Final Report

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Phase I: [CAB_project4_PhaseI.mp4]

Phase II:

Phase II Proposal - Empowering Municipal Sustainability

Greenhouse gas metrics allow emissions of different gasses to be reported in a common unit called CO2-equivalent. Greenhouse gas is a gas that absorbs and emits radiant energy within the thermal range. In simpler terms, it is a gas that lets sunlight pass through the atmosphere, but it is also preventing the heat that sunlight brings into earth's atmosphere. The unit CO2-equivalent enables comparisons of the efficiency of different farms and production systems and of alternative mitigation strategies across all gasses.

The greenhouse effect and greenhouse gasses are often associated with global warming and manmade climate change, but it is important to realize that it is actually necessary to have some base level greenhouse gasses or greenhouse effect just for earth to be habitable in the way that it is. Without greenhouse gasses, earth's surface would be about -18 degrees celsius, which is the same as 0 degrees fahrenheit. The issue with this would be if the concentration of these greenhouse gasses go out of equilibrium, become unusually high, and that seems to be what is occurring. The stakeholders may include a combination of investors, shareholders, litigants, non-governmental organizations (NGOs) and activists, governments, communities, suppliers, customers and employees. These stakeholders are increasingly focused on climate-related matters.

There are many other issues that are coming from the constant usage of combustible engines. Increased use of traditional gas-powered vehicles can lead to major air pollution which will do astronomical amounts of damage to the atmosphere through time. As stated above, the biggest threat is manmade climate change through the combustible engine in relation to the greenhouse effect. The Environmental Protection Agency (EPA) lists 6 categories of pollutants resulting from the use of fossil fuels today. These are Ground-Level Ozone, Particulate Matter, Carbon Monoxide, Lead, Sulfur Dioxide, and Nitrogen Dioxide. For the reduction of these common pollutants, we hope to shift the focus onto using more Electric Vehicles (EVs), by providing more information on sustainability attempts and their effectiveness in communities. The Environmental Protection Agency has stated that “while charging the battery may increase pollution at the power plants, total emissions associated with driving electric vehicles are typically less than those for gas cars - particularly if the electricity is generated from renewable energy sources like wind” (*Explaining Electric & Plug-In Hybrid Electric Vehicles* 2023). Using EVs is proven to cause less of the pollution listed above on average, pointing to the benefits of increased EV adoption in the future.

The data we will use is presented in the form of municipality-specific statistics, regarding electric vehicle usage as well as greenhouse gas emissions from both vehicles and other sources. The specific datasets we will be using are the Electric Vehicle Ownership Data, Community-Scale Greenhouse Gas Emissions Data, and

Greenhouse Gas Emissions by Vehicle Type Data. This data is provided as sourced from multiple sources for each datapoint in each municipality. The duality of the data will allow us to calculate the average annual change of municipalities' sustainability metrics using SQL queries. This can then be compared to that of other municipalities in the state or the average in the county or the state. Providing these metrics local to individual municipalities helps to inform a town or city's government in tracking their progress on sustainability issues over the past several years, or to help interested constituents track the progress of their municipality. The user will be able to select the municipality or county whose data will be displayed in the user interface. Additionally, users will be able to select a certain county on the map to see comparative visual data across the given county regarding either electric vehicles or greenhouse gas emissions, represented using color.

Use case: Select region for data display

1. System displays county selection options to User.
2. System displays municipality selection options to User.
3. System validates municipality selection.
4. System retrieves relevant data from the database.
5. System calculates comparative metrics based on aggregated data across the state.
6. System displays requested information and comparative metrics to User.

Use case: Select data for visual display

1. System displays counties and municipalities in a graphical user interface in the form of a map.
2. System displays selection options for comparative display to User.
3. System retrieves data from the database based on the user's selection.
4. System calculates a normalization value for each region based on the selected data and the maximum datum displayed in the interface.
5. System calculates the color value to be displayed on the graphical user interface map for each county and municipality.
6. System displays the retrieved data to the User as a color mapping on the provided map interface.

