



## Sustainable Transportation Energy Pathways (STEPS)

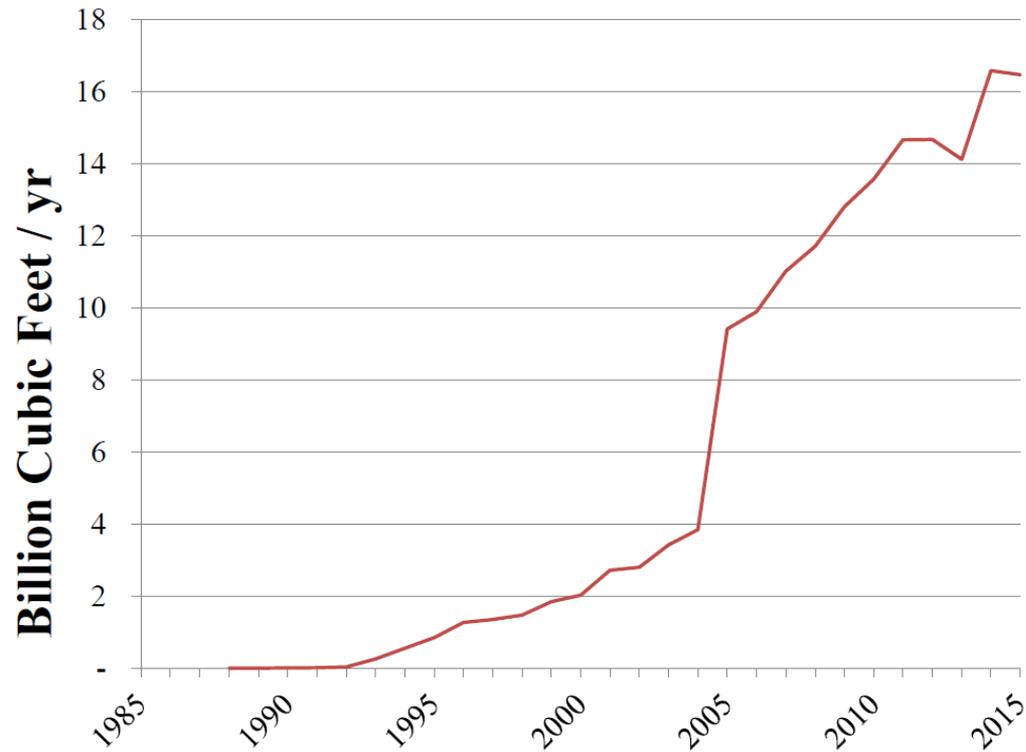
# Renewable Natural Gas in California: Natural Gas as an Enabler of Low Carbon Fuels

November 30, 2016

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Dan Scheitrum, Justin Wilcock, Marshall Miller

# Nat Gas small but growing fuel source

## CA Vehicular Nat Gas Consumption



Source: EIA

## Natural gas vehicles worse for climate than diesel ones?

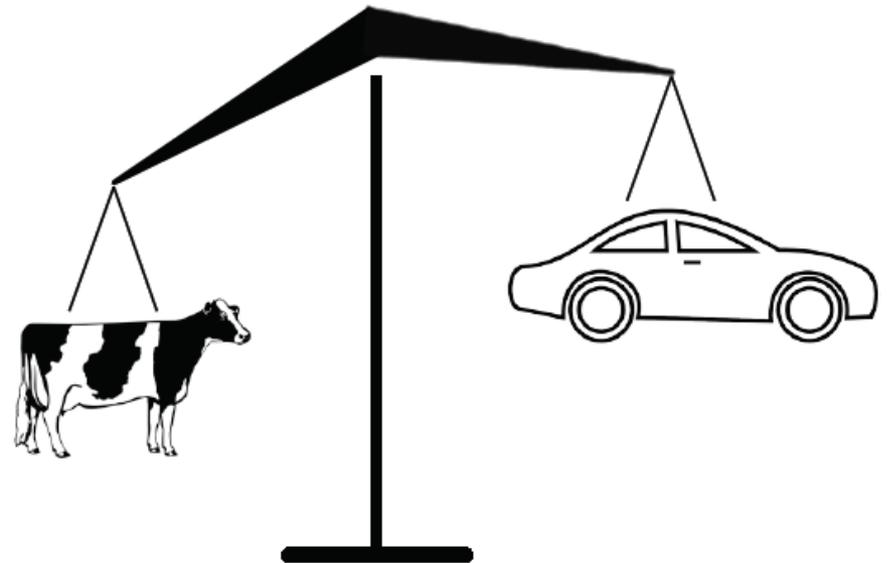


Wendy Koch, USA TODAY 1:32 p.m. EST February 14, 2014

**The New York Times**

### Is Natural Gas 'Clean'?

- Livestock and landfill emissions mostly methane ( $\text{CH}_4$ )
- Livestock → over half CA methane emissions
- 100-yr global warming potential  
 $1 \text{ g CH}_4 = 25 \text{ g CO}_2$



