EV Energy Analytics System

Group #2 Capstone Project

Dorian Luckie
Anam Mahmood
Kolbe Setzer
Ezekiel Redmond
Hien Pham
Daniel Dominguez

IS 436 Structured Systems Analysis and Design

Final Integrated Capstone Project Deliverable

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Executive Summary

Electric Vehicles (EVs) produce data at such a high rate that the current cloud processing infrastructure used by manufacturers cannot efficiently process the data. Manufacturers need to collect, compile, and process the EV data with the intention of identifying and increasing development for aspects of Evs that are underperforming, such as energy consumption. As a part of the IS 436 capstone project, our team of analysts at UMBC recommends that EV manufacturers shift away from their current cloud processing infrastructure in favor of using Microsoft's Azure Cloud as the infrastructure for their EV data processing.

Our group interviewed Anastasia Reitz, a cloud specialist at Microsoft, who helped us identify a business problem and prompted our collaboration to identify a potential solution. With her assistance, we were able to identify that cloud engineers had to constantly monitor the current architecture for crashes and system instability due to the sheer volume and velocity of data, which required them to shift attention away from other more pressing work and strategic projects at Microsoft. Based upon our conversations with Ms. Reitz and provided artifacts we created three primary use cases to suggest common functional requirements. These were: Update Charging Station, Generate EV Report, and Determine Charging Station Placement. Thus, these use cases allow cloud engineers to leave the new system unmonitored because of the system's new, smaller and more integrated software processes. To make these processes easier to visualize, we created data flow diagrams, a context, a level 0 and five level 1 diagrams for the new system. The resulting analysis and diagrams culminated in the design of an information system titled: The EV Energy Analytics System. We hope this capstone project serves as a potential future basis for Ms. Reitz's ongoing efforts at Microsoft to identify architecturally sustainable solutions in the new era of electric vehicles.

Finally, as a part of the capstone project alternative matrixes were used to portray realistic system design considerations and their capabilities to address alternative actions and how they might potentially benefit future development. Additionally, our Entity-Relationship Diagram portrays the digital connection between processes and the EV Energy Analytics System. Our first Alternative Matrix presented three design alternatives based on the technical, economic, and organizational benefits for organizations to consider in terms of system adoption, with information breakdowns to support each alternative. The second Alternative addressed the non-functional requirements with a breakdown of the operations, performance, security, and cultural/political requirements for each, as describing the best system's architecture for each. Using the Level 0 diagram created, Team 2 develops another Level 0 diagram showing the physical process models, as well as a physical ER Diagram modeled from the digital ER Diagram. Utilizing the physical ER Diagram and Level 0 diagram, Team 2 also developed user interfaces for the processes that were deemed integral to the overall system.

In conclusion, Section 1 includes the Systems Request which summarizing the business need and motivations to initiate the project. Section 2 includes the Requirements Definitions & Use Cases, a formalized requirements specification for the information system and its use cases. Section 3 presents the Process Modeling Documentation which breaks down the system into each of their digital processes using data flow diagrams and a data dictionary sample. Section 4 provides two Alternative Matrix Diagrams and an entity relationship diagram within the Data Modeling Document. Section 5 presents the User Interface, Physical Process & Data Models, depicting how the system shall be presented and how physical process will interact.

SECTION 1: SYSTEMS REQUEST

SECTION 1.1: PROJECT SPONSORS

The sponsors for this Capstone project will be the following members of Group #2: Dorian Luckie, Anam Mahmood, Kolbe Setzer, Ezekiel Redmond, Hien Pham, and Daniel Dominguez. The site correspondent for this Capstone project will be Anastasia Reitz, a Senior Cloud Solution Architect working at Microsoft, who can be contacted via email at anastasiareitz@gmail.com. The paragraphs below contain small bios about the sponsors for this project.

SECTION 1.2: BUSINESS NEEDS

This project has been initiated at Microsoft to address the usage of cloud environments to process the Big Data gathered by electric cars by providing Infrastructure(s) as a Service to manufacturers who cannot process the Big Data produced by electric-powered cars. New infrastructure provided by Microsoft is essential as society shifts towards electric-powered cars that continually produce data in the form of spatial maps, autonomous driving data, etc.

SECTION 1.3: BUSINESS PROBLEM SUMMARY

The current problem that electric vehicle manufacturers are facing is the inability to quickly and efficiently process the energy usage data that is produced by their electric vehicles. Their current system bottlenecks and stutters forcing the manufacturer to have an engineer watching over the system at all times, which takes them away from developing other projects.

SECTION 1.4: BUSINESS ASSUMPTIONS

Team 2 assumes that electric vehicle manufacturers want a data analytical system that shall quickly and efficiently process energy usage data, with the capability to create and send energy usage reports to consumers and other businesses.

SECTION 1.5: BUSINESS RECOMMENDATIONS

Team 2 recommends that electric car manufacturers use Microsoft's Azure Cloud to develop new infrastructure with capability to efficiently process and create reports using the energy usage data from electric vehicles and charging stations.

SECTION 1.6: BUSINESS REQUIREMENTS

Currently, electric car manufacturers are using infrastructure that are underpowered and inefficiently process the energy usage data coming from electric cars and charging stations. New infrastructure provided by Microsoft, via cloud environments, provides those manufacturers with the power and space to efficiently process the energy usage data coming in.

SECTION 1.7: BUSINESS VALUE

Developing a new energy usage analytical system using Microsoft's Azure cloud infrastructure would yield a completely autonomous system that shall quickly and efficiently process energy usage data and have the capability to generate energy usage reports following standardized guidelines.

SECTION 1.8: SPECIAL ISSUES & CONSTRAINTS

There are issues and constraints that need to be recognized that raises this system's priority level. Primarily, California lawmakers passed a law mandating that by 2030, all cars on the road must be electric cars and produce zero carbon emissions. Secondly, current systems utilized by electric car manufacturers are unable to process Big Data to such a degree that those manufacturers require engineers to be on standby to fix the systems when they bottleneck and/or crash due to the data. The new infrastructure shall not be running 24/7 to undergo maintenance during periods of low data traffic.

SECTION 1.9: TEAM BIOS

Hello, my name is Dorian Luckie, my email is luckid1@umbc.edu and I will be serving as the D1 Lead and D5 admin for Group #2's capstone project. I am a Senior Information Systems major, Africana Studies minor, and Friend of the Meyerhoff Scholars Program. I have experience as a Network Engineer, from my recent internship where I designed, implemented, and maintained networks for companies, and with a variety of programming languages, Python, Java, and SQL, that I have been able to apply to some job environments. In my free time, I enjoy playing video games, watching anime, and reading comics.

My name is Anam Mahmood, my email is anamm2@umbc.edu and I will be the D2 Lead and D1 Admin for Group #2's project. I am a senior in the Information Systems major and I am currently in my last semester. I don't have much experience in the Information Systems field as my past work experience consists of administrative positions and education. However, after graduation I would like to pursue some kind of entry level position as a systems analyst. My goal is to familiarize myself with all deliverables in this project, not just the one I signed up for, so that I may be better prepared for a future job's potential demands.

My name is Kolbe Setzer, I am a senior IS major, and I can be contacted via my email ksetzer1@umbc.edu. I work on campus as a tour guide and off campus as a server at a restaurant in Baltimore city. In addition to being a tour guide, I am also a digital media for the Women's Basketball team and a broadcasting intern as well. I am the event coordinator for the black student union and the treasurer for the black men's society on campus. I will be serving as one of Group #2's D3 Leads and the D2 Admin.

My name is Ezekiel Redmond, I'm an undergraduate at UMBC studying Information Systems, and I can be contacted via my email op29172@umbc.edu. I'm currently a senior set to graduate this semester with my bachelor's degree. I've got an extensive experience of varying coding languages with an aptitude for software development, and a desire to get into A.I. development. For our project, I will be our team's D3 Lead and one of our D5 Admins.

My name is Hien Pham, but my friends call me Harvev and I can be contacted via my email hpam4@umbc.edu. I am a senior majoring in Information Systems. Furthermore, my dream job is to be a data analyst. Some of my hobbies are swimming, fishing, and playing video games. In Group #2, I will be serving as the D4 Lead and D3 Admin.

My name is Daniel Dominguez, I am a Senior at UMBC in Information Systems and I can be contacted via my email bq72053@gmail.com. I am currently employed as a Software Engineer Intern in Full-Stack Development. My professional interests are AI and ML. Some of my hobbies are mountain biking, rock climbing, and snowboarding. I will be serving as the D5 Lead and D4 Admin for Group #2.

SECTION 2: REQUIREMENTS DEFINITIONS & USE CASES

SECTION 2.1: REQUIREMENTS DEFINITION

The following is a list of requirements that must be met for the new system to operate as intended. It includes both functional and nonfunctional requirements for Microsoft's Tracking EV (Electric Vehicle) Energy Usage Initiative. In the context of this initiative, a functional requirement should aim to streamline the process needed to produce the data gathering deliverable. For the nonfunctional requirements, these would include criteria, dependencies or constraints on the system intended to achieve the desired performance or result.

SECTION 2.2: FUNCTIONAL AND NON-FUNCTIONAL REQUIREMENTS

SECTION 2.2.1: Functional Requirements

1. **Process-oriented** - EV charging stations shall be able to communicate with Microsoft through a virtual private network (VPN) over a secure network connection.
2. **Process-oriented -** The system shall have access to data analytics tools in order to generate the needed reports.
3. **Process-oriented -** The system shall automatically generate weekly reports on total energy used by EV charging stations.
4. **Information-Oriented** – The system shall contain archiving capabilities such that Microsoft can refer back to previously logged data in order to inspect trends or conduct historical data analysis.
5. **Information-Oriented** – The system shall automatically send generated reports to the designated business analysts.
6. **Information-Oriented** – EV charging stations shall receive data package from EV including date and time of transaction, make and model of vehicle, amount of energy consumption (in kWh), etc.
7. **Process-oriented -** The system shall allow analysts to view generated reports on demand.
8. **Information-Oriented** – The system shall contain a digital dashboard display of all reports.

SECTION 2.2.2: Non-Functional Requirements

1. **Cultural and Political -** The system shall abide by government regulations.
2. **Cultural and Political -** Users shall reserve the right to not have data collected by the system.
3. **Operational -** Microsoft shall have a designated server space for all collected data.

4. **Operational -** The system shall be compatible with Microsoft's cloud infrastructure.
5. **Security -** The system shall only be accessible to authorized Microsoft employees.
6. **Security** - The system shall not leak unnecessary data, such as personal information, into the cloud storage.

SECTION 2.3: INTERVIEW GUIDE & SUMMARY

The following is an interview guide created to elicit the system requirements from our site contact. The purpose of these interviews is to obtain an understanding of the current as-is system and the goals of the project. Our primary objective for the interviews is to gain an understanding of what the to-be system shall look like and the expectations of how it should be performed.

