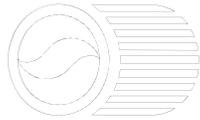


California Environmental Protection Agency



Air Resources Board

***Low Carbon Fuel Standard
Re-Adoption***

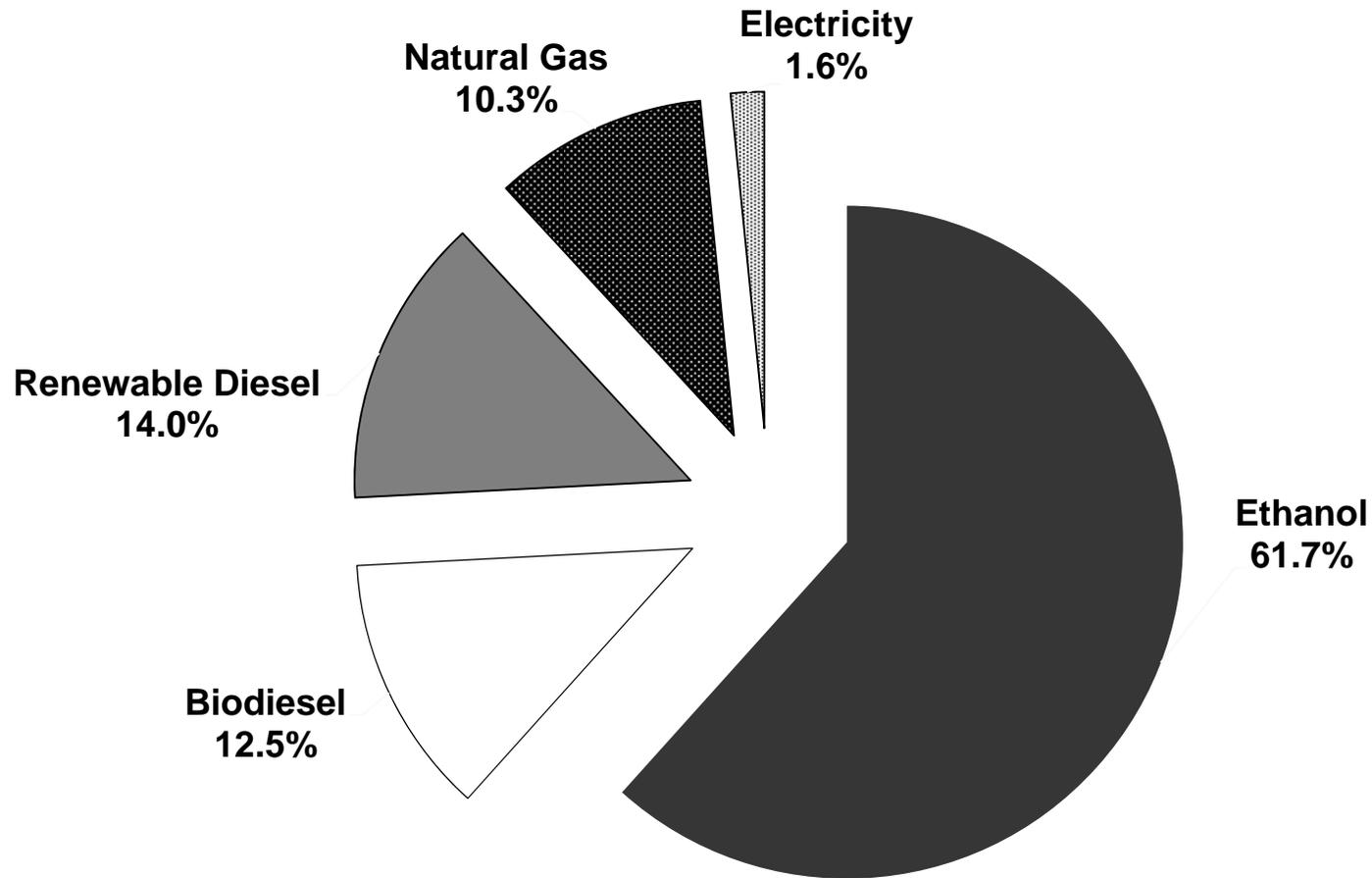
Fuel Availability

September 25, 2014

Agenda

- Overview
- Approach
- Gasoline Standard Low-CI Fuels
- Diesel Standard Low CI-Fuels
- Questions

