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Environmental Research & Innovation Center

Welcome to: ABC Operator Training

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Environmental Research & Innovation Center

US Composting Council
Seal of Testing Assurance

ASTM

AMERICAN BIOGAS COUNCIL

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

DEPARTMENT OF AGRICULTURE, TRADE & CONSUMER PROTECTION • WISCONSIN •

WISCONSIN DEPT. OF NATURAL RESOURCES

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Overview

- What is the ERIC Lab?
- What information can a lab provide you with?
- What does lab information look like and tell you?
- What does BMP and pilot-scale information look like and tell you?
- How can you incorporate the lab data into your projects?
- Results from a case study
- Summary
- Lab tour and Q&A with lab staff

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Contract Testing and Research Services

Environmental Research and Innovation Center (ERIC)

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Environmental Research and Innovation Center (ERIC)

- USEPA, WIDNR, WI DATCP, US Composting Council-certified facility
- Contract R&D for clients from the Canadian Yukon to Central America that provide real-world answers and solutions to their company's questions
- Provides state-of-the-art lab facilities for research and consulting for those interested in biogas applications
- Employ over 50 students each year
- Transfer of experience, technology, and expertise from public sector to add value to industry partners and their products and services
- Facilities and expertise not available anywhere else in WI or the nation
- Unique third party that possesses the operational and research expertise to bring projects from cradle to grave

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Water Analysis

- Satellite Labs in Eagle River, Sturgeon Bay, and Manitowoc
- Analyze over 10,000 drinking water samples per year
- Analyze over 12,000 surface water samples per year
- All types of microbiology analysis (i.e., pathogens, genetics, etc.)
- Bacteria, nitrate, nitrite, arsenic, etc.
- Private clients, 17 counties, grants/contracts and many corporate partners

qPCR

Membrane Filtration

Defined Substrate

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Environmental Research and Innovation Center (ERIC)

Digester Sample Analysis

- Standardized BMP analysis – based on international standards
- Onsite and in-lab gas testing
- Standardized feedstock, AD, and digestate testing
- Use of multiple techniques to keep costs low, increase throughput, and provide the exact data clients need
- Volatile Fatty Acids (VFA) via GC-FID
- Customized analysis – air, degradation, etc.

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Compost Analysis

- STA testing (US Composting Council)
- S-100, STA, Class A, 503 Metals, Premium, or Basic Packages
- Compostability studies
- Growth and vigor & customized growth studies
- Nutrient analysis for all agricultural products, soils, etc.

US Composting Council®
Proud Member

BASIC	PREMIUM	STA	503 METALS	S-100	CLASS A
Moisture/Total Solids, Organic Matter/Ash, pH, Electrical Conductivity, Total Nitrogen, Ammonia, Phosphorus (P2O5), Potassium (K2O)	BASIC PACKAGE plus: Inerts, Sieve Analysis, Calcium, Magnesium, Sodium, Iron, Sulfur, Boron, Chloride, TOC, C:N Ratio, Bioassay, Respirometry, Fecal Coliform, Agricultural Index	BASIC PACKAGE plus: Inerts, Sieve Analysis, Calcium, Magnesium, Copper, Zinc, Arsenic, Cadmium, Chromium, Lead, Mercury, Molybdenum, Nickel, Selenium, Bioassay, Respirometry, Fecal Coliform	Copper, Zinc, Arsenic, Cadmium, Chromium, Lead, Mercury, Molybdenum, Nickel, Selenium	Moisture/Total Solids, Organic Matter/Ash, pH, Electrical Conductivity, Inerts, Sieve Analysis, Copper, Zinc, C:N Ratio, Arsenic, Cadmium, Chromium, Lead, Mercury, Molybdenum, Nickel, Selenium, Respirometry, Fecal Coliform	Inerts, Copper, Zinc, C:N Ratio, Arsenic, Cadmium, Chromium, Lead, Mercury, Molybdenum, Nickel, Selenium, Bioassay, Respirometry, Fecal Coliform

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New US Digestate Standard

Does NOT replace EPA Part 503

www.Digestate.org

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CERTIFIED DIGESTATE
GENERALLY UNRESTRICTED

AMERICAN BIOGAS COUNCIL
CERTIFIED DIGESTATE
RESTRICTED

From Food **To Digestate** **To Value Added Products**

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Lab Information

- Does a feedstock cause microbial inhibition?
- How productive and of what quality is a feedstock?
- What nutrient value does a feedstock have?
- How well is a digester performing?
- What is an optimal co-feeding recipe for a digester?
- Does my digestate have value?
- Customized analysis to answer specific client questions

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Phased Approach for Project Success

