Fuels Regulation in California (Program Requirements)

Fuel Standards Workshop
International Best Practices
And Regulation In Mexico

August 11 , 2015

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California Environmental Protection Agency
Air Resources Board

Agenda

Day 1

- California Reformulated Gasoline Regulations
- California Diesel Fuel Regulations
- Fuel Additives
- Low Carbon Fuel Standard

Day 2

- Vapor Recovery
- Enforcement

Policy Drivers

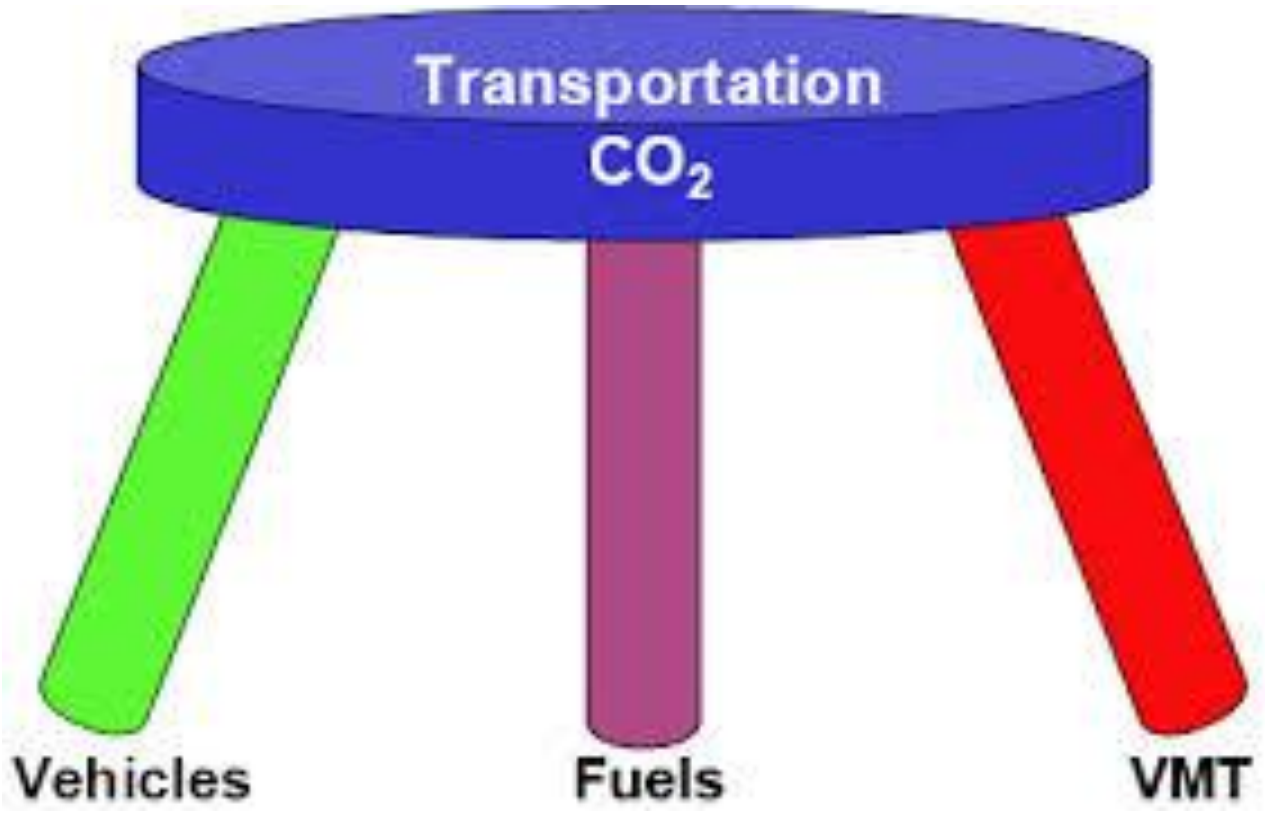
- 34 million Californians, 25 million cars
- Transportation: single largest source of emissions
  - 40% greenhouse gas (GHG) emissions
  - 80% of smog forming emissions
  - 95% of toxics (diesel particulate matter)
- Cleaner fuels enable cleaner vehicle technologies
  - Catalytic converters, diesel particulate filters (DPF)

Policy Drivers (cont.)

