# Wind Energy

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# Background

- IMSA has a one semester engineering course that has utilized a two-week, kit-based windmill challenge in the past.
- In recent years, it was also embedded in a unit on alternative energy, along with solar energy and microbial fuel cells.
- IMSA has now developed a condensed wind challenge to be completed in 2 hours.
- The concepts and procedures could be elaborated upon to create a longer project in the traditional classroom setting.

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# Wind Challenge

- Discussion of Energy, Alternative Energy, and Wind
- Round one – given a standard set of equipment:
  - Select the number blades (up to 12), cut out blade shape, & set blade angle
  - Record the voltage over a 30s period
  - Advance the best 2 designs from each cluster of 3 groups
- Discussion of Successes and Failures, Principles, etc.
- Round Two – differential shaft speed and orienting device:
  - Build up pulley diameter (spool shaft) with rubber bands
  - Allow device to orient in wind (add a tail?)
  - Record official 1 minute voltage recording at cross-wind table
  - Recognize top performers
- Discussion of Performance and Engineering Process

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# NGSS Engineering Standards

| | |
|---|---|
| HS-ETS1-1 (Analysis) | Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. |
| HS-ETS1-2 (Design) | Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. |
| HS-ETS1-3 (Evaluation) | Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts. |
| HS-ETS1-4 (Modelling) | Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem. |

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# Next Generation Science Standards

**HS-PS3-3**

Students who demonstrate understanding can:

**HS-PS3-3.** **Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.*** [Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.] [*Assessment Boundary: Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.*]

https://www.nextgenscience.org

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# UN Sustainable Development Goals


http://www.un.org

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# UN Sustainable Development Goals

- By 2030, ensure universal access to affordable, reliable and modern energy services
- By 2030, increase substantially the share of renewable energy in the global energy mix
- By 2030, double the global rate of improvement in energy efficiency
- By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology
- By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States, and land-locked developing countries, in accordance with their respective programmes of support

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# Next Generation Science Standards

The performance expectation above was developed using the following elements from *A Framework for K-12 Science Education*:

| Science and Engineering Practices | Disciplinary Core Ideas | Crosscutting Concepts |
| --- | --- | --- |
| **Constructing Explanations and Designing Solutions**<br>Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.<br>• Design, evaluate, and/or refine a solution to a complex real-world problem based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. | **PS3.A: Definitions of Energy**<br>• At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.<br>**PS3.D: Energy in Chemical Processes**<br>• Although energy cannot be destroyed, it can be converted to less useful forms — for example, to thermal energy in the surrounding environment.<br>**ETS1.A: Defining and Delimiting an Engineering Problem**<br>• Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. *(secondary)* | **Energy and Matter**<br>• Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.<br>- - - - - - - - - - - - - - - - - - - - - - - -<br>***Connections to Engineering, Technology, and Applications of Science***<br>**Influence of Science, Engineering and Technology on Society and the Natural World**<br>• Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. |

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# Pedagogically Speaking…

- IMSA's Core Competencies:
  - Competency Driven (Mastery of Content)
    - Disciplinary Core Ideas
  - Inquiry Based (Students question, discover)
    - Scientific and Engineering Practices
  - Problem Centered (Develop Interest, Real World)
    - Phenomenon
  - Integrated (Physics, Math, Engineering, Environment, Economics, Communication)
    - Cross Cutting Concepts

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# Round One

- Select the number blades (up to 12),
  cut out blade shape,
  & set blade angle
- Record the voltage over a 30s period
- Advance the best 2 designs from each cluster of 3 groups

# Successes?

# Round Two

- Build up pulley diameter (spool shaft) with rubber bands
- Allow device to orient in wind (add a tail?)
- Official 1 minute voltage recording at cross-wind table

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# Suggestions?

# Concepts & Skills

- Global Warming & Alternative Energy
- Wind Power, KE, (Bernoulli, Power Equation, & Betz?)
- Prototyping & Collaboration
- Test equipment (voltmeters, ammeters?, LabQuests?)
- Transduction, Energy (non)Conservation, Efficiency
- Mechanical Advantage and Torque
- Two-stage development
- Optional Extensions
  - Oral and written reports
  - Carbon footprint
  - Circuits
  - Induction
  - CAD and 3D printing
  - Modeling Fluid Flow
  - Rotational motion, RKE

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# Thank You!

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