The Role of Clean Fuel Standards on the Road to Carbon Neutrality

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Who We Are

The Policy Institute promotes constructive engagement between researchers and policy makers, in support of strong, science-based policy. Areas of focus include:

• Sustainable transportation
• Climate policy
• Low-carbon fuels
• Program Evaluation
• Environmental Justice
• Shared and autonomous vehicles

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Source:
## Clean Fuels Standards Spreading

<table>
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<tr>
<th>Jurisdiction</th>
<th>Instrument Name</th>
<th>Base Year</th>
<th>First Year of Regulation</th>
<th>Average CI Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2020</td>
</tr>
<tr>
<td>California</td>
<td>Low Carbon Fuel Standard</td>
<td>2010</td>
<td>2011</td>
<td>-7.5% (orig. -10%)</td>
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<tr>
<td>British Columbia</td>
<td>Renewable &amp; Low Carbon Fuel Requirements Regulation</td>
<td>2010</td>
<td>2011</td>
<td>-9.1% (orig. -10%)</td>
</tr>
<tr>
<td>Oregon</td>
<td>Clean Fuels Program</td>
<td>2015</td>
<td>2016</td>
<td>-2.5%</td>
</tr>
<tr>
<td>Washington*</td>
<td>Clean Fuel Standard</td>
<td>2017</td>
<td>2023</td>
<td>--</td>
</tr>
<tr>
<td>Canada*</td>
<td>Clean Fuel Standard</td>
<td>2016</td>
<td>Dec 2022</td>
<td>--</td>
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</tbody>
</table>

* Formally Proposed, but not implemented
Carbon Intensity by Fuel Pool

All 3 programs have seen over-compliance by diesel substitutes compensate for under-compliance by gasoline substitutes.
Ethanol provides very large volume of fuel, but relatively limited amount of credits.

Biomass-based diesel greatest contributor to credit generation in all jurisdictions (starting in 2019 for OR)

Outsized credit credit generation relative to energy implies low CI scores or high vehicle efficiency, e.g. electricity
Conclusions

• All 3 programs are working approximately as designed
• Most programs start slow; change is hard to perceive for first few years
• No evidence of fuel shortages or significant market failures
• Fuel pool is evolving.
  • All programs have increased the fraction of non-petroleum energy being consumed
  • Diesel substitutes have been critical to success so far.
  • Electricity is rapidly growing, but from a very small base
  • Dairy gas has supplied a lot of credits in CA due to deeply negative carbon intensity
  • Corn ethanol has incrementally improved
  • New pathways (CCS, refinery improvements, etc.) coming on-line
  • Cellulosics, hydrogen still quite limited

Program data and visualization tools available at: asmith.ucdavis.edu/data/LCFS
Modeling California’s Transition to Carbon Neutrality

Source:
Driving California’s Transportation Emissions to Zero by 2045
Background

2018 Executive Order B-55-18, set a target for carbon neutrality by 2045.

Legislature funded the UC Institutes of Transportation Studies to study of how this could be accomplished. Over 30 researchers across 4 campuses (Berkeley, Davis, Los Angeles, and Irvine) contributed to the report.

We define carbon neutrality as < 5 MMT of carbon from the transportation sector, assuming that amount could be addressed through CCS.

The study synthesized multiple streams of existing work across the campuses, and included evaluation of public health, employment, and environmental justice impacts.
CA Transportation Can Be Carbon Neutral by 2045

Multiple technology and policy portfolios could accomplish the goal.

Significant additional policy action required.

Change will be gradual. All scenarios look similar prior to 2030, changes become very apparent after that.
No Single Technology or Fuel Can Do It Alone

Electric vehicles are the most important element of a carbon-neutral transportation system.

But:

1. EVs struggle to meet 2030 or 2045 targets due to slow fleet turnover
2. EVs probably can’t meet all transportation needs (e.g. aviation, marine, specialty)
Near-Term Investments Yield Long-Term Savings

Change in Annual Costs for Vehicles & Fuel, LC1 Scenario

Higher cost of vehicles & infrastructure drives up total investment by around $10 billion through 2030 (about 1% of expected total cost in BAU).

By 2030, lower fuel and maintenance costs result in significant net savings compared to BAU. Total savings exceed $120 billion by 2045.
Key Results: Air Quality and Health

Valuation of Health Benefits in 2045, LC1 Scenario

Significant air quality improvements across the state, predominantly concentrated in areas most heavily affected by pollution.

