02-2
Energy Demand

Andrew Michael(michaea3@tcnj.edu), Sara Aly(alys4@tcnj.edu),
Juan Carmona(carmonj1@tcnj.edu), Anthony Pastor(pastora1@tcnj.edu), Nila Addo(addon2@tcnj.edu), Kevin Klaskala(klaskak1@tcnj.edu), Riley Furlong(furlon2@tcnj.edu)

I. Executive Summary

A. Need

The stakeholder of this project is the TCNJ Sustainability Team. The team currently has a great amount of data, but the data is hard to read for many reasons. This is because the data is inconsistent, unorganized, and a lot of data is just overwhelming to read in general. The need is then a way to simplify large sums of data into an understandable medium that is easily readable. Searching through thousands of excel cells is not optimal, thus a module that quickly accesses the data is important. Not all the data should be included, however. The module has to be catered to market the energy demanded side of the sustainability need.

B. Approach

We wanted to create a web module that would be connected to a database with relevant information to our topic. The approach consisted of a few objectives: allow the user to easily pick a building and get the energy it consumed in a period of time, allow the user to compare a building's usage in the hot and cold seasons, and allow the user to search for the basic components of a building. Our approach was to be able to connect a building to its corresponding meter, however due to the data given this was not realistic. Thus, we ended up with a unique approach. We created efficiency factors for all 47 buildings that were calculated based on a building's use, age, and size. This made our data very personalized to TCNJ. Our approach with the overwhelming amount of data was to remove any data that was unnecessary from the excel sheets, such as the occupancy and many of the questions that had no data attached to it. We also took measures such as converting all the usages (therms and ccf) to kWh, to make for easier comparisons between the buildings' usages.

C. Benefits

Our web module is unique and beneficial to the TCNJ Sustainability team. As mentioned above, the data is specific to TCNJ and energy consumption. For example, the efficiency factor is an attribute that the stakeholder can only find in our web module since it is personalized. We include data that

D. Cost:

If the TCNJ servers do not utilize a similar database paradigm as Postgresql, utilized for the development of this web application, consider costs would entail. For instance, much of the database implementation and code would need to be refactored to adhere to the standards of TCNJs databases. Furthermore, there is an inherent lack of security applied within the web application, therefore time would need to be spent in the development of security parameters prior to full release. Finally, it should be noted that this web application is completely separate from other commercial implementations.

II. Elaboration: Project Proposal and Specifications

Proposal: Energy Demand Project Specifications:

1. Problem Statement:
    a. Determine the estimated energy demanded and corresponding energy cost of each of the buildings on TCNJ campus.
2. Objective of the Module:
    a. What is the energy demanded for each building per square foot?
    b. Do hot or cold months require more energy for a specific building, if so how by how much?

c. What are the most significant characteristics that correspond to the energy demand of each building on the TCNJ campus (example: year built, use details, building operational hours)?

d. How much carbon-equivalent emissions are produced by a specific building due to the amount of energy consumed?

3. Description of the Desired End Product:

   a. <u>Use Case Name:</u> Get General Statistics

      i. **<u>Actors:</u>** Paul Romano & Sustainability Staff

      ii. <u>Flow of Events:</u>

         1. The Staff member navigates to energysavers website.
         2. The Staff member selects from the dropdown menus the desired buildings (Bliss Hall, STEM Building, Social Sciences Building, etc.).
         3. The Staff member selects the "General Statistics" option from the options menu on the page.
         4. The Staff member selects the "Submit" button.
         5. The database processes the Staff member's request and returns the attributes for the selected buildings.
         6. The Staff member views the returned results in a table format and eases the process of completing subsequent analysis.
         7. The Staff member clicks the exit button at the top-right of the window to leave the website.

   b. <u>Use Case Name:</u> Get Energy Demand

i. **<u>Actors:</u>** Paul Romano & Sustainability Staff

ii. **<u>Flow of Events:</u>**

1. The Staff member navitages to the energysavers website.
2. Staff member selects from the dropdown menus the desired buildings (Bliss Hall, STEM Building, Social Sciences Building, etc.).
3. The Staff member selects the “Energy Demand” option from the options menu on the page.
4. The Staff member selects the “Submit” button.
5. The database processes the Staff member’s request and returns a table for the estimated energy consumption per square foot for days, months, and years.
6. The Staff member views the returned table and completes their analysis.
7. The Staff member clicks the exit button on the top-right of the window to leave the website.

c. **<u>Use Case Name:</u>** Get Energy Consumption by Season

i. **<u>Actors:</u>** Paul Romano & Sustainability Staff

ii. **<u>Flow of Events:</u>**

1. The Staff member navigates to the energysaver website.
2. The Staff member selects from the dropdown menus the desired buildings (Bliss Hall, STEM Building, Social Sciences Building, etc.).

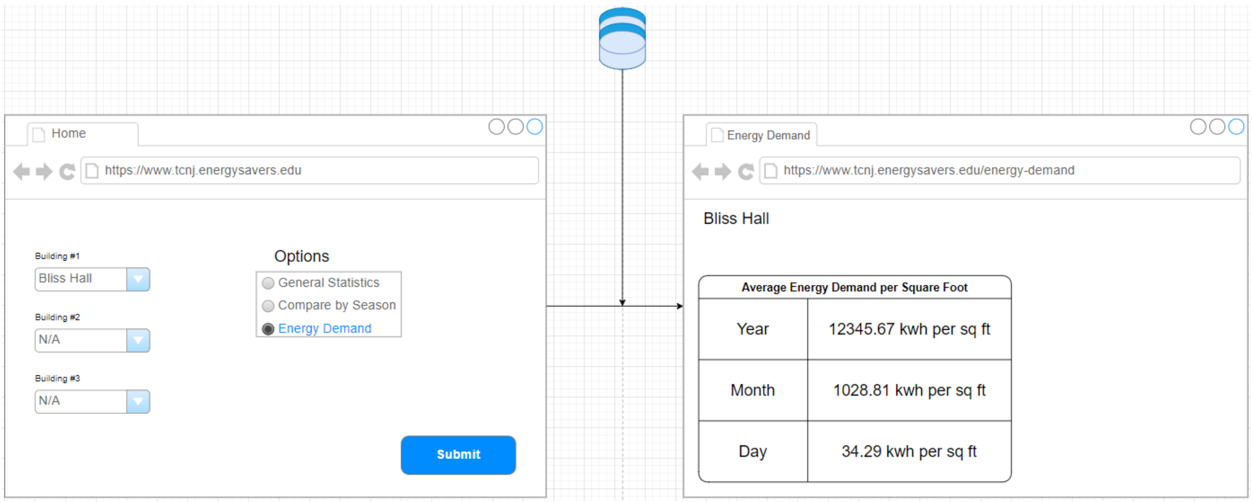
3. The Staff member selects the "Compare by Season" option from the options menu on the page.
4. The Staff member selects the "Submit" button.
5. The database processes the Staff member's request and returns the table for the energy consumption by seasonality.
6. The Staff member views the returned table and completes their analysis.
7. The Staff member clicks the exit button the top-right side of the window, leaving the website.

