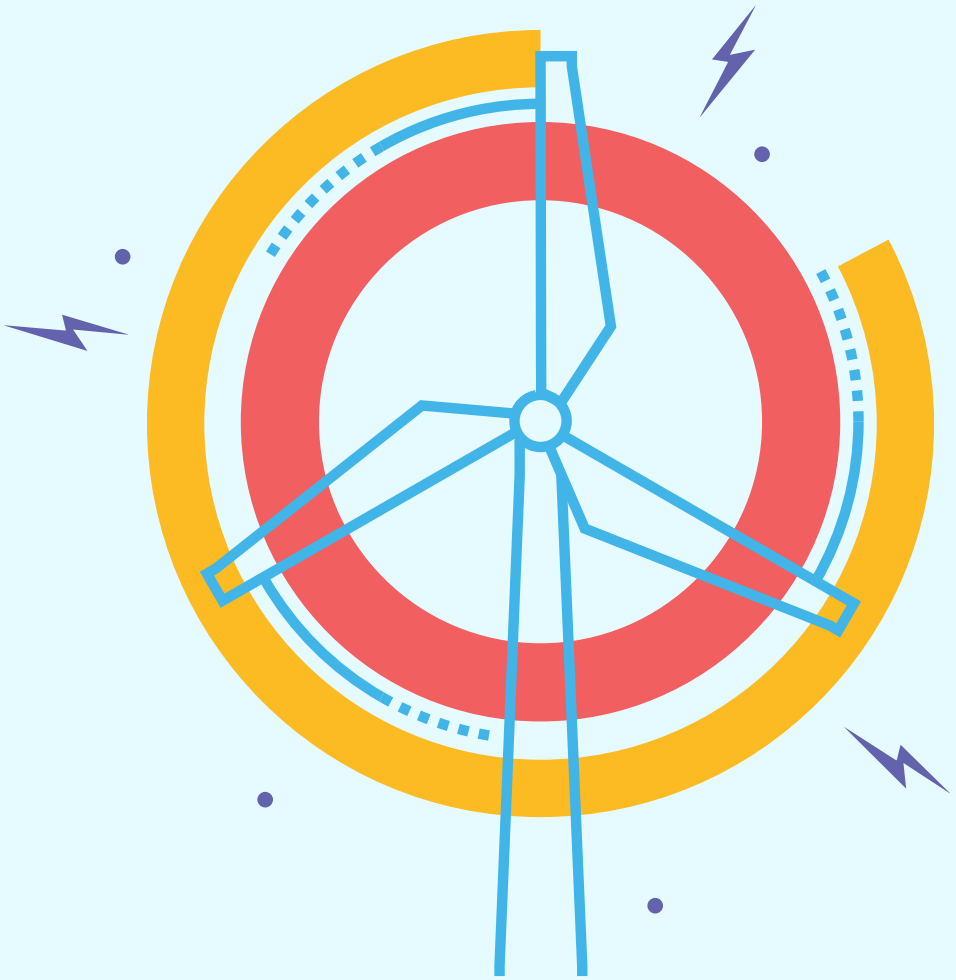
KidWind®
PROJECT



2024-2025 KidWind Challenge

WIND EDITION

GUIDEBOOK

www.KidWindChallenge.org
2093 Sargent Ave, Saint Paul, MN 55105 | Phone: 877.917.0079

Table of Contents

Introduction

Wind Challenge

Appendix

A Note on Reproduction

Dedication

Without some important visionaries, the KidWind Challenge would not be the success it is today. These organizations and individuals helped us start something great. We thank them for their passion, energy, and continued support.

- Asia Ward, Co-Founder of Recharge Labs
- Joe Rand, formerly KidWind's #2
- Larry Flowers (formerly of NREL Wind Technology Center)
- Trudy Forsyth (formerly of NREL Wind Technology Center)
- Original KidWind Challenge Team: Brad Weaver, Andy Lueth, & Linda Elie
- New York State Energy Research Development Authority (NYSERDA)
- Wright Center for Science Education at Tufts University
- Vernier Science Education
- Harbec Plastics

Partners & Volunteers

We have an amazing outreach team of individuals, organizations, and institutions who practically work for free. They love this project and make the magic happen at local and regional events. Without their hard work and dedication, none of this happens. We would like to specifically call out some superstars!

Thank you to the individuals who have contributed to the Wind Challenge!

- Allison Bender
- Andy Lueth
- Angela Christine Stoltz
- Colleen Fisk
- Colleen McDaniel
- David Andrade
- David Budai
- David Carter
- David Yaff
- Elise DeGeorge
- Fran Poodry
- Gus Goodwin
- James Brown
- Jerry Bernardini
- Kathy Jackson
- Meghan Phadke
- Mike Rinaldi
- Morgan Berkgren
- Ray Alls
- Ray Pitcher
- Remy Pangle
- Richard Anderson
- Sam Hindi
- Tim Noonen
- Yvonne Cook
- Zella Lobo

Educators, Students and Parents

None of this happens without great educators and students willing to try something new and the parents that support them! Thanks for all your passion and vision!

We invite you to share in our passion to inspire these future energy leaders, engineers, scientists, innovators, and problem solvers.

Please contact michael@kidwind.org to become a sponsor.

Thank you to our 2024 Sponsors!

While KidWind self-supports a few Challenge events around the country, our impact would be greatly limited without grants and sponsorships from clean energy industry organizations and foundations. Sponsoring a KidWind Challenge demonstrates an investment in our clean energy future.

Gale Force ($50,000+)

edp Renewables · Pattern · enel Green Power · NREL National Renewable Energy Laboratory · Invenergy · Ørsted · NJEDA Economic Development Authority · APEX Clean Energy · Vernier Science Education · RWE · aes

High Flyers ($25,000+)

U.S. Department of Energy · SOLSYSTEMS · RNWBL · The Beach at UNO

Wind Riders ($10,000+)

Mortenson · OW Ocean Winds · BSEE Bureau of Safety and Environmental Enforcement · Sea Grant Oregon · TIGERSOLAR · clearloop A Silicon Ranch Company

KidWind's **Mission**

The KidWind Project, a program of the 501c3 non-profit organization Gale Force Education, has been working with educators to integrate clean energy into classrooms since 2004. As the world is increasingly powered by clean energy, it is more critical than ever to develop a workforce and public who understand the complexities of this new power generation.

KidWind's mission is to empower educators and students to explore and engage with the challenges and opportunities of a clean-powered future.

Our primary goal is to help students find their place in a clean-powered future and help the public to better understand the impacts of clean power. The two primary challenges facing clean energy adoption are the lack of a knowledgeable and skilled clean energy workforce and public opposition to clean energy development.

We are addressing these challenges by working with educators within current frameworks to increase their capacity to teach about a wide range of clean energy concepts.