Interviewers: Anam Mahmood (D2 Lead) and Dorian Luckie (D1 Lead)

Interviewee: Anastasia Reitz, Microsoft Solutions Architect

SECTION 2.3.1: Interview #1

Interview #1 Details: Saturday, February 26th, 2022 at 10:00 A.M. over WebEx

Interview Questions

1. Can you please explain to us your role at Microsoft? **(Open-ended)**
   a. 34 years of experience, currently is a solution tech at Microsoft
   b. Specializes in cloud computing and quantum computing (specifically Microsoft Azure)

2. What kind of data do you process? **(Open-ended)**
   a. Big data ranging anywhere from the healthcare industry to electric vehicles

3. Where do you tend to run into problems when processing said data? **(Open-ended)**
   a. Processing big data is difficult for quantum computing (hardware cannot keep up with software specs)
   b. Bottlenecking issues
   c. Human error can also cause problems when processing data

4. How often do you face these issues? **(Close-ended)**
   a. Whenever the need arises to process big data (multiple times a day)

5. Who and what are directly affected by these issues? **(Close-ended)**

   a. The analysts who work with said data

6. What effects do these problems have on your overall productivity/ability to meet your goals? **(Open-ended)**
   a. Reduced efficiency

7. Have these issues been addressed before? If so, how? **(Open-ended)**
   a. Yes, by upgrading servers

8. Is there anyone else at your company who would be willing to interview with us on this topic? **(Close-ended)**
   a. We unfortunately will not be able to perform an interview with a second individual from Microsoft

9. Is the system running as a PaaS, IaaS, or SaaS? Would changing the service type affect data processing? **(Open-ended)**
   a. Iaas, a shift to a cloud computing environment would not change the system; would remain as an Infrastructure as a Service

*The interviewee provided the following information in addition to the above questions which helped guide our second interview:

Microsoft's main goal as an organization is to enable everyone throughout the world to realize their full potential. They believe all cars should be electric vehicles by 2030. To realize this goal, they need to track EV usage and energy consumption to better equip the public with the resources they need to make this possible.

SECTION 2.3.2: Interview #2

Interview #2 Details: Saturday, March 5th, 2022 at 10:00 A.M. over WebEx

Interview Questions

1. Why does Microsoft need the electric vehicle data? **(Open-ended)**
   a. Microsoft needs EV data to help improve the future of businesses and consumers in order to align with their organizational goals (implementing EV by 2030)
   b. Sustainability is very important to Microsoft, specifically the impact that cars have on the planet which is why they are so invested in EV data

2. What types of data are being transmitted and why is it important? What is being tracked? **(Open-ended)**
   a. The number of times an EV charging station is used and how much energy is consumed

3. Who is receiving the data? Why is that data important? **(Open-ended)**
    a. Data is received by Microsoft's cloud infrastructure
    b. Data can be accessed by EV manufacturers

4. What government agencies are involved, if any? **(Close-ended)**
    a. Many government agencies are involved but more specifically the Department of Energy and the US State departments are involved

5. For the IaaS infrastructure, which Microsoft containers or virtual apps need to be integrated with the electric vehicle data? Microsoft's platform for cloud is Windows Azure. Which component of Azure processes EV data from the field? **(Open-ended)**
    a. Azure is not using any sort of containers or virtual apps because it is a cloud infrastructure

6. What are the entities in the operating environment responsible for data interchange? What is the system responsible for transmitting data to Microsoft? **(Close-ended)**
    a. EV charging stations

7. How is the data presented? (e.g. digital dashboard for executive decision making?) **(Open-ended)**
    a. It is being presented on digital dashboards on Azure

8. What types of statistics need to be gathered on EV performance? **(Close-ended)**
    a. Main focus for current project is all statistics regarding their energy consumption

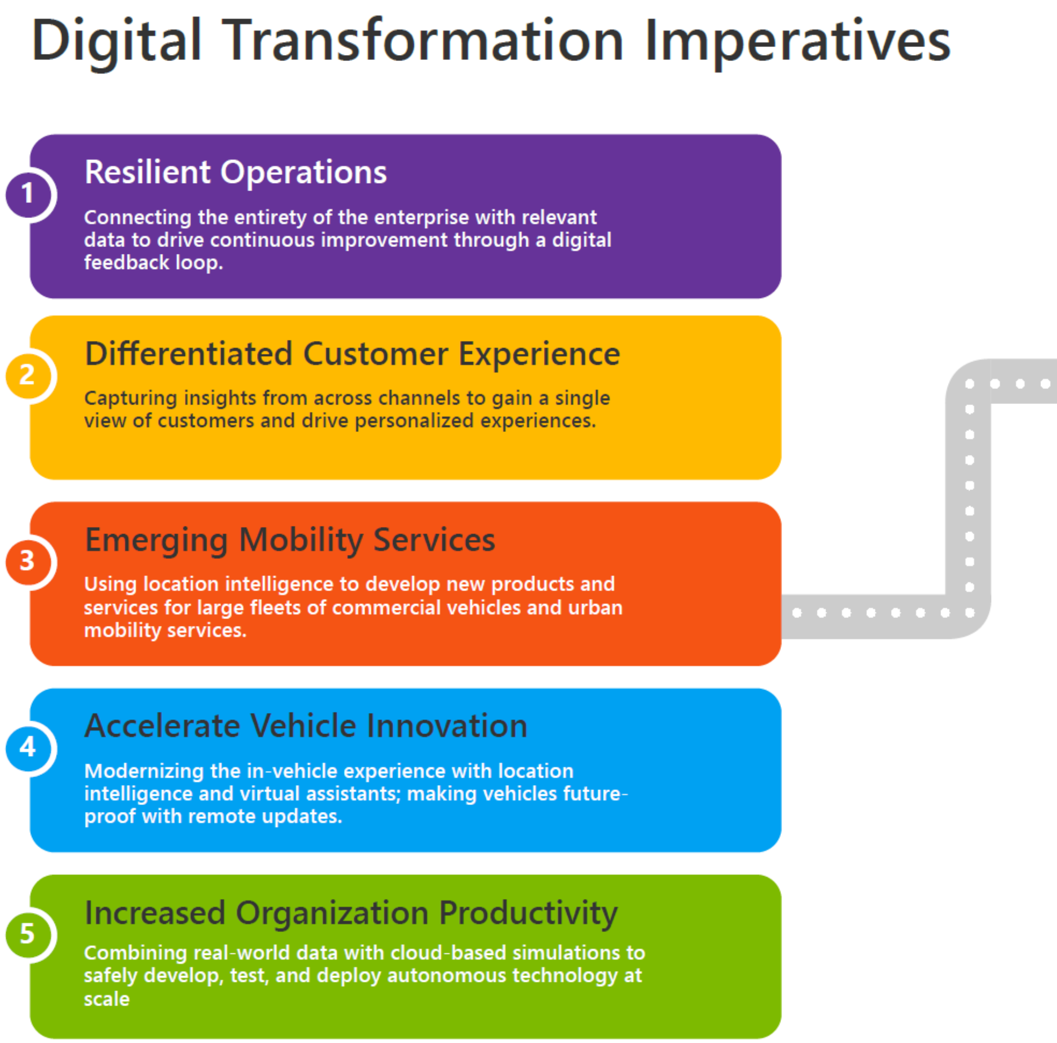
9. What types of reports need to be developed and how often should they run? **(Close-ended)**
    a. Weekly reports need to be developed to track energy consumption

From our interviews we were able to determine Microsoft's exact need for EV data. We learned that one of their main goals is sustainability and that they would like to increase their efficiency in trying to meet this goal. They are trying to accomplish this by tracking where the most EVs are in use, how much energy is being used by them, where to establish more charging stations, how often charging stations are used, etc. By using this data, Microsoft and potential EV manufacturers can make great strides in reaching their 2030 deadline.

SECTION 2.4: DOCUMENT/ARTIFACT ANALYSIS

The following section contains our document/artifact analysis of a report produced by Microsoft called "Reimagining Automotive." This report discusses Microsoft's technological solutions for automotive sustainability. The report highlights their initiative to combine real-world data with cloud-based data to increase efficiency in all aspects of electric vehicles including but not limited to the implementation of location intelligence which would be especially useful in Microsoft's goal to map out current and up to date locations of all EVs. The scope of this report, however, is much too vast as it discusses the possibilities of incorporating much more advanced solutions for automotive sustainability such as quantum computing. We instead are focusing on their current abilities in cloud computing and how to optimize those processes.

SECTION 2.4.1: Figure #1



SECTION 2.5: USE CASES

This section contains our use case analyses in which we cover three different functional requirements. These use cases help explain how the system is intended to function. It will model what a typical task completed by a user looks like by taking the user input and producing the appropriate output. They will describe the triggers and the preconditions necessary for the task to begin. They will also describe the normal course, exceptions and/or alternative courses, and postconditions of the scenario.

SECTION 2.4.1: Use Case #1

<table>
<tr><td colspan="2">Use Case Name: Update Charging Station</td><td>ID: UC1</td><td>Priority: Medium</td></tr>
<tr><td colspan="4">Actor: Charging Station</td></tr>
<tr><td colspan="4">Description: The charging station uploads energy usage and recharge data to the Azure cloud.</td></tr>
<tr><td colspan="4">Trigger: When the vehicle has reached between 80% and 100% charge on a recharge.</td></tr>
<tr><td colspan="4">Type: External</td></tr>
<tr><td colspan="4">Preconditions:
1. Charging station has a vehicle using it.
2. Vehicle is not at full charge before being brought to recharge
3. Vehicles has been paid to be charged at charging station</td></tr>
<tr><td colspan="3">Normal Course:
1.0 Vehicle reached designated charge range.
1. Charging Station sends the system confirmation vehicle in use.
2. System gives back confirmation.
3. Charging Station sends energy usage reports to system
4. System sends back results that it received the report.
5. Charging Station sends recharge period report to the system.
6. System sends back results that it received the report.
7. Charging Station sends report when vehicle leaves.
8. System saves and closes report in the cloud.
9. System sends receipt to customer.</td><td>Information for Steps
1. Vehicle ID
2. Vehicle Charging Details
3. Energy Usage Report
4. Energy Usage Confirmation
5. Energy Recharge Report
6. Energy Report Confirmation
7. Vehicle ID
8. Energy Consumption Report
9. Customer Energy Receipt</td></tr>
<tr><td colspan="4">Exceptions:
1a. If car on full charge, nullify use case and do not update energy usage information.</td></tr>
<tr><td colspan="4">Postconditions:
1. Charging Station is empty and ready for a new vehicle.
2. System has received both reports from charging station.</td></tr>
<tr><td>Summary Inputs</td><td>Source</td><td>Summary Outputs</td><td>Destination</td></tr>
<tr><td>Vehicle ID
Energy Usage Report
Energy Recharge Report</td><td>Charging Station
Charging Station
Charging Station</td><td>Vehicle charging details

Energy usage confirmation
Energy report confirmation
Energy consumption report
Customer energy receipt</td><td>Charging Station
Charging Station
Charging Station
Azure Cloud
Customer</td></tr>
</table>

