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Understanding Carbon Intensity of Renewable Fuels

September 16, 2022

Ashley Player, PE
Partner, Energy Compliance Services

At Weaver, there are no "one-size-fits-all" solutions. We combine leading technical knowledge with specific industry experience to provide highly customized services tailored to each client's needs.

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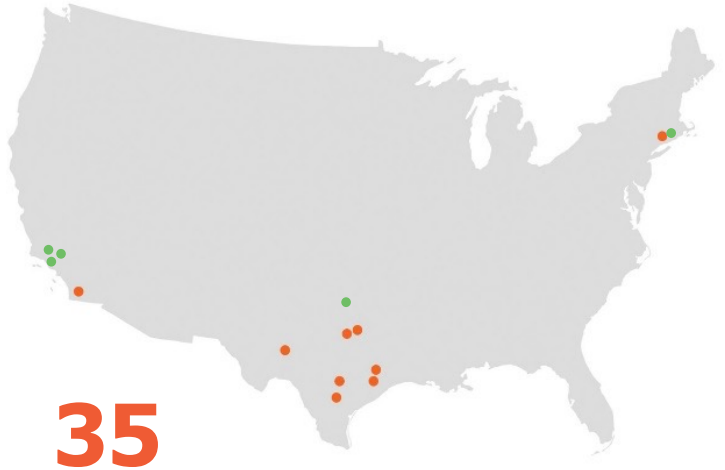


35

Top 35 Firm nationwide

Best of the Best Firms (2021)

Inside Public Accounting

Allinial GLOBAL

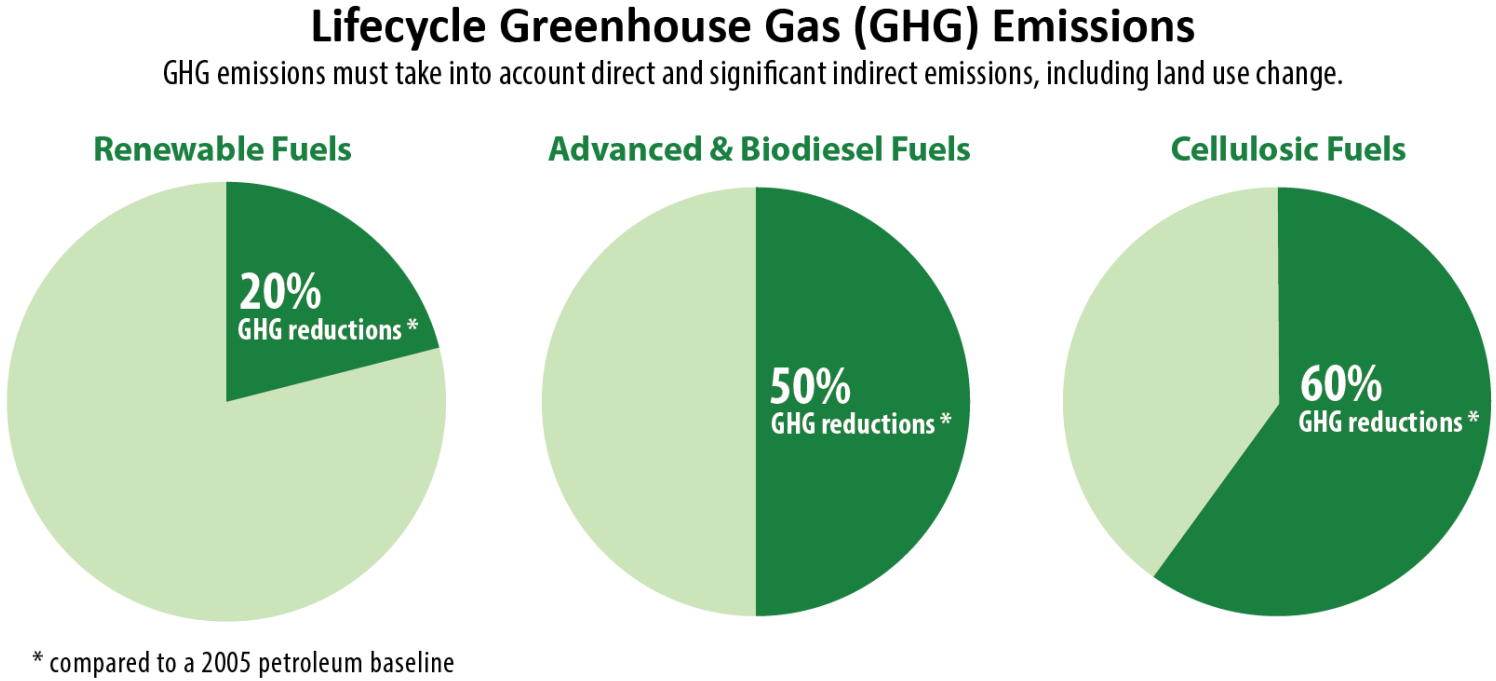
AltCredit FUND INTELLIGENCE US SERVICES AWARDS 2020 Shortlisted

