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CSC315/BUS385

Professor DeGood, Professor Michels

CAB12 Project Report

Phase I:

https://drive.google.com/file/d/1XYuStc3Y4o8PdlYjkD0t_t4DTbTufRJO/view?usp=share_link

Phase II:

Proposal and Specifications

What data the group will gather for incorporation into their database.

The data to be incorporated into the database include the “Aggregated Community-Scale Utility Energy Data”, “Solar Installation Data”, “Community-Scale Greenhouse Gas (GHG) Emissions Data”, “Community Profile Data by Municipality”, and “Lifetime Commercial Participation”/“Lifetime Residential Participation” data sets from the Sustainable Jersey Data Resources. The “Aggregated Community-Scale Utility Energy Data” will provide us with the total amounts of electricity and gas per sector in each municipality, and the “Community-Scale Greenhouse Gas (GHG) Emissions Data” will show us the greenhouse gas emissions per sector. Comparing these data sets to the “Solar Installation Data” and the “Lifetime Commercial Participation”/“Lifetime Residential Participation” (data regarding the participation in energy efficiency programs of businesses and homes per municipality) data sets we hope to see whether or not there is any relation between municipalities that participate in these programs and that have higher solar installations compared to their greenhouse gas emissions and energy

consumption. We also want to incorporate the “Community Profile Data by Municipality” to determine if average income per municipality/sector has any effect on the relationship.

What questions they will explore with the data.

There are many questions that the user can answer when retrieving data from the database. There are two main comparisons that a user can make with our data. The first is how sustainability programs improve the state from municipality to municipality. The user can see how much each municipality participates in these programs and the amount of utilities used per capita. They can then use this data to see if their neighbors are using the programs and how it has impacted their community compared to other municipalities. The second comparison the person can make is how much each municipality did these programs in different years and the number of utilities used during that time. A user can then understand how much programs have affected their community over time, and see if it is worth it for that individual to apply these programs to their business or home. If people can see the improvement these programs make for their community they would be more likely to use them. It is very hard to see how your everyday utilities affect the climate.

How the data could help them identify sustainability problems, and opportunities to propose positive change.

The data could help Sustainability Jersey determine the effectiveness of New Jersey energy efficiency programs, as well as the efficiency of solar installations, so as to better decide where to allocate resources when considering sustainability programs in the future. The data can also be used to help Sustainability Jersey ascertain the

extent to which a community's average income affects their ability to participate in energy efficiency programs and solar installations, or the amount of energy consumption and greenhouse gas emissions as well. If a relationship exists, the data could be used as evidence to help raise awareness to improve conditions for certain communities in order to improve sustainability as well.

An overview of the sustainability issue you will be exploring, offering background on the problem, why it persists, the various stakeholders affected by the problem, and ethical issues presented by the problem.

The sustainability issue we will be looking at is how sustainability programs affect utility usages such as electricity and greenhouse gas. One of the main issues we are trying to address is that it is very hard for people to see the positive impacts these sustainability programs have on their communities. It is very hard to notice how your everyday utilities affect the climate. The stakeholders are mainly the business owner who gets the most benefit from these programs and the people who live in the area that also use the utilities. Even though this change is hard to see it makes a big difference to the people who live in these areas. The other stakeholders are the groups that are offering and promoting these sustainability programs. If our project helps promote people to use these programs it will give these groups more funding to help with sustainability and potentially cause there to be more programs to support sustainability. We will also be helping groups such as Sustainability New Jersey achieve their goal.

Choose two representative user interactions with your completed project. Write a detailed textual use case for each.

1) A slider with different years from 2015 to 2020 each year will have its own graph explained in interaction 2. A user will have two of these maps and each one will have its own slider. This will allow the user to compare different time periods in NJ while still being able to look at all the municipalities.

   Use case: Interactive year slider that allows users to see which year's data will be on the map.

   Actors: Sustainability Jersey staff, or interested users.

   Goal: allow the user to compare utility and program usage in different time periods in NJ.

   Typical Course of Events: As the user interacts with the gradient map described below, on the bottom of the map will be the slider. The slider is a simple bar with a draggable button that can slide either left or right until it gets to one of the ends of the bar. It's initial state is on the most current year of records available in the database. The slider will be marked with the previous year at evenly spaced intervals. The user will click and drag the slider with their mouse to their desired year of research. Once the slider is let go of, the map will update the presented information to the corresponding year. If the database does not have data for a particular year, it may be able to interpolate values to give the presented data a more cohesive look instead of having missing values for years without recorded data.

2) Gradient map of New Jersey of the aggregated community-scale utility energy data, where municipalities with higher energy consumption are colored red, and those with lower energy consumption are colored green. Each municipality sector

will be clickable, which will then display the sector's energy efficiency program participation data, and average income. The user can then select one of the sector's variables to display a correlation graph between the two variables.

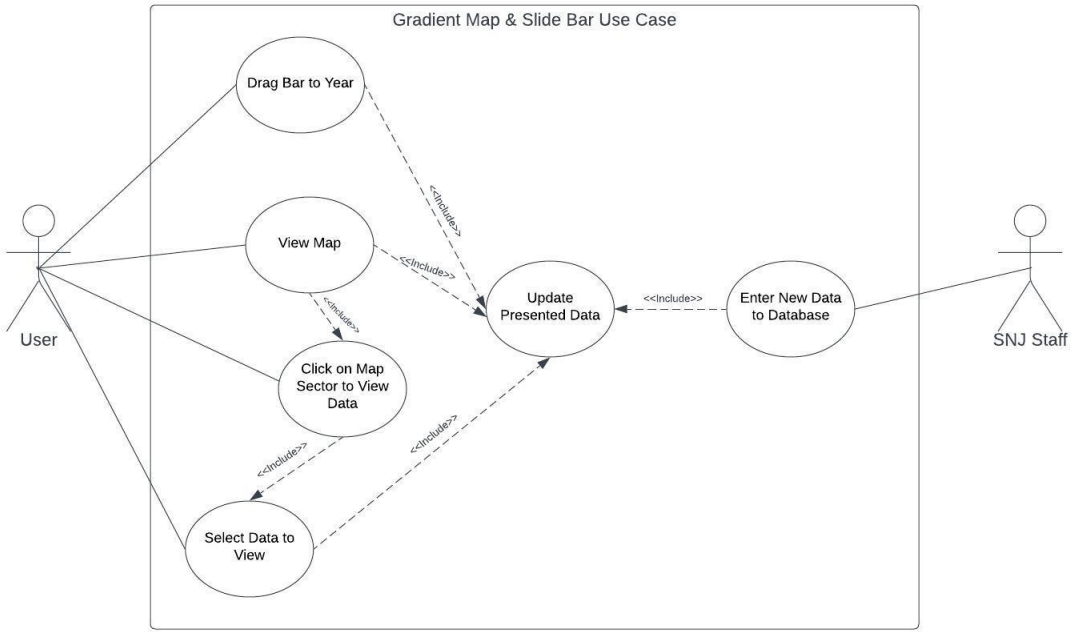
Use Case: Gradient Interactive Map of New Jersey of the Aggregated Community-Scale Utility Energy Data by Sector

Actors: Sustainability Jersey staff, or interested users.

