2026 Energy in Action Teacher Workshop

Hosted by the Kansas Energy Program

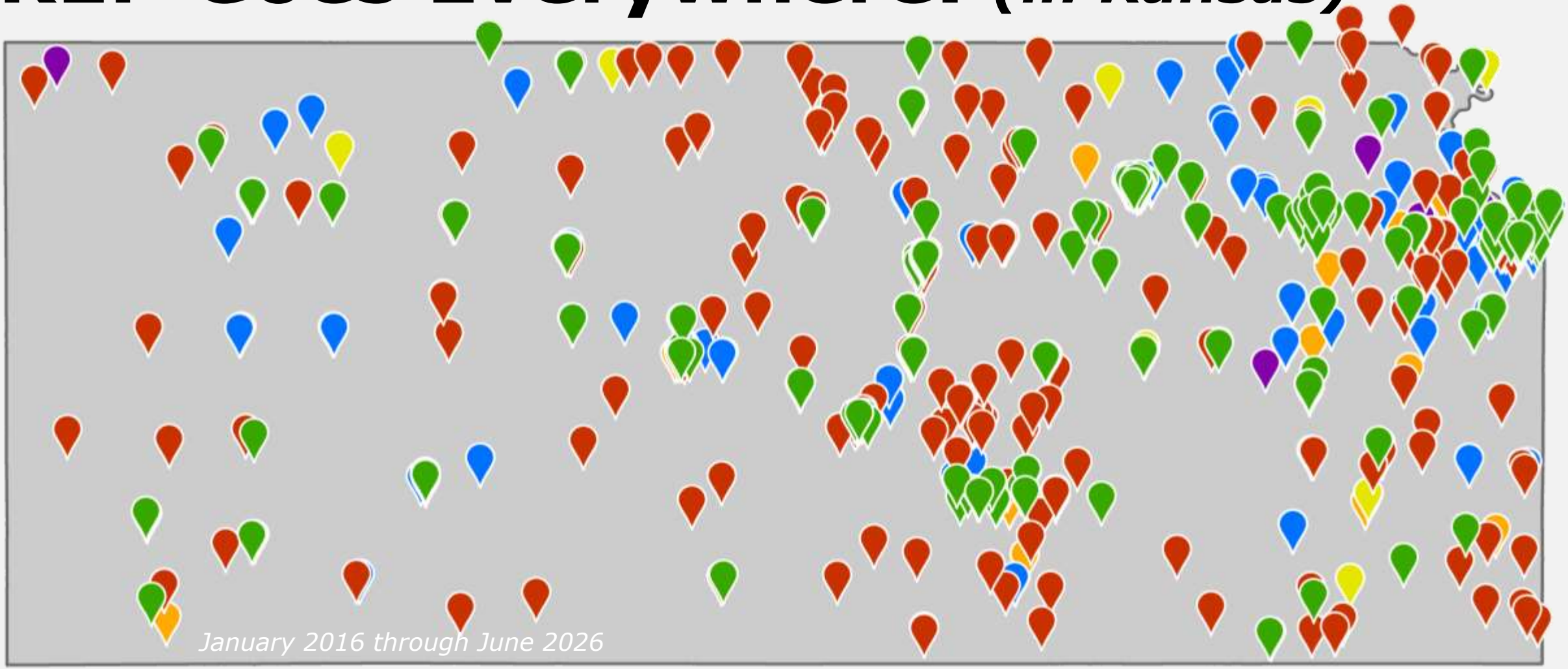
- Wichita (10/29)

Who are you talking with today?



The Kansas Energy Program (KEP) is part of Kansas State University Engineering Extension. KEP was established in 2016 through a partnership with the Kansas Corporation Commission Energy Office.

KEP Goes Everywhere! *(in Kansas)*



Educational Events (454) FCIP (14) K-12 Benchmarking (34) KidWind (131) Loans (306) Small Business Energy Assessments (232)

Introductions

- Name
- School
- Subject and grade level you teach
- Favorite food



Today is for Exploring

We’re covering a lot today! No need to remember everything. We want you to walk away with ideas, inspiration, and resources.



Before we get started . . .

- Please ask questions!
- Slides will be shared
- Flexible schedule today
- We'll cover many grade levels (4^{th} - 12^{th})

- Logistics
  - Bathroom
  - Drinks/Food

Newsletter Announcements

Subscribe to our monthly newsletter for KidWind and energy education updates
(use QR code or kansasenergyprogram.org/signup)

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https://kansasenergyprogram.org

Today's Agenda

- 9:00-9:30: KEP and Introductions
- 9:30-10:00: STEM Harvest
- 10:00-10:50: Energy Overview
- 10:50-10:55: Break
- 10:55-12:10: MacGyver Windmill Challenge
- 12:10-12:40: Lunch
- 12:40-2:00: Engineering and Problem Solving (Phenomenon-based learning)
- 2:00-2:30: KidWind and Energy Benchmarking
- 2:30-2:45: Wrap-up

General Energy Overview

Big Picture Energy | Efficiency | KEP Resources



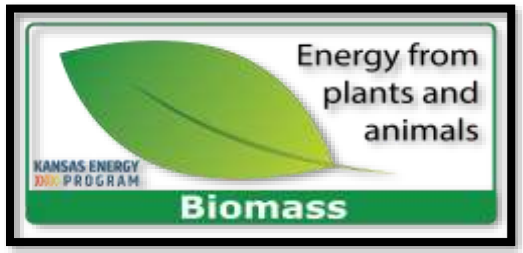
Price is Right: Energy Addition

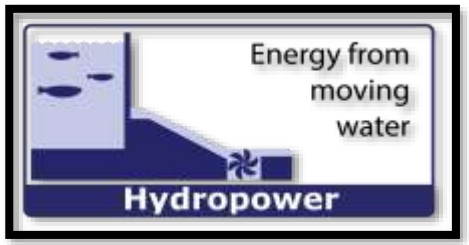


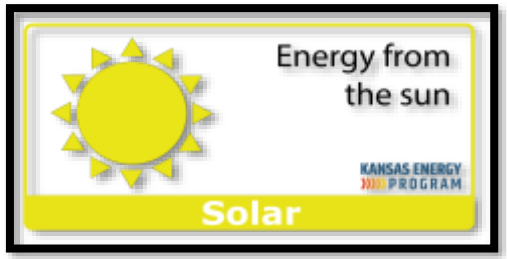
https://www.khou.com/video/news/entertainment-news/inside-the-price-is-rights-new-studio/285-5134d90b-b981-495f-b5d5-334a3fac0d18

Renewable and Nonrenewable

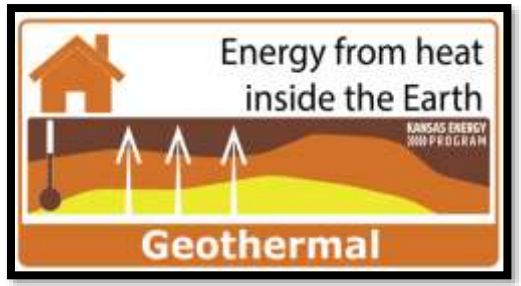
Renewable



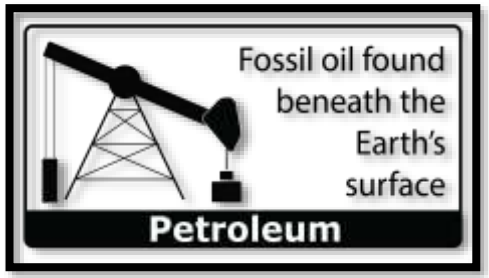


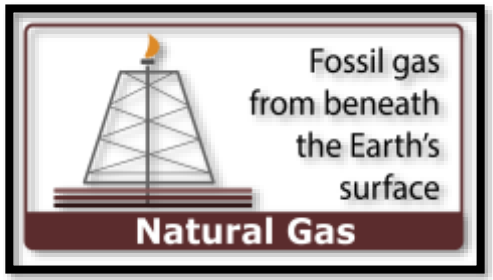


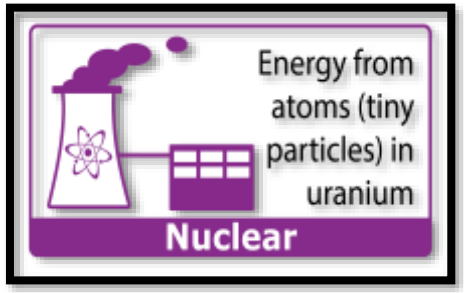




Nonrenewable



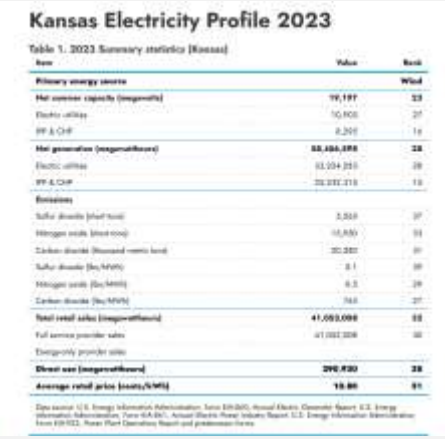






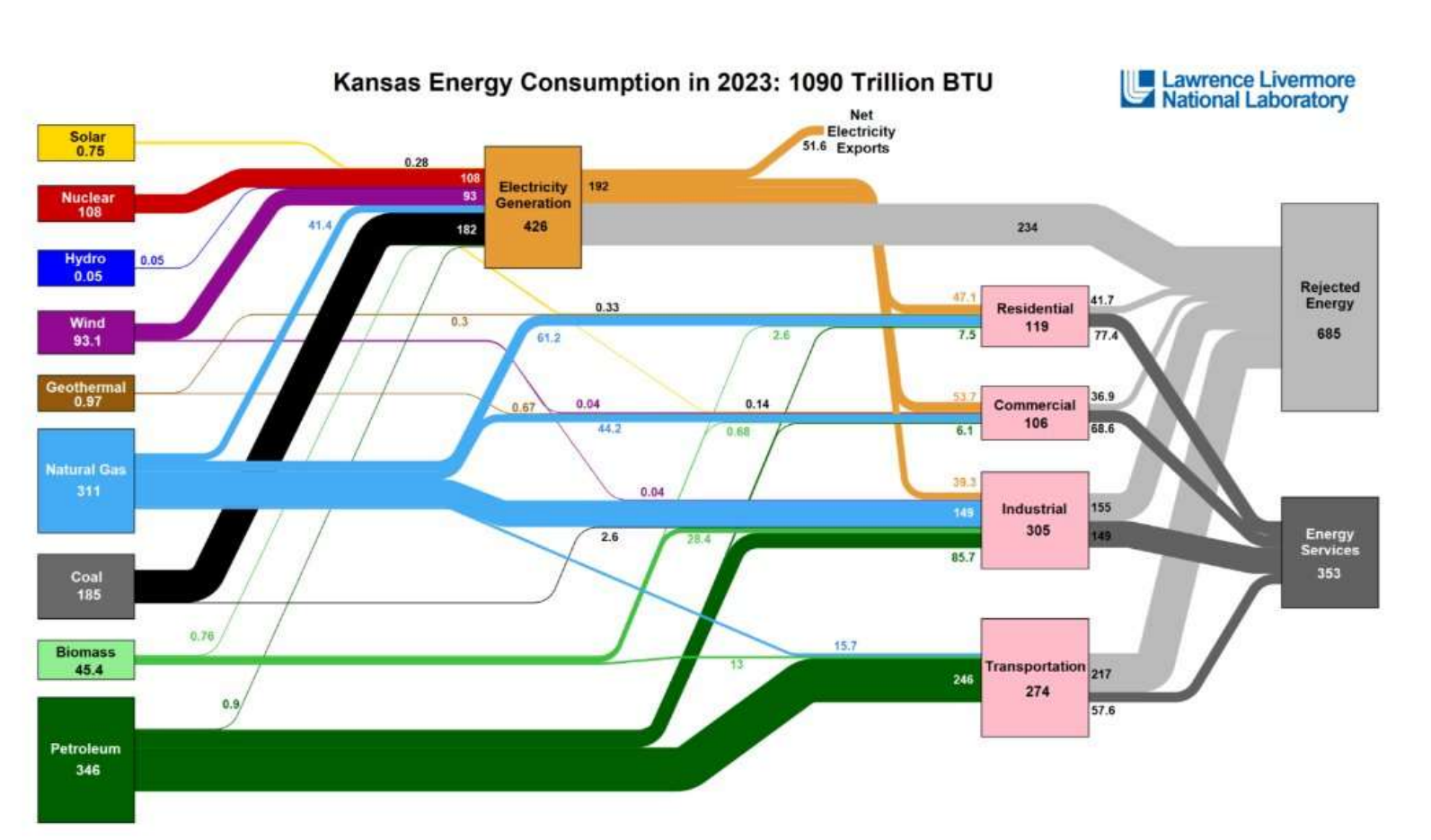
Electricity Generation in Kansas

Rank	Source	Net Generation MWh	% of Total
1	Wind	27.27 million MWh	46.58%
2	Coal	16.29 million MWh	27.87%
3	Nuclear	10.30 million MWh	17.62%
4	Natural Gas	4.37 million MWh	7.47%
5	Utility-Scale Solar	81,325 MWh	0.14%
6	Biomass	65,596 MWh	0.11%
7	Petroleum	59,081 MWh	0.10%
8	Hydroelectric	13,441 MWh	0.02%
9	Other	3,000 MWh	0.01%

