Accelerating a 21st Century Transportation System

Enabling Energy Technologies through Connectivity

Global Symposium on Connected Vehicles and Infrastructure
University of Michigan

Chris Gearhart, Director
Transportation and Hydrogen Systems Center
National Renewable Energy Laboratory

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NREL has led U.S. clean-energy innovation for 35 years

- Accelerates adoption of new transportation technologies, breaks down market barriers, and demonstrates economic viability
- Understands factors impacting technology commercialization
- Works closely with range of industry partners for real-world solutions; holds one quarter of DOE cooperative research and development agreements (CRADA)
- Integrates transportation RD&D with related renewables and efficiency research in the areas of building design, grid infrastructure, and energy generation.
The emergence of intelligent and automated vehicles presents significant energy and economic opportunities for the U.S.

NHTSA Levels of Vehicle Automation

Energy Opportunities

- Increase Energy Efficiency
- Reduce Petroleum Dependency
- Expand Manufacturing Capabilities
- Create High Tech Jobs
### Timing: Deployment of Connected and Automated Vehicles

#### Today

**Safety Benefits**
- Appealing consumer amenities commercially available now
  - Collision aversion
  - Park assist
  - Limited drive-cycle smoothing
  - GPS route mapping

#### Near-Term

**Fuel Economy Benefits**
- Additional amenities + savings
  - Efficient driving route selection
  - Improved drive-cycle smoothing
  - Traffic signal timing coordination
  - Vehicle “platooning”
  - Parking space location
  - Stationary wireless power transfer
  - Charging station location

#### Long-Term

**System-Wide Benefits**
- Dramatic innovations
  - Fully automated hands-free driving
  - Automated vehicle “valet” parking and retrieval
  - In-motion wireless power transfer

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*Image by NREL*

*Image courtesy of Ford*

*Image Courtesy of GM*
Advancing the Role of Energy in the Discussion

The most significant energy savings opportunities are enabled by near mid-term levels of automation and connectivity.

### Positive Energy Outcomes
- Enabling electrification
- Lightweighting & powertrain/vehicle size optimization
- Full cycle smoothing
- Efficient routing
- Efficient driving
- Platooning
- Higher occupancy
- Less hunting for parking

### Negative Energy Outcomes
- More travel
- Faster travel
- Travel by underserved

Bar chart showing Fuel Intensity, Energy Intensity, and Use Intensity.
Advancing the Role of Energy in Connected Vehicles: Research & Development

A number of current NREL activities can inform connected vehicles and infrastructure.

Vehicle Platooning

Table:

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<th>Distance, miles</th>
<th>Duration, minutes</th>
<th>Average elec rate, Wh/mi*</th>
<th>Average mpg*</th>
<th>Cost, $*</th>
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“Green” routing and adaptive control
NREL is a leader in the collection, validation, and dissemination of real-world energy-related transportation data.

- Securely archive sensitive data
- Provide public/composite data
- Quality control processing
- Spatial mapping/GIS analysis
- Custom reports for providers or DOE
- Application process for controlled access
- Detailed GPS drive cycle analysis

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**Alternative Fuels & Advanced Vehicles Data Center (AFDC)**
Clearinghouse of information on advanced vehicles and fuels

**National Fuel Cell Tech. Evaluation Center (NFCTEC)**
Tech validation of hydrogen and fuel cell applications and relevant infrastructure

**Transportation Secure Data Center (TSDC)**
Secure archival of and access to detailed transportation data (e.g., GPS travel profiles)

**FleetDNA**
Detailed MD/HD drive cycle and powertrain data from advanced fleets
Developing an Integrated R&D and Systems Analysis Framework

Integrated systems data analysis and vehicle R&D can enhance the impact of connected vehicle systems and ensure reliability and robustness of system components.

Current Analysis Framework

- Connected Vehicle Scenarios
- Market Adoption
- Energy and Emissions Impacts

Iterative Integrated R&D and Analysis Framework

- Connected Vehicle Scenarios
- Drive Cycle
- Driver Behavior
- Traffic Flow
- Powertrain Design and Options
- Vehicle Fuel Use/Performance
- Market Adoption
- Energy and Emissions Impacts
- Transportation System Impacts
Moving Forward: Opportunities

Technologies

- Globally, more efficient transportation can realize projected savings of $70 trillion over the next 40 years¹.

- Next-generation vehicle technologies and mobility solutions can reduce total energy consumption in the transportation sector and provide more choices to consumers. They can also have unintended consequences if not identified early on.

- Substantial RD&D is needed to meet the President’s goal of reducing oil use by 1/3 by 2025.

- Intelligent vehicle systems can support manufacturing competencies.

Partnerships

The National Labs can serve as a resource to

- Leverage existing technology work portfolios and partnerships

- Provide access to world-class test facilities and capabilities

- Serve as a third-party for technology validation, market acceptance, analysis, and data dissemination

- Provide systems-level energy analysis

Thank you

Questions?

Chris Gearhart
Transportation and Hydrogen Systems
chris.gearhart@nrel.gov