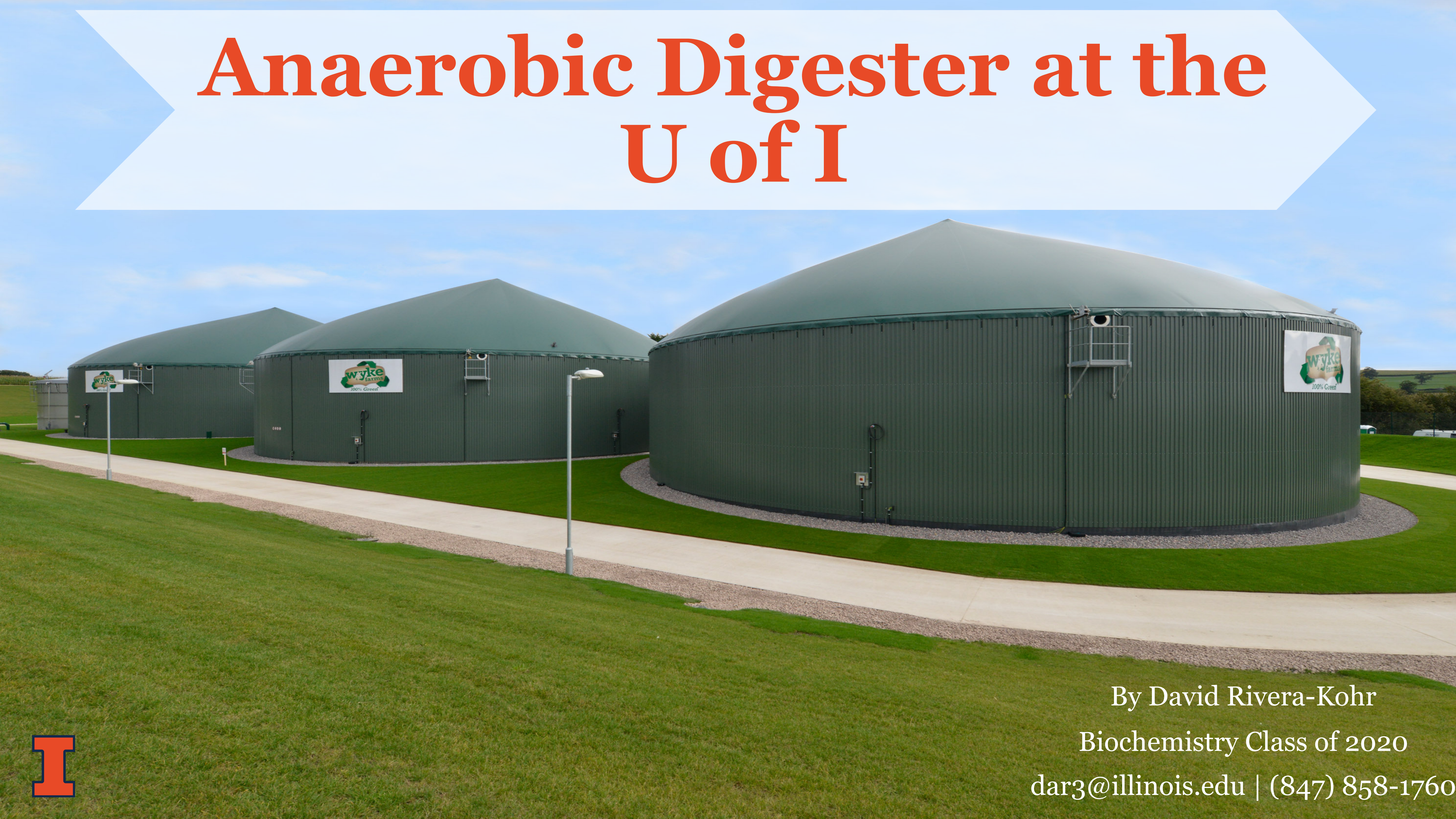
Anaerobic Digester at the U of I



By David Rivera-Kohr
Biochemistry Class of 2020
dar3@illinois.edu | (847) 858-1760

