
Building a Web App for Automated Vehicle's Energy and Emissions Estimations

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Project Overview and Motivation

- Web app that allows users to input the **speed profile of vehicles** and output different metrics for the user to **compare** across different engine and vehicle types
 - Allows users to make transportation decisions that are **environmentally conscious** and **data-driven**
 - **Key Features**
 - Allowing users to upload **new metrics** and **unique vehicles**
 - Displaying the data in **one graph**, as well as separate
 - Add the **particulate matter** metric to display on the graphs
-

Requirements and Deliverables

Required skills: Python, text processing, web application development, visualization, automation



Full Stack Web App

Including...

- automated metric and vehicle upload
- combined graph of energy emission data for each type of car

Website Source Code

Including...

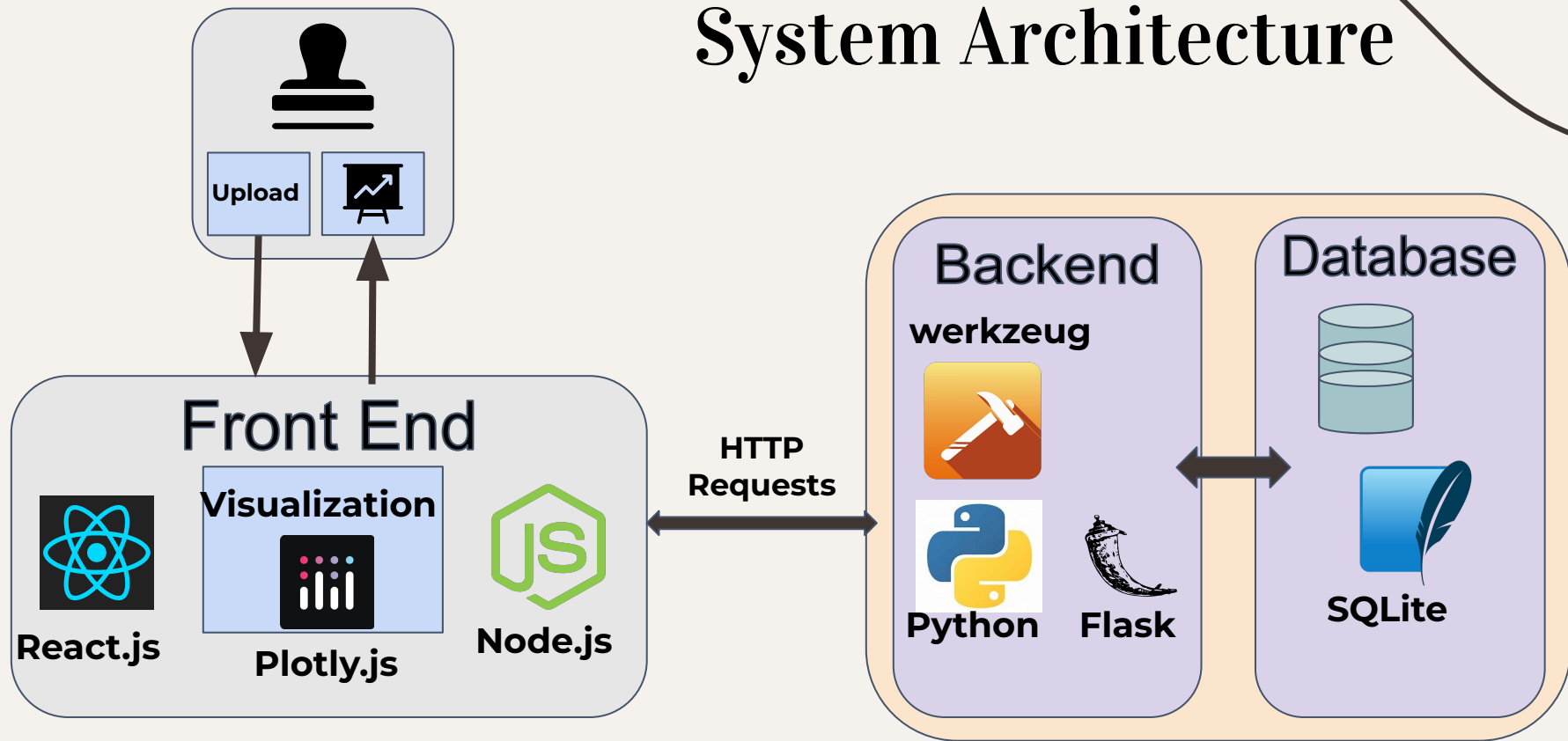
- support for the previous mentioned features
- an intuitive UI

Documentation

Including...

