Webinar: Upgrading Landfill Gas for Pipeline Gas and Vehicle Fuel

May 23, 2017

Presenters:
Dr. Veronika Pesinova (CARB)
Angela Schwarz (Element Markets)
Welcome

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Low Carbon Fuel Standard: Opportunities for Renewable Natural Gas

LMOP Webinar

May 23, 2017

Dr. Veronika Pesinova
Transportation Fuels Branch

California Environmental Protection Agency

Air Resources Board
LCFS Program

• 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
Basic LCFS Requirements

• Sets annual carbon intensity (CI) standards for gasoline, diesel, and the fuels that replace them

• CI is the measure of GHG emissions associated with producing and consuming a fuel, which is measured in grams of carbon dioxide equivalent per megajoule (gCO₂e/MJ)

• CI based on complete lifecycle analysis
Example: Fuel Lifecycle for Landfill Gas to CNG

Biogas to CNG in California  
\[25 \text{ gCO}_2\text{e/MJ}^*\]  
* Totals may not sum due to rounding

- **Landfill Gas Recovery**: 1 g/MJ
- **Biogas Upgrading**: 19 g/MJ
- **Pipeline Transmission**: 5 g/MJ
- **Compression & Refueling**: 2 g/MJ
- **CNG Trucks + efficiency penalty**: 3 g/MJ
- **Avoided Flare Credit**: -66 g/MJ

\[61 \text{ g/MJ}\]
How Does LCFS Work?

Fuels above standard generate deficits
Fuels below standard generate credits

Example uses carbon intensities based on composite of gasoline and diesel fuels
Program continues post-2020 @ to-be-determined stringency
LCFS Regulated Parties

- Providers in California of most petroleum and biofuels are “regulated parties”

- Providers of clean fuels that already meet 2020 target are exempt but can “opt in” to the program and earn credits (i.e., electricity, hydrogen, natural gas and biomethane)

- Low Carbon Credit Generating Fuels and Blendstocks
  - Biomethane (= renewable natural gas (RNG))
  - Fossil natural gas
  - Electricity
  - Hydrogen
  - Ethanol
  - Biomass-based diesel
  - Renewable diesel

- High Carbon Deficit Generating Fuels and Blendstocks
  - California Reformulated Gasoline Blendstock for Oxygenate Blending (CARBOB)
  - California diesel fuel
Before the LCFS, natural gas and ethanol were the only alternative fuels with any market share.

We now have 87 million gallons of RNG.
Out with the old, in with the (re)new…

In 2016, 60% of natural gas used in vehicles was RNG.
2016 Volume-weighted Average CI

Average CI = 36.17
Average CI = 38.07
Credits by Fuel Type
Q1 2011 - Q4 2016

Air Resources Board

[Graph showing the distribution of credits by fuel type from Q1 2011 to Q4 2016. The graph includes lines for Ethanol, Electricity, Biodiesel, Renewable Diesel, Natural Gas, Biomethane, and Other (CARBOB, ULSD, H2, Innovative Crude).]
Monthly LCFS Credit Price & Transaction Volume

- **Volume of Credits Transacted (MT)**
- **ARB Monthly Average Credit Price**

![Graph showing monthly LCFS credit price and transaction volume from 2013 to 2017.](image-url)
**Estimated LCFS Credit Revenue: Examples**

- **Additional** value from LCFS to MMBtu of biomethane

<table>
<thead>
<tr>
<th>LCFS Credit Price*</th>
<th>Value Added**</th>
</tr>
</thead>
<tbody>
<tr>
<td>$100</td>
<td>$5-$6/ MMBtu</td>
</tr>
</tbody>
</table>

*Average credit price in 2016  ** Assume avg. CI = 36; EER = 0.9

- **Annual** credit revenue for one transit bus powered by RNG

<table>
<thead>
<tr>
<th>LCFS Credit Price*</th>
<th>Annual Credit Revenue***</th>
</tr>
</thead>
<tbody>
<tr>
<td>$100</td>
<td>$7,368</td>
</tr>
</tbody>
</table>

***Assuming 3.42 mi/DGE fuel efficiency & 35,000 annual mileage; CI=36; EER = 0.9

Credit value calculator: [http://www.arb.ca.gov/fuels/lcfs/dashboard/dashboard.htm](http://www.arb.ca.gov/fuels/lcfs/dashboard/dashboard.htm)
Landfill gas is the most common source of RNG for transportation in the LCFS.
Opting Into LCFS - Requirements & Obligations

- Production facility (i.e. biogas upgrading facility) registration in AFP
- Fuel Pathway (CI) application & approval
- Company registration in LRT-C BTS to establish a reporting account
- NGV reporting on quarterly & annual basis
Fuel Pathway Application Process

1. **Register & submit a request** via the Alternative Fuels Portal (AFP)

2. **Provide all required information & documentation** required for a specific pathway based on the classification scheme

3. **Review.** After staff has confirmed the pathway CI, the applicant will be notified by an email to review the CI & verify its accuracy.