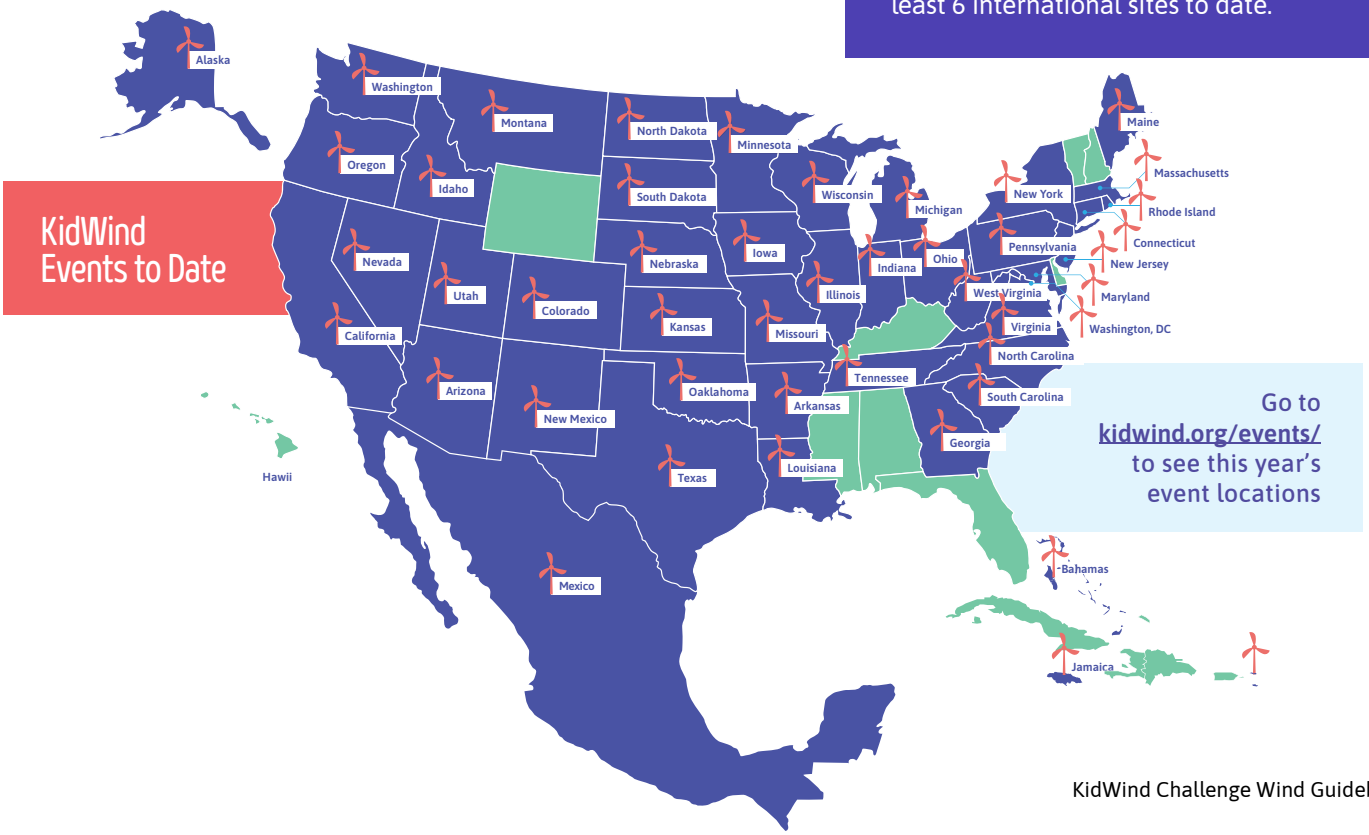
What is the KidWind Challenge?

The KidWind Challenge is a hands-on design competition where student teams showcase their small-scale wind turbines and solar home designs with the primary goal of providing a space for students to demonstrate their knowledge, skill, creativity, and passion for clean energy to their communities, industry, and the wider public.

Student teams design and construct small-scale wind turbines or solar homes that they test, and then meet with a panel of judges to present their design process and provide documentation. Teams also demonstrate their conceptual knowledge on clean energy and engage in a variety of Instant Challenges to demonstrate their teamwork and problem-solving skills.

The KidWind Challenge is a team effort by teachers, students, engineers, and practitioners, all working to make wind energy education and other clean energy education accessible in classrooms around the world. Since 2009, KidWind has hosted hundreds of Challenges in 39 states and at least 6 international sites to date.

KidWind Events to Date



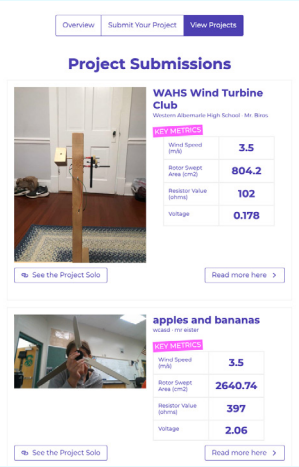
Go to kidwind.org/events/ to see this year's event locations

Types of **Wind Challenges**

You can participate and prepare for KidWind Challenges in many ways. We recommend starting by exploring the website and trying an Online Wind Challenge. This will help you get a feel for the kind of Wind Turbines teams have to build and the documentation teams need to provide at an In-Person KidWind Challenge. Once you are ready, your team can take their turbine on the road and participate in one of our In-Person Challenges. Those top performers from the Online and In-Person Challenges are invited to participate in the annual World KidWind Challenge.

In-Person Challenges

In-Person KidWind Challenges take place during the school year and are hosted by schools, community centers, and organizations across the country. Please note that not every site will have both a Wind and a Solar Challenge. KidWind Challenges may occur in-person, online, or in a hybrid model. **Please check the map for details** and contact the local organizer to learn more.



Online Wind Challenge

The Online Wind Challenge is open to international submissions, and provides the most accessible approach for any student team anywhere, to participate. Student teams in grades 4th-12th participate in suggested age-level divisions to construct and test wind turbines. Our online platform allows students to upload their wind project, design details, reports, presentation, and research to compete with other team submissions. Their wind turbine will also be shared with the international KidWind online community, displayed within the **Wind Challenge Gallery** on the KidWind website.

In order to participate, each team must have an adult coach whose contact information must be submitted with the project. A coach can be a parent, educator, or mentor and may supervise multiple teams.

Every quarter of the year, submissions will be judged by the KidWind team, and winners will be selected. Winners receive prizes and are invited to participate (optional) in the World KidWind Challenge, a large and prestigious in-person event, hosted at a conference center in a different state every year. If your team didn't win at an In-Person KidWind Challenge, they have another chance by submitting their work to the **Online Wind Challenge!**

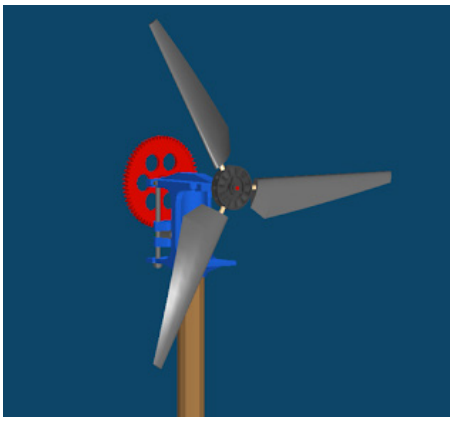
→ ***Please note:*** Not every site will have both a wind and solar challenge. Be sure you check the details of your local event and/or check-in with the event organizer to be sure they have a wind component.

