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Docketed Date:	7/28/2020

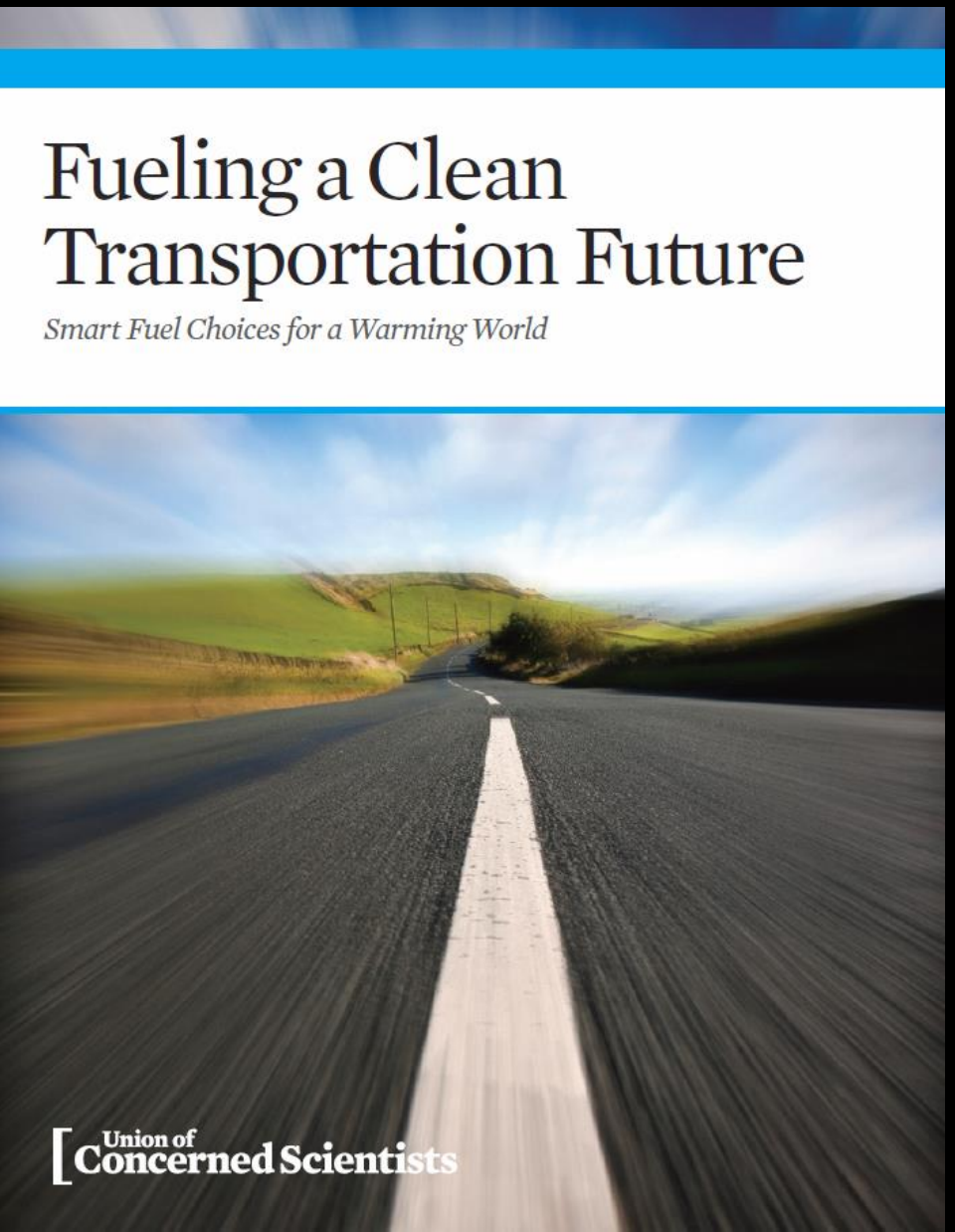
Perspectives on Low Carbon Fuels

In a Clean Transportation Future

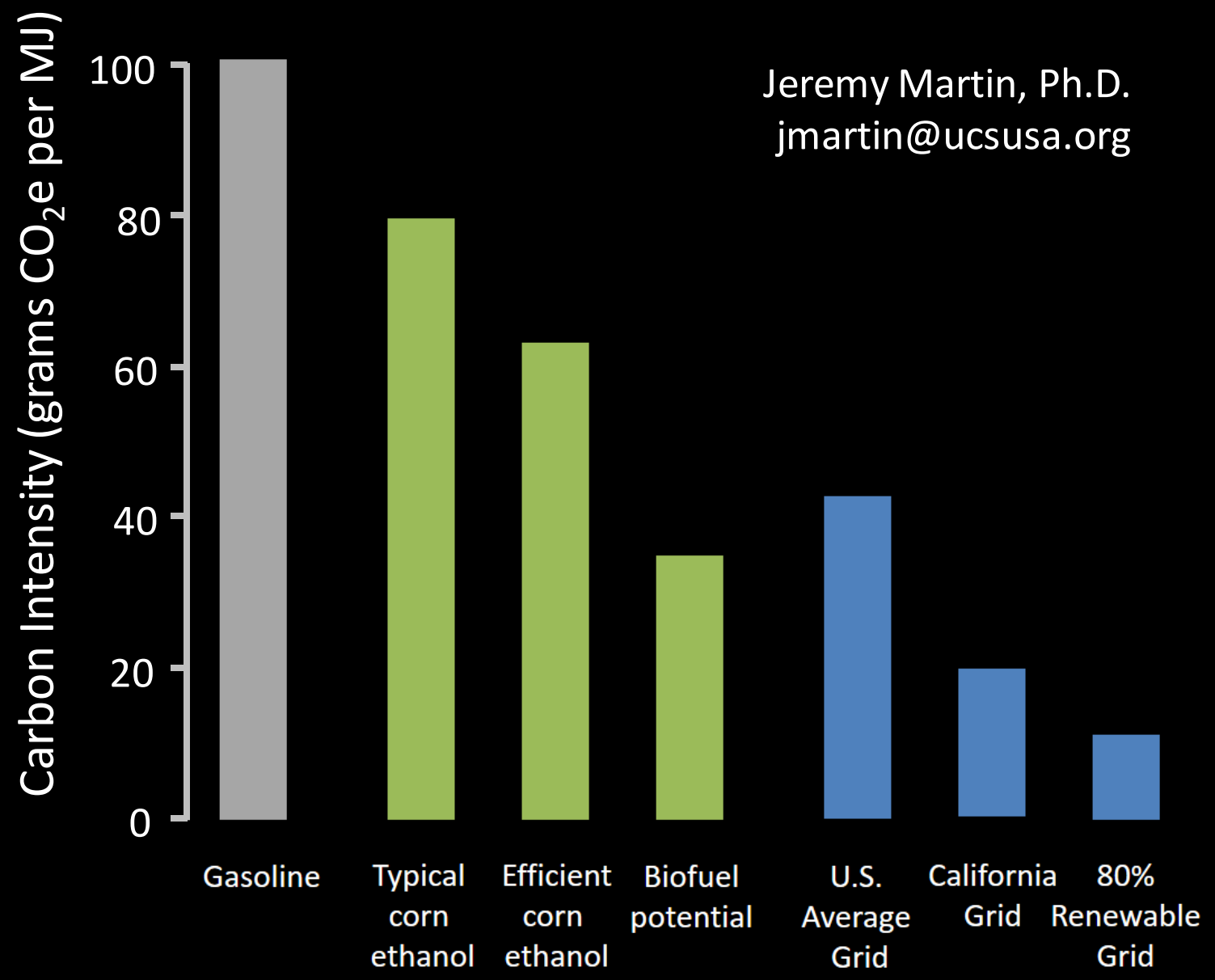
Union of Concerned Scientists

Jeremy Martin, Ph.D.
Director of Fuels Policy, Sr. Scientist
Clean Transportation Program

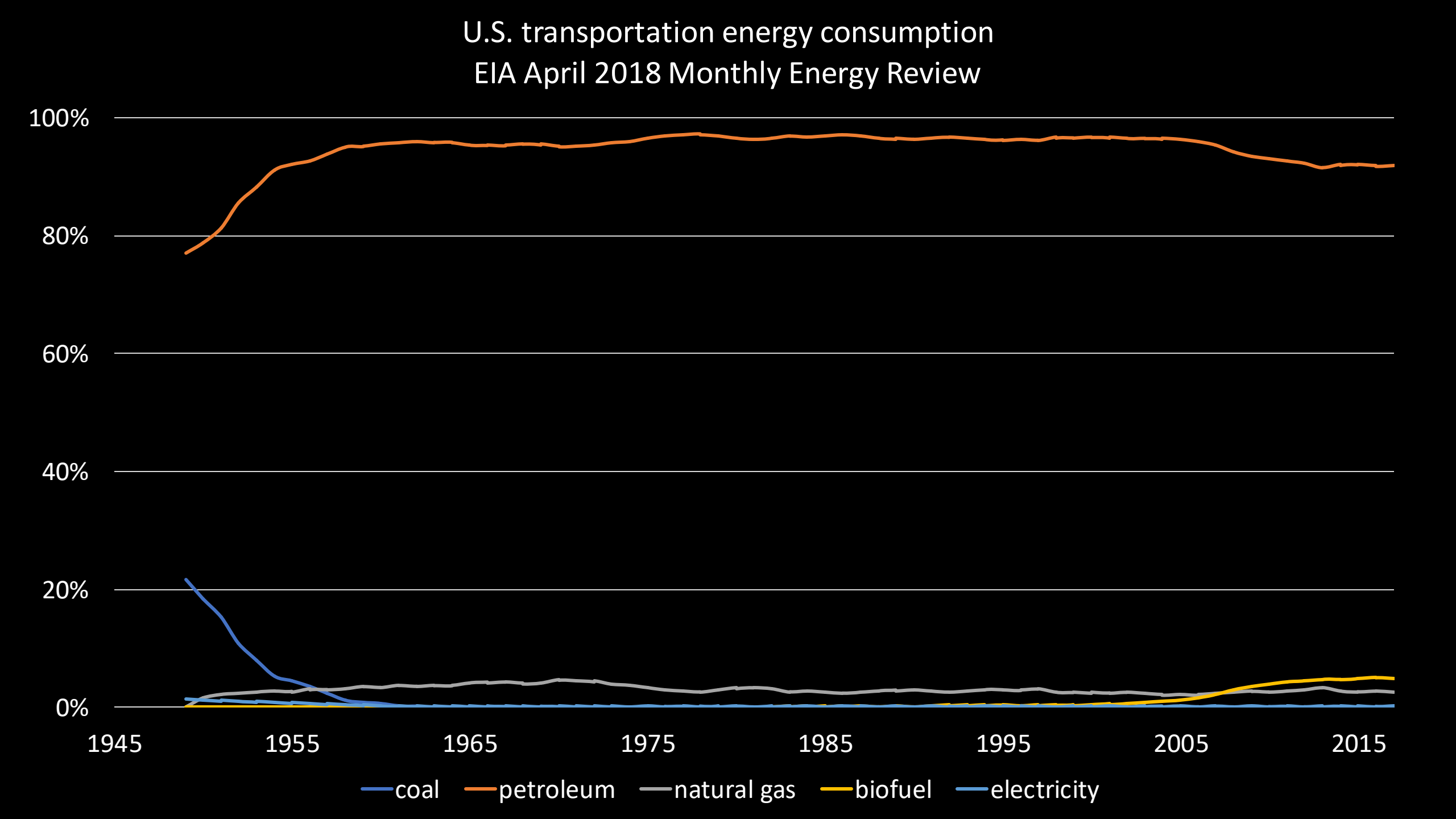
Clean transportation means using less oil, more renewable electricity, and being smarter about how we produce and use biofuels

