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CSC315&BUS/MGT385 – Collaborative Project

1 May 2023

Final Submissions

Collab Phase II - Project Proposal and Specifications

Increasing Solar Energy in New Jersey

1. Overview of Sustainability Issue

In the global energy consumption, the current major sources contribute to negative impacts on the environment. Fossil fuels are a limited resource that will eventually diminish over time and contribute to climate change and air pollution. In the U.S. about 79% of the nation's energy comes from fossil fuels, 8.4% from nuclear, and 12.5% from renewable sources (*Center for Sustainable Systems*). Renewable energy has significantly less negative impact on the environment and is much more sustainable. However, as mentioned, energy from fossil fuels is significantly more consumed than from renewable sources. Overtime, there is an opportunity to decrease the usage of fossil fuels and increase the usage of renewable energy sources such as solar energy.

Solar energy is electromagnetic radiation that is emitted by the sun. Solar technologies, such as photovoltaics (PV) and concentrating solar-thermal power (CSP), capture this radiation and turn it into renewable and clean energy. PV uses solar panels to absorb the sunlight into PV cells to create electrical charges that move in response to an internal electrical field in the cell, causing electricity to flow (*Energy.gov*). For larger facilities, CSP systems use mirrors to reflect the sunlight onto receivers that convert the sunlight into heat that is used to produce electricity.

The implementation of solar technologies is still a growing effort globally. However, the effort starts at a smaller scale such as the state of New Jersey.

A dataset can be used to pinpoint opportunities for improvement on the installment of solar energy technologies. This includes, where solar grids are currently located and what areas have the best solar infrastructure, areas that lack solar energy technologies and where there are opportunities to add solar technologies in the state.

2. Proposed Plan of Action

Our plan is to analyze and compare databases available to us on the Sustainable Jersey website as well as other trusted sources. More specifically, we want to look into using Sustainable Jersey's "Solar Installation Data" and "Community Profile Data by Municipality", as well as NJ Clean Energy's "Solar Energy Installation Data". By looking at the community profile of each municipality, we are taking into consideration the varying population count within each municipality and its effects on the amount of solar installed within the municipality.

In terms of how a user will interact with this information, we want to provide administrative and regular user interaction capabilities. An administrator will have the ability to update the database, if new installations occur. When this updated database is given, the system will adjust accordingly by updating information and county statistics. A regular everyday user will have the ability to view these statistics by county and by municipality through an appealing and easy to use user interface while also having the ability to view it straight from the database.

We want to provide a database that allows a user to see exactly where areas are lacking solar energy technologies as well as where it is thriving. Doing so will highlight counties and municipalities that are paving the way towards a more clean environment, while also showing concern for areas that need more environmental improvement.

3. Impacted Stakeholders and Ethical Issues

When we define stakeholders, this specifically refers to those who are affected by the utilities and actions that they perform. If we were to look at the stakeholders of solar energy, this would be not only those who have a monetary and financial stake in solar, but also those who have societal and future interests in the environment. This can include energy advocates, solar energy initiatives and programs, as well as the everyday person who believes in better and cleaner energy.

When looking at the United States, New Jersey is one of the leading states on solar energy with enough energy to power more than 600,000 homes with more than 370 solar companies in the state (Lutz). Solar energy and taking action for solar energy is so important in New Jersey and there are many companies, businesses, and individuals who take interest in this issue. This does stem to a broad environmental interest as well, but looking at just solar energy, there is clear intrigue of maintaining clean and effective energy.

However there seem to be some ethical dilemmas whether we implement solar energy or not. One of the main issues with initially implementing solar energy is the cost. There is the idea of pay now or later. This idea emphasizes that you either pay an increased price for solar energy now, or pay at the risk of the environment in the future ("The advantages and disadvantages of Solar Energy"). We do see ethical dilemmas of which prioritization we hold higher. Would we rather save money at the cost of the environment? This is an ethical dilemma to face as many groups and individuals advocate for solar energy and clean energy in general. Solar energy is not free, by any means, however the health and longevity of our environment should take precedence. There are also tax cuts and other incentives that help with paying for and

maintaining solar energy in New Jersey, among other states ("Solar rebates and Solar Tax Credits for New Jersey").