Where should I start?

Take a peek at what projects can look like by exploring the Online Wind Challenge submissions!

This will help you get a feel for the kind of turbines others are building and the information you will be expected to provide.

Simulation Challenge



KidWind and Flinn Scientific's WhiteBox Learning (WBL) is a National Challenge that gives students the chance to use the WhiteBox Learning simulation software to construct and test virtual turbines and wind farms. While learning the software takes a little time, students will not need any of their own materials to participate. An adult educator, coach, or parent must create an account to participate in the National Simulation Challenge. The cost for this account is $20, which you must pay during the registration process. This account holder will then be the primary contact for the Challenge and may register up to 25 students. Additional students can be added for $1 per additional student. The only other requirement is an internet-connected computer (tablets are not supported).

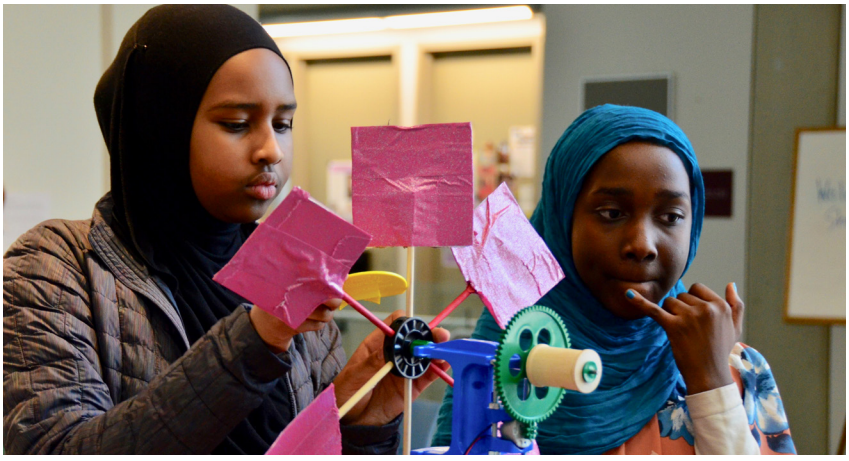
Students who chose to complete the Simulation Challenge AND submit a physical turbine to the Simulation Online KidWind Challenge will have the chance to receive an invite to the World KidWind Challenge.

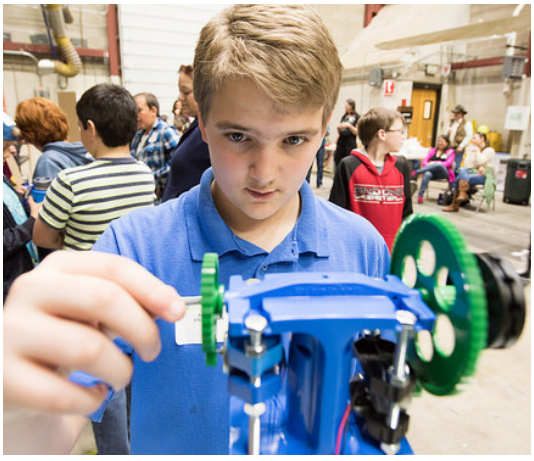
The 2025 Simulation Challenge begins January 1, 2025. **Learn more here.**

NEW! KIDWIND CHALLENGE JUNIOR

The KidWind Challenge Junior is a **new** in-person event designed for students and teams who want a KidWind Challenge experience, but don't have the knowledge, time, or resources to do it on their own. Teachers (coaches) and students just show up to the event and complete everything on-site. No preparation is required! Students will break up into teams and design blades for already-assembled towers. The event organizers will provide all the materials students will need and will have a wind tunnel on hand so that teams can test their designs out. This is a great event for regions that have not previously had KidWind Challenges and can help students and teachers build confidence and gain experience to participate in an official KidWind Challenge the following year.

Students who participate in KidWind Challenge Junior can go on to register for an In-Person KidWind Challenge or submit their project to the Online Wind Challenge to continue gaining experience and for a chance to receive an invitation to the World KidWind Challenge.





Participation **Checklist**

There are two ways you can participate in a KidWind Challenge: Online or at an In-Person KidWind Challenge.

KidWind Online Wind Challenge

- ☐ Explore student turbines on the Online Challenge
- ☐ Learn about the basic parts of wind turbine
- ☐ Get some turbine-building equipment
- ☐ Build a turbine
- ☐ Test and improve your turbine, over and over
- ☐ Collect some data about your turbine
- ☐ Upload information about your turbine and your team to the Online Challenge
- ☐ Wait to see if you are the quarterly winner

KidWind In-Person Wind Challenge

- ☐ See if there is an In-Person Challenge nearby
- ☐ Find a coach and form a team
- ☐ Send your coach to a virtual or in-person workshop!
- ☐ Explore student turbines on the Online Challenge
- ☐ Learn about the basic parts of a wind turbine
- ☐ Get some turbine-building gear
- ☐ Build a turbine
- ☐ Test and improve your turbine, over and over
- ☐ Collect some data about your turbine to share with judges (notebook, video, etc)
- ☐ Fill out your Wind Project Profile Form
- ☐ Before you go to the In-Person Challenge try the Online Challenge
- ☐ Get to the In-Person Challenge and have fun
- ☐ If you place in the top two, get an invite to the World KidWind Challenge

Don't forget to register your team for your local KidWind Challenge! Check the website for upcoming events in your area and links to registration.

KidWind Simulation Challenge

- ☐ Make sure you have an internet connected computer
- ☐ Register for the Simulation Challenge here
- ☐ Receive your WhiteBox learning log-in details.
- ☐ Get to work once it opens on January 1

What do I bring to the Challenge?

- → Turbine
- → Wind Project Profile Form
- → Extra parts, just in case
- → Tools, just in case
- → Pen/pencil
- → Snacks
- → Water bottle
- → Extra documentation for the judges (poster, notebook, photos)

How to **Participate**

Participating in the Wind Challenge

Step 1. Find a Coach

An adult coach is required to supervise the project process and sign up teams for In-Person and Online Challenges. During In-Person Challenges, coaches must be present and can supervise no more than 10 students.

Step 2. Assemble a Team

Teams can come in many shapes and sizes, but we've found that teams of 3-5 students are often the most successful!

Step 3. Decide: In-Person or Online?

Visit the **KidWind In-Person Challenge page** to see if there is an event near you, or contact the local organizer.

→ If there is no event near you, you can always participate in the **Online Wind Challenge**.

Step 4. Learn the Rules

Review the guidelines outlined on **page 15** of this Wind Challenge Guidebook.

Step 5. Learn about Wind

Coaches can help students gain knowledge and experience about wind energy by utilizing the activities found on the **KidWind Activities page** and in the Resources section of this guidebook. KidWind also has **webinars and instructional videos** to help provide information about wind power and turbine design and construction.

