

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 coastalm@calepa.ca.gov
 - Participate via conference call
 - 888-469-0876 (domestic)
 - 1-517-308-9246 (international)
 - Participant code: 3935848

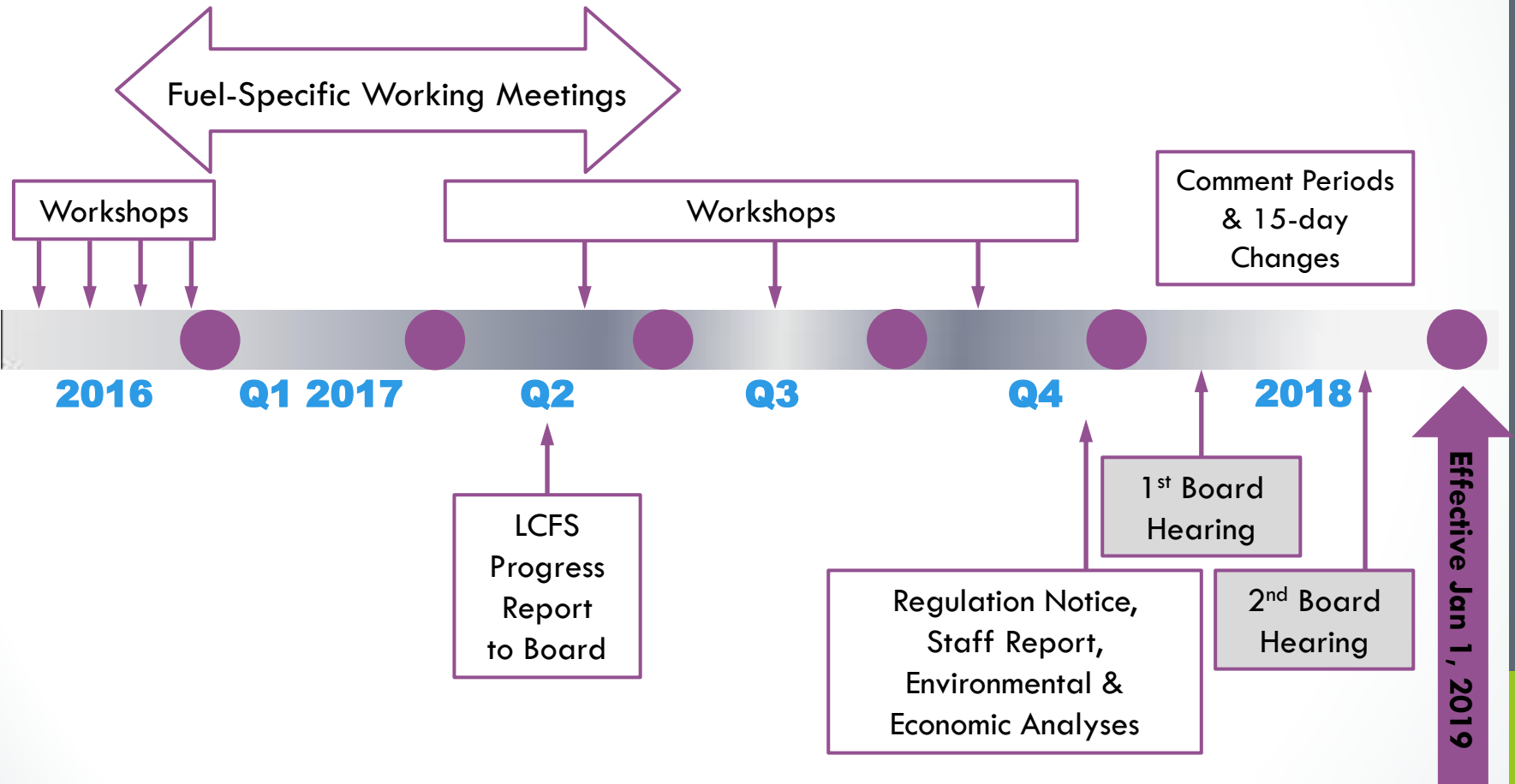
Outline

- 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

Updates on LCFS Program Activities

PUBLIC PROCESS AND FUEL-SPECIFIC WORKING MEETINGS

Public Process (subject to change)