4. Current State of Solar Energy Across New Jersey

Per New Jersey's Clean Energy Program (NJCEP), there have been over 137,000 solar installations across the state between 2000-2020. Since 2015, there has been a noticeable increase in installations, as over 100,000 of the 137,000 (roughly 75%) have taken place across the state. While not listed on the file, new data from the NJCEP confirms that through January 2021 and December 2022, 32,000 solar installations have taken place across New Jersey. Out of the total number of installations through December 2022, approximately 9,000 projects were for commercial properties, while the majority were for residential homes. With where we stand today, New Jersey has a capacity of 3.3 gigawatts of solar photovoltaic (PV) energy which is a crucial aspect that will allow the state to meet its clean energy goals. With a PV energy capacity this high, New Jersey is currently ranked top 10 in the nation for 2022.

With that being said, there are still opportunities for us to propose positive change in the state when it comes to solar energy. Per Solar Energy Industries Association (SEIA), only 6.7% of the state gets their electricity from solar energy. Despite the $12.3 billion investment that has been made in solar infrastructure, still has ways to go before the state is on track to reaching its *Clean Energy Future* bill, signed by Governor Murphy in 2021.

5. Opportunities to Propose Positive Change

Gathering and analyzing our data on solar energy use and sustainability can provide valuable insights that can be used to propose positive change in a variety of ways. By identifying areas where the state is doing well and areas where there is room for improvement, you can propose policies or incentives that encourage more widespread adoption of solar energy in

underserved areas. Additionally, data can be used to create compelling arguments for why transitioning to solar energy is a smart investment for individuals, businesses, and the state as a whole, which can help build public support for sustainable energy initiatives. This data can also be used to inform policy decisions related to sustainable energy. For example, if you find that certain policies or incentives have been effective in promoting solar energy adoption in other states, you can recommend similar policies for New Jersey. Moreover, data can help attract investment in sustainable energy projects. By showing that there is a strong demand for solar energy and a supportive policy environment, you may be able to attract investors who are interested in financing solar installations or other renewable energy projects.

Overall, data can be a powerful tool for proposing positive change in the area of sustainable energy in New Jersey. Gathering and analyzing data on solar energy use can help identify areas for improvement, build public support, inform policy decisions, and encourage investment in this important area. By using data to propose positive change, you can help New Jersey move towards a more sustainable and environmentally-friendly future.

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Collab & CSC315 Phase III - Database Model

Relational databases help organize and structure the similarities and, by effect, the differences of data and information. Usually in the form of a table or chart, the parameters set for the data in this database are predetermined based on their relationships with one another. Each piece of information is arranged in a column and then an identifier in each row. These databases, however, still follow certain rules. For example, a rule can state that multiple rows are not allowed as it could cause unnecessary errors. Relational databases are effective when you need to display information in a secure and consistent way ("What Is a Relational Database?").

