The Power of Waste:
Biogas for Transportation in the U.S.

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Global Methane Forum – Biogas Track

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- **Mission:** to advance global collaboration in adoption of the low-carbon renewable energy sources, transport fuels, and new technologies needed for a sustainable future

- **Program:** Research of alternative vehicle fuels to reduce reliance on petroleum in transportation, publication of reports on best options, newsletters, media, & educational outreach

- **Impacts:**
  - Inspired trend of truck/bus shifts to natural gas in the U.S.
  - Building awareness of U.S. policy, business, and solid waste leaders of RNG fuel as leading transportation strategy for tackling climate change
  - EV's Step-by-Step Guide to converting organic wastes into fuel, used in regional workshops, leading to expanding initiatives

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Biogas & Sustainability

- Biogas is a **renewable** resource
- Biogas (once refined) is **clean** and close to pollution-free
- Biogas is a **net-carbon neutral** or even carbon negative source of energy/fuel on a lifecycle basis

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Biogas: Multiple Sources

- Landfills
- Wastewater Treatment Plants
- Farms/Dairies
- Commercial Food Waste
- Residential Organic Waste

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Biogas: Multiple End-Uses

- Biogases can generate heat or power on-site.

- Refined biogases (removing moisture, CO2 & impurities) become "**renewable natural gas"** (RNG) or **biomethane**, a fuel that can be used like fossil gas to cook, heat, generate electricity, or power vehicles

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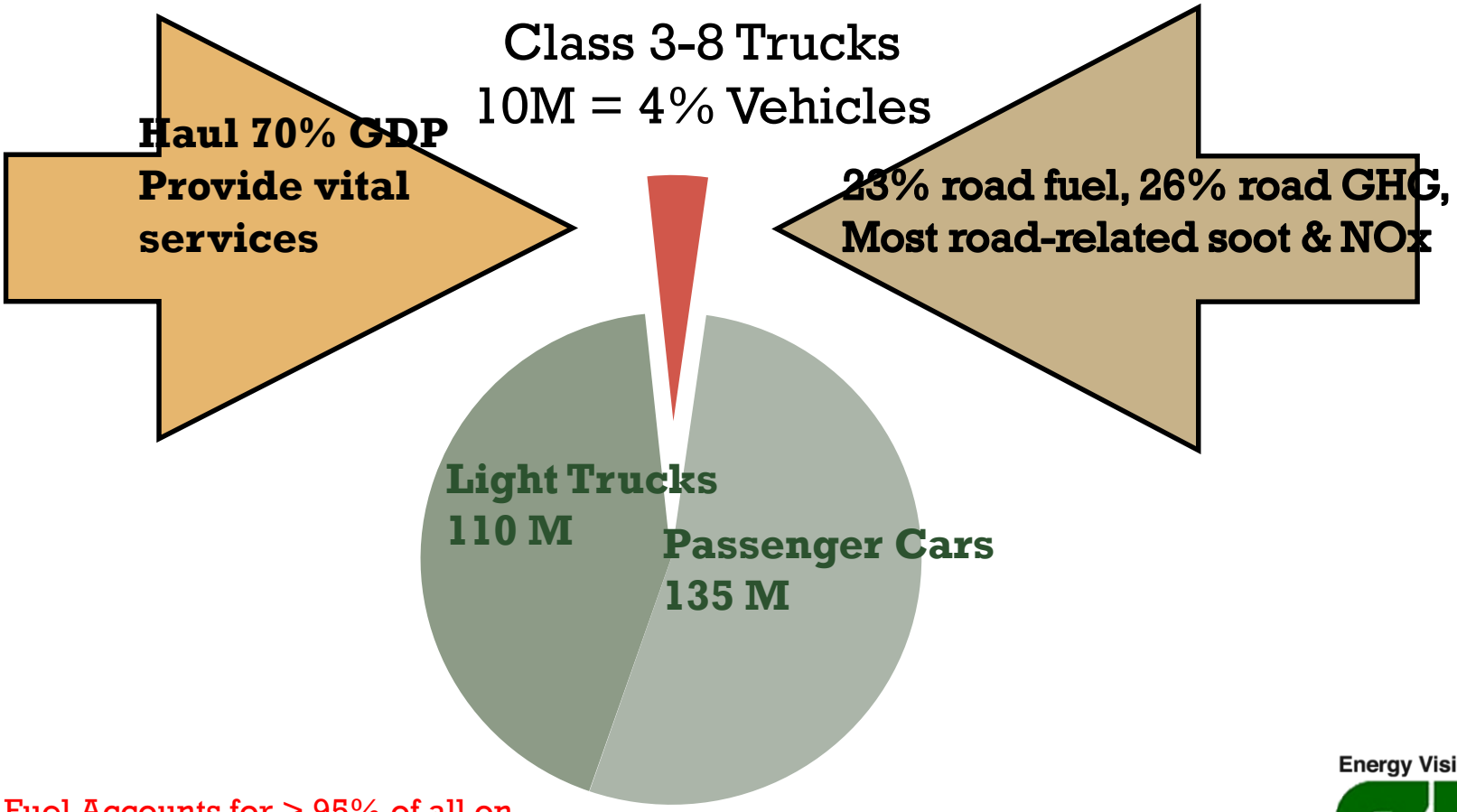
Why a Focus on Trucks & Buses?

