Renewable Natural Gas Potential in California

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Methods and Data Sources

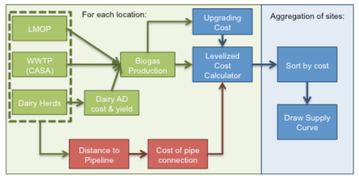
We use California Biomass Collaborative (CBC) feedstock estimates [1]

Table ES-1. Biofuel potential in California. No dedicated biomass crops were considered for this analysis.

Feedstock	Technically Available Supply (million bone dry tons or billion cubic feet)	Biomethane Potential (billion cubic feet)	Biofuel Potential (million gallons of gasoline equivalent)
Agricultural residues	5.4 MM BDT	31.5	272
Animal manure	3.4 MM BDT	19.7	170
Forest residues	14.2 MM BDT	82.3	710
Landfill gas	106 bcf	53	457
Municipal solid waste	1.2 MM BDT	12.3	106
Municipal solid waste (lignocellulosic)	7.0 MM BDT	40.6	350
Waste water treatment plants	11.8 bcf	7.7	66
Total		247	2,131

We know the locations of feedstock

We use a techno-economic approach :



Our techno-economic assumptions:

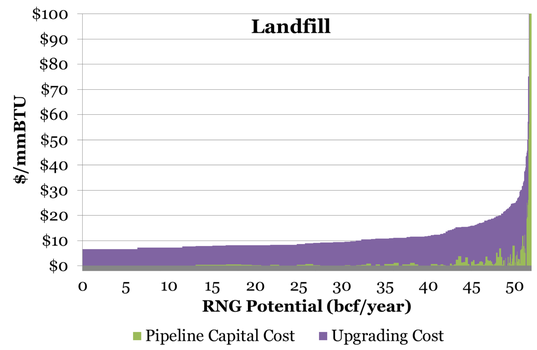
Levelized costs based on
60/40 debt/equity split
15% rate of return on equity
8% interest on debt
Equivalent cost of money of 11%
20-year lifespan

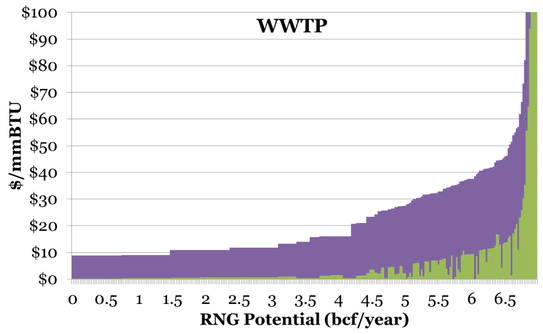
LCFS CI (gCO2e/MJ) values assumed:

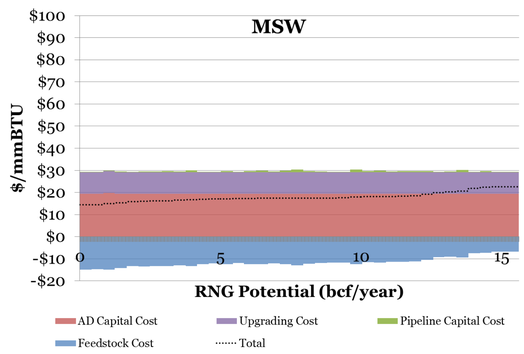
Diesel	Diesel	102.21
Target	2020 Target	88.23
CNG	Fossil	78.37
CNG	Landfill gas	46.42
CNG	Dairy	-276.2
CNG	MSW Digester	-22.93
CNG	WWTP	7.75

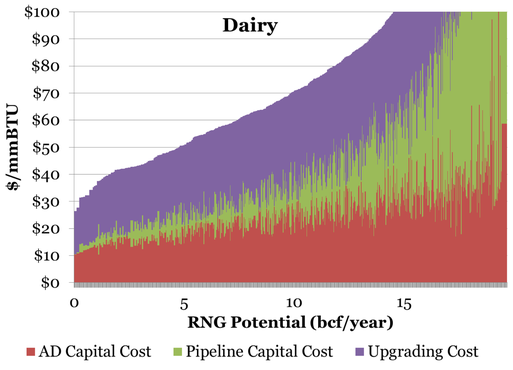
[1] Williams, R. B., B. M. Jenkins and S. R. Kaffka (2015). An Assessment of Biomass Resources in California, 2013 Data. CEC PIER Contract 500-11-020, California Biomass Collaborative