TIAG

A Worldwide Alliance of Independent Accounting Firms

RFS D Code Categories

- **Cellulosic Biofuel:**
  - D codes **3, 7**
  - At least **60%** reduction
- **Biomass-Based Diesel:**
  - D codes **4, 7**
  - At least **50%** reduction
- **Advanced Biofuel:**
  - D code **5 (or 3, 4, 7)**
  - At least **50%** reduction
- **Total Renewable Fuel:**
  - D code 6
  - At least **20%** GHG reduction; except:
  - Existing (2007) facilities are "grandfathered", i.e., exempt to its 2007 baseline



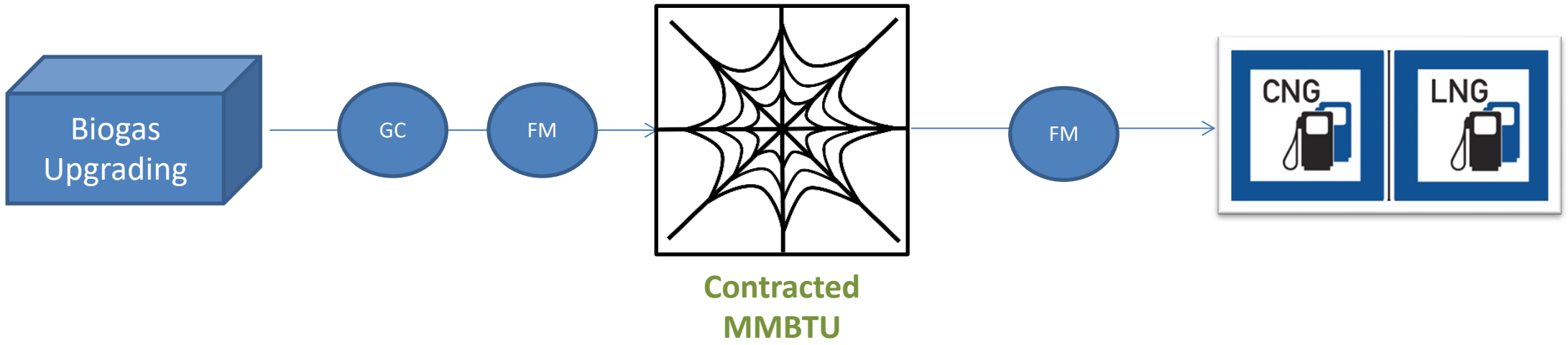
RFS Biogas Basics

- Anaerobic Digestion of Organic Matter (D3)
  - Landfills
  - Municipal Wastewater Treatment Plants
  - Agricultural Digesters
  - Separated MSW Digesters
- Other Digestion (D5)
  - Other Renewable Biomass Waste Digesters

- Renewable Fuel RIN Generation
  - CNG Sold/Used as Transportation Fuel
  - LNG Sold/Used as Transportation Fuel

