Group 02-04

Vehicle Fleet Management System

Group members:

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Group 02-4

Jenna Stiesi, Parvathi Krishnan, Joseph Carmichael, Peter Kobasa, Jessica Giardiello, Sarah Rulkiewicz, Christina Farah

Inception: Executive Summary

Need:

The stakeholders involved include Paul Romano, as well as TCNJ and the environmental staff. The market need we identified was for an application that assists in decision making to determine the best makeup of a vehicle fleet according to economic and environmental factors. The application should provide a way to analyze different economic cost and environmental attributes to determine which vehicles are more beneficial than others economically and environmentally.

Approach:

We took a user-friendly and straightforward approach. The data we received from the stakeholder was related to environmental and economic attributes of vehicles, so we focused on those two areas to determine what to analyze in the website. We built a database using PostgreSQL, and implemented a web-based user interface using Flask, HTML and CSS that connects to the database. When the user accesses the website, the user can fill out two different forms. Upon submitting a form, the user is shown a results table with data filtered according to their input.

Benefits:

Since TCNJ does not currently have a vehicle fleet management system, this would prove beneficial to the college by lowering cost. This will also be environmentally beneficial since it would help TCNJ in making decisions about which vehicles to employ, working toward the goal to lower their emissions.

Cost:

We are not aware of any existing website currently used at TCNJ for vehicle fleet management so we would have to create a new website. We would have to purchase a domain name and website hosting plan, and transfer the app to a new server. In order for TCNJ to use this application, they would need to host the application and database on a server, which may cost money depending on how large they want the database to be. A database administrator/website administrator would also need to be employed to maintain the site to manage and update the database.

Project Proposal: Fleet Vehicle Management

Team 02-4
Jenna Stiesi, Peter Kobasa, Parvathi Krishnan, Jessica Giardiello, Sarah Rulkiewicz, Christina Farah, Joseph Carmichael

Problem statement

The TCNJ vehicle fleet is composed of many vehicles of different types, all of which have internal combustion engines. The current fleet is not as efficient as it could potentially be, both economically and environmentally. Other types of fuel and engines exist which, in the long term, can end up being beneficial to the college in terms of lowering the cost to maintain the vehicles as well as reducing CO2 emissions that impact the environment.

Objective of the application

The objective of our application is to help in decision making for an economically and environmentally stable vehicle fleet for TCNJ. By determining the most eco-friendly fuel sources, we can develop a purchasing strategy that maximizes benefits in relation to cost, providing for a cleaner campus and most effective budget.

This objective also encompasses our plan for the development of a secure and informative database which can hold financial data that can facilitate the analysis of what vehicles to purchase with their respective fuel source(s).

The various cost items intended for input to the database include factors attributable to each vehicle, such as annual cost per year, annual pollution per year, the budget, estimated annual repair costs, estimated insurance costs, etc.

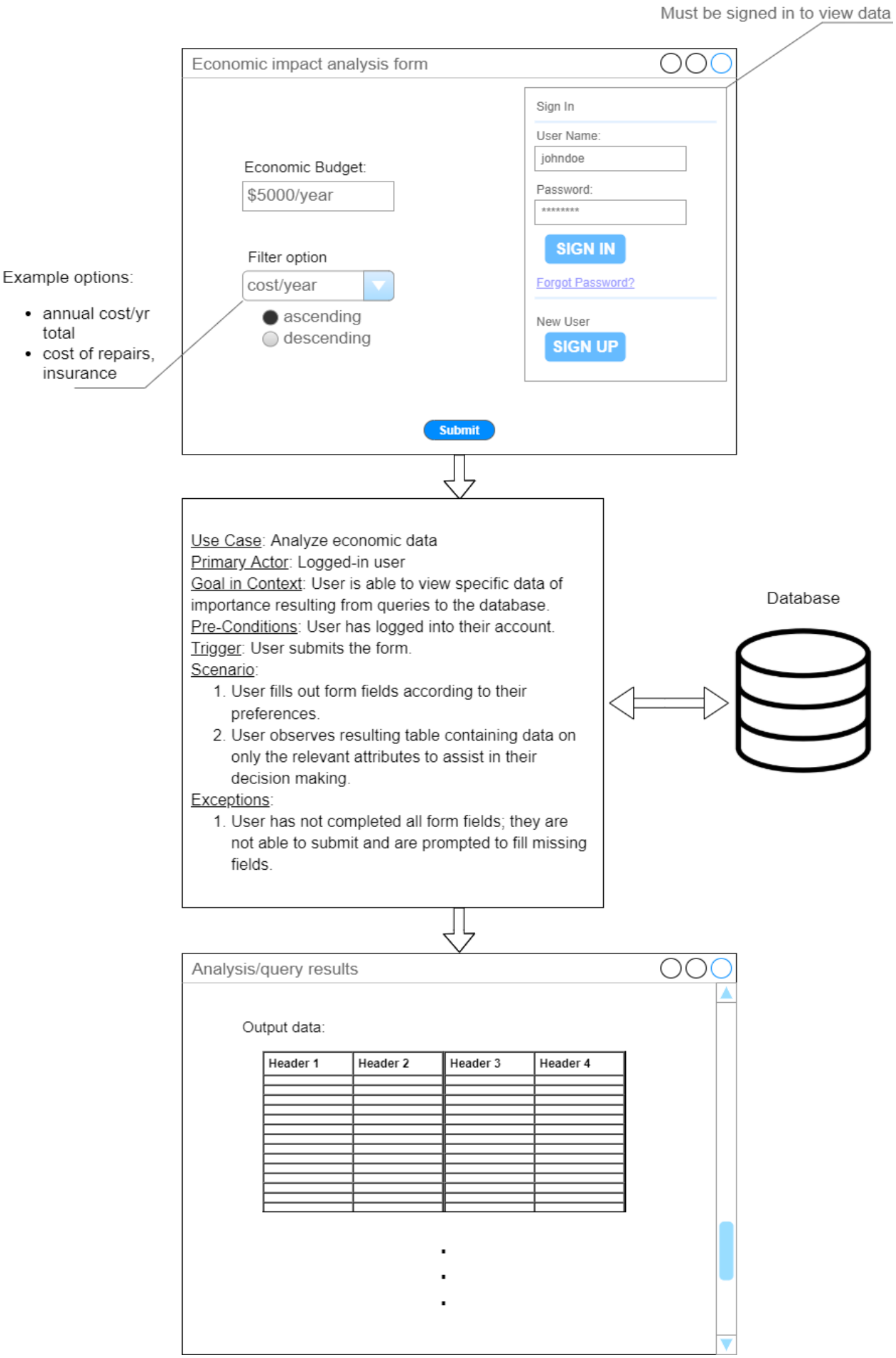
For example, a user would enter the respective budget at the top of the page. From there, they would select the various categories which they wish to analyze, such as the annual cost of owning each vehicle. The user will submit the 'annual cost of ownership' (or another) variable, and the database will display each proposed vehicle in descending order of the cheapest to most expensive vehicle to own on an annual basis.