SECTION 2.4.2: Use Case #2

<table>
<tr><td colspan="2">Use Case Name: Generate EV Energy Report</td><td colspan="2">ID: UC2</td><td>Priority: High</td></tr>
<tr><td colspan="5">Actor: Report Generating System</td></tr>
<tr><td colspan="5">Description: Report Generating System creates weekly reports on EV energy usage</td></tr>
<tr><td colspan="5">Trigger: 168 hours elapsed from last report</td></tr>
<tr><td colspan="5">Type: Temporal</td></tr>
<tr><td colspan="5">Preconditions:
1. Link established between EV computer and Microsoft’s Cloud Infrastructure
2. 168 hours elapsed from last report</td></tr>
<tr><td colspan="3">Normal Course:
1. Successfully establish link between EV system and Microsoft’s Cloud Infrastructure
0. Energy usage data compiled by EV
1. EV sends energy usage data to Microsoft’s Cloud Infrastructure
2. Microsoft’s Cloud Infrastructure confirms receiving energy usage data
3. Report Generating System processes energy usage data
4. EV Energy Report successfully generated</td><td colspan="2">Information for Steps:
1. Successfully establish link between EV system and Microsoft’s Cloud Infrastructure
0. Energy Usage Data
1. Energy Usage Data Package
2. Package Reception Confirmation
3. N/A
4. EV Energy Report</td></tr>
<tr><td colspan="3">Alternative Courses:
1. Unable to establish link between EV system and Microsoft’s Cloud Infrastructure
0. EV system will try to re-establish connection with Microsoft’s Cloud Infrastructure
1. Follow steps in Normal Course after successful connection</td><td colspan="2">Information for Steps:
1. Unable to establish link between EV system and Microsoft’s Cloud Infrastructure
0. N/A
1. N/A</td></tr>
<tr><td colspan="5">Postconditions
1. EV Energy report successfully generated</td></tr>
<tr><td>Summary Inputs</td><td>Source</td><td colspan="2">Summary Outputs</td><td>Destination</td></tr>
<tr><td>Energy Usage Data
Energy Usage Data Package</td><td>Electric Vehicle
Electric Vehicle</td><td colspan="2">Package Reception Confirmation
EV Energy Report</td><td>Electric Vehicle
Report Generating System</td></tr>
</table>

SECTION 2.4.3: Use Case #3

<table>
<tr><td>Use Case Name: Determine Charging Station Placement</td><td>ID: UC3</td><td>Priority: Medium</td></tr>
<tr><td colspan="3">Actor: Data Analyst</td></tr>
<tr><td colspan="3">Description: Analyst reviews latest EV location data to determine charging station placement</td></tr>
<tr><td colspan="3">Trigger: Spike in EV energy consumption occurs and Data Analyst is notified</td></tr>
<tr><td colspan="3">Type: Temporal</td></tr>
<tr><td colspan="3">Preconditions:
1. The data analyst is notified of abnormal spike in EV energy consumption
2. The data analyst is authenticated by logging into account using proper credentials</td></tr>
<tr><td colspan="2">Normal Course:
1. Need for additional charging station is recommended
1. Data analyst retrieves latest location data of EVs
2. System displays location of all registered EVs categorized by area
3. Data analyst determines that energy use spike is concentrated in a particular area
4. System displays locations of all current charging stations local to determined hotspot
5. Data Analyst determines that additional charging stations should be implemented
6. System sends recommendation to charging station implementation team</td><td>Information for Steps:
1. EV location data
2. Records of all registered EVs
3. EV hotspot determined
4. Charging station location data
5. Additional charging station required
6. New charging station request</td></tr>
<tr><td colspan="2">Alternative Course:
1.1 Additional charging station is not recommended
1. Data analyst retrieves latest location data of EVs
2. System displays location of all registered EVs categorized by area
3. Data analyst determines that energy use spike is not focused in any area
4. System displays locations of all current charging stations
5. Data Analyst determines that additional charging stations should not be implemented
6. System does not send recommendation to charging station implementation team</td><td>Information for Steps:
1. EV location data
2. Records of all registered EVs
3. No EV hotspot determined
4. Charging station location data
5. Additional charging station not required
6. No request sent</td></tr>
<tr><td colspan="3">Postconditions:
1. Recommendation for new charging station installation is submitted by analyst
2. No recommendation for new charging station is submitted by analyst</td></tr>
</table>

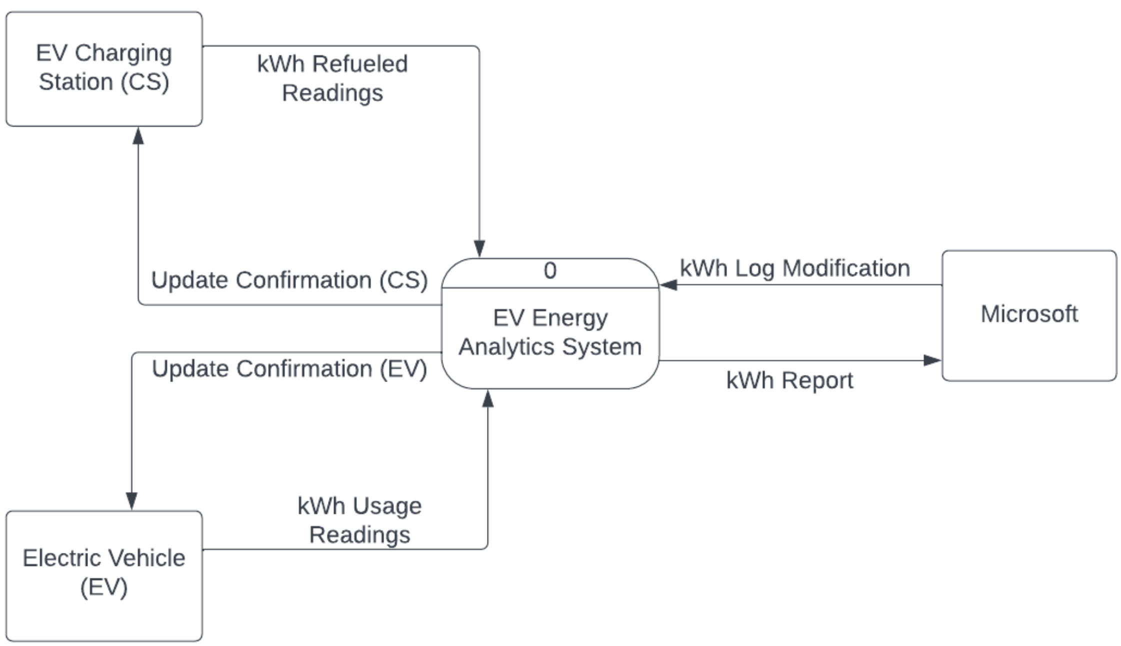
Summary Inputs	**Source**	**Summary Outputs**	**Destination**
Location data of EVs Location data of charging stations	Microsoft Cloud Microsoft Cloud	New charging station request	Charging station implementation team

SECTION 3: PROCESS MODELING DOCUMENTATION

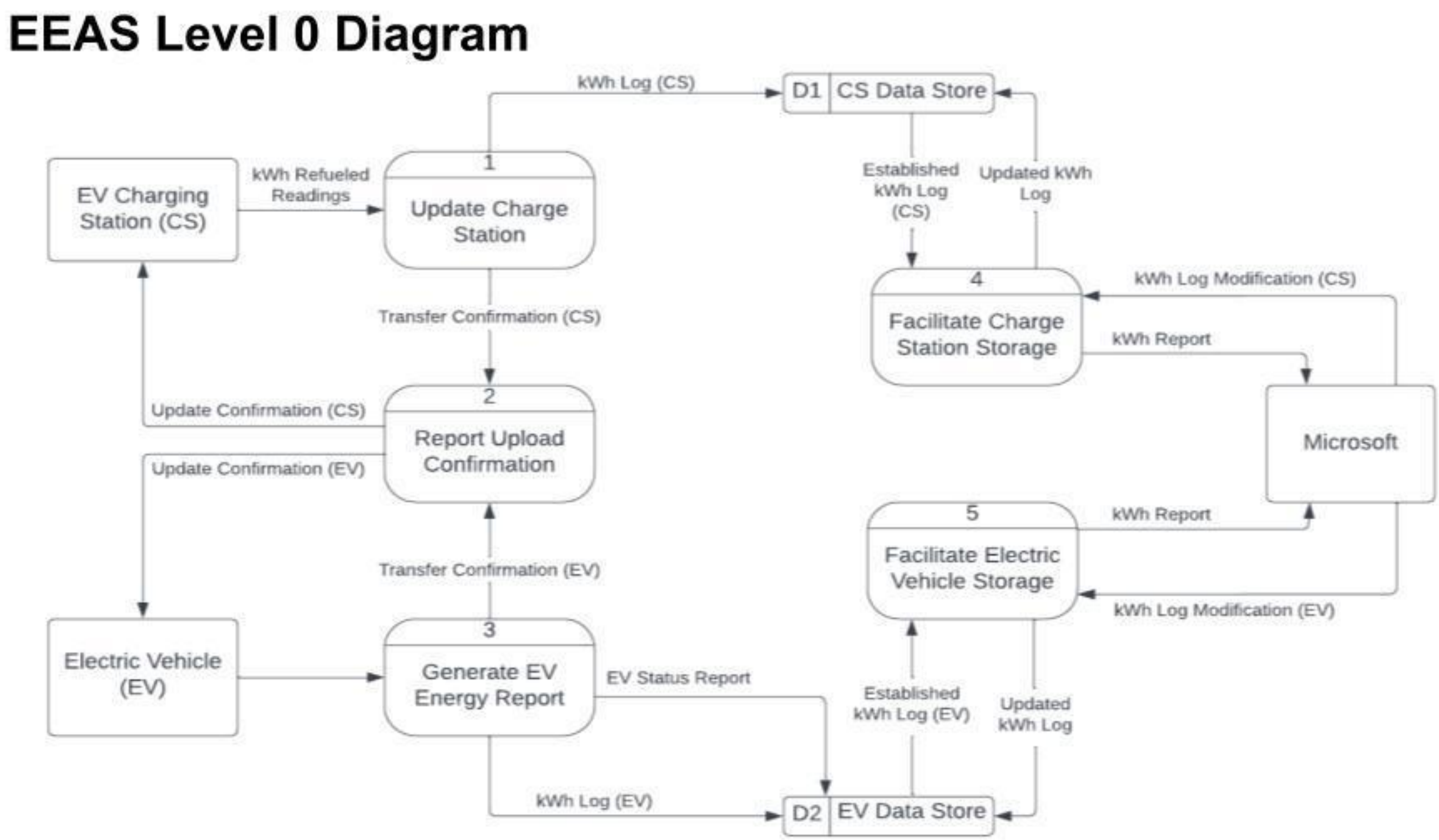
SECTION 3.1: LOGICAL DATA FLOW DIAGRAMS

In this section, based on the requirements and use cases previously set, data flow diagrams were made to display the actors in the system, in this case being the Electric Vehicles, the EV Charging Stations, and Microsoft itself, namely its employees acting on behalf of the company. This system has been given the name “EV Energy Analytics System”, or EEAS. The data flow diagrams include a context model, a Level 0 diagram, and five Level 1 diagrams that represent processes from the Level 0 diagram.

