Renewable Natural Gas for Vehicle Fuel: Projects, Progress and Prospects

Marianne Mintz
Argonne National Laboratory

Waste-to-Wheels 2
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What is U.S. DOE Clean Cities?

A voluntary, locally based industry/government partnership of local coalitions

Coordinated by US Department of Energy, with Argonne as one of the lead labs for Clean Cities support

~90 coalitions & partnerships in 47 states, covering 78% of US population

Builds markets for cleaner-burning natural gas & other alternative fuel vehicles to reduce petroleum dependence

Fleet customers are primary audience, including national fleets like Veolia, PepsiCo, FedEx, AT&T, Frito-Lay, UPS, Coca-Cola & transit

Educates fleets, civic groups and general public about economic, environmental and energy benefits of alternative fuels & vehicles (e.g., JOBS NG, GREET, AFLEET)

What is RNG (biomethane)?

Parameter	Unit	Tariff Values for Natural Gas	High-BTU Landfill Gas	Raw Biogas
Htg Value (dry): avg range	Btu/SCF	1050 900-1200	970 930-1010	615 498-697
Wobbe No.	Btu/SCF	1340	1275	644
CO2	% comp.	0-3	0-2.2	28.6-40.4
Nitrogen	% comp.	0-4	0.5-6	0.6-12.7
Oxygen	% comp.	0-1	0.1-0.9	0.2-2.9
Hydrogen	% comp.	0-0.1	BDL-0.9	-
Siloxanes	mg Si/m^3	not reported	BDL-0.4	-
H2S	ppmv	0-15.3	BDL	1480-6570

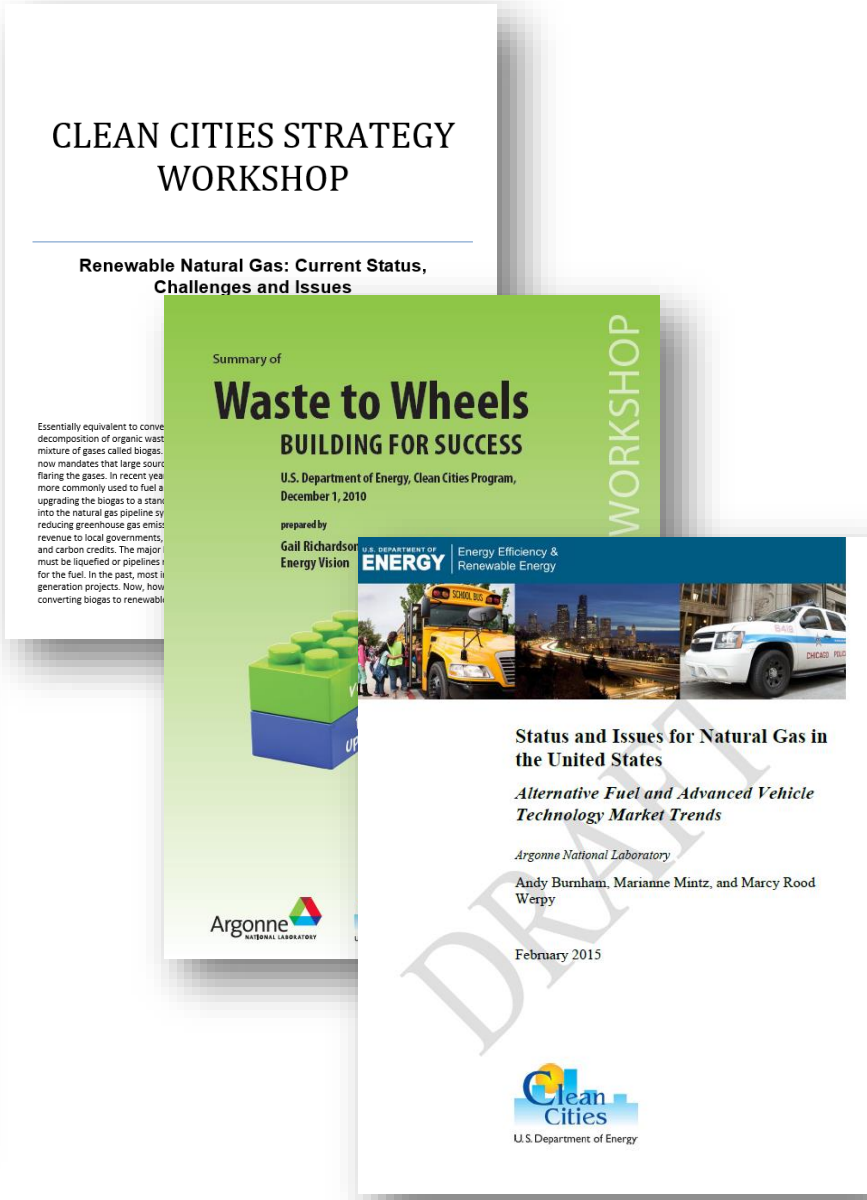
- A renewable source of methane, the primary constituent in natural gas (CH4)
- Produced when contaminants (primarily CO2) are removed from biogas (or LFG) which is produced from organic waste
- Following purification, RNG contains 90% or more methane
- Comparable to conventional, fossil methane, RNG CAN BE USED IN ANY NATURAL GAS-FUELED ENGINE)

