“Solutions-Oriented Learning” Storyline

MS-Renewable Energy: Solar

Storyline introduction and overview:

Solar energy in the form of light is available to organisms on Earth in abundance. Natural systems and other organisms have structures that function in ways to manage the interaction with and use of this energy. In this storyline, students will explore how light energy interacts with materials and how light energy can be transformed into energy for heating and cooling. Students design a solar water heater and explore how products like this can reduce carbon emissions to mitigate climate change.

Renewable Energy: Solar NGSS Learning Progression: The middle school storyline is part of a larger learning progression that includes students mastering standards pre-K to 12th grade. Take a look at how the middle school performance expectations fit in a continuum of learning for your students.

Placemaking: *Locally Relevant*	**Anchoring phenomena:**	**Drawdown:**
Students take temperature (using palms) at several places throughout a building (home or school) and note different materials and colors of those materials at each location. *Apps available for free on most smartphones.	Materials absorb, reflect and emit different amounts of solar energy. Meteorologist bakes cookies in his car	Insulation Solar Water
Indigenous and other relevant cultural connections: Since time immemorial Indigenous peoples used the energy from the sun and materials in their environment to heat their homes, mark the passage of time and grow and harvest food.	**NGSS PEs (progress towards):** **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 **MS-PS3-3**: Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. **MS-PS4-2**: Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.	

Estimated time required to implement this storyline: 3 weeks

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NGSS PEs:

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

MS-PS3-3: Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.

MS-PS4-2: Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.

Science & Engineering Practice (SEP)	Disciplinary Core Idea (DCI)	Cross Cutting Concept (CCC)
Developing and Using Models Modeling in 6–8 builds on K–5 and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop and use a model to describe phenomena. **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process or system.	**PS3.A: Definitions of Energy** • Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. **PS3.B: Conservation of Energy and Energy Transfer** • Energy is spontaneously transferred out of hotter regions or objects and into colder ones. **PS4.A: Wave Properties** • ~~A sound wave needs a medium through which it is transmitted.~~ **PS4.B: Electromagnetic Radiation** • When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object’s material and the frequency (color) of the light. • The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends. • A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media. • However, because light can travel through space, it cannot be a matter wave, like sound or water waves. **ETS1.A: Defining and Delimiting an Engineering Problem** • The more precisely a design task’s criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions. (secondary) **ETS1.B: Developing Possible Solutions** • A solution needs to be tested, and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary)	**Structure and Function** • Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used. **Energy and Matter** • The transfer of energy can be tracked as energy flows through a designed or natural system.

	• Models of all kinds are important for testing solutions. **ETS1.C: Optimizing the Design Solution** • The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution.	

Materials:

Learning Session	Materials
1	The story “How Raven Stole the Sun”
4	A class set of light sources such as flashlights, lasers, etc. and various materials of different transparencies (Gummy Bears)
5	Glass of liquid with ice cubes
6	Refer to lists in Keep it Hot and Feel the Heat

Learning Sessions

1.	Grounding Native Ways of Knowing	Estimated time: 30 minutes
	To connect to native ways of knowing consider exploring the following ideas in connection with your local tribal nation: ● Sun as part of life ● Sun in relation to dwelling design ● Sun used to produce and preserve food ● Sun as an indicator of time ● Gift of the Sun’s energy in abundance Read aloud or find the story “How Raven Stole the Sun” online. This story carries many messages, including touching on social justice issues - the sun has always been freely available for *all* people, providing benefits in a myriad of ways. In addition to stories of the past, research and connect with tribal nations close to your community and the actions they are taking to mitigate and adapt to a changing climate, specifically in the context of solar energy. To access information on how to reach out and build relationships with local tribes, visit the OSPI Office of Native Education: Partnering with Tribes webpage.	

2.	**Examine phenomenon: Materials absorb, reflect and emit different amounts of solar energy.**	Estimated time: 50 minutes for video/modeling investigation 50-minute session for investigation
	1. Students watch Heatwave! Meteorologist Bakes Cookies in His Car. Students record their thoughts and reactions in t-chart (noticing/wonderings). 2. Temperature Investigation (Sense Making) Initial Question: If you were to go outside and touch items, what can you expect about how they will feel, compared to your body temperature? a. Students design a data table that includes the object name/type of object, material, color, in sunlight or shade, level of transparency, texture, how warm it feels (rate on a scale cold to hot, body temperature would be the mean). Scale suggestion: 1-5, (1) cold, (2) cool, (3) body temp, (4) warm, (5) hot. b. Students use their palm to test the relative temperature of different materials (biotic/abiotic), in and out of the sun. Students record specific observations in a data table. Teacher Note: Make sure to have students touch a car...teacher probing question regarding the inside of the car, connection to greenhouse effect (transforming light energy into heat trapped in the car). Transparency (windows of the car).	

