Managing Increased Electric Vehicle Shares on Decarbonized Bulk Power Systems

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Project ID: VAN054

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OVERVIEW

Timeline

- Project Start Date: Nov 2022
- Project End Date: Sep 2025
- Percent Complete: 40%*
  **as of April 2024*

Budget

- Total Project Funding: $1,300,000
  DOE Share: 100%
- FY 2023 Funding: $500,000
- FY 2024 Funding: $500,000

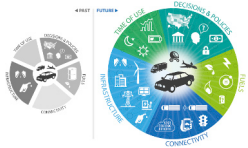
Barriers Addressed

- Electricity demand growth from electric vehicle (EV) charging
- System-level costs/benefits of EV managed charging (EVMC)
- Co-evolution of the bulk power system, EV adoption, EV supply equipment (EVSE) networks, and EVMC

RELEVANCE

Motivation

Transportation electrification and power sector decarbonization—the convergence of these two trends present a complex planning problem requiring realistic, region-specific modeling and analysis to ensure that both can happen rapidly and cost effectively.



Muratori et al., 2020, "Future integrated mobility-energy systems: a modeling perspective," Renewable Sustainable Energy Rev.

Objectives

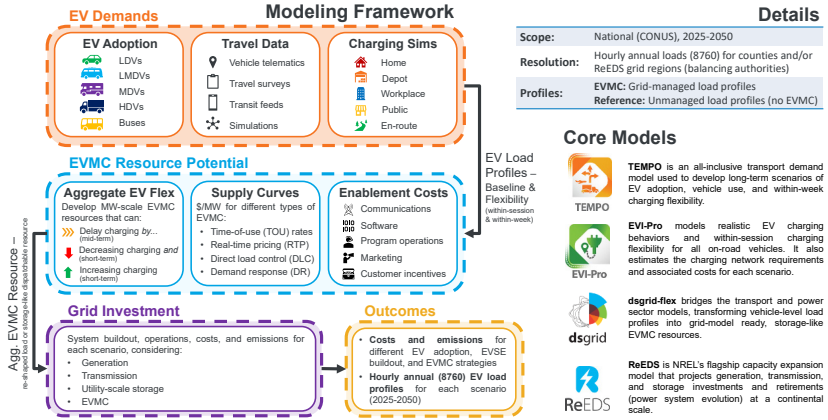
- Model the evolution of the U.S. bulk power system (through 2050) in response to large-scale EV charging (*clean transportation technology*) across all on-road vehicle segments.
- Assess the opportunity and value of demand-side flexibility (i.e., "smart" charging) for *reducing energy costs*, increasing renewable generation shares (*increased energy security*), and managing future EV loads on the bulk power system.
- Study how the buildout of EV charging networks can impact demand-side flexibility.

**DOE / VTO priorities*

Impact

- Improved understanding of least-cost solutions for managing EV load growth on the grid.
- EV load data sets will be made publicly available.

APPROACH



Details

Scope:	National (CONUS), 2025-2050
Resolution:	Hourly annual loads (8760) for counties and/or ReEDS grid regions (balancing authorities)
Profiles:	**EVMC:** Grid-managed load profiles **Reference:** Unmanaged load profiles (no EVMC)

Core Models

TEMPO is an all-inclusive transport demand model used to develop long-term scenarios of EV adoption, vehicle use, and within-week charging flexibility.

EVI-Pro models realistic EV charging behaviors and within-session charging flexibility for all on-road vehicles. It also estimates the charging network requirements and associated costs for each scenario.

dsgrid-flex bridges the transport and power sector models, transforming vehicle-level load profiles into grid-model ready, storage-like EVMC resources.

ReEDS is NREL's flagship capacity expansion model that projects generation, transmission, and storage investments and retirements (power system evolution) at a continental scale.

TECHNICAL ACCOMPLISHMENTS

1. Developed Travel Database for Weekly Charging Sims

- Acquired/Synthesized and processed ~200,000 unique 1-week vehicle travel profiles representing all on-road vehicle segments.
- Inferred trip locations (where required) enabling the modeling of location-specific charging behaviors and EVMC programs.
- Successfully ran all travel profiles through EVI-Pro and TEMPO charging modules.