Step 6. Gather Supplies

At the minimum, you will need a tower, generator, hub, blades, and a multimeter. You **can purchase a wind starter kit** from KidWind, get some PVC from a local hardware store and use **this guide** to build your own PVC tower, or purchase a kit from our partners at Vernier.

Step 7. Start Building

Start designing and building your turbine.

Step 8. Test it Out

Test your turbine over and over with a box fan or wind tunnel. Improve your turbine as you test!

Can I Hold an In-Person Wind Challenge?

Many educators ask us if they can host a Wind Challenge. For the most part we say, "yes", but start slow! Start out by holding a Wind Challenge in your classroom, then have the teams upload their projects to the **Online Wind Challenge**. If that goes well, try to visit an **In-Person Challenge** event to see a preview.

To have a KidWind sanctioned event that's featured on our map, you need to contact our team. **See our website** for more info about holding your own KidWind Challenge.

Does KidWind Provide Training?

Before you get into holding your own Wind Challenge, you may want training to learn more about wind power and how to host an In-Person Challenge. KidWind provides fee-based **workshops and free webinars** for those interested in learning more.

Are There KidWind Lessons that Teach About Wind?

KidWind has free lessons on their **Activities page**, that will get you and your students well prepared to enter into a Wind Challenge. You can also check out the resources page located in this guidebook.

Step 9. Tinker, Tinker, Tinker

Keep making adjustments to improve your design. Don't forget to keep track of any iterations or challenges you encounter during this process and how you addressed them. You'll want to share this documentation with the judges at an event, or upload it to the Online Challenge as an additional resource!

Step 10. COMPETITION TIME!

In-Person Challenge

Carefully pack up your turbine and bring it to your In-Person Wind Challenge. All members of the team and the coach must be present during at event. At the event, teams will run their turbine through at least one wind tunnel and present their design to the judges. Be sure you prepare for this and bring some documentation to help show the judges the design process and inspiration. Some events may also have Instant Challenges and/or a Knowledge Test component. Event winners will be announced at the end of the event!

Online Wind Challenge

Submit your project and required supplementary information (photos, designs, videos, etc.) to the Online Challenge. Keep an eye on the **Online Wind Challenge gallery** to check out your competition. At the end of each quarter, we will select and post the winners!

World **KidWind Challenge**

Each year, we invite top performing teams from In-Person and Online Challenges to compete for variety of awards. This large and prestigious in-person event, is held in conjuction with the American Clean Power Association's CLEANPOWER Conference tradeshow and alongside the Collegiate Wind Competition. The location changes each year!

How Do I Get to Worlds?

1. Teams must receive an invitation from World KidWind Challenge organizers in order to attend Worlds.

2. Check the **Worlds page** of the KidWind website for the event location, dates, and details. The coach and team members must attend this 4-day, in-person event. Typically teams arrive on a Sunday morning, compete all day Monday and Tuesday, and then for half the day on Wednesday. Our Awards Cermony is held in the afternoon, and then teams typically head to the airport that night or the next morning.

3. The coach must complete the Worlds registration form, which is included in their team's invitation. Each person attending Worlds, including coaches, team members, family, friends, etc. must also complete an Attendee Form and Liability and Media Release Form. Teams will be sent these forms after registering.

4. Book team travel and lodging. We encourage teams to take advantage of KidWind's hotel block that includes discounted hotel rooms near the competition venue. KidWind shares hotel block details in January.

5. Raise money! There's no registration fee or participation cost for team members, coaches, or family joining the team. Coaches and teams will need to provide transportation, as well as room and board for the duration of the event.

6. Attend the event with your teams' turbine and presentations. Teams participate in wind turbine testing, judging sessions, Instant Challenges, and a Quizbowl evaluating their clean energy knowledge. Meet other coaches and teams and maybe even secure a sponsor for next year.

Divisions

Age Divisions

There are three age divisions:

- Elementary Division (4th-5th Grade)
- Middle School Division (6th-8th Grade)
- High School Division (9th-12th Grade)

Note: *Specific events might have different age or grade divisions. See the* **event details on the website** *for more information.*

Generator Divisions

The generator your turbine uses determines how we classify and evaluate your turbine in the wind tunnel. There are three classes of generators you can use:

- KidWind Generator (ES, MS, & HS Divisons)
- Commercially Manufactured Generators (MS & HS Divisions ONLY)
- Homebuilt Generators (MS & HS Divisions ONLY)

Only teams participating within the same age group and division will compete against each other.

KIDWIND GEN DIVISION (KidWind Generator)

If you use a KidWind Generator, you will be placed in the KidWind division.

The easiest path is to get a few **KidWind Turbine Generators from Vernier.** If you use this generator, you will be in the KIDWIND GEN division.

PLEASE NOTE: ALL elementary division teams must compete in the KidWind Generator Division.

OPEN DIVISION (Commercial Manufactured Generators - MS & HS ONLY)

If you purchase a generator, you will be placed in the Open Division.

You can purchase a commercially sold AC or DC generator (not a regular KidWind generator) that better matches how much power your turbine can generate.

Who Has to Show Up?

To be eligible for the competition, all members of your team must be present on the competition day. We also require one adult for at least every ten students who attend.

Exceptions include:

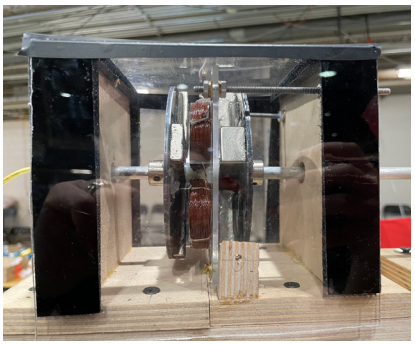
- Some of your team members are unable to attend because of a scheduling conflict with a school sanctioned trip.
- A team member cannot attend due to illness or family crisis.

Can I Change Generator Divisions at an Event?

It depends! Contact your event coordinator for details about declaring generator divisions at your local event.

Typically and at Worlds, before a KidWind Challenge event begins ALL teams must declare the generator division they wish to participate in (KidWind, Open, or Homebuilt). Judges will inspect your generator to confirm the division. Please make sure that your generator is visible. If this is not the case, once a team makes their first wind tunnel run, they will be locked into the division they have declared. Turbines may be marked with colored stickers to indicate their generator division.

HOMEBUILT DIVISION
(Homebuilt Generators - MS & HS ONLY)



If you make your own generator, you will be placed in the Homebuilt Division.

You can construct your own generator using a kit, online plans, or your own ingenuity. A homebuilt generator is defined as a generator where ALL of the major components of the generator are constructed by the students. This would mean the coils are wound by the students, the stators and other components have been constructed, 3D printed or otherwise built by the team. This does not extend to the magnets or driveshafts and similar components in this device.