# Options to reduce methane?

## Adjust diet

- Higher quality feed can reduce emissions
- Not much potential to increase fat & protein content in rations in CA (Lee & Sumner, 2014)

## Dietary supplements

- Economics & long-term impacts unknown
- Ongoing pharmaceutical research

## Collect and flare

- **Already required** for most landfills
- World Bank Initiative ending routine flaring

# RNG 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

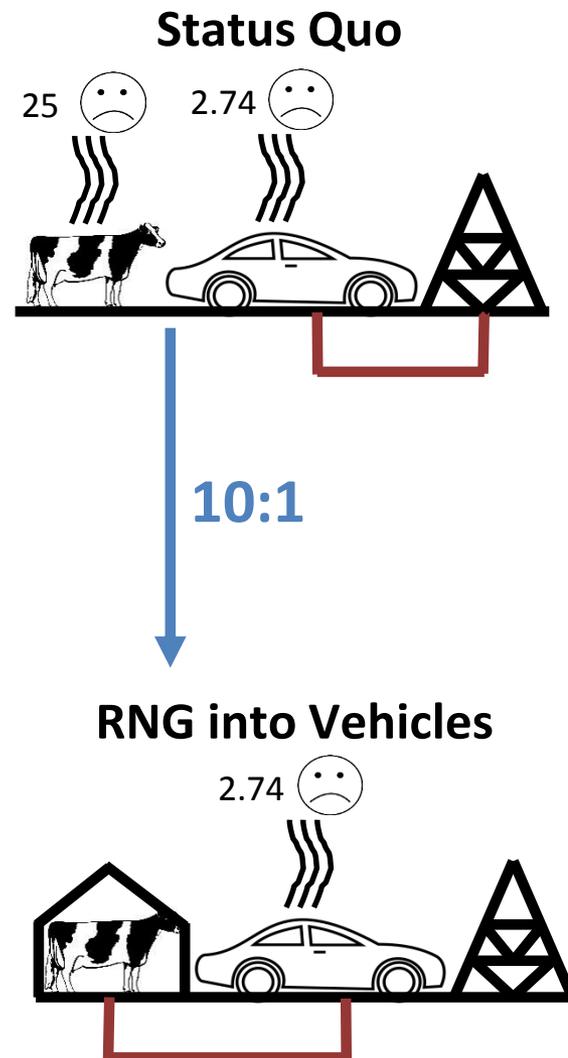
- Removing CO<sub>2</sub> and pollutants

