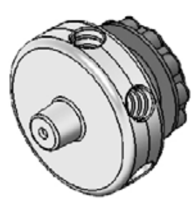
KidWind PROJECT

The KidWind Project is a team of teachers, students, engineers and practitioners exploring the science behind wind energy in classrooms around the US. Our goal is to introduce as many people as possible to the elegance of wind power through hands-on science activities which are challenging, engaging and teach basic science principles.

While improving science education is our main goal, we also aim to help schools become important resources for students, and the general public, to learn about and see wind energy in action.

We have three primary means of meeting our goals

Teacher Workshops — *Over the past 2 years we have held over 18 teacher workshops in more than 12 states. These are typically free to teachers and offer them time and materials to explore ideas for introducing wind energy in the classroom. Check the list below for a list of future workshops. If you are interested in having one in your neck of the woods, send us a note or give us a call. We are happy to go all over the US!*



Product & Curriculum Development — *In an effort to make materials more teacher friendly (cheaper, rugged & standards relevant), we have developed a wide variety of lessons and kits to help teachers introduce wind to their students. In the summer of 2007 we will unveil* ***Wind Energy Science: A Hands-On Guide for Teachers-*** *a 200 page guide with lessons and ideas. We are also developing some new kits & parts to make teaching easier.*

Web Resources— *http:// www.kidwind.org is an extension of the first two goals. Here you can find information on workshops and 100s of MB of videos, power point lectures and curriculum and construction PDFs. If we have written it, you can find it here for FREE.*

Future Workshops & Events:

Kidwind has held workshops all over the US. In the next few months we are working to offer events in the following states.

Indiana	***Texas***
Minnesota	***New York***
West Virginia	***North Dakota***
California	

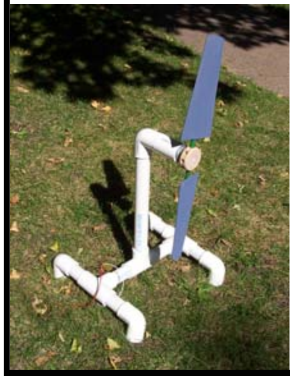
Locations of Previous Kidwind Workshops

For more information head to http://www.Kidwind.org
Check the WORKSHOP link to see more detailed schedules and apply online

Wind Turbine Kits

These are some of the kits and materials that we offer
More doodads can be found at http://www.kidwind.org

Basic PVC Turbine $40+



The most **affordable** and **robust** lab bench wind turbine on the market. If you want to start teaching about wind energy in the classroom we recommend you start here.

You can do some great blade experiments with a multimeter and if you make some really great blades you can get the motor w/ propeller to spin.

Yawing Basic PVC Turbine $55+

Designed to **YAW (*rotate*)** into the wind and is ideal for testing in outdoor wind conditions. Simulates a "real" small wind turbine quite accurately. Students can design and test different types of vanes and blades to see what type of design is the best!

Geared PVC Turbine $95+

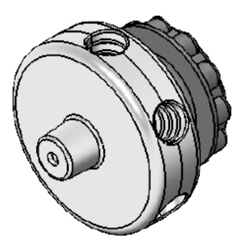
A rugged miniature wind turbine with a robust drive system that allows for much greater power production. This turbine will light LEDs, incandescent bulbs, small motors, buzzers and our favorite product—the water pump. You might even use this turbine to charge batteries or fill a capacitor!

Economy Geared Turbine $35+

An easy-to-assemble unit capable of powering a buzzer, LED, solar motor or pump. While this is a great low cost alternative, the gear box and hub are **not** as robust and if used with many students they may be prone to breakage. It is great for a student doing a science fair project or a device to demonstrate the power of wind.