If you'd like to build your own generator, our partners at Vernier sell the **GENPack (KW-GP)** or the **simpleGEN (KW-SGEN)** which can be a good way to start learning about building your own generator and conditioning AC output to DC. You can also find many more resources and kits online about building your own generator. For the really studious, check out **Homebrew Wind Power** by Dan Bartmann and Dan Fink and construct your own generator and turbine from scratch!

Wind Resources

As you construct and test your wind turbine, you may want to learn (or learn more about) the major parts of a wind turbine, wind energy and other related topics.

Check out these sites to learn about wind turbines and wind energy in general:

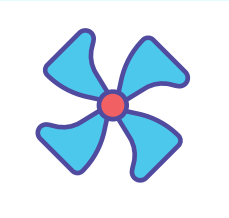
- **Student Energy - Wind Power**
- **PBS Wind Power Episode**
- **Department of Energy - Wind**
- **National Renewable Energy Lab - Wind**
- **Wind with Miller**

Equipment **to Build Your Turbine**

Whether you're building a turbine for an Online or In-Person Challenge, you will need some basic gear to get started. KidWind, through our partners at Vernier, have a number of kits and materials to get you exploring, but you can use materials from anywhere to participate in a KidWind Challenge as long as you are not violating the rules.

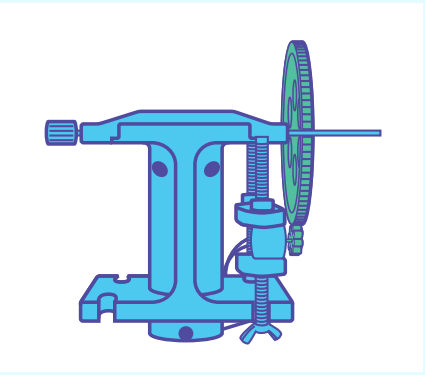
Generators

The generator your team uses determines how we classify and evaluate your turbine in the wind tunnel and compare energy and power generation. There are three classes of generators you can use.



Blades

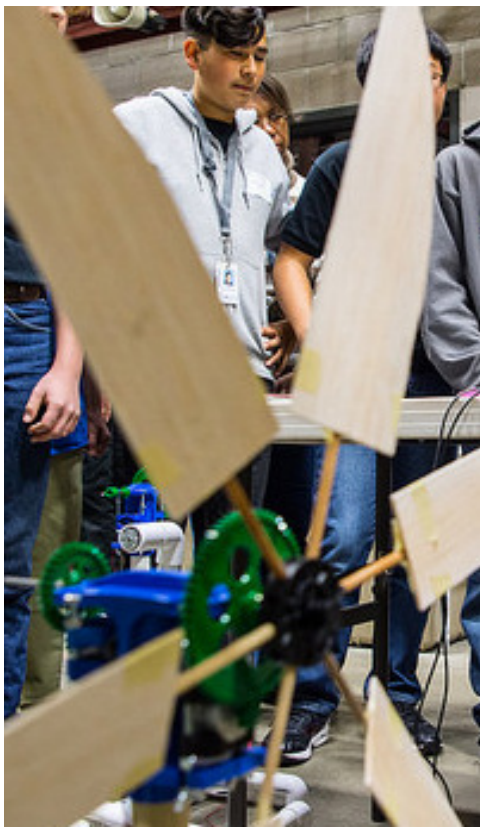
Wind turbine blades and their orientation to the wind are very important parts of a wind turbine design. You could study this for years and still not be an expert! Blades must use safe materials and fit within a 48" x 48" wind tunnel, and must **NOT USE PRE-MADE AIRFOILS** or other pre-manufactured blades. We see students using all kinds of materials to make blades: cardboard, balsa wood, 3D printers you name it. Just don't use razor blades!

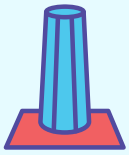


Gearboxes or Belt Drives

While building a gearbox or a belt drive can be challenging, it can also greatly increase the power output of your wind turbine. Belt drives or gears can give your wind turbine a mechanical advantage and multiply the mechanical force of the turning blades.

Your team can use **KidWind gearboxes** and parts through our partners at Vernier, you can find parts from other vendors, or your can construct your own gearboxes or belt drives. The only rule is that we must approve it as safe!





Towers

You can make a tower for your wind turbine out of practically anything. **Check out these plans to make simple PVC tower turbine** or get a simple KidWind tower from Vernier.

Don't limit yourself to just these towers! In fact, if you want to win you will need to adapt! We have seen some great towers made from wood, cardboard tubes, Tinker-Toys, plastic, etc.

Try experimenting with different designs! Which type of tower seems strongest? Why do you think certain wind turbines use the type of towers they use?

The only rule for making your tower is that it must have a firm base to sit securely on the ground, and it must be tall enough so that your blades will not hit the ground. If your turbine has a gear or pulley system, you will need to have some kind of platform or housing on top of your tower to hold the gear/pulley box.

Fans or Wind Tunnels

You can use any fan to test your turbine. At our workshops and while we are preparing and tinkering, we like to use simple box fans. At In-Person Challenges, we will have a KidWind Competition Wind Tunnel (KW-TUN) or something very similar to test your turbine. The KidWind Competition Wind Tunnel is easily constructed and can be purchased from our partners at Vernier.

If you are handy, you can try to construct your own — many teachers have done this! Unlike a box fan, our tunnels suck the air through the shroud which leads to cleaner less turbulent winds.

Challenges provide weights such as sand bags to weigh down wind turbines during testing. Teams are also welcome to bring their own weights for tunnel testing.

Power Measurement

You will need to learn how to measure power output from your turbine. You can use a simple multimeter or data logging equipment. The key is to make sure that your turbine is attached to a load whenever you are collecting data. If you use a KidWind Generator, we will use a 30 ohm load when we test it in the wind tunnel. If you have a homebuilt or other generator, we can use a load that you provide.

Through our partners at Vernier, you can get more sophisticated data collection equipment. We really love their Go Direct Energy Sensor (GDX-NRG). It connects to all devices and is an easy way to collect detailed turbine data and even has a built in load.

Learn More Online

You can find more details about each part of a wind turbine at the KidWind Challenge **website**.

Power Conditioning

We will allow devices (buck boost or other electronics) that reduce the output voltage and current from competing turbines to meet our 30V and 1A data collection limitations.

We will not allow devices that increase the voltage or current from your turbine.

Turbine Design Guidelines

As you construct your turbine please keep the following new rules in mind:

1. Student team members must do all of the work building wind turbines, preparing for Challenges, and making adjustments. Teams can be disqualified if it is discovered that parents or coaches have or are working on turbines.
2. Each registered team must have its own turbine. Teams can not share turbines, or simply switch blades with another team.
3. The turbine must fit inside the wind tunnel and operate within its 48" x 48" internal dimentions. Keep in mind that as the wind tunnel runs, it will suck in vinyl sides of the tunnel, reducing the internal dimensions. We HIGHLY recommend designing your turbine to fit within these dimensions with plenty of room to account for shake and wobble. Sand bags and other weights will be available for use.
4. There are no budgetary restrictions for your turbine design, but it is important to keep in mind that part of the judging process is the economical use of resources. Please use materials responsibly.
5. You may only use 1 generator per turbine.
6. Power must be generated solely by wind using the wind tunnel.
7. Your turbine can be built on either a vertical or horizontal axis.
8. Your turbine may use a gearbox, pulley system, or similar mechanism to increase power output. You may use premanufactured gearboxes and other parts, but keep in mind that innovation is a critical judging criteria, and parts that you make on your own will earn you more points.