Additional new drivers: Climate change, petroleum reduction, diversification

- AB 32: to1990 levels by 2020
- Interim and long term: GHGs to 40% below 1990 levels by 2030, 80% below by 2050
- Up to 50% reduction in vehicle petroleum use by 2030
- Infrastructure to support 1.0 million ZEVs by 2020
- Deployment of over 1.5 million ZEVs by 2025
- At least 100 hydrogen fueling stations

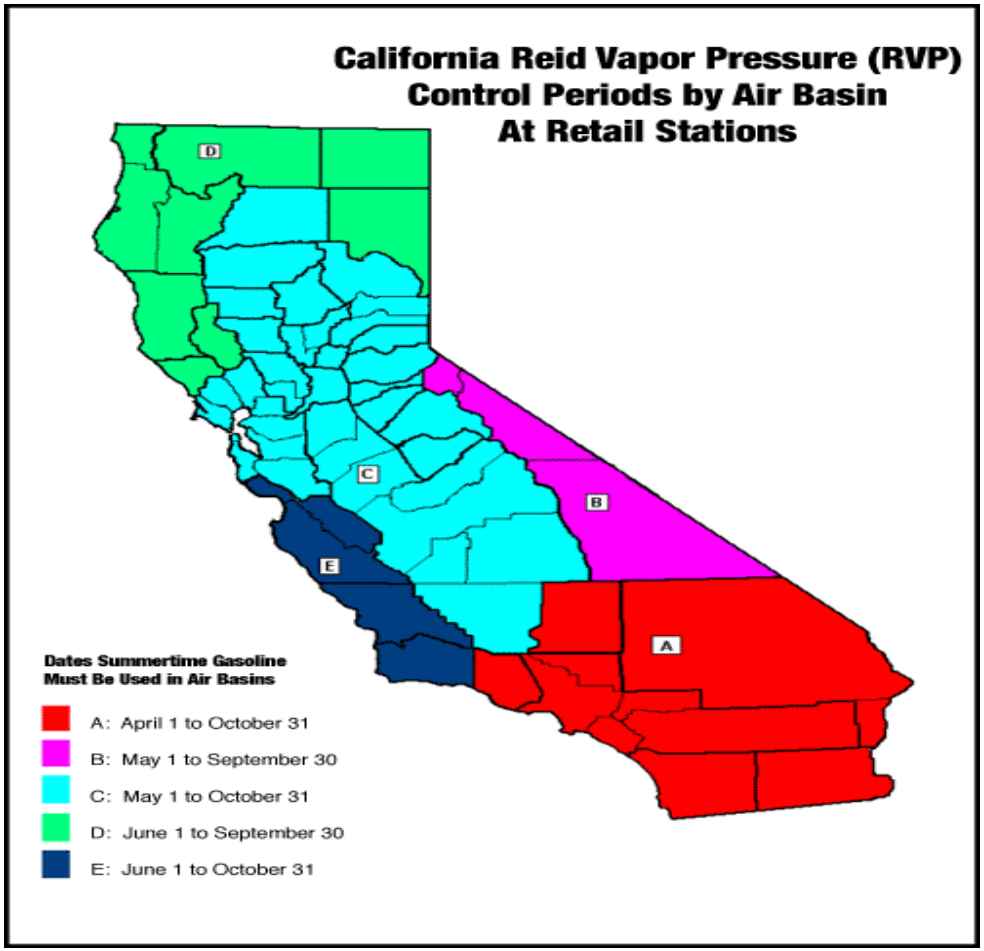
Policy Drivers (cont.)



California Reformulated Gasoline Regulations (CaRFG)

- Title 13, Calif. Code of Regs, §§2250-2273.5 (http://www.arb.ca.gov/fuels/gasoline/100912CaRFG_regs.pdf)
- Gasoline must meet specifications determined by the California Predictive Model
- Allow use of ethanol at 0 to 10 percent by volume
- Wintertime oxygenate for CO control (greater Los Angeles and Imperial County): 5.7 to 10% ethanol
- Summertime Reid Vapor Pressure requirements

Summertime Reid Vapor Pressure



CaRFG History, Benefits & Costs

- Phase 1 (CaRFG1, 1992)
  - Reduced Reid Vapor Pressure (RVP) cap from 9.0 to 7.8 psi
  - Eliminated lead
  - Required deposit control additives

- Phase 2 (CaRFG2, 1996)
  - Reduced RVP cap from 7.8 to 7.0 psi
  - Established flat limits and caps for:
    - ✓ Sulfur and oxygen contents
    - ✓ Aromatic hydrocarbon, olefin, and benzene contents
    - ✓ T50 and T90
  - Established California Predictive Model (PM) for determining alternative specifications

CaRFG History, Benefits & Costs (cont.)

- Phase 3 (CaRFG3, 1999)
  - MTBE prohibited, beginning December 31, 2003
  - Ethanol approved (multimedia evaluation)
  - Additional flexibility provided to enable ethanol use
- Phase 3 amendments, beginning December 31, 2009
  - Included permeation due to ethanol use in PM
  - Reduced sulfur cap to 20 ppmw, December 31, 2011

CaRFG History, Benefits & Costs (cont.)