Motor, Pumps & Meters

Water Pumps & Loads
Finally, a low cost water pump suitable for a wide range of hobby projects. Submersible. Works on 2-6V. We carry lots of load components!
$12.50



Turbine Hubs
The hub of the turbine is where you attach the blades. This is where the action is! We have spent the better part of two years developing our hubs! They rule!
$7.50+

Motors/Generators
We carry lots of motors that are great for making small wind turbines. They all have high power output at low RPM.
$5+

Wind Data Loggers/Hand-Helds
Interested in collecting and monitoring wind data? We have inexpensive gear to help you get a better bearing on the wind around you! From hand-helds to data loggers, we have what you need!
$65+

KidWind PROJECT

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Wind Energy Myths

Wind Powering America Fact Sheet Series

1 Wind energy is more expensive than conventional energy. Wind's variability does increase the day-to-day and minute-to-minute operating costs of a utility system because the wind variations do affect the operation of other plants. But investigations by utility engineers show these costs to be relatively small—less than about 2 mills/kilowatt-hour (kWh) at penetrations under 5% and possibly rising to 5 mills at 20% penetration. In fact, when the Colorado Public Service Commission issued a ruling in 2001 on the 161-megawatt (MW) wind project in Lamar, Colorado, the commission determined that wind energy provided the lowest cost of any new generation resource submitted to an Xcel Energy solicitation bidding process (except for one small hydro plant). The commission also noted that unlike the other generation resources considered, the Lamar project avoided the risk of future increased fuel prices.[1] And in a recent landmark study of wind integration into the New York State electric power system, a 10% addition of wind generation (3,300 MW of wind in a 34,000-MW system) actually projected a reduction in payments by electricity customers of $305 million in one year.[2]

Craig Cox, Interwest Energy Alliance/PIX11929

When the Colorado Public Service Commission issued a ruling in 2001 on the 161-MW wind project in Lamar, Colorado (pictured above), the commission determined that wind energy provided the lowest cost of any new generation resource submitted to an Xcel Energy solicitation bidding process (except for one small hydro plant).

2 Wind energy requires a production tax credit (PTC) to achieve these economics. True, but every energy source receives significant federal subsidies; it is disingenuous to expect wind energy to compete in the marketplace without the incentives enjoyed by established technologies.[3]

3 The production tax credit and accelerated depreciation are helpful only to big, out-of-state developers. The economic benefits aren't local, and rural electric cooperatives and municipal utilities can't receive the same benefits. It's true that only entities that pay federal taxes can use the tax credits to reduce their tax liability. But those tax credits result in lower wind energy costs for the benefit of all electricity customers. However, if local entities assume equity positions in wind plants, then they can receive the tax credit benefits. Whether or not the wind-plant equity is locally held, wind plants result in jobs for the local community and the need for local services—both during construction and during operation. Additionally, the added county and state taxes and the landowner lease payments directly benefit the local and state economies. And to the extent that debt financing comes from local sources, debt-service payments stay within the local community.

Also, in some cases farmers have joined together in a cooperative arrangement to build and own wind plants. In aggregate, their tax liability can be sufficient to make full use of the tax credits.[4]

4 Wind energy is unpredictable and must be "backed up" by conventional generation. No power plant is 100% reliable. During a power plant outage—whether a conventional plant or a wind plant—backup is provided by the entire interconnected utility system. The system operating strategy strives to make best use of all elements of the overall system, taking into account the operating characteristics of each generating unit and planning for contingencies such as plant or transmission line outages. The utility system is also designed to accommodate load fluctuations, which occur continuously. This feature also facilitates accommodation of wind plant output fluctuations. In

Denmark, Northern Germany, and parts of Spain, wind supplies 20% to 40% of electric loads without sacrificing reliability. When wind is added to a utility system, no new backup is required to maintain system reliability.

5 **If wind energy displaces energy from existing coal plants, then rates will go up.** Rates for electricity from wind plants being installed today are comparable to wholesale electric power prices of 2.5¢ to 3.5¢/kWh. The incremental cost of wind power, if any, will be negligible when distributed among all customers. A number of studies have examined the rate impacts of wind and have considered the costs of various renewable portfolio standard percentages from 5% to 10%, and average residential bill impacts are predicted to range from a savings to a premium of 25¢/month. In fact, some studies predict the accompanying decrease in demand for conventional fuels will reduce fuel prices enough to fully compensate for slightly higher costs for renewables. In the New York study mentioned above, wind displaced energy from both coal and natural gas plants. Rates decreased, and harmful emissions from the coal and gas plants were reduced as well.[5]