- Phase 1 – Physical, Chemical and Biological testing on each feedstock
- Phase 2 – Biomethane Potential (BMP) testing of each feedstock
- Phase 3 – Pilot unit testing (Wet and/or Dry)
- Phase 4 – Full scale trial

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Example of Potential Phase 1 Testing

- pH
- TS
- VS
- EC
- Alkalinity
- COD
- BOD
- Total N-P-K
- TOC
- NH3
- VFAs
- Secondary nutrients
- Metals
- Waste characterization
- Microbial Inhibition

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Phase 2: BMP Testing

- What method is being used?
  - Loading rate
  - Inoculum
  - Time, Temp, etc…
- How does the data compare to literature values?
- Understanding the data
  - Operator vs design engineer vs project developer

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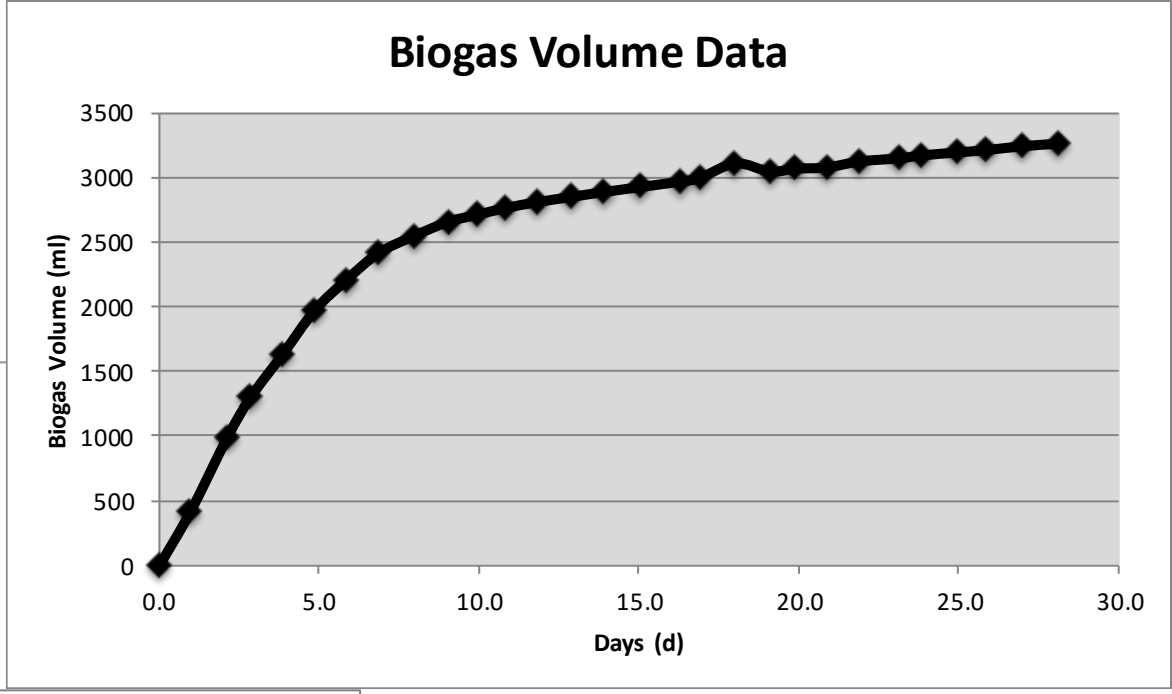
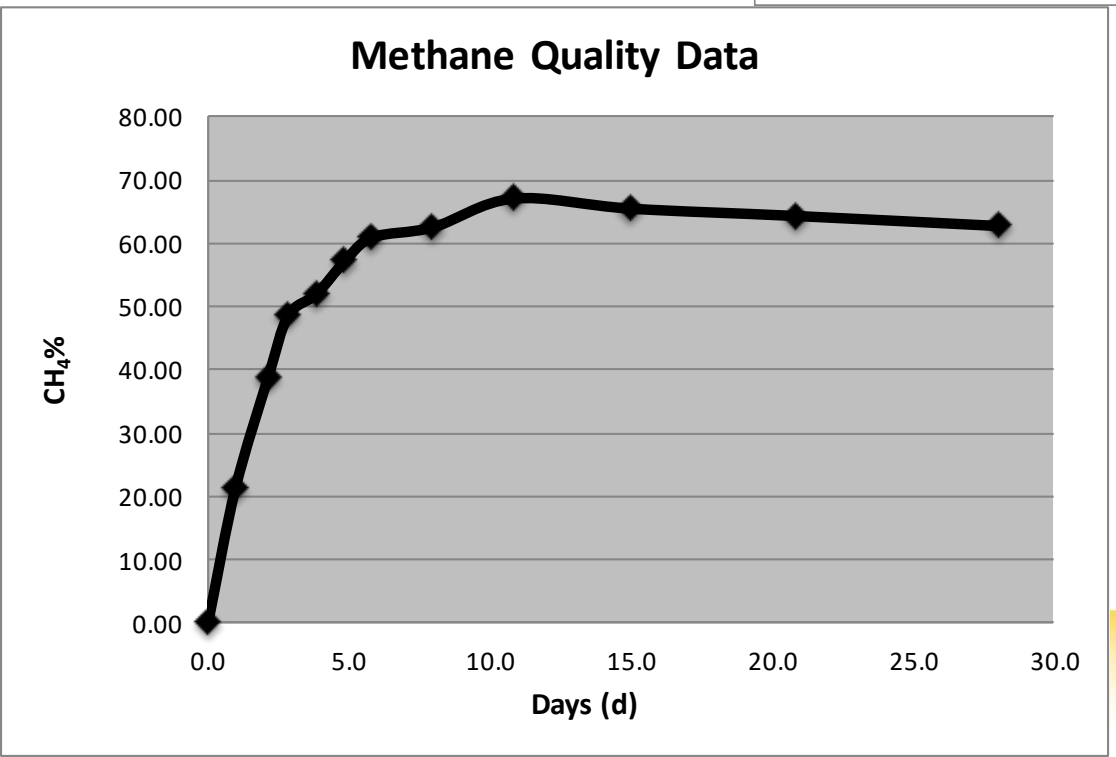
Data Collected