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

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

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

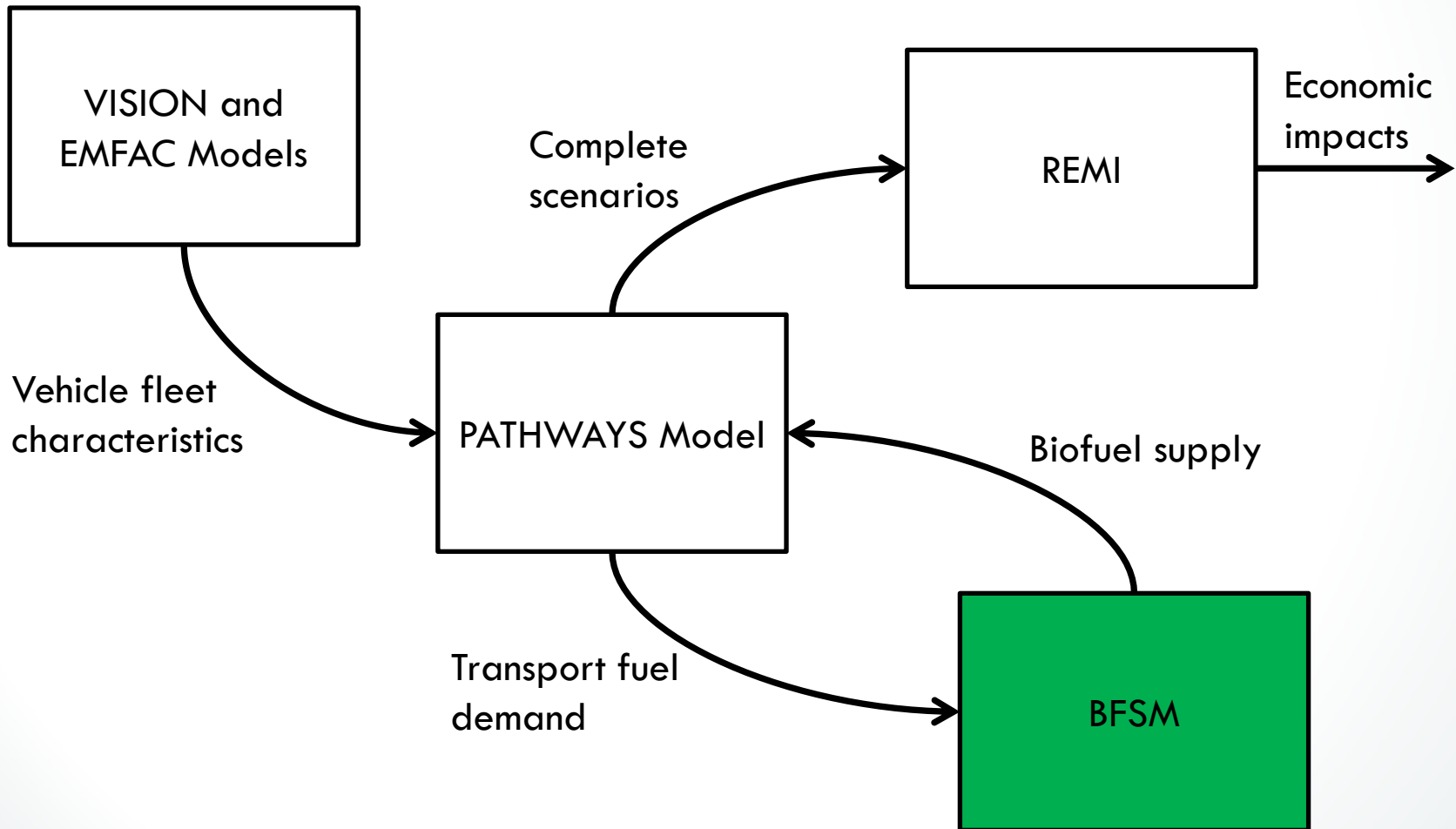
No follow-up meeting is anticipated for Electricity & Hydrogen stakeholders; discussion papers will be updated and posted

