Final Report

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Phase II

NJ Electric Vehicle Usage Analysis

Electric Vehicles (EVs) are becoming increasingly popular due to their environmental benefits and lower operating costs. As a result, many people in New Jersey are switching to electric cars. However, the lack of adequate charging infrastructure is hindering the growth of EV adoption in the state. To address this issue, our group aims to create a program that evaluates the EV friendliness of a county in NJ. The program will provide insights into the availability of charging infrastructure, population density, and traffic congestion, which will help EV owners make informed decisions about where to live and charge their vehicles based on a location provided by the user. This paper outlines our group's plan to build the EV friendliness evaluation program, highlighting the datasets we intend to explore and the methodology we will use to determine the EV friendliness of a county. By providing this tool to EV owners in New Jersey, we hope to accelerate the adoption of EVs, reduce greenhouse gas emissions, and improve the overall sustainability of the state.

Identifying Sustainability Problems

The data that we will gather from the The Electric Vehicle (EV) charging Locator dataset, New Jersey public transit dataset, and the NJ Census dataset will help us identify sustainability problems. Besides a lower fuel cost, electric vehicles offer a greener option in comparison to gas or diesel vehicles and greenhouse gas emissions are reduced. The data helps promote positive change in seeing the lower fueling costs and different types of counties where choosing electric vehicles won’t only be beneficial for the county, but for those individuals looking for ways to save money and make a positive impact on the environment.

Background on Sustainability Problem

We plan on diving into the problem of global warming with support from decreasing carbon emissions. Vehicle emissions cause air pollutants, which result in smog and health problems and greenhouse gasses. Through the investment of electric or hybrid vehicles, the amount of emission that will be produced will be a fraction compared to a gasoline vehicle. All electric vehicles produce zero tailpipe emissions. Enticing citizens to go sustainable with transportation, a significant amount of charging points will have to be put in place, with significant research done to alcoate charge manufacturers that make stations that can last for their promised lifespan to make the emissions being used to produce them worth it. The purpose of persisting in this issue goes back to the care for our community and plant, as carbon dioxide contributes to global warming and is linked to respiratory illnesses and premature deaths. Caring to minimize our carbon footprint is an action that will impact beyond just our county. It is important to look for a solution that will help us long term.

Proposed Datasets

The Electric Vehicle (EV) charging Locator dataset will be a core component of our tool. This database includes information about the address of the charging station, the type of charging port available (e.g. Level 1, Level 2, or DC fast charging), the charging capacity, the hours of operation, and the payment methods accepted. This information can help us answer many questions about EV friendliness, such as: How many chargers are there within a county? What types of chargers are they? Are they cheaper than gas options? All this information can help EV prospective owners find and use charging stations more efficiently and effectively. We can also contrast EV ownership data to determine if other people also felt that a county was better suited to handle EVs. This can help us answer questions such as: Are there higher concentrations of EVs in areas with more charging infrastructure? What counties have the highest concentration of EVs? This information can help us explore reasons why counties have higher/lower EV ownership.

The next dataset of interest will be the New Jersey public transit dataset. This includes information about total public transportation miles traveled and annual daily traffic counts within a county. Total public transportation miles traveled within a county will tell us how much the population depends on transportation by car. A higher number indicates a heavier reliance on public transportation, while a lower number may indicate more reliance on commuting by car. It is important to contrast this data with traffic counts to determine whether an EV can reduce the GHG emissions during commutes. These datasets will help us answer questions, such as: Which counties rely the most on public transportation? Which counties have the most traffic congestion? The answers to these questions can help a user make an informed decision on whether owning an EV makes practical sense within their county.

