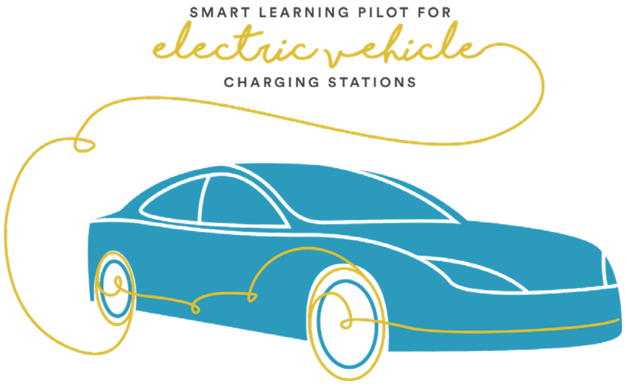
SlrpEV
Smart Learning Research Pilot for Electric Vehicles



Project Overview
Apr 4, 2023

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TotalEnergies

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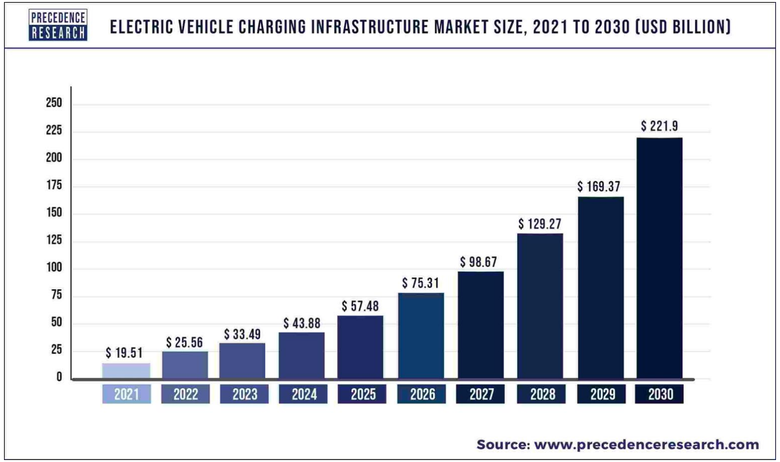
EV Charging Technology & Market



- 50,000 public EV charging stations in the U.S., with a total of nearly 130,000 individual (EVSE) charging ports
- EV Charging Infrastructure Market Projected Growth to $ 221.9 billion by 2030 from $25.56 billion in 2022 at CAGR of 31.02%

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Revenue Maximization at Workplace Charging Facilities

Behavioral modeling

Utilization

Menu of options:
Regular and Scheduled charging

Gross Revenue

Decreasing Costs

SMART LEARNING PILOT FOR electric vehicle CHARGING STATIONS

Trade-off between:

1. Price of charging and charger utilization
2. Decreasing cost and charger utilization

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Literature Review & Existing Projects

- **Smart-Charging Projects**
  - OptimizEV Project in Upstate New York
  - ChargeTO in Toronto

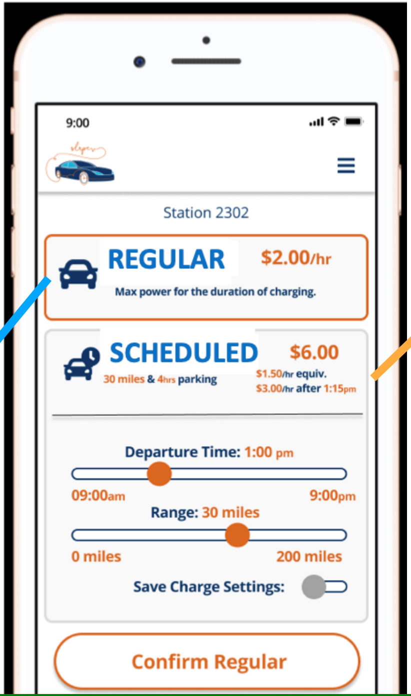
Residential place only
Fixed pricing options

- **Literature**
  - Control the deadline of users(A. Ghosh, 2019);
  - Nudge users to connect to more profitable chargers(N. Tucker, 2018).

