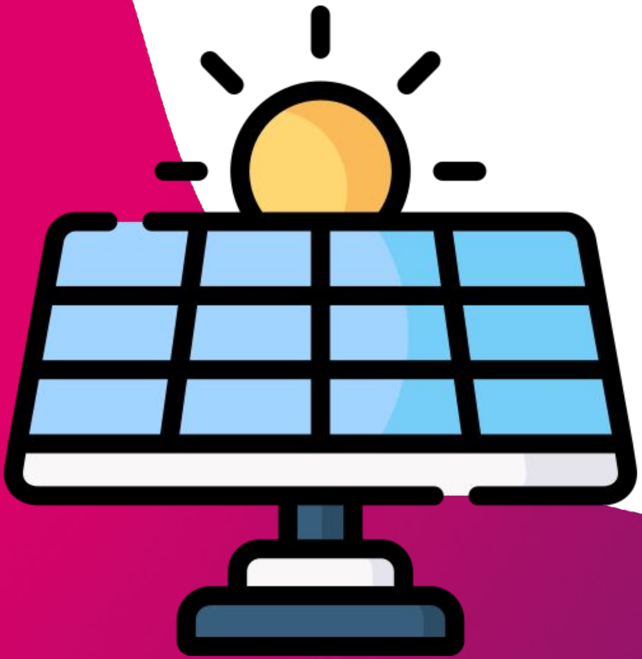


Solar, So Good

High School (Gr. 10-12)
Physics Unit Plan

edm8ker

Making the future of young minds

Unit Overview & Goals

edm8ker
Making the future of young minds

In this unit, students analyse the **feasibility of solar power** as a form of renewable energy in their communities. Students will explore how solar power works at different scales, and look at examples of how the energy of the Sun has been harnessed to support our daily lives.

Anchoring Phenomena

edm8ker
Making the future of young minds

Solar energy has gained prominence in recent years, with solar energy leading the charge. In 2021, 36% of all new electricity generation capacity in the country came from solar, surpassed only by wind with 41%. In Massachusetts, solar energy accounts for 7.7% of the electricity generated in Massachusetts in 2017 - the 5th highest percentage nationwide among the 50 states. However, solar energy has its drawbacks too. Can we be fully reliant on solar energy - and if not, how can we maximize our usage of this renewable energy source?

Essential Questions

edm8ker
Making the future of young minds

- How can we use solar energy to transfer and convert energy for different purposes? (PS3-1)
- What is the photoelectric effect, and how does it relate to the way solar panels produce electricity? (PS3-5)
- How can we design solar-powered devices to optimize their energy efficiency and performance? (PS3-3)
- What are the advantages and limitations of using solar energy as a renewable source of power, and how can we use this technology to reduce our dependence on fossil fuels? (ETS1-3)

EDP Throughline

How do we design and use solar-powered appliances for maximum efficiency?

The curriculum is organised around four (4) maker application projects which invite students to design simple solar appliances

edmaker
Making the future of young minds




	Introduction to Course	Project 1: Building a Solar Oven	Project 2: Building a Solar Lamp	Project 3: Building a Solar Charger	Summative assmt: Designing a Solar Powered Home
Duration	1h	3h	8h	8h	8h
Frameworks and Guiding Principles	N/A	Agency by Design Maker Capacities Engineering Design Process			Agency by Design Maker Capacities
Misc.	N/A	Formative assessments			Summative assessment

Mini-projects use the EDP as an organising frame, with Agency by Design (AbD) maker capacities infused into each step of the EDP process

edm8ker
Making the future of young minds

AbD (Fig. 1) sketches out three maker capacities critical to the maker mindset. The most crucial capacities at each stage of the EDP are indicated below.

