Food Waste Management

Presented by:

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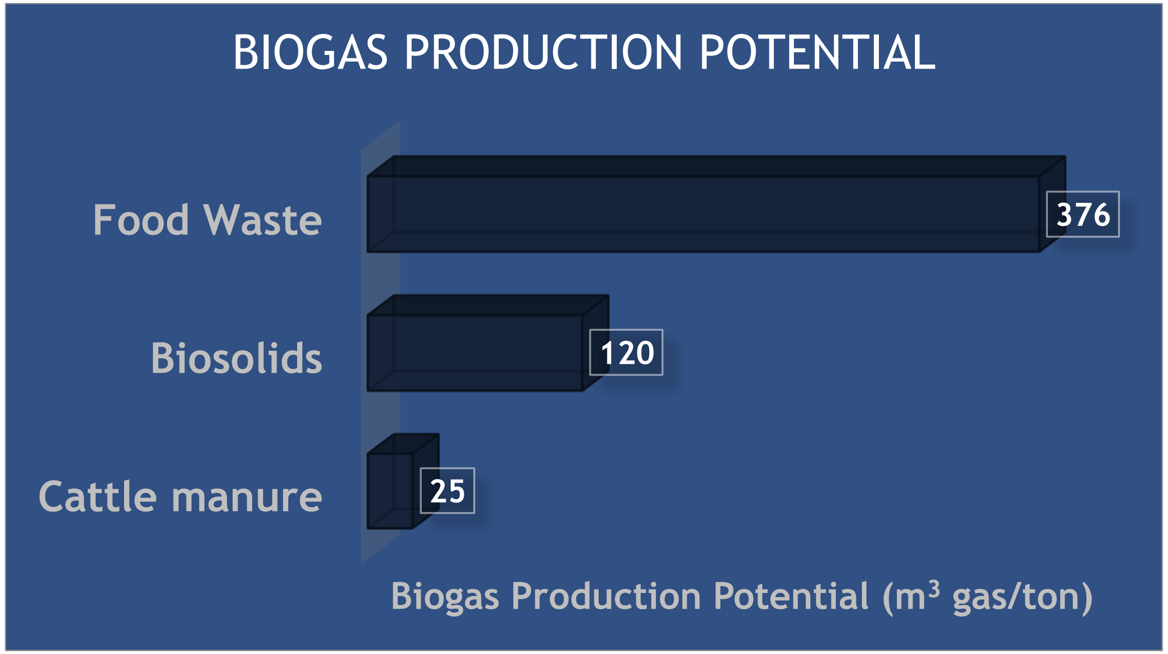
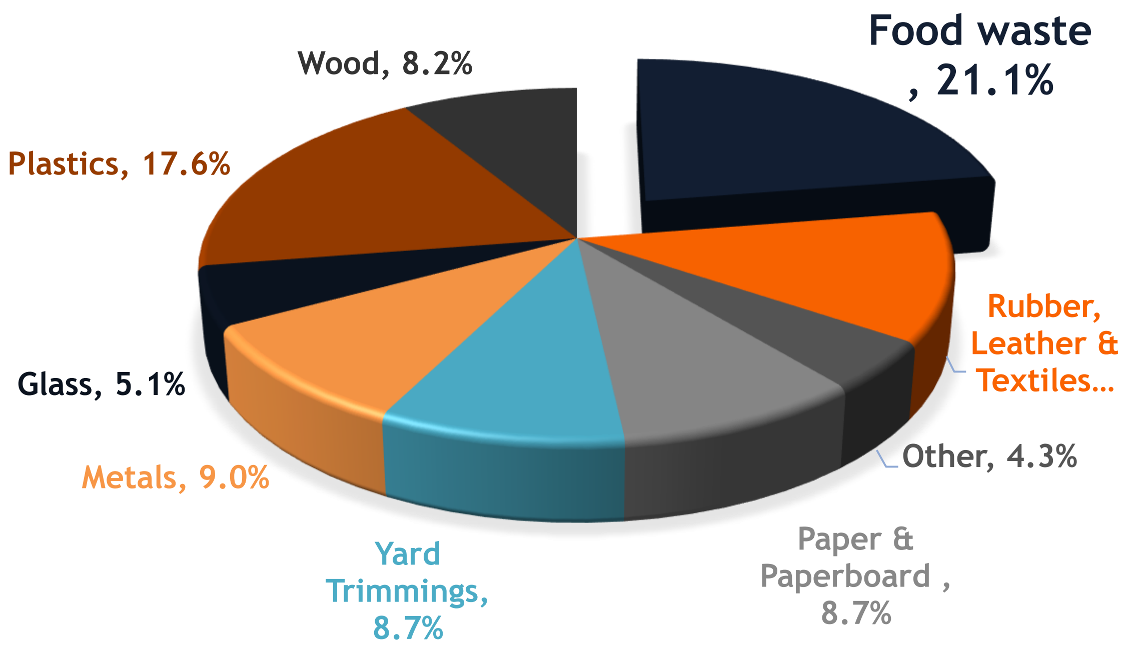
Food waste is an important problem…

