National-Level Energy Impacts of Cooperative Adaptive Cruise Control (CACC) Systems

Eleftheria (Ria) Kontou Ph.D., Jacob Holden, Matteo Muratori Ph.D., Jeffrey Gonder
Transportation and Hydrogen Systems Center, National Renewable Energy Laboratory (NREL)
Contact: ria.kontou@nrel.gov

Research Objectives

Research Questions
• What is the national-level energy impact of adopting connected and automated vehicles and technologies (e.g. Cooperative Adaptive Cruise Control) examined here, eco-signal implementation, automated mobility districts applications?
• How do different levels of CACC adoption affect on-road fuel economy for different vehicle powertrains?
• What changes in vehicle miles traveled distribution are induced by CACC adoption and what is the potentially induced change in demand, primarily on US freeways and highways?

Modeling Assumptions & Data Insights
• Insights and data from micro-simulation modeling of CACC vehicle use in a freeway stretch in Sacramento CA, conducted by Lawrence Berkeley National Lab (LBNL)
• Induced demand assumptions, using preliminary results of agent-based modeling simulations conducted by Argonne National Lab (ANL)

Methodology
The methodology proposed accounts for vehicle stock evolution, fuel consumption changes due to CACC adoption for different vehicle powertrains, and vehicle miles traveled (VMT) distribution changes as well as impacts of induced demand

Important modeling inputs:
• Modeling period: 2018-2050
• Existing vehicle stock & new sales of different powertrains, including CACC capabilities (e.g., AEO projections, ADOPT Scenarios, Shladover & Greenblatt white paper scenarios)
• CACC impacts on vehicles' fuel economy across speed bins (e.g., based on LBNL Aimsun microsimulation analysis)
• National-level impacts of CACC on VMT across speed bins (e.g., LBNL micro-simulation) and due to perceived changes in vehicle travel time and induced travel demand (e.g., ANL/IIUC agent based simulations)

Data Inputs

Powertrain Adoption Scenarios
Vehicle sales projected using NREL's ADOPT model, based on AEO 2017 fuel prices and different technology improvement trends over time

CACC Adoption
CACC VMT share on highways and freeways, 3 scenarios of CACC adoption:

Vehicle Fuel Consumption
Base year FC for all powertrains:

Impact of CACC Penetration Levels on VMT and Fuel Consumption
LBNL microsimulation data outputs inform fuel consumption & VMT metrics under CACC adoption (note that VMT & FC correspond to the LBNL freeway network and not the national level analysis)

Future Work
• Refine inputs and interactions with other tools
  o VMT transferability from ANL/UIUC (Chicago -> nation)
  o Microsimulation data outputs (trajectory data from local CACC implementation, automated mobility districts microsimulation, etc.)
• Sensitivity analysis to explore impact of several input parameters on the national-level fuel consumption results
  o Explore national-level fuel consumption impacts of eco-signal implementation
  o Explore national-level fuel consumption impacts of automated mobility districts and innovative mobility solutions
• Collaboration with other SMART Mobility pillars
  o e.g., Urban Sciences, Advanced Fueling Infrastructure, etc.