

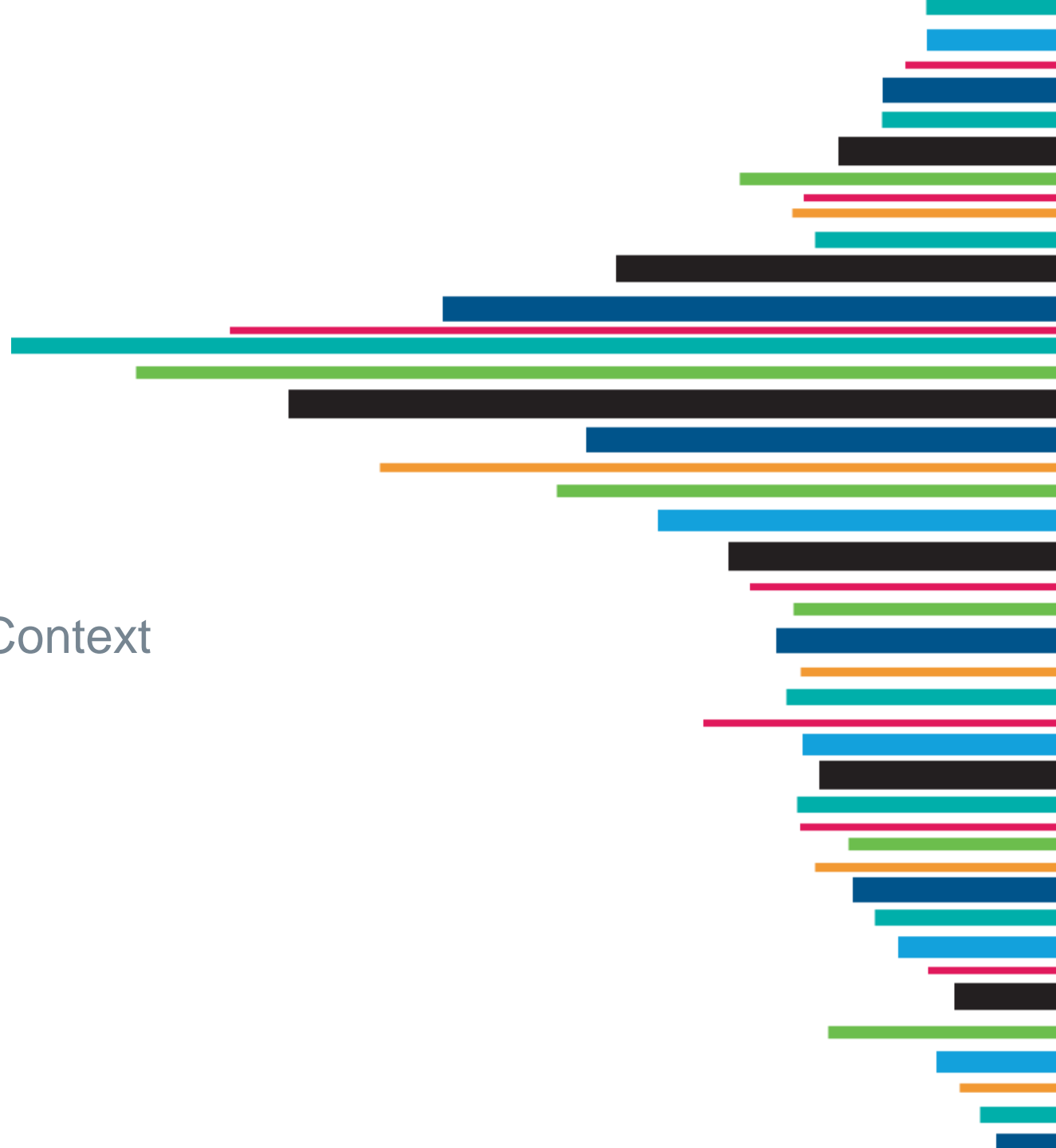
we are  **ICF**

Renewable Natural Gas

Sustainable Opportunities in an Indian Context

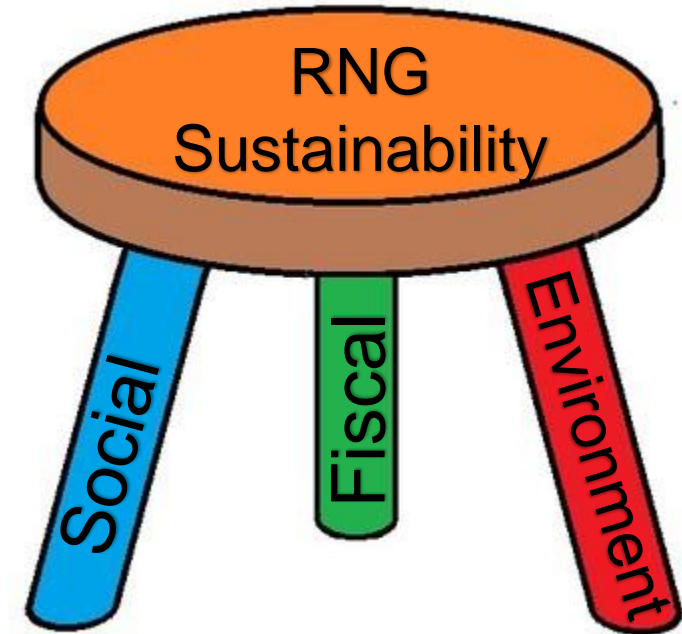


February 16, 2020

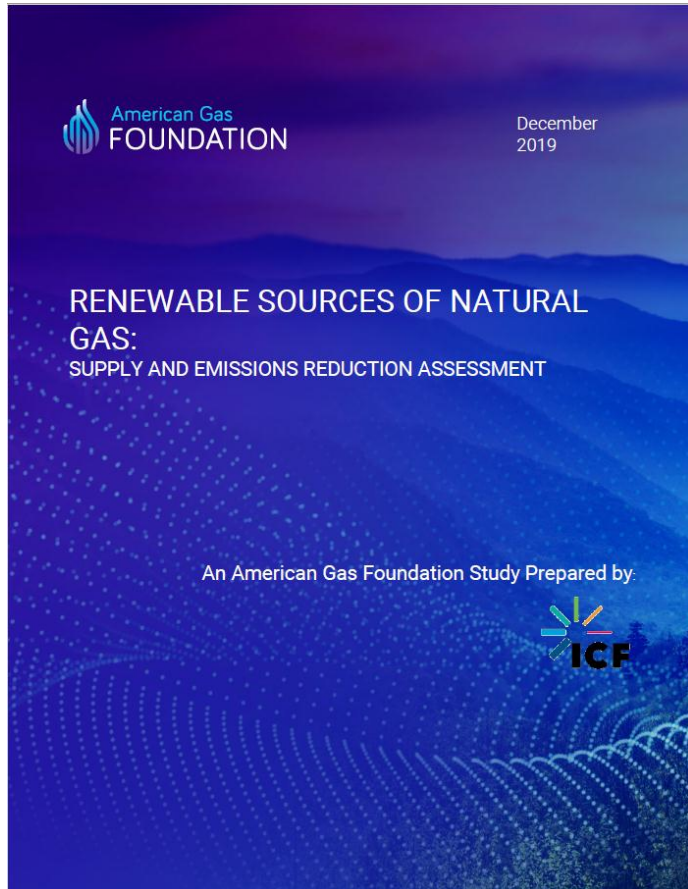


# RNG in an Indian Context

- Renewable Natural Gas (RNG) is of increasing interest to Governments, Investors, and Owners
- New technologies enable new sustainable resource production across India
- RNG is very sustainable new resource opportunity for India
  - Social – Energy Security and Jobs (particularly rural)
  - Fiscal – Monetizing environmental attributes enables fiscal performance
  - Environmental – GHG reductions, including negative GHG projects