- Food waste is generated during production, harvest, storage, transportation, retail, & consumption of food
- Accounts for 13% of methane emissions in landfills (EPA, 2015)
- Can produce 15 TIMES more biogas as compared to cattle manure (EPA, 2016)



Municipal Solids Waste after recycling in 2012 (EPA, 2014)



Current Situation On-Campus

- Total waste from campus buildings for FY17:
  - Landfilled: 5,303.34 tons
  - Recycled: 1,924.28 tons
- Dining Services – food waste data is collected by LeanPath 360. Food waste goes to
  - Aerobic Treatment: EnviroPure System
  - Garbage disposal
  - Landfills
- Food waste that does not goes through EnviroPure, is sent to the landfills
- Busey Evans Dining Hall and other University-owned/operated vendors do not have EnviroPure Systems

What do we propose?

- Anaerobic Digestion (AD) of food waste at the UCSD wastewater treatment plant
- Why Anaerobic Digestion?
  - Existing technique: UCSD has existing AD systems
  - Reduced landfill use
  - Reduced GHG emissions
  - On-site energy/power generation
  - Drop-in fuel generation
  - Renewable energy credit sales
- Process food waste before sending to AD: Insinkerator Grind2Energy system
- Other processing equipment/techniques considered: Insinkerator Tri-Cycle Pulper Unit,Insinkerator Waste Xpress, Somat Pulper, Grinder, Off-site Grinder