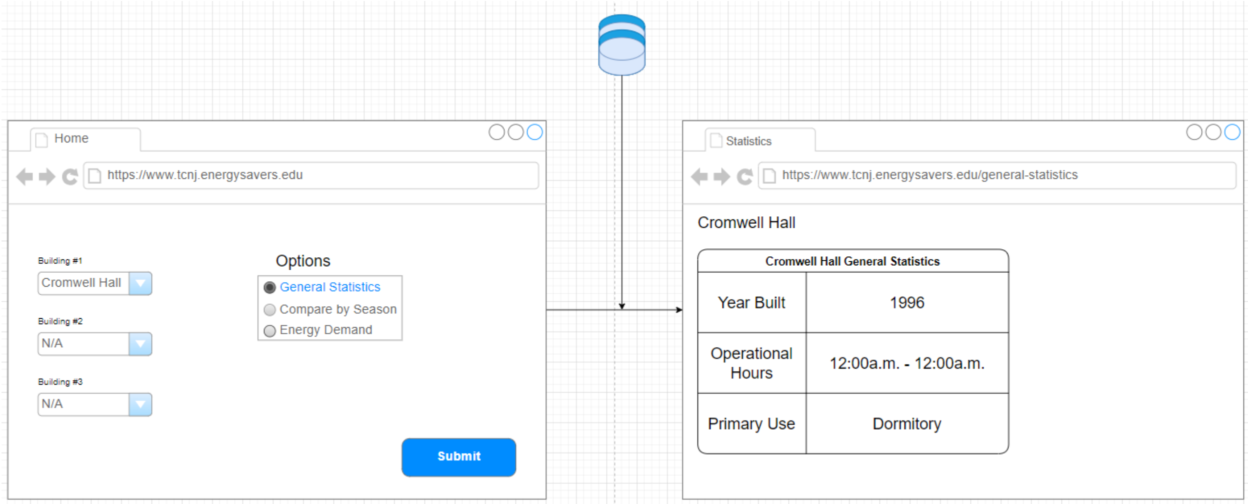
d. Provide database access to the TCNJ sustainability Staff and Paul Romano.

e. Create a home page that displays a description of the website and provides easy navigation.

f. Implement users with privileged (can modify the data) and non-privileged (can not modify the data) access.

g. Allow users to input desired information about specific buildings (based on questions from the objective of the module) and provide them corresponding tables.





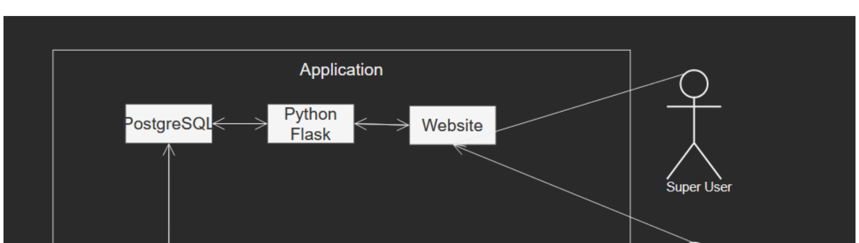
4. Description of the importance and the need for the module, and how it addresses the problem:
    a. Personalized database architecture offers the desired energy demand data to allow the TCNJ sustainability team to access and analyze a large amount of data easily.
    b. The data provided with the Excel sheet is cumbersome to read and understand for the average user, so we intend on clarifying certain data entries for the average user.
5. Plan for how you will research the problem domain and obtain the data needed:

a. To be able to compare the building's energy consumption on cold versus hot months, we will find weather data on temperature averages of the corresponding months.
b. We will use the building's area and use details to estimate the energy consumption of that building.
c. We will research conversion factors between the energy consumed for each building and the corresponding carbon-equivalent emissions. By using equivalent units, we can provide the client with a benchmark for CO_2 emissions categorized by building.

6. Other similar systems / approaches that exist, and how your module is different or will add to the existing system:
   a. Our module is personalized for The College of New Jersey. Similar systems like Energy Star can be overwhelming for the average user. Our interface is simple and provides comprehensible chunks of data based on the query instead of all the data at once.
7. Possible other applications of the system (how it could be modified and reused):
   a. While the database will be built on the goal of providing Paul Romano and his team an easy way to analyze TCNJ buildings' energy consumption, the data could be extended to other sectors of TCNJ. For example, TCNJ workers who analyze the college's budget can use the database to determine how much money is being used for energy in specific buildings.
8. Performance:

    a. The data is not at a large enough scale to significantly reduce performance. Thus, no extra measures are needed to address this.

9. Security:
    a. TCNJ server cluster and GitHub provides the authentication services for security.
    b. Access to the database will be provided by user authentication via login page.
    c. Access to the data is exclusive only to members of the TCNJ sustainability team and other authorized users.
    d. Security can be provided by a login page for sustained use off of Github.
10. Backup and recovery:
    a. The database will be hosted on the GitHub distributed servers therefore there is inherent redundancy. The TCNJ server cluster utilizes backup images thereby providing recovery for our application or database.
    b. After the database departs from GitHub, we plan to backup the database weekly to an external drive. Furthermore, redundancy will be provided by hosting the database on a multitude of database servers.
11. Technology and Database Concepts To Learn
    a. Develop an understanding of relational databases and how to efficiently and securely query the databases.
    b. Learn how to utilize data sanitation for protecting against SQL injection and other forms of malicious use.
    c. Learn how to create effective ER diagrams and identify keys to develop a comprehensive schema.
12. Diagrammatic Representation of the System Boundary



13. 1-Page Energy Demanded Quad Chart:

CAB Project – Energy Demanded

TCNJ THE COLLEGE OF NEW JERSEY

Riley Furlong, Sara Aly, Andrew Michael, Kevin Klaskala, Juan Carmona, Nila Addo, Anthony Pastor

Need

- How to optimize energy emissions
- How to provide more clean energy

Approach

- Generate graphical view of the data
- Utilize relational data model
- Use cost analysis to compare efficiency between different energy demands

Benefit

Easier data access to analyze:
•energy consumption of campus buildings on a Gross Square Footage basis
•the carbon equivalent emissions of campus buildings on a Gross Square Footage basis, on both a site and source basis

Competition

- More personalized data analysis
- Provide predicted emission for alternative sources of energy

02/05/2022

14. REVISIONS

a. After further feedback, we decided that the carbon emissions were more of a supply side factor.