Goal: To assist users in identifying the effectiveness of New Jersey community's energy efficiency programs on a sector's energy consumption. Also assists in determining the effect of the average income of a sector with its energy consumption.

Typical Course of Events: The user can click on sectors in a map of New Jersey, which will in turn display the sector's energy consumption rate. Each sector will also be color coded with red indicating a high and green indicating a low energy consumption rate. Once a user selects a sector, they can also see the sector's participation rate in energy efficiency programs, and the sector's average income. The user can then select either the participation rate, or the average income to display the correlation between the selected variable and the sector's energy consumption.

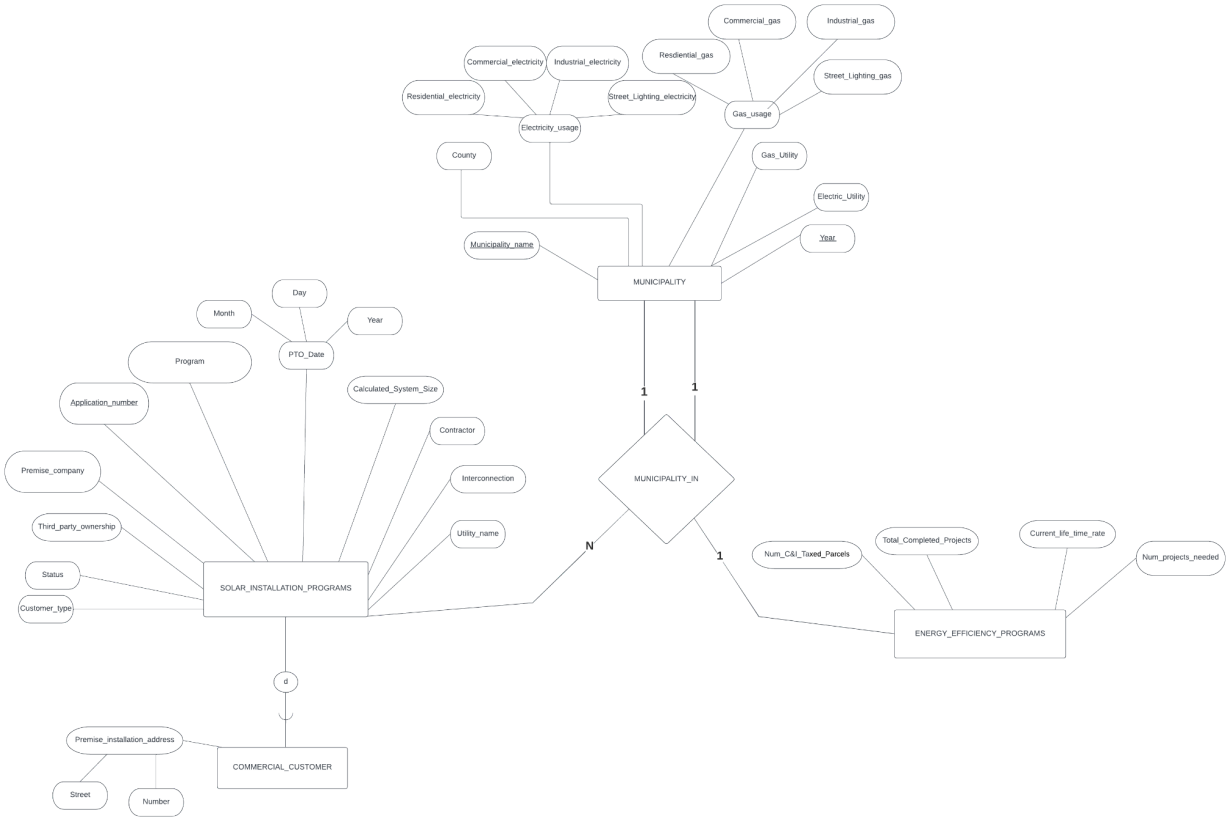
Diagram for the Above Use Cases:


Gradient Map & Slide Bar Use Case
Drag Bar to Year
View Map
Click on Map Sector to View Data
Select Data to View
Update Presented Data
Enter New Data to Database
<<Include>>
User
SNJ Staff

Phase III:

Effectiveness of NJ Energy Efficiency Programs and Solar Installations Model Relational Schema

ER Diagram:



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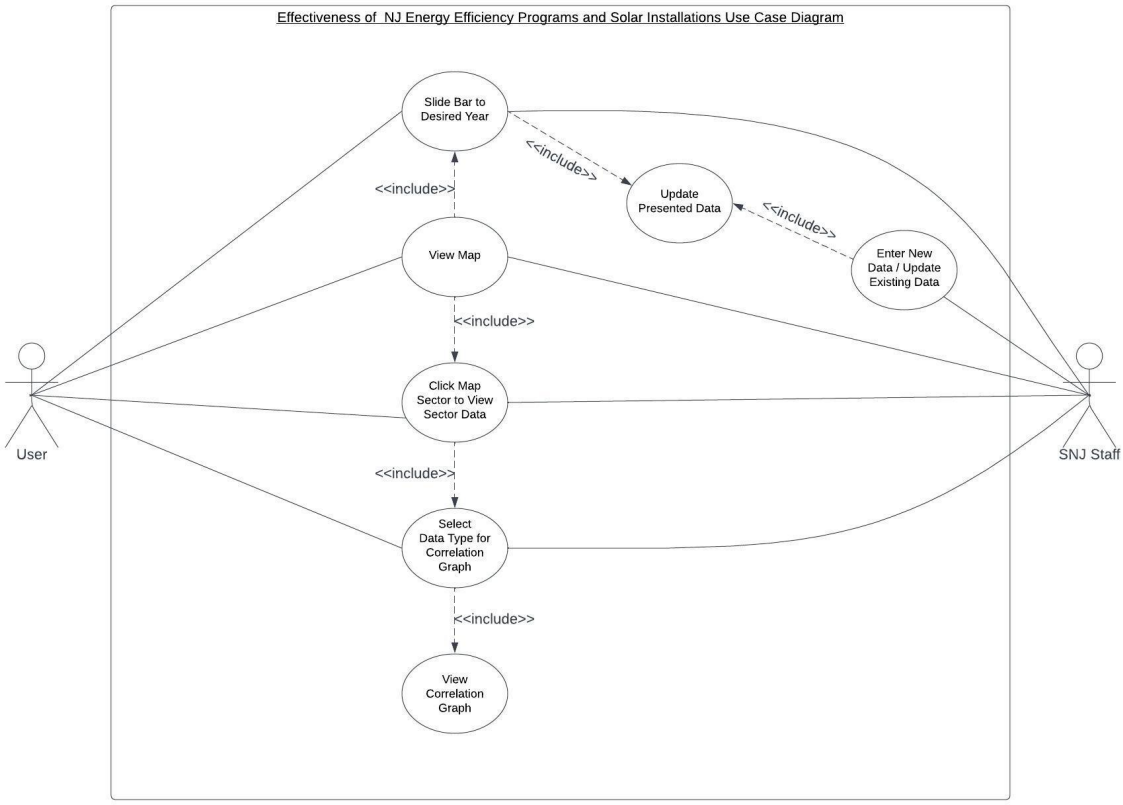
Relational Schema:

Size Estimation

	Municipalities						storage size (bytes)					
	Municipalities	Text	int	bigint			text	int	bigint	double	date	boolean
	3,955	3	8	2			16	4	8	8	4	1
Size	379,680											
	Solar Installations											
	Solar Installations	boolean	double	text	date							
	137,098	1	1	7	1							
Size	17,137,250											
	Energy Efficiency Programs											
	Energy Efficiency Programs	text	double	int								
	564	1	1	3								
Size	20,304											
total	17,537,234											

17,537,234 bytes = 17.537 megabytes

UML Diagram:



Narrative:

Relational Databases: How and Why?