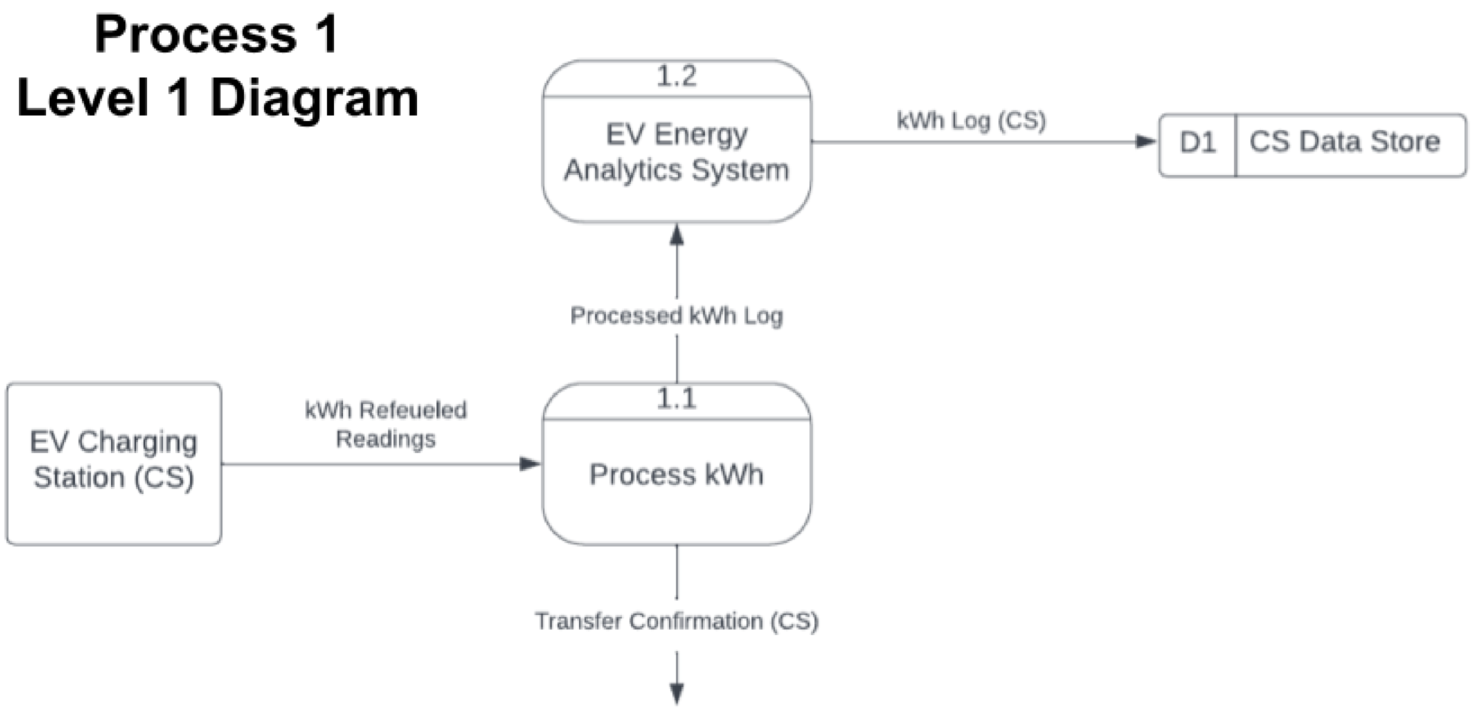
SECTION 3.1.1: EEAS Context Diagram



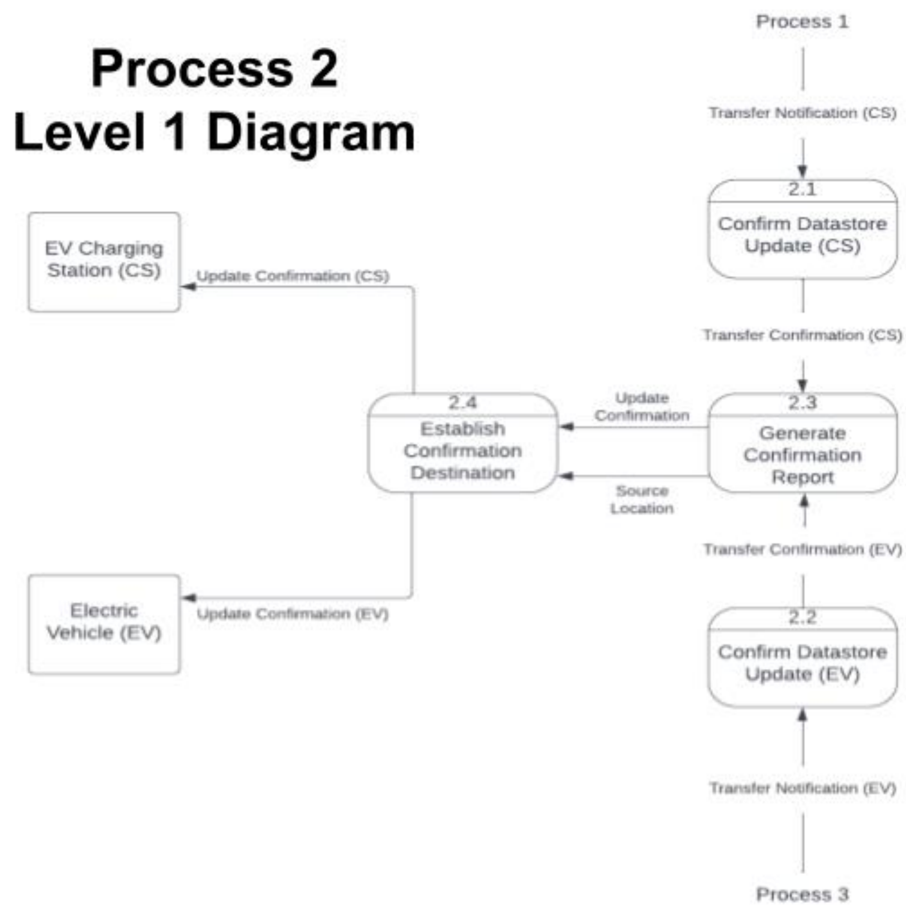
SECTION 3.1.2: EEAS Level 0 Diagram



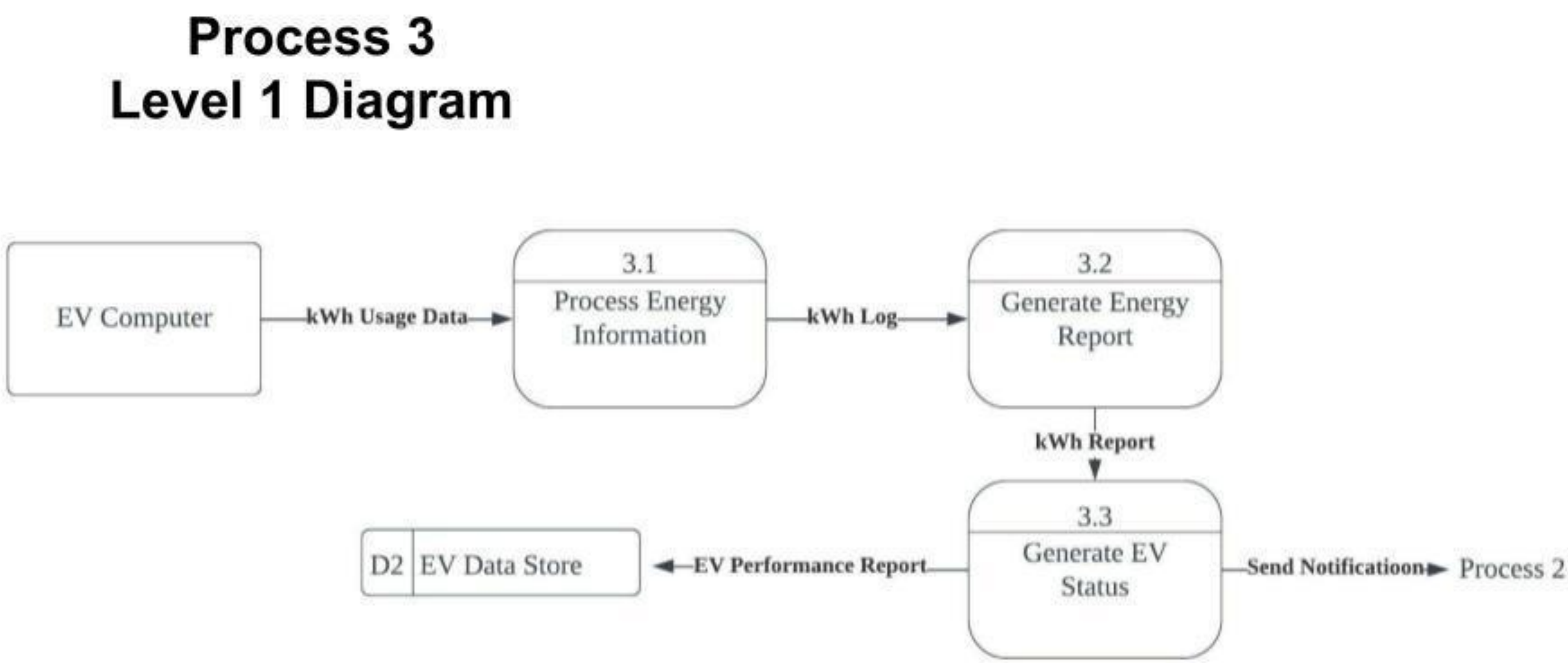
3.1.3: Process #1 Level 1 Diagram



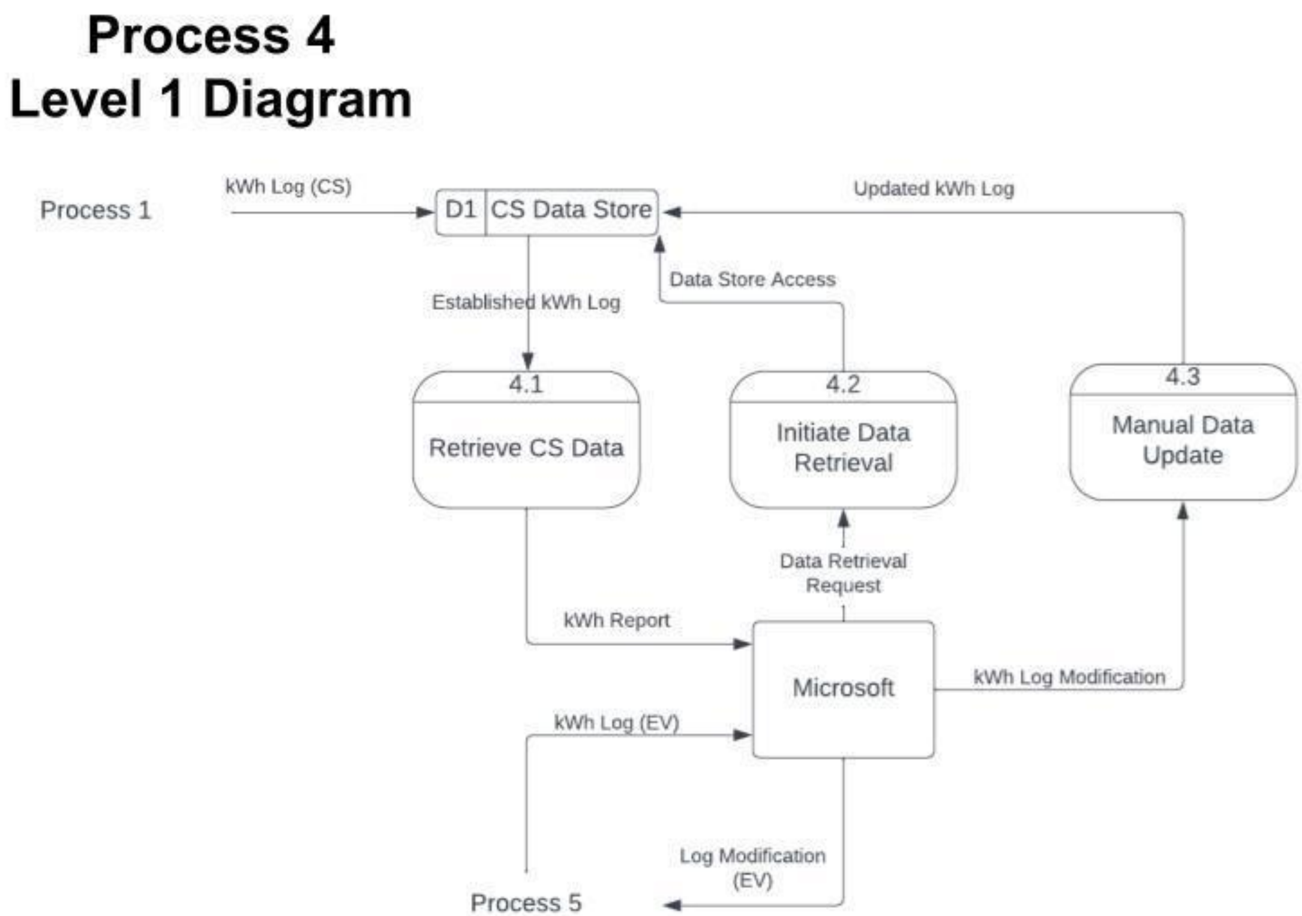
3.1.4: Process #2 Level 1 Diagram



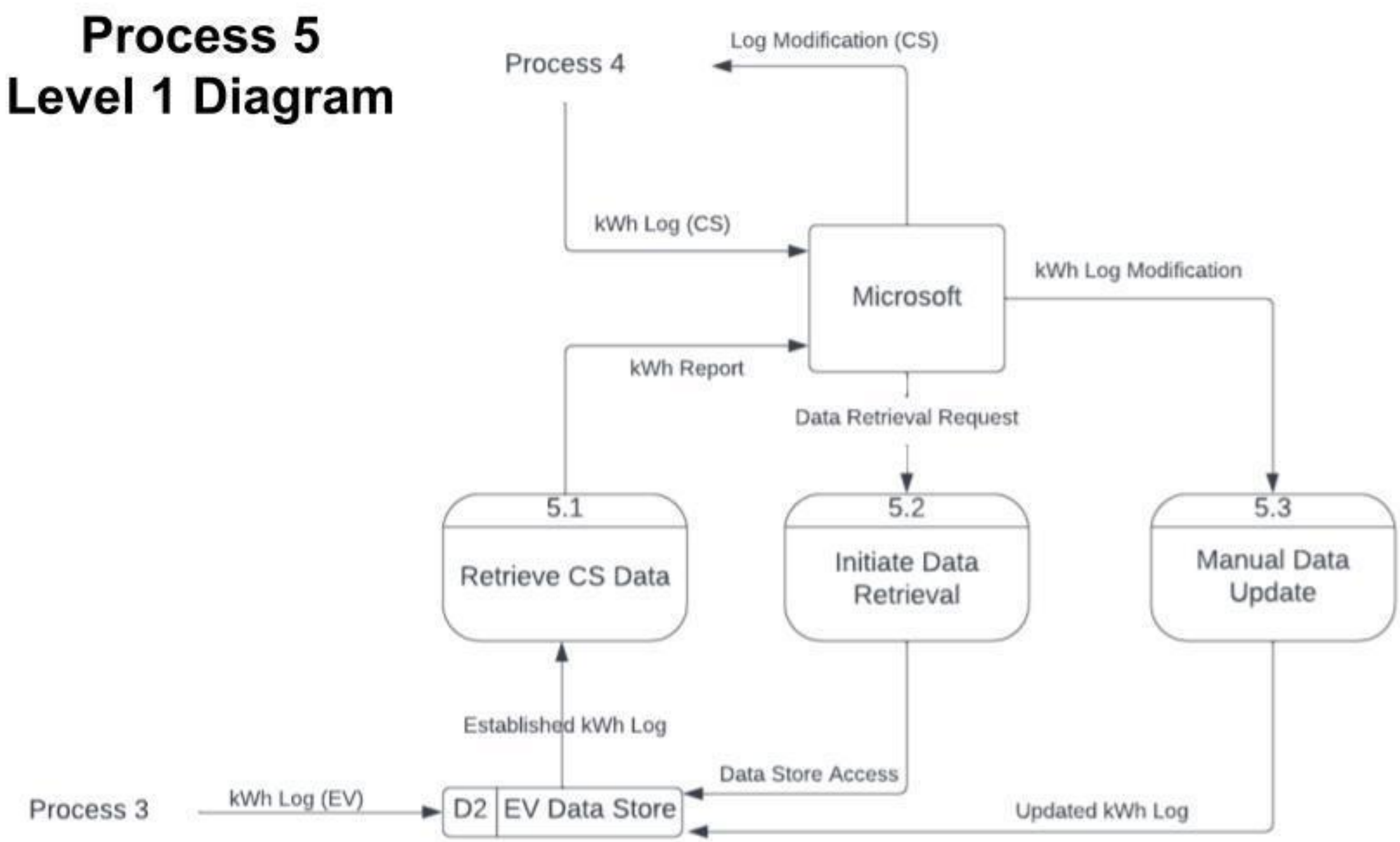
3.1.5: Process #3 Level 1 Diagram



3.1.6: Process #4 Level 1 Diagram



3.1.7: Process #5 Level 1 Diagram



SECTION 3.2: DATA DICTIONARY SAMPLE

To represent the values that are represented in the process models, the Data Dictionary is used to list in greater detail what each element in the model represents. It lists the name of the element, what type of element it is, a description of the element, what values it holds, what, if applicable, it is contained in, and any constraints that are enforced upon the element. For this section, only five of the many elements seen in the process model are represented here as a sample.

EEAS Data Dictionary Sample

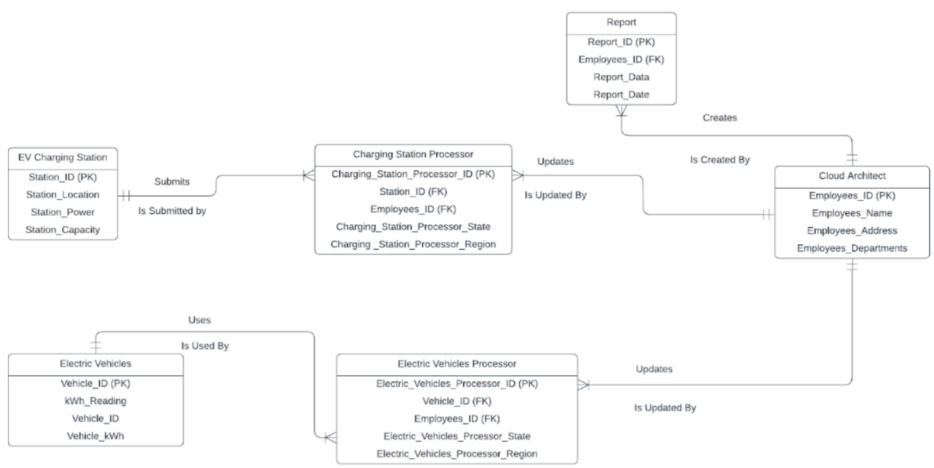
Name	Type	Description	What it contains	What it is contained in	Constraints
EV Charging Station	Entity	Device for electric vehicles to charge up in a reliable manner.	Attributes: Station_ID, Station_Area, Station_Power,	N/A	Station_ID must be Unique
Microsoft	Entity	Collection of employees that handle the processing of data	Attributes: Emp_ID, Emp_Name, Emp_Address, Emp_dept,	N/A	Emp_ID must be unique
D2: Electric Vehicle Data	Data Store	Stores the relevant data for the Electric Vehicles	EV Status Report, kWh Log	N/A	EV Table.
kWh Refueled Readings	Data Flow	Contains the kiloWatt hours from each car that uses the charging station	Station_Power, Vehicle_kWh	None	CSs must be used by EVs and able to collect data. Source: Charging Station Destination: Update Charge Station
kWh Log Modifications	Data Flow	Adjusts the amount kWh within the log	Station_Power, Vehicle_kWh	None	kWh log must be created first Source: Microsoft Destination: Facilitate Charge Station storage and Facilitate EV Storage

SECTION 4: DATA MODELING DOCUMENTATION

SECTION 4.1: ENTITY-RELATIONSHIP DIAGRAM

In this section, an entity-relationship diagram was created based on the data dictionary created for the EV Energy Analytics System. This elaborates further on the entities currently presented and the attributes they possess, as well as their respective primary and foreign keys that make them unique and connected.

Section 4.1.1: Figure #2



SECTION: 4.2: ALTERNATIVE MATRIX