4. **Submit an attestation letter** (both electronically & the original paper copy with a cover letter on company’s letterhead) to accept the final CI value
Fuel Pathway Classification

• **Tier 1 Pathway (simple):**
  Conventionally produced, first-generation fuels such as biomethane from landfill gas and natural gas, ethanol, biodiesel, and renewable diesel

• **Tier 2 Pathway (complex):**
  Next-generation fuels such as cellulosic alcohols, hydrogen, drop-in fuels, or conventional, first-generation fuels using innovative processes
# Operational Data Requirements for Tier 1 NG Pathway Applications

<table>
<thead>
<tr>
<th>A Tier 1 pathway application for Landfill Gas includes 24 months of the following monthly operational data:</th>
<th>Quantity of biogas captured and withdrawn from the landfill (typically measured in cubic feet per minute, logged over a time period in SCF, and converted to MMBtu)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Methane content of biogas (in percent)</td>
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<tr>
<td></td>
<td>All process energy used in biogas cleanup operations including:</td>
</tr>
<tr>
<td></td>
<td>- Electricity (kwh)</td>
</tr>
<tr>
<td></td>
<td>- Fossil NG (MMBtu)</td>
</tr>
<tr>
<td></td>
<td>- Raw biogas or biomethane (MMBtu)</td>
</tr>
<tr>
<td></td>
<td>- Propane or LPG (MMBtu)</td>
</tr>
<tr>
<td></td>
<td>- Diesel (gallons)</td>
</tr>
<tr>
<td></td>
<td>Pipeline transmission distance (miles)—maximum distance from source to fueling station</td>
</tr>
<tr>
<td></td>
<td>Methane content (%) biomethane after upgrading</td>
</tr>
<tr>
<td></td>
<td>Metered quantity of biomethane produced for pipeline injection (MMBtu)</td>
</tr>
</tbody>
</table>
## Operational Data Requirements (cont’d)

<table>
<thead>
<tr>
<th>A Tier 1 pathway application for CNG includes 24 months of the following monthly operational data:</th>
<th>If Bio-CNG, these requirements are in addition to data for landfill gas pathways above</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Electricity (kwh) used for compression at all dispensing stations covered by the pathway, and</td>
</tr>
<tr>
<td></td>
<td>- Metered quantity of CNG dispensed (MMBtu)</td>
</tr>
<tr>
<td></td>
<td>Pipeline transmission distance (miles)</td>
</tr>
<tr>
<td></td>
<td>- A default pipeline transmission distance of 1,000 miles is used for all fossil-based CNG pathways</td>
</tr>
</tbody>
</table>
## Operational Data Requirements (cont’d)

A Tier 1 pathway application for **LNG** or **L-CNG** includes 24 months of the following monthly operational data:

| If Bio-LNG or Bio-L-CNG, these requirements are in addition to data for landfill gas pathways above |
| All process energy inputs to liquefaction, and regasification-compression if L-CNG is produced, including: |
| - Electricity (kWh) |
| - Fossil NG (MMBtu) |
| - Quantity of NG used as feedstock (ft³) |
| - Quantity of LNG (gallons of LNG) produced |

If **L-CNG** is dispensed:

- Quantity of LNG used as feedstock (gallons)
- Quantity of CNG produced (ft³)

Transport mode (Rail and Heavy Duty Diesel Truck)

Maximum distance LNG is transported to farthest station (miles)
Reporting Requirements

- RPs must register in the LCFS Reporting Tool and Credit Bank & Transfer System (LRT-C BTS) to establish a reporting account
  - Provide company name, address, FEIN, & account administrator information

- RPs also must register all their fueling stations (called Fueling Supply Equipment (FSE))
  - Station name, address, GIS coordinates, the utility meter # & company (for CNG stations)

- Reported parameters are: the amount of biomethane dispensed per FSE for each FPC, and the vehicle application (e.g., light/medium duty, heavy duty)