Small Numbers, Big Impact

(U.S. Example)



Diesel Fuel Accounts for > 95% of all on-road heavy-duty buses and trucks

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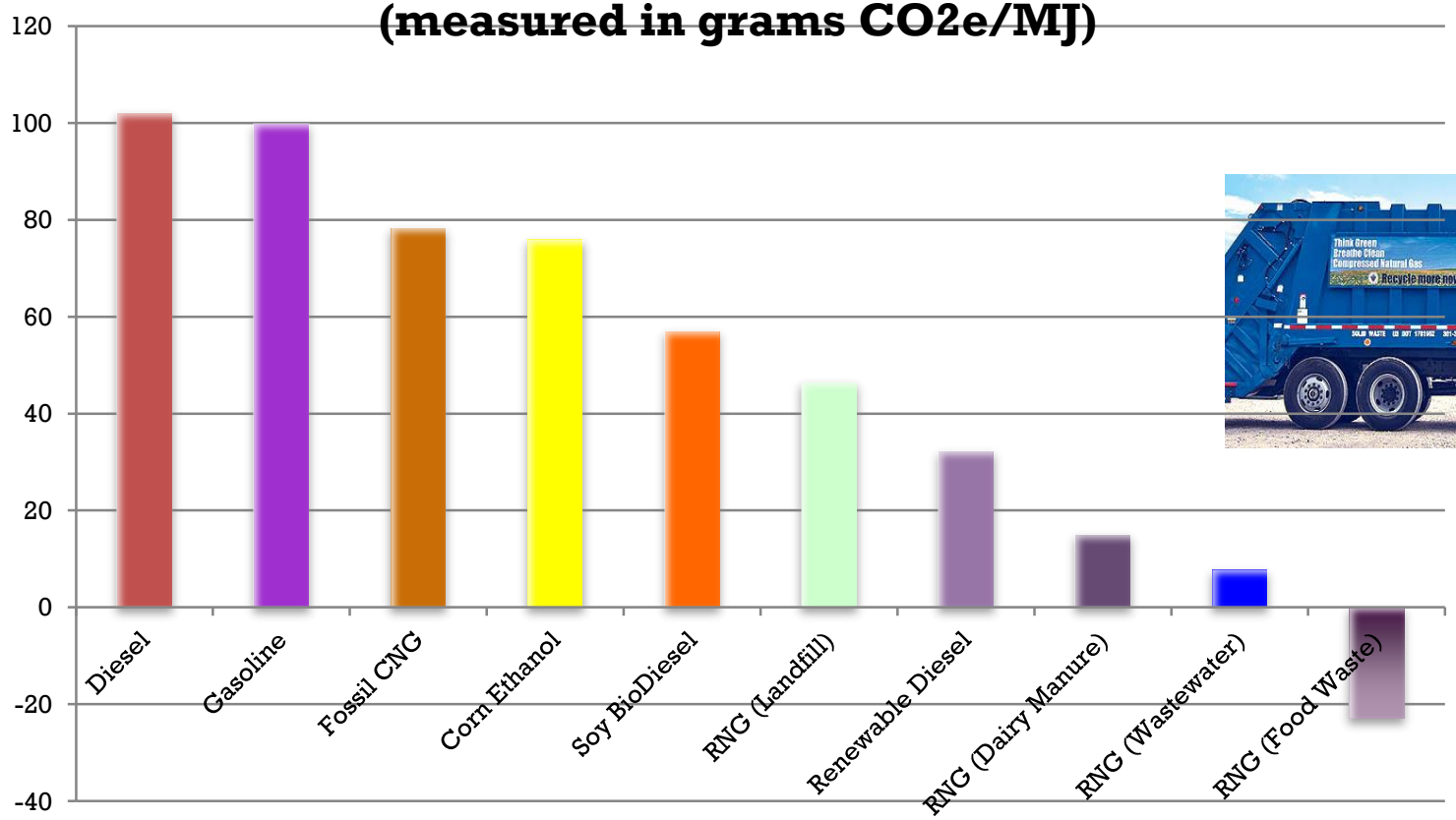
RNG Fuel: Optimal Transportation/ Climate Strategy