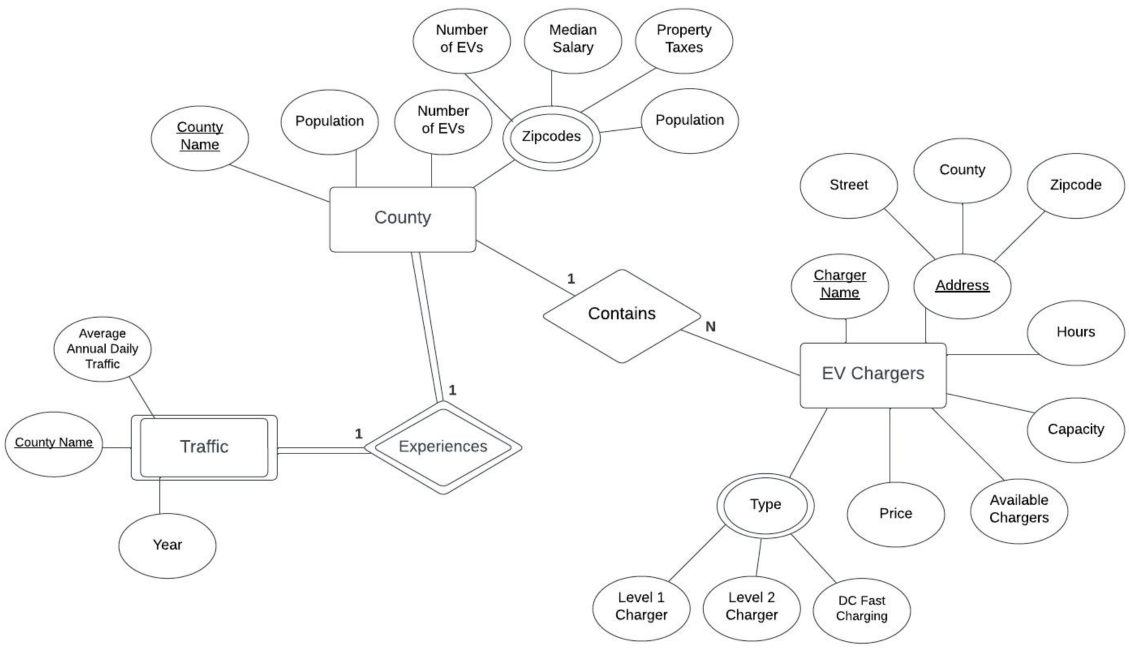
Lastly, our group plans to examine NJ Census data to determine the population demographics of areas with higher and lower EVs. Income, property taxes, and density are important factors when considering owning an EV. Are there tax deductions set in place at locations where taxes are higher? What is the median income of those counties that have higher EV populations? Are there patterns in housing characteristics that are better suited for at home charging? These questions can help a user determine whether an EV makes sense in their county.

Use Cases

Our first use case is that our actors will include a user interested in finding the amount of chargers in their counties. The actor will provide their location and the database will provide an evaluation of the electrical vehicle friendliness of the region. This will be in the form of either an interactive graph or some sort of heat map locating regions with friendlier EV ownership. The program also will provide more detailed information about what type of chargers are in the region in the form of text output. The user can provide as much information as they want such as income population, gas prices and zip to further narrow their search. These evaluation functions will consider these values and provide scores to regions within the selection. These scores are going to determine the EV friendliness of the region. Some more additional features are if the user wants to enter in their commute time. This could generate some sort of sphere or distance around a location to show feasible areas they can travel too.

Phase III

ER Diagram:



A general description of how relational databases work and why they are valuable.

A relational database is a type of database that stores data in a structured way, organized into tables or relations. Each table contains rows, also called tuples, and columns, also called attributes. The tables can be related to each other based on common columns, forming a network of interconnected data. Using these related tables, we can create a miniworld, where data about the real world is stored into a virtual representation. These tables provide a consistent and structured way to store, manage, and access data about the real world. In our case, we want to store real word data about the EV friendliness of a county in New Jersey. Using a database, we can quickly retrieve data that will provide the user with the information needed to make an informed decision about electric vehicles.

The various elements of your diagram and what they reveal about your database model.