- technology used
 - features
 - how to run the system
 - design and implementation information
-

System Architecture



Technologies

- **Frontend**

- React
- Node.js
- ~~Chart.js~~ -> Plotly.js **

- **Backend**

- Python
- Flask
- Werkzeug

- **Database:** SQLite

- **Deployment:** Docker

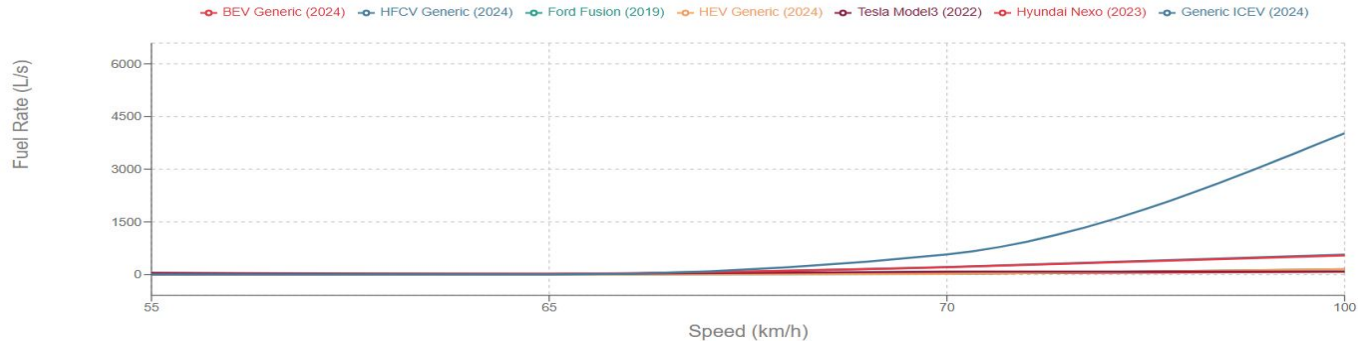
Graphs Together

- **Previous Implementation:** vague vehicle types on graphs, no combined metric graphs and ability to add metrics
- **Current Feature:** Added a combined metric graph to analyze multiple metrics and vehicle together

Test

Metric:

Fuel Rate



Metric Feature

- **Previous Implementation:** Given the speed date, the fuel rate, fuel economy, power output, and energy efficiency can be measured for each vehicle type (we also added Particle Matter)
- **Current Feature:** Users can **add a new metric** that is measured based on the speed profile of different vehicle types
- If a metric **doesn't apply** for a specific vehicle or engine type...

Particle Matter (micromet)



HEV Generic (2024)

Metric:

Particle Matter

No data available for visualization

Add a New Metric

Input the name and units for the metric.

Download the Python template file to add a new calculation.

Upload the completed template to then be able to see your metric in the collections visualization dashboard.

Click "Submit Metric" Button.

Enter a name for the new metric

Summing

Enter the units for the new metric

in

Enter a unique model name that matches the one in the template file

model1

Click to download the .py template file that you can fill out to add a new calculation

Download Template File



Click to upload your completed template file

.py file only

Upload File

Submit Metric

BEV Generic (2024) HFCV Generic (2024) Ford Fusion (2019) HEV Generic (2024) Tesla Model3 (2022) Hyundai Nexa (2023)

Summing (in)