3.	**Pre-Assessment:**	Estimated time 20 minutes
	MS-Renewable Energy: Solar Pre-Assessment MS-Renewable Energy: Solar Assessment Rubric	

4.	**Guiding question: In what ways can we use the light energy from the sun?**	Estimated time: Two 50-minute sessions
	1. Students watch PBSlearningmedia.org: The Electromagnetic Spectrum and PBSlearningmedia.org: Infrared: More Than Your Eyes Can See. Students are presented with the question: "What devices use the light energy directly to do work?" Students will discover that ALL light energy is converted to another form of energy (thermal) for it to do work. Asking the question will clarify the students initial thinking about light energy and how it is used to do work. Once students discuss this question, it is left to revisit at the end of the unit. 2. Students watch Light absorption, Reflection, and Transmission. The demonstration in	

	the video with a laser and Gummy Bears is an easy demonstration to perform in class. Students practice the terms above using any light source available and materials of various transparencies. 3. The Sun’s energy is free to all organisms on Earth, and they use it in different ways (Native Ways of Knowing). Students research how different animals use light absorption, reflection, and transmission. In their research, students will discover that light is used by animals to see and to heat. Students choose one animal and prepare a short presentation to share with the class on how their chosen animal uses the light energy from the sun. Students use the terms “reflection, absorption, and transmission” in their presentations. 4. Students revise their initial model (the pre-assessment).

5.	**Guiding question: What is heat? How is it transferred?**	Estimated time: 50 minutes
	1. When light is absorbed, it is usually converted to thermal energy. Students revisit their data from the Temperature Activity (their sense making activity) of the anchoring phenomena to confirm that some materials were absorbing more light energy than others and the evidence was the difference in temperature. 2. Heat is the transfer of thermal energy between two objects of different temperatures. Based on Page Keeley’s Uncovering Student Ideas/ “Ice cold Lemonade”), students observe a glass of lemonade with ice cubes. Students respond to the question: “Why are the ice cubes melting?” using the CER (claim, evidence, and reasoning) format. This probe will address the misconception that “cold goes out to heat air rather than heat from air goes into the ice to melt the ice”. 3. Students apply their knowledge of heat transfer to revise their initial model (the pre-assessment).	

6.	**Guiding question: What materials minimize/maximize heat transfer?**	Estimated time: Four 50-minute sessions
	1. In the activity Keep it Hot, students work to **minimize** heat transfer in order to keep the water hot in their container. 2. In the activity Feel the Heat, students will observe how light energy is absorbed and transformed into thermal energy. This lab will be revisited in a later learning session. Students will only build and evaluate their model. Later, they will work to **maximize** heat transfer to heat water.	

	3. Students revisit the Temperature Activity again to make a claim that one of the materials they tested is better than another in terms of either maximizing or minimizing heat transfer. Students identify materials that are insulators, list the modes of heat transfer, describe the effect of insulation thickness on heat transfer to support their claim. 4. Native Ways of Knowing: The Sun's energy is not consistent over the Earth, so organisms have adapted to make use of it in different ways. Indigenous people from the Arctic to the Equator have designed homes to keep themselves warm and cool, depending on the amount of sunlight. Students research one of these home designs and prepare a short presentation to the class explaining how heat transfer was managed.

7.	**Guiding question: Using solar energy as a source of power, how can we design a more efficient water heater?**	Estimated Time**:** Two to Three 50-minute periods
	1. Students will revisit their model built in the investigation Feel the Heat**.** Their goal is to test and refine the components of the model in order to maximize the efficiency of the heater. Students now use the Challenge sheet to record their measurements and design changes.	

8.	**Guiding question: How can we use solar energy to decrease the emission of greenhouse gases into the atmosphere?**	Estimated time: Four 50-minute periods
	1. Students watch Climate Science in a Nutshell #4: Too Much Carbon Dioxide followed by Climate Science in a Nutshell #5: Where Does Carbon Dioxide. Students diagram how: a. the light waves from the sun are absorbed by the surface of Earth and transformed into thermal energy b. the thermal energy is reflected by the atmosphere back to Earth c. increasing the amount of carbon dioxide increases the amount of thermal energy reflected to Earth thus increasing the temperature of the planet 2. Students respond to the question: "How does baking cookies in a car relate to how our atmosphere insulates the Earth?" Students use a Venn DIAGRAM (Earth and Car!) to show their understanding OR students create an analogous model/diagram. 3. Referencing their experience with the solar water heater, students research how much	

	carbon dioxide emission is prevented by using solar energy instead of fossil fuels to heat water for a home. This graphic is one of many resources available online: Net Zero Carbon Footprint. 4. Students create a visual presentation of the information they have learned about the drawdown impact (the reduced amount of carbon dioxide emitted) of using solar power. These presentations are an excellent way to communicate with community members.

9.	**Possible next steps:**	
	• Research how a solar panel works • Build a solar oven (maybe in teams, maybe a demonstration, maybe a competition) • Research degrees and careers in solar energy	

10.	**Post Assessment:**	Estimated Time: 30 minutes
	MS-Renewable Energy: Solar Post-Assessment MS-Renewable Energy: Solar Assessment Rubric	

MS-Renewable Energy: Solar OER Tracker

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