How Carbon Intense Is Your Fuel?

Featured speaker: Dr. Anil Prabhu, California Air Resources Board
March 8, 2017
Kimberley Cline
Coordinator | Partnerships, Policy & Outreach

Robin Gold
Coordinator | Alternative Fuels & Technology
Why renewable fuels?

- Reduce dependence on foreign oil
- Benefit American farmers
- Recycle waste products
- Reduce air pollution
- Improve engine performance
-Reduce greenhouse gas emissions
“Closed carbon lifecycle”
Not all renewable fuels are created equal
Low Carbon Fuel Standard

LOW-CARBON FUELS IN THE PACIFIC REGION
Today’s Webinar

• Pathways for renewable diesel & other fuels, and their carbon intensity scores
• How this information can inform fuel purchase decisions
• California’s system for fuel source verification and accountability

Questions?

• Use the webinar chat tool
Anil Prabhu, PhD
Fuel Evaluation Manager
California Air Resources Board
Carbon Intensity of Transportation Fuels under the Low Carbon Fuel Standard

Western Washington Clean Cities Coalition

Webinar

March 8, 2017

Anil Prabhu
Manager, Fuels Evaluation Section

California Environmental Protection Agency

Air Resources Board
Overview of Presentation

• Introduction to the Low Carbon Fuel Standard (LCFS)
• Lifecycle Analysis in the LCFS
• Status of the LCFS
• Monitoring and Verification
• Additional Information
LC FS History

• Original adoption in 2009, first compliance year in 2011, re-adopted in 2015

• Goal: Reduce carbon intensity (CI) of transportation fuel pool by at least 10% by 2020

• Expected benefits:
  • Reduce greenhouse gases
  • Transform and diversify fuel pool
  • Reduce petroleum dependency
  • Reduce emissions of other air pollutants
LCFS is Part of a Portfolio of GHG Policies

- Transportation sector responsible for:
  - 40% of GHG emissions
  - 80% NOx emissions
  - 95% PM emissions

- LCFS works with the following programs to reduce transportation GHG emissions:
  - Cap-and-Trade Program
  - Advanced Clean Car Program
  - SB 375

- Key program to achieve Governor’s petroleum reduction goal by 2030
Declining Carbon Intensity Curve

- Percent Reduction in Carbon Intensity

Histories CI Targets
- Future CI Targets
- Achieved CI Reduction

Fuels above standard generate deficits
Fuels below standard generate credits

= deficits
= credits
Lifecycle Analysis in the LCFS
Carbon Intensity (CI) Through Lifecycle Analysis

CI includes the direct effects of producing and using the fuel, as well as indirect effects, including land use change, that are primarily associated with crop-based biofuels.

Calculated using the following tools:
- California Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (CA-GREET) for direct carbon intensity of fuel production and use
  https://www.arb.ca.gov/fuels/lcfs/ca-greet/ca-greet.htm
- Oil Production Greenhouse Gas Emissions Estimator (OPGEE) for direct carbon intensity of crude production and transport to the refinery
  https://www.arb.ca.gov/fuels/lcfs/crude-oil/crude-oil.htm
- Global Trade Analysis Project (GTAP) and Agro-Ecological Zone Emissions Factor (AEZ-EF) for indirect land use change
  https://www.arb.ca.gov/fuels/lcfs/iluc_assessment/iluc_assessment.htm
Carbon Intensity Values for all Pathways

EER-Adjusted Carbon Intensity (gCO2e/MJ)
Fuel Lifecycle for California Reformulated Gasoline Blendstock for Oxygenate Blending (CARBOB)\textsuperscript{1}

- **CARBOB**: 100 gCO\textsubscript{2}e/MJ *  
  * Totals may not sum due to rounding
- **74 g/MJ**: Vehicle
- **1 g/MJ**: Transportation
- **14 g/MJ**: Refinery
- **12 g/MJ**: Oil Well

\textsuperscript{1} CARBOB makes up the petroleum fraction of California reformulated gasoline (CaRFG) before any fuel oxygenate is added.
**Fuel Lifecycle for Corn Ethanol**

- **Com Ethanol**: 79 gCO₂e/MJ
  * Totals may not sum due to rounding

- **Biogenic CO₂ Emissions**: 33 g/MJ

- **Other Tailpipe Emissions**: 1 g/MJ

- **Transportation Blend with CARBOB**: 32 g/MJ

- **Co-Products**: -13 g/MJ

- **Land Use Change**: 20 g/MJ

- **Other Tailpipe Emissions**: 1 g/MJ

- **Vehicles**: 3 g/MJ

- **Biorefining**: 3 g/MJ

- **Agriculture**: 3 g/MJ

- **Transportation**: 3 g/MJ
Fuel Lifecycle for Electricity in Light Duty Vehicles

California Average Grid Electricity
31 gCO₂e/MJ *
* Totals may not sum due to rounding

- EV Efficiency relative to gasoline (3x)
  -74 g/MJ

- Electrical Generation Facility
  - 84 g/MJ

- Transportation
  - 5 g/MJ

- EV Charging Station
  - 6 g/MJ

- Electric Vehicles
  - 0 g/MJ

- Electricity Resource Mix
  - 10 g/MJ

5 g/MJ
Fuel Lifecycle for Landfill Gas to CNG

- **Biogas to CNG in California**: 25 gCO₂e/MJ*
  - *Totals may not sum due to rounding

- **CNG Trucks + efficiency penalty**: 64 g/MJ

- **Compression & Refueling**: 2 g/MJ

- **Pipeline Transmission**: 5 g/MJ

- **Biogas Upgrading**: 19 g/MJ

- **Landfill Gas Recovery**: 1 g/MJ

- **Avoided Flare Credit**: -66 g/MJ *

* Totals may not sum due to rounding.
Fuel Lifecycle for Ultra Low Sulfur Diesel (ULSD)