The ER diagram representing our database will consist of the following databases: EV Ownership, NJ Annual Average Daily Traffic data, and NJ Census Data. The County relation would have a primary key called County Name. This would be unique for each tuple because there exists only one county with a given name. One County contains many EV Chargers (One-to-Many), thus a relationship exists between the two relations. The EV Chargers relation would have a primary key of Charger Name and a foreign key named Address, which is a composite of Street name, County, and Zip Code. The Traffic entity is a weak entity because its identification relies on the primary key of the relation County. None of the other attributes that exist in Traffic are unique. As a result, there exists an identifying relationship between County and Traffic. This relationship is One-to-One with full participation because every county has exactly one count of traffic.

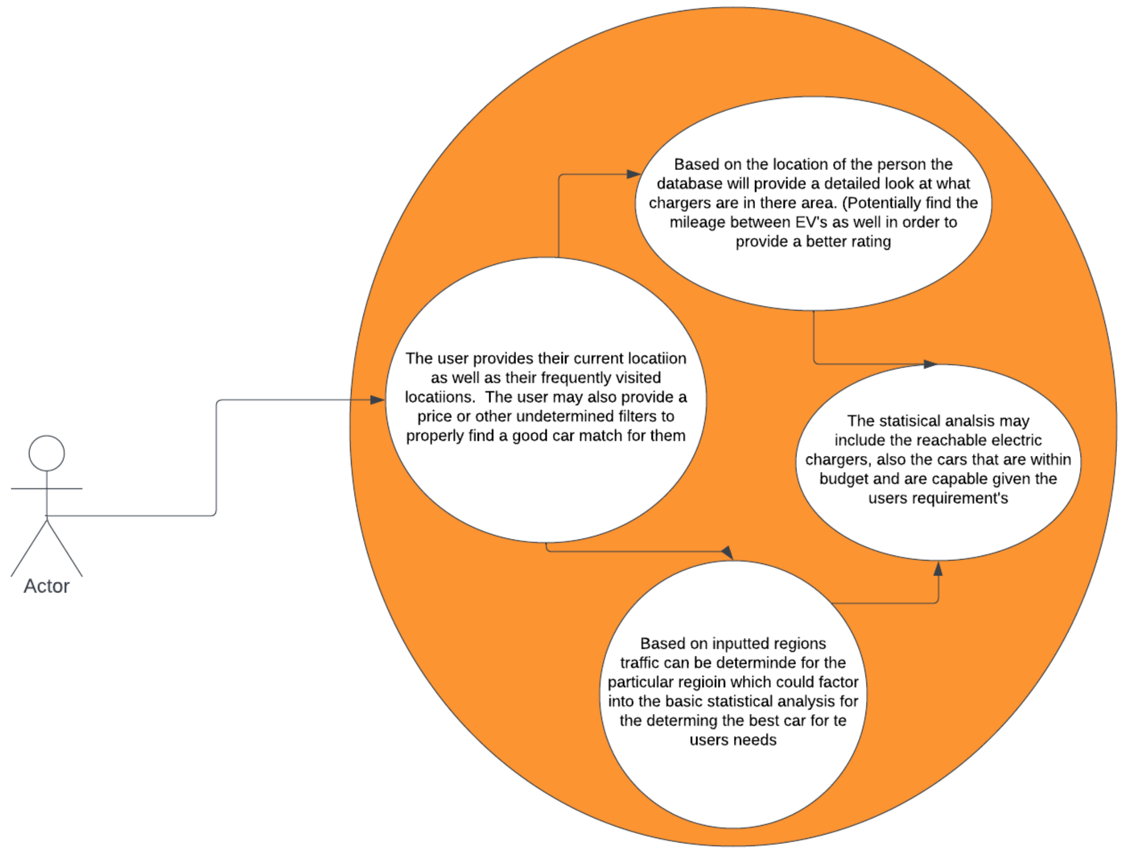
The reasoning behind your database design given the goals for the sustainability project.