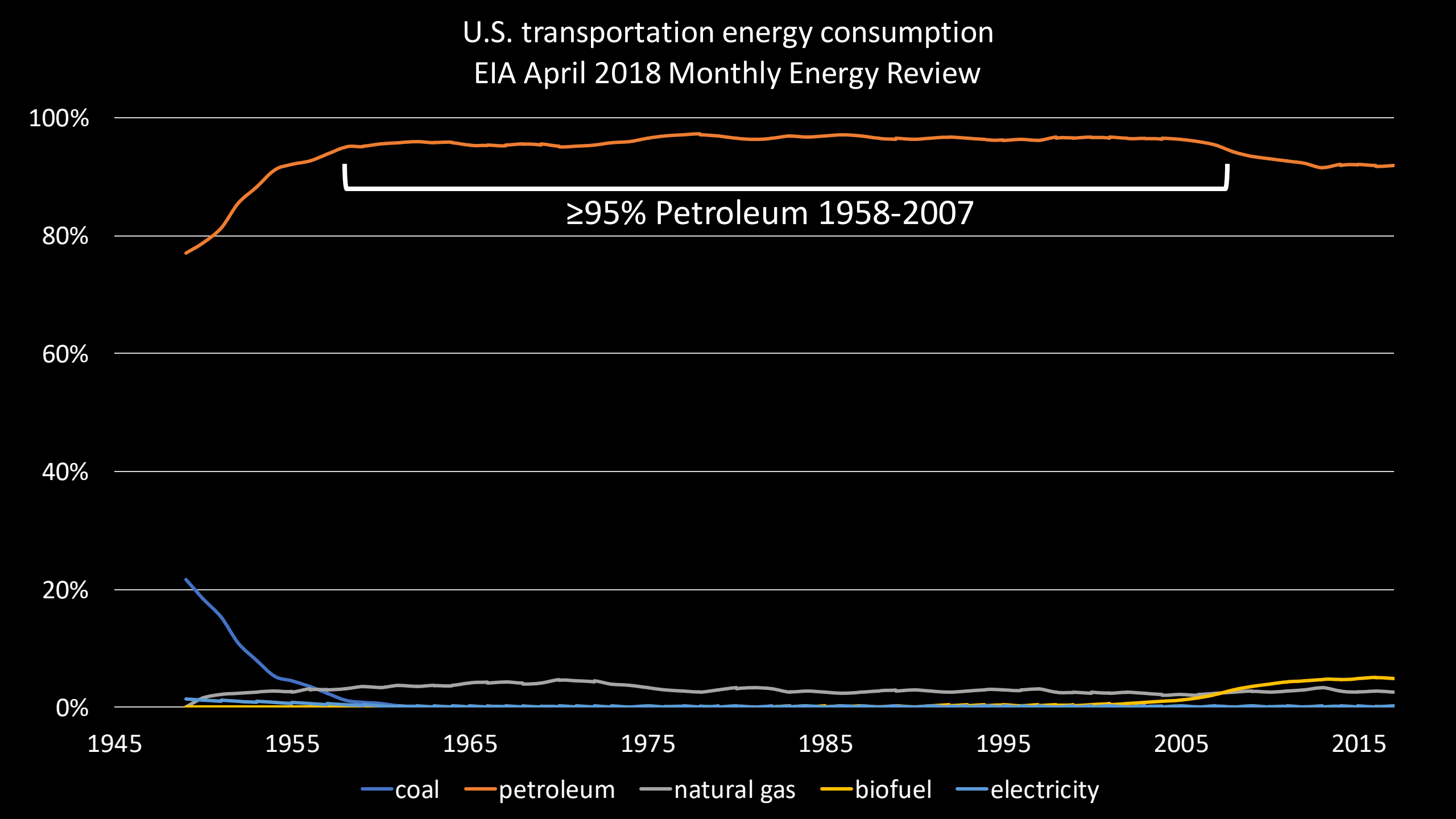


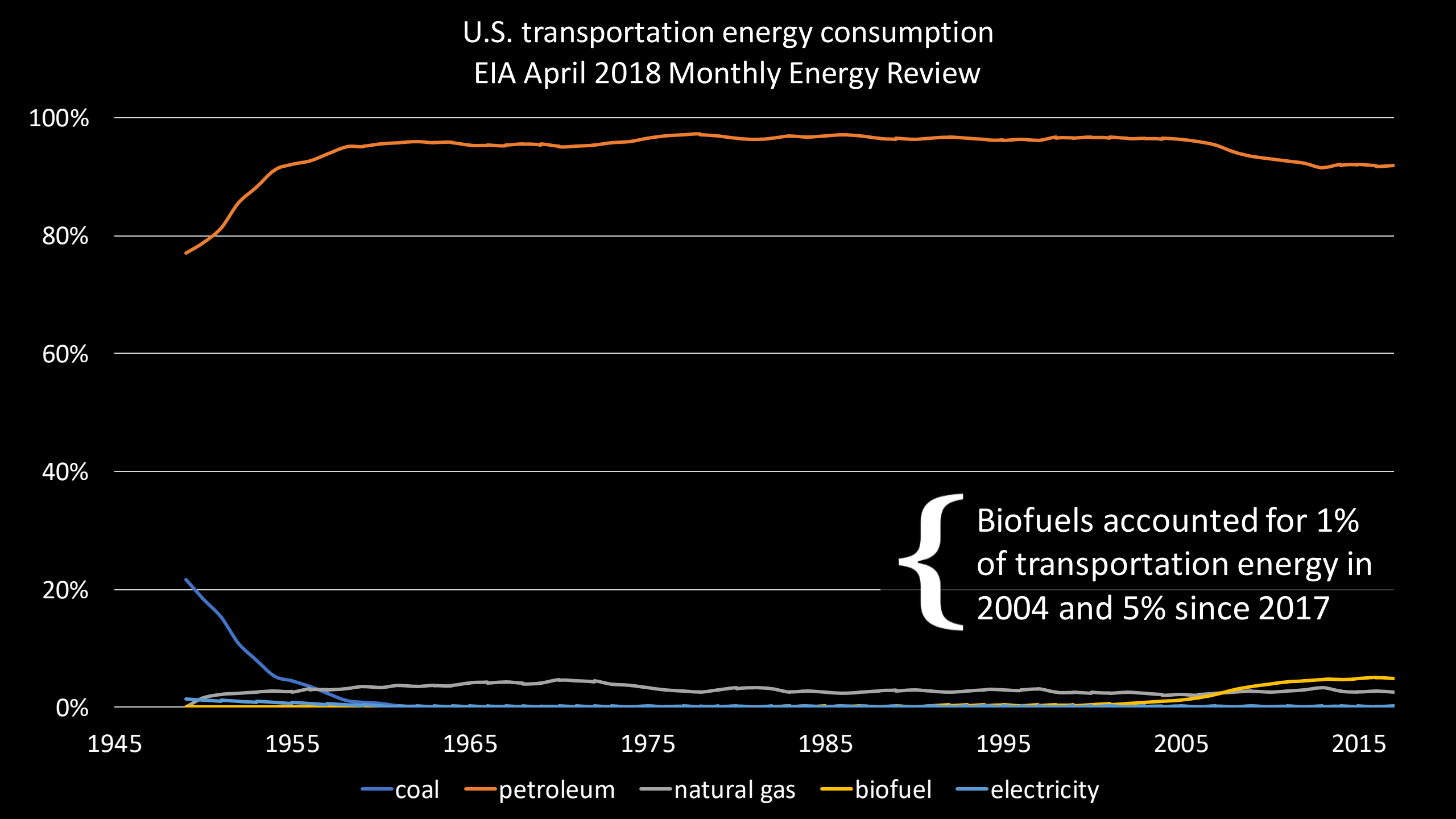
www.ucsusa.org/fuelingacleanfuture



Jeremy Martin, Ph.D.
jmartin@ucsusa.org

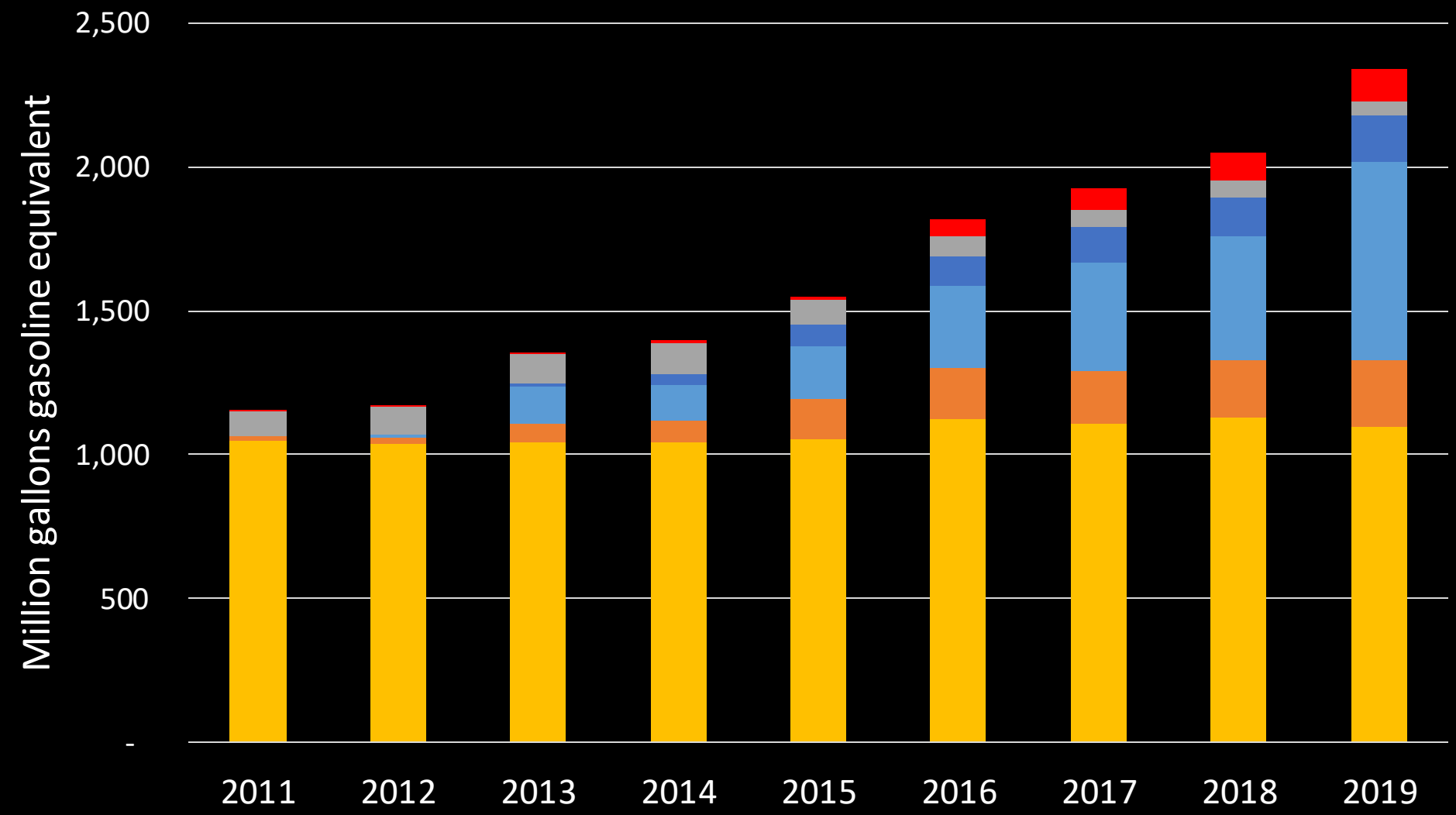

U.S. transportation energy consumption
EIA April 2018 Monthly Energy Review
100%
80%
60%
40%
20%
0%
1945
1955
1965
1975
1985
1995
2005
2015
coal
petroleum
natural gas
biofuel
electricity


U.S. transportation energy consumption
EIA April 2018 Monthly Energy Review
100%
80%
60%
40%
20%
0%
≥95% Petroleum 1958-2007
1945
1955
1965
1975
1985
1995
2005
2015
coal
petroleum
natural gas
biofuel
electricity


U.S. transportation energy consumption
EIA April 2018 Monthly Energy Review
100%
80%
60%
40%
20%
0%
1945
1955
1965
1975
1985
1995
2005
2015
Biofuels accounted for 1% of transportation energy in 2004 and 5% since 2017
coal
petroleum
natural gas
biofuel
electricity

