Electric Vehicle Charging Simulation Platform

Caldera links grid, transportation network to optimize charging

To develop strategies for managing charging impacts on the electric grid, INL researchers developed the Caldera software, which models how electric vehicle chargers like these extreme fast chargers draw power from the grid.

By 2040, electric vehicles (EVs) will make up 30% of the global vehicle fleet, according to BloombergNEF's Electric Vehicle Outlook. To accommodate these millions of vehicles, charging network providers, automakers and electric utilities are making large infrastructure investments. A visible result will be networks of charging stations that offer the same convenience as today's gas stations.

As charging infrastructure becomes increasingly widespread, public and private entities need to understand how they can manage this infrastructure to meet the needs of EV drivers while avoiding high electricity costs and negative effects on the electric grid.

Such information is elusive because existing models can't predict how widespread vehicle charging will impact the grid. Plus, every vehicle model draws power differently.

MODELING POWER DEMAND ON THE GRID

To help, Idaho National Laboratory experts have developed a tool, Caldera. The foundation of the Caldera software platform is a library of high-fidelity EV charging models derived from extensive charging and battery testing data that INL has collected over the past decade.

Caldera fills a clear technology gap. One set of existing tools enables simulation of transportation networks, in some cases modeling traffic down to the individual vehicle. Another set of tools provides similarly granular models of electric grids. But until Caldera, no tools accurately modeled operation of the charging infrastructure that ties together the transportation and grid systems.

Caldera's charging models accurately estimate charge power profiles, efficiency and power factors for a wide variety of vehicles and charging technologies under varying grid conditions. This capability is critical for predicting charging impact on the grid.

What's more, Caldera enables the co-simulation of the transportation network and the grid. By linking existing simulation tools with Caldera in a co-simulation environment such as HELICS, the grid impact of EV charging demand can be accurately modeled for a variety of future transportation scenarios.

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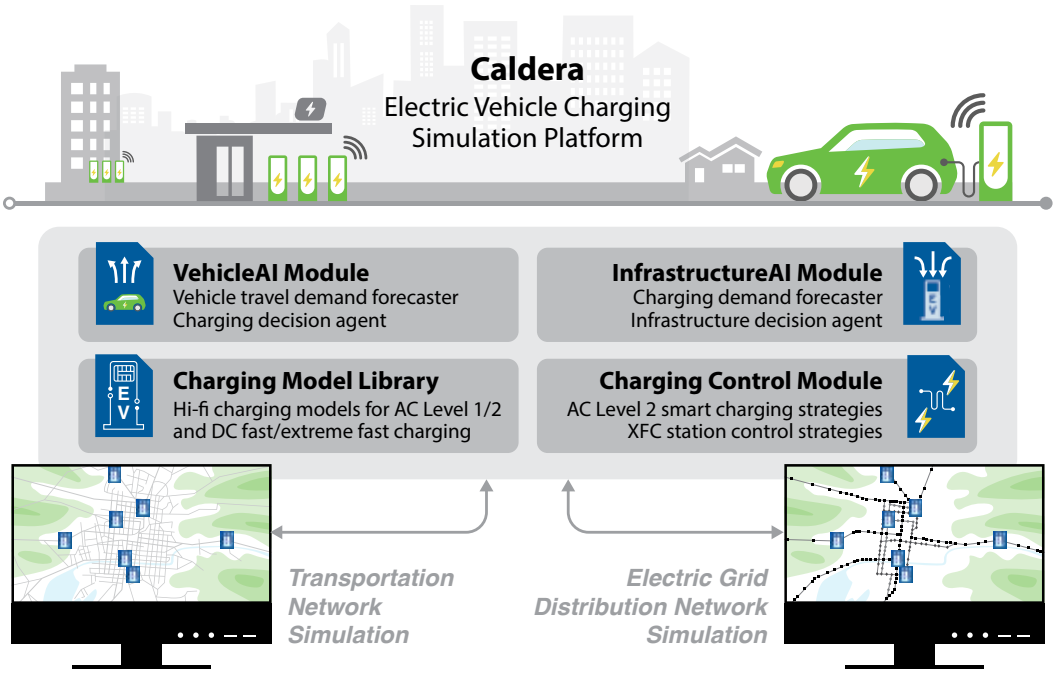

SMART CHARGING STRATEGIES

Because of its high-fidelity models and co-simulation capability, Caldera is an ideal platform for developing and testing smart charging strategies designed to lessen the stress on the grid of widespread EV charging. The platform includes a control strategy module that accommodates a variety of approaches for managing EVs and stationary energy storage at charging stations as controllable loads on the grid.

That module contains novel algorithms for smart charging management of Level 2 (2 to 20 kW) charging. One such scheme delays the charging of plugged-in vehicles until conditions are ideal for the grid. The module also includes algorithms to control power flow in extreme fast charging (XFC) stations that charge at up to 350 kilowatts.

EXTREME FAST CHARGING

XFC stations offer users the ability to rapidly complete charging. Although appealing to consumers, XFC creates large, intermittent loads on the grid that may present challenges to electric utilities. That's why it will become increasingly important to develop clever ways to manage XFC infrastructure as the number of EVs and charging stations grows.

One solution is fixed onsite battery storage. XFC stations could store power from the grid in batteries when traffic is light, then discharge those batteries when vehicles arrive and plug in. To properly charge the battery while keeping costs low and meeting demand for fast charging, accurate forecasting of EV charging is needed.

In another approach, price and projected availability of charging stations could be conveyed to drivers and driverless cars to influence when and where those vehicles charge.

Caldera's VehicleAI and InfrastructureAI modules make it possible to generate necessary forecasts and guide vehicles to make the most efficient charging decisions. The modules use machine learning to predict vehicle and charger use, grid conditions and other factors. The modules allow researchers to develop methods for coordinating, influencing and scheduling charging in advance for the benefit of drivers, charging networks and the grid.

With its charging model library, control strategy module, VehicleAI and InfrastructureAI, Caldera is a versatile tool for answering important questions about potential impacts of EV charging on the electric grid.

FOR MORE INFORMATION

Technical contact
Lee Walker
208-526-1728
lee.walker@inl.gov

General contact
Abby Todd
Communications Liaison
208-526-6166
abby.toddbloxham@inl.gov

www.inl.gov

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