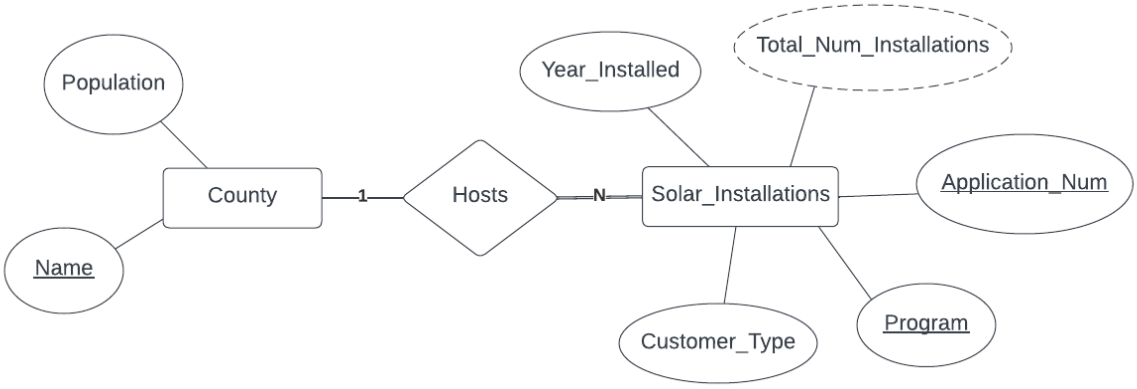
Organizing the data in this manner allows for easier understanding of how to read it and how to compare it to other necessary information within the database. It also allows for an easier way for the individual making the database to construct it. This is a more simple way to demonstrate data in a concise and effective way for the viewer. Because of its simplicity compared to other types of databases, it ensures the integrity of the data and makes it easier to keep it accurate and secure (Pedamkar).

The elements of our diagram are designed to make our database extremely user friendly. Within two clicks, any user will be able to easily see solar data relevant to the specific area or region they are interested in gathering information on. Whether you are looking to gather solar data for your local county to build public support for new solar projects, or you are just looking to familiarize yourself with New Jersey's solar infrastructure – our database will be extremely useful for our users.

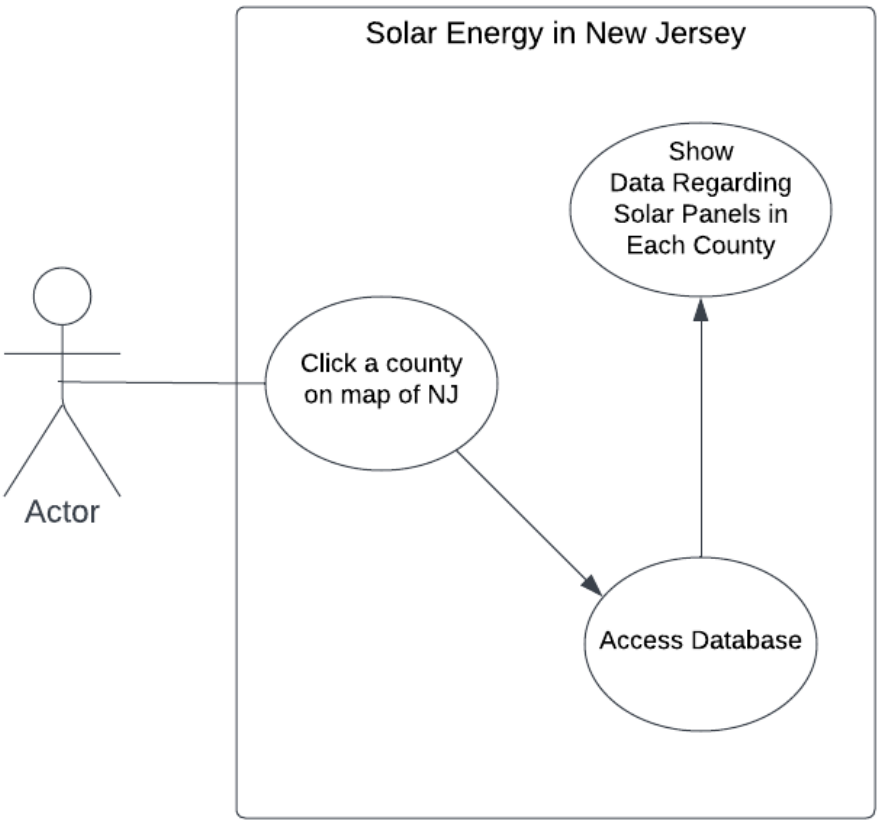
The reason for our database design is simple; to provide users with a view of the current state of solar energy in the state of New Jersey with an interactive map. There were various directions that our group was deciding to take with the database. After discussion, we agreed that