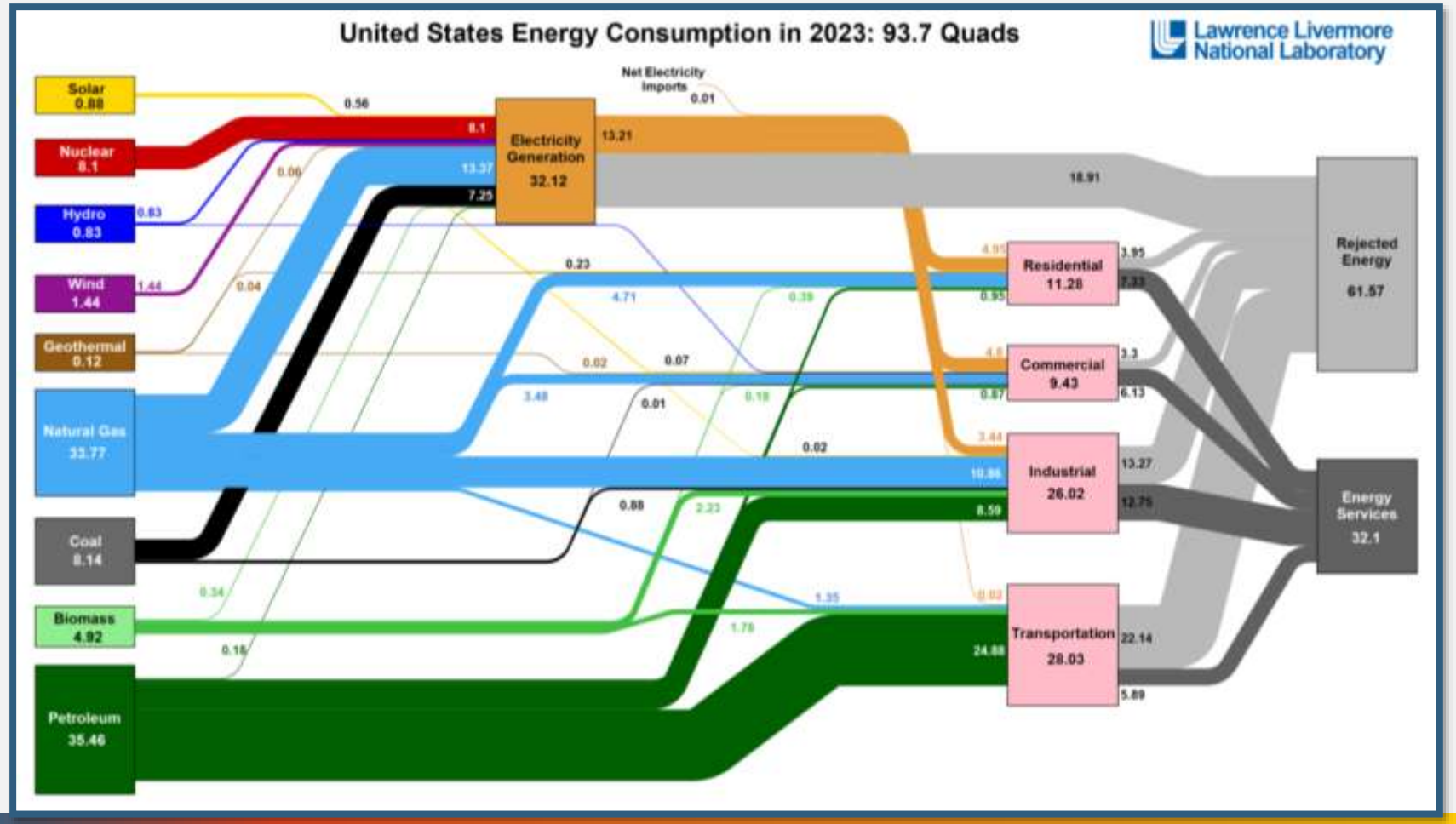

Kansas Electricity Profile 2023

- **TOTAL ELECTRIC INDUSTRY — 58,456,598 MWh**

Sankey Diagram – Energy Consumption-Kanas

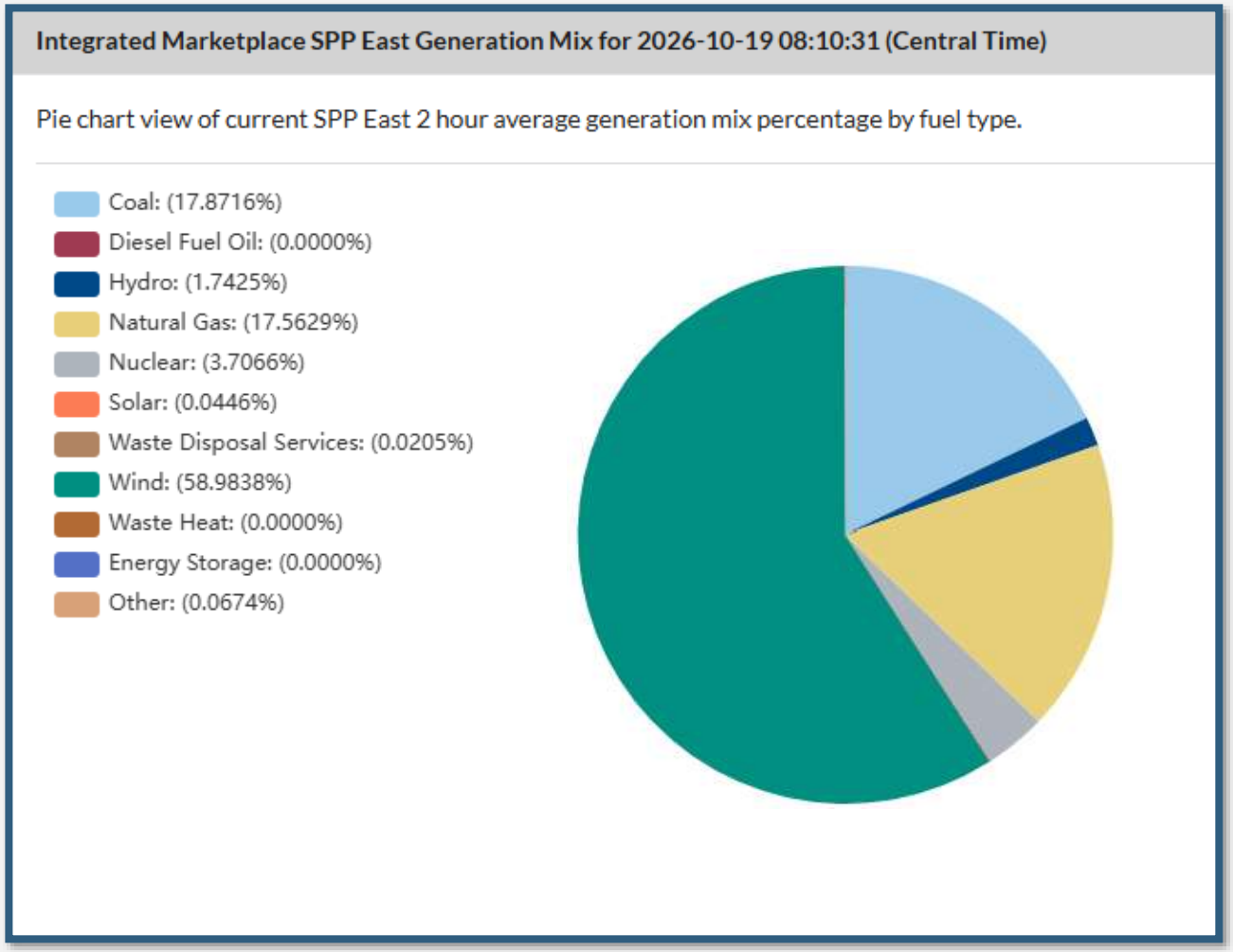


Sankey Diagram – Energy Consumption-US



What's Powering Our Grid?

In Kansas, the electric grid is overseen by the Southwest Power Pool (at least a portion of 17 states are included). Check on the current mix of sources at any time!
https://portal.spp.org/pages/integrated-marketplace-generation-mix



Quick Tour of KEP Website



https://kansasenergyprogram.org

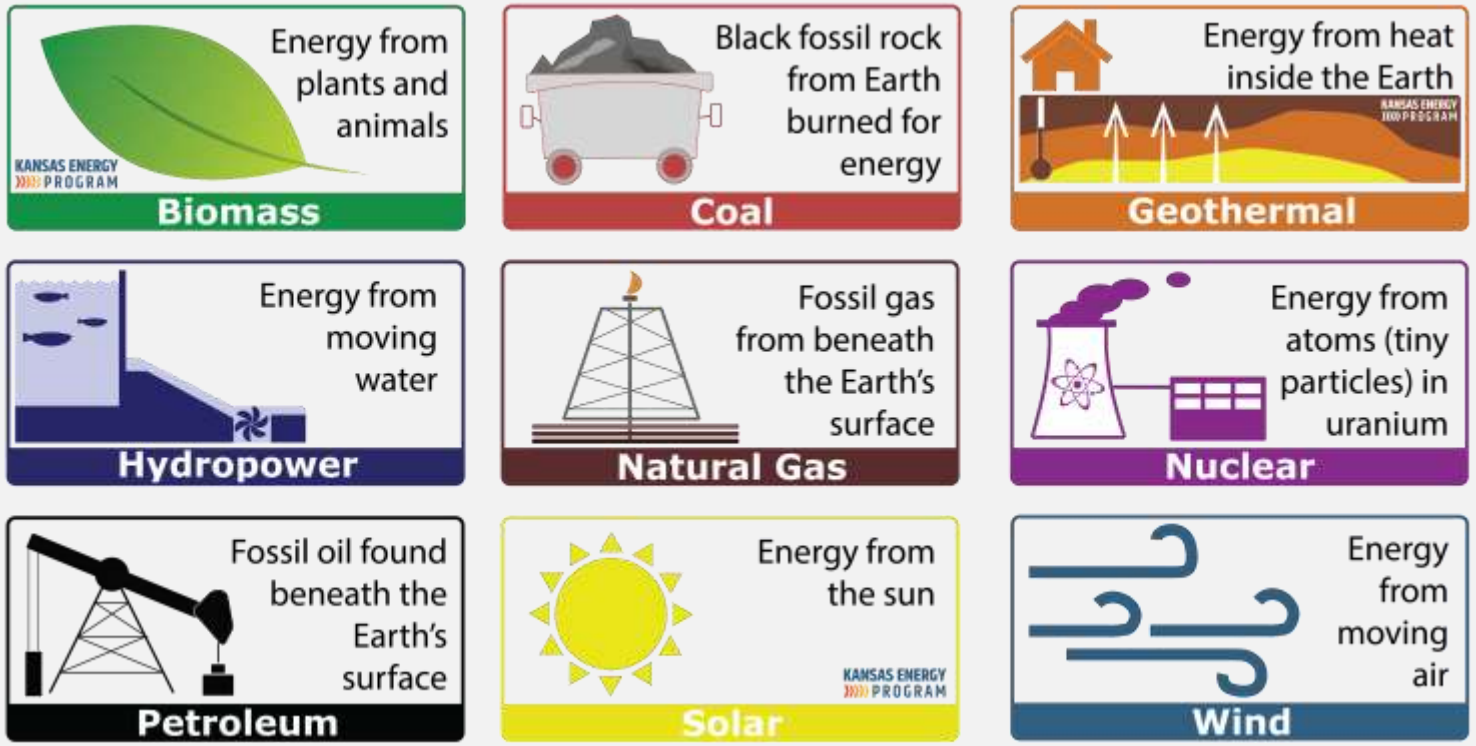
Break Time!



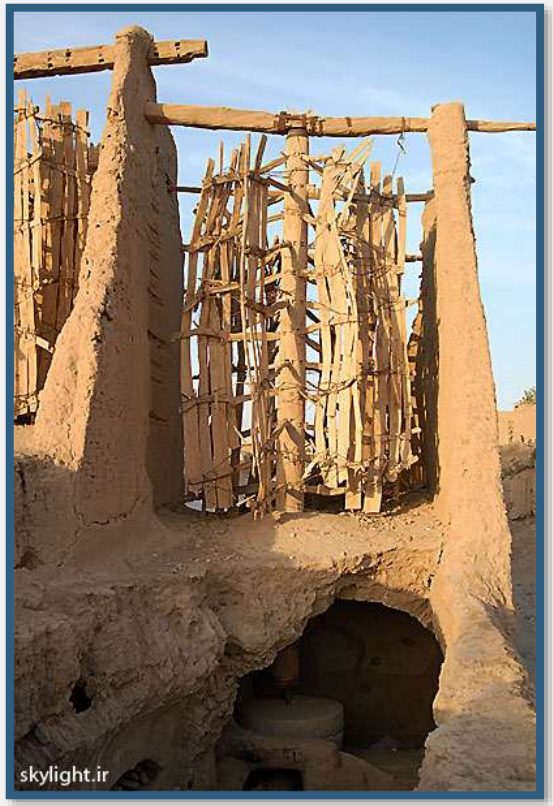
Renewable Energy:
MacGyver Windmill Challenge

Energy Resources

- Nine major sources of energy we use today
- Most current KEP resources are focused on wind
- More are in development!

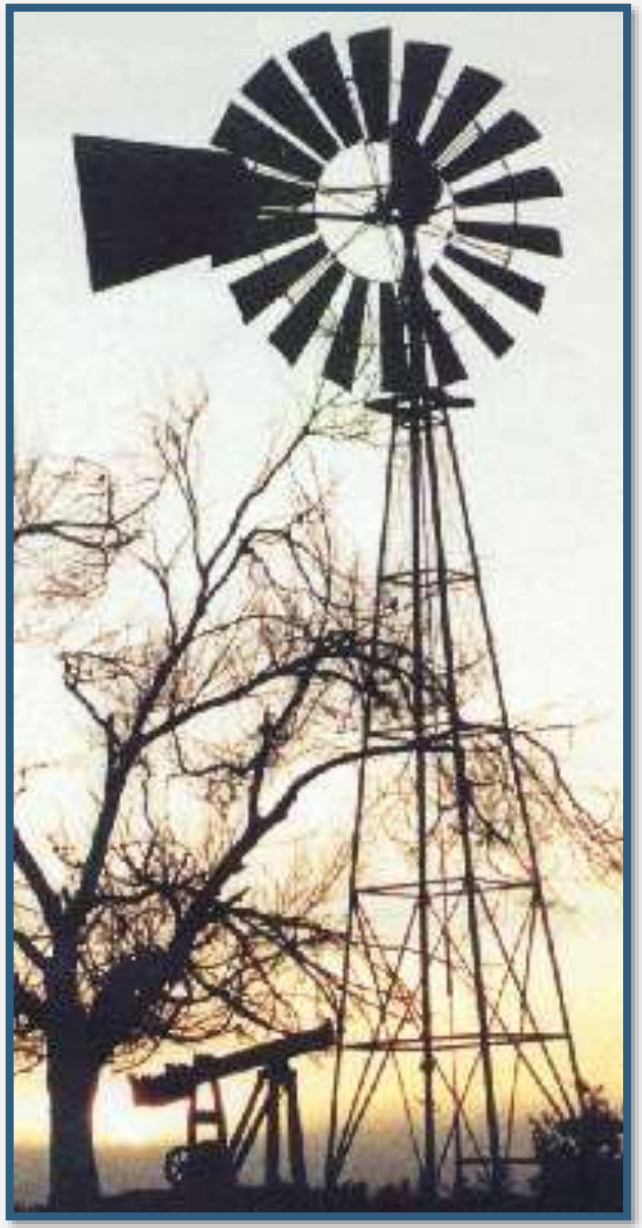


How did humans first harness wind energy?









What is the difference between a windmill and a wind turbine?

MacGyver Challenge

- Great intro activity for older students or as a lower primary-level activity.
- How-to video at: https://youtu.be/buwLFg7nVrE?si=C0nzSrurBacqlBHH
- View the curriculum from KidWind at https://kidwind.org/activity/macgyver-windmills/
- Supplies and support available



MacGyver Challenge

- **Lesson Overview:** Students design, build, and test windmills using everyday materials to explorehow energy is transferred from wind to mechanical motion.

- **Objectives:**
- Design and construct a function windmill using common materials.
- Test and analyze how variations in blade design and friction influence windmill performance.
- Calculate the energy (joules) and power (watts) produced by windmills.
- Explain the relationship between windmill models and real-world renewable energy systems.

- **Standards:** HS-PS3-3, HS-PS3-5, HS-ETS1-2, HS-ETS1-3, HS-ESS3-4.

- **Lesson Length:** 2 class periods (45-60 minutes each)

- **How to use the Glossary:** Words highlighted in green are found in the Glossary. InPresenter/Slideshow mode, hover your mouse over the word to see its definition or click on theword to jump to the Glossary section. You can use the Table of Contents icon at the bottom of theslide to quickly jump between sections.

Lunch and Discussion

Discussion Question

What challenges do you anticipate students having with these concepts?

Discussion Question

Now that you've built a wind turbine, in what aspects do you think your students would excel?