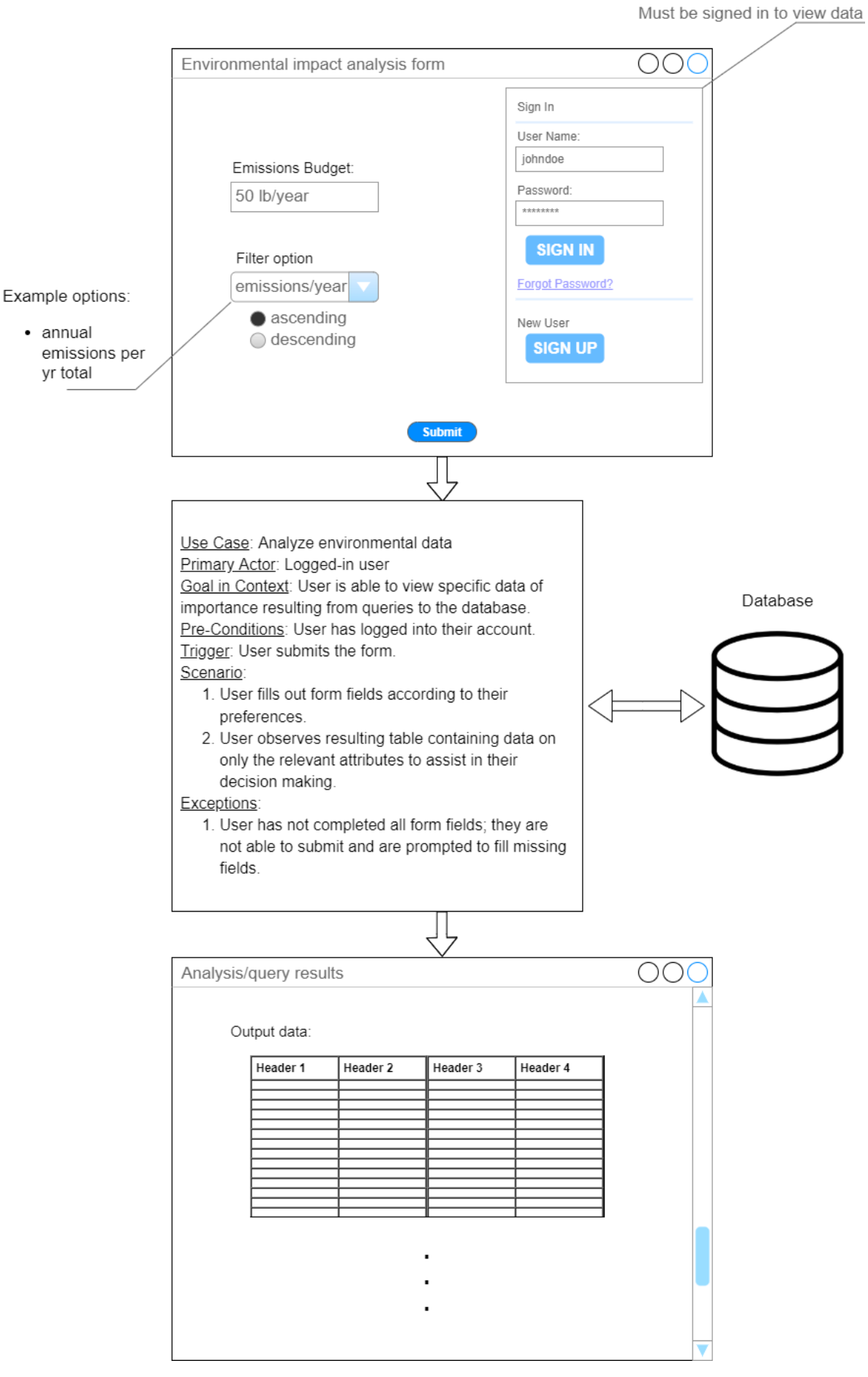
This same process can be used for any desired cost item, such as expected insurance per year, annual cost of fuel, annual pollutant levels, etc.

End product

We will develop a database system that allows for more cost-efficient and sustainable decisions relating to operation of the TCNJ vehicle fleet. A web-based user interface will also be implemented in connection with the database, to allow users to interact with, retrieve, and analyze the data using queries. Users can access this site and fill out fields and submit forms which will query the database, and the retrieved data from there can then be analyzed and displayed to best answer the users' questions about how best to compose the TCNJ vehicle fleet from an economical and environmental standpoint.

Mockups for the user interface where the user can fill and submit forms to view the data in a helpful manner can be seen below. Use cases can also be seen between input and output mockup screens. The first mockup/use case refers to the problem of determining economic impacts of upgrading the vehicle fleet, and the second refers to the problem of determining environmental impacts of upgrading the vehicle fleet:


Must be signed in to view data
Economic impact analysis form
Sign In
User Name:
johndoe
Password:
****
SIGN IN
Forgot Password?
New User
SIGN UP
Economic Budget:
$5000/year
Filter option
cost/year
ascending
descending
Example options:
annual cost/yr total
cost of repairs, insurance
Submit
Use Case: Analyze economic data
Primary Actor: Logged-in user
Goal in Context: User is able to view specific data of importance resulting from queries to the database.
Pre-Conditions: User has logged into their account.
Trigger: User submits the form.
Scenario:
1. User fills out form fields according to their preferences.
2. User observes resulting table containing data on only the relevant attributes to assist in their decision making.
Exceptions:
1. User has not completed all form fields; they are not able to submit and are prompted to fill missing fields.
Database
Analysis/query results
Output data:
Header 1
Header 2
Header 3
Header 4


Must be signed in to view data
Environmental impact analysis form
Sign In
User Name:
johndoe
Password:
****
SIGN IN
Forgot Password?
New User
SIGN UP
Emissions Budget:
50 lb/year
Filter option
emissions/year
ascending
descending
Example options:
annual emissions per yr total
Submit
Use Case: Analyze environmental data
Primary Actor: Logged-in user
Goal in Context: User is able to view specific data of importance resulting from queries to the database.
Pre-Conditions: User has logged into their account.
Trigger: User submits the form.
Scenario:
1. User fills out form fields according to their preferences.
2. User observes resulting table containing data on only the relevant attributes to assist in their decision making.
Exceptions:
1. User has not completed all form fields; they are not able to submit and are prompted to fill missing fields.
Database
Analysis/query results
Output data:
Header 1
Header 2
Header 3
Header 4

Importance and need for the module

The module will facilitate the analysis of which vehicles will provide the most environmentally and financially efficient option for the college. Using cost analysis, we will try and maximize the college's environmental objectives while maintaining the respective budget. Investing in the proper machinery will provide for a cleaner campus environment.

The database and web interface will provide a secure and accessible tool to guide the college on which vehicles to purchase. Given that technology and energy is susceptible to change, our database will provide an initial foundation for storing this type of data as infrastructure for hydrogen and electric vehicles develop.

To elaborate, the main cost determinant of the model is to use the fuel source which maximizes net environmental benefits in regards to cost. The best option may not be the most beneficial to the environment, but will still improve TCNJ's current pollution outputs, and stay within the anticipated budget for TCNJ's fleet.

Within our cost analysis, we can implement a side-by-side comparison of each type of vehicle with respective fuel source (ICE, Hybrid, Electric, and Hydrogen). We can estimate these costs with the three separate time periods as described in the data file (present day, approximately 2030, and around 2040).

Cost inputs we can use for our calculations include fixed costs, such as: Insurance costs per year, depreciation per year*, and estimated service/repair costs. Three fixed capital costs over the lifetime of the vehicle include the initial MSRP cost of the vehicle, any financial rebates (deductions) for environmental benefits, and the anticipated one-time battery replacement of the electric, and potentially hydrogen and hybrid powered vehicles. Variable costs include the given amount of fuel costs based on the anticipated miles driven per year. Mileage driven also impacts the amount of carbon emitted per year, which varies per gallon of a given fuel source.

The cost object is the annual cost of owning each vehicle with respect to estimated useful life of the vehicle. All of the aforementioned variables contribute to the annual cost of vehicle ownership.

* *For depreciation per year, we can utilize depreciation schedules to determine useful life of various vehicles if necessary*

Researching the problem and obtaining data

We will use data provided by Paul Romano on the current makeup of the TCNJ vehicle fleet. The provided data files include information pertaining to operational costs of current and proposed types of TCNJ vehicles, as well as information on what types of vehicles currently make up the fleet, what types are proposed for the near future, and what types are planned to be added in the far future.

