

DOCKETED

Docket Number:	17-IEPR-10
Project Title:	Renewable Gas
TN #:	219875
Document Title:	Presentation - The Feasibility of Renewable Natural Gas as a Large-Scale, Low Carbon Substitute
Description:	Presentation by Amy Jaffe of UCD
Filer:	Raquel Kravitz
Organization:	UC Davis
Submitter Role:	Public Agency
Submission Date:	6/23/2017 1:21:32 PM
Docketed Date:	6/23/2017



Sustainable Transportation Energy Pathways (STEPS)

The Feasibility of Renewable Natural Gas as a Large-Scale, Low Carbon Substitute

June 27, 2017

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Animal manures



Waste water biogas



Food & green waste



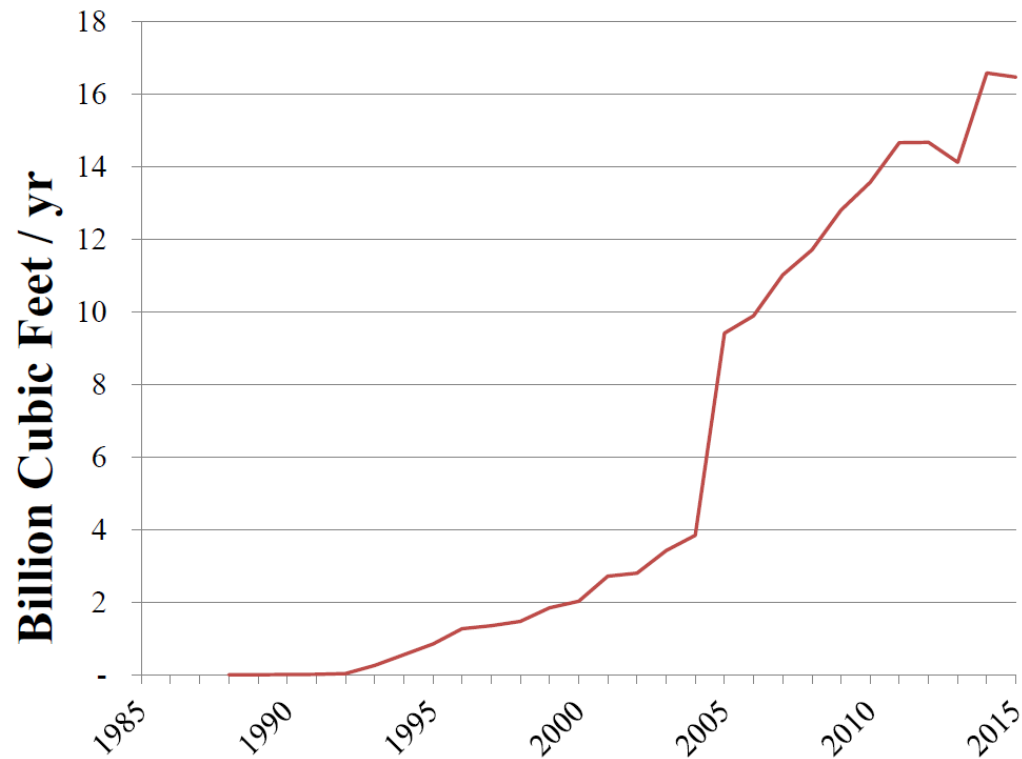
Landfill gas

Renewable Gas Market: Key Observations

- CA has **large RNG production potential** (90.6 bcf/yr \approx 750 million gasoline gallons)
- Our findings show that **RNG can achieve significant market penetration by the 2020s** of 14 BCF (roughly 85% of current natural gas use in transport in California) at LCFS credits of \$120 per metric ton of CO₂, much higher volumes if combined with RIN credits
- **Tipping fee increases** could incentivize **higher volumes** of RNG from MSW
- Cost of production is **sensitive to size of resource** at each site and **proximity to pipeline network**
- CA's high costs of **pipeline interconnect** and **upgrading to pipeline standards** as main **barriers** to RNG