In this section, based on the requirements set for the EEAS, the alternative matrix displays several design alternatives to provide the best solution for the design. These include hands-on development using Java or Python, and using prepackaged from Rockwell Automation, with the intention of being compatible with Microsoft Azure.

Evaluation Criteria	Relative Importance (Weight)	Alternative 1: Prepacked Software from Rockwell Automation	Score (1-5)*	Weighted Score	Alternative 2: Custom Application Using Java	Score (1-5)*	Weighted Score	Alternative 3: Custom Application Using Python	Score (1-5)*	Weighted Score
Technical Issues:										
Consistency	20	High consistency	4	80	High consistency	4	80	High consistency	4	80
Availability	10	High availability	4	40	Moderate availability	3	30	Moderate availability	3	30
Cloud integration	25	High integration	5	75	High integration	5	75	High integration	5	75
Economic Issues:										
Cost of development	10	Moderately expensive	3	30	More expensive	2	20	Moderately expensive	3	30
Cost to maintenance	10	Moderately expensive	3	30	More expensive	2	20	Moderately expensive	3	30
Organizational Issues										
Ease of learning	5	Moderate	3	15	Moderately easy	4	20	Moderate	3	15
Ease of use	5	Moderate	3	15	Moderately easy	4	20	Relatively hard	2	10
Diverse storage of data stores	15	High	5	75	High	5	75	Limited	2	30
Total	100			360			340			300

Our group decided to choose the second alternative with a total score of 360. Firstly, the consistency of using prepackaged software from Rockwell Automation. With the prepackaged software, testers can test different border cases and alternative cases to check for errors. Secondly, the availability of using prepackaged software is decent because we can test the software in our system and work our system around it, without having to implement our own code, which could be both temporally and financially exhausting. It also fulfills one of the requirements to be able to integrate in a IaaS cloud structure. Cost of the initial product may present a problem, but given that Microsoft would like to work quickly on the matter, it’s worth it. Microsoft will have to keep in touch with the makers of the software if issues arise. The ease of learning and use are moderately easy because Microsoft engineers can learn the custom software with the help of the contractors. Lastly, the diverse storage of data stores is another feature that the prepackaged software has to be able to work with before accepting it as the final product.

SECTION 4.3: SECOND ALTERNATIVE MATRIX

In this section, based on the non-functional requirements for EEAS, this second alternative matrix displays operational requirements, performance requirements, security and cultural requirements based upon which server architecture works best for the design.

