EPC-16-057
SCRIPT:Smart Charging Infrastructure Planning Tool

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November 19, 2020

Project Partners

gridmatic

chargepoint

SLAC NATIONAL ACCELERATOR LABORATORY

Funding Agency

CALIFORNIA ENERGY COMMISSION

External Contributors

U.S. DEPARTMENT OF ENERGY Office of Science

Carnegie Mellon University

Outline

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Overview: Goals

- Develop a predictive smart charging framework for EVs that considers future travel plans of drivers and various power system conditions.

- Perform a cost-benefit analysis for investment in charging infrastructure considering various future scenarios.

- Develop SCRIPT, a comprehensive tool that integrates the above elements and can be used by stakeholders to make decisions pertaining to new investments in charging infrastructure.

Overview: Approach

data

- Chargepoint commercial and residential data
- Surveys
- DMV vehicle registration data
- Population distribution by county in CA
- State-level goals and targets
- Utilities rate structure
- Privacy

analytics

Smart Charging

- As a function of ChargePoint data for different segments and rate structure.

EV Flexibility Forecast

- As a function of ChargePoint data, future projection, pop distribution, mix of EV and charging port types.

Cost Benefit Analysis

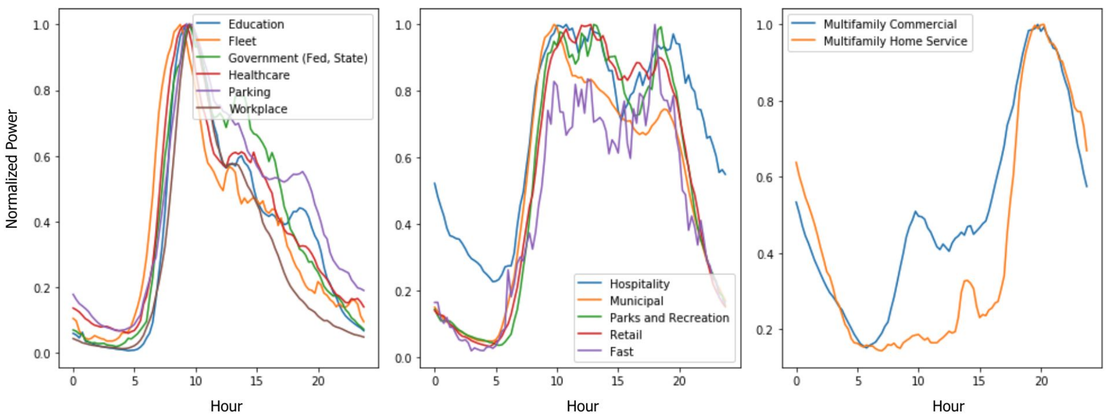
- Adoption rates, ICE total cost of ownership, emissions, smart charging vs. uncontrollable charging.
- Benefits/Costs to different stakeholders

interface

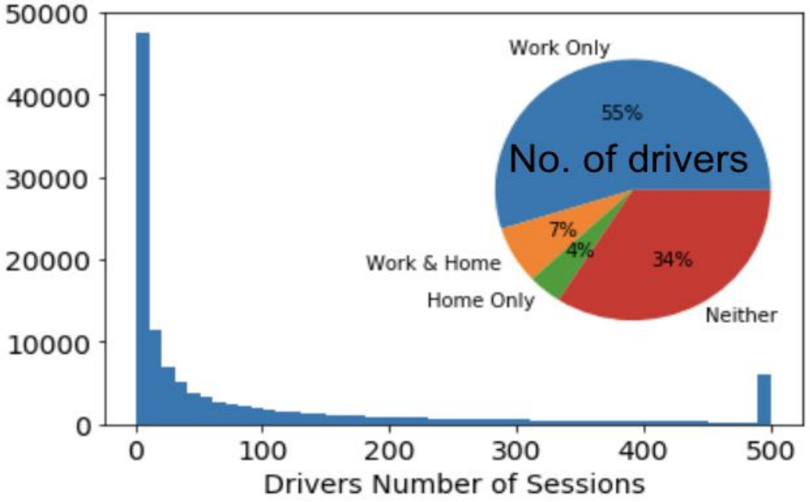
- Build the interface as a page/app.
- Inputs to different combinations of solutions defined in analytics.
- Optional: Allow file uploads for analytics to run on.

