2016-2017

Exploring Ocean Energy and Resources

Teacher Guide

Informational text, hands-on explorations, and critical thinking and engineering design activities introduce students to the sources of energy found offshore and the non-energy related mineral resources found in our ocean environments.

Grade Levels:

- Int Intermediate
- Sec Secondary

Subject Areas:

- Science
- Social Studies
- Math
- Language Arts
- Technology

NEED
National Energy Education Development Project

Teacher Advisory Board

NEED Mission Statement

The mission of The NEED Project is to promote an energy conscious and educated society by creating effective networks of students, educators, business, government and community leaders to design and deliver objective, multi-sided energy education programs.

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Teacher Advisory Board

In support of NEED, the national Teacher Advisory Board (TAB) is dedicated to developing and promoting standards-based energy curriculum and training.

Energy Data Used in NEED Materials

NEED believes in providing teachers and students with the most recently reported, available, and accurate energy data. Most statistics and data contained within this guide are derived from the U.S. Energy Information Administration. Data is compiled and updated annually where available. Where annual updates are not available, the most current, complete data year available at the time of updates is accessed and printed in NEED materials. To further research energy data, visit the EIA website at www.eia.gov.

NEED
National Energy Education Development

1.800.875.5029
www.NEED.org

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Table of Contents

Standards Correlation Information

www.NEED.org/curriculumcorrelations

Next Generation Science Standards

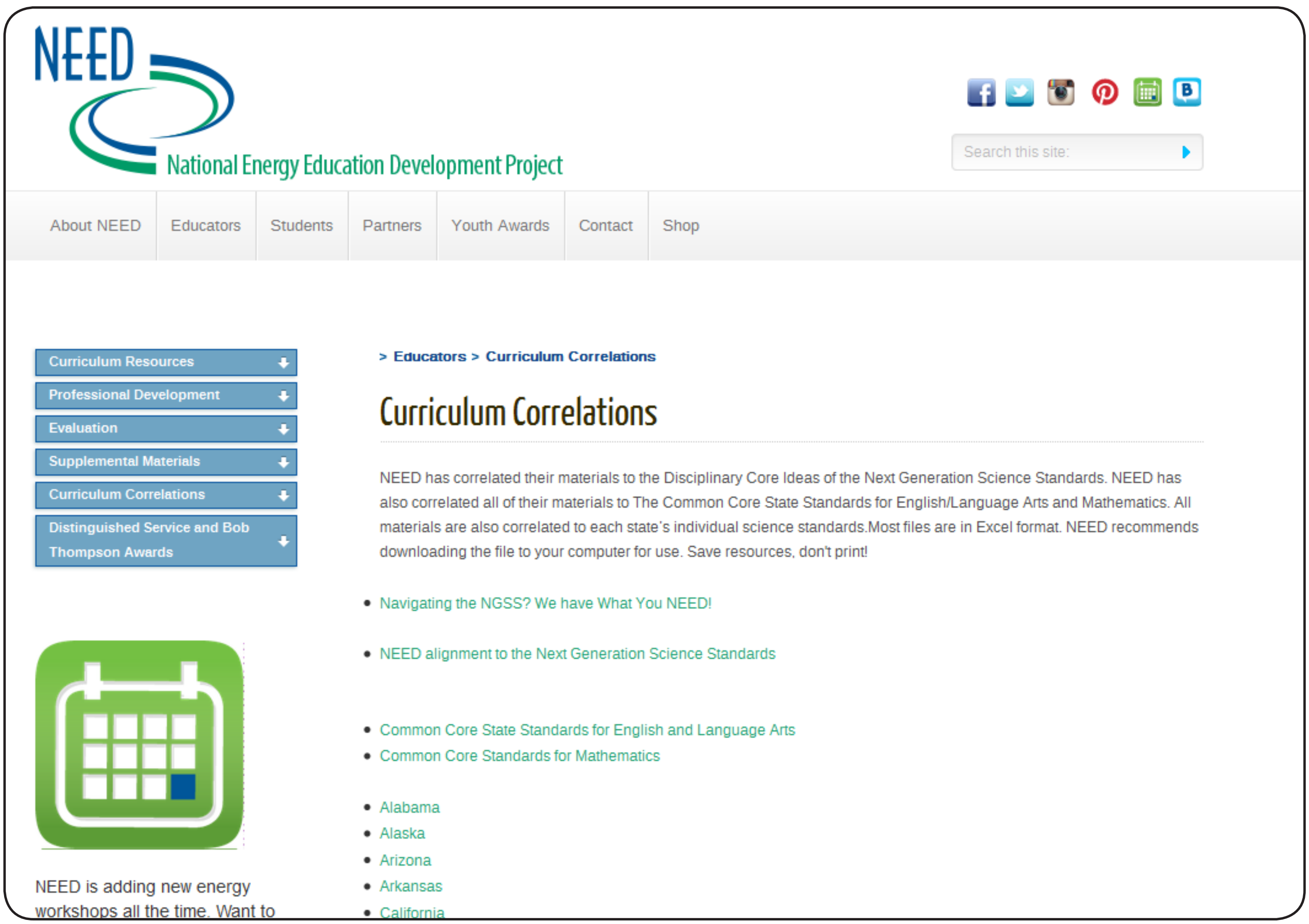
- This guide effectively supports many Next Generation Science Standards. This material can satisfy performance expectations, science and engineering practices, disciplinary core ideas, and cross cutting concepts within your required curriculum. For more details on these correlations, please visit NEED's curriculum correlations website.

Common Core State Standards

- This guide has been correlated to the Common Core State Standards in both language arts and mathematics. These correlations are broken down by grade level and guide title, and can be downloaded as a spreadsheet from the NEED curriculum correlations website.

Individual State Science Standards

- This guide has been correlated to each state's individual science standards. These correlations are broken down by grade level and guide title, and can be downloaded as a spreadsheet from the NEED website.



Exploring Ocean Energy and Resources Materials

The activities in this guide are designed so that the materials are inexpensive, and can be obtained easily at local stores. If you have difficulty locating any of the materials you need, e-mail NEED at info@need.org for information on procuring necessary materials.

ACTIVITY NAME	MATERIALS NEEDED	
Ocean Energy Expo	▪Display boards or poster board ▪Art supplies	
Exploring Oil Seeps & Exploring Oil Seeps Inquiry Investigation	▪Graduated cylinders ▪Clear cups or beakers ▪Sand (not aquarium sand) ▪Cooking oil ▪Plastic spoons ▪Small mixing bowls	▪Top soil (not potting soil) ▪Modeling clay ▪Water ▪Timer or watch
Offshore Oil and Gas Leasing	▪Scissors ▪Glue ▪Cardstock or colored paper ▪Calculators ▪Folders or manila envelopes ▪Post-It® notes	
Cake & Frosting Drilling Simulation (optional extension of Offshore Oil and Gas Leasing)	▪Yellow cake mix (prepared to instructions) ▪Plastic knife ▪Aluminum foil ▪Chocolate frosting ▪Dental floss	▪Tape ▪Straws ▪Paper towels ▪Red and green tassel toothpicks
Drilling Rig Models	▪Various recycled or "found" materials ▪Various construction tools ▪Various adhesives ▪Large sink or tub	▪Water ▪Fan (optional) ▪Ruler ▪Timer
Getting the Oil Out	▪Drinking straws ▪Masking tape ▪Scissors ▪Ruler ▪Paper towels ▪Dark-colored beverages	
Wind Energy at Work	▪Large foam cups (approximately 14 cm tall) ▪Extra-long straws ▪Small straws ▪Binder clips ▪Straight pins ▪Rulers ▪Hole punch ▪Markers ▪String or thread ▪Paper clips ▪Masking tape ▪Scissors	

ACTIVITY NAME	MATERIALS NEEDED
Science of Electricity	▪1 Small round bottle ▪4 Strong rectangle magnets ▪1 12" x ¼" Wooden dowel ▪1 Rubber stopper with ¼" center hole ▪Foam tube ▪Spool of magnet wire ▪Masking tape ▪Permanent marker ▪1 Small nail ▪1 Large nail ▪Fine sandpaper ▪Multimeter ▪Alligator clips ▪Sharp scissors ▪Ruler ▪Hand operated pencil sharpener ▪Push pin
Exploring Convection Currents	▪Clear plastic cups ▪Marbles ▪Hot water ▪Ice water ▪Food coloring
Ocean Energy	▪Shake flashlight with transparent body
Siting Renewable Energy Resources	▪Colored pencils
Offshore Ocean Resources	▪Transparency film (optional) ▪Salt dough materials (optional – see page 28)

Teacher Guide

Background

The ocean environment has many energy resources, both renewable and nonrenewable. As technologies are developed and improved, ocean resources will be able to meet some of the nation's energy needs. The ocean environment located on the outer continental shelf also supplies the United States with non-energy natural resources. Using ocean resources has varying economic benefits, environmental impacts, and risks. Decisions pertaining to using ocean resources often cause debate among politicians and concerned citizens. There are diverse career options for today's young adults in fields directly, and indirectly, related to ocean and offshore energy resources.

Unit Preparation

- Familiarize yourself with the information and activities in the guide.
- Make copies of the activities and resources you will use.
- Gather the materials needed for the activities you have chosen.

✔Unit Procedure

1. The activities within this guide are a suggested plan for completing a comprehensive unit covering ocean energy and ocean resources. Activities can be completed in any order. Pick and choose, simplify, or expand these activities to best meet your students' needs and to fit the time available.
2. You may choose to have students read the informational text for homework. You may find it beneficial to break up the reading to fit with the selected activities, having students read sections as they are applicable.

Grade Levels

- Intermediate, grades 6-8
- Secondary, grades 9-12

Time

- 10-25 45 - minute class periods, depending on the activities selected

Activity 1: Ocean Energy Expo

Background

Small groups of students will work together to create exhibits, and give short, informative presentations to teach others about an ocean energy topic.

Objectives

- Students will be able to dissect non-fiction text.
- Students will be able to identify important information related to energy and the oceans.

Time

- 3-4 class periods

Materials

- Display board or poster board
- Art supplies
- Internet access
- *Creating an Ocean Energy Expo Exhibit* worksheet, Student Guide page 31

Preparation

- Divide students into groups of 2-4. Assign each group an exhibit topic.
- Make an informational packet for each group. Each packet should include:
  - Relevant informational text, Student Guide pages 2-30
  - *Creating an Ocean Energy Expo Exhibit* worksheet
- Collect art supplies and other materials.

✔ Procedure

Part One - *INTRODUCTION OF ACTIVITY*

1. Introduce the activity to the class. Explain to the students that they will be working in small groups to prepare a short exhibit and presentation on one aspect of ocean energy. They will use their exhibit to teach the class in an expo setting about their topic. Assign students their groups and topics and distribute the informational text.
2. Give students the timeframe within which they are to accomplish their parts of the projects. If this will be a graded activity, explain the grading procedure. Refer to the rubric found on the *Creating an Ocean Energy Exhibit* worksheet on page 31 of the Student Guide, or create your own rubric.
3. Have the students read their informational text and answer the research questions.
4. Answer any questions the students may have.

Part Two - *PREPARATION OF PRESENTATIONS/EXHIBITS*

1. Give the groups time to prepare their presentations.
2. Encourage students to make exhibits or use multimedia for illustration and demonstration of their topics. Encourage students to practice the group presentation.

Part Three - *PRESENTATIONS*

1. Each group makes its presentation in turn.
2. Evaluate student performance using the rubric in the Student Guide.

Activity 2: Exploring Oil Seeps

Background

Oil seeps are underwater cracks in the Earth's crust that release crude oil directly into ocean water. Naturally occurring crude oil and natural gas seeps are valuable sources of energy found offshore. One of the largest seeps in the world is at Coal Oil Point near Santa Barbara, California. According to the National Oceanic and Atmospheric Administration (NOAA), every day an estimated 2,000 to 3,000 gallons of crude oil is released naturally from the ocean floor, just a few miles offshore from this beach. Two small underwater containment structures collect some of the natural seepage. Studies show that over 60 percent of all oil found in ocean environments comes from natural seeps through the ocean floor, compared to about one percent released during offshore oil and gas development.

✪ Objective

- Students will be able to describe the conditions that allow for oil to seep by creating and testing a model.

Materials *FOR EACH GROUP OR STUDENT*

- Graduated cylinder
- Clear cup or beaker
- Sand (do not use aquarium sand)
- Cooking oil
- Plastic spoon
- Water
- Small mixing bowl
- Top soil (do not use potting soil)
- Modeling clay
- Timer or watch
- *Exploring Oil Seeps* activity, Student Guide pages 32-33

Time

- 1 class period

Preparation

- Gather the materials and set up stations to allow students to work in small groups.
- If working in groups, it may be helpful to place top soil, sand, and water at each station, rather than in one location.
- Make copies of the worksheets for students.

✔ Procedure

1. Read and discuss the oil and gas sections of the student informational text. This can be assigned as homework if necessary.
2. Assist students as they build models and complete the *Exploring Oil Seeps* activity. It may take several minutes before oil seeping is visible. Encourage students to make observations and fill in the data table.
3. After students have recorded observations, completed the data table, and discussed the conclusion questions within their small groups, set up all of the models in a central location. As a class, observe, compare, and contrast the oil seep models. Lead students in a discussion about variables they find, and any aspects of the investigation that can be controlled. Create a list on the board of the independent variable, dependent variables, and controlled variables that students identify.
4. Continue the discussion by brainstorming a list of research questions students want to investigate. Determine the variables and controls for each question. Discuss student questions as a class. Suggestions include:
   - How long do you think it would take for all the oil to seep to the top? How would you design an experiment to test this?
   - What actions or materials would affect the rate of oil seeping to the surface?
   - What effect would salt water have on the system? How salty should the water be?
   - What effect would a taller container with more water have on the system? What about a wider container with more surface area?
   - How does the shape, size, and condition of the clay seal affect the rate of oil seeping to the surface?
   - How does the composition of the sea floor affect the rate of oil seeping to the surface?
   - How does the placement of the oil in the sea floor affect the rate of oil seeping to the surface?
5. If you are not continuing with Activity 3, you can dispose of all materials safely in the trash.

