ESR 173 Lab 11: Renewable Energies

Exploration of NOVA Energy Lab

Purpose:

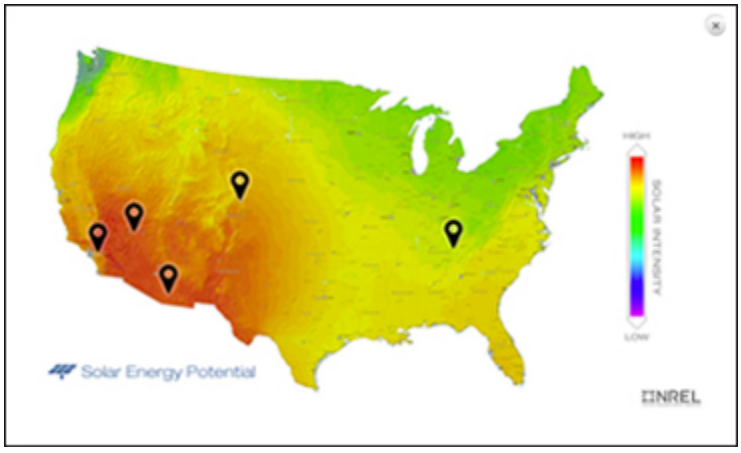
- Utilize a virtual tool to examine pros and cons of renewable energy systems
- Reinforce an understanding of different types of renewable energies
- Describe the advantages and disadvantages of alternative energy resources, specifically wind, hydroelectric, solar, geothermal, and biomass energy

Background:

Introduction to NOVA's Energy Lab - Video

The world's energy consumption is predicted to grow by 56% in the next 25 years (*Projected by The U.S. Energy Information Administration (EIA)*. As the demand for energy swells, the stores of fossil fuels we currently depend on are dwindling and becoming more costly to obtain. The burning of these fossil fuels also discharges carbon, which has long-lasting negative effects on the environment. For these reasons, researchers and engineers are working to find efficient and cost effective ways to harness energy from renewable sources like solar and wind.

In the Energy Lab, you'll design a city's renewable energy system by analyzing the same data as the experts. Just like these energy engineers, you'll need to weigh the pros and cons of each energy source, assess the availability in that area, and consider the needs of the location.



Local potential energy maps will help you design a renewable energy system.

THE CHALLENGE
You'll be presented with energy profiles for five different cities across the United States. Based on data from the U.S. Energy Information Administration (EIA), city officials, and local utility

companies, these profiles will give you a snap shot of the city's current energy needs and resources. You'll be given a budget and a renewable energy production target. Your challenge will be to design a system that meets this target as cheaply as possible.

DESIGN
Depending on a location's resources, your renewable energy system design may include solar, wind, geothermal, or biomass power. To help inform your design, you'll study energy potential maps created for NOVA Labs by the National Renewable Energy Laboratory (NREL). Using sliders, you can select the types of energy you want and how much of each you want. As you move the sliders, you'll instantly see how your choices impact your budget.

TEST YOUR SYSTEM
When you have designed your system, you can test it against yearly historical data. During the test you'll be given feedback and the opportunity to redesign your system.

POWER UP
When the test is complete, you'll power up your renewable energy system and find out if you met your production goals. Your system simulation is powered by real-time weather and solar data captured directly from NREL stations located in each city.

You'll see instant feedback as you design your system.

Videos
The Energy Lab also includes eight short videos about what energy is, how we can produce and store it more efficiently, and what our renewable energy alternatives to fossil fuels are. These videos can be viewed in the NOVA Labs Video Library or in the list below.

> Growing Appetites, Limited Resources – explores the impacts of energy use, the issue of dwindling resources, and the need for alternatives.

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Energy Defined – covers the basics of this abstract property, what energy is, how it's conserved, and what makes some forms more useful than others.

Putting Energy to Use – explains that making use of energy often involves converting it into other forms.

A Never-Ending Supply – explains what makes a renewable a renewable and explores some of the more promising alternative energy sources available.

Solar Power – covers the basics of capturing the enduring energy of the Sun and converting it into other forms, especially electrical energy.