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

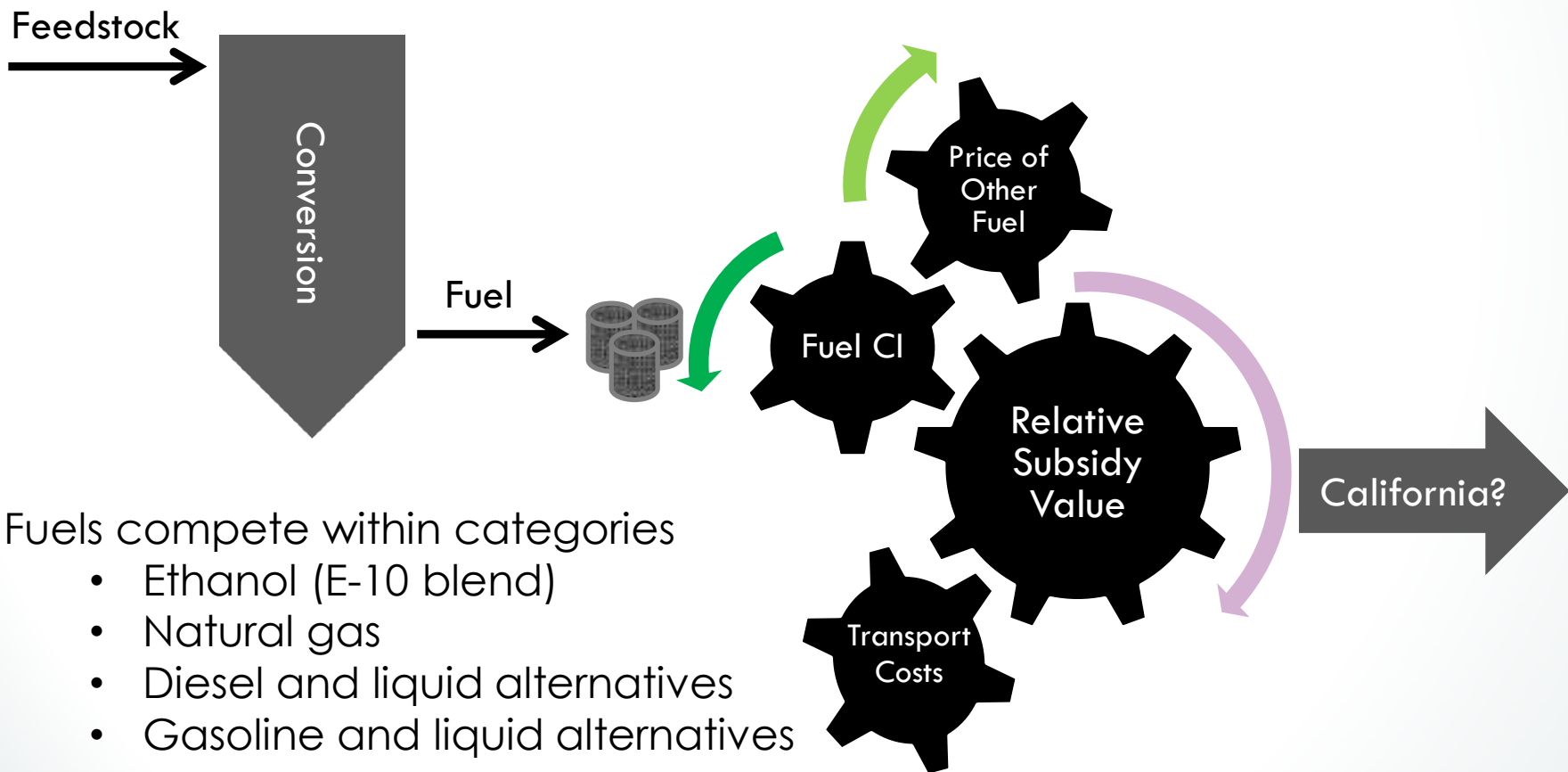
Updates on LCFS Program Activities

BIOFUEL SUPPLY MODULE (BFSM)