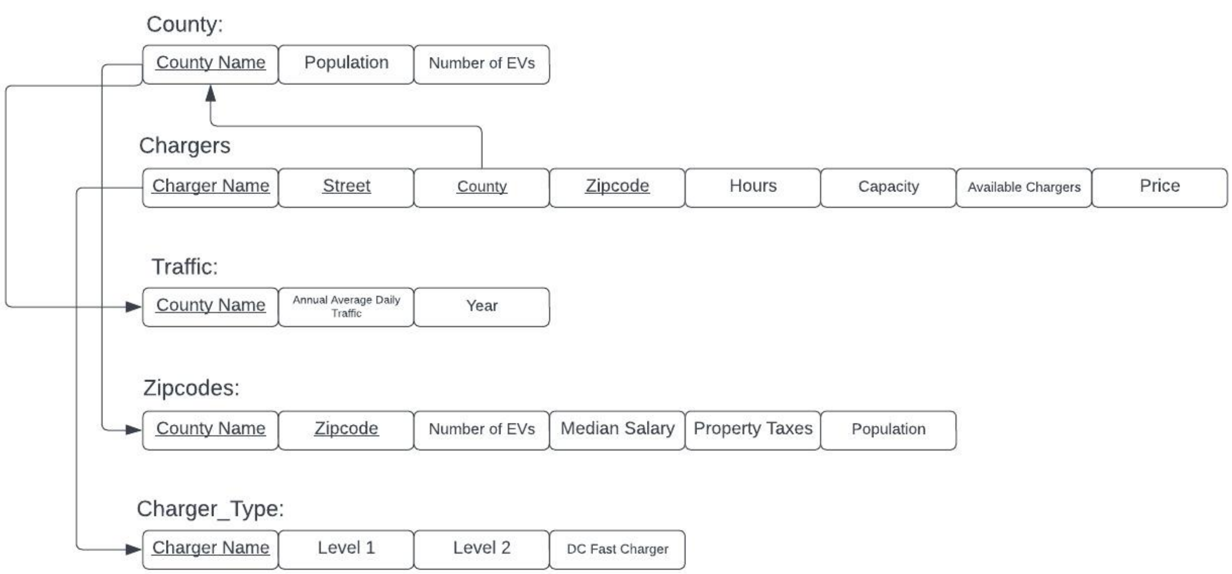
Traffic and population data is important when it comes to making a decision on whether to invest in an electric vehicle. Living in a county with lower average annual daily traffic counts can indicate that public transportation may be a more efficient method of commuting from one location to another. On the other hand, counties with higher traffic counts may indicate that public transportation options are barely accessible. Population data can be used to see where a user ranks within their community. Data such as property taxes and median salary can help a user understand why some locations may have higher EV ownership than others. It can help a user decide whether their income is similar to those in the same community that own electric vehicles. By having the user enter information about their nearby location, they can be presented with the necessary information to make an informed decision.

A detailed textual use case that describes interactions with your proposed graphical user interface.

The actor's for our project would initially put in a request through input boxes. These boxes would ask for the following information: the county they live in and propose a range of how many miles they would typically travel in a day. With this data, the software could reach into the database and pull out relative chargers within the range and region. Using the charger's street location we can visually map the charger's location to a map of New Jersey. Also based on location we can pull down traffic data which can provide more insight into the practicality of purchasing an electric vehicle. The front-end will send the request to postgres which will contain the data the user entered. The data then will be returned after being appropriately filtered through SQL commands. The data can be further pruned through python before being served to the frontend to be visualized to the user.

Use Case Diagram:





There are exactly 21 counties in the state of New Jersey. As a result, we can assume that the tables for County and Traffic will contain a maximum of 21 tuples. These relations may require only simple searches, as county name is the primary method of identification.

There are exactly 729 zipcodes in the state of New Jersey. As a result, we can assume that the table for Zipcodes will contain a maximum of 729 tuples. This relation may require more complex queries in order to retrieve more in depth information about a specific zipcode.

There are exactly three types of EV chargers. As a result, the Charger_Type relation will contain exactly 3 tuples. This relation will only require simple searches to retrieve information about charger type.

The table for Chargers is not a fixed sized table. It is possible that new chargers may be opened up in different parts of the state. Currently, there are over 300 EV chargers in the state of New Jersey, but this number is expected to grow in the future. Complex queries may be required for this relation to retrieve more in depth information about specific features of a charger.