Appendix

Last paragraph:

- The data we will use is presented in the form of municipality-specific statistics, regarding electric vehicle usage as well as greenhouse gas emissions from both vehicles and other sources. The specific datasets we will be using are the Electric Vehicle Ownership Data, Community-Scale Greenhouse Gas Emissions Data, and Greenhouse Gas Emissions by Vehicle Type Data. This data is provided as sourced from multiple sources for each datapoint in each municipality. The duality of the data will allow us to calculate the average annual change of municipalities' sustainability metrics, specifically EV usage data and carbon emission metrics, using SQL queries. This can then be compared to that of other municipalities in the state or the average in the county or the state. Providing these metrics local to individual municipalities helps to inform a town or city's government in tracking their progress on sustainability issues over the past several years, or to help interested constituents track the progress of their municipality. Furthermore, this comparison of data across municipalities will promote statewide adoption of sustainable practices when it comes to greenhouse gas emissions and electric vehicle ownership, in order to make these metrics for individual municipalities become better over time. The user will be able to select the municipality or county whose data will be displayed in the user interface. Additionally, users will be able to compare a number of municipalities or counties based on a specified statistic.

Data retrieved from:

- https://www.sustainablejersey.com/resources/data-center/sustainable-jersey-data-resources/#c4734
- https://www.sustainablejersey.com/resources/data-center/sustainable-jersey-data-resources/#c4735
- https://www.sustainablejersey.com/resources/data-center/sustainable-jersey-data-resources/#c4736

Second use case:

- **Use case: Select data for comparative display**

1. System allows User to view either the entire state or an individual county.
2. System displays selection options for comparative display to User, specifying Greenhouse Gas emission data or Electric Vehicle ownership data.
3. System retrieves data from the database based on the user's selection.
4. System calculates a normalization value for each region included in the selected area (either counties or municipalities in a county) based on the selected data and the maximum datum displayed in the interface.
5. System calculates the ranking of each county and municipality compared to all selected regions.

6. System displays the retrieved data to the User as a list of ranked percentile scores.

Phase III:

Relational databases are the most popular form of management of data applications, and this is for good reason. Relational databases are databases that primarily rely on the concepts of *relations* and *relationships* to store data in a way that is efficient to update and query. Relational databases are formed using rigid schemas, meaning the data at any given point in time is required to follow a set of constraints defined by this schema, and must be organized in a predictable way for the guarantee of this ease of access. Relational databases are made up of relations, which, through relationships, can be connected to other relations for complex queries on the stored data.

Relational databases are valuable because they allow dynamic complex queries on parts of a given state, as opposed to only allowing queries on the entire state, as some other database models do. The flexibility of relational databases makes them very versatile, hence their common use despite the age of the technology.

The first relation in the schema is Municipality. This relation contains information to uniquely identify each municipality in the state. To uniquely identify this, both the name of the municipality and the county in which it resides are necessary, as some town names are used in multiple counties. This is represented by the uppermost box in the ER diagram, with its two attributes branching off.

Branching off of Municipality is the weak relationship DESCRIBED_BY. The weak relationship refers to Municipality being necessary to uniquely identify Datum. The year attribute uniquely identifies a given datum of a given type in the set of all data present for that municipality of that type. Additionally, each Municipality can have any number of pieces of data, but each datum is linked to only one municipality.

Datum describes any piece of information stored about a municipality, and can be specialized into EV_Datum, Generalized_GHG_Datum, and Vehicle_GHG_Datum. Any piece of data must fall into exactly one of these three categories. Each piece of data contains information about a different metric measured in some municipality, to which it is related using DESCRIBED_BY, where the year measured is specified on the Datum.