Historical dataset only
Cannot reflect user behaviour and sensitivity

Cyber-Physical & Human System

- **3 sites:** UC Berkeley, UC San Diego, SunPower San Jose; 26 EVSEs fully operational since Nov 2020



REGULAR

- Fixed rate in USD/hr
- Max power until unplug or top-off
- Charging power is uncontrollable.

SCHEDULED

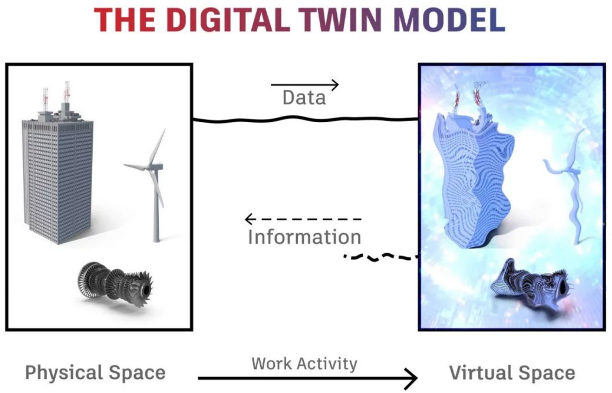
- User provides departure time & added range
- Total cost fixed *a priori*
- Charging power is controllable.

Charging schedules & pricing dynamically optimized based on congestion, electric demand, energy prices, user choices, etc.

SlrpEV Simulation

- Digital Twin
  - A digital twin is a virtual model of a physical object.
  - uses real-time data sent to simulate the behavior and monitor operations

- Objective
  - Data Ingestion
  - Evaluation of the charging station model
  - Data Analysis



SlrpEV Simulation flow chart

Session Generation

Goal
Retrieve random arrival, departure, and energy-needed data from the actual facility data. (11/2020 ~ 1/2022)

Input
Actual charging station facility data

Output
- 10 users per day
- 10 days Station-of level user data
- Arrival time
- Departure time
- Energy needed

Data Pre-processing

Goal
Receive Session Generator's input data frame and filter out unnecessary data

Input
Sessions generated from the session generator

Output
Filtered Session data
- Overnight charging scenario
- Energy needed overpasses the maximum charging limit.
- Pre-process arrival and departure data to conform with minimum time interval (15mins)

Main Simulation

Goal
Overall simulation. run the simulation until the given runtime (10 days)

Input
Integrate with station-level optimizer
- Session data (arrival time, departure time, energy needed)

Output
Filtered Session data
- Charger assignment – if all the chargers are assigned, "unavailability leave"
- Choice of each user
- User choice and (Regular /Scheduled) charging price
- Daily list of user's (Regular /Scheduled / Leave) choices.