California Alternative Fuel Use

California Air Resource Board Data



Ethanol | Biodiesel | Renewable diesel | Biomethane | Natural gas | Electricity

Energy Research and Development Division

FINAL PROJECT REPORT

Deep Decarbonization in a High Renewables Future

Updated Results from the California PATHWAYS Model

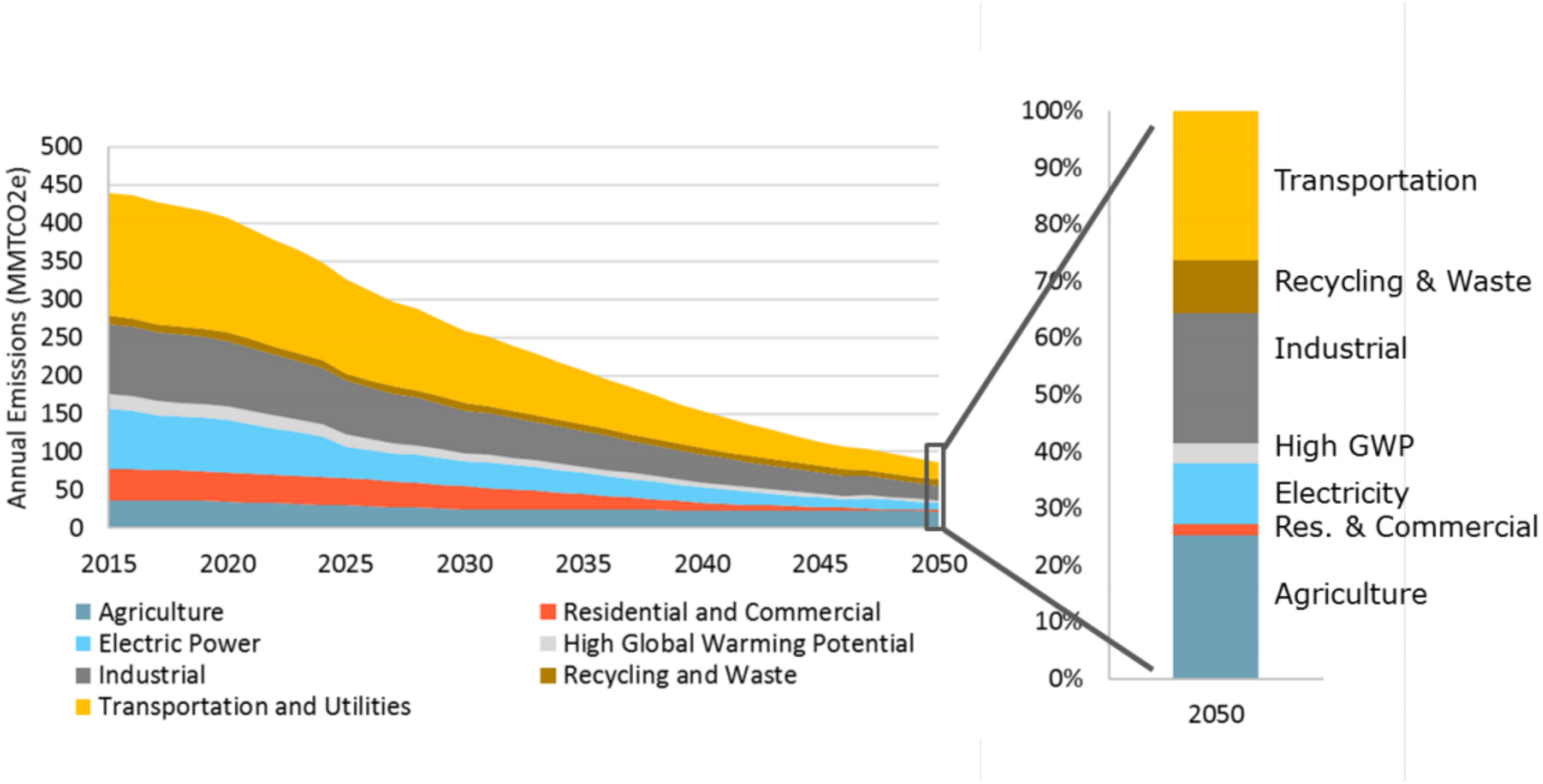
California Energy Commission

Edmund G. Brown Jr., Governor

June 2018 | CEC-500-2018-012

energy.ca.gov/2018publications/CEC-500-2018-012/CEC-500-2018-012.pdf

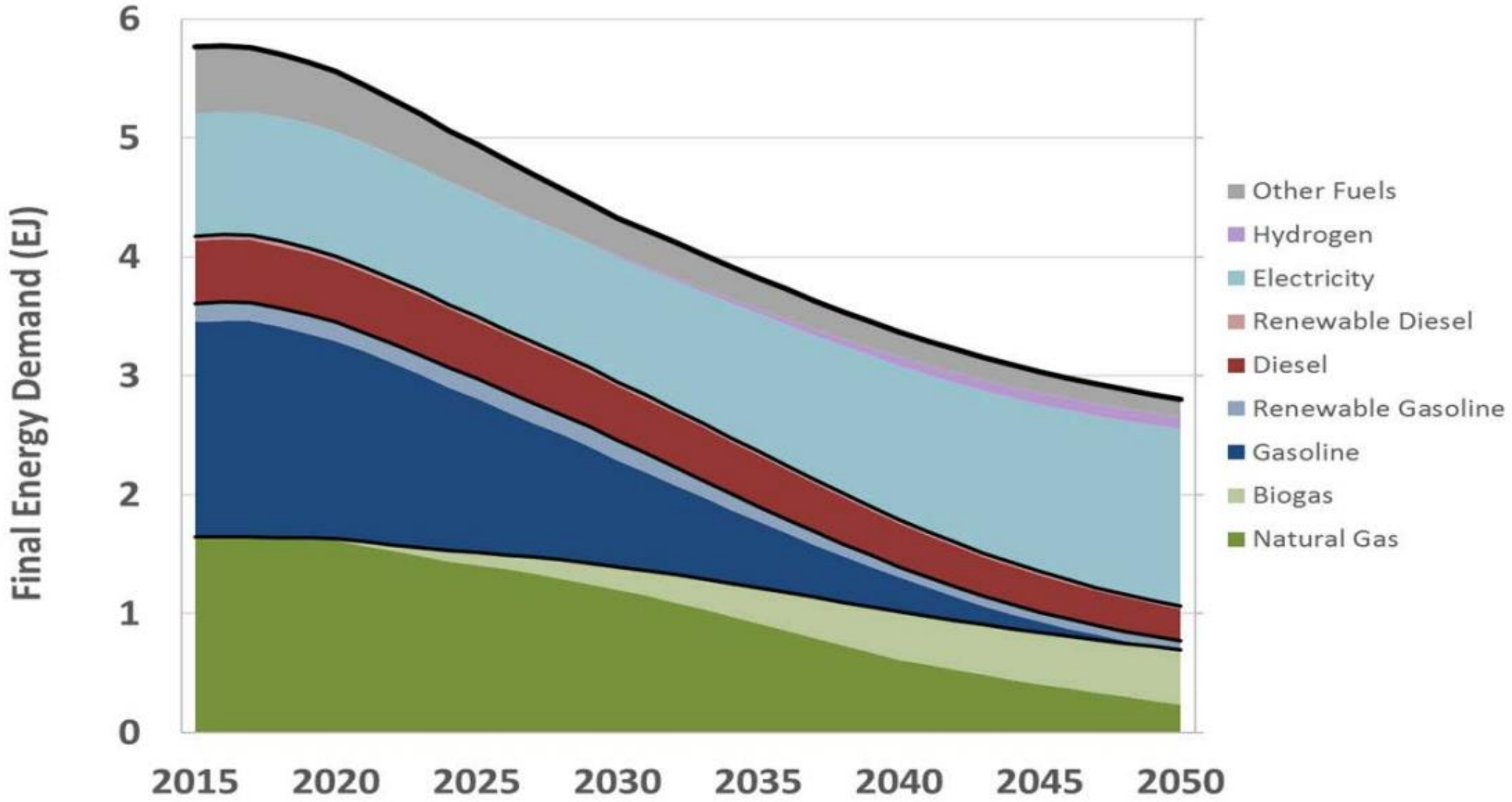
Figure 6: California Greenhouse Gas Emissions by Sector in the High Electrification Scenario



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

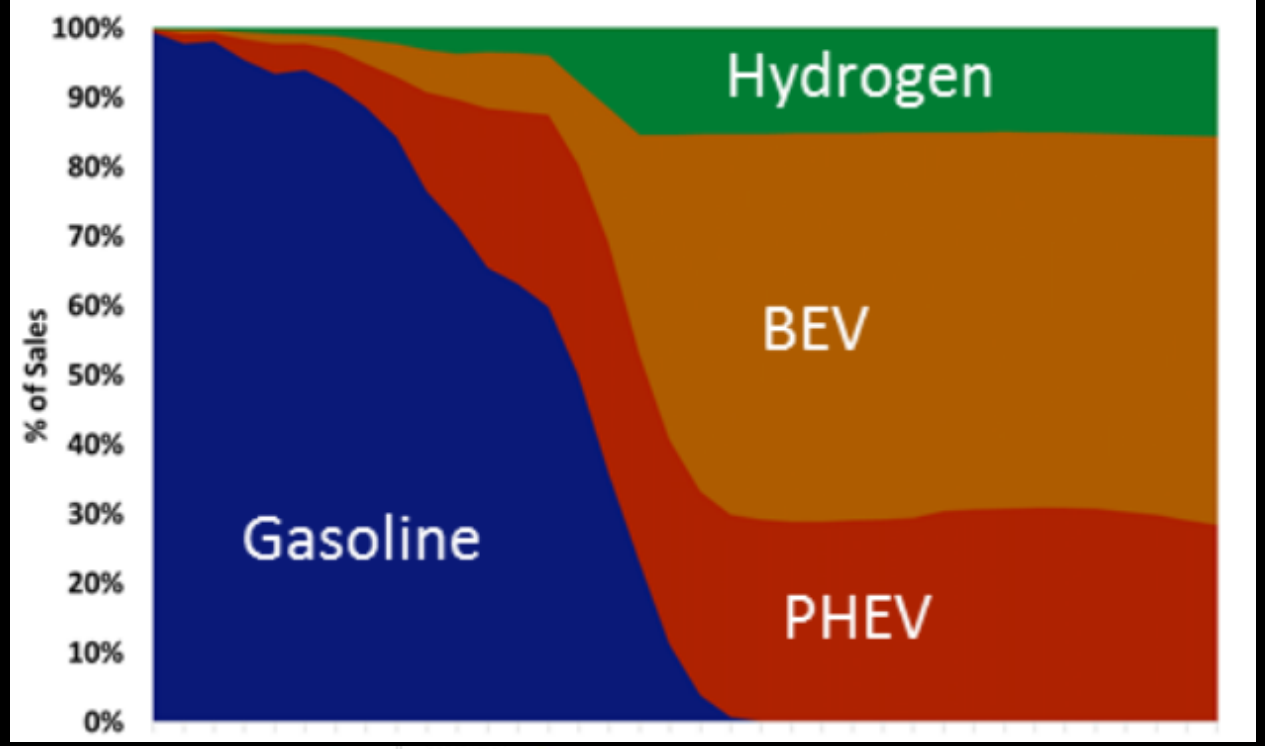


Source: E3

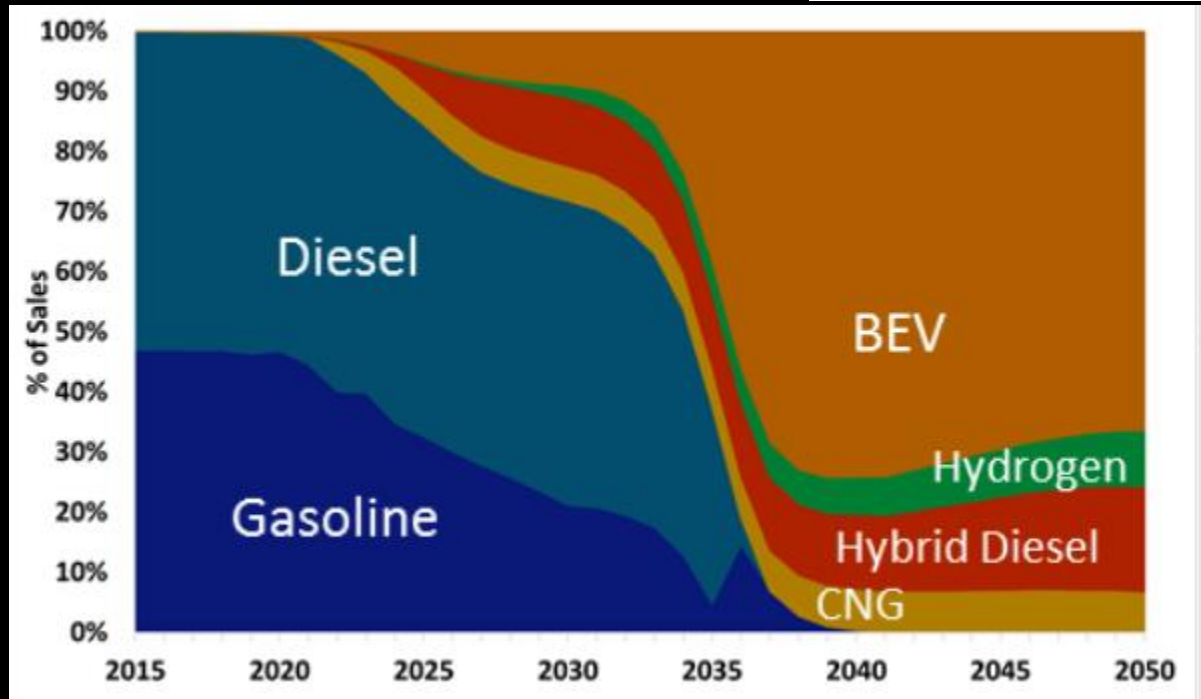
energy.ca.gov/2018publications/CEC-500-2018-012/CEC-500-2018-012.pdf