To help deepen our understanding of the problem domain, we can conduct more research on different vehicle options that are both environmentally beneficial and economically viable. This research can also consist of researching the types of pollutants that each fuel source emits, and the impacts those emissions have. This information can help to inform decisions in cost analysis, because the user can see both economic costs and environmental costs. This data can also help us to determine how to analyze the data provided by Paul Romano, so we can show the user an output analysis that shows, for example, vehicles with both low costs and low emissions.

Other existing systems

At the moment, TCNJ does not have an application to assist in economic and environmental analysis of the vehicle fleet. Our module will provide this functionality so that the college can use the module to facilitate decisions in the future relating to the campus vehicles.

Other applications of the system

In the future, the database should be able to be modified and upgraded to support new attributes and types of data that may become relevant to the topic of different types of fuel and engines for vehicles. The database can also be expanded upon to also provide support for other similar areas, where financial data may be stored to help when considering cost and budget in other TCNJ projects, not only the vehicle fleet.

Performance

At the moment, performance of our application is not a concern. The data files provided that we will be working with are small in size and should not slow down the app when analyzing data. Efficient organizations of the tables in the database to ensure absence of NULL since they waste space. This will also increase performance.

Security

The database should have restricted access, so that it can only be modified by authorized personnel. Since the database is unique to TCNJ and is not on a network, security is not a serious concern. When the application is handed over to TCNJ, database admins will similarly need a login to allow them access to the database so that no one who is not authorized can modify the database.

Backup and recovery

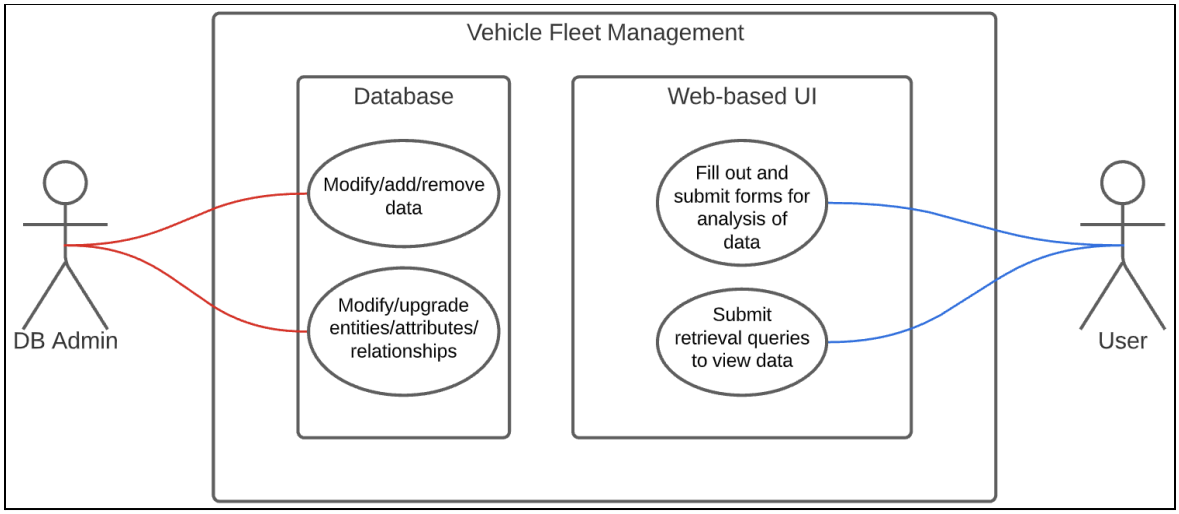
We will be using GitHub to store our application. GitHub is a well-known application for hosting code and managing software development used by many, so there is no concern of losing data that we host there. We will also use virtual machines on the TCNJ High Performance Computing Cluster. The manager of the cluster makes regular backups of all of the VMs, so in the event anything goes wrong we don't have to worry about losing our work.

When the application is handed over to TCNJ, the college can create backups in the same manner it has previously for other applications such as PAWS. It can be backed up physically by TCNJ, and a new private GitHub repository owned by the college could also be maintained.

Technologies and database concepts

Technologies and concepts that we will need to learn and use in the development of this application include git, Github, PostgreSQL, Python, SQL for simple queries to add, manipulate and retrieve data, and making ER diagrams.

System boundary diagram



This system boundary diagram shows the overall domain of our module, which is TCNJ vehicle fleet management. Within this module, we will have a database system as well as a web-based user interface for users to be able to access information about the data.

As seen in the use cases of each of these smaller components, database admins will be able to modify, add, or remove the data that is stored in the database. They can also modify and/or upgrade the database's entities, attributes, and relationships between those. Users can access only the web-based UI, and from there they can fill out forms and submit them to receive analysis of the data to answer their questions. If they wish to see a specific piece of information, they can use a form to submit a retrieval query to view the raw data.

Quad chart

TCNJ THE COLLEGE OF NEW JERSEY

Vehicle Fleet Management

Group 02-4

Need

- Develop a budget that maximizes benefit for environmental and economic reasons
- Application to assist in decisions relating to the vehicle fleet so that they are economical and sustainable

Approach

- Design a database system to store and organize data on vehicle fleet
- Develop application with user-friendly interface to allow access and analysis of data
- Manipulate and analyze data retrieved from the database to help in decision making for the college's budget

Benefit

- This app will help the stakeholders make better decisions from an economic and environmental standpoint
- Help TCNJ to become more eco-efficient
- TCNJ will save more money in the long term

Competition

- Focus on sustainability and environmental impact
- Can assist in more sustainable vehicle fleet operation both economically and environmentally

02/04/22

Vehicle Fleet Management System

Group 02-04:
Jenna Stiesi, Peter Kobasa, Parvathi Krishnan, Jessica Giardiello, Sarah Rulkiewicz, Christina Farah, Joseph Carmichael

Problem statement

- The TCNJ vehicle fleet is composed of many vehicles of different types which all have internal combustion engines
- The current fleet is not as efficient as it could potentially be, both economically and environmentally
- Other types of fuel and engines exist which can lower the cost to maintain the vehicles and reduce CO2 emissions that impact the environment

Objective of the application

- Effective decision making for an environmentally and economically stable vehicle fleet
- Determine eco friendly fuel sources
    - Purchasing strategy:
        - Maximize benefits relating to cost
        - Provides a cleaner campus
- Development of a secure and informative database
    - can hold financial data that can facilitate the analysis of what vehicles to purchase with their respective fuel source(s)

End product

- In the end, we will have database system that allows for a more cost-efficient and sustainable operation of the TCNJ vehicle fleet
- An interactive web-based user interface will also be implemented in connection with the database, to allow users to interact with, retrieve, and analyze the data using queries
- Users can access this site and fill out necessary fields and submit.
    - Retrieved data from the database can then be analyzed to answer the users' questions about how best to compose the TCNJ vehicle fleet from an economical and environmental standpoint.

Importance of this application

- Determine which vehicles will provide the most environmentally and financially efficient option
- Maximize environmental objectives while maintaining the respective budget
- Provide a secure and accessible tool to guide which vehicles to purchase
- Provide a foundation for storing this data as infrastructure for hydrogen and electric vehicles
    - technology and energy are susceptible to change

Researching and obtaining data

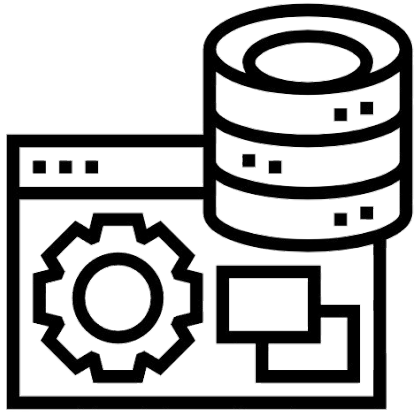
- Use data provided by Paul Romano on the current makeup of the TCNJ vehicle fleet.
- The provided data files include information pertaining to
  - Information on what types of vehicles currently make up the fleet
  - What types are proposed for the near future?
  - What types are planned to be added in the far future?
- Conduct external research on different vehicle/fueling options

Existing systems

- At the moment, TCNJ does not have an application to assist in economic and environmental analysis of the vehicle fleet.
- Our module will provide this functionality so that the college can use the module for decisions in the future relating to the campus vehicles.

