

# Development of an Integrated Anaerobic Digestion – SOFC System

NSERC Strategic Projects Group

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# Presentation Overview

- Brief description of project
  - Overview
  - Benefits
- Jillian's, Allison's and my responsibilities and role in the project
- Questions

# Overview of the SPG

- Pls: Dr. Peppley, Dr. Champagne, Dr. Thurgood
- Optimize municipal AD to generate biogas for use in an integrated AD-SOFC system
  - Minimize variability in composition and FC performance

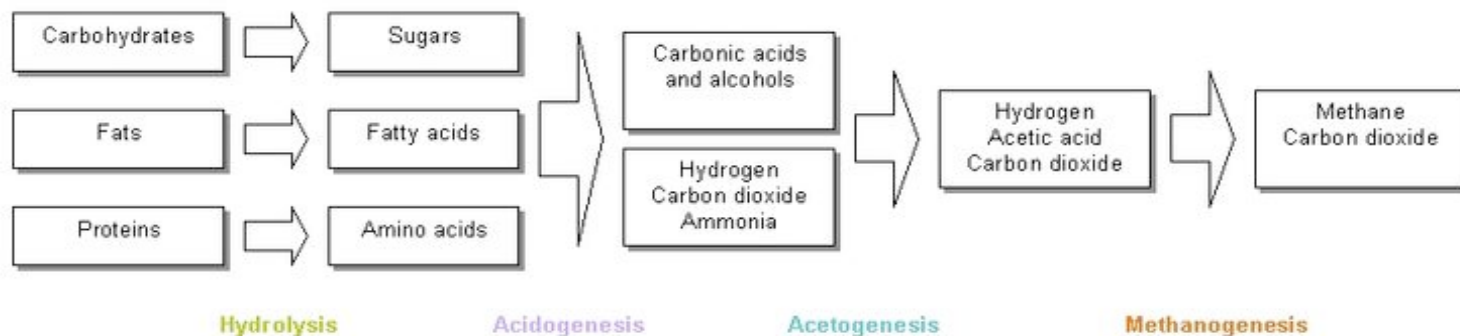


Table 2 Average biogas composition from WWTP-AD in Ontario.

Compound		Average	Range
Methane (CH <sub>4</sub> )	%	60.8	58–70
Carbon Dioxide (CO <sub>2</sub> )	%	34.8	30–43
Hydrogen Sulphide (H <sub>2</sub> S) <sup>a</sup>	ppm	78 <sup>b</sup> (570*)	2.5–3450
Oxygen (O <sub>2</sub> )	%	1.5	0.1–2.0
Nitrogen (N <sub>2</sub> )	%	2.4	1.2–7.1
Moisture (H <sub>2</sub> O)	%	0.01	0.01
Carbon Monoxide (CO)	ppm	<100	0–100
Hydrogen (H <sub>2</sub> )	ppm	<100	0–100
Silicon Compounds	ppm	n/a	0–2500

<sup>a</sup>All but two sites had H<sub>2</sub>S concentration ranging 2.5 – 200 ppm; two sites with higher concentrations had 350 and 3,450 ppm of H<sub>2</sub>S.

<sup>b</sup>The average value of H<sub>2</sub>S excluding the highest concentration.

\*The average value of H<sub>2</sub>S calculated by including all data.

Wheeldon *et Al.* 2005

- On-site cogeneration of electrical power and heat
- Address technical and operational challenges
  - Studies to date use PAFC

# Benefits

- Reducing existing grid demands for electricity
  - Theoretical maximum of 1.51GWh/d
- Reducing greenhouse gas emissions
  - Reduce CO<sub>2</sub> by 432 tonnes/d
- Improving air and water quality
- Promote the development of renewable energy sector
  - Economic potential → \$\$\$

# Simon's Work

- Assisting Gordon McAlary and Jason Wood in commissioning the existing FCT Tubular SOFC system
  - NI LabVIEW and DAQ to design and implement a software control system
  - Simulate a biogas reformate using UniSim
    - Using an average biogas feedstock composition obtained from Wheeldon *et. Al* as well as VOCs from Utilities Kingston OSB report.