- CaRFG2 Benefits
  - ✓ Equivalent to eliminating 3.5 million vehicles
  - ✓ Reduced emissions from motor vehicles by 15%
  - ✓ Reduced cancer risk from emissions by 40%
- Production cost increase, $0.05 to $0.15 per gallon

California Predictive Model

- Correlation of emissions, fuel properties ➔ determine emission-equivalent fuel specifications
- Extensive test data (42 studies, >10,000 observations, >1300 vehicles, >330 test fuels)
- Test-fuel oxygenate (MTBE, ethanol) contents: oxygen-equivalent of 0 to 10 percent ethanol

California Predictive Model (cont.)

- Included exhaust, evaporative, and supplemental permeation emissions studies
- Model predicts emission differences from reference for NOx, exhaust HCs, evaporative HCs, CO, ozone-forming potential, and toxic air contaminants
- Determines specifications for oxygen, sulfur, total aromatic hydrocarbon, benzene, and olefin contents, as well as T90, T50, and RVP

CaRFG E10 Properties (2014-2015, RVP-controlled)

Property	Cap Limits	Average PM Specification	Average of Samples
Reid Vapor Pressure (psi)	6.40-7.20	7.10	7.07
Sulfur Content (ppmw)	20	9.41	6.38
Benzene Content (vol. %)	1.10	0.89	0.57
Aromatic Content (vol. %)	35.0	22.98	22.23
Olefin Content (vol. %)	10.0	7.63	5.14
T50 (°F)	220	219.89	213.73
T90 (°F)	330	320.87	311.98
Oxygen Content (wt. %)	3.7	3.3-3.7	3.68

Gasoline Test Methods

Specification	ASTM
RVP	ASTM D 323-58 or 13 C.C.R. Section 2297
Sulfur Content	ASTM D 5453-93 (1993)
Benzene Content	ASTM D 5580-02 (2007)
Aromatic Content	ASTM D 5580-02 (2007)
Olefin Content	ASTM D 6550-10 (2010)
T50	ASTM D 86-99
T90	ASTM D 86-99
Oxygen Content	ASTM D 4815-09 (2009)

California Diesel Fuel

Title 13, Calif. Code of Regs., §2281 et seq.,

- § 2281. Sulfur Content of Diesel Fuel – 15-ppmw limit
- § 2282. Aromatic Hydrocarbon Content of Diesel Fuel
  - 10-percent-by-volume limit or
  - 10-percent-by-volume average with DAL or
  - Designated Equivalent Limits or
  - Certified emission-equivalent formulation
- Applies to all diesel sold in California
  - Stationary, marine-harborcraft, and most locomotive diesel-engines in California.

California Phase 1 Diesel Fuel History

- Pre-regulation by ARB, ASTM D975 allowed a sulfur content of up to 5000 ppm in diesel fuel oils

- Beginning in 1985, ARB's first diesel regulation limited the sulfur content of vehicular diesel fuel sold in the South Coast Air Basin and Ventura County to 500 ppm

California Phase 1 Diesel Fuel History (cont.)

- Implemented October 1, 1993
- Applicable to all vehicular diesel fuel sold in California
- Set a 500-ppm sulfur limit for entire state
- Set aromatic hydrocarbon limit of 10 percent by volume, but provided for certification of equivalent formulations

California Phase 1 Diesel Benefits & Costs

- Benefits (from average 2800-ppm S, 31-percent aromatic HC)
  - 25 percent reduction in direct PM emissions
  - 7 percent reduction in NOx emissions

- Cost: $0.11 to $0.12 per gallon

California Phase 2 Diesel Fuel History

- California Diesel Fuel Amendments
  - Phased implementation, June 1, 2006 – January 1, 2007
  - Maximum sulfur content, 15 ppmw
  - Aromatic HC content designated equivalent limits
  - Lubricity standard, later added to ASTM D975
  - Extended sulfur and aromatic HC standards to almost all diesel-engine fuel sold in California

California Phase 2 Diesel Fuel History (cont.)