a map of the state that breaks down solar energy data by county would be the best way to translate data. We will also be using a color scale that will reflect the current state of solar energy across the state. Those regions that have the most solar energy in relation to population and area, will be highlighted with a darker color (i.e. red or orange). Meanwhile areas that have a low number of solar grids/panels will be highlighted with lighter colors (i.e. pale or white shades). As our users click through the database and look at the differences in solar energy usage across the state, they will be able to pinpoint opportunities for improvement across the state. Similar to our sustainability project proposal, we hope that gathering and analyzing data on solar energy use can help identify areas for improvement, build public support, inform policy decisions, and encourage investment in this important area. By using data to propose positive change, we can help New Jersey move towards a more sustainable and environmentally-friendly future.

ER Diagram



Use Case Diagram



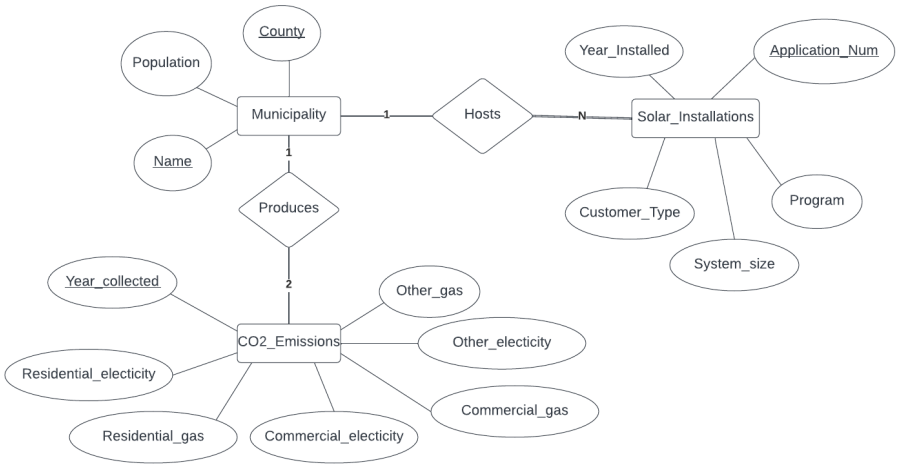
Textual Use Case

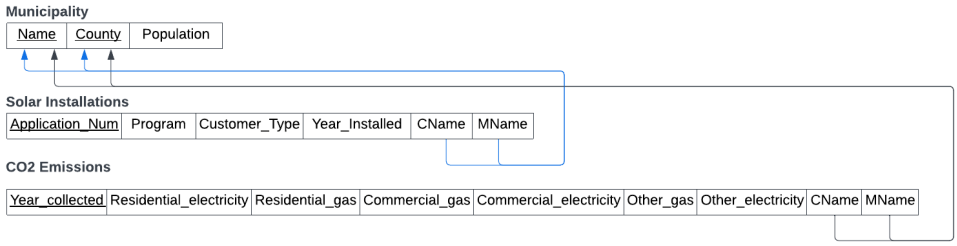
Use Case: Click a county on map of NJ
Primary actor: Normal User
Goal in context: Allow user to click on a county on the map and view information
Preconditions: N/A

Scenario:

1. User goes to website
2. User selects specific year
3. User views map of county in varying colors
4. User hovers over a county and selects one
5. System provides user with information on the county in regards to solar panels in the area