Other uses of this system

- System should be able to be modified and upgraded
- May need to support new attributes and types of data in the future
- Future will see new emerging alternative fuels and types of engines/vehicles
- Database can also be expanded upon to provide support for other projects
    - Can store financial data and run analyses to help in cost, budget, environmental impact decisions
    - Does not have to be limited to only the TCNJ vehicle fleet

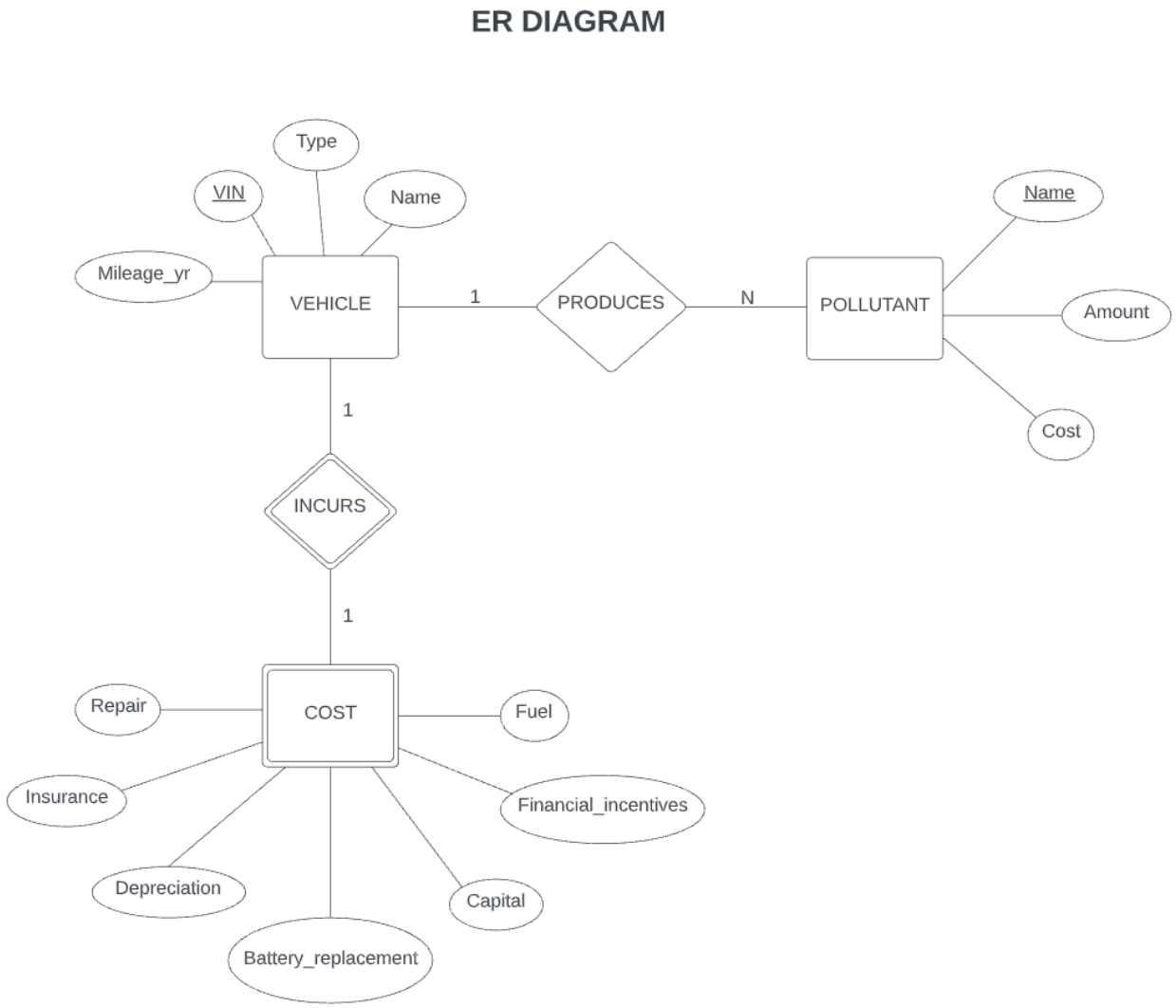


Stage III - Elaboration: Database Model

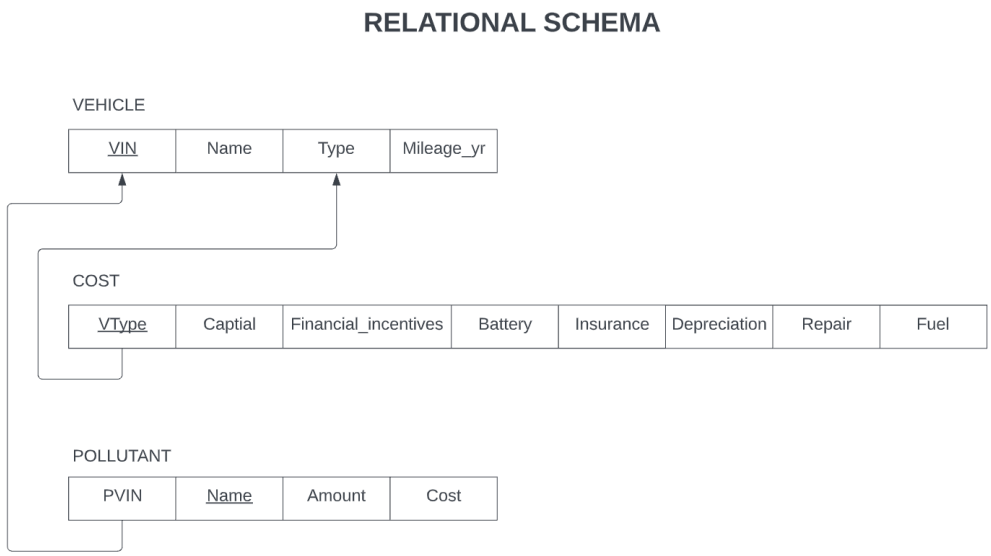
Team 02-4
Jenna Stiesi, Peter Kobasa, Parvathi Krishnan, Jessica Giardiello, Sarah Rulkiewicz, Christina Farah, Joseph Carmichael