Lifecycle Carbon Intensity: Petroleum & Alternative Fuels – CARB GREET 2.0 2015 (measured in grams CO2e/MJ)



Source: www.arb.ca.gov/regact/2015/lcfs2015/lcfsfinalregorder.pdf

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Biogas for Transportation: How It Works

Wastes

All organic wastes contain energy.

Biogas

Anaerobic digestion of wastes at landfills or in digester plants produces energy-rich biogas.

RNG Fuel

Biogas upgrading removes carbon dioxide & impurities to make ***renewable natural gas*** (RNG).

Fuel Stations

RNG goes to on-site fueling stations, or by truck or pipeline to off-site pumps.

Vehicles

RNG works just like regular natural gas to power vehicles.

The Pathway from Organic Waste to RNG

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Case Study 1: Small Landfill

St. Landry Parish, Louisiana Landfill

On-site fueling of public and private CNG vehicles

- 100 scfm landfill gas collected, refined and compressed on-site; then dispensed to municipal CNG cars/trucks and private refuse trucks.
- Capital cost of $2.7M; ~170,000 GGE's/yr at $1.50/gallon

Louisiana RNG Video: energy-vision.org/st-landry-parish-landfill-rng/

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Case Study 2: Wastewater Facility

Persigo Wastewater Biogas Project (CO)

- In 2015, the City of Grand Junction, Colorado (pop. 60,000) installed a small system to convert biogas into vehicle-quality fuel at a cost of $2.8M USD
- The City and County now fuel 38 natural gas buses and refuse trucks with locally-produced RNG, displacing ~170,000 gallons of diesel/year

See PBS NewsHour Story:
www.youtube.com/watch?v=ASoXPy8RWlQ

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Case Study 3: Large Dairy Farm

Fair Oaks Dairy (IN)

- ampCNG and Fair Oaks Farms convert manure from 11,500 cows into fuel - more than 1.5 Million gallons/year - which powers 42 long-haul delivery trucks hauling 300,000 gallons of milk a day.

- Total capital cost for biogas upgrading, refueling and CNG truck purchase was approximately $18M





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+ Case Study 4: Food Waste Digester

Sacramento Biodigester (CA)

CleanWorld/Atlas Disposal: First Closed-Loop Food Waste-to-Fuel (RNG) Initiative in U.S.; Public-Private Partnership

See Project Profile:
http://bit.ly/1Kv1U07

clean world
Sacramento Biodigester
Organic Waste Recycling Facility

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Case Study 5: Large Landfill

Seneca Meadows Landfill (NY)

Aria Energy & Clean Energy Fuels

- 3,000 scfm of landfill gas refined and injected into natural gas pipeline at Seneca Meadows (Progressive Waste landfill)
- Capacity to produce ~25,000 GGE's/day of RNG (9M GGEs/yr)
- 60% delivered to SMUD in Sacramento; 40% is delivered to the transportation market in California through a partnership with Clean Energy

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REDEEM™ by Clean Energy Fuels

- Utilize Existing Natural Gas Infrastructure to Offer RNG at 40+ Retail Stations in California + stations in Texas and Tennessee (UPS is the largest customer)
- ~50 Million GGE's of REDEEM (sourced from a number of landfills across the country) hit the market in 2015
- >135,000 GGE's of REDEEM dispensed daily in California, largely because of the state's Low Carbon Fuel Standard (carbon program)

For more on REDEEM, visit:
http://redeem.cleanenergyfuels.com/images/redeem-clean-energy-factsheet.pdf