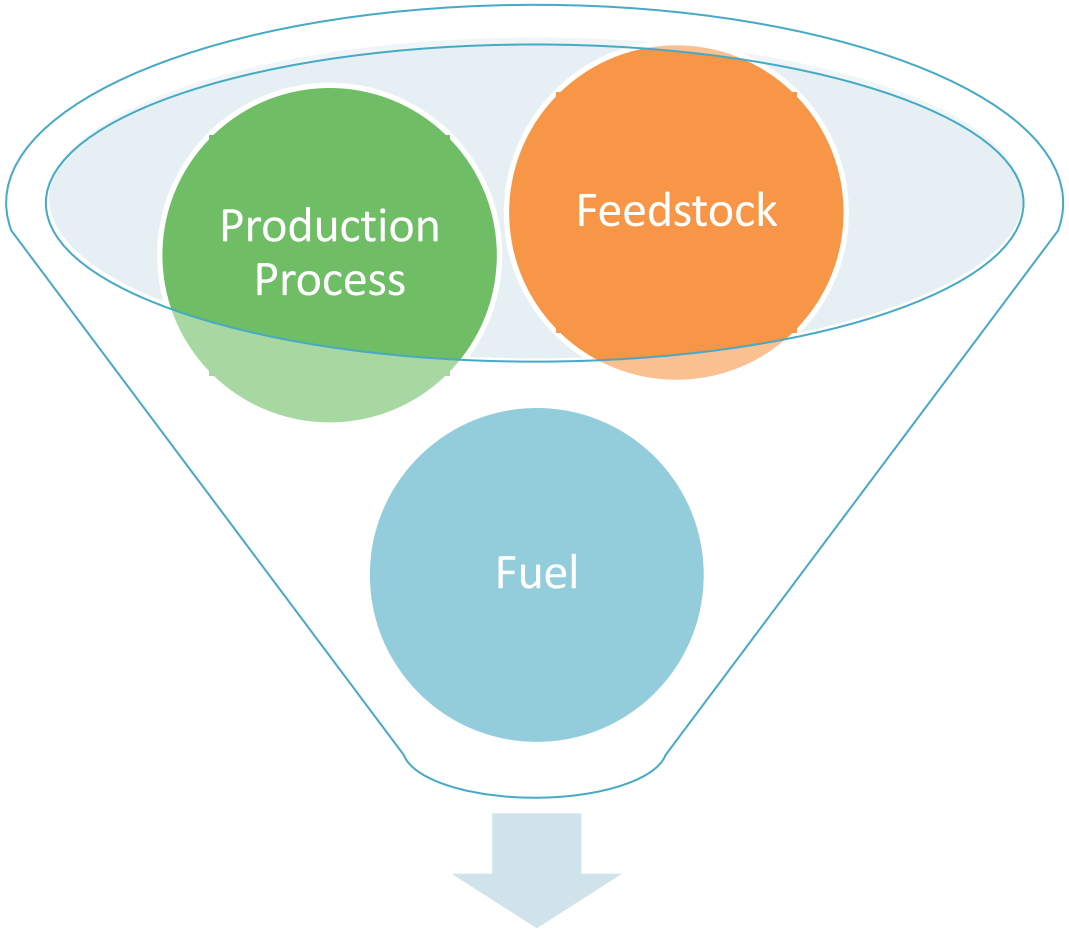
RFS Biogas RIN Generation

- RIN Generation Calculations
  - Volume and Heat Content Injected
  - Quantity Withdrawn CNG/LNG
  - Contracted RNG
  - Limited to Lowest MMBTU
  - [MMBTU] x 1,000,000 x 0.903 / 77,000 = [MMBTU] x 11.7273 = RINs



