# Intelligent Grid-level Energy Negotiation for Electric Vehicle Supply Equipment

Omair Farooqui, Alex Ramirez, Emon Sahaba, Krishan Solanki, Athrv Khoche, Huanjia (Sam) Liang, Bonnie Tang
Project Advisors: Dr. Michael Klopfer, Prof. G.P. Li
California Plug Load Research Center (CalPlug)

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## Project Overview

The EVSE Smart Charging System is an engineering project that aims to tackle the mass adoption of Electric Vehicles (EVs) as the standard for transportation for California[1], causing load on the grid to worsen (Fig. 1). Combining the benefits of IoT devices with an EVSE, allows for a new Big Data approach to distribute energy for the benefit of the grid infrastructure, which in turn aims to help providers, customers, and the environment.

## Project Scope and Goals

1. Smart EVSE Charger and User Application must be able to communicate relevant data to Backend Server for Scheduler to negotiate charging times
2. Smart EVSE Charger must be able to dynamically change current output based off the Scheduler's set times
3. Require minimal use for user: allow for immediate/ scheduled/ negotiated charging, preset preferences
4. Factors for Scheduler to consider: concurrent chargers, supply/demand of grid, cost preferences, energy emissions blend, charge start/end times, weather/generation forecasts

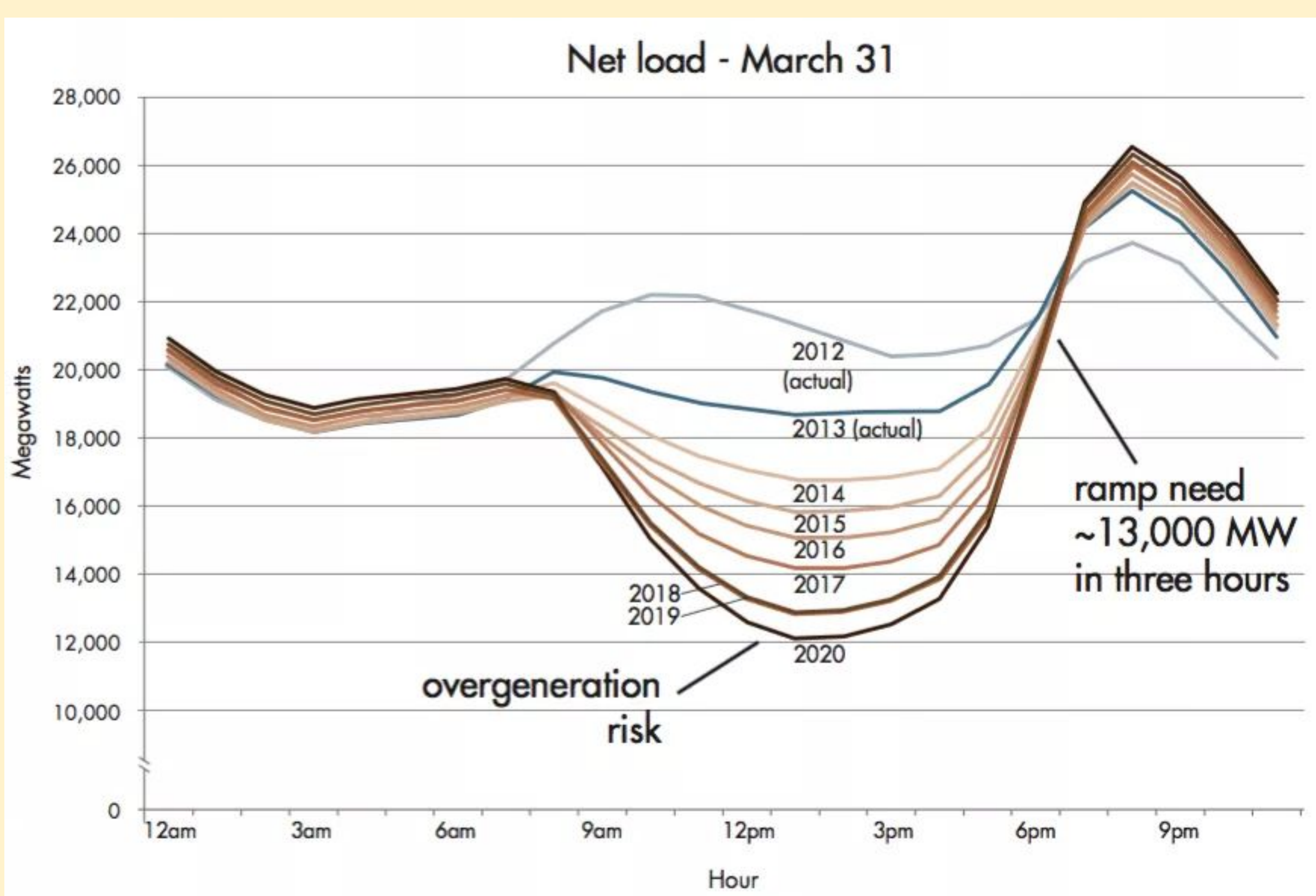


***Figure 1.*** *California's Net Load Duck Curve (CAISO)[3]*

## Developed Solution

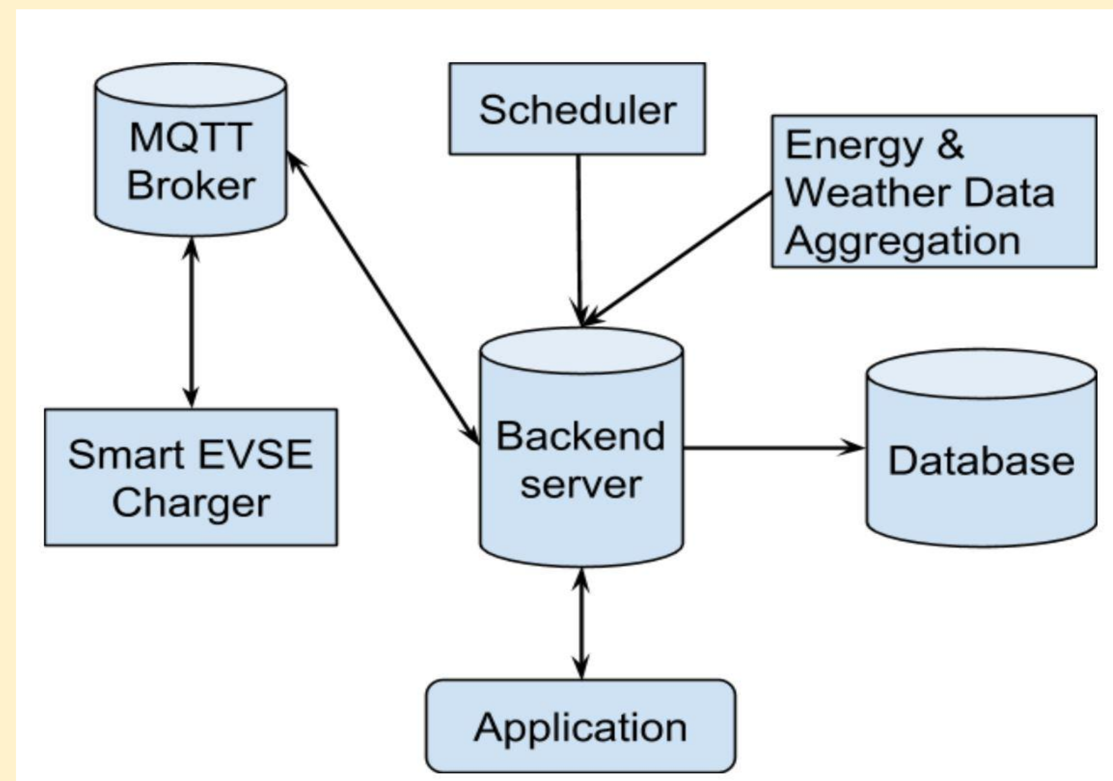


***Figure 2.*** *System Design*

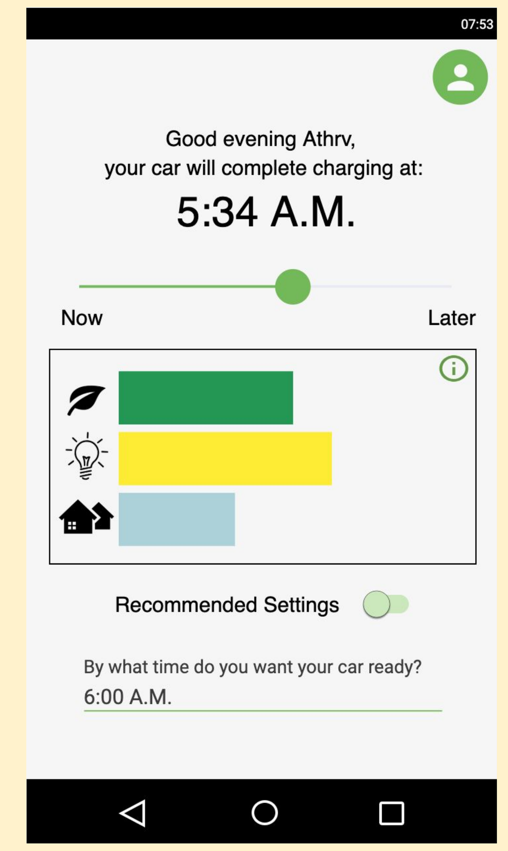


***Figure 3.*** *Application Mockup*

- Application (Fig. 3) will provide information to Backend Server:
  - Location, Energy Provider, Billing plan, Start/End Times, Environmental/Cost preferences, Recommended Settings
- Retrieve charging schedule generated by Scheduler (Fig. 5)
  - Time frames accompanied by a brief cost and environmental analysis in the context of the user
  - Scheduler implements Weighted Fair Queuing[2] (WFQ) for equal distribution of energy based off a certain resource capacity
- Select time frame to queue a charge or manually start charging
- Optimize charge rates in real time
- Backend will send Schedule to Smart EVSE to charge accordingly
- HTTPS for security