# RNG Social Sustainability – Energy Security



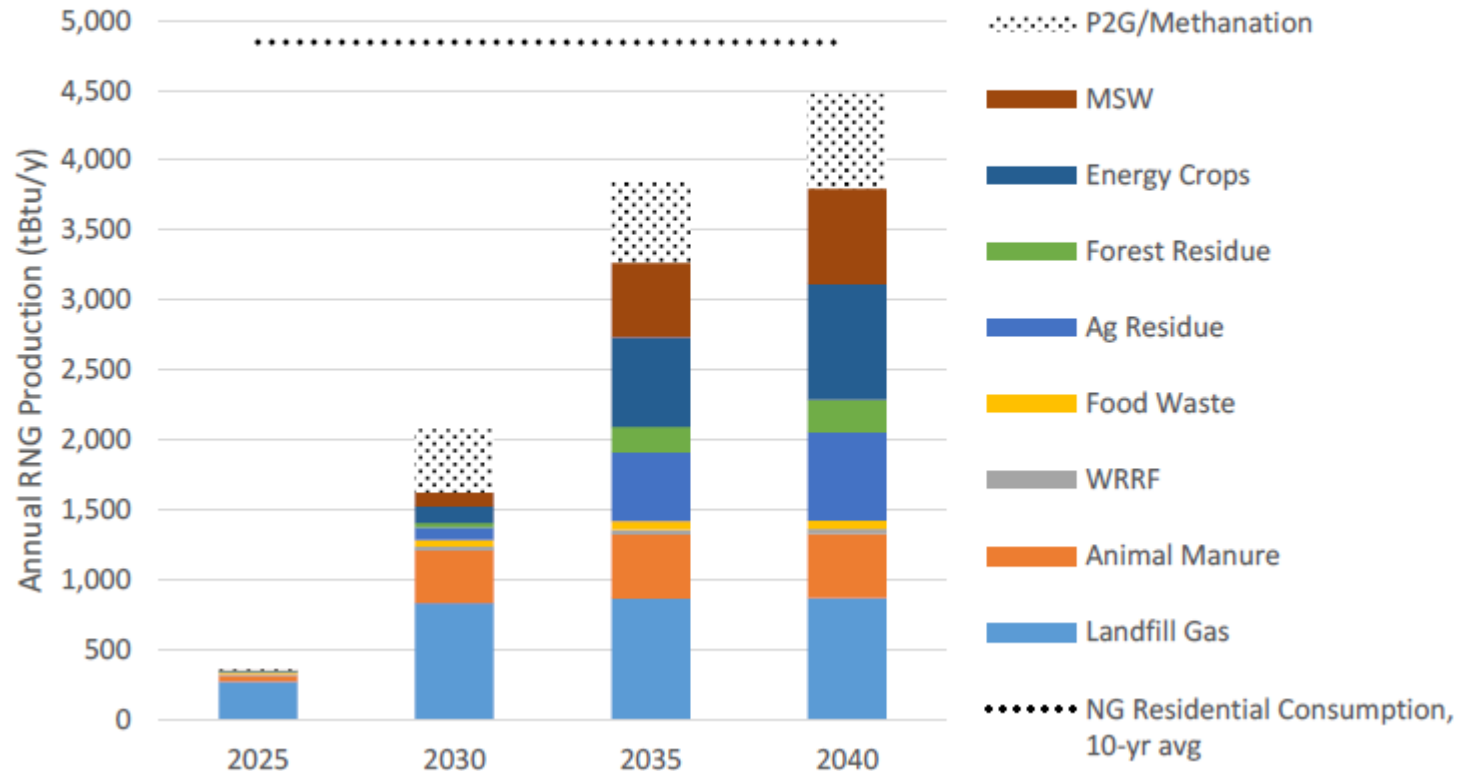
<https://www.gasfoundation.org/2019/12/18/renewable-sources-of-natural-gas/>

- Substantial resources available;
  - Landfills
  - Wastewater Treatment Plants
  - Biomass gasification
  - Power to gas
- ICF Market Study for the American Gas Foundation indicated that RNG could offset the residential gas usage in the US (approx. 1/3 of total gas use)

# RNG Social Sustainability – Energy Security

- RNG Generation sources are spread throughout the country
  - Landfills and MSW gasification provide resources near cities
  - Manure, Agricultural, and Forest Residues provide resources in rural areas

Figure 2. Estimated Annual RNG Production, High Resource Potential Scenario, tBtu/y



# RNG Environmental Sustainability – GHG's

Diesel Carbon Intensity (CI) standard = 94.17 gCO<sub>2</sub><sub>e</sub>/MJ (2019)