Requirements	Server-Based	Thin Client-Server	Thick Client-Server
Operational Requirements			
System Integration Requirements	✓	✓	✓
Portability Requirements		✓	
Maintainability Requirements	✓	✓	✓
Performance Requirements			
Speed Requirements		✓	✓
Capacity Requirements	✓	✓	✓
Availability/Reliability Requirements	✓	✓	✓
Security Requirements			
High System Value		✓	
Access Control Requirements	✓		
Encryption/Authentication Requirements		✓	
Virus Control Requirements	✓		
Cultural/Political Requirements			
Multilingual Requirements		✓	
Customization Requirements		✓	
Making Unstated Norms Explicit		✓	
Legal Requirements	✓	✓	✓

SECTION 4.4: HARDWARE AND SOFTWARE SPECIFICATION

	Standard Client	**Standard Web Server**	**Standard Application Server**	**Standard Database Server**
Operating System	. Windows 10 Pro	. Windows Server	. Windows Server	. Windows Server
Special Software	. Adobe Acrobat Reader . Real Audio	. Microsoft IIS	. Apache	. Oracle
Hardware	. 1 TB disk drive . Intel® Core™ i7-8750H six score processor . 24-inch monitor	. 16 TB disk drive . Intel® Xeon® Processor E5-4669 v4	. 16 TB disk drive . Intel® Xeon® Processor E5-4669 v4	. 32 TB disk drive . RAID . Xeon 28 score processor
Network	. Broadband preferred	. Dual 100 Mbps Ethernet	. Dual 100 Mbps Ethernet	. Dual 100 Mbps Ethernet

SECTION 5: USER INTERFACE, PHYSICAL PROCESS & DATA MODELS

SECTION 5.1: USER INTERFACE STANDARDS

Interface Metaphor:
- Home
- Energy Statistics
- Account Settings
- Summary
- Consumption

Interface Objects:
- Monthly Updates: Amount of energy readings to update the system
- Electric Vehicles: Amount of electric vehicles in the system
- Energy Consumption: Data visualizations to represent the amount of energy consumed by electric vehicles in the system
- Charge Station Locations: A map of charge stations recently used by an electric vehicle

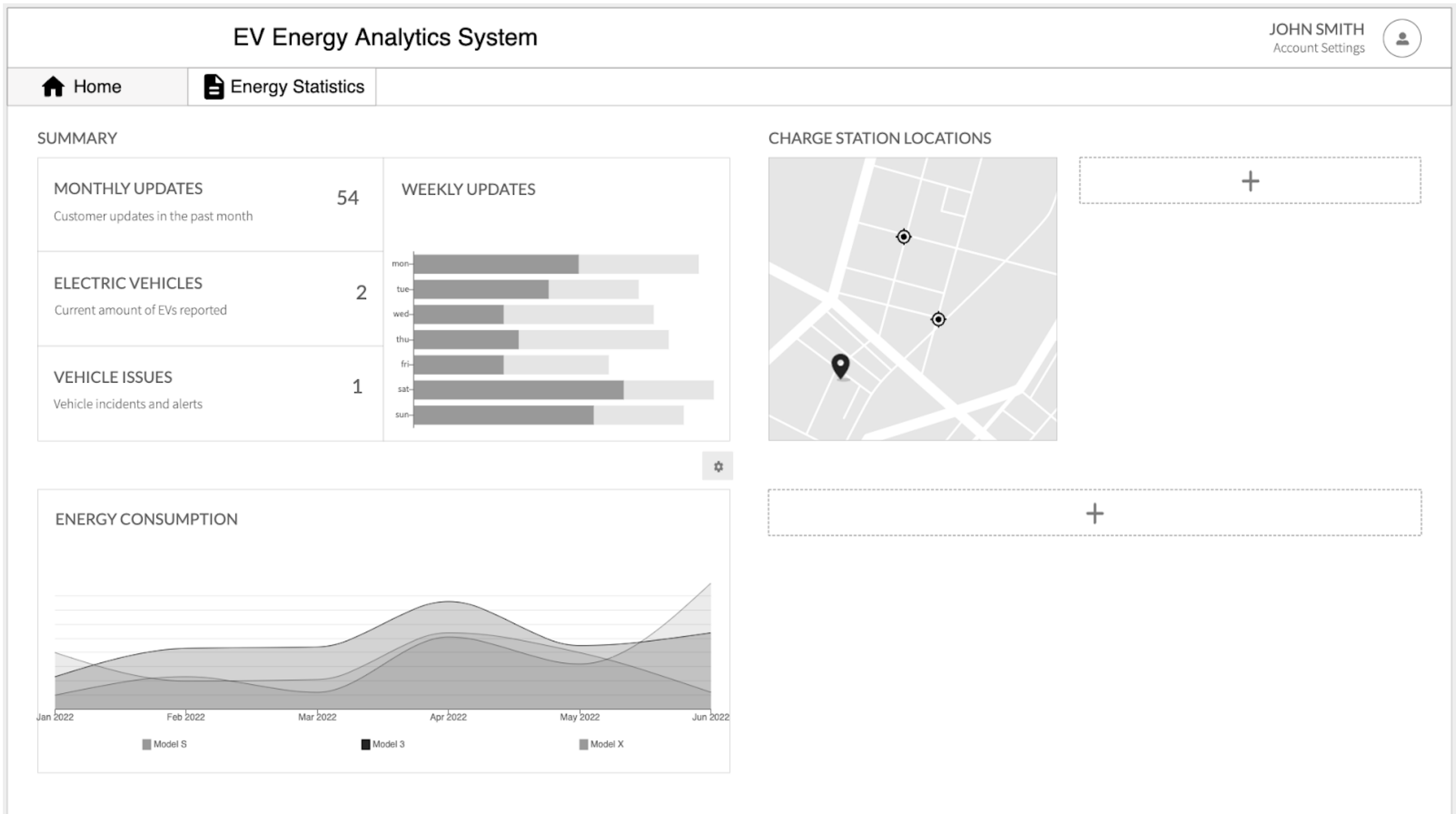
Interface Actions:
- More Details: Users can click on a vehicle record from the table in the energy statistics page to view a detail panel.
- Close: A clickable icon that removes the detail panel from view.
- Fullscreen: A clickable icon to expand the detail panel.
- Visual Filters: Recent Updates, Total Electric Charge, and Average Energy Consumption are interactive filters that users can click on to aggregate data.

Interface Icons:
- House: navigation menu item that will appear on all interfaces
- Document: navigation menu item that will appear on all interfaces
- User: image or icon to display current user
- Line Chart: navigation menu item within Energy Statistics panel

SECTION 5.2: INTERFACE DESIGN PROTOTYPES

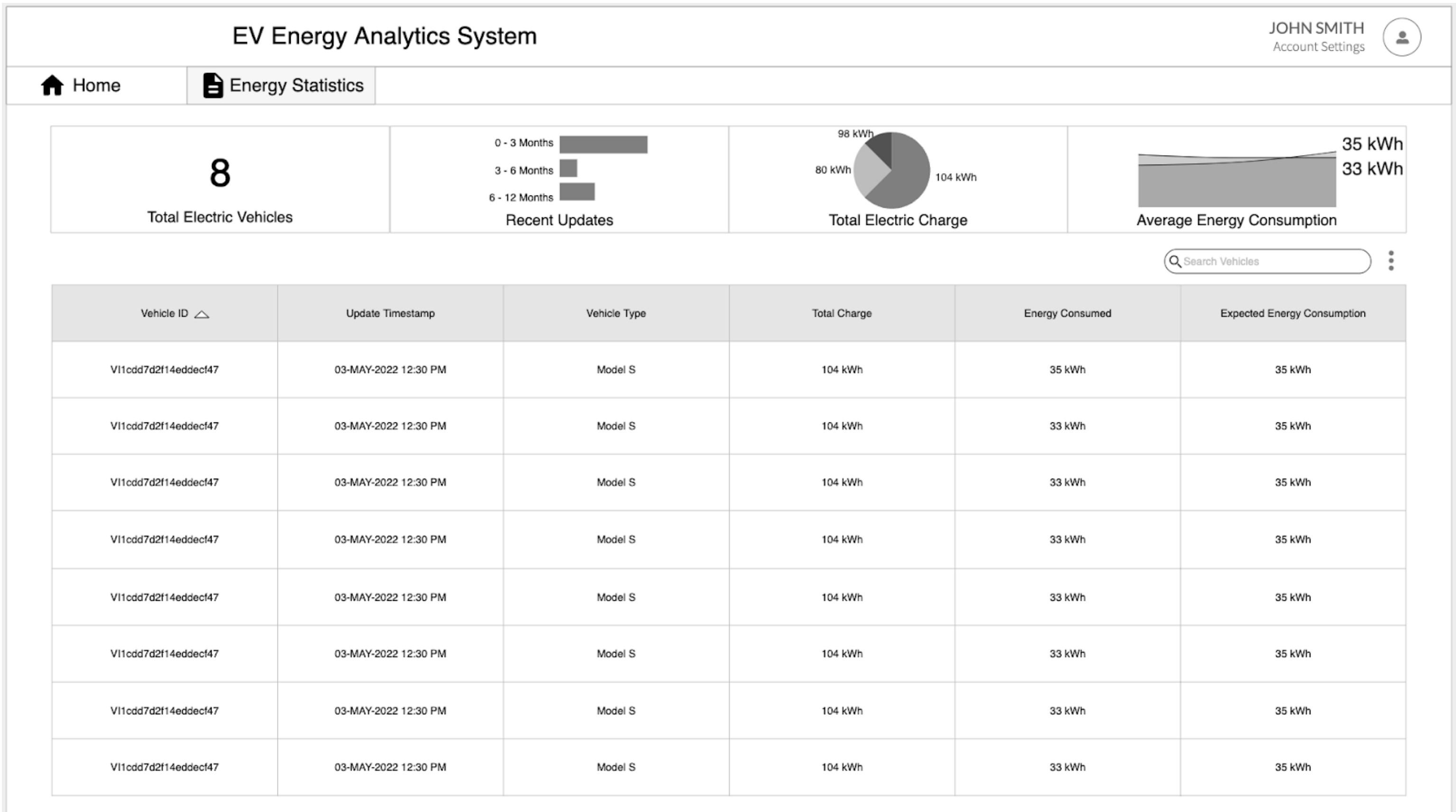
Section 5.2.1: Home Page

The interface below represents the home page that displays summarized statistics such as monthly updates, electric vehicles, and vehicle issues. Users can add components through widgets to display different information.



