



Grades 9–12

3.2.9-12.Q Physical Science: Energy

Students who demonstrate understanding can *design, build and refine a device that works within given constraints to convert one form of energy into another form of energy.*

Clarifying 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.

Science and Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CCC)
Constructing Explanations and Designing Solutions 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. <ul style="list-style-type: none"> 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. 	Definitions of Energy <ul style="list-style-type: none"> At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. Energy in Chemical Processes <ul style="list-style-type: none"> Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. Defining and Delimiting an Engineering Problem <ul style="list-style-type: none"> 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. 	Energy and Matter <ul style="list-style-type: none"> 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. <hr/> Connections to Engineering, Technology, and Applications of Science Influence of Engineering, Technology, and Science on Society and the Natural World <ul style="list-style-type: none"> 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.

Pennsylvania Context: Examples of Pennsylvania context include but are not limited to the various forms of power generation in Pennsylvania that convert one form of energy to another.

PA Career Ready Skills: Advocate for oneself in education, employment, and within the community.



Connections to Other Standards Content and Practices

Standard Source	Possible Connections to Other Standard(s) or Practice(s)
Agriculture (AFNR)	CS.01.02.01.c: Solve problems in AFNR workplaces or scenarios using technology.
Science, Environmental Literacy and Sustainability (NAEE)	<p>9-12 Strand 3.1.C. Identifying alternative solutions and courses of action: Learners identify and propose environmental action plans, including design solutions, and evaluate their likely effectiveness in specific environmental, cultural/social, and economic contexts. They identify ways that these action plans and design solutions might affect different groups of people, including possible environmental justice and social equity implications.</p> <p>9-12 Strand 3.1.D. Working with flexibility, creativity, and openness: Learners engage each other in evidence-based peer review and work collaboratively and cooperatively in the spirit of open deliberation, especially in contexts that bring to the surface deeply held priorities and values.</p>
PA Core Standards: ELA	CC.3.6.9-12.F: Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
PA Core Standards and Practices: Math	<p>MP.2: Reason abstractly and quantitatively.</p> <p>MP.4: Model with mathematics.</p> <p>CC.2.1.HS.F.3: Apply quantitative reasoning to choose and interpret units and scales in formulas, graphs, and data display.</p> <p>CC.2.1.HS.F.4: Use units as a way to understand problems and to guide the solution of multistep problems.</p>
PA Standards: Social Studies	N/A
Educational Technology (ISTE)	1.4. Innovative Designer: Students use a variety of technologies within a design process to identify and solve problems by creating new, useful or imaginative solutions.
Technology and Engineering (ITEEA)	STEL-1R: Develop a plan that incorporates knowledge from science, mathematics, and other disciplines to design or improve a technological product or system.