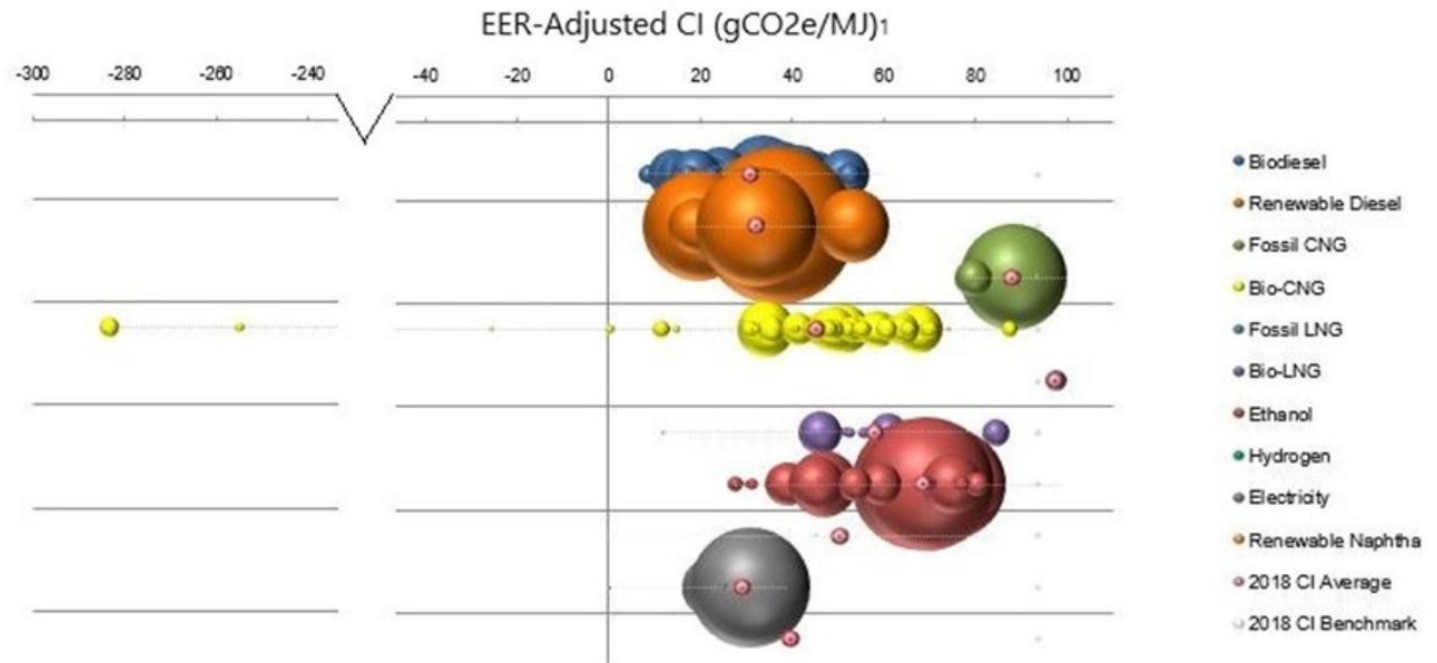
- Diesel has an energy density of 134.47 MJ/gal

Credits generated are proportional to the difference between the low carbon fuel and the standard

- i.e. against a standard of 94, an LFG facility with CI of 54 gCO<sub>2</sub>/MJ generates half the credits of a facility with a CI of 14 gCO<sub>2</sub>/MJ

Facilities can have a negative CI when including avoided non-CO<sub>2</sub> GHG emissions (i.e. methane)