Appendix: Updated Schema
County(county_name, number_of_evs)
Zipcodes(zipcode, median_income, households)
Zipcodes_nj(county, zipcode)
Traffic(county_name, traffic_count, year)
Charger(charger_name, street, zipcode, ports)

Phase IV

Normalizing Relations

County(<u>CountyName</u>, Population, Number of EVs)
CountyName → Population, Number of EVs
This relation is in BCNF form. There do not exist any partial dependencies that would violate 2NF, no transitive dependencies to violate 3NF, and no relationships where a dependency relies on a non-prime attribute within a relation to violate BCNF.

Chargers(<u>ChargerName</u>, <u>Street</u>, <u>County</u>, <u>Zipcode</u>, Hours, Capacity, Available Chargers, Price)
{ChargerName, Street} → Hours, Capacity, Price, Available Chargers, County, Zipcode
This relation is in BCNF form. There do not exist any partial dependencies that would violate 2NF, no transitive dependencies to violate 3NF, and no relationships where a dependency relies on a non-prime attribute within a relation to violate BCNF.

Traffic(<u>CountyName</u>, <u>Year</u>, AADT)
{CountyName, Year} → AADT
This relation is in BCNF form. There do not exist any partial dependencies that would violate 2NF, no transitive dependencies to violate 3NF, and no relationships where a dependency relies on a non-prime attribute within a relation to violate BCNF.

Zipcodes(<u>CountyName</u>, <u>Zipcode</u>, Number of EVs, Median Salary, Property Taxes, Population)
{CountyName, Zipcode} → Number of EVs, Median Salary, Property Taxes, Population

This relation is in BCNF form. There do not exist any partial dependencies that would violate 2NF, no transitive dependencies to violate 3NF, and no relationships where a dependency relies on a non-prime attribute within a relation to violate BCNF.

Charger_Type(<u>ChargerName</u>, Level 1, Level 2, DC Fast Charger)
ChargerName → Level 1, Level 2, FastCharger
This relation is in BCNF form. There do not exist any partial dependencies that would violate 2NF, no transitive dependencies to violate 3NF, and no relationships where a dependency relies on a non-prime attribute within a relation to violate BCNF.

Potential Virtual Views

ChargerInCountyView (Join Charger and County):
This view provides all the available chargers within a county. Using this view, a user can determine which counties contain the most amount of EV chargers, select chargers within a county based on price or capacity, and more. This type of view can be used with or without user input, where the input county name.

ZipcodesTrafficView (Join Zipcodes and Traffic):
This view provides the annual average traffic counts of various years for a zipcode within a county. This view will not provide the traffic count for a specific zipcode, but will for the entire county it sits within. Using this view, a user can view how many EVs may exist within a county and compare it with traffic data. In addition, the user could also compare population demographics to overall traffic data. This type of view can be used with or without user input, where the input could be the zipcode or county name.

ChargerTypeView (Join Charger and ChargerType):
This view provides the user the ability to select a specific type of charger (Level 1, etc.). For example, a user may only be looking for Level 2 chargers. This view can be combined with other views to search for specific charger types within a specific county/zipcode. This type of view can be used with or without user input, where the input could be the charger name or type of charger.

Example SQL Commands

<u>ChargerInCountyView (Join Charger and County):</u>

```
SELECT ChargerName, Street, Hours, Price
FROM ChargerInCountyView
WHERE price < $10
```

```
SELECT *
FROM ChargerInCountyView
WHERE zipcode = ‘08550’
```

```
SELECT County
FROM ChargerInCountyView
WHERE Number_of_EVs = (
	SELECT MAX(Number_of_EVs)
	FROM County
)
```

<u>ZipcodesTrafficView (Join Zipcodes and Traffic):</u>

```
SELECT annual_average_daily_traffic
FROM ZipcodesTrafficView
WHERE year = ‘2020’ AND county=’union’

SELECT number_of_EVs, annual_average_daily_traffic
FROM ZipcodesTrafficView
WHERE zipcode = ‘08550’ AND year=’2019’

SELECT Number of EVs, Property Taxes, Population
FROM ZipcodesTrafficView
```