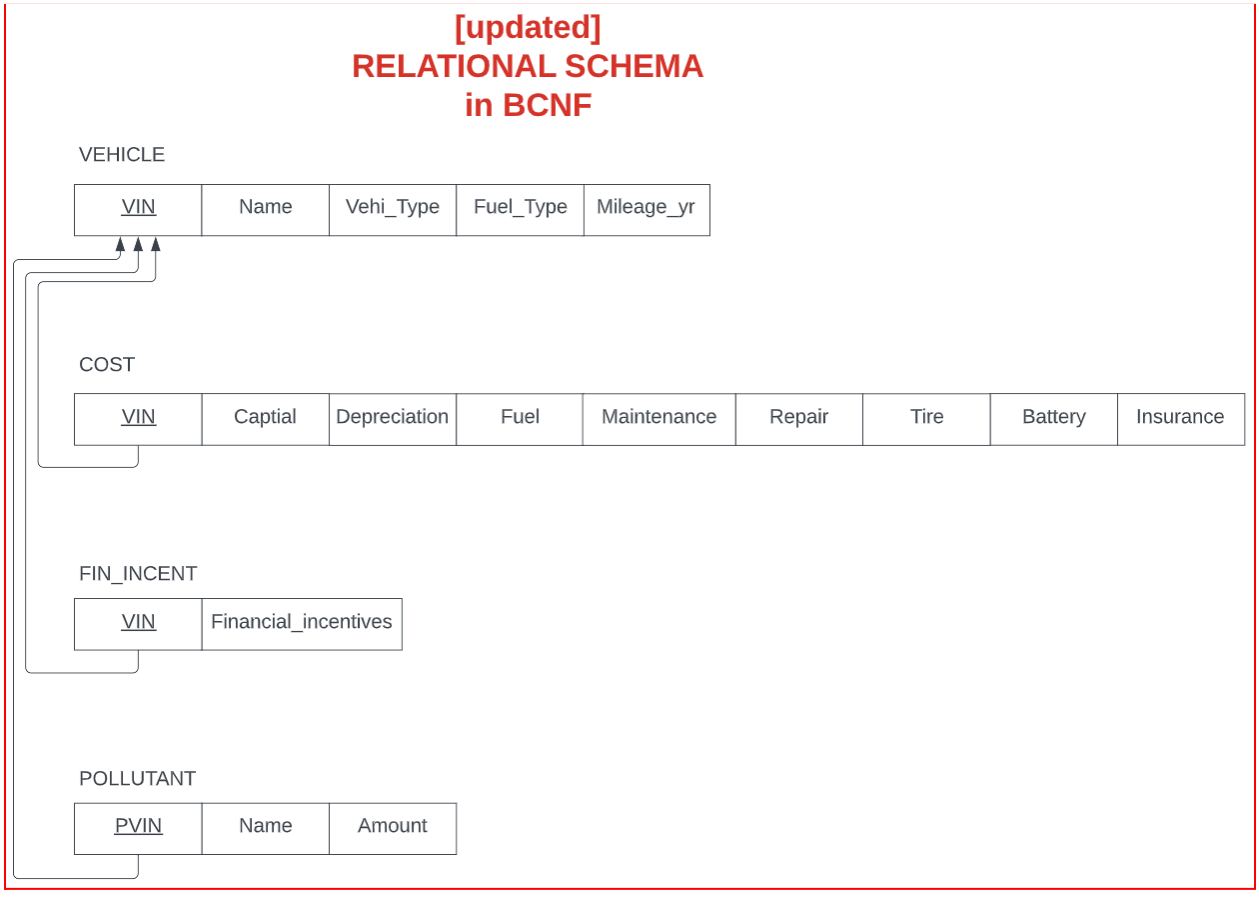
Modifications are shown in red.

ER Diagram:



Relational schema:





See *Stage IV – Elaboration: Database Design* for further details on the updated schema.

Additional estimations:

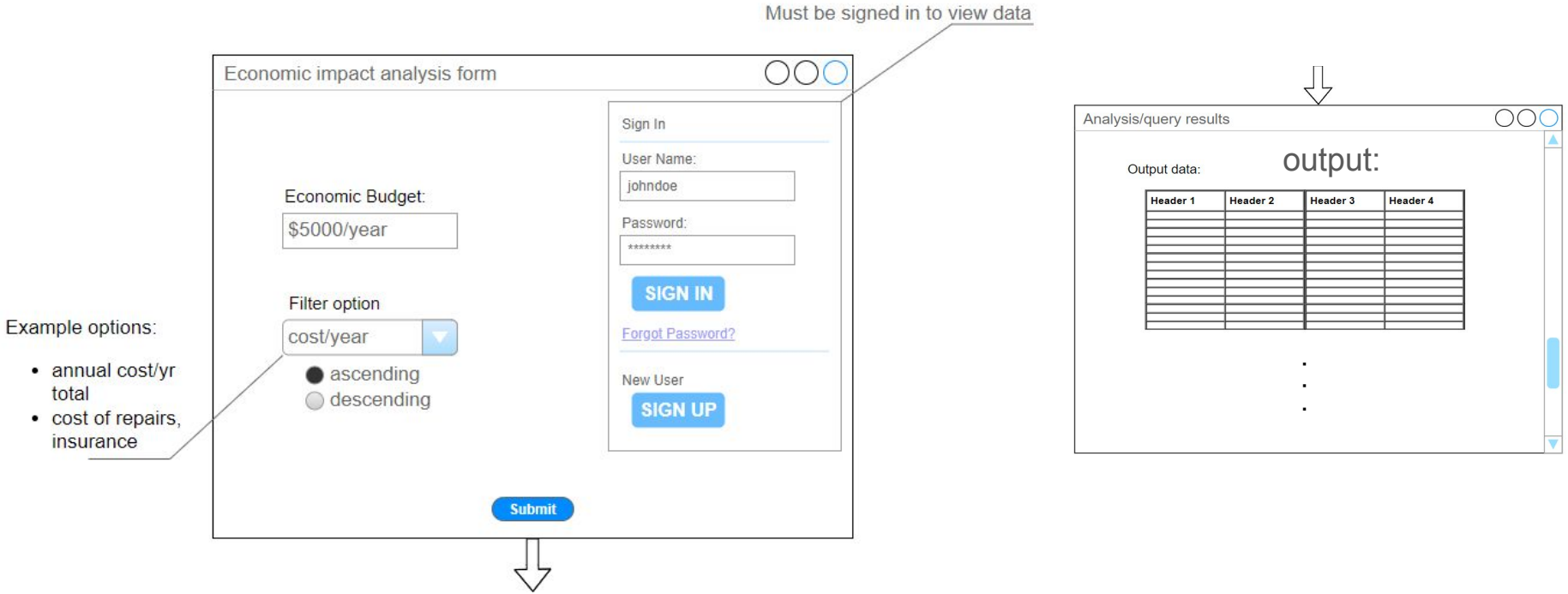
- Based on the data provided by Paul Romano as well as some data we expect to find through our own research, we estimate the database to have around 18 records in each of the vehicle, cost, and pollutant tables, and around 5 in the financial incentives table.
- The types of searches/queries to the database will likely be to see:
    1) types of vehicles and their economic costs based on an input dollar budget amount, and
    2) types of vehicles and their environmental costs based on an input emissions budget amount (in lbs)
- Searches will likely not be done frequently, as a user can make a query, keep the data for their own record, and only check back with the database if data is updated as time passes and new cost and emissions information is available