Vehicle Sales

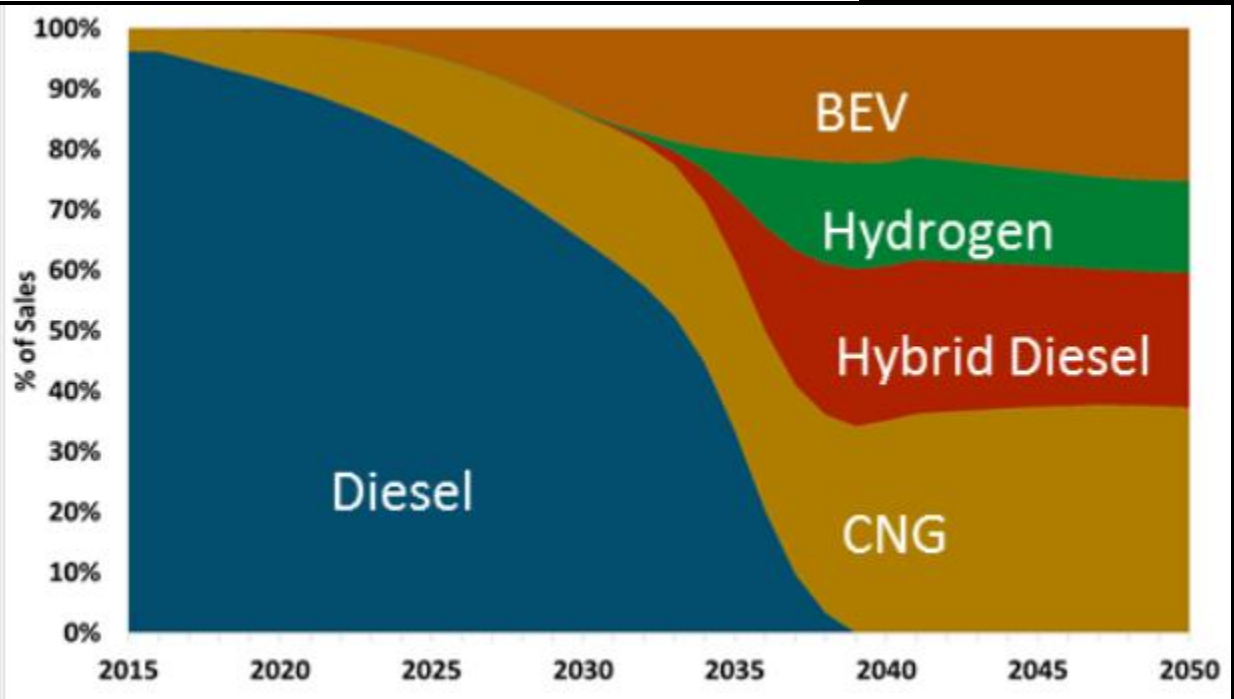
Light Duty



Medium Duty

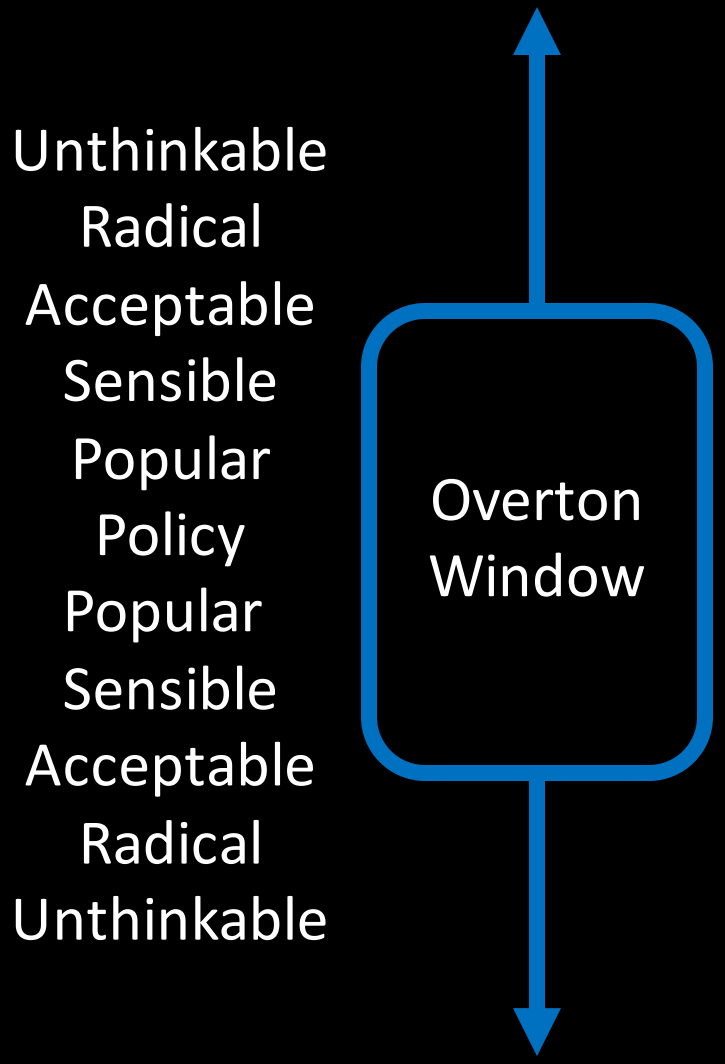


Heavy Duty



energy.ca.gov/2018publications/CEC-500-2018-012/CEC-500-2018-012.pdf

The Overton Window on low carbon transportation



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

September 2018

GLOBAL CLIMATE ACTION SUMMIT

EXECUTIVE ORDER B-55-18 TO ACHIEVE CARBON NEUTRALITY

IT IS HEREBY ORDERED THAT:

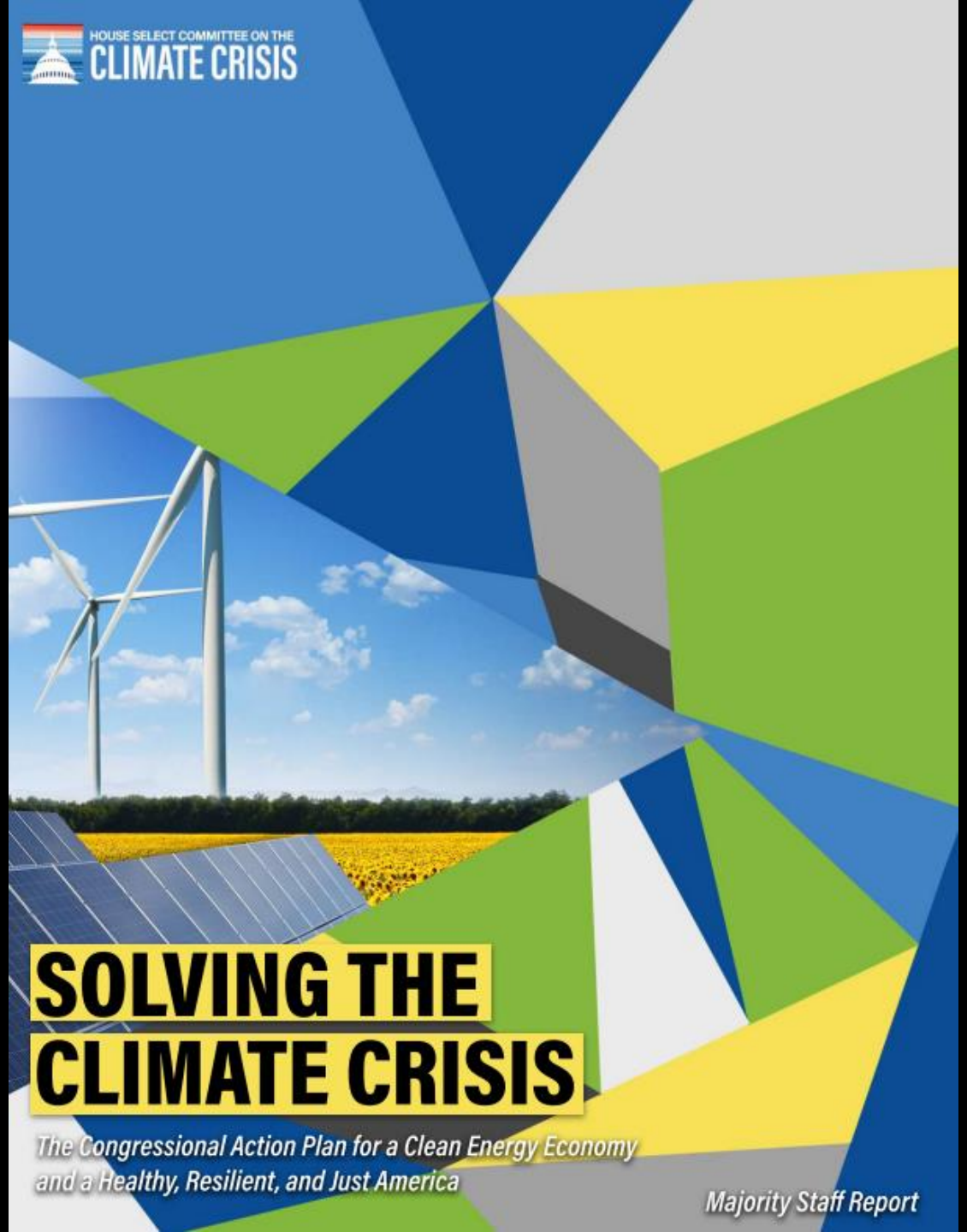
1. A new statewide goal is established to achieve carbon neutrality as soon as possible, and no later than 2045, and achieve and maintain net negative emissions thereafter. This goal is in addition to the existing statewide targets of reducing greenhouse gas emissions.

California Advanced Clean Truck Rule

Zero Emissions mandates for 2035

- 55% Class 2b-3
- 75% Class 4-8
- 40% Class 7-8

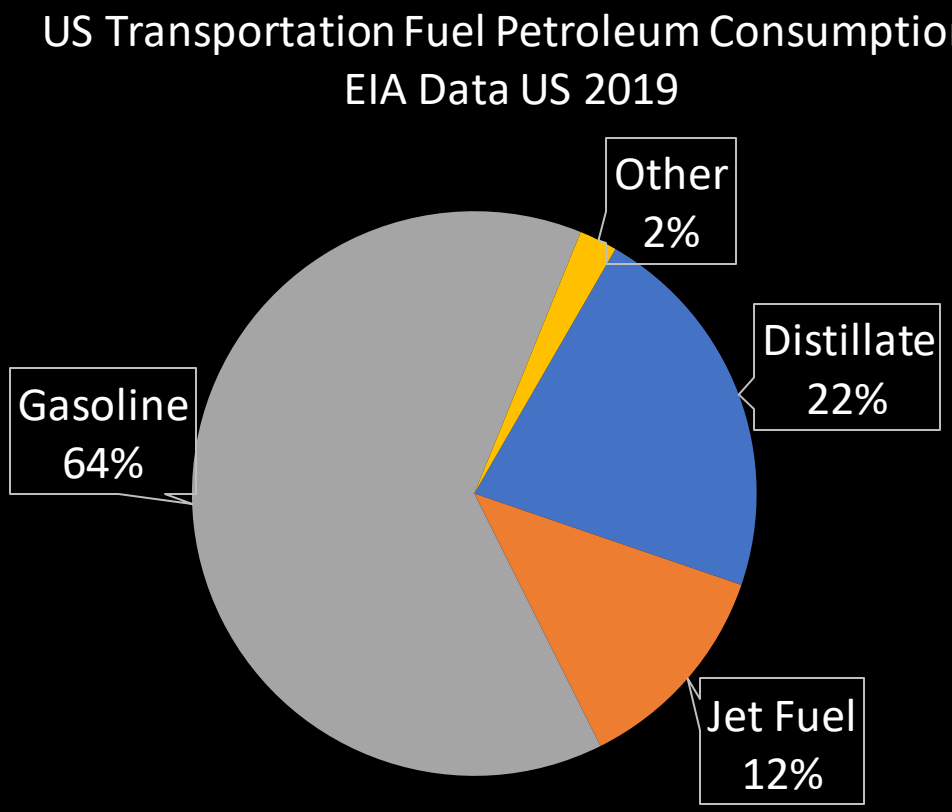
Begin work on transition of California's truck fleet to 100 percent zero-emission vehicles by 2045