# UniSim Modelling

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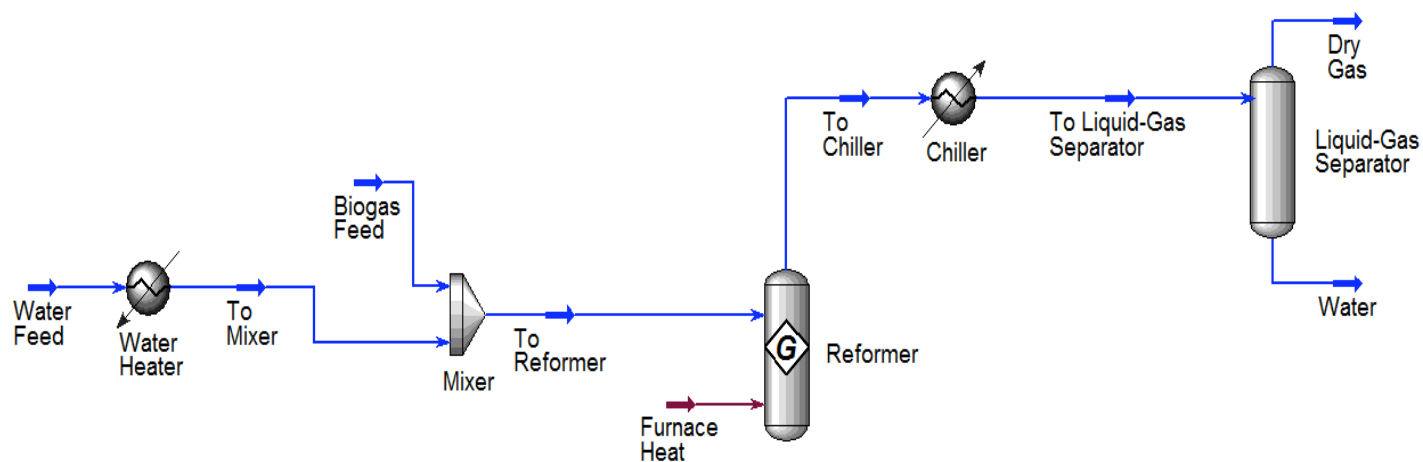
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Wheeldon *et Al.* 2005



COMPONENTS	MOLAR FLOW (gmole/min)	MOLE FRACTION	MASS FLOW (g/min)	MASS FRACTION	LIQUID VOLUME FLOW (m3/min)	LIQUID VOLUME FRACTION
Methane	7.51797200e-01	0.0023	12.0610	0.0027	0.0000	0.0035
CO <sub>2</sub>	6.12610782e+01	0.1837	2696.0817	0.5941	0.0033	0.2873
Oxygen	5.68214854e-19	0.0000	0.0000	0.0000	0.0000	0.0000
Nitrogen	2.36013105e+00	0.0071	66.1144	0.0146	0.0001	0.0072
H <sub>2</sub> O	5.47810027e+00	0.0164	98.6885	0.0217	0.0001	0.0087
CO	4.24321998e+01	0.1272	1188.5641	0.2619	0.0015	0.1308
Hydrogen	2.20222464e+02	0.6604	443.9685	0.0978	0.0064	0.5589
H <sub>2</sub> S	9.58757212e-01	0.0029	32.6706	0.0072	0.0000	0.0036
Toluene	1.18553372e-24	0.0000	0.0000	0.0000	0.0000	0.0000
diM-Sulphide	1.55179792e-14	0.0000	0.0000	0.0000	0.0000	0.0000
1-Butanol	8.97217026e-24	0.0000	0.0000	0.0000	0.0000	0.0000
n-Decane	0.00000000e-01	0.0000	0.0000	0.0000	0.0000	0.0000
p-Cymene	5.81753573e-20	0.0000	0.0000	0.0000	0.0000	0.0000
Naphthalene	0.00000000e-01	0.0000	0.0000	0.0000	0.0000	0.0000
SO <sub>2</sub>	2.43496853e-08	0.0000	0.0000	0.0000	0.0000	0.0000
COS	1.33350993e-03	0.0000	0.0801	0.0000	0.0000	0.0000
2-Propanol	1.41060605e-17	0.0000	0.0000	0.0000	0.0000	0.0000
Total	3.33465861e+02	1.0000	4538.2289	1.0000	0.0114	1.0000

# Jillian's Work

- Gather information on the operation of the T-SOFC (Acumentrics test stand)
- Using biogas variability data (as compiled by Allison and Jillian), conduct a sensitivity of the T-SOFC
  - Will use different biogas blends, as based on those determined from the pilot scale anaerobic digesters and municipal biogas data

# Allison's Work

- Preliminary biogas conditioning tests
  - Testing of commercial granular activated carbons to treat VOCs, siloxanes and halides
    - Comparing breakthrough curves
    - Tests will be done with butane and either cyclohexane or toluene
- Compiling current state of knowledge on North American municipal biogas composition, production and usage

# Thank You

## Questions?