Unused Campus Waste

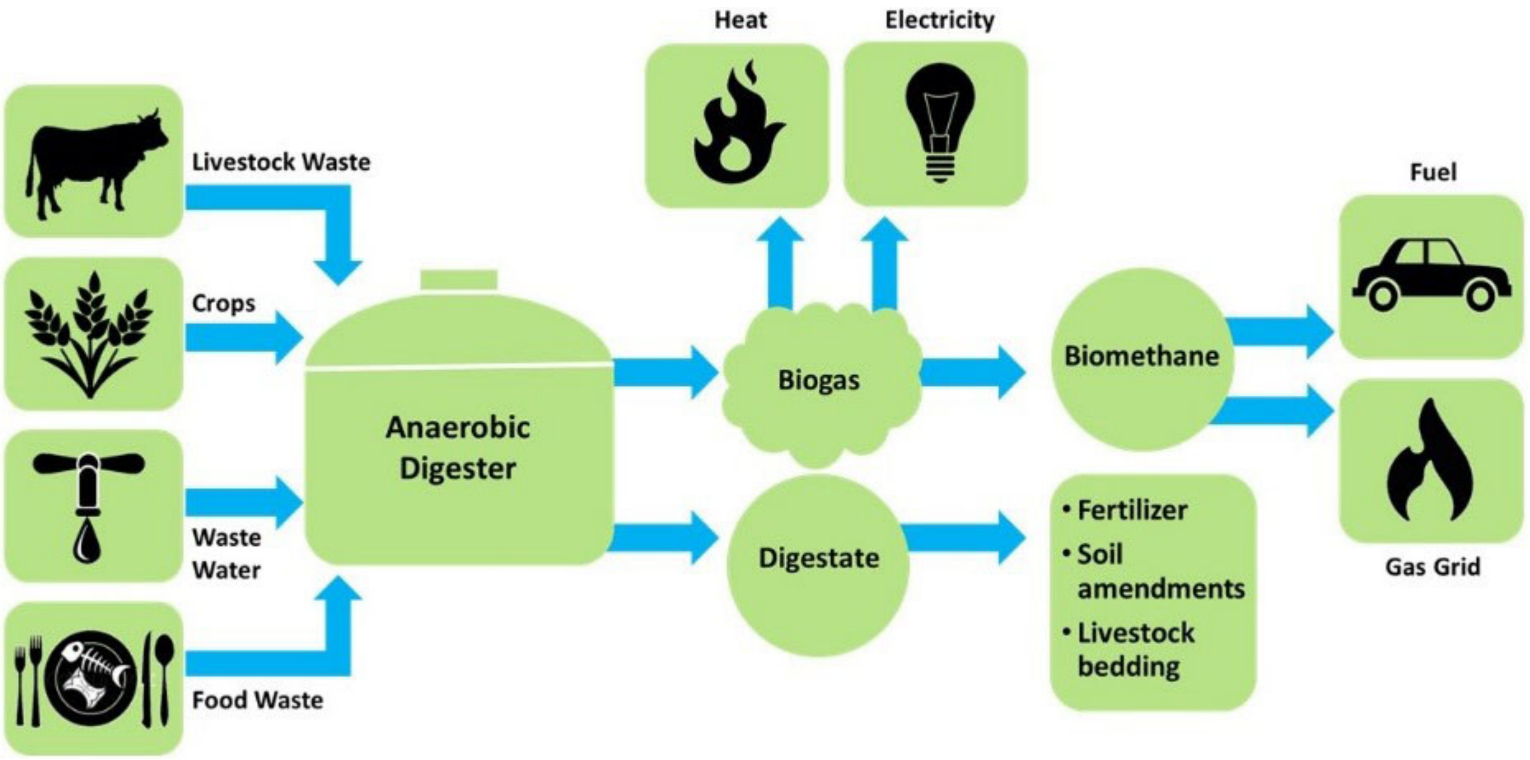
Table 5 – Projected Gross Energy Values

Assay	Source	Projected Monthly BTU @ 1000BTU/ft^3	Projected Yearly BTU @ 1000BTU/ft^3	Projected Monthly MMBTU	Projected Yearly MMBTU
13001	Horses	70,080,000	840,960,000	70	841
13003	Dairy Solid	617,989,667	7,415,876,000	618	7,416
13010	Hog - Manhole	708,000,000	8,496,000,000	708	8,496
13011	Beef/Sheep	308,127,297	3,697,527,563	308	3,698
13012	Poultry	8,458,875	101,506,500	8	102
13015	Dairy Liquid	333,666,667	4,004,000,000	334	4,004
Proxy	Animal Carcass	831,073,971	9,972,887,652	831	9,973

