# Growing Green

facilitator guide

Purple Plow

Uncovering STEM Solutions

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# Challenge Rationale

Agriculture consumes large amounts of energy in the production of our food. Farms consume energy both directly through the use of diesel, electricity, propane, natural gas and renewable fuels as well as in directly through the use of fuel in the production of fertilizers, pesticides and feedstock. In this challenge, students will learn about energy in various forms and design as well as build and share a solution that diversifies energy consumption.

# Establishing the Challenge

## Identify the Challenge

A well-established, diversified energy system can provide benefits to society. Investment in diversifying our energy portfolio can reduce emissions and insulate against price shocks from overreliance on one form of energy. About 90% of American energy consumption is from nonrenewable sources primarily distillate fuels and coal. Renewable energy comprises a fraction of the American energy portfolio — approximately 10% of total energy consumption.[i]

Energy is needed to produce the food we eat and transport it to consumers here at home and around the world. The most recent data from the USDA shows that the agricultural sector consumed "1,714 trillion British Thermal Units (BTU) of energy in 2014."[ii] Renewable energy can help farmers become more self-sufficient, diversify income and promote practices that can benefit the environment. While agriculture consumes energy in a multitude of ways, there is also an opportunity to utilize renewable energy to meet the needs of the industry.

## Challenge Question (Call to Action)

How can we improve or diversify the way agriculture generates or consumes energy?

## The solution must address the following needs:

- Production as well as economic, environmental and societal needs
- Trade-offs of using the different energy sources

## Success will be determined by

- Production of a model solution that uses a renewable energy source in an agricultural application to diversify energy consumption and demonstrates innovation
- Producing and sharing a presentation that communicates knowledge gained
- Sharing progress and results on social media by tagging @ThePurplePlow

# Next Generation Science Standards

**www.nextgenscience.org**

## NGSS —Engineering Design Process (3-5)

**3-5-ETS1-1** Define a simple design problemreflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

**3-5-ETS1-2** Generate and compare multiple possible solutionsto a problem based on how well each is likely to meet the criteria and constraints of the problem.

**3-5-ETS1-3** Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

## NGSS —Engineering Design Process (6-8)

**MS-ETS1-1** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

**MS-ETS1-2** Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

**MS-ETS1-3** Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

**MS-ETS1-4** Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

## NGSS —Engineering Design Process (9-12)

**HS-ETS1-1** Analyze a major global challengeto specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

**HS-ETS1-2** 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** 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** 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.

# Common Core Standards

## www.corestandards.org/Math

**CCSS.MATH.PRACTICE.MP2** Reason abstractly and quantitatively.
**CCSS.MATH.PRACTICE.MP3** Construct viable arguments and critique the reasoning of others.
**CCSS.MATH.PRACTICE.MP4** Model with mathematics.

## www.corestandards.org/ELA-Literacy

**Integration of Knowledge and Ideas:**
**CCSS.ELA-LITERACY.CCRA.R.7** Integrate and evaluate content presented in diverse media and formats, including visually and quantitatively, as well as in words.
**CCSS.ELA-LITERACY.CCRA.R.8** Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence.
**CCSS.ELA-LITERACY.CCRA.R.9** Analyze how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take.

**Comprehension and Collaboration:**
**CSS.ELA-LITERACY.SL.9-10.1** Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 9-10 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively.
**CCSS.ELA-LITERACY.SL.7.1** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 7 topics, texts, and issues, building on others' ideas and expressing their own clearly.

**Presentation of Knowledge and Ideas:**
**CCSS.ELA-LITERACY.CCRA.SL.5** Make strategic use of digital media and visual displays of data to express information and enhance understanding of presentations.
**CCSS.ELA-LITERACY.SL.7.5** Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points.
**CCSS.ELA-LITERACY.SL.9-10.4** Present information, findings, and supporting evidence clearly, concisely, and logically such that listenerscan follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task.
**CCSS.ELA-LITERACY.SL.9-10.5** Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

# Pacing Guide

## Classroom Program

This sample pacing guide is created for a 4-week unit with a 45 minute class.

| Design Process Step | Time |
|---|---|
| **Identify** | 2 days |
| **Imagine** | 2 days |
| **Design** | 2 days |
| **Create** | 5 days |
| **Test & Improve** | 5 days |
| **Share** | 4 days |

## Summer School Program

This sample pacing guide is created for a 10-day calendar with a 3-hour block.

| Design Process Step | Time |
|---|---|
| **Identify** | 1 day |
| **Imagine** | 1 day |
| **Design** | 2 days |
| **Create** | 2 days |
| **Test & Improve** | 3 days |
| **Share** | 1 day |

## After School Program

This sample pacing guide is created for 2 days a week for a 9-week quarter.

