

Low Carbon Fuel Standard: evaluation of alternative jet fuel inclusion

Public Working Meeting for Stakeholder Groups
March 17, 2017



Participating Remotely

- Posted materials can be found on the LCFS Meetings webpage https://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/lcfs_meetings.htm
- To ask questions or provide feedback during the working meeting
 - Email coastalrm@calepa.ca.gov
 - Participate via conference call
 - 888-469-0876 (domestic)
 - 1-517-308-9246 (international)
 - Participant code: 3935848



Outline

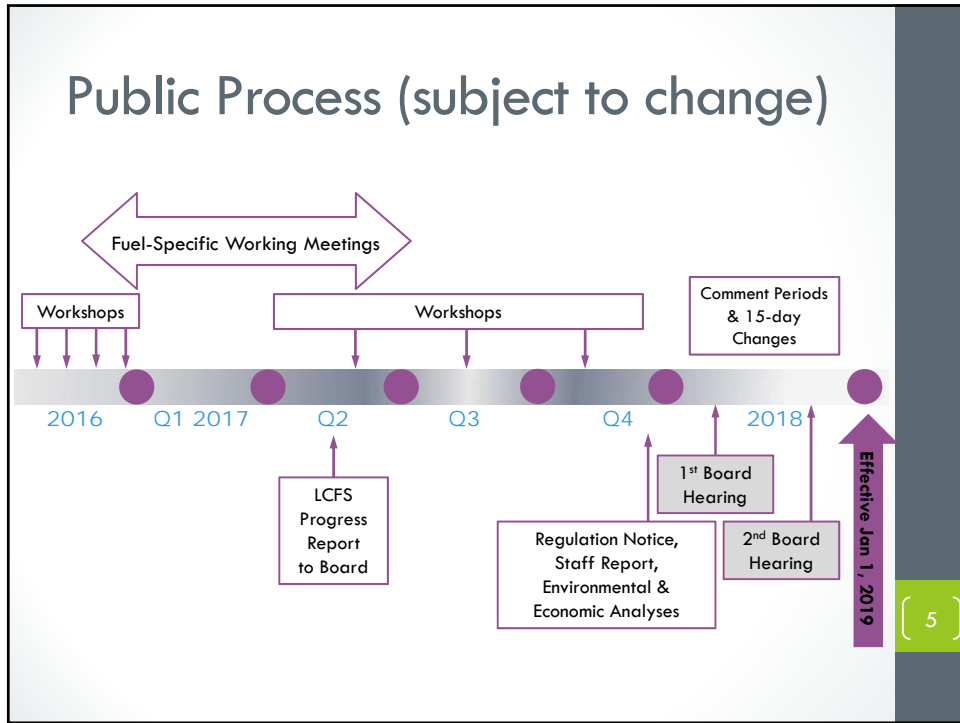
- Introduction
- Updates on LCFS Program Activities
 - Public Process and Fuel-Specific Working Meetings
 - Biofuel Supply Module
- Potential Inclusion of Alternative Jet Fuel
- Presentation by NREL on Potential AJF Volumes
- Next Steps

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Updates on LCFS Program Activities

PUBLIC PROCESS AND FUEL-SPECIFIC WORKING MEETINGS

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- ## Public Process cont.
- Quarterly Workshops
 - Workshops will focus on major program-related topics including:
 - Presentation of model updates
 - Findings from fuel-specific working meetings
 - Verification-related proposals
 - Consideration of post-2020 targets
 - Public materials will include: preliminary draft regulatory text for discussion and informal feedback, findings of new/updated models.
 - Next workshop tentatively scheduled for June 26
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Working Meeting Update

- Focus on verification requirements & related improvements/streamlining to pathway application, evaluation, and reporting
- Several fuel-specific working meetings were held in December 2016, January and February 2017:
 - Natural Gas and Biomethane
 - Electricity and Hydrogen
 - Potential Verifiers and Verification Bodies
 - Refinery Co-Processing
 - Ethanol
 - Biomass-based Diesel *

* Included topics relevant to stakeholders for alternative jet fuel, such as feedstock verification requirements

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Working Meeting Schedule

- Upcoming working meetings tentatively planned for the following dates:

Topic/Fuel Type	Proposed Date
Revisions to OPGEE	April 4
Natural Gas and Biomethane (follow-up meeting)	April 17
Biomass-based Diesel (follow-up meeting)	May 15
Refinery Co-Processing (follow-up meeting)	June 2
Gasoline, Diesel and Crude Oil (1 st meeting)	June 2
Ethanol (follow-up meeting)	June 19

No follow-up meeting is anticipated for Electricity & Hydrogen stakeholders; discussion papers will be updated and posted