Fuels Generating LCFS Credits



Sources of credits through Q1 2014

Fuel Availability Overview

- Staff has been keeping abreast of fuel availability for compliance with the LCFS standard
- Staff has considered what fuels are available nationally and internationally
 - Could these fuels come to California?
 - Would these fuels come to California?
- National fuel availability sets upper bound volumes of fuels that could be used to comply with the LCFS

Fuel Availability Approach

- Investigate statewide, national, and/or worldwide capacity of fuel
- Investigate past and current production of fuel
- Investigate past and current production by feedstock and look for growth patterns for each feedstock
- Set bounds for feedstocks that will have limited growth potential, such as used cooking oil and tallow



Gasoline Standard Low-Cl Fuels

Ethanol

- Dominant oxygenate for reformulated gasoline
- Typically blended with CARBOB at 10% by volume (E10)
- U.S. EPA allows E15 in 2001 and newer cars
- Flex-fuel vehicles can use ethanol blends to E85

Ethanol Feedstocks

- Corn
- Sorghum
- Sugarcane
- Molasses
- U.S. Cellulosic Ethanol
- Brazilian Cellulosic Ethanol

Ethanol Methodology

- Brazilian sugarcane production projections: Food and Agricultural Policy Research Institute (FAPRI) World Agricultural Outlook
- Corn and Sorghum ethanol fuels: EIA data and LCFS reporting tool data
- U.S. Cellulosic ethanol production projections: EIA's 2014 Energy Outlook
- Brazilian cellulosic ethanol projections: Publically available announcements from suppliers and discussions with Brazilian cellulosic producers

U.S. Ethanol Fuel Availability

- Estimated U.S. Ethanol Availability in 2020 (million gallons)
 - Corn and Sorghum: ~14,800
 - Sugarcane: 850 - 1,750
 - Molasses: 150 - 500
 - U.S. cellulosic: 100 - 250
 - Brazilian cellulosic: 150 - 300
- LCFS is expected to attract a significant portion of the lowest-CI ethanol fuels to CA

Potential Value Added for Low-CI Fuels (2020)

(For Illustrative Purposes)

Fuel Type	CI (g/MJ)	Credit Price			
		\$50 (\$/gal)	\$100 (\$/gal)	\$150 (\$/gal)	\$200 (\$/gal)
Corn Ethanol	70	\$0.08	\$0.16	\$0.24	\$0.31
Cellulosic Ethanol	20	\$0.28	\$0.56	\$0.84	\$1.12
Soy Renewable Diesel	50	\$0.29	\$0.58	\$0.86	\$1.15
Waste Grease Biodiesel	15	\$0.55	\$1.09	\$1.64	\$2.19
Renewable CNG	30	\$0.42	\$0.85	\$1.27	\$1.69

Renewable Gasoline

- Renewable gasoline is a collection of gasoline range hydrocarbons derived from biomass
- Next Generation fuel not yet commercially available
- Can be made via:
 - Pyrolysis
 - Hydropyrolysis
 - Catalytic Hydrotreating
 - Fermentation
 - Gasification
 - Liquefaction
- Feedstocks are mostly comprised of lignocellulosic biomass

Renewable Gasoline Facilities

- Cool Planet is expected to complete a 10 million gallon renewable gasoline plant in LA by the end of 2014
- Sundrop Fuels announced a 60 million gallon plant in LA to be completed in 2015
- Gasoline Technology Institute (GTI) had a successful pilot-scale demonstration making over 10,000 gallons through March 2014
- Viruent is capable of producing 10,000 gallons per year at its Madison, Wisconsin demonstration plant