Data: General Statistics

Clustered Segments

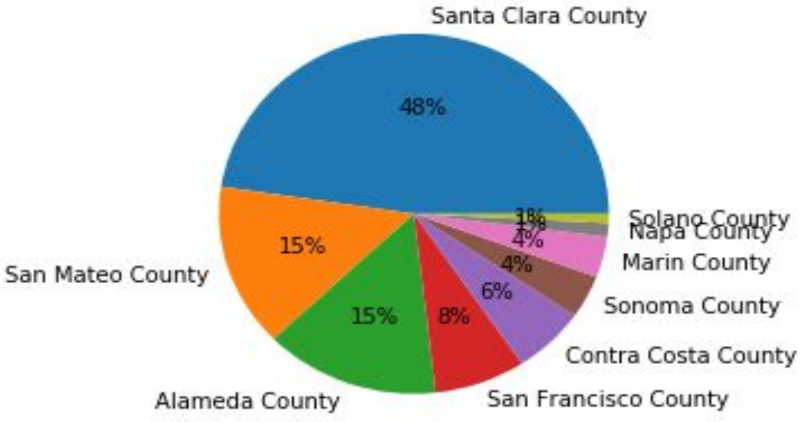


Driver's Statistics by Segment and # of Sessions

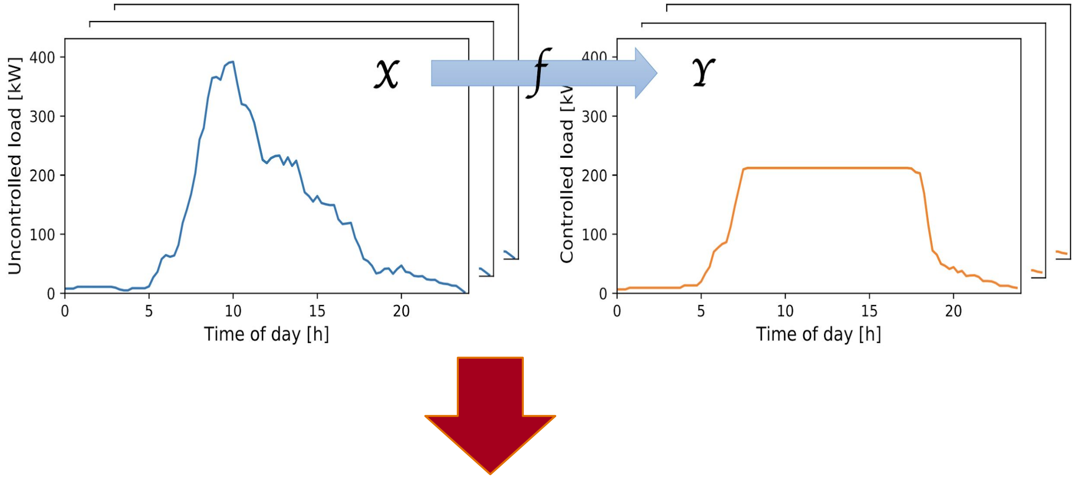


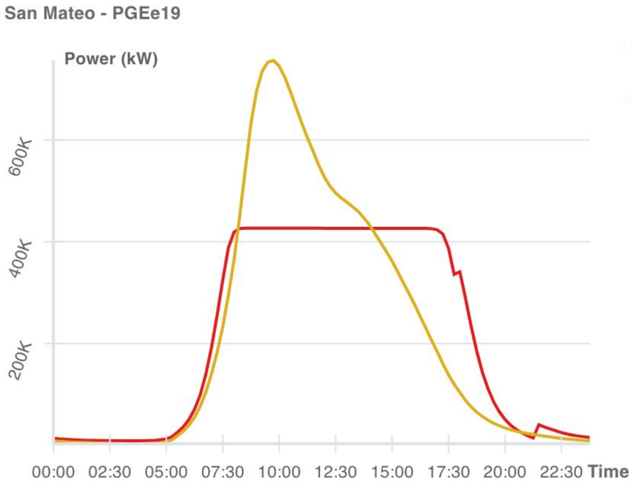
- <u>General Statistics</u>
  - 6.09mn sessions (2015-2019): 4.2mn from workplace, 521k residential single family, 148k multifamily, remaining from retail and public
  - 119k unique drivers
  - 9 counties