- Benefits
  - ✓ Primarily to enable catalyzed after-treatment of exhaust
  - ✓ Small direct PM emission benefits
  - ✓ Intrastate locomotives and harborcraft
    - ✓ 8-percent reduction in direct particulate emissions
    - ✓ 3-percent reduction in NOx emissions
- Cost, $0.02 to $0.04 per gallon

California Diesel Fuel Properties (2014-2015)

Property	Primary Standards	Designated Equivalent Limits	Average of Samples
Sulfur Content (ppmw)	15	15	4.71
Aromatic Content (vol. %)	10.0	21.0 (wt. %)	19.68 (wt. %)
PAH Content (wt. %)	Not Applicable	3.5	2.52
Cetane Number	Not Applicable	53 (min.)	Not Available
Nitrogen Content (ppmw)	Not Applicable	500	49.91
API Gravity	Not Applicable	36.9 (min.)	Not Available

Diesel Test Methods

Specification	ASTM Test Method
Sulfur	ASTM D5453-93
Aromatic Hydrocarbon Content	ASTM D5186-03 (2009)
PAH	ASTM D5186-03 (2009)
Nitrogen	ASTM D4629-96

Alternative Compliance Options

- Provide fuel producers and importers with alternative compliance options for compliance
- <u>Gasoline options include:</u>
  - Predictive Model (PM), CARBOB PM, and test-certified alternative gasoline formulations
- <u>Diesel options include:</u>
  - 10% aromatic HC flat, averaging, designated equivalent limits
  - Certified emissions-equivalent diesel formulations

Fuel Additives (Gasoline)

- Gasoline Additives
  - Banned
    - Lead (§2253.4)
    - Manganese, including methylcyclopentadienyl manganese tricarbonyl (MMT) (§2254)
  - Required
    - Deposit control (§2257)
    - Intake valve, combustion chamber, port fuel injectors
    - Reduces emissions, improves performance, durability

Fuel Additives (Diesel)

- Verified additives can be used for particulate matter or NOx control or both
- Only two additives approved to date
  - PuriNOx (50% PM, 15% NOx reduction)
  - Viscon (25% PM reduction)
- Required verification is a comprehensive testing and evaluation process (§2700-2710)
- Multimedia evaluation required

Multimedia Evaluation

- Identify and evaluate ***any significant adverse impact*** *on public health or the environment by vehicle fuel used to meet ARB's fuel specifications*

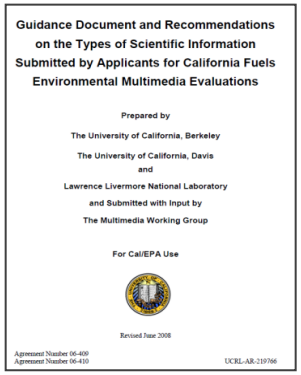
- <u>Requirements</u>
  - ✓ Required before ARB establishes motor vehicle fuel specifications
  - ✓ Must address:
    - – *Emissions of air pollutants*
    - – *Contamination of surface water, groundwater, and soil*
    - – *Disposal or use of byproducts and waste materials*
  - ✓ External Scientific Peer Review
  - ✓ CA Environmental Policy Council (CEPC) Review

Multimedia Evaluation (cont.)

Tier I
Work Plan

Work Plan

- Define framework and scope
- Identify key knowledge gaps
- Feedback provided



Guidance Document and Recommendations on the Types of Scientific Information Submitted by Applicants for California Fuels Environmental Multimedia Evaluations

Prepared by

The University of California, Berkeley

The University of California, Davis

and

Lawrence Livermore National Laboratory

and Submitted with Input by

The Multimedia Working Group

For Cal/EPA Use

Revised June 2008

Agreement Number 06-400
Agreement Number 06-410

UCRL-AR-219766

Tier II
Risk Assessment Protocol

Risk Assessment Protocol

- Experimental design developed and submitted
- Protocol reviewed, feedback provided

Final Report Risk Assessment

- Execution of Risk Assessment
- Final report used as basis for MMWG recommendations