ER Diagram and Relational Schema

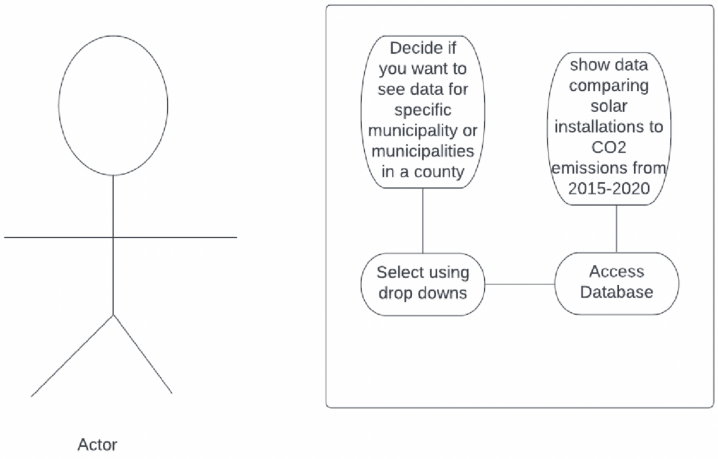




Estimated Database Size and Types: 137,101 rows * 8 = 1,096,808 KB

Average Number of Searches: 5

Updated Use Case Diagram



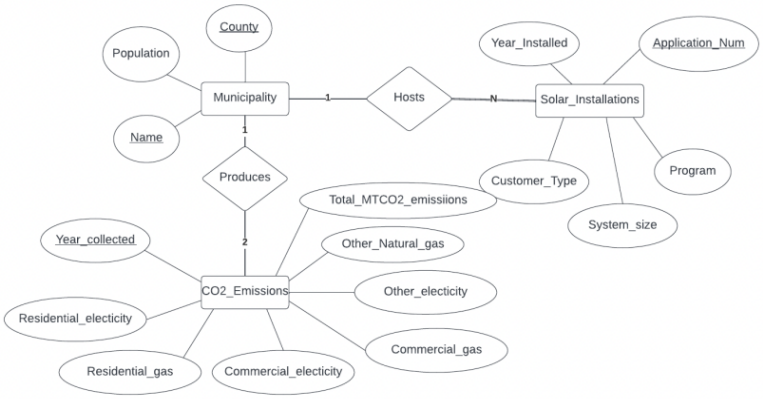
Updated Textual Use Case

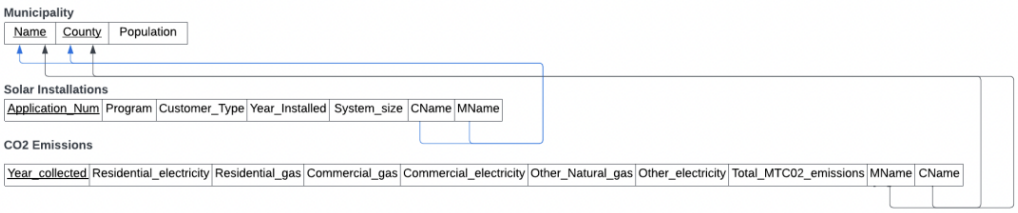
Use Case: Select a county or municipality with drop downs.
Primary actor: Normal User
Goal in context: Allow user to see comparing data
Preconditions: N/A

Scenario:

1. User goes to website
2. User selects municipalities or counties
3. User views data side by side from 2015 and 2020

Updated ER Diagram and Relational Schema





Estimated Database Size and Types: 137,101 rows * 8 = 1,096,808 KB

Average Number of Searches: 5

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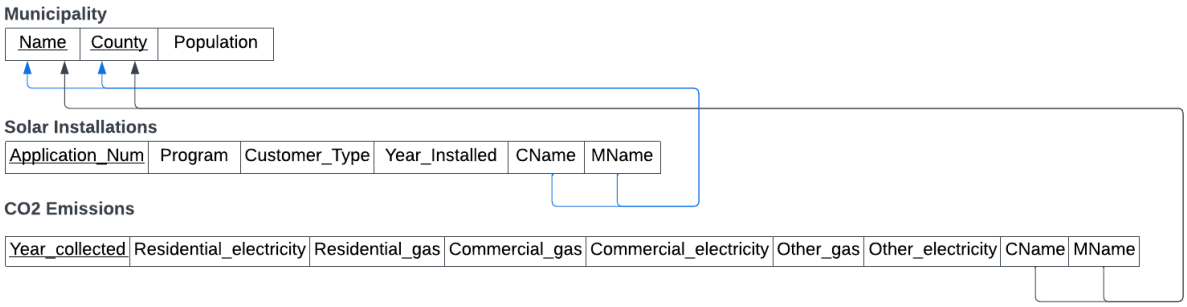
CSC315 Phase IV - Database Design



Demonstrate that all the relations in the relational schema are normalized to Boyce–Codd normal form (BCNF).