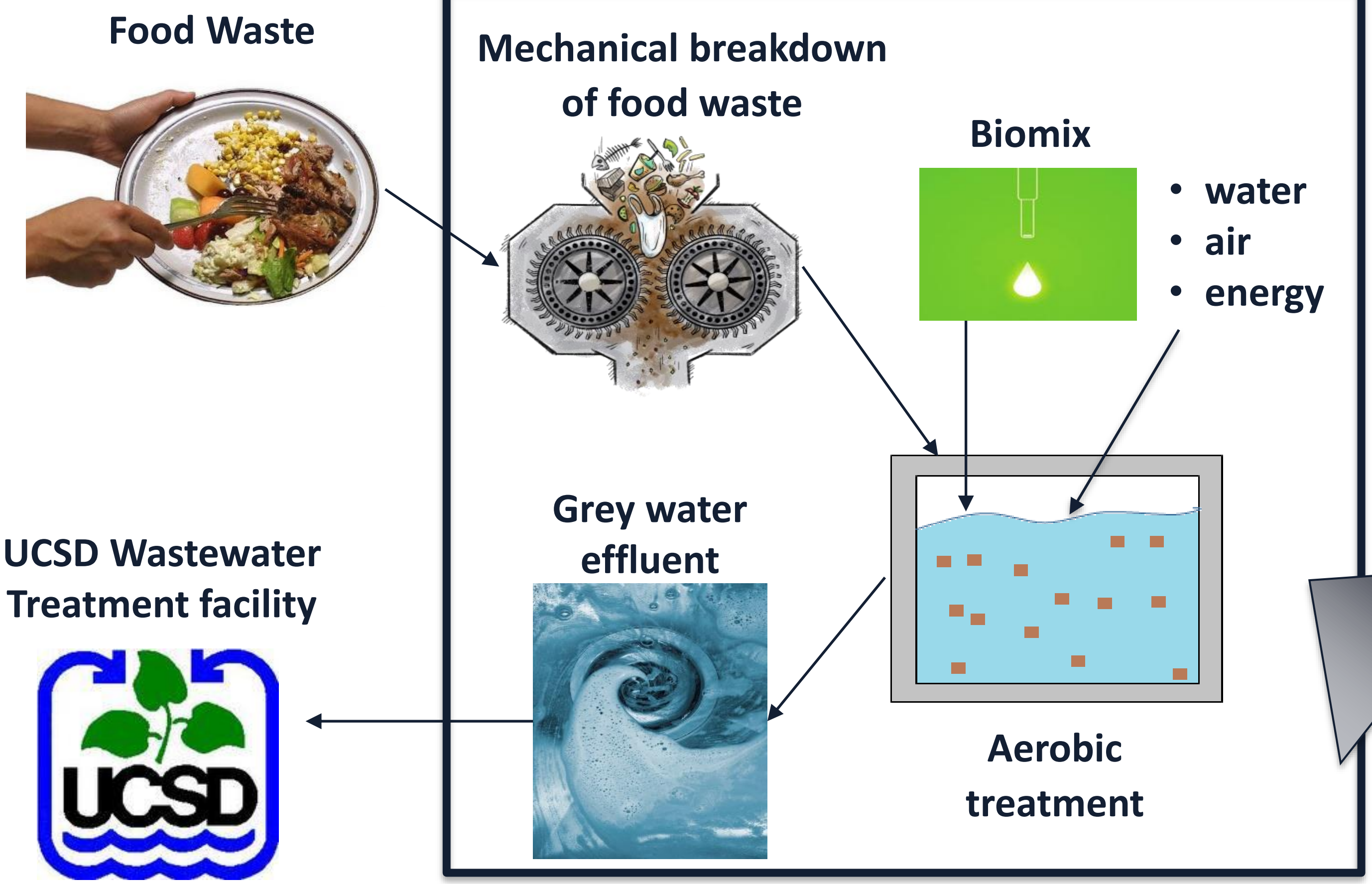
Anaerobic Digestion Process

Organic Waste
- Biosolids
- Food waste
- Manure
- Yard waste

Anaerobic Digester
- Solid co-product: Compost, soil amendments
- Liquid co-product: Fertilizer, concentrated fertilizer

Gas product: Biogas
- Electricity and Heat
- Transportation Fuel
- Flare excess

Current Situation: Aerobic Treatment – EnviroPure System



- 600 lbs – 1500 lbs food waste per day
- Retention Time: 24 hours or less
- Addition of water and air
- Addition of energy, w/ no energy recovery
- Releases CO_2

Cost analysis for 6 Aerobic Treatment units. Scenario 1: Connection Fee + High Sewer Fee

Capital Cost (Unit+ Equipment)	$243,000	$270,000	$297,000	UofI	6 units. Average Unit + Installation cost = $45,000. Capacity 600lbs/24 hr-1500lbs/24 hr. Data from Thurman. Error = ±10%
Connection Fee	$800k	$1M	$1.5M	UofI	UCSD connection fee. Data from Colleen. Low:$800k,Med:$1M,High:$1.5M
Annualized Capital cost	$89,650	$106,400	$148,250	UofI	Annual capital cost. Amortized at 3% for 15 years.
Operating Cost					
Biomix	$22,500	$25,000	$27,500	UofI	Data from Thurman. 20 barrels a year. 1 barrel = $1250. Error = ±10%
Electricity Aerobic Treatment	$2,330	$4,665	$9,330	UofI	Estimate based on average WWTP aerobic treatment. Low: -100% (highly optimized), Med: +0%, High: +100% (poorly optimized). 32 wks
Maintenance	$13,500	$15,000	$16,500	UofI	Data from Thurman. Error = ±10%
Electricity (pump and grinder)	$725	$800	$875	UofI	EnviroPure uses 0.32kwh/hr. 6 systems, 32 weeks, $0.0782/kwh. Error = ±10%
Freshwater	$1,080	$1,200	$1,325	UofI	60 lbs bucket, 5 minutes of grinding, 5 gpm freshwater supply. More water for 1% solid outflow. Freshwater= $4.18/kgal. Error = ±10%
Sewer Discharge	$6,500	$7,200	$7,925	UofI	60 lbs bucket, 5 minutes of grinding, 5 gpm freshwater supply. More water for 1% solid outflow. Higher Sanitary= $25/kgal. Error = ±10%
Annual Operating Cost	**$46,635**	**$53,865**	**$63,455**	**UofI**	**Annual Operating Cost**
Total Annual Cost	**$136,285**	**$160,265**	**$211,705**	**UofI**	**Annual Operating Cost + Annualized Capital Cost**

