Name:_____

Partners Name:_____

What Energy Choices are Best for a City?

In this lab you will explore how five different cities (Tucson, Boulder, Las Vegas, Los Angeles, and Oak Ridge) could integrate in renewable resources for electricity generation to lower their CO_2 emissions. Using the simulation at this website: https://www.pbs.org/wgbh/nova/labs/lab/energy/

These cities are considering one or more of the following renewable resources :

PV Solar: PV take the light energy from the sun and converts it into electricity.

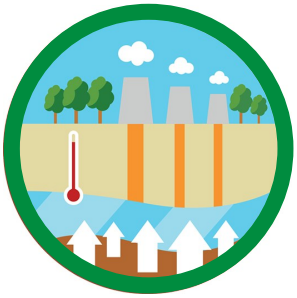
Pros: No CO_2 produced, no noise

Cons: Expensive, take up a moderate amount of space, aesthetics, only produces electricity when there is sun

Wind Turbines: Wind turbines take the kinetic energy from the wind and convert it into electricity.

Pros: No CO_2 produced

Cons: Takes up lots of space, aesthetics, noisy, kills birds, only produces electricity when it is windy



Geothermal: Takes the thermal energy from inside the Earth and converts it into electricity.

Pros: Some CO_2 gas produced (when installing the piping), very efficient, when present is available 24 hours -7 days a week

Cons: Needs some electricity for heat pumps to operate, can cause earthquakes

Biomass: Takes the chemical energy in organic mater and converts it to electricity.

Pros: Waste reduction, is available 24 hours -7 days a week

Cons: Releases CO_2 (considered carbon neutral), requires transportation of the biomass to the place that it is processed, can cause deforestation or requires large amounts of water to grow material

Each city has different energy needs, area that can be used, and budgets that must be taken into account. After you design their system you will test the system and get the following data.

Two-Year Projection: This projection looks back at the last two years and shows the amount of electricity that would have been generated per month with your system. The red line in this simulation shows you the city's desired renewable output. You will record the number of months that your system meet the city's needs.

Up to Two-Week Projection: This projection looks back at up to the last two weeks and shows how much energy your system would have produced. For the last two weeks you will record the energy output (MWh) and CO_2 saved.

Evaluating Systems

DO THIS PRIOR TO STARTING THE SIMULATION

The systems will be evaluated on the following criteria. As a class, rank (1-5) the criteria from most (1) to least (5) important and then decide on the percentage that each criteria should be worth. When you add up all of the percentages you should get 100%. A portion of your grade will come from how well you do on the "class" and the "EPA" grading systems.

Criteria	Data Used	Predicted Range	Rank	Percentage
Percent **under budget**	Budget	0%-100%		%
Percent of **area unused** by project	Area	0%-100%		%
Number of months over the course of **two years** when the electricity production exceeded the renewable needs of the city	Two Year Projection	0 –24		%
Amount of electricity **output** (kWh) per	Up to Two Week Projection	0 kWh—20 kWh Median: ~2		%
Amount (lbs) of **CO_2 saved** per day per person	Up to Two Week Projection	0 lbs —30 lbs Median: ~5		%
			Total:	100%

*Bolded words are what each criteria will be referred to on the results table.

As a class determine a rubric for each criterial based off a 10 point scale. You do not have to use all number from 0 to 10 in your rubric.

Things to keep in mind:

- 0% under budget means you used all of the allocated money.
- 0% area unused means you used all of the allocated area.

Under Budget (0-100%)		**Area Unused (0-100%)**		**Two Year (0-24)**		**Output (0-20 KWhr)** **Median: ~2 KWhr**		**CO_2 Saved (0-30 lbs)** **Median: ~5 lbs**	
Range	Score	Range	Score	Range	Score	Range	Score	Range	Score

To determine the scaled score use the rubric above to determine the score, then multiply it by the percent determined on page 2.

Systems Specification

Use the simulation to design a renewable system for each city and record the specifications of the systems below. For areas that have gray squares you must show your calculations on the calculations page. Make sure to fill out the cities in order.