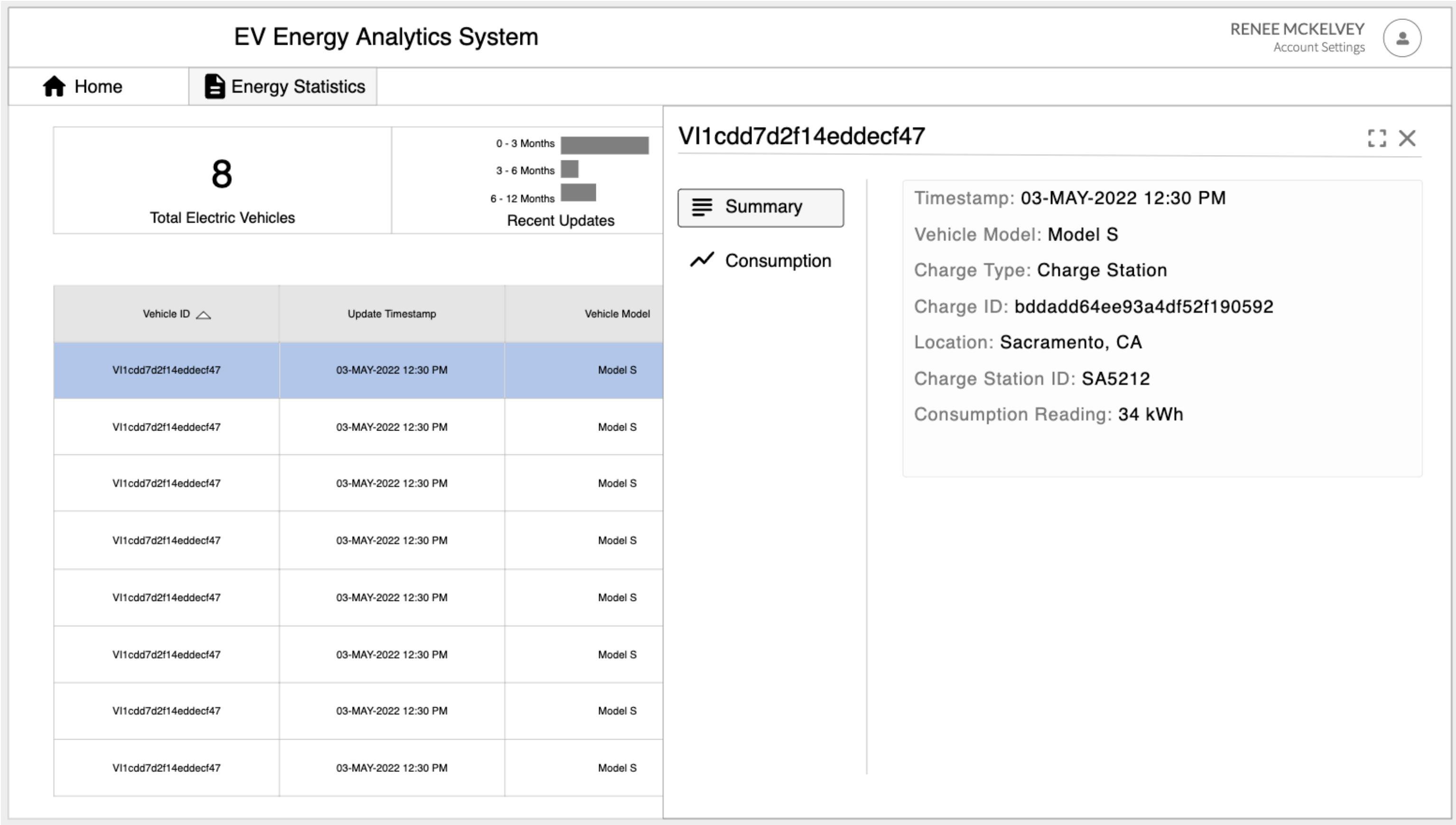
Section 4.2.2: Energy Statistics Page

The page below displays statistics about vehicle records in a table format, users can click on a record to display more information about the record. Above the table are visual filters where aggregated data can be isolated.



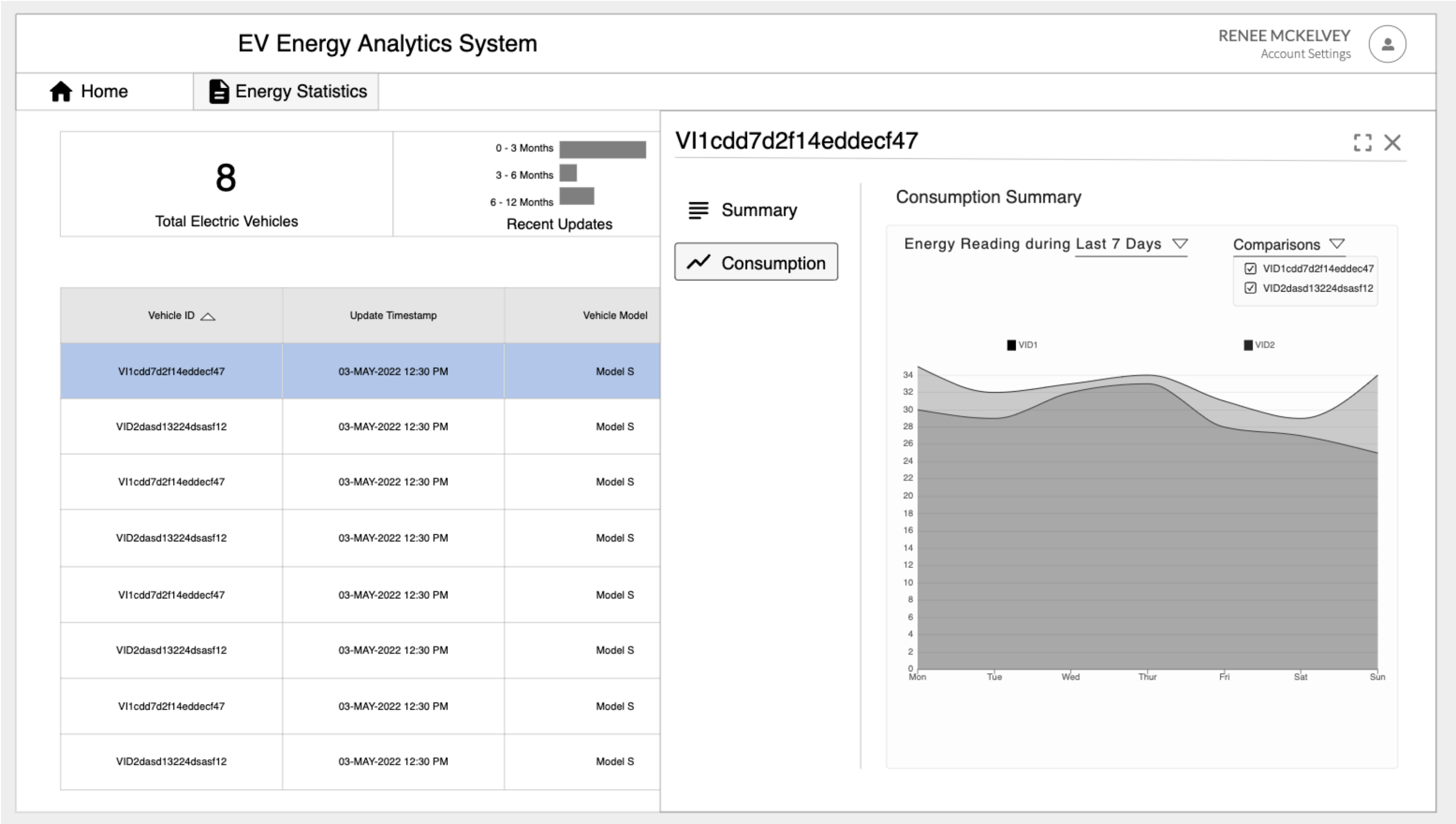
Section 5.2.3: Summary Panel

The panel below displays all information about a vehicle record. Information that may have been excluded from the table by filters will be displayed in this panel.



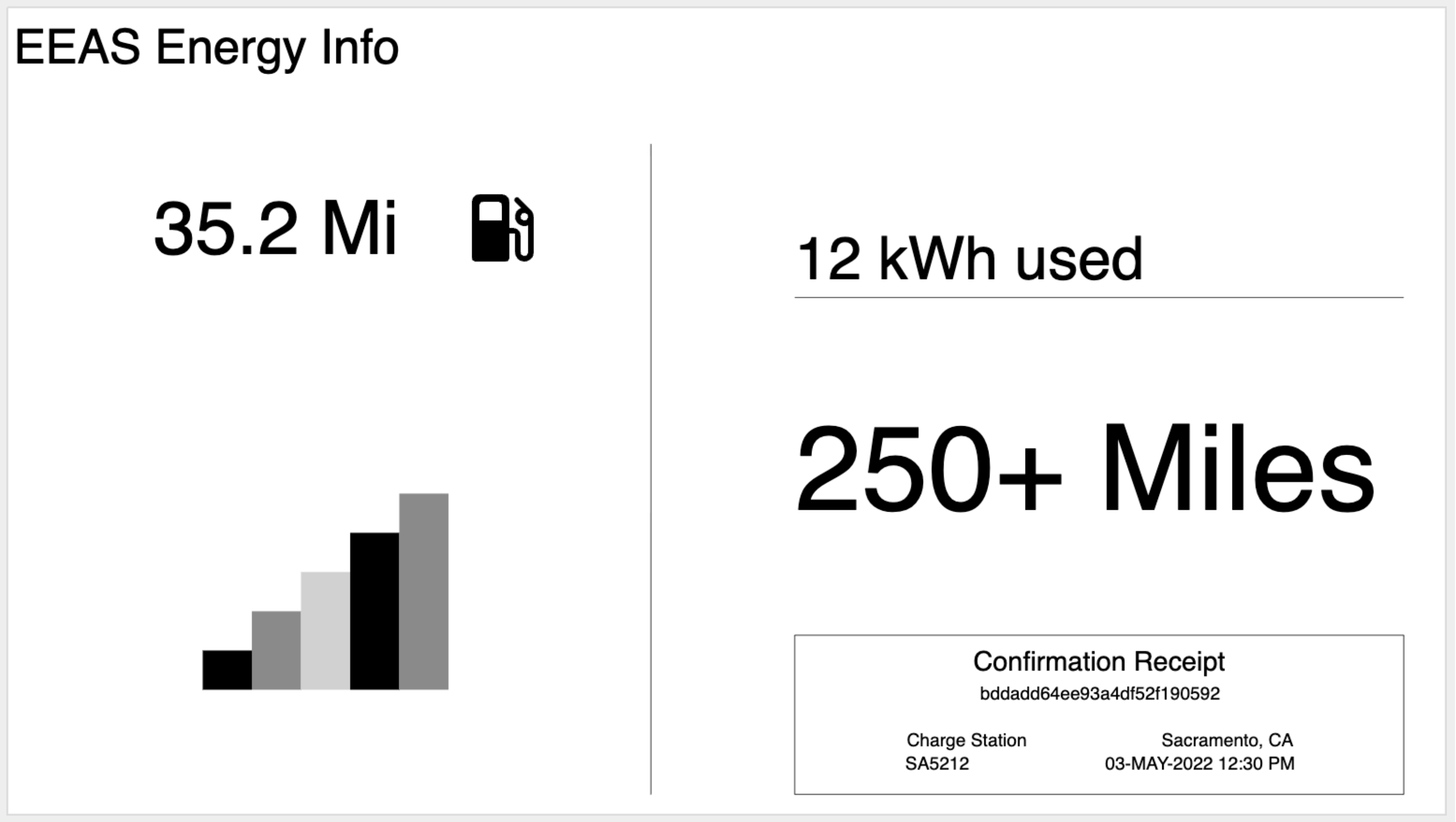
Section 5.2.4: Consumption Panel

The panel below displays a chart about the energy consumed by a vehicle. Multiple vehicles can be compared by selecting a checkbox, and the timespan can be altered as well through a dropdown menu.