## Connect to pipeline network

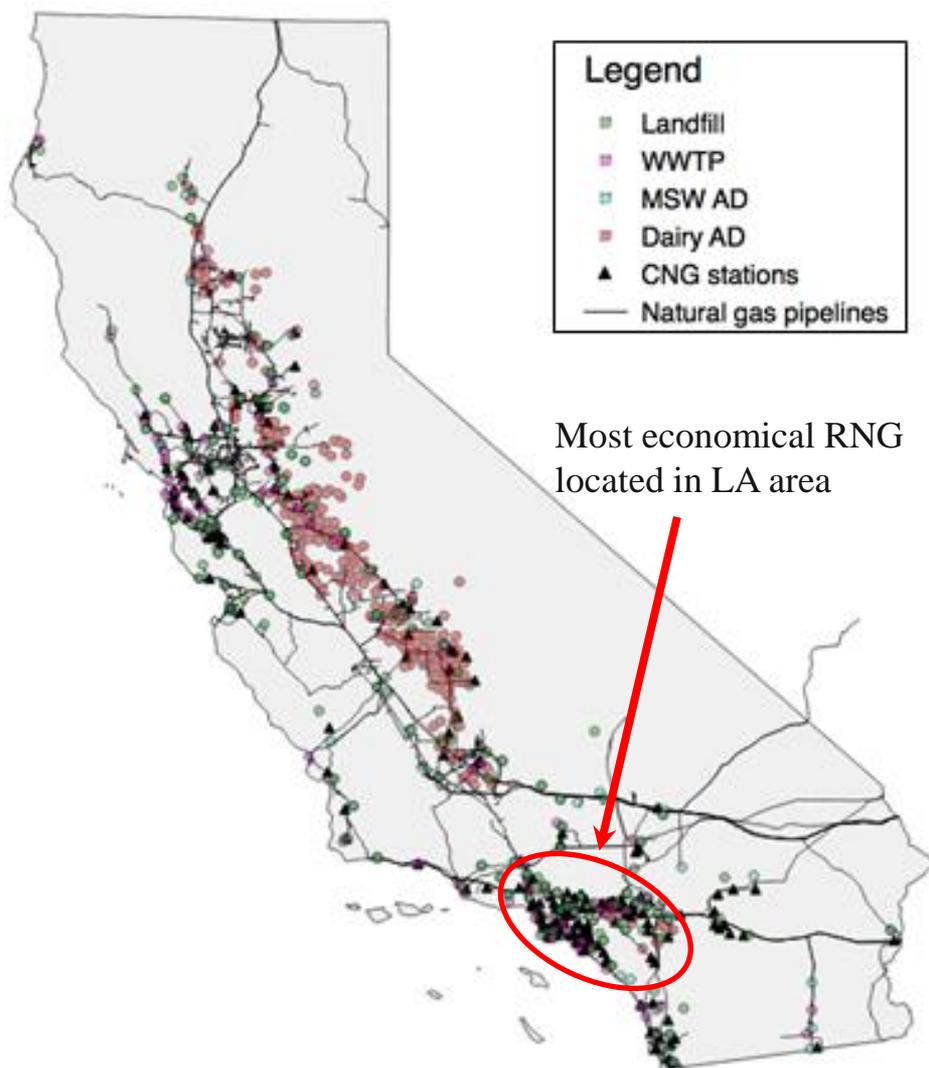
- construct pipeline to nearest nat gas pipe
- construction of interconnect (\$\$\$\$)