III. Proposal Pitch Presentation

Project Pitch- Energy Demand

By Riley Furlong, Sara Aly, Andrew Michael, Kevin Klaskala, Juan Carmona, Nila Addo, Anthony Pastor

Problem Statement

How can we determine the efficiency of the energy consumption and cost benefit of alternative energy resources in buildings across the TCNJ campus? With in depth analysis, we can offer a more personalized approach to potential distinct energy solutions.

Objective of the Module

- Can we view the data in a more comprehensible manner?
  - User-friendly web interface
- How do we analyze financial impact of energy demand?
- What options exist for green energy usage?

Desired End Product

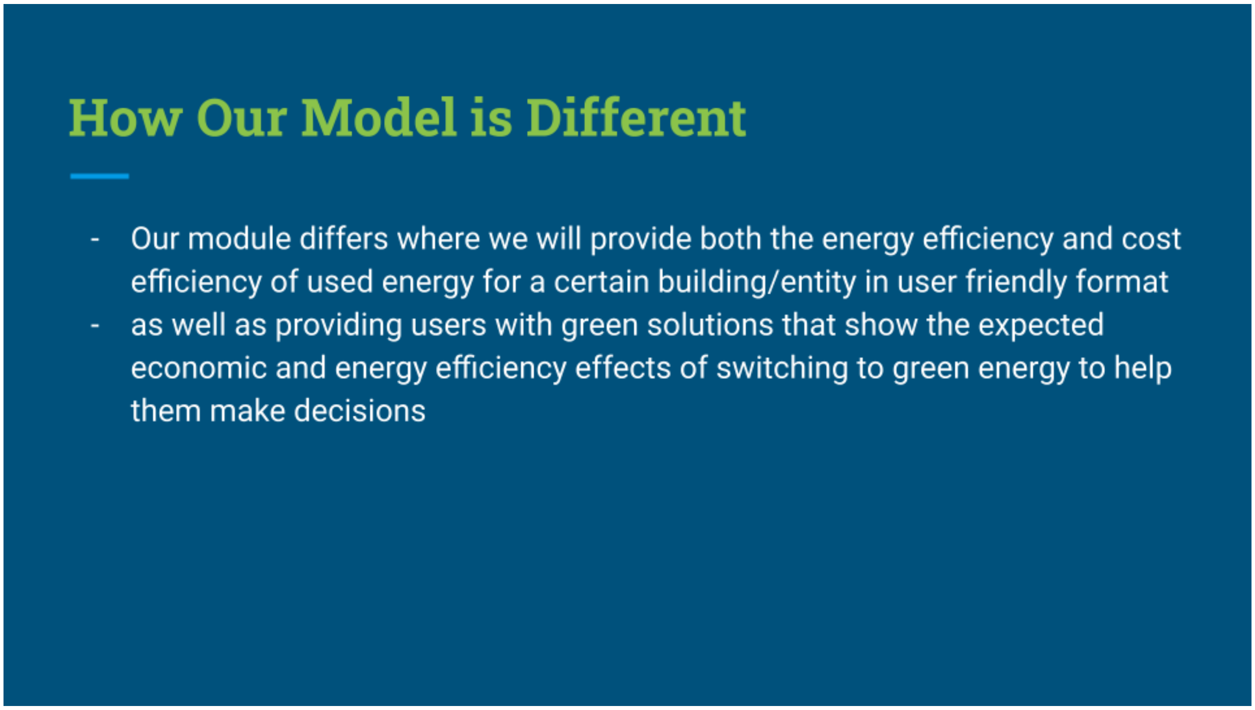
- Built upon a relational database
- Centralized access point
- Authentication provided through login page
- Implementation of homepage for ease of navigation
- Graphical representation for ease of viewing of the data

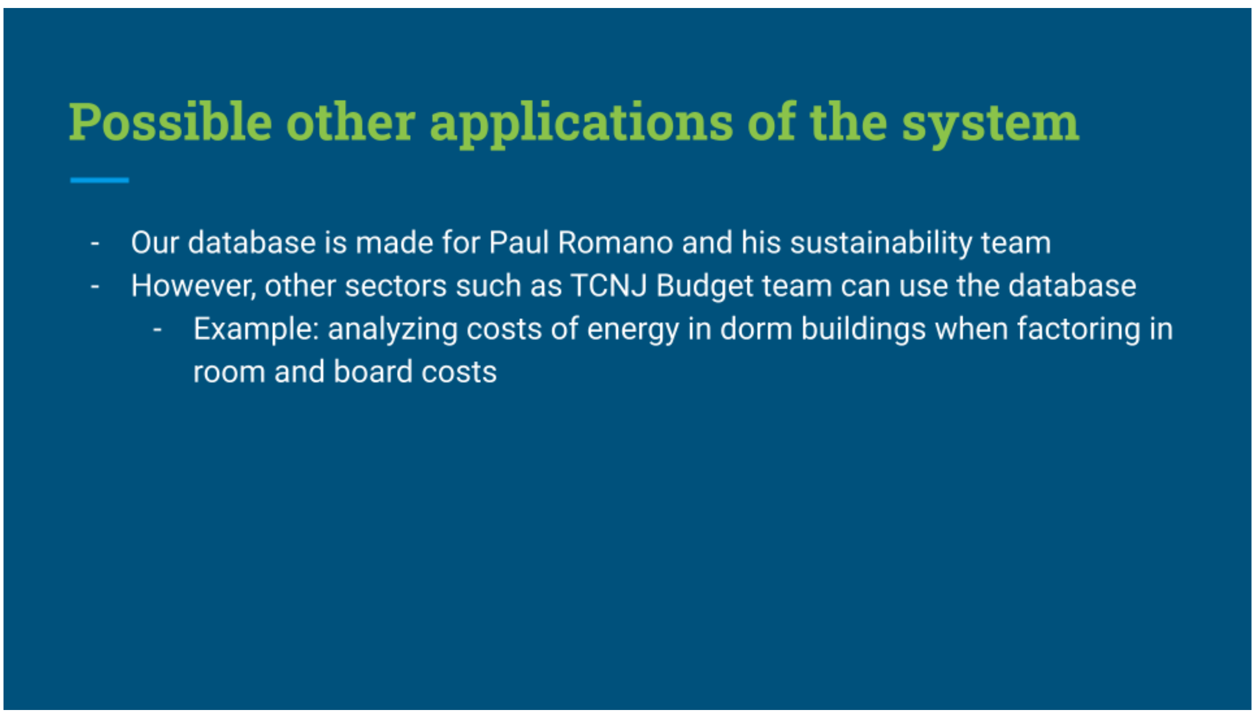
Importance and Need of the Module

- This module is essential to understanding the energy demand of TCNJ buildings and how to maintain an energy and cost efficient campus-wide protocol.
- There is a need for this module in order to truly identify the best energy sources for specific areas of the campus and understand the financial impact each will have.
- Our graphical representation will provide stakeholders with a more comprehensive understanding of energy consumption and carbon emission.