| Design Process Step | Time |
|---|---|
| **Identify** | 2 days |
| **Imagine** | 2 days |
| **Design** | 2 days |
| **Create** | 5 days |
| **Test & Improve** | 5 days |
| **Share** | 5 days |

# Materials List

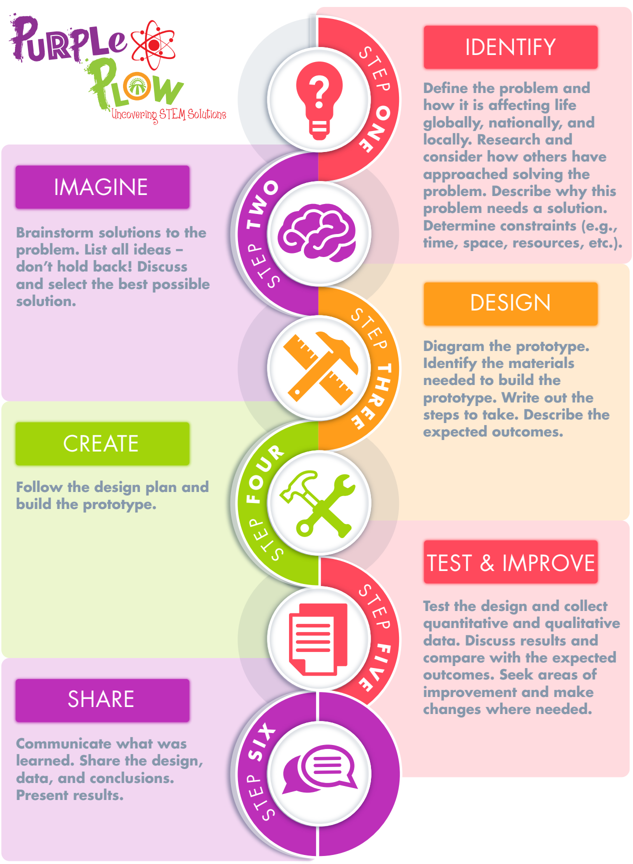
| Required Materials | Suggested Materials |
| --- | --- |
| • Computers with internet access | • Solar panels: https://amzn.to/2GzDMAg<br>• Model windmills, waterwheels, etc. (such as Lego Renewable Energy kits, Snap Circuits Green Energy Kits,or K'Nex Renewable Energy)<br>• Renewable Energy Education Kits (such as Horizon Renewable Energy Education Set: https://www.enasco.com/p/SB46790)<br>• Vernier Scientific Sensors<br>• Anemometers |

# Facilitating The Challenge

Each Purple Plow Challenge can be implemented in a variety of methods, timeframes, and programs. Follow the steps below to help determine how this challenge will best fit the current situation and educational environment.

1. Review the Purple Plow "Design Process" and the "Lesson Packet" documents. Note that the lessons are encouraged but not required.
2. Examine the suggested pacing guides to determine ways to integrate the challenge and lessons into your specific program.
3. With the timeframe in mind, use the guidance provided in this section to help students progress through the challenge. This guidance includes suggested student prompts, guiding questions for students, signs of step completion, and journaling opportunities. The student prompts, guiding questions, and journal prompts are found in the "Student Guide." Facilitators or students may determine the method by which they record their research and discoveries found for these prompts and journal reflection questions.

## Challenge Design Process



# 1. Identify

## PURPOSE OF STEP

Define the problem and how it is affecting life globally, nationally, and locally. Research and consider how others have approached solving the problem including how people have addressed this problem historically. Describe why this problem needs a solution. Determine constraints (e.g., time, space, resources, etc.).

### STUDENT PROMPTS AND GUIDING QUESTIONS

- What is energy?
- What are the different sources of energy?
- What are the trade-offs of using each type of energy?
- How do renewable and nonrenewable sources of energy affect the environment and climate?
- Why should we care about where we get our energy?
- How do we use energy in our daily lives? In food production?
- Compare and contrast energy generated from nonrenewablesources to energy generated from renewable sources.
- How does the agriculture industry consume energy?
- How does the agriculture industry produce energy?
- In what areas of production do farms use the most energy?
- What forms of renewable energy could be used on farms?

## SIGNS OF STEP COMPLETION

Students will present a description of the challenge to the facilitator. They should include how this problem affects communities globally, nationally, and locally. The description should also include ways in which others have addressed finding a solution and constraints to be considered (e.g., time, space, resources, etc.).

**At the completion of this step, direct students to the reflection questions in the "Growing Green Student Guide."**

# 2: Imagine

## PURPOSE OF STEP

Brainstorm solutions to the challenge. List all of your ideas – don't hold back! Discuss the possible solutions. Select the best possible solution from your brainstormed list.

