Sustainable Aviation Fuels Under a Low Carbon Fuel Standard

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LCFS Basics
Why Adopt a LCFS?

Transportation is One of the Most Difficult Sectors to Decarbonize

- Long term future of on-road transportation is largely electric, but vehicle fleet turns over slowly.
  - May take 20+ years to complete transition after high sales levels are reached.
- VMT reduction also very slow since urban design is largely fixed.
- Electrification + VMT reduction can likely meet decarbonization targets in 2050 and beyond, but probably can’t meet near-term targets.
  - These targets have scientific meaning; not just milestones.
- Need to reduce carbon from existing fleet of vehicles to meet near-term targets.
- Biofuels are only near-term option at scale, but need life cycle analysis to mitigate risk of unacceptably high emissions.
LCFS Sets a Declining Carbon Intensity Target

Life Cycle Carbon Intensity (gCO$_2$/MJ)

- Gasoline
- Alt Fuel X
- Alt Fuel Y

LCFS Credits or Deficits

LCFS Annual Target
LCFS Diversified the Fuel Mix and Reduced Emissions
LCFS – Projecting the Next Decade

Source: California’s Clean Fuel Future
Aviation Fuels Under LCFS: California’s Experience
Aviation Fuel “Opt-in”

- California currently consumes around 4.5 – 5 billion gallons of Jet Fuel per year.

- Aviation fuels do not generate deficits under the LCFS
  - California Air Resources Board (CARB) may have authority to regulate fuels for intra-state flights, which could lead to deficits

- SAF Producers can opt in to generate credits
  - Life cycle analysis done using CA-GREET model
  - Compared against jet fuel baseline of 89.37 g CO$_{2e}$/MJ life cycle carbon intensity (CI)
  - 1.4 Million gallons of SAF from registered pathways were consumed in California in 2019 (Q2 & Q3, last data available, likely all World Energy)
Current and Expected SAF Supply

**World Energy – Paramount CA**
- Converted asphalt refinery, uses locally sourced used cooking oil, ~3 million gallon/year capacity
- Delivers primarily to Los Angeles International Airport

**Neste – Singapore**
- New SAF unit co-located with existing Renewable Diesel facility ~ 1 million tonne/year (30 million gal/year)
- Multiple feedstocks, multiple customers, including CA

**Fulcrum Energy – Storey County, NV**
- Located at municipal landfill, will take selected organic waste
- Thermochemical conversion to syncrude, 11 million gallon per year rated capacity
- Refining to fuels by Marathon Petroleum (Martinez, CA), United and Cathay Pacific have offtake agreements

**Red Rock Energy – Lakeview, OR**
- Thermochemical conversion of woody biomass, including forest product residue and fire control thinning
- 15 million gal/year capacity, FedEx has signed offtake agreement for 3 million gal/year
The Big Problem:

Indirect Land Use Change (ILUC)
ILUC Explained

- **Bad Feedstock** (e.g. Palm Oil)
- **Good Feedstock** (e.g. UCO, tallow)

Biofuel Producer
ILUC Explained

Bad Feedstock (e.g. Palm Oil) → Other Producers → Biofuel Producers

Good Feedstock (e.g. UCO, tallow)
SAF and ILUC

• Magnitude of ILUC effect in oil-based fuels is incredibly uncertain.
  • Estimates range from 0 g CO$_2$e/MJ to > 150 g CO$_2$e/MJ (palm oil under GloBIOM model)

• Near term SAF volumes likely to be largely oils
  • As will be near-term biodiesel and renewable diesel.

• Global capacity oilseed, fats, greases, etc. to meet expanding demand is unknown.

• Economic & agronomic models (including ILUC) are calibrated under relatively stable market conditions, not massive fuel-driven growth

• Cellulosics, algae, direct air capture, electrofuel, etc. likely to be lower, but not zero, environmental impact, and a long ways from commercializing.
Thank You!

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