Researching the Problem Domain/Obtaining the Data

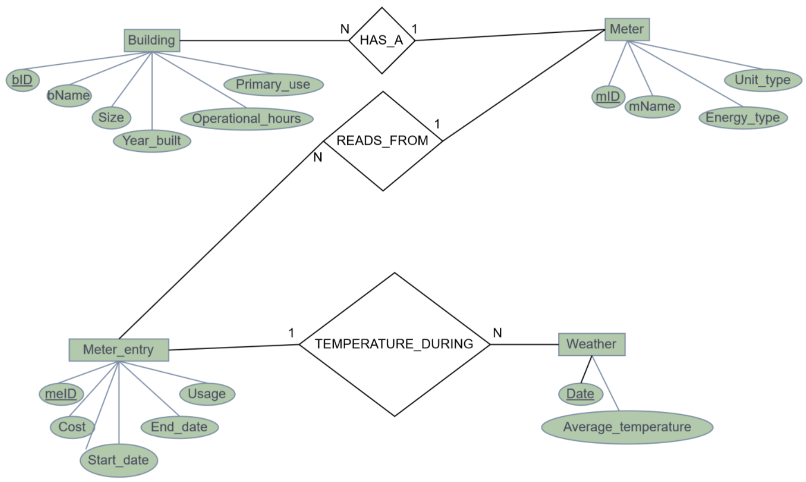
- By using accounting principles involving cost analysis, we can analyze TCNJ's individual buildings' energy efficiency, in order to get the economic data and resulting monetary effect of the current energy consumption across campus
- Consumption wise, we will utilize equivalent units in order to benchmark current actual CO_2 emissions against alternative energy forms (including green energy) and the amount of predicted CO_2 it would emit if that alternative energy source was utilized

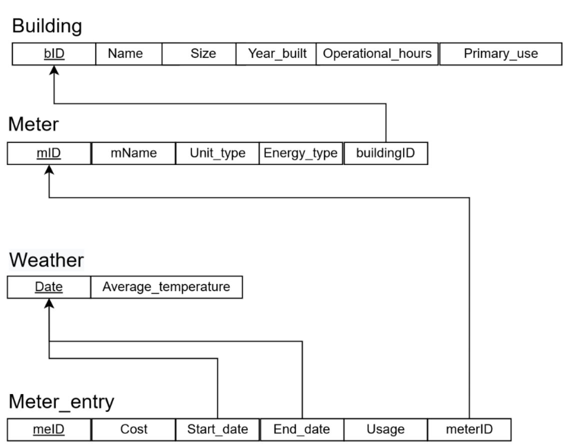




B. REVISIONS: We completely changed our objectives from this stage, and made them more geared to our topic and more specific to our database.

IV. Elaboration: Design

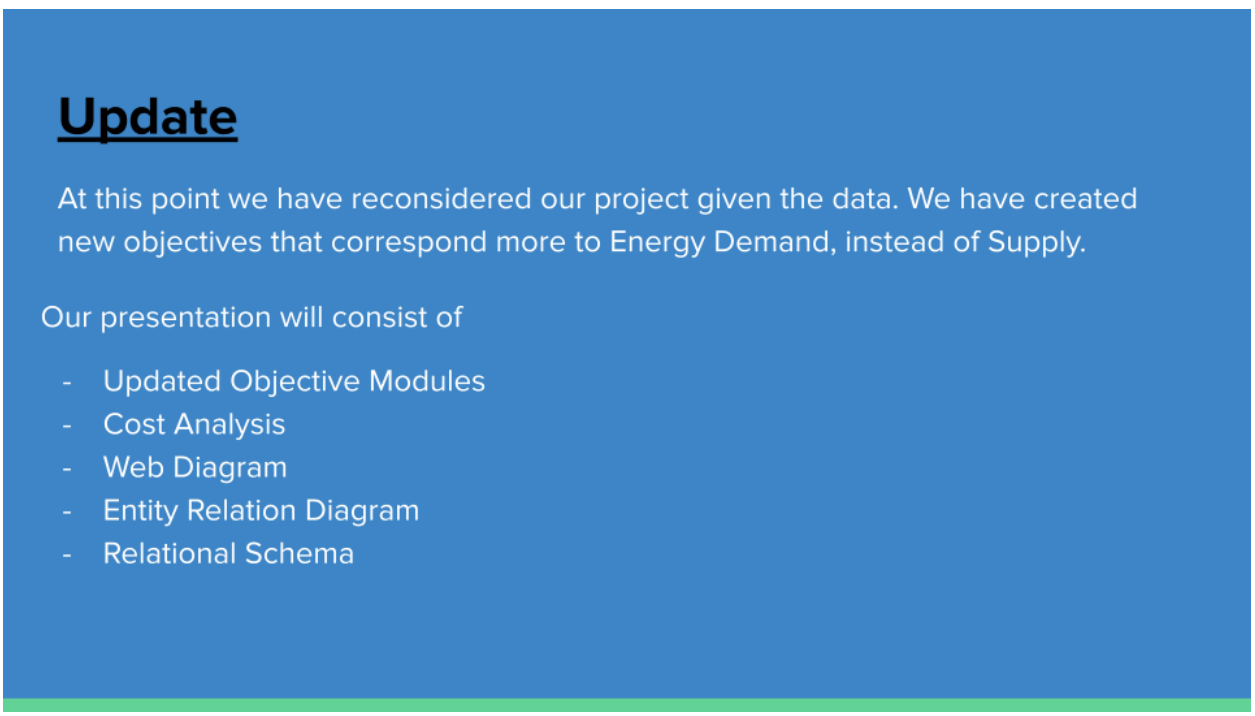




A.

B. REVISIONS**:** The ER diagram was updated significantly. Including removing every relationship except the one between the meter and the meter entry.

V. Mid-Semester Project Presentation



Objective of the Module

1) What is the energy demanded for each building per square foot?