Municipality(Name, County, Population)
The primary key for this relation is (Name, County) since each municipality is uniquely identified by its name and county. There are no non-trivial functional dependencies between the attributes of this relation, so it is in BCNF.

Solar Installations(Application_Num, Program, Customer_Type, Year_Installed, CName, MName)
The primary key for this relation is Application_Num. There are functional dependencies between (CName, MName) and (Name, County) in the Municipality relation. However, since (CName, MName) is a candidate key for the Municipality relation, this relation is in BCNF.

CO2 Emissions(Year_collected, Residential_electricity, Residential_gas, Commercial_gas, Commercial_electricity, Other_gas, Other_electricity, CName, MName)
The primary key for this relation is (Year_collected, CName, MName) since we want to track CO2 emissions by year and by municipality. There are functional dependencies between (CName, MName) and (Name, County) in the Municipality relation. However, since (CName, MName) is a candidate key for the Municipality relation and appears as part of the primary key for this relation, this relation is in BCNF.

Define the different views (virtual tables) required. For each view list the data and transaction requirements. Give a few examples of queries, in English, to illustrate.

Total solar installation count per municipality up until 2015
CREATE VIEW install AS
SELECT MName, CName, count(*)

```
FROM Solar_Installations
WHERE year_installed <= '12/31/2015'
GROUP BY MName, CName;
```

Total solar installations up until 2020

```
CREATE VIEW install AS
SELECT MName, CName, count(*)
FROM Solar_Installations
WHERE year_installed <= '12/31/2020'
GROUP BY MName, CName;
```

Transaction Requirements:

- Ensure year is within range
- Ensure duplicate municipality names correlate to correct county

Design a complete set of SQL queries to satisfy the transaction requirements identified in the previous stages, using the relational schema and views defined in tasks 2 and 3 above.

```
BEGIN TRANSACTION;
    UPDATE install SET Customer_Type = 'Commercial' WHERE Application_Num =
        'NJSRRE1537142619';
    UPDATE CO2_Emission SET Residential_electricity = 14,200 WHERE Year_collected
        = 2015 AND CName = 'Monmouth' AND MName = 'Aberdeen township';
    UPDATE  Municipality SET Population = 8,000 WHERE Name = 'Absecon city' AND
        'Atlantic';
END;

BEGIN TRANSACTION;
    DELETE FROM  install WHERE Application_Num = 'NJSRRE1537142271';
    INSERT INTO Municipality VALUES ('Absecon city',  'Atlantic', '8,471');
    UPDATE  CO2_Emission SET Commercial_electricity = 13,000  WHERE
        Year_collected = 2020 AND CName = 'Monmouth' AND MName = 'Aberdeen
        township';
END;
```

CSC315 Phase Va - Implementation: Tables and Queries

Installations

Show the number of solar panel installations up to 2015 for this municipality:

```
SELECT COUNT(*) AS num_installations
FROM installation
WHERE Year_Installed <= '2015-12-31'
  AND Municipality = 'municipality_name';
```

Show the number of solar panel installations up to 2020 for this municipality:

```
SELECT COUNT(*) AS num_installations
FROM installation
WHERE Year_Installed <= '2020-12-31'
  AND Municipality = 'municipality_name';
```

Show the number of residential solar panel installations for this municipality up to 2015:

```
SELECT COUNT(*) AS num_residential_installations
FROM installation
WHERE Year_Installed <= '2015-12-31'
  AND Customer_Type = 'Residential'
  AND Municipality = 'municipality_name';
```