- 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

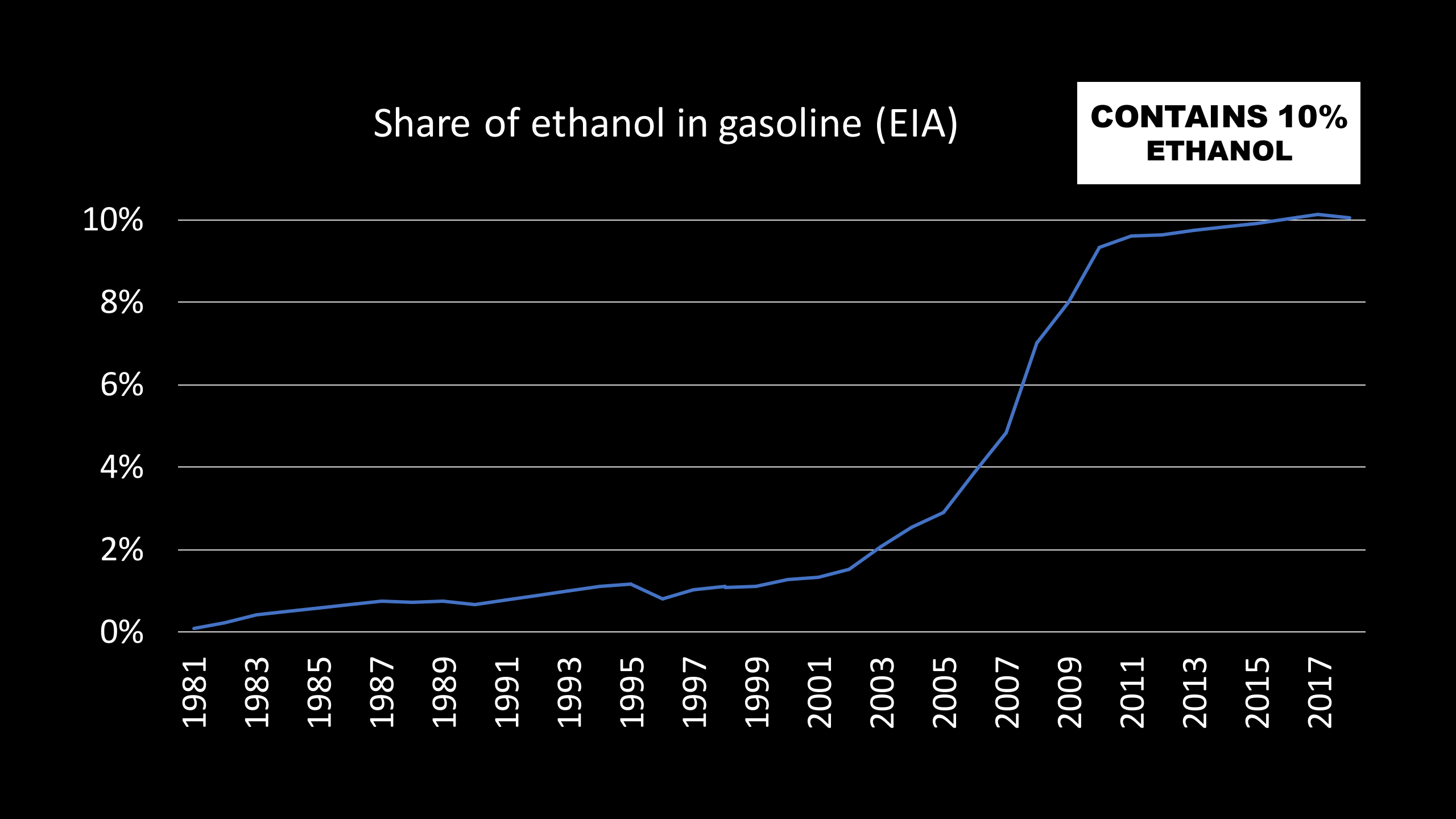
Inputs and Outputs

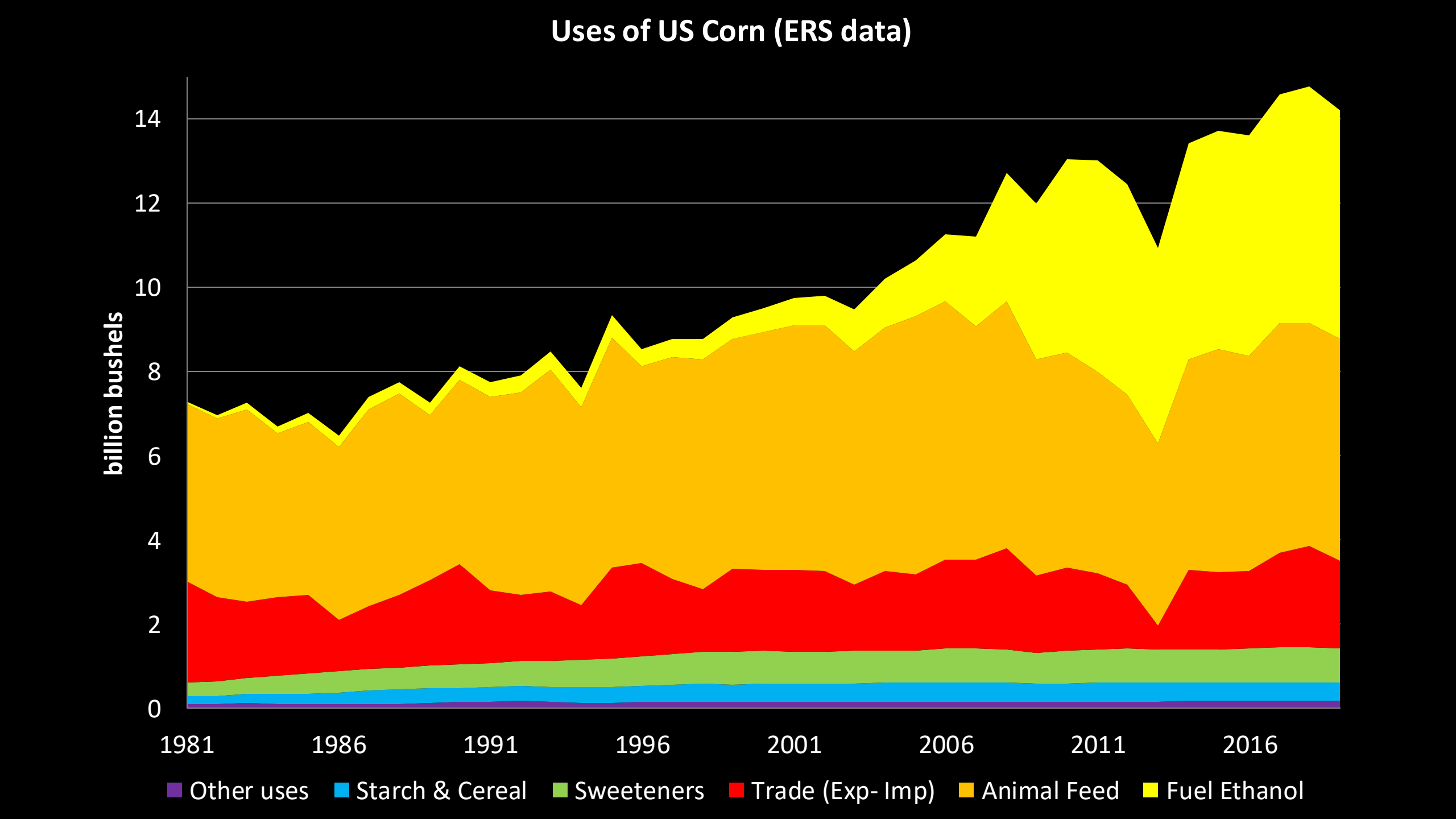
Feedstocks

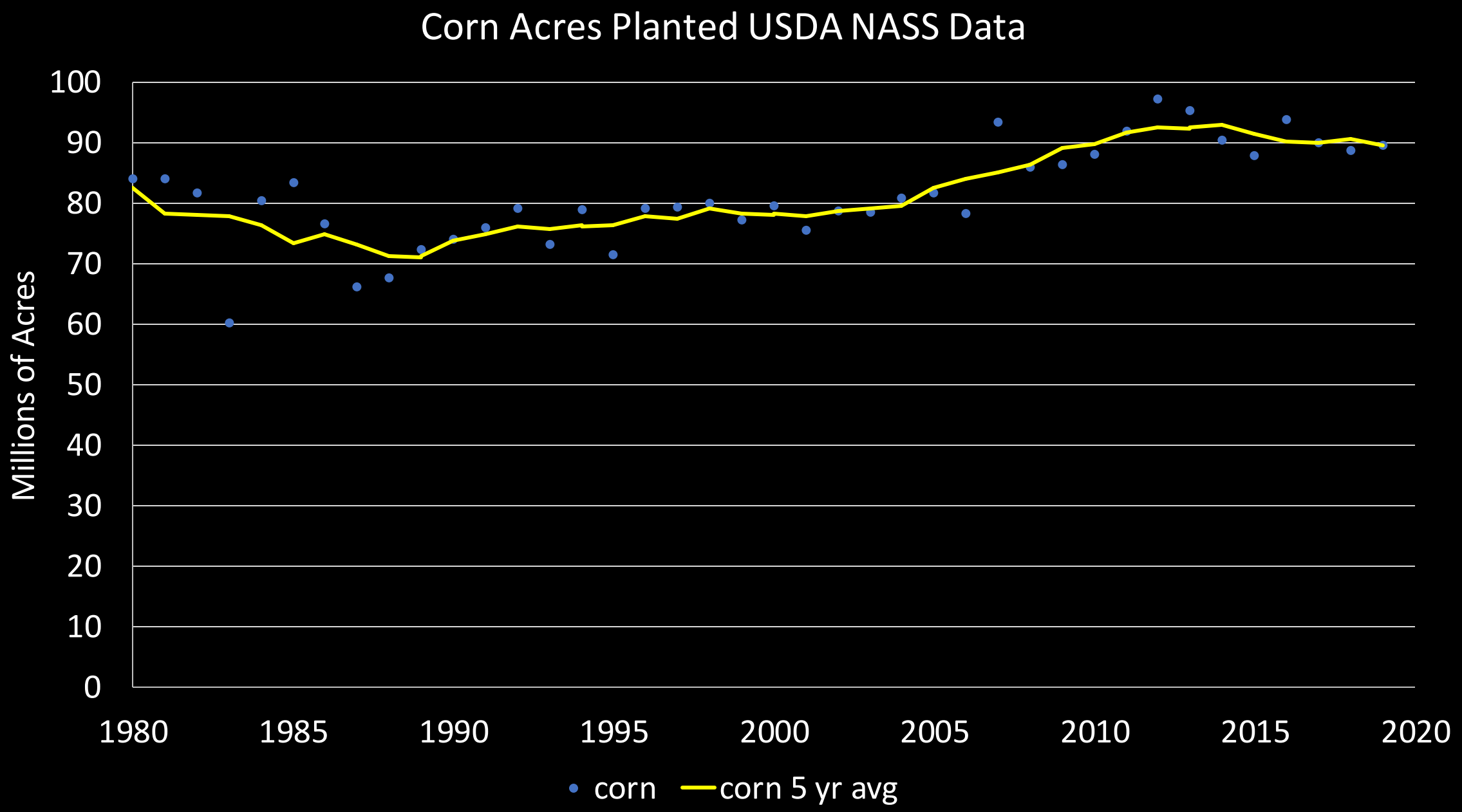
- Commodity Ag products
  - Grain

Final Products

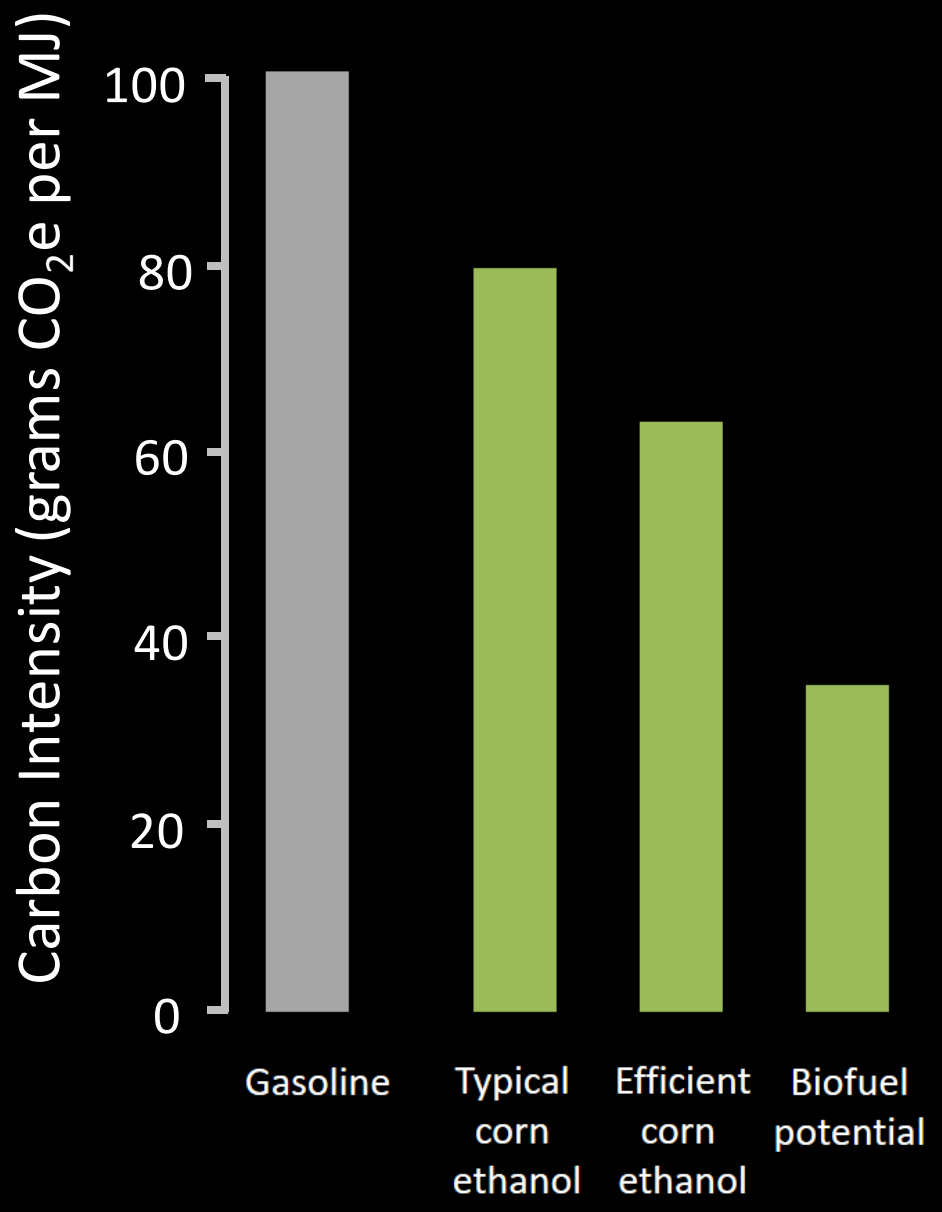
- Ethanol


Share of ethanol in gasoline (EIA)
CONTAINS 10% ETHANOL
10%
8%
6%
4%
2%
0%
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017


Uses of US Corn (ERS data)
billion bushels
14
12
10
8
6
4
2
0
1981
1986
1991
1996
2001
2006
2011
2016
Other uses
Starch & Cereal
Sweeteners
Trade (Exp- Imp)
Animal Feed
Fuel Ethanol


Corn Acres Planted USDA NASS Data
Millions of Acres
100
90
80
70
60
50
40
30
20
10
0
1980
1985
1990
1995
2000
2005
2010
2015
2020
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

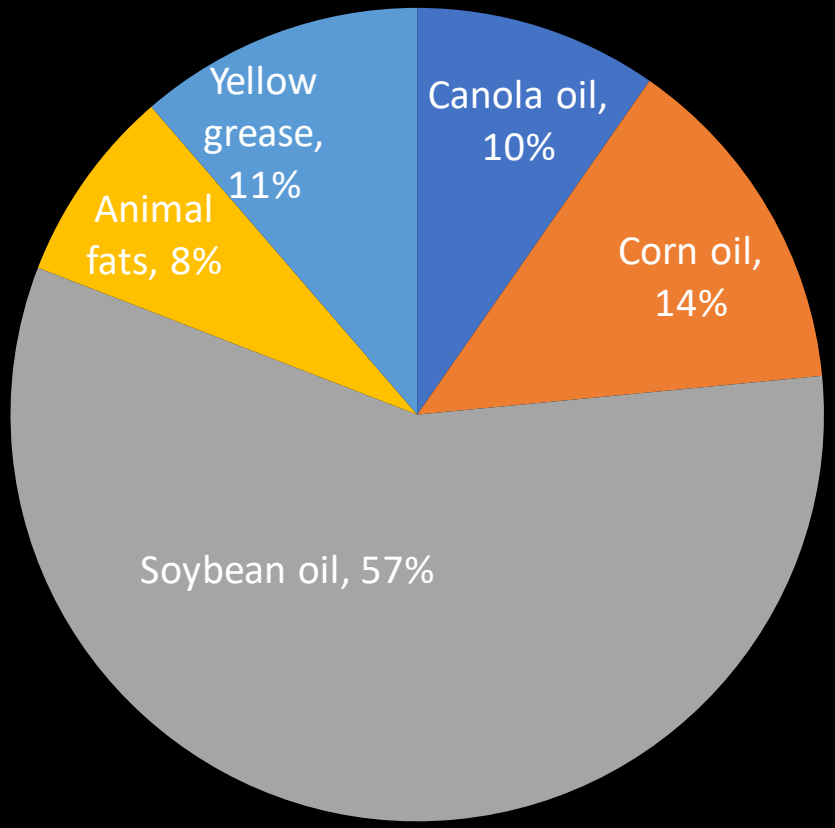
- Commodity Ag products
  - Grain
  - Vegetable oil
  - Second use oils and fats

