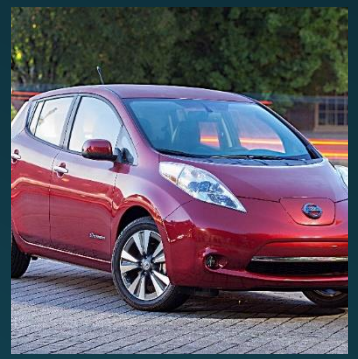
Clean Energy Transition

Repowering Mobility:
Envisioning a New Future for Transportation Energy

Eileen V. Quigley
Western Washington University
April 18, 2017

Agenda

- Decarbonizing Transportation
  - Freight
  - Aviation
  - Marine
  - Passenger Vehicles
- Transportation Pathways
  - Fuel Efficiency
  - Fuel Switching
  - Limit Vehicle Miles Traveled
- Lower Carbon Energy Sources
  - ✓ Electrification
  - ✓ Hydrogen/CNG/LNG
  - ✓ Biofuels
  - ✓ Autonomous Vehicles



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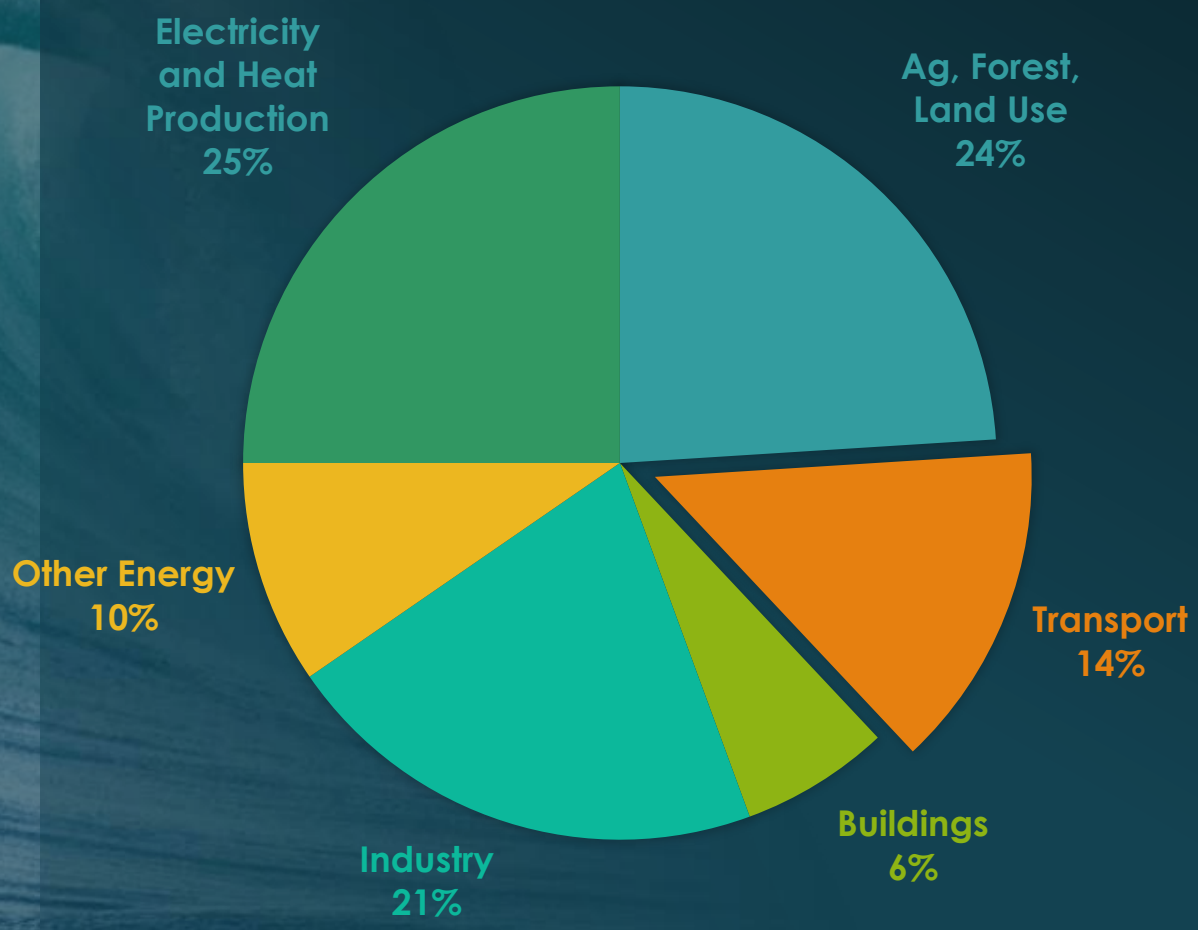
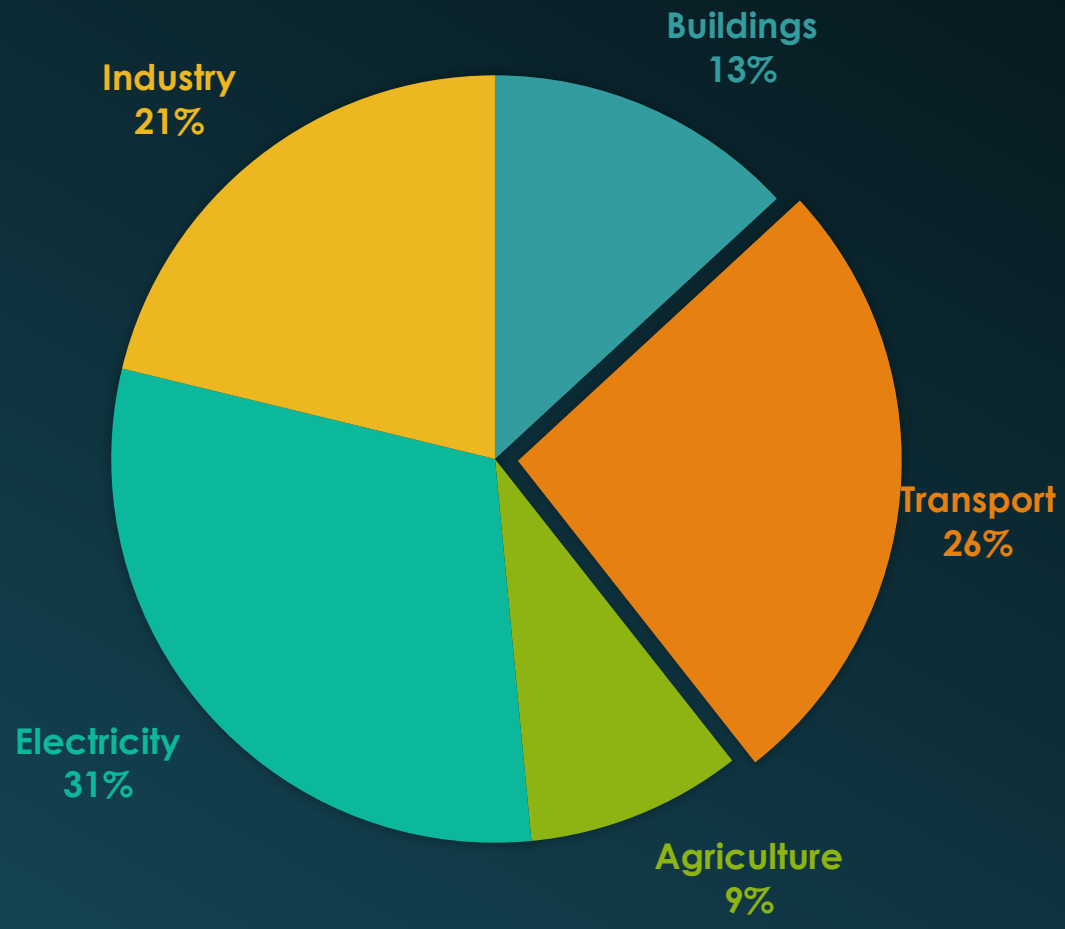
Global & U.S. GHG Emissions by Sector

Global (2010)



United States (2014)