Where would they need more guidance?

Discussion Question

Which wind energy vocabulary terms might be tricky for your students — or even for you to explain clearly?

What vocabulary would you intentionally front-load before beginning a wind unit?

Discussion Question:

What is your single biggest takeaway from today?

Discussion Question

How could you scaffold students in interpreting inconclusive or messy data?

Discussion Question

What strategies or classroom activities do you use to help students build presentation confidence?

How do you coach students to explain their design and data clearly — not just show the finished product?

Engineering & Problem Solving

Phenomenon-based Learning

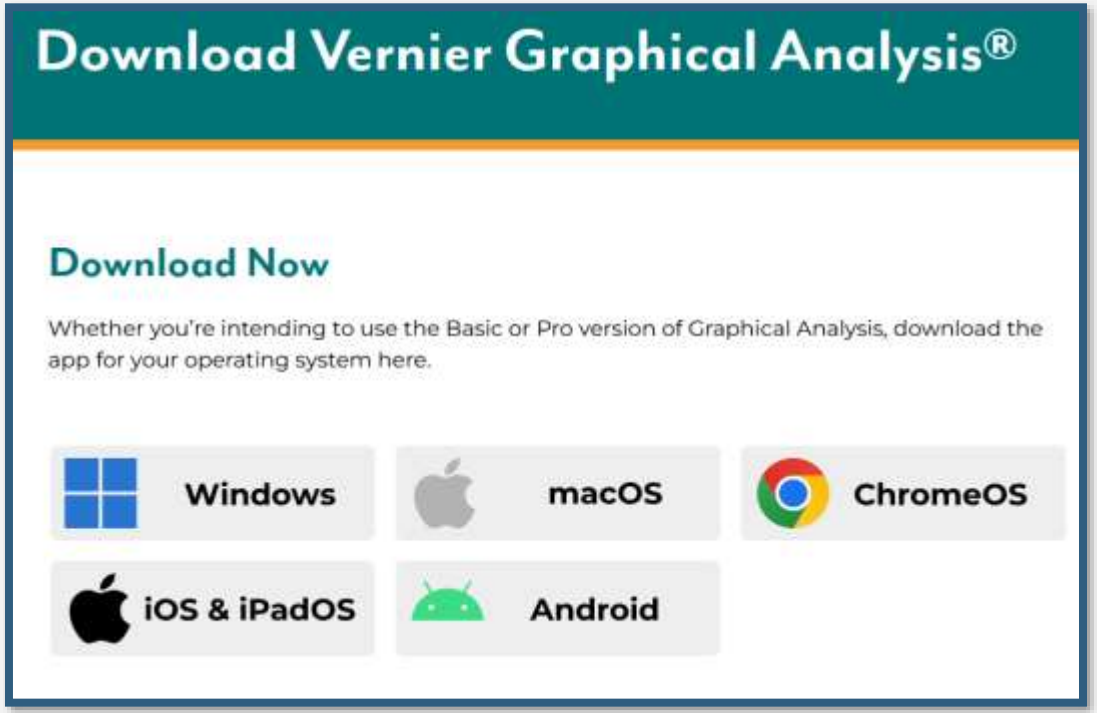
Turbine Testing

Now it is time to build and test your turbine!

- Use the Data Collection Handout
- Try different variables (blades, gear ratio, etc.)
- Repair Kit available
- Winner gets a prize!



Vernier Graphical Analysis

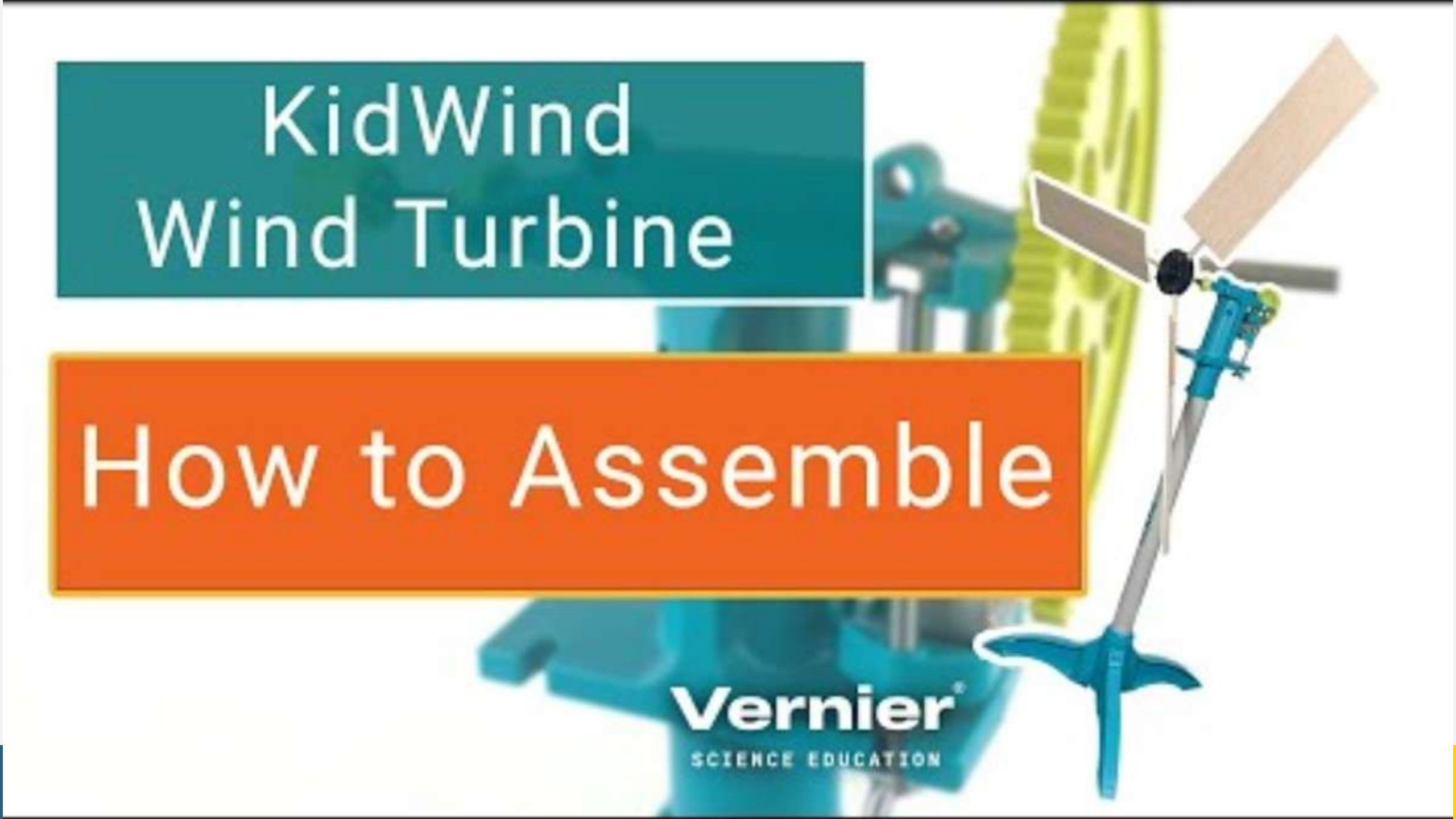


Download app:
https://www.vernier.com/downloads/graphical-analysis/

Instructions on how to use app and energy sensor:
https://kansasenergyprogram.org/educators/kansas-energy-programs-equipment-library/inventory/vernier-godirect-energy-sensor

KidWind Wind Turbine

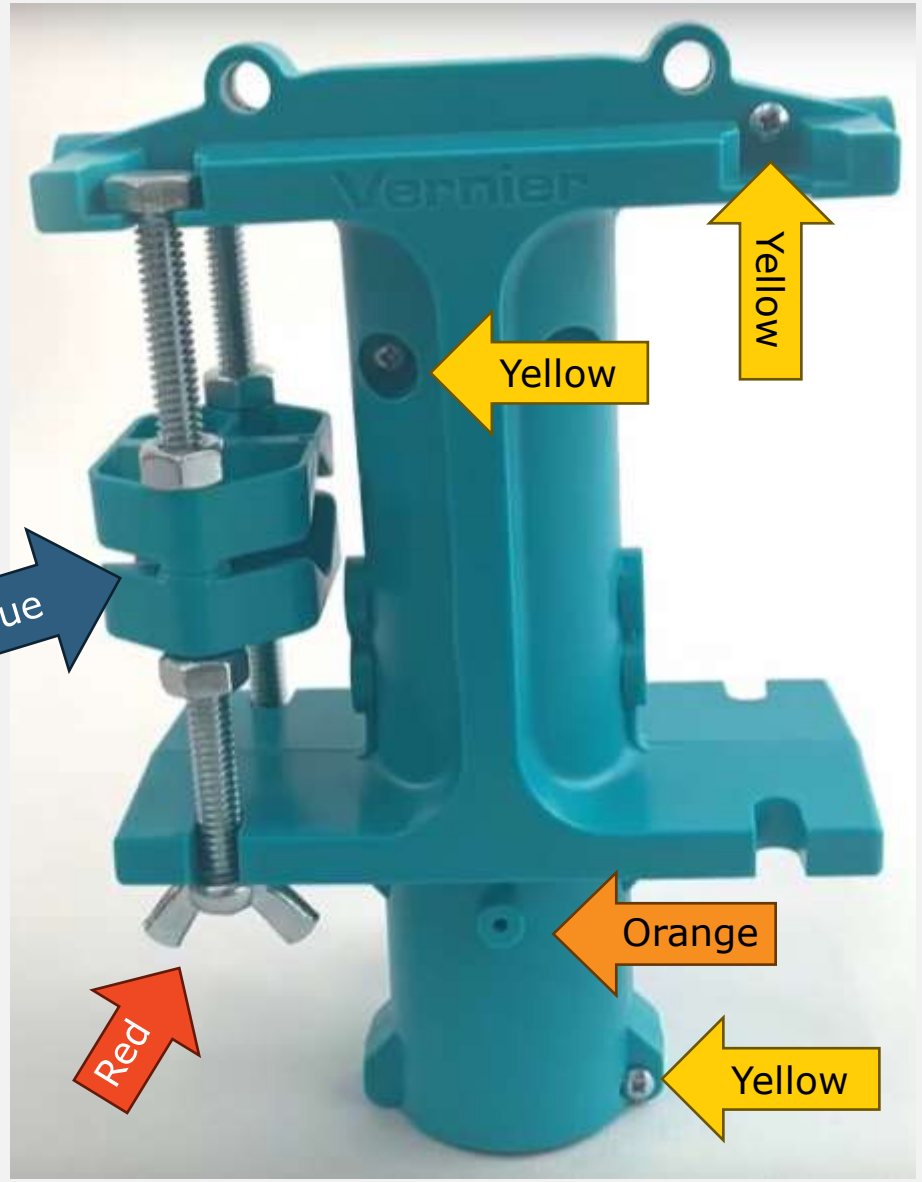
How to Assemble



Vernier®
SCIENCE EDUCATION

Nacelle-Building Tips

- Screwing the two halves of nacelle together only needs completed once *(yellow arrows)*.
- Don't overtighten wing nuts *(red arrow)*.
- Use optional set screw to keep nacelle from rotating on tower *(orange arrow)*.
- Why do you think height of the generator holder is adjustable? *(blue arrow)*



Turbine Examples





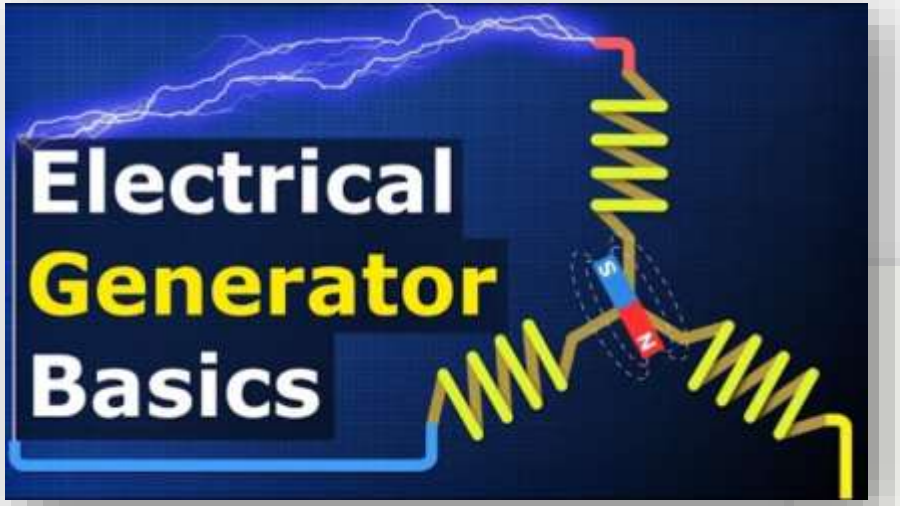


What Gear Did You Choose?



What happens if you choose a driver gear with more or less teeth?

What Does the Inside of a Generator Look Like?





Pitch Perfect



Use the pitch tool to ensure turbine blades are all at a consistent angle (or pitch).

KidWind & K-12 Energy Benchmarking

STEM projects developing skills for a technical career.

What is KidWind?