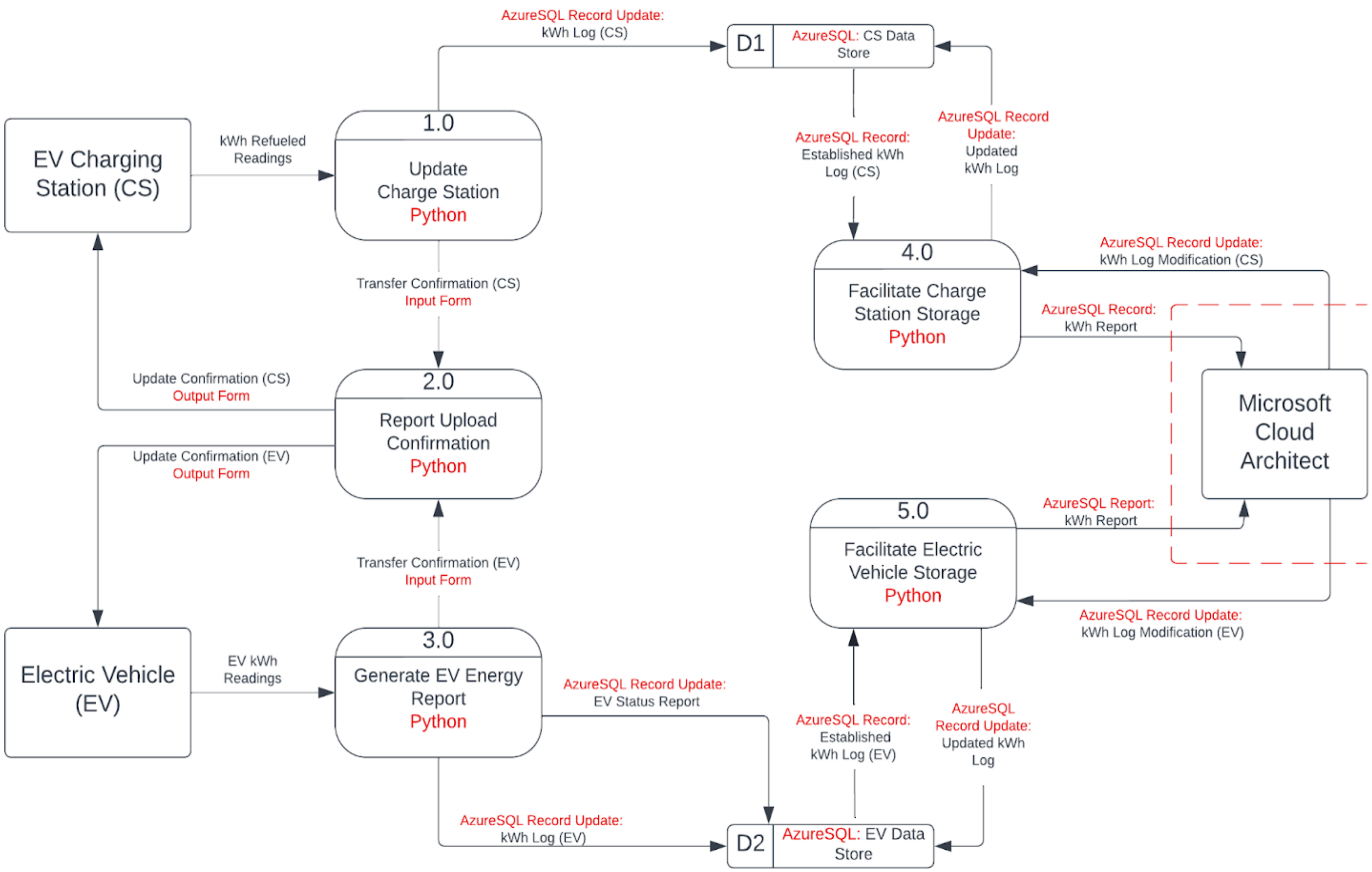


Section 5.2.5: Vehicle Display Interface

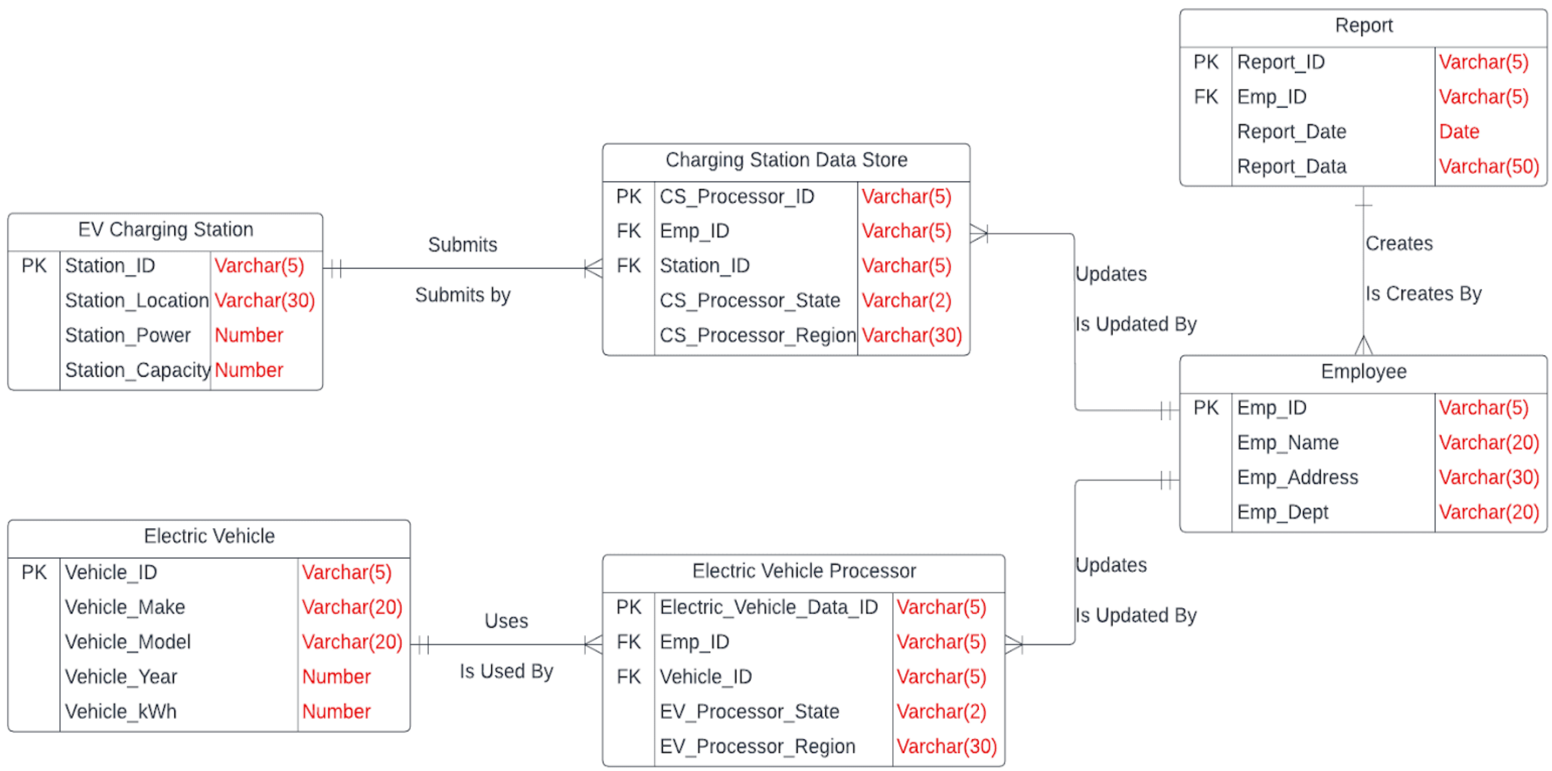
The interface below represents a vehicle display that will appear on EV's dashboard to give feedback about an EV's energy consumption. A confirmation receipt will appear when an update has been completed.



SECTION 5.3: PHYSICAL PROCESS



SECTION 5.4: PHYSICAL DATA MODELS



CONCLUSION

To conclude, Section 1 included the Systems Request which summarized the business need and motivations to initiate the project. Section 2 included the Requirements Definitions & Use Cases, a formalized requirements specification for the information system and its use cases. Section 3 presented the Process Modeling Documentation which broke the system down into each of their digital processes using data flow diagrams and a data dictionary sample. Section 4 provided two Alternative Matrix Diagrams and an entity relationship diagram within the Data Modeling Document. Section 5 presented the User Interface, Physical Process & Data Models, which depicted how the system shall be presented and how physical process will interact.

In summary, the analysts within Team 2 recommends that EV manufacturers shift away from their current cloud processing infrastructure in favor of using Microsoft's Azure Cloud as the infrastructure their EV data processing. Manufacturers can use Microsoft's Azure Cloud to develop the EV Energy Analytics System outlined in this document that shall have the capability to take in EV energy usage data and efficiently create reports, for consumer and manufacturer use, without requiring a Cloud Architect to monitor it at all times.

APPENDIX

DELIVERABLE #1 ADMINISTRATOR NOTES

- Problem Summary
  - Big Data is too much for current computers to process on cloud environment
  - Proposed using Quantum Computing to process Big Data
- Restraints: computing capacity (be specific)
- Business Requirements: materials necessary for new computer system
- Veering off into cloud computing too much, focus back into the problem at hand
- Big Data has more volume, veracity, and velocity than currently utilized
- Another call specifying problems that users are experiencing
- Need more detail on the business problem
- Mixture of quantum computing and cloud computing are too grandiose
- Forget quantum computing, and focus on the concerns regarding the current cloud environment
- Ask questions about PaaS, IaaS, and SaaS
- Research cloud services
- What kind of app do they need through the cloud?
- What are the major tasks they are trying to complete?
- What is being done and what is
- Where is the bottleneck, main issue?
- Call site contact before Saturday, ask for more detail about the specific business problem
- Don't tell me what the solution is, describe the problem at hand
- Want to know what the problem?
- Determine what type of system should be developed
- Prof will check next Tuesday and let us know what we need to do

DELIVERABLE #2 ADMINISTRATOR NOTES

- Build table of contents with section and sub-section numbers
- Need to know data definition and package of what is being transferred to the Azure IaaS (Definition of EV Package Data)
- More distinguishment and depth of IaaS for project for receipt of data package
- Pull more from interview transcripts
- Evolve artifact analysis a bit more with pictures
- Change Use Case to correct format
- Find statistics specifically for electric vehicles (General Data as well; Date/Time, Location, etc.)

DELIVERABLE #3 ADMINISTRATOR NOTES

- Shading: take shading out and use Microsoft office
- Data violations
- Energy usage data in Context diagram
- Level 0: 1.1., 2.1, 3.1, and no crossing lines
- Law balancing: name must remain exactly the same

- Bring decomposing to the Context diagram
- Good naming
- Cloud Architect as a name instead of Microsoft

DELIVERABLE #4 ADMINISTRATOR NOTES

- Cardinality identifiers are missing
- Microsoft entity could be possible named Cloud Architect
    - Based on the current ERD, the entity name should be Employee
- Two intersection entities should be made between the two data store entities and the Microsoft entity
- The Electric Vehicle Data Store (Parent Entity) primary key should be contained in the Electric Vehicle (Child Entity) rather than the Electric Vehicle (Child Entity) primary key being in the Electric Vehicle Data Store (Parent Entity)
- Remove the name Data Store form the two entities Electric Vehicle Data Store and Charging Station Data Store
- A report entity should be added somewhere in the ERD

DELIVERABLE #5 ADMINISTRATOR NOTES

- Presented Mid-High-Fidelity Wire-Frame Models
- Compliments
    - Likes how we included object examples that show what it could look like visually when live, especially liked the widgets
    - Very high quality
    - Enjoyed the three-dot icon and common interface types
    - Randomly generated vehicle ids
- Recommends other teams implement gradients for selected models/icons
    - Notes how energy statistics (selected model) is shaded with gradient grayscale
    - Adds sense of realism
- Overall, really enjoyed how in-depth we went with visual representations
- Very profound for time available