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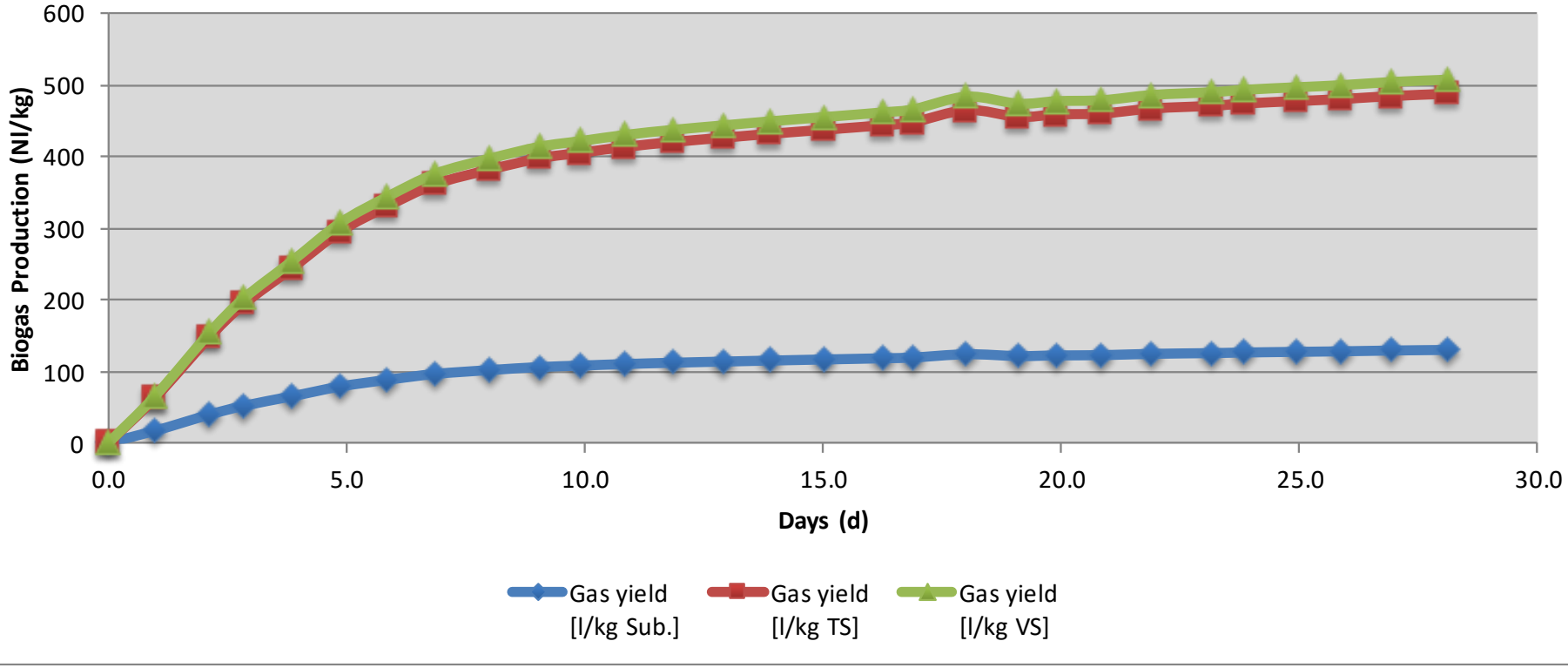
BMP Results