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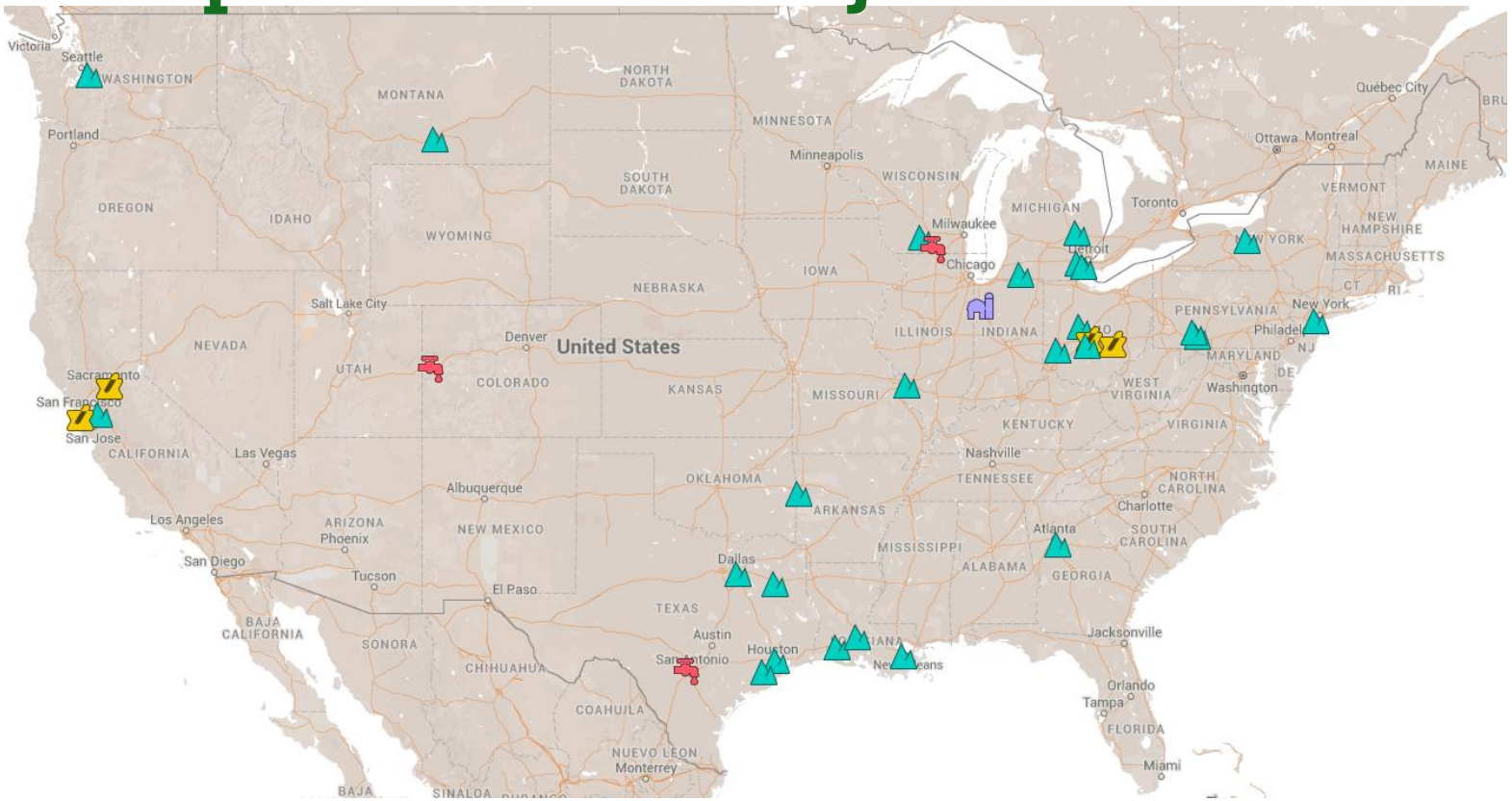
RNG for Transportation: Where Are We Now?

