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<th><strong>Docket Number:</strong></th>
<th>20-IEPR-02</th>
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<td><strong>Project Title:</strong></td>
<td>Transportation</td>
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<tr>
<td><strong>TN #:</strong></td>
<td>234045</td>
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<tr>
<td><strong>Document Title:</strong></td>
<td>Presentation - Perspectives on Low Carbon Fuels In a Clean Transportation Future</td>
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<tr>
<td><strong>Description:</strong></td>
<td>S1 1. Jeremy Martin, Union of Concerned Scientists</td>
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<td><strong>Filer:</strong></td>
<td>Raquel Kravitz</td>
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<td><strong>Organization:</strong></td>
<td>Union of Concerned Scientists</td>
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<td><strong>Submitter Role:</strong></td>
<td>Public</td>
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<tr>
<td><strong>Submission Date:</strong></td>
<td>7/28/2020 4:06:54 PM</td>
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<td><strong>Docketed Date:</strong></td>
<td>7/28/2020</td>
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Perspectives on Low Carbon Fuels
In a Clean Transportation Future
Clean transportation means using less oil, more renewable electricity, and being smarter about how we produce and use biofuels.

Jeremy Martin, Ph.D.
jmartin@ucsusa.org
U.S. transportation energy consumption
EIA April 2018 Monthly Energy Review

≥95% Petroleum 1958-2007
Biofuels accounted for 1% of transportation energy in 2004 and 5% since 2017.
Deep Decarbonization in a High Renewables Future
Updated Results from the California PATHWAYS Model
Greenhouse gas emissions in 2050 are 86 MMT CO2e, inclusive of non-combustion GHG emissions.

Source: E3
Figure 7: Final Energy Demand by Fuel Type in the High Electrification Scenario

Source: E3
Vehicle Sales

[Graph showing vehicle sales projections for Light Duty, Medium Duty, and Heavy Duty vehicles, with categories including Gasoline, Hybrid Diesel, BEV, PHEV, Diesel, Hydrogen, and CNG.]
The Overton Window on low carbon transportation

- Unthinkable
- Radical
- Acceptable
- Sensible
- Popular
- Policy
- Popular
- Sensible
- Acceptable
- Radical
- Unthinkable

- Power to Liquid Fuels
- Direct Air Capture
- Hydrogen Fuel Cell Vehicles
- Cellulosic Biofuels
- Biofuels with CCS
- Battery Electric Trucks
- Battery Electric Cars
- Biomethane
- Conventional Biofuels
- CNG Vehicles
- Gasoline
- Diesel
- Gas to Liquids
- Coal to Liquids
EXECUTIVE ORDER B-55-18 TO ACHIEVE CARBON NEUTRALITY

IT IS HEREBY ORDERED THAT:

1. A new statewide goal is established to achieve carbon neutrality as soon as possible, and no later than 2045, and achieve and maintain net negative emissions thereafter. This goal is in addition to the existing statewide targets of reducing greenhouse gas emissions.
California Advanced Clean Truck Rule

Zero Emissions mandates for 2035
- 55% Class 2b-3
- 75% Class 4-8
- 40% Class 7-8

Begin work on transition of California’s truck fleet to 100 percent zero-emission vehicles by 2045
Clean Energy Standard to achieve net-zero emissions in the electricity sector by 2040

National sales standard to achieve 100% sales of zero-emission cars by 2035 and heavy-duty trucks by 2040

At the same time, Congress should establish a **Low Carbon Fuel Standard** to reduce emissions from remaining gasoline-powered vehicles and transportation modes for which electrification may not be an option in the short to medium term, such as aviation, long-haul trucking, and shipping.
Cut oil use in half by 2040 and in half again by 2050

- Roughly 75 percent (±10) of current transportation energy can be replaced with renewable power and hydrogen by mid-century
- 25 percent of remaining transportation energy demand must be replaced with low carbon fuels
  - ~5 times more than current biofuel use
## Inputs and Outputs

### Feedstocks
- Commodity Ag products
  - Grain
  - Vegetable oil
  - Second use oils and fats
- Waste Methane
  - Manure
  - Wastewater treatment
  - Landfill gas
- Biomass
  - Energy crops
  - Forest biomass
  - MSW & wastes
  - Ag residues

### Final Products
- Ethanol
- Bio-based Diesel
  - Biodiesel
  - Renewable Diesel
  - Sustainable Aviation Fuel
- Biomethane
- Zero carbon fuels
  - Hydrogen
  - Electricity
- Carbon removal
Inputs and Outputs

Feedstocks

• Commodity Ag products
  • Grain

Final Products

• Ethanol
Corn Acres Planted USDA NASS Data

Millions of Acres

- corn
- corn 5 yr avg
Getting more climate benefits from the same amount of ethanol