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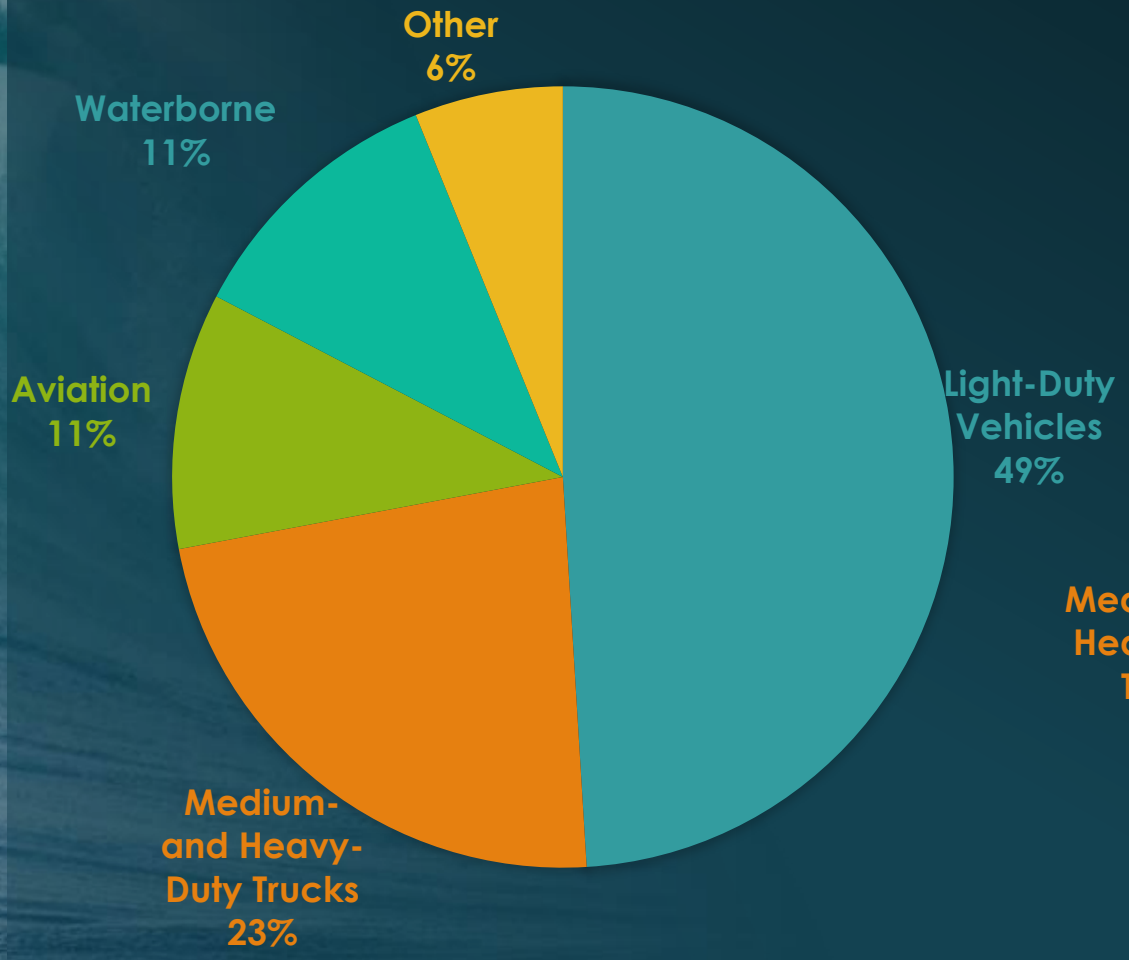
Global & U.S. Transportation Sector

Global (2010)



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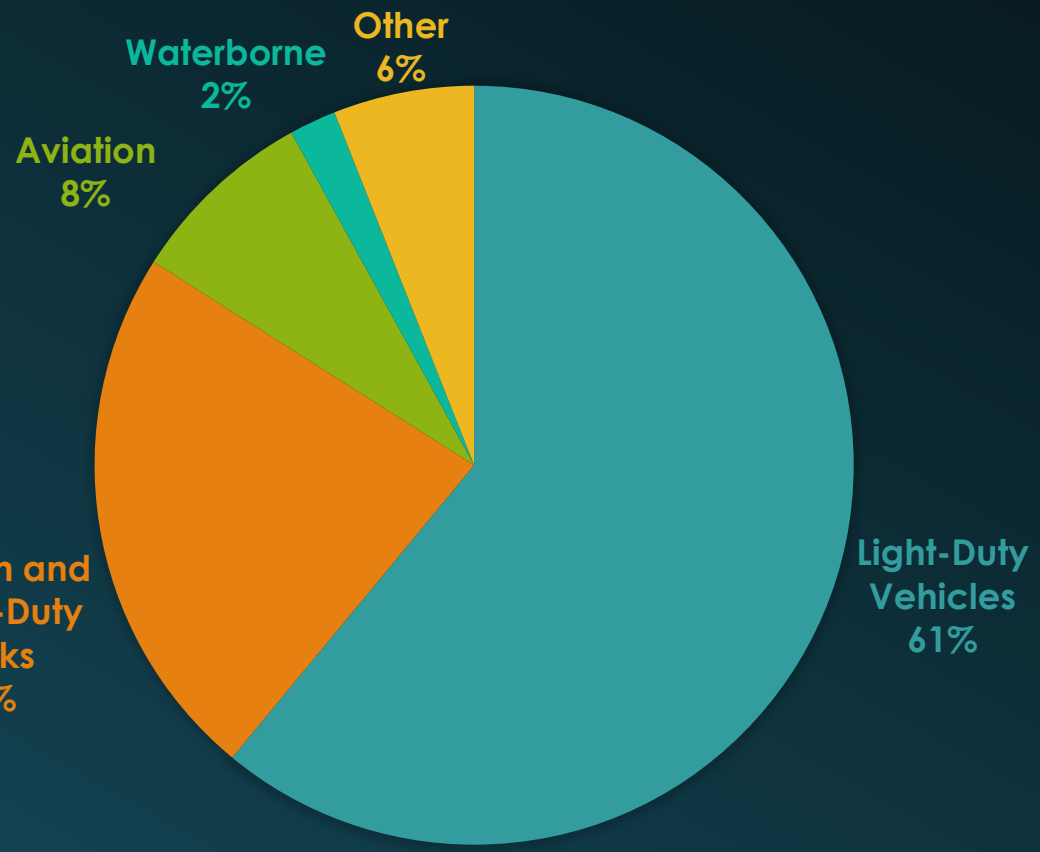