Clean Cities supports RNG via local coalitions

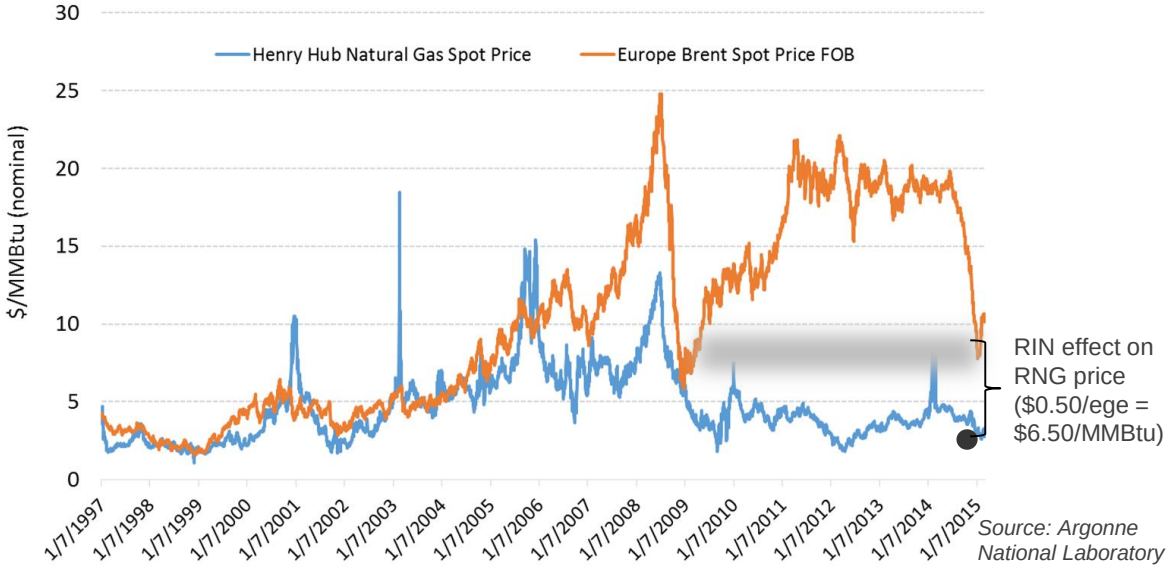
- *De Kalb County (CCG)*
- *Fair Oaks Dairies (GICC)*
- *Pierce Transit, SE-TAC Airport (WWCC)*
- *Rumpke Disposal, Quasar Energy (CFO)*
- *Linde/Waste Management/Altamont (EBCC)*
- *Atlas Disposal/Clean World Partners (SCC)*
- *……*