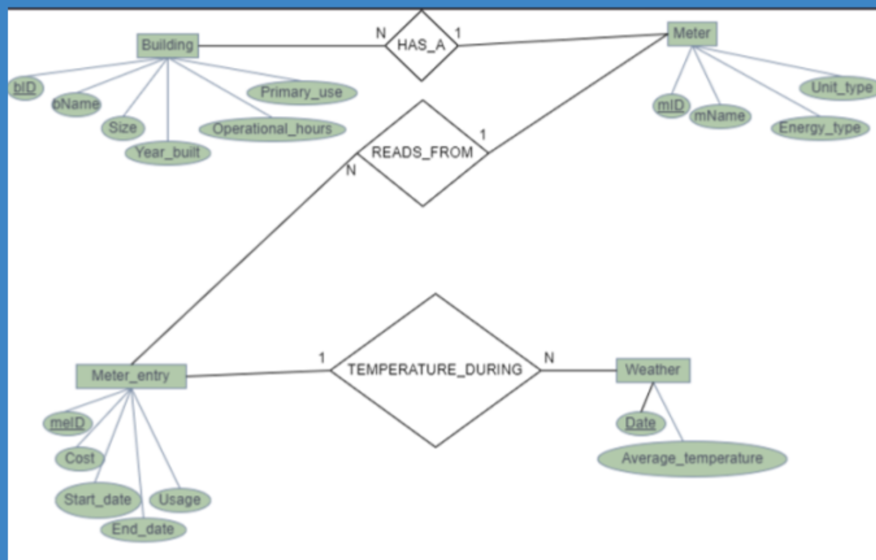
2) Do hot or cold months require more energy for a specific building. If so, by how much?

3) What are the most significant characteristics that correspond to the energy demanded of each building on the TCNJ campus (example: year built, use details, building operational hours)?

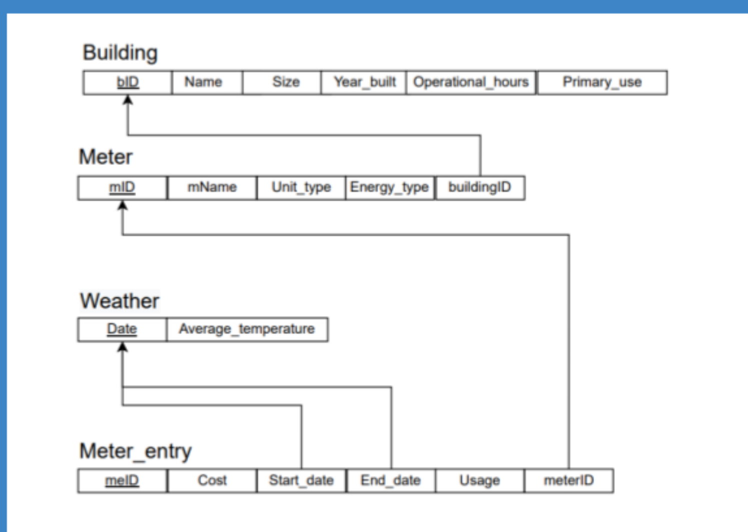
Cost Analysis

Initially one of our objectives is to determine the efficiency of buildings across campus. However, we could not determine such factors with the data given. As an alternative we have chosen to focus on an analysis of daily cost of running a building including during different seasons affecting heating and cooling. We will use the cost per kilowatt hour of energy demand to determine the cost of buildings per day using operational hours as a metric for each building.

