complete our portion of the project.

## Brainstorming

After doing some research we started to brainstorm many ideas that we thought would be useful to capture the student's attention while also ensuring that we cover items that are beneficial to learning. There are many activities that can be altered to fit the criteria to be accomplished, so we didn't throw things out prematurely. However, our activities are realistic in scope and goals. Below is a list of items that we came up with and a short explanation as to what each entails:

- Green Club Interaction – This activity will allow us to collaborate with Western Albemarle High School's Albemarle Green Club. Our goal is to provide the club with additional resources about renewable energy, specifically related to the future wind turbines and solar panels at Henley Middle School. Members of the Green Club are more likely to be interested in these topics, and our hope is that they will help to raise awareness about the renewable energy technologies and spread enthusiasm for the project. The resources that we could provide would be informational PowerPoint presentations, interactive project ideas, and technical and social information on renewable energy technologies, which they could then use to educate students that we would not be able to come in contact with. This could occur during lunch hours or through presentations they could give to other classes about the project at Henley Middle School. The excitement would lead more people to

attend the kick-off event, as students would ask their parents to take them to the opening ceremony.

- Workshops – Incorporating workshops will allow us to work directly with students in general science and physics classes to provide hands-on education and information on renewable energy. We will have an introductory presentation on renewable energies, and then break the students into three different groups. Every group will participate in each of the activities and spend approximately ten minutes at each station. The activities are as follows:

  · Wind Turbine Blades – We will instruct students in the process of building wind turbine blades, and allow them to produce their own models. We will provide the materials, such as cardboard and plastic. Students will be allowed to adjust the size, pitch, and number of blades to create the most efficient design. The blades will be tested on a model turbine, while a breeze will be produced by a fan. This would allow a competitive spirit to come about with the groups We will ask them what was good about their design and where they could improve, while providing insight where they lack knowledge and insight.

  · Social Issues – We will structure this station as a discussion about the social impacts of renewable energies. We will provide different questions to encourage the students to begin thinking about the impact of renewable energy globally, nationally, and locally. Possible topics include the impact of renewable technology in Charlottesville, the future without attention to renewable energy, and what individuals can do to encourage new energy paradigms, as well as the reasons some people do not want these measures near them.

  · Physics Problems – We will provide various problems related to physics and energy, so that students can get more exposure to realistic applications of the subjects they are learning in class. This could be given to students and possibly count as a homework grade or some form of extra credit. In class we would provide examples of questions that are similar to the take home portion. Also, we could include some of the social issues about how technology and science are changing the way people think and view electricity production.

- School-wide Assembly – This activity will allow us to reach a large body of students at once while educating them about the solar and wind energy measure being undertaken at Henley Middle School. This will allow us to have multiple grade levels and would be a presentation that could be supplemented by handouts. We could include time for questions and build in participation to engage the students, such as asking the students to come forward to answer questions or taking polls about whether they believe in global warming or not.

- Informational Resources - These would be handouts with information about wind turbines and solar panels that would include carbon reduction statistics and other figures to show how they can be used to harness much of the energy from earth using scientific principles. They would also include social issues such as permitting and NIMBYism (Not In My Backyard). They would be colorful to help grab student's attention. They would allow us to present information easily while not disrupting class time as they could be passed out at lunch time or during class changes in the hallways.

- Informational Booth - The booth could be set-up during lunch, which allows coverage of a large population of the school. It would no disrupt education time, and would allow those students that are most interested to get more time for conversation and questions. The booth could have resources to take away as well as videos/ pictures of wind farms and solar panel arrays. Also, the booth would have many facts presented about carbon reductions and the science behind the technologies.

## Evaluation Criteria

- Time Limit (40 or 85 minutes) - This will allow the option to be completed during class time or lunch. With the block scheduling that Western Albemarle uses, a longer lesson would need to be completed over two days. However, if the lesson is only 40 minutes, it will still allow the instructor to have some time before or after our lesson to include anything else that needs to be covered that day. It will also ensure that we could go in on a Monday as they have every class.
- Interactive and Hands-On - This goal allows the students to be more engaged with the concepts. As they sit through many lectures every day, it is important to get them involved so they enjoy the learning experience and take something away from the lesson. Also, hands-on activities allow students to come up with ideas of their own, thereby allowing them to learn more from the experience.
- Relationship to course goals - We will try to ensure that the lesson merges nicely with the curriculum and meets Virginia Standards of Learning (SOLs). We are focusing on the physics SOLs, specifically number four: "The student will investigate and understand how applications of physics affect the world. Key concepts include a) examples from the real world; and b) exploration of the roles and contributions of science and technology." We want to ensure that our presence in the classroom will not waste the teacher's or student's time. Ensuring we help meet the SOLs makes the project more sustainable and realistic for the teacher to reuse in the future.
- Relevance to maturity level - We want to ensure that student's are challenged to the proper level. Also, adjusting to their maturity level allows them to see some of the more complex issues and technical aspects of renewable energy production, while still being challenged and engaged. Making the lessons too simple will cause the students to lose interest and make it feel as if we are talking down to them.
- Low-cost - The project has a very low budget and did not allot money toward the education of the students. Therefore we need something low cost as we cannot afford a high expense activity and neither can our partners, the high school or the Virginia Center for Wind Energy. Also, using items that are readily available or recycled adds a layer of sustainability to the project.
- Teacher convenience - We do not want to burden teachers as they are already busy ensuring that they meet SOLs and other metrics. We need something that would allow them to ensure learning is still completed, while it did not require them to plan or condense too much material due to missed class time.