- LCFS Reporting Schedule

<table>
<thead>
<tr>
<th>Report</th>
<th>Period Covered</th>
<th>Deadline</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st calendar quarter</td>
<td>January - March</td>
<td>June 30th</td>
</tr>
<tr>
<td>2nd calendar quarter</td>
<td>April - June</td>
<td>September 30th</td>
</tr>
<tr>
<td>3rd calendar quarter</td>
<td>July - September</td>
<td>December 31st</td>
</tr>
<tr>
<td>4th calendar quarter</td>
<td>October - December</td>
<td>March 31</td>
</tr>
<tr>
<td>Annual</td>
<td>The prior calendar year</td>
<td>April 30th</td>
</tr>
</tbody>
</table>
RNG Reporting - Special Considerations

- Not possible to track the physical molecules of RNG through the commercial pipeline system.
- An energy balance system is used to track the ownership of the renewable attributes of RNG via invoices/contracts.
- The injected RNG is considered a fossil gas and when withdrawn from the pipeline in CA, the renewable attribute is “reattached” on an energy basis.
LCFS Verification Program

• Expected to be effective in January 2019

• Goals
  • Check a chain of custody of biomethane to its final use
  • Ensure renewable attributes are accurately accounted
  • Conditions & assumptions used to derive the CI value are maintained

• Validation & verification of CI value
  • Site visit of production facility (i.e., biogas upgrader and liquefaction facility)
  • Site visit of reporting party (credit generator)
    • Attestation letters/contracts through out chain of custody
    • Monitoring plan
For More Information

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

LCFS Contacts:

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  veronika.pesinova@arb.ca.gov; (916) 324-8153;  
  Manisha Singh, Manager,  
  manisha.singh@arb.ca.gov; (916)327-1501

• **FPC Application**: Hafizur Chowdhury  
  Hafizur.Chowdhury@arb.ca.gov; (916)322-2275;  
  Anil Prabhu, Manager,  
  anil.prabu@arb.ca.gov; (916)445-9227
Renewable Fuels Standard
Biomethane

May 2017
The RFS program is a federal policy that requires a certain volume of renewable fuel to replace or reduce the quantity of petroleum-based transportation fuel, heating oil or jet fuel.

Mandatory participants are called “obligated parties” and consists of US refiners and importers of gasoline and diesel.

There are 4 renewable fuel types – each assigned a category code under the RFS2:
- Cellulosic biofuel - classified a D3 (e.g., cellulosic biofuel) or D7 (cellulosic diesel)
- Biomass-based diesel - classified a D4
- Advanced biofuel - classified a D5
- Renewable fuel (non-advanced/conventional biofuel) - classified a D6

Renewable Identification Numbers (RINs) are the credits that obligated parties use to demonstrate compliance.

Obligated parties must obtain sufficient RINs for each category in order to demonstrate compliance with the annual obligation.

The EPA resets the Renewable Volume Obligation (RVO) annually thereby establishing the number of RINs each Obligated Party must retire for the following calendar year.

There is no “sunset” date to RFS.
## RFS 2 Volume Standards

### Target Volume of 36 Billion by 2022

Volume Standards as Set Forth in EISA [billion gallons]

*EPA sets actual standards each November; standards below are as published in the Act*

<table>
<thead>
<tr>
<th>Year</th>
<th>Conventional Renewable Fuels (D6)</th>
<th>Advanced Biofuels (D3, D4, D5)</th>
<th>Total Advanced</th>
<th>Total Renewable Fuels (D3, D4, D5, D6)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Cellulosic Biofuel (D3)</td>
<td>Biomass-Based Diesel (D4)</td>
<td>Non-Cellulosic Advanced (D5)</td>
</tr>
<tr>
<td>2008</td>
<td>9.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>10.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>12.0</td>
<td>0.1</td>
<td>0.65</td>
<td>0.2</td>
</tr>
<tr>
<td>2011</td>
<td>12.6</td>
<td>0.25</td>
<td>0.80</td>
<td>0.3</td>
</tr>
<tr>
<td>2012</td>
<td>13.2</td>
<td>0.5</td>
<td>1.0</td>
<td>0.5</td>
</tr>
<tr>
<td>2013</td>
<td>13.8</td>
<td>1.0</td>
<td>1.0</td>
<td>0.75</td>
</tr>
<tr>
<td>2014</td>
<td>14.5</td>
<td>1.75</td>
<td>1.0</td>
<td>1.00</td>
</tr>
<tr>
<td>2015</td>
<td>15.0</td>
<td>3.0</td>
<td>1.0</td>
<td>1.50</td>
</tr>
<tr>
<td>2016</td>
<td>15.0</td>
<td>4.25</td>
<td>1.0</td>
<td>2.00</td>
</tr>
<tr>
<td>2017</td>
<td>15.0</td>
<td><strong>5.5</strong></td>
<td>1.0</td>
<td>2.50</td>
</tr>
<tr>
<td>2018</td>
<td>15.0</td>
<td>7.0</td>
<td>1.0</td>
<td>3.00</td>
</tr>
<tr>
<td>2019</td>
<td>15.0</td>
<td>8.5</td>
<td>1.0</td>
<td>3.50</td>
</tr>
<tr>
<td>2020</td>
<td>15.0</td>
<td>10.5</td>
<td>1.0</td>
<td>3.50</td>
</tr>
<tr>
<td>2021</td>
<td>15.0</td>
<td>13.5</td>
<td>1.0</td>
<td>3.50</td>
</tr>
<tr>
<td>2022</td>
<td>15.0</td>
<td>16.0</td>
<td>1.0</td>
<td>4.00</td>
</tr>
</tbody>
</table>