Entity Relationship Diagram

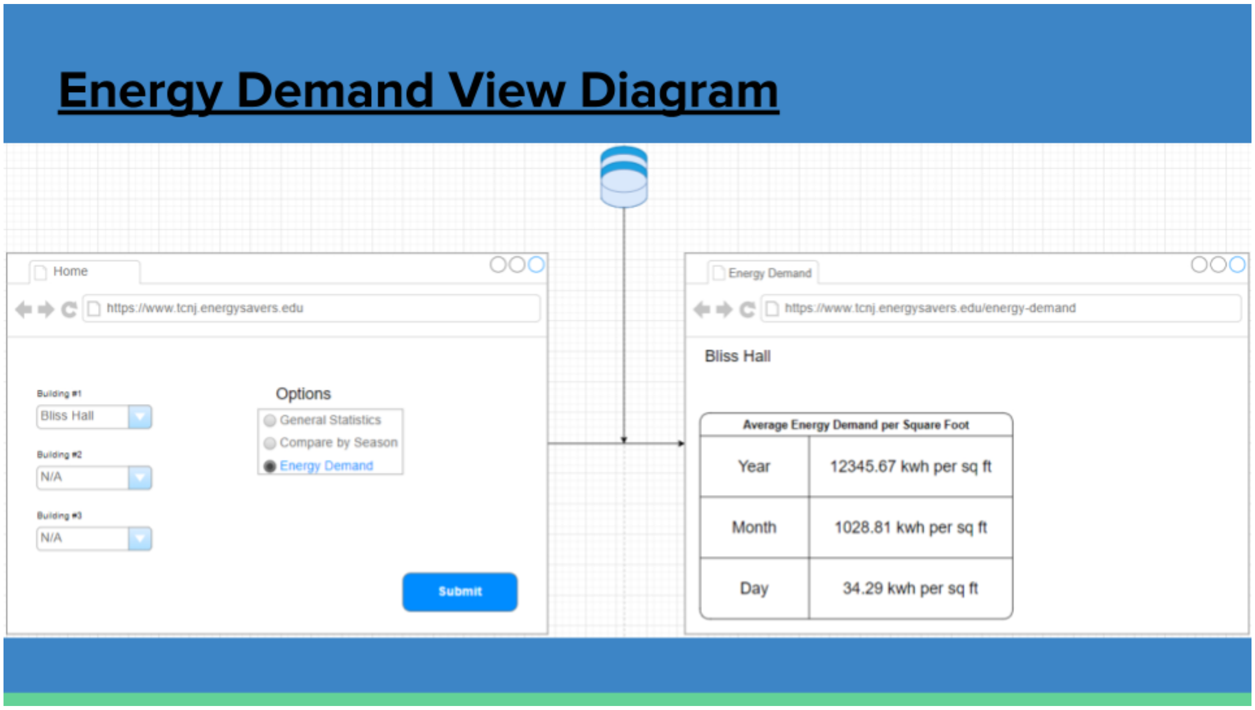


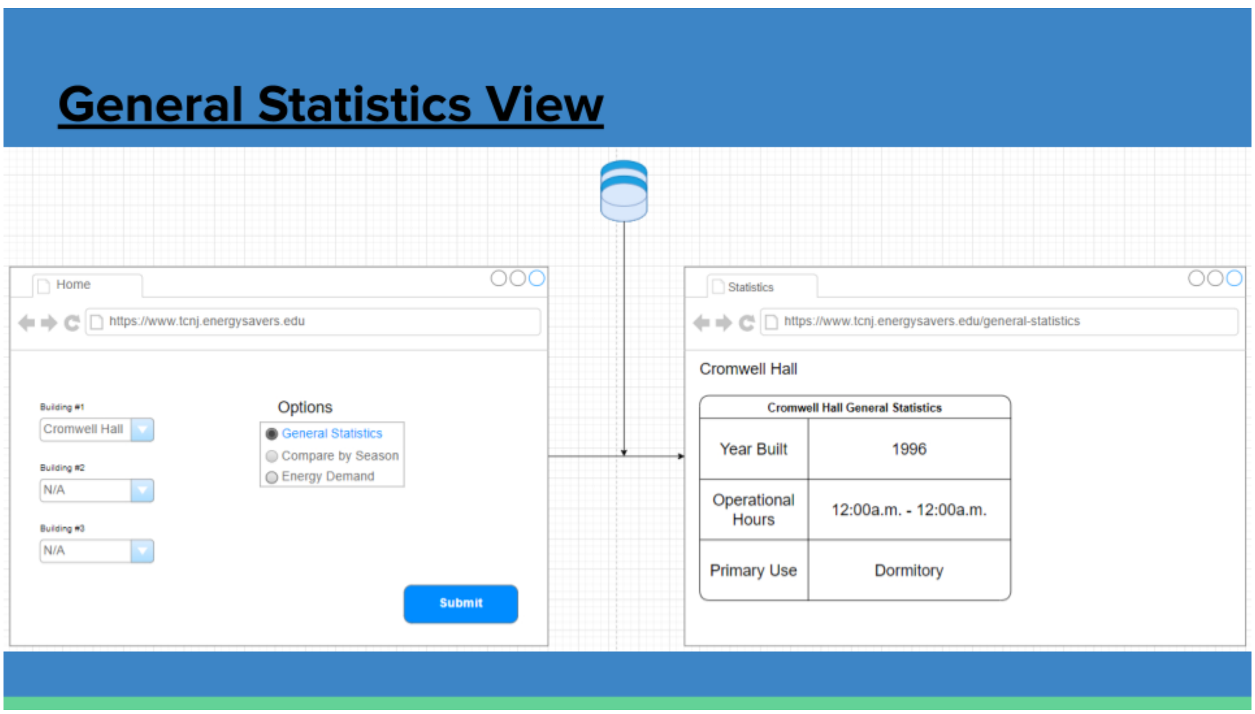
Relational Schema



Database Information:

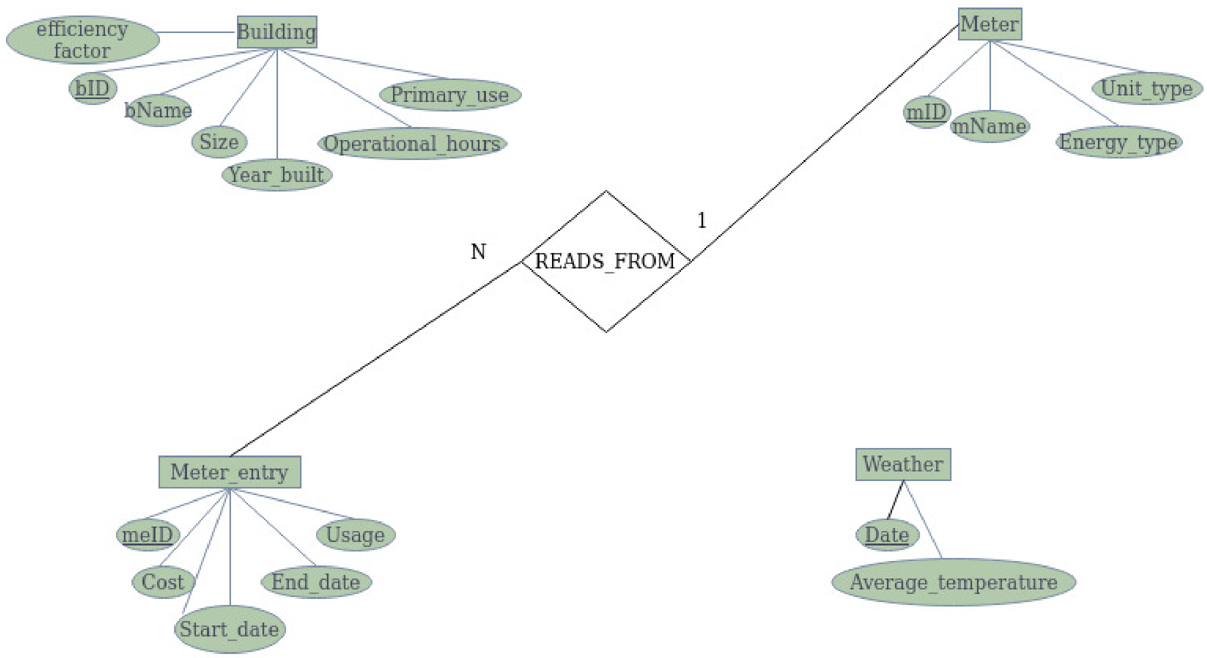
- Database size: **5000** (Degree days, buildings, meter entries, meters)
- Most popular type of search: **Energy Demand**
- Average number of searches per year: **40**





B. REVISIONS: We mostly kept our objectives the same, except for the energy demanded. We allowed for the user to pick a specific time span for the energy consumption, instead of giving them an hourly/daily basis. We also only allow the user to select one building instead of three. The ER diagram has been changed.