And via DOE's national program

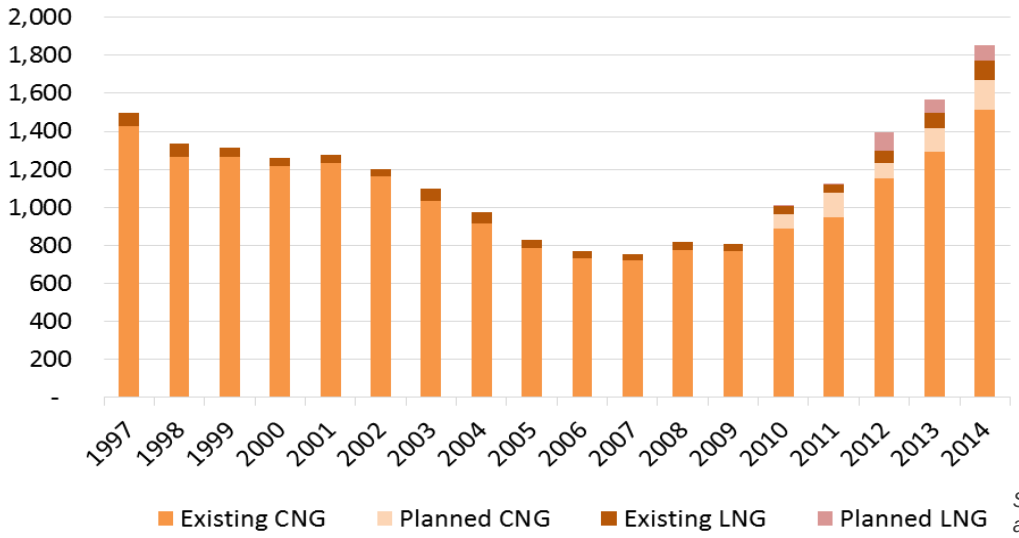
- Clean Cities Strategic Plan (2010)
  - RNG white paper
  - Waste-to-Wheels
- Clean Cities Strategic Plan (2015)
  - NG white paper
  - RNG toolkit
  - Case studies
  - **RNG is a priority opportunity**