Extension

- Use the same set-up but substitute a heavier oil, like motor oil. Dispose of the models responsibly, if selecting this option.

Activity 3: Exploring Oil Seeps Inquiry Investigation

Objective

- Students will design an investigation using the *Exploring Oil Seeps* model to further explain the factors that effect the rate at which oil seeps occur from the ocean floor.

Time

- 1-3 class periods

Materials *FOR EACH GROUP OR STUDENT*

- Oil seeps models used in Activity 2
- Graduated cylinder
- Clear cup or beaker
- Sand (do not use aquarium sand)
- Cooking oil
- Plastic spoon
- Water
- Small mixing bowl
- Top soil (do not use potting soil)
- Modeling clay
- Timer or watch
- *Exploring Oil Seeps* activity, Student Guide pages 32-33
- *Exploring Oil Seeps Inquiry Investigation*, Student Guide page 34

Preparation

- Make copies of the worksheet for students.

Procedure

1. Select several questions to investigate from Activity 2, and assign student groups to each question. Give students time to work together to design their experiments.
2. Using the materials above, students can test and re-test their investigations.
3. Students will make observations, and record data and conclusions. Have any groups that examined similar questions conference together to share and compare results. Allow time for groups to report to the class about their experiment, results, and conclusions, and compare to the original model from Activity 2.

Extension

- Additional informational text, activities, and hands-on explorations with a wider coverage of the energy resources petroleum and natural gas, can be found at www.NEED.org. *Exploring Oil and Gas* helps students understand the formation, production, and uses of oil and natural gas. Activities illustrate the exploration, extraction, production, and processing of petroleum and natural gas, and introduce students to the many careers available in the oil and gas industry. Sample activities include: mapping the ocean floor, core sampling, exploring porosity, drilling for oil, hydraulic fracking, fracking a cake, and using density to extract petroleum. In *Fossil Fuels to Products*, students learn about exploration, production, refining, chemical manufacturing, transportation, marketing, and uses of petroleum, natural gas, and their products in the industrial sector, with informational text and hands-on activities.

Activity 4: Offshore Oil and Gas Leasing

Background

The Outer Continental Shelf (OCS) is a significant source of oil and natural gas for our nation's energy supply. In 2014, about 6 percent of America's domestic natural gas production and about 17 percent of America's domestic oil production came from approximately 43 million acres leased on the OCS. The Bureau of Ocean Energy Management (BOEM) manages the nation's offshore resources to ensure that production and drilling are done in an environmentally and economically responsible manner.

This activity explores some aspects of the planning, budgeting, bidding, and leasing that occurs before a company begins drilling an exploratory well on the OCS. Students will form company teams, determine their budget, place bids for leases, and drill for oil if they win a lease.

While this critical thinking activity simplifies the multi-year process oil and natural gas developers must go through, the regulations and paperwork, the amount of blocks available to lease, and other aspects of the activity are modeled directly after real events and processes. Data for this activity comes directly from Oil and Gas Lease Sale 208 in the Central Gulf of Mexico Planning Area. This lease sale occurred on March 18, 2009 in New Orleans, Louisiana. In 2009, when this lease sale occurred, the now disbanded government agency, Minerals Management Services, was responsible for lease sales on the OCS. Today, BOEM runs all aspects of oil and natural gas leasing, therefore, this activity refers solely to BOEM.

Original documents are available from the Bureau of Ocean Energy Management at this website:
http://www.boem.gov/Oil-and-Gas-Energy-Program/Leasing/Regional-Leasing/Gulf-of-Mexico-Region/Lease-Sales/208/Index.aspx.

Objectives

- Students will be able to explain that the Federal Government governs all aspects of offshore oil and natural gas development, including permits, lease sales, collecting rental fees, and receiving royalties from profits.
- Students will be able to describe the costs associated with leasing on the OCS.
- Students will be able to describe the uncertainty and risk in offshore oil and natural gas development.

Materials

- Scissors
- Glue
- Card stock or colored paper
- Calculators
- Post-It® notes (optional)
- Folders or manila envelopes
- *Energy Bucks* master, page 31
- *Bid Envelope* master, page 32
- *Bid Record* master, page 33
- *Lease Sale 208* master, page 34
- *Final Notice of Sale 208 Package*, Student Guide pages 35-36
- *Budget Calculations & Planning Form*, Student Guide pages 37-38
- *Bid Form*, Student Guide page 39
- *Bid Record*, Student Guide page 40
- Cake lease map model (optional), page 12
- Lease Sale 208 PowerPoint (optional)

Time

- 1-2 class periods

Preparation

- Make copies of the *Energy Bucks* master on colored paper or card stock. Cut and place into stacks so that each student has $50 million.
- Make copies of the final notice, budget, and bid worksheets for each student.
- Prepare a copy of the *Lease Sale 208* and *Bid Record* masters for projection.
- Make several copies of the envelope master and affix to large envelopes or folders for students to conceal their bids.
- Download the lease sale power point from www.NEED.org or create a model of the lease map area using cake (see page 12 for instructions).

✔ Procedure

Part 1 – *PLACING BIDS*

1. Each student should start with $50 million dollars worth of energy bucks.
2. Pass out the *Final Notice of Sale 208 Package* worksheets. Have students write in the day, date, and time bids are due on the front cover of the package sheet in the summary line.

3. Review the *Final Notice of Sale 208 Package* as a class. In order for students to decide how much to bid, they need to understand some key facts:
   - The bid is a bonus payment, paid immediately if you win a lease.
   - The highest eligible bid will be the winner of each block.
   - There are minimum bid requirements. These can be found in the *Final Notice of Sale 208 Package* under the lists of blocks available.
   - Submitting a bid is a legal contract.
   - You are agreeing to pay the full bid amount, rent, and royalties if you win a lease.
   - You will be paying a monthly rental fee if you win a lease, for five to ten years.
   - You will be paying a monthly royalty if/when you begin production.
   - Fees vary depending on which block you wish to bid on.
   - Students may want to pool money to have more buying power. Several people may comprise one company and choose one company name.
   - Or, individual students/companies may decide to partner together and split the fees and profits. With partnerships, they will have to decide how to fairly split the financial obligations and rewards. For example, four companies, each with their own name, may submit one bid together, each listed with a 25% share. When rent is due, each contributes 25% of the rent, etc.
4. Discuss possible scenarios that may occur during the auction. There may be blocks with no bidders, one company may be the high bidder for several blocks, or, a company with a very low bid may win a block.
5. Allow time for students to strategize, possibly combine themselves into larger companies, or form partnerships.
6. Students submit their company name to BOEM (the teacher) and receive a (Gulf of Mexico) GOM Company Number. Make a list of all the companies and randomly assign them a four or five digit number.
7. Allow time for students to plan bidding. Companies need to fill out a *Budget Calculations & Planning Form* for each block they want to bid on. This is not a form that BOEM requires, but is offered here to help students budget, plan, and make realistic bids.
8. Students should prepare one *Bid Form* and one envelope for each bid, and submit bid envelopes by the due date/time.

Part 2 – *THE AUCTION*

1. At the designated date and time, teacher opens each bid envelop and reads them aloud. Fill in the *Bid Record* master as bids are read. Students can complete their own on their individual record to keep track of bids.
2. Determine the winner of each block after all the bids are read.
3. Any students who are not part of a winning bid become the BOEM. Have them sit at the front of the room, and assign each person to cover a block with a winning bid on the projected lease sale master. They will be responsible for collecting bonuses, rents, and fees during the rest of the activity. They should keep a ledger detailing the transactions. Also, one student can be designated as the "bank", to collect drilling fees not associated with BOEM.
4. Each company with a winning high bid must pay 1/5th of their bonus bid immediately to BOEM (this payment occurs within 24 hours of the auction).
5. Next, each company with a winning high bid must pay BOEM the remaining 4/5 of the bonus bid AND one year's rental fee (these are paid as a lump sum to BOEM on the 11th business day following bid acceptance).
6. Each company may now make plans to drill an exploratory well in their block. Each group should write a plan.

Part 3 – *DRILLING FOR OIL*

1. Each block lessee pays rental fees to BOEM for years 2-5 as they are planning for drilling. Groups should draw a plan. Have the bankers collect from each company.
2. It is now year 5 and each company is ready to drill an exploratory well. Each company must pay BOEM $10,000 to cover processing their Exploration Plan, Development Operations Coordination Document, and Permit to drill an exploratory well. Groups should hand in their written plans and drawings.
3. Drilling an exploratory well may cost 25-40 million dollars, even 80-100 million dollars in deep water. Decide if you will approve each group, and ask them to pay the bank $40 million for an opportunity to drill one exploratory well.

4. If you prepared the optional cake model for the drilling simulation, (page 14), follow those instructions for drilling using the cake as your lease map and drilling area. Otherwise, project the Lease Map PowerPoint slide two and allow a representative from each block to color in or mark a spot that represents where they want to drill an exploratory well. If you do not have an interactive board, students may place a post-it note on the screen/board where they wish to drill. Be sure conceal slide three of the PowerPoint, so groups can not yet determine if any exploratory wells struck oil. Do not show the location of oil to students yet. Tell each lessee the status of their first exploratory well by secretly comparing their marks or sticky notes with slide three in the PowerPoint that shows where oil is.
5. Each block lessee must pay rental fees to BOEM for years 6-8, if necessary as per the terms of their lease.
6. Go through each plot and offer the opportunity to drill another exploratory well. Repeat steps 3-4.
7. Show students the layered map (slide 3) of the PowerPoint so they can see where oil and gas are located and which exploratory wells struck oil.
8. Each block lessee must pay rental fees to BOEM for years 9-10, if necessary as per the terms of their lease.
9. After exploration, companies move into the development and production stage. Due to the complexity of the economics involved, this offshore leasing activity ends here. However, make sure students understand that they would be required to pay 18 ¾% royalties to BOEM if their company has a well producing oil or natural gas. Royalties are paid to BOEM on the last day of the month, following the first month production begins. Royalty payments are difficult to simulate since they are tied to the fluctuating market prices of petroleum and natural gas. There are minimum payments required, Royalty Suspension Provisions, and specific regulations that allow Royalty Relief for some leases. For example, ultra-deep gas wells in the shallow waters of the GOM can often qualify for Royalty Relief or suspension. In addition, companies would be making money from the oil and gas they produce and sell, while paying out money for labor, administration and overhead, maintenance, etc. While this activity focuses only on the leasing process of offshore oil and gas resources, students should know that the Federal Government is receiving a share of the profits from offshore production.

⁂Conclusions

1. BOEM representatives should summarize for the class how much money was collected from each block lessee.
2. Discuss the activity as a class:
   - Did anyone place multiple bids? How did you budget and plan? Does it make better financial sense to bid a lot of money on the block you really want, or spread your money out over several bids and hope to get something?
   - Did any lessees run out of money before they paid out all their rent and fees to BOEM?
   - How might companies need to do business in order to have enough money available to purchase leases and pay rents and drilling fees before they start producing resources and making a profit?
   - Did anyone want to drill more exploratory wells? Why or why not? Discuss the economics of drilling multiple exploratory wells. Companies typically drill several exploratory wells once a temporary drilling rig is in place. It costs thousands of dollars per day to rent the drilling ships that drill exploratory wells, so it makes sense to drill several wells at once. However, there is no financial return on a well drilled that does not find fossil fuel.
   - Discuss the uncertainty and risks a company faces during the exploratory drilling phase.
   - Look at your Lease Map. What percent of your exploratory wells struck oil? (In the U.S., about 61% of exploratory wells find oil.)
3. Review the statistics from Summary of Sale 208 from Department of the Interior, sale date March 18, 2009.

Summary of Sale 208 from Department of the Interior, sale date March 18, 2009

6,458 blocks were available
Only 348 blocks were bid on - over 1.8 million acres
70 companies participated in the auction
476 total bids made
Sum of all bids – over 933 million dollars
The highest bid for a single tract was over 65.6 million dollars
BOEM collected over 690 million dollars in bonus payments
BOEM collected almost 18 million dollars in first year rental fees
To put these bids into perspective as part of the entire Gulf Coast OCS, show students this map which color codes active leases and bids received through 2009, and also shows areas not open for leasing (as of 2009). http://www.boem.gov/Oil-and-Gas-Energy-Program/Leasing/Regional-Leasing/Gulf-of-Mexico-Region/Lease-Sales/208/cpa208_xmas-pdf.aspx

Optional Extension: Cake Lease Map Model and Drilling SImulation

Materials

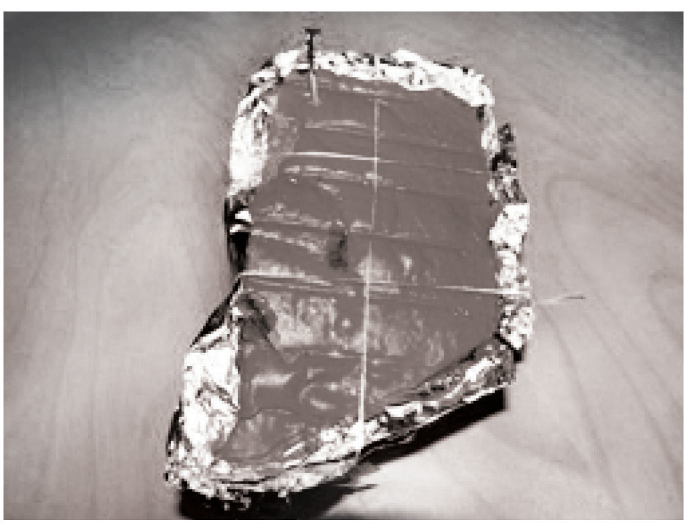
- Yellow boxed cake mix, prepared to instructions
- Plastic knife
- Aluminum foil
- Chocolate frosting
- Dental floss
- Tape
- Straws
- Paper towels
- Red and green tasseled toothpicks

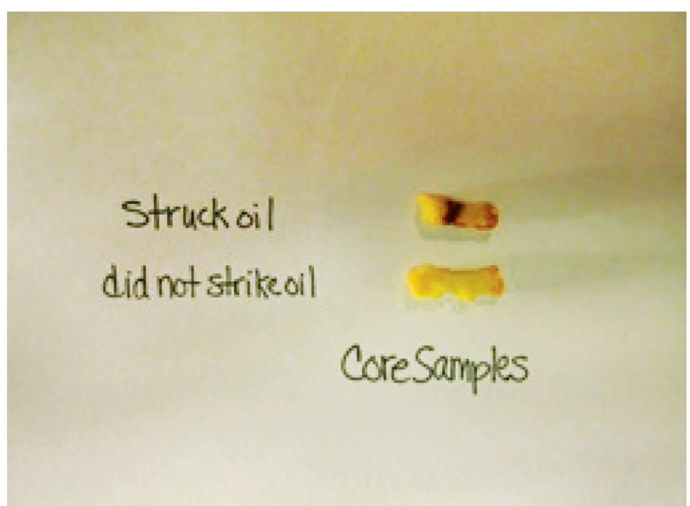
Preparation

- Bake two yellow cakes so that you will have two layers.
- When cool, trim both layers to match the lease sale map shape.
- Place the bottom cake on a layer of foil.
- Randomly frost about 2/3 of the bottom layer with chocolate frosting. Frosting from a pressurized squirt can works well for this. Make note for your reference on a lease sale map where you have used chocolate frosting.
- Place the second cake layer on top.
- Fold the foil to encase the cake on all sides, concealing the frosting locations between layers.
- Create plot lines for each of the blocks that match the lease sale boundaries by taping dental floss across, or scoring with a knife.