## Preliminary Plan

Workshops - The workshops could be about 10-12 minutes each with 3 workshops putting us under the 40 minute time limit we imposed. This extra time would allow us to answer any lingering questions and to test the blade designs made by the students. Also, by having the workshops it would be very hands on as students would be designing the blades. The social issues would also encourage students who are not as technical to participate, and get them engaged in some of the other issues outside of the design. We could accomplish this by breaking the students into the groups involved in a project such as the land owners, developers, neighbors who support and oppose action, and government entities. They could then uncover the social issues themselves, while making it more interactive. The workshops would present material that relates to Physics SOL number four as students would understand how physics was used to help the world through a real, local example. The cost of the workshops would be fairly cheap, as creating math handouts and a presentation/discussion on social issues will be low cost. The materials for the blades will be cheap as

they are materials that can be recycled from boxes and packaging. The turbine could cost money if we buy a kit, or we could see if the electrical engineering department may be able to assist us in building a scale turbine on which to attach blades. The workshops would be convenient for teachers as they would be allowed to watch the presentation and have little planning with us. Also, our physics worksheets could also be used as part of their homework for the day, meaning the teacher would not need to come up with homework either. The sheets would include some social issues as well, that way students would be covering everything they learned in class that day.

Informational Resources for Parents - This project is good on the front of not taking up precious class time and would allow parents to interact with their students. This makes it hard to ensure they cover the SOL we are trying to present. It would be age appropriate as would be dictated by the information included. The cost would be low as these would be paper handouts that could easily be printed. It would also be convenient for teachers, as they would have no class time disruptions. This would allow the students to get increased interaction with their parents, and help to spread awareness to adults in the community as well, which could lead to a push for height restrictions to be changed.

Green Club Interaction - This could fit easily with the time limit as we could speak with them during lunch time. It would definitely be interactive as the Green Club would take what we gave them as resources and could continue spreading ideas about renewable energy to new students through presentations and advertising information about the kick-off event. This could help create a large interest as students might get their parents to attend as well. It would be low cost as we would be providing them with the lessons and problems we presented in the science classes, such as a PowerPoint and links to informative websites. These items would be age appropriate and would allow students who are interested in green measures to share that with other students allowing them to gain experience in supporting a position they are adamant about. This would only involve allowing the green club's advisor to allow us to share some time with them. They meet during lunch time, so missing class or disrupting instruction would be kept to a minimum.

The above three activities were chosen because they fit the criteria well, and it will be easy to accomplish all three. The activities will provide a good working knowledge in the school and help reach out to more students and even the parents. The school wide assembly was not chosen because it would not be interactive, it would require a large loss of instructional time and require teachers to plan around the event. The information booth would not allow us to bring information to the students, but require them to already have an interest. Passing out informational handouts in the hallways during class change would not be helpful as many students would not look at it on their way to class and either throw it away or forget about the paper. However, passing out information the students can take to their parents after instructing them means they will be more interested in the topics and would have a higher success rate. We decided that students would respond best to larger amounts of interaction with use that would come from smaller groups and more hands on activities.

## PLANNING AND MODIFICATION

### Teacher Interaction

The initial contact we were given at the start of the was the ecology teacher at Western Albemarle High School, Mr. Gahring. He was given as a point of contact because he is involved with sustainability at the high school and is a science teacher. We contacted him to introduce ourselves, present our project definition and set up an initial meeting. Coming across as professional and enthusiastic in all communications about the project helped to ensure the teacher that the activity will be worthwhile and thoroughly planned. A sample initial e-mail is included in the Appendix. After exchanging e-mails we met him at the school for a preliminary meeting. We brought a copy of our conceptual design, which was a production of our brainstorming and activities we felt met the criteria we wanted to accomplish. After

meeting with him, we learned he was new to the sustainability role and not the primary ecology teacher. Therefore, he was unsure of how much help he could provide in getting us into the ecology classes. He proposed that we could offer a lecture during lunch that would count as extra credit for the students, as the entire school has a common one hour lunch session. He liked our ideas of interacting with the Green Club and trying to ensure that students got their parents involved. We also mentioned that we were hoping to visit physics classes. He agreed that the project overlaps well with physics and that he would present our project to the physics teacher, Carey Taylor. He also stated that the Monday or Tuesday before Thanksgiving would be the best days to visit the school as they are relatively low-key. We then got in contact with Ms. Taylor. It took a great deal of emailing back and forth about ideas, plans, expectations, class sizes, and scheduling in order to facilitate the final product. Almost all of the communication is done via e-mail as we are located twenty minutes apart, so face-to-face communication is difficult.

We ensured that all e-mails were professional in manner and give a quick overview of the project, while making sure to introduce yourselves. Attaching a larger file of ideas and the significance of the project will show teachers' the thought and care placed into the project. We felt they would be more receptive to a group that is organized and can express their contributions to the students. After all, it is the students that stand to gain the most from a project such as this.

## Adapting Ideas

After receiving our graded conceptual design from our Teaching Assistant and overall project leader, Sameer-Andrew Rayyan, we made some changes based on his input. We had originally planned to have the students engage in a discussion that focused on the social issues involved with using solar panels and wind turbines. However, Sameer suggested that we split them up into multiple groups so that they could work through the issues from a particular perspective, like a role-playing activity. This activity would be more engaging and allow the students to come up with and work through the issues themselves, thereby making the learning more challenging and meaningful. Also, Sameer made suggestions as to how the Green Club could interact with the larger student body as well as the engagement level of some our activities. He also suggested that we truly challenge these students as they are in high school and science classes contain many bright young minds. Keeping them challenged will ensure they stay interested in the project and take the most away from our time at the school. Sameer also expressed worry about the physics problems not covering enough of the issues involved so we decided to incorporate a social aspect to the worksheets.