Final Products

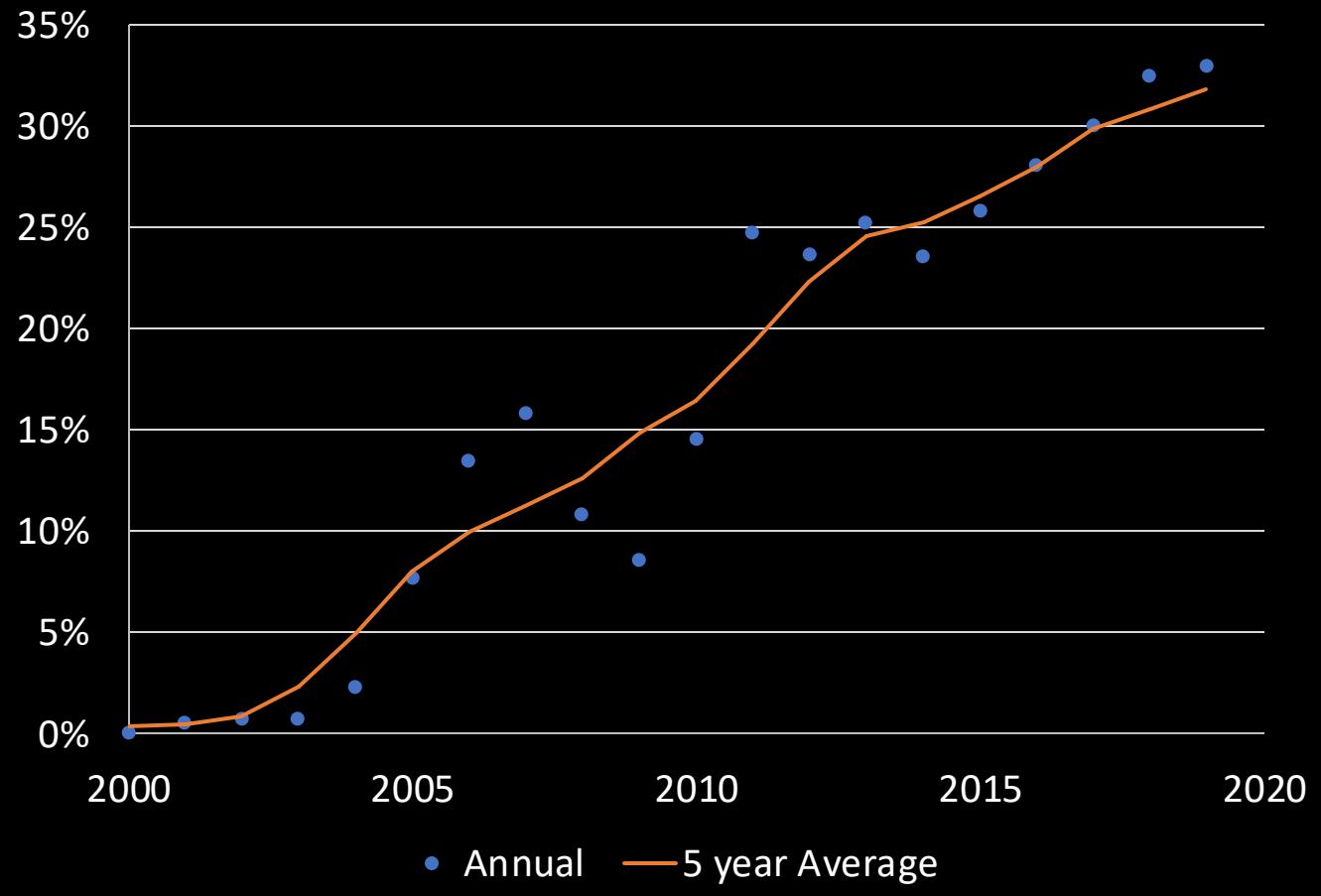
- Bio-based Diesel
  - Biodiesel
  - Renewable Diesel
- Sustainable Aviation Fuel

Feedstocks for Biodiesel, Renewable Diesel

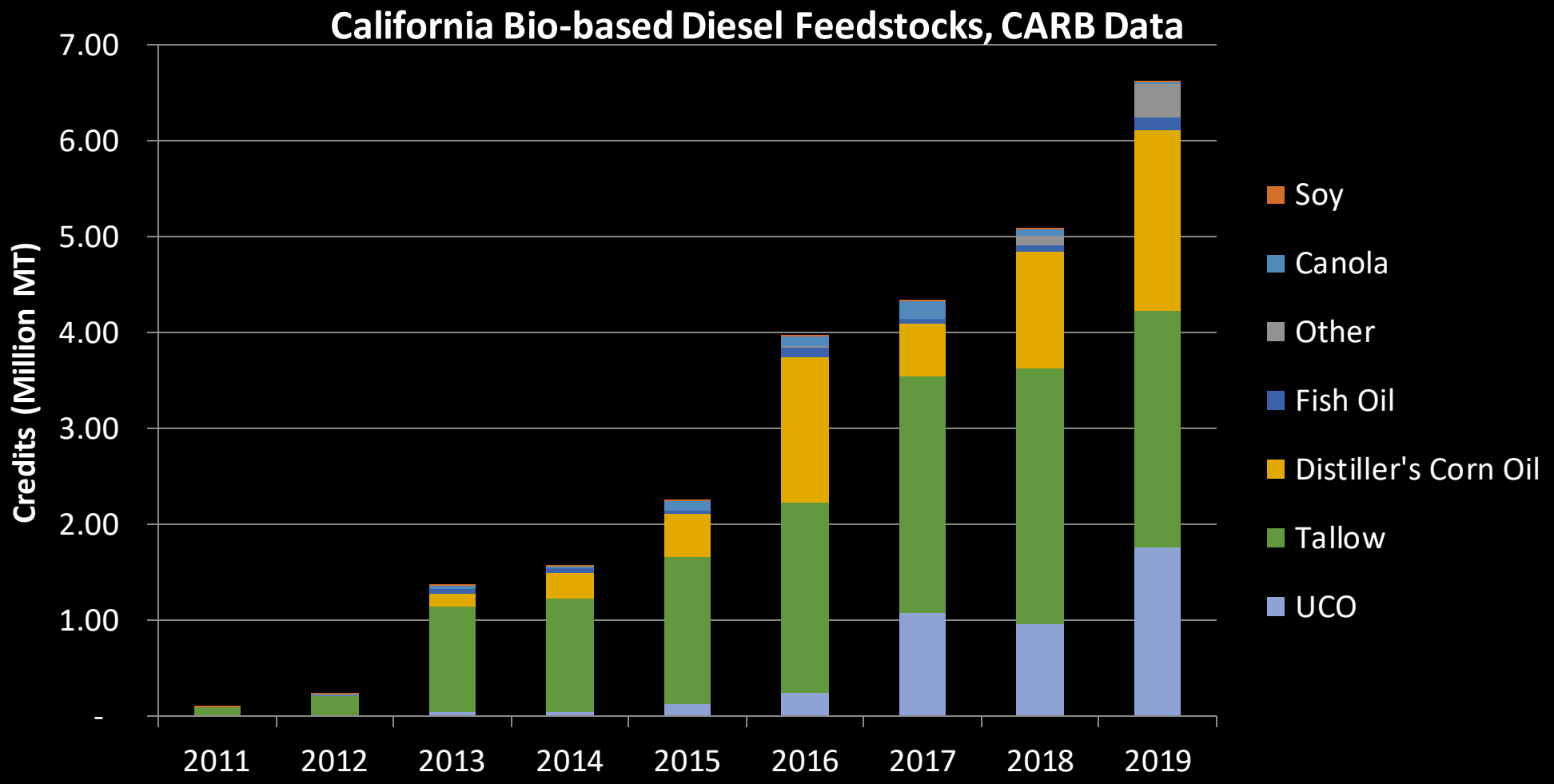
US Biodiesel Feedstocks
(2019 DOE Data)



Share of US Soybean Oil Production for Biodiesel
USDA Data



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

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  - 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

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  - 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

Union of Concerned Scientists

FACT SHEET

The Promises and Limits of Biomethane as a Transportation Fuel

HIGHLIGHTS

As California explores strategies to reduce global warming emissions from transportation, there is interest in using methane generated at landfills, wastewater treatment centers, and dairies to fuel heavy-duty vehicles. While "biomethane" from waste has climate benefits, it is limited in supply. Biomethane can be used as a direct replacement for natural gas in vehicles, yet policymakers must not conflate the two fuels because they have significantly different life cycle emissions. A large shift to natural gas–powered heavy-duty vehicles with a limited amount of biomethane could increase California's reliance on natural gas and undermine the state's climate goals.

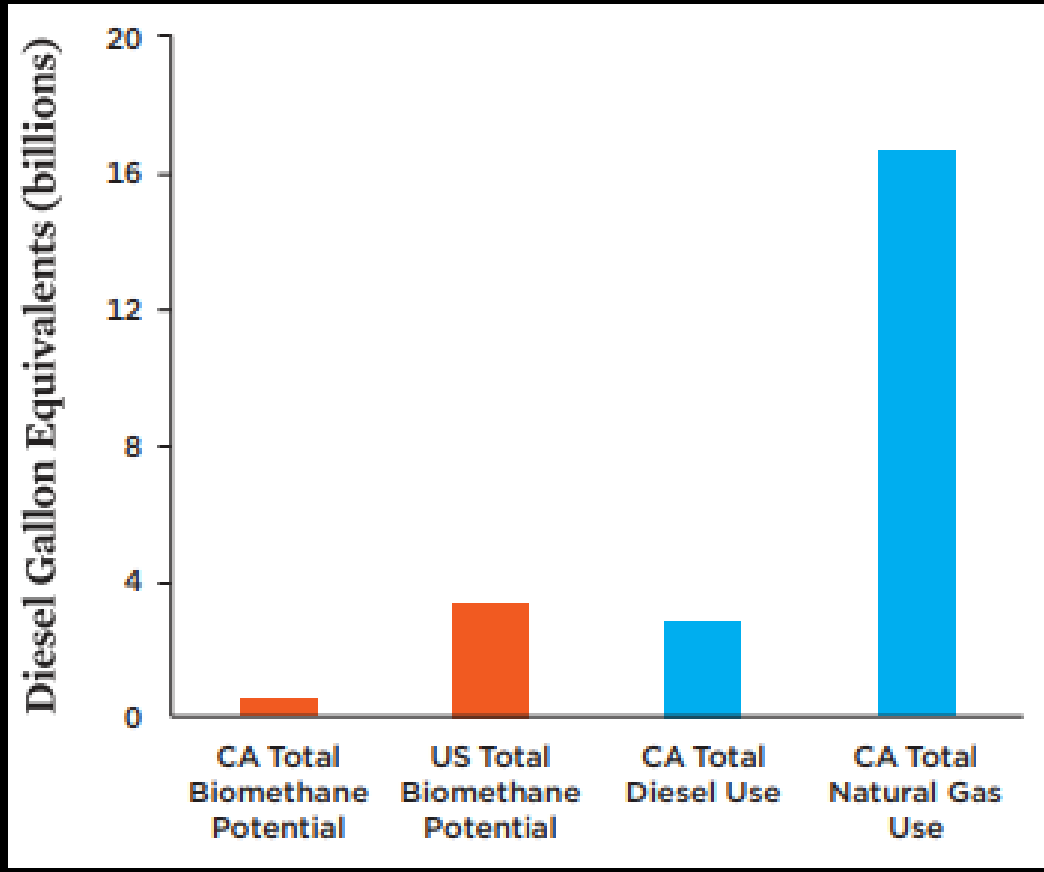
Methane is a potent global warming gas—34 times more powerful than carbon dioxide at trapping Earth's heat over a 100-year period (Myhre et al. 2013). Methane comprises nearly 10 percent of California's total global warming emissions. About half of the state's methane emissions come from decomposing organic waste at landfills, wastewater treatment centers, and dairy farms[1] (CARB 2016a; CARB 2016b). Methane derived from these sources—also called **biomethane**—goes largely uncaptured today but could be used to reduce the consumption of fossil fuels.

Natural gas and biomethane both consist primarily of methane and can be used interchangeably (see Box 1, p. 2). They differ in their source—natural gas coming from ancient plant and animal matter decomposed beneath Earth's surface and biomethane coming from the decomposition of present-day plant or animal matter. Biomethane can be produced under controlled environments (e.g., an anaerobic digester at a wastewater treatment center) or non-controlled environments (e.g., a landfill) (Babson 2015).

Decomposing waste at landfills—as well as at wastewater treatment centers and dairies—generates methane gas. While reducing waste overall should be a priority for California, methane from these sources can be harnessed and used to displace fossil fuels.

www.ucsusa.org/biomethane-transportation

{ Waste biomethane potential is very limited



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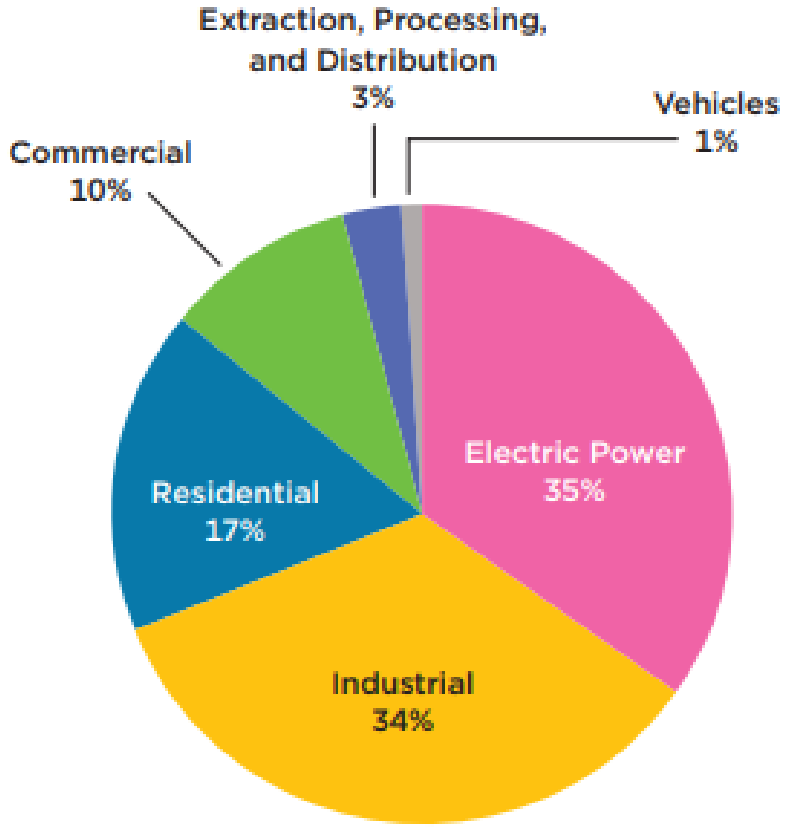
www.ucsusa.org/biomethane-transportation