Accompanying this system are IoT-based EVSE units with the following:

- SAE J1772 protocol compliance
- Safety checks
- RTOS firmware implementation
- MQTT communication

***Figure 4.*** *Electric Vehicle Simulator Board*

## Results

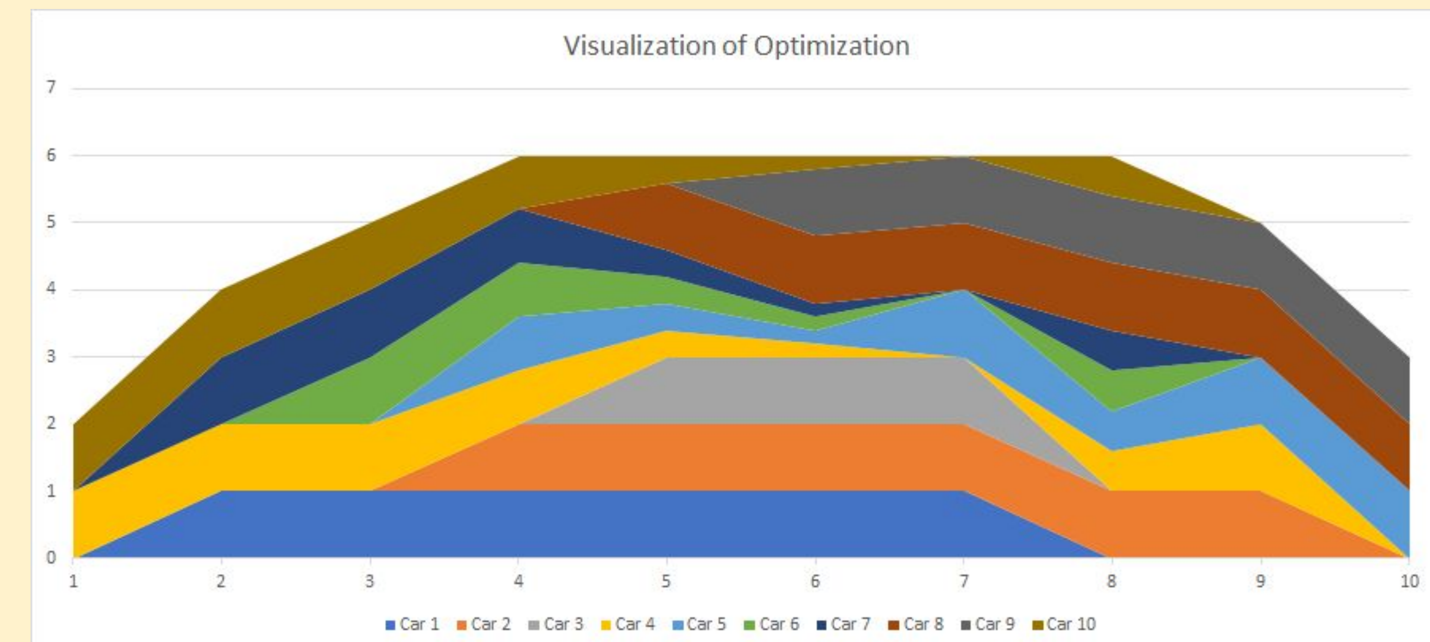


***Figure 5.*** *Results of charge distribution optimization over 10 hours*

## Accomplishments

- Hardware: Implemented state detection and interfacing with calibration. Tested and validated multiple approaches including a non-linear thresholding approach.
- Software: Scheduling algorithm pulls from information stored in database to make informed decision on optimizing schedule of charge based of WFQ optimization.

## Conclusion & Future Developments

We can conclude that our proof of concept was successful.
There are several areas of future development for our system:

- Development of voice assistant integrations
- Enhanced optimization based on external factors, such as car model, battery health, energy status updates (e.g., California Flex Alerts), etc.
- Aggregate cost analysis
- Industry hardware security standards compliance

## Citations

1. *California Auto Outlook*, vol. 14, no. 3, Aug. 2018, www.cncda.org/wp-content/uploads/California-Covering-2Q-2018.pdf.
2. Parekh, A.k., and R.g. Gallager. "A Generalized Processor Sharing Approach to Flow Control in Integrated Services Networks-the Single Node Case." *[Proceedings] IEEE INFOCOM '92: The Conference on Computer Communications*, 1992, doi:10.1109/infcom.1992.263509.
3. "Confronting the Duck Curve: How to Address Over-Generation of Solar Energy." *Department of Energy.* https://www.energy.gov/eere/articles/confronting-duck-curve-how-address-over-generation-solar-energy

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CalPlug California Plug Load Research Center University of California · Irvine
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