2018 Volume-weighted Average Carbon Intensity by Fuel Type



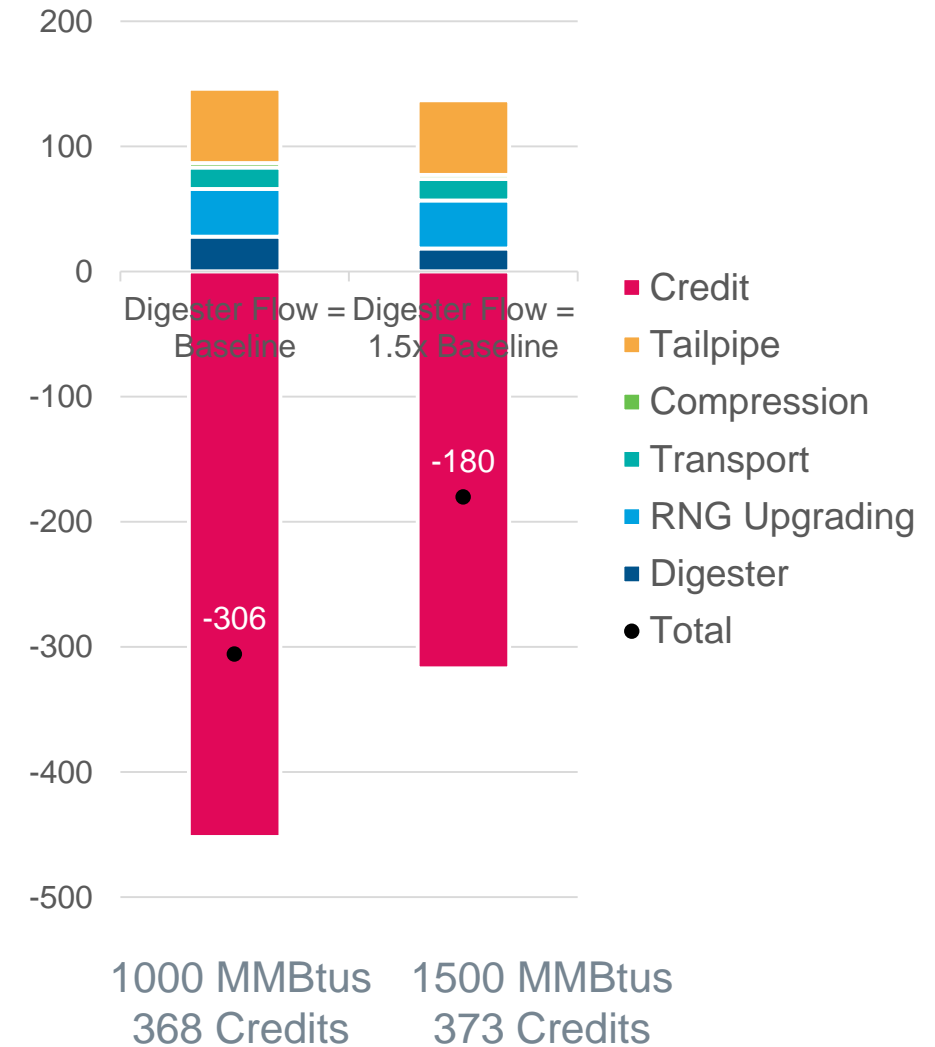
Source: California Air Resources Board

Last Updated 05/31/2018

# RNG Environmental Sustainability - Negative CI via Animal Manure

- Methane is potent GHG contributor (25 X CO<sub>2</sub> in LCFS)
- Offset credit is given for currently uncaptured methane emissions
- The total methane offset is based on cow/swine counts and baseline manure management practices
- CI Impact can be substantial
  - Fair Oaks Dairy -254.94 gCO<sub>2</sub>/MJ
  - Smithfield/Roeslein Swine -373 gCO<sub>2</sub>/MJ

*Remember, offset value and overall LCFS credit generation remains constant so generating more gas reduces the negative CI impact per unit!*



# RNG Fiscal Sustainability – Predictable Costs

- LFG based RNG requires minimal equipment, and technologies are well understood
- LFG's can produce consistent, albeit declining, production for decades
- Easier to finance

Table 32. Cost Consideration in Levelized Cost of Gas Analysis for RNG from Landfill Gas