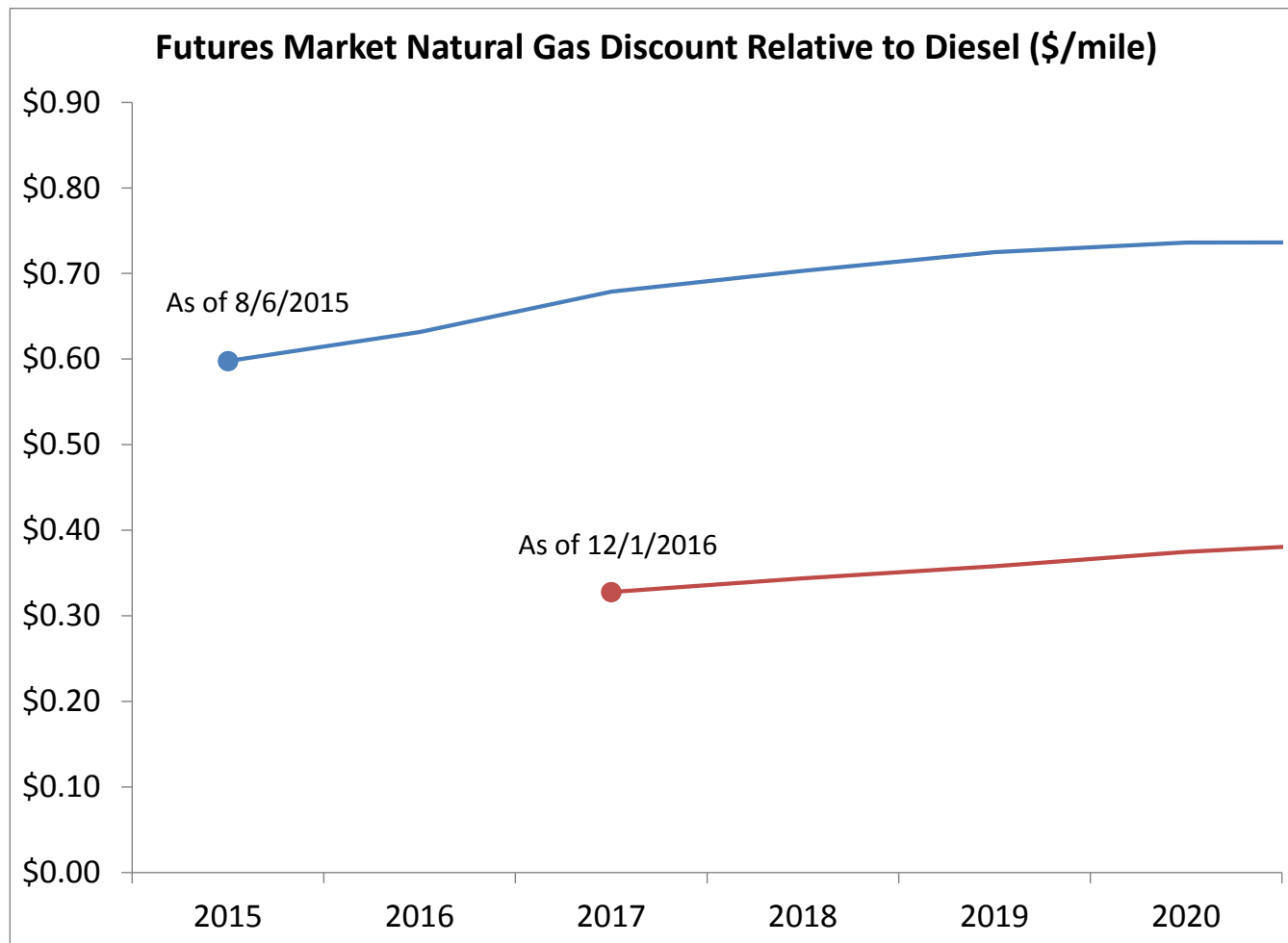
Natural Gas small but growing fuel source