Note: No valuable co-product generated from Aerobic Treatment of food waste

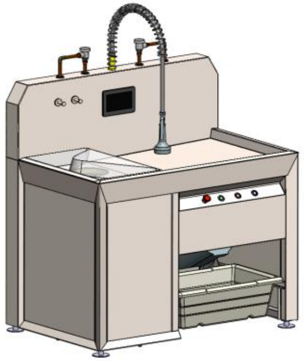
Cost analysis for 6 Aerobic Treatment units. Scenario 2: High Sewer Fee

	Low	Medium	High	Who Pays	Comments
Capital Cost (Unit+ Equipment)	$243,000	$270,000	$297,000	UofI	6 units. Average Unit + Installation cost = $45,000. Capacity 600lbs/24 hr-1500lbs/24 hr. Data from Thurman. Error = ±10%
Connection Fee	$ -	$ -	$ -	UofI	No Connection fee.
Annualized Capital cost	$20,350	$22,600	$24,880	UofI	Annual capital cost. Amortized at 3% for 15 years.
Operating Cost					
Biomix	$22,500	$25,000	$27,500	UofI	Data from Thurman. 20 barrels a year. 1 barrel = $1250. Error = ±10%
Electricity Aerobic Treatment	$2,330	$4,665	$9,330	UofI	Estimate based on average WWTP aerobic treatment. Low: -100% (highly optimized), Med: +0%, High: +100% (poorly optimized). 32 wks
Maintenance	$13,500	$15,000	$16,500	UofI	Data from Thurman. Error = ±10%
Electricity (pump and grinder)	$725	$800	$875	UofI	EnviroPure uses 0.32kwh/hr. 6 systems, 32 weeks, $0.0782/kwh. Error = ±10%
Freshwater	$1,080	$1,200	$1,325	UofI	60 lbs bucket, 5 minutes of grinding, 5 gpm freshwater supply. More water for 1% solid outflow. Freshwater= $4.18/kgal. Error = ±10%
Sewer Discharge	$6,500	$7,200	$7,925	UofI	60 lbs bucket, 5 minutes of grinding, 5 gpm freshwater supply. More water for 1% solid outflow. Sanitary= $25/kgal. Error = ±10%
Annual Operating Cost	**$46,635**	**$53,865**	**$63,455**	**UofI**	**Annual Operating Cost**
Total Annual Cost	**$66,985**	**$76,465**	**$88,335**	**UofI**	**Annual Operating Cost + Annualized Capital Cost**

Note: No valuable co-product generated from Aerobic Treatment of food waste

Proposed 1: Pulper - InSinkErator Tri-Cycle Pulper Unit to grind & de-water food waste

Food waste is collected in buckets



Tri-Cycle Unit: Addition of water, grind food waste, dewatering unit

Dewatered product collected in buckets

Buckets carted to Blue bin near the loading dock

Trucked to UCSD

UCSD

Pros:

- Low capital cost
- 100 units of food waste in and 42 units of food waste out
- Reduced hauling cost
- Low freshwater demand
- Very low operating cost
- Self-clean after every cycle/day use
- Can process paper napkins, disposable utensils

Cons:

- Labor cost
- Processed food waste in non-flowable form
- Currently, UCSD cannot accept waste in solid form to feed the Anaerobic Digester
- UCSD and UofI prefer slurry form
- Possible odor issues