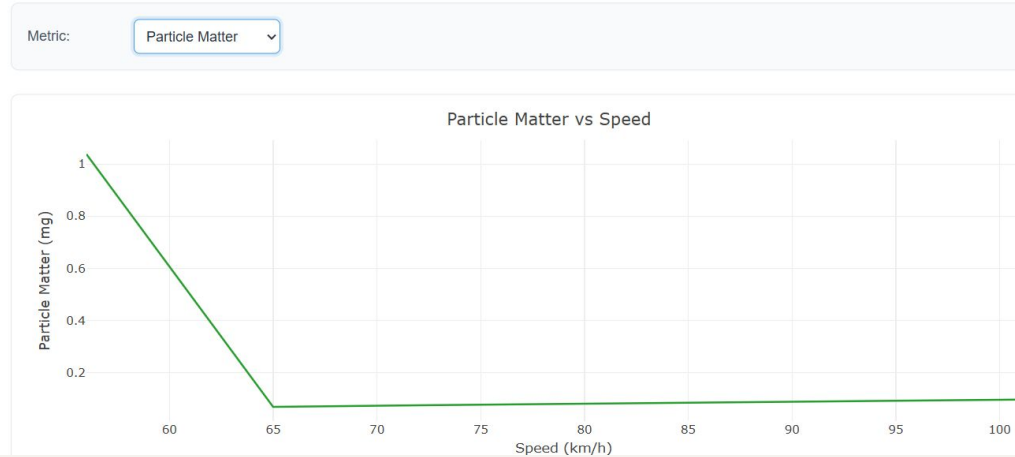


Speed (km/h)

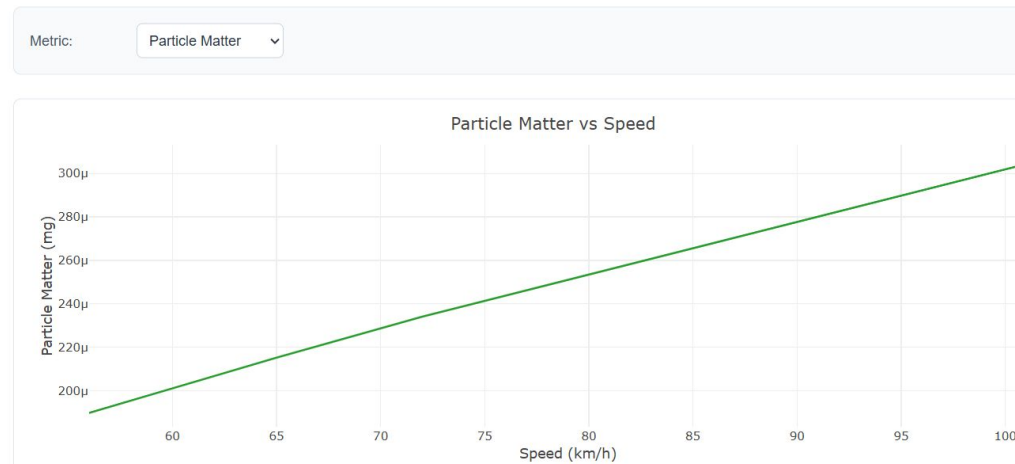
Particle Matter

- **What is it?:** Mix of **solid and liquid particles** that are released in the air when fuel is burned
 - Reduces air quality
- **Our Task:** **Calculating** the particle matter for vehicle and engine types and **displaying** in the graph(s)
 - Excluding cars that we cannot display the PM of

Generic ICEV (2024)



BEV Generic (2024)



Vehicle Feature

- **Previous Implementation:** Only supported adding and editing generic engine parameters (BEV, HFCV, HEV, ICEV).
- **Current Feature:** Users can **add a new vehicle** that has a unique set of parameters. Vehicles can be viewed, with parameters being editable and whole profiles being deletable. The user can also easily view the specific vehicles with each type of engine, helping with analysis.