Virtually every alternative to petroleum delivers improved air pollution characteristics as well.
Lessons and Challenges
The Obvious Stuff:

1. Support EVs As Much As Possible - EVs have the clearest trajectory to zero life cycle carbon emissions, in addition to numerous other emission, health, and economic benefits.

2. Need Fuels Policy – Need to reduce emissions from in-use vehicles, plus create supply for hard to decarbonize applications.

3. Fuels Policy Must Consider Full Life Cycle, Including Indirect Land Use Change – Biofuels can contribute to a solution, but they can be done badly without proper policy.
Target Low-Carbon Gasoline Substitutes

Consumption of Gasoline and Liquid Gasoline Alternatives (billion gasoline-equivalent gallons per year)

<table>
<thead>
<tr>
<th></th>
<th>2040 Gasoline</th>
<th>2040 Alternatives</th>
<th>2045 Gasoline</th>
<th>2045 Alternatives</th>
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</thead>
<tbody>
<tr>
<td>BAU Scenario</td>
<td>8.7</td>
<td>1.3</td>
<td>8.2</td>
<td>1.3</td>
</tr>
<tr>
<td>LC1 Scenario</td>
<td>1.6</td>
<td>3.2</td>
<td>0</td>
<td>2.6</td>
</tr>
<tr>
<td>ZEV Scenario</td>
<td>1.3</td>
<td>2.6</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

Even under the most ambitious ZEV deployment scenarios, substantial liquid fuel demand remains through 2045. Sufficient options probably exist for diesel, but gasoline will be a challenge.

Need ~ 2 billion gallons/year of <12 g CO₂e/MJ gasoline substitute by 2040. Several possible options:

- Advanced cellulosic fuels.
- Algal biofuels.
- Electro-fuels.
- Intensive CCS during fuel production.
Emissions Reduction vs. CCS

Carbon-neutral scenarios assume ~5 MMT of net-negative CCS (i.e. not part of an already counted fuel pathway) in 2045 to deal with residual emissions.

More emission reductions mean less need for CCS. Especially important re: liquid fuels.
LCFS Will Radically Change by Late 2030’s

LCFS helps ensure that economic incentives match emission-reduction priorities. Current model: Small charge applied to very large pool of conventional fuels provides large per-gallon incentives for small pool of alternative fuels.

If we succeed, petroleum will represent less than 50% of fuel by mid-2030’s.

• Difficult to maintain same per-gallon level of support with much smaller pool of petroleum fuels accumulating deficits.
• Many alternative fuels will be cost-competitive without subsidy by then (e.g. electricity)
• Some types of low-carbon fuel will still need a lot of support (very-low carbon gasoline, SAF)

Will likely need to reduce support for electricity & other cost-competitive fuels in order to focus support on most difficult areas to decarbonize.
Multiple Revolutions Ahead

• Most currently available options lack a clear pathway to zero carbon
• Likely to see fuels emerge, grow to > 1 billion gallon/year volumes, then disappear from CA market over next 20 years.
• RNG important now, but rapidly fades out once avoided methane credit is lost.

Need to start differentiating between fuels with plausible pathway to zero (or very near zero) emissions, and those without.
Carbon Neutrality is Likely to Enhance Equity

Insufficient data exist to fully quantify emission benefits of most alternative fuels.
  • Where are alternative fuels consumed?

LCFS has historically seen over-compliance by diesel substitutes. This is likely to continue through mid-late 2020’s.
  • Major PM benefits for diesel substitutes.

Disadvantaged communities are disproportionately affected by diesel pollution.

Alternative fuel production is likely to be lower emitting than petroleum overall
  • High uncertainty around refinery conversions from petroleum to renewable fuels
  • There may be some local impacts

Likely to see concentration of air quality benefits in disadvantaged communities.

Need more data, esp. vehicle activity data, to quantify benefits.
LCFS Benefits a Broad Coalition

17 In-state biofuel production facilities

14 Businesses receive at least $6.5 million annually in LCFS credits.

20 Utilities receive LCFS credits for household charging.

76 On-road electric fleets, 1600+ electric forklifts

12,000+ EV Charging Stations, 500 CNG Stations

Almost $3 Billion in total credit value in 2019

> 81 million metric tons of GHG reduction to date

Source: CARB – LCFS Data Dashboard
For More Information

LCFS Program Website
https://www.arb.ca.gov/fuels/lcfs/lcfs.htm

LCFS Data and Analytics Website
https://asmith.ucdavis.edu/data/LCFS

Driving California’s Transportation Emissions to Zero – UC Institutes of Transportation Studies
Report on Carbon Neutrality in CA Transportation
https://doi.org/10.7922/G2MC8X9X

Review of LCFS Programs in California, Oregon and British Columbia
https://escholarship.org/uc/item/080390x8

California’s Clean Fuel Future

ICF Study of LCFS and Cap-and-Trade Interaction
Resources and Further Reading

- Forbes blog written by Dan Sperling and Colin Murphy – “How (Almost) Everyone Came to Love the LCFS”. This discusses the history of the LCFS and the political coalition that has emerged to defend it.