EPA set 2017 RVO at 311 MM; a 35% increase over 2016. Market is currently pacing short with 32MM reported as of March 31.
RFS - Renewable Pathways

• Biomethane is the **feedstock**, CNG and LNG produced with Biomethane will produce either a Cellulosic Biofuel or an Advanced Biofuel
  
  • In either case, biomethane must be injected into a common carrier pipeline for delivery to CNG/LNG facilities or used at an on-site CNG/LNG facility
  
  • Production facilities must be registered with the EPA prior to producing qualified fuels
  
  • CNG/LNG Cellulosic Biofuel (D3) can be produced from the following feedstock sources:
    
    • Landfill biomethane
    
    • Separated municipal solid waste digester biomethane
    
    • Municipal wastewater treatment facility digester biomethane
    
    • Agricultural digesters biomethane (manure, crop residues, separated yard waste)
  
  • Advanced Biofuel (D5) can be produced from biomethane derived from protein production byproducts and/or separated food waste anaerobic digesters
Biomethane CNG/LNG Pathway

Eligibility of Supplier is established

Biogas Plant

Biomethane is injected into Common Carrier Pipeline

Environmental Attribute separation, tracking and matching

Natural Gas Sale

Natural Gas Usage

Biomethane CNG/LNG Pathway

Accounting of biomethane usage and inventory

EA’s married with natural gas deliveries

Natural gas deliveries made by 3rd party

Gas Delivery

CNG/LNG Facility

DOCUMENTATION

Sales Contracts;
Monthly invoices by Biogas Plant;
Documentation establishing plant eligibility approved by EPA

Pipeline statements with utility-grade meter data of biogas injection;
Producer attestation establishing quantity and transfer of Environmental Attributes

Invoices and/or pipeline statements of Natural Gas sales and purchase;
Stringent accounting of Environmental Attributes

Pipeline statements with utility-grade meter data of natural gas delivery;

Data on the facility’s gas consumption, inventory and sales;
Documentation needed for verification

Documentation for banking/inventory of Biogas
Cellulosic Waiver Credit and Impact on Market Price

• For any calendar year for which the projected volume of cellulosic biofuel production is less than the applicable volume of cellulosic biofuel, EPA must:
  • Reduce the required volume of cellulosic biofuel for that year to the projected volume
  • Provide obligated parties the opportunity to purchase cellulosic waiver credits (CWC)
  • Establish the annual CWC price using the following formula:
    • The greater of $0.25 or $3.00 minus the wholesale price of gasoline, where both the $0.25 and $3.00 are adjusted for inflation
• Obligated Parties have the choice to settle their D3 requirements financially by purchasing a D5 plus a Waiver Credit or physically by purchasing a D3
• In March of 2016, OPIS and Argus started to publish a D3 Index
  • Very limited liquidity but a benchmark price
  • 2017 transactions are moving to utilizing D3 Index
Lookback at Biomethane Gross Yields

Total Value from Biogas

<table>
<thead>
<tr>
<th>RIN Year</th>
<th>Credit Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>$1.56</td>
</tr>
<tr>
<td>2011</td>
<td>$1.13</td>
</tr>
<tr>
<td>2012</td>
<td>$0.78</td>
</tr>
<tr>
<td>2013</td>
<td>$0.42</td>
</tr>
<tr>
<td>2014</td>
<td>$0.49</td>
</tr>
<tr>
<td>2015</td>
<td>$0.64</td>
</tr>
<tr>
<td>2016</td>
<td>$1.33</td>
</tr>
<tr>
<td>2017</td>
<td>$2.00</td>
</tr>
</tbody>
</table>