- More efficient ethanol production
- Carbon capture and sequestration
- Better farming practices
- Use in high octane fuel blends
Inputs and Outputs

Feedstocks

• Commodity Ag products
  • Grain
  • Vegetable oil
  • Second use oils and fats

Final Products

• Bio-based Diesel
  • Biodiesel
  • Renewable Diesel
  • Sustainable Aviation Fuel
Feedstocks for Biodiesel, Renewable Diesel

**US Biodiesel Feedstocks** (2019 DOE Data)

- Soybean oil: 57%
- Corn oil: 14%
- Canola oil: 10%
- Yellow grease: 11%
- Animal fats: 8%

**Share of US Soybean Oil Production for Biodiesel**

- **USDA Data**
  - Annual 5 year Average
90% of California bio-based diesel is made from imported feedstocks.
Inputs and Outputs

Feedstocks

• Commodity Ag products
  • Grain
  • Vegetable oil
  • Second use oils and fats

Final Products

• Bio-based Diesel
  • Biodiesel
  • Renewable Diesel
  • Sustainable Aviation Fuel
Inputs and Outputs

Feedstocks
- Commodity Ag products
  - Grain
  - Vegetable oil
  - Second use oils and fats

Final Products
- Ethanol
- Bio-based Diesel
  - Biodiesel
  - Renewable Diesel
  - Sustainable Aviation Fuel
- Carbon removal
Inputs and Outputs

Feedstocks
• Commodity Ag products
  • Grain
  • Vegetable oil
  • Second use oils and fats

Final Products
• Ethanol
• Bio-based Diesel
  • Biodiesel
  • Renewable Diesel
  • Sustainable Aviation Fuel
• Carbon removal
Inputs and Outputs

Feedstocks

• Waste Methane
  • Manure
  • Wastewater treatment
  • Landfill gas

Final Products

• Biomethane
The Promises and Limits of Biomethane as a Transportation Fuel

Waste biomethane potential is very limited
The Promises and Limits of Biomethane as a Transportation Fuel

- Little natural gas is used as transportation fuel, industrial applications are harder to decarbonize.
Cow poop could fuel California’s clean energy future. But not everyone’s on board

- Avoid agricultural methane emissions while displacing fossil gas
- Sustainable food systems require more than methane mitigation
- Protect clean air and water
Inputs and Outputs

Feedstocks

• Waste Methane
  • Manure
  • Wastewater treatment
  • Landfill gas

• Biomass
  • Energy crops
  • Forest biomass
  • MSW & wastes
  • Ag residues

Final Products

• Biomethane
Inputs and Outputs

Feedstocks

• Waste Methane
  • Manure
  • Wastewater treatment
  • Landfill gas

Final Products

• Biomethane
• Zero carbon fuels
  • hydrogen
  • electricity
• Carbon removal
Inputs and Outputs

Feedstocks
- Biomass
  - Forest biomass
  - MSW & wastes

Final Products
- Electricity
GETTING TO NEUTRAL
OPTIONS FOR NEGATIVE CARBON EMISSIONS IN CALIFORNIA

January 2020

Figure ES-1. Goals of California’s emissions plan extrapolated to 2045 (CARB, 2017) with negative emissions estimates from this report.

www.gs.llnl.gov/content/assets/docs/energy/Getting_to_Neutral.pdf
Using biomass for hydrogen plus carbon removal offers the maximum climate benefit.
Inputs and Outputs

Feedstocks

- Biomass
  - Energy crops
  - Forest biomass
  - MSW & wastes
  - Ag residues

Final Products

- Ethanol
- Bio-based hydrocarbons
  - Renewable Diesel
  - Sustainable Aviation Fuel
- Biomethane
- Zero carbon fuels
  - Hydrogen
  - Electricity
- Carbon removal
Inputs and Outputs

Feedstocks

- Commodity Ag products
  - Grain
  - Vegetable oil
  - Second use oils and fats
- Waste Methane
  - Manure
  - Wastewater treatment
  - Landfill gas
- Biomass
  - Energy crops
  - Forest biomass
  - MSW & wastes
  - Ag residues

Final Products

- Ethanol
- Bio-based Diesel
  - Biodiesel
  - Renewable Diesel
  - Sustainable Aviation Fuel
- Biomethane
- Zero carbon fuels
  - Hydrogen
  - Electricity
- Carbon removal
Renewable power is the primary strategy for clean transportation, but low carbon fuels have an important role to play.

Low carbon fuels should:
- Steadily reduce carbon intensity
- Target hard to decarbonize applications
- Support carbon removal
- Support sustainable agriculture and forests

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