

# **Visualizing the Impacts of Renewable Energy on City-Wide Emissions**

Patrick Conway, Elizabeth Ranatza, Matt Robinson, Daniel Zhang  
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## **Introduction**

This project will visualize how changing the makeup of a city's energy sources can lead to a change in greenhouse gas emissions. This project will promote positive examples of cities taking steps to improve the condition of the Earth, highlight areas where attention is needed, and provide empirical evidence of which methods of renewable energy have the greatest impact on emissions. The project will present city-level emissions data, as well as the make-up of their energy sources. By visualizing how these data sources connect, interact, and changes over time, users will be able to see the impacts, and make decisions about how to better the planet.

## **Motivation**

“Human activities (primarily the burning of fossil fuels) have fundamentally increased the concentration of greenhouse gasses in Earth's atmosphere, warming the planet.”<sup>1</sup> Because of this, it is critical that we, as a society, make systematic changes to reduce our impact. In order to understand what steps need to be taken, educating decision-makers is critical. Changes need to be made at the individual level, all the way up to the corporate and national level. By looking at city-level data, the project will hopefully represent a happy medium between individual decisions to go green and urban planning efforts to increase sustainability.

There are two intended users of our visualization. Decision-makers, such as politicians, urban planners, and local activists will have access to emissions data for their city, will be able to compare their statistics to cities of a similar size or geographic area, and see how their impacts compare to the rest of the country. Having better access to this information is beneficial<sup>2</sup> and will ideally lead to better decisions about handling carbon emissions. In addition, citizens who aren't considered to be decision makers will benefit from our visualization. They will gain an understanding of how their city is contributing to the ecosystem, and decide whether they need to push leaders to change, or re-align their individual energy use to match the makeup of their city.

## **Data**

Data for this project will be primarily obtained from The Carbon Disclosure Project (CDP)<sup>3</sup>, a global non-profit that gathers data and reports on the environmental impacts of companies, cities, and regions. Provided is a list of data sources, with a brief description of how they will be utilized.

1. City-Wide Emissions (2018, 2019, 2020, 2021) – This data set contains geographic information about reporting cities, basic information about the governmental structure, and statistics about total Direct and Indirect emissions of CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O. This set

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<sup>1</sup> <https://climate.nasa.gov/causes/>

<sup>2</sup> The Use of Climate Knowledge in Urban Planning, Ingegärd Eliasson, Landscape and Urban Planning, Volume 48, Issues 1–2, 2000, Pages 31-44

<sup>3</sup> <https://data.cdp.net/>

will be the primary data source, and the project will visualize how those numbers have changed over time.

2. City-Wide Percentage Energy Mix (2018, 2019, 2020, 2021) – This data set contains information about the energy sources of global cities. It is in the form of a percentage breakdown of Coal, Gas, Oil, Nuclear, Hydro, Biomass, Wind, Geothermal, Solar, and Other. By examining the changes to the percentage breakdown, and comparing it to the emissions data, this project can paint the picture of the impacts of energy sources on emissions.
3. Population information (The World Bank) – There is an assumption that as a population grows, the energy use will grow as well. By incorporating population data for the selected cities, the project can account for that assumption.

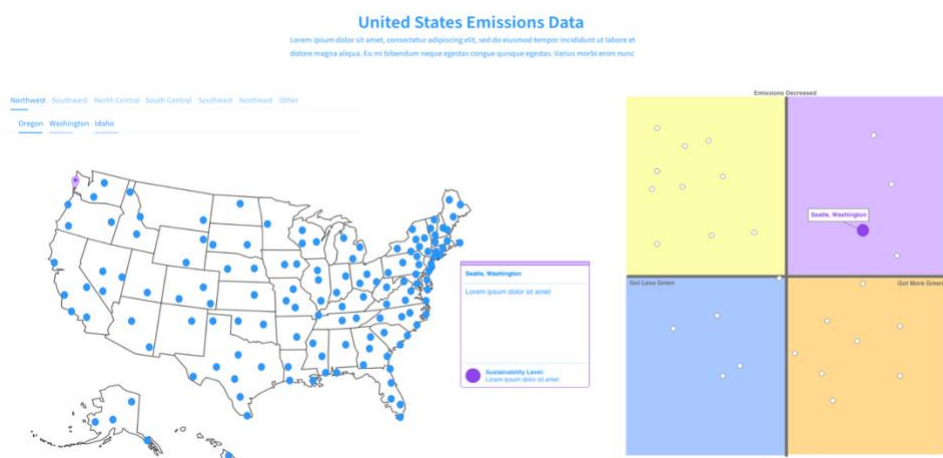
## Data Notes

We have completed a few rounds of data analysis, and have a working data set. Right now, our data includes about 125 cities in the United States, and we have decided to limit our range to four years. This will allow us to create a visualization, write some statistical functions, and display our data on a map. As the project grows, we are open to expanding our scope to include data from other countries. That being said, just focusing on the United States will still be representative of the problem we want to solve and should result in an effective visualization.