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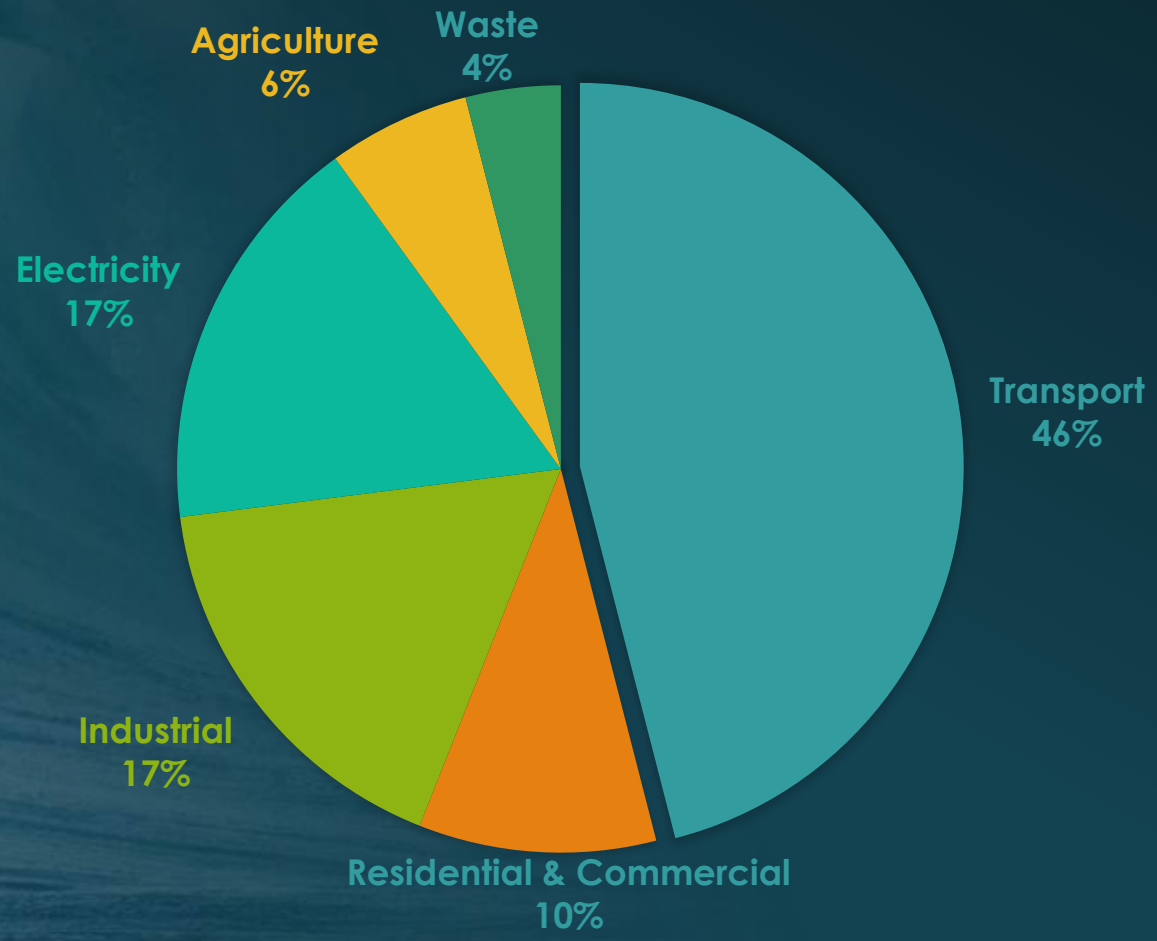
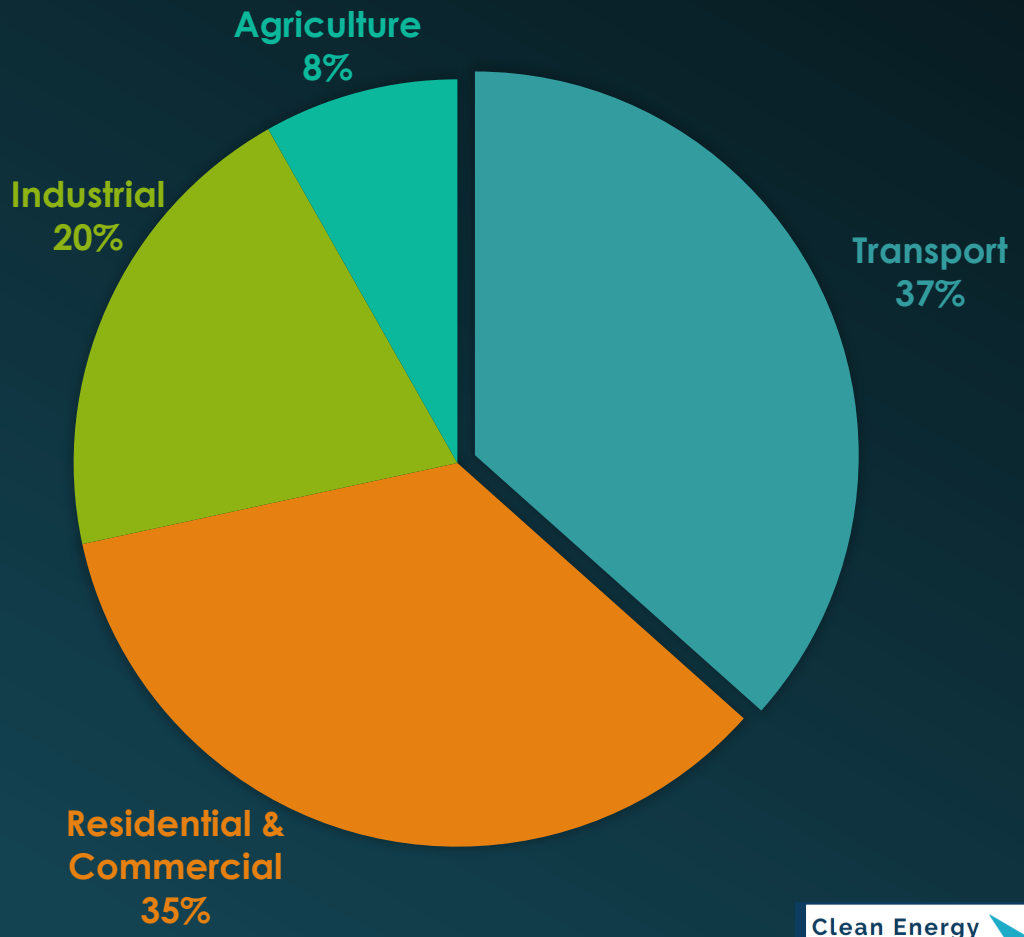
Washington & Oregon GHG Emissions by Sector

Washington(2011)



Oregon (2015)



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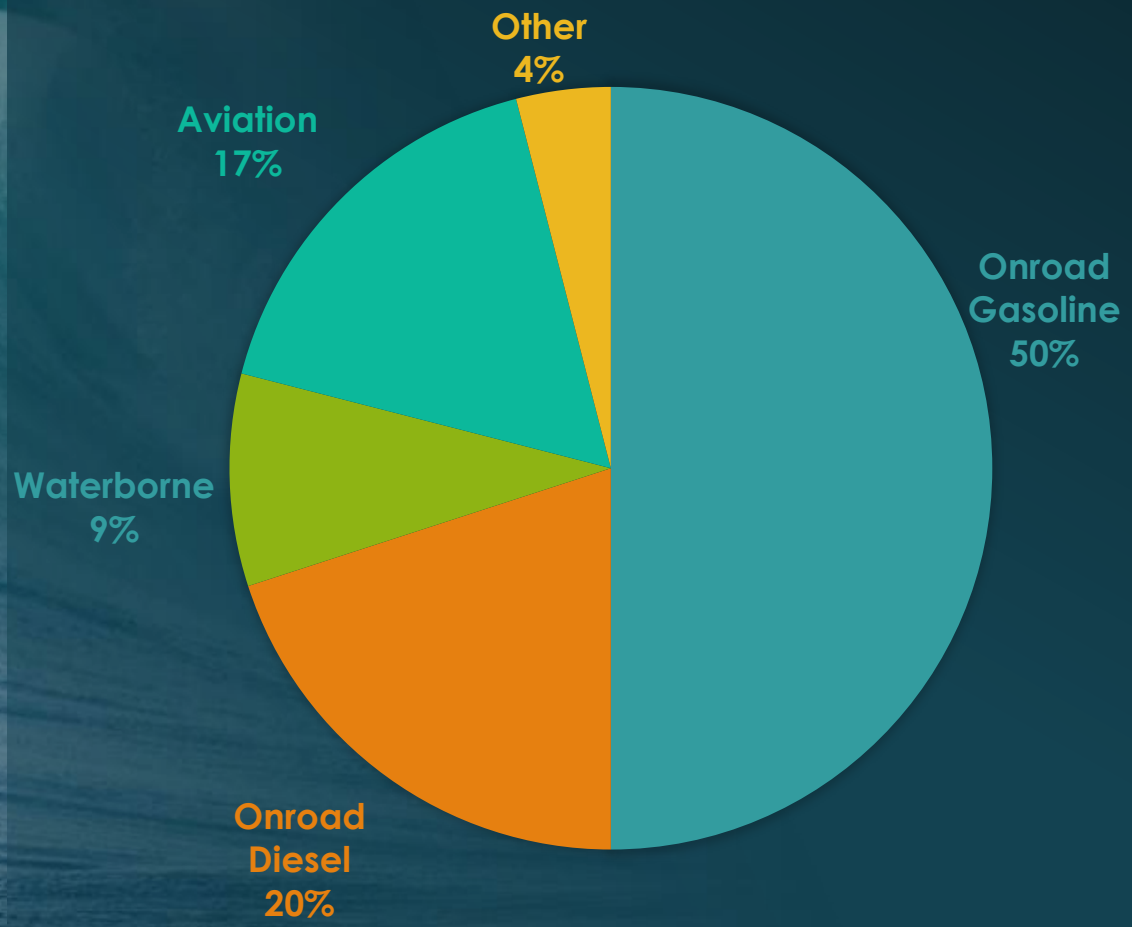
Washington & Oregon Transportation Sector

Washington(2011)



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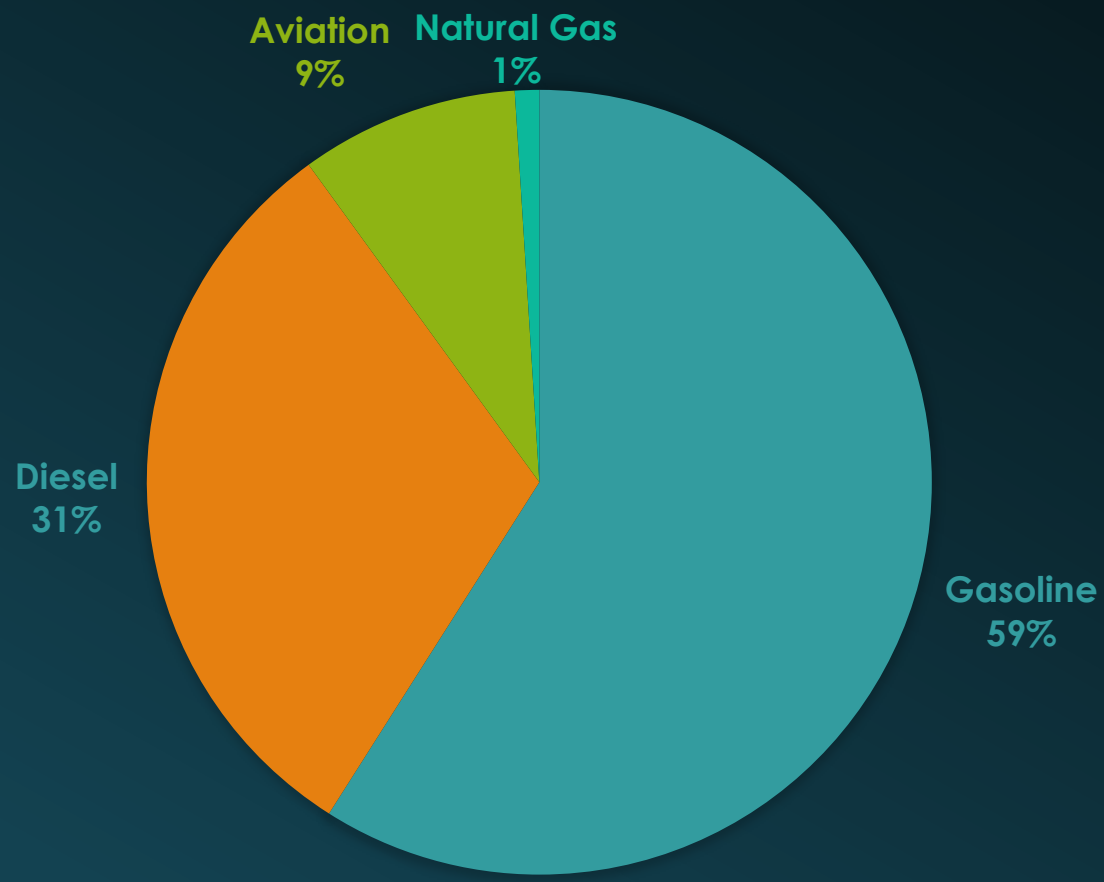