Connection and Loads

- You must have two wires at the base of your turbine. You must label which wire is positive and negative, and the turbine must produce DC power for our data logging system. If you make your own generator and it is generating AC power, you must rectify it to DC power.
- Teams that use KidWind Generators will be tested using a 30 ohm load.
- Teams in the OPEN or HOMEBUILT divisions are allowed to provide their own load during testing. They must provide the load and have it inspected by local judges. Teams may not use Maximum Power Point Tracking (MPPT) devices or variable resistors. Only static loads are allowed as the wind speed of the tunnel is not variable. You will be allowed to change your load between each test. You cannot change the load during a test. If you do not provide a load, your turbine will be tested at 30 ohms.

Power Output

- Our data-logging software and hardware can measure Direct Current at 30V / 1A. Teams in all divisions must make sure to regulate their power output below these specifications. If your turbine exceeds this output, even for a millisecond, it may be disqualified as the equipment will not be able to properly record its power and energy output. This is very important!
- If your turbine produces so much power that it damages the generator before testing is complete, you will be able to retest your turbine as long as you can repair or replace your generator. If we are unable to record power and energy data with our equipment due to generators overheating, your turbine may not receive a power and energy score.
- Local judges reserve the right to use other methods to collect power and energy output data if probeware is unable to collect data.

9. You cannot use pre-manufactured wind turbine blades or airfoils/sheets.
10. Your wind turbine must be free-standing. A tower/stand will not be provided.
11. The use of 3D printed parts and components is allowed. While you do not have to use files you created yourself, you should bring documentation about the CAD files to the Challenge and be prepared to discuss the design and the 3D printing process. Judges will want to make sure you understand this technology if you decide to use it.
12. No shrouds are allowed.

Example of a turbine using a shroud.

Safety

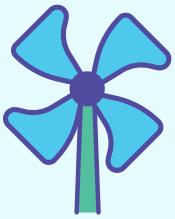
- Metal, plexiglass, and similar blade materials are highly discouraged because they are potentially dangerous. On occasion, we have allowed these types of blades to be used, but only after local judges determined that there was an extremely low risk of failure due to assembly.
- 3D printed blades must have dull ends to prevent puncturing the plastic tunnel sides if blades fly off the turbine during testing.
- Bicycle wheels are allowed on turbines but they may be disqualified if local judges deem the structure unsafe.

Local judges have the final call for safety, and turbines will be disqualified if they are deemed unsafe. If you're not sure about something, send a photo to **michael@kidwind.org**.

Turbine Testing

Wind Tunnel

- Wind turbines will be tested in a 48" x 48" wind tunnel at a wind speed of approximately 3.5 to 5m/s. Wind moving at 3.5 m/s within a space this large is much more powerful than a single box fan.
- All teams may be given time to tweak their turbine in the tunnel before actual testing begins. How much time will be determined by the type of event, number of entries, and free time available.



Testing Guidelines

- Once the testing session begins, you will be given two minutes to set up your wind turbine inside the tunnel.
- If you are using a KidWind Generator, the wires at the base of your turbine will be attached to a circuit with a 30 ohm resistor in series and will simultaneously measure voltage and amperage.
- If you are using a homebuilt or advanced generator, you will attach your desired load to the turbine or our measurement tools and then attach the wires at the base of your turbine to the circuit that will simultaneously measure voltage and amperage.
- In order to receive full marks for functionality, your wind turbine must be able to start producing power without external assistance once the wind tunnel is activated.
- Once your turbine is in the tunnel and connected to the data collection system, the judge will turn on the fans and ask your team if you want this test to count. If your team says yes, the judges will collect data on your turbine. If your team says no, you may remove your turbine, make a small tweak and try again. If there is a line of students waiting, you will probably need to head to the back of the line. This process will vary depending on event.
- During testing, the wind tunnel will be running constantly. We will collect power and energy output data between 30–60 seconds. Your energy output score will be calculated using a Vernier datalogging system that collects voltage and amperage readings simultaneously.
- If your wind turbine slips, breaks, or falls over once the timer is started, you will either be given two minutes to set up your wind turbine again, or you will be allowed to remove the turbine to make repairs. In the latter case, you will be moved to the back of the line for retesting.
- Depending on your local Challenge rules, size, and time frame, you may have between 1 and 5 trials for testing, and only your best trial will contribute to your final score.
- **Local judges have final say on rulings and disputes**.

Defining Catastrophic Failure

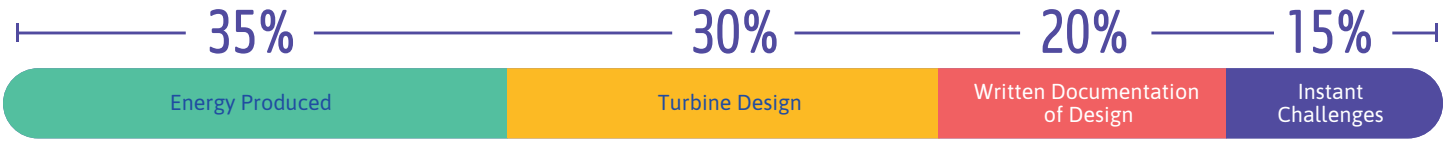
An event that causes a turbine in the wind tunnel to produce zero power while collecting test data is defined as a Catastrophic Failure Event. This could be due to either a mechanical or electrical failure. If this happens you will be offered the following options:

- Take two minutes to set up your wind turbine again ***OR*** remove the turbine to make repairs.

In the latter case, you will be moved to the back of the line for retesting. Failures that lead to REDUCED performance are NOT Catastrophic Failure Events.

Turbine and Team Evaluation

At every KidWind Challenge, teams can expect to be evaluated on energy produced. Depending on the local event and the number of teams present, there may be turbine judging, Instant Challenges, and a knowledge quiz that are part of your overall score. All team members must participate in all components. Here is an example score breakdown:



Please keep in mind that Judging Rubrics and categories may be different at your local event. The specifications below are intended to offer guidance and local organizers will share details of how *your* turbine will be evaluated prior to your event.

Energy Produced (35%)

The total energy output of your turbine over the 30 to 50 second trial period will be collected using data-logging software. Each team's energy, measured in joules produced during the trial period, will be ranked relative to that of other competitors. Each team will receive points corresponding to its rank.

Energy scores will be ranked on a comparative basis using one of two methods.