Renewable Gasoline Methodology

Renewable Gasoline Projection Assumptions

- Cool Planet facility (10 MGY) to be operational by 2016
- Sundrop facility (60 MGY) to be operational by 2017
- Growth estimates
 - Low case: Growth of 30 million gallons from 2018-2020
 - Mid case: Growth of 60 million gallons from 2018-2020
 - High case: Growth of 90 million gallons from 2018-2020

Low-, Mid-, and High-Volume Projections

2020 Projected U.S. Renewable Gasoline Supply

(MGPY)	Announced Facilities online by 2016	Announced Facilities online by 2017	Projected U.S. Facilities 2018-2020	Total
Low	10	60	30	100
Mid	10	60	60	130
High	10	60	90	160



Diesel Standard Low-Cl Fuels

Renewable Diesel

- Renewable diesel is a liquid hydrocarbon fuel, chemically indistinguishable from conventional diesel, produced from triglyceride fats or oils
- Produced by hydrotreating process, similar to refinery process reducing aromatic or sulfur content
- Compatible with existing engines
- Technically compatible with existing distribution infrastructure, some labeling difficulties

U.S. Availability of Renewable Diesel

Factors in analysis

- U.S. Feedstock capacity
- Current RD facilities (U.S. or international)
- Announced RD facilities (focus on U.S.)
- Projected RD capacity increase (focus on U.S.)
- Low-, mid-, and high-volume projections

U.S. RD Feedstock Availability

- Tallow comprises most of current capacity, but additional volumes are uncertain
- Soybean oil likely 1 - 1.5 billion gallons available
- Corn oil likely 400 - 900 million gallons available
- Used cooking oil uncertain and likely to vary regionally
- Soy and corn oil combined 1.4 - 2.4 billion gallons available

Current RD Facilities



Diamond Green – 137 MGPY

2013



Neste Porvoo – 158 MGPY

2006, 2009



Neste Singapore – 240 MGPY

2010



Neste Rotterdam – 240 MGPY

2011



REG Synthetic Fuels – 75 MGPY

2010

Previous Growth in RD

- U.S. Capacity growth:
 - 212 million gallons over 4 years
 - ~50 million gallons of capacity added per year on average
- International RD capacity growth:
 - 638 million gallons over 8 years
 - ~80 million gallons of capacity added per year on average

Announced RD Facilities

- **United States**

- AltAir (CA): 40 MGPY
- Red Rock Biofuels (OR): 16 MGPY
- Fulcrum Bioenergy (NV): 10 MGPY
- Emerald Biofuels (LA): 88 MGPY
- East Kansas Agri-Energy (KS): 3 MGPY
(expandable to 6 MGPY)
- SG Preston (OH): 120 MGPY