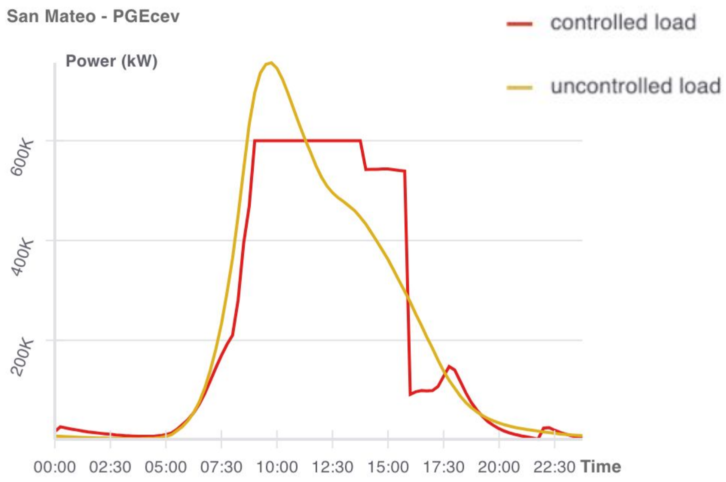
Driver's Home County



Analytics: Smart Charging Approach



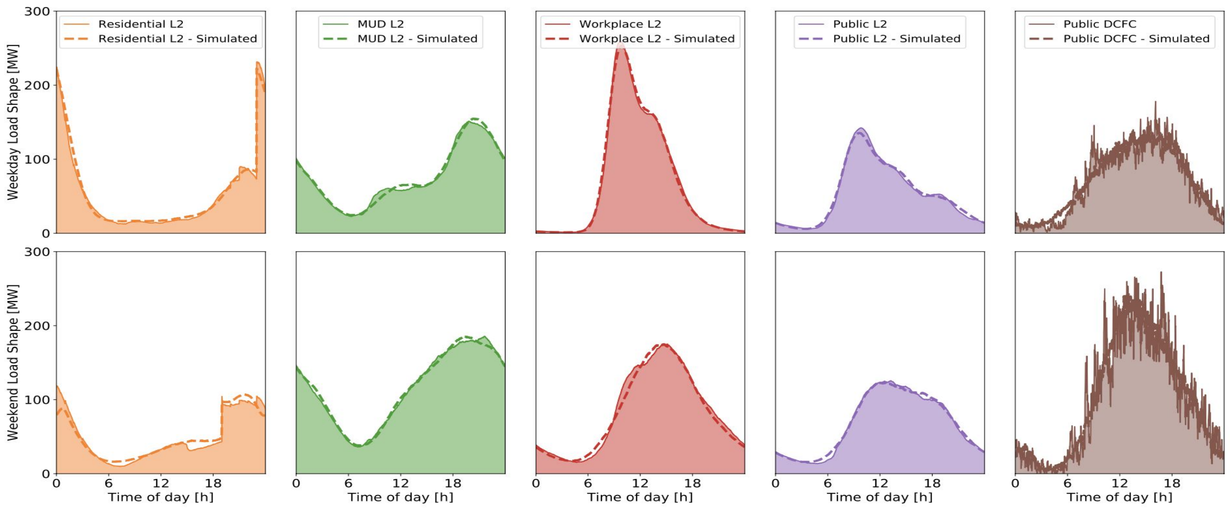


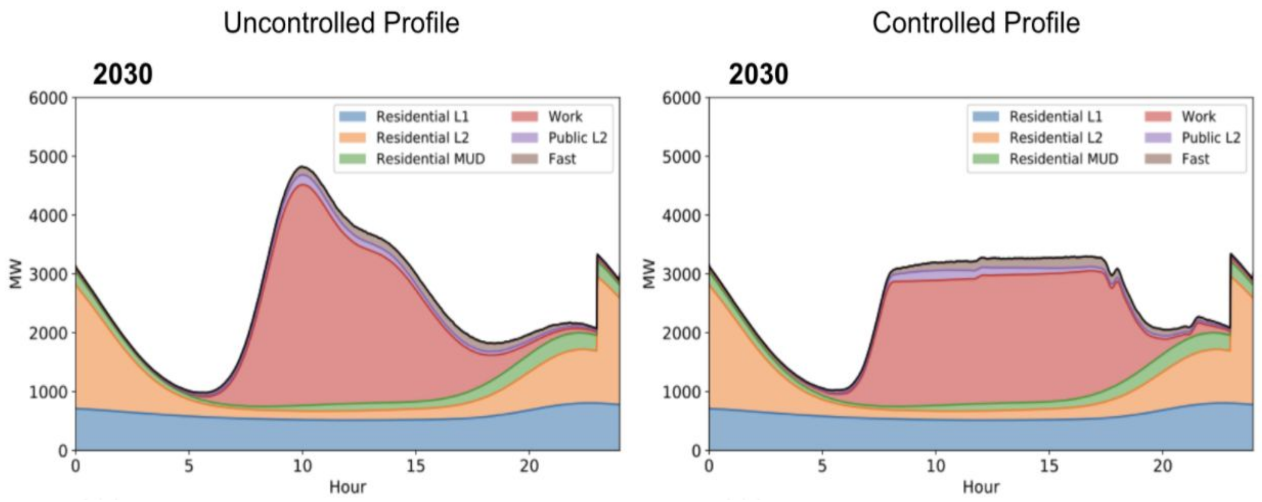


- Data-driven method to model charging control to drastically reduce computational time
  - Learn a mapping function **F** that given an uncontrollable profile generates a controllable one given an objective (e.g. rate structure, capacity limit etc).
- Benefits of proposed approach
  - Speed in estimation of controlled EV load profile
  - Scalability to millions of vehicles

Analytics: Forecasting Approach

EV load profiles from statistics and original data in different charging segments



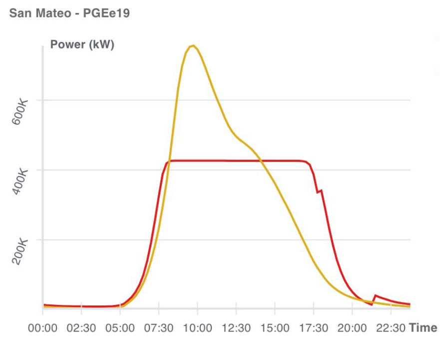


- Statistical modeling framework for EV load profile generation.
  - Multiple inputs can be changed:
    - Aggregation Level