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Freight

- Trucks haul **70% of freight** in the U.S.
- Make up **5%** of vehicles, **23%** of transportation emissions
- **Fastest growing** emission source in transportation sector

Vehicle Efficiency
- CAFE standards

Fuel Switching
- Biofuel
- Battery electric
- Fuel cell

Limit VMT Increases
- Rail
- Marine

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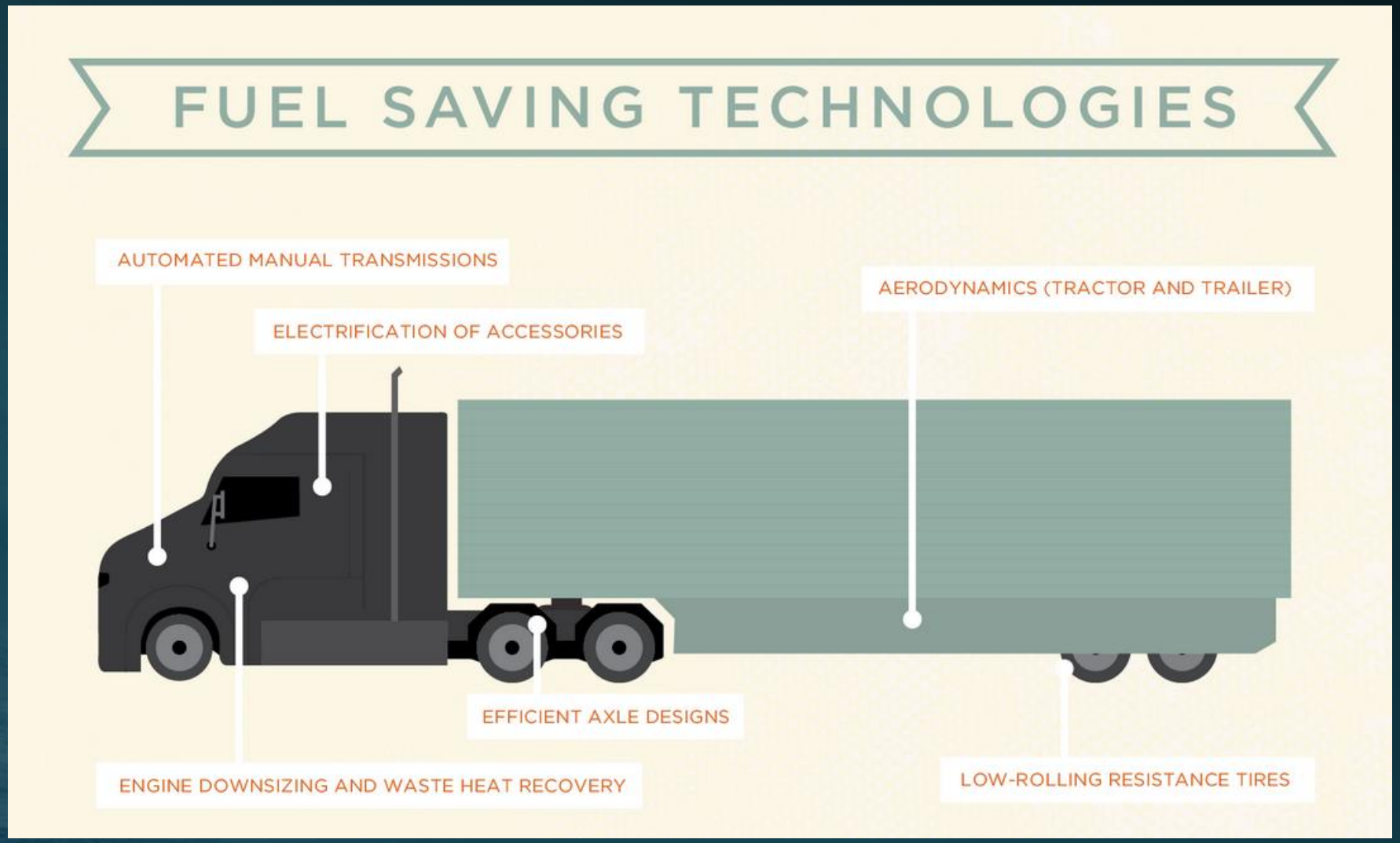
Vehicle Efficiency



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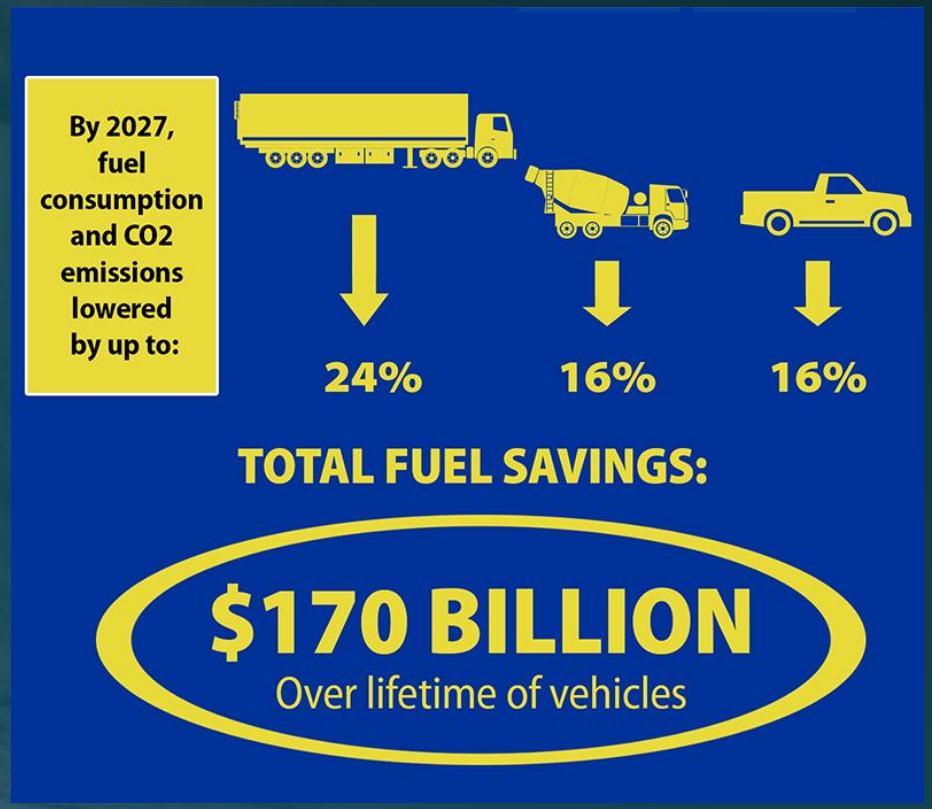
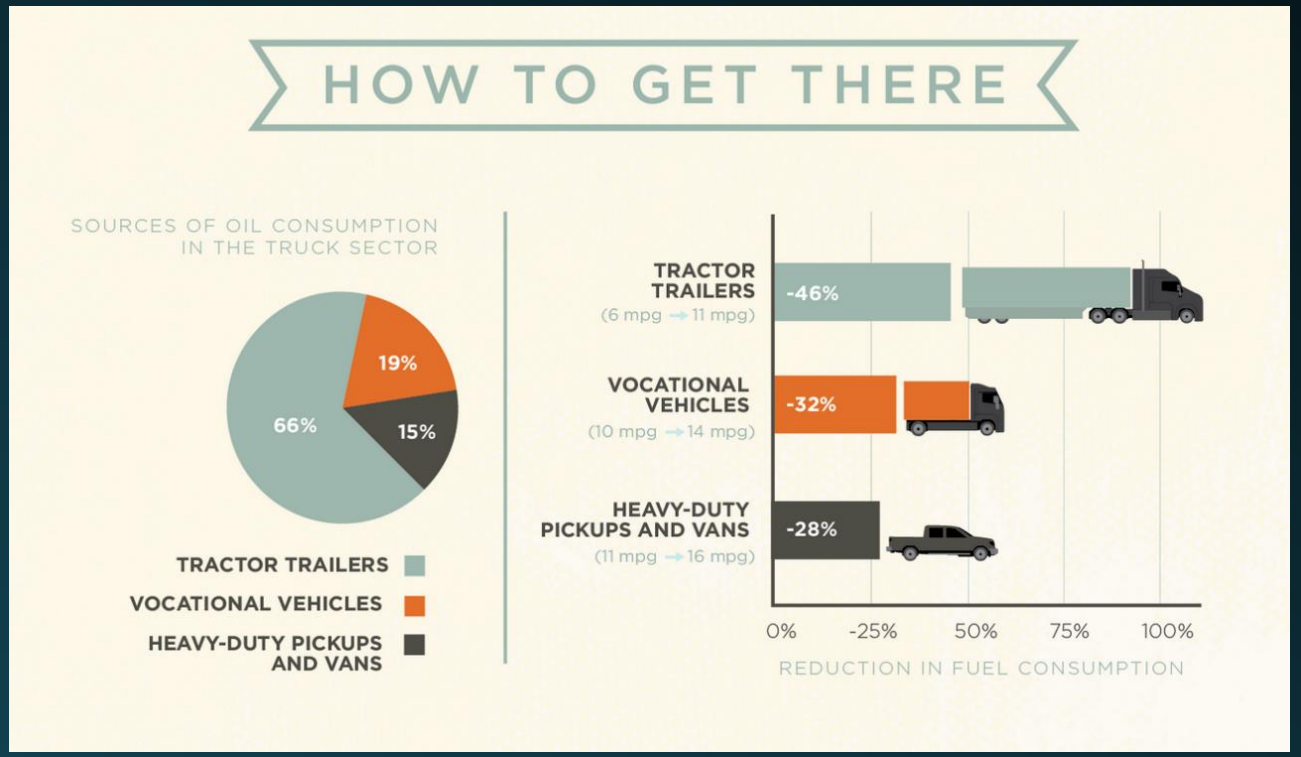
Freight Vehicle Efficiency