Databases are collections of sets of data that are managed by a database management system (DBMS). They are designed in a way such that the various sets of data are all ultimately related in some way or another, which allows us to process the data efficiently and get answers to queries that we have regarding the data. It also allows multiple users to easily insert, modify and delete existing data (depending on their permissions), and the changes from one user appear consistently for all other users of the database (Oracle, 2023).

Database Design, Elements, and Goals:

Our database consists of three entities, a specialization, and a ternary relationship between all entities. The municipality entity describes the energy and gas consumption of each township; the municipality is identified by its name and the year

the data was collected. The other two entities describe a municipality's participation in the energy efficiency and solar installation programs. The solar installation program has a specialization to specify between residential and commercial customers of solar companies. The ternary relationship MUNICIPALITY_IN describes that a municipality participates in one or both of the environmental programs. The goal of our database is to show the relationship between participation in these programs and how ecologically friendly the municipality is. We hope to see that municipalities that participate in one or both programs will use less electricity and gas.

Use Case Description:

Use Case: View Map

Actors: User or Sustainability NJ staff

Goal: Show overview of information on entire state of NJ

Typical Course of Events:

1. User navigates to the database application
2. Map will load as it is the main GUI
3. Map will be color coded for increased user readability

Exceptions:

1. Database application is not working or online, map will not load

Use Case: Slide Bar

Actors: User or Sustainability NJ Staff

Goal: Change the data presented based on year

Typical Course of Events:

1. Slide bar will start in the most recent year
2. User will click and drag slide bar to desired year
3. Once selected, the presented data will update to reflect the chosen year

Exceptions:

1. User selects a year that is not represented in the database. The slidebar will only be able to choose from 2015 to 2020. Some years in between do not have any recorded data but can be interpolated from surrounding years.

Use Case: Selecting Map Sector

Actors: User or Sustainability NJ staff

Goal: allow user to view details about specific areas in the state of NJ

Typical Course of Events:

1. While viewing the map, user will be able to click on any sector inside the map
2. This will bring up data on the specific sector, including average income and participation in eco programs

Use Case: Select Data Type for Correlation Graph

Actors: User and Sustainability NJ staff

Goal: Show comparisons on different data in a specific sector

Typical Course of Events:

1. While viewing the map, the user will click on the desired sector
2. The user will then be able to select between the available data
3. Once Selected, a correlation graph will be presented for the correlation between the specified data and energy consumption of the sector

Use Case: View Correlation Graph

Actors: No one

Goal: provide users with a comparison of energy consumption and a specified variable

Typical Course of Events:

1. User will select a sector on the map and select the variable desired for the graph
2. The graph will then be displayed over the map, showing now the selected variable correlates with energy consumption in the sector
3. The user may switch between variables at will and the graph will reflect their choices

Exceptions:

1. There is no direct user interaction, other use cases describe how the user will interact with and influence the graphs

Use Case: Enter New Data / Modify Existing Data in Database
Actors: Sustainability NJ staff
Goal: be able to expand available data and make changes to stored data
Typical Course of Events:

1. Staff will have a new or updated CSV file formatted similarly to the database
2. Staff will upload the CSV file to the database application
3. The database stores new data and correctly updates existing data

Exceptions:

1. If there is data for years not previously accounted for, the slide bar must be able to extend to show those years.
2. CVS may not be formatted correctly and database will not be able to understand the information.
3. Updating the existing data may cause conflicts in the map and graphs.

Use Case: Update Presented Data
Actors: No one
Goal: Take the user's specifications and modify the graphical interfaces to reflect the changes
Typical Course of Events:

1. User will select some option to view a specific set of data
2. The database will make a query to find the specified data
3. The map / graph will update the presented data to reflect the user's choice

Sources

Oracle. "What Is a Database?" *Oracle*, 2023, https://www.oracle.com/database/what-is-database/#:~:text=Database%20defined,

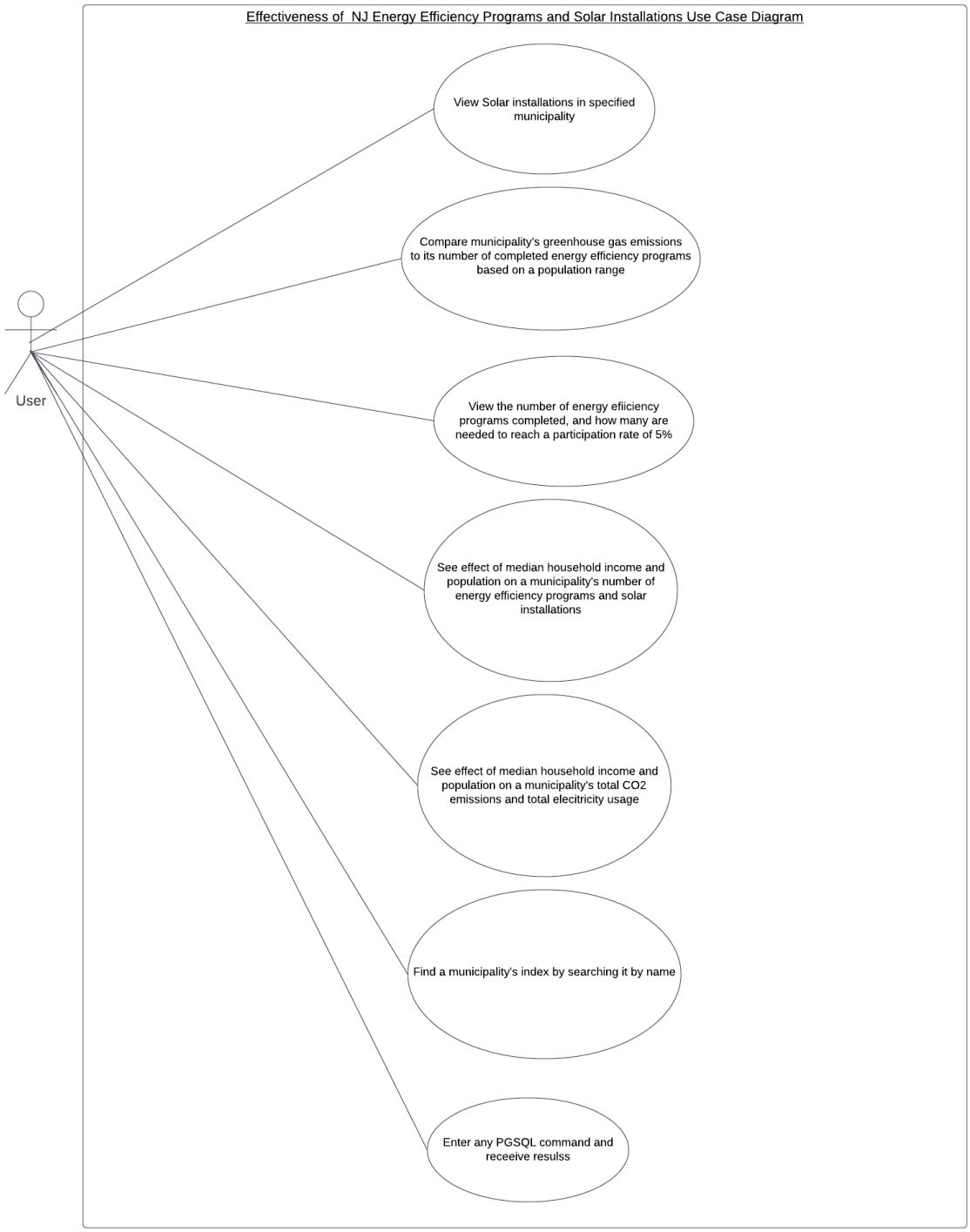
-A%20database%20is&text=Data%20within%20the%20most%20common,updated%2C%20controlled%2C%20and%20organized.