Vehicle Identification

Column 1: Engine type:

- 1: ICEV (Internal Combustion Engine Vehicle)
- 3: BEV (Battery Electric Vehicle)
- 6: HEV (Hybrid Electric Vehicle)
- 7: HFCV (Hydrogen Fuel Cell Vehicle)

Physical Properties

Column 2: Vehicle mass (kg)

Column 3: Vehicle length (m)

Column 4: Mass proportion on tractive axle

Column 5: Coefficient of friction

Column 6: Engine power (kW)

Column 7: Maximum battery power (kW)

Operation Parameters

Column 9-13: Performance coefficients

Column 14-16: Driver and gear parameters

Column 17-22: Battery and motor parameters

Column 23-25: Power management

Column 26-29: Model coefficients (α_0 - α_3)

Vehicle Feature

Available Vehicles

Internal Combustion Engine Vehicle

Make	Model	Year	Actions
Generic	ICEV	2024	<button>Edit</button> <button>Delete</button>
Toyota	Corolla	2024	<button>Edit</button> <button>Delete</button>

[Add New Vehicle](#)

Available Vehicles

Internal Combustion Engine Vehicle

Make	Model	Year	Actions
Generic	ICEV	2024	<button>Edit</button> <button>Delete</button>

[Add New Vehicle](#)

localhost:3000
 really delete this vehicle?
OK Cancel

Edit Vehicle

Engine Type:
Internal Combustion Engine Vehicle

Make:
Generic

Model:
ICEV

Year:
2024

Param String:
0 1 1500 4.50 0.60 0.015 100 100 0.92 0.30 2.20 0.015 4 0 0 3.50 0 0 0
0 0 0 0 0 0 0.01 0.02 0.03 0.00

Save Cancel

Add New Vehicle

Engine Type:
-- Select --
Internal Combustion Engine Vehicle
Battery Electric Vehicle
Hybrid Electric Vehicle
Hydrogen Fuel Cell Vehicle

Year:

Param String:

Save Cancel

Vehicle Parameters

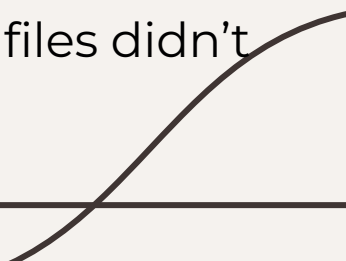
Current vehicle configurations and their parameters.

ID	Type	Make	Model	Year	Mass (kg)	Length (m)	Mass Proportion	Friction Coef.	Engine Power (kW)	Battery Power (kW)	Trans. Efficiency	Drag Coef.	Front Area
18	BEV	BEV	Generic	2024	4.75	0.6	0.5	317	317	0.92	0.23	2.652	1.75
20	HFCV	HFCV	Generic	2024	1,858	4.89	0.6	0.5	113	113	0.92	0.28	2.372
22	HEV	Ford	Fusion	2019	1,600	4.3	0.62	0.77	140	160	0.87	0.3	2.4
29	ICEV	Generic	ICEV	2024	1,500	4.5	0.6	0.015	100	100	0.92	0.3	2.2