1. RNG enables continued natural gas uptake



Source: Argonne National Laboratory

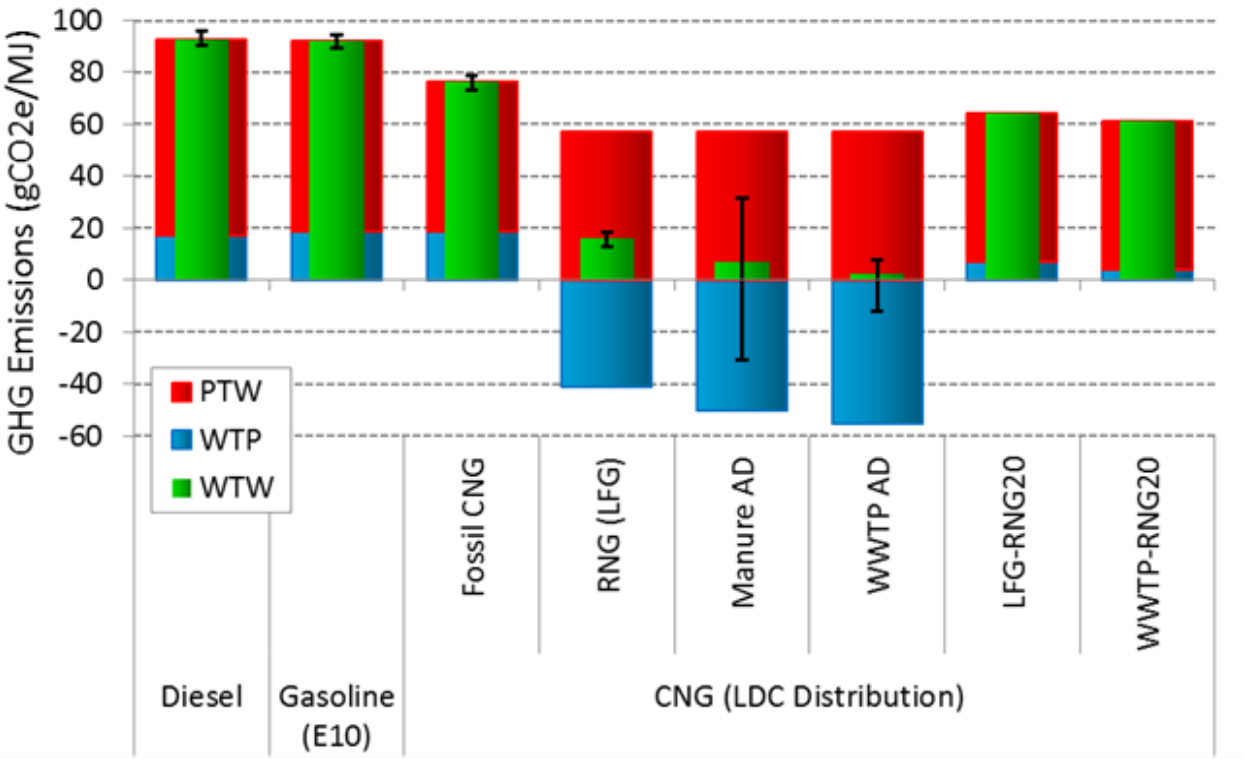


Sources: AFDC and NGVA

- Historically, natural gas and oil prices were "coupled"
- Price & new technology spurred exploration, production & new supply (~2000)
- Shale gas "revolution" (2006-09) uncoupled prices
- In past 5 years, ARRA & price differential enabled penetration and doubled number of stations
- Now, price differential narrowed & station additions down (20-30 to 10-20/mo)
- Unlike gasoline, NG upgrading accounts for larger share of retail price. Hence, NG use has greater impact on local economy

2. RNG reduces CO_2e and "greens the grid"

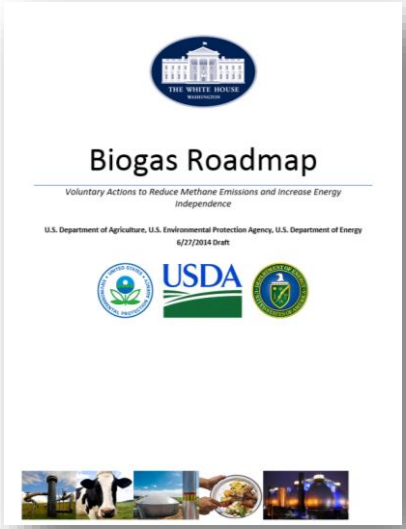
- GREET™ pathways include LFG, dairy or swine manure, and WWTP sludge
- With pipeline injection, "neat" RNG cuts GHGs by 80–95% "well-to-wheel" (WTW) compared with gasoline
- In a 20% blend, RNG reduces GHGs by 30–35% WTW
- Uncertainty is greatest for farm-based sources due to variations in manure management, grid access, etc.

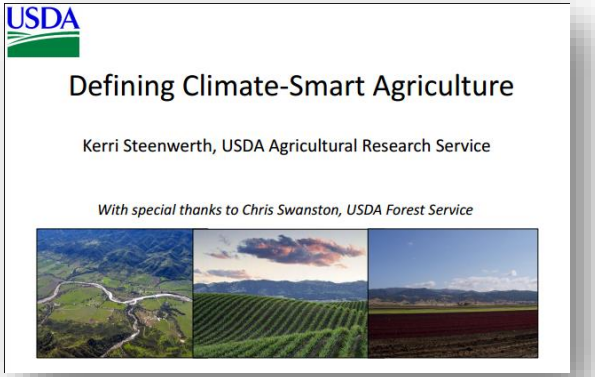


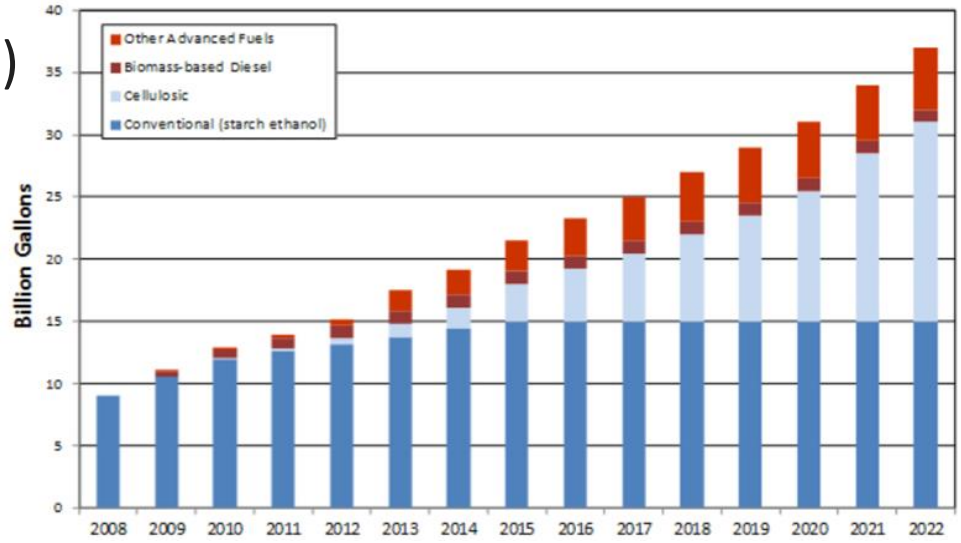
Source: J. Han, preliminary GREET 2015 results, http://greet.es.anl.gov.