- CAFE standards approved for 2022-2027 models.
- Reductions necessary to decrease truck fuel consumption 40% by 2025.

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Freight Fuel Switching

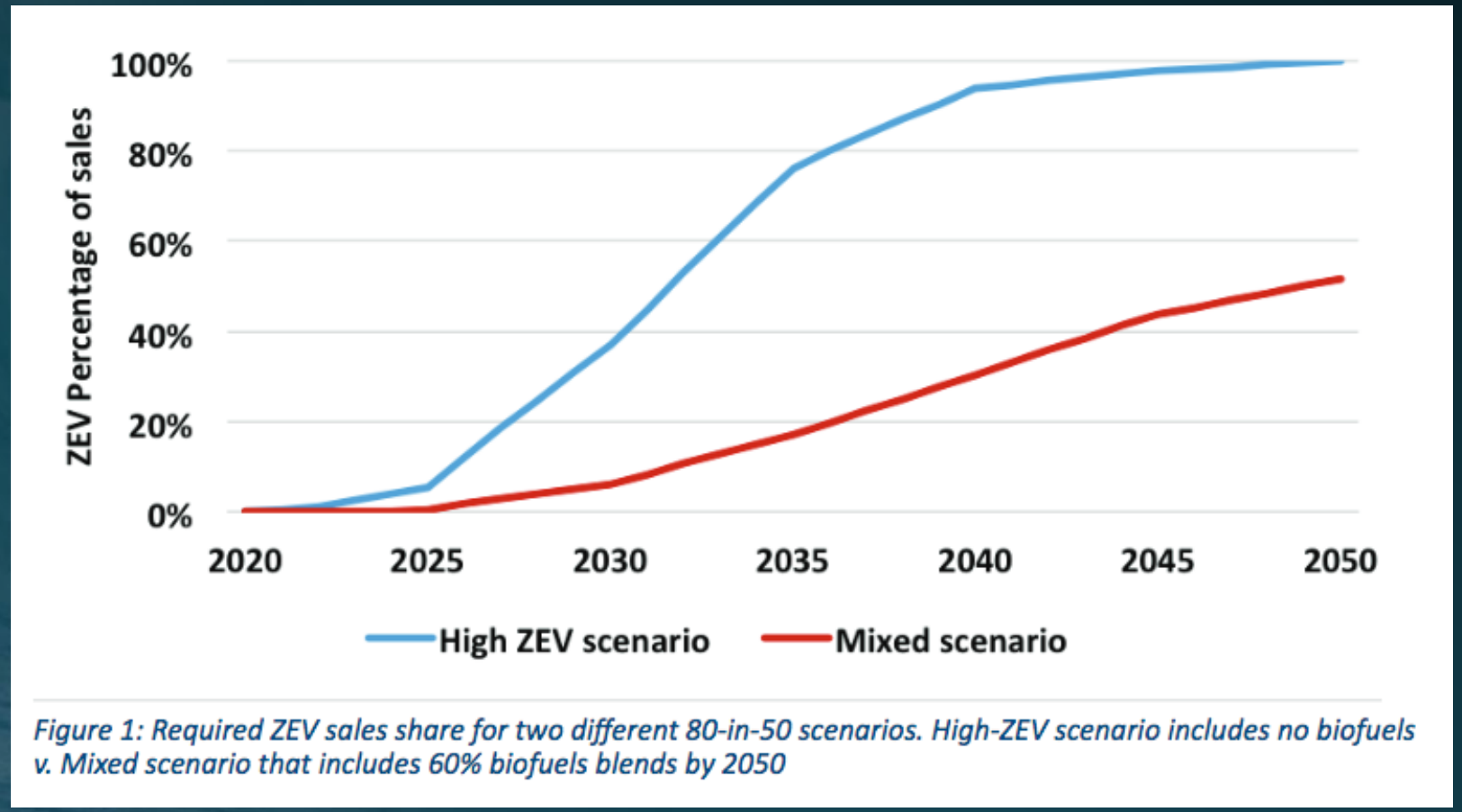

Figure 1: Required ZEV sales share for two different 80-in-50 scenarios. High-ZEV scenario includes no biofuels v. Mixed scenario that includes 60% biofuels blends by 2050

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Aviation

- Commercial aviation=2% of global GHG; projected to grow to 3-4.4% by 2050 without action
- Industry goal to reduce sector's emissions 50% by 2050
- June 2015 EPA finding under Clean Air Act

Aircraft Efficiency

- More efficient aircraft and engine design

Alternative Fuels

- Various biojet feedstock pathways

Air Traffic Management

- Streamlined flight operations

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Context for Action on Aviation Fuels

- **Cost** – Reliance on petroleum causes challenging price swings; biggest factor in airline costs
- **Conflict** – Key driver for developing home-grown sustainable fuel supplies for the military
- **Climate** – Reduce the aviation industry's carbon dioxide emissions

