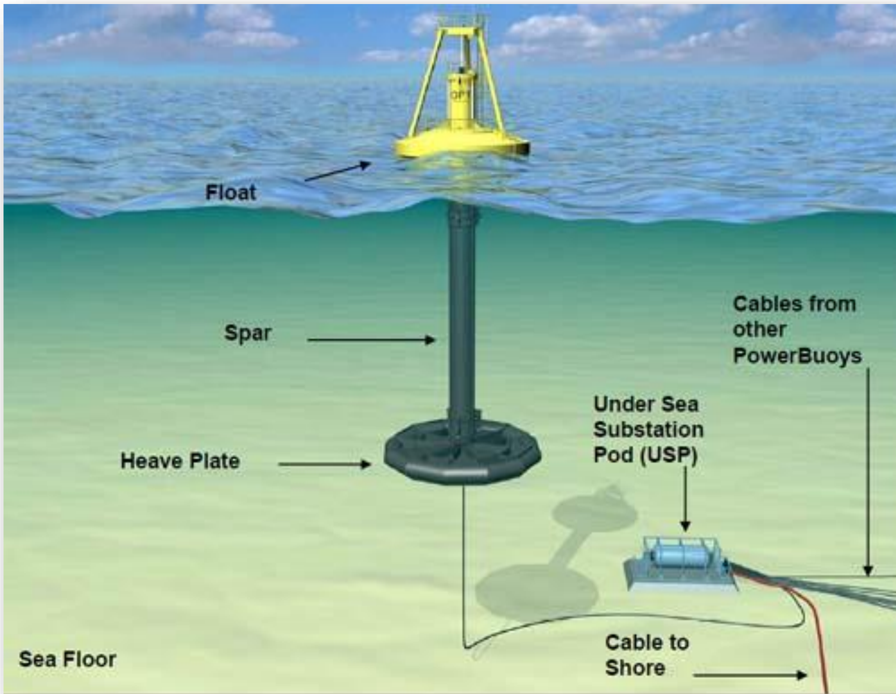

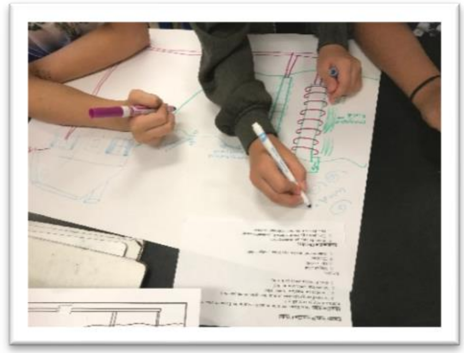

Middle School Integrated Science: Magnetic & Electric Fields

7th Grade

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Anchoring phenomenon:
The Northwest National Marine Renewable Energy Center at Oregon State University facilitates test sites for wave energy converters to evaluate and develop effective marine energy technology to capture useable energy from ocean waves.

Context for the phenomena: http://nnmrec.oregonstate.edu/

Essential question about phenomenon/unit:
How does energy from an ocean wave become energy that is used in your home?

Scientific explanation (instructor's background knowledge):

Develop a gapless explanation through research to include, but not limited to:

1. <u>How and why the ocean wave has energy</u>.
   a. Ocean wave pushes/crushes, makes sound, evidence of mechanical energy transfer and transformations
   b. Ocean wave got energy transferred from the wind (energy never created/destroyed)
   c. Ocean wave molecules move in circular motions (wave transfers energy not matter)
   d. Ocean wave properties describe how much potential energy is present (wave amplitude, gravitational potential)
2. <u>How and why magnetic forces in the buoy attract/repel electrons in wire coils</u>.
   a. Atoms are made up of pieces that are neutral, positive, and negatively charged (neutrons, protons, electrons)
   b. Magnets, magnetic materials, non-magnetic materials have differences in orientation of domains (groups of atoms)
   c. Magnetic fields have forces attract/repel materials that have different/like charges
   d. Magnetic force strength is affected by distance, orientation, magnet size, magnet strength
3. <u>How and why electrical current travels through cables to the house</u>.
   a. Separating an electron from an atom releases energy
   b. Copper atom has one valence electron, outer location easier to separate
   c. Negative pole of magnet moving past copper atom pushes electron to next atom, bumping the next valence electron
   d. If in a complete circuit the electrons continuously transfer generating electrical current