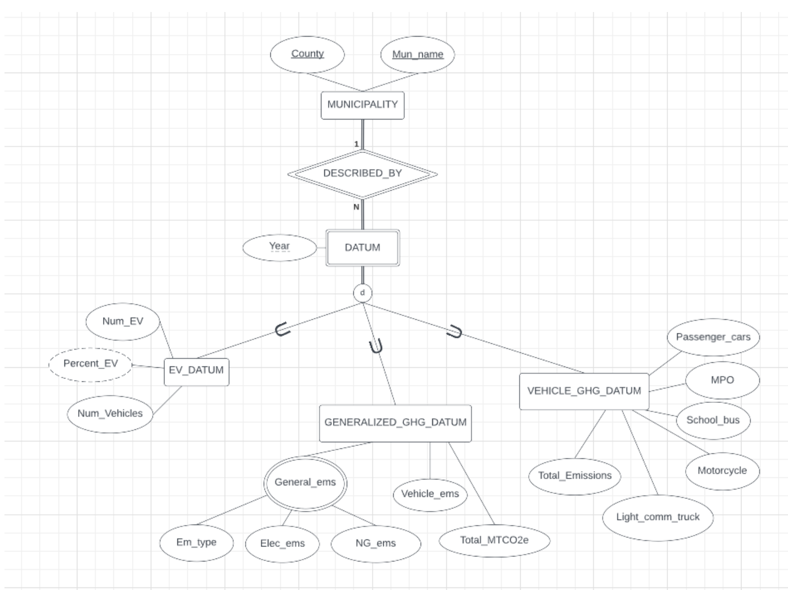
The EV_Datum represents the number of electric vehicles and the number of emissions-based vehicles within a given municipality. Furthermore, the inclusion of EV_Datum would help to reduce redundancy within our dataset. This would be the case because it would be redundant to store the average in our database when it would be simpler to calculate it through the attributes already present, hence the dotted circle around the attribute in the ER diagram.

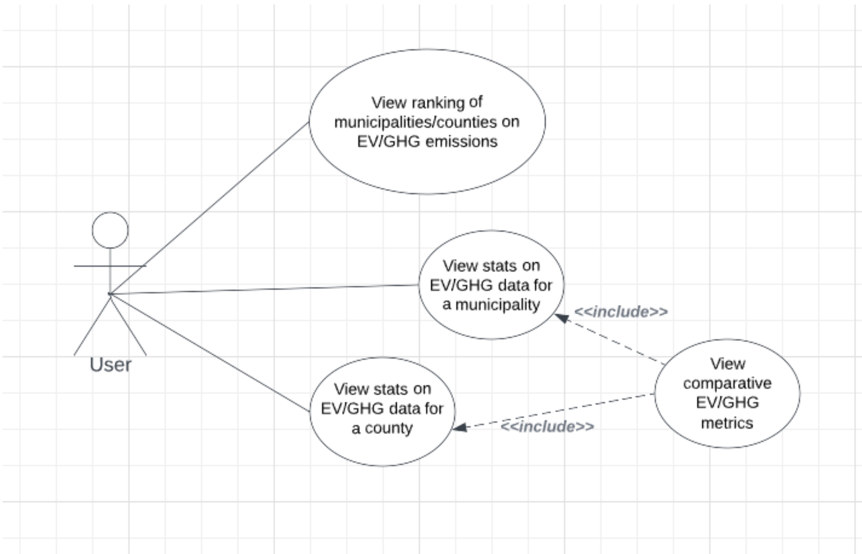
The greenhouse gas emissions by vehicle type dataset consists of 18 columns with municipality name, county, MPO, year, as well as greenhouse gas (GHG) emissions (metric tons carbon dioxide equivalent) for 13 vehicles. For instance, passenger cars, light commercial trucks, motorcycles, and school buses are only a few examples. Each row holds data for the various municipalities for the 21 counties in New

Jersey. The Vehicle_GHG_Datum also shows the total emissions that correlate with electric vehicles.

Each Generalized_GHG_Datum consists of 4 different types of emission metrics, stored in General_ems. These represent the residential, industrial, commercial, and streetlight metrics found in the data provided by Sustainable Jersey. Each type of emission keeps track of the natural gas emissions and electrical emissions related to the specified part of infrastructure. Additionally, each Generalized_GHG_Datum keeps track of a municipality's carbon emissions related to vehicle use, as well as the total MTCO2e produced.