	Methane emissions (mtCO2e/yr)	Methane potential (MMBTU/yr)
Animal waste	1,832	34,528
Dining hall food waste*	18.85	413
Total	**1,851** (=390 cars)	**34,941**

*Contributes ~50% of total campus food waste

Anaerobic Digester



- Carbon neutral source of energy and fertilizer
- Recommended by:
  - Student body
  - SWATeams
  - iWG

Digestion Benefits

Environmental	Economic	Other
Reduce GHG emissions	Lower heating, electricity and/or vehicle fuel costs	Provide research opportunities
Reduce waste in landfills	Sell excess energy to the grid	Reduce odor from manure
Reduce nutrients in runoff	Earn energy credits	
Reduce pathogens and weed seeds in manure	Reduce fertilizer, soil amendment and/or livestock bedding costs	
Reduce global water consumption	Reduce spending on landfill waste	

Domestic Digesters

Project	Feedstock	Daily Tons	Yearly Tons	#	Reactor Size Gallons	Use	Amount	Note	Cost
Vermont Technical College	Manure, energy crops, pre and post-consumer food waste	63	22995	2	1 EA 135,000 1 EA 410,000	Co-generation	2,8 million kWH	Electricity is sold to grid, heat is put back to campus; excess is flared	$4,000,000
Ohio State OBIC	Manure, food waste, fog	96	35000	1	1 EA 550,000	electricity	600 kW		$6,000,000
Michigan State University[13]	manure, food waste	47	17000	1	1 EA 450,000	Co-generation	2.8 million kWh	Electricity, heat to digester, eventually CNG	$5,000,000
Fiscalini	manure, whey, expired cheese, energy crop	100	36500	2	2 EA 860,000	Co-generation	710 kW	heat is used to heat digester, and cheese plant	$4,000,000
North State Rendering	Animal mortality waste, grease trap waste	100	36500	2	2 EA 244,500 1 EA 611,000	Co-generation	710 kW	Electricity, heat to digester, eventually CNG	$8,000,000

- Sanitary District (U-CSD)
- Purdue
- UC-Davis

Biogas & Fertilizer Potential

	Emissions reduced (mtCO2e/yr)	Annual savings/profits	Additional benefits/ comments
Displaced NG*	1,854	$83,305	• 1.04% of Abbott NG demand FY 2019 • 1.24% of 2050 projected energy usage
Utilization of waste**	1,851	$20,179	• Reduce landfill waste volume • Reduce waste disposal spending and emissions
Credits	--	RIN potential (after market): $654,095 LCFS potential: $37,050 REC potential***: $7,169	• Burning for electricity is the lowest priority option
Displaced fertilizer (max)	352	$157,362	• Reduce global water consumption • Enhanced nutrient retention • Reduce weed seeds, pathogens, odor from manure • Digestate could also be used for livestock bedding, etc.
Total	**Global: 4,057 Campus: 3,705**	**$951,991**	--