BMP Value = 508 Nl biogas / kg VS or 320 Nl CH_4 / kg VS
TS = 26.8% VS = 95.9%



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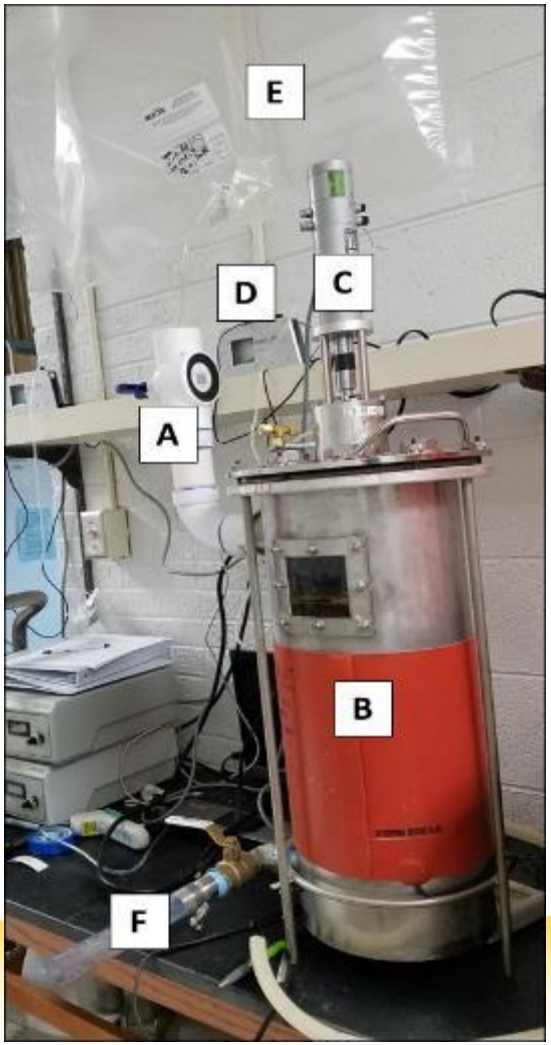
Phase 3: Pilot Testing (Dry & Wet AD)



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Mimic Full Scale Operating Parameters

- Develop “recipes” based on the results from phase 1 & 2 results
- HRT?
- OLR?
- Mesophilic or Thermophilic?
- Recycle rate?

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Do you have the ability to do full scale testing or trials?

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How are the lab results being used?

Parameter	Unit	Sample A	Sample B	Result C	Result D	Result E	Result F
Alkalinity as CaCO3 on solids	mg/kg WWB	ND	ND	1,969	667	1,600	9,000
Chemical Oxygen Demand (COD)	mg/kg WWB	234,825	145,075	54,075	57,825	291,150	52,230
Carbon : Nitrogen Ratio	unitless	32:1	23:1	47:1	17:1	39:1	30:1
Determination of pH	unitless	4.1	4.4	4.7	5.4	5.1	7.6
Nitrogen, Ammonia (NH3) as N on solids	mg/kg WWB	85.7	260.5	18.6	35.0	137.8	203.2
Nitrogen, Nitrate + Nitrite (NO3 + NO2) on solids	mg/kg WWB	11.61	48.61	8.3	3.2	14.3	9.61
Nitrogen, Total Kjeldahl as N on solids	mg/kg WWB	4,432	9,261	2,866	7841	2,000	7,060
Phosphorus, Total on solids	mg/kg WWB	465	851	400	255	2,028	662
Potassium (K) on solids	mg/kg DWB	6,895	7,266	10,969	621	19,672	11,573
Solids, Total	%	27.3	35.5	24.4	25.0	16.1	41.8
Solids, Total Volatile	% TS	95.2	94.3	93.7	96.4	91.5	85.7
Total Organic Carbon (TOC) on solids	mg/kg WWB	142,428	216,967	136,365	128,449	77,633	213,940
Volatile Fatty Acids	mg/kg	3,169	5,062	1,020	517	560	115