✔ Procedure

1. When a team is ready to drill, in Part 3 of the oil and gas leasing activity, give them a straw and let them choose where they want to drill within their block.
2. Have student press the straw straight down into the cake, twist, and draw it back up. Then student should gently squeeze the end of the straw until the core sample pushes out onto a sheet of paper towel.
3. Decide if the core sample struck oil or not.
4. Mark the drill site with the appropriate colored tasseled toothpick - red representing no oil found, and green representing oil discovered.
5. Continue with the next team to drill and complete the rest of the activity following the teacher guide instructions.





Activity 5: Drilling Rig Models

Background

Today, there are many drilling platforms located on the OCS, mostly in the Gulf of Mexico and off the coast of California. There are several types of offshore drilling rigs providing us with oil and natural gas. As the oil and gas industry expands to new offshore areas, exploration wells are being drilled in deeper water, requiring new technology. In this activity, students will research and explore drilling rigs in use on the OCS, then design, build, test, and reengineer a model to meet given design specifications.

Objectives

- Students will be able to list and describe important features of drilling rigs.
- Students will be able to design a model rig and apply engineering and design principles to the building, testing, and redesign of their model.

Materials

- Various recycled or found materials
- Various construction tools
- Various adhesives
- Large sink or tub filled with water
- Fan (optional)
- Ruler
- Timer
- *Drilling Rig Model* worksheets, Student Guide pages 41-43

Time

- 2-3 class periods

Preparation

- Make copies of the worksheets for each student.
- Gather materials for construction and assembly. Preview the activity with students a few days in advance so they may collect items to build with.
- Depending on the abilities of your students and time available to complete a design project, you may decide to add more challenging design specifications, such as:
    - build model to scale;
    - drill into sand/dirt on the bottom of the tub with a straw;
    - stay afloat as mass is added to drilling platform;
    - stay afloat under severe weather conditions; and/or
    - design and build a deepwater drilling rig.
- Split up the class into groups for design and assembly work.

✔ Procedure

1. Assign students to cooperative groups, pass out the worksheets, and discuss the design specifications.
2. Review the informational text, highlighting deepwater oil and natural gas technology.
3. Review the process of basic engineering design, if needed. Encourage students to research other drilling rig information. Students will then design, build, and test their structure, evaluate the problem areas, and spend time reengineering the model until it meets the design specifications.
4. After completing the activity, debrief with students and discuss what they learned. Let groups share their models and talk about their design and engineering processes they worked through. What did students learn about drilling rig structures by building the models? How does that correlate to the real-world? What types of careers are involved in designing, building, and maintaining oil rig structures?

Activity 6: Getting the Oil Out

Background

Drilling for oil in the ocean requires combatting many engineering and design challenges. Often, wells in the OCS are drilling to reach the ocean floor a few miles below the surface, and then the resources thousands of feet further below. Several layers of thick metal casing are used to reach the reservoir deep below the ocean surface.

Petroleum and natural gas reservoirs may initially have natural pressure that cause the fluids, when accessed through drilling, to flow naturally to the surface on their own. Deepwater wells must try and limit the amount of natural pressure pushing those liquids to the surface. Devices are installed on wells called blow out preventers (BOP) to help control the flow of liquids into the well casing. The deepwater environment exerts a lot of pressure on the outside of the casing, too. Controlling the flow of liquids is necessary to ensure the integrity of the well.

In both offshore and onshore wells, however, the natural pressure that exists to push liquids to the surface eventually declines. In this activity, students will explore the challenges of drilling to major depths and maintaining adequate amounts of pressure necessary to produce fluids at the surface.

Objective

- Students will be able to describe the relationship between well depth and effort to recover resources.

Time

- 1 class period

Materials *PER GROUP*

- 8-10 Drinking straws
- 8 oz. Carton of chocolate milk or dark-colored beverage
- Masking tape
- Rulers
- Scissors
- Paper towels

Materials *PER STUDENT*

- *Getting the Oil Out* worksheet, Student Guide page 44

Preparation

- Gather all materials.
- Make a copy of the worksheet for each student.
- Keep paper towels on hand for spills. It's easy to tip a carton or cup of chocolate milk over with the straw apparatus.

✔ Procedure

1. Distribute the activity. Discuss with students that it may be necessary to have a partner stabilize the container of beverage, as it may easily tip.
2. Have a place for students to dispose of their beverage when the activity is complete.
3. Discuss student results and encourage them to think about and identify the challenges of deep well drilling based on their results.
4. Have students discuss how viscosity or other variables might impact their results. Allow them to experiment, if time allows.

Extension

- Have students experiment by simulating conditions that might occur in the deepwater environment (adding external pressure, simulating corrosion, etc.). Students should explain how they would re-design their model to combat those conditions and challenges.

Activity 7: Wind Energy at Work

Background

Wind has been used for centuries as a way for explorers to traverse the ocean. More recently winds over the oceans are used as a powerful way to generate electricity. Wind typically blows more steadily over bodies of water than on land. There is ample wind available in offshore areas. The United States has ample amounts of coastline that could access offshore wind, and soon states like Massachusetts, Virginia, and North Carolina may see offshore wind become a reality off their coasts. Over 90% of the global offshore wind capacity is installed on European coast lines. Strong ocean winds in these areas provide energy to large population centers. Students will explore how wind can do work in this activity, and experiment to optimize their design for greater output or use in stronger winds.

Objectives

- Students will be able to explain and diagram how wind can do work.
- Students will use engineering and design process skills to enhance and test a model for specifications.
- Students will be able to identify challenges of using a wind turbine in the offshore setting.

Time

- 1 class period

Materials

FOR EACH STUDENT OR PAIR

- 1 Large foam cup (approximately 14 cm tall)
- 1 Extra-long straw*
- 1 Small straw
- 1 Binder clip
- 2 Straight pins
- Ruler
- Hole punch
- Marker
- 50 cm String or thread
- Paper clips
- Masking tape
- Scissors
- *4-Blade Windmill Template*, Teacher Guide page 35
- *Wind Can Do Work* worksheet, Student Guide page 45

FOR THE CLASS

- Fan(s)

***Note:** The extra-long straw is long enough for two windmills, when cut in half.

Preparation

- Gather the materials needed and set up work stations for students. Gather extra "found" or alternative materials for students to use in the engineering and design process.
- Make copies of the template and the worksheet for students.
- Prepare copies of the template at an enlarged scale, if a copier is accessible with that feature.

✔ Procedure

1. Review the informational text sections related to offshore wind.
2. Students should build windmills following the instructions on the worksheet.
3. Discuss the conclusion questions as a class.
4. Ask the class to discuss the challenges present in siting wind turbines in areas where strong, steady winds exist. Both onshore and offshore wind turbines are often sited in areas that are removed from a population, thus an infrastructure to transport the electricity must be put in place. How is this challenge exacerbated in the offshore setting?

5. Explain to students that offshore wind turbines are typically even larger than those seen onshore. Also, offshore wind turbines must deal with potentially stronger and steadier winds. Challenge students to design a bigger, better model that uses larger blades and can withstand stronger wind speeds (from a hairdryer, perhaps). Students may opt to use the same template, but enlarged. Students may also choose to improve upon this design, if they wish.

Extension

- If your students take an interest in wind turbines, explore NEED's wind curriculum. *Exploring Wind* for secondary students and Energy from the Wind for Intermediate allow students to investigate the variables involved with creating a functional wind turbine for electrical generation. The activities encourage students to build their own blades and improve upon their design as they investigate each variable, such as pitch, mass, shape, aerodynamics, and number of blades.

Activity 8: Science of Electricity

Background

While not all ocean energy sources produce electricity, many emerging technologies do. Electricity is generated by wind and water using a generator. Generators consist very simply of magnets and copper wire that must move in relation to each other in order to generate electric current. Wind, waves, currents, and tides can drive the turbine to create the motion in the generator. This activity will allow students to learn about electricity and build a model that generates electricity. If your students require more background on electrical energy and the generation of electricity, it may be helpful to download NEED's Energy Infobooks from www.NEED.org.

Objectives

- Students will be able to explain how electricity is generated.
- Students will be able to describe how various ocean resources can work with a generator to generate electricity.
- Students will use engineering and design process skills to identify and improve upon the strengths and limitations of a model.

Time

- 1-3 class periods, depending on student design process

Materials

- 1 Small round bottle
- 4 Strong rectangle magnets
- 1 12" x ¼" Wooden dowel
- 1 Rubber stopper with ¼" center hole
- Foam tube
- Spool of magnet wire
- Masking tape
- Permanent marker
- 1 Small nail
- 1 Large nail
- Fine sandpaper
- Multimeter
- Alligator clips
- Sharp scissors
- Ruler
- Hand operated pencil sharpener
- Push pin
- *Science of Electricity Model Instructions*, pages 36-38
- *Science of Electricity Model* worksheet, Student Guide page 46

Preparation

- Prepare the model ahead of time.
- Make a copy of the worksheet for each student.

✔ Procedure

1. As a class, review how electricity is generated from previous reading.
2. Show students the model. Ask them to explain how the model is working to generate electicity. Pass the model around for students to test.
3. After students have tested the generator by spinning it by hand, have them think about other ways that could be used to turn the dowel that would be easier and more consistent. Discuss as a class options for optimizing the model.
4. Ask students to complete the worksheet as an assessment.

Extensions

- Provide your students extra time and materials to add to or improve the design of the generator using less materials and generating more electricity.
- Provide students with extra time and materials to add to the generator to produce electricity from another source, other than the motion energy of their hands.

Activity 9: Exploring Convection Currents

Background

Thermal energy is constantly on the move in our oceans. Thermal energy transfers through liquids in the process of convection. Thermohaline circulation is a process that begins in the Earth's polar regions. Ocean waters become very cold in these regions and sea ice forms. The surrounding water becomes saltier and more dense because salt does not freeze. This cold, salty and dense water sinks, starting a global conveyor belt of ocean currents. Surface waters flow in where cold waters sank. Colder, deep waters move south and become recharged by cold temperatures, or are warmed and begin to rise towards the surface (upwelling). Warm surface waters circulate and eventually move towards the polar regions to again become cooled. These waters continue this loop over and over through the process of convection. The temperature differences created in the oceans and the currents that move them is a renewable source of energy. Ocean Thermal Energy Conversion (OTEC) capitalizes on this temperature difference and uses it to generate electricity through the use of a heat exchanger. In this activity, students will create their own miniature convection apparatus to simulate thermohaline circulation that occurs in the oceans.

✪ Objectives

- Students will be able to describe how thermal energy is transferred in the process of convection.
- Students will be able to explain how ocean currents continuously loop as a global conveyor belt moving waters of different densities and temperatures.

Time

- 1 class period

Materials *FOR EACH STUDENT or GROUP*

- 2 Clear plastic cups
- 4 Marbles
- Hot water
- Ice water
- Food coloring
- *Global Conveyor Belt* master, page 39
- *Exploring Convection Currents* worksheet, Student Guide page 47

Preparation

- Gather the materials for the activity and set up stations for hot and ice water.
- Make a copy of the worksheet for each student.
- Prepare a copy of the master for projection, or print a copy for each student to use as an assessment.

✔ Procedure

1. Review the informational text sections on ocean currents.
2. Explain to students that ocean currents travel in patterns. There are surface currents and deep currents. Currents are driven by many forces, but a process called thermohaline circulation allows for surface waters to move to deep waters and deep waters to upwell to the surface.
3. Ask students to propose what they think thermohaline might mean. A turn-and-talk format can work well in this scenario.
4. Explain to students that ocean currents move as a global conveyor belt, and this movement is driven by temperature and salinity (thermo = temperature, and haline = salt or halite).
5. Ask students to draw or jot down a picture of how they think this process works.
6. Explain to students that in this activity they will explore ocean current circulation by making their own convection current model. Review the process of convection, if necessary.
7. Give students time to set-up and execute the activity, answering questions as needed.
8. Discuss the activity and conclusion questions. Explain to students that the temperature differences that exist between surface and deep waters from this process can be a source of energy through OTEC. Review the informational text section on OTEC.
9. Display or hand out the *Global Conveyor Belt* master. If displaying the master, ask students what parts of the arrows would represent warm surface waters, and which parts would represent cold, dense deep waters. If handing the map out to individuals, ask students to shade in the arrows with blue and red to represent the different currents.
10. Ask students to write a paragraph explaining how thermohaline circulation works. Student answers should be sure to discuss temperature, salinity, and density.

Activity 10: Ocean Energy

Background

Around the world, the energy in waves, tides, currents, and OTEC systems is generating electricity. Scientists believe there is huge potential in generating electricity with ocean sources of energy, and they are working on developing a wide variety new technologies and testing small scale and commercial scale demonstration projects.

