MIS6349 – Final Post-Project Documentation

Team Name: Watt Explorers

Client Name: Commodit Edge LLC

1. Statement of Group Contribution

Prepared by: Jatin Gopisetty

Group Member	**Role** Developer, Business Analyst, etc.).	**Level of Contribution** 0=No Contribution 1=Weak Contribution 2=Equal Contribution 3=Strong Contribution	**Statement of Work**
Vaishnavi Gawali	• Data Analyst	3	• Completed Market Research study of Canadian EV Market • Studied and documented the Government initiatives for EV • Designed the architecture for the predictive modelling service and stated which model and fields are necessary
Suresh Gopalakrishnan	• System Architect	3	• System Architecture • Solution Design
Jatin Gopisetty	• Project Manager	3	• Designed Gant Chart. • Acted as liaison between the team and the client. • Assigned task to team. • Gathered proper insights from the client and made sure the project was aligned according to the client's requirements.
Tarun Latchireddi	• Data Analyst	3	• Researched about the data collection process and how to process the data. • Proposed a solution for the client based on his needs. • Collected different datasets with regards to the EV Charging station and analyzed it.

Aleen Le	• Business Analyst	3	• Researched potential competitors in the Canadian EV market. • Performed SWOT analysis on competitors. • Detailed potential risks and methods to manage them. • Documentation formatting
Saurabh Nair	• Product Manager	3	• Defined project goals for EV charging platform in Canada. • Identified fragmentation & info gaps in Canadian EV charging. • Proposed app & predictive maintenance system for EV charging. • Described user benefits of EV charging app (real-time info, recommendations). • Explained station owner benefits (reduced downtime, data insights). • Set metrics for app development, maintenance & user/owner adoption. • Defined methods to track project metrics. • Planned post-launch evaluation using metrics, feedback & industry trends. • Generated multiple product ideas, led to chosen concept. • Facilitated communication & client meetings.
Yash Shiyani	• System Architect	3	• Made System Design • Researched compliance and regulatory requirements • System Architecture

Sowmya Yella	• Market Analyst	3	• Helped come up with new and creative ideas to solve project problems. • Created a brief overview of the project discoveries and suggestions. • Created and managed records of all changes made during the project.

2. Post-Project Overview

2.1 Executive Summary

Author: Sowmya Yella ***Editors:*** Saurabh Nair, Jatin Gopisetty

Executive Summary

Our goal is to revolutionize EV (Electric Vehicle) charging infrastructure in Canada by developing predictive modelling services and simple mobile apps that will increase the reliability and availability of the grid by boosting the user experience of electric vehicle (EV) owners. Our mission transforms the EV charging infrastructure by using AI (Artificial Intelligence) and IoT technology for predicting maintenance problems, anticipating fleet utilization, and simplifying the user experience of the EV drivers. From cleaner power generation to a more sustainable transportation system, our solution uses system predictive maintenance models as well as near-real time data analytics to anticipate and prevent maintenance problems to reduce downtime and enhance customer satisfaction by detecting potential problems earlier and taking action to avoid interventions. Furthermore, our solution does not stop here but also aims to simplify the charging experience for EV drivers by providing them with more precise information in terms of station availability, features and anticipated wait times.

Our solution is primarily centered around creating a predictive maintenance model specifically designed for public and private charging stations. Our goal is to use data from both past and current sources at these stations to forecast possible issues and inform owners beforehand, ultimately minimizing operational disruptions and improving station availability Finally, in addition to the predictive maintenance feature, we'll also offer repair services to improve the reliability of the charging infrastructure.

We are creating an app that carter for the EV owners gives better user experience wherein they have the facility of finding the charging station near-by, getting real-time information of stations, expected charging times according to car information and rate at which it is being used. It will aid the owners of EV

cars to plan their trip in a better way without being fear about running out of power. We are developing a user-friendly app for charging station owners, which displays the various real-time performance data of stations including alerts for its maintenance prediction, report and analysis. Such a system will help the owners to decide which is far better, to improve their operation resulting in more usage, hence earning more out of it providing better customer satisfaction.

The impact of our solution extends across all stakeholders involved:

1) *Charging Station Owners*: Increased revenue streams through reduced downtime, improved operational efficiency, and valuable insights into station performance and maintenance needs.

2) *EV Owners*: Enhanced peace of mind through reliable access to functional charging stations, better planning capabilities, and an improved overall charging experience.

3) *Government Stakeholders*: Improved public perception of EV infrastructure, data-driven policy development, and better monitoring and regulation of EV schemes.

Our solution has many different benefits.

1) *Enhanced Reliability*: EV owners will have a more dependable charging experience and charging station owners will get more revenue from their predictive maintenance capabilities which decrease downtime and increase station uptime.

2) *Streamlined User Experience*: EV owners can plan more effectively and feel less anxious thanks to user-friendly mobile applications that give them access to real-time information on station availability and functionality.

3) *Data-Driven Decision Making*: Through real-time data analytics and historical data analysis government stakeholders and charging station owners can obtain insightful information that helps them make well-informed decisions and develop policies.

With the use of proactive maintenance our solution can provide charging station owners with increased revenue, improved operational efficiency and possible cost savings. With improved charging infrastructure and a reduced sense of anxiety when searching for working chargers more people will opt for electric cars. Furthermore, crucial data for creating policies and keeping an eye on EV infrastructure will be available to government stakeholders.

The market for EV chargers is predicted to grow rapidly over the next five years, which presents significant opportunity for our solution. There will be substantial revenue opportunities from predictive maintenance subscriptions maintenance and repair services and app transactions due to the anticipated increase in the number of public charging ports from 26500 to over 56000.

Conclusion:

Our project's main goal is to improve Canadas EV charging infrastructures availability and dependability to benefit EV drivers charging station operators and government stakeholders. Our objective is to accelerate the transition to electric vehicles while increasing profitability and optimizing operations for our clients by leveraging state-of-the-art predictive modeling services and user-friendly mobile apps.

2.2 Project Overview and Objectives

Author: Saurabh Nair ***Editors:*** Jatin Gopisetty

Project Objective:

To develop a comprehensive platform that streamlines the EV charging experience in Canada by addressing key pain points for both EV users and charging station owners.

Business Problem:

The current EV charging landscape in Canada suffers from fragmentation and lack of real-time information. EV users face difficulties due to:

- Multiple and inconvenient apps for different charging networks.
- Limited information on station functionality, occupancy, and available brands.
- Unreliable station status with non-functional stations listed on maps, leading to wasted trips.

This creates a negative user experience and hinders the adoption of EVs. Charging station owners also lack efficient methods to:

- Proactively maintain their stations and prevent downtime.
- Gain insights into user behavior and optimize station operations.

Project Solution:

This project proposes an intelligent EV charging network platform with two interconnected components:

1. Predictive Maintenance System for Charging Stations:

- Utilizes machine learning to monitor charging units for potential downtimes.
- Generates real-time alerts for early intervention and troubleshooting by station owners.
- Recommends solutions to minimize or prevent downtime, ensuring optimal station functionality.

2. EV Charging Network App for Users:

- Provides a user-friendly, single-app solution for finding and utilizing charging stations across Canada.
- Displays real-time information on station functionality, including:
    - Operational status
    - Available charging units
    - Voltage availability
    - Estimated charging time for specific vehicles
    - Queue wait times
- Recommends optimal charging stations based on location, availability, and user vehicle data (battery size, charging speed compatibility).

Benefits:

This platform will offer significant benefits for both EV users and charging station owners:

- EV Users:
    - Improved user experience with a convenient and informative app.
    - Increased confidence in finding functional charging stations.
    - Optimized charging experience with real-time data and station recommendations.
- Charging Station Owners:
    - Reduced downtime through predictive maintenance and proactive interventions.
    - Increased user traffic and potential revenue through a user-friendly platform.
    - Valuable data insights for informed business decisions on station operations and expansion.

Overall, this project aims to create a win-win situation for both user groups, accelerating the adoption and efficient utilization of EV charging infrastructure in Canada.

2.3 Stakeholder Information

Author: Jatin Gopisetty ***Editors:*** Aleen Le, Sowmya Yella

Charging Station Owners

•***Role***: Operates charging station

•***Contributions***: Provide charging infrastructure, and implement our predictive model for maintenance.

Government Stakeholders

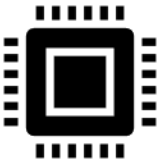
• ***Role***: Regulators and policymakers over the EV infrastructure and car development.

•***Contributions:*** Provide funding, regulatory support, data for policy development, and monitoring.

Maintenance and Repair Service Providers

•***Role***: Maintenance and provides services for charging infrastructure.

•***Contributions:*** Conduct repairs as needed as predicted by the model.



Technology Partners

• ***Role****:* Providers of AI, and mobile app technology for development.

•***Contributions****:* Design, Develop and implement model's mobile apps.

Data Analysts and Scientists

Roles: Expert in data analytics, predictive modeling, and AI.

Contributions: performs Data analysis, model development.

2.4 Project Plan and Schedule

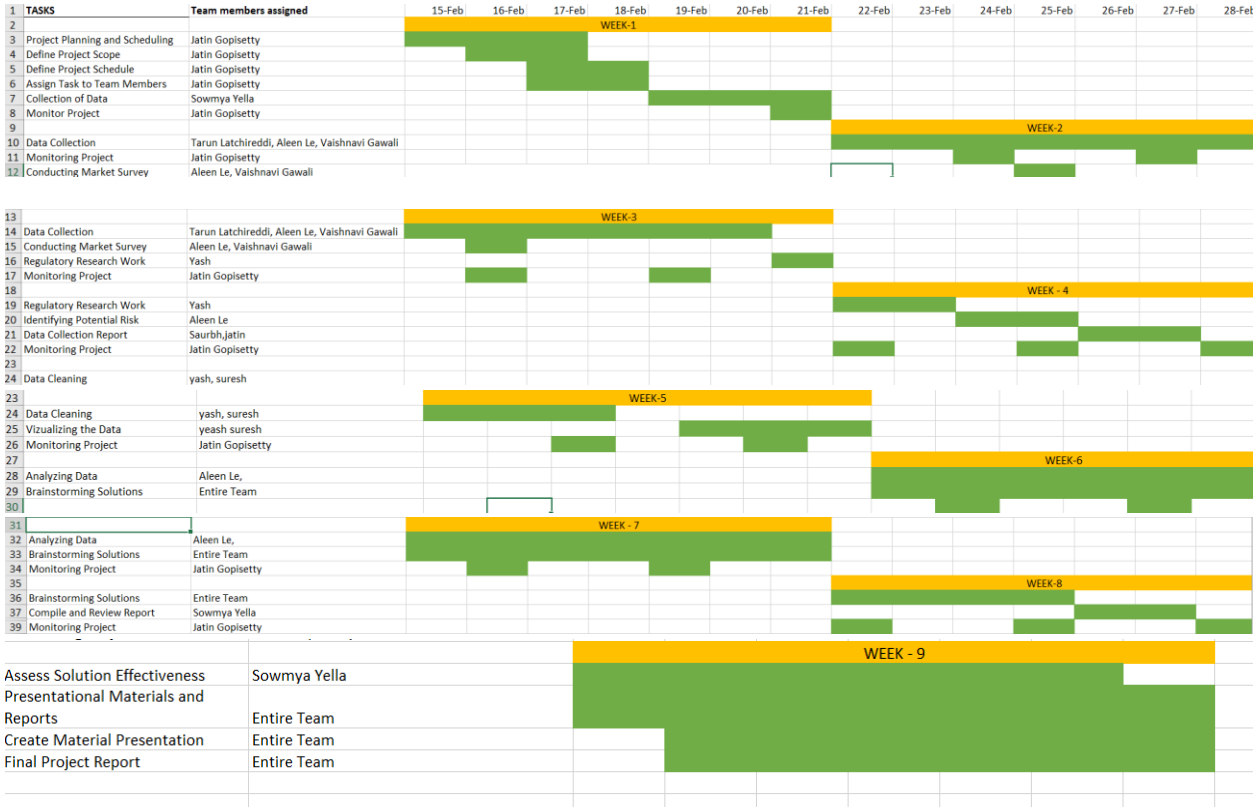
Author: Jatin Gopisetty ***Editors:*** Sowmya Yella

Our initial plan was to do in-depth market research on Canadian EV market extending our research to different sectors that contribute to the changes in the EV market and we performed analysis on collected data to find the trends of the market.

We have done a SWOT analysis which helped us to understand the gap in the market (gap analysis) where we found a scope for new business and has scope of growth in the market.

The next step for the project is to find innovative solutions for which we had brainstorming sessions, from which we were able to find three innovative solutions culminating in the creation of a comprehensive project report.

Gantt Chart



2.5 Technology and Infrastructure

Author: Suresh Gopalakrishnan ***Editors:*** Vaishnavi Gawali, Yash Shiyani, Tarun Latchireddi, Jatin Gopisetty

(We have to brief in this section as we will be explaining in detail in coming section)

The technological platform and infrastructure are critical to the project's success, especially when venturing into an emerging market. The proposed system for this project will leverage Amazon Web Services (AWS), a leading public cloud service provider. In Dec 2023, Gartner Magic Quadrant announced that AWS is a Strategic Cloud Platform Services leader and the longest-running leader in the cloud space. AWS offers a wide range of services than any other public cloud service provider which includes compute, database, serverless computing, machine learning (ML) services, data analytics, and the Internet of Things (IoT). The comprehensive service offerings will enable us to build applications faster, easier, and cost-effective.

Figure 1: Magic Quadrant for Strategic Cloud Platform Services

Using cloud solutions offers several advantages-

1. Scalability – on-demand resource scalability to facilitate large-scale market analysis without huge cap expense.
2. Cost-effective—A pay-as-you-go model for most of the services and spot instances for computing will result in significant cost savings (up to 60%) as our project will have fluctuating workloads.
3. Community and Support – AWS has large community and supported by 10K plus partners
4. Security and Compliance – Comprehensive security features
5. Availability – Global data centers will allow us to deploy and transfer data around the world with high-performance and secure

To build the platform for the proposed system, we have included several AWS services in our technology stack. Here are the high-level details:

Mobile Application (User Interaction Layer)

- **AWS Amplify & React SDK**: Used for building the mobile application interface.
- **Amazon Cognito**: Manages user authentication and authorization.
- **Amazon API Gateway**: Serves as an entry point for the mobile app to interact with backend services.

Data Management (Data Layer)

- **AWS IoT Core & AWS IoT SiteWise**: Collects data from IoT devices at the charging stations.
- **Amazon S3**: Stores large amounts of data including user profiles, session details, and IoT data.
- **Amazon Aurora**: A relational database used to store transactional data like station details and session information.
- **AWS Lambda**: Used for serverless computing to run code in response to events, such as payment processing, retrieving station details, and processing IoT data.

CI/CD and Development (DevOps Layer)

- **AWS CodeCommit**: Source code management tool
- **AWS CodeBuild**: To compile and build packages
- **AWS CodePipeline**: To deploy the code in all region using Pipelines
- **Kubernetes on AWS (EKS)**: Manages container applications with auto-scaling.
- **Elastic Container Registry**: Container Images storage and management

Analytics and Machine Learning (Analytics Layer)

- **AWS Glue**: ETL service used for data preparation and loading.
- **AWS SageMaker**: To train and deploy machine learning models.
- **Amazon CloudWatch**: Monitors the application and system-wide performance changes.