Wind Power – explains how wind can be captured and transformed into electrical energy and explores some of the challenges of using wind to power cities.

Solving the Storage Problem – explores the need for storage, namely the intermittent nature of many renewable resources and explains why this is not an easy problem to solve.

Toward a Smarter Grid – looks at the state of the current electric power grid and explains how making the grid "smarter" will make it both more reliable and more efficient.

Types of Alternative Energy Sources:

SOLAR ENERGY

Solar Cells or panels, also known as photovoltaic cells, convert energy from the sun directly into electricity.Another method of collecting solar energy is through the use of solar thermal systems.These systems use large collectors to concentrate sunlight to superheat a liquid. The steam that is created is used to power electrical generators.

There are no emissions associated with generating electricity from solar energy. One disadvantage of solar energy is that it is currently very expensive to produce, especially in regions that receive comparatively little sunlight.

WIND ENERGY

Wind Energy is collected by wind turbines which are ty pically m ounted on tall towers to better catch the wind. Most electricity production occurs on large wind farms. The best places to erect wind turbines are areas where wind speeds average 12 miles per hour. High wind areas can be damaging to the turbines.

The main advantage to using wind energy is that it is a source of clean, nonpolluting electricity. Disadvantages of using wind energy include very high start-up costs for power plants, and the fact that good wind sites are often located in remote locations far from areas of electric power demand.

HYDROPOWER

Hydropower is energy that comes from the force of moving water. As water flows through a device such as a waterwheel or turbine, energy produced by the water can be used to grind grain, drive a saw mill, or produce electricity. Hydropower is an inexhaustible energy source because it is replenished constantly by the water cycle.

The main advantages of using hydropower are that it produces little or no pollution. It is renewable, and its operating costs are very low. Unfortunately, large hydroelectric power plants are often associated with serious environmental problems caused by damming the river. The impacts include flooding, reduction of water quality, mortality of fish that pass through hydroelectric turbines, and blockage of fish migration.

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GEOTHERMAL ENERGY

Geothermal energy comes from the heat within Earth's surface. There is more than one kind of geothermal energy, but the only kind that is widely used is hydrothermal energy.

Hydrothermal energy has two basic ingredients: water and heat. Water near magma bodies beneath the earth's surface contacts the heated rocks and changes into steam. The steam is used to drive a turbine which operates an electrical generator.

Geothermal energy produces little or no pollution and is considered to be an inexhaustible resource. The major disadvantages to using geothermal energy are the high start-up and maintenance costs of power plants. Another disadvantages is that resources such as magma bodies are only found in certain locations.

BIOMASS

Biomass is any organic substance that can be used as an energy source. The most common examples are wood, crops, seaweed, garbage, and animal wastes.Bio mass is a renewable energy source because its supply is unlimited and more can be produced in a relatively short time. When used for generating electricity, biomass is typically burned to transform water into steam, which is then used to drive a turbine and electrical generator.

Although it typically costs more to produce electricity using biomass, the great advantage is that it reduces the amount of waste entering landfills. In addition, biomass energy generates fewer air emissions than burning fossil fuels.

Instructions:

- Navigate to https://www.pbs.org/wgbh/nova/labs/lab/energy/ using a web browser and Select “Play Game” to explore the NOVA Energy Lab.
- Follow prompts in the virtual lab and included in this worksheet packet to explore ways to design energy systems, specifically utilizing various renewable sources.
- Reflect on your findings in responses for your final Lab Reflections discussion (found in D2L)