6 **New natural gas power plants provide cheaper energy than wind plants.** This is not likely with today's rising gas prices. At $3/MBTU, the fuel cost alone is 2.5¢ to 3¢/kWh, and capital and O&M costs add a similar amount. Today, gas prices have risen to more than $6/MBTU, yielding a fuel cost alone in the 5¢ to 6¢/kWh range. And gas prices have spiked to more than $10/MBTU in past years. Betting on low gas prices over the foreseeable future is highly risky, while energy costs from wind plants will be relatively stable over time. In a recent study, Lawrence Berkeley National Laboratory found that the natural gas "hedge value" of wind could be conservatively estimated to be 1/2 cent/kWh.[6,7]

7 **Large, utility-grade wind turbines can't be installed on the distribution grid without expensive upgrades and power-quality issues.** In situations with weak distribution grids (long lines with thin wires and few customers—maybe even single-phase), this can be true. However, in many cases wind generation can be connected to the distribution system in amounts up to about the rating of the nearest substation transformer. One study of a rural Midwestern county estimated that several tens of megawatts of turbines could be installed on the local distribution grid with a minimum of upgrade expense and minimal power-quality impacts. A number of single wind turbines and clusters of turbines are currently connected to the distribution system.[8]

8 **Small projects that might be suitable for co-ops or small municipal utilities are not economical.** Small projects generally have a higher cost per megawatt than larger wind plants, as would be expected. However, the incremental costs on customers' bills are likely to be small. The energy premium for a small project is unlikely to exceed 50%. If the project provides a small portion of the community's needs—say 2%—then the premium is reduced to about 1% if distributed among all customers. Some communities view this premium as a worthwhile investment to obtain local environmental benefits and experience with wind power.

9 **Wind turbines kill birds and thus have serious environmental impacts.** Bird kills have caused serious scientific concern at only one location in the United States: Altamont Pass in California, one of the first areas in the country to experience significant wind development. Over the past decade, the wind community has learned that wind farms and wildlife can and do coexist successfully. Wind energy development's overall impact on birds is extremely low (<1 of 30,000) compared to other human-related causes, such as buildings, communications towers, traffic, and house cats. Birds can fly into wind turbines, as they do with other tall structures. However, conventional fuels contribute to air and water pollution that can have far greater impact on wildlife and their habitat, as well as the environment and human health.

10 **Wind turbines are noisy.** Modern wind turbines produce very little noise. The turbine blades produce a whooshing sound as they encounter turbulence in the air, but this noise tends to be masked by the background noise of the blowing wind. An operating modern wind farm at a distance of 750 feet to 1000 feet is no more noisy than a kitchen refrigerator.

You can find more information on wind energy myths at www.eere.energy.gov/windandhydro/windpoweringamerica/pdfs/wpa/34600_misconceptions.pdf

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1 www.eere.energy.gov/windandhydro/windpoweringamerica/pdfs/xcel_wind_decision.pdf

2 www.nyserda.org/publications/wind_integration_report.pdf

3 For more on energy subsidies, visit www.earthtrack.net

4 Mark Bolinger, A Survey of State Support for Community Wind Power Development (http://eetd.lbl.gov/ea/EMS/cases/)

5 www.nyserda.org/publications/wind_integration_report.pdf

6 http://eetd.lbl.gov/ea/ems/reports/56756.pdf

7 Alan Greenspan, Federal Reserve Chairman, testimony at Senate committee hearing, July 10, 2003

8 Distributed Wind Power Assessment, National Wind Coordinating Committee, February 2001, available at www.nationalwind.org

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Myths and Facts About Wind Energy and Birds in the Altamont Pass

The wind industry is committed to, and has demonstrated, continual innovations leading to greater protection of the environment and wildlife. Modern wind turbines are far less harmful to birds and other wildlife than plate-glass windows, vehicles, pesticides and even house cats. And unlike fossil fuel power plants and other industrial processes, wind energy power plants do not emit any harmful emissions that threaten wildlife. Wind energy is clean energy, with no air pollution, no water pollution, no greenhouse gases, and no waste. The regional, national and global benefits of obtaining more of our electricity from the wind would be enormous.