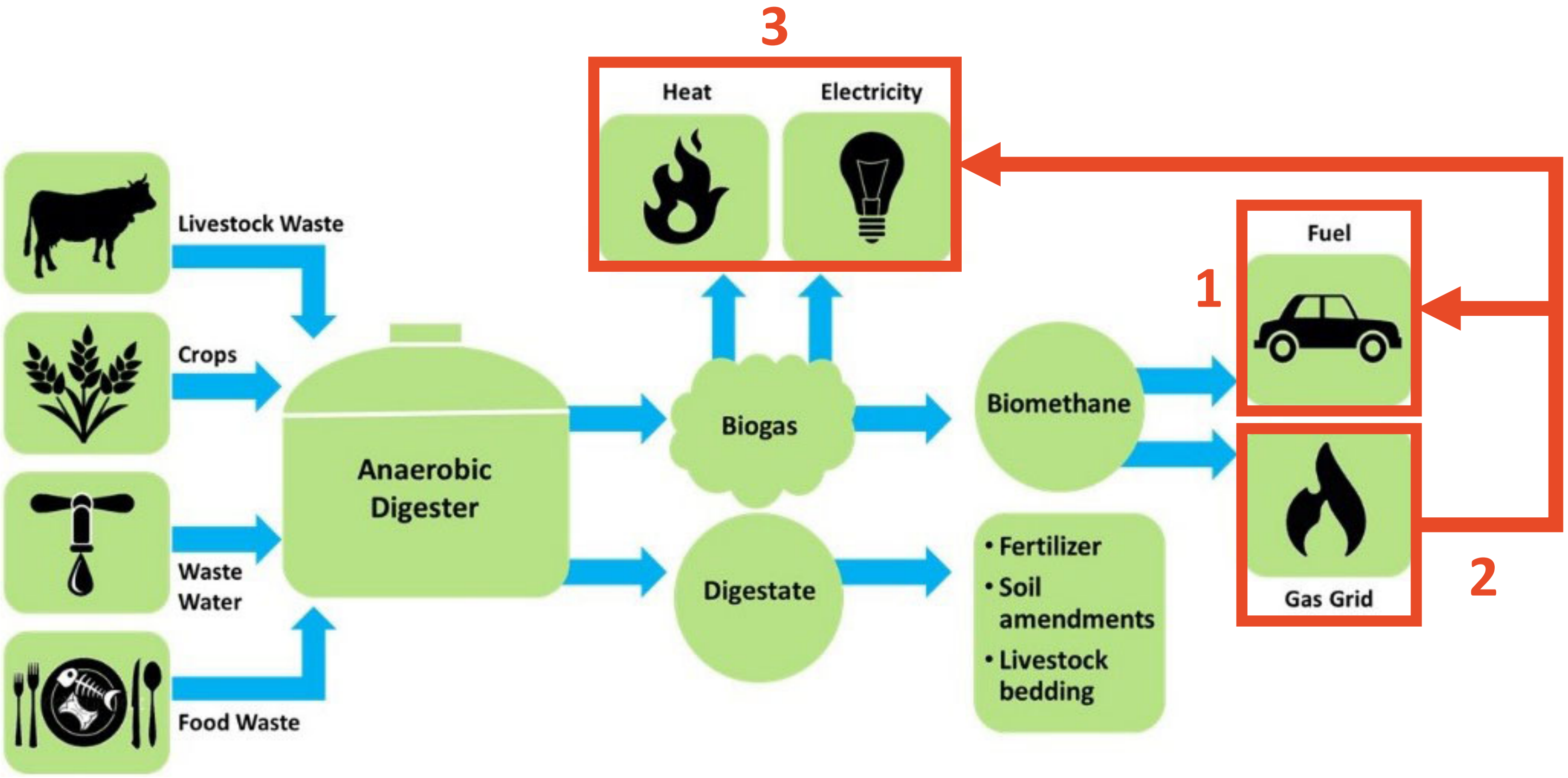
*not including energy demand from AD, upgradation, CNG or pipeline injection
**not including offset animal waste disposal costs or transportation/rendering emissions
***not included in overall savings

Production Option Comparison

Option	Cost	Lifetime (yrs)	Methane output (MMBTU/yr)	Nitrogen output (tons/yr)	Emission reduction (mtCO2e/yr) **	Annual savings/ Profits ***	Additional benefits
Anaerobic Digester	$10.048 million + $351,069/yr O&M*	Digester Tanks: 45 Machinery: 20	34,941	309	Global: 4,057 Campus: 3,705	$600,922	• Reduce nutrient runoff • Reduce pathogens and weed seeds in manure • Reduce manure odor • Reduce global water consumption • Provide research opportunities • Reduce waste in landfills
Siphon from Beef & Sheep manure tanks			3,698	49	Global: 449 Campus: 393	$33,744 ***	• Reduce global water consumption

*only applicable if RNG is produced (expected)
**not including energy required to separate biosolids and liquid digestate
***assuming 100% methane use for RNG
****not including O&M