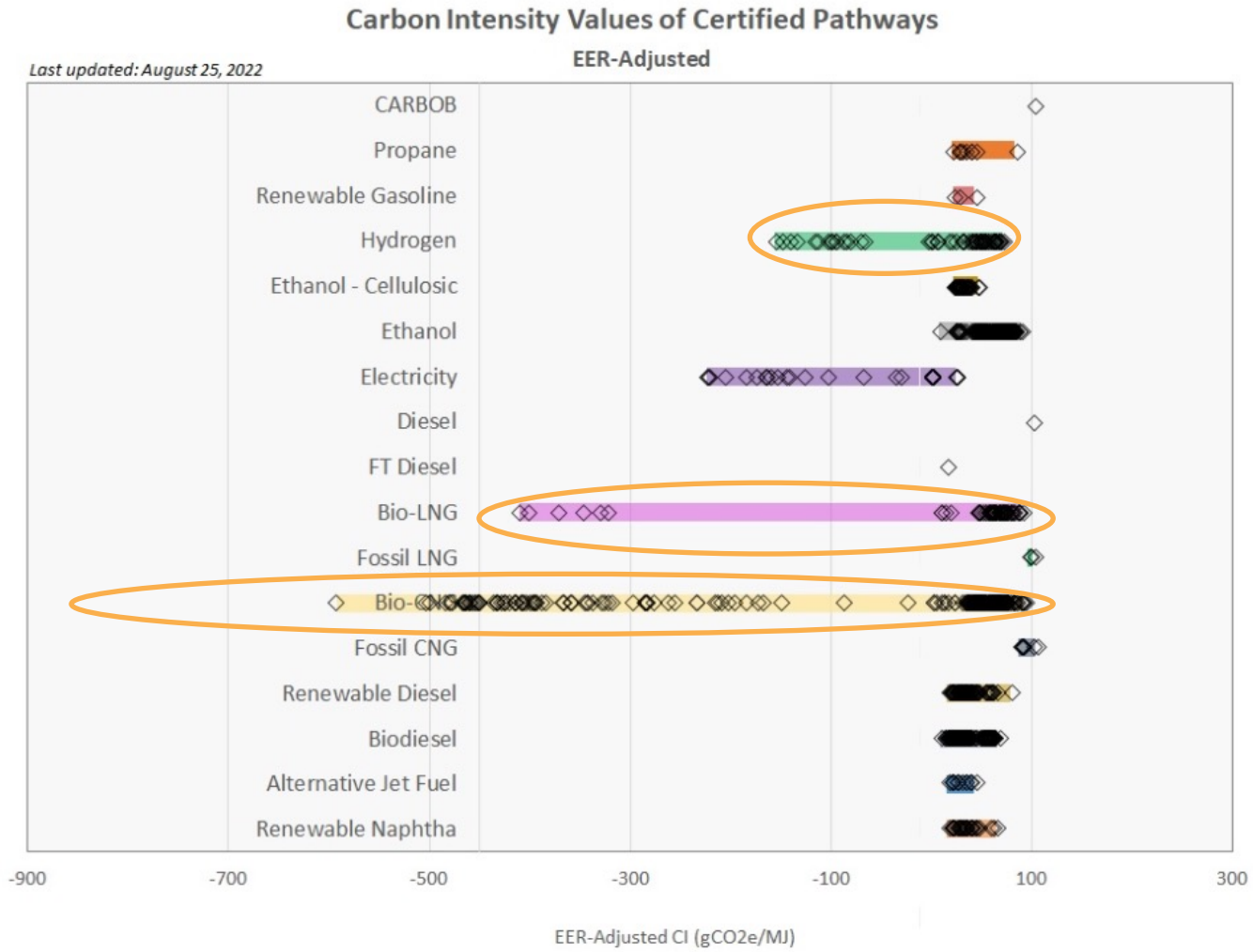
Low Carbon Fuel Standard

Carbon Intensity (CI)



- CA-GREET 3.0 Model
  - Feedstock
  - Production Process
  - Fuel
- Simplified Tier 1 Calculators
  - Landfills
  - Wastewater Sludge
  - Organic Waste
  - Dairy and Swine Manure

LCFS Fuel Pathway CI



https://www.arb.ca.gov/fuels/lcfs/fuelpathways/pathwaytable.htm

Biogas Pathways (CNG)

- Landfill Gas (40)
- WWTP (30)
- Organics (-10)
- Manure Digester (-300)

Hydrogen

- Grid Electricity (160)
- Zero CI Electricity (10)
- Landfill Gas (105)
- WWTP (130)
- Manure Digester (-240)

LCFS Credit Calculation

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$$Credits_i^{XD}/Deficits_i^{XD}(MT) = \left(CI_{standard}^{XD} - CI_{reported}^{XD}\right) \times E_{displaced}^{XD} \times C$$

$$CI_{reported}^{XD} = \frac{CI_i}{EER^{XD}}$$

- CI_i Is the carbon intensity of the fuel
- EER^{XD} Is the Energy Economy Ratio

$$E_{displaced}^{XD} = E_i \times EER^{XD}$$

- E_i Is the energy of the fuel, in MJ
- EER^{XD} Is the Energy Economy Ratio

CI Validation and Verification

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- **Validation**
  - Fuel Pathway Applications
    - 3+ Months of Data
- **Verification**
  - Annual Fuel Pathway Reports
    - 24 Months of Data
  - Quarterly Fuel Transactions Reports
    - 12 Months of Transactional Data