CA Vehicular Nat Gas Consumption



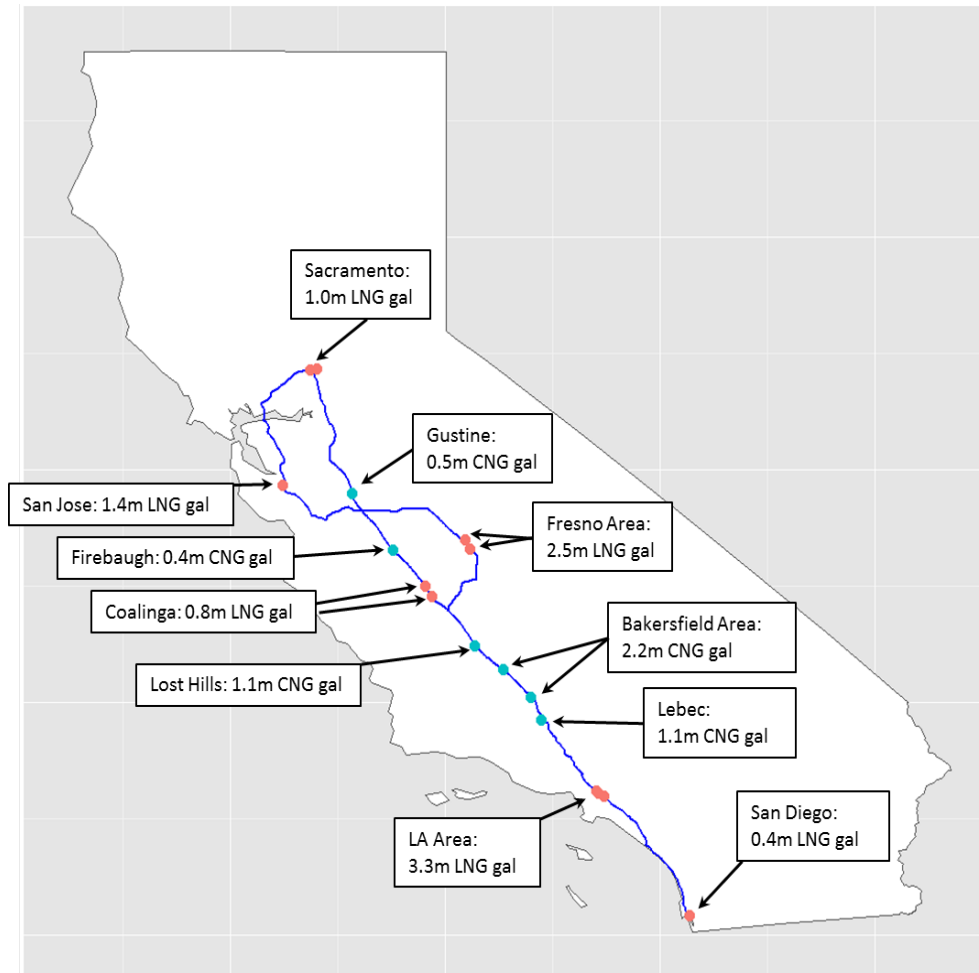
Source: EIA

Natural Gas Price Discount Relative to Oil



Source: CME Group

Evolution of Natural Gas Refueling Network



Initial locations of LNG (red dots) and CNG (blue dots) refueling infrastructure and route deployment.

Annual gallons of LNG and CNG fuel delivered at outset- 0.2% Penetration Rate.

No Subsidy.

Renewable gas as an emissions reduction mechanism

Capture methane

- Collect natural methane emissions (landfill)
- Anaerobic digestion of organic matter (dairy, MSW, WWTP)

Upgrade to pipeline quality standards

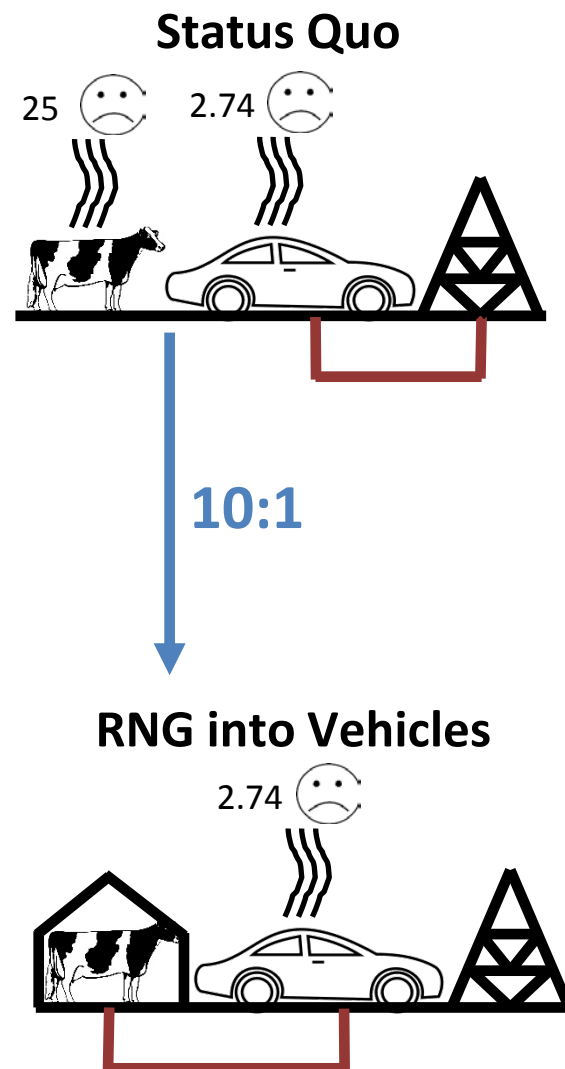
- Removing CO₂ and pollutants

Connect to pipeline network

- construct pipeline to nearest nat gas pipe
- construction of interconnect (\$\$\$\$)