NGSS *Performance Expectations* addressed in this unit:

Standard	PE	DCI	CCC
MS-PS2-3	**Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.** [Clarification Statement: Examples of devices that use electric and magnetic forces could include electromagnets, electric motors, or generators. Examples of data could include the effect of the number of turns of wire on the strength of an electromagnet, or the effect of increasing the number or strength of magnets on the speed of an electric motor.] [Assessment Boundary: Assessment about questions that require quantitative answers is limited to proportional reasoning and algebraic thinking.]	**PS2.B: Types of Interactions** • Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects. (MS-PS2-3)	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS2-3),(MS-PS2-5)
MS-PS2-5	**Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.** [Clarification Statement: Examples of this phenomenon could include the interactions of magnets, electrically-charged strips of tape, and electrically-charged pith balls. Examples of investigations could include first-hand experiences or simulations.] [Assessment Boundary: Assessment is limited to electric and magnetic fields, and limited to qualitative evidence for the existence of fields.]	**PS2.B: Types of Interactions** • Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, a magnet, or a ball, respectively). (MS-PS2-5)	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS2-3),(MS-PS2-5)
MS-PS3-2	**Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.** [Clarification Statement: Emphasis is on relative amounts of potential energy, not on calculations of potential energy. Examples of objects within systems interacting at varying distances could include: the Earth and either a roller coaster cart at varying positions on a hill or objects at varying heights on shelves, changing the direction/orientation of a magnet, and a balloon with static electrical charge being brought closer to a classmate's hair. Examples of models could include representations, diagrams, pictures, and written descriptions of systems.] [Assessment Boundary: Assessment is limited to two objects and electric, magnetic, and gravitational interactions.]	**PS3.A: Definitions of Energy** • A system of objects may also contain stored (potential) energy, depending on their relative positions. (MS-PS3-2) **PS3.C: Relationship Between Energy and Forces** • When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object. (MS-PS3-2)	**Systems and System Models** • Models can be used to represent systems and their interactions – such as inputs, processes, and outputs – and energy and matter flows within systems. (MS-PS3-2)
*MS-PS4-1 (limit to ocean wave properties, also in 8th grade)	**Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.** [Clarification Statement: Emphasis is on describing waves with both qualitative and quantitative thinking.] [Assessment Boundary: Assessment does not include electromagnetic waves and is limited to standard repeating waves.]	**PS4.A: Wave Properties** • A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. (MS-PS4-1)	**Patterns** • Graphs and charts can be used to identify patterns in data. (MS-PS4-1)
*MS-PS1-1 (limit to electrons	**Develop models to describe the atomic composition of simple molecules and extended structures.** [Clarification Statement: Emphasis is on developing models of molecules that vary in	**PS1.A: Structure and Properties of Matter** • Substances are made from different types of	**Scale, Proportion, and Quantity** • Time, space, and energy

negative charge, also in 7th chemical reactions)	complexity. Examples of simple molecules could include ammonia and methanol. Examples of extended structures could include sodium chloride or diamonds. Examples of molecular-level models could include drawings, 3D ball and stick structures, or computer representations showing different molecules with different types of atoms.] [*Assessment Boundary: Assessment does not include valence electrons and bonding energy, discussing the ionic nature of subunits of complex structures, or a complete description of all individual atoms in a complex molecule or extended structure is not required.*]	atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. (MS-PS1-1) • Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals). (MS-PS1-1)	phenomena can be observed at various scales using models to study systems that are too large or too small. (MS-PS1-1)