Simplified Tier 1 Calculator

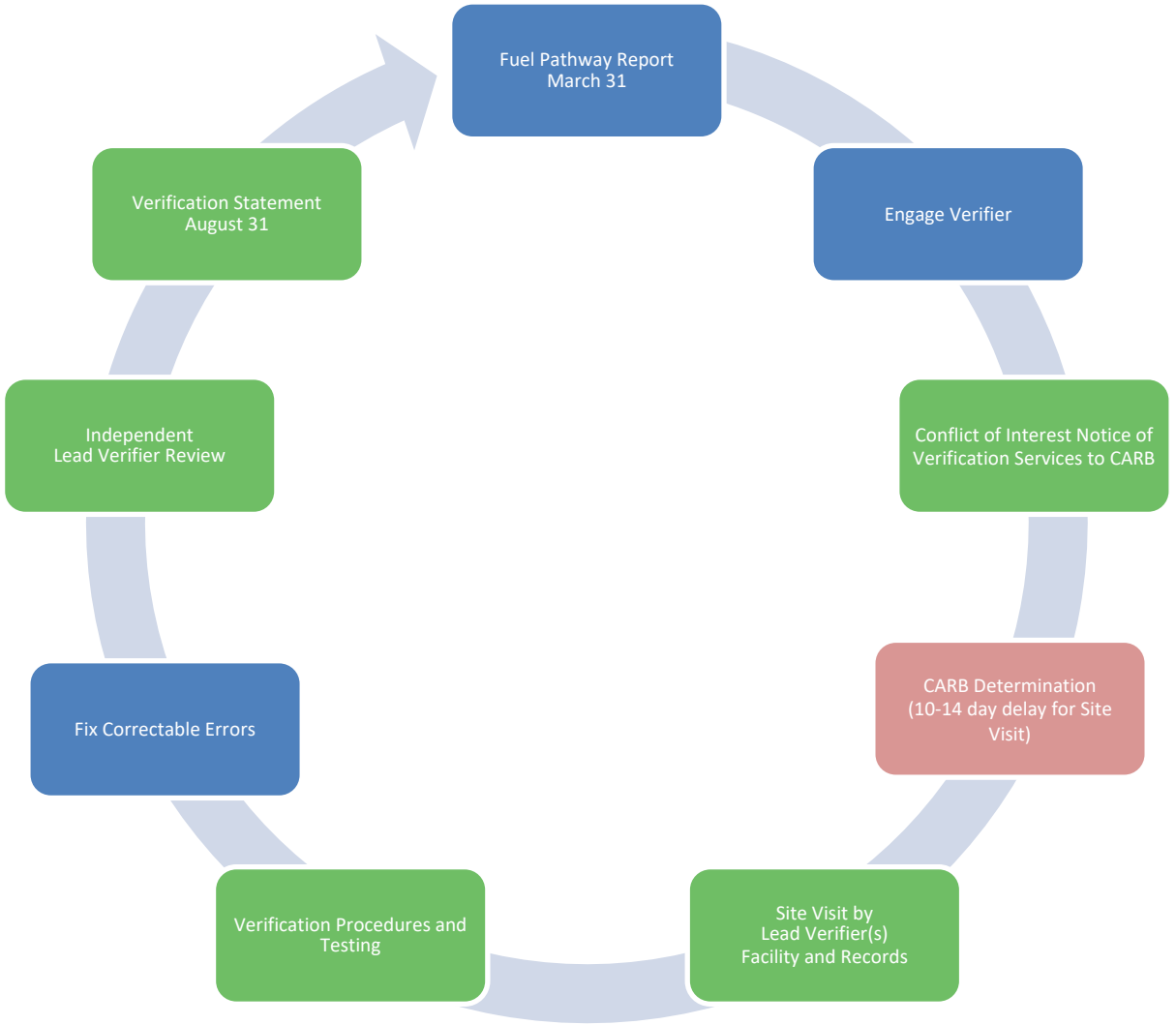
Summary of the Tier 1 Landfill Biomethane Pathway
Release Date: August 13, 2018

Pathway Descriptions and Results			
Finished Fuels	**Carbon Intensity from Inputs (gCO_2e/MJ)**	**Conservative Margin of Safety (gCO2e/MJ)**	**Total Carbon Intensity (gCO2e/MJ)**
Compressed Natural Gas (CNG)	0.00	0.00	0.00
Fuel Producer: . landfill gas to pipeline-quality biomethane; delivered via pipeline; compressed to CNG in California.			
Liquefied Natural Gas (LNG)	0.00	0.00	0.00
Fuel Producer: . landfill gas to pipeline-quality biomethane; delivered via pipeline; liquefied to LNG at ; transported by trucks to California.			
Liquefied CNG (or L-CNG)	0.00	0.00	0.00
Fuel Producer: . landfill gas to pipeline-quality biomethane; delivered via pipeline; liquefied to LNG at ; re-gassified in California.			