BFSM utilized for scenario modeling in the 2017 Scoping Plan Update



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



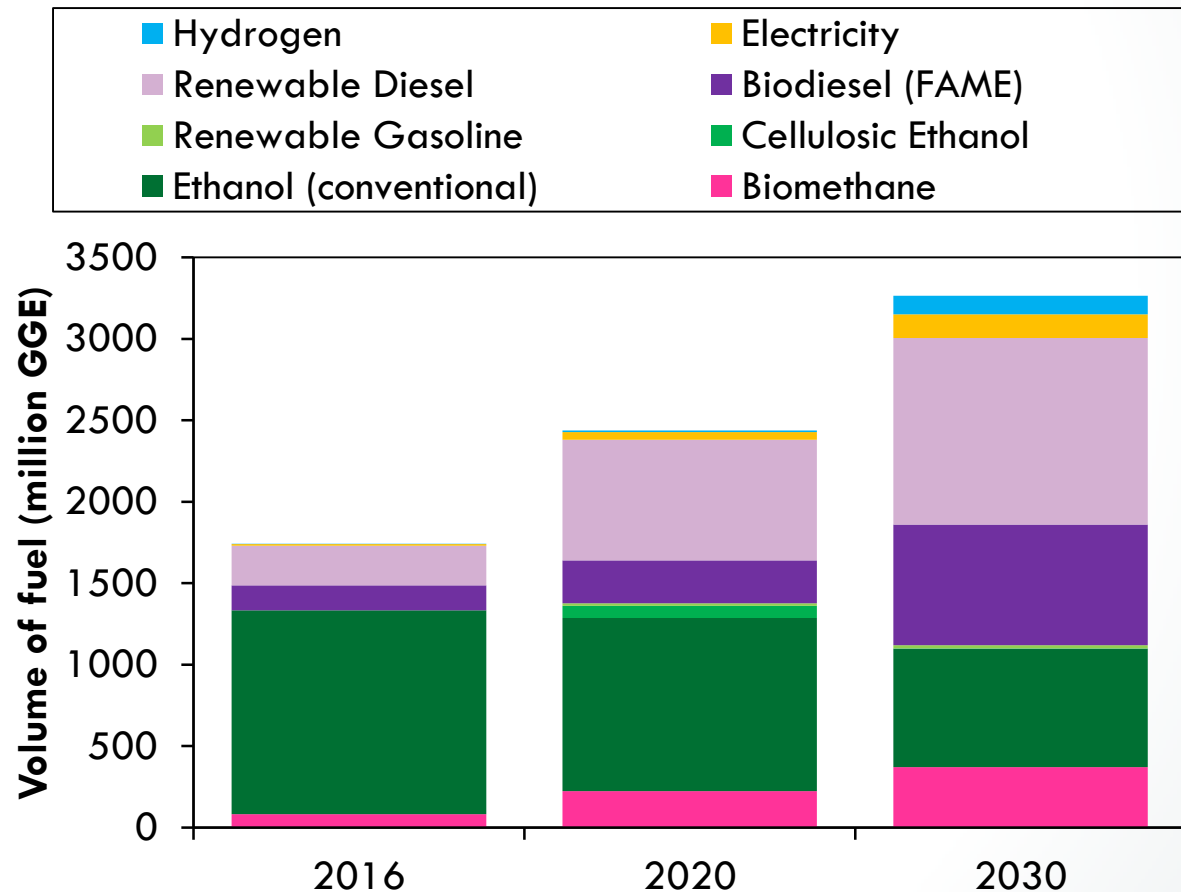
New version of BFSM released January 2017 (v 0.91b)