Summary Table of Activities in Unit

Activity/LT	***Evidence Students Could Gain***	***Connection to Phenomenon (will vary per students)***	***Questioning Strategies/Discussion Suggestions***
Activity 1: Initial Model & explanation LT: SWBAT model initial ideas about energy	• Invent strategies for modeling energy • Record initial ideas • Note: Revise initial model periodically	• Model the phenomena– accept all student ideas	• How might energy be made and move through the system? • What are ways we could draw energy that we cannot see with our eyes?
Activity 2: Forms of energy investigation stations LT: SWBAT observe and describe each form of energy	• Energy is the ability to do work • Energy exists in several forms; chemical, nuclear, mechanical, electrical, radiant, thermal, sound, etc • Gravitational forces create potential/kinetic mechanical energy	• Mechanical energy is present in the wave • Electrical energy moves in the cables • Other forms of energy could be present in this system	• What is energy? • Where do you see energy around you every day? • How are different forms of energy the same? Different? •
Activity 3: Energy transfer and transformation diagraming w/online simulation LT: SWBAT represent energy transfers and transformations in diagrams	• There are many ways to draw all the forms of energy we cannot see in a system • Energy is never created or destroyed • Energy can transfer between objects • Energy can transform from one form of energy to another form of energy •	• Mechanical energy in the wave transforms into another form of energy • Energy is transformed inside the buoy to electricity • Electricity in the cables transfer to objects that use electricity in the house	• How is energy created? • Where does energy go to/come from? • How does energy move and change?
Activity 4: Potential and kinetic card sort	• Energy can be stored (potential) or in use (kinetic) • All forms of energy can be potential/kinetic depending on the	• Energy in this system could be stored (potential) or in use (kinetic) • Waves have gravitational	• Where/how is energy stored? • When/how is stored energy used?

<u>LT</u>: SWBAT distinguish between potential and kinetic energy behaviors	situation • Potential and kinetic are not considered their own forms of energy	potential energy • Waves have mechanical kinetic energy (in-use)	• How can forces (like gravity) give an object potential energy? •
<u>Activity 5</u>: Wave videos and reading, physical simulation <u>LT</u>: SWBAT describe ocean wave properties	• Waves get energy from wind • Ocean waves do work on the shore, breaking rocks, eroding banks, etc. • Waves in matter (such as water) have potential mechanical energy and kinetic mechanical energy, depending on where in the wave you look • We describe waves by measuring frequency, wavelength, amplitude • Waves can move transverse, longitudinal, or combination waves • Waves transfer energy without transferring matter	• Energy in an ocean wave can be seen in the "work" being done on the shore • There is more energy in an ocean wave that has a higher amplitude • A wave has the most potential energy at the crest • Ocean waves are combination, water molecules move in circular motion •	• How do we know there is energy in an ocean wave? • Where did energy in an ocean wave come from? • How can we measure how much potential energy is in a wave? • If you were a molecule of matter in a wave (transverse, longitudinal, then combination) how would you move? • If matter in the wave does not move far, how can the energy move long distances?
<u>Activity 6</u>: Magnet investigation stations <u>LT</u>: SWBAT observe and describe behaviors of magnets and magnetic materials	• Magnetic fields exert forces on other magnetic objects when not in contact • Like charges repel each other • Opposite charges attract each other • Magnetic fields do not exert forces on non-magnetic objects • Magnetic fields are stronger when closer to an object • Magnetic fields are stronger when additional magnets are aligned beside each other •	• Generator inside the buoy has a magnet generating forces affecting magnetic materials (the negatively charged electrons in cables)	• When did you notice the magnetic forces were strongest? • What are characteristics of materials were magnetic/non-magnetic • How did iron filings behave when over a bar magnet?
<u>Activity 7</u>: Atoms videos & reading <u>LT</u>: SWBAT predict how a magnetic force could affect an atom	• Atoms are the smallest unit of matter • Each atom has neutrons, protons, and electrons • Electrons are negatively charged particles • Electrons can be lost/gained in the outer shell of the atom •	• Negatively charged electrons could be repelled by a negative pole on the magnet • Copper atoms have one valence electron that is easier to "push" to the next atom	• How do you think a strong magnetic field could affect an electron? •
<u>Activity 8</u>: Physical & digital magnet and copper coil simulations	• Electricity is movement of electrons in a circuit (won't move if circuit isn't complete) • Copper has an "extra" electron on its atoms	• The buoy's generator has a magnet (moved by wave energy) inside copper coils • The magnetic forces move electrons in the copper	• What did you do in the simulation to generate the most volts? • What does a copper