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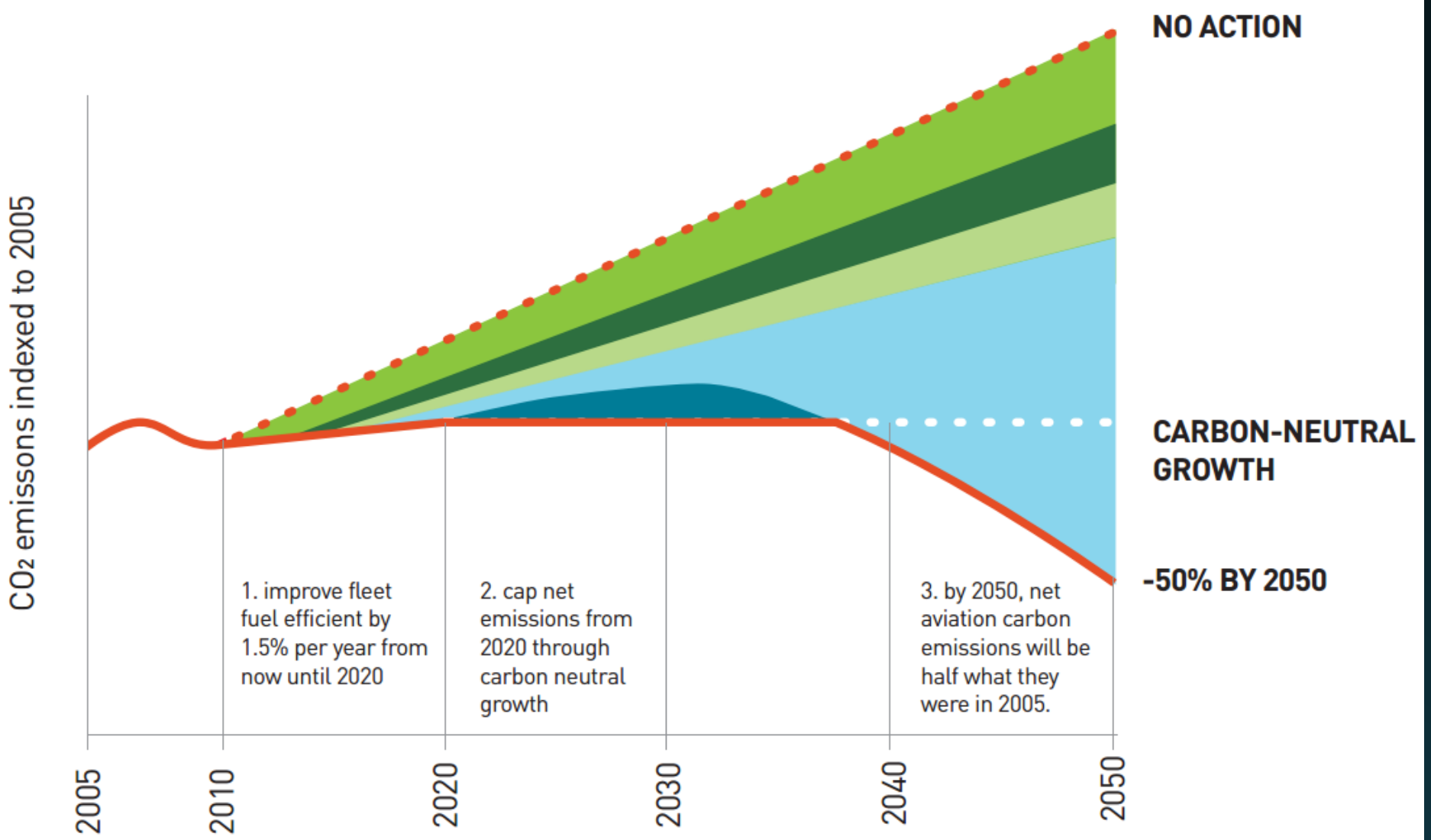

Known technology, operations and infrastructure measures

Biofuels and additional new-generation technologies

Economic measures

Net emissions trajectory

'No actions' trajectory

Feedstock → Conversion Process → Fuel Logistics → End Use

Oilseeds

Forest Slash

Solid Waste

Algae

ASTM-Certified:

Fischer-Tropsch
HEFA
DSHC

In development:

ATJ
Green Diesel
HDCJ
Others

Blending with fossil jet

Recertifying to ASTM standards

Transporting to airport

Delivering planeside

Pathway

Supply Chain

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Marine

- **57% of total global freight** is transported by ships, the **most efficient** method of cargo transport
- Business-as-usual forecasts project up to a **250% emission growth** by 2050
- **85% of emissions are international**, so industry must be regulated globally

Vehicle Efficiency

- Ship and engine optimization
- Smart shipping

Fuel Switching

- Natural gas
- Wind (sails)
- Electric

Increase Miles Travelled

- Short-sea shipping

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Marine-Ship and Propulsion Efficiency

IMO INTERNATIONAL MARITIME ORGANIZATION

Operational
Weather routing **1-4%**
Autopilot upgrade **1-3%**
Speed reduction **10-30%**

Auxiliary power
Efficient pumps, fans **0-1%**
High efficiency lighting **0-1%**
Solar panel **0-3%**

Aerodynamics
Air lubrication **5-15%**
Wind engine **3-12%**
Kite **2-10%**

Thrust efficiency
Propeller polishing **3-8%**
Propeller upgrade **1-3%**
Prop/rudder retrofit **2-6%**

Engine efficiency
Waste heat recovery **6-8%**
Engine controls **0-1%**
Engine common rail **0-1%**
Engine speed de-rating **10-30%**

Hydrodynamics
Hull cleaning **1-10%**
Hull coating **1-5%**
Water flow optimization **1-4%**

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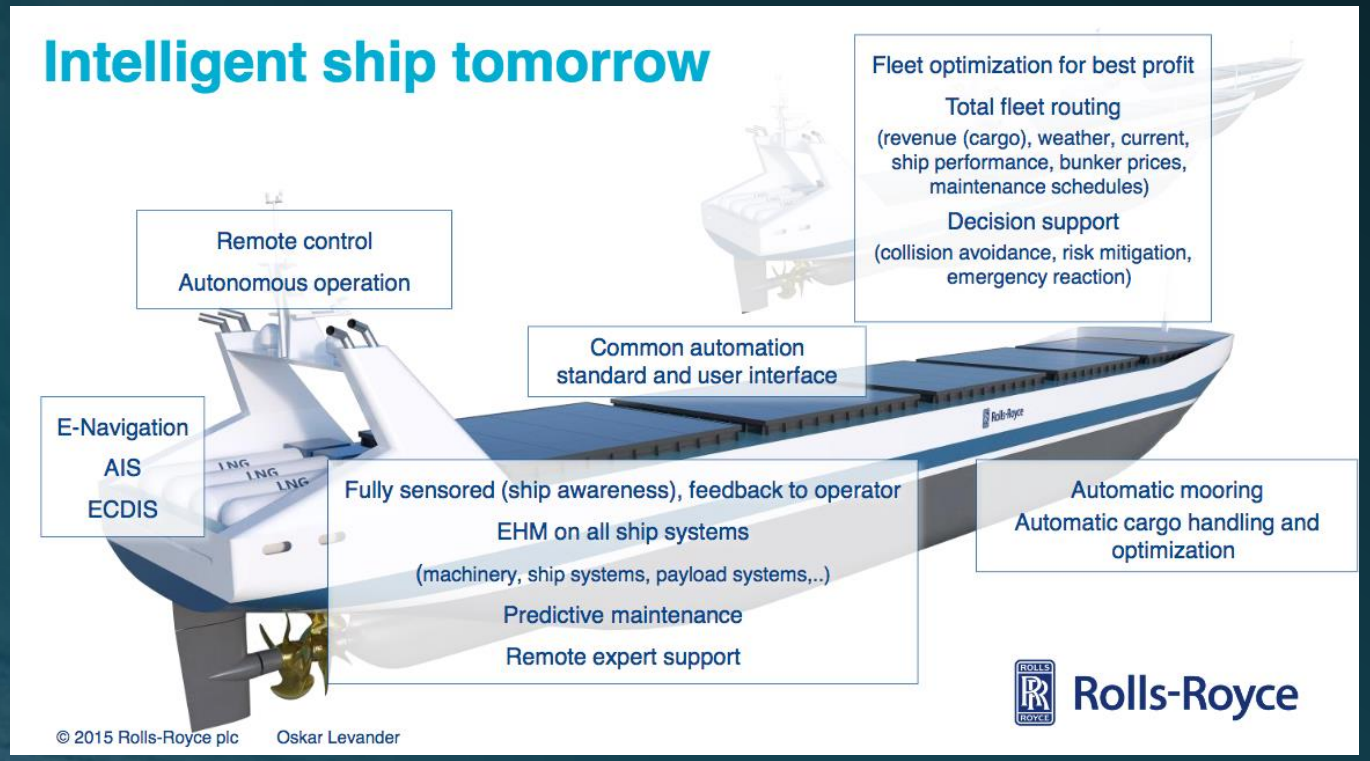
Marine Operations Efficiency



