



Investigation of Landfill Gas as a Transportation Fuel in Brazil

Global Methane Initiative Agriculture, Municipal Solid Waste and Municipal
Wastewater Best Practices Workshop

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Project Goal

- To investigate opportunities related to the use of landfill gas (LFG) for transportation fuel applications in Brazil
- Focus on two urban areas:
 - Rio de Janeiro
 - Belo Horizonte

Project Steps

1. Stakeholder Identification & Engagement
2. Assemble Landfill Information
3. Perform Sketch-Level Analysis
4. Develop Conclusions & Recommendations
5. Follow-Up Workshop & Outreach
6. Final Deliverables

Task	Year/Month																	
	2013				2014												2015	
	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
1.Stakeholder Identification & Engagement																		
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Relative Natural Gas Vehicle Population

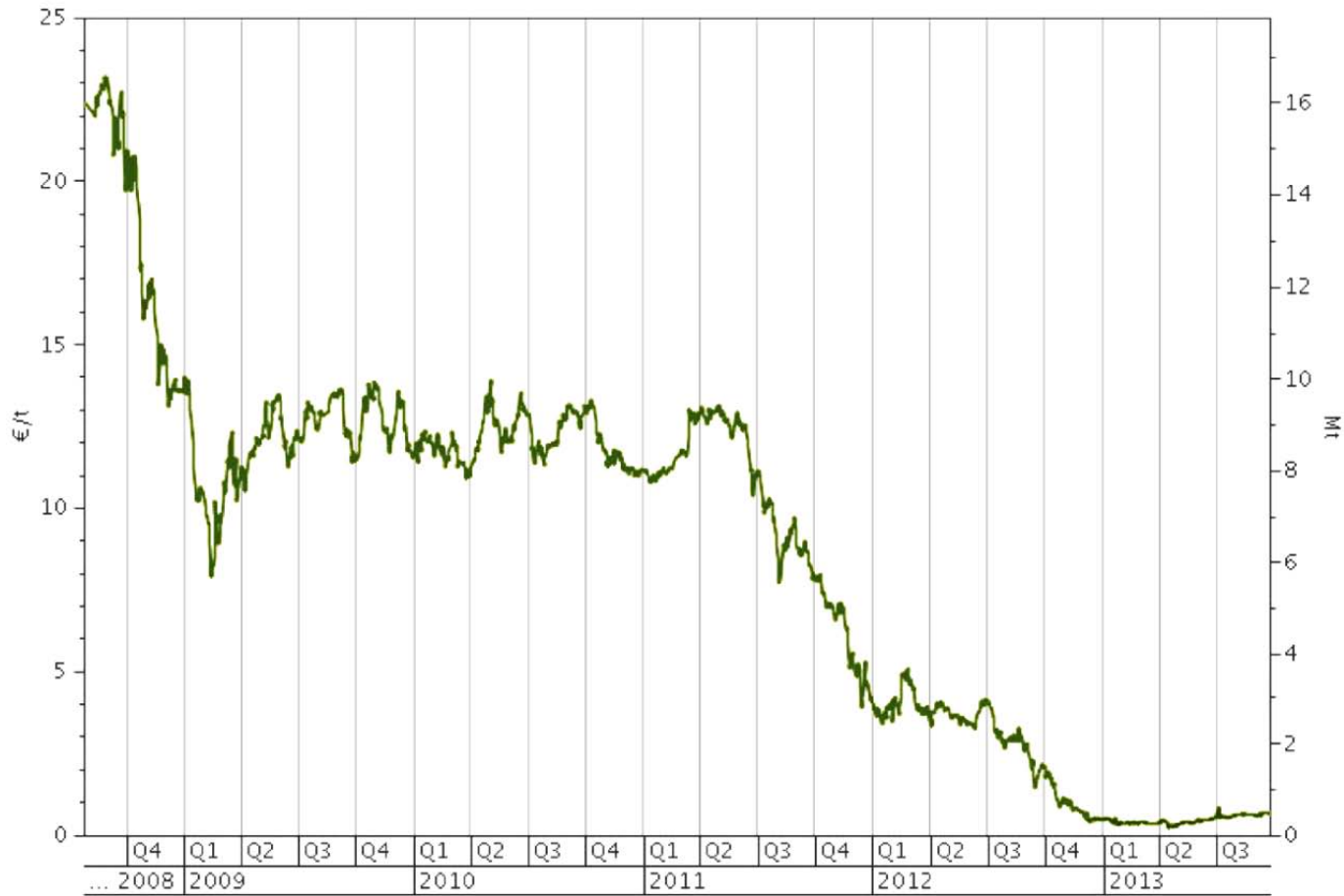
Rank	Country	Natural Gas Vehicles	Refuelling Stations	Year data received
1	Pakistan	2,400,000	3,105	2008
2	Argentina	1,807,186	1,851	2008
3	Iran	1,734,431	1,079	2008
4	Brazil	1,632,101	1,704	2008
5	India	725,000	520	2008
6	Italy	580,000	730	2008