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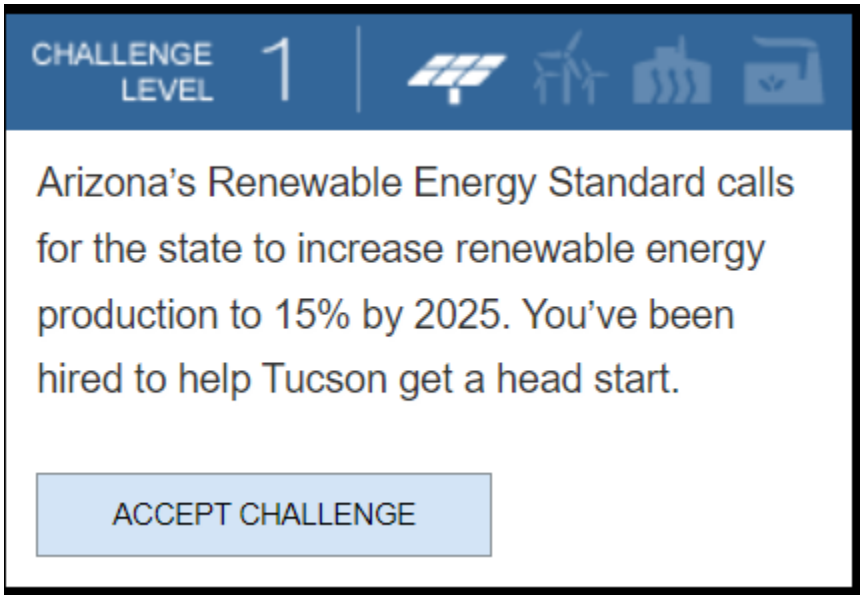
Questions & Reflections:

1. Start by selecting the city Tucson, AZ (Challenge Level 1):



   a. For this challenge, the goal is to generate the most energy for the lowest cost. Test up to three different combinations of area and efficiency (3 points)

Area km^2	Efficiency (%)	Outcomes					Feedback received *(pop up windows)*
		Temperature (F)	Wind Speed (m/s)	Solar Intensity (W/m^2)	Tons of CO_2 saved	Cost per Ton ($)	
1.5	11	49	0.09	0	4,199	197	Low power

1.6	13	49	0.09	0	5,293	233	Low power
1.6	15	49	0.09	0	6,108	269	NA

b. Did any of your designs “fail”, and if so why? (1 point)

No.
All the three designs functioned well with none failing.

c. Which design would you rank the best and why? (1 point)

The design comprising of 1.6 km^2 area and 15 percent efficiency are the best. This design saves the largest quantity of CO_2 (6,108) released into the environment, thereby promoting sustainable development. It also produces the highest amount of electricity for the largest area, within the allocated budget.

d. When considering the criteria of cost and output, what other ways might we approach this design that also factor into the need for alternative energy sources, or environmental impact of current practices? (2 points)

The efficiency of the system should be improved to increase the output while keeping the costs and environmental pollution low. Additional renewable sources should also be implemented to provide additional power to supplement the already produced energy. More solar energy should be tapped because the area has long sunny days and short cloudy days. This makes solar energy a better option to increase the output and lower costs due to its low-cost nature.