City	Tucson		Boulder		Las Vegas		Los Angeles		Oak Ridge	
Solar Size (km^2)										
Efficiency (%)										
Wind Diameter (m)										
# of wind turbines per 200										
Geothermal (MW)										
Biomass (MW)										
Budget ($)	$1,800,000,000		$300,000,000		$2,000,000,000		$2,500,000,000		$150,000,000	
Budget Left Over ($)										
Percent Under Budget (%)										
Under Budget Score	Class	EPA	Class	EPA	Class	EPA	Class	EPA	Class	EPA
Under Budget Scaled Score Multiply by: ____Class ____EPA	Class	EPA	Class	EPA	Class	EPA	Class	EPA	Class	EPA
Percent Area Used (%)										
Percent Area Unused (%)										
Area Score	Class	EPA	Class	EPA	Class	EPA	Class	EPA	Class	EPA
Area Scaled Score Multiply by: ____Class ____EPA	Class	EPA	Class	EPA	Class	EPA	Class	EPA	Class	EPA

Systems Performance

Use your model to fill out the table below. You will need to look up information on the internet to answer some of the questions. For areas that have gray squares you must show your calculations.

City (Population)	**Tucson** _____		**Boulder** _____		**Las Vegas** _____		**Los Angeles** _____		**Oak Ridge** _____	
Number of Months Over Needed Supply										
Two-Year Score	Class	EPA	Class	EPA	Class	EPA	Class	EPA	Class	EPA
Two-Year Scaled Score Multiply by: ____Class ____EPA	Class	EPA	Class	EPA	Class	EPA	Class	EPA	Class	EPA
Two-Week Output (MWh)										
Output per Day (MWh)										
Output per Day per Person (KWh)										
Output Score	Class	EPA	Class	EPA	Class	EPA	Class	EPA	Class	EPA
Output Scaled Score Multiply by: ____Class ____EPA	Class	EPA	Class	EPA	Class	EPA	Class	EPA	Class	EPA
Two-Week CO_2 Saved (tons)										
CO_2 Saved per Day (tons)										
CO_2 Saved per Day per Person (lbs)										
CO_2 Saved Score	Class	EPA	Class	EPA	Class	EPA	Class	EPA	Class	EPA
CO_2 Saved Scaled Score Multiply by: ____Class ____EPA	Class	EPA	Class	EPA	Class	EPA	Class	EPA	Class	EPA

Final Scores

Add up all of the scaled scores for each city and put the scores in the table. Then add all the cities up and put the total underneath the table.

Class					
City	**Tucson**	**Boulder**	**Las Vegas**	**Los Angeles**	**Oak Ridge**
Score					

Total Final Class Score of all Cities:_____

EPA					
City	**Tucson**	**Boulder**	**Las Vegas**	**Los Angeles**	**Oak Ridge**
Score					

Total Final EPA Score of all Cities:_____

Reflection

What did this activity teach you about solar?

_____
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What did this activity teach you about wind turbines?

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What did this activity teach you about geothermal?

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What did this activity teach you about biomass?

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Letter to the Editor (This part of the lab report is individual work.)

Pick one of the cities and write a letter to the editor of their local newspaper stating why you think they should support your energy plan. Make sure that you use statistics and data from your lab on why this choice is good for that particular city (this may require you to do internet research). Letters to the editor should be not longer than 1 pages (double spaced).

Calculations

Tucson

Percent Under Budget (%)	[redacted]
Output per day (MWhr)	Output per Day per person (KWh)
CO_2 Saved per Day (tons)	CO_2 Saved per Day per Person

Boulder

Percent Under Budget (%)	[redacted]
Output per day (MWhr)	Output per Day per person (kWh)
CO_2 Saved per Day (tons)	CO_2 Saved per Day per Person

Las Vegas

Percent Under Budget (%)	[redacted]
Output per day (MWhr)	Output per Day per person (kWh)
CO_2 Saved per Day (tons)	CO_2 Saved per Day per Person

Calculations

Los Angeles

Percent Under Budget (%)	
Output per day (MWhr)	Output per Day per person (kWh)
CO_2 Saved per Day (tons)	CO_2 Saved per Day per Person

Oakridge

Percent Under Budget (%)	
Output per day (MWhr)	Output per Day per person (kWh)
CO_2 Saved per Day (tons)	CO_2 Saved per Day per Person