<u>LT</u>: SWBAT model magnetic forces interacting with copper atoms	• Negative magnetic fields "push" electrons from the copper atoms, bumping the next electron next to it, bumping the next... down the wire • Spinning or passing a magnet past copper wires continually puts electrons in motion = generating electrical current	atoms to create electrical current in the cables	atom feel when the magnet moves by it? (hand electron to neighbor as magnetic field pushes by)
<u>Activity 9</u>: Magnetism videos & reading <u>LT</u>: SWBAT compare properties of magnet, magnetic, and non-magnetic material	• Atoms have their own magnetic poles • Materials have groups of atoms in magnetic domains • Domains can be not aligned (non-magnetic material), temporarily aligned (magnetic material), or always aligned (permanent magnets •	• The generator must be made with a permanent magnet that has magnetic domains aligned	• Why are some materials magnetic and others not? • How can a nail (magnetic material) become a magnet and attract a paperclip for a short amount of time?
<u>Activity 10</u>: Engineering wave generators <u>LT</u>: SWBAT design and test prototype model	• Design magnet/coil assemblies that could generate electrical currents • Test various strengths of magnets • Test number of turns in coils • Test distance of magnet to coils	• It is not simple to generate large electrical current • Efficient wave generator designs require many iterations	• What design features will make a wave generator make more electrical current? •
<u>Activity 11</u>: Electricity for modern life & energy poverty empathy <u>LT</u>: SWBAT develop empathy for others to understanding a user's problem	• Electrical energy is most versatile and useable form of energy • Modern infrastructure/technology is a complex network set up to run on available electrical energy • Not all countries/areas have reliable energy infrastructure • People living without reliable electricity experience many challenges • Everyday examples of energy use	• Wave generators could provide reliable electricity for costal communities • Cost/location makes wave generators not feasible for many communities	• How do you use electricity in your life? • How would your life be different if all electricity stopped working? •
<u>Activity 12</u>: Engineer solutions for energy poverty <u>LT</u>: SWBAT	• A magnet moving in coiled wire could create electricity when incorporated into someone's daily activity (movement) • Criteria/constraints for designs may include: simple to build, affordable cost, manageable size, fun or easy to use		• How can you use what you know about magnets and electricity to help people living in energy poverty?
<u>Activity 13</u>: Final Model & Explanation <u>LT</u>: SWBAT	• Develop and refine energy modeling strategies • Record final ideas supported by evidence from unit activities	• Model the phenomena-evidence supported causal explanations including the "how" and "why"	• What evidence do you have to support your new ideas? • How can you show more than you did in previous revisions to

			explain what is happening?
Activity 14: Unit and modeling reflection LT: SWBAT	• Reflect and give feedback on usefulness of unit activities • Identify evidence of personal growth between initial/final ideas	•	•

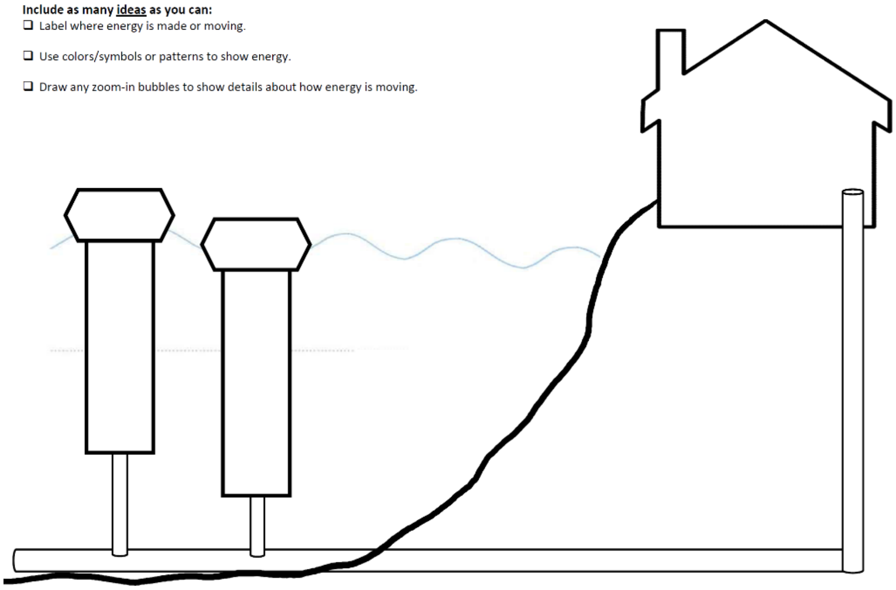
(*Add Rows as Necessary*)