According to the National Oceanic and Atmospheric Administration (NOAA), about 39 percent of our nation's population lives in a county directly on a shoreline. They project that population in coastal areas will increase another eight percent by 2020, which would mean about half the population of the U.S. will live near an ocean. As the population shifts to our coastlines, generating electricity from ocean sources of energy – directly on the coasts where it is needed – may become a more prominent part of the U.S. energy picture.

Since these technologies are not as familiar to students, use this activity to expand students' knowledge about these four offshore renewable sources of energy, with suggested video clips, quick demos, and discussion prompts to go with the informational text in this guide.

Objective

- Students will describe how energy in waves, tides, currents, and OTEC systems generates electricity.

Materials

- Access to the internet
- Computer with projection capability and speakers or classroom computers
- Shake flashlight with transparent body

Time

- 1-2 class periods

Preparation

- Verify that you have access at your school to view the suggested websites and video clips.
- Decide which topics, clips, demonstrations, and discussions you will use with the class.

✔ Procedure

INTRODUCTION

1. View The Department of Energy's "Marine and Hydrokinetic 101" video which explains how some technologies work and highlights some of the government led Water Power Program's efforts in research and development in this area. This video is three minutes long and is an excellent introduction to hydrokinetic technologies, including actual examples of technologies shown in their real world environment. Visit http://www1.eere.energy.gov/water//marine-and-hydrokinetic-energy-research-development, and click on the video link to view the You-Tube™ video.

WAVE ENERGY

1. Understanding wave energy:
   - This video from the Exploring Earth website, created by the Center for Earth and Space Science Education at TERC, Inc., is an excellent animation that shows how energy is transferred through ocean waves while water moves in a circular motion. http://www.classzone.com/books/earth_science/terc/content/visualizations/es1604/es1604page01.cfm?chapter_no=visualization
   - After viewing this video, draw a sine wave on the board. Label the crests and troughs, and discuss how ocean waves are surface waves. Address any misconceptions about how ocean wave energy is generated or transferred. Waves are generated by wind, gravity, and water pressure. Water molecules are not moving from the middle of the ocean all the way to shore, they transfer energy from one to another as they move in a circular motion returning to their original position.

2. Shake light demo:

- A point absorber is one type of wave energy device. It is a floating buoy-like structure that captures energy from the vertical motion of waves. The up-and-down motion of the device drives generators that create an electric current. This 37 second video from Oregon State University shows how magnets and coils of copper wire generate electricity inside a point absorber device. http://seagrant.oregonstate.edu/video/wave-energy-2
- Hold the shake light perpendicular to the sine wave drawn on the board. Bob it up and down as if it is a buoy bobbing with the wave's motion until the LED lights. Pass the shake light around and let students look inside to see the magnets and coil of wire.

3. Wave energy tank videos:

- Chicago's Museum of Science and Industry has a 30 foot wave energy tank exhibit. This 35 second video demonstrates the power of tsunami waves. http://www.msichicago.org/whats-here/exhibits/science-storms/the-exhibit/tsunami/tsunami-wave-tank/tsunami-wave-tank-video/
- Live cameras allow students to watch researchers and scientists at work in Oregon State University's O.H. Hinsdale Wave Research Laboratory. http://wave.oregonstate.edu/

4. Understanding wave energy discussion prompts:

- Discuss how waves are formed.
- Tsunamis are powerful waves that can do major damage. How can you determine the amount of energy transported by a wave? Would occasional large waves or smaller, more constant waves be better for generation?
- What challenges might exist for finding a good wave energy spot?

TIDAL POWER

1. Tidal power videos:

- NOAA's education resources website includes a short time lapse video clip of changing tides along a coastline. It is a good visual showing the difference between a low tide and a high tide. This website also offers a two minute video discussing how ships coming and going from ports are affected by tides, and a series of photos of the tide rising in an estuary. http://www.education.noaa.gov/Ocean_and_Coasts/Tides.html
- The nation's first commercial, grid-connected tidal energy project began generating electricity off the coast of Eastport, Maine, in the summer of 2012. Developed by the Ocean Renewable Power Company (ORPC) in partnership with the Department of Energy, the Cobscook Bay Tidal Energy Project represents the first tidal energy project in the United States with long-term (20 year) contracts to sell electricity. Initially, ORPC's Cobscook Bay pilot project will provide enough clean, renewable electricity to power 25 homes, with plans to install additional tidal energy devices to power 1,000 Maine homes and businesses.

    a. PBS Newshour created a 7 minute video about ORPC's Cobscook Bay pilot project. It also discusses the Depart of Energy's Water Power Program, which funds hydrokinetic research in the U.S., and shows footage of other ocean energy projects around the U.S. http://www.pbs.org/newshour/bb/science/july-dec13/tidalpower_09-15.html

    b. The ORPC created a 12 minute You-Tube™ video showing how their tidal power device works and is installed. The installation footage gives us a look into this industry we would never have an opportunity to witness. You will see laborers working, cranes and barges maneuvering the structures into position on the ocean floor, laying underwater cables, hard hat divers connecting the base structure to the tidal energy device 60 feet under water, and evidence the underwater turbine is generating electricity. The video itself is promotional in nature. Consider viewing ahead of time and deciding if you will cut any segments from classroom viewing.
    http://www.youtube.com/watch?v=s6AiaDgsPN8

2. Understanding tidal power discussion prompts:

- Discuss how tides are formed.
- Explain to a partner the difference between waves and tides.
- Find tidal power plant locations on a world map. Discuss why these locations are well suited to generating electricity through tidal power.

OCEAN CURRENTS

1. Animations of Earth's ocean surface currents:
   - NASA's Goddard Space Flight Center has put together a Scientific Visualization Studio. Their 3 -minute Perpetual Ocean Video shows the world's surface ocean currents and how they travel. http://svs.gsfc.nasa.gov/index.html. Search "Perpetual Ocean".
   - Planet in Action took NASA's Perpetual Earth images and created an interactive 3D Google Earth program. http://www.planetinaction.com/currents/
2. Understanding ocean currents discussion prompts:
   - Harnessing energy from ocean surface currents is the least developed of our ocean resources. Discuss the power of water surface currents – compared to wind. Ask students which is more powerful and have them discuss why. Ocean water is more dense than air, so an ocean current has more kinetic energy than wind. According to the Ocean Energy Council, a 5 knot ocean current has more kinetic energy than a 350 km/h wind.
   - Discuss the difference between surface currents and deep ocean currents.
   - Explain to a partner the difference between waves, tides, and currents. Explain to a partner the similarities between waves, tides, and currents.
   - In March 2011, a tsunami devastated the coast of Japan, washing an estimated 5 million tons of debris into the ocean. Ocean currents (and winds) have moved some pieces of debris around the globe. Research maps showing the path of the debris – where did scientists predict debris would go? Where has debris been found? Why do you think debris came ashore where it did? Does this support your understanding of surface currents, or has debris been found in unexpected locations? NOAA's Marine Debris Program would be a good resource to begin your research. http://marinedebris.noaa.gov/tsunamidebris/

OCEAN THERMAL ENERGY CONVERSION

1. OTEC videos:
   - The Ocean Energy Council has a 4 minute YouTube™ video which gives facts about ocean water, explains thermohaline circulation, shows locations for hot and cold water around the world, and explains how OTEC technology works. The video also demonstrates how Puerto Rico could be a good place for OTEC energy use. http://www.oceanenergycouncil.com/index.php/Ocean-Thermal-OTEC/OTEC.html
   - Since 2008, the U.S. Department of Energy and the Department of Defense have given Lockheed Martin millions of dollars to conduct research and develop OTEC technology. In April 2013, Lockheed Martin announced they are building an OTEC pilot power plant off the coast of southern China. The 10-megawatt offshore plant will be the largest OTEC project developed to date, supplying 100 percent of the power needed for a green resort to be built by Reignwood Group. Lockheed Martin has a short video that explains how an OTEC system works, and highlights some of the challenges and benefits of using this technology. This video is commercial in nature and contains promotions after about 2 minutes. Preview and decide what you will show to the class. http://www.lockheedmartin.com/us/products/otec.html
2. Understanding OTEC discussion prompts:
   - Explain to a partner how thermohaline circulation works.
   - Trace the flow of energy from the sun to electricity produced by OTEC. Sketch and label the parts of the system in three or four comic strip-like panels.
   - Discuss where in the world OTEC systems will be most efficient, and why. Label these locations on a map.
   - Discuss some of the benefits of using OTEC (baseload power, water desalination, hydrogen production, energy savings in air conditioning systems).

Activity 11: Siting Renewable Energy Resources

Background

Many energy resources associated with the ocean are renewable sources of energy. There are advantages and disadvantages to using each source of energy. Often, these resources are found in only very specific areas of the world, and may, or may not have the potential to be developed in the U.S. as well. In this activity, small cooperative groups will research and study maps showing known areas of renewable energy resource potential. Suggested websites are listed for student research, and map masters are provided. After color coding their own U.S. map with the best sites for each resource, each group works through one of the scenarios provided, conducting more research if necessary. Each group shares its scenario, research, and response with the class during an informal presentation session. Suggested renewable sources of energy include: offshore wind, wave energy, tidal power, ocean currents, and OTEC.

Objective

- Students will be able to analyze maps and synthesize information from text with map data.

Materials

- Colored pencils
- *Siting Scenarios* worksheet, page 40
- Internet access and/or color copies of map masters, pages 41-46
- *North America Map*, Student Guide page 48

Time

- 1-2 class periods

Preparation

- Assign students to small cooperative research groups.
- Make a copy of the *North America Map* for each student.
- Verify students can access the suggested website addresses if using school computers. Since maps are published in color, and students may need to read supplemental information found with the maps to be able to interpret them, it is suggested students go online to look at the resource maps provided. However, if this is not possible, make one color print out of each map provided on pages 41-47 for each group.
- Copy and cut apart enough scenarios to have one for each group.

✔ Procedure

1. Break students into research groups, pass out worksheets, and explain the activity.
2. Give students time to research and study U.S. maps showing known areas of renewable energy resource potential for each of the renewable ocean energy resources. Encourage students to use government sponsored websites in their research. If necessary, work with students to interpret the information on the maps. Students should analyze the information on each map, create a key, and color code their U.S map with the best sites for each resource.
3. Assign each small group one of the scenarios and allow time for discussion and preparing a response. Each group will prepare a short presentation about their response to the assigned scenario. If time allows, have students do additional research to learn about these technologies in use today. For example, each of the fictional university projects listed in scenario number one are based on real, commercial demonstration projects in development today. Students should be able to find news articles about their current progress.
4. Each group will share their scenario, research, and response with the entire class.
5. Discuss the groups' responses. How many groups provided similar responses?

Online Resources & Map Links

MarineCadastre.gov is an integrated marine information system that provides authoritative and regularly updated ocean information, including offshore boundaries, infrastructure, human use, energy potential, and other data sets. Students can explore the maps listed or build their own maps layer by layer from existing data. To look at layers and build upon those layers, click "national viewer".
http://www.marinecadastre.gov/

Offshore Wind Energy
http://apps2.eere.energy.gov/wind/windexchange/windmaps/offshore.asp
This offshore wind resource map from DOE/NREL includes links to individual state's offshore wind resources, too.

Ocean Wave Energy
http://www.boem.gov/Renewable-Energy-Program/Renewable-Energy-Guide/Ocean-Wave-Energy.aspx
The National Renewable Energy Laboratory (NREL) provides a number of useful maps and tools regarding wave energy resources, including an interactive wave energy resource atlas, available at http://www.nrel.gov/gis/mhk.html.

Ocean Tidal Energy
http://www.tidalstreampower.gatech.edu/
Assessment of Energy Production Potential from Tidal Streams in the U.S., developed by the Center for GIS at Georgia Tech. Have students zoom in on the map to see data more clearly.

Ocean Current Energy
http://www.boem.gov/Renewable-Energy-Program/Renewable-Energy-Guide/Ocean-Current-Energy.aspx

Ocean Thermal Energy Conversion & Energy From the Oceans
http://oceanexplorer.noaa.gov/edu/learning/11_energy/energy.html#slide

Activity 12: Offshore Ocean Resources – Topographic Maps and Presentations

Background

In this activity, students will explore the variety of energy resources and non-energy mineral resources located offshore. Students will create a large map of the United States, including the Outer Continental Shelf (OCS) and the Exclusive Economic Zone (EEZ), and major land and underwater formations. Small groups will research and prepare short presentations on various offshore ocean resources. Presentations will reference the map and discuss where resources are located, how they were formed, how they can be recovered, their uses and economic benefits, environmental impacts associated with their recovery, advantages and disadvantages of their use, and associated technologies, industries, and careers. Presentation topics include offshore sources of energy and non-energy minerals.

Objectives

- Students will be able to describe or explain the following:
  - The OCS and EEZ contain reserves of many resources of economic and strategic benefit to the United States.
  - Ocean resources may be associated with particular land formations.
  - Few ocean resources are recovered at this time, but potential for future use exists.
  - The recovery of offshore resources impacts the ocean environment, just as land-based extraction does.
  - The use of resources, whether land or ocean based, is determined in large part by economic and environmental factors.

Materials

- *Student Informational Text,* Student Guide pages 2-8 and 23-27
- *Offshore Ocean Resource Presentation Planner,* Student Guide, page 49
- Computers with internet access
- *North America Map* master (optional), page 47
- Transparency film (optional)

Time

- 3-4 class periods

Preparation

- Assign students to small research/presentation groups as follows:
  - Petroleum and natural gas
  - Methane hydrates
  - Phosphorite
  - Gold, platinum, and heavy minerals
  - Metallic sulfide ores, manganese nodules, and cobalt crusts
  - Sand, gravel, and shell
- Make copies of the informational text pages and planner for each student.

OPTIONAL: Make a copy of the map master on transparency film for students to create a large map on chart paper.