Countries with 0.5 million or more NGVs

Source: IANGV 2009



Economics – Carbon Credit Prices



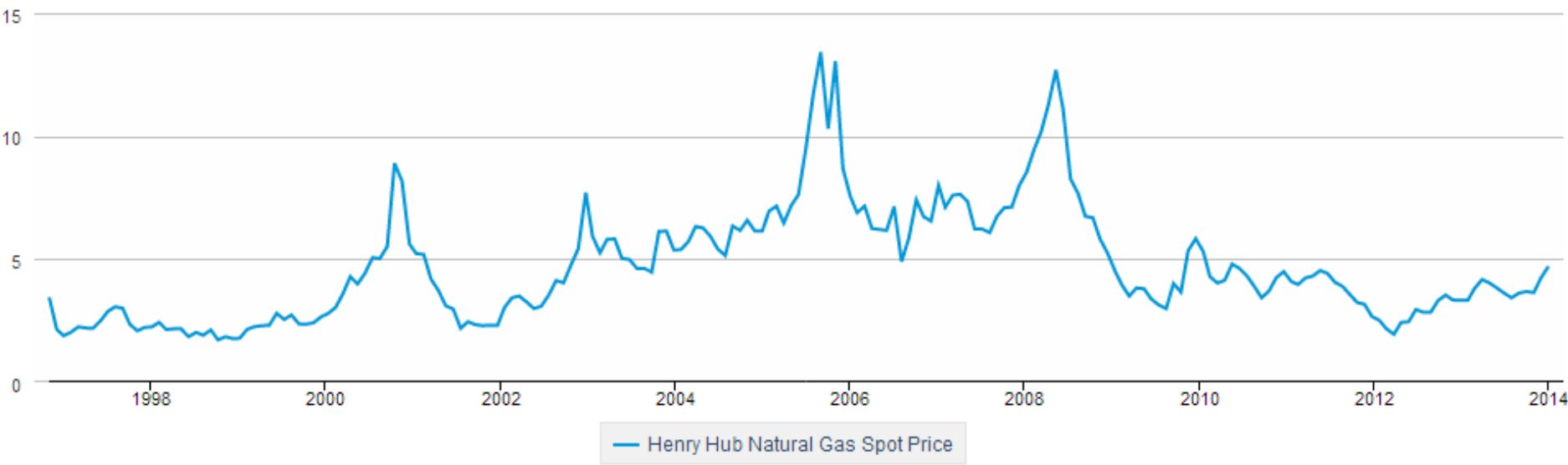
Source: Global Alliance for Clean Cookstoves



Economics – Natural Gas Prices

Henry Hub Natural Gas Spot Price

Dollars per Million Btu



Source: <http://www.eia.gov/dnav/ng/hist/rngwhhdm.htm>



Initial Stakeholder Engagement

- There is interest in concept
- Past and current applications
- Concerns regarding economic viability
- Possibility of alternative sources – such as sugar industry