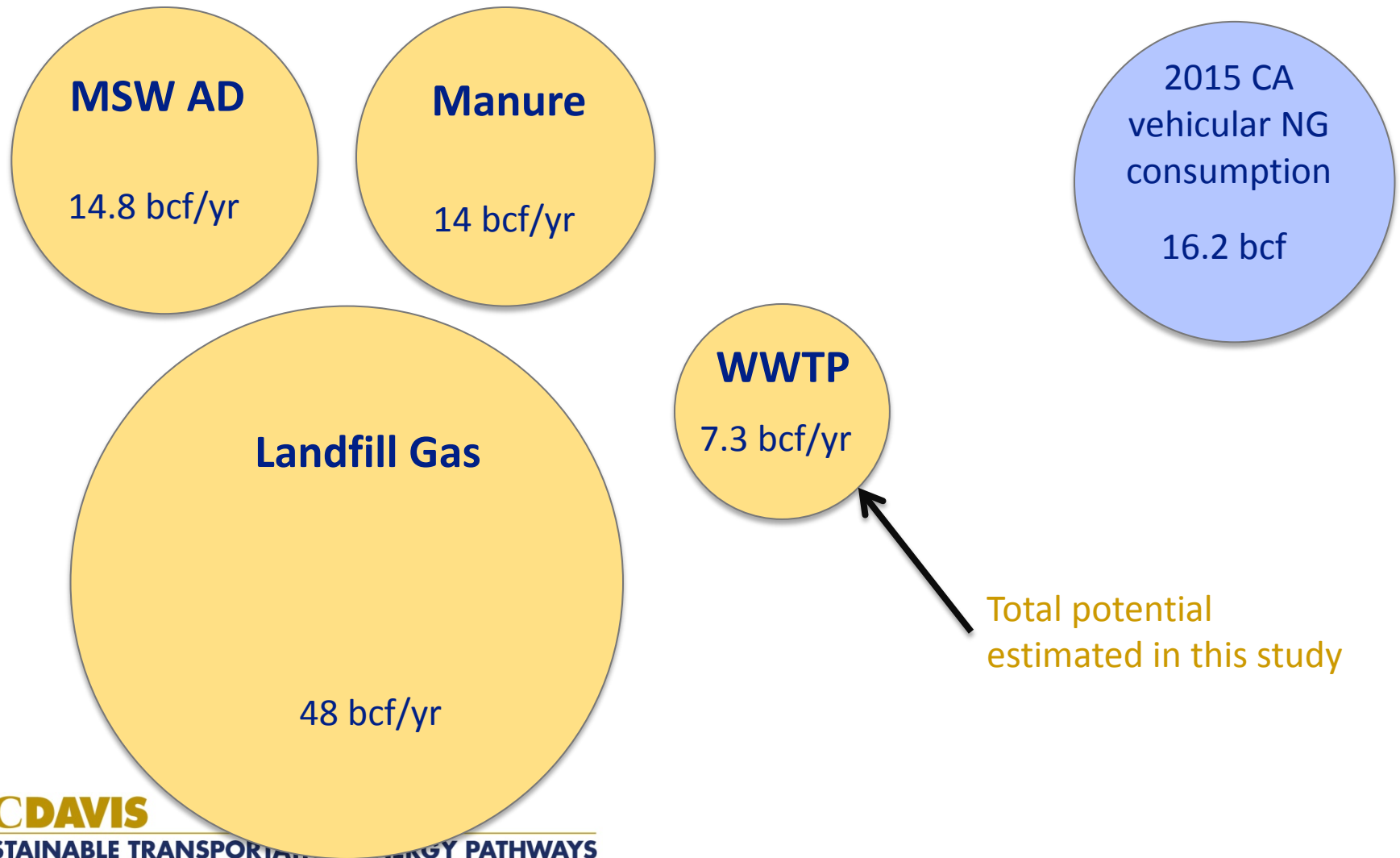
Use in vehicles

- Large carrot already dangling

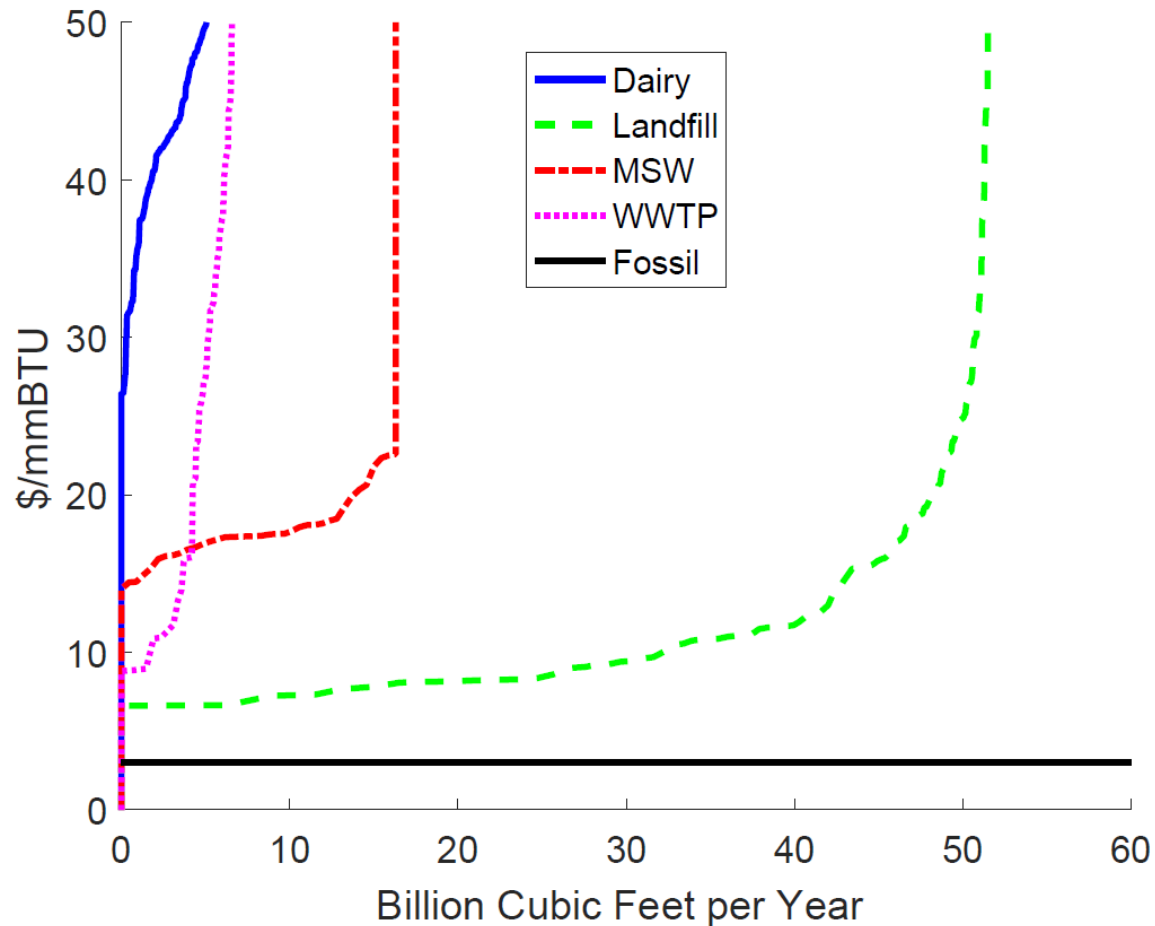