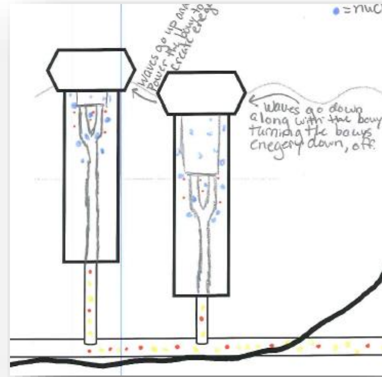
Model Template: Individual Models

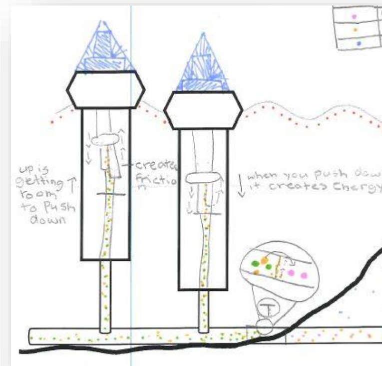
INITAL MODEL: ***How does energy from an ocean wave power stuff in a house?***

DIRECTIONS: Using the drawing below, add information to show how energy gets from the wave to the house.

Include as many ideas as you can:
- ❑ Label where energy is made or moving.
- ❑ Use colors/symbols or patterns to show energy.
- ❑ Draw any zoom-in bubbles to show details about how energy is moving.