Phase IV:

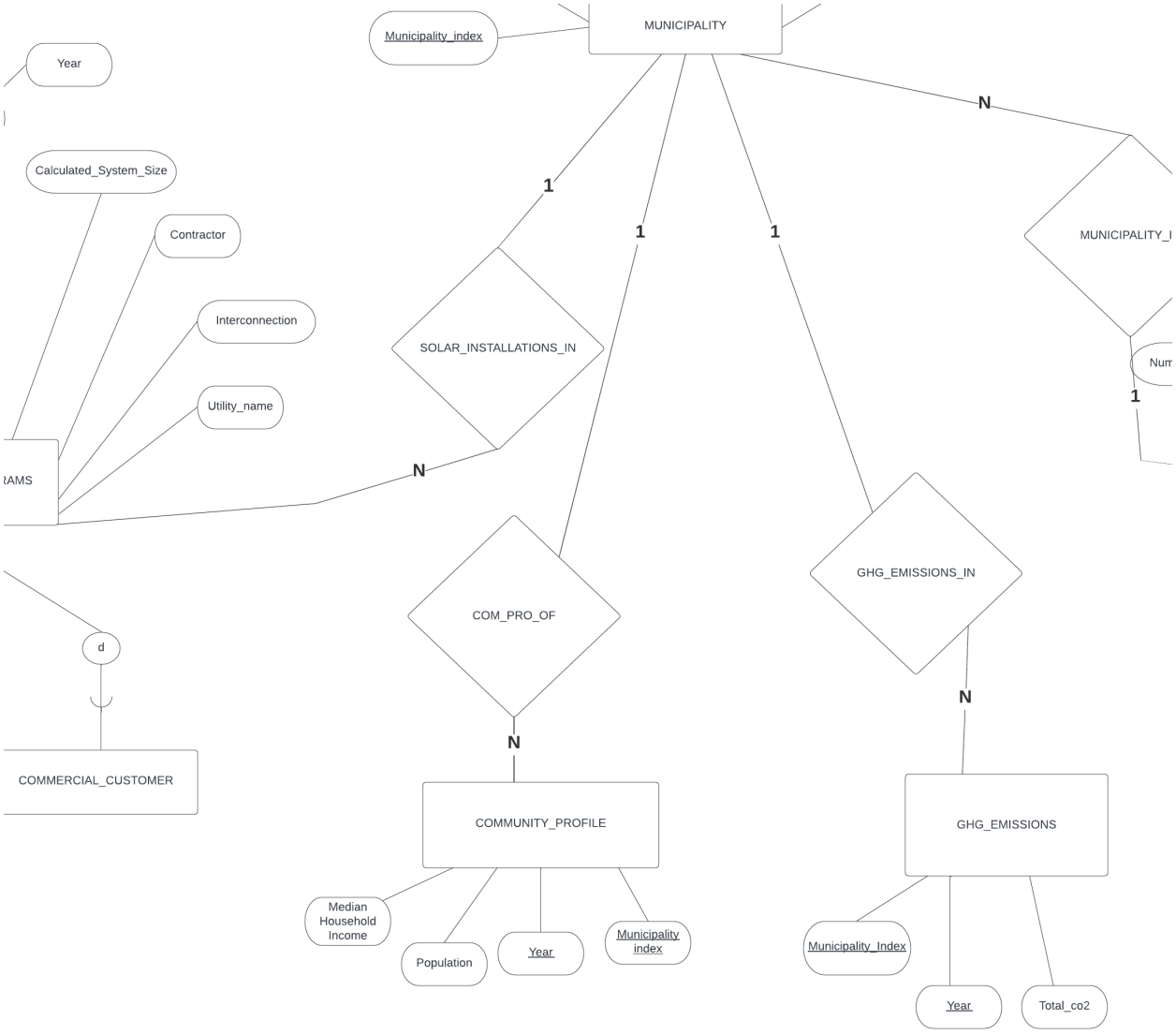
Changes made to previous Phases:

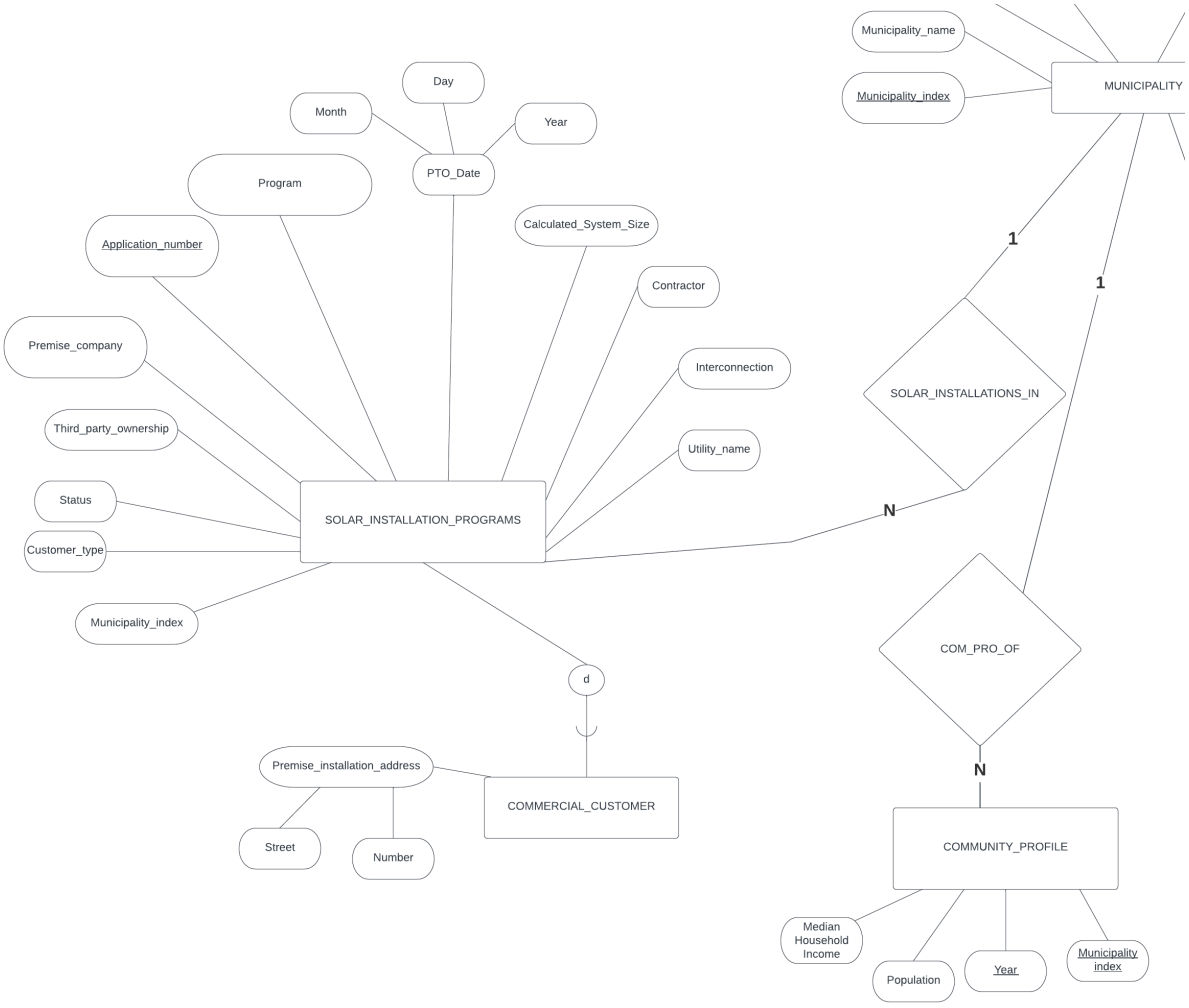
Use Cases Changes:

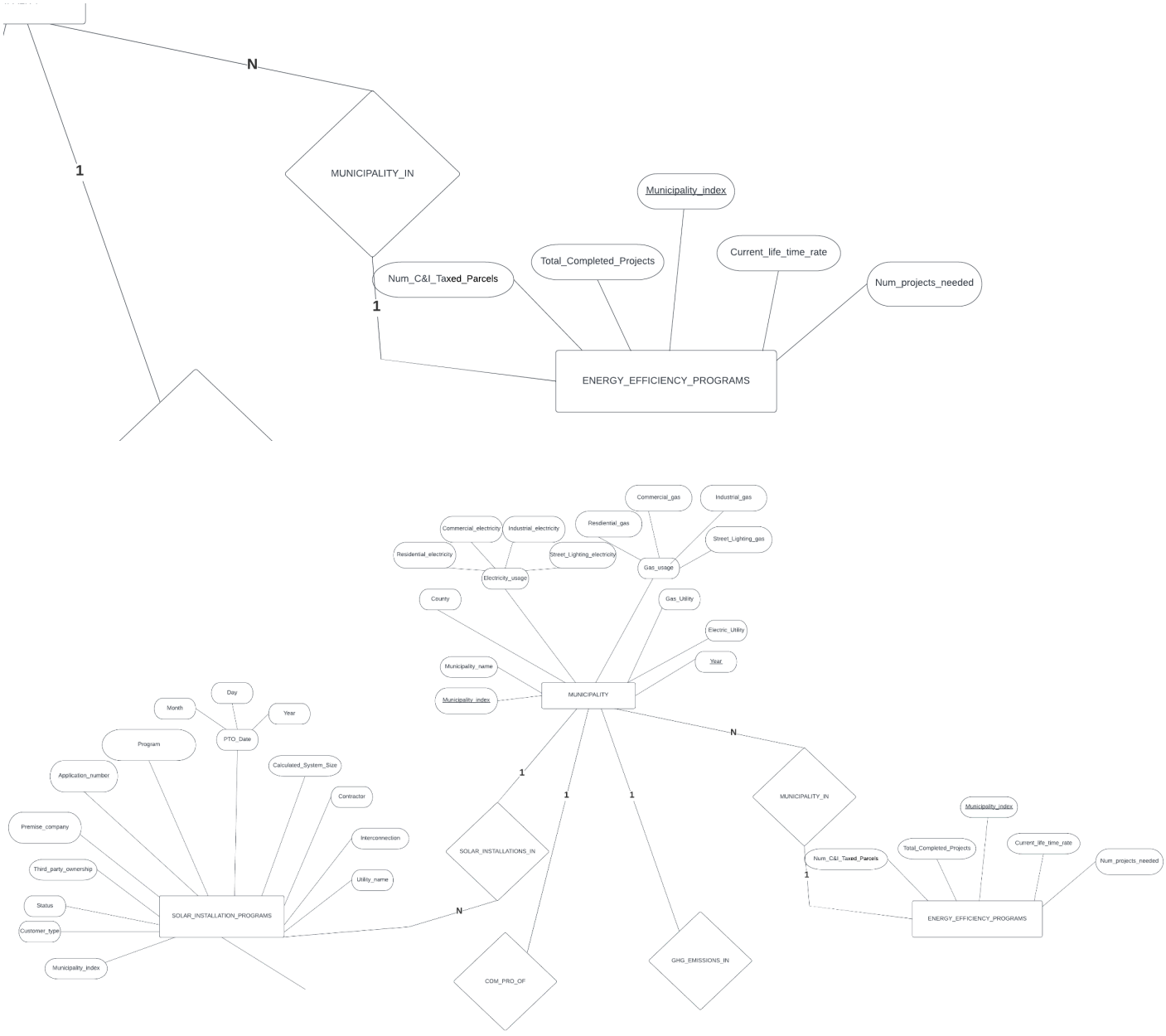
During the course of our collaborative project and learning about databases this semester, we realized that we originally sought out more work then we could manage. While some of us in the group were versed in Python, we were all unfamiliar with using Flask to build a web application. Because of this we had to simplify much of our UI and scrap the interactive map and slidebar. In place of them are simple text entry boxes that are accompanied by directions with how to use them. While the web application may be simple, the functionality it produces can be used to inspire and create change.