Station-level Optimizer

Input
- Session data

Output
- User choice probability
- (Regular / Scheduled) charging price

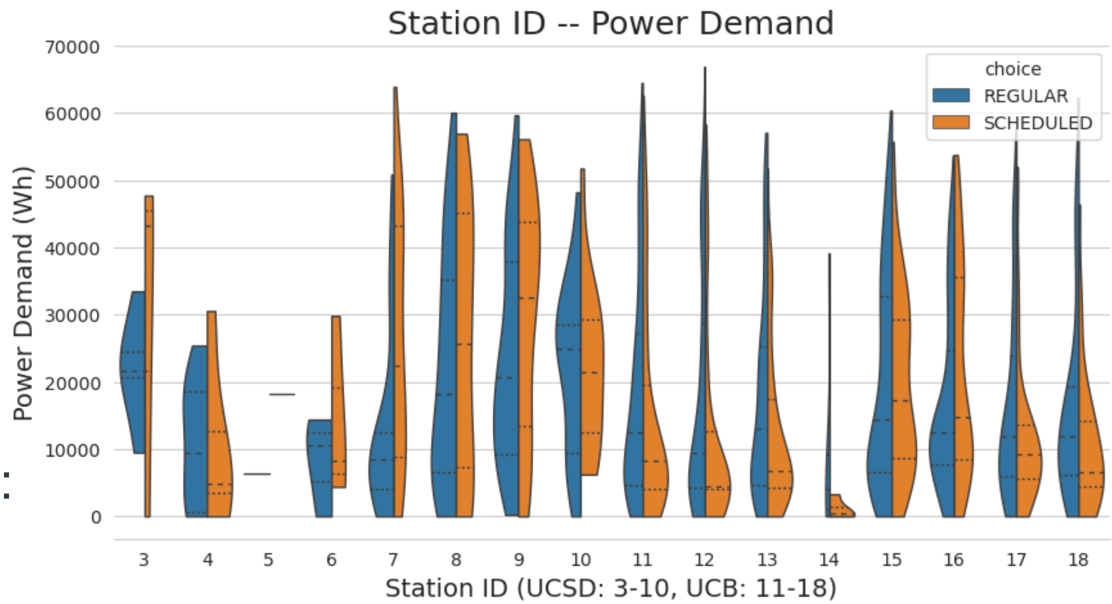
Simulator Choice Function

Input
- Charging price

Output
- User's charging mode choice (Regular / Scheduled / Leave)

Data Analysis

- **User** Trends:
  - Time
  - Demand
  - Choice
  - ……
- **Supplier** Trends:
  - Different Costs
  - ……



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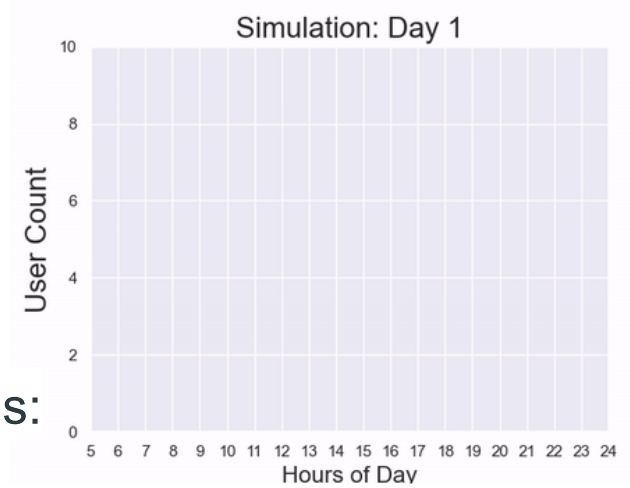
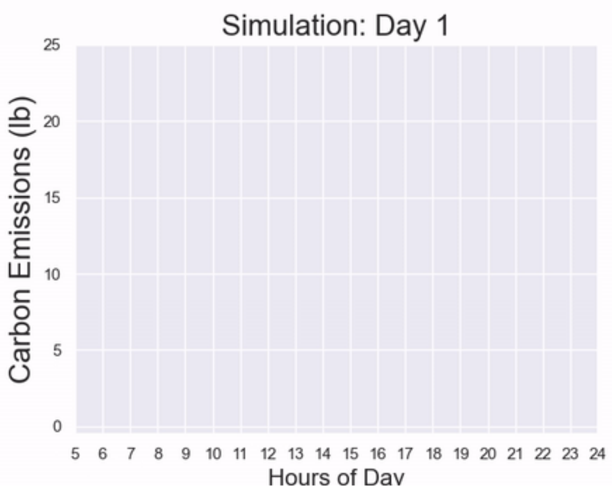
Data Analysis

- **User** Trends:
  - Numbers
  - Emissions
  - Choice
  - ……





- **Supplier** Trends:
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Data Analysis