✔ Procedure

1. Explain to students that they will be working in small groups to research an offshore ocean resource and prepare a short presentation. Each group will select one member in the group to join the map-making team. This special group will create a class map.
2. Groups will use the informational text and the planner to organize their inforrmation, but they can consult outside sources. Presentations should cover the following information about the resources: where they are located, how they were formed, how they can be recovered, their uses and economic benefits, environmental impacts associated with their recovery, advantages and disadvantages of their use, and associated technologies, industries, and careers.
3. Communicate the time frame for completing projects and the grading procedure you will use.
4. Assign group members, topics, and pass out materials.
5. Allow time for groups to plan, make individual tasks assignments, and select one member to work on the map.
6. Meet with the map making group separately while the others are planning. Discuss the basics of topographic maps and how they are used.
    - Show students the U.S. Geological Survey's National Atlas of the United States website: http://www.nationalatlas.gov, a good resource for creating their map.
    - Show students BOEM's and NOAA's MarineCadastre.gov National Viewer found at: www.MarineCadastre.gov. This mapping program allows students to layer specific ocean data and customize the map view. Bathymetric contours and seafloor geology are available here.
    - Explain that the map should include:
        - Continental United States, Alaska, and Hawaii
        - OCS and EEZ boundaries
        - Major land forms
        - Major sedimentary basins
        - Major volcanic ridges and fault lines
        - Areas where their specific group's resources are located
    - Review the suggestions for creating a map:
        - Sketch out the map by hand onto a large piece of chart paper. Draw in some contour lines to highlight mountain ranges. Use colored pencils to add details, locations of mineral resources, etc.
        - Create a layered map using an online resource such as http://www.nationalatlas.gov/maplayers.html. Choose the options you want to have on your map, like state boundaries, satellite relief views, and ocean depth bathymetry. Maps can be printed for free.
        - Create a topographic map out of salt dough (see page 28 for information).
7. Have the map making group give a brief overview of the map, pointing out the major features.
8. Have each group make their presentation, allowing a few minutes for questions and discussion.
9. Wrap up the activity by discussing the pros and cons of developing ocean resources.

Optional Extension: Salt Dough Topographic Map

In place of drawing a mural-sized map, have crafty, kinesthetic learners construct a large topographical map of the United States, OCS, and EEZ out of salt dough, forming the land features and underwater formations and painting them.

Materials

- Large foam board
- Flour
- Salt
- Water
- Paints and brushes
- *North America Map* master, enlarged
- Pencil
- Permanent marker
- Maps/resource materials

✔ Procedure

1. Transfer the map master to the foam board by shading the back of the map with pencil, flipping the map over, and tracing the map outline onto the board.
2. Draw in offshore features of the OCS and EEZ you want to add. Trace outlines with permanent marker.
3. Make salt dough with equal parts flour and salt. Add small amounts of water until you reach Play-Doh® consistency.
4. On the board, shape salt dough along the map outlines. Create basic land features such as mountain ranges and lakes, and features of the OCS and EEZ.
5. Place map in the sun for several hours to dry.
6. Paint land and water features.

Salt dough topographic map created by students at Kennedy Middle Grade School, Kankakee, IL.

Photo Credit: Constance Beatty

Activity 13: Town Council Meeting

Background

The ocean environment within the EEZ off U.S. coasts provides many valuable resources. The Bureau of Ocean Energy Management (BOEM) is tasked with managing the extraction of offshore minerals from the OCS. While the largest component of this extraction is exploration and development of oil and natural gas resources, BOEM is also responsible for "non-energy minerals" (primarily sand and gravel) excavated from the ocean floor. Other non-energy mineral resources include shells, phosphorite, gold, platinum, titanium, chromium, cobalt, manganese, magnetite, and metallic sulfides. Some of these resources are currently mined, while some aren't economically feasible. As steward for these resources, BOEM must ensure that the removal of any mineral resources is done in a safe and environmentally sound manner, and that any potential adverse impacts to the marine, coastal, and/or human environments are avoided or minimized.

In this activity, students will focus on offshore non-energy mineral resources, and research the pros and cons of mining and recovering them. They will participate in a mock town council meeting, representing part of the process of gathering public comment before the BOEM decides whether to grant the permit.

Objectives

- Students will be able to describe or explain the following:
  - The OCS and EEZ contain reserves of many non-energy mineral resources with economic and strategic benefits to the United States.
  - Few offshore resources are being recovered at this time, but future potential exists.
  - Recovering non-energy mineral resources will impact the ocean environment, just as land-based extraction does.
  - The use of resources, whether land or ocean based, is determined in large part by economic and environmental factors.
  - All actions people take, and all products that people make, use resources. All decisions about resource use involve trade-offs.

Materials

- Copies of *Student Informational Text*, Student Guide pages 2-8 and 23-27
- Internet access

Time

- 2-3 class periods

Preparation

- Make copies of the informational text for each student.

✔ Procedure

1. Explain that after learning about non-energy mineral resources located offshore, the class will choose a scenario to be the inspiration of their mock town council meeting. Students will choose their own roles based on their interests. Students will have time to research the feasibility of recovering these resources as it pertains to their role in the scenario, and then the class will conduct the town council meeting to gather public opinion and to discuss the pros and cons of their specific recovery operation.
2. Have students read the informational text covering offshore non-energy mineral resources.
3. Discuss the scenarios provided on page 30, or come up with your own based on current events or an issue affecting your community. Vote on which scenario students want to present.
4. Brainstorm a list of roles/witnesses needed for your chosen scenario. Role examples include: BOEM officials, company representatives seeking permit approval, specific scientists and engineers, environmentalists, citizen groups opposed to the operation, citizen groups in favor of the operation, members of the town council, mayor, government agency employees, etc.
5. Choose student roles.
6. Allow time for students to complete research and prepare for the meeting. Witnesses will have a maximum of three minutes to present their testimony.
7. Hold the mock town council meeting. Invite teachers or other adults to help make up the voting council members.

8. Review and discuss the activity. Summarize the pros and cons, environmental impacts, economic benefits, and public opinions from the town meeting. Students should realize that using offshore ocean resources has both positive and negative impacts and involves trade-offs.

Town meeting format:

- Mayor convenes the meeting and explains the purpose of the meeting.
- The company requesting the permit presents its petition.
- Town council members question the company representatives.
- Expert witnesses and citizen groups each have three minutes to testify.
- Town council members may question each witness.
- After all testimony, the town council discusses the permit request and makes a decision to represent the public opinion of the town – do you support or reject the requested permit?

Suggested scenarios:

- The Bling Company is applying to BOEM for a permit to mine for gold in the waters off the coast of Alaska.
- Blue, Inc. is applying to BOEM for a permit to mine cobalt along the volcanic ridges in waters off Hawaii.
- Splash City, a coastal town in Louisiana, is applying to BOEM for a permit to replenish its hurricane damaged public beaches using offshore sand from the OCS.
- Situated on the Atlantic coast is a major metropolitan area in Surf County. The county's public works department is applying to BOEM for a permit to collect aggregate material to use in constructing and repairing roads.

Activity 14: Island Resort Design Project

Background

This design activity helps synthesize knowledge gained throughout the unit, as students must design an island home that uses ocean energy resources. This activity could be used for informal assessment or as a creative writing language arts connection.

Preparation

- Make copies of *Island Resort Design Project* on page 50 of the Student Guide.

✔ Procedure

1. Pass out copies of *Island Resort Design Project*.
2. Allow time for students to finish their maps and one page written reports following the prompt provided.
3. Let students share their design ideas with each other.
4. As a class, critique and discuss the ideas for the real-world where cost, location, and technology available are ultimate factors. As an example, where should the hotel be located on the island, on the coast or in the center? Having the hotel located along the coast, closer to where electricity is being generated, would save on electricity transmission costs, and, offshore winds would cool the home naturally, requiring less air conditioning. Discuss which sources of ocean energy are unrealistic to use due to construction costs, size, location, etc.?

Extensions

- Have students complete their designs using a mapping or CAD software program.
- Have students create a 3D model of their proposal, similar to how design firms present ideas to clients.


$5 MILLION ENERGY BUCKS


$5 MILLION ENERGY BUCKS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$5 MILLION ENERGY BUCKS

Bid Envelope

Company Name ___________________– GOM Company Number _________

Map Name ___________________________________

Block Number ___________________

SEALED BID FOR OIL AND GAS LEASE SALE 208

NOT TO BE OPENED UNTIL TIME __________, DAY _________, DATE _____________

Bid Record

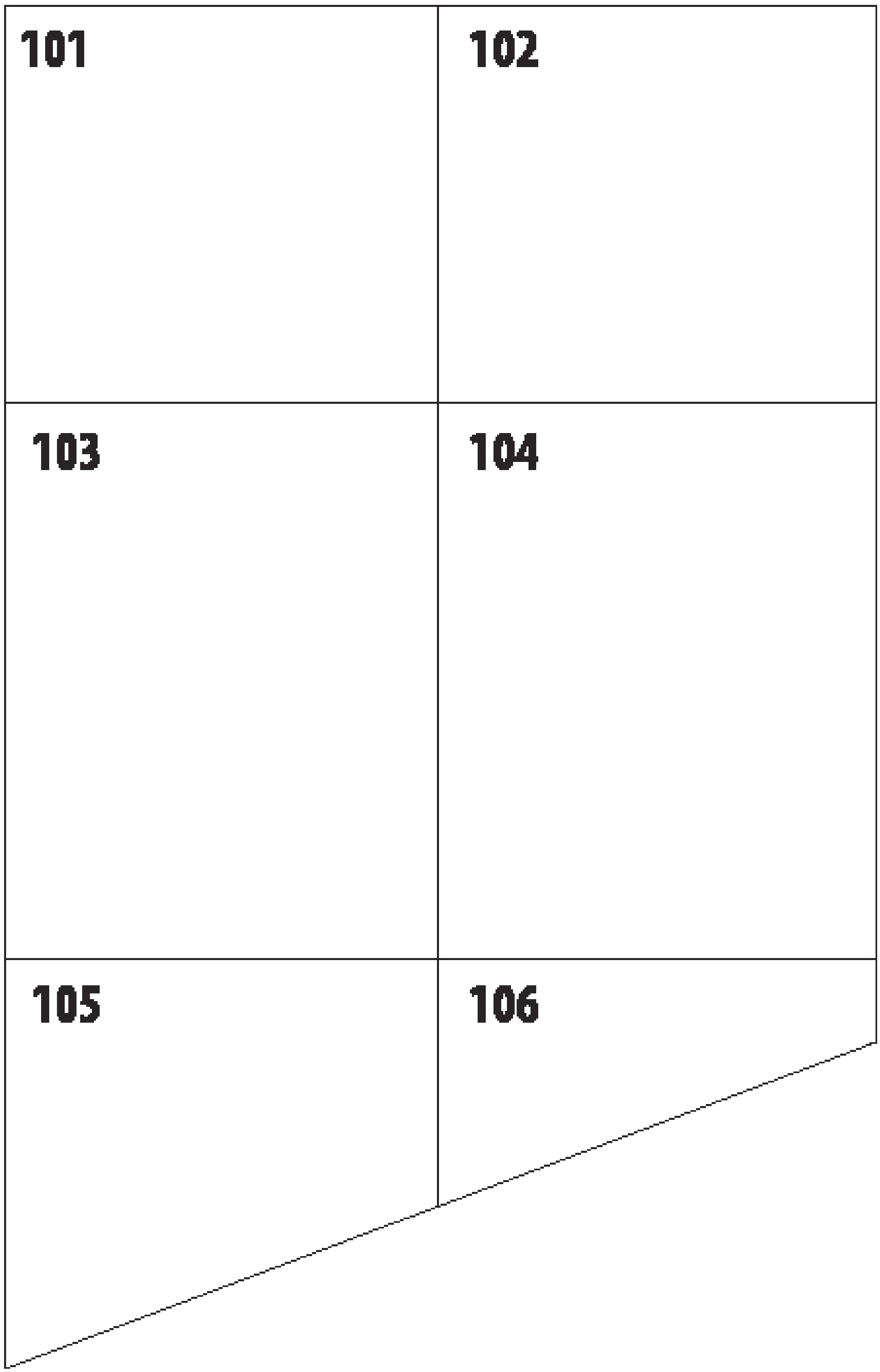
Oil and Gas Lease Sale 208

Instructions

Use this form to record each bid as it is read aloud. After the auction, rank the bids within each block to determine the winners.