Tier III
Multimedia Risk Assessment Final Report

Multimedia Evaluation Guidance Document , June 2008

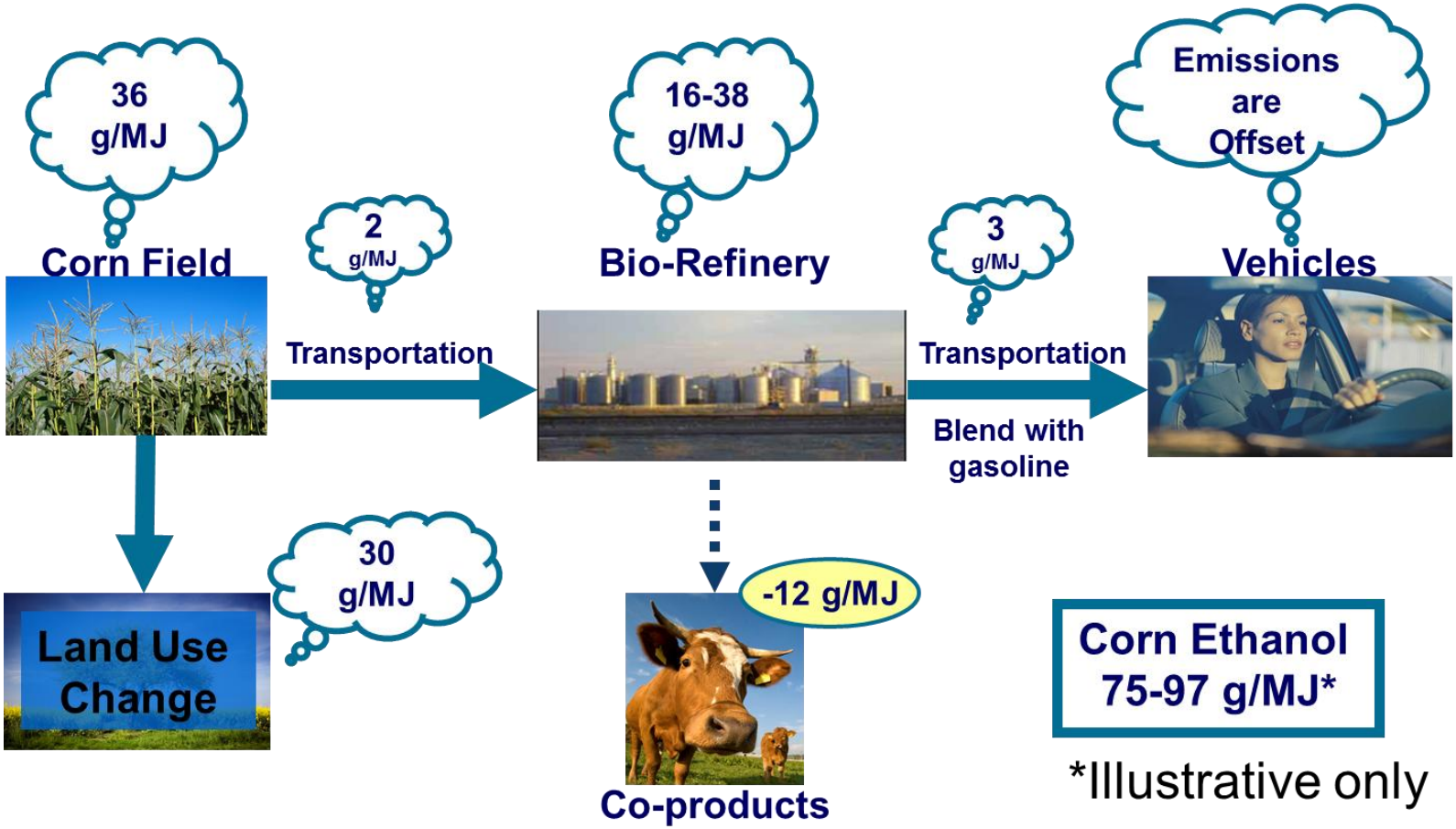
Past, Current and Future Directions

- Past
  - Criteria pollutants (NOx, ROG, CO, PM)
  - Reduce toxics (BTEX, PAHs)
- Current and Future
  - Low Carbon Fuel Standard
  - Fuels with multiple air quality and GHG benefits

