Bridging Low-Carbon Innovation Gaps

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Sources of Greenhouse Gas Emissions in 2016

US GHG Emissions



U.S. Mid Century Strategy



MCS Vision for a Low-Carbon U.S. Energy System in 2050

U.S. ENERGY CO_2 EMISSIONS IN 2005 AND 2050 IN THE MCS BENCHMARK SCENARIO BY SECTOR

> **2005** 5917 MMT

- **1.** Improving energy efficiency, including smart growth.
- 2. Near-complete decarbonization of electricity.
- 3. Switching to electricity and other low-carbon fuels in transportation, buildings, and industry.

2050 1537 MMT



- Commercial Buildings
- Residential Buildings
- Industry
- Transportation
- Electricity

The 4-legged stool driving transportation fuel use and emissions



- Low oil prices are a challenge
- Most historical progress in the U.S. has been through vehicle efficiency standards
- Other legs more difficult
- Three revolutions could be game changers: electrification, mobilityas-a-service, and automation

GHG Emissions could go either way with vehicle automation: from 60% reduction to tripling of LDV energy use by 2050



Total U.S. LDV Fuel Use (Billion Gallons per Year)

Figure ES-2. Estimated bounds on total U.S. LDV fuel use per year under the base (Conventional) and three CAV scenarios, based on the study's synthesis approach from CAV feature impact ranges reported in existing literature

Source: Joint study by NREL, ANL, and ORNL; http://www.nrel.gov/docs/fy17osti/67216.pdf

Airline hub system may not be optimal: 70-year shift to larger and longer-range aircraft decline in regional air service



96% of air traffic in 1% of airports



96% of regional trips on ground



1,000s of communities without high-speed links

Inflexible and capital-heavy alternatives, e.g., HSR

Source: ZUNUM Aero

Source: ZUNUM Aero

Electric propulsion delivers far reaching impact

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Close the regional transport gap

Rival highways and high-speed rail

Zero-emissions for regional travel

Erode the scale economics of aviation with service to thousands of airports.

Reduce travel time and fares w/ less infrastructure, more flexibility.

Path to address 50% of aviation emissions by 2030

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2050 is 32 years away

FIGURE 4.4: APPROXIMATE LIFETIME RANGES FOR VARIOUS CAPITAL STOCKS



Source: Lutz et al. 2011; Davis, Diegel, & Boundy 2015; EIA 2011; O'Connor 2004.

Key takeaways

- Bridging low-carbon innovation gaps is a challenge, but it's doable
- Transportation needs more attention
- Time is of the essence: We have to innovate faster
- There are no facts about the future
- Our emissions are up to us: policy, markets, innovation, & behavior

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Backup slides

Applied Hope

- Amory Lovins on whether he's an optimist or a pessimist:
- "I am neither because they are just two different forms of fatalism. The optimist says things have to get better, and the pessimist says things have to get worse."
- "I believe in applied hope. Things can get better, but you have to make them so."



Electricity Sector:

- Portfolio of decarbonizing electricity supply solutions
- Energy efficiency and grid modernization
- Innovation across the board



Electricity Capacity Additions: The pace of needed change is rapid by historical standards



Source: United States Mid Century Strategy for Deep Decarbonization, November 2016

Transportation Strategy, USMCS

- Continue to increase fuel efficiency standards at same pace
- Developing low-carbon transportation fuels and vehicles, including electric vehicles, fuel cell electric vehicles and biomass-fueled vehicles
- Reducing vehicle miles traveled through smart growth and other strategies



The combination of technology advances and additional policies can drive greater emission reductions than the sum of each approach on its own.





United States Mid-Century Strategy FOR DEEP DECARBONIZATION



http://unfccc.int/files/focus/longterm_strategies/application/pdf/us_mid _century_strategy.pdf

U.S. Energy Emissions



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Marked a 70-year shift to larger aircraft & longer ranges

Evolution of the U.S. regional fleet (seats)