Factor	Cost Elements Considered	Costs
Performance	<ul style="list-style-type: none"> <li>• Capacity factor</li> </ul>	<ul style="list-style-type: none"> <li>• 95%</li> </ul>
Installation Costs	<ul style="list-style-type: none"> <li>• Construction / Engineering</li> <li>• Owner's Cost</li> </ul>	<ul style="list-style-type: none"> <li>• 25% of uninstalled costs of equipment</li> <li>• 10% of uninstalled costs of equipment</li> </ul>
Gas Upgrading	<ul style="list-style-type: none"> <li>• CO2 separation</li> <li>• H2S removal</li> <li>• N2/O2 removal</li> </ul>	<ul style="list-style-type: none"> <li>• \$2.3 to \$7.0 million depending on facility</li> <li>• \$0.3 to \$1.0 million depending on facility</li> <li>• \$1.0 to \$2.5 million depending on facility</li> </ul>
Utility Costs	<ul style="list-style-type: none"> <li>• Electricity: 25 kWh/MMBtu</li> <li>• Natural Gas: 6% of product</li> </ul>	<ul style="list-style-type: none"> <li>• 4.6–13.7 ¢/kWh</li> <li>• \$3.00-\$8.25/MMBtu</li> </ul>
Operations & Maintenance	<ul style="list-style-type: none"> <li>• 1 FTE for maintenance</li> <li>• Miscellany</li> </ul>	<ul style="list-style-type: none"> <li>• 10% of installed capital costs</li> </ul>
For Injection	<ul style="list-style-type: none"> <li>• Interconnect</li> <li>• Pipeline</li> <li>• Compressor</li> </ul>	<ul style="list-style-type: none"> <li>• \$2 million</li> <li>• \$1.5 million</li> <li>• \$0.2-0.5 million</li> </ul>
Financial Parameters	<ul style="list-style-type: none"> <li>• Rate of Return</li> <li>• Discount Rate</li> </ul>	<ul style="list-style-type: none"> <li>• 10%</li> <li>• 7%</li> </ul>



# RNG Fiscal Sustainability – Negative CI Valuation in new GHG Based Standards

- New GHG based standards place high valuations on negative CI projects
- CO<sub>2</sub> and methane unlike other pollutants, new standards recognize reductions globally not just locally like SO<sub>x</sub>, NO<sub>x</sub>, and soot
- RNG Value (Dairy) - October 2019
  - LCFS (@CI of -254) = \$74.75 (\$203.50)
  - RIN<sup>(1)</sup> = \$7.62 (D3 \$0.65)
  - HH<sup>(2)</sup> NG = \$2.69 per MMBTU
  - **Total = \$85.06 per MMBTU**

(1) 77,000BTU/RIN (LHV) => 0.903 LHV to HHV conversion  
 (2) Henry Hub October 2019

## Potential LCFS Credit Value (2020)

Fuel	Assumed CI Value (g/MJ)	LCFS Credit Price (\$/MT CO <sub>2</sub> e)				Units
		50	100	150	200	
Corn Ethanol	71	0.07	0.14	0.22	0.29	\$/gal
Cellulosic Ethanol	30	0.24	0.48	0.72	0.96	\$/gal
Biodiesel	30	0.37	0.74	1.11	1.48	\$/gal
Renewable Diesel	30	0.38	0.76	1.14	1.52	\$/gal
Hydrogen	88	0.80	1.60	2.40	3.20	\$/kg
Landfill NG	40	2.10	4.20	6.30	8.40	\$/mmBTU
Dairy NG	-276	18.92	37.84	56.76	75.67	\$/mmBTU
Electricity	105	0.04	0.07	0.11	0.14	\$/kW-hr