India Project



Overview

- Focus on Mumbai landfills
- Pre-feasibility of LFG to transportation fuel
- Collaboration with NEERI



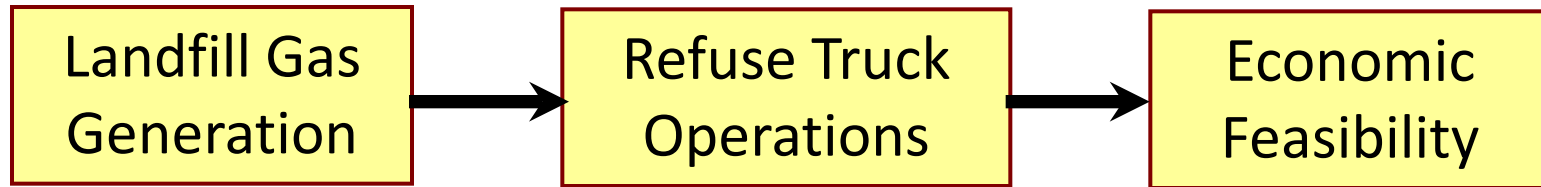


Research Approach

- Assemble landfill data
- Vehicle characteristics and operations
- Economic feasibility of landfill gas to energy scenarios
- Conclusions and recommendations



Model Development



CO₂ Wash Technology



Analysis Scenarios

- Landfill Management Options:
 - Do Nothing;
 - Cap the landfill and flare; or
 - Flare from an active landfill.
- LFGTE Options:
 - Convert the LFG to CNG as fuel;
 - Convert the LFG to pipeline grade natural gas; or
 - Convert the LFG to electricity.

Analysis Results

Scenario	Gorai		Deonar		Mulund	
	Net Benefit (\$)	Return (%)	Net Benefit (\$)	Return (%)	Net Benefit (\$)	Return (%)
Landfill Management Options						
Scenario 1: Do Nothing	\$(17,015,502)	N/A	\$(44,693,492)	N/A	\$(43,859,505)	N/A
Scenario 2: Cap the Landfill and Flare the LFG	\$(3,140,569)	-31%	\$(7,870,880)	-30%	\$5,252,208	42%
Scenario 3: Flare the LFG from an Active Landfill	\$(1,377,397)	-16%	\$(18,025,538)	-48%	\$8,389,332	80%
LFGTE Options						
Scenario 4: Convert LFG to CNG for Use as a Transportation Fuel	\$(7,375,991)	-33%	\$465,457	1%	\$13,208,186	54%
Scenario 5: Convert the LFG to Pipeline Grade Natural Gas	\$(9,374,035)	-51%	\$(11,718,243)	-33%	\$1,332,408	6%
Scenario 6: Convert the LFG to Electricity	\$(3,719,716)	-29%	\$(15,788,418)	-40%	\$(1,965,718)	-9%



Additional Analysis – Without Capping Costs

Scenario	Gorai		Deonar		Mulund	
	Net Benefit (\$)	Return (%)	Net Benefit (\$)	Return (%)	Net Benefit (\$)	Return (%)
Scenario 4: Convert LFG to CNG for Use as a Transportation Fuel	\$ (1,665,390)	-10%	\$ 22,084,157	135%	\$ 21,366,186	130%
Scenario 5: Convert the LFG to Pipeline Grade Natural Gas	\$ (3,663,435)	-29%	\$ 9,900,457	70%	\$ 9,490,408	67%
Scenario 6: Convert the LFG to Electricity	\$ 1,990,884	28%	\$ 5,830,282	33%	\$ 6,192,282	46%



Concluding Remarks

- Investigate LFG for transportation fuel applications in Brazil
- Some India landfills showed potential
- Considerable interest but concerns about economics
- Other options can be considered
- Next steps – perform feasibility analysis, stakeholder workshop, facilitate implementation