Still, one of the first wind projects installed in the United States does impact local raptors. The Altamont Pass remains the only wind development area in the U.S. that experiences significant bird deaths (with "significant" defined as deaths of individuals of particular species that are numerous enough to possibly impact local populations of those species). While the industry recognizes that this situation represents a real problem, it is largely limited to this one area and is not widespread. Unfortunately, media coverage about Altamont often gives the impression that all wind power projects are harmful to birds, despite overwhelming evidence to the contrary. In part, this is due to myths about wind energy that are often repeated. Left unchallenged, these myths become accepted as true. The following information attempts to provide a more balanced view and debunk the most common myths about the Altamont Pass.

Myth: The raptor deaths seen in the Altamont Pass are indicative of a problem with all wind farms across the U.S.

Fact: Wind projects normally do not significantly impact birds. The Altamont Pass is unique in the U.S. Studies conducted at a dozen other wind projects across the country have found low impacts on birds. These impacts are dramatically lower than other human-related sources of mortality for birds (for example, cars, buildings, and communications towers),

Myth: The wind industry is simply studying the problems at the Altamont Pass and not taking any action.

Fact: Wind businesses have implemented many strategies to reduce bird impacts at the Altamont. Over the years, wind companies have painted blades, reduced rodent populations, added "perch guards" to prevent perching on turbine towers, and tested raptors' hearing, vision and avoidance capabilities to learn how to reduce bird impacts. One particularly successful strategy greatly reduced raptor electrocutions. Based on earlier research, project owners modified their equipment by insulating wires, covering some exposed electric components on poles, and relocating overhead powerlines to protect raptors. The industry is continuing today to test new measures to reduce bird kills, and to put into effect those that are helpful. One of the most promising of these is to replace older, smaller turbines with fewer new, large turbines, often referred to as "repowering".

Recently, project owners in the Altamont Pass announced an "aggressive adaptive" management plan to cut raptor mortality by 35%. Project owners will shut down some turbines in the winter, relocate or permanently remove about 100 of the highest risk turbines, remove some of the older non-operating infrastructure, and continue their commitment to repowering.

Myth: Strategies to reduce bird impacts in the Altamont Pass are relevant to other wind projects.

Fact: The Altamont Pass is unique in the U.S. No other wind project combines a similar topography, raptor population, and old turbine technologies. Bird mortality, especially raptor mortality, at other wind sites is already quite low, so most management techniques are not likely to be applicable elsewhere.

Myth: Raptors are killed in the Altamont Pass because the site is in a migratory flyway.

Fact: A wind project in a migratory flyway does not necessarily pose a threat to birds. The San Gorgonio wind resource area, about 400 miles south of the Altamont Pass, is in the same migratory flyway as the Altamont Pass. 25 million birds pass through San Gorgonio every year, but there is no significant raptor or bird mortality at that site. The presence of birds in an area does not connote risk, nor is building a wind plant in a migratory flyway a risk to birds. Raptors are most likely killed in Altamont Pass because it has a high year-round raptor population, an abundant prey base, and many smaller turbines that are sited relatively closely together.

Myth: The wind turbines in Altamont Pass are very dangerous to birds in general.

Fact: The annual number of birds killed by collisions with wind turbines in Altamont Pass is about one bird for every five turbines. This is probably less than the number killed each year by the average house cat. Altamont is important not because it is dangerous for birds in general, but because of the number of raptor kills. This is a key distinction, because the rate of raptor deaths at other wind sites is much lower.

Myth: Tens of thousands of birds have died because of the wind turbines in Altamont Pass.

Fact: This is actually true . . . when looking over 20 years (22,000 birds). But that number should be viewed in context. In the U.S. during that same time:

- 2 billion to 20 billion birds were killed in collisions with buildings;
- 1.2 billion to 1.6 billion in collisions with autos and trucks; and
- 100 million to 600 million in collisions with communications towers.