<u>ChargerTypeView: All Charger joined with ChargerType</u>

```
SELECT number_of_EVs, charger_name
FROM County NATURAL JOIN ChargeTypeView;

SELECT *
FROM ChargerTypeView
WHERE county=”Union”;

SELECT *
FROM ChargerTypeView
WHERE charger_type = “Level 1” AND county=”union”
```

Final Report

Proposal

Given the research that our group has done, we propose incentivizing the creation of charging stations and also incentivizing consumers to purchase EVs through legislation. With the current EV environment, the number of EV charging stations may be able to satisfy the demand, however, it may also be inhibiting the growth of EV ownership. Our group found that less than 1% of households in each of the New Jersey counties have an EV. This means that 99% of the households in every county solely rely on gas vehicles for their daily needs. As previously discussed, gas vehicles produce twice the amount of greenhouse gas emissions than electric powered vehicles. Another issue that affects not only NJ, but the entire USA, is the up front cost of owning an EV. Unfortunately, not everyone is able to afford an electric vehicle due to the cost of manufacturing and the battery. As a result, we hope our application brings awareness to lawmakers to lower the up front cost through the use of incentives. Tax credits, rebates, or direct subsidies can help offset the higher initial cost of EVs, making them more accessible to a wider range of consumers. Our application can provide evidence for the low EV ownership per household, along with the other datasets we used for this project. Although these incentives could create an influx of EVs in NJ, it could overwhelm the already struggling EV charging station infrastructure. As a result, we also propose incentivizing the construction of new public charging stations. Locations with the highest traffic densities, populations, and number of EVs should be prioritized first as those locations would face a much higher demand for charging. A larger charging infrastructure would appeal to people looking to own an EV.

Potential Impact

Implementing our proposal to incentivize the construction of EV charging stations and EV ownership through legislation can have several positive ethical implications. As previously discussed, it can significantly reduce greenhouse gas emissions, improve air quality, and help mitigate the negative effects of climate change. This proposal can benefit stakeholders such as EV manufacturers, charging station operators, and the public by creating jobs and promoting economic growth. Additionally, providing tax credits, rebates, or direct subsidies to consumers can make EVs more affordable and accessible to a wider range of people, including those who are environmentally conscious and have limited financial resources. However, there are also potential negative ethical implications to consider. The construction of new charging stations may require the use of additional land, which can potentially affect natural habitats and the ecosystems around it. This could temporarily contribute to climate change if charging stations are built en masse. Additionally, the promotion of EV ownership through incentives may not be equitable, as it may primarily benefit individuals who can afford to purchase an EV and leave out those who cannot. There may also be unintended risks or ethical concerns that arise, such as charging station monopolies or conflicts of interest within political parties in the implementation and administration of incentives. To address these concerns, it is important to carefully design and implement the incentives to ensure they are transparent and environmentally sustainable. It will also be important to engage with stakeholders from diverse communities, such as neighborhoods, construction workers, and township governments to understand their needs and concerns and to involve them in decision-making processes around the implementation of our proposal.

Conclusion

Despite the potential ethical concerns and unintended risks associated with incentivizing EV ownership and the construction of EV charging stations, we believe that this proposal is still worth pursuing. The need to address climate change and improve air quality in our communities cannot be overstated, and transitioning to cleaner forms of transportation is an important step in the right direction that will drastically reduce our daily greenhouse gas emissions. With careful planning and community involvement, it is possible to mitigate many of the potential negative impacts and ensure that these incentives are implemented in a sustainable manner. By prioritizing the construction of new public EV charging infrastructure and offering incentives for EV purchases, we can accelerate the adoption of EVs in New Jersey and transition to a cleaner and more sustainable future, while also promoting economic growth and job creation in the EV sector. We believe that the benefits of this proposal far outweigh the potential risks and ethical concerns, and that it represents a necessary and important step towards a more sustainable New Jersey.