Source: California Air Resources Board



# Going Beyond the Pipe...

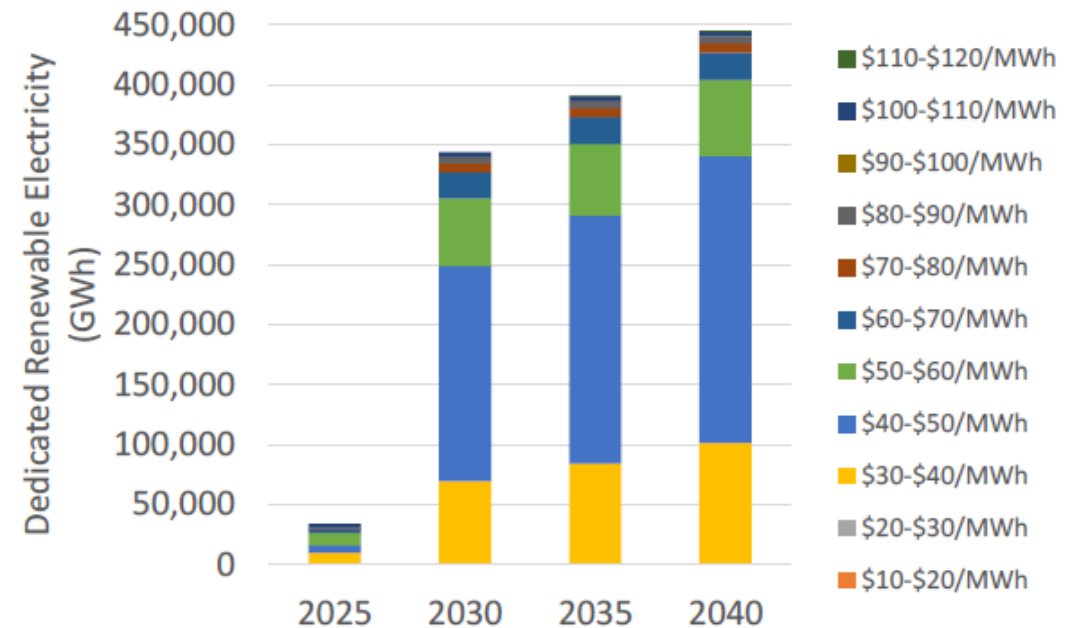
- Power-to-Gas

- Renewable hydrogen produced from renewable energy used to convert CO<sub>2</sub> from digester/landfill to methane
- NREL/SoCal Gas biologic conversion demo, other catalytic options available



NREL/SoCal Gas Power-to-Gas Demonstration Unit

Figure 24. Supply-Cost Curve for Dedicated Renewable Electricity for P2G Systems, 2025-2040

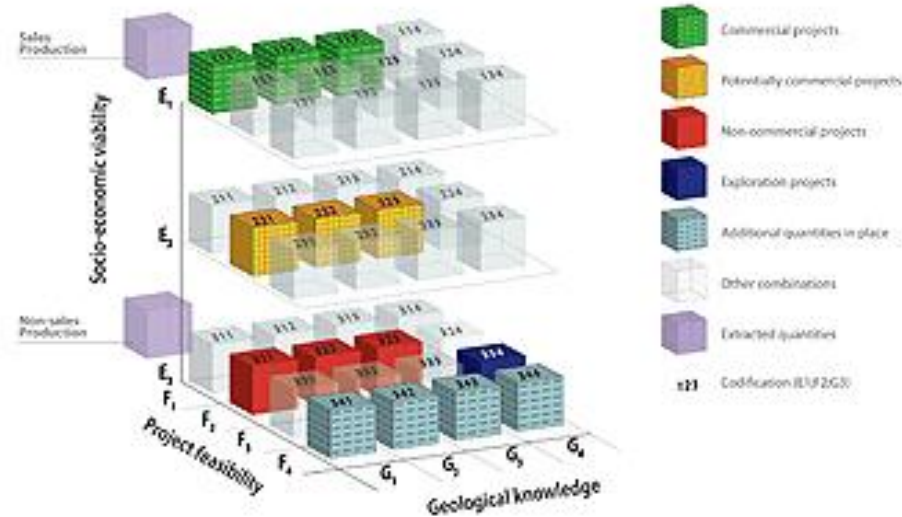


# Potential Future Opportunities – RNG Reserve Classification



UNFC maps to UN SDG's and new Sustainable Resource Management systems, may open new opportunities in public backed finance

- UN Framework on Resource Classification (UNFC) Bioenergy Specification Adopted September 2017
- Methodology to quantify and classify renewable reserve quantities
- Maps to the Petroleum Resource Management System (PRMS) allowing direct comparison between conventional and bioenergy reserves
- Value projects based on total RNG produced from the asset during its lifetime, not annual EBITDA





# In Conclusion...

- RNG can provide secure indigenous resource in localities throughout India
- Negative Carbon Intensity RNG projects can be GHG negative while providing resource to India and financial returns to their owners
- Power-to-Gas could become a significant resource in the near future
- New UNFC Bioenergy specification and Sustainable Resource Management systems align with UN SGD's and may facilitate public backing of projects

# Let's Get Started...

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