Network Infrastructure (Infrastructure Layer)

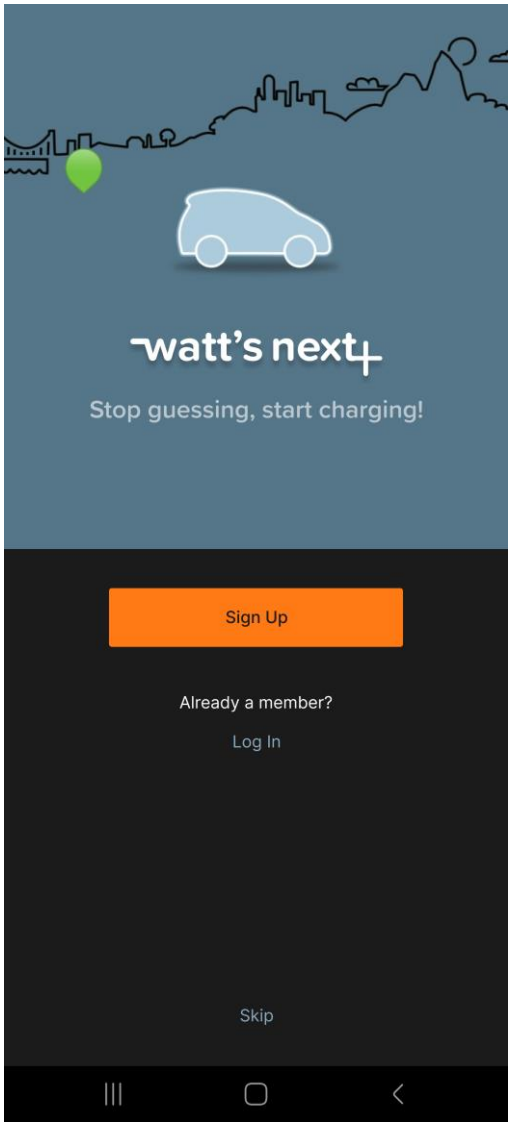
- **VPC with Public and Private Subnets**: Private network to isolate traffic
- **Elastic Load Balancing (ELB)**: Distribute traffic to different targets
- **NAT Gateway & Bastion Host**: Securely manage traffic going in and out of a VPC.

2.6 System Design and Architecture

Author: Yash Shiyani, Suresh Gopalakrishnan ***Editors:*** Vaishnavi Gawali, Tarun Latchireddi, Jatin Gopisetty

Here's our prototype showcasing the UI design for our idea "Watt's Next!". A glimpse of the intuitive and efficient platform that can be developed to empower charging station owners with comprehensive control and insights. From monitoring individual station statuses to analyzing usage patterns and receiving timely alerts, our prototype demonstrates the seamless integration of functionality and user-friendly design.


watt's next


watt's next
Stop guessing, start charging!
Sign Up
Already a member?
Log In
Skip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Search
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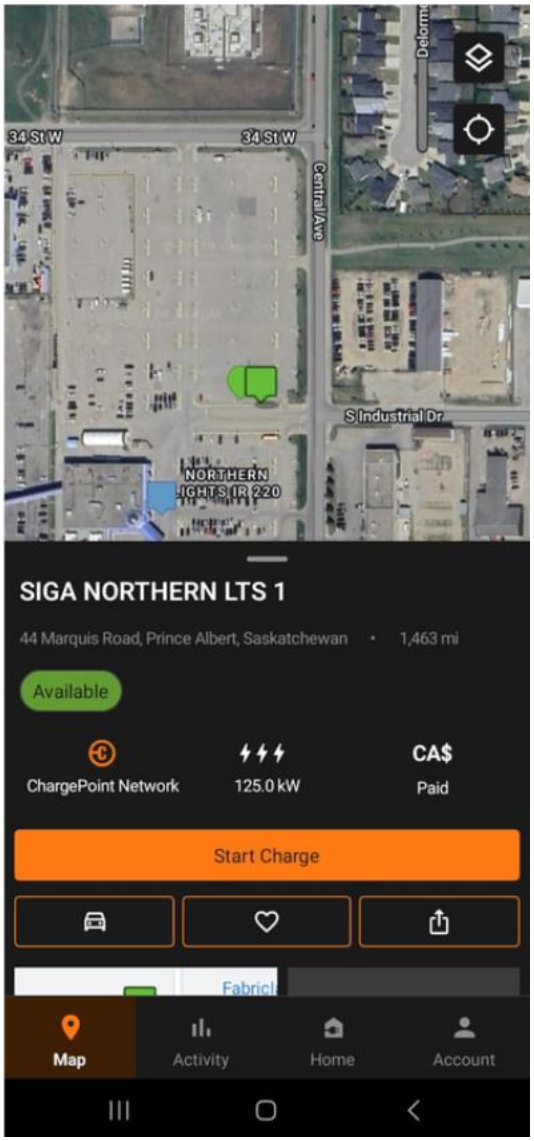
Home
Account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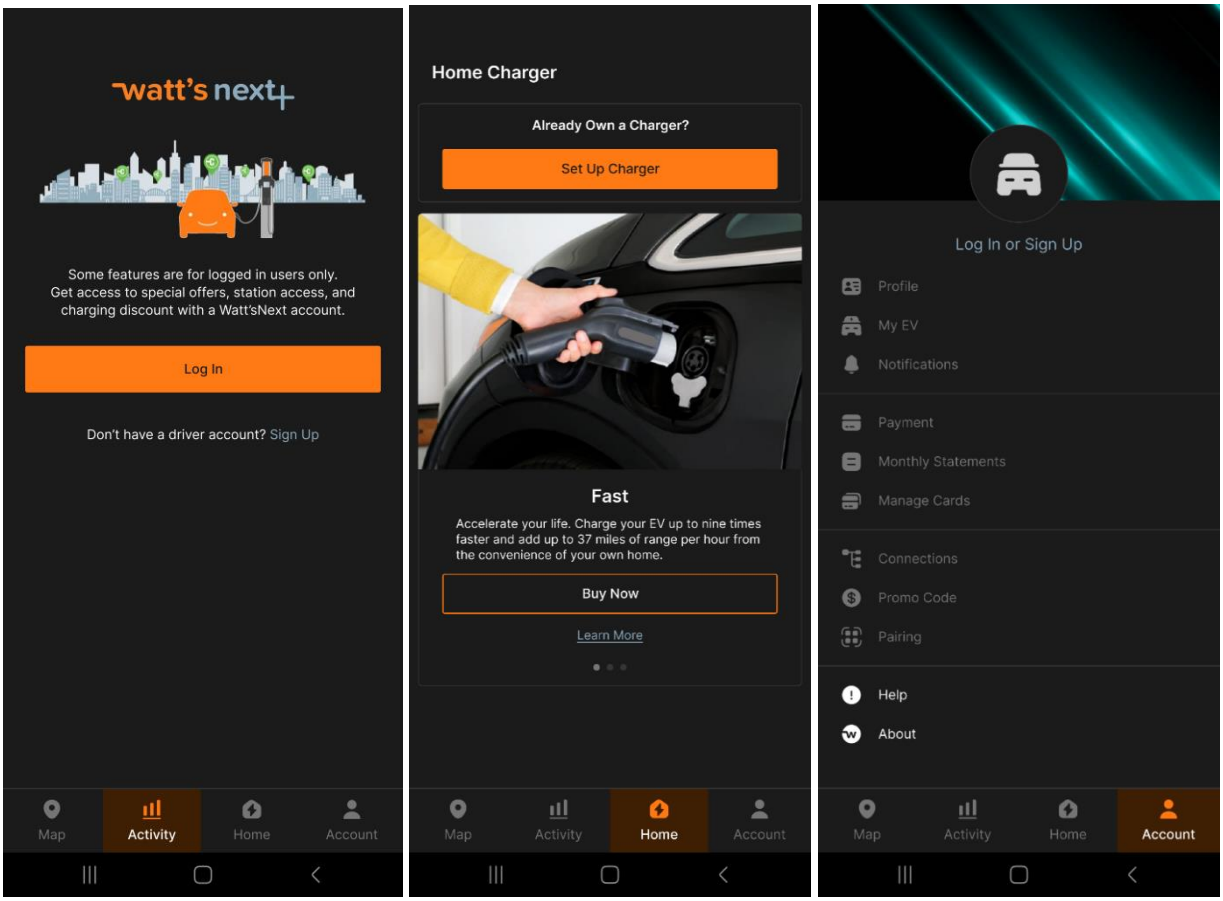
watt's next
Some features are for logged in users only.
Get access to special offers, station access, and charging discount with a Watt'sNext account.
Log In
Don't have a driver account? Sign Up
Map
Activity
Home
Account
Home Charger
Already Own a Charger?
Set Up Charger
Fast
Accelerate your life. Charge your EV up to nine times faster and add up to 37 miles of range per hour from the convenience of your own home.
Buy Now
Learn More
Map
Activity
Home
Account
Log In or Sign Up
Profile
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Manage Cards
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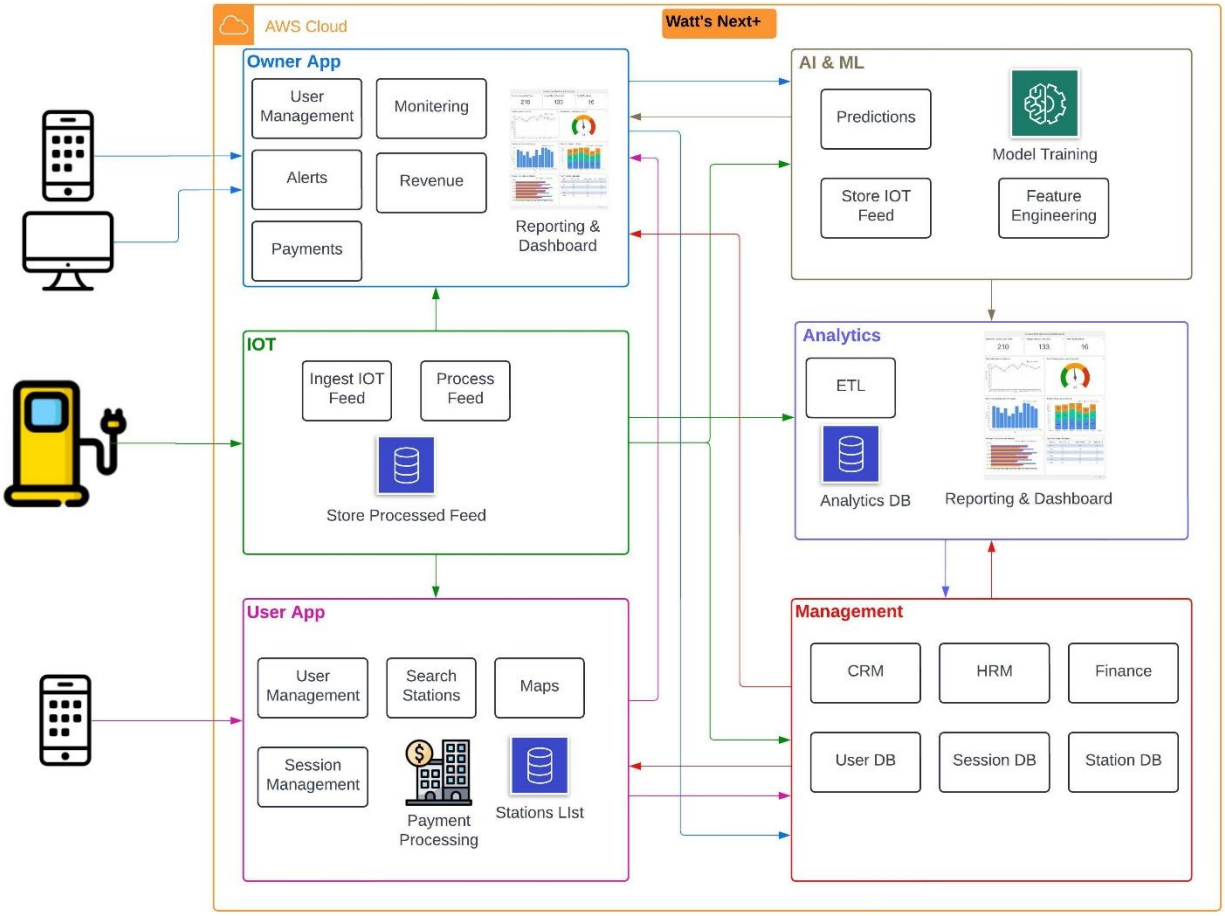
System Architecture:



User App

- **Mobile Application**: Built with AWS Amplify and React SDK, this app allows public users to create accounts, find available charging stations, and initiate charging sessions. Station health and availability are presented to the users, and defective stations are hidden.

Owner App

- **Owner Application**: Station owners application interface is to monitor station health, update station details to main DB, receive alerts, view revenue data, and manage user payments.

IoT Layer

- **IoT Device Integration**: IoT sensors at each charging station send data to AWS IoT SiteWise and AWS IoT Core for real-time monitoring and health assessment of the stations.
- **Data Processing**: AWS Lambda functions process the IoT data, which is then stored in Amazon S3 and RDS for further use and share with other sub systems

AI & ML Layer

- **Machine Learning**: AWS SageMaker is used for building predictive models that analyze the health of charging stations. These models can predict failures, thus enabling preemptive maintenance.
- **Feature Engineering**: This code transforms IoT data into features suitable for machine learning predictions

Analytics Layer

- **ETL Process**: AWS Glue is used to extract, transform, and load data into the Analytics DB for reporting.
- **Reporting & Dashboard**: Various intelligence tools like Tableau, PowerBI are used for creating visual dashboards to provide 360 views for station owners and management.

Management Layer

- **Database Management**: User, session, and station data are managed using relational databases, using Amazon Aurora, which ensures data integrity and fast access.
- **CRM, HRM, Finance**: Different management modules for Customer Relationship Management, Human Resources, and financial operations interact with the databases for operational purposes.

CI/CD and DevOps Layer

- **Development Pipeline**: AWS CodeCommit, CodeBuild, and CodePipeline are used for end-to-end Software Development Lifecycle (SDLC)
- **Kubernetes and Container Management**: The management application uses EKS (Elastic Container Services) to deploy container applications

Infrastructure Layer

- **AWS VPC**: The Virtual Private Cloud (VPC) is configured with public and private subnets to isolate traffic and secure application.
- **High Availability**: Elastic Load Balancing and Auto Scaling ensure the application remains highly available and scales as per demand.

Connectivity and Data Flow

- **API Gateway**: It acts as a conduit between the mobile app, owner app, and backend services.
- **Payment Processor**: It securely processes payments for Stations users, interfacing with banks and financial institutions.

2.7 Data Collection

Author: Tarun Latchireddi ***Editors:*** Aleen Le, Vaishnavi Gawali

Here is a summary of the steps we are doing to gather, store, process, and secure the data to meet the needs of aggregation through predictive modeling:

***Data Collection**:*

1. Charging Station Data Collection*:*

-Real time station information*:* IoT devices are deployed at each station to gather data and record metrics like voltage, current, energy consumption, and station status.

- Predictive maintenance alerts: Collect data on station health parameters such as temperature, voltage, and usage patterns for predictive analytics.

2. EV User App Data Collection:

- Location-based services: Utilize GPS data from mobile devices to determine user location.

- Car Specifications: User inputs the relevant data like the size of the battery and charging capacity to determine the nearby charging station and estimated charging time.