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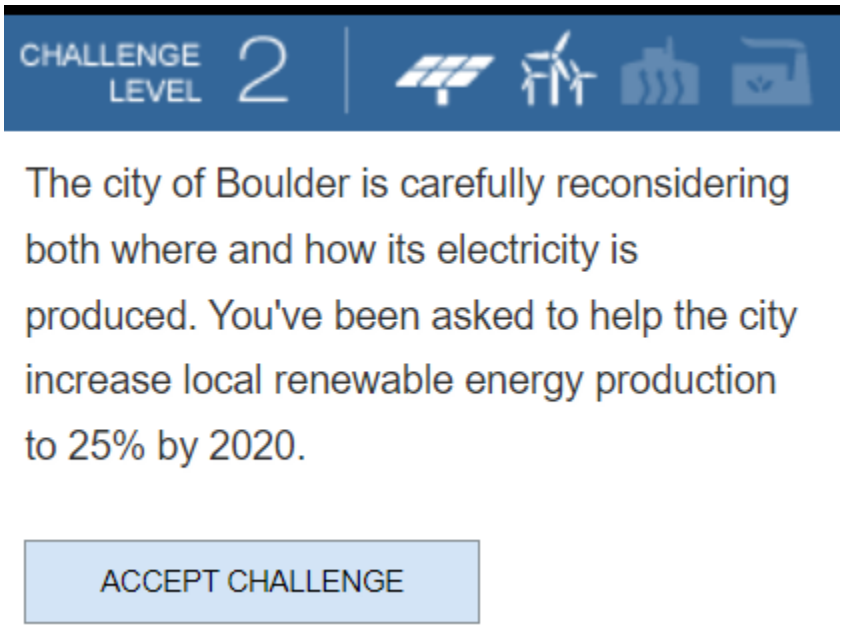
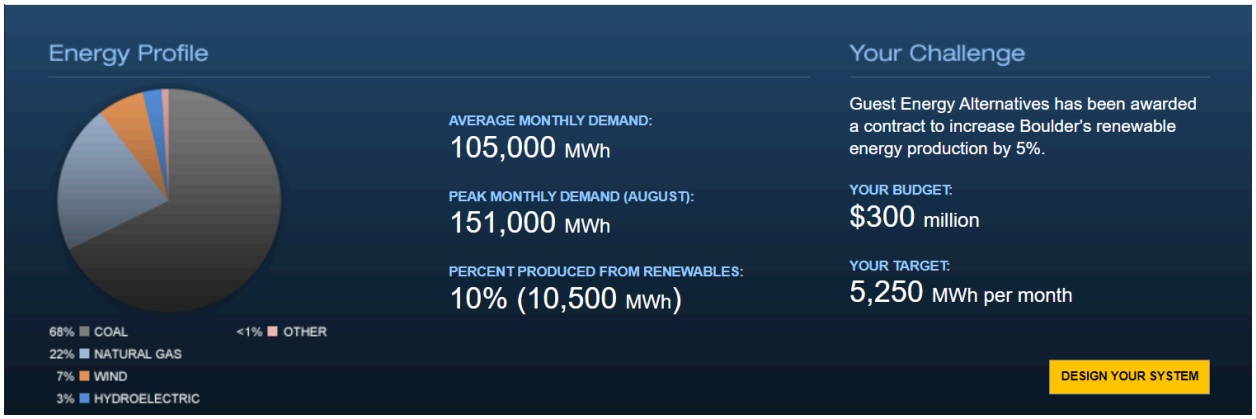
2. Start by selecting the city Boulder, CO (Challenge Level 2):





In Boulder, CO, you have the option to explore the utilization of both solar and wind system designs.

a. Test up to three different combinations of area and efficiency (Solar), and Diameter and # (Wind) (3 points)

Solar		Wind		Outcomes					Feedback received *(pop up windows)*
Area km^2	Efficiency (%)	Diameter (m)	#	Temperature (F)	Wind Speed (m/s)	Solar Intensity (W/m^2)	Tons of CO_2 saved	Cost per Ton ($)	

0.4	10	78	12	28	0.03	0	611	449	Low power
0.6	10	40	0	28	0.03	0	853	321	Low power
0.5	10	43	10	28	0.03	0	722	380	Low power

b. Did any of your designs “fail”, and if so why? (1 point)

No.
All the three designs worked well, with no failure recorded.

c. Which design would you rank the best and why? (1 point)

The second design involving 0.6 km^2 and 10-efficiency of solar power with 0 wind turbines is the best. This design is the best because it produces the greatest amount of electricity at the lowest cost. Besides, the design saves the highest level of CO_2, making it most environmental friendly.

3. Consider the criteria established, and variables associated with employing two different renewable energy systems versus one. What recommendations might you provide citizens or elected officials of Boulder, CO regarding the optimal systems to explore, and trade-offs to consider (2 points)?

Employing two different renewable energy systems is costlier but less effective compared to focusing on one renewable energy source. On the other hand, one energy source is less costly to implement, and produces higher amount of power. I would recommend to the locals of Boulder, CO to focus on employing one source with highest capacity. This would allow them to produce optimum power at the lowest cost, and within the budget. If both solar and wind must be implemented, I would advise the locals to consider increasing the solar panel area while reducing the number of wind turbines to optimize the output.

4. As a basic exploration of renewable energy designs and challenges associated with large scale production of renewable energy, was this tool helpful to you? Why or why not? (1 point)

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This tool was indeed helpful because it enabled me assess various renewable sources by feeding in various variables and getting a clue of the possible outcome. I can, therefore, use this tool in future to establish a more suitable renewable energy system to implement based on the output and cost factors.