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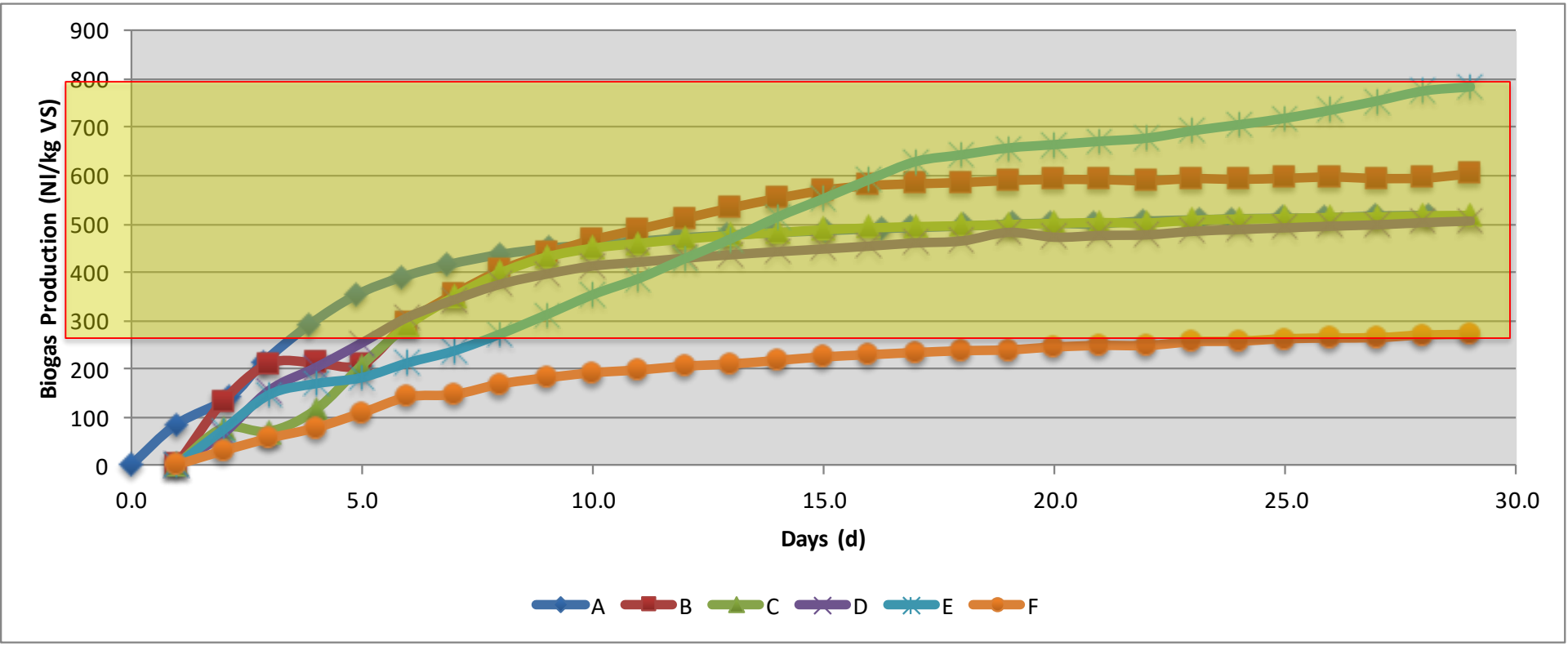
BMP Curves