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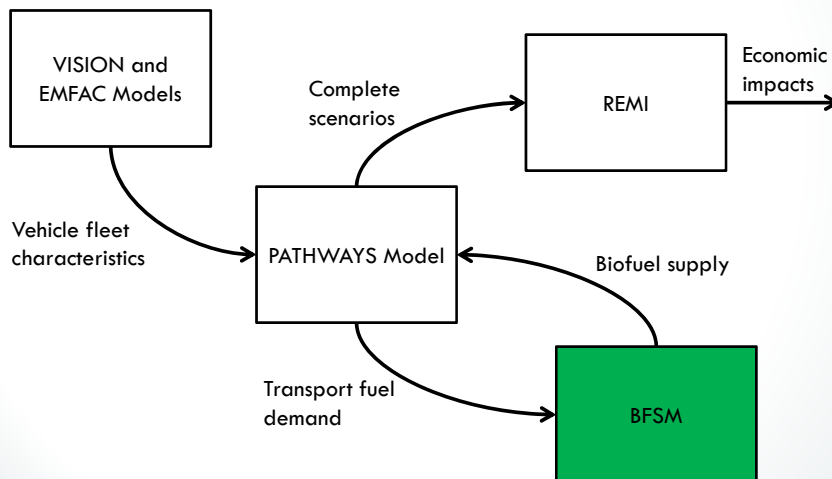
Meeting details and supporting documents available at:
https://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/lcfs_meetings.htm

Updates on LCFS Program Activities

BIOFUEL SUPPLY MODULE (BFSM)

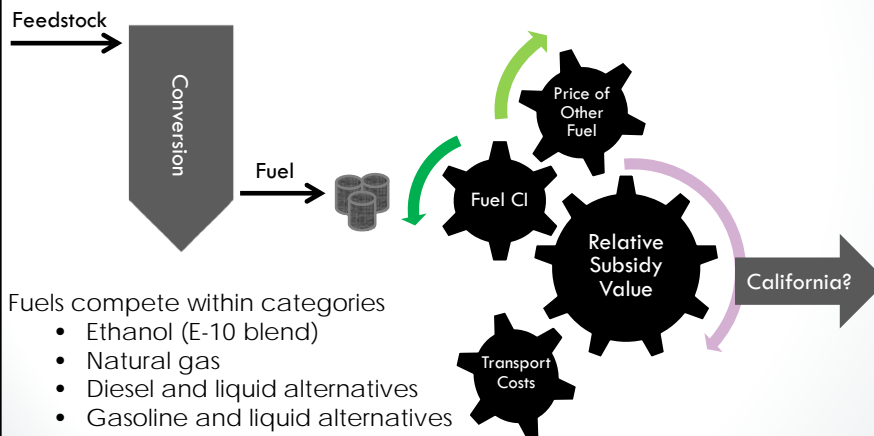
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BFSM utilized for scenario modeling in the 2017 Scoping Plan Update



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Initial Release of BFSM Model was in September 2016 (v0.83b)



<https://www.arb.ca.gov/cc/scopinaplan/meetings/090716/bfsmv83b.zip>

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New version of BFSM released January 2017 (v 0.91b)

Updates in response to stakeholder comments:

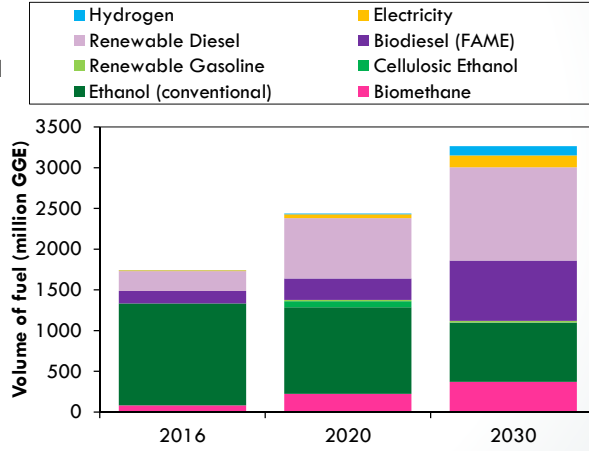
- Feedstock carbon intensities
- Costs for a variety of technology pathways
- Dairy Digester supply based on supply curves from California-specific study
- Biodiesel and Renewable Diesel compete for same lipid supply
- California share of available biomass decreases over time
- Technology adoption ramp rate reduced

https://www.arb.ca.gov/cc/scopinaplan/bfsm_module.zip

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Proposed 2017 Scoping Plan: 18% LCFS – Volumes