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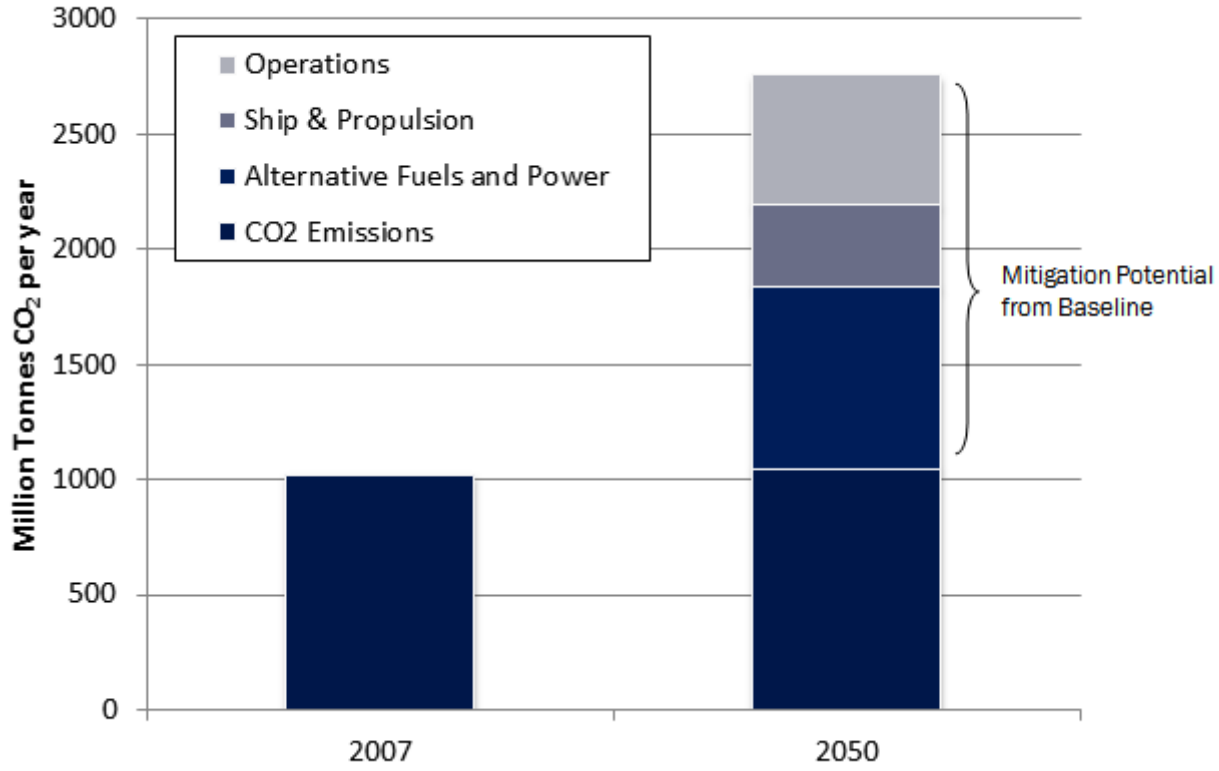
Marine Fuel Switching

Figure 3: Global GHG Mitigation Potential from the Marine Shipping Sector



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Passenger Vehicles

- Light duty vehicles account for **61% of transportation emissions** in the U.S.
- United States **EV sales increased 37%** in 2016 compared to 2015.
- **Autonomous vehicles** are an emerging opportunity and challenge

- Vehicle Efficiency
  - CAFE standards?
  - Electric motors
- Fuel Switching
  - Battery electric
  - Biofuels
  - Fuel cell
- Vehicle Miles Traveled
  - Smart growth
  - Multi-modal
  - Shared mobility
  - Transit

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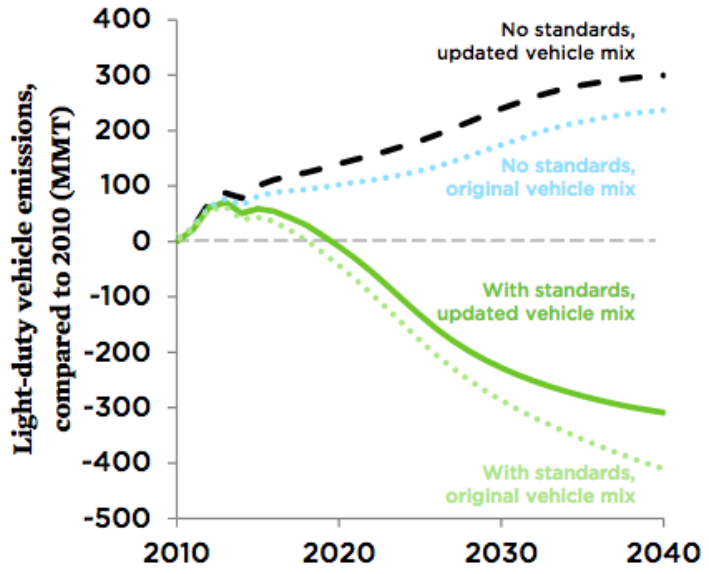
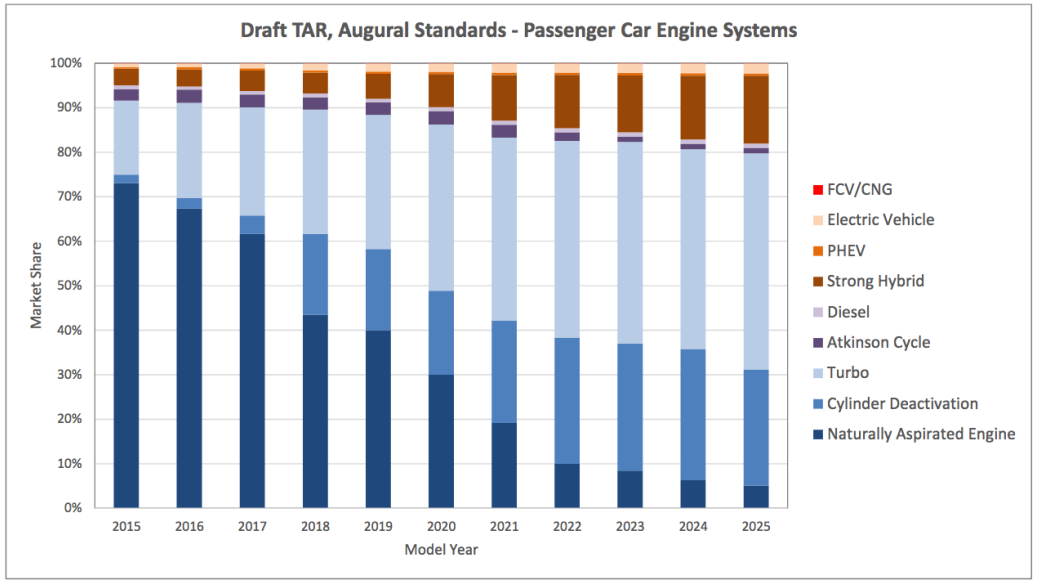
CAFE Standards

FIGURE 2. Global warming emissions reductions under light-duty vehicle standards, compared to 2010



Turbo engines, Hybrids, or Cylinder Deac. will be effective pathways for many cars



"**No other federal policy is delivering greater oil savings**, consumer benefits, and global warming emissions reductions than these two rounds of standards."

-Union of Concerned Scientists

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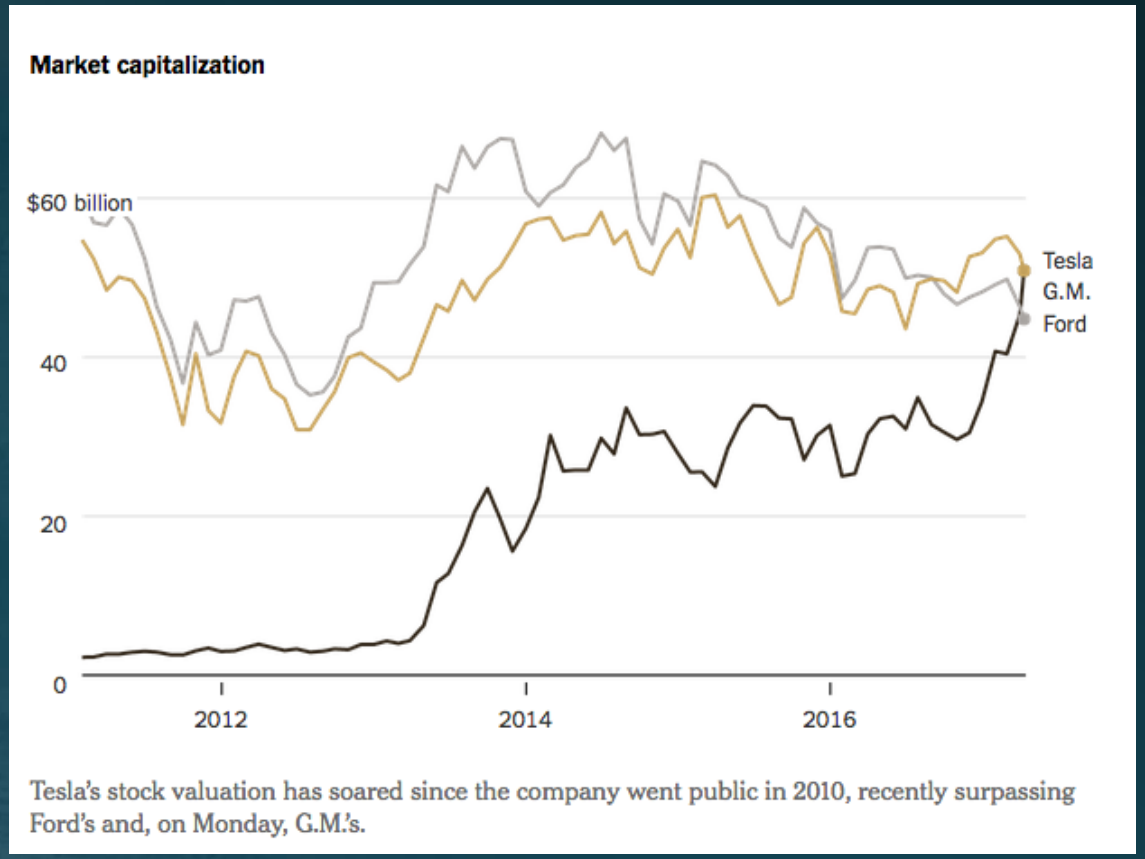
CAFE Standards?