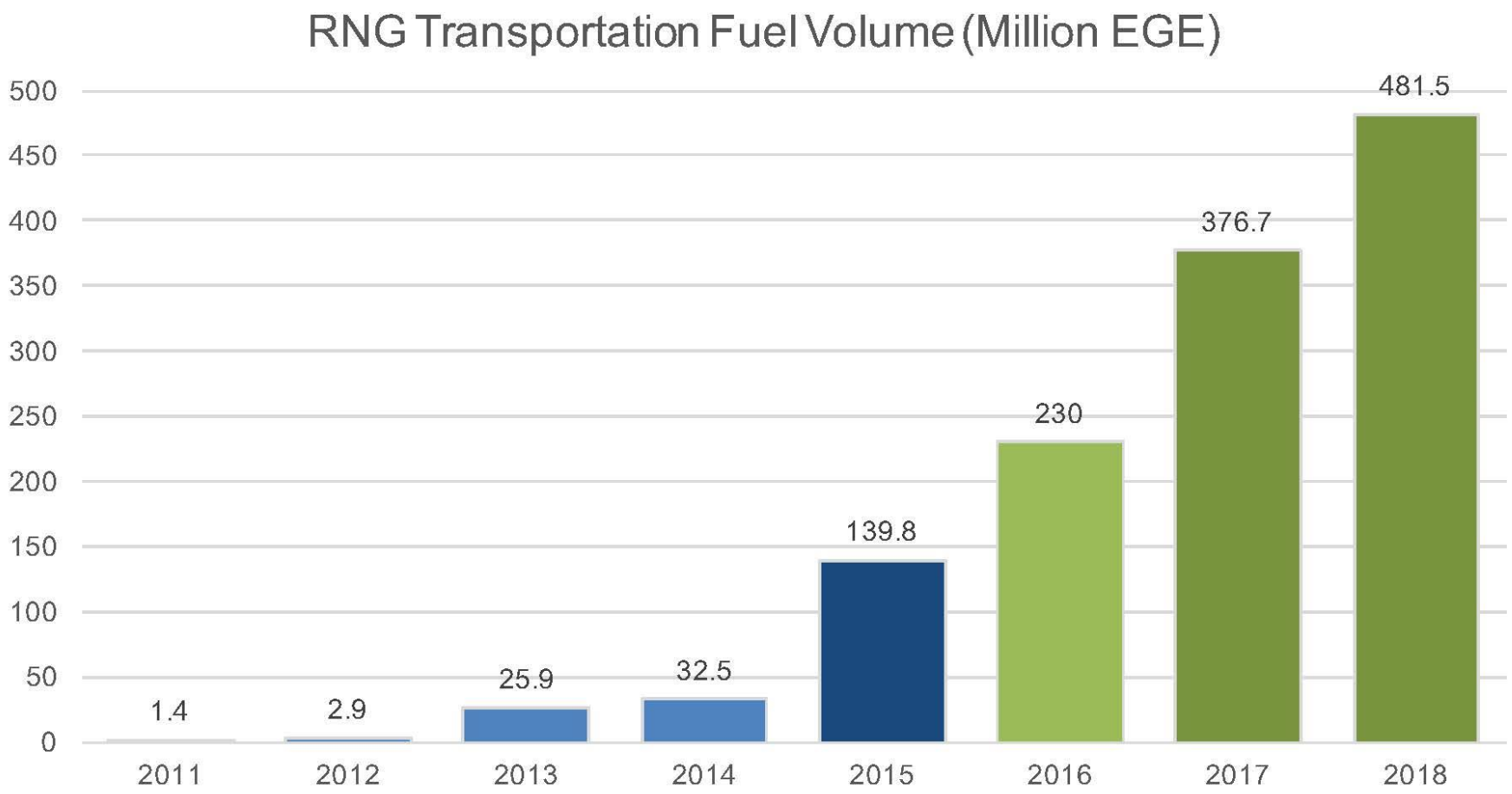
33 Operational U.S. Projects in 15 States!



In total, these 33 projects produced more than 90 million gallons of ultra-low-carbon RNG in 2015

For more, visit : www.energy-vision.org/organics-to-fuel-case-studies/

US RNG Industry Growth: 2011-2018



THE COALITION FOR RENEWABLE NATURAL GAS

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RNG Policy Drivers & Hurdles

- Current Policy Drivers Include:
  - US EPA Renewable Fuel Standard
  - California Low-Carbon Fuel Standard
  - Natural Gas Vehicle/Infrastructure Incentives
  - City & State Level Landfill Diversion Laws

- Primary Hurdles to RNG are Logistics & Financing:
  - All Technologies are Proven & Commercial