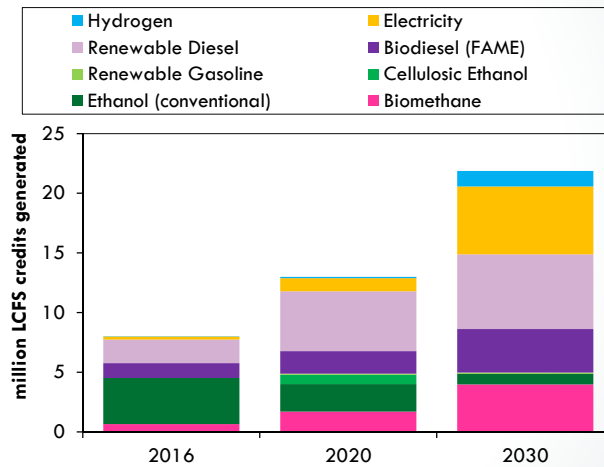
18% Scenario: model results indicate increased volumes for renewable diesel, biodiesel, and biomethane.



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Proposed Scenario: 18% LCFS – Credits

Electric vehicles, biomass-based diesels and low-carbon biomethane are responsible for the majority of credit generation in the modeled 18% LCFS scenario



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Next Steps

The BFSM can be used for exploring LCFS target setting.

- Explore different fuel demand scenarios and EV adoption rates
- Explore additional low-carbon fuel pathways (e.g. alternative jet fuel)
- Explore additional credit generating opportunities (e.g. CCS)

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More information is available

Revised Module and Documentation:

<https://www.arb.ca.gov/cc/scopingplan/meetings/meetings.htm>

Modeling Contact:

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POTENTIAL INCLUSION OF ALTERNATIVE JET FUEL

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Initial Staff Thinking

ARB staff is considering developing a proposal to:

- Allow alternative jet fuel (AJF) to generate LCFS credits as an opt-in fuel
- Conventional jet fuel would not be subject to the regulation and would not generate deficits
- Not developing new set of specifications for jet fuel

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Aviation Industry Interest in Alternative Jet Fuel

- Provide potential environmental benefits
 - In February 2016, U.S. and 22 countries reached an agreement on global carbon standards for commercial aircraft to reduce carbon emissions more than 650 million tons between 2020 and 2040
- Diversify sources of jet fuel and reduce volatility in price
- Improve reliability and security of supply
- Provide other economic benefits

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Background: Alternative Jet Fuels

- AJFs are drop-in fuels which can replace conventional jet fuels without the need to modify aircraft engines and existing fuel distribution infrastructure
- When blended with conventional jet fuel, AJFs have the same performance characteristics as conventional jet fuel
- Feedstocks include both renewable and non-renewable sources

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ASTM International Standard (D7566)

Annex	Blending Limit
Fischer-Tropsch Hydroprocessed Synthetic Paraffinic Kerosene (FT-SPK)	50%
Synthesized Paraffinic Kerosene from Hydroprocessed Esters and Fatty Acids (HEFA-SPK)	50%
Alcohol-to-Jet Synthetic Paraffinic Kerosene (ATJ-SPK)	30%
Synthesized Iso-Paraffins Produced from Hydroprocessed Fermented Sugars (SIP)	10%
Synthesized Kerosene with Aromatics Derived by Alkylation of Light Aromatics from Non-Petroleum Sources (SPK/A)	50%

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Alternative Jet Fuel Pathways: Bio-Oil-to-Jet

Process	Bio-oils are converted to drop-in jet fuels by a series of hydrogenation, hydrodeoxygenation, hydroisomerization, and hydrocracking reactions
Feedstock	Plant oils, algal oils, used cooking oil, and animal fats (tallow); pyrolysis oil
Producers (Feedstocks)	<ul style="list-style-type: none"> • AltAir Fuels (agricultural waste and non-edible oils) • SG Preston (waste and various non-edible oils) • Monarca Biofuel (jatropha seed oil) • Neste (camelina oil, PFAD) • ARA (any fat, oil, or grease using CH process)

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Alternative Jet Fuel Pathways: Gas-to-Jet

Process	Biogas or syngas (from gasification) is converted to drop-in jet fuels by Fischer-Tropsch or gas fermentation
Feedstock	Natural gas, renewable natural gas, and biomass or coal via gasification
Producers (Feedstocks)	<ul style="list-style-type: none"> • Fulcrum Bioenergy (municipal solid waste) • Red Rock Biofuels (woody biomass)

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Alternative Jet Fuel Pathways: Alcohol-to-Jet

Process	Alcohols (ethanol, butanol, etc.) are converted to drop-in jet fuels by alcohol dehydration, oligomerization, hydrogenation, and fractionation
Feedstock	Alcohols from corn, crop residues, forest residues, dedicated energy crops, and industrial waste gases
Producers (Feedstocks)	<ul style="list-style-type: none"> • Gevo (renewable carbohydrates to isobutanol) • Lanzatech (industrial waste gases) • Byogy (any ethanol feedstock)