After meeting with Mr. Gahring, he was unsure of our ability to interact with his ecology classes because they do not cover renewable energy until May. Since we would be executing the activities around November, he suggested that we do a presentation during the school's lunch period. Attendance to this would be extra credit, so students would have the option of attending; this way it would attract students who were interested in renewable energy, though some would still be there only for the extra credit. This would allow us to both reach out to students, describe the project at Henley Middle School and provide background information about the technology of wind turbines and solar panels. As this would probably be open to both physics and ecology classes we would also have to ensure that it wasn't just limited to these students.

We also updated our contact at the Virginia Center for Wind Energy, Remy Luerssen, about the status of our project. She suggested that the social issues would not really fit well into the physics classes but seemed excited about the idea of having students play out the various roles of a large project. She told us of a similar activity to role-playing that she heard was a great success, so she was very happy to see us incorporate this into the curriculum. Also, she has a model turbine made from PVC which we can use to test the students' blade designs on. This helped to keep costs down and allow us to complete one of our more hands on activities, the turbine blade design. Remy brought the actual turbine to Henley Middle School, where we could encourage students to stop by and look at it before it goes up in the larger monopole outside the school. Remy updated us in on the construction progress, especially letting us know that the

foundation for the monopole was poured, but still has to cure. This means everything is on schedule for the kick-off event in December.

After taking all these suggestions into account we decided that an extra credit presentation during lunch from multiple science classes would be beneficial. This would be an overview of the project underway at Henley Middle School as well as information about the how wind turbines and solar panels work. This presentation would be about 20 minutes at the direction of Mr. Gahring. We could ask the students questions and get their responses as well as allowing time for them to ask any questions they might have. This will be the best we can do for allowing interaction in this activity. This kind of presentation is not our first choice for educating the students about the project, but the teacher's know the students and how they respond better than us.

If teaching in the physics classrooms we will try to focus on technical objectives such as the inner workings of the turbines and solar panels as well as the fact that they represent the conservation of energy. The wind turbine activity would be very useful in this setting as designing blades also incorporate physics principles such as wind drag and creating low pressures behind them. We will also try to ensure we show how calculations for the energy produced from turbines can be determined, which is done with fluid mechanics. We will speak with Ms. Taylor about whether she thinks it would be beneficial to try and include social aspects, but expect her to want the focus to be technical physics principles and equations used to analyze these devices. However, if we work with the ecology classes we will focus more on the social aspects involved. Here we could easily implement our activity about the development of turbines and solar panels and the many groups involved with such a large project. We could also present a few of the cases and locations where turbines are implemented or proposed to be constructed in the future. This would allow us to show students the wind and solar rich areas of the United States, as well as showing them where the majority of the populations lives. We hope to be able to visit both classes as we could then talk about the technical and social issues, giving a large overview of renewable energy forms.

## Timeline

Below is a timeline of the activities completed in this project.

- Beginning of September - Understand Background of Project
    - Meet with community partners
    - Create project definition
- End of September - Create Conceptual Design
    - Do introductory research about wind and solar energy
    - Brainstorm ideas for high school education
    - Create metrics to evaluate ideas
    - Produce Intended Activities
- Middle of October – Get in contact with Western Albemarle teachers
    - Coordinate with class schedules
    - Choose a time to work in the classrooms
- End of October – Meet with teachers and create educational materials
    - Research renewable energy technologies
    - Outline lesson PowerPoint
    - Create information sheet for wind turbines
    - Create information sheet for solar panels
    - Create instructions for wind turbine activity
- Beginning of November – Refine educational materials
    - Finish lesson PowerPoint
    - Refine model wind turbine workshop
- Late November – Meet with students in class

    - Conduct each of the workshops with science classes
    - Get the students excited about the Kick-Off Event Dec. 16th
- Beginning of December
    - Send Thank-You email to teacher
    - Reflect on the project and the accomplishments of our goals
    - Follow up with community partners to discuss strengths and weaknesses of educational efforts

### Division of Activities

The division of activities should allow all participants to be involved in the project, while also playing to the strong points of each of the students. It should also allow each participant to step outside their comfort zone to ensure that they are learning through the project as well. Even distribution of responsibility among the group should be considered as well to ensure that no one is carrying the group throughout the project.

- Research background information on wind turbines, solar panels, and general renewable energy technologies – ALL
- Contact Western Albemarle Teachers – Kelsey
- Contact Community Partners – Kelsey
- Contact Green Club – Shayna
- Create materials about wind turbines – John
- Create materials about solar panels – John
- Pick up model materials – John
- Create introductory PowerPoint – Shayna/Devon
- Create resources sheet – Devon
- Lead workshops - ALL

## IMPLEMENTATION

### Finalizing Plan

As we developed the final plan, we concluded that it would be best to just attend the physics classes. We decided that the wind turbine blade design activity, a solar panel demonstration and a PowerPoint would be the most useful and all encompassing approach. We spoke with our community partner Remy, and she suggested we teach during the longer block scheduled classes. This way we would have enough time to attempt the design activity, which is estimated of taking at least 45 minutes. With that in mind, we decided that we would attend the classes over two days, for the 85 minute time slots. We sent a contact email to the high school's Green Club advisor in hopes of meeting with them while we were in the school; however, we received no response. Plans for the blade design activity and the solar panel demonstration were easily obtained from Remy. We also had easy access to the wind turbine kits and the solar panel kits since the local middle school, Henley, had them. After looking through the given lesson plans and kits, we modified them slightly to better suit our needs and goals. Remy also suggested that it might be more beneficial to do the activity first to engage the students and then follow up with the PowerPoint to review what they had learned from the activity. Therefore, we edited the PowerPoint so that it would be used a wrap-up, instead of the introduction. We also edited our informational handouts to ensure that they were suitable to the students. The handouts and PowerPoint were sent to Ms. Taylor the night before we were in the classroom so that she could post them online for all of her students to reference after our presentation.