3. RNG supports environmental initiatives & incentives

- Sustainability, GHG reduction goals
  - HI, VT, CA, NY, etc.
- USDA/EPA/DOE Biogas Opportunities Roadmap
- USDA Climate Smart Agriculture & Forestry
  - REAP
- California Low Carbon Fuel Standard
  - Fossil NG may not qualify with revised leakage, methane GWP estimates
- Renewable Fuel Standard (RFS2)

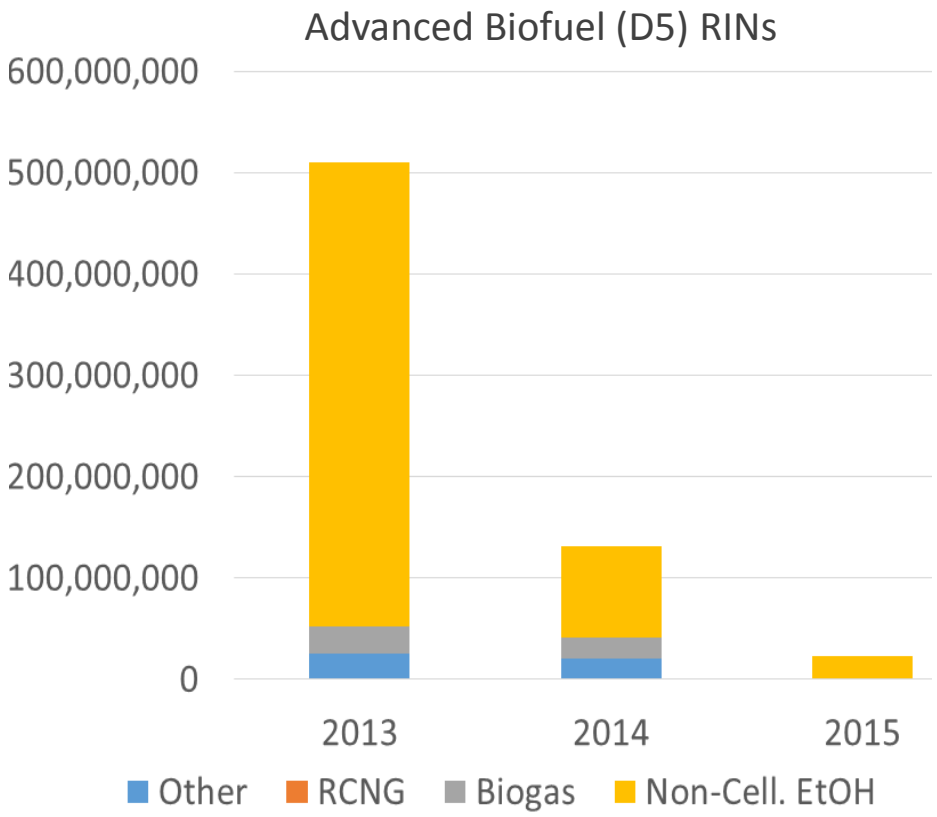


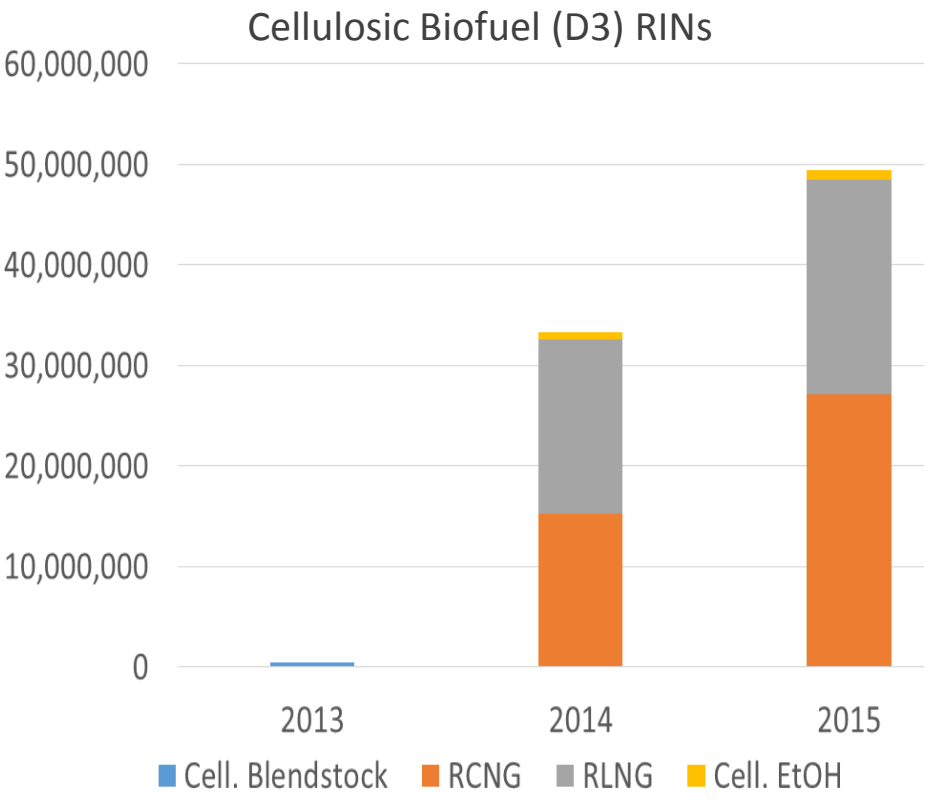




RNG accounted for ~53 million RINS in 2014*

(98% of all D3 RINS; negligible D5 RINs)





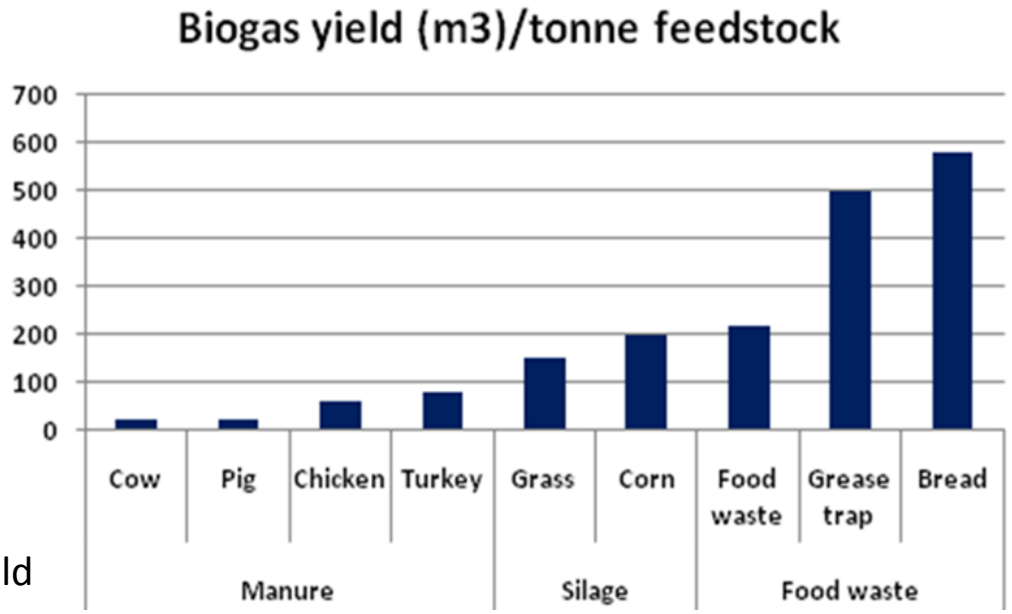
*Since RINs are in units of ethanol gal equivalent (ege), 1 RIN = 0.664 gasoline gal equivalent (gge).