- ***Carbon Price/Tax would further incentivize RNG***

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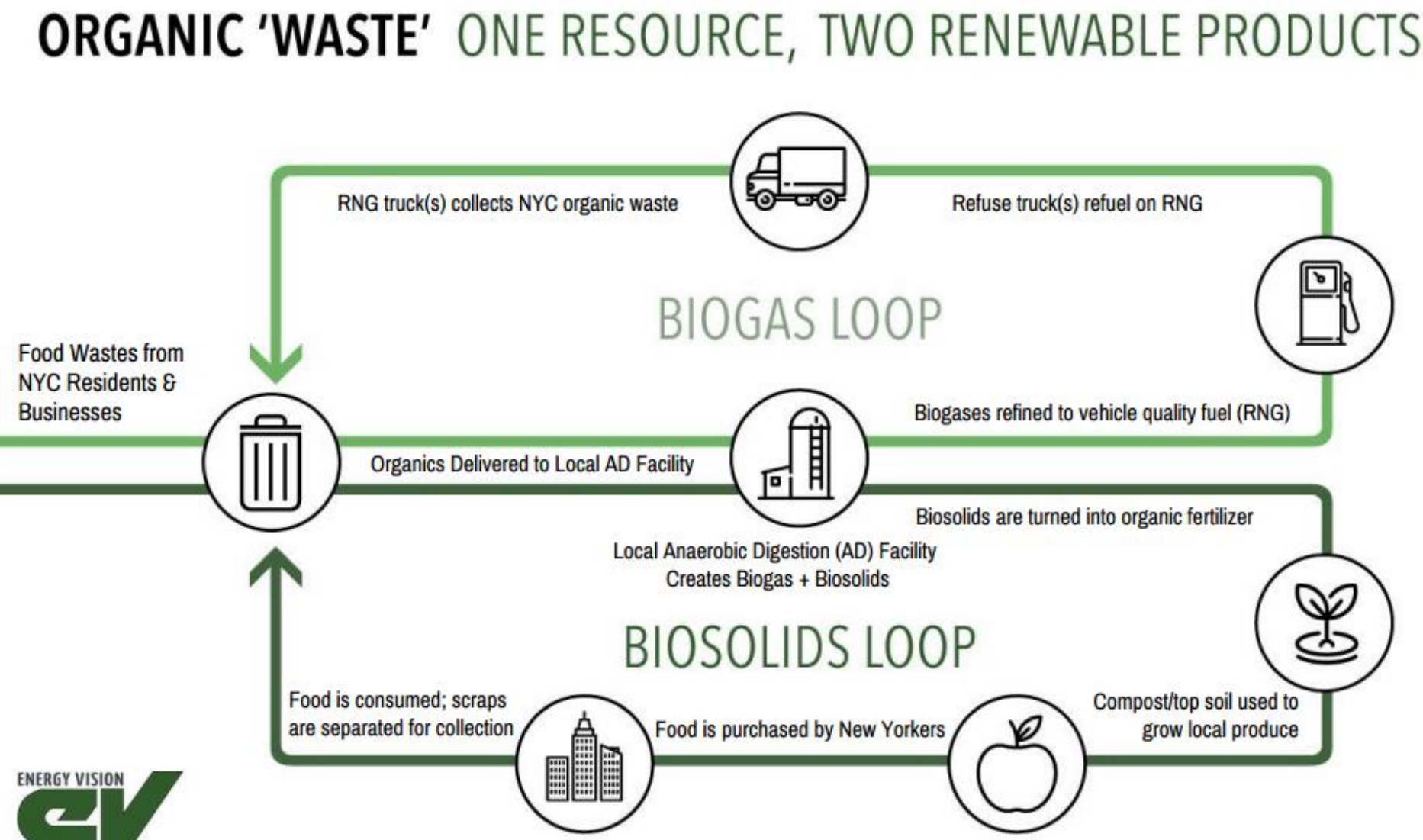
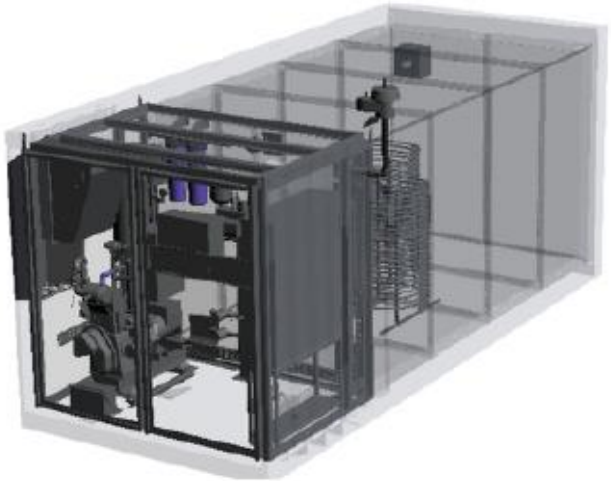
The Future of Organics Management?



Emerging On-Site Management Options Coming to North America

It's About Going From Here

To Here



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Eliminate the Hauler & Turn a Liability into an Asset

Electricity

Transport Fuels (& RINs)

On-Site Organics
Transformed Into
REAL $

Heat / Hot Water

Liquid Fertilizers

Carbon Credits

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