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

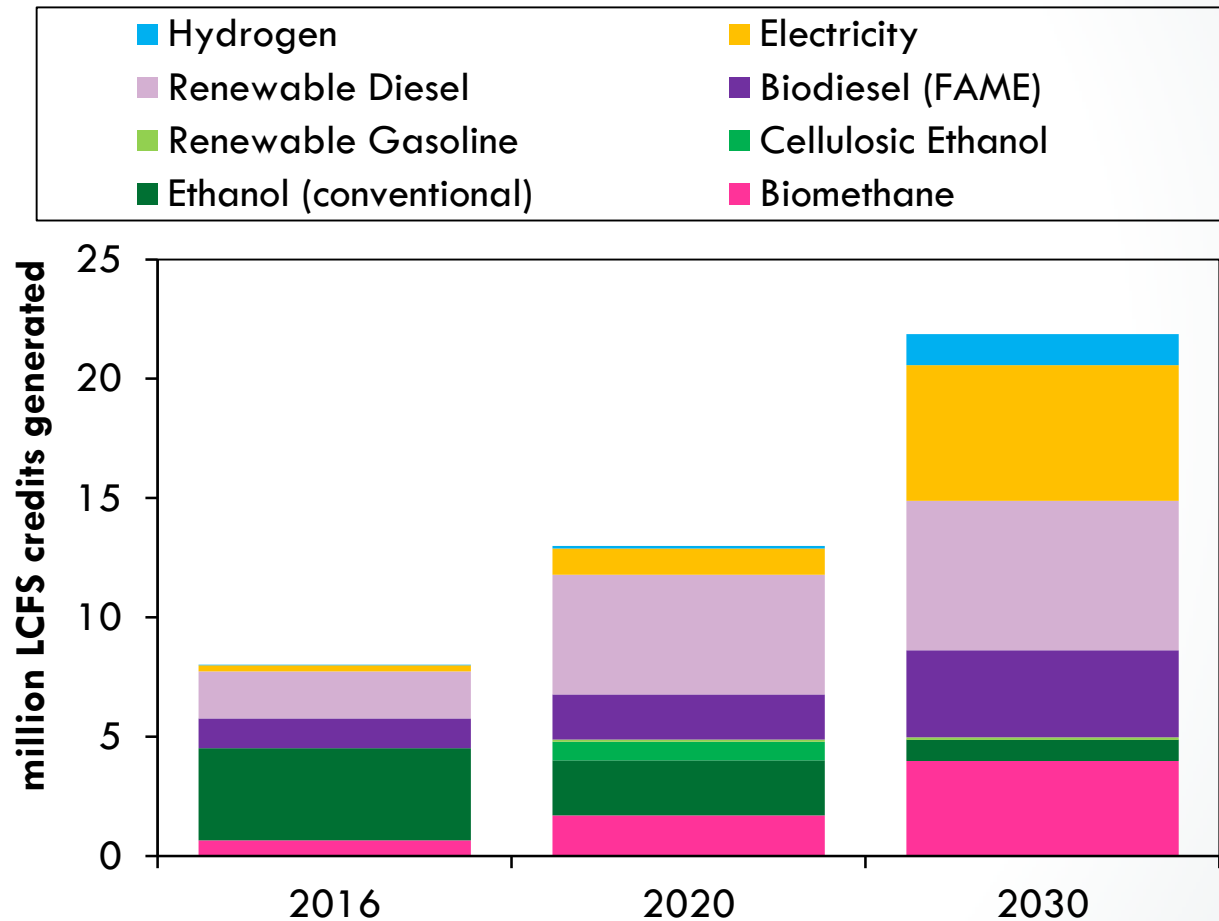
Proposed 2017 Scoping Plan: 18% LCFS – Volumes

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



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



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)

More information is available

Revised Module and Documentation:

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

Modeling Contact:

Jeff Kessler: (916) 327-8216, jeff.kessler@arb.ca.gov

POTENTIAL INCLUSION OF ALTERNATIVE JET FUEL

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

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

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

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%

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)

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)

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)

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)