ULSD
102 g CO$_2$e/MJ *
* Totals may not sum due to rounding

75 g/MJ
Vehicle

1 g/MJ
Fuel Transportation

15 g/MJ
Refinery

11 g/MJ
Transportation

Oil Well
Fuel Lifecycle for RD from Soy Oil

- **Biogenic CO₂ Emissions**: 4 g/MJ
- **Other Tailpipe Emissions**: 1 g/MJ
- **RD Transport & Delivery**: 3 g/MJ
- **Hydrotreater**: 11 g/MJ
- **Transportation**: 4 g/MJ
- **Soy Oil Extraction**: 1 g/MJ
- **Agriculture**: 1 g/MJ
- **Land Use Change**: 29 g/MJ
- **Vehicle**: Soy Oil Renewable Diesel 54 gCO₂e/MJ*

*Totals may not sum due to rounding.
Fuel Lifecycle for RD from Used Cooking Oil (UCO)

- **Biogenic CO₂ Emissions**
  - Used Cooking Oil Collection
  - Used Cooking Oil Filtration/Rendering
  - Oil Transport
  - Biorefining (Hydrotreater)
  - Oil Transport
  - Used Cooking Oil Collection

- **Other Tailpipe Emissions**
  - 1 g/MJ
  - 3 g/MJ
  - 11 g/MJ
  - 1 g/MJ
  - 4 g/MJ

- **Diesel Cars/Trucks**

- **Renewable Diesel**
  - 20 gCO₂e/MJ*
  - Totals may not sum due to rounding
Fuel Lifecycle for BD from Soy Oil

**Agriculture**
- **Soy Transportation:** 5 g/MJ
- **Soy Extraction:** 1 g/MJ

**Transport**
- **Oil Transportation:** 4 g/MJ
- **Bio-refining (Transesterification):** 11 g/MJ
- **Vehicle:** 2 g/MJ

**Bio-refining (Transesterification)**
- **Soy Oil Biodiesel:** 55 gCO₂e/MJ*
  * Totals may not sum due to rounding

**Land Use Change**
- 29 g/MJ

**Tailpipe Emissions**
- 1 g/MJ

**Biogenic CO₂ Emissions**
- 4 g/MJ
# Feedstock Carbon Intensities (g/MJ)

<table>
<thead>
<tr>
<th>Biodiesel Feedstock Production</th>
<th>Crop-Based</th>
<th>Secondary Product</th>
<th>Residue-Based</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Soy Oil</td>
<td>Canola Oil</td>
<td>Palm Oil</td>
</tr>
<tr>
<td>Crop Faming, Agricultural Chemicals, N₂O in Soil</td>
<td>5</td>
<td>23</td>
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<tr>
<td>Crop Transport</td>
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<td>1</td>
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<tr>
<td>ILUC</td>
<td>29.1</td>
<td>14.5</td>
<td>71.4</td>
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<tr>
<td>Oil Extraction</td>
<td>4</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Oil Transport</td>
<td>2</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Treatment/Rendering</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Rendered Oil Transport</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Example Feedstock Upstream CI</td>
<td>41</td>
<td>46</td>
<td>high</td>
</tr>
<tr>
<td>Biodiesel CI Range</td>
<td>49-60</td>
<td>51-62</td>
<td>high</td>
</tr>
</tbody>
</table>
Feedstocks used for RD reported in the LCFS*

*Q1 through Q3, 2016
Status of the LCFS
Before the LCFS, natural gas and ethanol were the only alternative fuels with any market share.

In 2015, we had 320 million gge of Bio- and Renewable Diesel, and 80 million gge of Biomethane (50% of natural gas used in transport).
Monitoring and Verification
Current Process to Ensure Compliance

- Regulation requires fuel producers to attest to all information submitted as part of fuel CI certification.
- LCFS requires end-user to maintain records which list fuel pathway code (FPC) and corresponding carbon intensity (CI).
- Records can be requested by ARB as part of an audit.
Verification Considerations

- Addition of mandatory third-party verification for all fuels being considered in the LCFS

- Initial proposal for all liquid fuels:
  - The producer may be subject to verification of CIs and corresponding fuel volumes
  - The importer may be subject to verification of LRT-C BTS reports, when the producer does not opt in, for FPC allocation to fuel volumes
  - The exporter may be subject to verification of LRT-C BTS reports of exported fuel volumes

- For renewable diesel and biodiesel, a major emphasis may be on feedstock verification
Verification for UCO

Need for focused attention on UCO verification:

- Ultra-low CI for UCO derived renewable diesel generates significant LCFS credits
- Potential for vegetable oil or other higher CI feedstocks to be mischaracterized as UCO
- Challenges related to chain-of-custody verification for UCO
- Exploring several options to implement traceability for UCO
Additional Information
LCFS-like policy has been implemented elsewhere in North America

- **Pacific Cost Collaborative**
  British Columbia, Washington, Oregon, and California (Recent workshop in Nov 2016)

- **Canada’s Clean Fuel Standard** - Early Planning Stages

- **Oregon’s Clean Fuels Program** - Fully implemented in 2016, Requires 10% CI reduction by 2025

- **BC’s Low Carbon Fuel Requirements** - Standard requires 15% reduction in CI by 2030
For More Information

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

LCFS Pathways Table:  
https://www.arb.ca.gov/fuels/lcfs/fuelpathways/pathwaytable.htm

LCFS Contact:

• Anil Prabhu, Manager, Fuels Evaluation Section  
  Anil.Prabhu@arb.ca.gov  (916) 445-9227

• Sam Wade, Chief, Transportation Fuels Branch  
  Samuel.Wade@arb.ca.gov  (916) 322-8263