Show the number of residential solar panel installations for this municipality up to 2020:

```
SELECT COUNT(*) AS num_residential_installations
FROM installation
WHERE Year_Installed <= '2020-12-31'
  AND Customer_Type = 'Residential'
  AND Municipality = 'municipality_name';
```

Show the number of commercial solar panel installations for this municipality up to 2015:

```
SELECT COUNT(*) AS num_residential_installations
```

```
FROM installation
WHERE Year_Installed <= '2015-12-31'
  AND Customer_Type = 'Commercial'
  AND Municipality = 'municipality_name';
```

Show the number of commercial solar panel installations for this municipality up to 2020:

```
SELECT COUNT(*) AS num_residential_installations
FROM installation
WHERE Year_Installed <= '2020-12-31'
  AND Customer_Type = ‘Commercial’
  AND Municipality = 'municipality_name';
```

Show the number of other solar panel installations for this municipality up to 2015:

```
SELECT COUNT(*) AS num_other_installations
FROM installation
WHERE Year_Installed <= '2015-12-31'
  AND Municipality = 'municipality_name'
  AND Program != 'Residential'
  AND Program != ‘Commercial’;
```

Show the number of other solar panel installations for this municipality up to 2020:

```
SELECT COUNT(*) AS num_other_installations
FROM installation
WHERE Year_Installed <= '2020-12-31'
  AND Municipality = 'municipality_name'
  AND Program != 'Residential'
  AND Program != ‘Commercial’;
```

<u>Relation to municipality population</u>

Create table that shows the percentage of solar panel installations in regards to population up to 2015 for this municipality:

```
CREATE TABLE insallations_population_2015 AS
    SELECT  *, COUNT(Solar_Installations.Municipality) AS Total_installations
    FROM Municipality
    WHERE Year = ‘2015’
    AND Municipality = 'municipality_name'
    JOIN Solar_Installations
    ON Municipality.Municipality = Solar_Installations.Municipality
    AND Solar_Installations.PTO_Date <= '2015-12-31'
```

Create table that show the percentage of solar panel installations in regards to population up to 2020 for this municipality

```
CREATE TABLE insallations_population_2020 AS
    SELECT  *, COUNT(Solar_Installations.Municipality) AS Total_installations
    FROM Municipality
    WHERE Year = ‘2020’
    AND Municipality = 'municipality_name'
    JOIN Solar_Installations
    ON Municipality.Municipality = Solar_Installations.Municipality
    AND Solar_Installations.PTO_Date <= '2020-12-31'
```

Create table that show the percentage of total MTCO2e in regards to population in 2015 for this municipality

```
CREATE TABLE MTCO2e_population_2015
    SELECT *, CO2_Emissions.Total_MTCO2e
    FROM Municipality
    WHERE Year = ’2015’
    AND Municipality = 'municipality_name'
    JOIN CO2_Emissions
    ON Municipality.Municipality = CO2_Emissions.Municipality
    AND CO2_Emissions.Year = ‘2015’
```

Create table that show the percentage of total MTCO2e in regards to population in 2015 for this municipality

```
CREATE TABLE MTCO2e_population_2020
    SELECT *, CO2_Emissions.Total_MTCO2e
    FROM Municipality
    WHERE Year = ’2020’
    AND Municipality = 'municipality_name'
    JOIN CO2_Emissions
    ON Municipality.Municipality = CO2_Emissions.Municipality
    AND CO2_Emissions.Year = ‘2020’
```

Total MTCO2e

Show the total MTCO2e in 2020 for this municipality

```
SELECT TOTAL_MTCO2e AS Total_CO2_2020
FROM C02_Emissions
WHERE Year_collected = ‘2020’
AND Municipality = 'municipality_name'
```