Effectiveness of NJ Energy Efficiency Programs and Solar Installations Use Case Diagram
User
View Solar installations in specified municipality
Compare municipality's greenhouse gas emissions to its number of completed energy efficiency programs based on a population range
View the number of energy efiiciency programs completed, and how many are needed to reach a participation rate of 5%
See effect of median household income and population on a municipality's number of energy efficiency programs and solar installations
See effect of median household income and population on a municipality's total CO2 emissions and total elecitricity usage
Find a municipality's index by searching it by name
Enter any PGSQL command and receeive resulss

Updated ER Diagram:


MUNICIPALITY
Municipality_index
Year
Calculated_System_Size
Contractor
Interconnection
Utility_name
SOLAR_INSTALLATIONS_IN
COM_PRO_OF
GHG_EMISSIONS_IN
MUNICIPALITY_I
Num
1
1
1
N
N
N
N
COMMERCIAL_CUSTOMER
COMMUNITY_PROFILE
GHG_EMISSIONS
Median Household Income
Population
Year
Municipality index
Municipality_Index
Year
Total_co2


Municipality_name
Municipality_index
MUNICIPALITY
Day
Month
Year
PTO_Date
Program
Application_number
Calculated_System_Size
Contractor
Premise_company
Interconnection
Third_party_ownership
Utility_name
Status
SOLAR_INSTALLATION_PROGRAMS
Customer_type
Municipality_index
SOLAR_INSTALLATIONS_IN
1
1
N
COM_PRO_OF
N
d
Premise_installation_address
COMMERCIAL_CUSTOMER
Street
Number
COMMUNITY_PROFILE
Median Household Income
Population
Year
Municipality index



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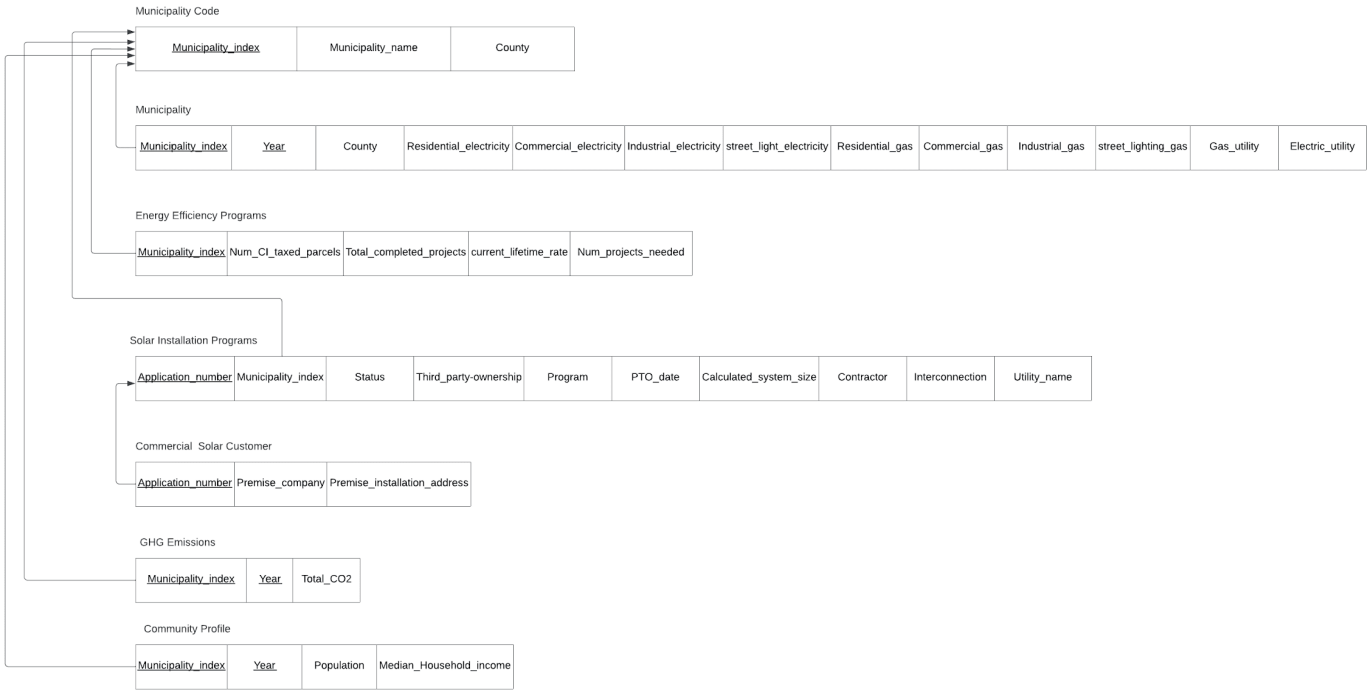
Updated Relational Schema:



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Findings from the Analysis of the Data:

One big finding from the analysis of the data is that increasing the number of solar installations in a municipality does not seem to always have a significant impact on decreasing the total amount of electricity usage. In some cases, it does, such as in the following examples:

Year	Municipality	County	Number of Solar Installations	Total Electricity Usage (kWh)
2015	Deerfield township	Cumberland	234	33147276
2016	Deerfield township	Cumberland	384	32178030
2017	Deerfield township	Cumberland	636	31584566
2018	Deerfield township	Cumberland	753	36738218
2019	Deerfield township	Cumberland	832	27259245
2020	Deerfield township	Cumberland	879	22102764
2021	Deerfield township	Cumberland	879	21986069

Electricity usage down 34% from 2015 to 2021 and Solar Installations up 376%

Year	Municipality	County	Number of Solar Installations	Total Electricity Usage (kWh)
2015	Princeton	Mercer	246	320054713
2016	Princeton	Mercer	281	316236291
2017	Princeton	Mercer	314	296425825
2018	Princeton	Mercer	350	313738043
2019	Princeton	Mercer	381	278951420
2020	Princeton	Mercer	428	224401381
2021	Princeton	Mercer	428	226724053

Electricity usage down 29% from 2015 to 2021 and Solar Installations up 174%

However, in other cases, even a major increase in solar installations does not prevent the total electricity usage of the municipality such as in these examples:

Year	Municipality	County	Number of Solar Installations	Total Electricity Usage (kWh)
2015	Bellmawr borough	Camden	65	95917244
2016	Bellmawr borough	Camden	129	101384478
2017	Bellmawr borough	Camden	189	97023616
2018	Bellmawr borough	Camden	231	101313720
2019	Bellmawr borough	Camden	266	103773621
2020	Bellmawr borough	Camden	303	99253597
2021	Bellmawr borough	Camden	303	103449843