Mid-Semester Project Presentation

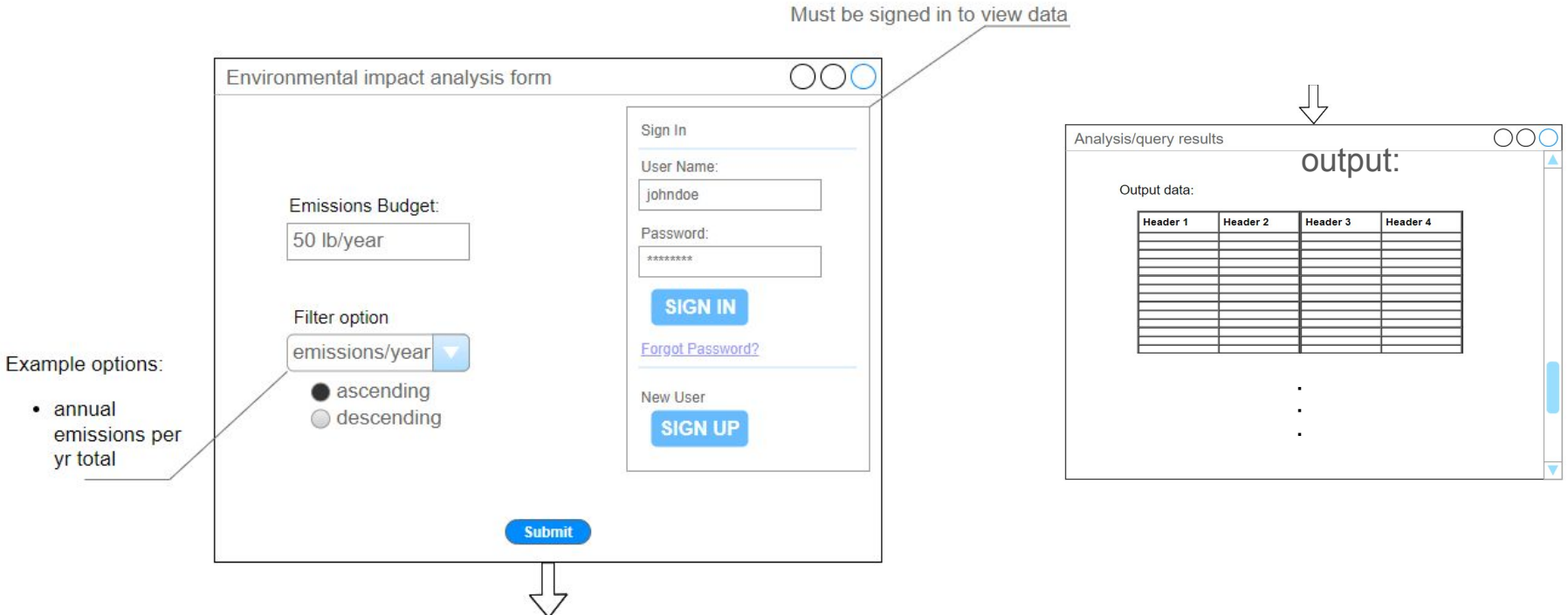
TCNJ Vehicle Fleet Management

Jenna Stiesi, Parvathi Krishnan, Peter Kobasa, Christina Farah, Jessica Giardiello, Sarah Rulkiewicz, Joey Carmichael