Proposed 1: Cost Analysis for 6 Pulpers: Insinkerator Tri-Cycle Unit

	Low	Medium	High	Who Pays	Comments
Capital Cost (Equipment, Collection and construction)	$278,200	$330,700	$388,200	UofI	Unit cost $25k. Construction. Low: Installation = 0.5*Unit cost; Med: Installation = 0.75*Unit cost; High: Installation = Unit cost
Annualized Capital Cost	$23,300	$27,700	$32,520	UofI	Annual capital cost. Amortized at 3% for 15 years.
Operating Cost					
Hauling	$14,400	$19,200	$28,800	UofI	$50/hour for F&S drivers, half a day per week 3 trips per week, 32 weeks. Low: 3hrs, Med: 4 hrs, high: 6 hrs
UCSD Delivered Waste Fee	$3,125	$3,475	$3,820	UofI	$0.09/gal in liquid form is equivalent to $21.53/wet ton. 85% water removal. 32 weeks. Error = ±10%
Maintenance	$13,500	$15,000	$16,500	UofI	Assuming maintenance cost is same as EnviroPure. Data from Thurman. Error = ±10%
Labor Cost @ UCSD (unload)	$4,320	$4,800	$5,280	UofI	$50/hr. 3 trips per week, 1 hour per trip. 32 weeks. Error = ±10%
Electricity	$780	$1,050	$1,110	UofI	Data from Insinkerator Sales Rep. Low: 1.5 kWh, Med: 2.0 kWh, High: 2.1 kWh. Runs 5 hrs/day. 32 wks
Freshwater	$650	$725	$800	UofI	Based on number of meals served every week. 32 weeks. 3 gpm fresh water supply. Freshwater charge = $4.18/kgal. Error = ±10%
Sewer	$520	$580	$635	UofI	Based on number of meals served every week. 32 weeks. Sanitary charge = $3.35/kgal. Error = ±10%
Annual Operating Cost	**$37,295**	**$44,830**	**$56,945**	**UofI**	**Annual Operating Cost**
Total Annual Cost	**$60,595**	**$72,530**	**$89,465**	**UofI**	**Annual Operating Cost + Annual Capital Cost**

Proposed 2: Insinkerator Grind2Energy System with Anaerobic Digestion at the Urbana-Champaign Sanitary District (UCSD)

Food waste is collected in buckets

Food waste is ground into a slurry, collected in this tank in the loading dock

Transported to UCSD

Pros:

- Moderate capital cost
- Food waste in slurry form, stored in a sealed tank
- Low hauling cost
- Low freshwater demand
- Low operating cost
- Labor cost is minimal
- Both UCSD and UofI prefer food waste in the slurry form
- IoT will notify the haulers when the tank is full

Cons:

- Transporting water

Cost Analysis for 6 Insinkerator Grind2Energy Units

	Low	Medium	High	Who Pays	Comments
Capital Cost (Equipment and Collection)	$359,700	$395,670	$431,640	**UofI**	Starting cost for one unit = $59,950. Includes installation. 6 units. Low= Total, Med= Total * 1.1 (10% more); High= Total * 1.2 (20% more)
Annualized Capital Cost	$30,125	$33,150	$36,150	UofI	Annual capital cost. Amortized at 3% for 15 years.
Operating Cost					
UCSD Delivered Waste	$10,750	$24,200	$29,570	UofI	Low: $0.04/gal; Med (Current): $0.09/gal; High: $0.11/gal. 32 wks
Hauling	$5,375	$8,050	$10,750	UofI	Based on hauling cost for tanker trucks currently used by UCSD. Assuming 3 gpm water inflow. Low: $20/kgal, Med: $30/kgal, High: $40/kgal
Maintenance	$13,500	$15,000	$16,500	UofI	Assuming maintenance cost is same as EnviroPure. Data from Thurman. Error = ±10%
Electricity	$540	$600	$660	UofI	Emerson Electric Company rep said <$100/year per equipment. Assuming error = ±10%
Freshwater	$240	$480	$720	UofI	6 systems. Based on number of meals served every week. 2 gpm fresh water supply. 32 weeks. Freshwater charge = $4.18/kgal. Error = ±10%
Sewer Discharge	$ -	$ -	$ -	UofI	The slurry goes to the tank. Little to no water down the drain.
Optional IoT fee	$9,300	$9,300	$9,300	UofI	*Opt: Internet of Things (IoT) mo charge $129/unit. (Not recommended)*
Annual Operating Cost	**$30,405**	**$48,330**	**$58,200**	**UofI**	**Annual Operating Cost**
Total Annual Cost	**$60,530**	**$81,480**	**$94,350**	**UofI**	**Annual Operating Cost + Annualized Capital Cost**

Proposed 3: Offsite Grinder

Food waste

Food waste collected in trash bags and taken to dumpster

Dumpster

Trucked to UCSD

UCSD Wastewater Treatment facility

- Pros –
  - Minimal capital cost
  - Centralized grinding at UCSD; can be used by other university or community members
  - Renewable energy generation
  - Electricity and heat generation
  - RECs, RINs, and LCFS sales
  - Transportation fuel, pipeline quality Natural Gas
- Cons –
  - Transporting air and water
  - Rodents and odor issue
  - Very high labor cost
  - High annual operating cost