### In the Classroom

The day of the activity we arrived early enough to set up the wind turbine and grab the last minute items we needed such as scissors and tape. The classroom experience began by introducing ourselves and giving a

little background knowledge on why we were there. We proceeded to explain to the students that they were going to have the opportunity to build wind turbines, and to help them out the power equation was provided (P=1/2*rho*A*V^3). We split the class up into teams that consisted of 4-5 students, and the teacher proposed that the winning team receive three bonus points on their next test. We then supplied the students with lightweight cardboard, plastic, and balsa wood. Dowel rods, tape, and the hub were handed out as well and the students were 30 minutes to complete their blade design. They were able to control the number, size, shape, and pitch of the blades. Worksheets were handed out at the beginning of the activity for the students to fill out about certain specifications for their design, like pitch and dimensions of the blades, and also for record keeping on the voltage measured. After the 30 minute elapsed, each team was able to test their blades on the turbine. A box fan was held directly in front of the blades and turned on high and the voltage produced was recorded. The students also had a chance to discuss their design considerations, like why they chose a certain number of blades or the shape. The team's blade design that produced the highest voltage was declared a winner. In the event of a tie, the designs were weighed and the lightest was declared the overall winner; students were notified of this rule before starting. We also incorporated a solar activity that followed the design challenge. In using a light bulb and a solar panel connected to a multi-meter we were able to show the students how the changing seasons create less voltage; this is due to the increasing distance from the sun as we move from summer to winter. In concluding these classroom activities we ended the classes with a PowerPoint about renewable energy, specifically solar and wind energy. The project at Henley was also discussed to help raise awareness and interest. Any questions were answered at the end of the PowerPoint, as well as providing our group email if they had any questions later on. We also incorporated questions during the PowerPoint to encourage participation and discussion.

## ASSESSMENT

### Follow-Up and Reflection

After the project we followed up with Ms. Taylor to hear about the student's responses, which was overwhelmingly positive. They really enjoyed the hands on nature of the design activity and said they also learned a lot about wind and solar energy. The students also were very interested in the renewable energy and had many good questions about other sources of energy and also the cost of installing these methods. Ms. Taylor had a positive reaction to the activity, and saw many things she would like to continue to do in her classroom. Using this feedback we determined that the major goals of our project were successful as we educated the students in a manner that helped them to be excited about renewable energy. Also, having the teacher say she would like to continue the activity meant that she thought a great deal about our project and that it has a place that could easily fit into here curriculum. Ms. Taylor also suggested allowing the students time to adjust one thing on their blade design, such as length, pitch, or number of blades, and then retest to gain additional knowledge and understanding. Ensuring that there is sufficient material for the blade design is another aspect to consider before beginning because some students may want to create large blades or redo their design and we started to run short on certain materials. However, keeping yourself open to any changes that need to be made is critical with a project like this.

The project also helped to get the students interested in renewable energy, and many of them already had a good awareness of these power types. The project also served to notify them about the wind turbine and solar energy methods that Henley Middle School is employing and officially opening December 16th. We are going to send an e-mail to encourage the students to attend the kick-off event at Henley Middle School, and hope that some of the students can attend. The event in the classroom went well, and had no major issues. If we were to do the project again, we might give the students a little more time to design their turbine blades as many of them seemed pressed for time at the end. We achieved the majors goals we set out to cover, however we did not get to meet with the ecology classes or really delve into the social aspects of renewable energy. In the future, it would be beneficial to meet with other classes and to discuss some of these issues.

Unfortunately, we were unable to get in contact with the Green Club, so we did not interact with them. However, we reached a large group of students and those who were most qualified to learn about the physics of renewable energy, so lack of interaction with the Green Club was not a major issue.

## Future Work

The remaining work for the project is to continue to educate and increase the awareness about renewable energy. As climate change continues to be a large problem for the world increasing awareness with younger people will be paramount, as they will be the ones making difficult decisions in the coming years. In this way working with the students yearly would allow a large group of students to be introduced to these renewable methods. Also, the teacher, Ms. Taylor, saw the activity and was thinking of incorporating it into her classroom in the coming years. This will allow all here students to learn about renewable energy and also allow Ms. Taylor to structure it into the curriculum where it most connects with what the students are learning. Another item about renewable energy that would be beneficial to students is to learn about the social issues that revolve around these projects. The only remaining thing left to do is to notify Ms. Taylor and her students of the kick-off event on December 16th with the hope that some of them can attend.

## Helpful Hints

Best practices and helpful hints for future activity implementers:

- Start interaction with the teacher early, as coordinating schedules can be difficult.
- Talk to a teacher that aligns with the goals you want to accomplish, such as physics teachers for more technical instruction or ecology to approach the social issues involved in development of these resources
- Talk earlier with your other contacts as they may have many suggestions or know of activities similar to those that you want to accomplish
- Stay in contact with the community partner, as they have useful knowledge and hints to help you along the way.
- For future activities, other materials can be substituted for the blade design challenge
- Our timeline is longer than necessary due to class structure

# APPENDIX

## Materials Created

### Professional Email

Introduction Email
Dear Mr. Gahring,

We hope you have had a wonderful start to the school year. We would like to introduce ourselves as a group of 3rd and 4th year students from the University of Virginia, with backgrounds in chemical and civil engineering, urban and environmental planning, history, and share an interest in sustainability. This semester we are taking part in the Global Sustainability course with Professor Crisman and are working on a sustainability education project with Albemarle County Schools and the Virginia Center for Wind Energy. We are very excited to collaborate with you and your students at Western Albemarle High School and with your support hope to raise awareness about alternative energy sources.

We have attached a project definition that outlines our objectives and hopes for this project. Our goal is to visit science classes and instruct students in the social aspects and technical concepts associated with the wind turbine and solar panels that will be installed at Henley Middle School. At your convenience we would like to meet with you to discuss the overall project in more depth and receive your feedback on the attached

definition.