Web interface: Economic impact



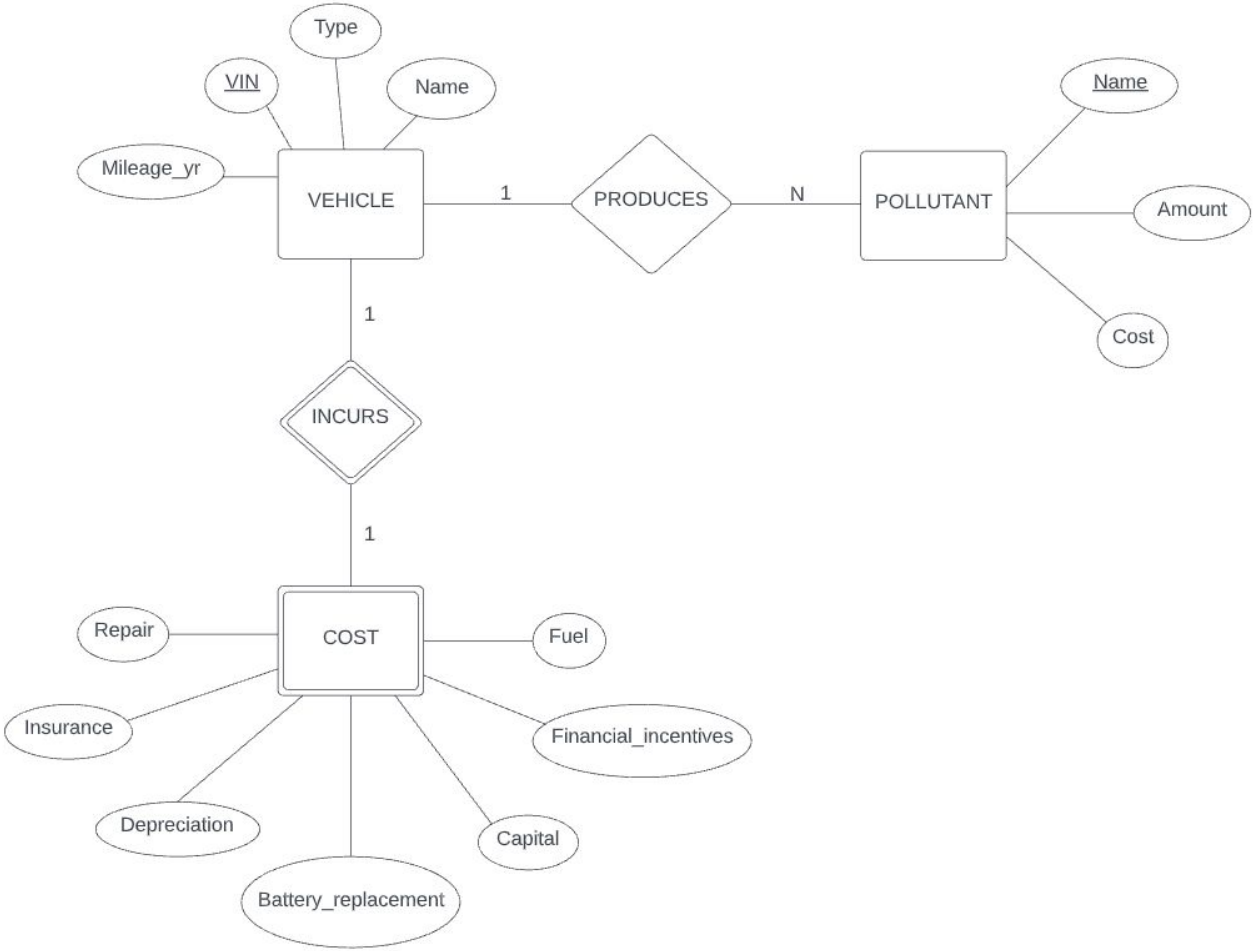
Web interface: Environmental impact



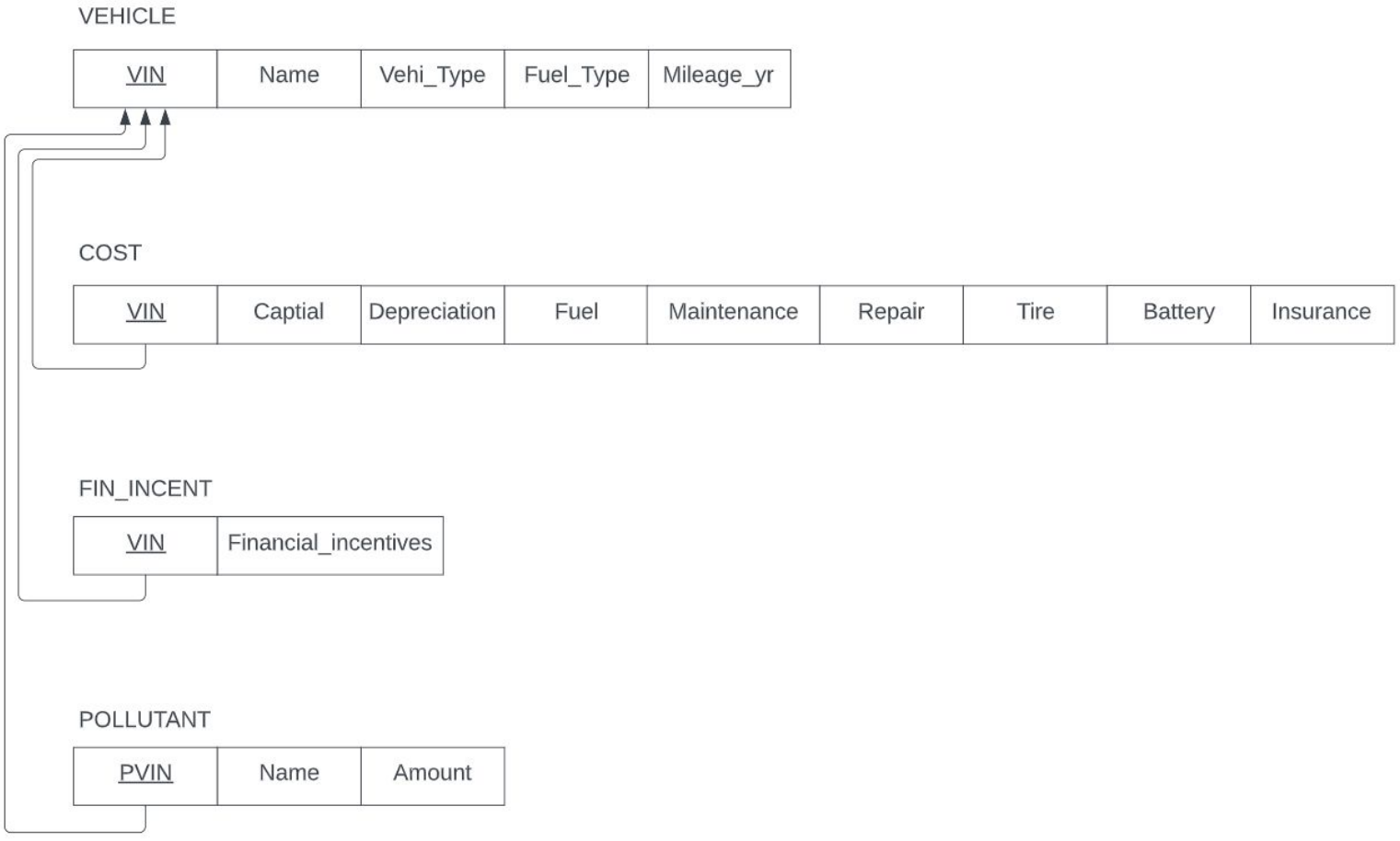
Financial Variables Considered

- Direct, Fixed, and Indirect Costs
  - Direct: Depreciation exp., monthly payments, significant maintenance (tires, brakes, batteries, etc.)
  - Indirect: Unexpected breakdowns, insurance, routine maintenance (oil changes)
  - Fixed: Insurance, depreciation exp., monthly payments, expected routine maintenance
  - Variable: Gasoline, unexpected (significant) maintenance
- Cost Drivers
  - Type of fuel determines how much is spent
  - Size/weight of each vehicle drives up fuel costs
  - Miles driven→ the more miles driven leads to more repair/maintenance costs
- Cost Objectives
  - Annual and total cost of vehicle ownership per year
  - Annual and lifetime pollutants emitted per year

ER DIAGRAM


Type
VIN
Name
Mileage_yr
VEHICLE
1
PRODUCES
N
POLLUTANT
Name
Amount
Cost
1
INCURS
1
COST
Repair
Fuel
Insurance
Financial_incentives
Depreciation
Capital
Battery_replacement

[updated]
RELATIONAL SCHEMA
in BCNF



Questions?

Stage Va – Construction: Tables in PostgreSQL, Queries in SQL

Jenna Stiesi, Parvathi Krishnan, Joseph Carmichael

```
CREATE TABLE VEHICLE(
VIN SERIAL PRIMARY KEY,
Name varchar(50),
Vehi_type varchar(50),
Fuel_type varchar(50),
Mileage_yr integer
);

CREATE TABLE COST(
VIN integer PRIMARY KEY,
Capital integer,
Depreciation integer,
Fuel integer,
Maintenance integer,
Repair integer,
Tire integer,
Battery integer,
Insurance integer,
FOREIGN KEY (VIN)
REFERENCES VEHICLE (VIN) MATCH FULL
);

CREATE TABLE FIN_INCENT(
VIN integer PRIMARY KEY,
Financial_incentives integer,
FOREIGN KEY (VIN)
REFERENCES VEHICLE (VIN) MATCH FULL
);

CREATE TABLE POLLUTANT(
PVIN integer PRIMARY KEY,
Name varchar(50),
Amount integer,
FOREIGN KEY (PVIN)
REFERENCES VEHICLE (VIN) MATCH FULL
);
```

Hand-written insertions for testing

```
INSERT INTO VEHICLE(Name, Vehi_type, Fuel_type, Mileage_yr)
VALUES('Ford Escape', 'Passenger Vehicle', 'ICE', 12000);

INSERT INTO VEHICLE(Name, Vehi_type, Fuel_type, Mileage_yr)
VALUES('Ford Bolt', 'Passenger Vehicle', 'Electric', 12000);

INSERT INTO FIN_INCENT(VIN, Financial_incentives)
VALUES(2, 4000);

INSERT INTO COST(VIN, Capital, Depreciation, Fuel, Maintenance, Repair, Tire, Battery,
Insurance)
VALUES(1, 25555, 2556, 24000, 12000, 5500, 1800, 200, 800);

INSERT INTO COST(VIN, Capital, Depreciation, Fuel, Maintenance, Repair, Tire, Battery,
Insurance)
VALUES(2, 36500, 4050, 6000, 7200, 5500, 1800, 7500, 800);

INSERT INTO POLLUTANT(Name, PVIN, Amount)
VALUES('GHG', 1, 9400);

INSERT INTO POLLUTANT(Name, PVIN, Amount)
VALUES('GHG', 2, 3840);
```

See source code on github or run the application to view user interface implementation.

Transition: Maintenance

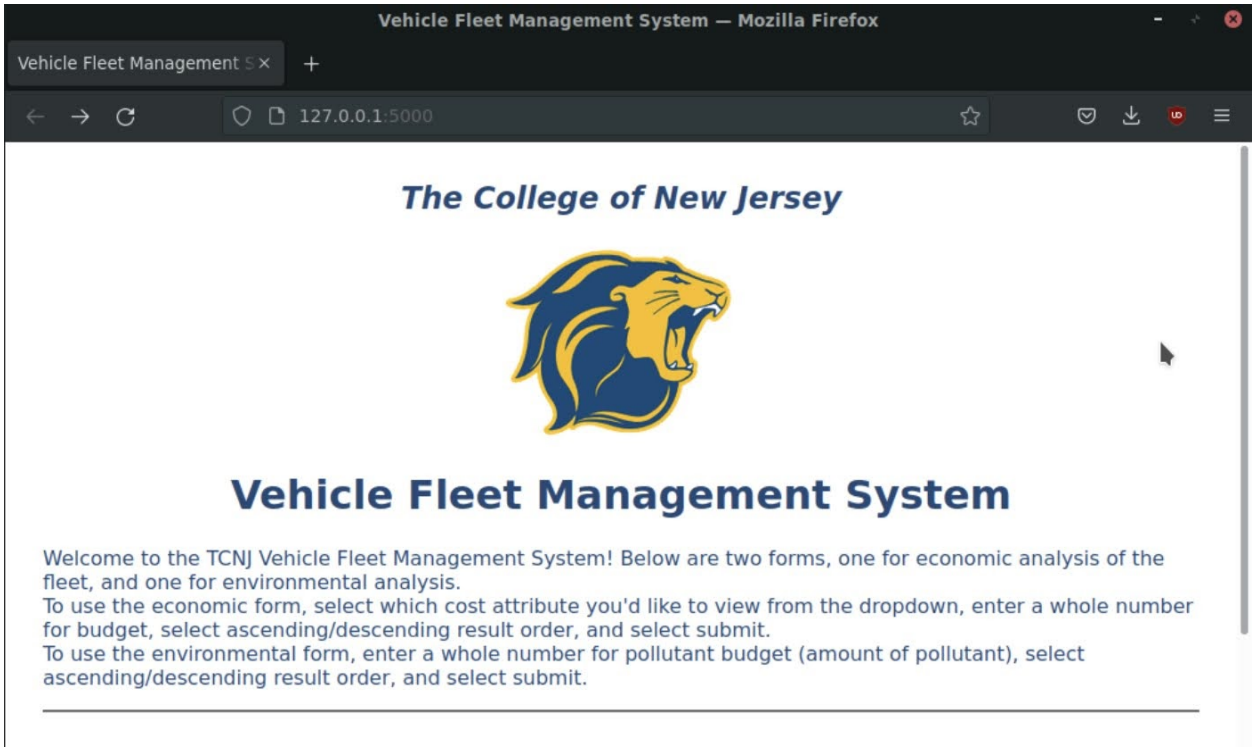
Private GitHub project URL:
Team 02-4
Jenna Stiesi, Peter Kobasa, Parvathi Krishnan, Jessica Giardiello, Sarah Rulkiewicz, Christina Farah, Joseph Carmichael