Basic Competition Overview

Form teams (typically 3-5 students) in three divisions *(4th-5th, 6th-8th, or 9th-12th grade)*

Students design and build a wind turbine, learn about energy, and prepare a presentation

Optional: Host a Challenge at Your School

Attend a 1-day regional KidWind Challenge (four competition areas)

Winners advance to State and World Challenges

Benefits of KidWind

- NGSS-Aligned Science and Engineering standards
- Career connections
- Project-based
- Compete with peers in a supportive environment
- Students learning and using soft skills
- Support from KEP (events, resources, equipment, reimbursements)

Four Parts in Photos



Judges Panel

Instant Challenge





Knowledge Quiz

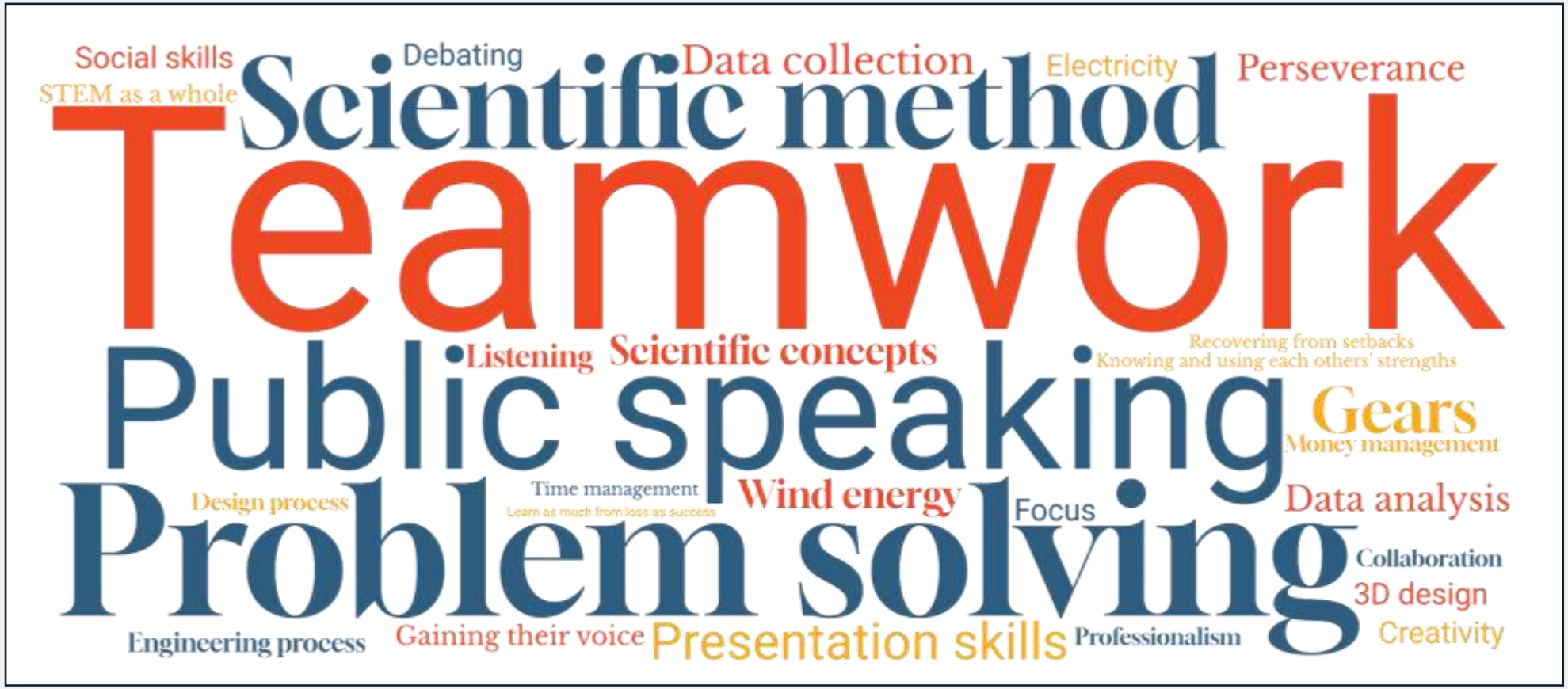
Turbine Performance



How Points Are Scored



What your students will learn through KidWind



(based on feedback from 2025 KidWind teachers/coaches)

KidWind Rules and Logistics

Visit the KidWind Resources page and look for the “Rules, Logistics, and Tips” section.



https://kansasenergyprogram.org/educators/kidwind-challenge/kidwind-challenge-resources

Opportunities Are All Around!

STEM-Focused Classes

Career & Technical Education

Clubs & Competitions

Job Shadowing & Internships

Dual Credit or Technical College Courses



Many Energy Educational Opportunities in Kansas

- **Colby Community College** – Wind Technology, Solar Photovoltaic
- **Cloud County Community College** – Wind, Solar, Blade Repair, Substations, Drones
- **Hutchinson Community College** – HVAC, Industrial Electrical Tech, Industrial Mechanical Maintenance, Renewable Energy Technology, Welding, Automation Engineer
- **Johnson County Community College** – Automation Engineer, Data Analytics, Electrical/Electronics, HVAC
- **Kansas City KS Community College** – Electrical Technology, Electronics Engineering Technology, Env. Studies, HVAC, High Voltage Line Tech
- **Manhattan Area Technical College** – Electric Power & Distribution, HVAC, Welding, Industrial Maintenance Technology
- **K-State** – Engineering, Agriculture, Chemistry, Education
- **KU** – Law (Env, Energy, Natural Resources), Engineering, Chemistry

K-12 Energy Benchmarking

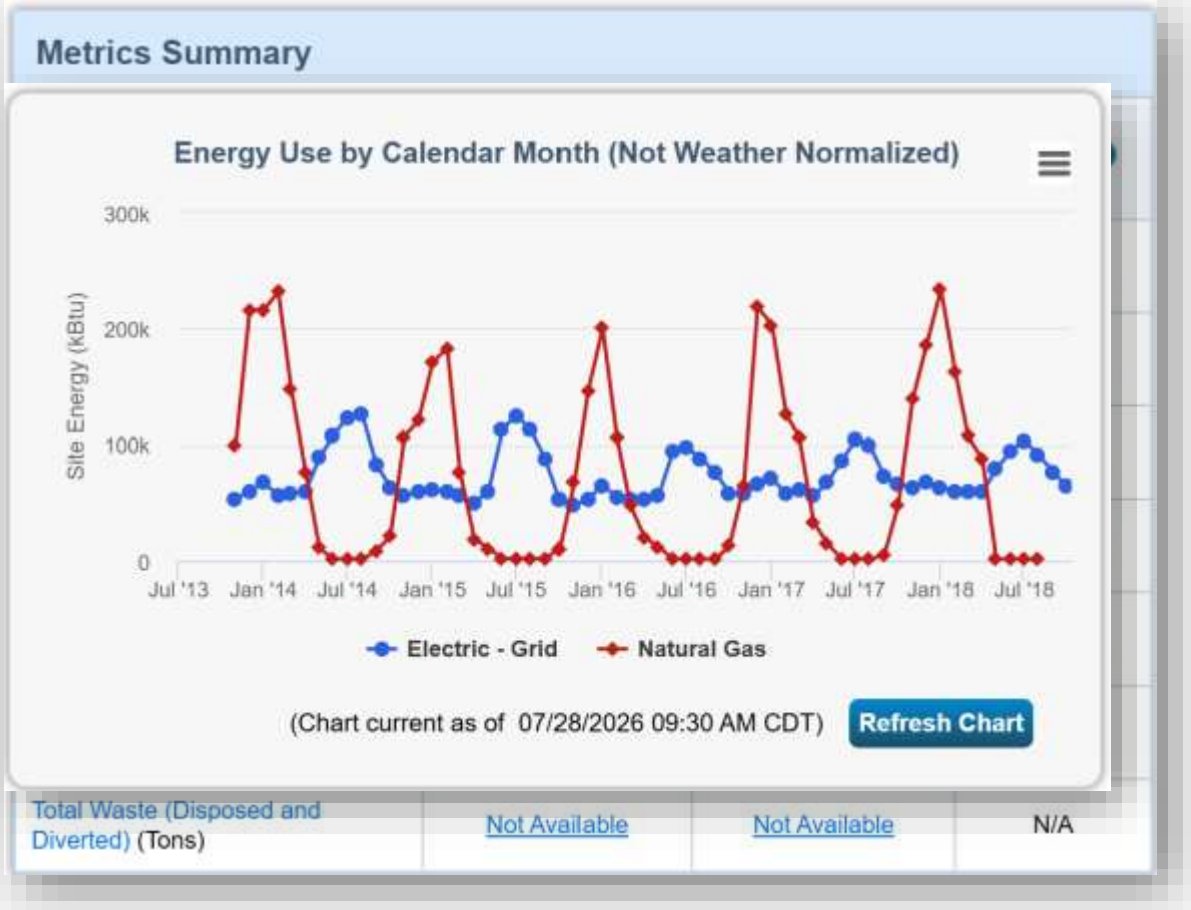


What is Energy Benchmarking?

- Measurement and tracking of energy use in your building, compared to energy use in similar buildings
- K-12 school districts spend over $8 billion nationwide on energy costs each year
- More than 30% of energy use goes to waste
- Up to 10% can be saved through low-cost measures

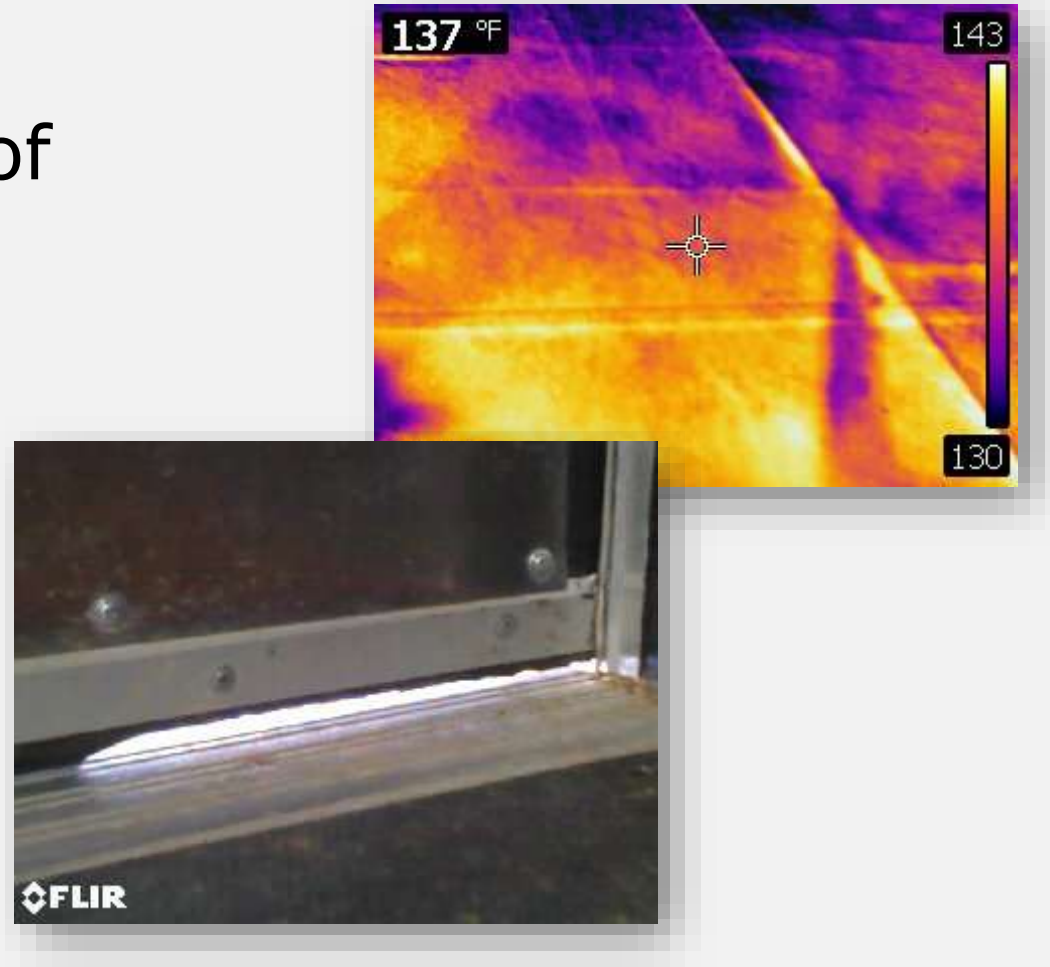
K-12 Energy Benchmarking Project

- Student-led project to investigate energy use in the school
- KEP gathers school utility and facility data to benchmark in ENERGY STAR Portfolio Manager



Student Energy Audit

- Students work through a series of lessons to learn about energy
- Project ends in a student energy audit of one or multiple systems in the school building (lighting, building envelope, electrical appliances)



Benchmarking Educational Consultants

Earn $750!

Wrap Up

- Workshop Survey *(online or paper)*
- PD Hours Form
- Travel/Substitute Reimbursement Form
- W-9 Form

The following slides are available as a resource for you

KEP Resources

- Many of KEP's activities and equipment focus on real-world issues or problem solving while encouraging data collection and analysis.
- They are adaptable for different ages and skill levels.
- There is often no one "right answer" but encourage students to explore and improve.
- This afternoon we'll focus on two of these and you'll later learn more about KidWind and K-12 Energy Benchmarking

Light Box




By the Numbers
Light bulb in a typical Kansas home: 50
Your Electric Bill
Lighting accounts for 10% to 12%
Westar Energy
INCANDESCENT
BULB LIFE 1,000 HOURS
CFL
BULB LIFE 6,000 TO 8,000 HOURS
LED
BULB LIFE 25,000 TO 50,000 HOURS
CAUTION HOT
DO NOT TOUCH LIGHT BULBS
W
WATT METER

Light Box – Many Add-ons

- Don't limit students to just testing light bulbs.
- Calculate how much coal is consumed.
- Use EPA tools to calculate emissions and pollutants associated with electricity use.
- Life cycle cost
- How the US energy grid is used. Discuss the Southwest Power Pool and its generation mix.

Handcrank Generators



Students get to feel how much energy it takes to power an incandescent vs. LED light bulb. This is a great follow-up to the light box!

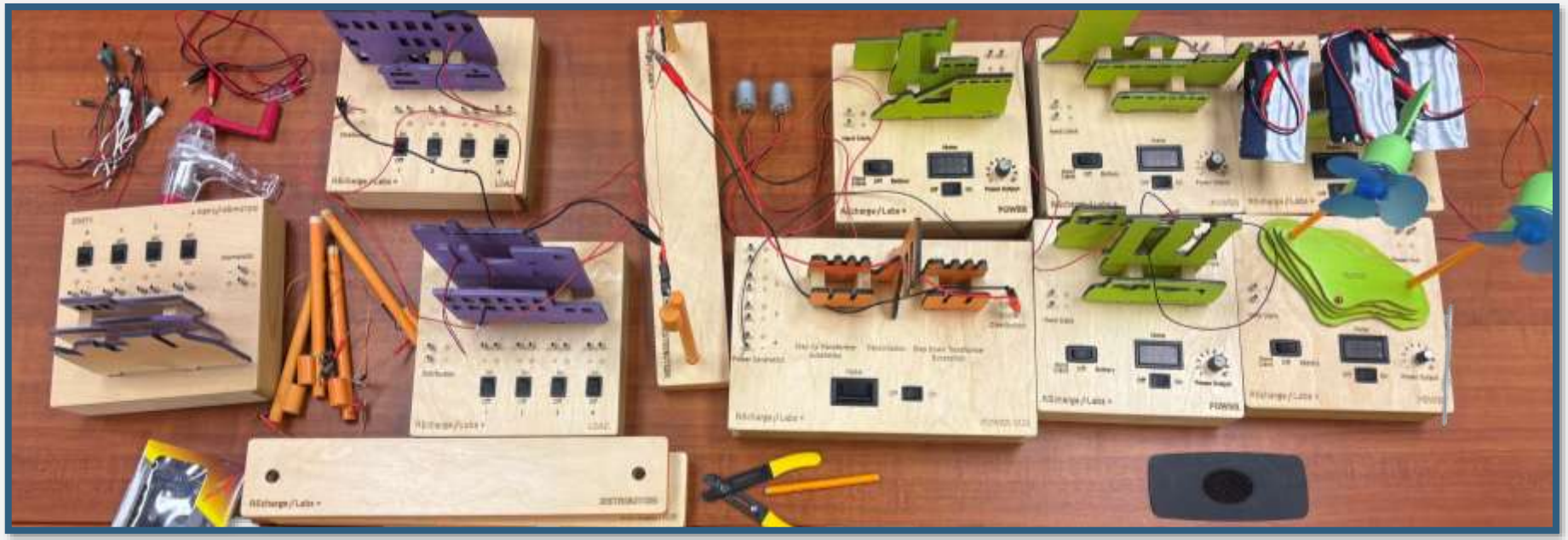
Breakout Rooms

- Energy Auditing
- Energy Efficiency
- More in development!