- Charging Port Availability: Information regarding the availability of charging port at a particular charging station or we should wait in queue etc.

Data Storage:

1. Charging Station Data Storage:

- We are using the IOT devices for storing the data related to station performance which is sent to the AWS IoTSiteWise service to store the process feed.

2. EV Owner App Data Storage:

- User-related data: We are storing the user personal data, vehicle information, weekly reports securely on the AWS S3 buckets with appropriate IAM policies and authorizations.

- Real-time station information:

Data Processing:

- We are using the AWS Lambda functions to process the data which is stored in the AWS IoTSiteWise and then moved into S3 buckets and RDS for storage and further processing.
- Using AWS Glue for extracting, transforming and loading the real-time data to analyze station performance and predict maintenance and downtime.

- Using the AWS SageMaker, we are using machine learning algorithms for predictive maintenance alerts based on previous data and current station conditions.

- Perform real-time analytics using visualizations tools like Tableau and PowerBI on station performance data to predict the maintenance beforehand and optimize the usage of all the charging ports and reduce the downtime.

Data Security:

We are securing the data in the AWS S3 buckets using the IAM policies and authorizations provided to the concerned parties as per their requirements and needs.

2.8 Evaluation Metrics

Author: Saurabh Nair ***Editors:*** Aleen Le, Jatin Gopisetty

This project will utilize various metrics to track progress and ensure successful development of the Intelligent EV Charging Network Platform.

App Development:

- Feature Completion Rate: We will track the percentage of features completed on schedule according to the project timeline.
- User Interface (UI) Testing Results: Usability testing with a representative user group will measure user satisfaction with the app's interface and functionalities.

Predictive Maintenance System:

- Downtime Prediction Accuracy: We will monitor the accuracy of the system's predictions for potential downtimes at charging stations.
- Station Downtime Reduction: We will track the percentage reduction in reported downtime at charging stations integrated with the platform's maintenance system**.**

User Adoption:

- Number of App Downloads: This metric will indicate the overall interest and user base growth.
- Active Users: We will track the number of users who consistently engage with the app to find and utilize charging stations.
- User Satisfaction Surveys: Periodic surveys will measure user satisfaction with the app's features, ease of use, and overall experience.

Station Owner Engagement:

- Number of Stations Integrated: We will track the number of charging stations successfully integrated with the platform's network.
- Station Owner Feedback: Feedback forms will gather insights and satisfaction levels from charging station owners regarding the platform's benefits.

Data Collection Methods:

- App development progress will be tracked internally using project management tools.
- UI testing results will be obtained through user testing sessions with a recruited participant group.
- Predictive maintenance system performance data will be collected automatically by the system itself.
- User adoption data will be gathered through app analytics tools and user surveys.
- Station owner engagement information will be collected through integration records and feedback forms distributed to station owners.

By monitoring these metrics throughout the project lifecycle, we can identify areas for improvement, ensure the platform meets user and owner needs, and ultimately achieve project goals.

2.9 Risk Management Documentation

Author: Aleen Le ***Editors:*** Yash Shiyani

The main risks to consider would be financial, market, technology, execution risks [1].

- **Financial risks**
    - Sustainability
        - Research into the Canadian EV market shows that the Canadian government has set a target for having 100% of all vehicle sales to be zero-emission by 2035 [2], so this is a low risk because the market trend for sales should increase over the next few years and services for EVs should increase in demand accordingly.
    - Profitability
        - No research was found on how much it costs to manufacture chargers because companies do not publicly publish this information. However, depending on factors such as location, level 2 charging stations can generate a profit margin of 15% to 35% with an operational cost of 20-30% of revenue [3].
        - To manage: Choosing a suitable location for setting up seems to be the most important factor for profit in terms of charging stations, so locating high traffic areas to establish would be needed.

- **Market risks**
    - Market size
        - The current trend shows that Canada is experiencing a steady growth in EV sales that is increasing by about 1 billion annually [4]. Charging stations are increasing in revenue by about 15 million annually as well [4]. This means that it is a low risk to invest in this market because of consistent growth.
    - Competition
        - There are at least 6 well known EV manufacturers in Canada [5], but it appears that some of them have started to transition their business model away from manufacturing chargers. They all offer a wide range of products.
        - To manage: In order to penetrate the market, a wide range of products needs to be manufactured or a unique product that is not currently being marketed needs to be created.
    - Location
        - Currently there are three provinces in Canada that are experiencing the fastest growth, which are Ontario, Quebec and British Columbia [6]. These are the most urbanized and populated, so growth is much slower in the more rural areas of Canada.
        - To manage: When selecting where to construct stations, urbanized areas should be targeted first to take advantage of the current growth.

- **Technology risks**
    - Startup time
        - Because the EV market is rapidly growing there is a chance for the technology being developed will be out of date and obsolete before the client can capitalize on it [1].
        - To manage risk: The trends in the market need to be monitored and if there is a downward trend in the current technology being developed, then the assets should be converted or liquidated to avoid financial loss.

- **Execution risks**
    - Poor management
        - A startup can suffer from a lack of direction, so the business plan needs to be well designed, which involves setting goals and objectives, researching the competition, creating a marketing plan, building a strong team, planning the finances, etc.
        - To manage: One of the ways to mitigate the risk involves hiring a team of legal experts to make sure everything meets local and federal regulations. Another would be to evaluate and adjust by tracking progress and making changes as necessary [1].
    - Product failure
        - Manufactured products can experience technological failures and services can fail to meet customer expectations.
        - To manage: Products should be tested thoroughly before launch and evaluations need to be considered so products can be updated to meet customer demands.

2.10 Compliance and Regulatory Documentation

Author: Yash Shiyani ***Editors:*** Sowmya Yella

1. Data Privacy and Security Compliance:

- Ensuring compliance with the (PIPEDA), safeguarding the privacy of user data.

- Implementing robust security measures, including encryption and access restrictions, in line with Canadian privacy legislation.

2. Charging Station Standards:

- Compliance with Canadian electrical safety standards and regulations for charging station installations, including certification requirements.

3. Communications Protocol Compliance:

- Integration with Open Charge Point Protocol (OCPP) or other standard communication protocols in accordance with Canadian industry standards.

4. Accessibility Compliance:

- Compliance with the Accessibility for Ontarians with Disabilities Act (AODA) and any provincial accessibility regulations to ensure accessible features in charging station applications.

5. Service Level Agreements (SLAs):

- Creating clear agreements about how well the service will work, following the rules set by the Canadian government for how good and reliable it should be.

6. Regulatory Reporting:

- Provision of tools and features for charging station owners to comply with regulatory reporting requirements, including energy usage reporting and adherence to federal and provincial regulations related to EV infrastructure.

7. Health and Safety Regulations:

- Compliance with Canadian health and safety regulations, including Electrical Safety Authority (ESA) requirements, for safe charging station installations and operations.

8. Environmental Regulations:

- Adherence to environmental regulations and sustainability standards set by Environment and Climate Change Canada for charging station operations, including waste management practices.

9. Consumer Protection Regulations:

- Compliance with Canadian consumer protection laws, ensuring transparency in pricing, billing practices, and resolution procedures for charging services.

10. Data Protection and Privacy Policies:

- Creating rules to keep data safe and private, following Canadian privacy laws. This outlines data handling practices, retention policies, and breach response procedures.

11. Ethical Considerations:

- Commitment to use data ethically by being open about how we collect and use it, and by respecting your privacy rights, following the rules set out in Canadian guidelines for ethical behavior.

2.11 Change Management Logs & Documentation

Author: Sowmya Yella ***Editors:*** Jatin Gopisetty

1) Presentation Requirement

- *Description:* The client initially was looking for a project proposal presentation, but then indicated that an official approval email would be enough if the team decided it was required.
- Impact Analysis: This improvement reduced the amount of time and effort required by the team to prepare and deliver the presentation, allowing them to focus more on research and proposal creation.
- Approval: The client authorized the update by email.
- Implementation: The team communicated the project proposal and updates via email

2) SWOT analysis and strategies

- *Description:* The client provided feedback that the team not only conduct a SWOT analysis, but also build SWOT-based plans to address the project's challenges and opportunities.
- *Impact Analysis:* This change required the team to expand their SWOT analysis and develop additional plans and suggestions based on the findings.
- *Approval:* The client gave his approval for this change during a team meeting.
- *Implementation:* The team updated the SWOT analysis report with project-specific strategies and recommendations.

3) Innovative Solution Development

- *Description:* The client asked the team to build unique EV charging options to address existing market problems.
- *Impact Analysis:* This modification shifted the team's focus from the initial research phase to the solution creation phase, requiring more time and effort.
- *Approval:* The client approved this change by email, allowing the team to move forward with the solution development.
- *Implementation:* The team developed a "Project Solution Proposal and Feasibility Analysis" paper that detailed three innovative EV charging solutions.

4) *Solution selection*

- *Description:* After reviewing the team's recommended solutions, the client decided on Solution #3, "Aggregation Through Predictive Modelling Services," to be executed.
- *Impact Analysis:* This adjustment allowed the team to focus its efforts on the chosen solution rather than thoroughly researching all three options.
- *Approval:* The client approved this change via email, giving the team the go-ahead to proceed with Solution #3.
- *Implementation:* The team began working on Solution #3 in accordance with the client's requirements.

Throughout the project, the team maintained open communication with the client, actively sought feedback, and documented all changes to ensure alignment and efficient project execution. The change management logs, and documentation will be included in the final project deliverables to provide a comprehensive record of the project's evolution.

2.12 Lessons Learned and Recommendations

Author: Jatin Gopisetty ***Editors:*** Yash Shiyani

Identification of Problem: Identifying the right problem by eliminating the core other problems will help us understand and provide dedicated solutions to the problem.

Approach: Finding solutions in the old traditional style will not help us outstand our competitors. Solutions that are innovative and out of the box will help us stand at the top of the chain in any category.

Plan B: In a situation when our plan encounters obstacles or a solution might not be feasible, a Plan B will help us to succeed in the project.

Data Quality: One of the major challenges we faced was the Data quality, we had data from different sources and the task was to identify the relevant data for the problem.

Data-Driven Decision Making: Collecting and cleaning the right data helps us to make informed decisions that help us understand the gap in the market.

2.13 Final Project Evaluation

Author: Saurabh Nair ***Editors:*** Jatin Gopisetty, Yash Shiyani

Following the platform's launch, a comprehensive evaluation will assess its success in fulfilling the objectives outlined in the Project Overview.

Project Objectives Review:

- To streamline the EV charging experience in Canada.
- To address pain points for both EV users and charging station owners.
- To develop a user-friendly app with real-time station information.
- To implement a predictive maintenance system to minimize station downtime.

Evaluation Metrics Analysis:

Data collected through the evaluation metrics will be analyzed to assess progress towards project objectives.

- A high feature completion rate and positive UI testing results will indicate a user-friendly and functional app.
- Increased accuracy in downtime prediction and reduced reported downtime at stations will show the predictive maintenance system's effectiveness.
- A growing number of app downloads, active users, and positive user satisfaction survey results will signify user adoption and satisfaction with the platform.
- An increasing number of integrated charging stations and positive feedback from station owners will indicate successful owner engagement and platform benefits for their businesses.

Additional Considerations:

We will also consider qualitative factors alongside the quantitative data:

- User testimonials and reviews on app stores.
- Media coverage and industry recognition of the platform.
- Potential impact on overall EV adoption rates in Canada based on industry reports and user feedback.

Overall, Success Assessment:

Based on the analysis of evaluation metrics, user feedback, and industry trends, a final assessment will determine if the project successfully addressed the initial business problem of a fragmented and unreliable EV charging landscape in Canada. This evaluation will consider the platform's effectiveness in improving user experience, increasing charging station efficiency, and ultimately accelerating EV adoption within the country.

2.14 Transition Plan

Author: Jatin Gopisetty ***Editors:*** Saurabh Nair

This Research project will be handed over to the client through a structured transition plan, which includes:

Initial Project Proposal (Presentation and Documentation): This Documentation has the initial proposal and approach towards the project, this will help the client to understand the primary base of the project which will help them reconstruct the project if needed.

SWOT Analysis Report: This report will help the client know their competitors by understanding their weaknesses, strengths, and gaps within the market.

Weekly Reports: These reports will provide insights into the duration required for data collection, cleaning, and analysis, enabling the client to develop an accurate project timeline. These reports also contain the report of the three innovative solutions proposed

Final Project Proposal (Presentation and Documentation): This document will help the client understand more about the final solution out of the proposed 3 innovative solutions, this document talks about the right system architecture, predictive model, and SWOT report required for the project in the future.

3 Market Research and Feasibility Study

3.1 Identification of Target Market Segmentation

Author: Vaishnavi Gawali ***Editors:*** Saurabh Nair, Aleen Le

The solution proposed to the client is Aggregation through predictive modelling. The target audience for this solution would be EV owners and charging station owners. Before investing in this implementation of this solution, it is essential to understand the EV market of Canada. We need to understand the adequate scope of the EV market. The Market Research is categorized into the following sections.

1) Market Size & Growth

As per the data released by Statistics Canada [7] we can see there is significant increase in the number of registrations for Electric Vehicles with fuel type – Battery Electric (BEV), Hybrid Electric and Plug-in Hybrid Electric (PHEV). On a similar note, there is a constant decline in the registrations for vehicles with fuel type – Gasoline & Diesel as compared to the EVs. The following table shows the number of vehicle registrations:

Year	Quarters	Fuel Type						
		Gasoline	Diesel	Battery Electric	Hybrid Electric	Plug-in Hybrid Electric	Other Fuel Types	All Fuel Types
2017	Q1	403,087	14,283	1,664	4,185	1,824	0	425,043
	Q2	581,151	17,643	2,195	7,199	1,830	0	610,018
	Q3	521,730	18,150	2,400	7,264	2,784	1	552,329
	Q4	423,659	15,711	2,820	5,473	3,179	4	450,846
2018	Q1	380,187	14,642	2,639	4,377	4,205	70	406,120
	Q2	563,103	21,781	7,393	8,034	7,486	79	607,876
	Q3	500,791	19,327	6,506	6,944	6,116	70	539,754
	Q4	390,802	14,850	6,032	6,482	3,906	38	422,110
2019	Q1	373,971	13,223	5,273	6,596	3,002	58	402,123
	Q2	527,118	16,058	12,370	13,053	7,076	88	575,763
	Q3	487,211	16,810	10,120	10,349	6,066	51	530,607
	Q4	388,271	12,998	7,760	8,392	4,498	33	421,952