Please let us know your availability. You can reach the entire group by emailing energyedu_high@virginia.edu. We look forward to hearing from you!

Thank you,
Kelsey Dickman
Shayna Stern
Devon Thompson
John Ward

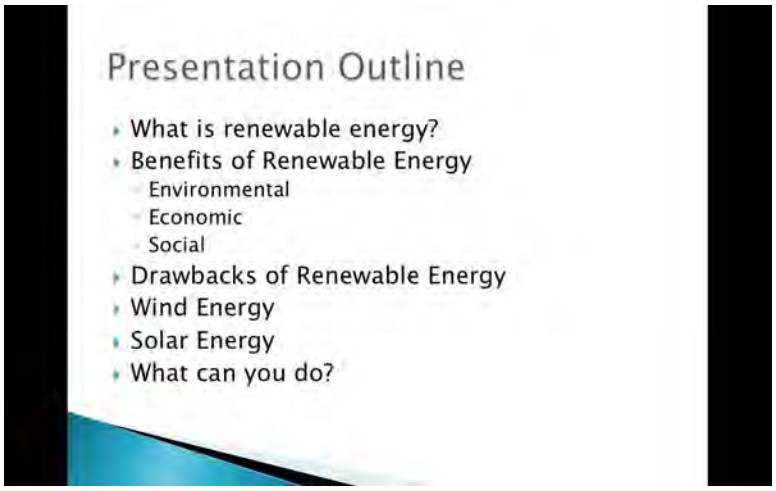
Conclusion/Thank You Email

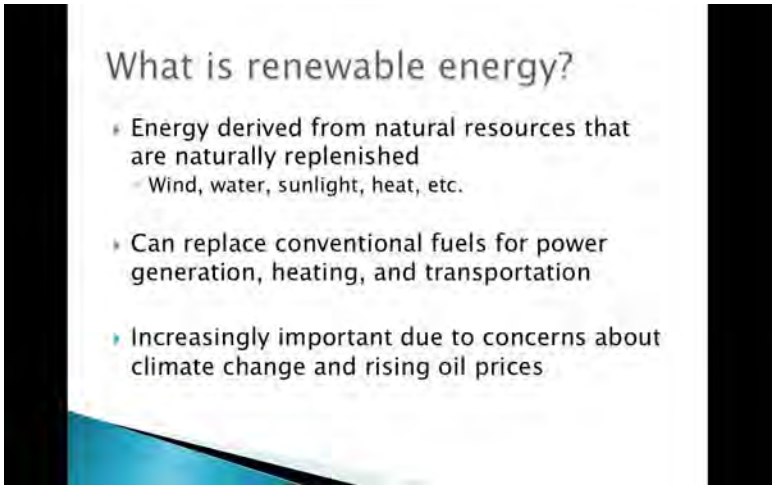
Ms. Taylor,

We wanted to sincerely thank you for letting us work with your classes for the past two days. It was a truly enriching and learning experience for all of us. It was a pleasure getting to know you and work with you. Thank you for being so helpful and flexible in working with us. Your patience, guidance, and assistance as we made continual adjustments to the project was greatly appreciated. We were happy to see that the students not only enjoyed the activity but really learned some things as well. We hope we were able to provide a lesson that you can build off of and reference as you begin to move into forces. If you or your students have any further questions from us, please do not hesitate to email us. We will pass along information about the kick-off event at Henley very soon. Thank you again and we hope you have a happy holidays!

Best,
Kelsey
John
Shayna
Devon

PowerPoint Presentation

## Environmental Benefits of Renewable Energy

- Avoids negative impacts of fossil fuels – air pollution, toxic waste, climate change
- Causes fewer direct land impacts – oil spills, mining, drilling
- Emits less carbon dioxide and nitrogen oxides

## Economic Benefits of Renewable Energy

- Causes fewer externalities
- Encourages technological innovation
- Allows industries to spend less overall to comply with government environmental regulations

## Social Benefits of Renewable Energy

- Improves human health
- Increases customer satisfaction by allowing companies to provide the products that consumers want
- Lessens dependence on foreign oil

## Drawbacks of Renewable Energy

- Expensive
- NIMBY – "Not in my back yard"
- Reliability and problems with quantity of supply

## Wind Energy

- Wind turbines harness wind airflow
- Long-term potential is five times current energy production

## Power Equation

$$\text{Power} = \frac{1}{2} \cdot \rho \cdot A \cdot V^3$$

ρ = Density of Air
A = Area
V = Velocity

- Wind speed is the most important factor
- As you move up from ground level, wind speed increases.

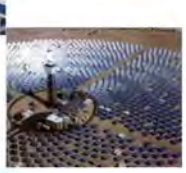
## Solar Energy

- Solar panels harness sun's power in the form of solar radiation
- United States' usage of solar energy is expected to increase over the next few years

## Types of Solar

- Photovoltaic

- Concentrated Solar



- Solar Thermal

## Wind and Solar?

- Why do you think wind and solar would be a good combination?