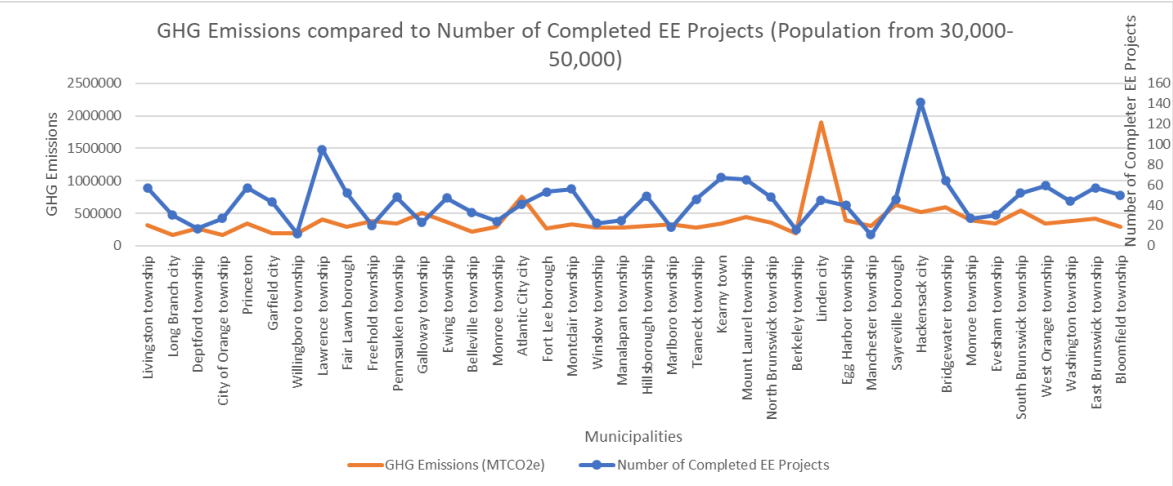
Electricity usage up 7% from 2015 to 2021 and Solar Installations up 466%

Year	Municipality	County	Number of Solar Installations	Total Electricity Usage (kWh)
2015	Berkeley township	Ocean	344	236042436
2016	Berkeley township	Ocean	501	0
2017	Berkeley township	Ocean	624	0
2018	Berkeley township	Ocean	734	232095353
2019	Berkeley township	Ocean	811	225631730
2020	Berkeley township	Ocean	880	237520568
2021	Berkeley township	Ocean	880	244567645

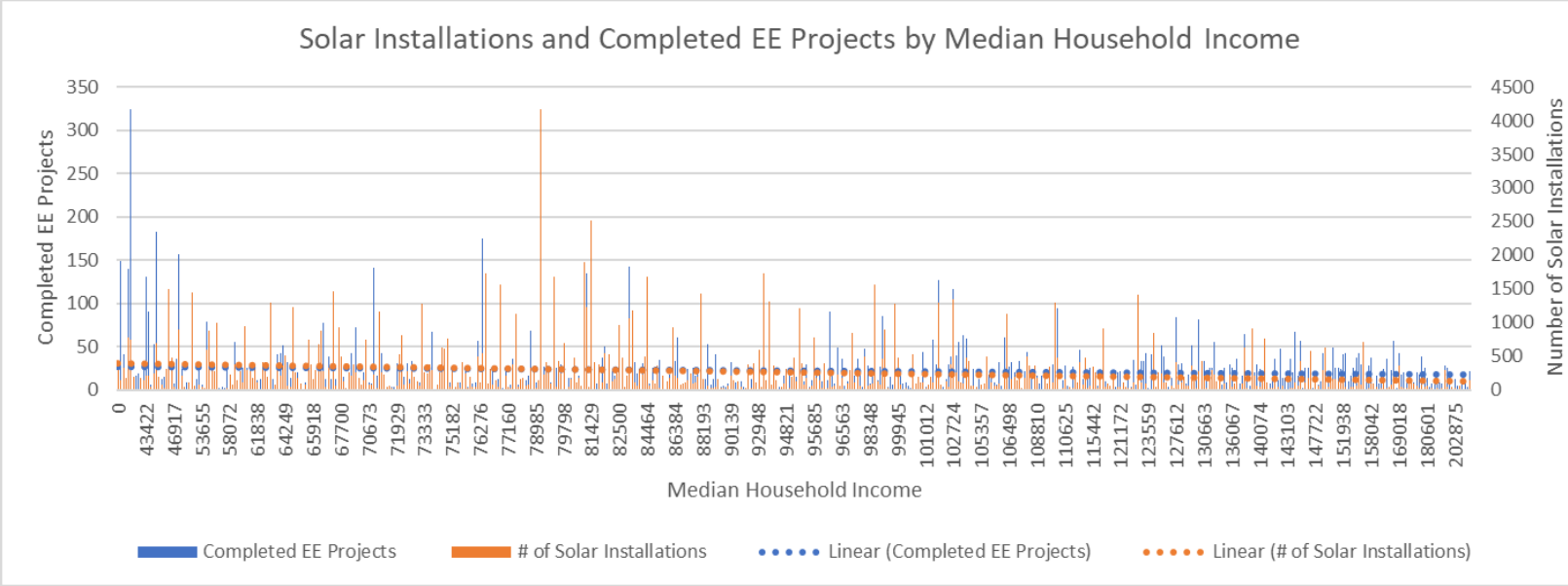
Electricity usage up 3% from 2015 to 2021 and Solar Installations up 256%

These results suggest that there may be other factors that lead to lowering electricity usage in a municipality, and further research is necessary to see what is most effective.

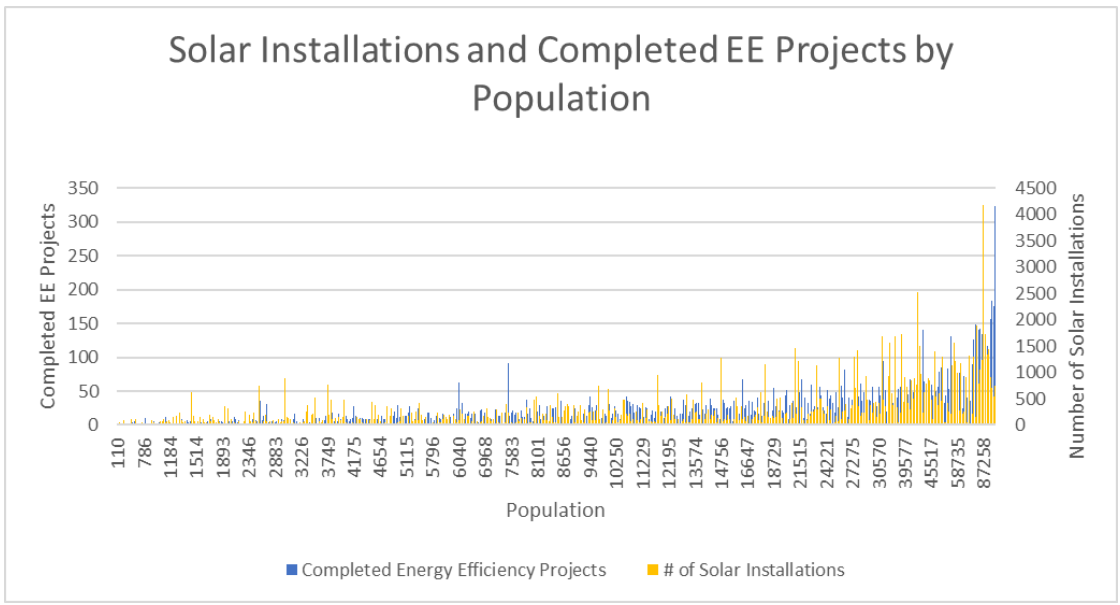
Next, it also appears that there was little correlation between a municipality's number of energy efficiency programs completed, and its total amount of greenhouse gas emissions, which suggests that once again, the energy efficiency projects had little effect, at least in terms of limiting greenhouse gas emissions.