- CARB LCFS Program Page - Very deep resource containing many important resources including regulatory text, fuel pathway carbon intensities, quarterly program data, rulemaking documents and more.

- CalETC / ICF Evaluation of ZEV and other low-carbon technologies for Medium and Heavy Duty Vehicles – Compares emissions and total cost of ownership of conventional, EV, hydrogen and NG vehicles for first owner for a variety of MD and HD vehicle types.

- Potential low carbon fuel supply to the Pacific Coast region of North America (2015) – Report by (ICCT), led by Dr. Chris Malins, on LCFS credit supply to Pacific Coast Collaborative jurisdictions (CA, OR, WA, BC)

- Half the Oil: Pathways for Petroleum Reduction on the West Coast (2016) – Report by ICF on policy measures which would allow CA, OR, WA to reduce petroleum consumption by half in 2030.

- 2013 Expert Evaluation of BCG Report - UC Davis-led evaluation of oil industry-sponsored study that was highly critical of proposed LCFS. Spoiler: Oil industry projections of harm from LCFS were not justified then, and have not come true.

Presentations

- Transportation Fundamentals: LCFS, Introductory talk for policy makers

- Keynote talk from Oil Price Information Service LCFS conference - Role of LCFS in energy markets.
Selected Academic Papers from UC Davis


D. Sperling and Sonia Yeh, “Transforming the Oil Industry into the Energy Industry,” Access (University of California Transportation Center), No. 34, Spring 2009, pp. 20-28.


We Are Happy to Answer Questions!

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Fuel Transition: Gasoline

- Ethanol is primary option in near-term, but electricity is primary long-term solution.
- ZEV-focused scenario (not pictured) showed you can deploy EVs slightly faster, but not much.
- Need for low-emission gasoline substitute to deal with residual conventional vehicles
Fuel Transition: Diesel

- LC1 depends on RD, BD & RNG at first, but electricity and hydrogen take over at the end.
- Fossil diesel displaced by 2041
2. Set ambitious LCFS targets

Consider: 24% 2030 LCFS Target
54% 2035 LCFS Target

Current 2030 LCFS target is 20% CI reduction. Long-run target is essentially zero. The more you do early, the less you have to back-load the reductions.

These results reinforce conclusion of modeling done for 2018 LCFS extension: Likely to see significant credit surplus by late 2020’s without change.

Fuel producers need long-term guarantees to support investment, setting 2035 target now provides that.
3. Land Use Change Risk Must Be Addressed

Lipid-based BD, RD, SAF are scalable and cost-competitive with current policy incentives, but the supply of waste & residual lipids is far smaller than fuel demand.

Crop-based oils likely to comprise majority of growth in this space, which creates risk of habitat and carbon loss due to expanded cultivation (a.k.a. Indirect Land Use Change or “ILUC”).

ILUC is insufficiently understood, difficult to model, and challenging to prevent.

Soybean oil BD/RD generally yields 30-40% lower carbon than petroleum over full life cycle, accounting for (ILUC), plus > 90% PM reduction (and small NO$_x$ reduction for RD)

Challenge: How to maximize GHG and air pollution benefits of lipid-based fuels, but not increase demand beyond sustainable limits.
The Role for Fuels Policy

• Near-term emission reductions matter

• EVs are the long-term future, but the fleet turns over slowly

• Biofuels are the dominant (only?) near-term option for existing vehicles
  • May be the dominant/only long-term option for some applications, e.g. aviation

• Without life cycle analysis, easy to get biofuels wrong
  • E.g. European palm oil biodiesel

• Need to balance incremental benefit of 1st gen fuels while providing large incentives for advanced, very low-carbon fuels.
LCFS Creates Monetary Incentives to Lower Fuel CI

- If credits & deficits balance, average fuel CI rating hits target
- To comply, distributors of high-carbon fuels must reduce fuel emissions, or buy enough credits to comply
  - Incentive to squeeze carbon out anywhere along supply chain
  - Declining target creates long term incentive for innovation
- Credits are tradable, bankable
  - Lower compliance costs
  - Revenue neutral (not zero cost)