Consider Virginia and climate in your answers

## What can you do?

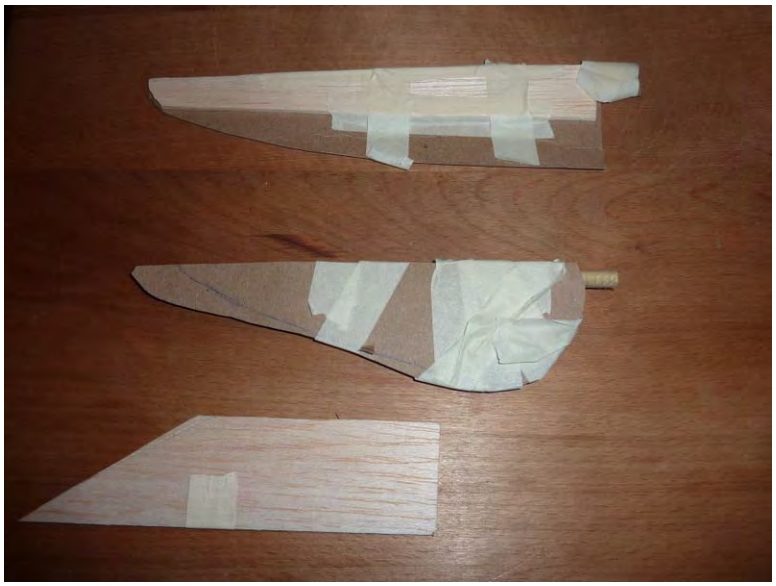
- Attend the Kick-Off Event on December 16th
- Visit the model wind turbine at Henley Middle School
- Advocate for renewable energy education and implementation in your community

## Questions and Discussion

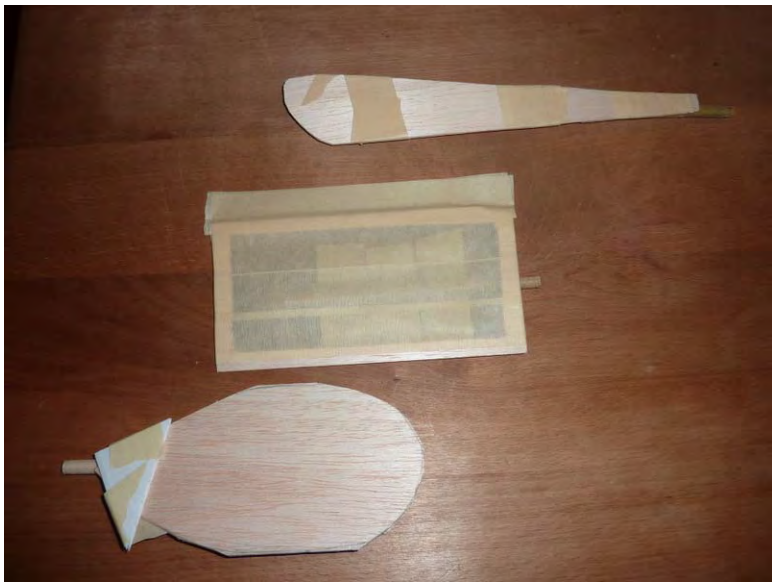
- Email us!