Renewable Natural Gas Potential in California

CA Production Potential



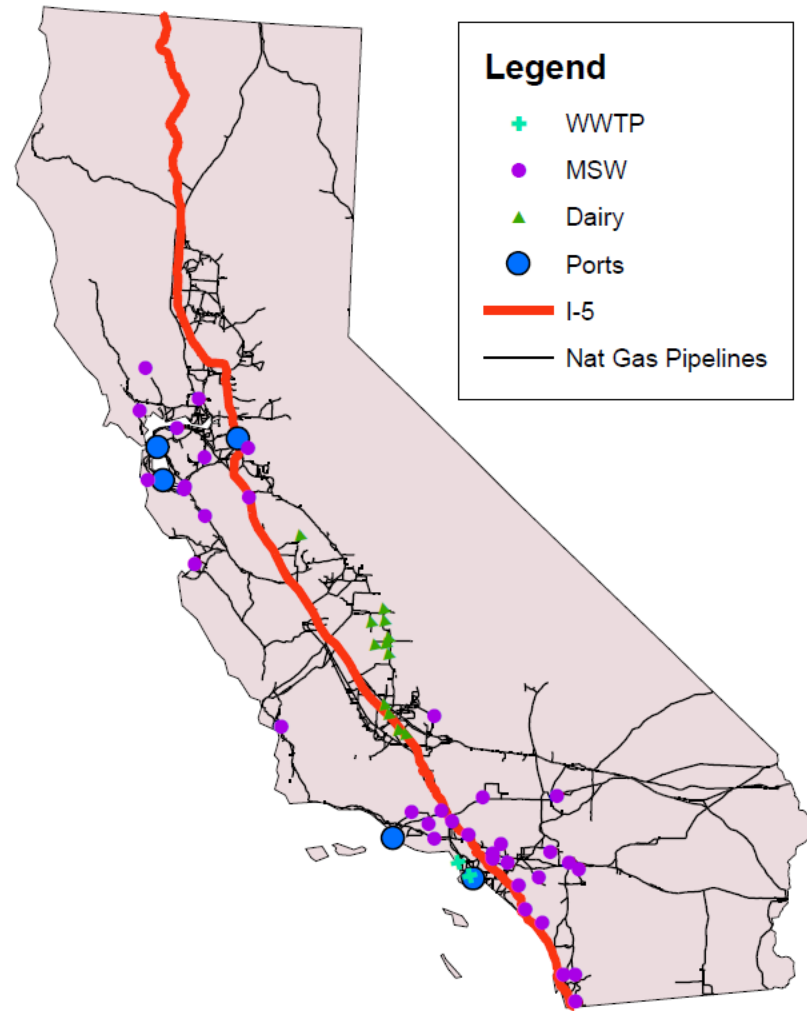