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Alternative Jet Fuel Pathways: Sugar-to-Jet

Process	Sugars are converted to drop-in jet fuels by catalytic upgrading or fermentation to hydrocarbon intermediates followed by upgrading
Feedstock	Sugars and sugar intermediates from crops, crop residues, forest residues, dedicated energy crops
Producers (Feedstocks)	<ul style="list-style-type: none"> • Total/Amyris (sugarcane) • BioEnergy Hawaii (sorghum and eucalyptus)

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Potential Benefits of Including AJF

- Reduction in global GHG emissions
 - GHG emissions from airlines contribute 2 to 3% of total global emissions and are increasing
 - Airlines can directly reduce GHG emissions through efficiency improvements and use of renewable fuels
- Increase in total volume of renewable fuels
 - Airline industry is developing a strong track record for partnering with AJF producers to build new facilities
- Reduced criteria pollutant emissions from jet fuel combustion
 - Significant reduction in PM and SO_x
 - Slight reduction or no change in NO_x

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Examples of Airline Partnerships with AJF Producers

Producer	Airline Partner	Offtake Agreement
Fulcrum Bioenergy	Cathay Pacific	375 MMG over 10 years
	United Airlines	90-180 MMGPY over 10 years
Red Rock Biofuels	Southwest	3 MMGPY for 8 years
	FedEx	3 MMGPY for 8 years
AltAir Fuels	United Airlines	5 MMGPY from 2016
SG Preston	JetBlue	10 MMGPY over 10 years

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Examples of Airline Partnerships with AJF Producers cont.

Producer	Airline Partner	Offtake Agreement
Hawaii BioEnergy	Alaska Airlines	Supply from 2018
Total/Amyris	Cathay Pacific	180,000 gal
Gevo	Lufthansa	Up to 40 MMG over 5 years (MOU)
Monarca BioFuel	Mexican government's Aviation services Department	30 MMGPY

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Credit Generation of AJF in the LCFS

- Initial thinking:
 - Allow producers or importers of AJF to opt in as credit generators
 - Allow credit generation for AJF loaded to all planes in California, whether destinations are in state or out of state
 - Allow credit generation for military use of AJF
- Potential amendment would be included in the subsequent rulemaking amendment process, proposed to go into effect on January 1, 2019

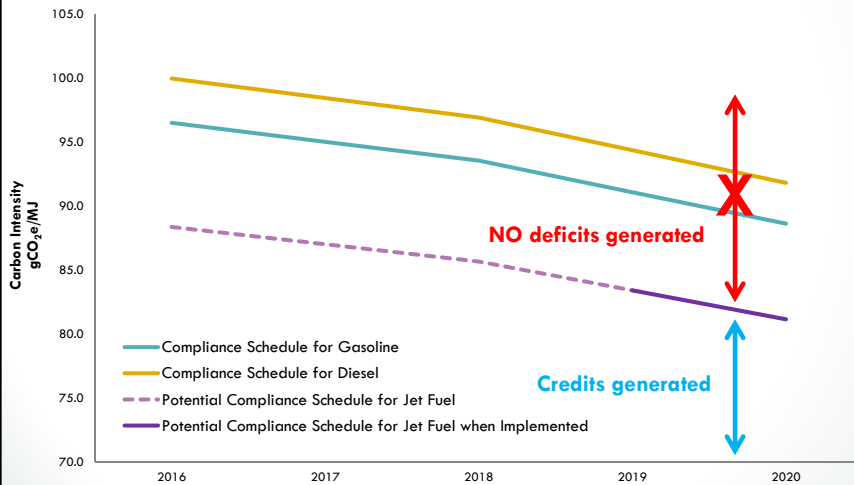
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Calculation of Carbon Intensity

- CA-GREET model would be used to calculate the CI of
 - Alternative jet fuel pathways
 - 2010 baseline CI for conventional jet fuel
- “Well to wheels” lifecycle assessment examines GHG emissions associated with production, transportation, and use of the fuel
- CI for alternative jet fuel will be compared to an annual compliance curve anchored to the 2010 baseline CI for conventional jet fuel

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How Credits would likely be Calculated for Alternative Jet Fuel



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Re-Evaluation of other Fuel Exemptions under LCFS

- Propane
 - Considering removing exemption on propane from 95482(c)(2)
 - Limited to propane used as a transportation fuel
- Alternative fuels used in military tactical vehicles
 - Considering removing exemption on military tactical vehicles from 95482(d)(1) to allow it to become opt-in fuel

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NREL PRESENTATION ON POTENTIAL AJF VOLUMES

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THANK YOU!

Feedback should be sent to
LCFSworkshop@arb.ca.gov
by April 17, 2017

Posted information from today's working meeting can be found at
https://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/lcfs_meetings.htm

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