energyedu_high@virginia.edu

Images of Turbine Blades

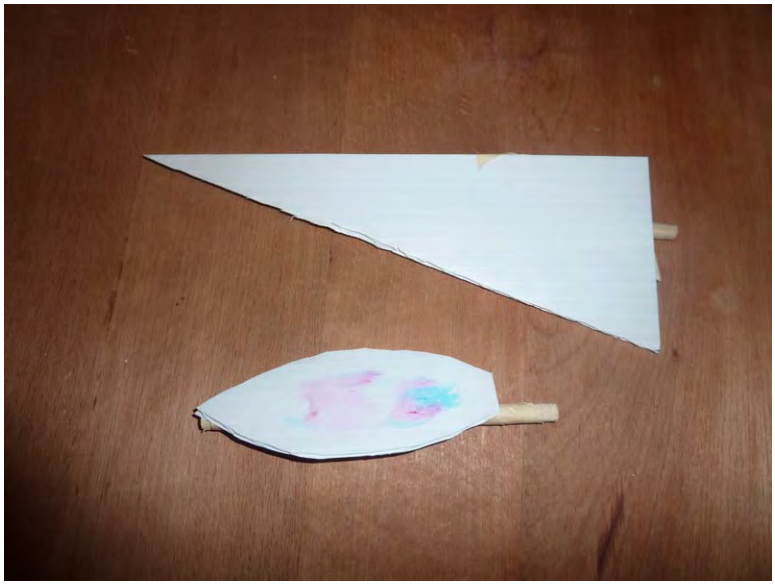


Sample Blades



Sample Blades

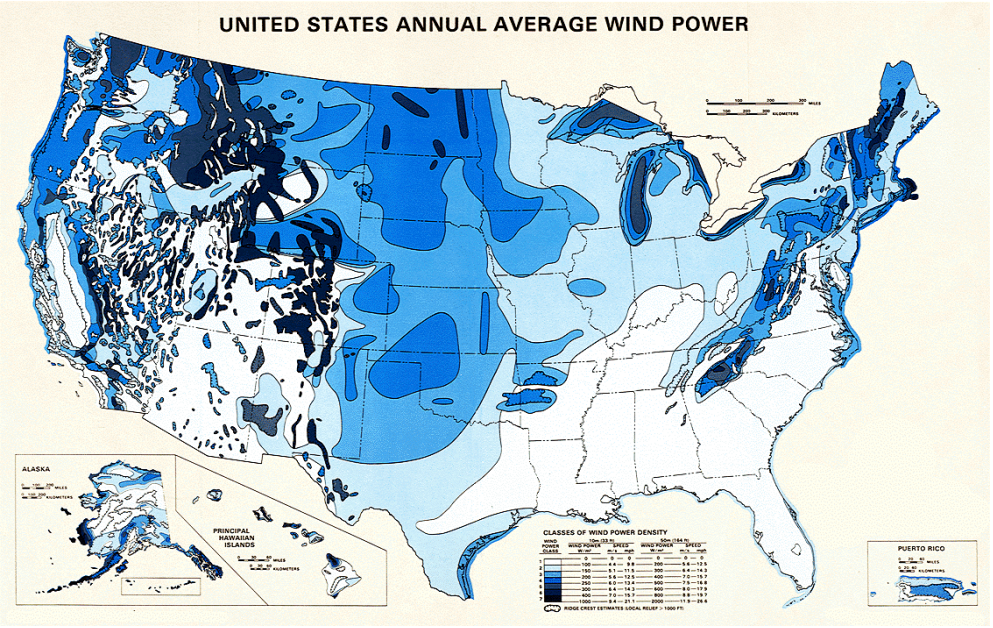
High Performance Blades



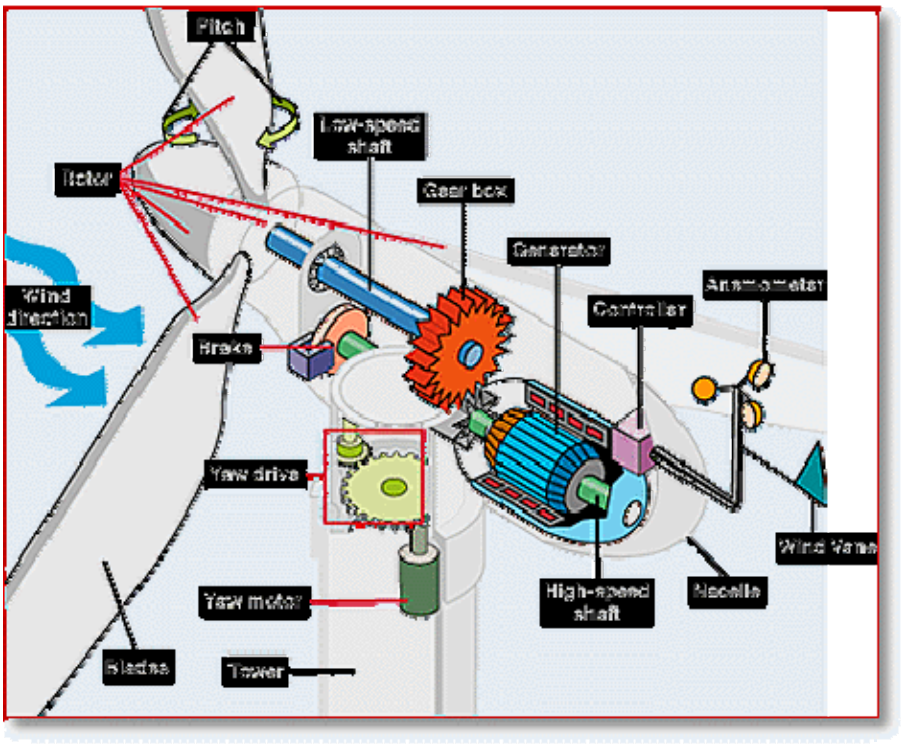
High Performance Blades

## Wind Energy in the United States

- Installed Wind Energy in United States is approximately 42, 432 Megawatts (MW)
- Wind Potential is in the plains where mountains do no inhibit the movement
- Approximately 10,500 Gigawatts of capacity on lower 48 states
- Offshore contains approximately 98,000 MW



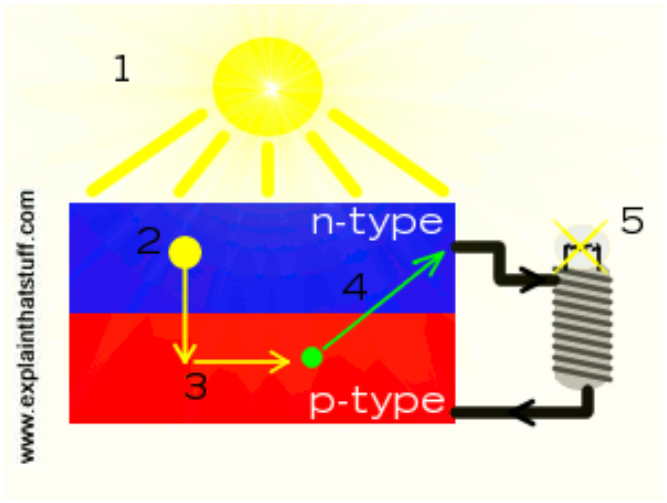

- Problem is that wind energy on land is far from the largest concentration of people
- Looking at placing wind turbines offshore
- Enough in shallow water areas to power 20-26% of American Homes
- Offshore areas closer to large cities along East and West Coasts



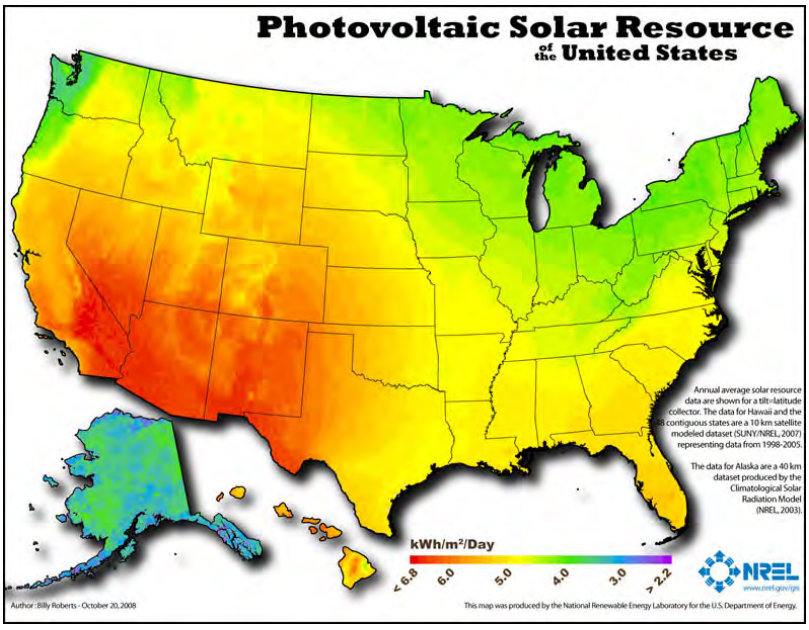

- Turbines take the potential energy of the wind and convert it into electrical energy
- As energy passes over the blades it spins the shaft, turning the generator
- The spinning of the generator creates electricity
- Wind speeds increase as you move upwards, which means taller turbines are more useful

