Decarbonizing Transportation & Off Road Sector

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March 22, 2022
What Does Economy-wide Decarbonization Look like

• Transportation is the largest source of GHG emissions
  - 50% of energy expenditures and local pollution issues
  - Significant implications for global competitiveness, trade, and domestic jobs

• Transportation provides essential access to services and economic opportunities
  - Must support demand for growth in mobility options
Achieving Net-Zero by 2050 Requires Change from the Status Quo in 2021

- Incremental change will not get us to net-zero
- Achieving 2050 goal requires success in the market by 2035 which requires coordinated strategy and direction in 2021
  - The magnitude of industrial change and direct consumer touch points with transportation require market-pull solutions
  - Must support demand for growth in mobility options – fuel switching and vehicle/system efficiencies must dominate
  - 100% clean electricity and dramatic technology cost reductions enable deep transportation decarbonization
  - Must consider many use cases

![Energy-related carbon dioxide emissions by sector](chart.png)
Decarbonization is part of a Broader Sustainable Transportation Approach

Meet everyone’s needs
Provide reliable mobility solutions for people and goods recognizing diverse needs of different communities and stakeholders

Affordable
Affordable (for consumer) and competitive for industry by supporting economy/jobs

Environment
Need to address local air quality and water as well as GHG emissions
Zero GHG & Convenient Mobility Solutions for All Is Formidable Task

\[ \text{Emissions} = \text{Activity} \times \text{Energy Intensity} \times \text{Carbon intensity} \]

Three strategies to address these three fundamental drivers of transportation emissions:

**ACTIVITY**
- System-Level and Design Solutions
  - Meet needs for services with reduced travel demand

**ENERGY INTENSITY**
- Shift Travel Towards Efficient Modes
  - Greater accessibility and improved mobility options

**CARBON INTENSITY**
- Improve Efficiency and Zero Emission Vehicles/Fuels
  - Transition to renewable solutions
Multiple but Targeted Solutions are Needed

- **Light Duty** (cars/SUV/PU) largest share (~52%), and can largely be electrified leveraging **cheap and abundant clean electricity**

- Strategy must also address **remaining 45+% of transportation** (projected to grow more rapidly)
  - **Hydrogen** and **Biofuels** will be critical to these other sectors
  - Diversification also improves resiliency

- Focus on solutions that can be **incrementally deployed**, delivering results by 2030
- Full **lifecycle emissions** must be addressed
- Effective **integration with the grid** and energy infrastructure
Current State Of Technology

Off-Road Energy Use by Sector and Equipment Type, 2019

- Agricultural
- Industrial
- Construction & Mining
- Lawn & Garden
- Recreational
- Commercial
- Other

- Forklifts 10.8%
- AC Refrigeration 2.6%
- Other 3.1%
- Oil Field Equipment 2.9%
- Terminal Tractors 1.2%
- Other 1.9%
- Tractors & Mowers 16.4%
- Tire Loaders 5.0%
- Dozers 4.6%
- Excavators 4.6%
- Off-Highway Trucks 4.4%
- Tractors Loaders Backhoes 3.1%
- Skid Steer Loaders 2.1%
- Generators 3.9%
- Compressors 1.5%
- Irrigation 0.3%
- ATV 0.9%
- Golf Carts 0.7%
- Motorcycle 0.3%
- Snowmobiles 1.8%
- Welders 1.2%
- Pumps 1.0%
- Other 1.2%
- Lawn Mowers 5.9%
- Leaf-blowers 1.0%
- Chipper 1.0%
- Turf Equipment 3.9%

Other 9.3%
Solutions from industry show range of technology solutions, reflective of use cases. Technology solutions not comprehensive of all use cases.
Thank you.

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