Proposed 3: Cost Analysis for 6 Offsite Grinder at UCSD

	Low	Medium	High	Who Pays	Comments
Capital Cost (Equipment, Collection and construction)	$71,960	$91,960	$116,960	UofI	Unit cost $25k. Construction. Low: Installation = 0.5*Unit cost; Med: Installation = 0.75*Unit cost; High: Installation = Unit cost
Annualized Capital Cost	$6,025	$7,700	$9,800	UofI	Annual capital cost. Amortized at 3% for 15 years.
Operating Cost					
Hauling	$28,800	$38,400	$57,600	UofI	Assuming 1 trailor truck can carry 50 bins at a time. $50/hour for F&S drivers, half a day per week 3 trip per week, 32 weeks. Low: 3hrs, high: 6 hrs
UCSD Delivered Waste Fee	$7,440	$8,265	$9,100	UofI	$0.09/gal in liquid form is equivalent to $21.53/wet ton. 85% water removal. 32 weeks. Error = ±10%
Maintenance	$ -	$ -	$ -	UofI	
Labor Cost @ UofI (Student labor or Ac Hourly)	$18,820	$23,520	$31,560	UofI	Low: $12/hour, Med: $15/hour, High: $20/hour. If number of bins/dining hall =6 or less/day, 1 hour per day. Otherwise 2 hrs/day., 32 weeks.
Labor Cost @ UCSD (unload)	$4,320	$4,800	$5,280	UofI	$50/hr. 3 trips per week, 1 hour per trip. 32 weeks. Error = ±10%
Annual Operating Cost	**$59,380**	**$74,985**	**$103,540**	**UofI**	**Annual Operating Cost**
Total Annual Cost	**$65,405**	**$82,685**	**$113,340**	**UofI**	**Annual Operating Cost + Annual Capital Cost**

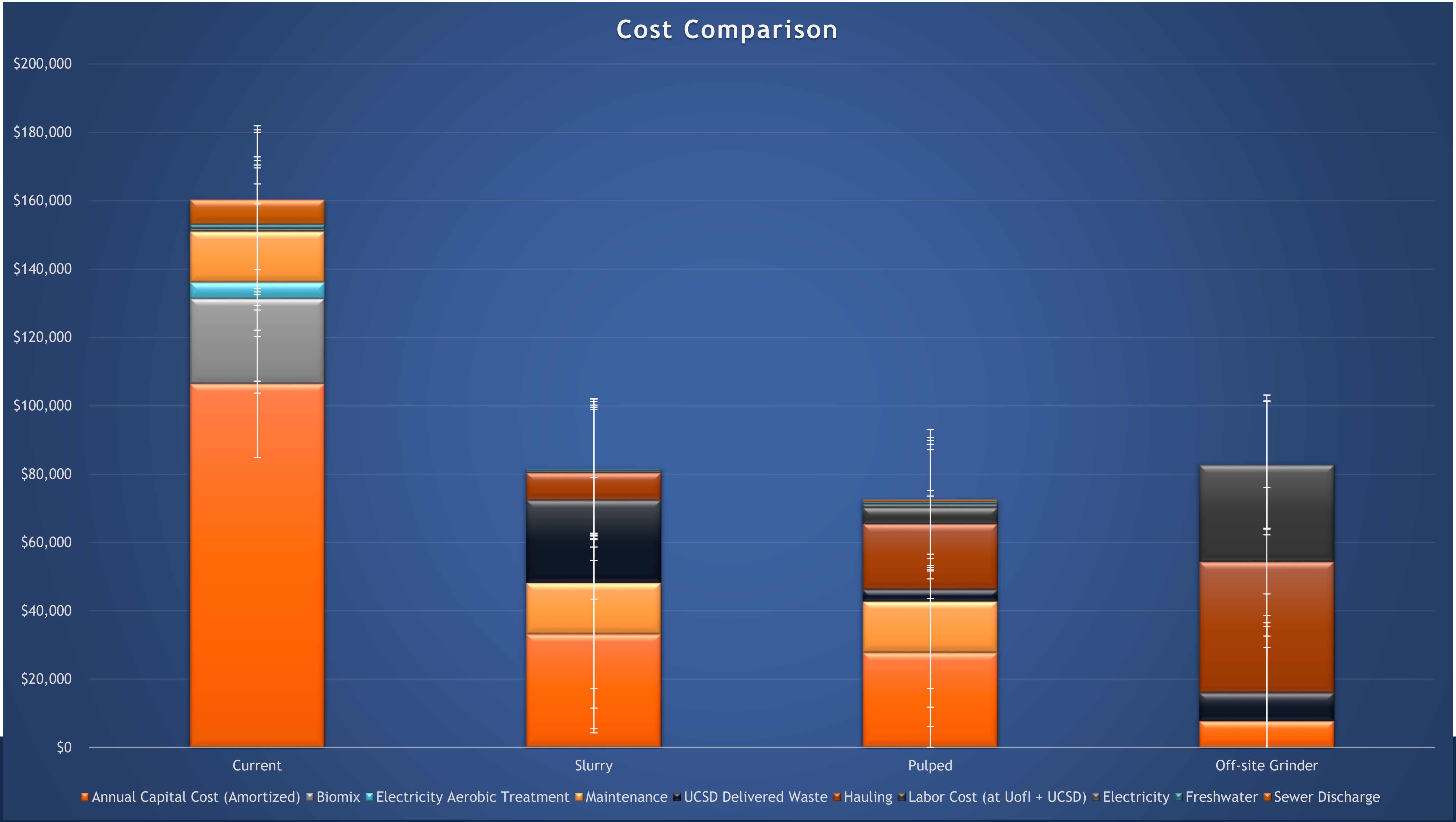
Potential added value from 6 Insinkerator Tri-Cycle Units