# Solar Energy in the United States

- Majority of Solar Panels are Photovoltaic, but many other methods
- As solar energy is absorbed in a Photovoltaic cell, an electron is emitted as it jumps to a higher energy state
- The difference in n-type and p-type creates a change in electric field
- The change in the electric field inside the panel creates a current
- The current is then used as electricity to power homes or supply energy to the grid
- The southwest of the United States receives about 5 killowatt-hours of daily energy in every square yard of land




- Most photovoltaic cells are approximately 14% efficient
- Newer technologies promise efficiencies of upwards of 50%
- Solar panels that track the sun are much more efficient than standard panels




- Large amounts of solar potential across majority of United States
- Photovoltaic Cells can be installed on the roof of houses to help offset energy costs
- Current US usage of photovoltaic cells is 440 MW, but is expected to grow over the next few years

# RENEWABLE ENERGY

Information | Resources

- Renewable Energy
  - Derived from natural resources that can be replenished, like wind and sunlight
  - Can replace conventional fuels for power generation, heating, and transportation
  - Has benefits:
    - Environmental – no negative impacts from fossil fuels like climate change
    - Economic – allows industries to spend less overall to comply with government environmental regulations and green jobs market
    - Social benefits – improves human health, allow for products consumers want
  - Price and issues such as NIMBY – "Not in my back yard" are drawbacks
- Wind Energy
  - The energy in the wind turns the blades of the turbine around a rotor which is connected to the main shaft, this in turn spins a generator to create electricity
  - The northern area of the Midwest and West hold large potential for wind energy in the United States, as do areas off-shore
- Solar Energy
  - One of the more popular types are photovoltaic (pv) panels
  - Sunlight photons hit the solar panels - the cells within the panels consist of a positive and a negative layer that creates an electric field - and knock electrons loose creating an electrical current
  - Within the United States, the Southwest region has the most solar energy potential
- Additional Resources
  - http://www.eere.energy.gov/
  - http://energy.gov/
  - http://aeer.cisat.jmu.edu/
  - http://learn.kidwind.org/learn
  - http://awea.org/
  - http://need.org/
  - http://www.youtube.com/watch?v=tsZITSeQFR0&feature=relmfu
  - http://www.youtube.com/watch?v=0elhIcPVtKE&feature=relmfu

**Presentation Outline**

I. Introduction – “Hello!”
II. Wind Turbine Blade Design Challenge
    a. Directions (5-10 minutes)
        i. Talk about power equation
    b. Materials and Groups
        i. 5 groups – choose how many blades to make, shapes, length,
        ii. One piece of bulsa, plastic, cardboard
    c. Design and Build (30 minutes)
    d. Test (20 Minutes)
        i. Give suggestions
    e. Declare a winner
III. Solar Panel Demonstration (10 minutes)
    a. Seasonal
IV. PowerPoint Presentation

# Wind Turbine Blade Design Challenge Lesson Plan

LONG VERSION (~3 class periods)

1. Build Turbine – assemble model in class, discuss the major parts of a turbine and how it works
2. Demo turbine with sample blade designs – have students hypothesize which will be best and why, demo each, discuss why or why not results matched prediction
3. Review blade characteristics – have students make a list of important characteristics
4. Assign each group characteristic – hypothesis, experimental design, test (keep notebook), conclusions (report and presentation)
5. Groups use data from characteristic experiments to build ULTIMATE design – design, build, test and refine (keep notebook and write report/presentation) fill out spec sheets on final design
6. Final Challenge – test all designs. Winner gets prize!

SHORT VERSION (1 class period)

1. Introduction - discuss the major parts of a turbine and how it works
2. Demo turbine with sample blade designs – have students hypothesize which will be best and why, demo each, discuss why or why not results matched prediction
3. Groups build ULTIMATE design – design, build, test and refine, fill out spec sheets
4. Final Challenge – test all designs. Winner gets prize!

# Wind Turbine Blade Design Specifications

**Name:** _____ **Date:** _____

**Location:** _____

**Number of Blades:** _____ **Pitch of Blades:** _____ **Length of Blades:** _____

**Blade Material:** _____ **Distance from hub to blade:** _____

**Was weight added? If so, how much? Where?**

**Shape of Blades (feel free to draw this):**

**Other special design features:**

**Maximum Voltage output (with fan on HIGH):** _____

## References


Virginia SOL for Physics
http://www.doe.virginia.gov/testing/sol/standards_docs/science/courses/stds_physics.pdf

Sources for Ideas
http://learn.kidwind.org/ - contains models and curriculum

http://www.windpoweringamerica.gov/schools/- contains general information and areas of wind availability across the United States

http://www.alliantenergykids.com/EnergyandTheEnvironment/RenewableEnergy/022397- contains general information on turbines and other renewable sources, lower level explanantions

http://aeer.cisat.jmu.edu/- Has information about many wind activities, as well as links to many more resources

http://www.need.org/- Large amounts of curriculum and activity ideas, as well as PowerPoints, lectures, and presentations

Western Albemarle High School
http://schoolcenter.k12albemarle.org/education/school/school.php?sectionid=20

Sources for Wind Turbines
http://science.howstuffworks.com/environmental/green-science/wind-power.htm

http://www.alternative-energy-news.info/technology/wind-power/wind-turbines/

References for Solar Panels
http://www.youtube.com/watch?v=YCLHl0FoTp0

http://www.scientificamerican.com/article.cfm?id=how-does-solar-power-work