Rank Method

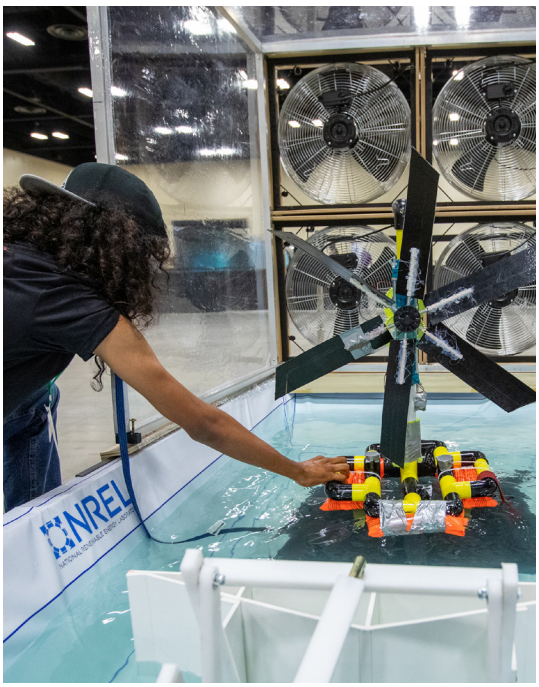
Turbines will all be ranked by energy output. The highest producing turbine will receive the full number of energy points. Each turbine below that will receive from 2-5 less points than the one above them.

Example: The top turbine produces a total of 100J and receives 35 points. Your turbine is ranked 6th at 80J and each rank down receives 2 less points. You get 25 points.

Ratio Method

Turbines will all be ranked by energy output. The highest producing turbine will receive the full number of available energy points. All other scores are calculated based on the percentage of the top score. Example: The top turbine produces a total of 100J and receives 35 points. Your turbine produces a total of 80J, so your team would receive 80% or 28 points.

In all cases you want to generate as much energy as possible to get a high score.

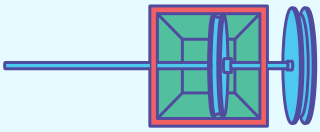


Presentation (30%)

A panel of judges will examine your wind turbine design at an In-Person Challenge. This 10-20 minute interview is to get a better understanding of the process you went through as you designed and tested your turbine. You should be prepared to discuss/defend the choices you incorporated into the design.

Questions judges may ask about your turbine design:

- Does your turbine have a gearbox, a pulley system, or is it direct drive?



- Did you have any issues with friction? How did you reduce friction in your drive train?
- When building your turbine, what kinds of obstacles or challenges did you face?
- How did you balance your blades? Do you notice any vibration when your turbine spins up to speed?
- Why are modern wind turbine blades shaped like airfoils? Are your blades shaped like airfoils? Did you try to make any airfoils?
- How did you determine the number of blades you would use? What experiments or testing did you perform?
- How did you determine the pitch (angle) of the blades?
- Why are your blades as long as they are?
- What materials did you use to make your blades? Why? What was important as you were building your blades?
- What techniques did you use to increase the power output of your wind turbine?
- What materials did you use to make your tower? What were some of the challenges you faced making a tower?
- What changes did you make to your turbine that lead to the most performance gains?
- Discuss the craftsmanship of your design, including creativity, economic, and environmental decisions.
- Did you use recyclable materials?

Written Documentation of Design (20%)

All students must complete a Project Profile Form **(see Appendix)**. This sheet should be presented to your judges when you enter the judging room.

In addition to this sheet, teams may also share additional documentation with the judges that showcases with more detail their design process and knowledge of wind energy science. It is up to each team to determine how they want to document this part of their project. In the past we have seen:

- Short reports
- Engineer's notebooks
- Videos (maximum of 4 minutes)
- PowerPoints
- Science fair poster boards

Students must provide the means to play any multimedia. A projector may be available — check with your event organizers for details.

Instant Challenges (15%)

At some KidWind Challenges, students may be asked to put their knowledge of wind energy to work at an Instant Challenge. Instant Challenges don't require any preparation or planning before the Challenge, just a solid knowledge base to refer to for on-the-spot engineering.

The number of points that these Instant Challenges are worth will vary among Challenges.

During past Challenges, Instant Challenges have accounted for 10-15% of the final score. At some locations, we may be piloting bonus Instant Challenges and other categories for testing. Please check the KidWind Challenge website and your local Challenge registration page for more details.

A Note on AI Generated Content:

While we are excited about the possibilities of AI and know it can be a great learning tool, any information you present or provide to judges at a Challenge must be written, developed, designed, and/or created by you (from your brain!). If you used AI to help you brainstorm or polish your own content, please cite it so that judges are aware. Also know that judges may ask you about something you present and AI won't be in the room to answer! You'll want to be sure you are 100% confident in all the details about your project.

Appendix

Wind Project **Profile Form** (Novice)

Team Name: School Name:

This document is meant to help guide your design process and provide documentation to the judges about your wind turbine. You should present this document to the judges at your KidWind Challenge event.

1. ☐ **a. We are using a KidWind Generator**

☐ **b. We are using a premade, non-KidWind generator.**

Brand/Model/Where you got it:

☐ **c. We made our own generator.**

Describe the design/construction:

2. **Does your turbine fit in the 4'x4' wind tunnel?**

☐ **Yes** ☐ **No**

3. **Do you have wires at the bottom of the wind turbine?**

☐ **Yes** ☐ **No**

4. **Are your wires labeled + and - ?**

☐ **Yes** ☐ **No**

5. **Do you have a gearbox?**

☐ **Yes** ☐ **No**

a. If so, what is your gear ratio?

6. **What was your maximum voltage output?**

7. **If your turbine was under a load at the time of testing the voltage, describe the load.**

8. **How many blades**

9. **What materials are the blades made from?**

10. **What was the optimal pitch of your blades?**

Don't forget to bring the following items to the Challenge:

- **Your wind turbine**
- **This form!**
- **Any notebooks, drawings, videos that you kept while building your turbine**

Wind Project **Profile Form** (Advanced)

Team Name: School Name:

This document is meant to help guide your design process and provide documentation to the judges about your wind turbine. You should present this document to the judges at your KidWind Challenge event.

1. ☐ **a. We are using a KidWind Generator**

☐ **b. We are using a premade, non-KidWind generator.**

Brand/Model/Where you got it:

☐ **c. We made our own generator.**

Describe the design/construction:

What resources did you use to guide your design (books, kits, etc.)?

2. What kind of power does your wind turbine generate

☐ **a. AC:** Did you rectify your output to DC?

☐ **Yes** ☐ **No**

☐ **b. DC:** Is your power output conditioned to be DC and below 30V and 1A?

☐ **Yes** ☐ **No**

3. Does your turbine fit in the 4'x4' wind tunnel?

☐ **Yes** ☐ **No**

4. Do you have wires at the bottom of the wind turbine?

☐ **Yes** ☐ **No**

5. Are your wires labeled + and -?

☐ **Yes** ☐ **No**

6. Do you have a gearbox?

☐ **Yes** ☐ **No**

a. If so, what is your gear ratio?