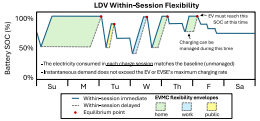
Vehicle Travel Database for Weekly EV Charging Sims

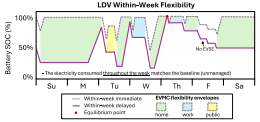
Vehicle Segment	Vehicle-Weeks	Source
LDVs (Class 1-2a)	116,638	2017 NHTS
Local LMDVs (Class 2b-3)	23	Fleet DNA
Local MDVs (Class 4-6)	349	Fleet DNA
Local HDVs (Class 7-8)	2,200	Telematics
Regional MHDVs (Class 2b-8)	11,588	Telematics
Long-haul MHDVs (Class 2b-8)	37,075	Telematics
Transit buses	21,694	GTFS
School buses	254	Fleet DNA
1-Week Vehicle Profiles	**189,821**	

NHTS: National Household Travel Survey; GTFS: General Transit Feed Specification

2. Revised EV Flexibility Models

EV flexibility models define when and to what extent vehicles can participate in EVMC while preserving mobility. Developed in Hale et al. (2022), the study assumed ubiquitous access to EVSE and EVMC at all LDV stops. The current study revises the original flexibility model structure and data to increase realism.



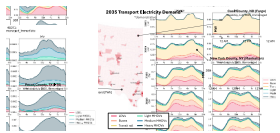


Enhancements:

- Location-specific variable EVSE access enabling the comparison of different EV charging network buildouts.
- Location-specific EVMC opportunities enabling the study of location-specific managed charging programs.
- More realistic charging behaviors in the baseline (unmanaged) scenario and within-session flexibility profiles simulated in EVI-Pro.

3. Modeled High Resolution EV Demands

Developed framework to model annual hourly (8760) county-level EV loads through 2050 by linking TEMPO (EV adoption and use), EVI-Pro (charging behaviors, EVSE network design), and NREL grid models.



COLLABORATIONS

Technical advisory committee: Diverse group of research and industry stakeholders to help guide technical and strategic aspects of the project:

- Virtual meetings (2-3 per year) to solicit feedback, review progress and findings, and advise on project approach and results dissemination.
- The technical advisory committee will review all written and data products prior to release.

Industry	Organization(s)
Auto OEMs	Daimler Truck NA, Ford
Bulk Power System Operators	CAISO, PJM
Communities	Dallas-Ft. Worth Clean Cities, NJ Clean Cities, TN Clean Fuels
Equity	Boston University
EV Charging	ChargePoint
Regulators	CPUC
Research/Consulting	Atlas, Carnegie Mellon, NC A&T State, Karlsruhe IT, SEPA
Software/Aggregators	Camus Energy, FlexCharging
Utilities	National Grid, PG&E

FUTURE WORK

Any proposed future work is subject to change based on funding levels

FY 2024

- 2x technical advisory committee meetings: April (EVMC supply curves) and Summer (prelim. EV load profiles).
- Finalize annual hourly (8760) EV load profiles for all scenarios, 2025-2050.
- Complete ReEDS implementation (including EVMC supply curves) and finalize EV aggregation approach.

FY 2025

- Complete national-scale grid analysis of EVMC strategies. Publish findings in journal article(s) or technical report.
- Make EV load datasets (annual hourly county-level loads) for all scenarios–both unmanaged and managed, publicly available.
- Develop and enact results dissemination plan to maximize the impact of the study.

SUMMARY

- Transportation data preparation, model enhancements, and analysis pipeline development complete; Ready to conduct large-scale EV charging simulations.
- Project scenario framework finalized – will study the impacts of different charging network buildouts and location-specific EVMC on system costs and emissions.
- Annual hourly (8760) county-level EV load profiles for all on-road vehicle segments finalized by end of FY 2024.
- Project is coordinated with VAN052 and VAN050 around shared TEMPO and EVI-Pro model enhancements; Complementary to the Multi-State Transportation Electrification Impacts Study (VAN061) which focuses on mid-term (2032) distribution-level impacts of EV charging (vs. long-term bulk power system impacts); Aligned with DOE EERE DECARB project enhancing it through detailed modeling of EVMC potential across all on-road vehicle types.

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