Power Grid

The power grid is a demonstration of the network that delivers electricity from power plants to homes, schools, and businesses. ***Currently available by request.***



Power Grid Overview Video

Gear Ratio Kit

Students create different gear ratios and evaluate which ratio would benefit electricity production the most.



https://kansasenergyprogram.org/educators/activities-and-curricula/gear-ratio-activity

Energy Sticks

An energy stick is a hands-on tool that shows how electricity flows through a complete circuit. When the circuit is closed, the stick lights up and buzzes, helping students explore basic electrical concepts.



Currently available by request.

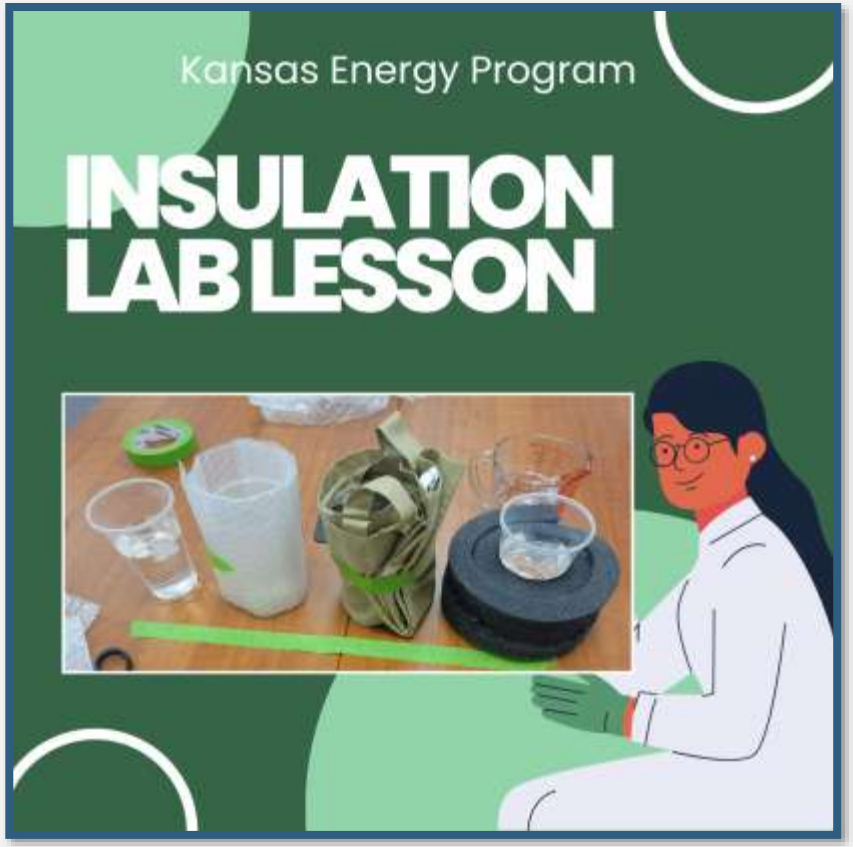
Energy Stations

Students move from one energy station to another to learn about different forms of energy and energy transformations.

https://kansasenergyprogram.org/educators/kansas-energy-programs-equipment-library/inventory/energy-stations-kit



Insulation Lab



Students will use scientific tools to conduct an investigation on thermal energy. Discuss conductors and insulators, state your claim, evidence, and reasoning and tell us the most efficient type of insulation material from your experiment!

https://kansasenergyprogram.org/educators/activities-and-curricula/insulation-lab-lesson

National Energy Education Development (NEED)

- Many types of energy-related curricula are available. No cost, but you do need to add lessons to your cart
- Some NEED kits that require equipment are available through KEP

https://www.need.org/shop/

Wind-Powered Sailcar Activity

- Great intro activity for older students or as a lower primary-level activity.
- Watch our how-to video at: www.youtube.com/watch?v=ieFaGsl8tww
- View the curriculum at https://kidwind.org/activity/sail-cars/
- Supplies and support available



Fireflies

Students make the blades for a small wind turbine that captures kinetic energy from moving air, converts it into mechanical rotation, and then into electrical energy that can power a small LED or other low-power device.

https://kansasenergyprogram.org/educators/kansas-energy-programs-equipment-library/inventory/firefly-kit



Build the Turbine

Students work in teams to “build” a wind turbine by rotating through challenge stations, learning turbine parts, and drawing a labeled turbine by the end.

https://kansasenergyprogram.org/educators/activities-and-curricula/build-turbine-activity



Build Your Own Generator

The simpleGEN is an easy-to-build generator that allows students to explore the basics of electrical generator design.



Currently available by request.

Be the Blade





Be-the-Blade Follow-Up Activity: Calculate wind tip speed

Assume 400’ rotor diameter (200’ radius); 10 revolutions per minute (10rpm)

$$Distance\ traveled\ (circumference)\ in\ one\ revolution = \pi\ x\ diameter \quad OR \quad 2\pi\ x\ radius$$

$$Distance\ traveled\ per\ revolution = \pi\ x\ 400\ feet = 1{,}256.6\ feet$$

$$\frac{10\ revolutions}{1\ minute}\ x\ \frac{1{,}256.6\ feet}{1\ revolution}\ x\ \frac{1\ mile}{5{,}280\ feet}\ x\ \frac{60\ minutes}{1\ hour} = 143\ \frac{miles}{hour}$$

https://kansasenergyprogram.org/educators/activities-and-curricula/be-blade-activity

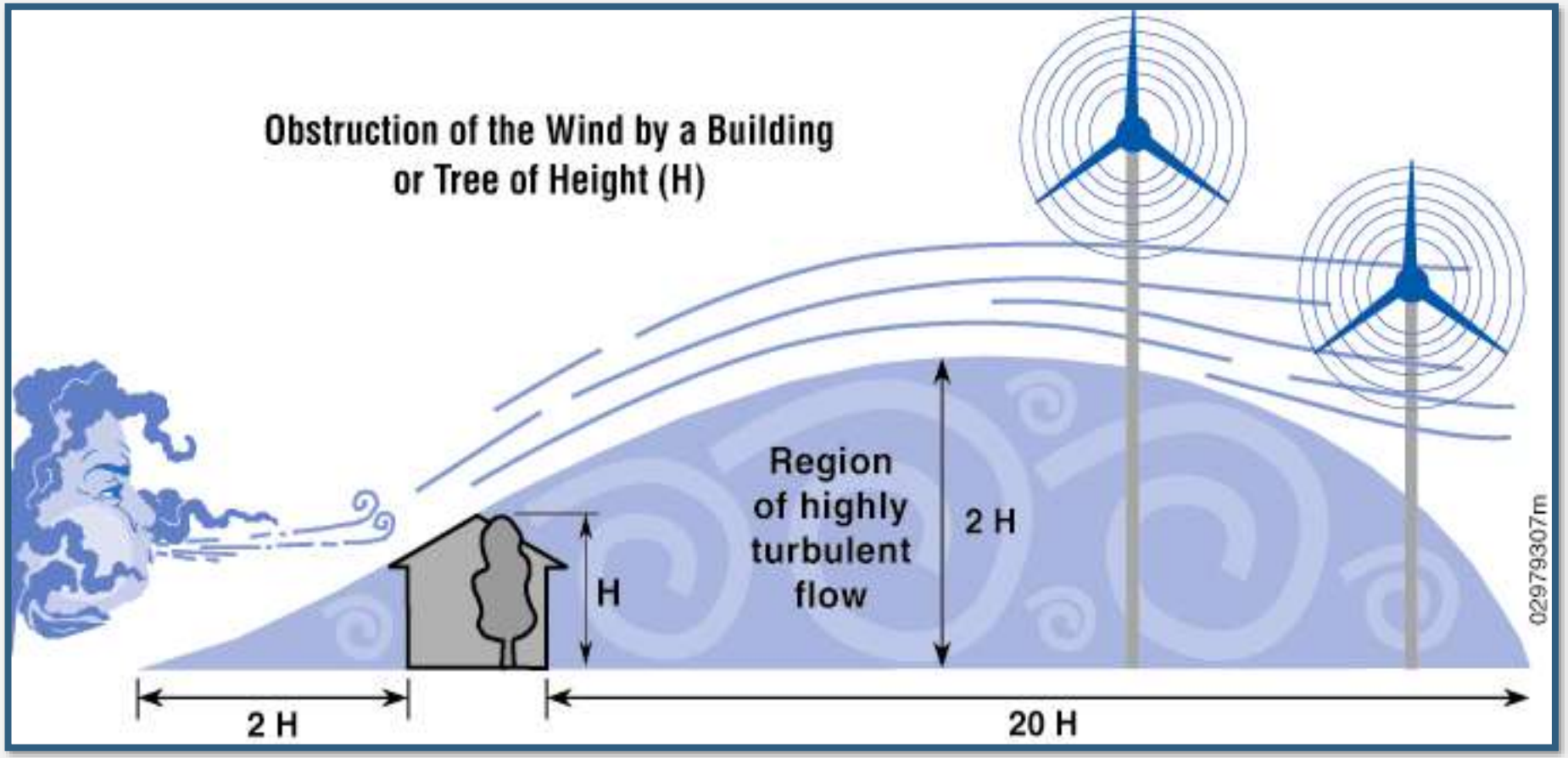
Go the Distance





https://kansasenergyprogram.org/educators/activities-and-curricula/measure-distance-activity

Why are Wind Turbines so tall?



Activity Demo Tables

We have set up different tables with materials and QR codes to our lesson plans like:

- Sail cars
- MacGyver
- Fireflies
- Build a Turbine





Other Resources about Wind As a Resource

- Wind farm locations: https://eerscmap.usgs.gov/uswtdb/viewer/#7.18/38.514/-98.32
- Wind turbines in Kansas and U.S: https://energy.usgs.gov/uswtdb/data/
- Kansas state energy profile: https://www.eia.gov/state/?sid=KS
- Wind energy in Kansas: https://www.energy.gov/cmei/systems/windexchange/maps-and-data?keywords=kansas
- NEED Project (energy curricula): https://www.need.org/educators/

Geothermal Energy

This kit is designed for high school earth science to help students learn about geothermal energy generation and surface area and heat transfer.



https://kansasenergyprogram.org/educators/kansas-energy-programs-equipment-library/inventory/carolina-stem-challenge-geothermal-kit

Hydropower Kit

6th-8th grade students can explore kinetic and potential energy, hydroelectricity generation, and hydropower with this kit!



https://kansasenergyprogram.org/educators/kansas-energy-programs-equipment-library/inventory/need-project-energy-moving-water-kit

Solar Energy

- Equipment
  - Vernier Solar Thermal Exploration Kit
  - Vernier Solar Energy Kit
  - Solar Panel System
- Activities
  - Exploring Photovoltaic Cells

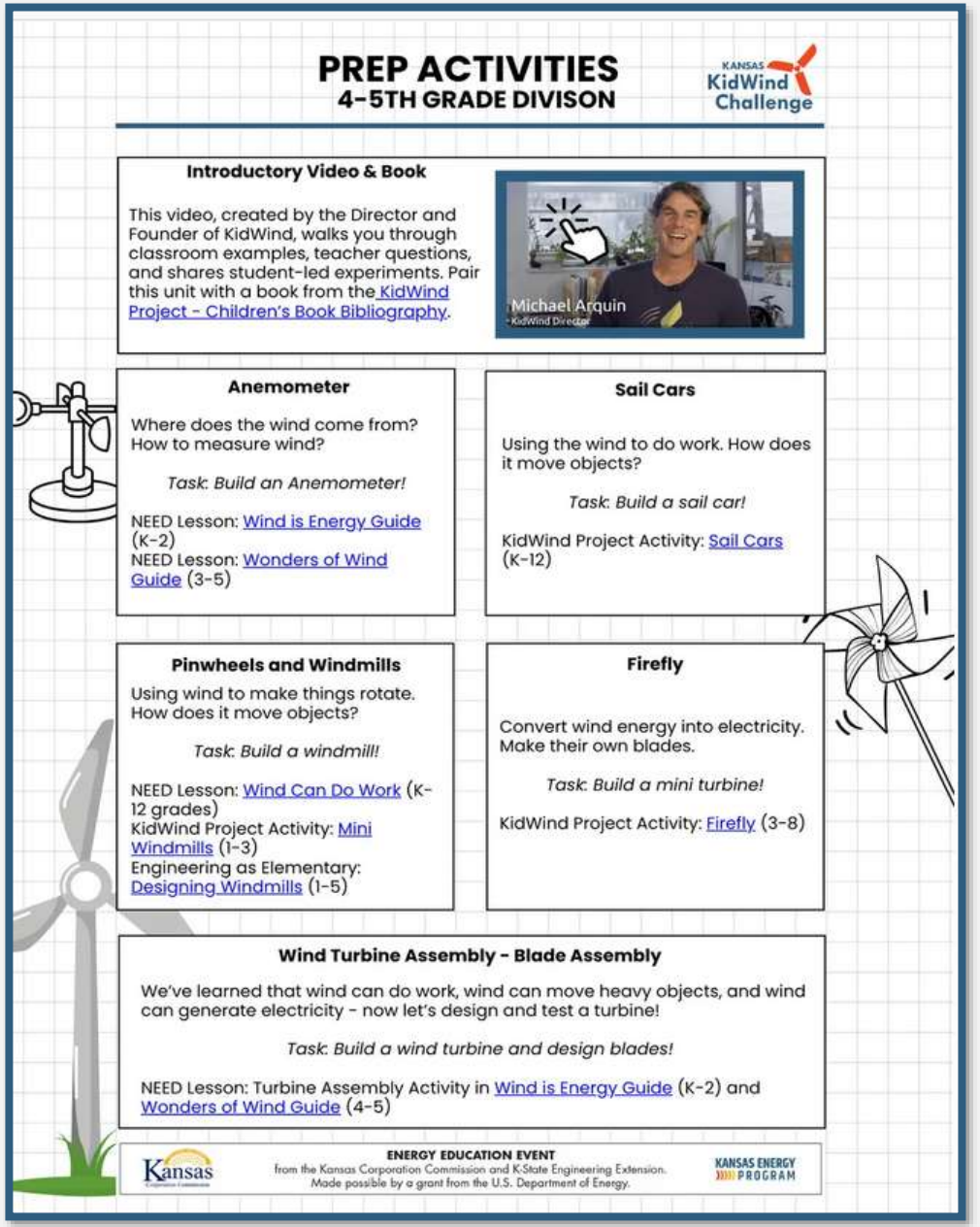
More to come!



Where to start with wind energy?

One-page "Prep Activities" by age division is available to help you get started!

https://kansasenergyprogram.org/educators/activities-and-curricula/kidwind-challenge-prep-activities



KEP's Wind Energy Resources

- Find nearly everything on the KidWind Resources page
  - https://kansasenergyprogram.org/educators/kidwind-challenge/kidwind-challenge-resources
- We are also creating a wind energy unit – stay tuned!



KidWind Challenge Details and Logistics

Who can participate?

- Any student in the 4th-12th grade.
- There is no restriction on team size, but 3 to 5 students per team is recommended.
- Teams can come from public schools, home schools, after-school clubs, etc.
- Teams need to have an adult (coach) with them at the event (one adult per 10 students).