Block Number	Company Name	Amount Bid/Acre	Total Bonus	Rank
101				
102				
103				
104				
105				
106				

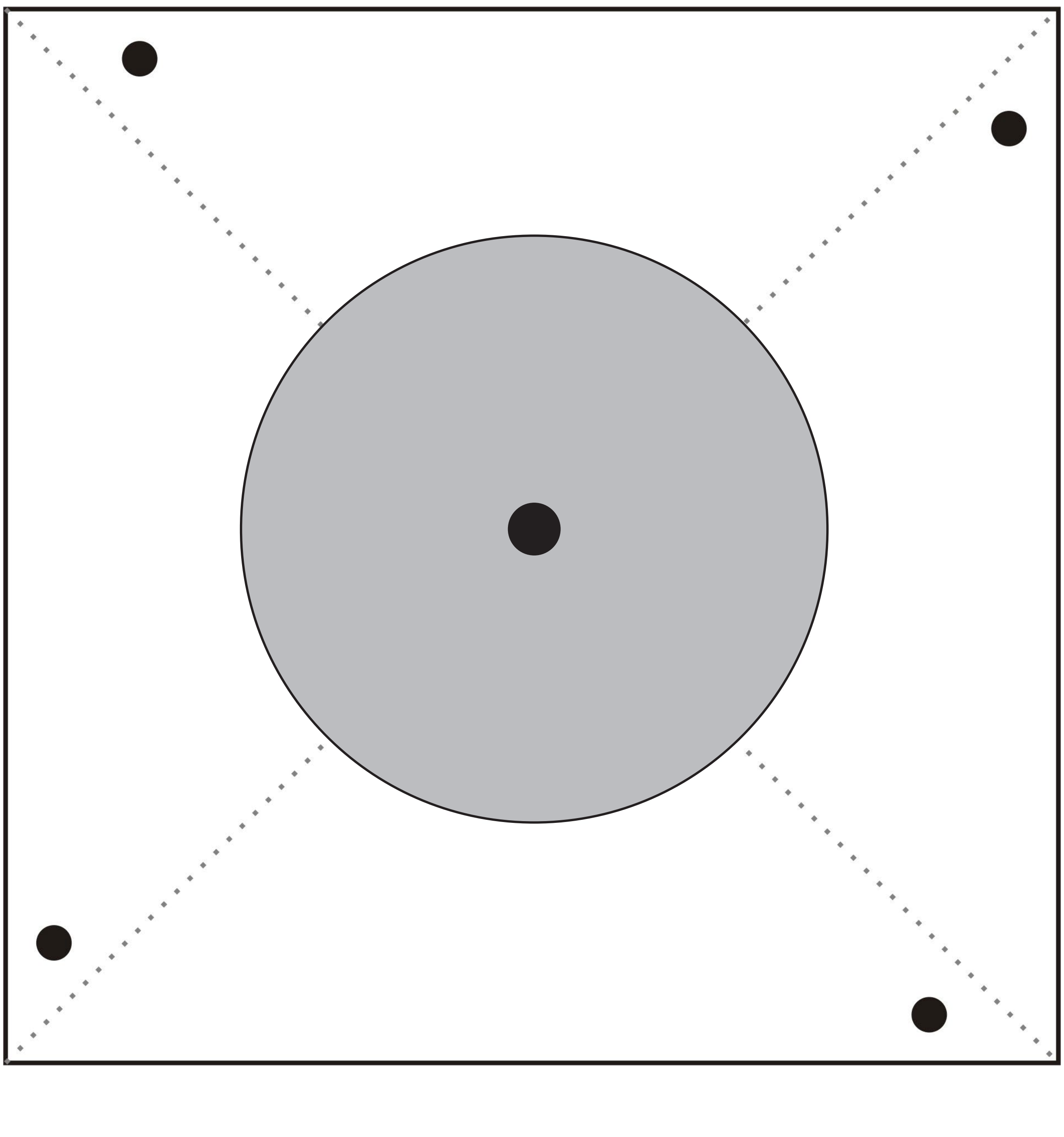
Lease Sale 208



4-Blade Windmill Template

✔ Procedure

1. Cut out the square.
2. Cut on the dotted, diagonal lines.
3. Punch out the four black holes along the side (being careful to not rip the edges) and the black hole in the center.
4. Follow the directions on the *Wind Can Do Work* worksheet to complete the windmill.



Science of Electricity Model Instructions

Objective

To demonstrate how electricity is generated.

Caution

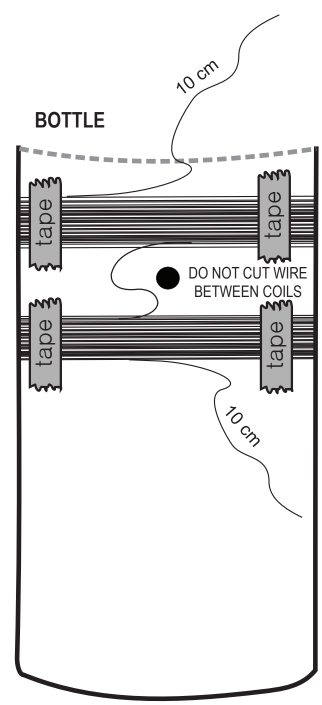
- The magnets used in this model are very strong.
- Use caution with nails and scissors when puncturing the bottle.

Materials

- 1 Small bottle
- 1 Rubber stopper with ¼" hole
- 1 Wooden dowel (12" x ¼")
- 4 Strong rectangle magnets
- 1 Foam tube
- 1 Small nail
- 1 Large nail
- Magnet wire
- Permanent marker
- 1 Pair sharp scissors
- Masking tape
- Fine sandpaper
- 1 Push pin
- 1 Multimeter with alligator clips
- Hand operated pencil sharpener
- Ruler
- Utility knife (optional)

Preparing the Bottle

1. If needed, cut the top off of the bottle so you have a smooth edge and your hand can fit inside. This step may not be necessary. If necessary, a utility knife may be of assistance.
2. Pick a spot at the base of the bottle. (HINT: If the bottle you are using has visible seams, measure along these lines so your holes will be on the opposite sides of the bottle.) Measure 10 centimeters (cm) up from the base and mark this location with a permanent marker.
3. On the exact opposite side of the bottle, measure 10 cm up and mark this location with a permanent marker.
4. Over each mark, poke a hole with a push pin. Do not distort the shape of the bottle as you do this.
   CAUTION: Hold a rubber stopper inside the bottle behind where the hole will be so the push pin, and later the nails, will hit the rubber stopper and not your hand, once it pokes through the bottle.
5. Widen each hole by pushing a nail through it. Continue making the hole bigger by circling the edge of the hole with the side of the nail. (A 9/32 drill bit twisted slowly also works, using a rubber stopper on the end of the bit as a handle.)
6. Sharpen one end of the dowel using a hand operated pencil sharpener (the dowel does not have to sharpen into a fine point). Push the sharpened end of the dowel rod through the first hole. Circle the edge of the hole with the dowel so that the hole is a little bigger than the dowel.
7. Remove the dowel and insert it into the opposite hole. Circle the edge of the hole with the dowel so that the hole is a little bigger than the dowel. An ink pen will also work to enlarge the hole. Be careful not to make the hole too large, however.
8. Insert the dowel through both holes. Hold each end of the dowel and swing the bottle around the dowel. You should have a smooth rotation. Make adjustments as needed. Take the dowel out of the bottle and set aside.
9. With a permanent marker, label one hole "A" and the other hole "B."



Generator Assembly: Part 1

1. Tear 6 pieces of tape approximately 6 cm long each and set aside.
2. Take the bottle and the magnet wire. Leave a 10 cm tail, and tape the wire to the bottle about 2 cm below hole A. Wrap the wire clockwise 200 times, stacking each wire wrap on top of each other. Keep the wire wrap below the holes, but be careful not to cover the holes, or get too far away from the holes.
3. DO NOT cut the wire. Use two pieces of tape to hold the coil of wire in place; do not cover the holes in the bottle with tape (see diagram).
4. Without cutting the wire, move the wire about 2 cm above the hole to begin the second coil of wraps in a clockwise direction. Tape the wire to secure it in place.

5. Wrap the wire 200 times clockwise, again stacking each wrap on top of each other. Hold the coil in place with tape (see diagram).
6. Unwind 10 cm of wire (for a tail) from the spool and cut the wire.
7. Check your coil wraps. Using your fingers, pinch the individual wire wraps to make sure the wire is close together and close to the holes. Re-tape the coils in place as needed.
8. Using fine sandpaper, remove the enamel coating from 4 cm of the end of each wire tail, leaving bare copper wires. (This step may need to be repeated again when testing the model, or saved for the very end).

Rotor Assembly

1. Measure 4 cm from the end of the foam tube. Using scissors, carefully score a circle around the tube. Snap the piece from the tube. This piece is now your rotor.
2. On the flat ends of the rotor, measure to find the center point. Mark this location with a permanent marker.
3. Insert the small nail directly through the rotor's center using your mark as a guide.
4. Remove the small nail and insert the bigger nail.
5. Remove the nail and push the dowel through, then remove the dowel and set aside. Do **NOT** enlarge this hole.
6. Stack the four magnets together. While stacked, mark one end (it does not matter which end) of each of the stacked magnets with a permanent marker as shown in Diagram 1.
7. Place the magnets around the foam piece as shown in Diagram 2. Make sure you place the magnets at a distance so they do not snap back together.
8. Wrap a piece of masking tape around the curved surface of the rotor, sticky side out. Tape it down at one spot, if helpful.
9. Lift the marked end of Magnet 1 to a vertical position and attach it to the rotor. Repeat for Magnets 2, 3, and 4.
10. Secure the magnets in place by wrapping another piece of masking tape over the magnets, sticky side in (Diagram 3).

WARNING: These magnets are ***very*** *strong. Use caution when handling.*

Diagram 1

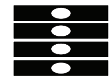


Diagram 2

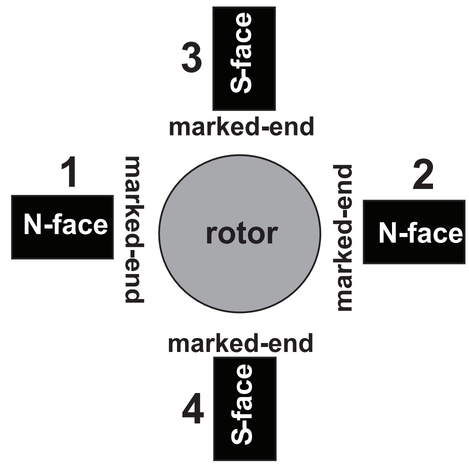
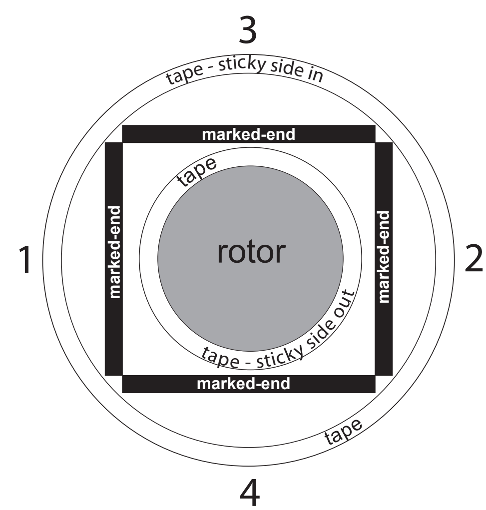
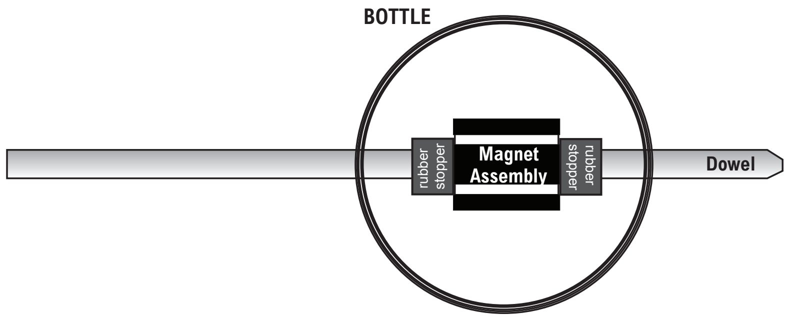


Diagram 3



Generator Assembly: Part 2

1. Slide the sharp end of the dowel through Hole A of the bottle.
2. Inside the bottle, put on a stopper, the rotor, and another stopper. The stoppers should hold the foam rotor in place. If the rotor spins freely on the axis, push the two stoppers closer against the rotor. This is a pressure fit and no glue is needed.
3. Slide the sharp end of the dowel through Hole B until it sticks out about 4 cm from the bottle.
4. Make sure your dowel can spin freely. Adjust the rotor so it is in the middle of the bottle.



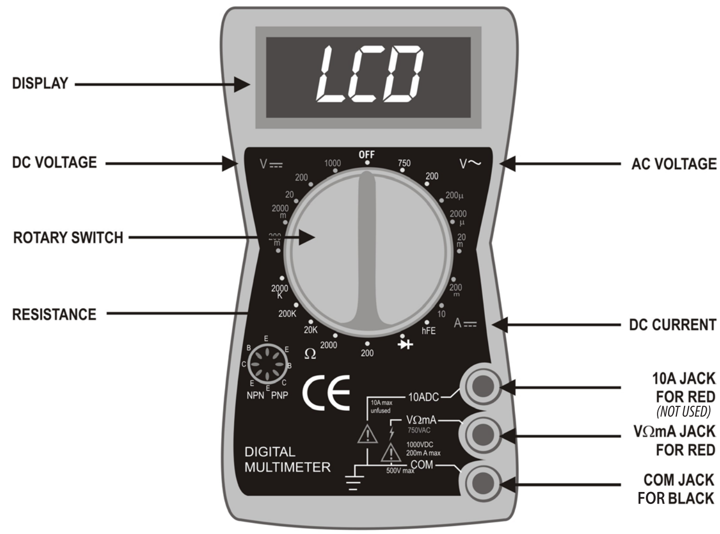
Assembly Notes

- The stoppers can be cut in half so that one stopper is made into two, to allow for more materials. These often slide more easily on the dowel. This must be done using sharp scissors or a utility knife, and can often be dangerous. As this step is not required (the kit supplies you with two stoppers to use), exercise extreme caution.
- If the foam rotor fits snugly on the dowel, put the stoppers on the outside of the bottle to help center the rotor in the bottle. Leave enough space to allow free rotation of the rotor.
- The dowel may be lubricated with lip balm or oil for ease of sliding the stoppers, if necessary.
- If a glue gun is available, magnets can be attached to the rotor on edge or on end to get them closer to the coils of wire. Use the magnet to make an indentation into the foam. Lay down a bead of glue, and attach the magnets. If placing the magnets on end, however, make sure they clear the sides of the bottle for rotation.

Testing the Science of Electricity Model

1. Connect the leads to the multimeter to obtain a DC Voltage reading.
2. Connect one alligator clip to each end of the magnet wire. Connect the other end of the alligator clips to the multimeter probes.
3. Set your multimeter to DC Voltage 200 mV (millivolts). Voltage measures the pressure that pushes electrons through a circuit. You will be measuring millivolts, or thousandths of a volt.
4. Demonstrate to the class, or allow students to test how spinning the dowel rod with the rotor will generate electricity as evidenced by a voltage reading. As appropriate for your class, you may switch the dial between 200 mV and 20 volts. Discuss the difference in readings and the decimal placement.*
5. Optional: Redesign the generator to test different variables including the number of wire wraps, different magnet strengths, and number of magnets.

*Speed of rotation will impact meter readings.



Note: Your multimeter may look different than the one shown. Read the instruction manual included in the multimeter box for safety information and complete operating instructions.

