Long-Term Scenarios of Transportation Decarbonization

Matteo Muratori, Christopher Hoehne, Paige Jadun, Arthur Yip, and Catherine Ledna

Matteo.Muratori@NREL.gov

CONTEXT

Achieving a net-zero emissions economy by 2050 requires **aggressive curbing of transportation emissions**, currently the largest source of U.S. greenhouse gas (GHG) emissions and the fastest growing source of emissions in many countries.

Transportation—a heterogeneous sector with many different passenger and freight travel modes and applications—will **require a portfolio of solutions to decarbonize**.

METHODS

We use the **T**ransportation **E**nergy and **M**obility **P**athway **O**ptions™ (TEMPO) model to explore many transformation pathways under expert-informed bounding ranges of assumptions on:

TEMPO

- Future **travel behavior** → vehicle ownership and occupancy, availability of transit, *etc.*
- **Technology advancements** → vehicle costs and fuel economies, fueling infrastructure, *etc.*
- **Policies** → carbon pricing, zero-emission vehicle (ZEV) mandates, biofuel blending, *etc.*

Scope: Inform how to achieve significant emissions reductions in U.S. passenger and freight mobility.

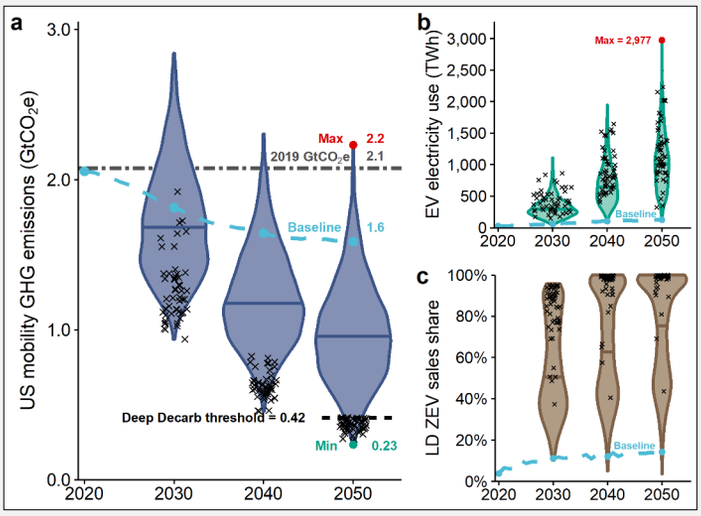
CONCLUSIONS

A combination of technological, behavioral, and policy strategies enables a staggering **89% reduction in transportation GHG emissions by 2050**.

- Rapid adoption of **zero-emission electric vehicles (EVs) for all on-road passenger and freight applications**, alongside a simultaneous decarbonization of electricity (supported by managed charging and proper planning).
  - **1,100–3,000 TWh of electricity** needed by 2050, a 25–75% increase from today's electricity demand (range driven by uncertainties in travel demand and vehicle efficiency).
- **10–42 billion gallons of sustainable aviation fuel** needed by 2050 for domestic air travel alone.
- **Managing travel demand growth can ease the transition** by reducing the requisite amount of clean electricity and sustainable fuels supply.

RESULTS

We performed more than 2,000 simulations to explore possible transformation pathways.



"x" = 50 scenarios achieved "deep decarbonization," an 80% reduction in transportation well-to-wheel GHGs from the 2050 baseline.

a) Many pathways exist to significantly reduce transportation well-to-wheel GHG emissions, but **multiple levers are needed to achieve 80% or more** emissions reductions.
   - Besides EVs, reducing travel demand is the most consistent strategy—yet one of the hardest to implement—and we find no significant shifts away from personal cars in the United States.

b) Deep decarbonization can be achieved even without travel demand reductions but requires a rapid and massive transition to ZEVs: **90% passenger sales and 70% medium/heavy-duty sales by 2030**, and 100% ZEVs by 2040.

c) The median electricity demand for EV charging alone is **1,000 TWh with a range 120–3,000 TWh** (plus any electricity used to produce hydrogen or sustainable fuels).

REFERENCES

The **U.S. National Blueprint for Transportation Decarbonization** – A Joint Strategy to Transform Transportation. 2023. https://www.energy.gov/sites/default/files/2023-01/the-us-national-blueprint-for-transportation-decarbonization.pdf

Hoehne, C., Muratori, M., Jadun, P. *et al.* **Exploring Decarbonization Pathways for USA Passenger and Freight Mobility**. *Nature Communication*. 2023. https://doi.org/10.1038/s41467-023-42483-0

This work was authored by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Strategic Analysis. The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government. The U.S. Government retains and the publisher, by accepting the article for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes.

16th IAMC Annual Meeting
Venice, Italy
November 14-15, 2023
NREL/PO-5400-87963