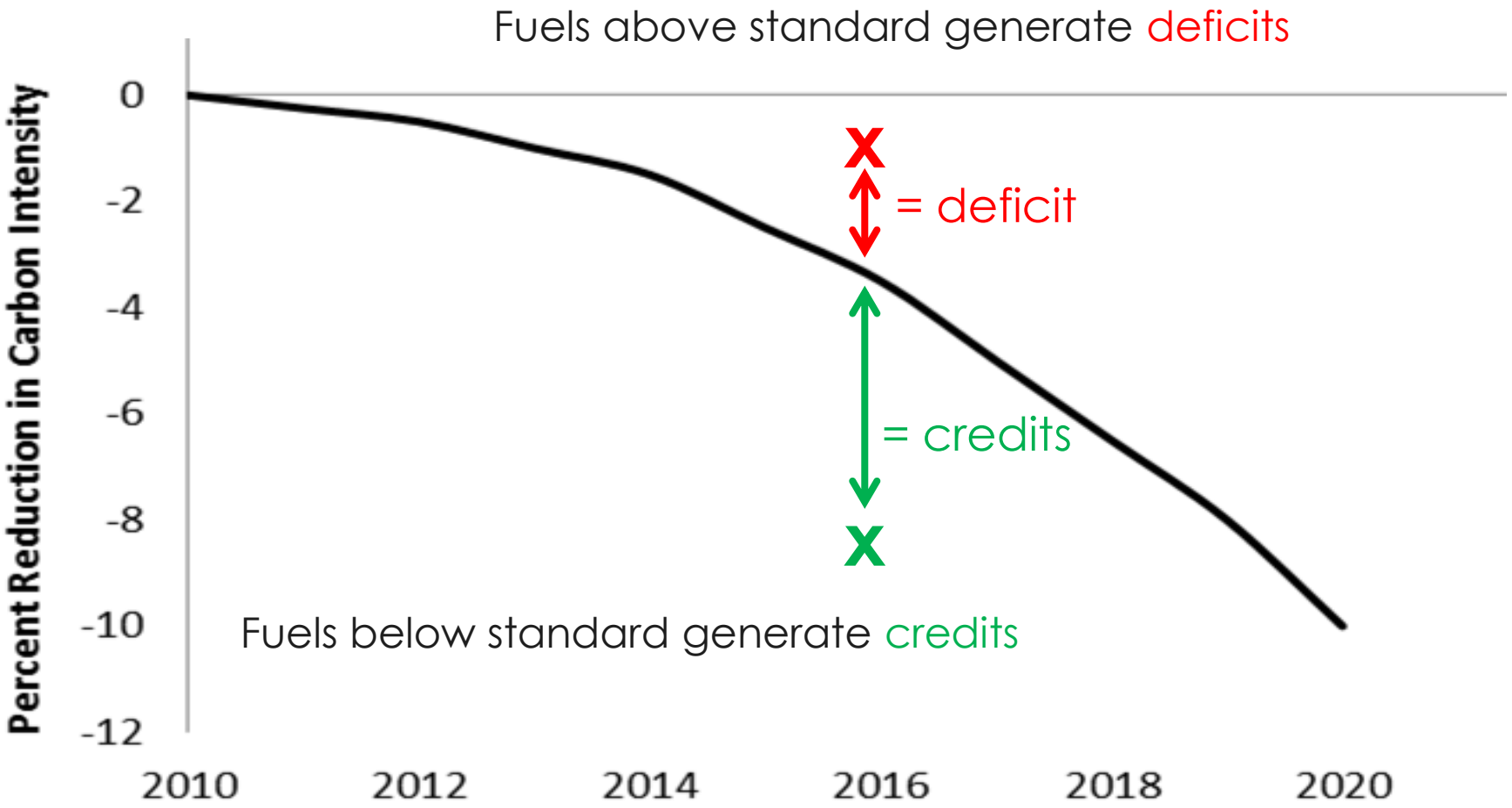
Low Carbon Fuel Standard

- Original adoption in 2009, amended in 2011, program changes proposed September 2015
- Reduce carbon intensity (CI) of transportation fuel pool by at least 10% by 2020
- Expected benefits:
  - Complement other measures to reduce greenhouse gases (GHG) emissions to 1990 levels by 2020
  - Transform and diversify fuel pool and reduce petroleum dependency
  - Reduce emissions of other air pollutants