Show the total MTCO2e in 2015 for this municipality

```
SELECT TOTAL_MTCO2e AS Total_CO2_2015
FROM C02_Emissions
WHERE Year_collected = ‘2015’
AND Municipality = 'municipality_name'
```

Collab Phase IV. Final Submissions

For our initial plan in our Phase II Proposal, our group's goal was to analyze Sustainable Jersey's "Solar Installation Data" and "Community Profile Data by Municipality", as well as NJ Clean Energy's "Solar Energy Installation Data". By looking at the municipality breakdowns, we focused on considering the varying population count within each municipality and its effects on the amount of solar installed within the municipality. Tying this to the plan for our initial database, we planned to create a user-friendly interface that could be updated by the administrator with the most recent solar energy data at any time.

From our initial plan, we also established what we believed were opportunities for positive change from our database. By gathering and analyzing our data on solar energy use and sustainability, we could provide valuable insights that could be used to propose positive change in a variety of ways. By identifying areas where the state is doing well and areas where there is room for improvement, policies or incentives could be proposed that encourage more widespread adoption of solar energy in underserved areas. Additionally, our initial data can be used to create compelling arguments for why transitioning to solar energy is a smart investment for individuals, businesses, and the state as a whole, which could help build public support for sustainable energy initiatives. This data could also be used to inform policy decisions related to sustainable energy. For example, if you find that certain policies or incentives have been effective in promoting solar energy adoption in other states, you could recommend similar policies for New Jersey. Moreover, data could help attract investment in sustainable energy projects. By showing that there is a strong demand for solar energy and a supportive policy environment, you may be able to attract investors who may be interested in financing solar installations or other renewable energy projects.

While our final database kept the same user-friendly interface as our proposal suggested, it also included more components. Per our database, the project will compare the amount of solar panels within the county or specified municipality to indicate whether an increase in the amount of solar panel installations result in a decrease in CO2 emissions. More specifically, we also included data for solar panel installations and CO2 emissions across the user-selected municipality or county from 2015 and from 2020. By getting all available information from two points in time, we are able to analyze if there is a correlation between the two variables we selected. With our findings, we have found that there is a correlation with solar panels and CO2 emissions. As we expected, the more solar panel installations that occur across residential and commercial buildings in a specific municipality, the lower that municipality's CO2 emissions will be.

Essentially, the solar and CO2 information we are using for our database can be a powerful tool for proposing positive change in the area of sustainable energy in New Jersey. Gathering and analyzing data on this information can help identify areas for improvement for solar energy, build public support for more solar installations, inform policy decisions, and encourage investment in this important area. By using data to propose positive change, we can help New Jersey move towards a more sustainable and environmentally-friendly future.

With this project we are proposing, there are both positive and negative ethical implications with the research being conducted. With our proposal, this will allow easier access and understanding to the relationship between solar panel installations and the emittance of CO2. This requires research and data-pulling of the solar installations in municipalities across the state and comparing their effectiveness when it comes to the decrease of CO2.

However because this requires data collection of solar installation and a “before and after” effect of them, it also requires a light form of tracking the solar within the municipality. This can be somewhat off putting to some individuals as tracking and monitoring is not usually explicitly stated when buying certain products or services. While this is more of a negative ethical implication, there are still plenty of positive ethical implications that are worth discussing. We have a duty to others to protect them and be transparent with the environment and how to amend any issues within it. With that being said, making it transparent with this proposal about the impact of installing solar energy is an important component to showing the public how necessary it is.

Of course the negative ethical implications should not go unnoticed and should be important to address. The idea of monitoring these solar installations and where in the municipality it is located in order to get a “before and after” of CO2 emissions can be a bit surprising at first. The reason it would be surprising is because they are not explicitly told of this before purchasing the solar panels. A way to do this ethically would be to inform the buyer of the monitoring of these solar panels and to inform them before they purchase them. This would be the most effective way to perform this ethically and emphasize how necessary this data is in order to better the environment and community.

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