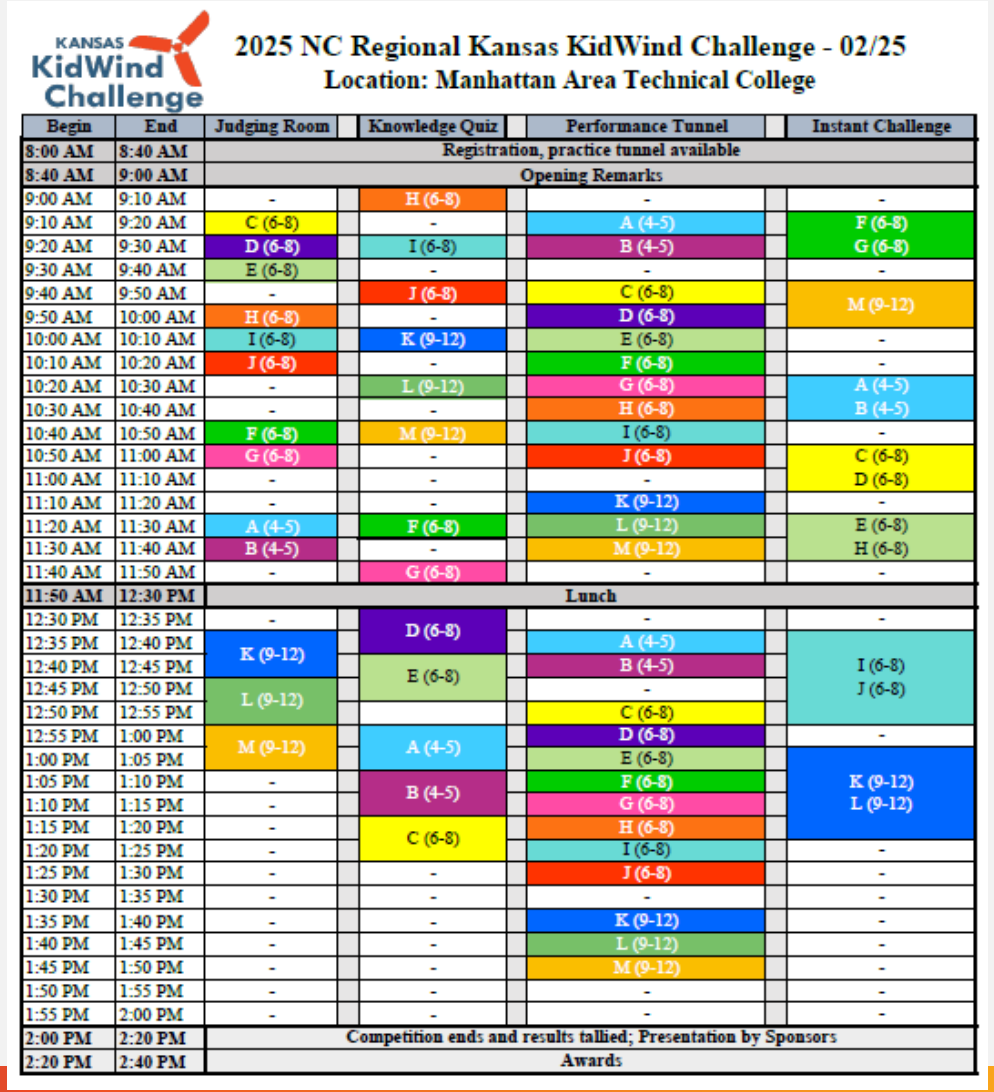
What does it cost?

- No cost! *(only supplies to build the turbine)*
- Only required part is a KidWind Generator from Vernier
  - 3-pack is $25 or 10-pack is $69
  - We can provide one generator/team
- Mileage reimbursement and stipends for teacher substitutes are available.
- Lunch is provided at each event.

How to Incorporate KidWind?

- Some teachers kick off lessons after winter break and spend a couple weeks on the project; others start in the fall and then come back to it in January/February.
- Some teachers will use the KidWind Challenge as a capstone project for students.
- Teachers can host an internal competition to decide who will attend a regional Challenge *(more on this later).*
- Many resources available *(more on this later)*

What does the day look like?



KANSAS KidWind Challenge

2025 NC Regional Kansas KidWind Challenge - 02/25
Location: Manhattan Area Technical College

Begin	End	Judging Room	Knowledge Quiz	Performance Tunnel	Instant Challenge
8:00 AM	8:40 AM	Registration, practice tunnel available			
8:40 AM	9:00 AM	Opening Remarks			
9:00 AM	9:10 AM	-	H (6-8)	-	-
9:10 AM	9:20 AM	C (6-8)	-	A (4-5)	F (6-8) G (6-8)
9:20 AM	9:30 AM	D (6-8)	I (6-8)	B (4-5)	
9:30 AM	9:40 AM	E (6-8)	-	-	-
9:40 AM	9:50 AM	-	J (6-8)	C (6-8)	M (9-12)
9:50 AM	10:00 AM	H (6-8)	-	D (6-8)	
10:00 AM	10:10 AM	I (6-8)	K (9-12)	E (6-8)	-
10:10 AM	10:20 AM	J (6-8)	-	F (6-8)	-
10:20 AM	10:30 AM	-	L (9-12)	G (6-8)	A (4-5) B (4-5)
10:30 AM	10:40 AM	-	-	H (6-8)	
10:40 AM	10:50 AM	F (6-8)	M (9-12)	I (6-8)	-
10:50 AM	11:00 AM	G (6-8)	-	J (6-8)	C (6-8) D (6-8)
11:00 AM	11:10 AM	-	-	-	
11:10 AM	11:20 AM	-	-	K (9-12)	-
11:20 AM	11:30 AM	A (4-5)	F (6-8)	L (9-12)	E (6-8) H (6-8)
11:30 AM	11:40 AM	B (4-5)	-	M (9-12)	
11:40 AM	11:50 AM	-	G (6-8)	-	-
11:50 AM	12:30 PM	Lunch			
12:30 PM	12:35 PM	-	D (6-8)	-	-
12:35 PM	12:40 PM	K (9-12)		A (4-5)	I (6-8) J (6-8)
12:40 PM	12:45 PM		E (6-8)	B (4-5)	
12:45 PM	12:50 PM	L (9-12)		-	
12:50 PM	12:55 PM			C (6-8)	
12:55 PM	1:00 PM	M (9-12)	A (4-5)	D (6-8)	-
1:00 PM	1:05 PM			E (6-8)	K (9-12) L (9-12)
1:05 PM	1:10 PM	-	B (4-5)	F (6-8)	
1:10 PM	1:15 PM	-		G (6-8)	
1:15 PM	1:20 PM	-	C (6-8)	H (6-8)	
1:20 PM	1:25 PM	-		I (6-8)	-
1:25 PM	1:30 PM	-	-	J (6-8)	-
1:30 PM	1:35 PM	-	-	-	-
1:35 PM	1:40 PM	-	-	K (9-12)	-
1:40 PM	1:45 PM	-	-	L (9-12)	-
1:45 PM	1:50 PM	-	-	M (9-12)	-
1:50 PM	1:55 PM	-	-	-	-
1:55 PM	2:00 PM	-	-	-	-
2:00 PM	2:20 PM	Competition ends and results tallied; Presentation by Sponsors			
2:20 PM	2:40 PM	Awards			

Staging Area





Practice Wind Tunnel

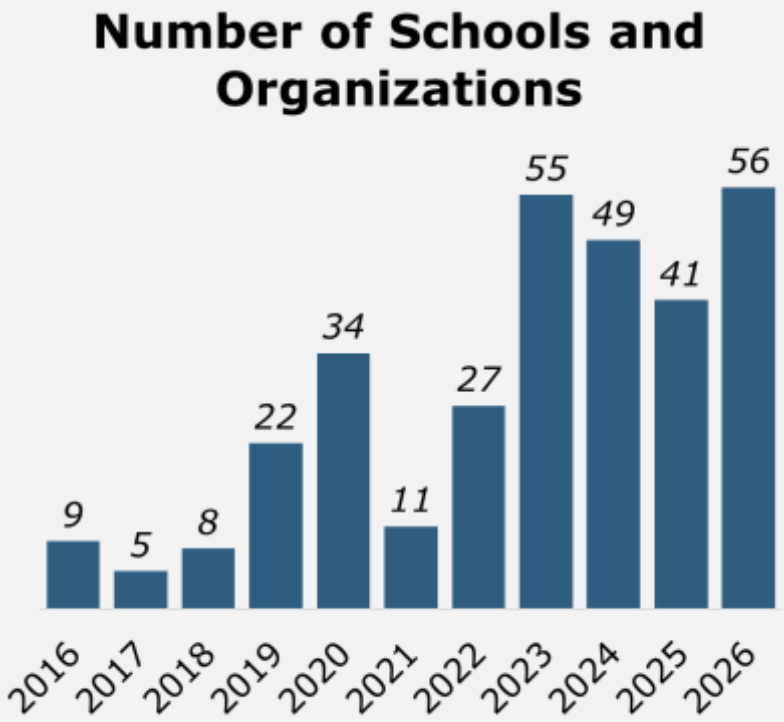


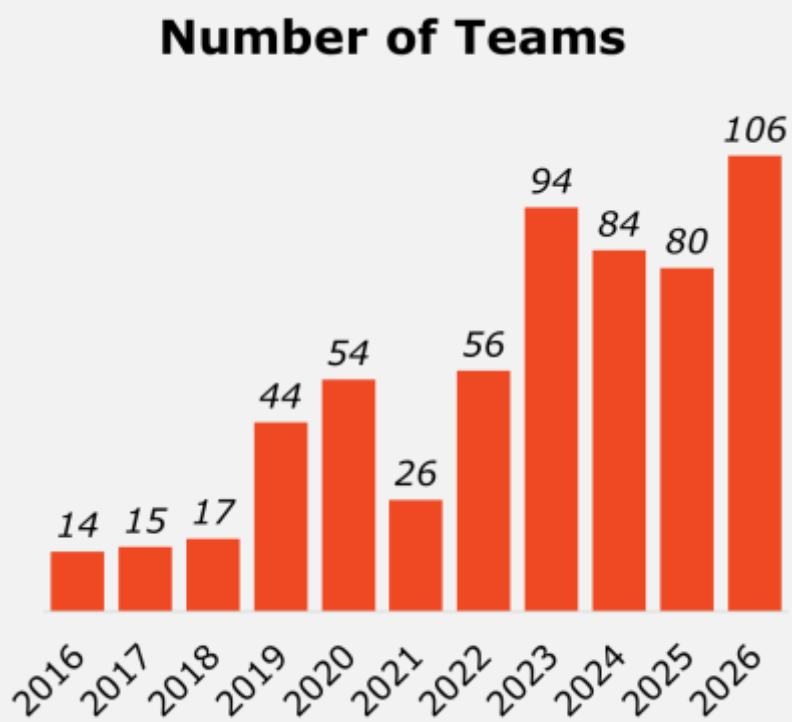


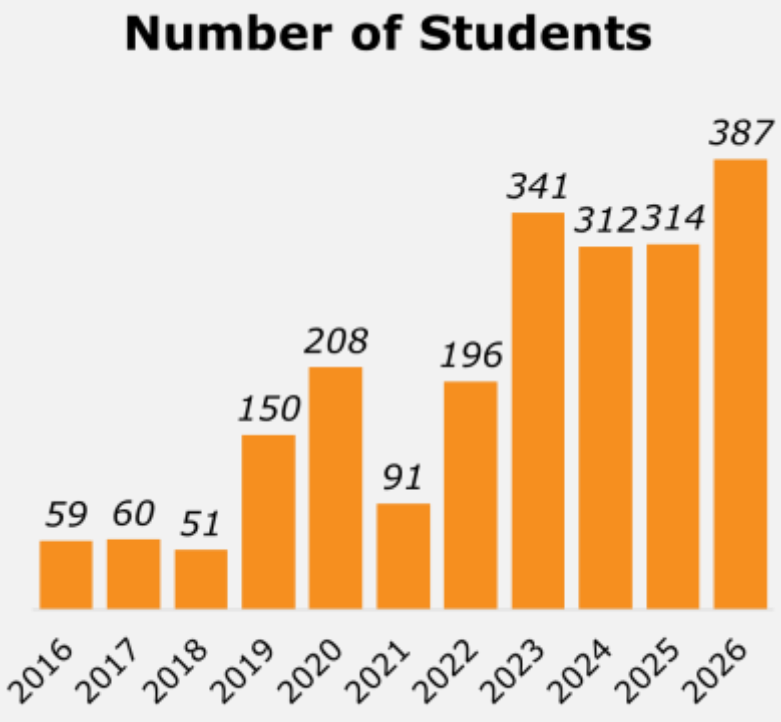
Internal Challenges

- If you want to involve an entire class or grade level, we recommend holding an internal challenge to decide the winning teams to attend regionals.
- We can provide resources and limited assistance (including sending 1-2 volunteers)

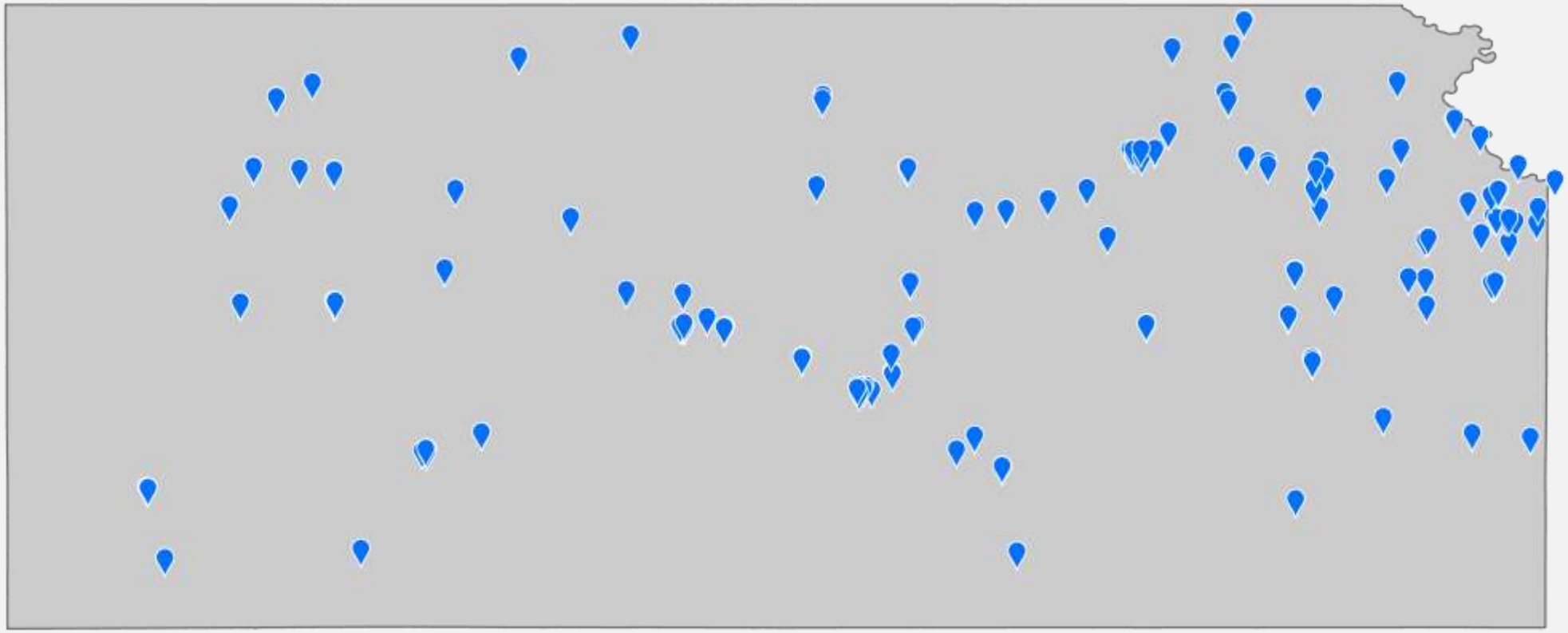
KidWind Over the Years







Who Participates?