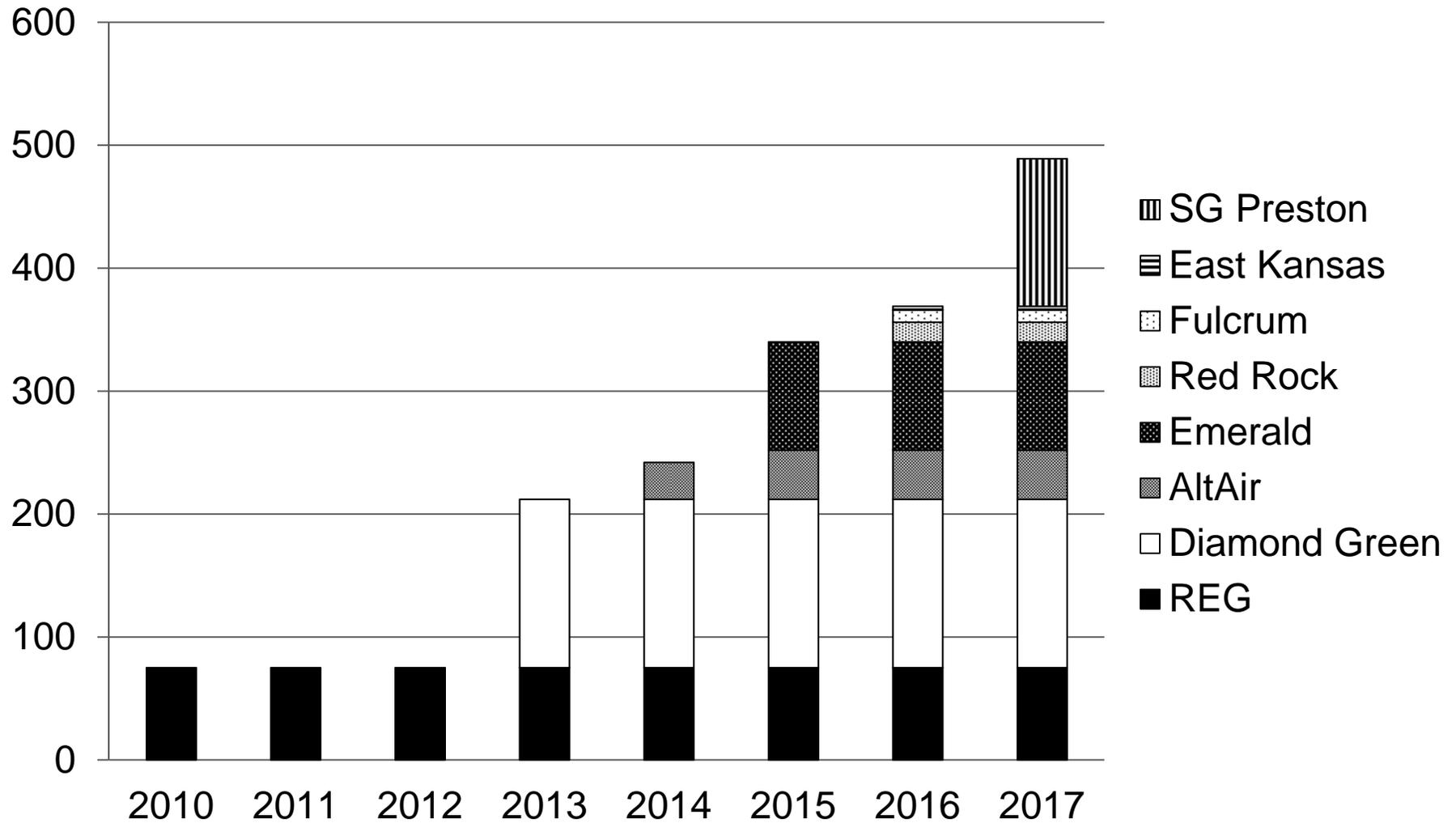
- **International**

- Petrioxo Oil and Gas (U.A.E): 150 MGPY
(plus another 150 MGPY of jet)

Announced RD Growth

- U.S. Capacity growth:
 - 277 million gallons over 3 years
 - ~100 million gallons of capacity added per year on average
- International RD capacity growth:
 - 300 million gallons over 2 years
 - ~150 million gallons of capacity added per year on average

U.S. RD Capacity Growth



Projected RD Capacity Increase

- Expect growth beyond what has been announced
- Projected capacity additions based on previous growth rates and announced facility growth rates
- Growth from 2017 - 2020 (4 years):
 - Low: 200 million gallons, current facility growth rate
 - Mid: 400 million gallons, projected facility growth rate
 - High: 800 million gallons, double mid-growth rate

Low-, Mid-, and High-Volume Projections

2020 Projected U.S. Renewable Diesel Supply

(MGPY)	Current U.S. Facilities	Announced U.S. Facilities	International Facilities	Projected U.S. Facilities	Total
Low	212	277	240	200	~900
Mid	212	277	240	400	~1,100
High	212	277	240	800	~1,500

Potential Value Added for Low-CI Fuels (2020)

(For Illustrative Purposes)