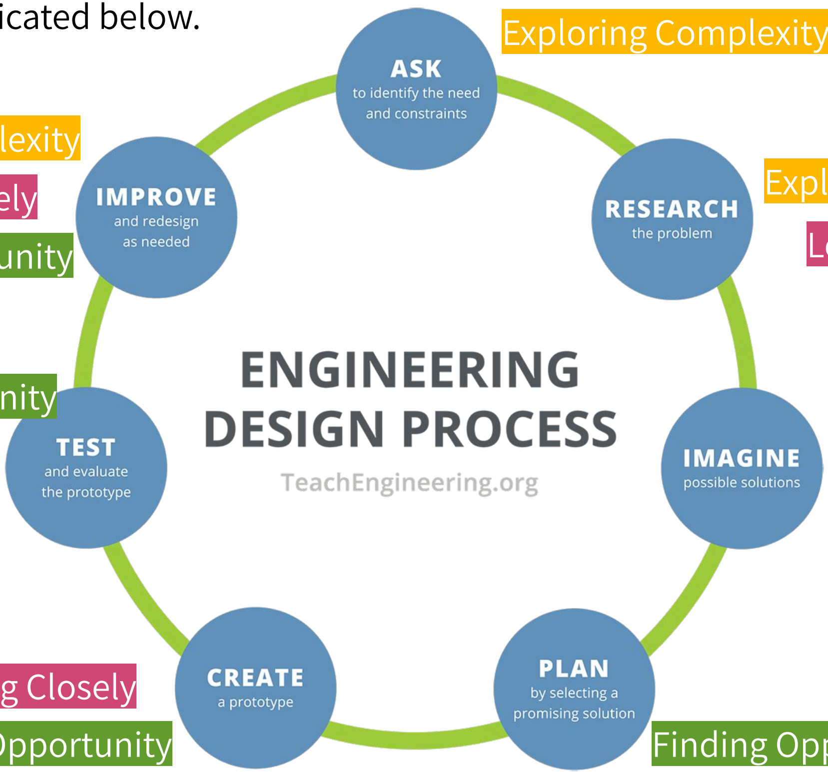


Fig. 1: AbD Maker Capacities

edm8ker

Making the future of young minds

Project 1: Building a Solar Oven (8h)

Steps in the EDP	Project Details
Ask	Students read about a fictionalized account of a family in the global South who face constant electricity outages. They are called upon to design a solar oven for the family. They are introduced to criteria & constraints for the project. Key criteria: temperature within oven.
Research	Students investigate existing solar oven concepts to unpack how they work, and learn about the Physics concepts behind them. Students learn about the different factors that affect the function of a solar oven.
Imagine	Students work in small teams to brainstorm possible solutions, drawing on their knowledge of heat transfer, thermodynamics and other related concepts to optimally design the solar oven for maximum output.
Plan	Students develop a decision matrix to evaluate their solutions, and identify a solar oven solution to prototype.
Create	Students prototype their solar oven, using given materials.
Test	Students test their prototypes qualitatively, by cooking S'mores, and quantitatively, by taking temperature measurements over time.
Improve	Students reflect on their experiences and think of ways to improve their solar ovens.

Making the future of young minds

Project 1: Building a Solar Oven (8h)

Physics Concepts	Sample Differentiation Options
- Energy/heat transfer - Energy/heat conversion - Heat loss and heat gain - Thermodynamics	- For learners who need more support: teachers may need to re-teach the concepts behind heat transfer and heat gain before explaining how a solar oven exemplifies these concepts. - For advanced learners: teachers can bring in concepts of black-body radiation and thermodynamics to explain the optimal design of solar ovens.





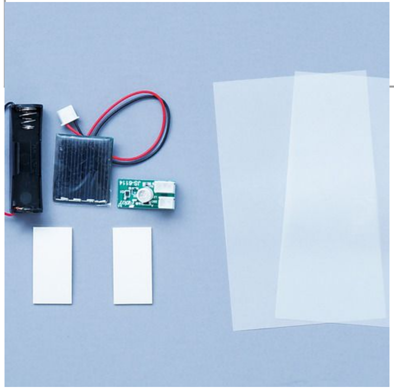
edm8ker
Making the future of young minds

Project 2: Building a Solar Lamp (9h)

Steps in the EDP	Project Details
Ask	Students read about the amount of energy that is used in a typical American household for lighting purposes. How can solar power be employed to complement residential lighting, while beautifying a house in the process? Students are told they will be designing a solar lamp, which charges during the day and lights up at night, to be used in lieu of mood lighting in a home. Key criteria: Battery capacity, amount of light emitted, aesthetic sensibility. Key constraint: fixed electrical equipment (see next slide)
Research	Students explore how small-scale solar lamps (e.g. garden solar lamps) work, and learn about batteries, the photoelectric effect, and how wires conduct electrical energy. They explore the benefits, constraints and limitations of solar lamps.
Imagine	Students work in small teams to brainstorm possible solutions, based on the design brief given.
Plan	Students develop a decision matrix to evaluate their solutions, and identify a solar lamp solution to prototype. Students estimate how long it will take for their solar batteries to charge, and how long this will power the LED bulb.
Create	Students prototype their solar lamp, using given materials and recycled materials which they will bring from their homes.
Test	Students showcase and test their prototypes using light meters and battery capacity meters. Students vote for the most aesthetically pleasing lamp!
Improve	Students reflect on their experiences and think of ways to improve their solar lamp.

Project 2: Building a Solar Lamp (9h)

Physics Concepts	Sample Differentiation Options
- Photoelectric effect - Energy transformation in wires - Batteries	- For learners who need more support: teachers may want to provide more scaffolds to guide students to assemble the solar battery, e.g. providing circuit diagrams, providing pre-assembled circuits - More advanced learners can investigate if there is a difference between estimated and actual charged battery capacity, and suggest reasons for the difference (if any).