Tesla's stock valuation has soared since the company went public in 2010, recently surpassing Ford's and, on Monday, G.M.'s.

"The Trump EPA will need to navigate a **minefield of legal and technical obstacles** if it tries to withdraw or weaken the standards, and missteps will bring near-certain defeat in the courts."

-Bob Sussman, Senior Policy Counsel to EPA Administrator 2009-2013

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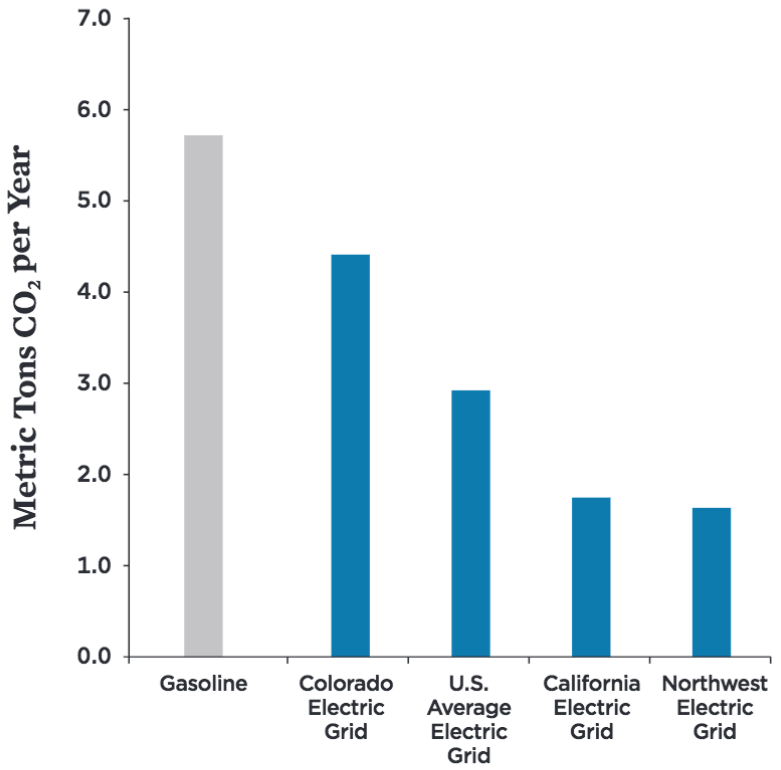
Fuel Switching: Electricity

FIGURE 19. Electricity Is Cleaner than Gasoline



Cars that run on gasoline put out more emissions than even electric cars charged in areas where coal is the biggest source of electricity. When electricity is created from cleaner sources, emissions are reduced further.

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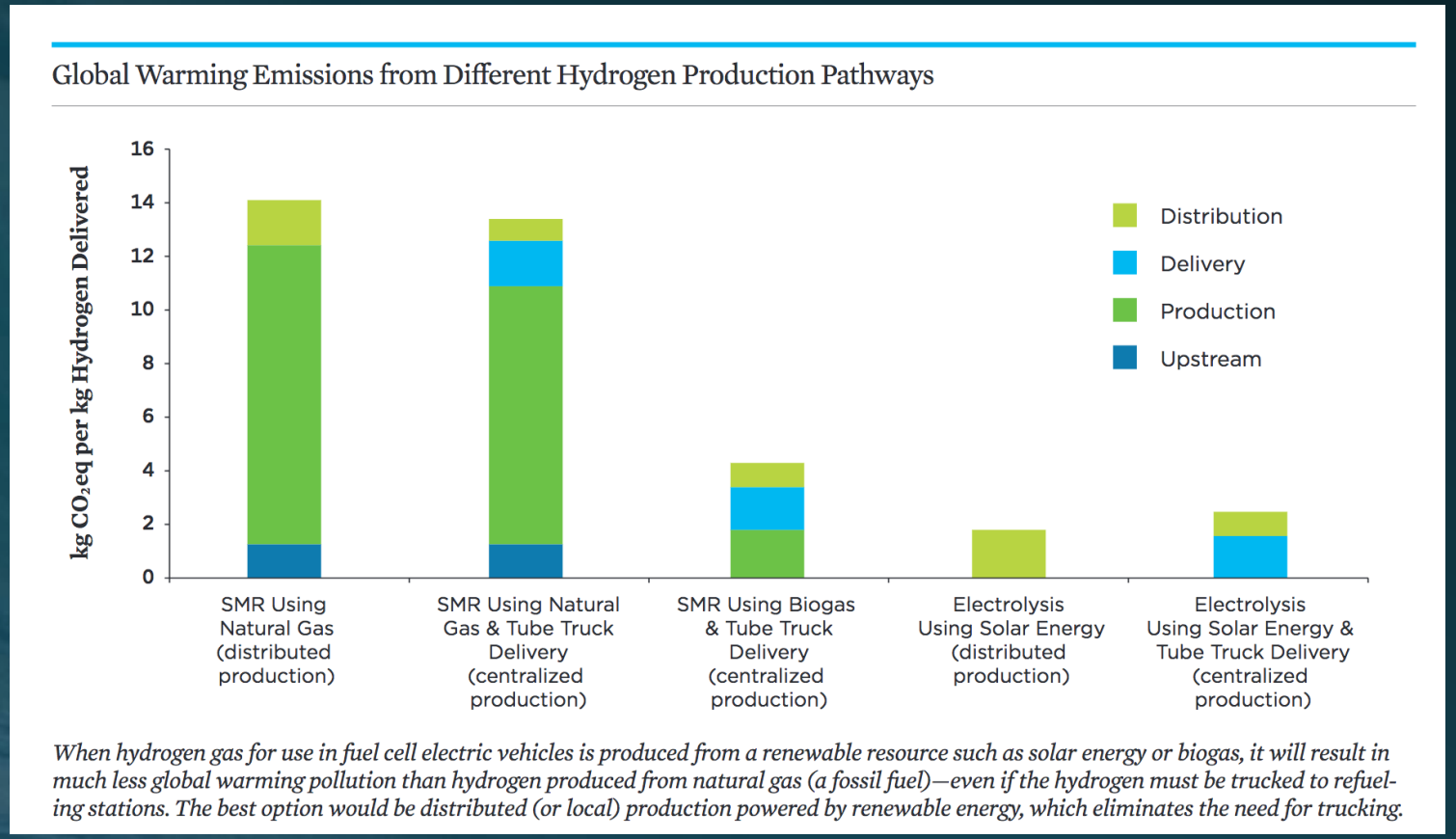
Fuel Switching: Hydrogen



When hydrogen gas for use in fuel cell electric vehicles is produced from a renewable resource such as solar energy or biogas, it will result in much less global warming pollution than hydrogen produced from natural gas (a fossil fuel)—even if the hydrogen must be trucked to refueling stations. The best option would be distributed (or local) production powered by renewable energy, which eliminates the need for trucking.

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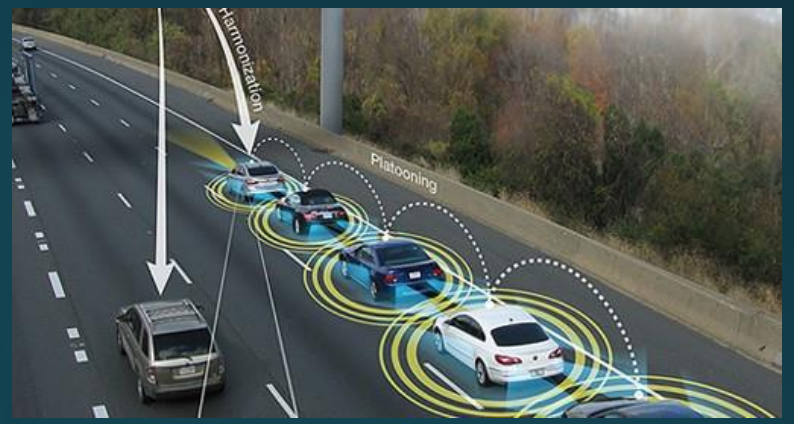
Autonomous Vehicles



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Autonomous Vehicles

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Transitioning from Fossil Fuel to Clean Energy

www.cleanenergytransition.net

Thank you!

Eileen V. Quigley, Director
eileen@cleanenergytransition.net
Jamie Daudon, Research Analyst
jamie@thecaspiangroup.com