U.S. DOE’s National Lab System
The National Renewable Energy Laboratory (NREL) spearheads transportation research, development, and deployment to accelerate the widespread adoption of high-performance, low-emission, energy-efficient passenger and freight vehicles.

NREL is assessing the potential for energy diversification in transportation (CNG, biofuels, hydrogen and electrification) and related infrastructure requirements and providing technical support to national, state, and local entities to:

- Assess long-term electrification opportunities across different transportation segments & evaluate policy/technology scenarios for alternative fuel vehicle adoption
- Estimate infrastructure requirements to support vehicle electrification
- Understand EV charging costs (affordability) and optimize DCFC station design
- Explore opportunities for EV integration with buildings and the electric grid
Vehicle electrification has the potential to disrupt the U.S. transportation energy landscape. Different opportunities for electrification across different segments and applications in real-world technology adoption.

- **Today**: Complete reliance on petroleum, 90+%
- **Possible future**: in the EFS High scenario 76% of on-road miles traveled from electricity in 2050
  - ~85% for light-duty vehicles
  - ~95% for buses
  - ~40% for heavy trucks

Transportation accounts for 23% of U.S. electricity consumption in 2050, up from 0.2% today.
NREL developed EVI-Pro to analyze charging behavior and translate those in public charging infrastructure requirements to support PEV adoption, including interstate corridors and support for “garage orphans”.

Estimated requirements for EV charging infrastructure are heavily dependent on:
- Home charging availability
- Evolution of the EV market,
- Consumer preferences,
- Technology development

A free simplified online version of EVI-Pro to assist US state and local governments and make insights from recent studies accessible to public and private organizations investing in EV charging infrastructure.

EVI-Pro Lite

Your Results
In Colorado, to support 250,000 plug-in electric vehicles you would need:

5,590 Workplace Level 2 Charging Plugs
3,693 Public Level 2 Charging Plugs
550 Public DC Fast Charging Plugs

Where Do I Start?
Planners may want to prioritize installation of fast charging infrastructure above Level 2 charging.

Build DC Fast First: Establishing fast charging networks that enable long-distance travel, serve as charging safety nets, and provide charging for drivers without home charging as critical to support all-electric vehicles that have no other alternative for quickly extending their driving range.

Build Level 2 Second: EVI-Pro typically simulates the majority of Level 2 charging demand coming from plug-in hybrid electric vehicles, which have the ability to use gasoline as necessary for quickly extending driving range.
EVs are an additional load that increases total electricity demand and changes its shape. Integrating EVs creates load growth opportunities for electric utilities but also poses new challenges in a system of growing complexity.

- Impact on the overall energy consumption increase is limited (e.g., 10% PEV market share → demand increase of 5%)
- Impact on system-level peak electricity demand can be more significant.
- At the local level, clustering effects in EV adoption and high power charging exacerbate the impact on distribution systems.
Flexible EV Charging

The grid is evolving into a more integrated supply/demand system in which demand-side distributed resources respond to supply-side requirements.

Flexible PEV charging can satisfy mobility needs while also supporting the grid (cheaper electricity) by optimizing the design and operation of the electric power systems and facilitate the integration of renewables:

- Peak shaving /valley filling
- Ramping mitigation
- Support operations (e.g., curtailment)
- Distributed services (e.g., reserve, contingency)
Conclusions

**Emerging topic:**

- **Vehicle electrification** is rapidly changing the transportation demand landscape and requires advanced modeling tools to explore future scenarios.

**System-level changes:**

- **Integrated demand/supply models** are required to inform this transformation, including the key role of recharging infrastructure and EV-grid integration.

**Integration challenges/opportunities:**

- Electric vehicles introduce load that the grid was not designed to accommodate and can **impact the electricity system**, especially the distribution networks.
- Electric vehicles offers great opportunities to **optimize the design and operation of future integrated transportation/energy systems**.
References & Acknowledgement

References:


• Muratori, M., Mai, T. “The Shape of Electrified Transportation”. Forthcoming


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The views and opinions expressed in this presentation are those of the author alone and do not reflect the positions of NREL or of the US government.
Thanks! Questions?

Matteo.Muratori@NREL.gov
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EV charging profiles can look significantly different (and would require different levels of charging infrastructure) if vehicles are charged at different locations (while respecting mobility needs)
Mitigate DC Fast Charging Cost

Cost of fast charging can be high, due to **low utilization & demand charges**

**Technology solutions** can be used to reduce cost, including batteries and PV