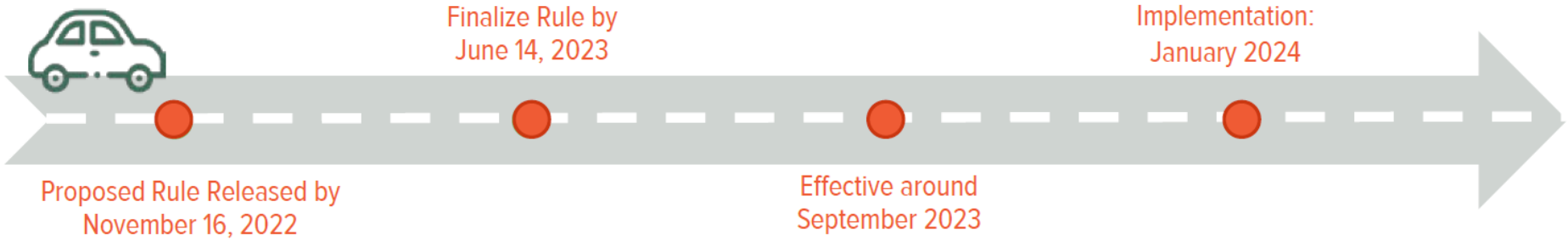
- Operational CI < Certified CI
  - May keep Certified CI or request to Update CI
- Operational CI > Certified CI
  - **Out of Compliance**
  - **Subject to Investigation and Enforcement**
  - **Credits Adjusted Retroactively**

Verification Requirements

- Accreditation through CARB
- Verifiers
  - 2+ years Relevant Experience
  - Qualification Examples: QAP, Attestations
- Lead Verifiers
  - Process Engineering & Alternative Fuel Production Technology
  - Independent Reviewer
- Annual Review
- Site Visits
  - Production Facility
  - Records Location



RFS Update: Renewable Electricity Pathways



- Options being considered:
  - Vehicle Manufacturers
  - Charging Station Owners
  - Both with Geofencing and Charging Station Priority
- RIN Generation
  - Equivalence Value
    - 22.6 kWh = 1 gallon = 1 RIN
    - 1 MWh = ~44.25 RINs
    - Could change in proposed rule
  - Must match renewable electricity to electricity used for transportation fuel only

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Questions?

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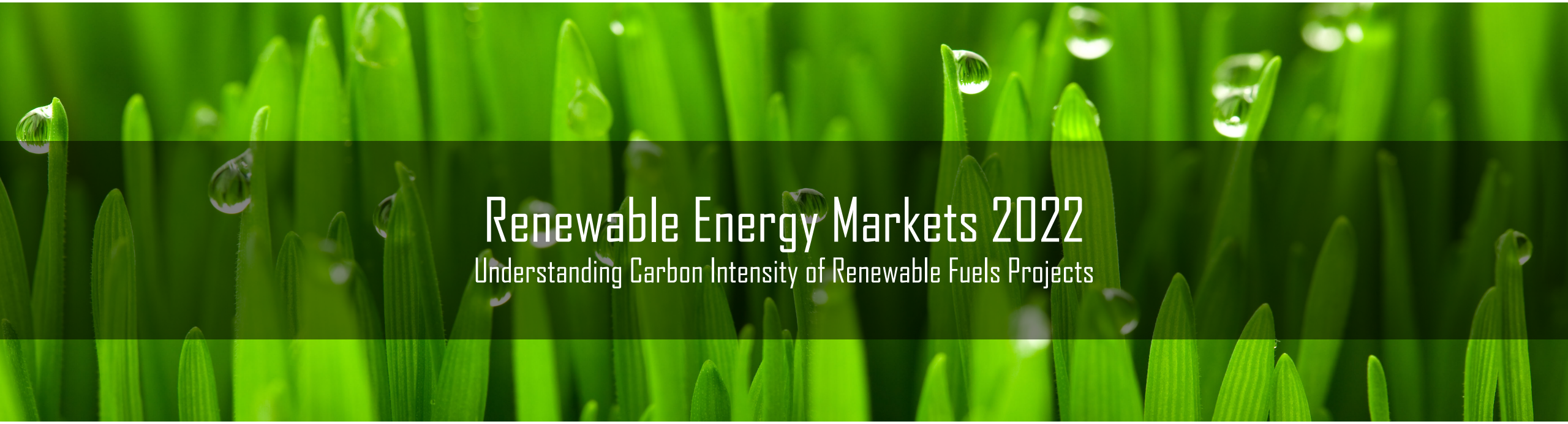

Renewable Energy Markets 2022

Understanding Carbon Intensity of Renewable Fuels Projects

September 16, 2022

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Our Approach Makes the Clean Energy Economy Possible

Our 360° project approach has evolved through hard-earned experience and unites our talented team with our core strengths — **training and education, regulatory engagement, life-cycle analysis, asset optimization, compliance management, and audit** — to deliver the results you seek and the return you count on.