    - Number of EVs
    - Charging Segment Percentage
    - Battery Capacity
    - Control
    - Day Type
- Benefits of the proposed approach
  - Models can be stored and shared without any individual driver information
  - Scenarios can be generated targeting particular use cases, e.g. predominance of a charging segment etc

Analytics: Cost-Benefit Analysis

Key Inputs

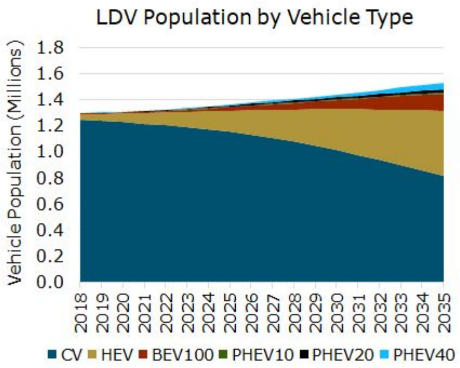
EV Load Shapes



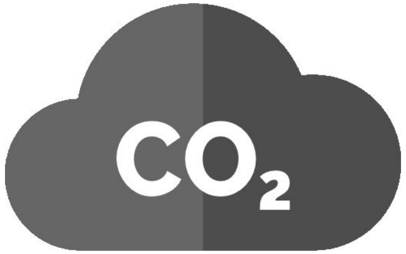
Utility Marginal Costs

Utility Rates

EV Adoption Forecasts

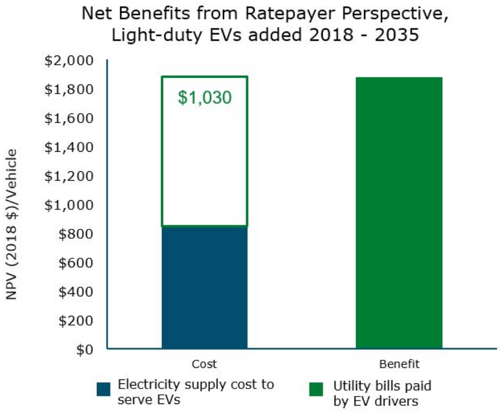


Emissions



Gas Prices

CBA Results



- Costs and benefits from different stakeholder perspectives (EV owners, ratepayers, and region (state/county))
- Compare results for smart charging versus unmanaged charging scenarios, to see value of smart charging