<< Students are provided with a LED module, solar panel, wires, a rechargeable battery & tracing paper. Other items can be drawn from recyclables.

edm8ker
Making the future of young minds

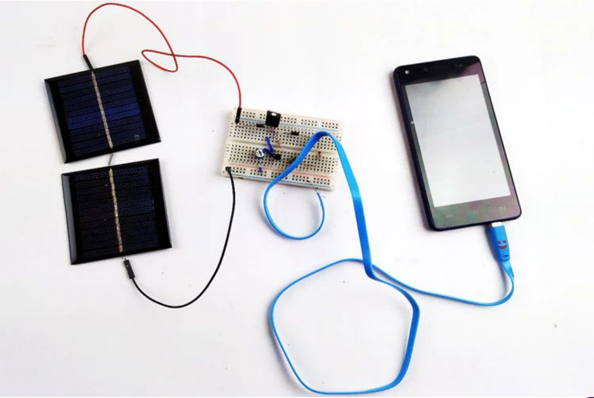
Project 3: Building a Solar Charger (8h)

Steps in the EDP	Project Details
Ask	Students read about the energy that is used in charging modern consumer appliances (e.g. handphone, laptop). Wouldn't it be great if solar power can be used to to charge our appliances? Students are told they will design a portable solar charger with a USB-C outlet which can charge regular consumer appliances. Key criteria: time to charge. Key constraint: budget.
Research	Students explore how solar chargers work, building on their understanding of electrical circuits and solar panels in Project 2. They will also understand how to maximise the efficiency of solar panels by e.g. appropriate positioning of solar panels when charging.
Imagine	Students work in small teams to brainstorm possible solutions, based on the design brief given.
Plan	Students develop a decision matrix to evaluate their solutions, and identify a solar charger solution to prototype. They are given an assigned fixed budget which they can 'spend' on a range of materials (e.g. solar panels) provided by the instructor. Electrical materials can be 'bought' while maker materials will be freely available.
Create	Students prototype their solar chargers, using materials they have obtained from the instructor.
Test	Students showcase and test their prototypes quantitatively, by e.g judging how long it takes to charge a phone battery by 5%.
Improve	Students reflect on their experiences and think of ways to improve their solar chargers.

Making the future of young minds

Project 3: Building a Solar Charger (8h)

Physics Concepts	Sample Differentiation Options
- Factors affecting the efficiency of solar panels	- For advanced learners: students can be encouraged to explore how the angle that solar panels are placed affects the efficiency of energy transfer



Project 4 (Summative Assessment): Designing a Solar Powered Home (9h)

- Scenario: A family is thinking about installing solar panels, but unsure about whether it's worth it. They have contracted you, a sustainability consultant, to advise.
- Task: Students will individually design a house powered by solar panels, on the TinkerCAD platform.
- Additionally, students will:
  - Explain the design considerations behind the placement of the solar panels (project 3)
  - Explain how the panels reduce heat loss and maximise efficient energy transfer (project 2)
  - Explain how the energy from solar panels is stored in batteries (project 2)
  - Calculate how much energy solar panels can convert into electricity, and estimate household cost savings as a result (new info)

Annex: NGSS Standards Covered

edm8ker

Edumakers for innovation

edm8ker
Making the future of young minds

NGSS Performance Expectations

- HS-PS3-1
- HS-PS3-3
- HS-ESS3-4
- HS-ETS1-1
- HS-ETS1-3

edm8ker
Making the future of young minds

NGSS Disciplinary Core Ideas

- PS3.A: Definitions of Energy
- PS3.D: Energy in Chemical Processes
- ESS3.C: Human Impacts on Earth Systems
- ETS1.A: Defining and Delimiting Engineering Problems
- ETS1.B: Developing Possible Solutions

edm8ker
Making the future of young minds

NGSS Evidence Statements

HS-PS3-1

1. Representation

HS-PS3-3

1. Using scientific knowledge to generate the design solution
2. Describing criteria and constraints, including quantification when appropriate
3. Evaluating potential solutions
4. Refining and/or optimizing the design solution

HS-ESS3-4

1. Using scientific knowledge to generate the design solution
2. Describing criteria and constraints, including quantification when appropriate
3. Evaluating potential refinements

HS-ETS1-1

1. Identifying the problem to be solved
2. Defining the criteria and constraints

HS-ETS1-3

1. Evaluating potential solutions
2. Refining and/or optimizing the design solution

edm8ker
Making the future of young minds

NGSS Science and Engineering Practices

Developing and Using Models
Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

- Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS3-2),(HS-PS3-5)

Planning and Carrying Out Investigations
Planning and carrying out investigations to answer questions or test solutions to problems in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS3-4)

Using Mathematics and Computational Thinking
Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

- Create a computational model or simulation of a phenomenon, designed device, process, or system. (HS-PS3-1)

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.

- 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. (HS-PS3-3)