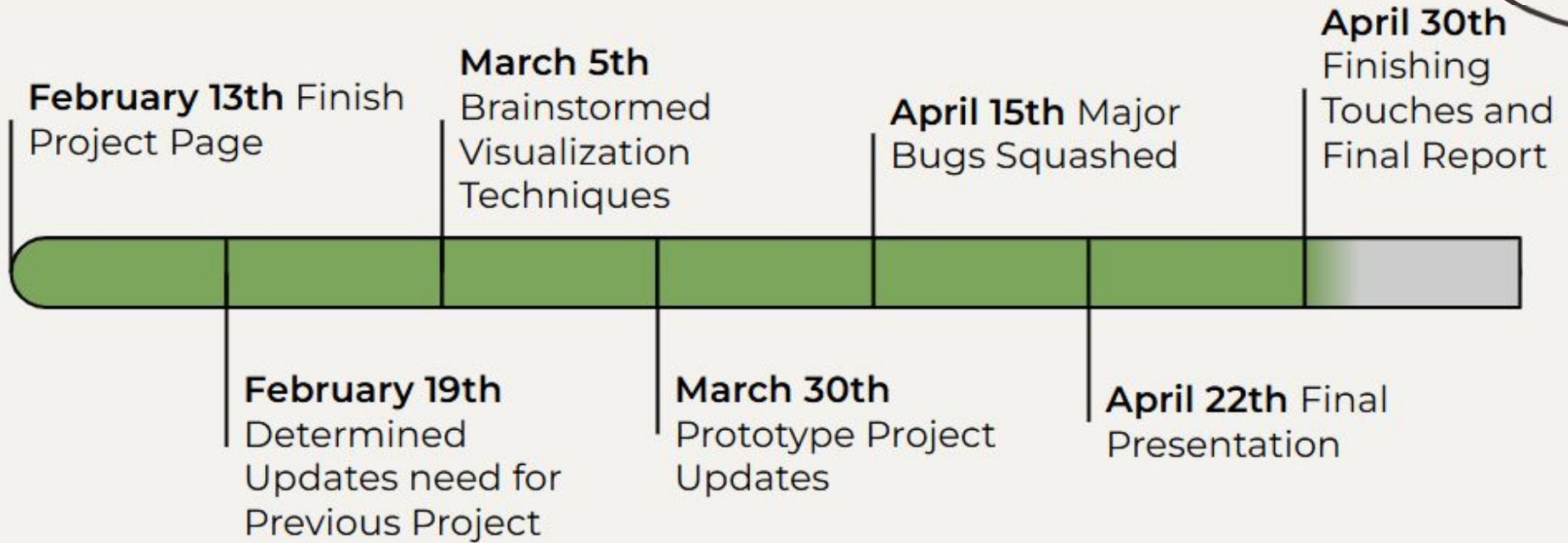
Problems

- 1) Merging together features developed in **parallel**
- 2) Issues with understanding and finding errors in **legacy** code
- 3) How to display graphs when a metric that **doesn't apply** is selected (especially for combined graph)
- 4) **Converting** fortran code measurements to python
- 5) Vehicle parameters table had **misaligned** columns

Solutions

- 1) **Manually** merge code
 - 2) Lots of **console.log** and **print** statements to understand what was going on
 - 3) Display a **not available message** or just have that vehicle or engine type **not appear** on the combined graph
 - 4) **Researching** fortran methods and their python equivalents
 - 5) Ensure css in different files didn't **conflict**
- 

Timeline



Future Work

- **Current Design:** Default collections that show data about main street and I-81
- **Future:** Allow users to search for there state (or city) and see **public collections** that have data about roads in their state (or city)
- People who collect similar data in other states could **crowdsource** their data to allow the data set to grow



Main Street

Street in Blacksburg

Created: 12/2/2024

Analyze

Download

Edit

Delete



I-81

Highway in VA

Created: 12/2/2024

Analyze

Download

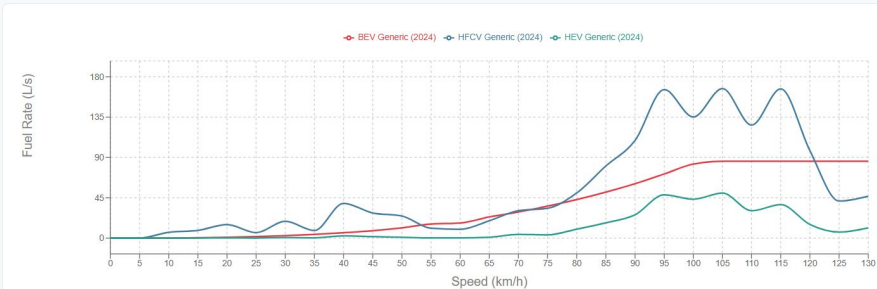
Edit

Delete

Main Street

Street in Blacksburg

Metric: Fuel Rate



Client: Dr. Farag

Acknowledgements:

Thank you to Dr. Farag for guiding us and providing background and details for this project!



Research references

[1] C. Quinn, L. Scott, C. Chao, E. Tapia, and R. Batra, “Building Web App for Automated Vehicles Fuel/Energy Estimation,” *Vt.edu*, Dec. 16, 2024.

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[3] EPA, “Particulate Matter (PM) Basics,” *United States Environmental Protection Agency*, Jul. 11, 2023.

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