## STUDENT PROMPTS AND GUIDING QUESTIONS

- How do farms consume energy?
- In what areas of production do farms use the most energy?
- What forms of renewable energy could be used on farms?
- How is renewable energy used in agriculture?
- What current solutions are being used to conserve energy? To reduce greenhouse gases?
- What are engineers doing to improve our energy sources?

## SIGNS OF STEP COMPLETION

Students will present a list of possible solutions to the identified challenge to the facilitator.

**At the completion of this step, direct students to the reflection questions in the "Growing Green Student Guide."**

# 3: Design

## PURPOSE OF STEP

Diagram the prototype and identify the materials needed to create your solution. Write out the steps to take and describe the expected outcomes.

## STUDENT PROMPTS AND GUIDING QUESTIONS

- What form of energy will be used and why?
- How will you demonstrate energy conservation?
- What materials are needed?
- What environmental factors should be considered?
- How do material costs and other creative constraints factorin?
- Justify your particular design choice.

## SIGNS OF STEP COMPLETION

Students present a detailed diagram of the solution as well as a written plan of how it will be built/carried through. Students should include a materials list with budget, detailed directions, and expected outcomes.

**At the completion of this step, direct students to the reflection questions in the "Growing Green Student Guide."**

# 4: Create

## PURPOSE OF STEP

Follow the design plan and build your solution.

## STUDENT PROMPTS AND GUIDING QUESTIONS

- Use all research, knowledge gained and the design plan to create the solution.
- Repeat any of the previous steps should issues arise during the building process.
- Consider the parameters of the Challenge and what needs to be accomplished for a successful Challenge.

## SIGNS OF STEP COMPLETION

Students build out their designs and share with the facilitator.

**At the completion of this step, direct students to the reflection questions in the "Growing Green Student Guide."**

# 5: Test + Improve

## PURPOSE OF STEP

Test the design and collect quantitative and qualitative data. Discuss results and compare with the expected outcomes. Seek areas of improvement and make changes where needed.

## STUDENT PROMPTS AND GUIDING QUESTIONS

- What will need to be observed (qualitative data)?
- What information can be put into a chart or graph (quantitative data)?
- Create data tables, graphs, photographs showcasing data, etc.
- How will you demonstrate conservation of energy?
- How will you evaluate the tradeoffs of your chosen energy source?

## SIGNS OF STEP COMPLETION

The students will keep records of all test trials and share data with the facilitator. Entries should include both qualitative and quantitative data. The should record any improvements made to your  solution and the effect they had on outcomes.

**At the completion of this step, direct students to the reflection questions in the "Growing Green Student Guide."**

# 6: Share

## PURPOSE OF STEP

Communicate what was learned throughout the Challenge. Share the design, data, and conclusions. Present results.

## STUDENT PROMPTS AND GUIDING QUESTIONS

- Develop a presentation including knowledge gained, design plans, materials used to create the structure, testing completed during challenge, and data analysis.
- How is your design approach an appropriate, innovative solution that realistically responds to the precise design competition problem?
- How does your design address budgetary constraints, timeline issues or other challenges?
- How successful was your solution in addressing the well-being of pollinators?
- Describe and/or demonstrate what you learned from this Challenge.

## SIGNS OF STEP COMPLETION

The students present what was learned through the design process, including sharing how the solution addresses the problem, key aspects of design, data from test trials, and end results.

# Additional Resources

The resources listed below are links to additional information to help you and your students complete the Growing Green Challenge. In addition, be sure to check out the supplemental lessons on the Purple Plow website.

California Foundation for Agriculture in the Classroom – *Agriculture STEM Connections, Energy and Agriculture: Careers in Sustainable Energy Curriculum*
https://learnaboutag.org/resources/lesson/stem.pdf

Iowa Agriculture Literacy Foundation – *Ag and Energy Curriculum*
http://www.iowaagliteracy.org/resources/lesson-plans/lesson-plans.aspx

U.S. Energy Information Administration – *Today in Energy*
https://www.eia.gov/todayinenergy/detail.php?id=18431

U.S. Energy Information Administration – *Renewable Energy Explained*
https://www.eia.gov/energyexplained/?page=renewable_home

United Nations – *Goal 7: Energy*
https://www.un.org/sustainabledevelopment/energy/

United Nations – *Goal 7: Energy*
https://www.ers.usda.gov/amber-waves/2017/januaryfebruary/energy-consumption-and-production-in-agriculture/

United States Department of Energy – *Energy Sources*
https://www.energy.gov/science-innovation/energy-sources

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## REFERENCES

[i]U.S. Energy Information Adiminstration. (2018, July 13). *Renewable energy explained*. Retrieved from https://www.eia.gov/energyexplained/?page=renewable_home

[ii]United States Department of Agriculture, Economic Research Service. (2017, February 6). *Energy production and consumption in agriculture*. Retrieved from https://www.ers.usda.gov/webdocs/charts/82357/janfeb17_infographic_hitaj.png?v=0