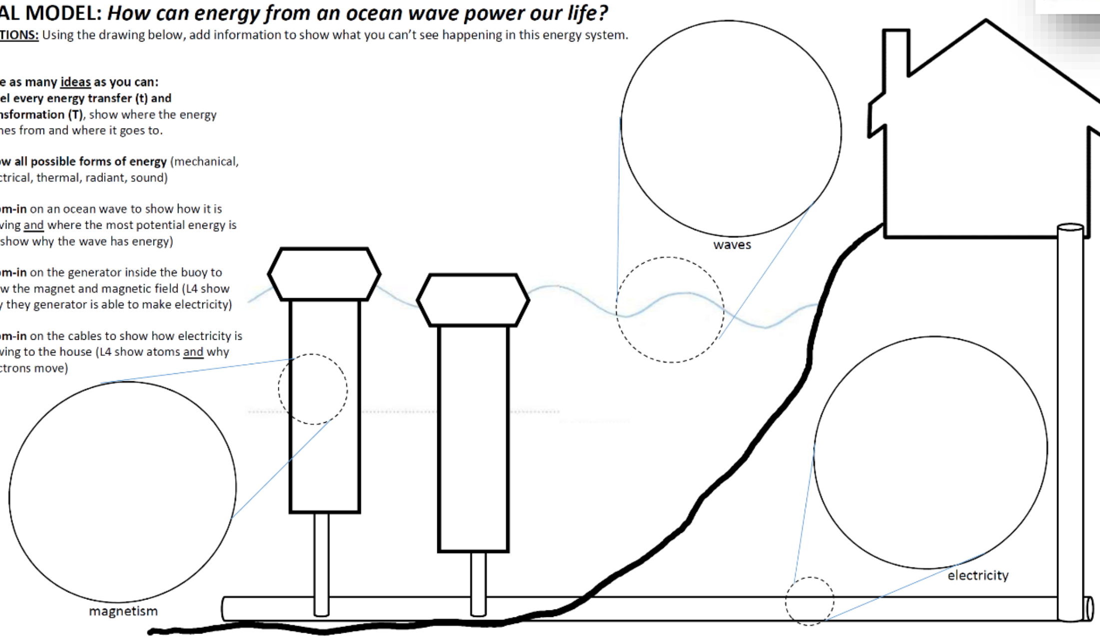


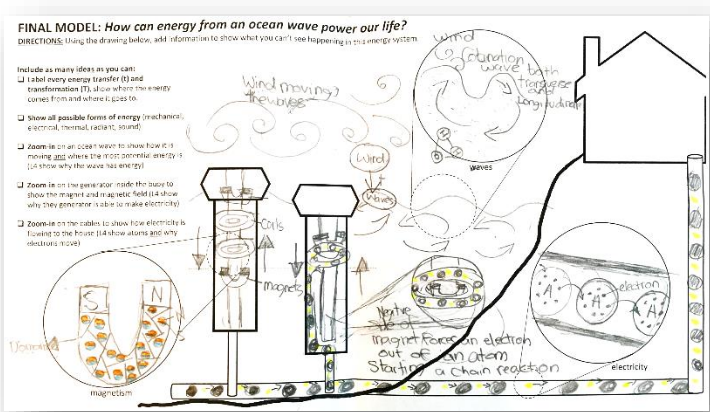


FINAL MODEL: ***How can energy from an ocean wave power our life?***

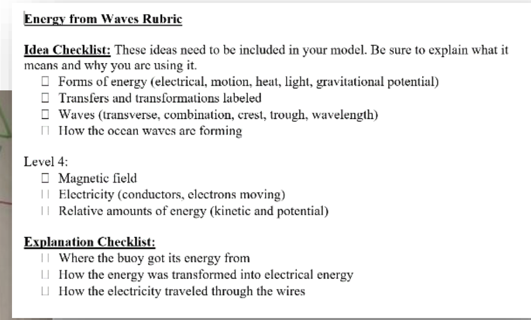
DIRECTIONS: Using the drawing below, add information to show what you can't see happening in this energy system.

Include as many ideas as you can:
- ❑ **Label every energy transfer (t) and transformation (T)**, show where the energy comes from and where it goes to.
- ❑ **Show all possible forms of energy** (mechanical, electrical, thermal, radiant, sound)
- ❑ **Zoom-in** on an ocean wave to show how it is moving and where the most potential energy is (L4 show why the wave has energy)
- ❑ **Zoom-in** on the generator inside the buoy to show the magnet and magnetic field (L4 show why they generator is able to make electricity)
- ❑ **Zoom-in** on the cables to show how electricity is flowing to the house (L4 show atoms and why electrons move)





Group Modeling Examples:



Energy from Waves Rubric

Idea Checklist: These ideas need to be included in your model. Be sure to explain what it means and why you are using it.