Fuel Lifecycle Assessment

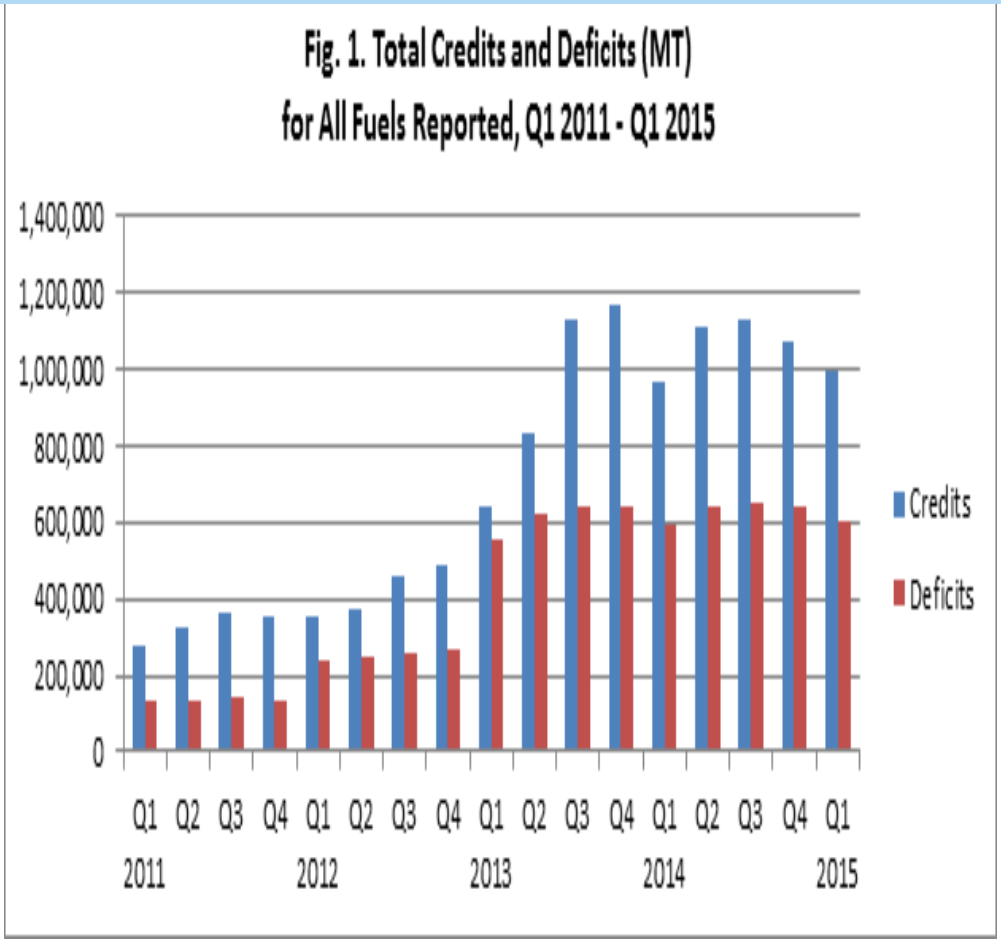


Declining Carbon Intensity Curve



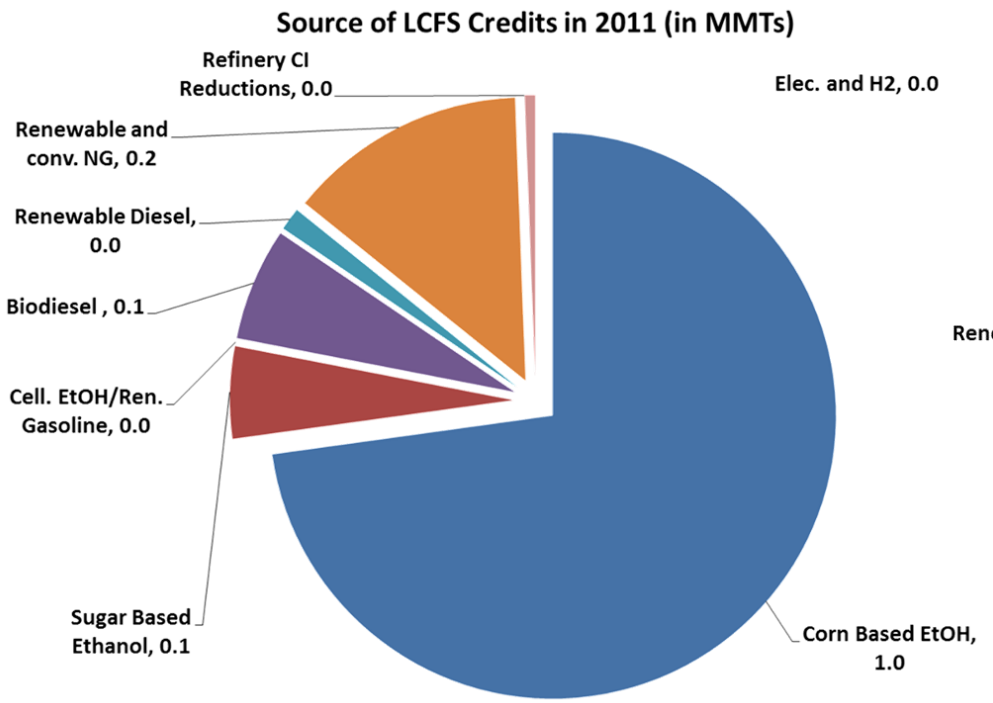
The LCFS is Working

- Low-C fuel use is increasing, crude CI remains stable
- Regulated parties engaged in credit market, price has rebounded recently
- Credits have exceeded deficits in all quarters and a significant credit bank has been built