Fuel Type	CI (g/MJ)	Credit Price			
		\$50 (\$/gal)	\$100 (\$/gal)	\$150 (\$/gal)	\$200 (\$/gal)
Corn Ethanol	70	\$0.08	\$0.16	\$0.24	\$0.31
Cellulosic Ethanol	20	\$0.28	\$0.56	\$0.84	\$1.12
Soy Renewable Diesel	50	\$0.29	\$0.58	\$0.86	\$1.15
Waste Grease Biodiesel	15	\$0.55	\$1.09	\$1.64	\$2.19
Renewable CNG	30	\$0.42	\$0.85	\$1.27	\$1.69

Biodiesel

- Biodiesel is a diesel substitute that is made from vegetable oils, animal fats, or used cooking oil
- Transesterification process to make biodiesel is a mature process: Over 1.3 billion gallons produced in the U.S. in 2013
- Biodiesel can be blended/sold at various levels: B2, B5, or B20

Biodiesel Methodology

- Used EIA “Biodiesel by Inputs” data to look at growth patterns in feedstock use and biodiesel production trends
- Conducted literature research on feedstock constraints and feedstock availability
- Applied growth pattern based on historical data, while limiting the feedstocks that have restricted growth potential, such as tallow and waste grease

Current U.S. Biodiesel Fuel Volumes

Fuel Type (millions of gallons)	2013
Canola Biodiesel	87
Soy Biodiesel	744
Waste Grease/UCO Biodiesel	157
Corn Oil Biodiesel	136
Tallow Biodiesel	147
Palm Oil Biodiesel	85
Total Biodiesel	1,356*

*Calculated using biodiesel feedstock inputs from EIA. EIA total biodiesel production number is 1,339 million gallons

Biodiesel Availability

- 2013 U.S. biodiesel production is at about 1.3 billion gallons
- Current U.S. biodiesel capacity is 2.2 billion gallons
- By 2020, staff projects that U.S. biodiesel production to be about 2 billion gallons
- Staff expects an ample supply of biodiesel to fulfill California market demands through 2020 and beyond
- The LCFS will attract the lowest-CI biodiesel fuels to CA

Potential Value Added for Low-CI Fuels (2020)

(For Illustrative Purposes)

Fuel Type	CI (g/MJ)	Credit Price			
		\$50 (\$/gal)	\$100 (\$/gal)	\$150 (\$/gal)	\$200 (\$/gal)
Corn Ethanol	70	\$0.08	\$0.16	\$0.24	\$0.31
Cellulosic Ethanol	20	\$0.28	\$0.56	\$0.84	\$1.12
Soy Renewable Diesel	50	\$0.29	\$0.58	\$0.86	\$1.15
Waste Grease Biodiesel	15	\$0.55	\$1.09	\$1.64	\$2.19
Renewable CNG	30	\$0.42	\$0.85	\$1.27	\$1.69

Natural Gas

- As transportation fuel:
 - Compressed natural gas (CNG)
 - Liquefied natural gas (LNG)
- Renewable natural gas (RNG), or biomethane, is natural gas produced from various biomass resources:
 - Landfills
 - Wastewater treatment facilities
 - Food and green waste
 - Dairies

Natural Gas Methodology

- Reviewed various sources that contain natural gas transportation projections for 2020
 - CEC IEPR 2013, Cal ETC, Boston Consulting Group, Bloomberg New Energy Finance, Ca Natural Gas Vehicle Coalition, and Historic EIA data trend
- Surveyed medium duty and heavy duty fleets about adoption rates of NG vehicles
- Low-demand case for RNG based on survey of RNG providers, citing contracts in place
- High-demand case for RNG based on what RNG providers thought was likely to come to CA

2013 California Transportation Natural Gas Consumption

Fuel Type (million DGE)	2013
Fossil LNG	28
Fossil CNG	61
Renewable LNG	5
Renewable CNG	6
Total Natural Gas	100