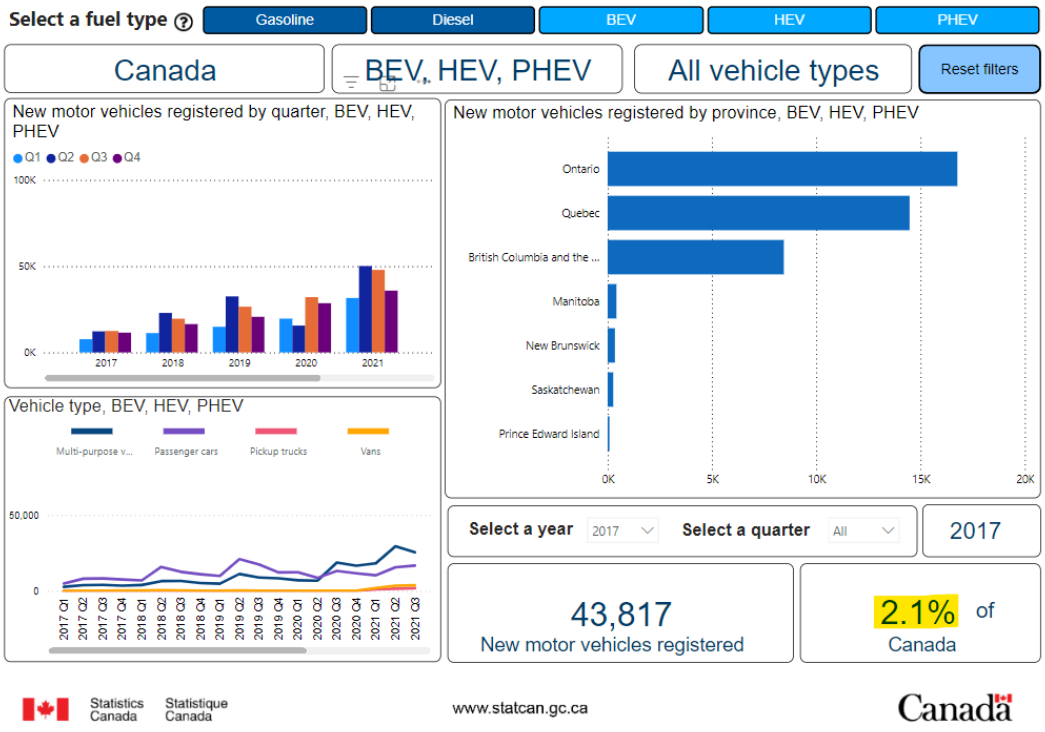
	Q1	303,035	13,567	8,386	7,680	3,537	9	336,214
	Q2	277,460	12,867	6,088	6,367	3,115	14	305,911
	Q3	457,057	19,494	12,601	14,782	4,698	10	508,642
2020	Q4	347,376	18,841	11,961	12,624	3,967	25	394,794

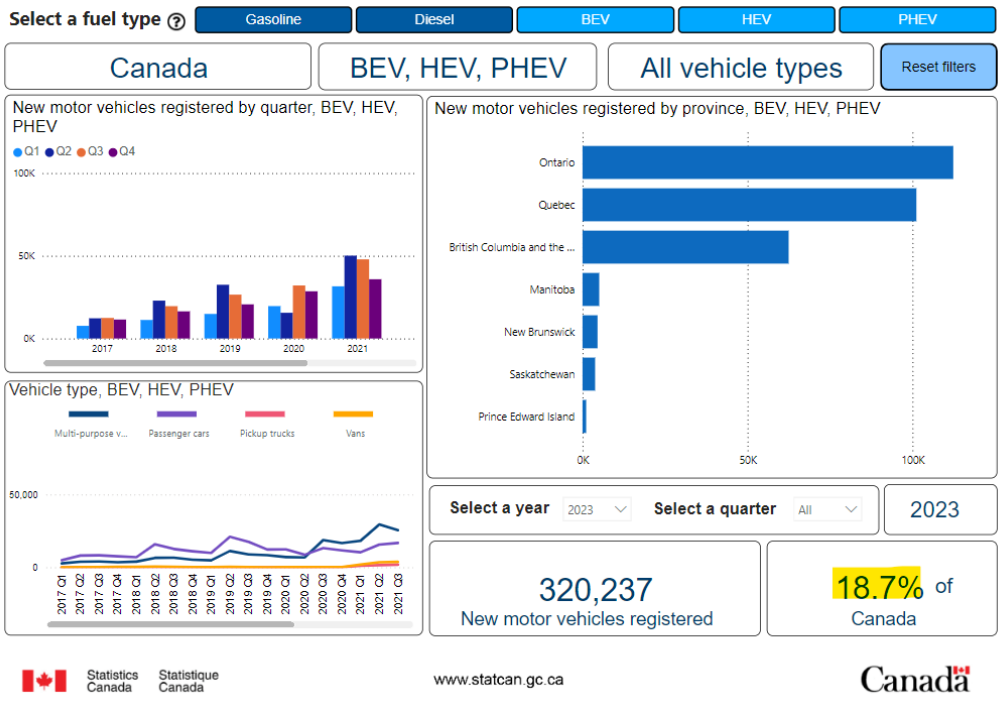
	Q1	326,146	18,112	12,693	14,278	4,592	5	375,826
	Q2	416,441	20,057	16,167	26,088	7,839	0	486,592
	Q3	384,338	14,411	15,845	23,909	8,117	0	446,620
2021	Q4	288,436	13,301	14,021	15,055	6,758	0	337,571

	Q1	282,993	15,982	19,695	14,826	6,323	1	339,820
	Q2	351,524	23,044	21,764	27,449	8,068	12	431,861
	Q3	318,834	19,682	29,376	21,514	4,937	5	394,348
2022	Q4	279,074	16,536	27,754	17,361	5,645	0	346,370

	Q1	285,757	16,562	23,774	22,916	6,759	6	355,774
	Q2	367,971	19,751	34,610	38,987	12,047	5	473,371
2023	Q3	345,491	17,790	42,260	38,933	13,333	29	457,836

From the following dashboards presented by Statistics Canada [7], we can say that there is a growth in the EV registration from 2.1% to 18.7% in Canada from 2017 to 2023 respectively. The below shows the year wise growth:


Select a fuel type
Gasoline
Diesel
BEV
HEV
PHEV
Canada
BEV, HEV, PHEV
All vehicle types
Reset filters
New motor vehicles registered by quarter, BEV, HEV, PHEV
Q1 Q2 Q3 Q4
100K
50K
0K
2017
2018
2019
2020
2021
New motor vehicles registered by province, BEV, HEV, PHEV
Ontario
Quebec
British Columbia and the ...
Manitoba
New Brunswick
Saskatchewan
Prince Edward Island
0K
5K
10K
15K
20K
Vehicle type, BEV, HEV, PHEV
Multi-purpose v...
Passenger cars
Pickup trucks
Vans
50,000
0
Select a year
2017
Select a quarter
All
2017
43,817
New motor vehicles registered
2.1% of
Canada
Statistics Canada
Statistique Canada
www.statcan.gc.ca
Canada


Select a fuel type
Gasoline
Diesel
BEV
HEV
PHEV
Canada
BEV, HEV, PHEV
All vehicle types
Reset filters
New motor vehicles registered by quarter, BEV, HEV, PHEV
Q1 Q2 Q3 Q4
100K
50K
0K
2017
2018
2019
2020
2021
New motor vehicles registered by province, BEV, HEV, PHEV
Ontario
Quebec
British Columbia and the ...
Manitoba
New Brunswick
Saskatchewan
Prince Edward Island
0K
50K
100K
Vehicle type, BEV, HEV, PHEV
Multi-purpose v...
Passenger cars
Pickup trucks
Vans
50,000
0
Select a year
2023
Select a quarter
All
2023
320,237
New motor vehicles registered
18.7% of
Canada
Statistics Canada
Statistique Canada
www.statcan.gc.ca
Canada

Year	Number of EVs (HEV, BEV, PHEV) Registered	% of total vehicles in Canada
2017	43,817	2.1%
2018	70,120	3.5%
2019	94,555	4.9%
2020	95,806	6.2%
2021	165,362	10.0%
2022	204,712	13.5%
2023	233,619	18.2%

2) Provinces with Maximum EVs

From the following dashboard by Statistics Canada [7], we can find that provinces - Ontario, Quebec and British Columbia & Territories have the maximum registrations, they are as follows:

	2017	2018	2019	2020	2021	2022	2023
Ontario	16,763	26,030	35,721	34,628	53,069	74,130	82,089
Quebec	14,474	24,685	25,578	27,332	52,443	62,557	72,534
British Columbia & Territories	8,444	14,414	24,226	23,926	37,784	42,856	46,501

3) Government Initiatives & Opportunities

From the above numbers, we can infer that there is rise in the EVs in the Canadian Market. One reason could be the Government Initiatives. The Government of Canada has launched 2030 Emission Reduction Plan [8], where the target is to reach its emissions reduction target of 40 percent below 2005 levels by 2030 and net-zero emissions by 2050. For that, they have already set the target that by 2035 100% new light duty vehicles and trucks need to be ZEV (Zero Emission Vehicles) [9].

The Government has introduced a $660 million Zero-Emission Vehicles (iZEV) Program which provides incentives and encourages the adoption of ZEVs [9]. There are incentives introduced up to $5000 for ZEVs and up to $200,000 for Medium and Heavy duty Zero Emission Vehicles [10].

Apart from the government incentives, there are other reasons as well for the switch to EVs. A press release by EY [11] indicates rising fuel costs as a primary reason Canadians are switching to EVs. With increasing fuel prices and government incentives, 52% of Canadians are considering purchasing an EV. The same press release also indicates that 24% of the potential buyers still have doubts due to lack of proper charging infrastructure.

Based on the above research, we can say that EV demand is rising in Canada due to Government initiatives and the increase in fuel prices. When more people adopt, aggregation service through predictive modelling can be a good business idea for our client.

3.2 Competition Research

Author: Aleen Le ***Editors:*** Vaishnavi Gawali

Because the focus was initially on single phase EV chargers, research was done on companies that manufactured chargers in Canada. Six of the top companies include Enel X, FLO, Grizzl-E, SWTCH Energy, the Electric Circuit, and Hypercharge. Two of them, SWTCH Energy and the Electric Circuit, seem to have switched their focus from the manufacture of chargers to selling services related to chargers and therefore can be considered indirect competitors. The product listings for the indirect competitors are services and would require consultation to find a price.

The products that have a listed price for the top four direct competitors will be detailed below:

Company: Enel X

Product Name	**Product Type**	**Price (in USD $)**
JuiceBox® 32	Home EV Charging Station	469.00
JuiceBox® 40	Home EV Charging Station	489.00
JuiceBox® 48	Home EV Charging Station	529.00
JuiceBox® Pro 32	Commercial Charging Station	1,199.00
JuiceBox® Pro 40	Commercial Charging Station	1,249.00
JuiceStand Pro	Accessory	649.00
14” Mounting Bracket	Accessory	40.00
2-piece Mounting Bracket	Accessory	29.99
Input Cable	Accessory	29.00
JuiceNet® Green	Service (Software Upgrade)	50.00
JuiceEco	Service	30.00 / year
Enel X Way RFID Card for Commercial EV Chargers (10 Count)	Service	39.00
Enel X Way RFID Card for Commercial EV Chargers (25 Count)	Service	95.00
Enel X Way RFID Card for Commercial EV Chargers (100 Count)	Service	349.00

Additionally, Enel X has commercial charging stations under the names of JuicePedestal, Juice Pump 50 kW, JuicePump 180-360 kW, and JuicePump 175 kW that do not have a listed price online *[12]*.

Company: FLO

These products in the table show discontinued on their main site, but none of their new products are listed on their store site.

Product Name	Product Type	Price (in USD $)
FLO Home G5 – Level 2 EV Charging Station	Home EV Charging Station	549.00
FLO Home X5 – Carbon (Black) Smart Level 2 EV Charging Station	Home EV Charging Station	599.00
Power-line Communication (PLC) adapter	Accessory	32.40
Replacement Cable & Connector	Accessory	220.00

On their main site, they show that they have home EV chargers (FLO Home X3, X6, X8), charging stations (CoRe+, CoRe+ MAX), smart public charging stations (SmartTWO, SmartTWO-BSR), fast charging stations (SmartDC 50 kW, SmartDC 100 kW), and FLO Ultra All-in-one DC Charger. None of these have a listed price *[13]*.

Company: Grizzl-E

Product Name	Product Type	Price (in USD $)
Alpha Classic 40A	Home EV Charging Station	299.00
Grizzl-E Classic 40A	Home EV Charging Station	349.99
Grizzl-E Commercial	Commercial Charging Station	2,299.00
Grizzl-E Duo 40A	Home EV Charging Station	799.00
Grizzl-E Mini 40A	Home EV Charging Station	399.00
Grizzl-E Smart 40A	Home EV Charging Station	395.99
Grizzl-E Ultimate 80A	Home EV Charging Station	699.00
Kodiak DC	Commercial Charging Station	18,428.00
EasyEvPlug	Accessory	9.99
Heavy-Dury EasyEvPlug	Accessory	18.99
Mounting Bracket to Wall	Accessory	14.99
Mounting Cradle for Grizzle-E Mini	Accessory	14.99
Outdoor Safety Lock	Accessory	14.99
Pedestal	Accessory	799.00
SAE J1772 to Tesla Charging Adapter	Accessory	35.00
TP Link WiFi Extender	Accessory	24.99

[14]

Company: Hypercharge

Product Name	Product Type	Price (in USD $)
Hypercharge home Level 2 EV Charger	Home EV Charging Station	680.00

Hypercharge has more products but none of them have listed prices and require a request for a quote. Some of those include level 2 chargers (Hypercharge EVC10, Hypercharge EVC11, and AUtel MaxiCharger AC Ultra), DC fast charging stations (Kempower, ABB Terra Series, and FreeWire Boost Charger 200), software (Eevion Integrated Charging, Quantev Operations Suite, and Driver Mobile App), and services (Carbon Credit Program, Charging-as-a-Service, Comprehensive Warranty, Flexible Ownership Options, Proactev Station Monitoring, Project Design & Installation, and Site Preparation Package) *[15]*.

The competitor's strengths and weaknesses will be evaluated in the sections below.

3.3 SWOT Analysis

Author: Aleen Le ***Editors:*** Saurabh Nair

There are four major competitors in the Canadian market for EV chargers. Because our client is trying to enter the market, they currently do not have any products or services to compare directly with the competition. Therefore, a SWOT analysis was performed in each one to help identify a gap to create a solution to penetrate the market.

All Competitors

Because all the companies operate in Canada, they will all share certain opportunities and threats.

Opportunities

- The Canadian government has set a target of having all vehicle sales be zero-emission nationally by 2035 with an intermediate goal of 60% new vehicles being EVs by 2030 [2].
- This increasing greener demand will increase the need for infrastructure and equipment in relation to EVs, so the demand for EV chargers should rise proportionally.

Threats

- Because of the transition to 100% zero-emission vehicle sales, a common a threat for the companies in Canada is that it may open the market up to foreign competitors especially from China [2].
- The production costs for EVs are increasing due to requiring different types of batteries, equipment and minerals that are increasingly becoming harder to obtain [16]. It will make it less likely for customers to purchase EVs and the related components like chargers.

Enel X

Strengths

- Enel X has a strong brand identity because it was established as a subsidiary of the Enel Group, which is a Fortune 200 renewable energy leader founded in 1962 [12] so it has a long history in the energy market.
- As a global competitor, it has over 500 thousand charging ports worldwide with 230,000 of those ports located in North America [12].
    - Specifically, in regard to North America, it has a wide customer base with about 3,400 energy customers at more than 10,000 sites [12].
- Enel X also has a wide range of products ranging from home EV chargers, commercial EV charging stations, to accessories for EV charging stations [12].
- It also states that it has a high annual revenue of over $80 B [12]

Weaknesses

- Enel X has a poor reputation in regard to its service and phone app functionality. Based on online review sites it has overwhelmingly negative reviews for its services, especially concerning its customer service department.
    - Currently, on Trustpilot it has a rating of 1.2 [17] and on the Better Business Bureau it has a score of 1.33 [18].
    - Its phone app also has very bad reviews with a score of 2.7 on the App Store [19] and a 1.8 on Google Play [20].