Troubleshooting

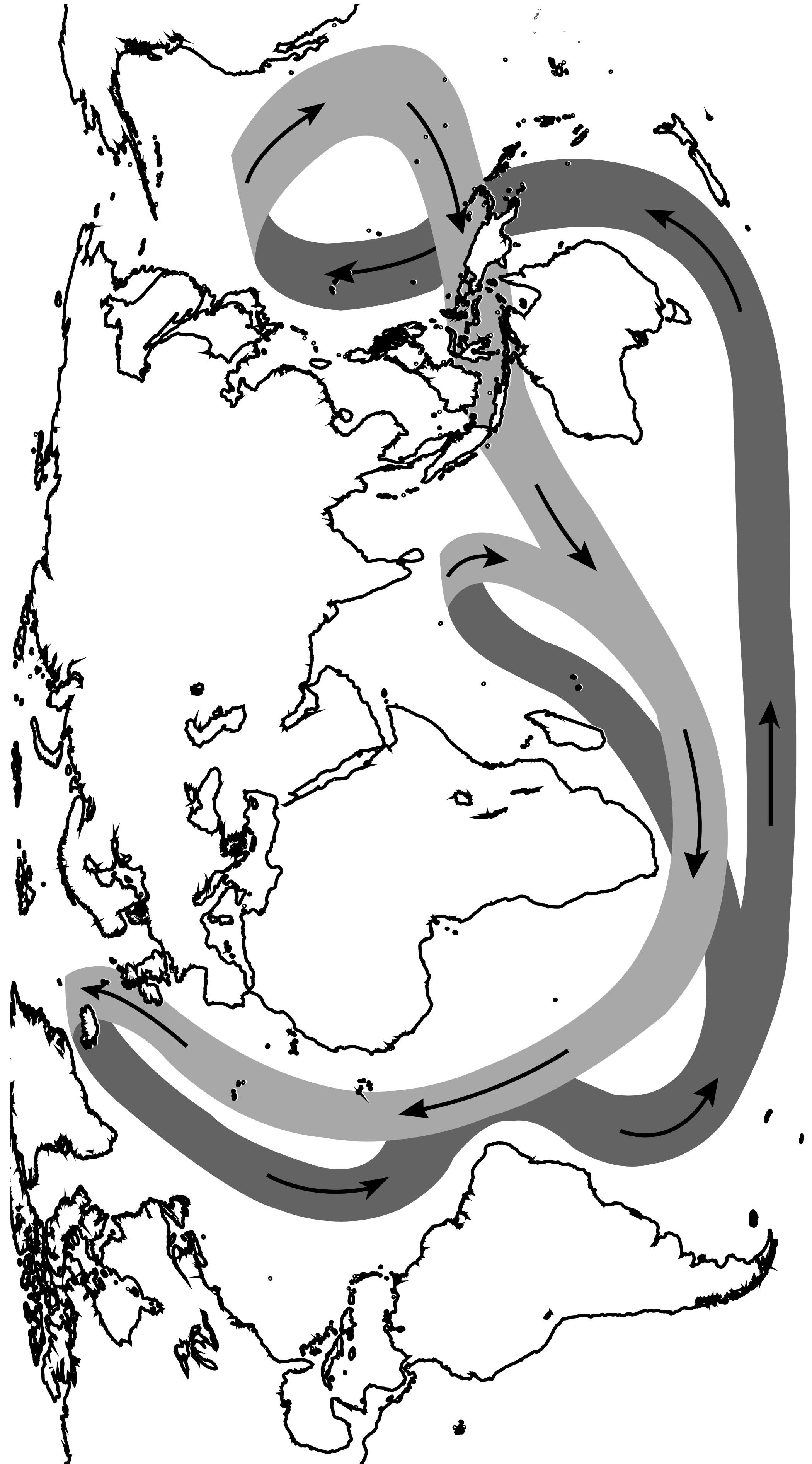
If you are unable to get a voltage or current reading, double check the following:

- Did you remove the enamel coating from the ends of the magnet wire?
- Are the magnets oriented correctly?
- The magnet wire should not have been cut as you wrapped 200 wraps below the bottle holes and 200 wraps above the bottle holes. It should be one continuous wire.
- Are you able to spin the dowel freely? Is there too much friction between the dowel and the bottle?
- Is the rotor spinning freely on the dowel? Adjust the rubber stoppers so there is a tight fit, and the rotor does not spin independently.

Notes

- The *Science of Electricity Model* was designed to give students a more tangible understanding of electricity and the components required to generate electricity. The amount of electricity that this model is able to generate is very small.
- The *Science of Electricity Model* has many variables that will affect the output you are able to achieve. When measuring millivolts, you can expect to achieve anywhere from 1 mV to over 35 mV.
- More information about measuring electricity can be found in NEED's *Intermediate Energy Infobook*. You may download this guide from www.NEED.org.

Global Conveyor Belt: Thermohaline Circulation



Data: NOAA

Siting Scenarios

Scenario 1

Your group works for the Department of Energy. You have five million dollars to fund a university research project involving a renewable source of ocean energy. The universities have already submitted applications proposing their projects. Now you must analyze each proposal and vote on the demonstration project you will fund. You may need to do additional research to make your decision. Think about: the technologies being proposed and where the projects are located. Be prepared to defend your reasoning on why the winning project should be funded over the others.

Keep in mind that a demonstration project is meant as a test. The technology may be a prototype design, and the researchers – university students and faculty – study their small-scale project as a way to determine how to build better technology, or to decide if a specific site will be good for commercial power generation. Demonstration projects in the real world cost many million dollars, can take decades to complete, and are often partnerships between private industries, utilities, universities, and state and federal government agencies.

Current Energy Project – Orange University in Miami, Florida, proposes to build and test an underwater turbine twenty miles off the coast of Fort Lauderdale. The underwater turbine will be connected to a floating platform secured to the ocean floor. The extremely powerful flow of the Gulf Stream will spin the turbine's blades to generate electricity. It is unknown if the project will have an impact on sea turtles and dolphins, or to the coral beds where the turbine needs to be anchored.

Tidal Power Project – Snow University in Anchorage, Alaska, proposes to build and test a submerged hydrokinetic system. It will be located in the Cook Inlet, which has one of the largest tidal ranges in North America. Most of Alaska's industry and population is located in this area. The tidal project will generate electricity as its underwater turbines spin with the underwater currents caused by the extreme tides. It is unknown if the project will have any impact on the endangered population of Beluga Whales that live in the area.

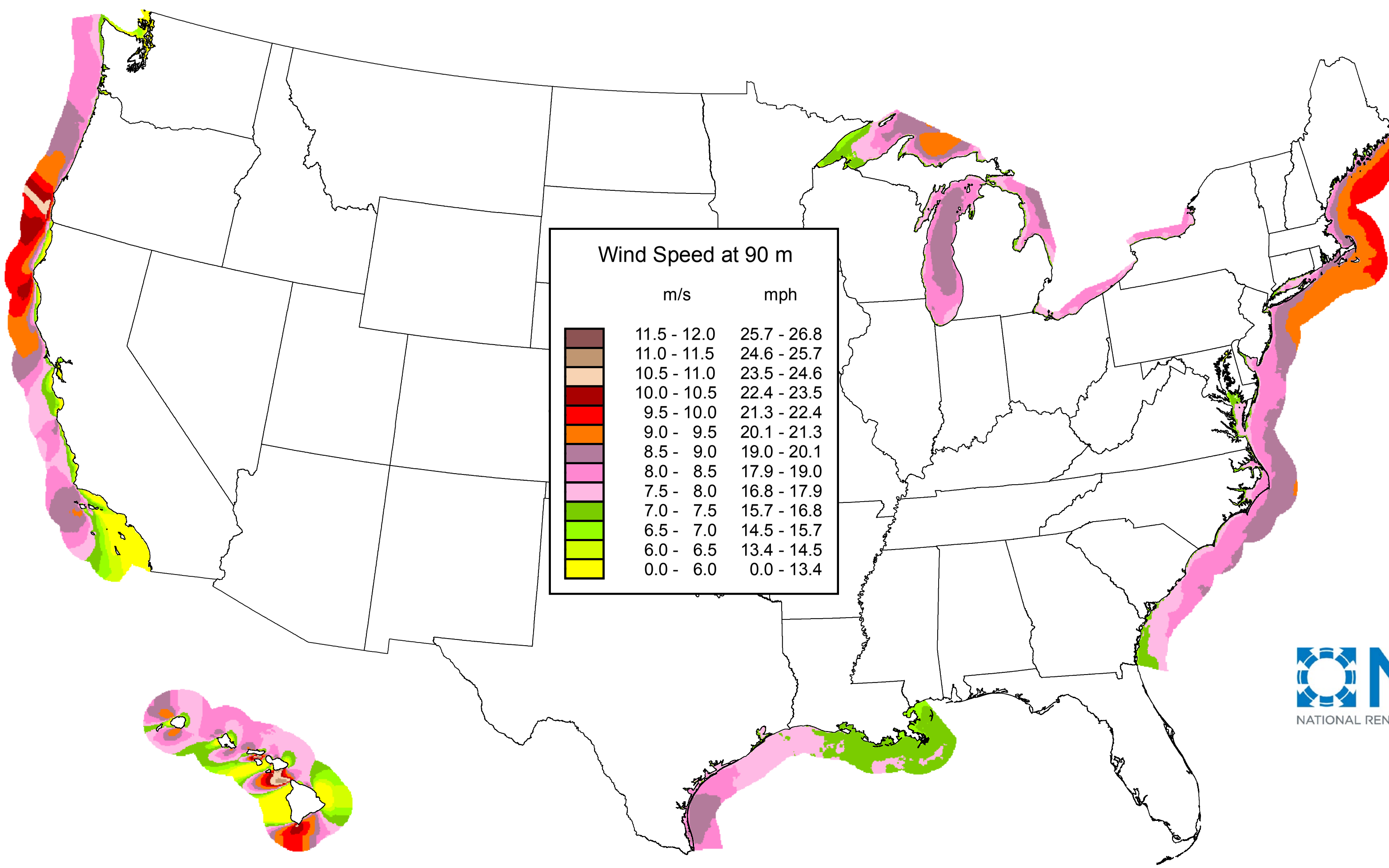
Wave Energy Project – Coast University in Portland, Oregon, proposes to build and test a point absorber wave energy conversion system in Coos Bay. A point absorber is a floating structure that looks like a large buoy. It captures energy from the vertical motion of the waves. The buoy's up-and-down motion drives generators that create an electric current. It is unknown if the project will have an impact on whale migration routes or the local crab fishing industry.

Scenario 2

Your group has been hired by a theme park franchise to scout a location for their next big theme park. The theme park is going to be called "Renewable Energy World," and will be powered completely by various sources of renewable energy. The park has hired your firm to scout out three potential locations for Renewable Energy World. They require the park to be located near an ocean. You may need to do additional research to make your decision. Think about where renewable resources are located, and where metropolitan areas are located. Prepare a two minute pitch and present it to the park executives (your classmates), convincing them of potential locations.

Offshore Wind Potential

United States - Annual Average Offshore Wind Speed at 90 m



NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Areas of Wave Energy Potential

Key:

Shallow Bathymetric Impact Regions

- Shallow Bathymetric Impact Regions
- < 10
- 10 -15
- 15 - 20
- 20 - 25
- 25 - 30
- 30 - 35
- 35 - 40
- 40 - 50
- 50 - 60
- 60 - 70
- 70 - 80
- 80 - 100
- > 100

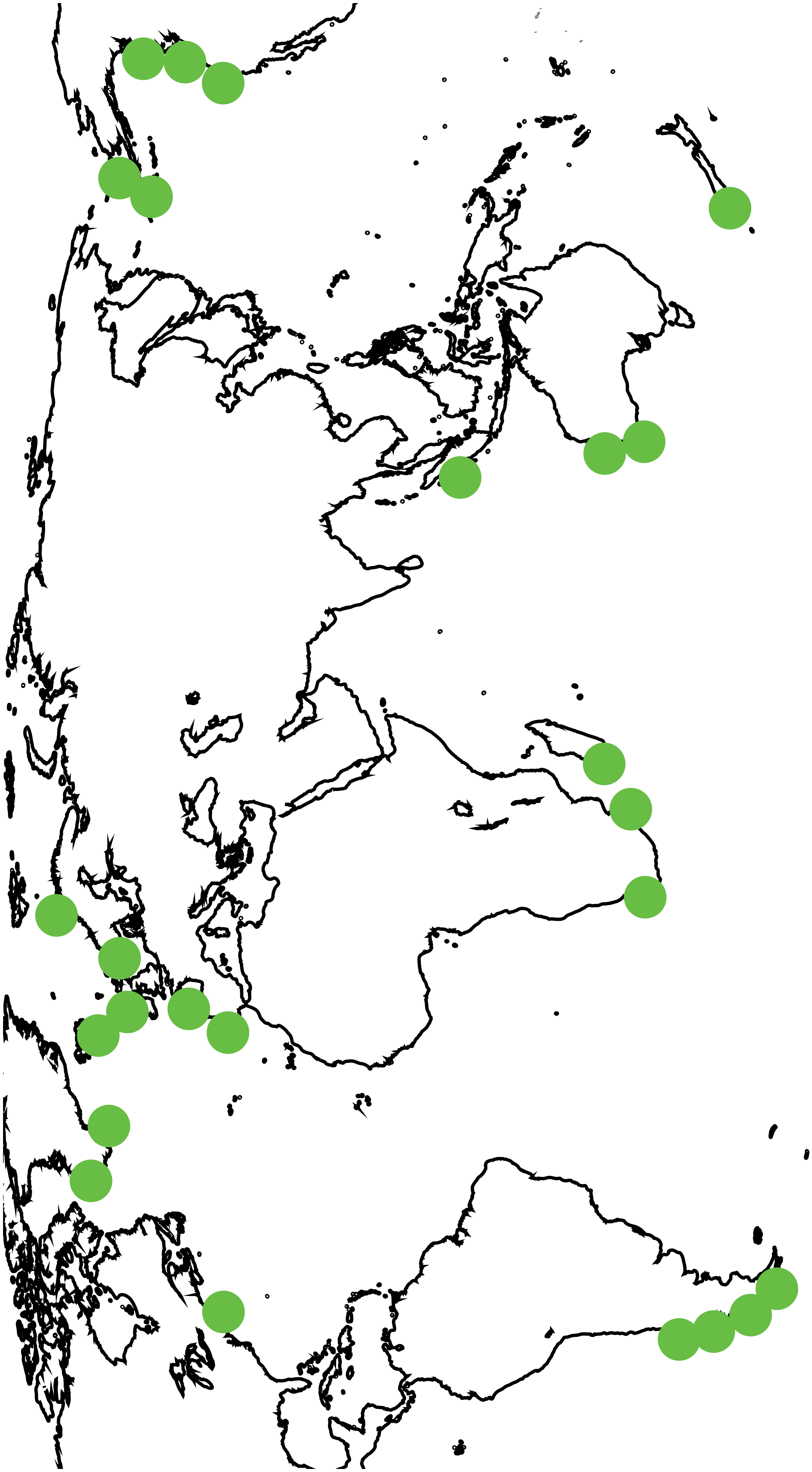
The recoverable wave energy resource for each region is estimated as:

- West Coast 250 TWh/year
- East Coast 160 TWh/year
- Gulf of Mexico 60 TWh/year
- Alaska 620 TWh/year
- Hawaii 80 TWh/year
- Puerto Rico 20 TWh/year

Source: NREL

*TWh/year = Terawatt-hours per year, 1TWh = 10^9 kWh

Wave Energy

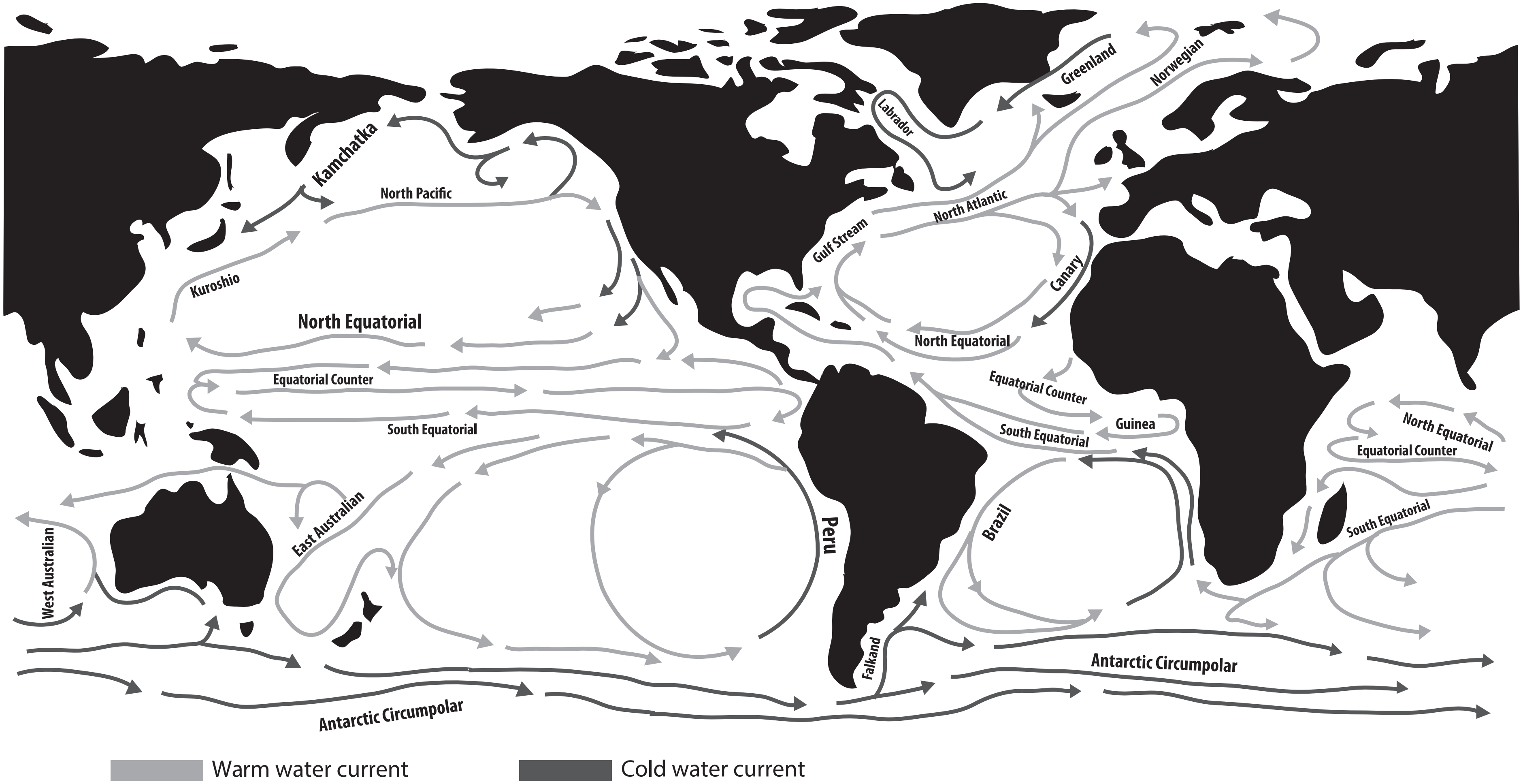


Data: NOAA

Tidal Stream Resources

Data: U.S. Department of Energy, EERE

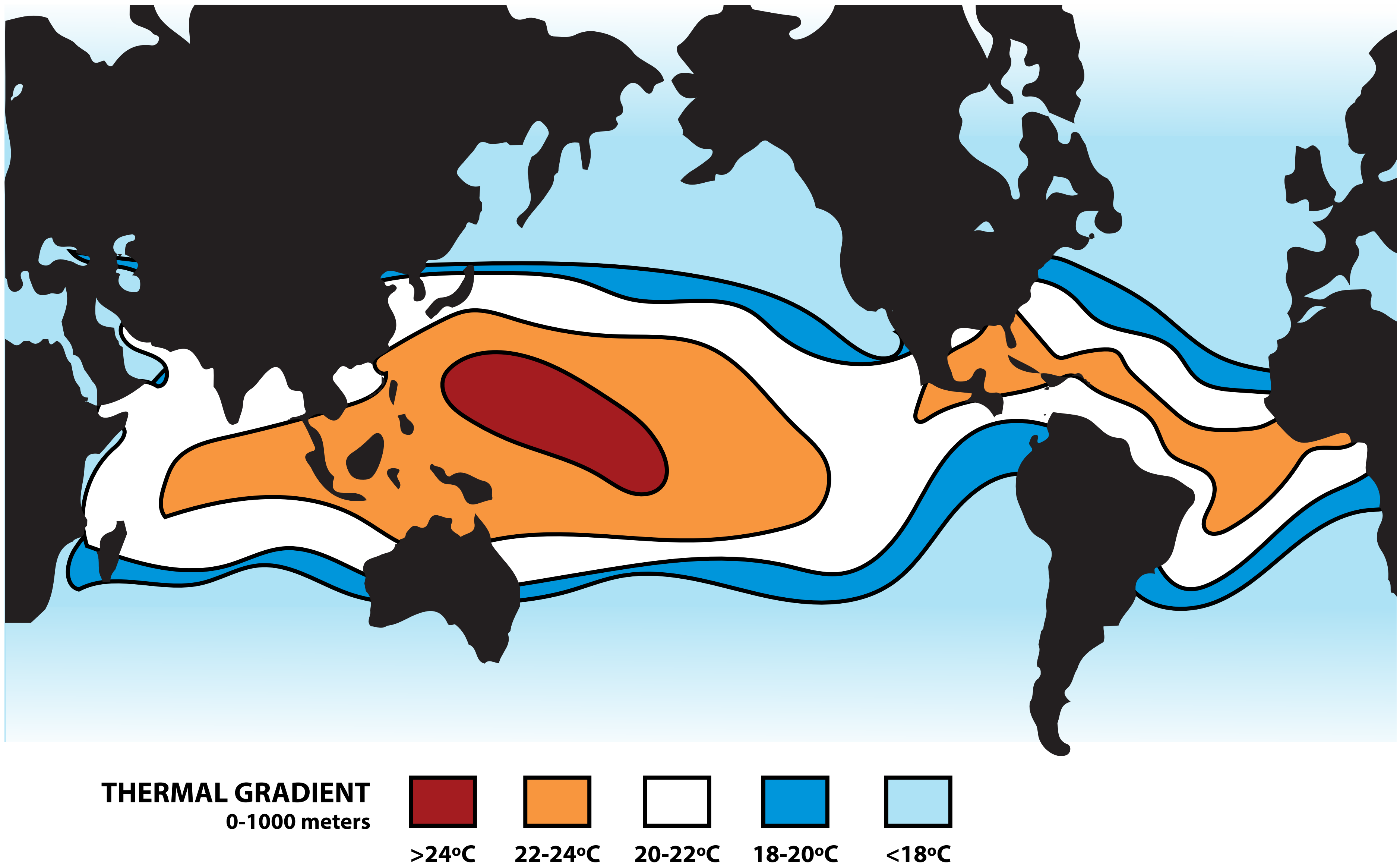
Ocean Current Paths



Data: NOAA

Ocean Thermal Energy Conversion Potential

Ocean thermal energy conversion can only be done effectively where the thermal gradient exceeds 20º C within the upper 1,000 meters of the ocean. These conditions occur in most of Earth's tropical waters. Nearly 100 countries, including the United States, are situated in the area where OTEC is possible.



Data: NOAA

North America Map

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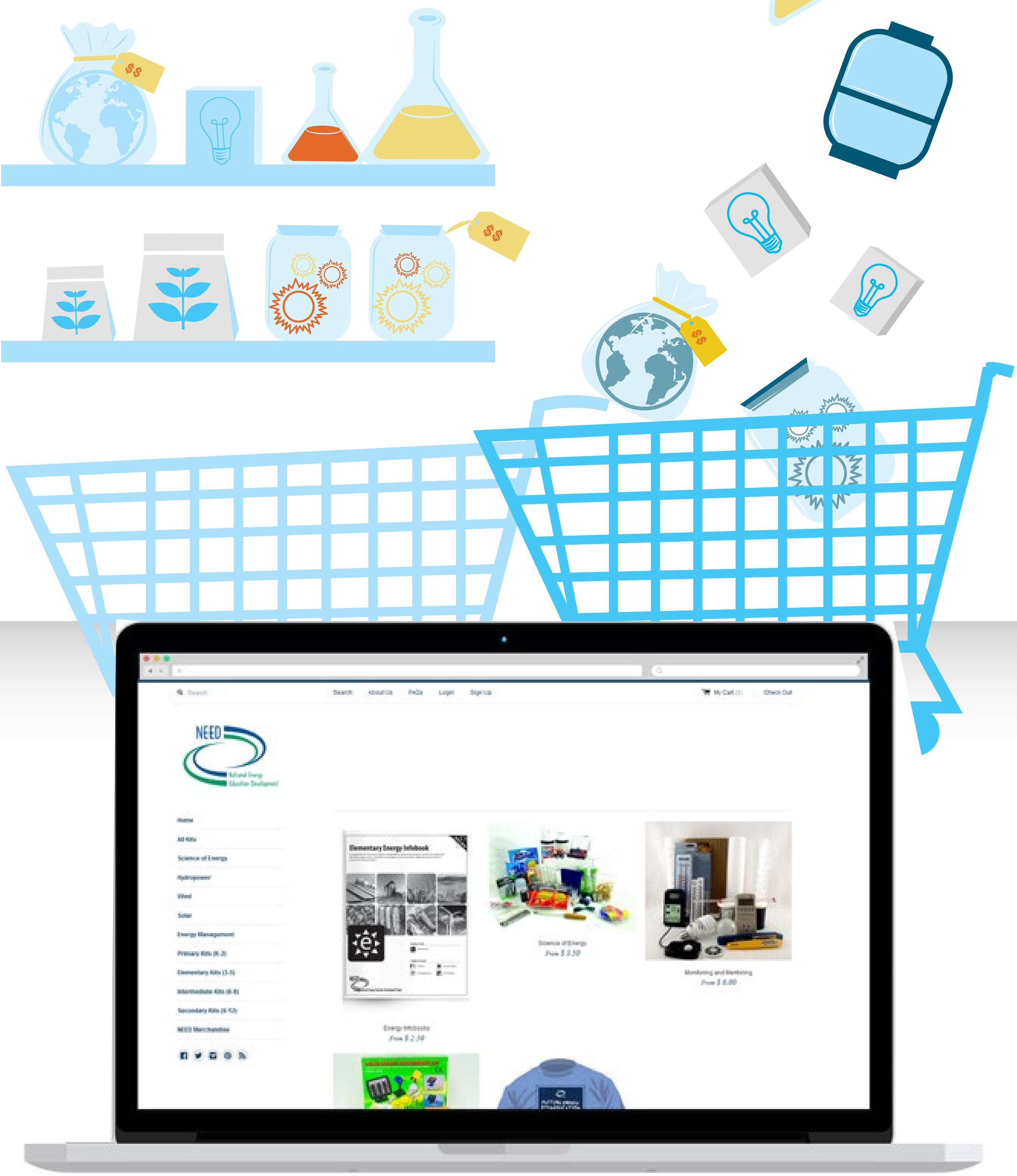

Exploring Ocean Energy and Resources Evaluation Form

State: ____________ **Grade Level:** ____________ **Number of Students:** ____________

1. **Did you conduct the entire unit?**	❑ Yes	❑ No
2. **Were the instructions clear and easy to follow?**	❑ Yes	❑ No
3. **Did the activities meet your academic objectives?**	❑ Yes	❑ No
4. **Were the activities age appropriate?**	❑ Yes	❑ No
5. **Were the allotted times sufficient to conduct the activities?**	❑ Yes	❑ No
6. **Were the activities easy to use?**	❑ Yes	❑ No
7. **Was the preparation required acceptable for the activities?**	❑ Yes	❑ No
8. **Were the students interested and motivated?**	❑ Yes	❑ No
9. **Was the energy knowledge content age appropriate?**	❑ Yes	❑ No
10. **Would you teach this unit again?**	❑ Yes	❑ No

Please explain any 'no' statement below.

How would you rate the unit overall?	❑ excellent	❑ good	❑ fair	❑ poor
How would your students rate the unit overall?	❑ excellent	❑ good	❑ fair	❑ poor

What would make the unit more useful to you?

Other Comments:

Please fax or mail to **The NEED Project**
8408 Kao Circle
Manassas, VA 20110
FAX: 1-800-847-1820

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