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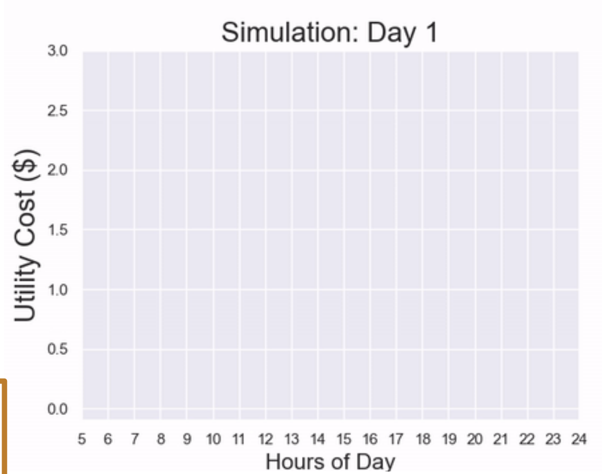
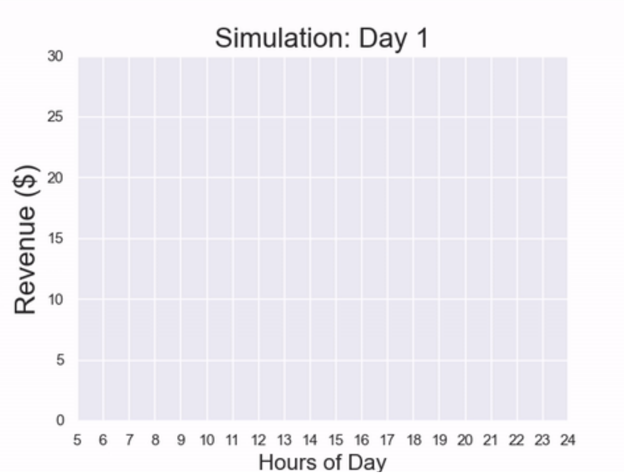
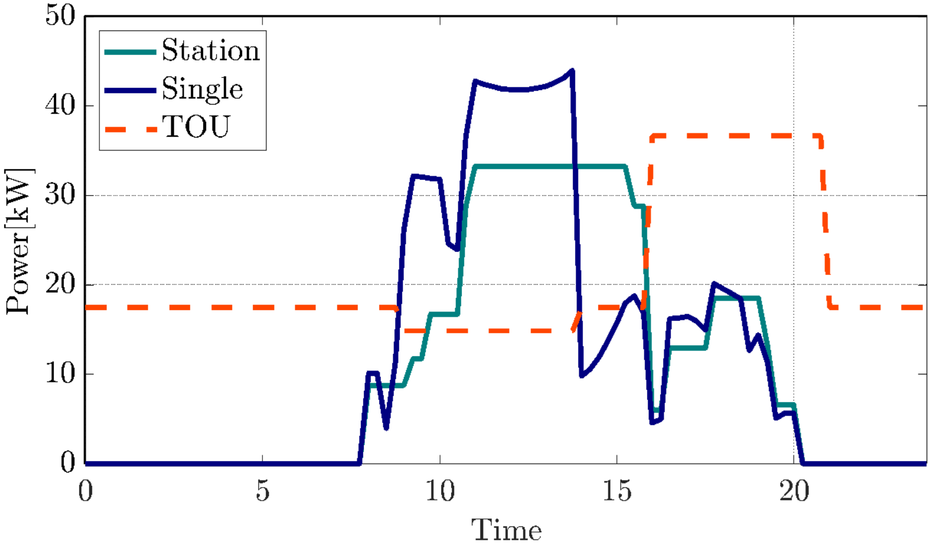




Data Analysis

- **Station** optimization:
  - Station
  - Demand
  - Choice
  - ……



	Single-charger	Station-level
Max Power(kW)	**43.98**	**33.23**

Conclusion

- **Overview**
  - Simulator/Optimizer
  - Data Analysis
- **Next Steps**
  - Deployment
  - More chargers
- **Opportunities**
  - Relationship between supply and demand
  - Industry growth
  - ……

References

[1] P. Alexeenko and E. Bitar, "Achieving reliable coordination of residential plug-in electric vehicle charging: A pilot study," 12 2021. [Online]. Available: http://arxiv.org/abs/2112.04559.

[2] J. Bauman, M. Stevens, S. Hacikyan, L. Tremblay, E. Mallia, and C. Mendes, "Residential smart-charging pilot program in toronto: Results of a utility controlled charging pilot," World Electric Vehicle Journal, vol. 8, pp. 531–542, 6 2016.

[3] A. Ghosh and V. Aggarwal, "Control of charging of electric vehicles through menu-based pricing," IEEE Transactions on Smart Grid, vol. 9, pp. 5918–5929, 11 2018.

[4] N. Tucker and M. Alizadeh, "Online pricing mechanisms for electric vehicle management at workplace charging facilities." IEEE, 10 2018, pp. 351–358.