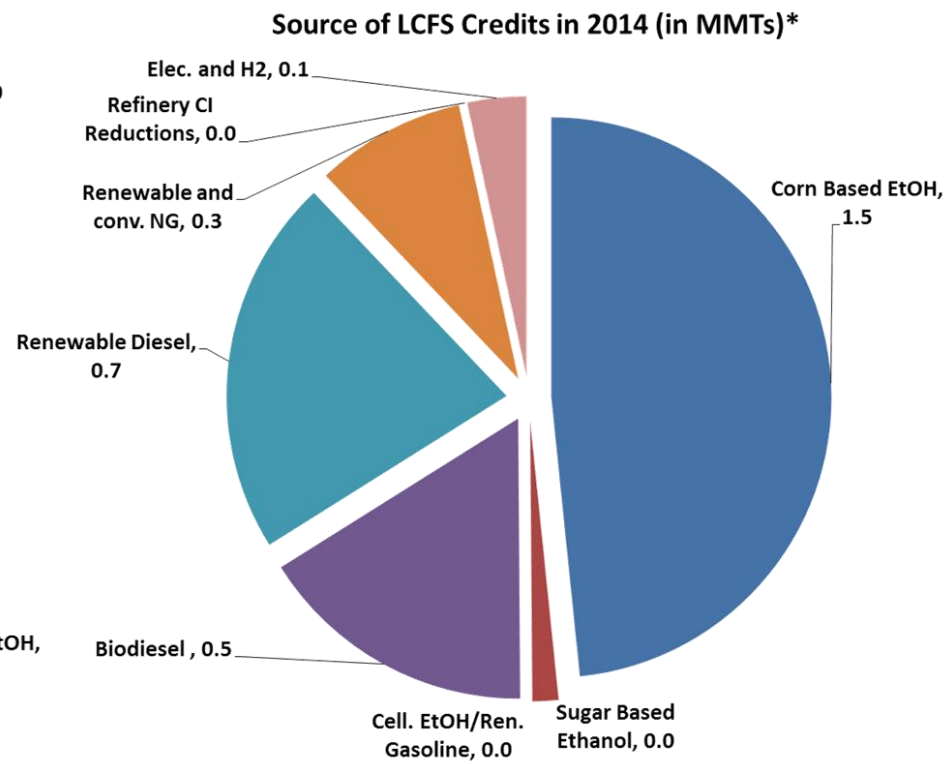


Fuels Are Diversifying: 2011 v. 2014

Total 2011 Credits = 1.31 MMT



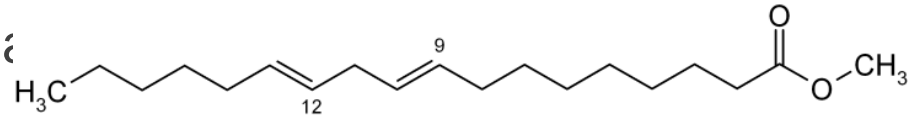
Total 2014 Credits = 3.04 MMT

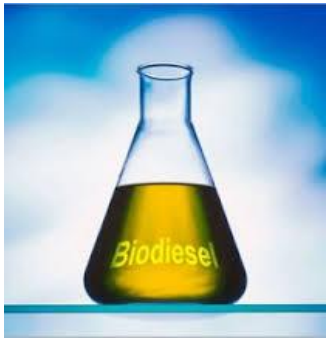


* Through first 3 Quarters of 2014

Biodiesel Fuel

- *What is Biodiesel?*
  - Fatty a





  - Derived from renewable feedstocks
    - Vegetable Oil – Soy, Palm, Corn, Canola, Safflower
    - Animal Fat – Tallow
  - Meets ASTM International Standards
    - D975 – B5
    - D7467 – B6 to B20
    - D6751 – B100

Renewable Diesel Fuel

- *What is Renewable Diesel?*
  - Aliphatic hydrocarbons, subset of CARB diesel (C11-C22 vs. CARB diesel C9-C45)
  - Derived from renewable feedstocks (same as biodiesel)
    - Vegetable Oil – Soy, Palm, Corn, Canola, Safflower
    - Animal Fat – Tallow
  - Meets ARB diesel fuel specifications and ASTM D975
- *How is it Produced?*
  - Hydrotreatment of feedstocks – Common refinery process
  - Produced on a relatively large scale

Benefits of Biodiesel & Renewable Diesel (Compared to CARB Diesel)

- Low carbon, renewable feedstocks
- Reduced GHGs, particulates, CO, and air toxics (both), reduced NOx (RD)
- Drop-in fuel at low blends (biodiesel), all blends (RD)
- Important fuel in LCFS and Federal RFS2
- Reduces petroleum use – Help achieve 2030 goal
- Reduces GHG – Help achieve 2030 and 2050 goals
- Energy security – Feedstocks sourced in U.S.

Conclusions

- CA has some of most stringent fuels specifications
- Existing program designed for substantial reductions in criteria, toxic pollutants
- Ongoing and next-gen programs (LCFS) designed for substantial reductions in GHGs, others
- Some fuels, such as biodiesel and renewable diesel, can achieve multiple benefits
  - GHGs, criteria, toxic pollutants, petroleum reduction

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Questions and Answers