7. What was your maximum voltae output?

8. If your turbine was under a load at the time of testing the voltage, describe the load.

Don't forget to bring the following items to the Challenge:

- **Your wind turbine**
- **This form!**
- **Any notebooks, drawings, videos that you kept while building your turbine**

Wind Project **Profile Form** (Advanced) Continued

9. **What materials did you use?**

10. **What was the optimal pitch of your blades?**

11. **Detail any use of airfoils in your design.**

☐ No airfoils used.

12. **Detail any computer software you used to design/print/build your blades.**

☐ No software used.

13. **Detail any advanced manufacturing used to create your wind turbine (i.e. laser cutting, 3D printing, etc.).**

☐ No advanced manufacturing used.

14. **Describe any mechanisms or capacitors you have used to store electricity.**

☐ No mechanisms or capacitors used.

15. **Detail any microcontrollers integrated into your device. Describe the goal and the benefit of your microcontroller(s).**

☐ No microcontrollers used.

10 Big Questions **About Energy**

Here are some questions to get you thinking about clean energy in broader terms. You will likely need to draw on your understanding of these questions to be successful at Instant Challenges, knowledge tests, and in the judging room!

While these broad and expansive questions can be explored by students across the grades, some subquestions may be geared to younger or older students. Coaches can help steer students to the questions most appropriate for their grade-level.

You do not need to become an expert! Just make yourself knowledgeable.

1. How do we generate and use electricity — and how do we move it around?

From what sources do we generate most of our electricity in the U.S.? How does a generator work? What are the primary sources of electricity in your region of the U.S.? What are some of the ways we transform energy from one form to another? How much of the electricity that is used in your country is generated by wind, solar, or other clean energy? How has this changed over the last ten years? How do we move electricity from power plants to our homes? What is distributed generation?

2. How do we measure and quantify electricity?

What are the units we use to measure electrical energy consumption? How much does it cost to power your house each month? What is the difference between energy and power? How much power and energy do common objects like toasters, TV, cell phones and other devices use? Can you read a power bill? How can we reduce our electrical consumption or make it more efficient? How does electrical energy usage vary between countries?

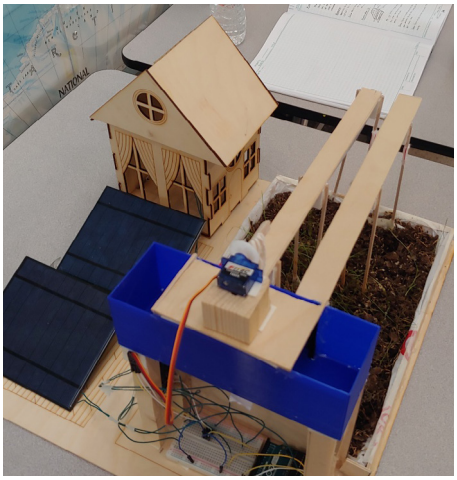
3. What is climate change and how can clean energy impact this phenomenon?

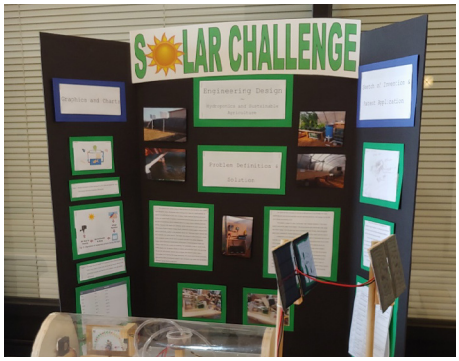
What is climate change and who does it impact? What are the environmental benefits of generating electricity using wind or solar power? What are some of the tradeoffs? What challenges might we face in generating over 50% of electricity from clean resources in the U.S.? How does efficiency and conservation play a role in reducing the climatic impact of electricity generation?

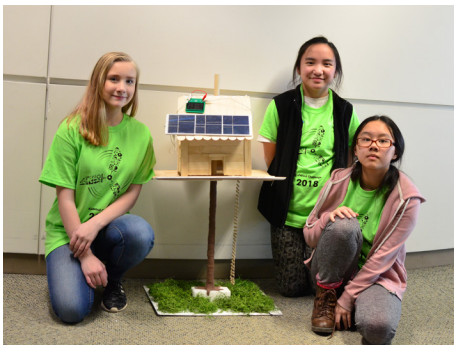
4. What kinds of devices transform the power of the wind and the sun?

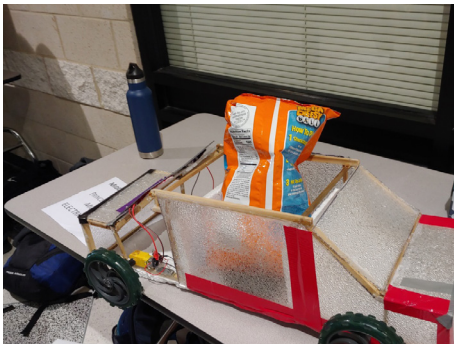
What types of devices have been used to harness wind or solar power, apart from being used to generate electricity, and what were their uses? What are the various styles of windmills and turbines? What are the various types of solar thermal and solar photovoltaic panels? What is the equation that defines how much power is in the wind and what are the most important variables? How do we measure the power coming from the sun? What components of wind turbines are undergoing rapid change and development? Which changes seem to be having the most impact in improving turbine performance? How has the performance of solar panels been improved?

Wondering where to start exploring these questions? Check out the KidWind website for important links and resources: **KidWind.org**









5. How does weather and geography impact clean energy production?

What causes wind? What are the windiest or sunniest parts of the U.S.? Where are most of the wind turbines or solar farms located in the U.S.? How does an offshore wind farm work, and where are they located? How do the seasons affect wind or solar energy production? How could the science of meteorology impact and improve the performance of solar or wind farms?

6. How can we store electricity?

What is electrical storage? How can storage impact the "variability" of clean energy resources? What are the challenges of implementing small or large scale storage? What kinds of technologies are used in the storage of electricity? Electric vehicles have huge batteries in them — can we use them for storage in our homes?

7. What are local impacts of a wind and solar powered future?

What are some of the physical and social impacts of solar and wind farm construction and operation? How can we reduce these impacts? Which impacts seem most concerning to local communities? How do these impacts compare to those of fossil fuel generating facilities?

8. How do we pay for clean energy?

How do we financially subsidize clean energy resources? How does this compare to fossil fuel and nuclear subsidies? Do you feel that subsidies are appropriate in the energy industry? If you feel that subsidies are okay, what energy sources would you subsidize and why? How can we provide affordable, clean energy to all communities around the globe?

9. What does a clean energy powered future look like?

Is it realistic to think we can power the grid with 100% clean energy? What role does nuclear have to play in a clean energy future? What are smart grids and microgrids and how could they be an improvement over the power grid we currently have? How would large numbers of Electric Vehicles impact the power grid? How can use less electrical energy but still have all the modern conveniences we want?

10. What are clean energy careers?

Developing and installing clean energy components and systems like wind turbines and solar panels, requires professionals and experts from many different fields of study. What are some of the careers and jobs that make clean energy possible? What do you need to study to work in these fields?

**The development of these questions was guided by the DOE Energy Literacy and NGSS Energy Standards.*