There are market costs associated with credit generation that are not accounted for in this slide.
Contracting for Biomethane Offtake

- Producer needs to identify and determine the level of financial and contractual risk they are willing to take:
  - Financial Considerations
    - Debt Coverage; Operating Cashflow needs
    - Ability to handle volatility of commodities markets
  - Contractual Risks
    - Minimum delivery requirements
    - Project Registration with EPA – Registrant becomes the RIN Generator and takes on associated risks of generation, record keeping and EPA required audits
  - Marketing Consideration
    - Supply chain management
      - Gas scheduling, management and delivery
      - CNG/LNG Conversion
  - Monetization of Credits
    - Offtake contracts with Obligated Parties
Contract Structures – NAESB Contracts

- Fixed Price Structure
  - Fixed price paid for every MMBtu of Biomethane Delivered
    - Usually at steep discount to spot market
    - Will have minimum delivery requirements with liquated damages
    - Possible Change in Law termination clause
    - Facility has no participation in EA revenue but must agree to provide documentation and allow for site visits
    - Necessary for financing

- Variable Structure
  - Revenue Share
    - Seller transfers biomethane to marketer in return for the majority of the net margin
    - Seller can retain EPA registration or allow marketer to be the Registrant
    - Higher upside but market risk
    - Not useful for financing

- Hybrid Structure
  - Floor Price for biomethane plus share of EA revenue
    - Provides certainty of break even cashflow
    - Allows for some upside with no downside
How Biomethane Moves in the Market

• Biomethane and associated Environmental Attributes are received by marketer at pipeline injection point
• Marketer delivers biomethane to their portfolio of contracted renewable fuel tolling facilities, where biomethane is used to produce Cellulosic biofuel- (CNG/LNG)
  • Tolling facilities may include California capacity, where LCFS credits can be generated in addition to RINs
• Biomethane is delivered via exchange - biomethane injection can be directly matched to delivery, without the need for owning pipeline capacity
• Once Cellulosic Biofuel is dispensed, renewable fuel credits (e.g. RINs & LCFS credits) are generated, usually by marketer
  • LNG – Bill of Lading and Buyer Attestation
  • CNG – Meter Data and Buyer Attestation
• Marketer then transacts either directly with obligated parties or through the secondary broker market
Launched in 2005, Element Markets has become a leading producer and marketer of renewable natural gas and environmental commodities in the US.

- Transacted over $1.6 billion in environmental commodities since inception
- Currently provide environmental asset management services for over 6,000 MW and 18 landfill gas projects
- Extensive expertise in the major North American Biogas Market
- Customer base of over 800 companies within the environmental markets
- Robust back-office and risk management practices for ease of execution

**Marketing**

<table>
<thead>
<tr>
<th>Emissions &amp; GHG Credits</th>
<th>Renewable Energy Credits</th>
<th>Biogas &amp; RINs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Largest regional marketer of emission credits in US</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Offset project developer managing 18 GHG projects</td>
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<td></td>
</tr>
<tr>
<td>Transacted over 40 million tonnes of GHG credits</td>
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<td></td>
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<tr>
<td>Active in all compliance and voluntary REC markets in North America</td>
<td></td>
<td></td>
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<tr>
<td>Transacted over 19 million RECs</td>
<td></td>
<td></td>
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<tr>
<td>Have transacted RECs in 38 different markets</td>
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<td></td>
</tr>
<tr>
<td>Currently Marketing Biogas from 12 different Projects + More Pending</td>
<td></td>
<td></td>
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<tr>
<td>Successfully Generating RINs and LCFS from Biogas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Over 60 million RINs transacted</td>
<td></td>
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</table>
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“US Emissions House of the Year”, 2014 and 2010 by Energy Risk

Energy Risk Environmental Rankings
• #1 U.S. Regional Greenhouse Gas Dealer
• #1 U.S. Voluntary GHG Credit Dealer
• #2 Renewable Energy Credit Dealer
  • #1 NOx & SO₂ Dealer

Environmental Finance Magazine
• Best Trading Company in North American Renewable Energy
• Runner- Up, Best Trading Company of North American GHG Markets (California)
  • Best Trading NOx & SO₂ Company Emission Credits