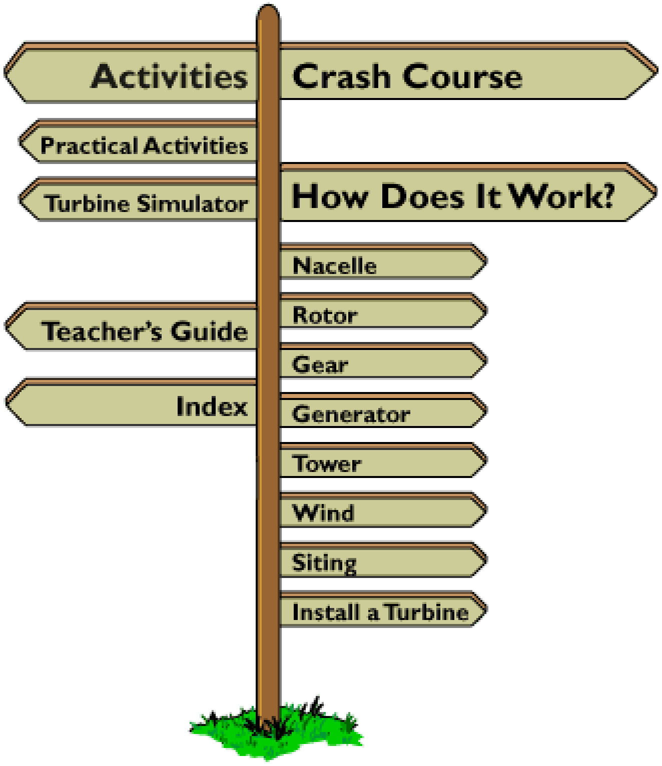
And the Altamont Pass wind project provided 100,000 California homes with clean, emissions-free electricity.

The implication that Altamont Pass is dangerous to birds in general is false.

Myth: The evidence of raptor deaths at Altamont Pass means that wind energy cannot coexist with birds and other wildlife and new wind development should therefore be halted.

Fact: Wind projects around the nation have been shown to pose minimal risks to birds and other wildlife. The wind energy industry has worked hard over the past decade to reduce the impact of wind turbines on wildlife such as birds and bats. Those efforts have largely been very successful - wind turbines and wildlife can and do coexist successfully.

The wind industry welcomes scrutiny of, and comparison with, all of the impacts of all sources of power generation. Many extensive studies of avian collisions at wind farms – most of them funded by project owners - have been carried out, a fact that contrasts greatly with the lack of a systematic effort to monitor bird deaths resulting from fuel mining/extraction, emissions, pollution and habitat loss associated with other energy sources. Any public or private research effort, regulatory effort, or legislative proposal designed to quantify the impact of power generation on birds, bats, and other wildlife should encompass all power sources, not just wind.



WIND WITH MILLER

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Search

The search engine requires an Internet connection to work

Produced by Bryan d'Emil, Morten Jacobsen, Martin Starcke Jensen, Søren Krohn, Kim Conrad Petersen and Katrine Sandstrøm. Translations by Alicia Andúgar, Hanne Jersild, Søren Krohn, Norbert Pöcksteiner, and Katrine Sandstrøm. Produced with support from the Danish Ministry of Education, the Danish Ministry of the Environment and Energy, and the Danish Wind Industry Association.

How to harness the wind ... Students compete for best turbine design

By Lorraine Cavener
Times-News correspondent
February, 25 2004

TWIN FALLS -- Anybody planning to build a wind turbine might want to consult with Nick Mindock or Daniel Moreno. Mindock and Moreno aren't engineers and don't have college degrees, but the two Twin Falls High School seniors won a model wind turbine design contest at the school Tuesday.

The contest, sponsored by the Magic Valley chapter of Idaho Society of Professional Engineers and supported by the College of Southern Idaho, Twin Falls High School and EHM Engineers Inc., was held in conjunction with National Engineering Week. "We chose this competition because wind energy is a big topic now," said Richard Hawkes, a member of the engineers group. "Idaho ranks 12th or higher as far as wind."

But Idaho has only three or four working wind generators, he said. "It's not been tapped," Hawkes said.

Thirteen teams of two to three students each competed using turbines with blades constructed from 5- by 8-inch note cards. Among other specifications, the turbines could have up to eight blades with a maximum diameter of 24 inches.

Orla Walsh and her twin brother, Brian, both seniors at Twin Falls High School, test their working model of a wind turbine Tuesday at the school.The competition was held by the Magic Valley chapter of the Idaho Society of Professional Engineers.
Photo by ASHLEY SMITH
The Times-News

The contest was judged by connecting the turbines to a computer and measuring voltage and current. Samples were taken every minute and data downloaded onto a spreadsheet.

Materials used to construct the turbine bases included PVC, copper pipe, wood dowels and cardboard. Spray paint was used on some of the blades.