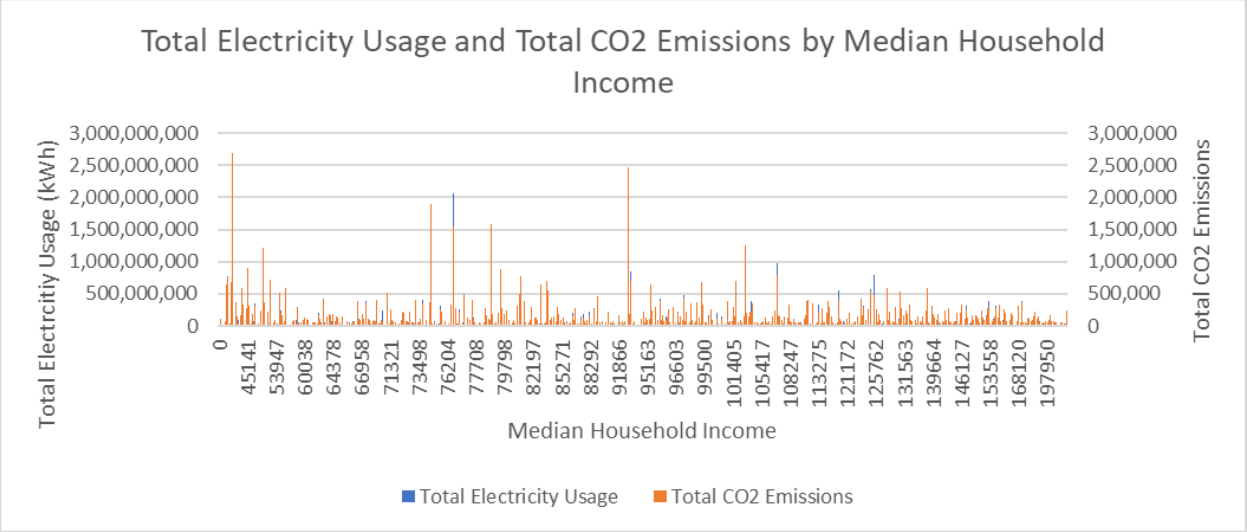
Correlation coefficient of 0.18

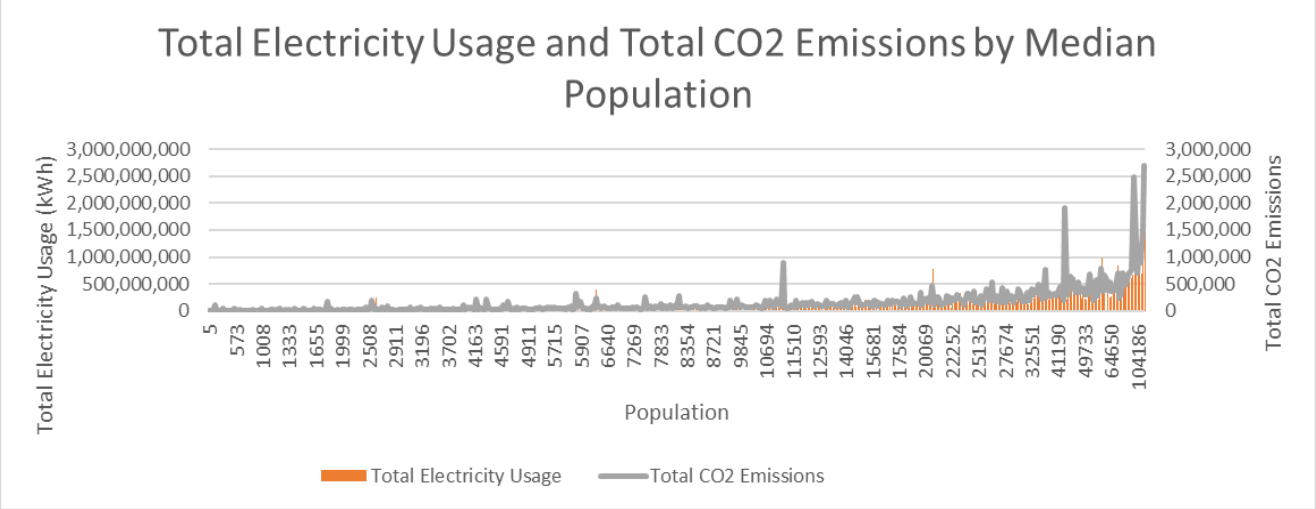


Another interesting finding was that the number of completed energy efficiency projects and solar installations seemed to have a slight downward trend as median household income increased (shown above) which was unexpected. This is the opposite of with population however, as the number of solar installations and number of completed energy efficiency projects increased with the population as shown here:



Similarly, we did not find much of a correlation between the median household income of a municipality and its total CO2 emissions and total electricity usage. However, we did find a correlation between the increase in population and the increase in both total CO2 emissions and total electricity usage of the municipality as shown here:





The Solution

With this database, we can see that these eco-friendly programs do not have the impact that they should. The powers in government and environmental regulations should rework and rebuild these programs to not only be incentives for industry companies but also have the impact necessary for the environment.

We see that participation in the solar installation program did not have a noticeable effect on a municipality's energy consumption in all cases. While some did have a slight decline in consumption many other municipalities reported consumption at similar or even elevated rates to previous years. There is at most a weak correlation between the number of Energy Efficiency Projects and reducing greenhouse gas emissions. We should expect these programs and projects to have some impact on these municipalities yet the data tells us otherwise. At this point generating clean energy is not an issue, the true issue is keeping up with demand. With large cities so close in today's world, the demand for energy is extravagant. Clean energy sources cannot produce that much and must rely on less eco-friendly means of energy production. To try and combat the raging demand, we can try limiting the amount of energy a municipality can use based on population density and other factors.

The government office that runs these programs and awards the benefits from them should have a thorough review of such programs. These programs deserve a massive overhaul to rework and redesign how incentives are awarded. Saving the environment should be a reward enough in itself, however, many companies and municipalities spend a lot to protect the environment and compensation gives them even more reason to be eco-friendly. These government offices have to incentivize

reducing the overall energy consumption. The incentives could be tax breaks, and have brackets so the more you reduce the consumption energy the larger the tax break.

This task is a large and possibly very controversial one. Companies and municipalities must consume a certain amount of electricity for their basic functions. This amount may be more than possible to produce cleanly. This will cause participation in the programs to drop drastically in the imminent future. What we hope to see is that municipalities will rebuild or reconfigure in a way to only need so much energy to sustain themselves, and hopefully it can all be produced cleanly. As more municipalities follow suit, we should see participation rise back up while energy consumption and greenhouse gas emissions fall.