CA Renewable Gas Supply Estimates



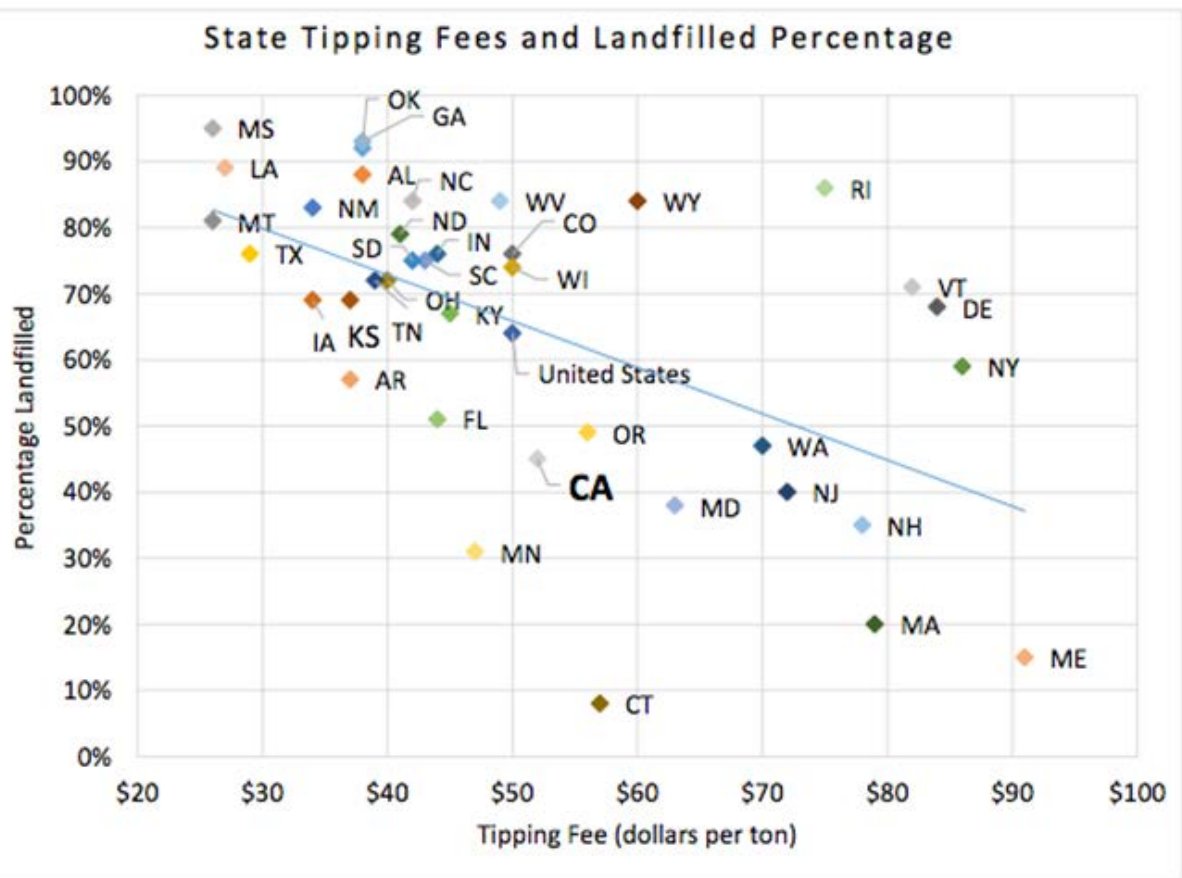
Carbon or Other Credit Support Required for Renewable Gas