Currently, each city has a unique ID, name, amount of each type of energy source, emissions totals, population in a given year, and their geographic location in the form of latitude and longitude. We included cities that appear at least 3 times out of our 4 year range. Our data will need to be augmented with some created attributes. We already have latitude and longitude data for creating a map, but we also need to organize the cities into regions manually. We also will break down the energy sources into ‘renewable’ or ‘non-renewable’ to allow more detailed analysis of a cities make up. Some attributes, such as percentages, change over time, and linear regression information about the correlation between energy sources and emissions will be developed using SimpleStatistics.

## Visualization Overview

After a design workshop, we have decided on what our visualization will look like. We plan to display two graphics at once, that depend on the same information. That way, users of all kinds can immediately utilize the application in the way they want, and a large amount of data can be displayed at one time. This image serves as a prototype for the default view of our visualization.

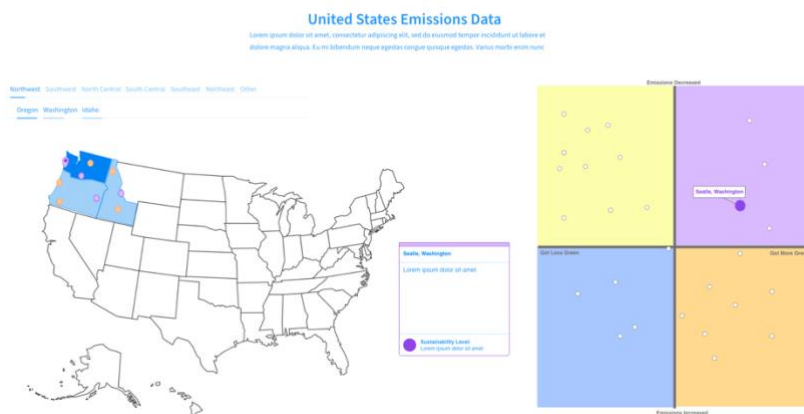


On the left side is a map of cities in our dataset. We believe that users will first try to locate their city, and a map is the easiest way to do that. Users will be able to click on a circle, and data about the city will be displayed on the screen. Right now, we plan to display geographic information, and the individual emissions and energy source data for the selected city. This will be valuable for users researching their own city.

On the right side, there is a scatterplot with two axes, creating four quadrants. The x-axis will display how the emissions level of a city has changed over time. The y-axis will display if the energy mix of the city has become more or less renewable over time, in the form of a percentage increase or decrease. Cities in the top right quadrant will be cities that have reduced their emissions and increased their percentage of energy coming from renewable sources. Cities in the bottom left will have opposite data. This will allow users to see nation-wide trends, understand where their city is on the spectrum, and learn where to direct resources to improve emissions. It is important to note that the data on these two sections will update simultaneously and can be used interchangeably. If a user clicks on a node on the map, it will be highlighted on the scatterplot, and vice-versa. It is hard to predict how users will ultimately interact with our visualization, but this current iteration allows ultimate flexibility.

Another key aspect of our visualization is the ability to add filters. We want users of all kinds to filter and adjust the visible data to fit their needs. Currently we plan to allow users to set a population range. That way, they can see cities of a similar size to theirs, or only look at large cities to see which ones need the most impact. We also want users to be able to focus on specific

regions for analysis. We are going to divide the data into seven regions, and users can look at a single region or combination to perform analysis. We also plan to allow users to focus on specific energy types. If a user is interested in wind energy, for example, they could chose to only look at cities utilizing wind energy, and how that number of cities has changed over time.



## Concluding Thoughts

Solving the environmental crisis is going to depend on a lot of factors, and proper data gathering and visualization is an important one. Our group hopes that this website will serve as a framework for future, larger-scale projects. As data collection standards improve, and the amount of data available increases, this prototype visualization can be expanded and more analysis can be done.