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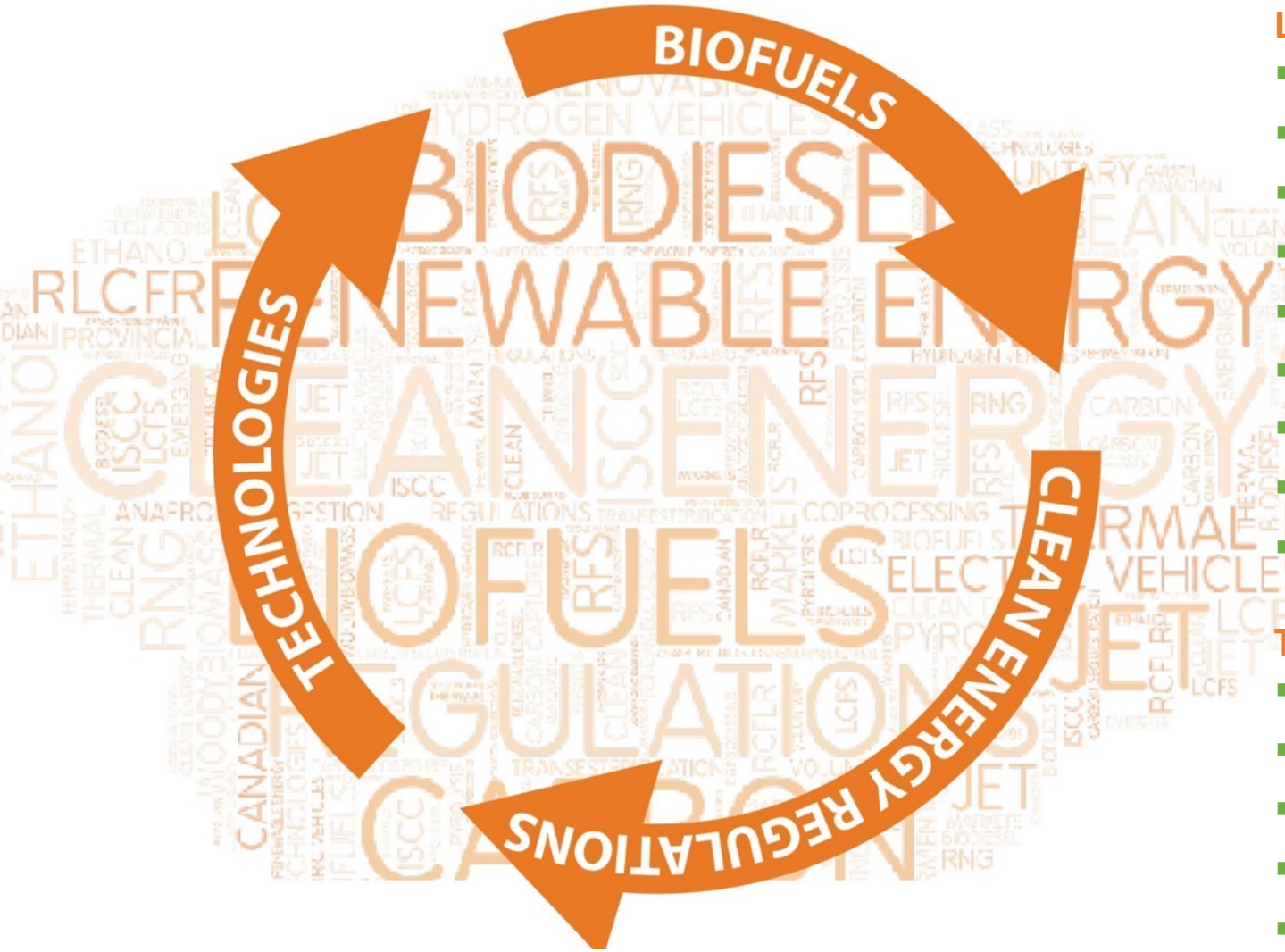
We Combine our Core Services with Areas of Expertise



Low-Carbon Fuels

- RNG
- Ethanol
- Biodiesel
- Renewable Diesel
- Woody Biomass
- Renewable Electricity
- Hydrogen
- Renewable Jet
- Thermal energy

Clean Energy Regulations

- USA – (RFS, LCFS, CFP)
- Canada – (RLCFR and provincial regulations
- Brazil – (RenovaBio)
- Voluntary markets – (utilities, higher education, municipalities)
- ISCC

Technologies

- Anaerobic digestion
- Fermentation/Pyrolysis
- Transesterification
- Carbon capture, utilization, and sequestration
- Coprocessing
- Gasification

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What is Life-Cycle Analysis?