Potential: Supply Curves with cost component

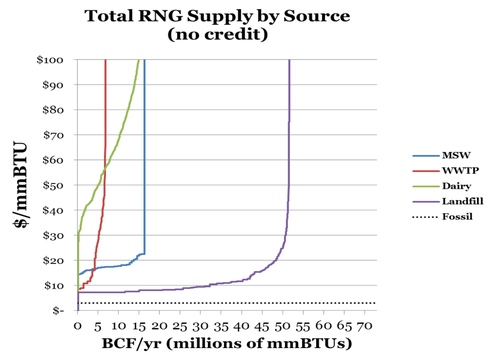




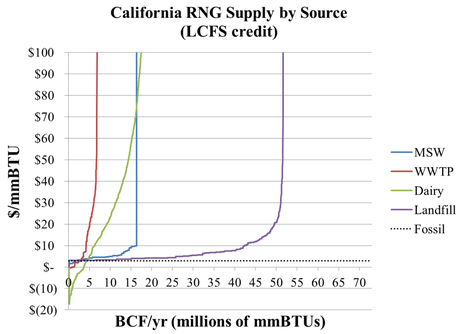




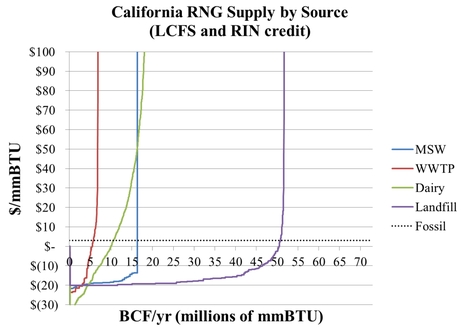
Potential with and without subsidies



Most sources of biogas require carbon externalities to be priced



About 8.1 BCF/year (50% of all transportation NG use in California[2]) are commercially feasible with an LCFS credit of $120/ton of carbon:
8.1 (total) = 0 (Landfill) + 4.3 (Dairy) + 3.1 (WWTP) +1.7 (MSW)



About 83.5 BCF/year (five times all transportation NG currently used in California[2]) are commercially feasible with an LCFS credit of $120/ton of carbon and a RIN credit of $1.78 per gallon of ethanol equivalent:
83.5 (total) = 50.8 (Landfill) + 16.3 (MSW) + 10.6 (Dairy) + 5.8 (WWTP)

[2] **16,467 Million Cubic Feet were used for transportation in California in 2015 http://www.eia.gov/dnav/ng/ng_cons_sum_dcu_SCA_a.htm**

Barriers to Development

Biogas must be cleaned (adds costs)

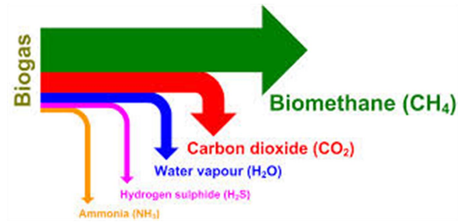


Illustration for Landfill Diverted Waste	Biogas	For power "Treated" Biogas	For Injection Biomethane*
Gas Composition and Heating Value			
CH4	62.0%	62.0%	98.5%
CO2	37.6%	37.6%	0.8%
O2, H2, N2, Others	0.4%	0.4%	0.7%
Heating Value (btu/scf)	625	625	990+
Two of the Key Trace Constituents			
H2S	300 ppm	1 ppm	1 ppm
Siloxanes	4,000 ppb	70 ppb	Non-detectable

* Gas composition and trace constituent limits will/may differ by utility

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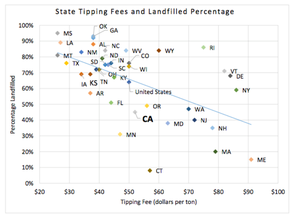
Biogas specs vary from utility to utility (no standard process)

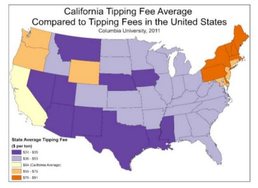
Table 7-3 Basic Pipeline Quality Standards for Major California Distributors

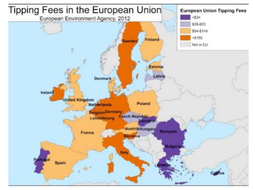
Gas Component or Characteristic	Pacific Gas and Electric Company	Southern California Gas Company
Carbon dioxide (CO_2)	≤1%	≤3%
Oxygen (O_2)	≤0.1%	≤0.2%
Hydrogen sulfide (H_2S)	≤0.25 grains/100 scf	≤0.25 grains/100 scf
Mercaptan sulfur	≤0.5 grains/100 scf	≤0.3 grains/100 scf
Total sulfur	≤1 grain/100 scf	≤0.75 grains/100 scf
Water (H_2O)	≤7 lb/million scf	≤7 lb/million scf
Total inerts	No requirement	≤4%
Heating value	Specific to receipt point	970 – 1,150 Btu/scf
Landfill gas	Not allowed	No requirement
Temperature	60 – 100º F	50 – 105º F
Gas Interchangeability [3]		
Wobbe number	Specific to receipt point	Specific to receipt point
Lifting index	Specific to receipt point	Specific to receipt point
Flashback index	Specific to receipt point	Specific to receipt point
Yellow tip index	Specific to receipt point	Specific to receipt point

scf = Standard cubic feet
Btu = British thermal units
[3] The various indices— Wobbe number, Lifting index, Flashback index, and Yellow tip index—are all means of determining the gas interchangeability (AGA, 1946)

It is cheap to dump in landfill







Source: http://www.calrecycle.ca.gov/publications/Documents/1520%5C20151520.pdf

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