	Support Required to Incentivize Production over \$3.00/mmBTU nat gas market price (2015\$)		RNG Supplied under \$120 LCFS under 2020 target
RNG Production Pathway	\$ per mmBTU	\$ per gasoline gallon equivalent	Billion cubic feet/year
MSW	\$11.50	\$1.38	1.75
Landfill	\$3.75	\$0.45	6.3
WWTP	\$5.90	\$0.71	1.5
Dairy	\$26.00	\$3.15	4.3

RNG supplied under \$100 LCFS credit price



MSW RNG Production sensitive to tipping fees

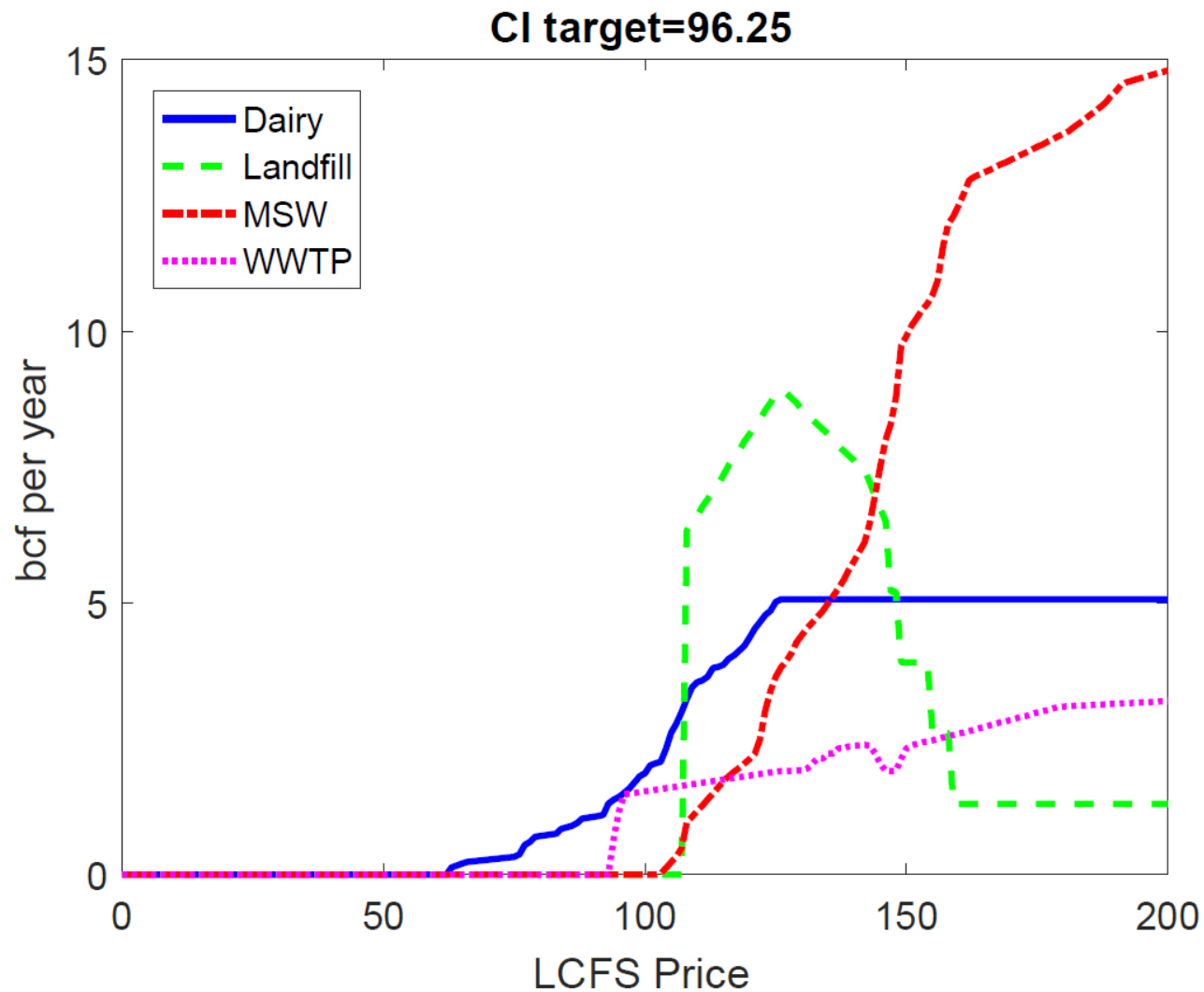


We recommend that by increasing CA tipping fees by **20%**

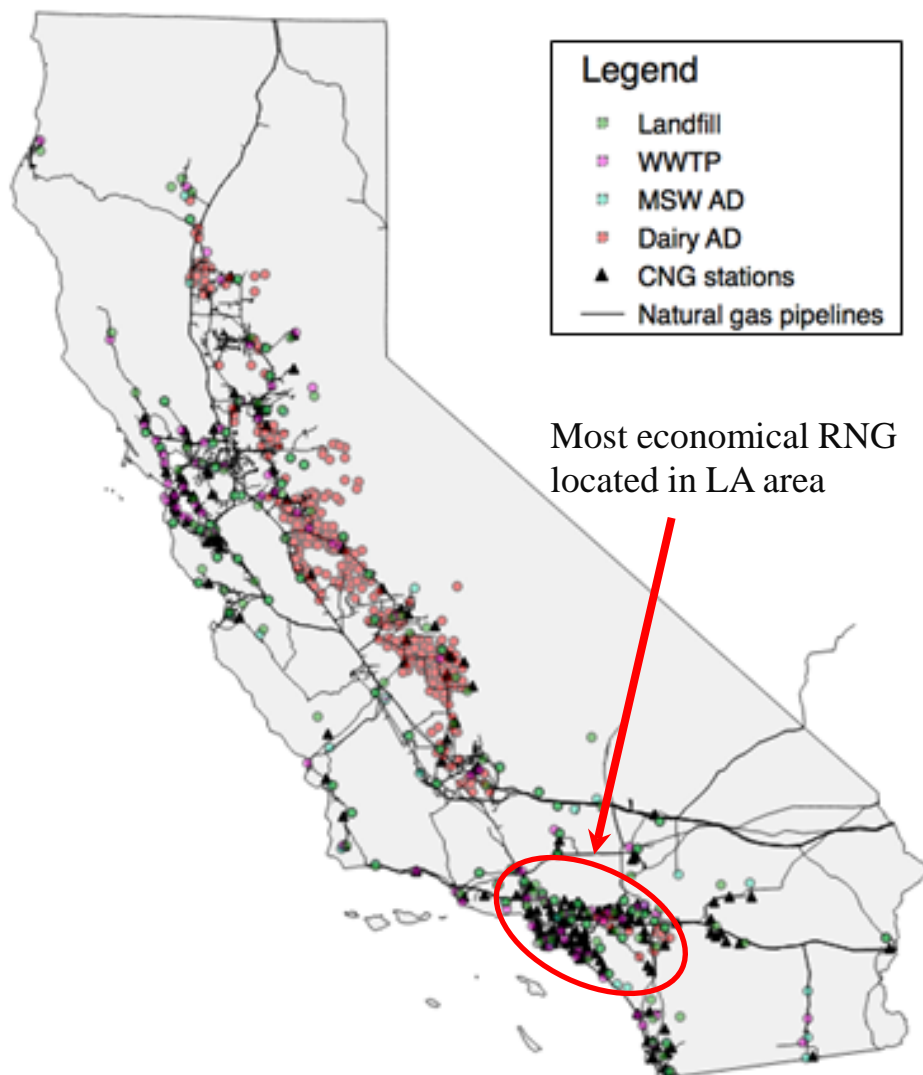
Combined with a **\$120** LCFS price

Would increase MSW RNG production from **1.75 bcf/yr** to **12.4 bcf/yr**

RNG supplied as a function of LCFS price



Renewable Gas Estimation Data



Geolocated Data:

- **Dairies: 1,369 sites**, Central Valley and Santa Ana Regional Water Quality Control Boards
- **Landfills: 147 sites**, Landfill Methane Outreach Program
- **WWTP: 86 sites**, California Association of Sanitation Agencies
- **MSW: 38 sites**, California Biomass Collaborative, Solid Waste Information Systems, CalRecycle