Biogas Use



1. Campus Fleet Vehicle CNG
2. RNG Pipeline Injection
3. On-Site CHP

Use Option Comparison

Option	Cost	Lifetime (yrs)	Maximum annual output from biogas	Annual savings***	Advantages	Disadvantages	Comments
Vehicle CNG	Facility: $800,000 Conversion of 8-12 vehicles per year: $120,000 - 180,000*	12-13.6	306,500 GGE	$791,690 (B20 diesel) - 821,420 (gas)	• Most efficient way to use RNG • Fuel fleet vehicles used to transport digester waste and byproducts	• Requires upgradation, compression and potentially transportation	• Determine feasibility of use at CUMTD vs. campus fleet trucks vs. cars
RNG Pipeline Injection	Upgradation & Injection: $991,000 (O&M included in digester cost)	40 (upgradation equipment)	34,941 MMBTU	$83,305	• Multiple options for using pipeline RNG	• Requires upgradation • Costly construction of injection site	• May be required for CNG
Biogas CHP (710 kW/2.8 million kWh reciprocating engine)	$1.42 million O&M: $42,000/yr		10,241 MWh**	$83,305	• Most efficient way to use non-upgraded biogas	• Not feasible to use off-site due to transportation costs and emissions	• Determine appropriate size and type of CHP technology for lowest emissions • Determine whether CHP is feasible given other biogas use options

*not including CNG transportation costs
**only accounting for energy from methane combustion
***from offset fuel costs only assuming 100% reliance on diesel/NG

Overall Economics

Scenario	Construction Cost	Methane output	Nitrogen output	Annual savings*	Annual emissions offset (mtCO2e/yr) **
Pipeline injection	$11.039 million	34,941 MMBTU/yr	309 tons/yr	$420,922 to 480,922	Global: 4,057 (= 854 cars) Campus: 3,705 (= 780 cars)
CNG + pipeline injection + CHP	$13.259 million	34,941 MMBTU/yr	309 tons/yr	$378,922 to 438,922 plus vehicle fuel savings minus displaced NG savings	Global: 4,057 (= 854 cars) Campus: 3,705 (= 780 cars)
CNG + pipeline injection	$11.839 million	34,941 MMBTU/yr	309 tons/yr	Assuming maximal CNG use: $1.13 to 1.22 million	Global: 4,057 (= 854 cars) Campus: 3,705 (= 780 cars)

*not including offset animal waste disposal costs; vehicle conversion to CNG (8-12 diesel vehicles annually) and O&M costs subtracted from annual savings

**not including offset animal waste transportation/rendering emissions or parasitic energy load from digester and other equipment, assuming equal emissions from upgraded biogas byproducts

iCAP & SWATeam Goals

	Goal
iCAP	• Carbon neutrality by 2050
Energy SWATeam	• Decrease reliance on fossil fuels
Zero Waste SWATeam	• Decrease landfill waste • Streamline campus food and animal waste disposal
Transportation SWATeam	• Decrease reliance on fossil fuels
Land & Water SWATeam	• Decrease nutrients in runoff • Decrease pathogens and weed seeds in manure • Decrease global water consumption
Resilience SWATeam	• Advance University energy, agricultural and waste disposal independence
Education SWATeam	• Provide research opportunities

Recommendation

Feasibility Study for Anerobic Digester on South Farms

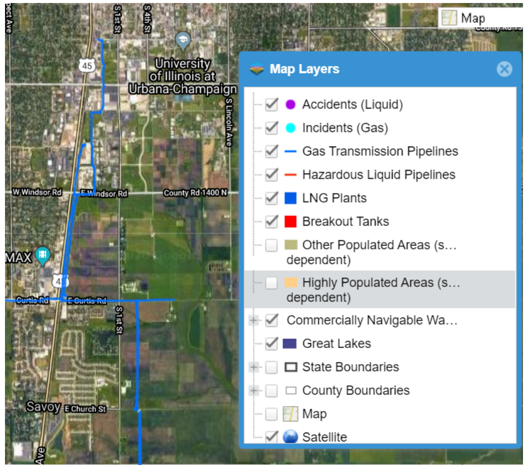
1. Optimal digester location
2. Feedstocks and products
3. Optimal biogas and digestate use
4. Optimal CNG facility location
5. Economics
6. Integration into campus operations
7. Funding and partnership options
8. List of environmental, economic and other benefits
9. Address “recommended next steps” from previous study
10. Address concerns from or shortcomings of previous study

Acknowledgements

- Thank you to Bill Rose, Andy Stumpf, Sarthak Prasad, Morgan White, Meredith Moore, Mike Larson, Lance Schideman, Shantanu Pai, Michael Marquissee, Miles Redden, Jackie Christensen, Pete Varney, Neslihan Akdeniz Onuki
- Questions?

RNG Pipeline Injection

Biogas Use #3



- Upgrade to pipeline-quality methane
  - System cost: $991,000 (Alton Report)
- Inject into NG pipeline
  - Requires addition of injection site: $___