DRISI
CALTRANS DIVISION OF RESEARCH, INNOVATION AND SYSTEM INFORMATION
TRANSFORMING IDEAS INTO SOLUTIONS

Research Notes

Remote DCFC (Direct Current Fast Charger) Reliability and Downtime Detection Tool

This project will use the zero-emission vehicle (ZEV) station usage data to understand the reasons for charging errors and validate real failures from charging attempts. This study aims to detect and quantify ZEV charging station downtime when instruments are unable and develop a downtime detection tool based on machine learning techniques.

Design / Construction

MAY 2025

Project Title:
Remote DCFC Reliability and Downtime Detection Tool

Task Number: 4353

Start Date: October 14, 2024

Completion Date: October 14, 2026

Task Manager:

Jaskaren Virk
Transportation Engineer (Electrical)
Jaskaren.Virk@dot.ca.gov

WHAT IS THE NEED?

The California Department of Transportation (Caltrans) ZEV 30-30 project aimed to help meet these goals by filling gaps within California's corridor ZEV charging network along key routes of the State Highway System. While the construction of these charging stations was successful, recent issues have arisen regarding the ability of the infrastructure to build driver confidence and allow users in low density and rural communities to drive electric vehicles. A new study found that public open access charging stations in the greater Bay Area are far less reliable than what station operating companies had reported. Out of a random survey of charging stations, they found that only 72.5% of surveyed chargers were functional.[1] The new CA Assembly Bill 2061 also aims to understand this issue. Unless resolved, low charger reliability has the potential to derail the State's goals to achieving a cleaner passenger transportation system for all Californians. The Caltrans ZEV 30-30 project is a unique opportunity to serve as a test bed for developing criteria for charging reliability and dependability, maintenance needs, users experience and policies that can then be used for future installation of chargers using the National Electric Vehicle Infrastructure (NEVI) funds were similar future funds.

Caltrans

DRISI provides solutions and knowledge that improves California's transportation system.

1 Rampel et. al. (2022), "Reliability of Open Public Electric Vehicle Direct Current Fast Chargers". Link: https://evadoption.com/wp-content/uploads/2022/05/Cool-the-Earth-UCB-study.pdf

WHAT ARE WE DOING?

This project supports Caltrans in improving the reliability of its electric vehicle (EV) charging infrastructure by developing an anomaly detection tool that identifies subtle or hidden failures at charging stations – failures that are not always captured by backend network monitoring systems.

The tool uses patterns in actual charger usage to detect when a charger may be unavailable due to access barriers, broken connectors, or other site-level issues. Two complementary detection models are under development:

- A naive probability-based model to identify statistically unlikely usage gaps, and;
- A Long Short-Term Memory (LSTM) neural network to detect more complex temporal anomalies in charging behavior.

While the project planned to use live Caltrans charger data from the outset, the team encountered some logistical difficulties in acquiring access to current Caltrans data during the first few months of the project. To ensure continuity, the team initially developed and validated the models using historical Caltrans data previously shared through the ZEV 30-30 project. This enabled early testing and iteration while active data access pathways were being resolved.

The first three research tasks are now complete or underway:

- **Model Conceptualization:** Conducted a literature review and comparative analysis of statistical anomaly detection techniques to assess their strengths, limitations, and suitability for identifying EV charging failures.
- **Data Collection and Processing:** Processed and analyzed ZEV 30-30 project data and later began incorporating newly received Caltrans datasets. Time-series transformations and descriptive analyses were conducted to inform model design.
- **Model/Tool Development:** Developed two core anomaly detection models—the naive model and the LSTM model – and completed initial validation using the ZEV 30-30 dataset. A technical report documenting datasets, model structure, and validation results was submitted to Caltrans.

The team is now transitioning to integration testing and field validation using active Caltrans infrastructure data as access improves.

WHAT IS OUR GOAL?

The project's goal is to deliver a robust, scalable tool that enables Caltrans to detect real-world EV charger failures more quickly and accurately. By supplementing existing monitoring protocols, this tool can support proactive maintenance, improve reliability reporting, and ultimately enhance the EV charging experience for the public.

WHAT IS THE BENEFIT?

This tool offers Caltrans a new approach to identifying charger reliability issues based on how chargers are actually used. It helps detect "silent failures" that might otherwise go unnoticed – such as a charger that appears online but is consistently unused due to access barriers or equipment malfunctions.

In the long term, the tool can:

- Reduce downtime by enabling quicker response to failures,
- Support the state's reliability reporting requirements,
- Improve the credibility of public EV infrastructure,
- And assist in prioritizing maintenance based on real-world usage.

WHAT IS THE PROGRESS TO DATE?

The project has made significant progress through the first three technical tasks:

- In Task 1, the team completed a comparative

literature review of anomaly detection methods – including statistical, machine learning, and deep learning approaches – to evaluate their suitability for identifying charging anomalies. This review helped define the technical foundation for the modeling work.

- In Task 2, the team began with data previously shared by Caltrans under the ZEV 30-30 initiative due to initial delays in accessing current charging station data. The dataset was cleaned, transformed into hourly time series, and used to identify temporal and spatial usage patterns. More recent Caltrans data is now being incorporated as access issues are addressed.
- In Task 3, the team developed two anomaly detection models: (1) a naive probability model that flags unexpectedly long gaps in usage, and (2) an LSTM-based model capable of capturing more complex usage disruptions over time. Both models were initially validated using the ZEV 30-30 dataset and are now being further tested with current Caltrans data.

The next phase of the project will focus on refining the models through field testing and collaborating with Caltrans staff to explore operational integration into charger maintenance and reliability workflows.