VI. Construction: Tables, Queries, and User Interface



Building

bID	Name	Size	Year_built	Operational_hours	Primary_use	Efficiency Factor

Meter

mID	mName	Unit_type	Energy_type

Meter_entry

meID	Cost	Start_date	End_date	Usage	meterID

Weather

Month	Average_temperature

CREATE TABLE BUILDING (
name text unique,

```
	bID char(7) PRIMARY KEY,
	Year_built char(4),
	Prim_use text,
	Eff_factor decimal(20,20),
	Size integer
);

CREATE TABLE METER(
	mID char(8) PRIMARY KEY,
	mName varchar(4) UNIQUE,
	etype text,
	utype  text

);

CREATE TABLE WEATHER(
	Month varchar(9) PRIMARY KEY,
	Avg_temp decimal(3,2)
);
CREATE  TABLE METER_ENTRY(
	meconsumpID char(10) PRIMARY KEY,
	Start_date text,
	End_date text,
	Usage decimal(10,2),
	Cost decimal(10,2),
	mName varchar(4),
	FOREIGN KEY (mName) REFERENCES meter (mName)
);
 CREATE TABLE belongs_to(
	buildingID char(7),
	meterID char(8),
	PRIMARY KEY(buildingID, meterID)
	FOREIGN KEY (buildingID) REFERENCES building (bID)
	FORIEGN KEY (meterID) REFERENCES meter (mID)
);
```

QUERIES:

QUERY #1:

```
SELECT SUM(Usage) FROM METER_ENTRY
WHERE EXTRACT(MONTH FROM Start_date) = 3;
```

sums the usage of all meters in march

QUERY #2:

CREATE VIEW Result AS SELECT eff_factor FROM Building WHERE name = 'Cromwell Hall';

CREATE VIEW Prod as SELECT sum(Usage) FROM meter_entry WHERE EXTRACT(MONTH FROM Start_date) =3;

CREATE VIEW Total as SELECT * FROM Prod, Result;

SELECT sum * eff_Factor FROM Total;

QUERY #3:

CREATE VIEW TEMP AS SELECT SUM(Usage) FROM METER_ENTRY
WHERE EXTRACT(MONTH FROM Start_date) >= 3
AND EXTRACT(MONTH FROM End_date) <= 6;

CREATE VIEW Result AS SELECT eff_factor FROM Building WHERE name = 'Cromwell Hall';

CREATE VIEW DEMAND AS SELECT * FROM temp, result;

create view answer AS SELECT sum * eff_Factor as ans FROM demand;

CREATE VIEW SPRINGWEATHER AS SELECT AVG(avg_temp) FROM WEATHER
WHERE month >= 3
AND month <= 6;

select * from answer, springweather;

Gives building usage in spring and corresponding average temperature

QUERY #4:

Select * from building;

Gives all the basic facts of the building

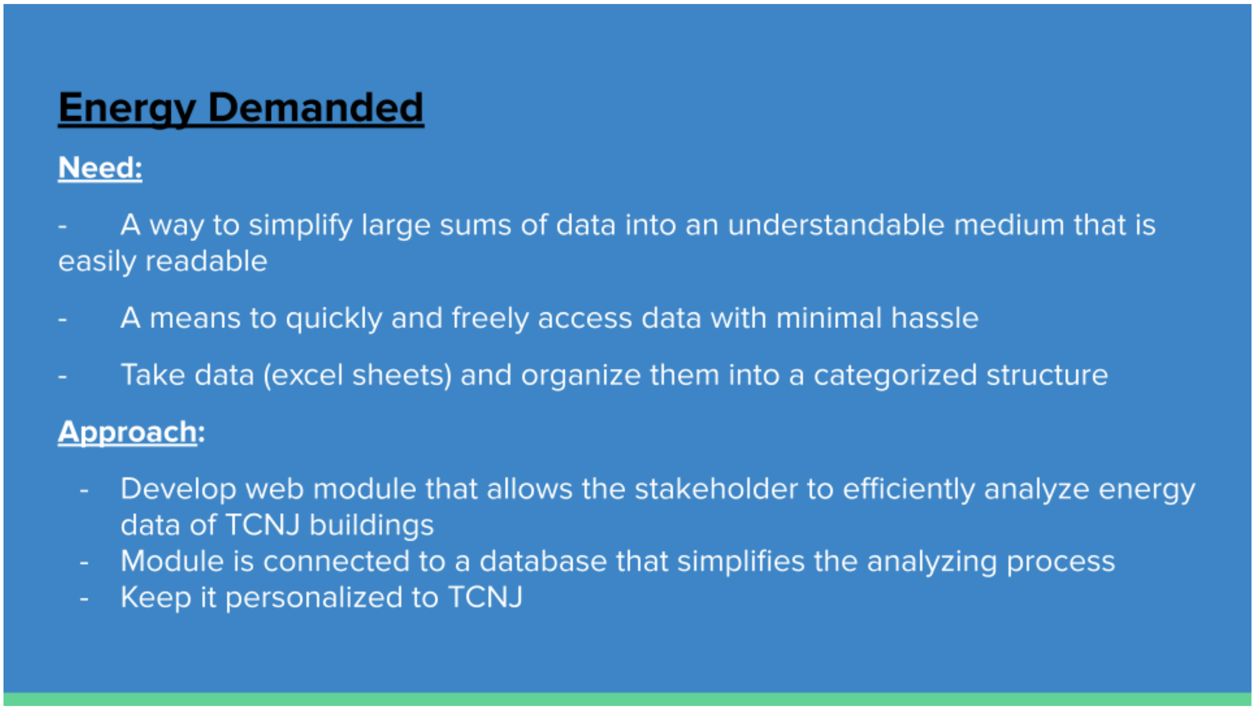
B. REVISIONS: We added the queries to satisfy our new objectives that we wish to use on the database. All of these queries are going to return information that will be useful for the user.