https://github.com/TCNJ-degoodj/cab-project-02-4

Team 02-4

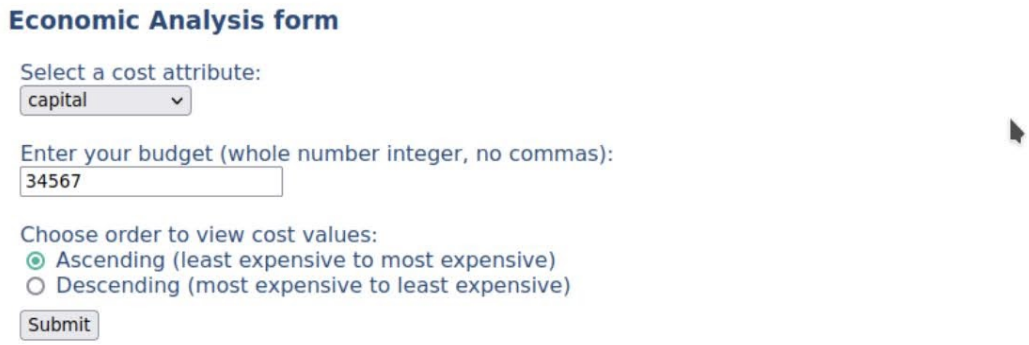
Final application screenshots:

After setting up and starting the application, navigate to the app URL. You should see the home page like below:

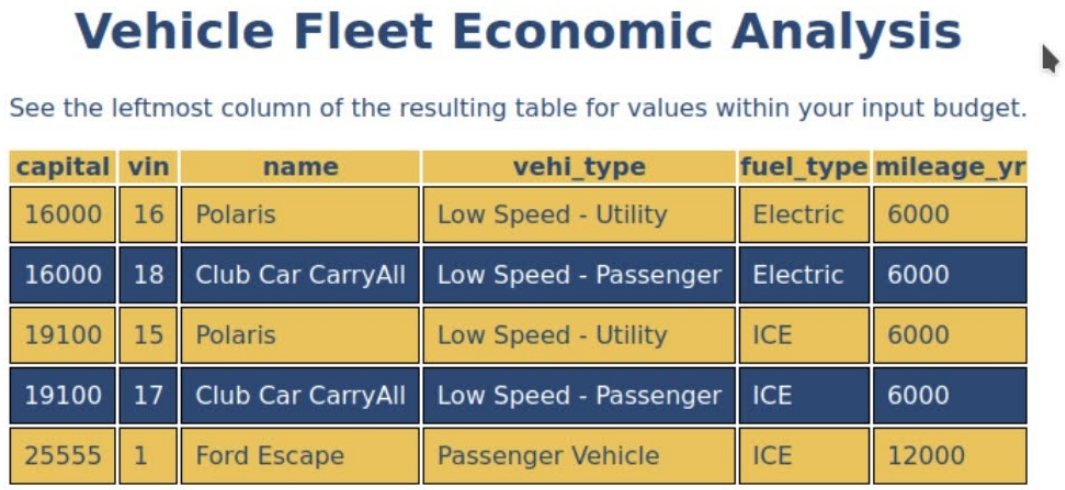


Scroll down on the home page to view the two forms. First is the economic analysis form, which contains three fields.

1. A dropdown menu that pulls column names from the COST table. Select a cost attribute you are interested in analyzing.
2. A budget field so that you are only shown vehicles that have a cost equal to or less than your budget.
3. An option to view results in ascending or descending cost value order.



Upon submitting this form you are shown a results page like below. A table is displayed, with your cost attribute of interest in the leftmost column. Any vehicles that were outside your budget are not shown.



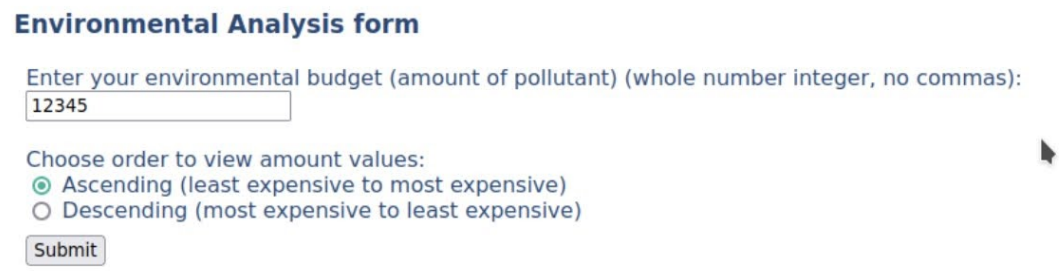
Vehicle Fleet Economic Analysis

See the leftmost column of the resulting table for values within your input budget.

capital	vin	name	vehi_type	fuel_type	mileage_yr
16000	16	Polaris	Low Speed - Utility	Electric	6000
16000	18	Club Car CarryAll	Low Speed - Passenger	Electric	6000
19100	15	Polaris	Low Speed - Utility	ICE	6000
19100	17	Club Car CarryAll	Low Speed - Passenger	ICE	6000
25555	1	Ford Escape	Passenger Vehicle	ICE	12000

Back on the home page, scroll further down to view the second form for environmental analysis, which contains two fields.

1. A budget field so that you are only shown vehicles that have pollutant emission amounts equal to or less than your emissions budget.
2. An option to view results in ascending or descending emissions amount order.



Environmental Analysis form

Enter your environmental budget (amount of pollutant) (whole number integer, no commas):
12345

Choose order to view amount values:
- (•) Ascending (least expensive to most expensive)
- ( ) Descending (most expensive to least expensive)

Submit

Upon submitting this form you are shown a results page like below. A table is displayed, with the emissions amount attribute in the leftmost column, as well as a pollutant name column to the right of the amount column. Any vehicles that have emissions greater than your budget are not shown.

Vehicle Fleet Environmental Analysis

See the leftmost column of the resulting table for values within your input budget.

amount	pollutant.name	vin	vehicle.name	vehi_type	fuel_type	mileage_yr
0	GHG	9	Ford F450	Pick-Up Truck - Med./Heavy Duty	Hydrogen	6000
0	GHG	14	Ford Transit-350 Passenger	Van - Passenger	Hydrogen	6000
1920	GHG	18	Club Car CarryAll	Low Speed - Passenger	Electric	6000
1920	GHG	16	Polaris	Low Speed - Utility	Electric	6000
3840	GHG	11	Ford E-Transit	Van - Cargo	Electric	12000
3840	GHG	2	Ford Bolt	Passenger Vehicle	Electric	12000
3840	GHG	5	Tesla Model 3	Public Safety Vehicle	Electric	12000
3840	GHG	7	Ford F-150 Lightning	Pick-Up Truck - Light Duty	Electric	12000
5222	GHG	15	Polaris	Low Speed - Utility	ICE	6000
5222	GHG	17	Club Car CarryAll	Low Speed - Passenger	ICE	6000

Transition: Product Handover

Public GitHub project URL:

https://github.com/jstiesi/vfleet