California Natural Gas Availability

- Total transportation natural gas consumption in 2020 expected to be 600-1,200 million DGE
- Of that, renewable natural gas consumption expected to be 250-500 million DGE
- Majority of the supply of RNG is expected to come from out of state
- CPUC working on a pipeline injection standard for RNG in CA

Potential Value Added for Low-CI Fuels (2020)

(For Illustrative Purposes)

Fuel Type	CI (g/MJ)	Credit Price			
		\$50 (\$/gal)	\$100 (\$/gal)	\$150 (\$/gal)	\$200 (\$/gal)
Corn Ethanol	70	\$0.08	\$0.16	\$0.24	\$0.31
Cellulosic Ethanol	20	\$0.28	\$0.56	\$0.84	\$1.12
Soy Renewable Diesel	50	\$0.29	\$0.58	\$0.86	\$1.15
Waste Grease Biodiesel	15	\$0.55	\$1.09	\$1.64	\$2.19
Renewable CNG	30	\$0.42	\$0.85	\$1.27	\$1.69

Electricity

- Several studies show that existing grid capacity can fuel a significant number of EVs in California
- Many power plants are underutilized during off-peak hours and could be used to recharge a majority of vehicles
- Smart charging is important for grid management

Hydrogen

- By the end of 2015, 51 stations are expected to be operational statewide, providing up to 9,400 kg/day
- This capacity will be nearly sufficient through 2017 to support the FCEV fleet within that timeframe
- Up to 49 additional stations are projected to be needed to meet 2020 demand
- Current operational and funded hydrogen stations in California are well within compliance with the SB 1505 (33.3% renewable resources) standard

Other Potential Low Carbon Fuels

- **Algal diesel**
 - Solazyme, Amyris
 - Potential additional feedstock for RD
- **Gas-To-Liquid diesel**
 - Sasol
 - Potentially biogas or flare gas derived
- **Biomass to Liquid diesel**
 - Sierra energy
 - Potential MSW feedstocks
- **Dimethyl Ether**
 - Oberon
 - Potential biogas feedstock
- **Biobutanol**
 - Cobalt, Gevo, Butamax
 - Can be added in higher volumes than ethanol

Attracting Low-CI Fuels to CA

- Ethanol CI values continue to decrease
- Renewable diesel production is increasing
- Renewable natural gas production is increasing and moving toward transportation use

These fuels can come to California.

Will these fuels come to California?

Potential Value Added for Low-CI Fuels (2020)

(For Illustrative Purposes)

Fuel Type	CI (g/MJ)	Credit Price			
		\$50 (\$/gal)	\$100 (\$/gal)	\$150 (\$/gal)	\$200 (\$/gal)
Corn Ethanol	70	\$0.08	\$0.16	\$0.24	\$0.31
Cellulosic Ethanol	20	\$0.28	\$0.56	\$0.84	\$1.12
Soy Renewable Diesel	50	\$0.29	\$0.58	\$0.86	\$1.15
Waste Grease Biodiesel	15	\$0.55	\$1.09	\$1.64	\$2.19
Renewable CNG	30	\$0.42	\$0.85	\$1.27	\$1.69

LCFS Will Attract Low-CI Fuels

- LCFS provides real value for low-CI fuels
- Higher credit value will encourage needed infrastructure to get low-CI fuels to CA
- LCFS will encourage production of low-CI fuels
- LCFS programs along Pacific Coast will encourage additional production of low-CI fuels

Next Steps

- Feedback due October 16, 2014
- Submit via email to Katrina Sideco at ksideco@arb.ca.gov
- Staff report – Winter 2014
- Board Hearing – January 2015

Contact Information

LCFS Fuels Availability (Primary Contact)	Adrian Cayabyab (916) 327-1515 acayabya@arb.ca.gov
Ethanol Availability	Kirsten King (916) 327-5599 kking@arb.ca.gov
Renewable Diesel Availability	Lex Mitchell (916) 327-1513 amitchel@arb.ca.gov
Natural Gas and Renewable Natural Gas Availability	Anil Prabhu (916) 445-9227 aprabhu@arb.ca.gov

Thank You