Opportunities

- Enel X, as a global company, has additional opportunities because they can expand globally by entering the international market and are also open to collaboration with businesses allowing them to create new partnerships.
    - They offer many different partnership programs such as reseller partnerships, referral partnerships, financial partnerships, equipment manufacturer (industrial) partnerships, contractors (industrial), developers, platform/SW (secure wireless) providers, and commercial service providers [12].

FLO

Strengths

- Flo has a strong brand identity that is mostly focused in North America.
    - It was established in 2009 and has over 83,000 charging stations that include public, private, and residential stations.
    - Additionally, it has a wide customer base which includes over 490,000 EV drivers [13].
- They also offer a wide range of products including level 2 home chargers, level 2 charging stations, DC fast chargers, and accessories for their chargers [13].

- As of the time of writing, they have good reviews on their products.
    - Their phone app on the App Store and Google Play has high reviews with scores of 4.7 [19] and 4.2 [20] respectively.

Weaknesses

- Flo has a small team with around 550 employees compared to some of the other companies [13].
- There is a location gap between where their HQ is located (Quebec City, Canada) compared to where they are providing most of their business (in the US) [13].

Opportunities

- Flo has a goal of rolling out more charging stations in the province of Ontario [13] because of the Canadian government's initiative to implement more green technology.

Grizzl-E

Strengths

- Their parent company, United Chargers, has a focus on research, development, and manufacturing of EVSE (Electric Vehicle Supply Equipment) to create affordable EV charging solutions to increase the number of users switching EVs.
    - Grizzl-E has a unique price positioning because their products are less expensive than other residential EV charging brands [14] because their manufacturing process is more efficient by using only 1 PCBA (Printed Circuit Board Assembly) in their design without unnecessary components [21].
- They have a diverse range of products including residential chargers, DC chargers, and accessories for charging stations [14].
- They also have good product reviews based on Amazon with most of them rating around 4 or greater [22].

Weaknesses

- They were slow in their phone app deployment and just released their app in Aug 2023 despite being founded in 2019, and there is a lack of reviews on the app.
    - Currently, on the App Store there are 3 reviews [19].
    - On Google Play, there are 19 reviews [20].

Opportunities

- They are attempting to expand globally to push sales to Mexico, the Caribbean, and Japan and have purchased an EVSE company in Ukraine and will build a manufacturing center for Europe once the war ends [21].
- They have a goal to open distribution centers to cover 80% of the world's population and have proposed locations in France, the UK, UAE, Japan, India, China, Australia, and New Zealand [21].

Threats

- Because they're attempting to expand globally, they must meet different international certification standards for different countries. This can be an expensive and lengthy process [21].

Hypercharge

Strengths

- Hypercharge can provide a complete EV charging solution including hardware, software, and expert services [15].
- They have a flexible approach because they have adopted a hardware-agnostic approach based on OCPP (Open Charge Point Protocol) industry standards that lets them cater to customer needs and have a cloud-based platform that allows customers to activate and monitor their charging stations [15].
- They also have strong partnerships with leading electrical contractors, parking lot management companies, dealership distributors, and other affiliates [15].
- They have a diverse range of products including level 2 chargers, DC fast chargers, software, and services [15].
    - Software includes Eevion Integrated Charging, Proactev Network Management, and the Quantev Operation Suite [15].
    - Services include Charging-as-a-Service, Site Preparation Packages, Carbon Credit Programs, Flexible Ownership Options, and project design and installations [15].

Weaknesses

- They have a smaller customer base than other companies mentioned.
    - They only operate in Canada and in the US with only about 2,600 chargers and have a little over 280 public or commercial charging locations [15].
- Additionally, their phone apps do not have many reviews at this time, so it is hard to determine their quality.
    - App Store has only 2 reviews [19].
    - Google Play does not have any reviews [20].

Opportunities

- Hypercharge is listed on the Neo Exchange as of Nov 2022.
    - It is Canada's first publicly traded EV charging solutions provider. This gives it an opportunity to reach and increase the number of investors and stakeholders [15].
    - They are open to new collaborations to create new partnerships through their Preferred Partner Benefits program [15].

3.4 Porter's 5 Analysis

Author: Aleen Le ***Editors:*** Saurabh Nair

A Porter's 5 analysis was performed to identify the main forces of competition in the EV Charging industry. By understanding the main factors affecting the industry, it becomes easier to determine what advantages can be leveraged or what weaknesses need to be improved upon. Exploring each of the five main forces would help improve the proposed solution's profitability. Each of the forces will be explored below:

Threat of New Entrants:

With the government initiative to increase the number of EV sales in Canada, there is an increase in demand for charging stations all over the nation. This will drive up the necessity of EV-related projects and products, so new entrants will more easily be able to enter the market.

Bargaining Power of Suppliers:

The materials required to manufacture EVs are becoming increasingly harder to acquire, therefore driving up the prices of making EV chargers. It will require a substantial investment to break into the field if focusing on manufacturing EV chargers alone.

Bargaining Power of Buyers:

EVs are generally more expensive than a traditional gas-powered vehicle, therefore, it can be assumed that EV owners have more spending power as well. However, the cost for faster DC charging stations can cost as much as or more than a traditional vehicle, which drives down the incentive to purchase an EV and the associated chargers.

Threat of Substitute Products or Services:

There is not a true substitute for EVs on the market currently, so EV chargers will be necessary for them to function. Although not available yet wireless EV charging technology is currently being developed *[23]*.

Rivalry Among Existing Competitors:

The competition between rival companies will likely increase over time as more companies attempt to enter the market due to the government initiative. From the research done, it seems that some companies that manufactured chargers previously have shifted their strategies to EV related services instead.

3.5 PEST Analysis

Author: Saurabh Nair ***Editors:*** Aleen Le

Through this PEST analysis, we are aiming to examine the macro-environmental factors that could impact the proposed business model for single-phase EV chargers with predictive maintenance and an EV user app in the Canadian market. Using this PEST analysis, we will be able to develop a strategic approach for long-term success.

Political:

Government Incentives: There are several Canadian government incentives for EV adoption and charging infrastructure which could significantly boost the demand for our services. By staying updated on government policies and actively advocating for advocate might support our business model.

Regulations: We need to ensure compliance with all relevant regulations regarding data privacy, charging station safety, and electrical installation standards.

Trade Relations: Trade relations with key EV charger component manufacturers could impact our costs and supply chain.

Economic:

Economic Growth: A healthy Canadian economy with rising disposable income would positively impact consumer spending on EVs and charging solutions.

Fuel Prices: High gas prices could accelerate EV adoption, benefiting our business.

Interest Rates: Fluctuations in interest rates could affect access to financing for charging station owners, potentially impacting on our customer base.

Social:

Environmental Awareness: Growing environmental concerns are driving consumer preference for EVs. This trend aligns perfectly with our focus on promoting sustainable transportation.

Urbanization: The increasing concentration of population in urban areas is likely to increase demand for convenient charging solutions, which our app can facilitate.

Consumer Behavior: Understanding evolving consumer preferences for charging speed, convenience, and mobile payment options will be crucial for app development.

Technological:

Advancements in EV Technology: As battery range and charging speeds improve, single-phase chargers might become less relevant in public charging stations. We need to assess the long-term viability of this focus.

Smart Grid Integration: The integration of charging infrastructure with smart grids could optimize energy usage and create new business opportunities.

App Development Trends: Staying updated on app development trends and user interface best practices will be essential for maintaining a user-friendly and competitive app.

Conclusion

By considering our PEST factors, we will be able to develop a robust business strategy that leverages favorable trends, mitigates potential risks, and positions our company for long-term success in the Canadian EV charging market. We should continuously monitor these factors and adapt our approach as needed.

3.6 Feasibility Study

Author: Saurabh Nair ***Editors:*** Jatin Gopisetty

Executive Summary

This feasibility study examines the viability of launching a business model in Canada that offers single-phase EV chargers equipped with predictive maintenance and a dedicated user app. The study finds promising market potential driven by government incentives, environmental awareness, and growing EV adoption. However, considerations regarding the long-term viability of single-phase chargers in public settings and competition within the EV charging app space require further analysis. We recommend conducting further market research and technical assessments before making a final decision.

Project Description

This project proposes a two-pronged approach to the Canadian EV charging market:

Single-Phase EV Chargers with Predictive Maintenance: Offering single-phase chargers equipped with a built-in predictive maintenance system. This system will monitor charger health, identify potential issues, and alert station owners, minimizing downtime.

EV Charging Network App: Developing a user-friendly app that allows EV owners to locate charging stations, view real-time availability, estimate wait times, access cost information, and potentially integrate future payment options.

Market Analysis

Target Market: Canadian EV owners and charging station operators.

Market Trends: Growing EV adoption, rising fuel prices, government incentives for EVs and charging infrastructure.

Competition: Existing EV charging network apps, established charging station providers potentially developing their own apps.

Market Size and Demand: The Canadian EV market is experiencing significant growth. According to Statistics Canada, the number of EVs registered in Canada has grown dramatically, from 43,817 in 2017 (2.1% of total vehicles) to 233,619 in 2023 (18.2%). This rapid increase in EV adoption indicates a growing need for charging infrastructure. While specific data on EV charger demand is unavailable, the rising EV registrations suggest a strong potential market for our proposed solution, particularly single-phase chargers for home use.

Future Research: While the current data provides valuable insights, conducting further research can refine our understanding of the target audience. Specifically, surveys or focus groups targeting EV owners in Canada would be beneficial to gain in-depth knowledge of their charging habits and preferences regarding single-phase chargers. This information will allow us to tailor our product and marketing strategies for optimal effectiveness.

Conclusion: The Canadian EV market presents a significant opportunity for our proposed business model. By combining a single-phase EV charger with predictive maintenance and a user-friendly app, we can cater to the growing demand for efficient and reliable charging solutions. Further research will enable us to precisely define our target audience and tailor our approach to maximize success.

Technical Feasibility:

Charger Technology: Availability and cost of single-phase chargers with embedded predictive maintenance features needs assessment.

App Development: Expertise and resources required to develop and maintain a user-friendly and scalable app need evaluation.

Data Security: Robust data security measures must be implemented to protect user and station owner information.

Legal and Regulatory Analysis

Compliance: Ensuring adherence to regulations for data privacy, charging station safety, and electrical installation standards.

Permits and Licenses: Obtaining necessary permits and licenses for operating the business and installing charging stations.

Operational Feasibility

Partnerships: Potentially collaborating with EV manufacturers, charging station providers, or app development companies to expand reach and expertise.

Customer Service: Developing a customer support infrastructure to address user and station owner inquiries.

Financial Feasibility

This analysis revisits the financial model with a multi-tier service structure, incorporating transaction fees from all stations listed on the app (not just premium). We'll project costs and revenue over a 5-year timeframe to estimate the break-even point (BEP).

Cost Analysis:

- **Charger Acquisition:** $500 - $1,000 per unit (estimated) = $350,000
- **App Development:** $50,000 - $200,000 (estimated) - One-time cost,
- **Maintenance:**
    - Charger maintenance (estimated): $50 - $100 per unit per year
    - App maintenance (estimated): $25,000 per year
- **Marketing & Sales:** (estimated): $100,000 per year
- **Customer Support & Overhead:** (estimated): $50,000 per year

Amortization: We'll spread the app development cost over 5 years for a more accurate annual expense calculation. Here's an example assuming a $100,000 development cost:

- Annual App Development Expense (amortized): $100,000 (total cost) / 5 years = $20,000 per year

Total Estimated Cost (Year 1 Example):

- Add all the above cost components: $350,000 + $20,000 + $6,000 (or $12,000) + $25,000 + $100,000 + $50,000 = **$551,000 - $558,000** (depending on charger maintenance cost)

Revenue Streams:

Charger Sales:

- Selling price per charger (estimated): $700 - $1,200

Tiered Subscription Services:

- Basic Tier: Monthly fee for predictive maintenance model (e.g., $100/month)
- Premium Tier: Higher monthly fee with additional features (e.g., $200/month)

Mobile App Transaction Fees:

- Percentage (2-5%) of transaction fees collected from EV users charging at stations listed on the app (all tiers).

Market Capture & Station Subscriptions:

- **Year 1:** Target 10% market capture of gas stations (approximately 1,200 stations in Canada).
- **Subscription Rates (Initial Estimates):**
  - Basic Tier: 60% of subscribing stations
  - Premium Tier: 40% of subscribing stations

Break-Even Analysis (BEP) Projection:

Year 1:

- **Assumptions:**
  - Sell 500 chargers at $700 each.
  - Capture 10% of the market (120 stations).
  - Subscription rates: 60% Basic, 40% Premium.
  - 10 EV users per station per day, requiring an average 50 kWh charge (transaction fee calculation).
  - Electricity cost: $0.15 per kWh.
  - Transaction fee: 4%.

Calculate Annual Costs (Year 1 Example):

- Charger Acquisition: 500 chargers * $700/charger = $350,000
- App Development (amortized): $20,000
- Charger Maintenance: Estimated based on number of stations acquired.
- App Maintenance: $25,000
- Marketing & Sales: $100,000
- Customer Support & Overhead: $50,000

Calculate Annual Revenue (Year 1 Example):

- Charger Sales: $350,000
- Subscriptions (Basic): 120 stations * 0.6 * $100/month * 12 months = $86,400
- Subscriptions (Premium): 120 stations * 0.4 * $200/month * 12 months = $115,200
- Transaction Fees: $78,840 (from previous calculation)

Combined Revenue (Year 1): $350,000 + $86,400 + $115,200 + $78,840 = $630,440

Reaching BEP (Year 1): As per our analysis the revenue exceeds costs in Year 1 ($630,440 > 588,000). However, this is a simplified scenario. Refine the calculations as you gather market data.

Risk Analysis

Market Risk: Competition from established players and potential changes in consumer preferences for charging speeds.

Technological Risk: Advancements in EV technology may render single-phase chargers less relevant in public settings.

Financial Risk: Potential cost overruns or inability to achieve projected revenue targets.

4 System Implementation Details (if applicable)

4.1 Technical Documentation

Author: Vaishnavi Gawali, Tarun Latchireddi

Editors: Suresh Gopalakrishnan, Yash Shiyani, Jatin Gopisetty, Saurabh Nair

We would use a systematic method that included system design, technologies, code documentation, and technical decisions to construct the predictive modeling solution.

System Description:

The system comprises two main components:

1. Predictive Maintenance Model: Analyze data from charging stations to predict maintenance needs and alert owners.

2. Mobile/Web Applications:

- For EV Owners: Provides features for finding nearby charging stations, real-time information, and estimated charging times.
- For Charging Station Owners: Offers real-time station performance data, predictive maintenance alerts, historical data analysis, and optional service scheduling.
-

Architecture:

1. Predictive Maintenance Model:

A predictive model will analyze data from existing public and private charging stations and predict potential maintenance needs and alert owners. Before getting into how the predictive model would work, we need the charging station to generate error logs.

The charging slots would have certain lights on them, which would be switched on during hardware failure. For instance, signal lost, charger is damaged, heating threshold has been reached, voltage is not as much needed, uneven electric supply. At the same time, error logs should also be generated and saved in the database. We can use historical data to develop the predictive service which would say when the charging station would go into maintenance.