In regards to our database, the Generalized_GHG_Datum would show specific data such as showing a correlation between either the increase/decrease of electric vehicle usage with the percentage of greenhouse gas emissions in a given year. Essentially, the GHG datum will help conceptualize the data and create comparative metrics. Furthermore, you can view the data values included in the vehicle greenhouse gas data.




View ranking of municipalities/counties on EV/GHG emissions
User
View stats on EV/GHG data for a municipality
<<include>>
View comparative EV/GHG metrics
View stats on EV/GHG data for a county
<<include>>

Upon analyzing Greenhouse Gas emissions data across the state, we discovered that certain municipalities and counties have made much larger efforts than others to lower their emissions. Based on our research, a large factor in town-wide emissions decreases may be the increased adoption of electric vehicles as of late. According to the Environmental Protection Agency, “while charging the battery may increase pollution at the power plants, total emissions associated with driving electric vehicles are typically less than those for gas cars - particularly if the electricity is generated from renewable energy sources like wind” (*Explaining Electric & Plug-In Hybrid Electric Vehicles* 2023). Increased EV adoption has been shown to be effective in decreasing overall pollution and emissions, making this metric a good one to promote to municipalities in order to increase the efficacy of their sustainability practices. Additionally, because of the differences in sustainability efforts in towns, we thought it would be beneficial to use comparative metrics to motivate better practices statewide.

Our application will allow us to use Electric Vehicle ownership and Greenhouse Gas emission data, including specific vehicle emissions, to compare and contrast these related sustainability metrics among municipalities and counties, as well as relating municipalities’ data to their county’s. We used 3 main datasets to make comparative metrics to identify how municipalities are doing in terms of how sustainable they are for the environment. The data sets we used were EV ownership data, Community scale Greenhouse Emissions and GHG Emissions by Vehicle type. Our database can be used to better the future of sustainability and allow for a quick, user-friendly, and efficient way to check up on the specific records in regards to EVs and Greenhouse Gas emissions.

The interface displays an interactive state map, in which each county is differently colored depending on a normalized value for the relative growth of the requested statistic: Electric Vehicle ownership, Greenhouse Gas emissions (MTCO2e), or specifically GHG emissions for vehicles in the county. These are shown as averages between all municipal annual increases in a county. If a county is selected, a similar map will be displayed: this time showing all municipalities in the county, with the same three color options available. These color maps show how a municipality (or county) is doing in terms of sustainability progression, especially when compared to neighboring regions. This comparison between municipalities makes it easy to compare a municipality against the rest of its county, and further research can then be done to recognize the areas where emissions improvement is needed to keep up with surrounding towns.

If a user selects a municipality, the three aforementioned values are displayed as absolute metrics, not normalized values. This gives a municipality specific numbers to match with the color maps mentioned above.

If our proposal is implemented, this will allow for increased sustainability across the state. We believe this because the information displayed will allow for municipalities to question one another and show where they need to be in relation to others across the state. This also will perhaps encourage competition between the municipalities allowing for more efforts to increase the use of Electric Vehicles and lower Greenhouse Gas Emissions within certain areas of the state, improving the statistics of the areas that decide to become more sustainable.

In general, our solution is simply a tool to be used by state officials and residents as they see fit, so they do not present many ethical issues. Essentially all of the data stored in the database and therefore presented to users is already publicly available data retrieved from Sustainable Jersey's website. The only new data presented is the culmination of comparative metrics between municipalities in a county, as well as between county averages. This data is calculated to provide a baseline for municipalities in an area to see how a municipality or county is progressing in its greenhouse gas sustainability efforts in comparison with surrounding areas. Although it is unlikely, it is possible that this data could be used for unethical purposes, such as some party utilizing power metrics in a municipality for personal or financial gain. Additionally, in combination with other municipality-local metrics, unintended statistics and information may be determined using town averages or data points. However, because all of this data is simply represented in a new medium, any negative outcomes from this application would be possible before its development by using the original datasets. Because of this, this idea is one that is worth pursuing. The possible benefits of displaying emissions data in such a user-friendly and digestible format greatly outweigh the ethical concerns posed by it.

Works Cited

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