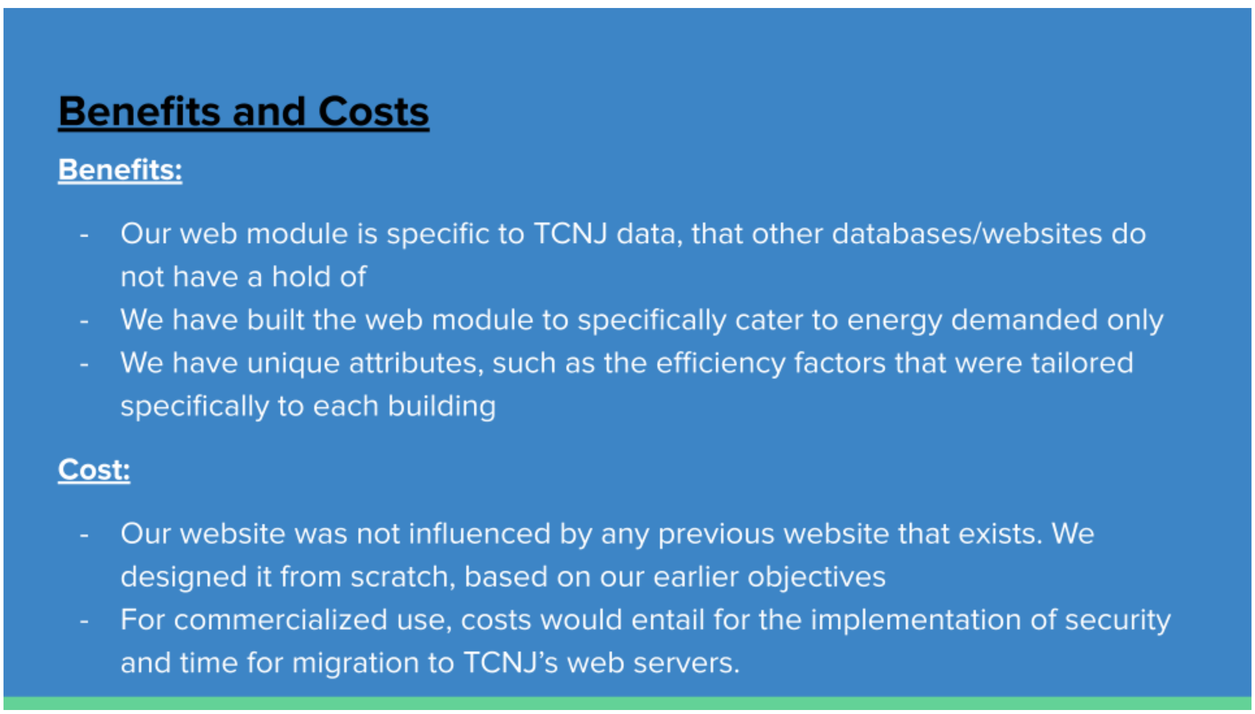
VII. Transition: Private Github

A. Private GitHub URL

https://github.com/TCNJ-degoodj/cab-project-02-2.git

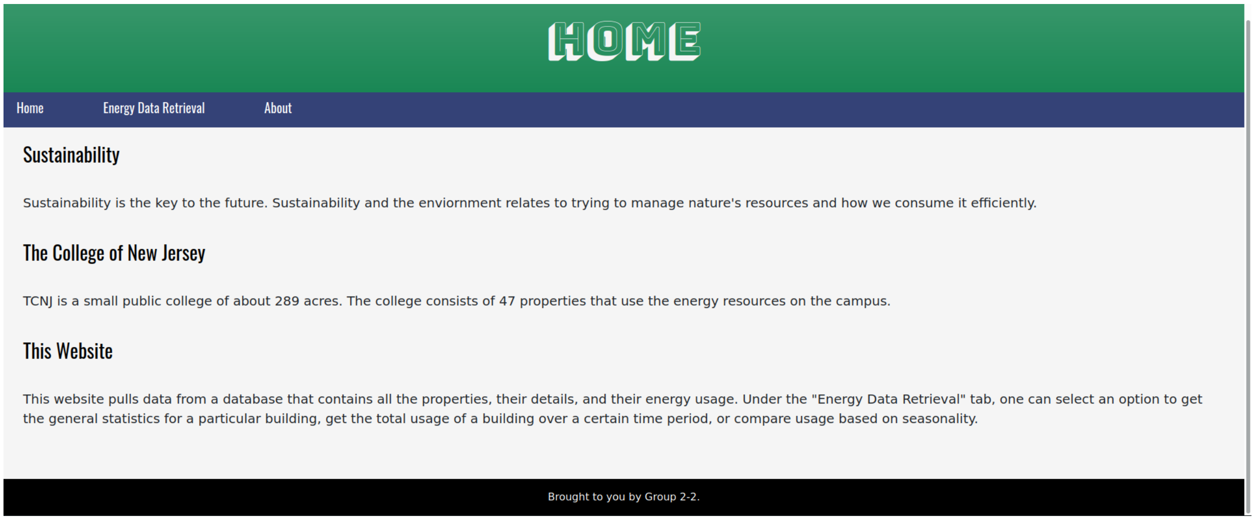
VIII. Final Project Demonstration



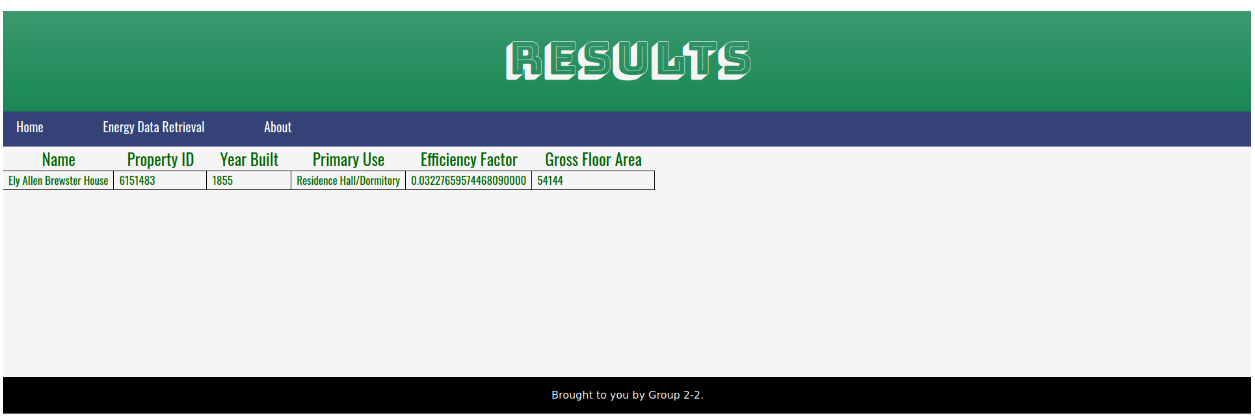


IX. Transition: Public Github

A. This section of the Project Report is simply your public GitHub project URL


HOME
Home
Energy Data Retrieval
About
Sustainability
Sustainability is the key to the future. Sustainability and the enviornment relates to trying to manage nature's resources and how we consume it efficiently.
The College of New Jersey
TCNJ is a small public college of about 289 acres. The college consists of 47 properties that use the energy resources on the campus.
This Website
This website pulls data from a database that contains all the properties, their details, and their energy usage. Under the "Energy Data Retrieval" tab, one can select an option to get the general statistics for a particular building, get the total usage of a building over a certain time period, or compare usage based on seasonality.
Brought to you by Group 2-2.


DATA RETRIEVAL
Home
Energy Data Retrieval
About
Choose a Building Below
Ely Allen Brewster House
What type of Information would you like?
Basic Statistics
Energy Demanded
Seasonality Comparison
Submit
Brought to you by Group 2-2.


RESULTS
Home
Energy Data Retrieval
About
Name
Property ID
Year Built
Primary Use
Efficiency Factor
Gross Floor Area
Ely Allen Brewster House
6151483
1855
Residence Hall/Dormitory
0.03227659574468090000
54144
Brought to you by Group 2-2.