RNG from LFG & food waste is especially attractive

DRIVERS:

- Supply

  Plentiful, primarily urban resources
- Environmental benefits:
  - WTW "neat" RNG = 85-115% GHG reduction
  - Blends reduce GHGs (e.g., RNG20 ~ 30% less)
  - Cellulosic biofuel under RFS2 provides significant price support (98% of 2014 D3 RINS)
  - Qualifies under LCFS which is stackable
- Efficiency. High calorie food wastes boost yield

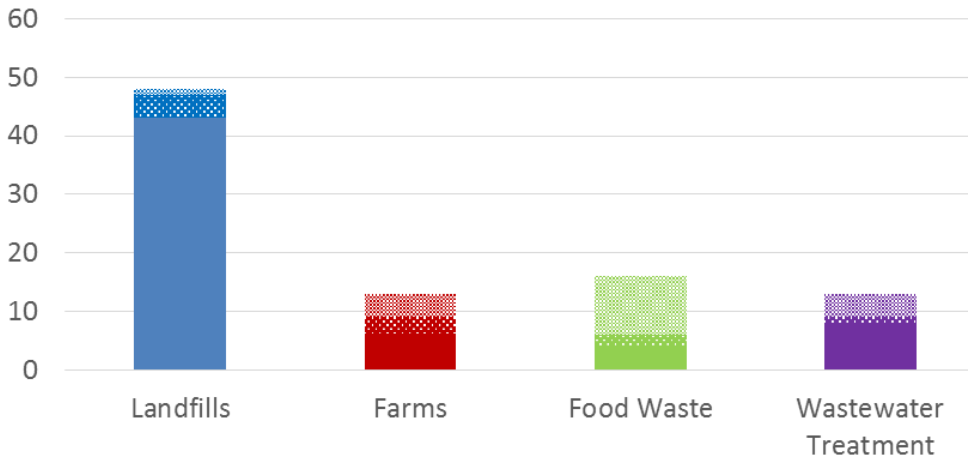


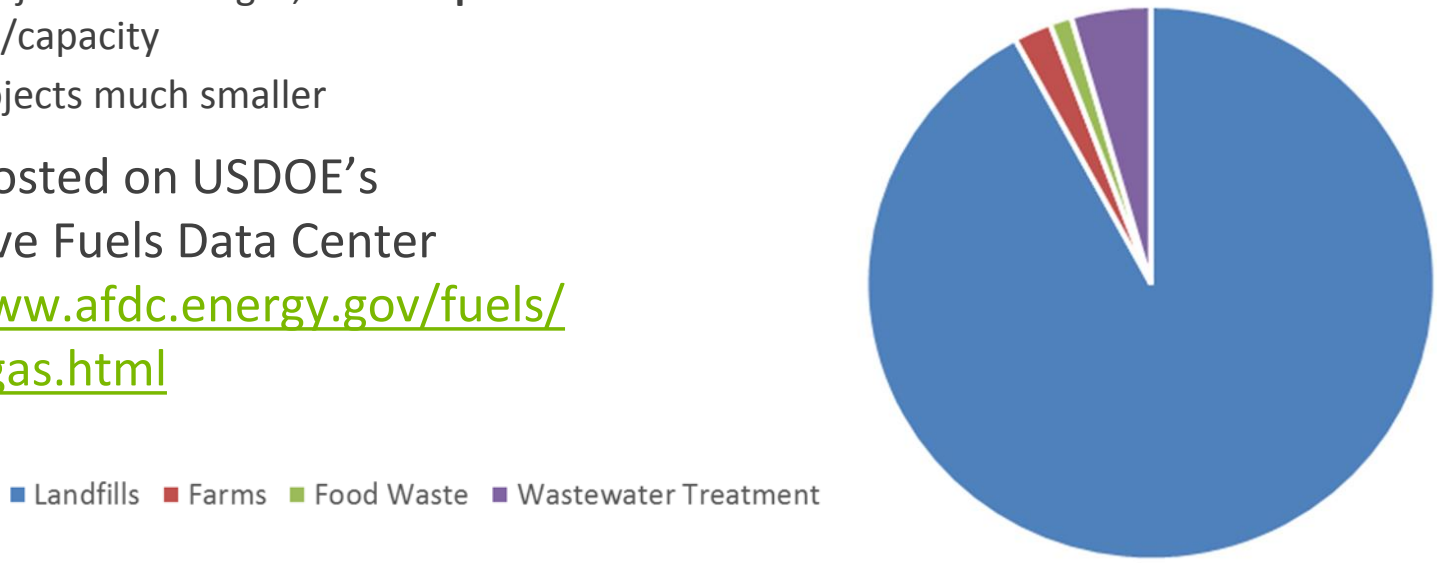
BARRIERS:

- Cost. High capex especially compared to CHP and composting. Feedstock price limits collection.
- Complexity. Long lead times, multiple vendors, approvals and partners.
- Temporary and uncertain incentives.
- Financing. Limited access to conventional financing. Incentives & RINS not "bankable".
- Utility interconnection. Costly, difficult and historically poor ROI (but may be changing).

RNG project database summarizes >100 projects

- 110 Projects (as of July 31, 2015)
  - 60 operational; 70% LFG
  - 10 under construction
  - 20 planned; 53% food waste
- Project size scales with resource in place
  - 4.5 million gge/yr overall average
  - LFG projects 33% larger; >90% **reported** output/capacity
  - AD projects much smaller
- Will be posted on USDOE's Alternative Fuels Data Center http://www.afdc.energy.gov/fuels/natural_gas.html





42 Landfills have operational RNG projects*

State	Landfill
AR	**City of Fort Smith Landfill**
CA	**Altamont Landfill**
CA	Central Disposal Site (Sonoma)
GA	**Seminole Road Landfill**
GA	Live Oak Landfill
GA	Oak Grove Landfill
IL	Milam Recycling and Disposal Facility
KS	**Deffenbaugh Landfill of Johnson County**
LA	**St. Landry Parish Landfill**
LA	**Jefferson Davis Parish Landfill**
LA	River Birch Landfill
MI	**Sauk Trail Hills Landfill**
MI	**Westside Recycling and Disposal Facility**
MI	**Riverview Land Preserve**
MT	**Billings Regional Landfill**
NH	Turnkey Recycling & Environmental Enterprises
NY	**Fresh Kills Landfill**
NY	**Seneca Meadows SWMF**
OH	**Franklin County Sanitary Landfill**
OH	**Rumpke Sanitary Landfill**
OH	**Pinnacle Rd Landfill (North Sanitary Landfill)**
OH	**Stony Hollow Landfill**
OK	Oklahoma City Landfill
PA	Imperial Sanitary Landfill
PA	**Laurel Highlands Landfill**
PA	Monroeville Landfill
PA	Seneca Landfill
PA	**Shade Landfill**
PA	South Hills (Arnoni) Landfill
PA	**Southern Alleghenies Landfill**
PA	Valley Landfill
PA	Veolia ES Greentree Landfill, LLC
TN	**North Shelby Landfill**
TN	Carter Valley Landfill
TN	Meadow Branch Landfill
TX	**Greenwood Farms Landfill**
TX	**McCommas Bluff Landfill**
TX	Turkey Creek Landfill
TX	**Fort Bend Regional Landfill**
TX	**McCarty Road LF**
WA	**Cedar Hills Regional Landfill**
WI	Dane County Landfill #2 – Rodefeld

* As of July 31, 2015. Please contact author with info on additional projects.

18 Anaerobic digesters have operational RNG projects*

State	Farm-Based Digester
CA	Hilarides Dairy
IN	**Fair Oaks Dairy - Digester 2**
OH	**Zanesville Energy**
OH	Renergy
OH	Buckeye Biogas
NE	O'Lean Energy

State	WWTP-Based Digester
CA	Point Loma Wastewater Treatment Plant
NY	Newtown Creek Wastewater Treatment Plant
OH	Newark Wastewater Treatment Plant
OH	Dayton Wastewater Treatment Plant
TX	**Dos Rios Water Recycling Center**
WA	South Wastewater Treatment Plant
WI	Janesville Wastewater Treatment Plant
CO	Persigo Wastewater Treatment Plant

State	Food-Waste-Based Digester
CA	Northstate Rendering Anaerobic Digester
CA	Blue Line Biogenic CNC Facility
CA	Sacramento BioDigester - South Area Transfer Station
OH	**Central Ohio BioEnergy**

* As of July 31, 2015. Please contact author with info on additional projects.

Questions/Comments??

mmintz@anl.gov

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