Life-cycle Analysis (LCA) is a technique to assess the environmental aspects and potential impacts associated with a product, process, or service, by:

- Compiling an inventory of relevant **energy and material inputs** and **environmental releases**
- Evaluating the potential environmental **impacts** associated with identified inputs and releases
- Interpreting the results to help you make a **more informed decision**

Source: Wiki Commons

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LCA Drivers

Why track environmental impact with LCA ?

- Carbon policies and regulations
- ESG reporting directives
- Calculate emissions reduction
- Comparison to other alternatives
- Gain competitive advantage
- Corporate image
- Set/adjust internal cost of carbon

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LCA Tools

- **GREET** – Fuel pathways
  - California LCFS CA-GREET 3.0
  - Oregon CFP OR-GREET
  - USEPA RFS
  - Voluntary markets
  - Open source
- **GHGenius** – Fuel pathways
  - British Columbia LCFS
- **SimaPro**
  - Licenses for many different industries
  - Often used for product-based CI analysis
- **Open LCA**
  - Canada Clean Fuel Standard
- Others typically focused on a specific product/industry segment

Example Fuel Carbon Intensity Calculation

Key CI Inputs

No. 1 is process energy consumption

- Utility source - natural gas, coal, electric
- On-site power, CHP

Fuel yield

- Driven by process technology efficiency
- Feedstock conversion efficiency, type of feedstock

Co-products

- Displacement credits - DDG for cattle feed
- Co-product processing efficiency

Transportation

- Mode of transportation - truck, rail, ship
- Feedstock, fuel

Chemicals, other factors

Biogas CI Example at Municipal WWTP

Parameter	CI contribution (g/MJ)
NG	0.43
Electricity	14.60
Feed loss*	5.03
Pipeline transport	11.41
Compression of CNG*	3.18
Tailpipe of CNG vehicles*	3.66
Total	**38.32**

*Set Values

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Dairy RNG to Renewable Fuel Example for CA LCFS

- Type of manure matters
  - Dairy and swine manures only get methane avoidance credit
  - Beef cattle excluded
- What is the baseline manure management practice?
  - Lagoon scores are best
  - No lagoons = no methane avoidance credit
- How much of the manure goes to lagoons?
  - Can have 40- to 75-point CI impact
- How often are lagoons cleaned out? Agitated?
  - Can have 50- to 100-point CI impact
- How much RNG will be produced?
  - Set amount of methane avoidance credit

Available Tier 1 Simplified Calculators
Biomethane from North American Landfills
Biomethane from Anaerobic Digestion of Wastewater Sludge
Biomethane from Organic Waste
Biomethane from Dairy and Swine Manure

https://ww3.arb.ca.gov/fuels/lcfs/ca-greet/ca-greet.htm

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CI Analysis Result Variables in Manure Projects

Stage of Life Cycle	S1	S2	S3	S4	S5	Note
Manure Handling	0	0	0	0	0	User control
Grid electricity for upgrading	25	25	25	25	25	User control
Utility source NG for biogas production and upgrading*	14	14	14	14	18	User control
Biomethane flaring	2	2	2	2	2	User control
Fugitive	10	10	10	10	10	Almost fixed
Transmission	13	13	13	13	13	Proportional to distance, almost fixed
Compression	3	3	3	3	3	Fixed
Tailpipe	61	61	61	61	61	Fixed
Avoided emissions credits	-244	-316	-253	-280	-290	Dependent on baseline vs. project volume
Total	**-116**	**-187**	**-125**	**-152**	**-162**	

Key inputs and variables:

1. Dairy farm manure management practices (baseline)
2. RNG production
3. Utility inputs
4. Transmission (distance to CA)
5. Most other variables are fixed in CA LCFS Simplified GREET models

(All CI values are in the unit of g CO_2e/MJ, numbers are rounded)

* Assuming it does not change when biogas yield changes

**Other cases when this value is between 40-100% were analyzed and reported separately

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Example Voluntary Market Buyers

- Is CI important? Volume-based or CI-based?
- Potential voluntary market buyers
  - Utilities
    - Green Tariff
    - Upcoming regulations
    - Corporate Goals
    - $$$$
  - Universities
  - Fortune 500 companies
  - Other renewable fuel production facilities
  - Municipalities

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Q&A Session

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