{ Little natural gas is used as transportation fuel, industrial applications are harder to decarbonize

FIGURE 2. Natural Gas Consumption by Sector in California, 2015



CLIMATE & ENVIRONMENT

Cow poop could fuel California's clean energy future. But not everyone's on board

Holstein cows at Riverview Dairy outside Pixley, Calif., in March. The liquid part of their manure is directed into a nearby anaerobic digester, which captures methane that would otherwise be emitted into the atmosphere. (Mel Melcon / Los Angeles Times)

By SAMMY ROTH | STAFF WRITER

APRIL 9, 2020 | 6 AM

Los Angeles Times

- 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

Final Products

- Waste Methane
  - Manure
  - Wastewater treatment
  - Landfill gas
- Biomass
  - Energy crops
  - Forest biomass
  - MSW & wastes
  - Ag residues

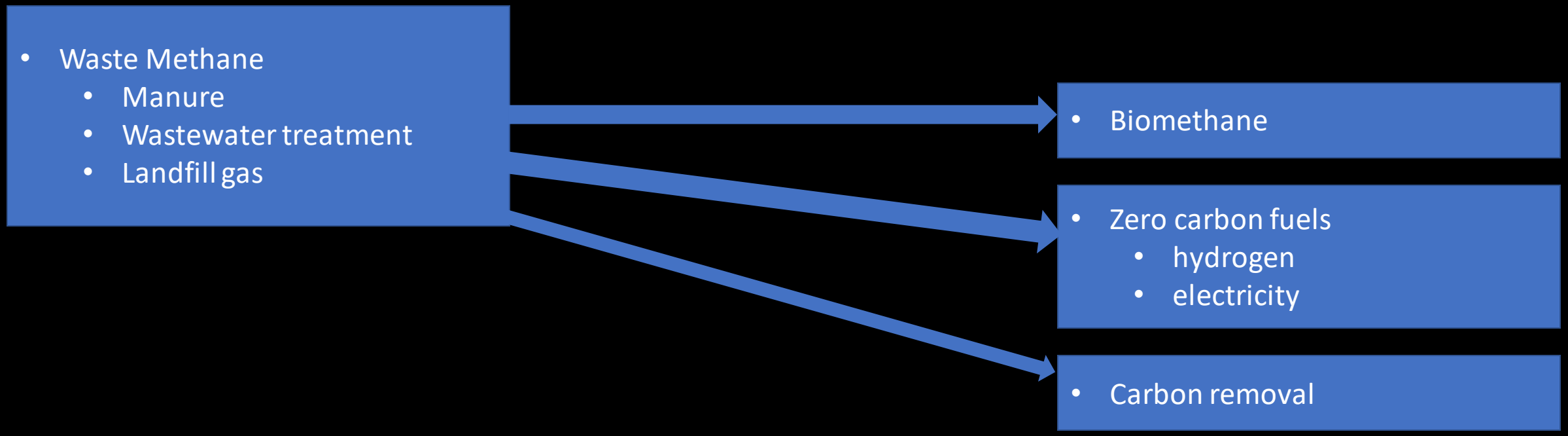
?

- Biomethane

Inputs and Outputs

Feedstocks

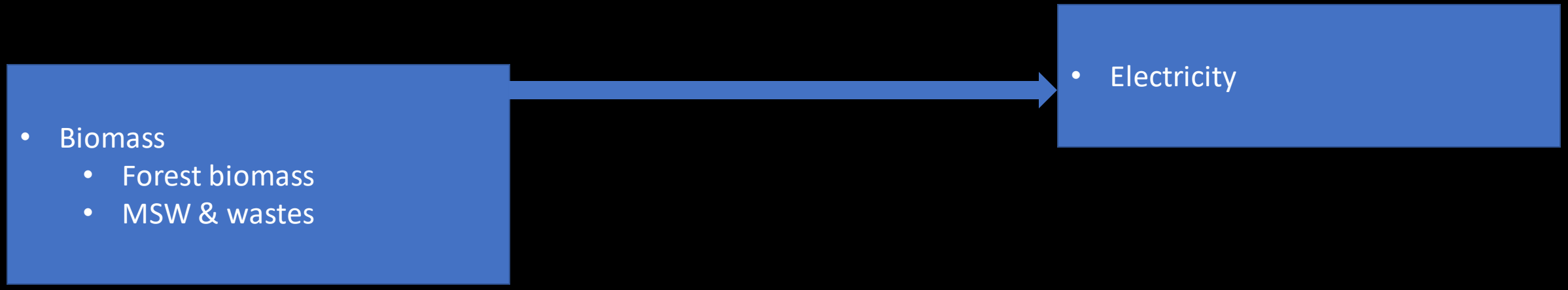
Final Products

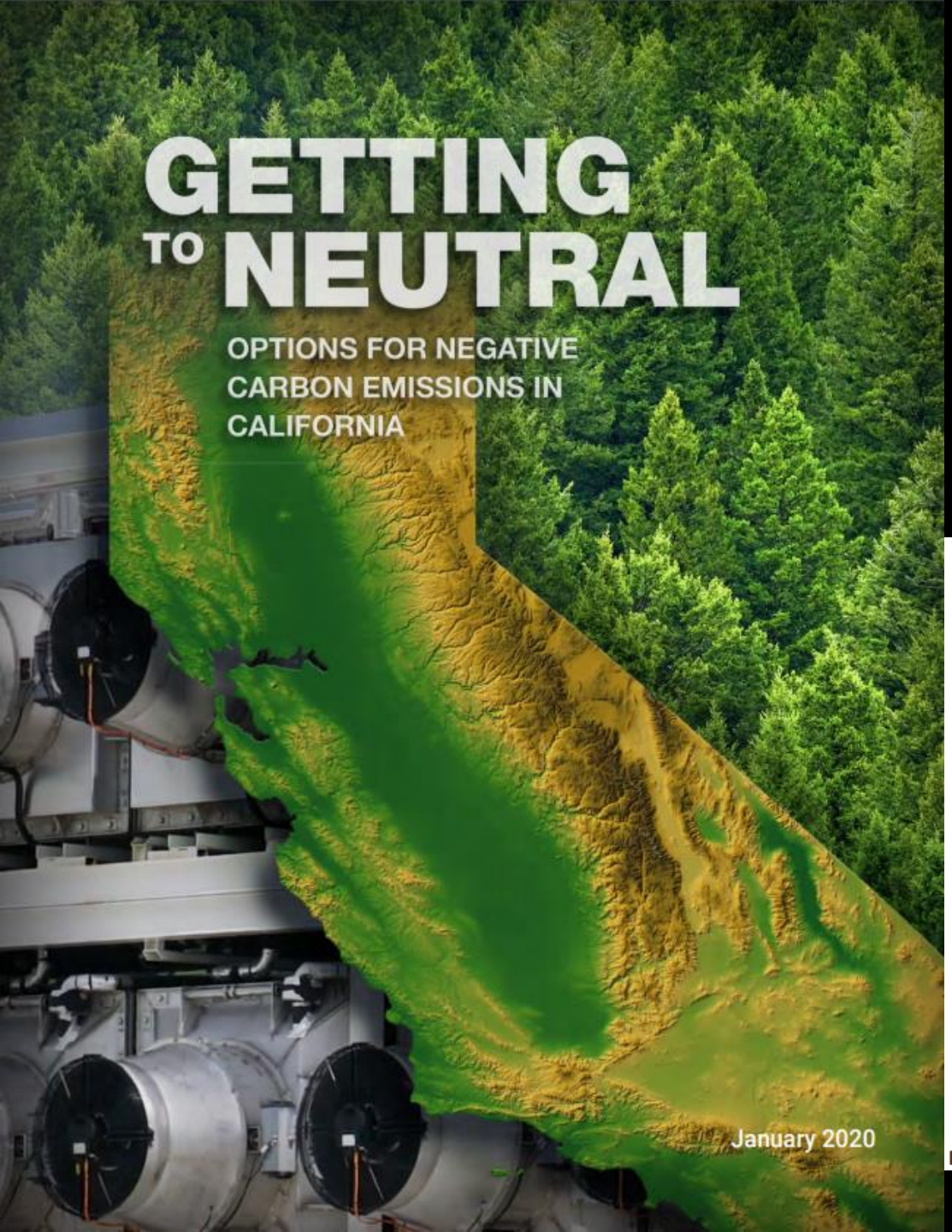


Inputs and Outputs

Feedstocks

Final Products





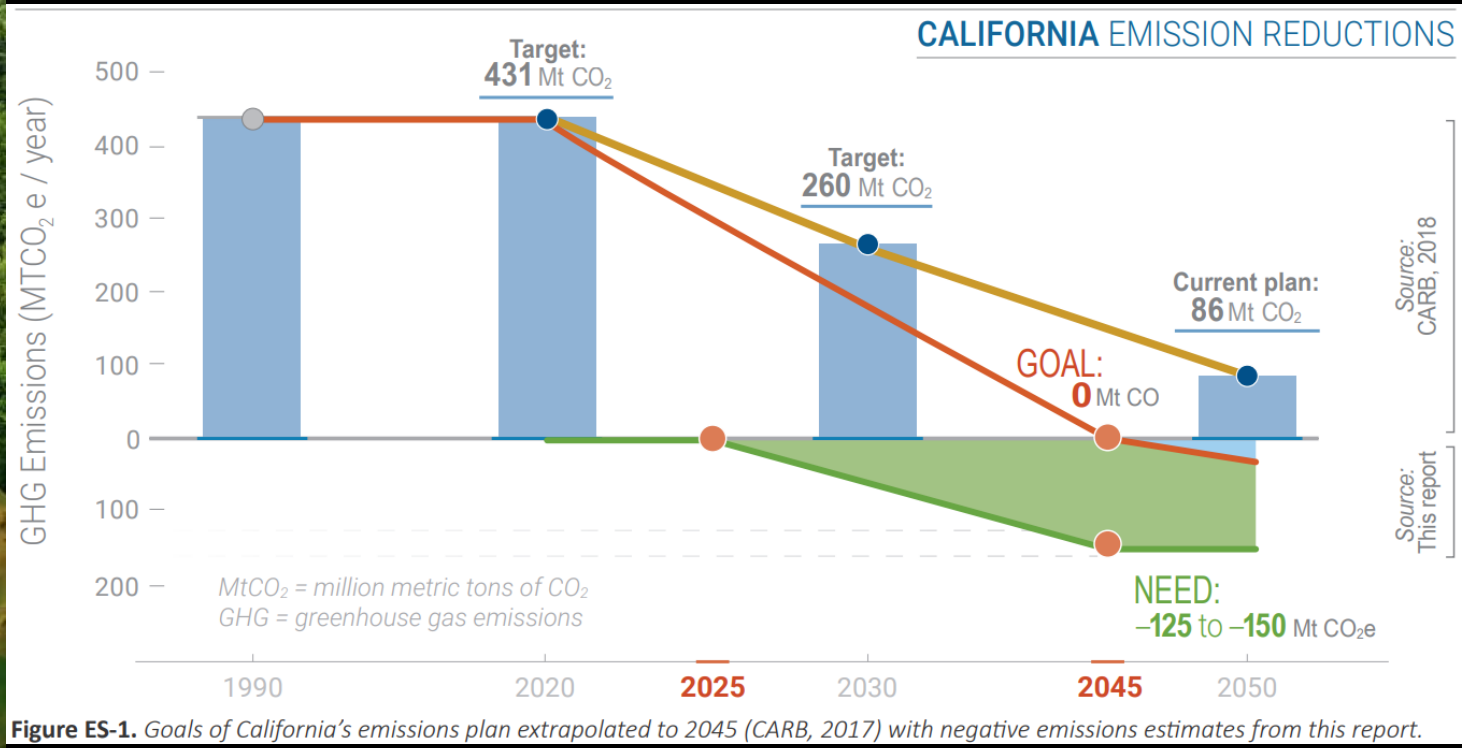
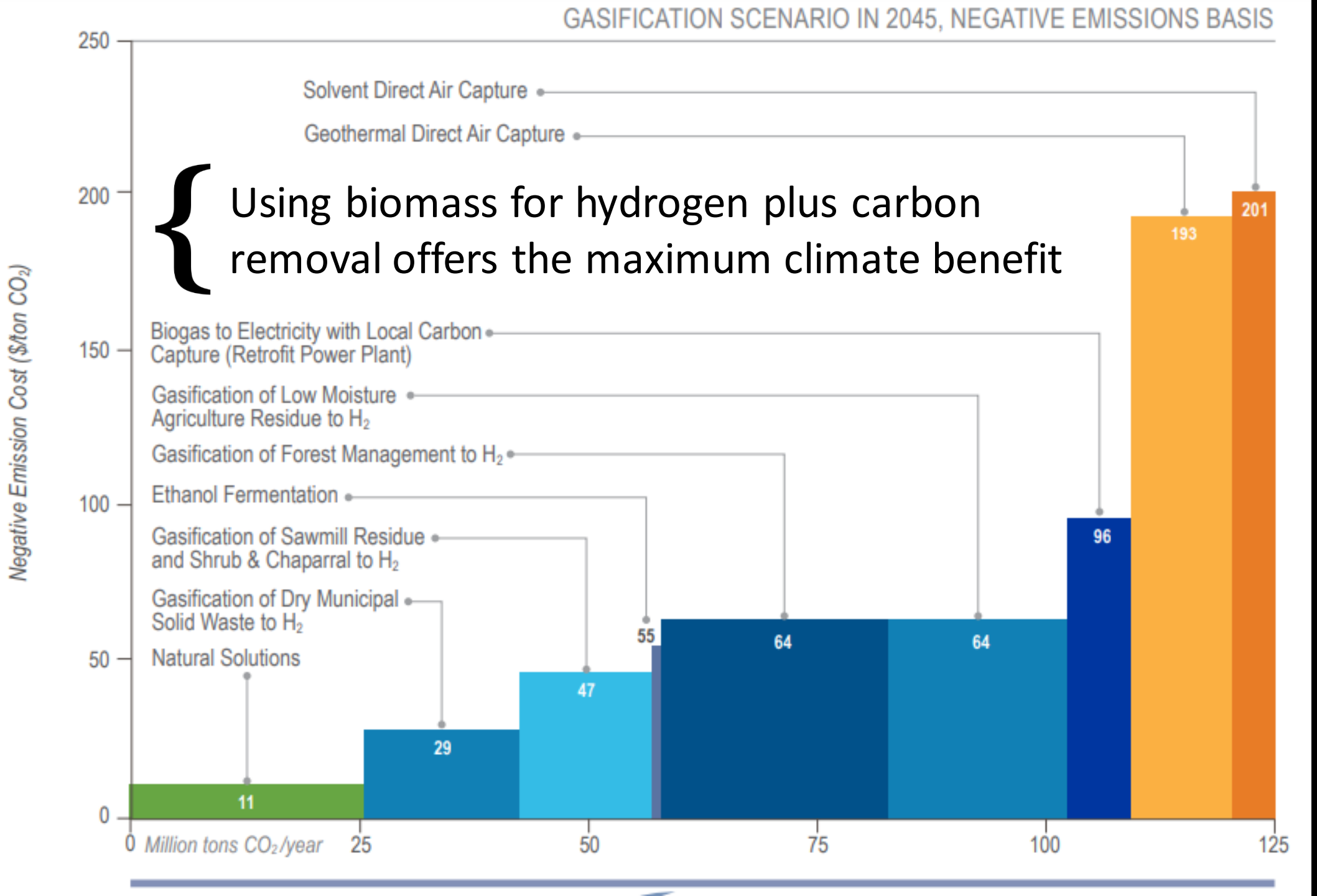