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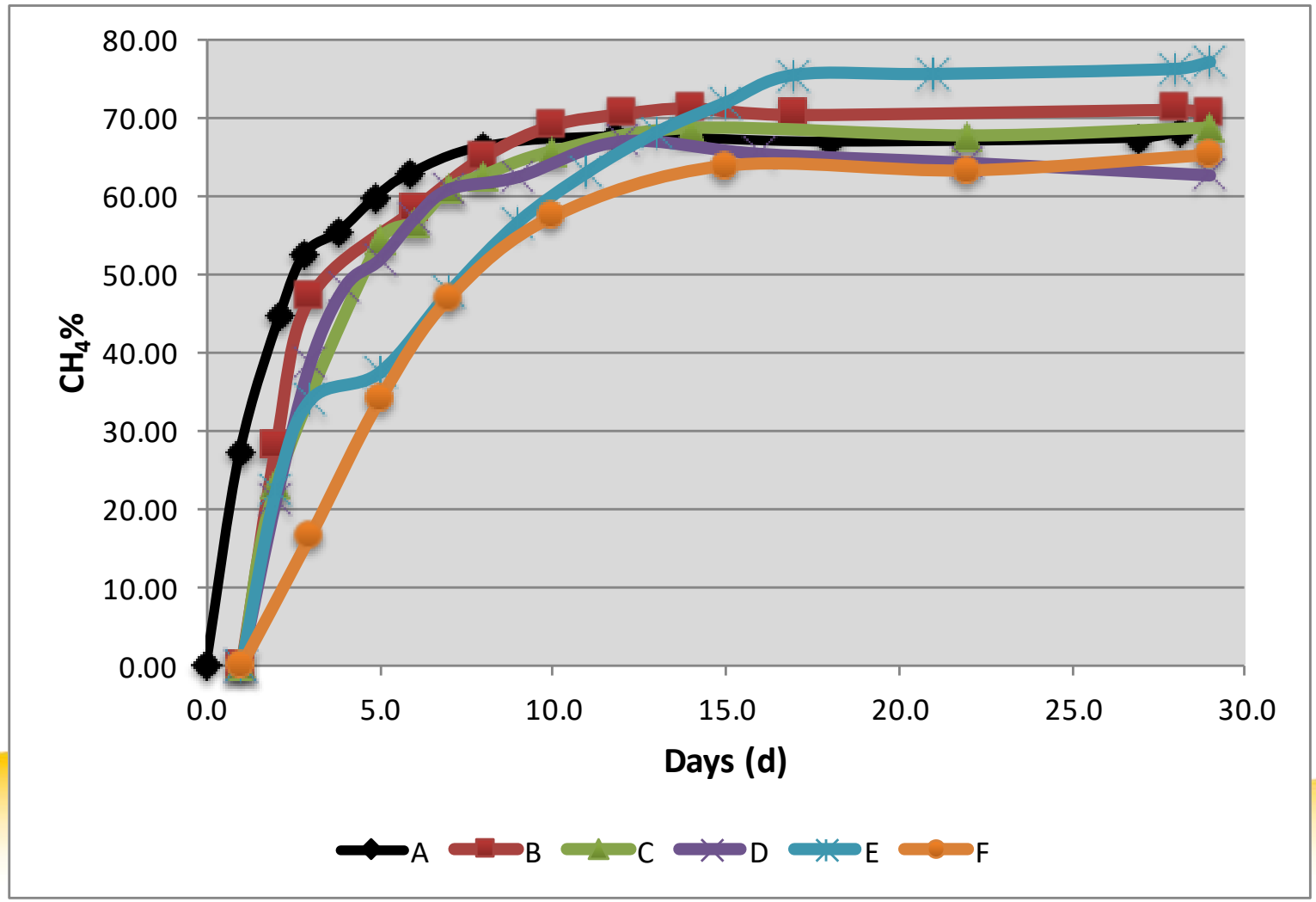
Methane Curves



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Full Scale Production Potential

Example Feedstocks	Tons / Year	% WT	TS (%)	VS (%)	BMP Value (NL biogas/kg VS)	Mean CH_4 (%)	Theoretical Calculation: Total Biogas Yield per Year (ft^3)	KWH per Year	MMBTU per Year	MMBTU per Day
F	96,000	65.66	41.8	85.7	270	49.7	297,470,212	16,955,802	146,364	401
A	15,000	10.26	27.3	95.2	519	58.1	64,820,085	3,694,745	37,284	102
B	15,000	10.26	35.5	94.3	603	62.3	97,006,313	5,529,360	59,831	164
C	11,500	7.87	24.2	93.7	519	58.7	43,358,229	2,471,419	25,197	69
D	8,300	5.68	26.8	95.9	508	54.7	34,717,352	1,978,889	18,800	52
E	400	0.27	16.1	91.5	783	58.8	1,478,155	84,255	860	2
		0.00					0	0	0	0
Total	***146,200***	***100.0***	***37.4***	***88.8***	***364.2***	***57.1***	***538,850,346***	***30,714,470***	***288,336***	***790***
If we assume we will achieve 80% of Theoretical										
							431,080,277	***24,571,576***	***230,669***	***632***

Revenue Potential

- $0.09/kWh = $2.8M
- $0.04/kWh = $1.2M
- $8/MMBTU = $2.9M
- $56/MMBTU = $16M

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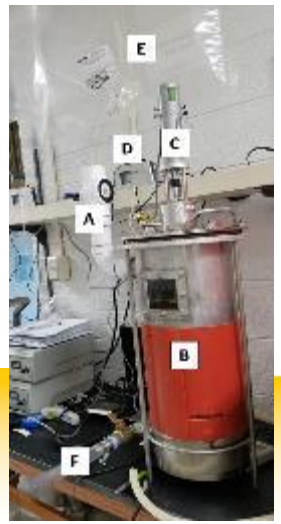
Recipe Development for Pilot Unit Testing