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

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

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

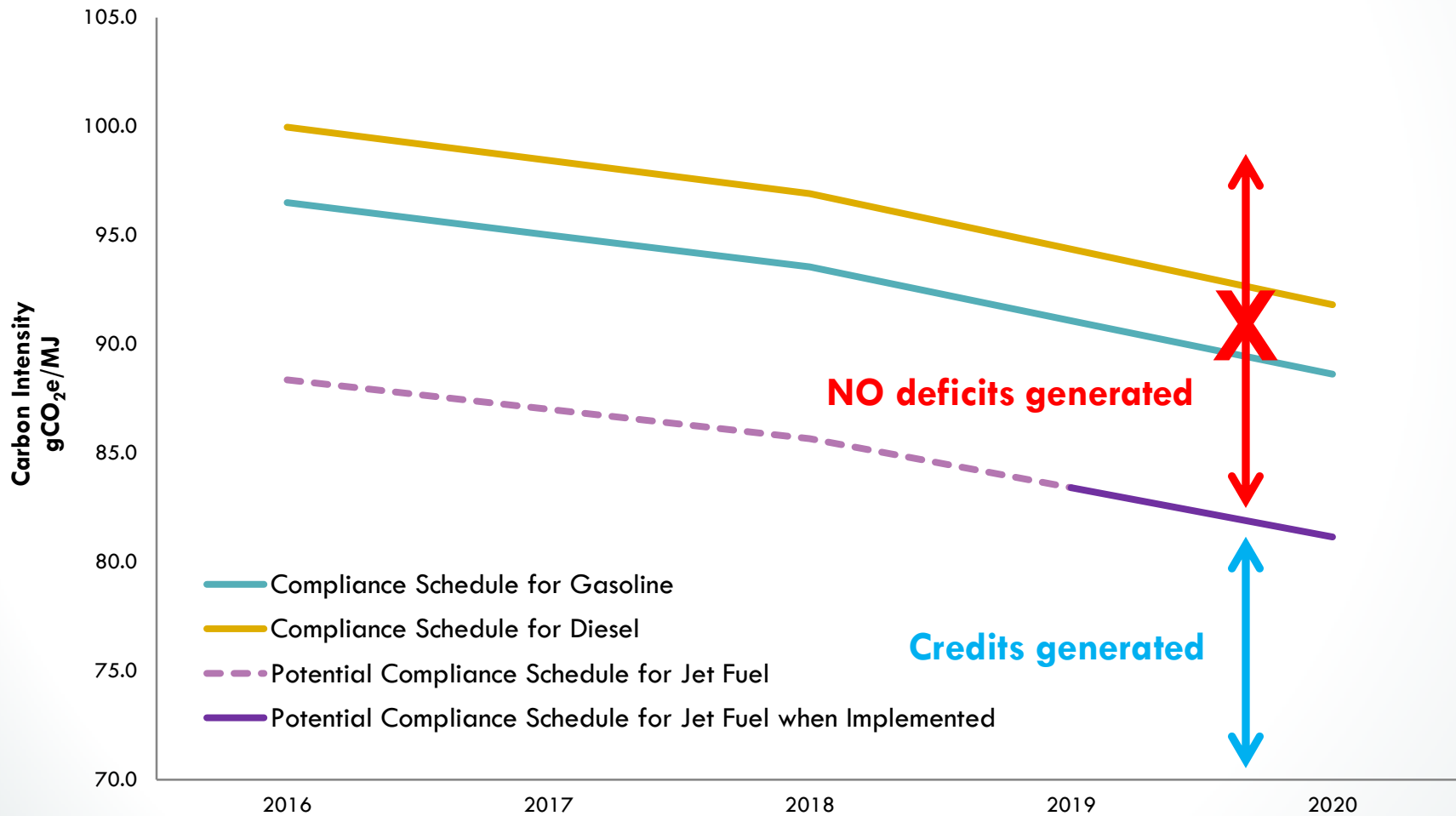
Credit Generation of AJF in the LCFS

- 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

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

How Credits would likely be Calculated for Alternative Jet Fuel



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

NREL PRESENTATION ON POTENTIAL AJF VOLUMES

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