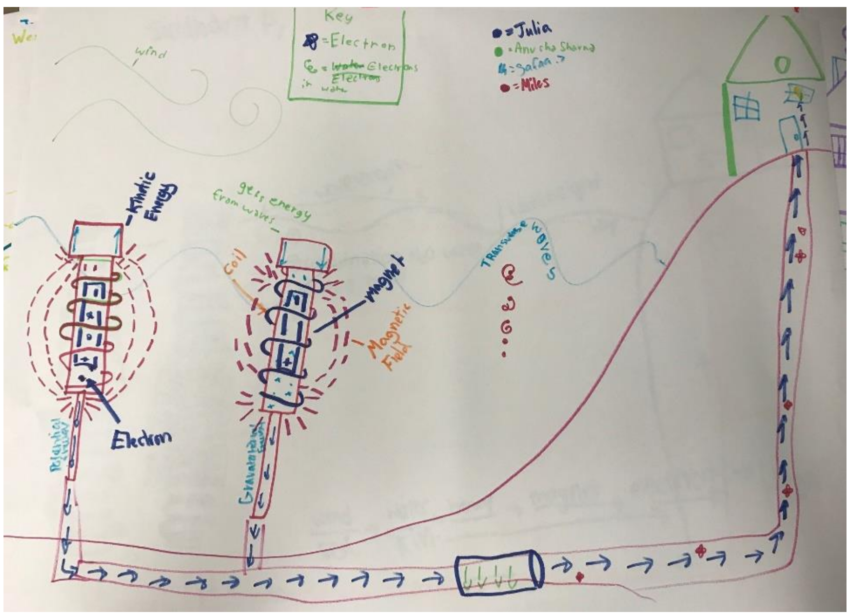
- ☐ Forms of energy (electrical, motion, heat, light, gravitational potential)
- ☐ Transfers and transformations labeled
- ☐ Waves (transverse, combination, crest, trough, wavelength)
- ☐ How the ocean waves are forming

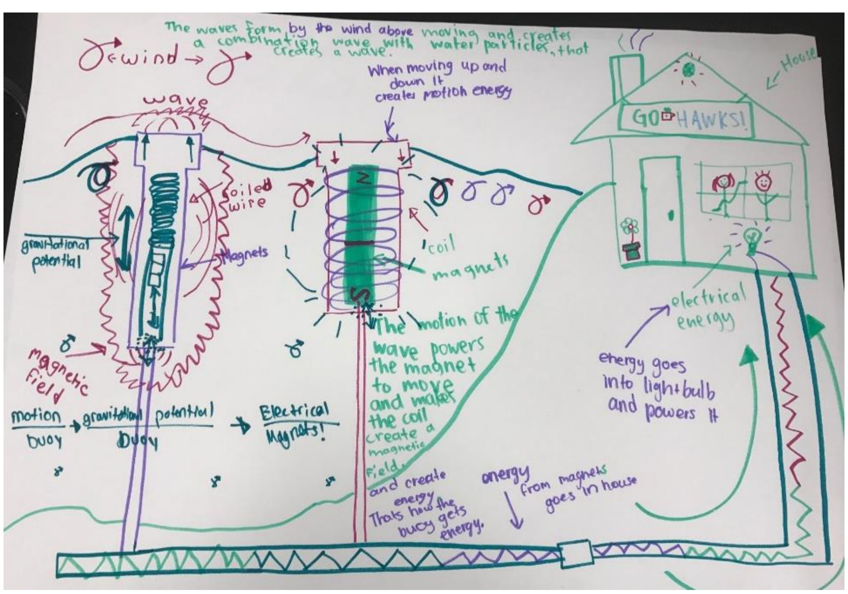
Level 4:

- ☐ Magnetic field
- ☐ Electricity (conductors, electrons moving)
- ☐ Relative amounts of energy (kinetic and potential)

Explanation Checklist:

- ☐ Where the buoy got its energy from
- ☐ How the energy was transformed into electrical energy
- ☐ How the electricity traveled through the wires





Additional Documents:

Title/Description	Resource
Activity 2 – Forms of energy presentation with videos	https://sway.com/qyhCC6KS8BSs8fSi?ref=Link
Activity 3 – Phet Simulation "Energy Systems"	https://phet.colorado.edu/en/simulation/legacy/energy-forms-and-changes
Activity 5 – Waves presentation (includes phenomena prompt) with videos	https://sway.com/YSBAew40CBXShp3o?ref=Link
Activity 8 – Phet Simulation "Pick Up Coil"	https://phet.colorado.edu/en/simulation/legacy/generator
Activity 10 – Teacher Resource How-to Build Model Buoy	https://youtu.be/5dK19QAqjgA http://nnmrec.oregonstate.edu/education/k-12-resources
Activity 11 – Energy Poverty Sway with Videos	https://sway.com/BLg5riCBMdokcFsX?ref=Link

LWSD PowerSchool "6-8 NGSS Hub" for all files, links, and video files related to the summary table activities.