Feedstock	Recipe #1			Recipe #2			Recipe #3			Recipe #4		
	% WT	TS (%)	VS (%)	% WT	TS (%)	VS (%)	% WT	TS (%)	VS (%)	% WT	TS (%)	VS (%)
F	18.6	41.8	85.7	19.6	41.8	85.7	32.8	41.8	85.7	19.7	41.8	85.7
A	0.0	27.3	95.2	11.8	27.3	95.2	5.1	27.3	95.2	11.0	27.3	95.2
B	19.9	35.5	94.3	11.8	35.5	94.3	5.1	35.5	94.3	11.0	35.5	94.3
C	0.0	24.2	93.7	0.0	24.2	93.7	3.9	24.2	93.7	8.4	24.2	93.7
D	11.0	26.8	95.9	6.5	26.8	95.9	2.8	26.8	95.9	0.0	26.8	95.9
E	0.5	16.1	91.5	0.3	16.1	91.5	0.1	16.1	91.5	0.0	16.1	91.5
Digestate Innoculum	50.0	34.3	55.1	50.0	34.3	55.1	50.0	34.3	55.1	50.0	34.3	55.1
Total	**100**	**31**	**76**	**100**	**31**	**76**	**100**	**32**	**74**	**100**	**31**	**76**



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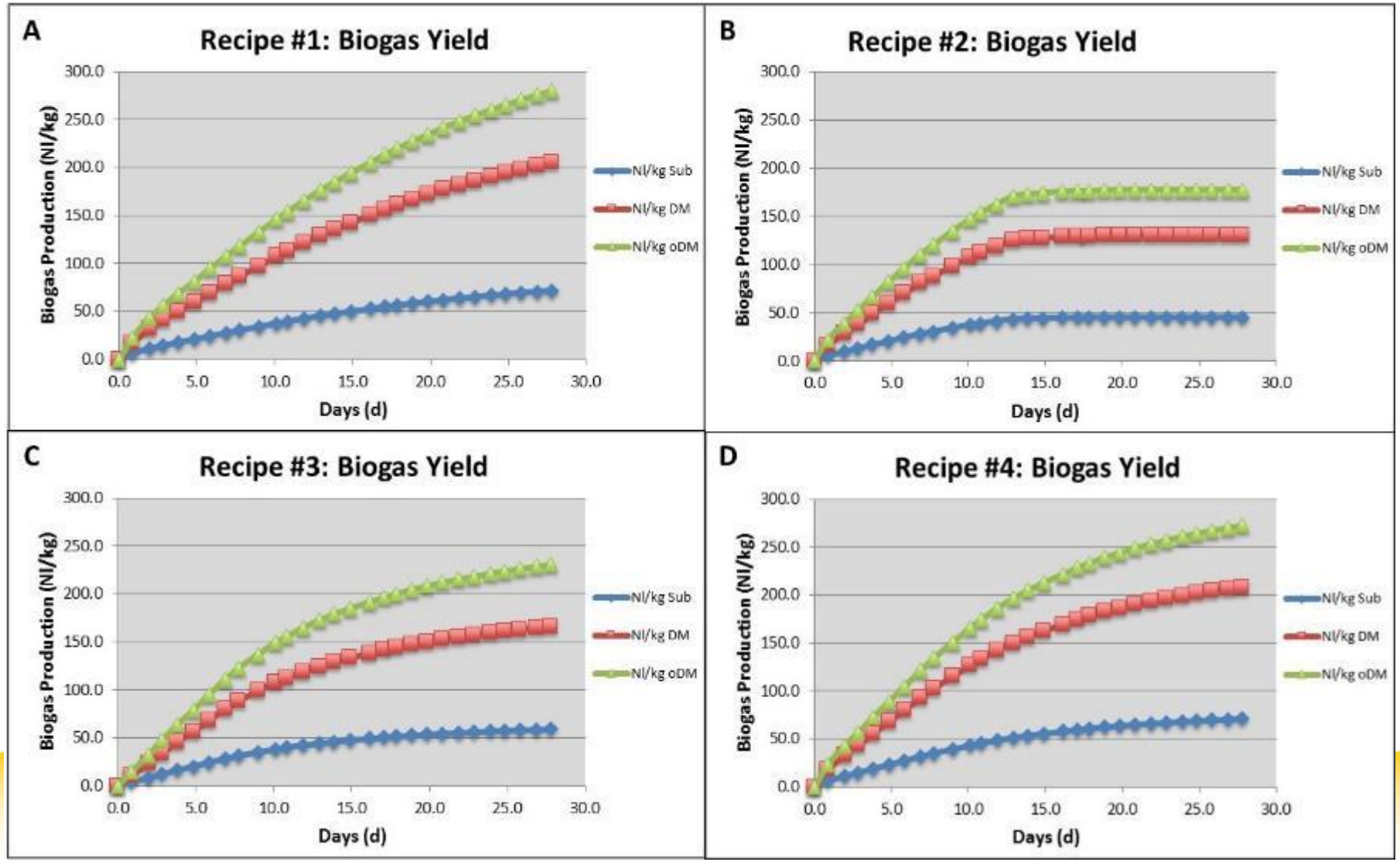
Results from Pilot Testing