Figure ES-1. *Goals of California's emissions plan extrapolated to 2045 (CARB, 2017) with negative emissions estimates from this report.*

www-gs.llnl.gov/content/assets/docs/energy/Getting_to_Neutral.pdf



www-gs.llnl.gov/content/assets/docs/energy/Getting_to_Neutral.pdf

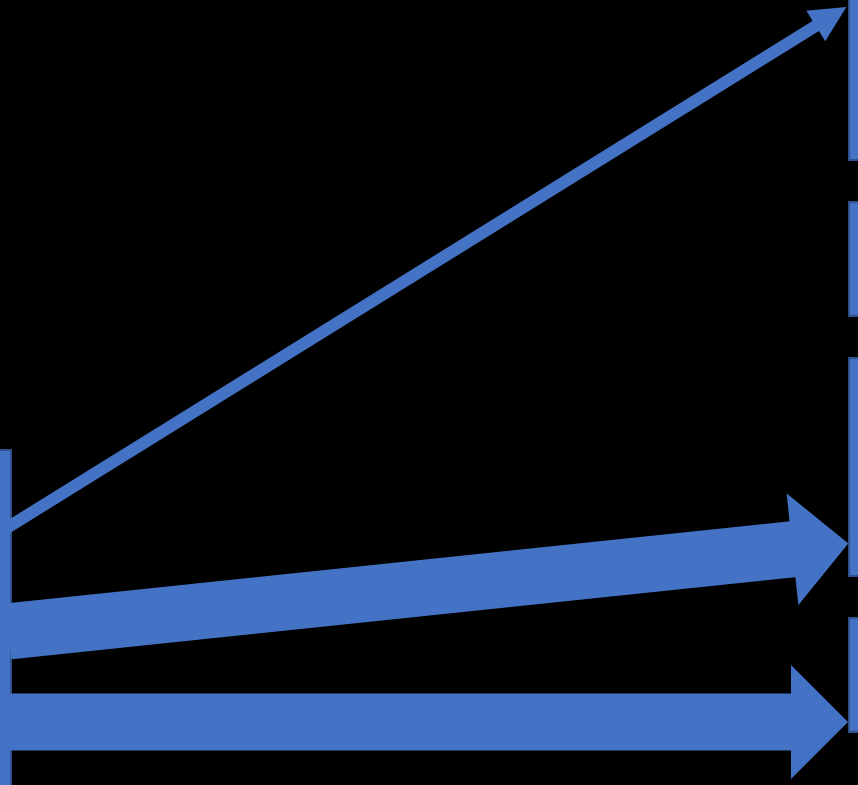
Inputs and Outputs

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

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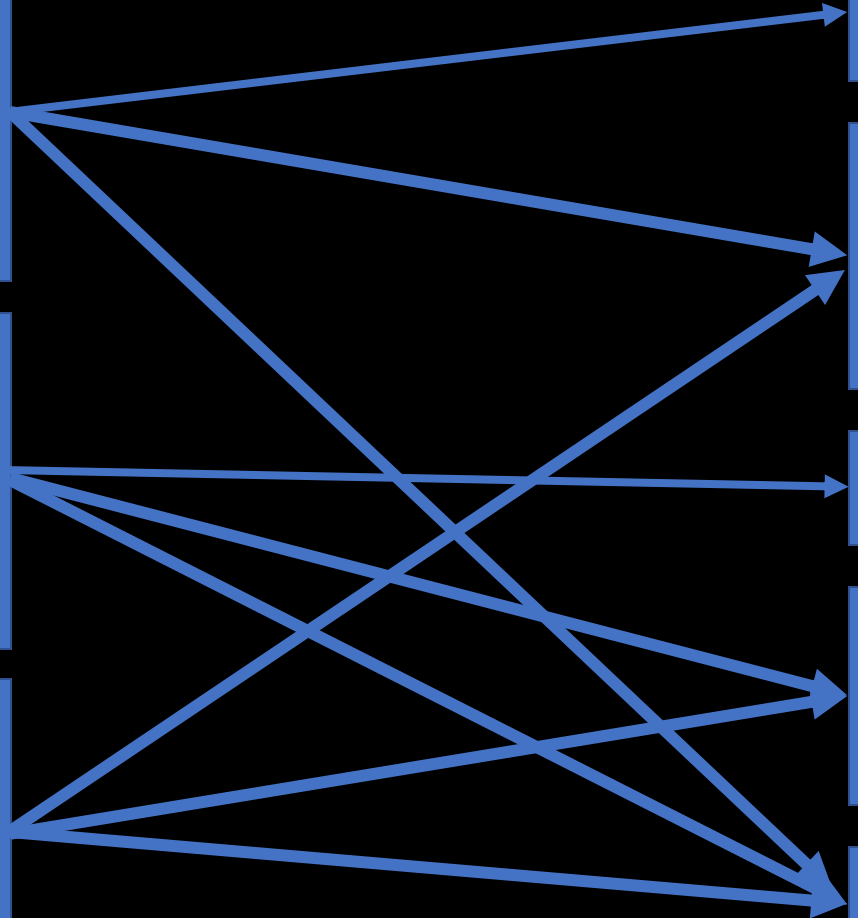
  - Forest biomass
  - MSW & wastes
  - Ag residues



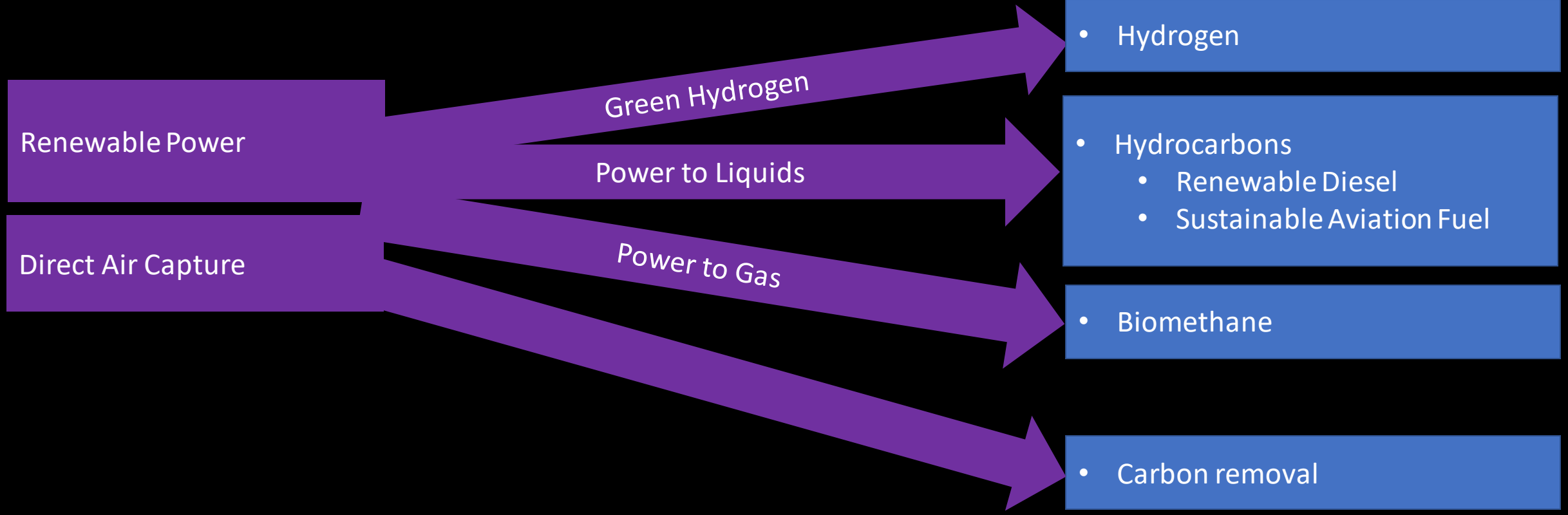
Final Products

- Ethanol
- Bio-based Diesel
  - Biodiesel
  - Renewable Diesel
- Sustainable Aviation Fuel
- Biomethane
- Zero carbon fuels
  - hydrogen
  - electricity
- Carbon removal

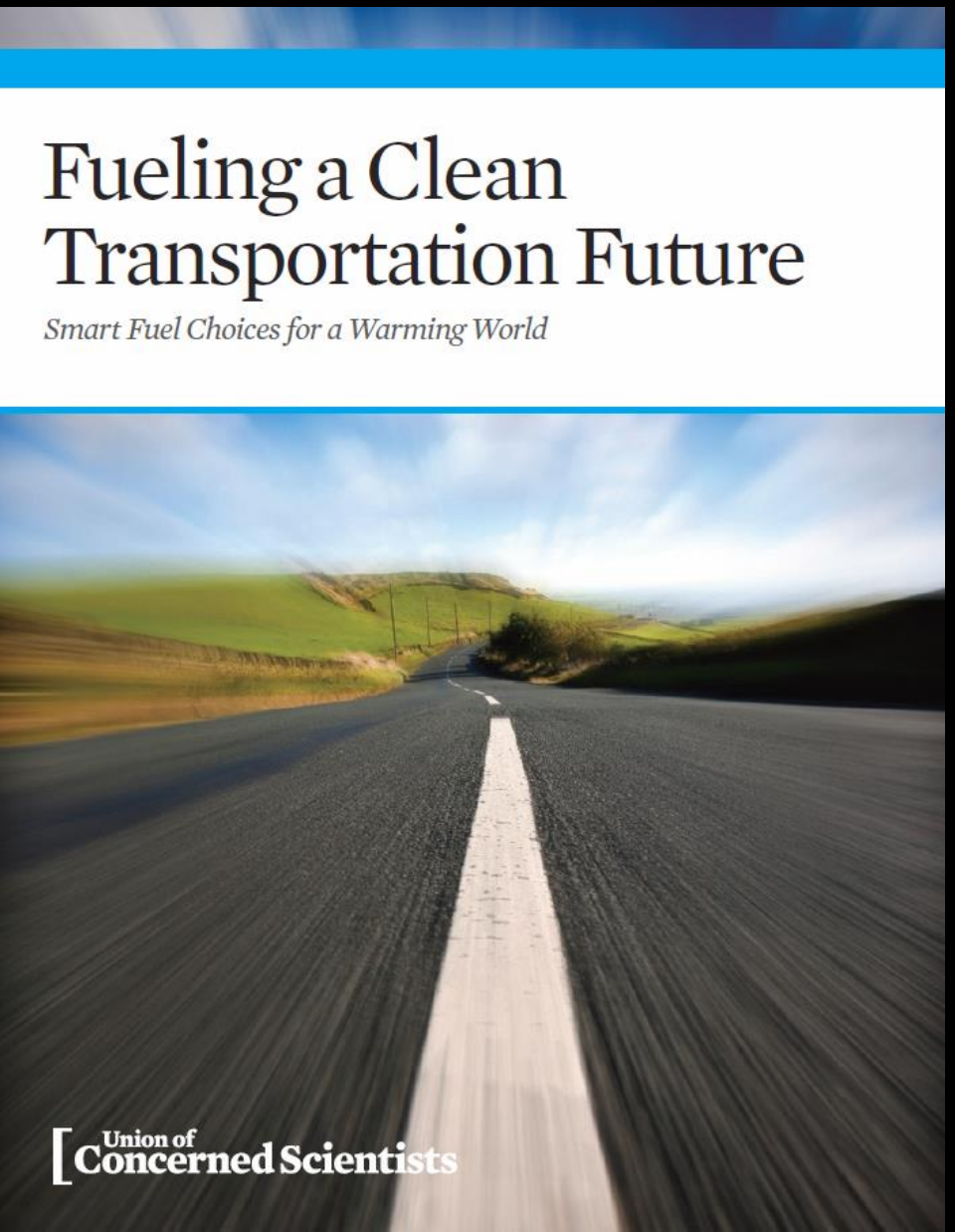
Exotic Fuels

Feedstocks

Final Products



www.ucsusa.org/fuelingacleanfuture



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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