Low-Carbon Pathways
Transportation

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Agenda

- Transport Sector
  ✓ Brief overview freight, aviation, marine
  ✓ Focus on passenger vehicles

- Low-Carbon Pathways
  ✓ Fuel Efficiency
  ✓ Fuel Switching
  ✓ Limit Vehicle Miles Traveled

- Lower Carbon Energy Sources
  ✓ Electrification
  ✓ Hydrogen/CNG/LNG
  ✓ Biofuels
Global & U.S. GHG Emissions by Sector

Global (2010)

- Electricity and Heat Production: 25%
- Industry: 21%
- Transport: 14%
- Other Energy: 10%
- Buildings: 6%
- Ag, Forest, Land Use: 24%

United States (2014)

- Buildings: 13%
- Agriculture: 9%
- Transport: 26%
- Industry: 21%
- Electricity: 31%

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- Electricity: 31%
Global & U.S. Transportation Sector

Global (2010)
- Aviation: 11%
- Medium- and Heavy-Duty Trucks: 23%
- Waterborne: 11%
- Other: 6%
- Light-Duty Vehicles: 49%

United States (2014)
- Aviation: 8%
- Medium and Heavy-Duty Trucks: 23%
- Waterborne: 2%
- Other: 6%
- Light-Duty Vehicles: 61%
Washington GHG Emissions by Sector & Transport Breakdown (2011)

- Electricity: 17%
- Industrial: 17%
- Residential & Commercial: 10%
- Agriculture: 6%
- Waste: 4%
- Other: 4%

Transport: 46%
- Onroad: 50%
- Offroad Diesel: 20%
- Waterborne: 9%
- Aviation: 17%
- Other: 4%
Low Carbon Solution Pathways

1. Increase **Vehicle Efficiency** to reduce energy consumed

2. Drive **Fuel Switching** to electricity, hydrogen, biofuels, biojet, and lower carbon fossil fuels

3. Reduce **Vehicle Miles Travelled** (VMT) land use, multi-modal transportation, and transit and other shifts in trucking, rail, & shipping
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

FuelSwitching
- Biofuel
- Battery electric
- Fuel cell

Limit VMT
- Rail
- Marine
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

- More efficient aircraft and engine design
- Various biojet feedstock pathways
- Streamlined flight operations
Marine

- 57% of total global freight is transported by ships, the most efficient method of cargo transport
- 11% of total global transportation GHG emissions and petroleum consumption is marine shipping (5m barrels a day)
- 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
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.
“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
Importance of CAFE to Shoreline’s Goal
25% Cleaner Fuels & Vehicle Technologies

[Graph showing the importance of different policies to greenhouse gas emissions reduction.]
CAFE Standards?

“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
Fuel Switching

A typical car produces 6.7 metric tons of global warming pollution each year, once emissions from oil extraction and refining are added to tailpipe emissions. Biofuels and electricity are cleaner, and have the potential for dramatic improvements in the future.
Fuel Switching: Biofuels
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.
Hydrogen Fueling Network in California

Figure ES1: California’s Currently Open Hydrogen Fueling Network
Fuel Switching: Electricity

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.
Electric vehicle outlook to 2040

Annual global light duty vehicle sales

Global light duty vehicle fleet

Source: Bloomberg New Energy Finance EVO 2017
Figure 3: Annual global EV sales by market

Figure 4: Annual global EV sales by vehicle class

Source: Bloomberg New Energy Finance. For a detailed description of the ‘intelligent mobility’ segment, see the methodology.
Impact of Electric Vehicles on Oil

Growing Expectations
OPEC's electric vehicle forecast grew by almost 500% last year

Source: Bloomberg New Energy Finance
Battery Electric Vehicle Model Availability

**BEV model availability, 2008-20**

- **SUVs/Trucks**
  - Land Rover Defender
  - Toyota RAV4
  - Audi Q5
  - M-B B-Class
  - BYD e6
  - BMW X5
  - Tesla Model S
  - VW Atlas
  - Audi e-tron
  - Mercedes-Benz E Class
  - BMW 5 Series

- **Sports cars**
  - McLaren 570S
  - Porsche 911
  - Tesla Roadster
  - Lamborghini Huracan
  - Audi R8

- **Sedans**
  - Hyundai Ioniq
  - Honda Clarity
  - Kia Rio
  - Geely Emgrand
  - Tesla Model 3
  - Mercedes-Benz E Class
  - Audi A6
  - BMW 3 Series

- **Hatchbacks**
  - BMW i3
  - VW e-Golf
  - Kia Rio
  - Hyundai i20
  - Ford Focus
  - Nissan Leaf
  - Tesla Model X
  - Smart Fortwo

- **Runabouts**
  - Smart Fortwo
  - BMW i3
  - Ford Transit
  - Mercedes-Benz Sprinter
  - Nissan NV200
  - Toyota Prius
  - Tesla Model S
  - BYD e6
  - Renault Kangoo

- **Small vans**
  - Ford Transit
  - Nissan NV200
  - Peugeot Partner
  - M-B Vito

**2020**

Source: Bloomberg New Energy Finance, Images various.

Notes: Not exhaustive. (*) Range is estimate.
2017 Electric Car Models

- **EMVC SOLO** $15,500, 16 kWh battery, 100 miles (EPA), 150 MPGe, kW motor
- **Mitsubishi i-MiEV** $23,845, 16 kWh battery, 59 miles (EPA), 112 MPGe, 49 kW motor
- **Ford Focus Electric** $29,995, 33.5 kWh battery, 115 miles (EPA), 107 MPGe, 107 kW motor
- **Nissan Leaf** $31,545, 30 kWh battery, 107 miles (EPA), 112 MPGe, 80 kW motor
- **Fiat 500e** $32,780, 24 kWh battery, 84 miles (EPA), 112 MPGe, 83 kW motor
- **Kia Soul EV** $32,800, 27 kWh battery, 93 miles (EPA), 105 MPGe, 81 kW motor
- **Chevrolet Bolt EV** $37,495, 60 kWh battery, 238 miles (EPA), 119 MPGe, 150 kW motor
- **Mercedes-Benz B250e** $40,825, 28 kWh battery, 87 miles (EPA), 84 MPGe, 132 kW motor
- **BMW i3** $43,395, 22-33 kWh battery, 81-114 miles, 118-124 MPGe, 125 kW motor
- **Tesla Model S** $69,200-$135,700, 60-100 kWh battery, 210-315 miles (EPA), 98-104 MPGe, 234-396 kW motor
Brown’s EV target for California

- 5 million EVs by 2030
- $2.5B in next 8 years
- 250,000 charging
- 200 hydrogen fueling
Electric Bus Market
Autonomous Vehicles

Figure 1: Autonomous Vehicle Sales, Fleet and Travel Projections (Based on Table 6)
Promise Safety; Free Up Parking, Roads
AVs Free Up Time for Other Pursuits
Cause Traffic and More Driving
AVs and Sociolinguistic Cues
Public Wariness

- More than ½ worried
- Only 15% prefer AVs
- Fear of crashes
- Love to drive
Summary

- Less mobile all renewable future
- Transport electrification burden solar and wind
- Challenge of replacing oil
- Challenge of expanding population
Thank you

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Transitioning from Fossil Fuel to Clean Energy

www.cleanenergytransition.net