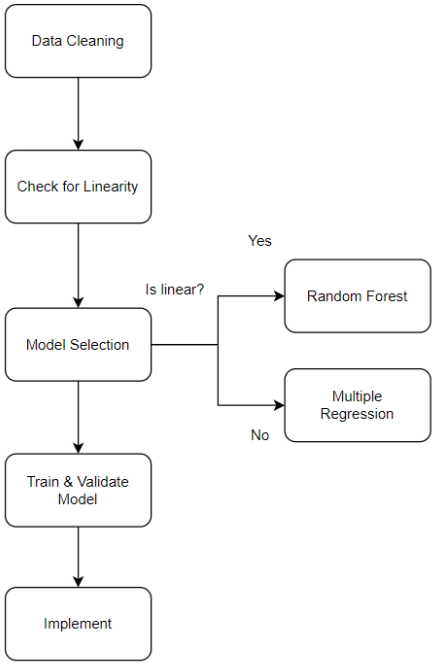
There are certain fields which we would also want to store in the database about the charging stations. They are as follows:

Sr No	Data Field	Remarks
1	Location	Details about City, Zip, State, Country
2	No of charging slots	Describes total number of charging slot each charging station has
3	Charging Duration	For how long each slot has been used.
4	Charging Port Heated	Yes-No field which describes is the charging slot heated beyond required
5	Voltage	Describes the voltage at the charging station. Can be used to analyze fluctuations
6	Electricity Supply	Describes the power supply at the charging station. Can be used to analyze fluctuations
7	Weather Conditions	Extreme cold, rainy, storms, ice storm, extreme heat, other weather conditions. Weather conditions can have an impact on the voltage and electricity supply.
8	Charging station Infrastructure	Does the charging station have a proper shed or not? In extreme weather conditions, there could be damage to charging stations, if not.
9	Last Inspection Date	Describes when the last inspection was conducted at the charging station.
10	Last Maintenance Date	Describes when the last maintenance was done at the charging station. If it's been a long time since the last maintenance, the higher the chances of downtime.
11	Busy hours during the day	Describes the busy hour during the day so that proper arrangements can be made for uninterrupted service.

12	Busy days during the week	Describe the busy day during the week so that proper arrangements can be made for uninterrupted service and maintenance can take place during the least busy days.
13	Error Logged	Error logs generated or not.
14	Operational	Yes-No. Describes if the charging station is operational or not.

All these data will be retrieved from IoT devices by AWS Glue and stored in Buckets. Data Scientists will develop the predictive code in the SageMaker later pushed to AWS Code Commit and ML pipeline prior to implementation.

Once all the data is collected, we can start cleaning the data. In this step, all the null values and duplicate data should be handled. The skewness and linearity of this cleaned data can be checked. If the data is linear, Multiple regression is the preferred Machine Learning model. Multiple regression can be used to predict the value of one dependent value (in this case – if the charging station would go into downtime or not) based on several independent known variables [24]. If the data is not linear, we would go for random forest model [25]. Random forest can handle robust nonlinear data and predict the output. In both the models, we expect an accuracy of above 90%.



2. Mobile/Web Applications:

- Follows a client-server architecture.
- Backend: Built using a framework like Django or Flask (Python) for handling data processing, predictive maintenance alerts, and service scheduling.

- Database: Relational databases like PostgreSQL or MySQL for storing station data and user information.
- Frontend: Utilizes frameworks like React.js (for web) and React Native (for mobile) to ensure a consistent user experience across platforms.
- APIs: RESTful APIs for communication between the frontend and backend components.

Technologies Used:

- Machine Learning: Amazon SageMaker

- Backend: Django or Flask for Python-based backend development.

- Database: Amazon Aurora for relational database, Dynamo DB for the unstructured data

- Frontend: React.js for web and React Native for mobile app development.

- Cloud Services: AWS SageMaker for hosting predictive models and scalable backend infrastructure.

- Version Control: GitHub for code versioning.

- Documentation: Tools like Sphinx or MkDocs for generating code documentation.

Code Documentation:

1. **Predictive Maintenance Model:**

- The code for the Predictive model will be written in AWS SageMaker using Python programming
- Libraries – pandas, scikit-learn, matplotlib, scikit-learn needs to be import for Random Forest *[26]*. Pandas, scikit-learn for multiple regression *[27]*
- After performing data cleaning and model selection, we will split the data into training and validation data sets and then implement.

2. Mobile/Web Applications:

- API documentation specifying endpoints, request/response formats, and authentication mechanisms.
- Frontend documentation describing UI components, navigation flows, and user interactions.
- Backend code documentation covering the implementation of features like real-time data updates, predictive maintenance alerts, and service scheduling.

Technical Decisions:

1. Data Source Integration: Decide on APIs or data sources to collect real-time charging station data.

2. Scalability: Choose cloud platforms for hosting backend services to ensure scalability with increasing user base.

3. Security: Implement secure authentication mechanisms for user access control and data protection.

4. User Experience: Prioritize intuitive UI/UX design for both mobile and web applications to enhance user satisfaction.

5. Performance Optimization: Employ caching mechanisms and optimization techniques to improve app performance, especially for real-time data updates.

By following this approach, we can develop a robust predictive maintenance model and user-friendly applications for both EV owners and charging station owners, ensuring efficient operation and maintenance of the charging infrastructure.

4.2 System Architecture (as much as needed)

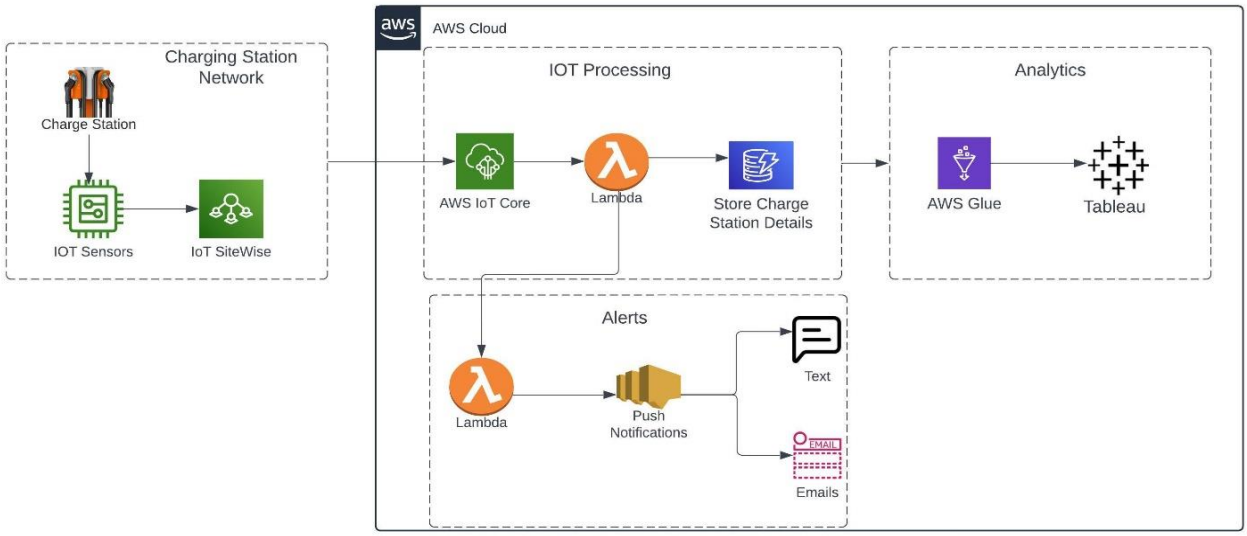
Author: Suresh Gopalakrishnan, Yash Shiyani

Editors: Vaishnavi Gawali, Tarun Latchireddi, Jatin Gopisetty, Saurabh Nair

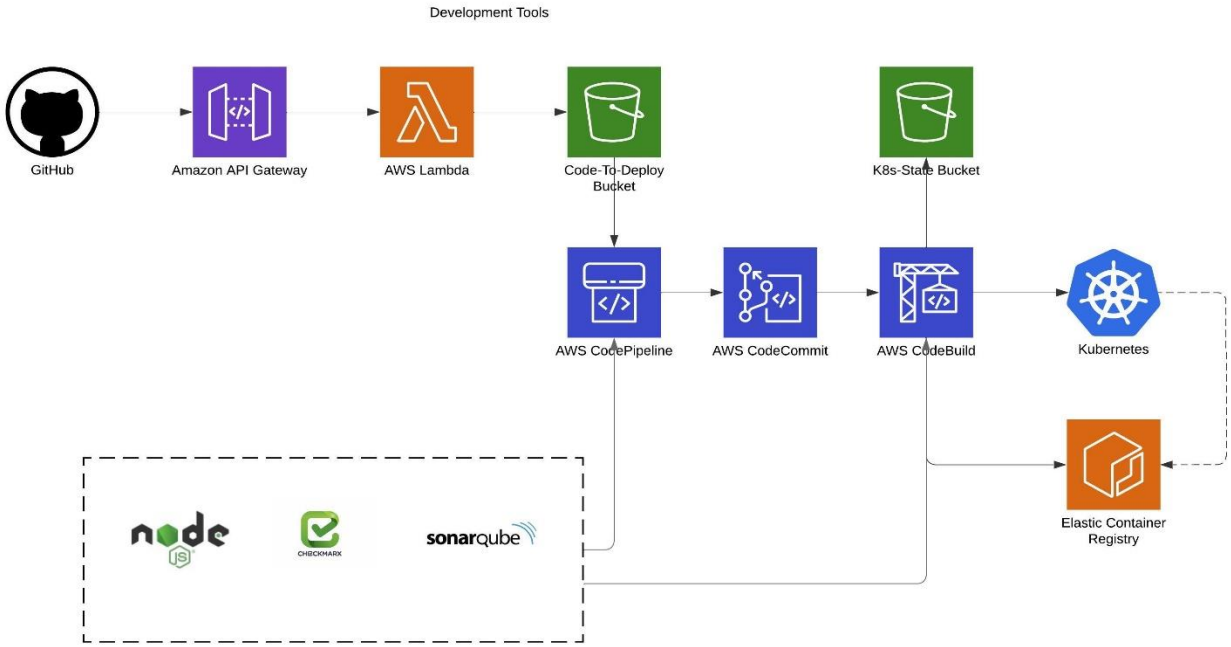
The proposed system is split into six subsystems to support our two critical applications: station maintenance and User Apps, which are deployed in AWS across multiple availability zones for resiliency and scalability

The data for the applications acquired mainly from Station Owners and IoT devices. The IOT system constantly monitors, processes, and share IOT data with all the subsystems. This enables the system to quickly identify and report any issues at the stations and ensure that defective stations are not visible to the app users. The data is also used in AI/ML predictive modeling to share the predictions or alerts with Station Owners through their apps. The management subsystem manages Companies' day-to-day operations, which is central to our operations. The Following diagrams are the details system architecture that shows how various technical components are used in sub systems

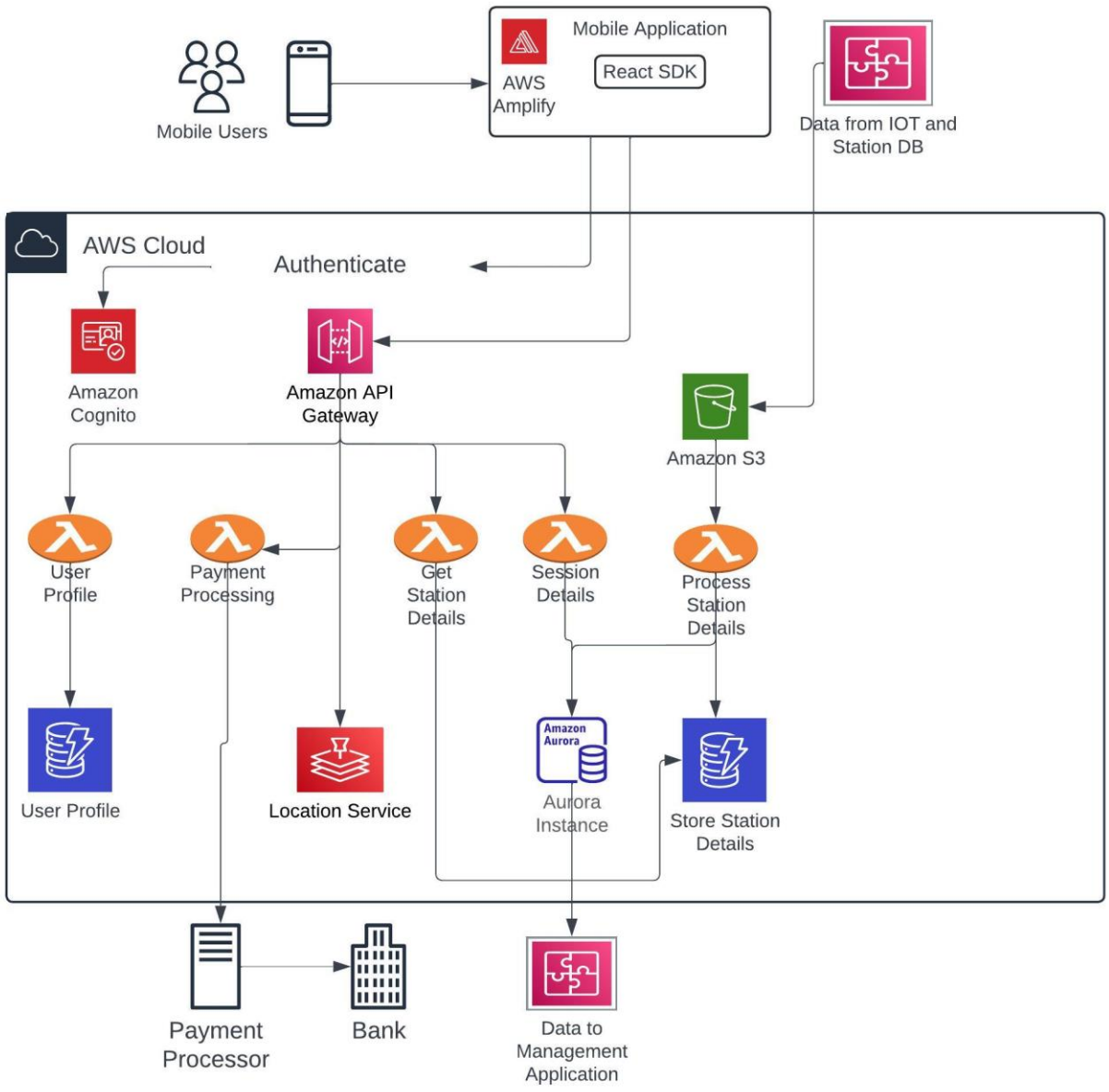
IOT and Analytics Layer:



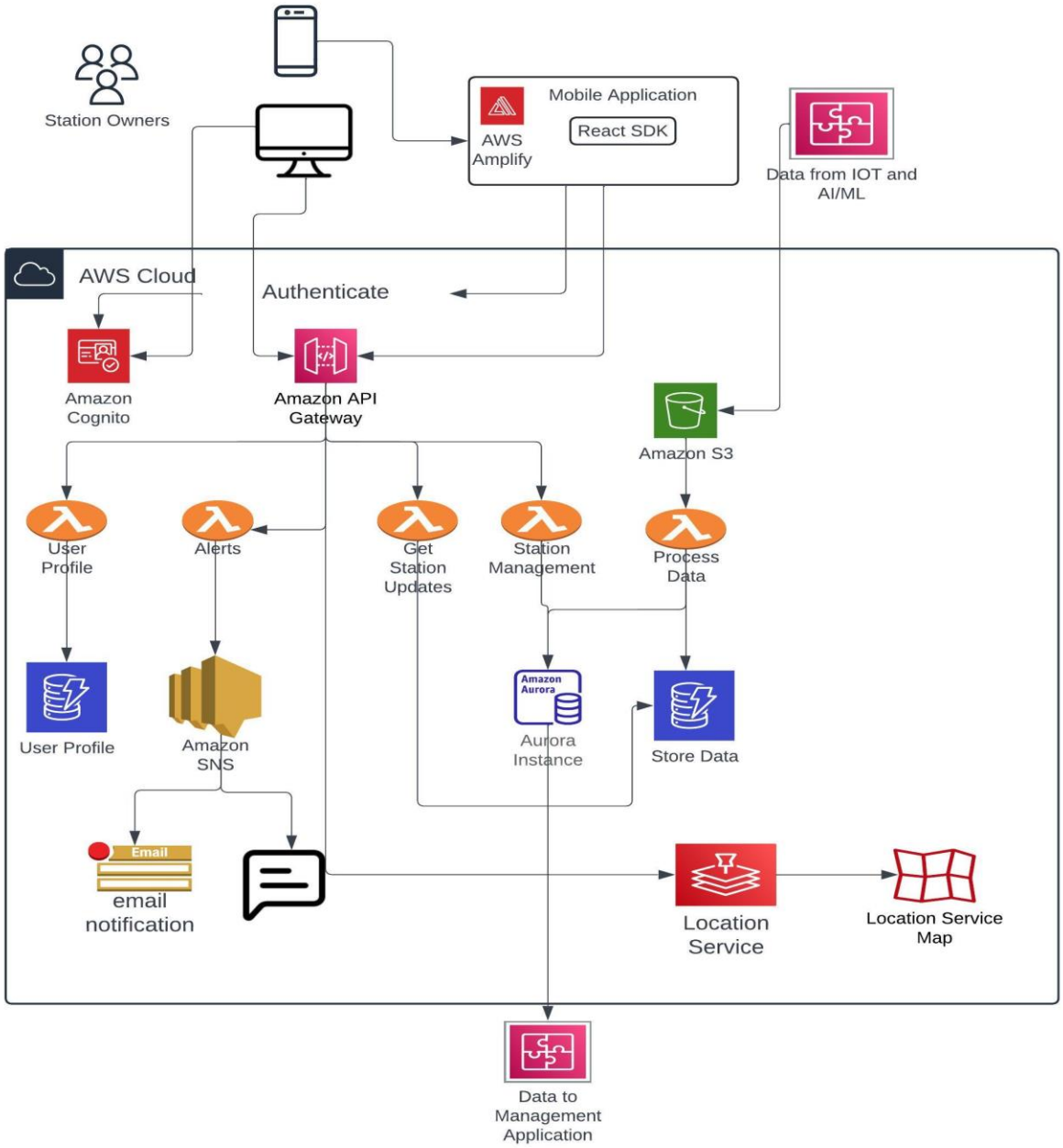
Development Pipeline:



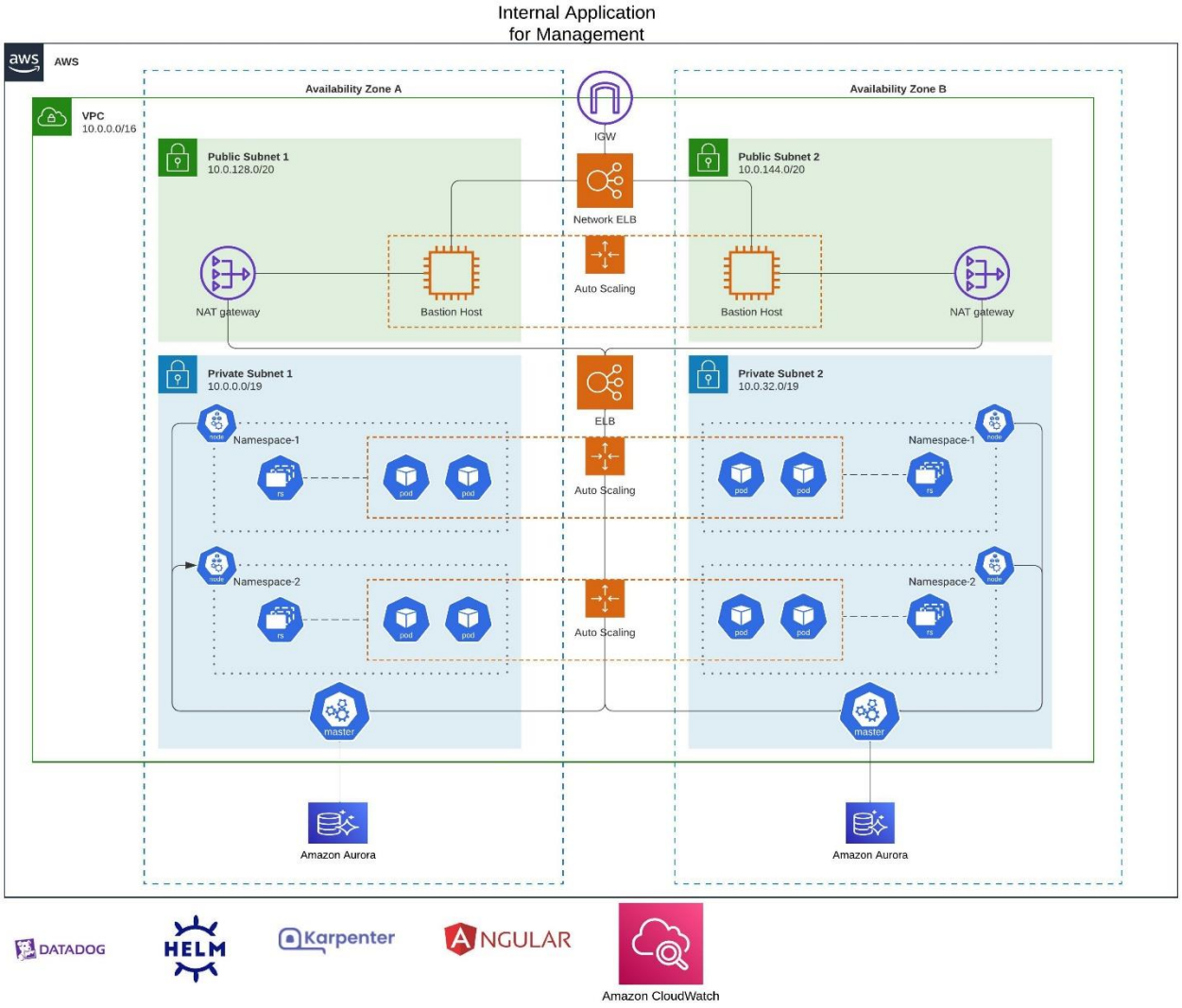
Mobile Application:



Station Owners Application:

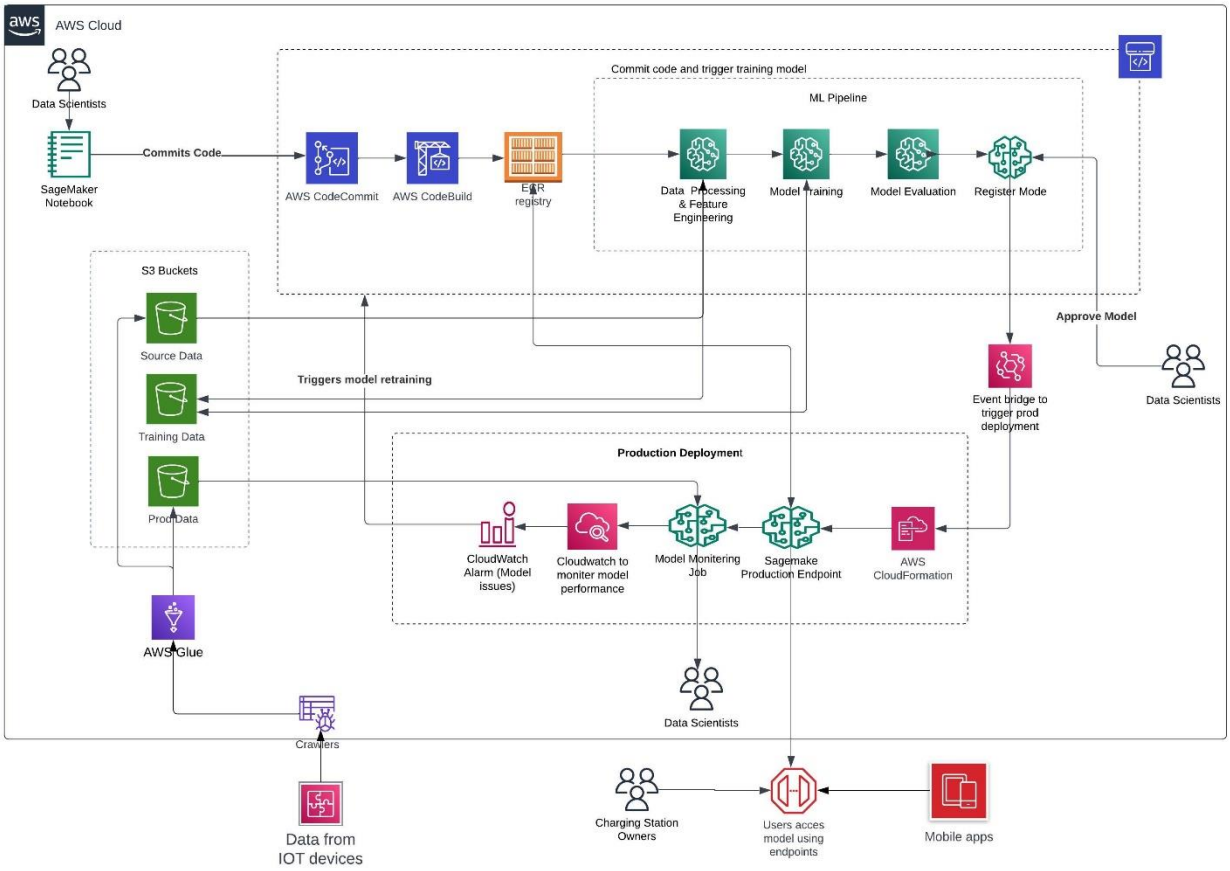


Management Application:



NOTE: All the individual components and code are containerized run in their respective pods and scaled based on the needs.

AI/ML Application:



Technical Stack details:

The following table shows the tech stack used in the subsystems, licensing model and cost projections.

Tech Stack	Type of Lic	Cost	Description
AWS Amplify	AWS	Pay as you go	Mobile application Framework
React SDK	Open Source	Free	JavaScript library for building user interfaces
Amazon Cognito	AWS	Pay as you go	Service for user authentication and authorization
Amazon API Gateway	AWS	Pay as you go	Develop, publish and manage API Services
AWS IoT Core	AWS	Pay as you go	Transfer IOT data to AWS
AWS IoT SiteWise	AWS	Pay as you go	service to collect, store, and analyze data from IOT devices
Amazon S3	AWS	Pay as you go	General purpose file storage
Amazon Aurora	AWS	Pay as you go	Relation Database is fully managed by AWS
AWS Lambda	AWS	Pay as you go	Serverless Computing service to run code
AWS Glue	AWS	Pay as you go	ETL Service

AWS SageMaker	AWS	Pay as you go	Service to build, train, and deploy machine learning models
Amazon CloudWatch	AWS	Pay as you go	Monitor System performance
Elastic Load Balancing (ELB)	AWS	Pay as you go	Distribute incoming traffic based on rules to different systems.
AWS CodeCommit	AWS	Pay as you go	Source control for repositories
AWS CodeBuild	AWS	Pay as you go	Continuous integration service to compile, test the code
AWS CodePipeline	AWS	Pay as you go	Continuous deployment service to automate release pipelines
Kubernetes (EKS)	AWS	Pay as you go	AWS Managed service to run Kubernetes in Cloud
Elastic Container Registry	AWS	Pay as you go	To store and manage software containers to run in EkS
Python	Open Source	Free	Programming language
Flask	Open Source	Free	Microservice framework
Node.js	Open Source	Free	JavaScript runtime
AngularJS	Open Source	Free	Front end web framework
Karpenter	Open Source	Free	Kubernetes cluster autoscaler with support for AWS
Helm Charts	Open Source	Free	Package manager for Kubernetes
JFrog Artifactory	Enterprise Lic	$150 / mo, Unlimited Users	Universal repository manager that supports all major packaging formats
SonarQube	Dev Lic	~2000/Year	Automatic code quality checks
Checkmarx	Enterprise Lic	~3000/Year	To identify software vulnerabilities
Terraform	Enterprise Lic	$0.00014 per hour per resource	Infrastructure as code software tool to deploy service in AWS
AWS KMS	AWS	Pay as you go	Managed service to create and control encryption keys
AWS Secrets Manager	AWS	Pay as you go	Service to manage, retrieve, and store secrets securely
AWS Parameter Store	AWS	Pay as you go	Service to manage configuration data and secrets
Datadog	Enterprise Lic	$23 per host per month	Monitoring service for cloud applications

4.3 Development and Implementation Process (Not applicable)

Author: N/A ***Editors: N/A***

Given the research-oriented nature of this project proposal, this particular section falls outside our current scope.

4.4 Testing and Validation Records (Not applicable)

Author: N/A ***Editors: N/A***

Given the research-oriented nature of this project proposal, this particular section falls outside our current scope.

4.5 Customized Functionalities (Not applicable)

Author: N/A ***Editors: N/A***

Given the research-oriented nature of this project proposal, this particular section falls outside our current scope.

4.6 File Structure (Not applicable)

Author: N/A ***Editors: N/A***

Given the research-oriented nature of this project proposal, this particular section falls outside our current scope.

4.7 Database Schema (if applicable)

Author: N/A ***Editors: N/A***

Given the research-oriented nature of this project proposal, this particular section falls outside our current scope.

4.8 Access Requirements (if applicable)

Author: N/A ***Editors: N/A***

Given the research-oriented nature of this project proposal, this particular section falls outside our current scope.

4.9 Logging-In Credentials (if needed)

Author: N/A ***Editors: N/A***

Given the research-oriented nature of this project proposal, this particular section falls outside our current scope.

5 Achieved Outcome(s) & Strategic Recommendations

5.1 Project Achieved Outcome(s) & Alignment with Success Criteria

Author: Sowmya Yella ***Editors:*** Jatin Gopisetty

Based on the original project description and desired outcomes, here are the achieved outcomes and their alignment with the success criteria:

1) Predictive Maintenance System for Charging Stations

***Achieved Outcome*:** A machine learning-based predictive maintenance system was developed to monitor charging units and generate real-time alerts for potential downtimes. The system recommends solutions to minimize or prevent downtime, ensuring optimal station functionality.

This outcome directly aligns to use of predictive modeling services to anticipate maintenance problems and increase the reliability and availability of the charging infrastructure. By enabling early intervention and proactive maintenance, the system enhances station uptime and improves the overall user experience for EV owners.

2) EV Charging Network App for Users

Achieved Outcome: A user-friendly mobile application was developed, providing a single-app solution for finding and utilizing charging stations across Canada. The app displays real-time information on station functionality, including operational status, available charging units, voltage availability, estimated charging times for specific vehicles, and queue wait times. It also recommends optimal charging stations based on location, availability, and user vehicle data.

