# Investigating Landfill Gas to Energy with Syngas Addition

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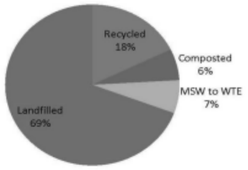
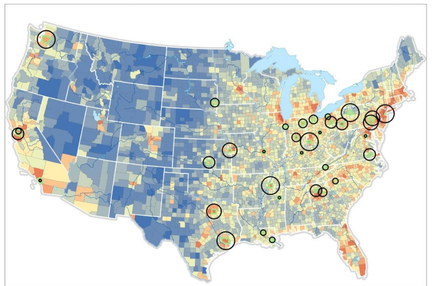
## Motivation




Despite increased efforts to remove material from the waste stream via recycling and WTE, more than 60% of MSW is sent to landfills. Currently, 85% of NYC waste is shipped by truck to out-of-state landfills.[1] Due to the size and cost of Landfill Gas to Energy (LFGTE) projects, the generated methane is usually flared rather than used as a fuel. Improving the cost and efficiency of LFGTE projects could increase their implementation throughout the country.

## Current Status

LFGTE projects located near densely populated cities[2]



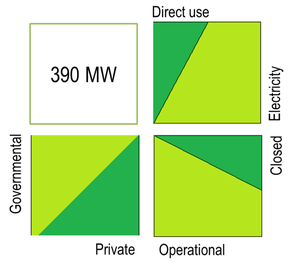




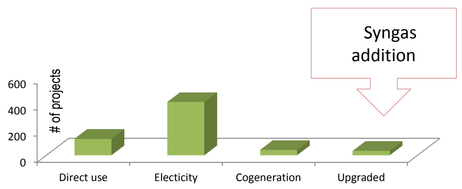
Out of 147 operating LFGTE projects in NY, NJ and PA, the majority are governmentally owned, still receiving MSW and generating electricity.

National wide there are 621 currently operational LFGTE projects. Out of this total only 33 use upgraded methods to improve their operations. Syngas addition falls into this category, however it is not a method that is currently implemented.

Tri-state LFGTE projects approach



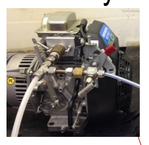

Electricity generation is the most common output of LFGTE projects in US

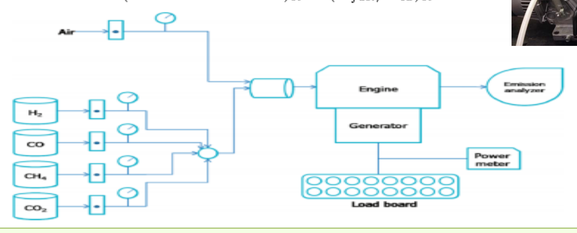



## Experimental Set Up

- Simulated LFG =1:1, $CH_4$:$CO_2$
- Electrical load on the system 0.4 kW
- Syngas added as 5% by enthalpy of the reaction
- Syngas = 2:1, $H_2$:CO
- Tested in terms of emissions and engine efficiency
- The equivalence ratio held constant 0.5

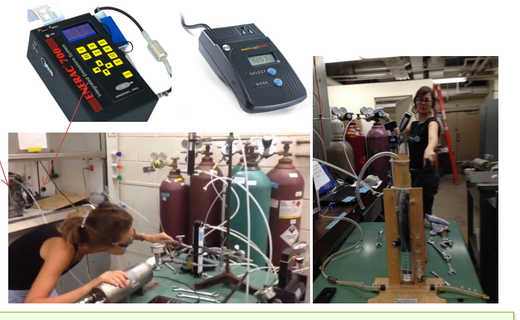
$$\phi = \frac{\text{fuel-to-oxidizer ratio}}{(\text{fuel-to-oxidizer ratio})_{st}} = \frac{m_{fuel}/m_{ox}}{(m_{fuel}/m_{ox})_{st}}$$





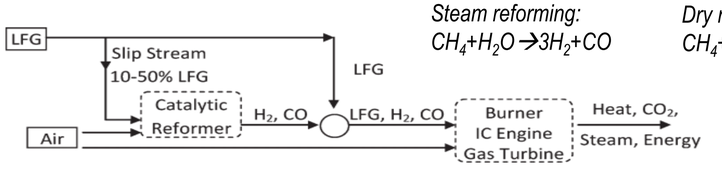

List of instruments

| | |
|---|---|
| 4 stroke 5HP IC Engine | HONDA GC 160E-QHA |
| Electrical Generator | PRAMAC EG2800 |
| Combustion emissions analyzer | ENERAC 700 |
| Power meter | WattsUp Pro meter |



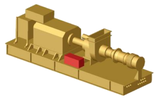
## Syngas Generation and Economic Feasibility

- The addition of $H_2$ to LFG improves the combustion due to it high laminar flame speed and flammability limit and it's low ignition energy
- In-situ autothermal reforming of methane offers the most economically feasible source of $H_2$ [3]

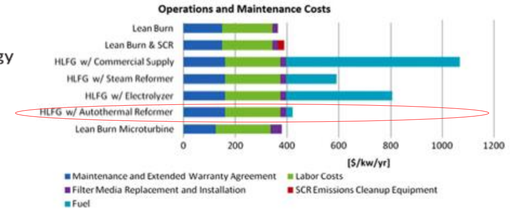



*Steam reforming:* $CH_4+H_2O \rightarrow 3H_2+CO$

*Dry reforming:* $CH_4+H_2O \rightarrow 2H_2+2CO$

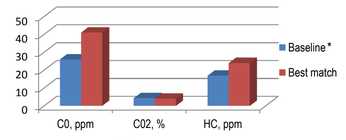


Schematic of a proposed in-situ LFG reforming process. A catalytic reactor for a 200kW turbine would be about the size of a soda bottle and cost~$10/kW$_e$.[4]

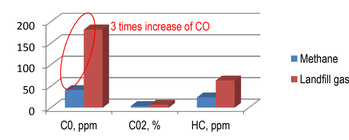



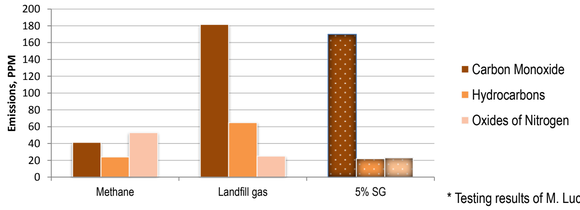

## Results

Initial experimental results were found to emulate the work of previous CCL members




Simulated LFG created more emissions compared to methane




THC and CO emissions follow the same tendencies:

- significant increase in LFG compared to $CH_4$
- decrease with SG addition, by 66 and 7% respectively
- An increase of only 15% to the levelized cost of electricity for in-stream reforming is justified by its potential to decrease $NO_x$

* Testing results of M. Lucardi was used as a baseline

## Further Work

- Continue testing 5 and 10% syngas additions at different loads to get a complete picture of the effect on emission and efficiency
- Vary the $H_2$ and CO ratio in the syngas, ideally landing on an optimal composition that can be produced by autothermal reforming
- Reduce the amount of $CH_4$ in simulated LFG to determine minimum concentration

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## References

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3. Kornbluth, et al. Economic feasibility of hydrogen. Energy Policy. 2012
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