"We wanted to jazz it up a bit," said Katie Harding, who along with partner Nicole Bulcher built a turbine fashioned after a pinwheel. "When we were little kids, we were fascinated with pinwheels," Harding said. "We took that idea to make blades. The blades have a flap to direct the air in."

The team did not spend any money, she said. "We used stuff we found around the house."

Virginia Reynolds and Josie Morse also based their turbine on a pinwheel. "When we moved it, we noticed air escaped through the back. So we put a plate behind it," Reynolds said. "It goes a lot faster that way."

Eric Nutsch and Jared Adams used a large paper funnel-like object behind their turbine, reasoning that a funnel would give more wind.

Inertia, torque, velocity, and RPM -- which the boys learned about in their physics class -- were all factored into the experience, Nutsch said."This is all physics," Adams said. "After a certain amount of torque -- you need enough to turn the motor -- after that you want as much RPM as possible," he said. The ratio of torque and RPM is dependent upon the shape and angle of the blades, Nutsch said.

"If you have a steep angle, it will give you more torque," he said. "A shallow angle gives higher RPM. You have to balance that. Higher RPM will give you more voltage."

While Adams and Nutsch had put a lot of thought into their turbine, Mindock and Moreno explained what it was that gave their machine the winning touch."It was the asymmetrical airfoil," Mindock said. "We maximized the lift while minimizing the drag." The blades were placed as far out as was allowable to get the maximum torque for the lift of each blade, he said.

Moreno said they debated about the shape of the blades. "We researched the shape of the blades," he said. A book on helicopter blades was used for research. "Different shapes produce different levels of lift and drag," Moreno said.

For their efforts, Moreno and Mindock won engineering calculators, compliments of the CSI math and engineering departments. Second-place winners Justin Doble, Chert Griffith and Greg Kahla won $60 Barnes and Noble gift certificates, and third-place winners Damond Isham and Eric MacMillan won $30 Barnes and Noble gift certificates. "Each design is different and has unique characteristics," Eberlein said."There are a number of different ways to accomplish this endeavor. Some ways are more reasonable."

What can these mini wind turbines power?

Kidwind model wind turbines are designed for use in science classes or as a hobby or science fair project. They are designed to produce a measurable amount of power so you can perform various blade design experiments. They are not specifically designed to light bulbs, spin motors and charge batteries but they can if you have a good fan and manage to design some efficient blades.

Our kits come with a variety of load components— **incandescent and LED light bulbs, small DC motors, fuel cells, water pumps and buzzers**. Some of our turbines can power all of these devices but some cannot. This is important to understand! When in doubt you should hook up your meter to make sure that you are making enough voltage to do the job you want the turbine to do.

How much power can KidWind turbines make?

The **Basic** and the **Yawing PVC turbines** use the same DC motor as a generator. As we have not "geared up" the drive train we can created limited amounts of power. With a nice box or room fan and well designed blades we can create, at maximum, about 1-1.5 volts at 50 –100mA. This is not really enough power to light a bulb, but will run the small DC motor with the propeller attached….and many people think that is cool!

If you need more power output then you have to gear up the drivetrain like we have done on the **Geared and Yawing Geared PVC Turbines**. Using the same fans these turbines will produce 3-4 volts at 100-500mA. This is plenty of power to run small lights, pumps, motors, buzzers etc. If you need more power these are the turbines to buy...but they might cost you some more because of that gearbox.

Why can't the Basic or Yawing Turbines make enough juice!?

Power output on a small DC motor is related to how **fast** we spin the drive shaft (RPM) and how **hard** we can turn it (torque). With regular fans and student made blades it hard to get enough RPM to make the little DC motors make enough power to run bulbs, etc.

You need RPM in the 1000s range to make voltage over 2 volts and if you did that on a direct drive system your blades would be moving very fast—so fast they would fly out!! On the geared systems we have a 7:1 gear box hooked to the small DC generator. So if the blades are moving at 200 RPM the driveshaft is traveling at 1400 RPM. While this requires more torque to overcome the friction in the gearbox it is something we can live with to make more power.