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Results Continued

Analysis	Unit	Recipe #1	Recipe #2	Recipe #3	Recipe #4
Total Normalized Biogas Volume	NL	129.4	80.8	107.1	128.4
Theoretical Biogas Yield	L	146.9	136.8	118.9	133.8
Percent Recovery	%	88	59	90	96
Organic Loading Rate	kg VS / m^3 day	3.3	3.3	3.3	3.3
Biogas Production from Fresh Material	Nl biogas/kg (FM)	71.8	44.9	59.5	71.3
Biogas Production from Dry Matter	Nl biogas/kg (TS)	205.1	130.0	166.0	207.8
Biogas Production from Organic Dry Matter	Nl biogas/kg (VS)	279.9	177.5	230.7	272.4
Mean Methane (CH_4)	%	56.5	56.0	54.4	56.4
Mean Carbon Dioxide (CO_2)	%	43.5	44.0	45.6	43.6
Mean Hydrogen Sulfide (H_2S)	ppm	22.3	22.5	9.8	17.9
Final Methane Reading (CH_4)	%	63.2	59.6	57.8	60.3
VS Reduction	%	56.6	52.1	45.9	48.1

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Results Continued

Sample Description	Sample ID	pH	TS %	VS %	Total VFA (mg/Kg WWB)
Final Digestate (Recipe #1)	B5515	8.8	28.0	50.3	21
Final Digestate (Recipe #2)	B5516	8.8	28.2	48.6	14
Final Digestate (Recipe #3)	B5517	8.8	26.5	56.9	15
Final Digestate (Recipe #4)	B5518	8.8	29.2	52.2	16

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Full Digestate Analysis and the ABC Testing Program

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Parameter	Result	Units
Alkalinity as CaCO3 on solids	**14000**	mg/kg WWB
Chloride	**3110**	mg/L
C:N Ratio	**15:1**	unitless
Nitrogen, Total on solids	**7117**	mg/kg WWB
Nitrogen, Total Kjeldahl as N on solids	**7106**	mg/kg WWB
Nitrogen, Nitrate + Nitrite on solids	**10.70**	mg/kg WWB
Nitrogen, Ammonia (NH_3) as N on solids	**1268**	mg/kg WWB
pH	**8.9**	at 26.1°C
Phosphorus, Total on solids	**2309.2**	mg/kg WWB
Solids, Total	**32.8**	%
Solids, Total Volatile	**63.4**	% DM
Organic Carbon, Total (TOC) on solids	**103716**	mg/kg WWB
Volatile Fatty Acids (Total)	**1999**	mg/kg
Acetic Acid	**506**	mg/kg
Propanoic Acid	**194**	mg/kg
Butanoic Acid	**653**	mg/kg
Isobutanoic Acid	**134**	mg/kg
Valeric Acid	**343**	mg/kg
Isovaleric Acid	**169**	mg/kg
Arsenic (As) on solids	**1.36**	mg/kg
Boron (B) on solids	**12.0**	mg/kg DWB
Calcium (Ca) on solids	**24865.70**	mg/kg DWB
Cadmium (Cd) on solids	**0.81**	mg/kg
Chromium (Cr) on solids	**5.14**	mg/kg
Copper (Cu) on solids	**30.9**	mg/kg
Iron (Fe) on solids	**308.10**	mg/kg DWB
Potassium (K) on solids	**13465.30**	mg/kg DWB
Lead (Pb) on solids	**7.42**	mg/kg
Mercury (Hg) on solids	**0.021**	mg/kg
Magnesium (Mg) on solids	**8198.10**	mg/kg DWB
Manganese (Mn) on solids	**1.10**	mg/kg DWB
Molybdenum (Mo) on solids	**0.78**	mg/kg
Sodium (Na) on solids	**455.70**	mg/kg DWB
Nickel (Ni) on solids	**3.84**	mg/kg
Sulfur (S) on solids	**857.0**	mg/kg DWB
Selenium (Se) on solids	**ND**	mg/kg
Zinc (Z) on solids	**55**	mg/kg
Soluble Salts (electrical conductivity EC_5)	**2.2**	dS/m (mmhos/cm)
E. coli on solids (quantification)	**<50**	MPN/g
Salmonella (1-2 Test)	**Negative**	Presence/Absence

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Summary

- **Lab analysis can:**
  - **Help you run your digester more effectively**
  - **Understand baseline operation of your system**
  - **Evaluate changes and new feedstocks**
  - **Evaluate end product value**
- **Understand BMP testing and how to use the data**
- **Find a lab that works for you**

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Questions?