## Use in vehicles

- Large carrot already dangling



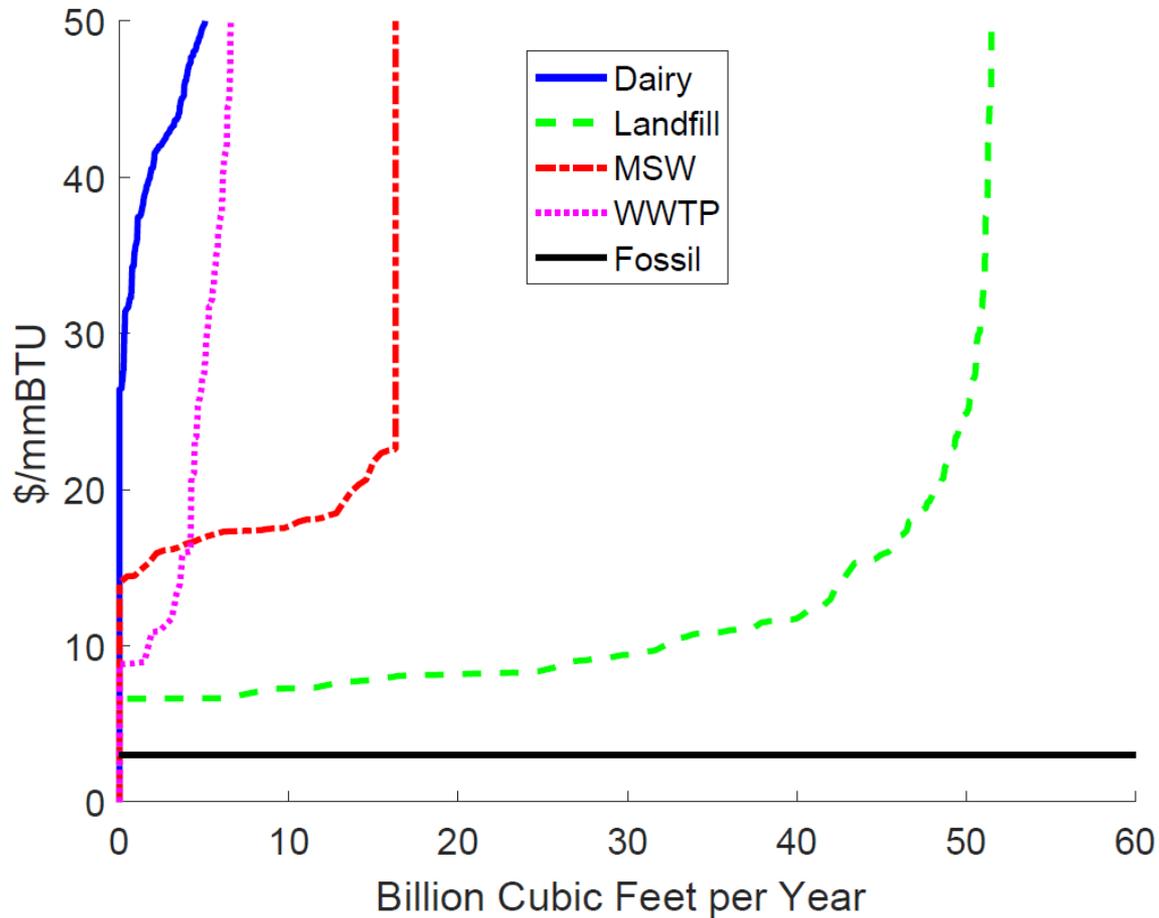
# RNG Estimation Data



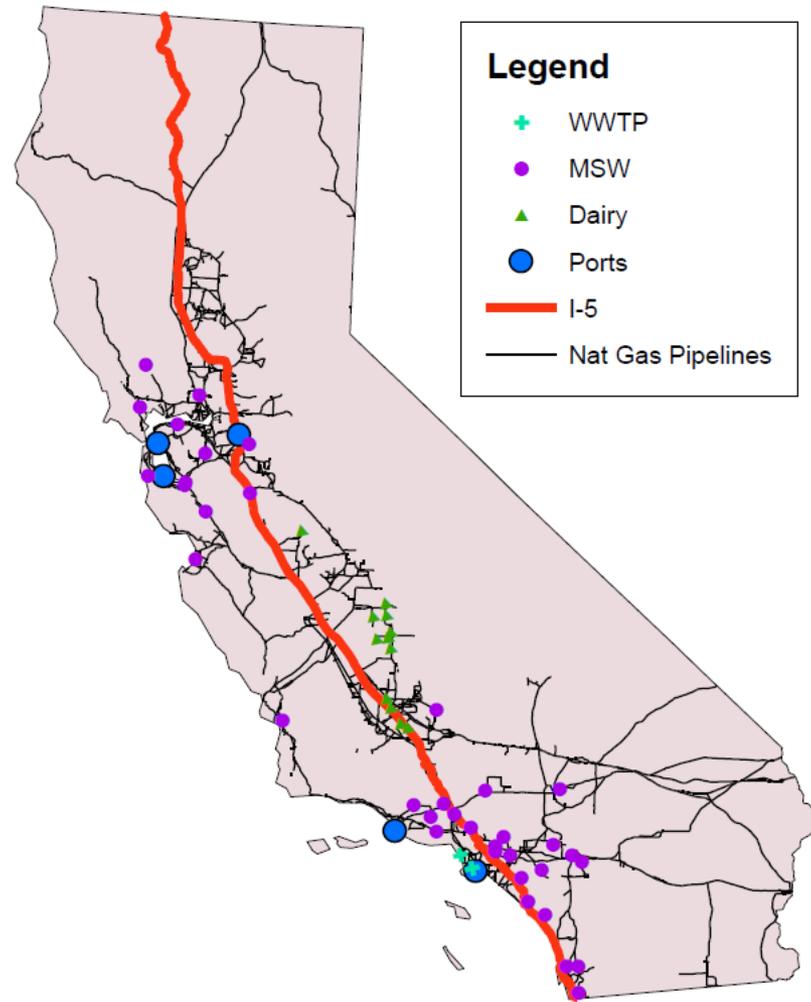
## Geolocated Data:

- **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

# CA RNG Supply Estimates



# RNG supplied under \$100 LCFS credit price



## RNG minimum support required

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

# Main findings

- 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 CO<sub>2</sub>, much higher volumes if combined with RIN credits
- Tipping fee increases could incentivize higher volumes of RNG from landfill and 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