Project Results and Insights

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Scenarios Analyzed

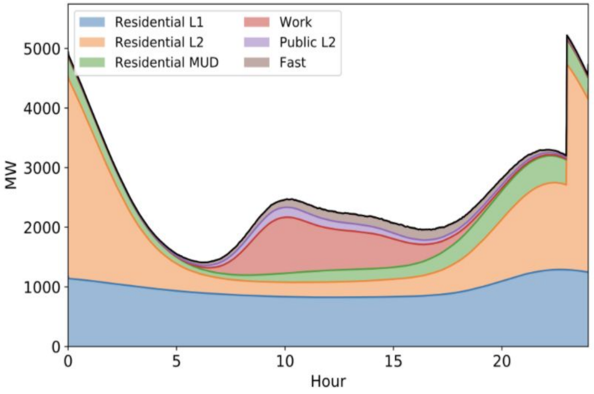
	Adoption: Number of Drivers	Geographic Distribution	Segment Split as % of Drivers (Res, Work, Pub L2, Pub DCFC)
Base Case	2025: 1.5 mn 2030: 5 mn	Current dist x Population dist	(80, 10, 5, 5)
Low Adoption	2025: 1 mn 2030: 1.5 mn	As in Base Case	As in Base Case
High Adoption	2025: 5 mn 2030: 20 mn	As in Base Case	As in Base Case
Fast-Public	As in Base Case	As in Base Case	(50, 10, 20, 20)
Work-Public	As in Base Case	As in Base Case	(60, 15, 15, 5)
Work	As in Base Case	As in Base Case	(50, 40, 5, 5)
Equity	As in Base Case	By Population	As in Base Case

- Base Case, High Adoption, Low Adoption and Equity scenarios all rely heavily on the residential segment to meet the needs of growing EV adoption
- Fast-Public scenario presents a good tradeoff between residential and non-residential charging throughout the day.
- Work scenario significantly increases the EV load during the middle of the day which is beneficial to confront solar over generation. EV load management and coordination is simpler to implement.