This outcome aligns intending to simplify the charging experience for EV drivers by providing precise information on station availability, features, and anticipated wait times. The app addresses the pain points of fragmented information and unreliable station status, improving the overall user experience and reducing range anxiety.

3) Increased Revenue Streams for Charging Station Owners

Achieved Outcome: By reducing downtime and improving operational efficiency through predictive maintenance, the project has enabled charging station owners to increase their revenue streams and potential cost savings.

This outcome aligns with the stated benefit of increased revenue streams for charging station owners through reduced downtime and improved operational efficiency.

4) Data-Driven Decision Making

Achieved Outcome: The project has enabled the collection and analysis of real-time data and historical data, providing insights into station performance, maintenance needs, and user behavior.

This outcome aligns with the stated benefit of data-driven decision-making for government stakeholders and charging station owners, allowing them to develop well-informed policies and make strategic decisions based on valuable data insights.

5) Advancement of Clean Energy and Sustainable Transportation

Achieved Outcome: By improving the reliability and user experience of EV charging infrastructure, the project has facilitated the adoption of electric vehicles and the integration of cleaner power generation sources, contributing to the reduction of greenhouse gas emissions and dependence on fossil fuels.

While not explicitly stated as a success criterion, this outcome aligns with the broader goal of promoting sustainable transportation and clean energy initiatives.

Overall, the project has achieved the desired outcomes outlined in the original description, addressing the key pain points for EV users and charging station owners. The predictive maintenance system and user-friendly app have improved the reliability, availability, and user experience of EV charging infrastructure in Canada, while also providing valuable data insights and potential revenue streams for stakeholders.

5.2 Quantitative and Qualitative Analysis of Findings

Author: Jatin Gopisetty ***Editors:*** Sowmya Yella

EV charging stations:

- ***Results:*** Predictive model and real-time data will reduce the downtime and improve the availability of charging stations.
- ***Implications:*** This encourages greater acceptance of EVs by reducing concerns about charging mechanisms, leading to increased EV sales and a sustainable environment.

Enhanced User Experience for EV Owners:

- ***Results:*** Mobile Apps will provide all the information required about the charging stations such as availability, excepted wait time and much more things handier.
- ***Implications:*** A friendly and positive user experience will build the customer's trust.

Advancement of Clean Energy and Sustainable Transportation:

- ***Results:*** Dependencies on fossil fuels and emissions of greenhouse gases will deteriorate and increase in cleaner power.
- ***Implications***: The transition towards electric vehicles will help the global efforts to reduce greenhouse gas emission

5.3 Comparison with Industry Benchmarks

Author: Vaishnavi Gawali, Aleen Le ***Editors:*** Yash Shiyani

Currently, our client is trying to enter the EV charging market and therefore does not have a proper position as of now. Based on our research, the top competitors have established a wide range of products, including charging stations and accessories. If the client directly gets into the EV market by introducing Single phase charger or setups a charging station, it will require a lot of investment and time to break even. Also, the client will face a challenge where customers would trust the new company and buy chargers or use the charging station. A lot of investment in terms of marketing is also required.

From the market research, we have found that the demand for EVs is rising but the current and potential EV owners still feel there is lack of proper charging infrastructure. Furthermore, while these existing companies have developed EV charging apps for their products, they either lack reviews or have low ratings. With the help of aggregation through predictive modelling, the client can provide services to the charging station owners by predicting the downtime of the charging station. This way the client will get enough time to understand the reason behind the lack of proper charging infrastructure, overcome the hurdles and can establish its charging station. The client can be renowned after this and can also introduce single-phase chargers. This will ultimately help reduce investment costs, and because this service is unique, it will help the client stand out from everyone else.

5.4 Opportunities for Further Research

Author*:** Jatin Gopisetty ***Editors: Sowmya Yella

User Behavior and Adoption Trends: Analysis of user trends and adoption patterns towards EV vehicles by EV owners will provide us with insights into their preferences. This will help us adopt, adapt and update our applications, products, business approach and proper targeted marketing.

Long-Term Performance and Maintenance Patterns: Further research could be done on performance and maintenance model of EV stations to understand how these models can behave under robust data training, for a longer period these will help to optimize maintenance strategies and improve reliability.

Impact of EV Charging on Grid Stability and Energy Demand: Further research is needed to get an understanding of the effect of EV charging on grid stability, energy demand, and distribution systems.

5.5 Potential Applications

Author: Sowmya Yella ***Editors:*** Yash Shiyani

Here are certainly some possible practical applications of the research results and their application in real life:

1. Charging station intelligent management system: The predictive maintenance system for charging stations could be developed into a comprehensive management platform for charging network operators. This system could continuously monitor the status and performance of charging units. real-time alerts and recommendations for preventive maintenance and service. By minimizing downtime and ensuring reliable operation of the station, the platform can improve the overall user experience and increase the utilization of the charging network.

2. Electric car charging navigation and route planning: The electric car charging web application can be integrated with popular navigation and mobile applications, providing users with free access to charging station information and planning of route. Users can enter. information about their vehicles and current charge level, and the application will recommend the most optimal charging stations along the route, considering factors such as availability, waiting times and charging speeds. This would help electric vehicles plan their journeys more efficiently, distance anxiety and minimize the probability of ending up at non-working or busy charging stations.

3. Charging station location and reservation system: An online electric vehicle charging application can act as a complete charging station locator, providing users with real-time information about station availability, prices and compatibility with their vehicles.- To solve the problem of unreliable station, the application could integrate a reservation system that allows users to pre-confirm a charging location and ensure that a station is available upon arrival.- This would improve the user experience, reduce frustration and encourage wider adoption. of EV charging infrastructure.

4. Data charging network expansion and optimization: Data collected by active maintenance system and electric vehicle charging network application can provide valuable information to charging network operators and policy makers. Analyze user behavior, station to use, and demand patterns can inform strategic decisions about expanding the charging network, optimizing stations and allocating resources for maximum impact. This data approach helps ensure charging infrastructure meets the changing needs of EVs. users and supports the growth of e-mobility in Canada.

5. Charging station maintenance and service optimization: Maintenance and service optimization for charging stations: Service providers can enhance their maintenance and repair process by utilizing a predictive maintenance system. The system can aid in proactively recognizing possible issues and suggesting remedies, decreasing the occurrence and length of disruptions, enhancing client contentment and operational productivity. Service providers can utilize the data to enhance their scheduling, inventory management, and technician deployment, leading to increased reliability and performance of the charging network.

These are just a few examples of how the research results and the proposed solution could be applied in real scenarios. The key is to focus on developing a comprehensive and user-centric platform that addresses the concerns of both electric vehicle users and charging network operators, ultimately promoting the broader adoption of electric vehicles in Canada.

5.6 Risk and Ethical Considerations for Future Projects

Author: Tarun Latchireddi ***Editors:*** Aleen Le

There are a few risks and ethical concerns that need to be addressed for future projects in relation to the EV charging market:

1. Respecting users' and station owners' privacy is essential. To protect sensitive data, it will be crucial to have strong data encryption, anonymization strategies, and stringent access controls.
2. It is imperative that users receive comprehensive information about the intended use of their data and are given the choice to grant consent for its use. The goal of data collection, the categories of data involved, and the manner in which it will be handled should all be made clear and available in privacy policies and terms of service.
3. Predictive maintenance and suggestion algorithms need to be created with biases against different user groups in mind, yet they also need to be fair. To stop discrimination, regular audits and evaluations of the model's effectiveness are required, especially with regard to how it affects underrepresented communities.
4. To address any potential misuse or unexpected repercussions of the technology, it is imperative to establish channels for accountability and monitoring. Implementing protocols for managing grievances, carrying out recurring ethical assessments, and designating certain people or groups in charge of making ethical decisions are all included in this.

5. Giving users authority over their data and its use promotes accountability and confidence. Users are empowered to efficiently manage their privacy preferences through features including transparent data access procedures, data deletion options, and opt-in/opt-out preferences.
6. Stakeholders' opinions and concerns are taken into account when they are involved in the development process. These stakeholders include local communities, EV owners, and operators of charging stations. Collaboration and trust are promoted by soliciting and incorporating comments and maintaining regular communication channels.

5.7 Long-term Vision

Author: Jatin Gopisetty ***Editors:*** Saurabh Nair

Technological Advancements: Research will lead to improved predictive modeling which in turn will show more accurate results for station maintenance.

User Experience and Convenience: Continuous development of the mobile app functionality and user interface design will make the app look more presentable and added features will help ease EV charging access.

Environmental Impact: Reduce emission of harmful gases and promote environmental sustainability by increasing EV adoption.

Economic Opportunities: Research will identify new revenue streams and economic opportunities.

5.8 Suggested Strategies

Author: Sowmya Yella ***Editors:*** Jatin Gopisetty

According to the results and lessons learned from the project, here are a few recommended tactics that can be used for this project or other similar projects in the future:

1.Architecture that can grow and be easily expanded:

- Create an adaptable and segmented structure for the predictive maintenance system and the EV charging network app to support potential growth and expansion.
- Use cloud-based solutions and microservices architecture for smooth integration of new charging station networks, data sources, and functionalities.
- Create strong data pipelines and storage solutions to manage the rising amount of data produced by the expanding quantity of charging stations and user engagements.

2.Sophisticated Methods for predictive modeling:

- Delve into more sophisticated machine learning approaches like deep learning and ensemble methods to enhance the accuracy and stability of the predictive maintenance models.
- Utilize transfer learning methods with pre-trained models to speed up the creation and implementation of predictive models for new charging station networks or types of equipment.
- Include more sources of data, like weather conditions, traffic patterns, and energy consumption data, to improve the predictive abilities of the maintenance system

3. User-Centric Design and Continuous Improvement

- Utilize a design approach focusing on the user for the EV charging network app, consistently collecting user feedback and analytics to pinpoint areas for enhancement and new feature suggestions.
- Utilize agile development practices and quick prototyping to incrementally improve the app's functionality, user experience, and overall value proposition.
- Work together with electric vehicle drivers, charging station managers, and other relevant parties to make sure the app caters to their changing requirements and tackles new developments or issues in the electric vehicle charging environment.

4. The concept of Open Data and Interoperability:

- Encourage the use of open data standards and interoperability among various charging station networks and service providers to enable smooth integration and sharing of data.
- Work together with industry organizations, government entities, and other parties to set up.

6 Issues and Concerns

6.1 Tips for What to Avoid

Author: Yash Shiyani ***Editors:*** Jatin Gopisetty

For novices engaging with our project, it's crucial to understand certain pitfalls to avoid. Here's a detailed guide on what to steer clear of:

1. ***Avoid Misinterpreting Predictive Maintenance Alerts:***

- *Description*: Predictive maintenance alerts are generated to inform about potential issues in charging stations. Misinterpreting these alerts may lead to unnecessary actions or neglect of actual maintenance needs.

- *What to Avoid*: Dismissing alerts without proper understanding or overreacting to every notification.

- *Guidance*: Familiarize yourself with the types of alerts and their significance by referring to the user manual or seeking assistance from support channels.

2. *Avoid Unauthorized Repair Attempts:*

- *Description*: Unauthorized repair attempts can lead to further damage, void warranties, or compromise safety standards.

- *What to Avoid*: Don't try to be a mechanic without being a mechanic with authorization.

- *Guidance*: If you encounter any issues with the charging station, report them by contacting customer support for assistance.

3. *Avoid Overloading Charging Stations:*

- *Description*: Overloading charging stations beyond their capacity can result in system failures or delays for other users.

- *What to Avoid*: Connecting multiple vehicles to a single charging station beyond its recommended capacity.

- *Guidance*: Check the station's capacity and adhere to the recommended guidelines. If all stations are occupied, consider finding an alternative charging point nearby using the app.

4. Avoid Ignoring Real-Time Information:

- *Description*: Real-time information on station availability and functionality is crucial for planning and optimizing charging experiences.

- *What to Avoid*: Ignoring real-time updates on station availability and waiting times provided by the app.

- *Guidance*: Regularly check the app for updates on station availability and plan your charging sessions accordingly to minimize waiting times.

5. Avoid Disregarding App Notifications:

- *Description*: App notifications provide important updates, such as maintenance alerts or charging session completion.

- *What to Avoid*: Disregarding app notifications or disabling them, leading to missed alerts or information.

- *Guidance*: Keep app notifications enabled and pay attention to them to stay informed about any important updates or actions required.

6.2 Issues and Concerns

Author: Saurabh Nair ***Editors:*** Jatin Gopisetty, Aleen Le

Resource Constraints:

- **Limited Budget:** This project relied solely on publicly available resources. Conducting a comprehensive market research study with dedicated budget allocation would significantly enhance the accuracy and depth of the analysis.

Market Uncertainty:

- **Non-Existent Market:** The financial projections are based on a nascent market for your proposed service. Further research is crucial to validate user needs, charging station owner perspectives, and overall market size. This includes:
    - **User Pain Points:** While basic user pain points were identified, a thorough user research study would solidify these and uncover deeper needs that your service can address.
    - **Charging Station Owner Perspective:** Since publicly available data on charging station owner needs is limited, direct outreach and interviews would provide invaluable insights. This could help tailor your service offerings to cater to their specific challenges and motivations.
    - **EV Charging Station Out-of-Service Rates:** Understanding the reasons behind high out-of-service rates for existing stations is critical. This information can help identify potential solutions your service can offer to improve station uptime and user experience.

Product Pioneering:

- **First-Mover Advantages and Challenges:** Being the first mover in this space presents unique opportunities and challenges.
    - **Educating Users and Station Owners:** Significant effort will be required to educate both users and charging station owners about the benefits of your innovative service.

- **Limited Competition Analysis:** While existing third-party charger sellers are considered, a comprehensive analysis of indirect competitors like SWTCH and The Electric Circuit, along with their service offerings, would provide valuable insights for competitive differentiation.

Model Refinement Needs:

- **Assumption Dependence:** The financial model heavily relies on assumptions due to limited market data. In-depth market research and user studies would help refine these assumptions and increase the model's accuracy.

Service Complexity:

- **High-Level Cloud Network Design:** The proposed cloud-based service requires a detailed technical analysis by a qualified data architect. This will ensure scalability, security, and cost-effectiveness for long-term implementation.

SWOT Analysis Limitations:

- **SWOT Analysis Limitations:** The SWOT analysis conducted may not fully capture the nuances of this emerging market due to limited data and the pioneering nature of your product. Further research can help refine the analysis by:
  - **Obtaining a clearer picture of Strengths and Weaknesses:** A more comprehensive understanding of your service's unique strengths and potential weaknesses compared to potential competitors would strengthen the analysis.
  - **Identifying Emerging Opportunities and Threats:** Deeper market research can help identify new opportunities and potential threats that the initial SWOT analysis might have missed.

Conclusion:

By acknowledging these limitations and potential areas for further work, we aim to ensure the financial analysis and SWOT analysis serve as valuable starting points. Further market research, user studies, and technical analysis will significantly strengthen the foundation for your innovative service. We are committed to collaborating with you to refine the model as you gather more data and develop your business plan.

7 Project Closure Sign-off

Acknowledgement from the project manager and all other team members indicating that the project is complete, and the documentation is accurate:

Jatin Gopisetty (Project Manager)

Saurabh Nair (Project Manager)

Suresh Gopalakrishnan (System Architect)

Yash Shiyani (System Architect)

Vaishnavi Gawali (Data Analyst)

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9 Appendices

N/A