More than 850 students participated in the KidWind Process in 2025 and more than 880 in 2026.

Regionals, State, Worlds - OH MY!

How to Register for Regionals *(2-part process)*

- **Initial Registration (by mid-December or until full):**
  - Contact info
  - Number and age division of teams (*NO details*)
  - Which Challenge you want to attend
  - *The third team in age division is automatically waitlisted*

- **Team-Info Registration (December-January)**
  - Names of students and teams
  - Dietary restrictions
  - Photo release forms

KidWind Timeline

Register
- Oct. 1 to mid-December: Register basic information and # teams
- Waitlisted teams announced mid-to late-December

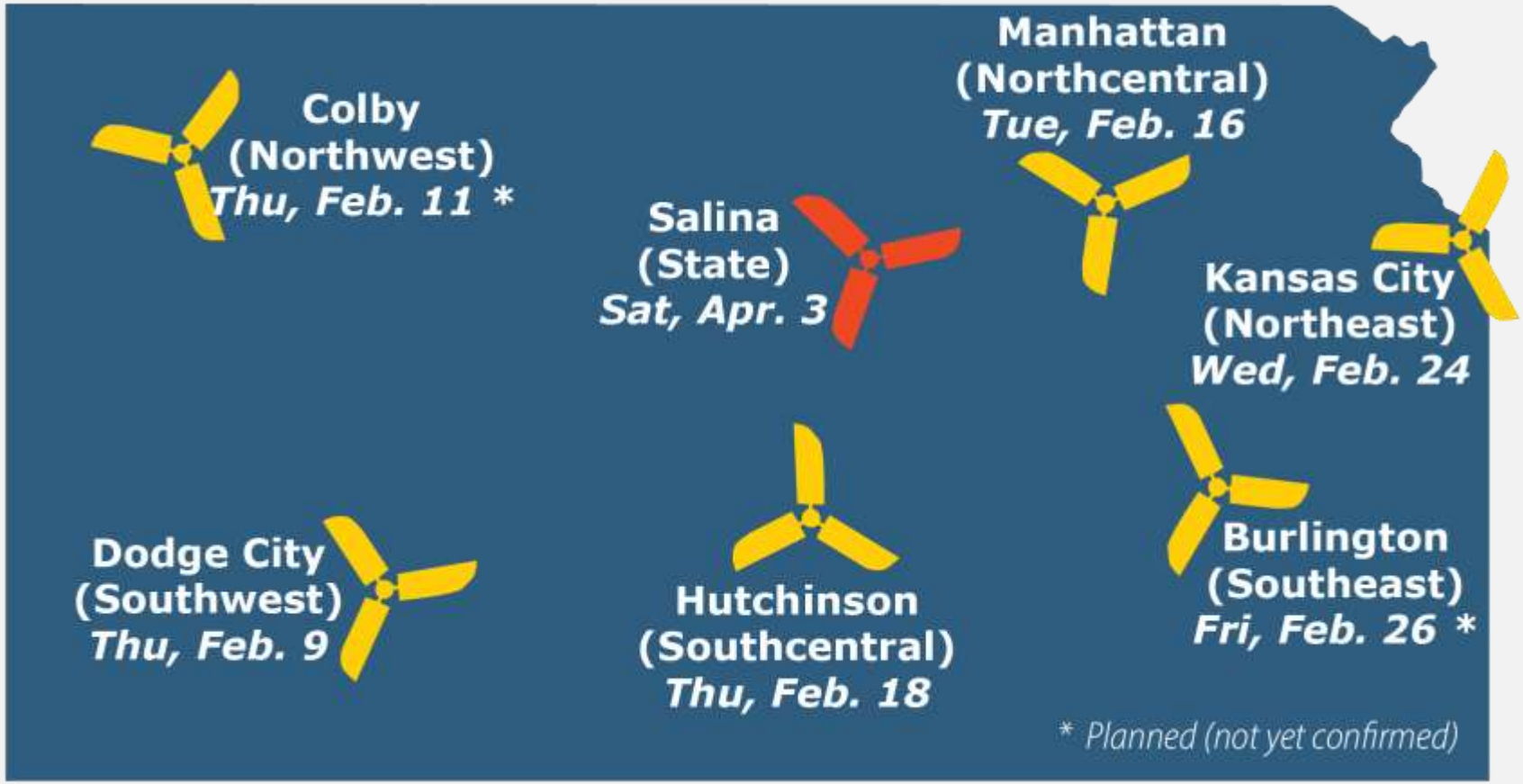
Prepare
- Throughout the fall and/or early spring semester, teams explore, design/build, and prepare (borrow a wind tunnel!)

Attend Regional
- February 2026: Regional events (map with locations and dates coming up). Top two teams in each age division advance.

Attend State
- April 3, 2026 (Sat) in Salina *(teams can totally redesign turbines if desired)*

Attend Worlds
- Typically held in early to mid-May. Details to come.

2027 KidWind Locations



You choose which to attend based on date and location.

NOTE: Each school is limited to 3 teams per age division maximum. You cannot send more than 3 teams by splitting between multiple challenges.

Miscellaneous

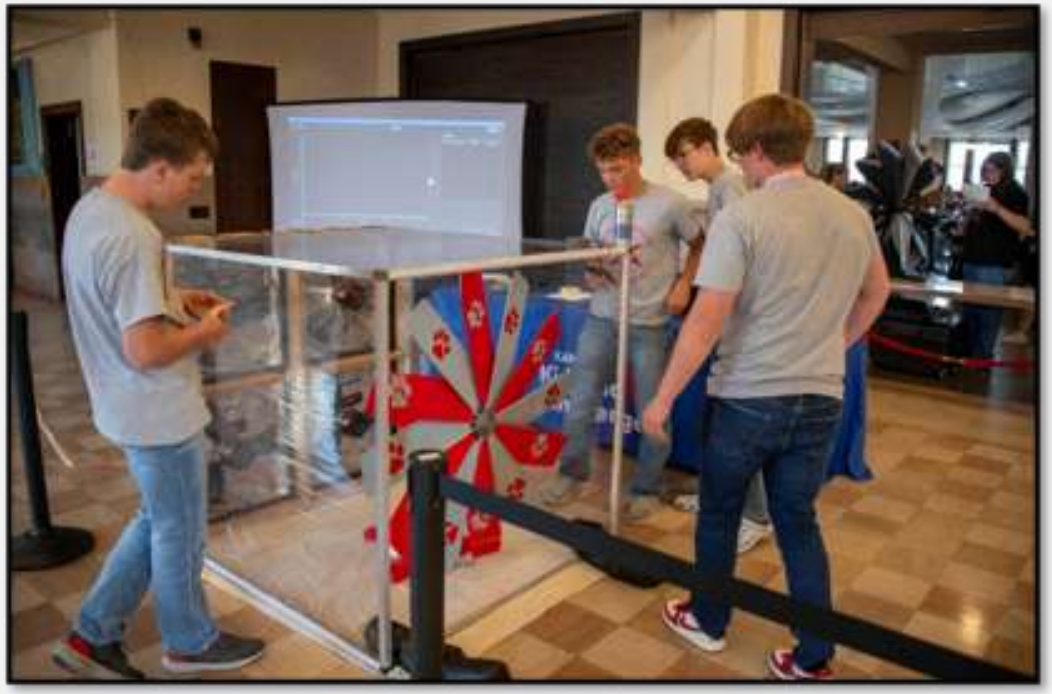
- Register as soon as you can (should open in Aug-Sep)
- Scoresheets – emailed approx. one week after the event
- Changes can be made from regionals to State to World



Turbine Performance Testing

Basic Turbine Performance Rules

- Each team must have its own turbine and base
- Turbines must fit inside wind tunnel (4’x4’, but leave some space)
- Each turbine must use the KidWind generator



Basic Turbine Performance Rules *(cont)*

- The turbine must be free-standing (has its own base and tower).
  - We will provide weights to help hold turbine in place.
- Power must be generated solely by wind (you cannot "help" get it started).
- You are allowed to use purchased parts (other than pre-made airfoils), but judges may award points for creativity and economical use of resources.
- Blades must be made of safe materials (avoid metal, plexiglass, or anything with sharp edges).

Basic Turbine Performance Rules *(cont)*

- When measuring power output from the turbine during the KidWind Challenge, it will be hooked up to a 30-ohm resistor to create a load, so don't forget to test it that way.
- Approximate wind speed in the tunnel is 3.5 meters/second (7.8 mph), so make sure to test your device for high winds.



Basic Turbine Performance Rules *(cont)*

- Scored based on amount of energy produced (in units of Joules) in a 30-second period
- The best 30-second run will be used for scoring; there is no penalty for a bad run.
- Read all the rules



Basic Terminology

- **Joule** – measure of energy (very small: Watt-second)
- **Watt** – instantaneous measure of power (Joule/second)
- **Kilowatt (kW)** – 1,000 watts
- **Kilowatt-hour (kWh)** – seen on electricity bills; measures energy use/production over time; 1 turbine producing 1 kW electricity for 1 hour produced 1 kWh
- **Megawatt (MW)** = 1 million watts (often used in reference to power generation plants)

Presentation *(Judges Panel)*

Judges Panel (40 points)

- No spectators, teachers, and parents are allowed
- Panel of 3-5 judges
- Total score is an average of each judge's score.
- 10 minutes total
  - Teams present (3-4 min)
  - Judges ask questions (4-5 min)



Presentation/Judges Panel *(cont)*

- Students bring turbine and documentation
  - Examples: short report, PowerPoint presentation, notebooks, booklets, poster boards, etc.
- The presentation should be about the students' design and build process and *not* be about wind energy in general.
- Be prepared if technology fails!



Knowledge Quiz

Knowledge Quiz Rules (10 points)

- Time: typically 10 minutes
- No electronic devices.
- Teams work together to answer multiple choice, true/false, & fill in the blank questions.
- Need accommodations? Please inform the event organizers.
- Review Games available.
- Adapted for each age division
- Use the study guide!



Instant Challenge

Instant Challenge Rules (10 points)

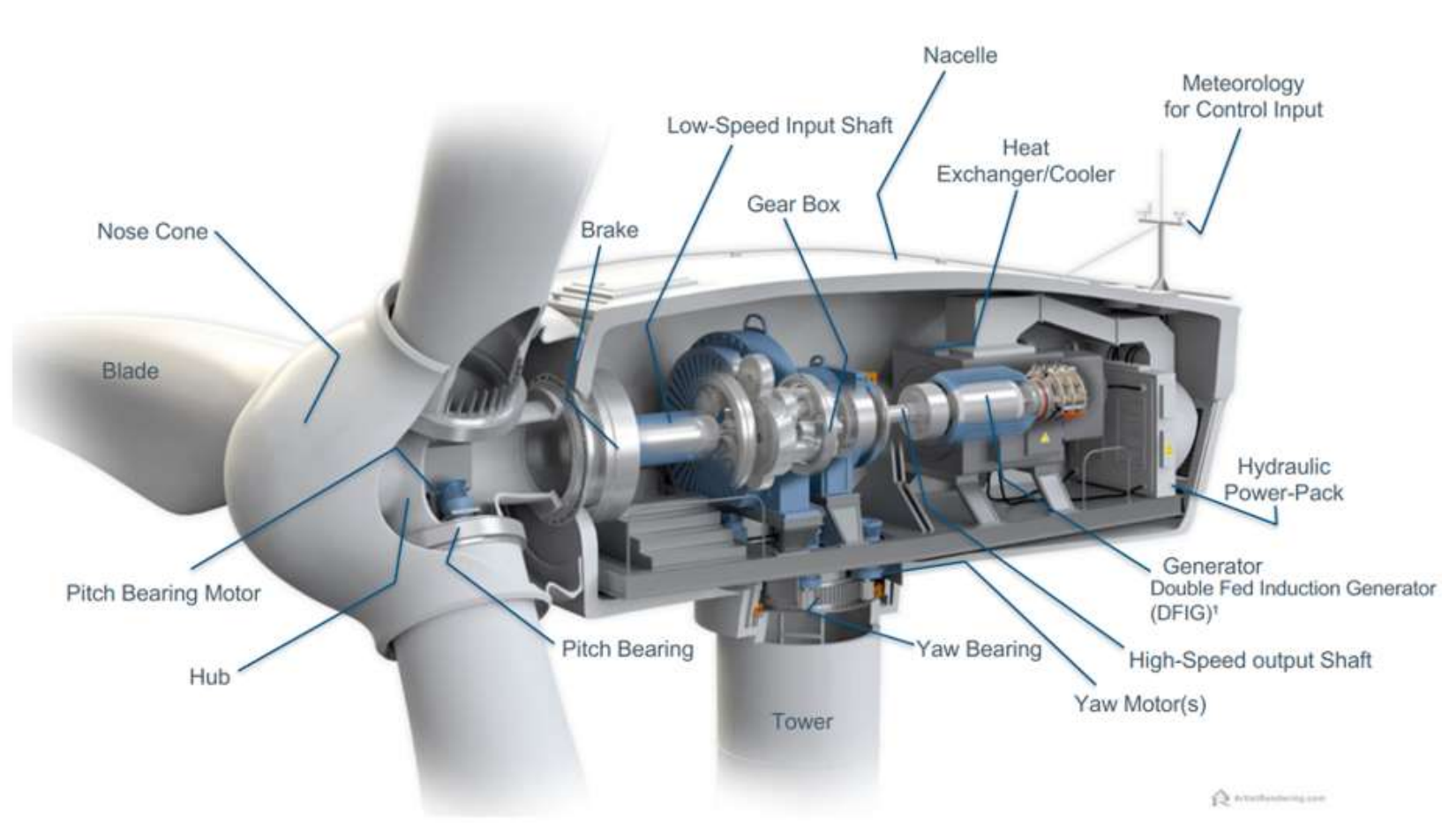
- Unannounced until students arrive, so no preparation is necessary
  - Study Guides available by age division
- Set amount of time to complete
- Instructions and materials will be provided
- Adapted to each age division



Previous Instant Challenges:

- Wind Siting
- Gear Ratio
- Data analytics
- Circuits
- MacGyver Windmill

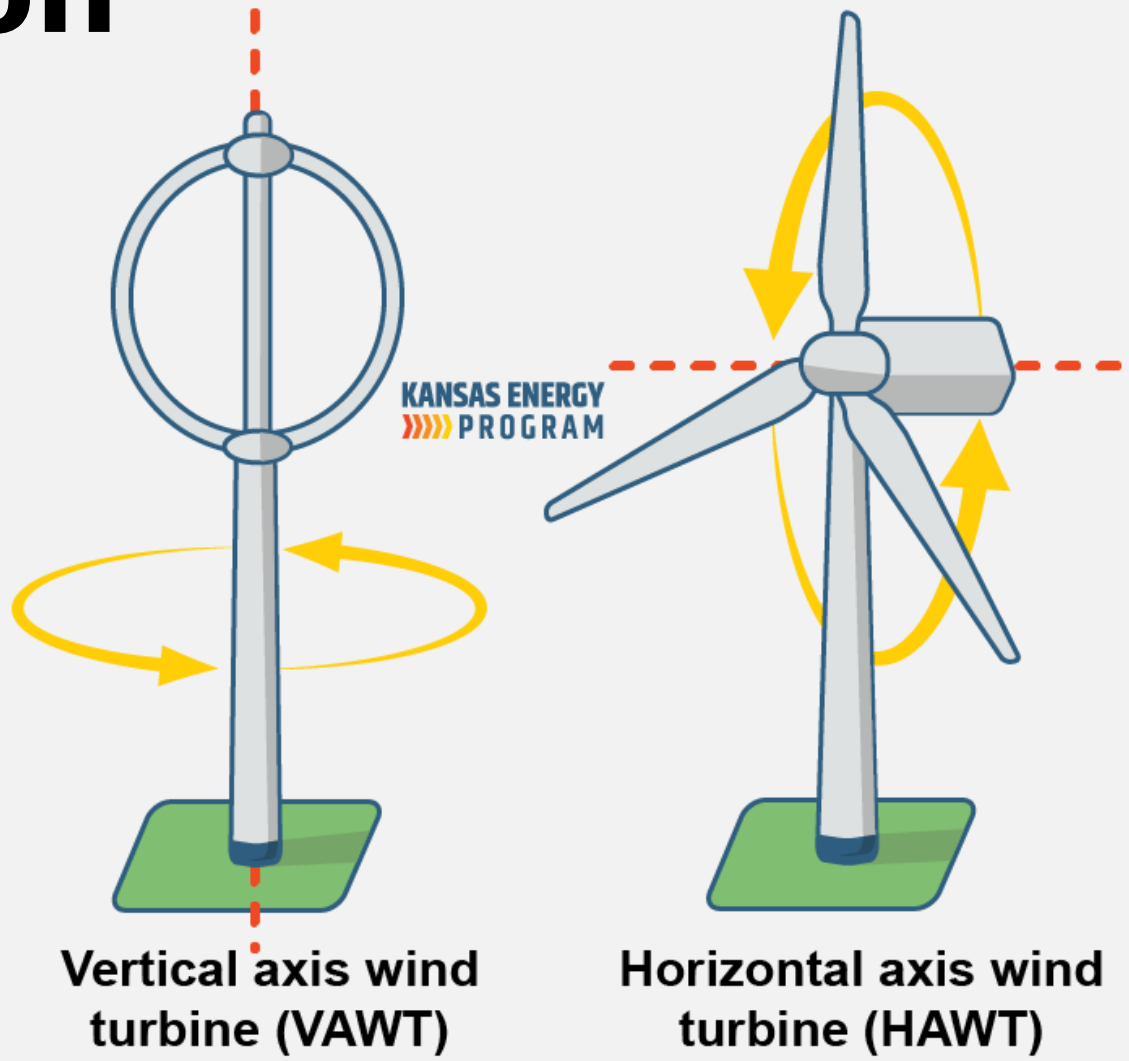
Detailed View of Wind Turbine



Turbine Orientation

The dotted red line represents the wind turbine axis or shaft. The orientation of the axis is what determines whether the wind turbine is “vertical” or “horizontal.”

The turbine rotates around the axis as shown by the yellow arrows.



Vertical Axis Wind Turbines (VAWT)

Advantages

- Omnidirectional
- Accepts wind from any angle
- Components can be mounted at ground level
- Ease of service
- Lighter weight towers
- Can theoretically use less materials to capture the same amount of wind

Disadvantages

- Shorter turbines capture poorer wind
- Centrifugal force stresses blades
- Poor self-starting capabilities
- Requires entire rotor to be removed to replace bearings
- Overall poor performance and reliability
- Have never been commercially successful (large scale)

Horizontal Axis Wind Turbines (HAWT)

Advantages

- High power output
- High efficiency
- High reliability
- High operating wind speed

Disadvantages

- Logistics to transport, install, and maintain
- Environmental impacts
  - Noise, drop shadow, wildlife
- Strict regulations

Blades

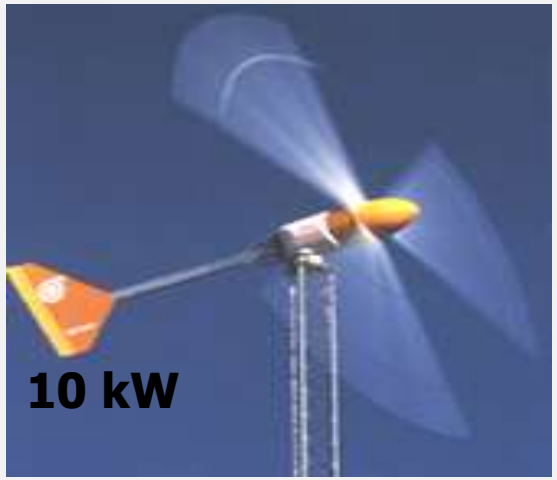
- Blade designs are continuously being extended
- Blades are an important driver for increasing capacity factor
  - Capacity factor = avg power output / max power capability
- Swept area is directly dependent on blade length
  - Swept area = πR^2
- Greater swept area leads to lower Levelized Cost of Energy (LCOE)
  - LCOE = Lifetime Costs / Annual Energy Produced

KidWind-related activities

- Wind turbines – have students list the different independent variables (number, length, and shape of blades; gear ratio; wind speed; etc.) to determine their impact on performance
- Generator – construct your own generator instead of using a pre-made Vernier generator
- Based on energy produced by turbine, determine what it could power, how long it would need to spin to produce enough energy to power a lightbulb, etc.

Modern Small Wind Turbines

- High tech
- Reliable
- Low maintenance
- 2-3 moving parts











Large Wind turbines In Kansas

- More cost-effective
- 4,415 turbines in Kansas
- Rated 0.05 – 4.8 MW
- Tallest: 182.6 m (599’) base to blade tip
- Largest rotor diameter: 149 m (489’)





Yawing – Facing the Wind

- Passive Yaw (small turbines)
  - Wind force directs the rotor
  - Tail vane
- Active Yaw (medium & large turbines)
  - Anemometer on nacelle tells the controller which way to point
  - Yaw drive turns gears to pivot the rotor into the wind



Capacity of Generation Units

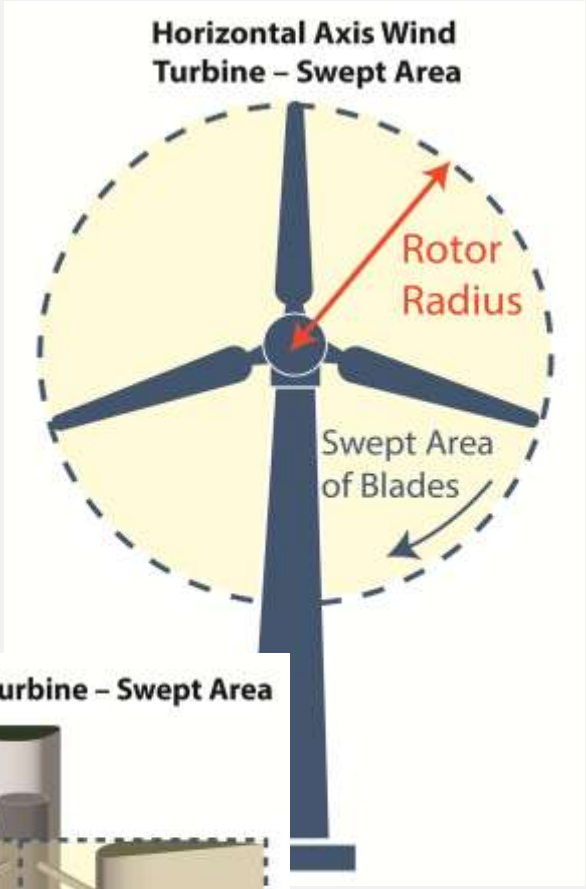
- **Capacity** – Maximum output of electricity that a generator can produce under ideal conditions (typically measured in megawatts)

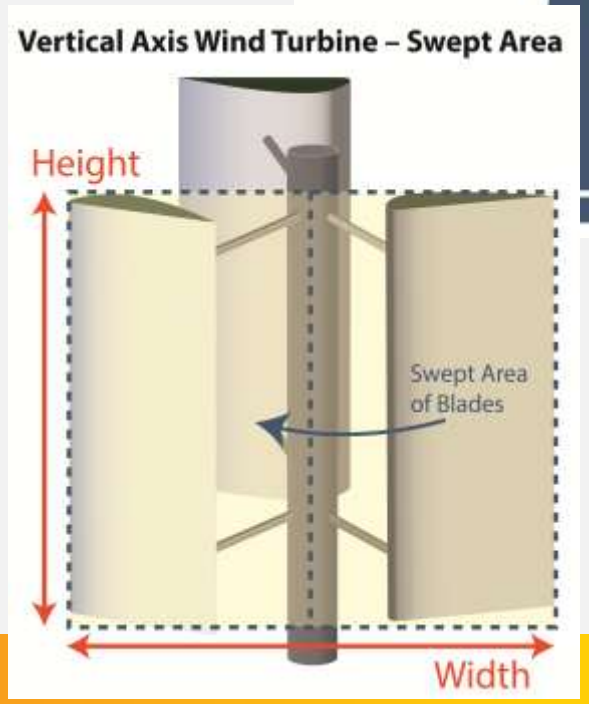
Add-On Activities

And ideas for upper-level students

Calculating wind power

- Power in the Wind = $\frac{1}{2}\rho AV^3$
  - Air density, ρ
  - Swept area, A
  - Wind speed, V
- Swept area (horizontal): $A = \pi R^2$
  - Area of the circle swept by the rotor
  - Doubling the length of a blade will result in 4x the power
- Betz limit (59%)
  - Theoretical maximum power that can be produced by a wind turbine





Activity: Calculating wind power *(Part 1)*

Your students want to know how blade length affects energy output. Use the Wind Power formula to evaluate two wind turbine designs:

Turbine A: 20-cm (0.2 meter) blade length *(radius: 0.2m)*
Turbine B: 40-cm (0.4 meter) blade length *(radius: 0.4m)*

First we'll need to calculate the Wind Swept Area:

$$Turbine\ 1\ wind\ swept\ area = \pi r^2 = \pi \times 0.2^2 = 0.126\ square\ meters$$

$$Turbine\ 2\ wind\ swept\ area = \pi r^2 = \pi \times 0.4^2 = 0.503\ square\ meters$$

Activity: Calculating wind power *(Part 2)*

Assumptions:
- Air density of 1 kg/m^3
- Wind speed of 3 meters/second

Wind swept area (from previous slide):
- Turbine 1: 0.126 square meters
- Turbine 2: 0.503 square meters

Next we can calculate Available Power:

$$Turbine\ 1\ available\ power\ = \frac{1}{2}\rho AV^3 = \frac{1}{2} \times 1\frac{kg}{meter^3} \times 0.126\ sq.meters\ \times 3\frac{meters}{second}^3 = 1.70\ Watts$$

$$Turbine\ 2\ available\ power\ = \frac{1}{2}\rho AV^3 = \frac{1}{2} \times 1\frac{kg}{meter^3} \times 0.503\ sq.meters\ \times 3\frac{meters}{second}^3 = 6.79\ Watts$$

Results: By doubling the blade length, available wind power was increased 4x!

Remember to take the Betz limit into account – meaning the theoretical maximum power will be about 59% of these values (but most likely quite a bit less than that).

Wind Speed

- It’s the most important factor when generating power from wind
- Power is a cubic function of wind speed
  - V × V × V (also written as V^3)
- 20% increase in wind speed means 73% more power
  - 1.0 m/s wind speed: 1 × 1 × 1 = 1
  - 1.2 m/s wind speed: 1.2 × 1.2 × 1.2 = 1.73
- Doubling wind speed means 8x more power (700% increase)
  - 2.0 m/s wind speed: 2 × 2 × 2 = 8

Activity Idea: How many homes can a wind turbine power?

Assumptions: 2-MW turbine; 40% capacity factor; average home uses 11,000 kWh electricity per year

$$2\ Megawatts\ x\ \frac{40}{100}\ x\ \frac{24\ hours}{day}\ x\ \frac{365\ days}{year}\ \text{x}\ \frac{1{,}000{,}000\ Watts}{1\ Megawatt}\ x\ \frac{1\ kilowatt}{1{,}000\ Watts} = 7{,}008{,}000\ kWh/year$$

$$\frac{7{,}008{,}000\ kWh}{year}\ x\ \frac{year/home}{11{,}000\ kWh} = 637\ \text{homes}$$

Follow-up Activity

Based on information in the previous slide, how many hours would it take one wind turbine to power a single home for one year?

One option:

$$\frac{7{,}008{,}000\ kWh}{year}\ x\ \frac{1\ year}{365\ days}\ x\ \frac{1\ day}{24\ hours} = 800\ \frac{kWh}{hour}$$

$$\frac{11{,}000\ kWh}{home}\ x\ \frac{1\ hour}{800\ kWh} = 13.75\ \frac{hours}{home}$$

A simpler option:

$$\frac{365\ days}{year}\ x\ \frac{24\ hours}{1\ day}\ x\ \frac{1\ year}{637\ homes} = 13.75\ \frac{hours}{home}$$

How many turns/revolutions does it take to power a home for one day?

Assumptions: 15-Megawatt (MW) off-shore wind turbine is operating at full (optimum) speed for one hour (10 revolutions per minute). The average U.S. home uses 11,000 kWh electricity per year (30 kWh per home per day).

Step 1: $15\ MW\ x\ 1\ hour = 15\ MWh$

Step 2: $\frac{10\ revolutions}{minute}\ x\ \frac{60\ minutes}{1\ hour} = \frac{600\ revolutions}{hour}$

Step 3: $\frac{15\ MWh}{600\ revolutions}\ x\ \frac{1{,}000{,}000\ Watts}{1\ MW}\ x\ \frac{1\ kW}{1{,}000\ Watts} = 25\ \frac{kWh}{revolution}$

Step 4: $\frac{\frac{30\ kWh/home}{day}}{\frac{25\ kWh}{revolution}} = 1.2$ revolutions per home per day

Overwhelmed?

- You do NOT need to know everything to get started. Tell your students you're learning alongside them and they may advance beyond you. That's exciting!

- Rather than trying to explain everything, first let students explore and play. Subjects like gears and aerodynamics will come up more naturally.

- We are available to help you adapt and incorporate what we're sharing today.

Discussion Question

How can you make sure your students go beyond building and truly grasp the science of wind energy?

Discussion Questions:

- *What ideas were sparked by this activity?*
- *What would your first lesson or activity on wind energy look like?*
- *What inspired you to make KidWind part of your teaching?*

KidWind: 4-5 Division















KidWind: 6-8 Division















KidWind: 9-12 Division

















KANSAS ENERGY PROGRAM

KidWind State

















KidWind Worlds















KidWind Growth