Fuel Cells

We developed the *Geared PVC Wind Turbine* with this application in mind. Using this wind turbine you can generate enough electricity to run a simple fuel cell electrolyzer (great ones can be purchased from Kidwind or at the Fuel Cell Store.com). The electrolyzer will create hydrogen and oxygen in a storage chamber which you can recombine to generate electricity. You could use this stored electricity to run the mini-water pump, a small DC motor or you can attach it to a fuel cell car and see how far it travels on two minutes of wind produced electricity. The ultimate in closed loop travel!

To run this device your turbine needs to produce at least **1.5 volts**. **More than 2.5 volts** for sustained periods can also damage your fuel cell so be careful.

Light Bulbs & LEDs

You can use a geared wind turbine to light small incandescent bulbs or LEDs. Lately we have been using small LEDs that are found in the *Forever Bright Christmas Light* set. LEDs require much less current then incandescent so they are easier for the turbine to light. You can also use other bulbs from flashlights just make sure they are designed for low voltage and low current. The *Basic PVC wind turbine* can power some LEDs with really great blades and high wind speeds.

LED lights need at **least 2.0 volts to light**, but very little amperage. LEDs also require that the electricity runs in the **"right" direction.** If your turbine is making more than 2 volts, but the LED is not lighting try reversing the turbine output wires that are connected to the LED bulb and try again.

Another cool experiment if your turbine can create more than 2 volts is to see many LEDs you can light versus regular Christmas bulb. LED require much less amperage so you can light a long line of these compared to the regular bulbs.

Small DC Motors

The power needs of most small DC motors is pretty minimal. Especially if you are using ones that have a low voltage rating. The *Geared PVC Wind Turbine* can easily power a variety of small DC motors and the *Basic and Yawing PVC Wind Turbines* can weakly power a few as well. Look for small DC motors in broken electrical toys. You can also find a wide variety of at Kelvin.com, Pitsco or All Electronics an online electronics store.

You need around .**6 - .8 volts** to power a small motor with propeller.

Low Voltage Water Pumps.

Kidwind has found a low voltage water pump that works well with our *Geared Wind Turbines*. You need to produce around **2.5 volts** for these pumps to run well and a good deal of torque as pumping water requires a great deal of energy. This is one of our favorite demonstrations using wind energy. We typically hook it up to some type of graduate cylinder and see whose turbine blades can pump the most amount of water in 1-2 minutes! **Do not try to run 6V or 12V aquarium pumps using our wind turbines it will not work!**

More Power: How to Improve Your Blades

Kidwind model wind turbines are designed for use in science classes or as a hobby or science fair project. They were created to allow students a cheap method to perform various blade design experiments quite quickly. They are not specifically designed to light bulbs, spin motors and charge batteries but they can if you have a good fan and manage to design some efficient blades. **Having efficient blades is a key part of making power from a wind turbine. Sloppy, poor made blades will never make enough energy to do anything. It takes time and thought to make good blades so get to it!!!**

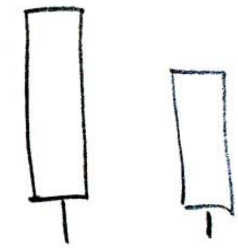
One thing you must always think about when making turbine blades is, **"Are my blades creating DRAG?"**. Sure your blades are probably catching the wind and helping to spin the hub and motor drive shaft, but are they slowing you down as well? Because if they are adding **DRAG** your who system will slow down and in most cases low RPM means less power output. The faster you go the more power you make!

Some tips on improving blades:

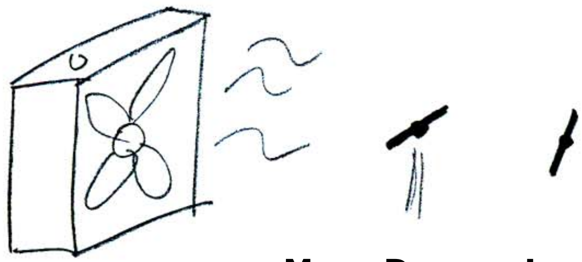
- **SHORTEN THE BLADES** - Many times students make very big, long blades thinking bigger is better. Well in the turbine business bigger is better, but students and teachers have a very hard time making long blades that add lots of drag and inefficiency. See what happens when you shorten them a few centimeters.
- **CHANGE THE PITCH** - Often students will set the angle of the blades to around 45° the first time they try to use the turbine. Try making the blades flatter towards the fan and see what happens. Pitch dramatically affects power output, play with it a bit and see what happens.
- **USE LESS BLADES** - In an effort to reduce drag try using 2, 3 or 4 blades.
- **USE LIGHTER MATERIAL** - In effort to reduce the weight of the blades use less material or lighter material.
- **SMOOTH SURFACES** - The smoother your blade surface the less drag you will have. A blade with lots of tape and rough edges will have more drag.
- **GET MORE WIND** - Make sure you are using a decently sized box or room fan. Something with at least a diameter of 14"-18".
- **BLADES VS. FAN** - Are your blades bigger than your fan? That could be a problem as the tips of your blades are not catching any wind and are just adding drag.
- **BLADE SHAPE** - Are the tips of your blade thin and narrow or wide and heavy? The tips travel much faster than the root. That means if you have lots of junk out there you will add more drag.

These are a few ideas to help you improve your turbine blades. For more information head to www.Kidwind.org and look for the Blade Design Lesson under the curricular materials. There are lots of helpful links and ideas there to help you make the best blades.

How to Reduce Blade Drag!!



More Drag Less Drag



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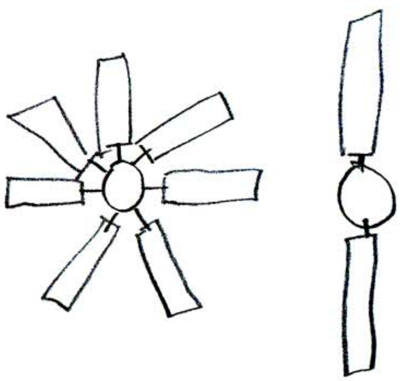

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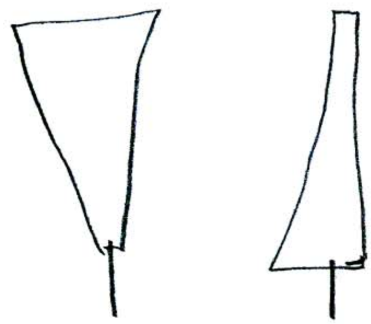

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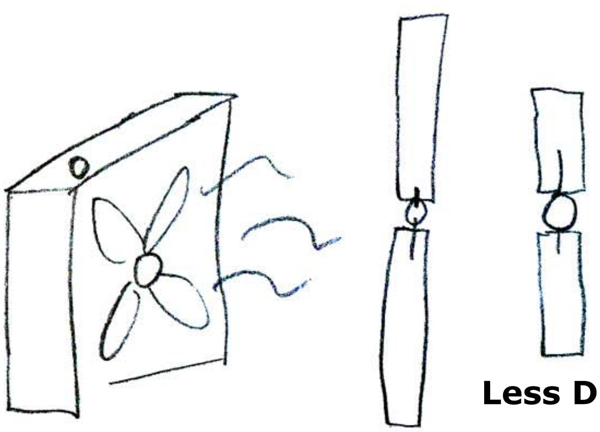
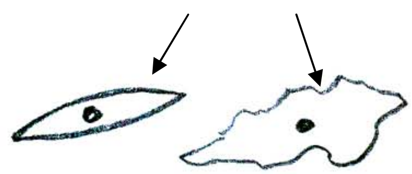


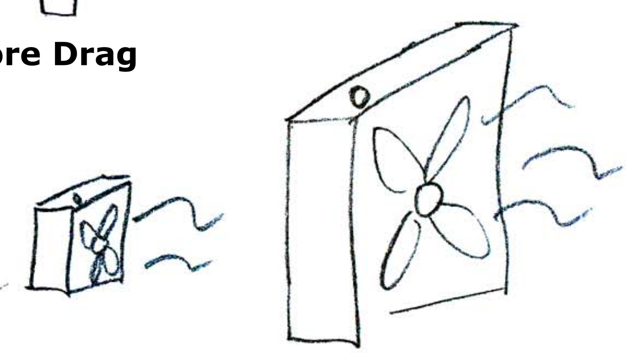
Less Drag

More Drag

Blade Cross-Section



Less Drag More Drag



Less Wind More Wind