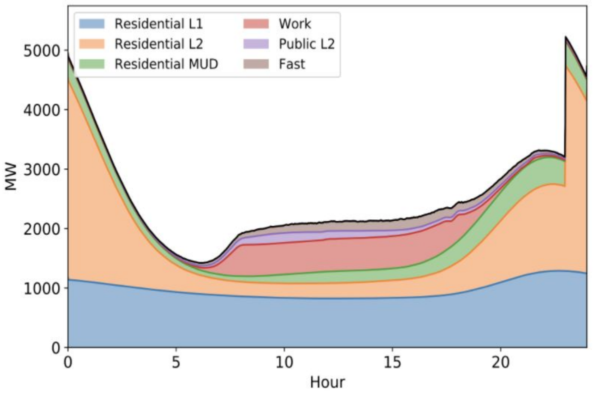
Project Results and Insights: Scenarios

Base Case Scenario

Uncontrolled Load

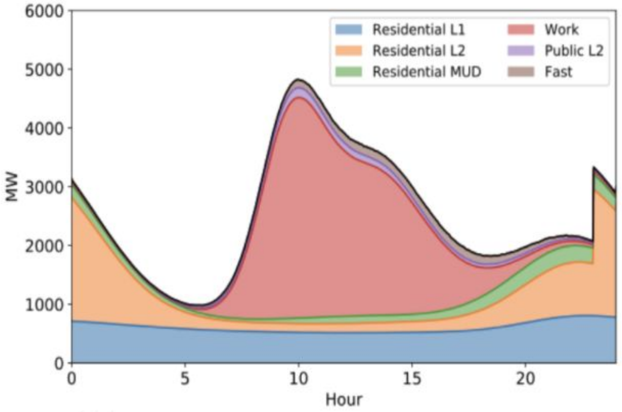


Controlled Load

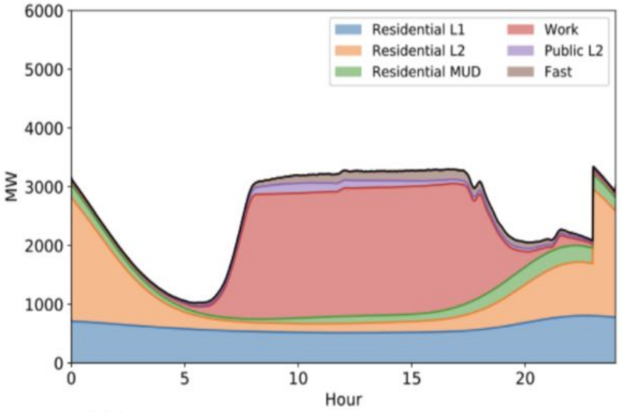


Work Scenario

Uncontrolled Load

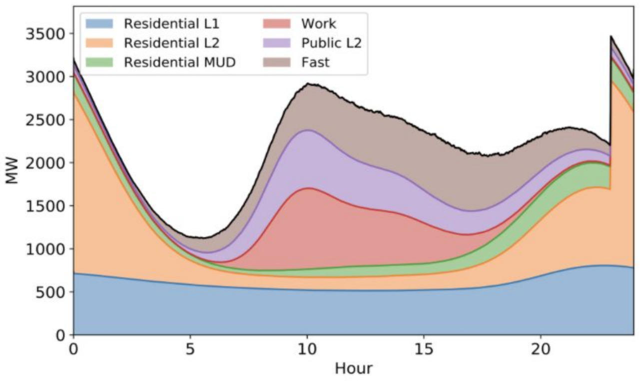


Controlled Load

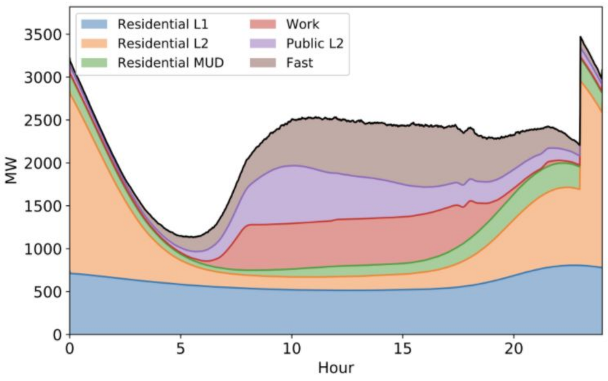


Fast-Public

Uncontrolled Load



Controlled Load



Project Results and Insights: Cost-Benefit Analysis

- Assessment included the societal (TRC), ratepayer (RIM), and EV driver (PTC) perspectives
  - TRC: state as a whole, and each county, benefit overall from EV charging - indicating that policymakers should continue efforts to spur EV adoption and bring benefits to California and its counties.
  - RIM: all utility ratepayers who do not have EVs may still benefit from broader EV adoption: EV charging brings in additional utility revenue that outweighs the electricity supply costs, thus putting downward pressure on rates over time.
  - PTC: EV drivers benefit from their choice to adopt an EV, with lower lifetime costs compared to conventional vehicles.
  - Differences in benefits using smart-charging compared to not using it are minimal (~ $100 per EV lifetime) for all stakeholders perspectives. EV owners increase benefit and ratepayers and state has slightly decrease in benefits.

Takeaways and Lessons Learned

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- Flexibility in generating future EV demand across different charging segments can help inform utilities where to target investments.
- Understanding how EV load profiles change given a rate structure can help utilities design more appropriate rate structures to target specific segments of customers to shape the load to support grid operation.
- Increase adoption of EVs will financially benefit entire state/county, all ratepayers and EV owners.
- If charging continues to predominantly happen in the residential sector major upgrades in infrastructure will need to happen in different levels which may include both medium and low voltage systems, transformers, lines, and residential panels.
- Workplace charging is better suited for smart-charging than other segments.
- Large EV charging datasets are not widely available to research community.
- Difficult to obtain dataset that is heterogeneous and include multiple EVSE vendors and/or EV data.
- Lack of communication standards and data schema makes it difficult to obtain complete visibility of the system.