Option	Value	Low	Medium	High	Who Gets	Comments
1	**Electricity Generation**					**Option 1: Electricity generated from Biogas**
	Electricity Value	$4,100	$4,575	$5,000	UCSD	Based on information provided by UCSD. Error = ±10%
	RECs ($1.5/MWh)	$170	$185	$205	UCSD	Assuming $1.5/MWh electricity generated. Error = ±10%
	Heating Value	$780	$870	$950	UCSD	Based on information provided by UCSD. Error = ±10%
	Maintenance	$(2,500)	$(2,775)	$(3,050)	UCSD (pays)	Maintenance of electricity generators. Error = ±10%
	Net Annual Value	**$2,550**	**$2,855**	**$3,105**	**UCSD**	**Net Value**
2	**Pipeline-quality Renewable Natural Gas & Credit Sales**					**Option 2: Pipeline-quality NG & Renewable Credit Sales**
	RINs Value	$3,625	$9,665	$13,290	UCSD	Low: $0.75/RIN; Med: $2/RIN; High: $2.75/RIN
	LCFS Credit Value	$1,095	$2,190	$3,285	UCSD	Low: $50/MTCO2e; Med: $100/MT CO2e; High: $150/MT CO2e
	Total Credit Sales	**$4,720**	**$7,475**	**$10,445**	**UCSD**	
	RNG Sales	$1,110	$1,235	$1,360	UCSD	Natural Gas = $3/MMBTU. Error = ±10%
	RNG Upgradation	$(165)	$(180)	$(200)	UCSD (pays)	Cost: $1M (EcoEngineer report). Amort=3%, 10 years, Error = ±10%
	RNG O&M cost	$(3,725)	$(4,150)	$(4,560)	UCSD	Based on data from Alton (EcoEngineer) report. Error = ±10%
	RNG Marketing	$(945)	$(2,370)	$(3,315)	UCSD (pays)	20% of the Credit Sales. Error = ±10%
	Net Annual RNG and Credits value	**$995**	**$6,390**	**$9,860**	**UCSD**	

Cost-Value comparison for current and proposed systems (Medium Case)

COST (to UofI)				
	Current	Slurry	Pulped	Off-site Grinder
Capital Cost (Equipment, Collection bins and construction)	$1.27M	$395,670	$330,940	$91,960
Annual Capital Cost (Amortized)	$106,400	$33,150	$27,725	$7,700
Operating Cost				
Biomix	$25,000	$ -	$ -	$ -
Electricity Aerobic Treatment	$4,665	$ -	$ -	$ -
Maintenance	$15,000	$15,000	$15,000	$ -
UCSD Delivered Waste	$ -	$24,200	$3,475	$8,265
Hauling	$ -	$8,050	$19,200	$38,400
Labor Cost (at UofI + UCSD)	$ -	$ -	$4,800	$28,320
Electricity	$800	$600	$1,050	$ -
Freshwater	$1,200	$480	$725	$ -
Sewer Discharge	$7,200	$ -	$580	$ -
Annual Operating Cost	**$53,865**	**$48,330**	**$44,830**	**$74,985**
Total Annual Cost	**$160,265**	**$81,480**	**$72,555**	**$82,685**

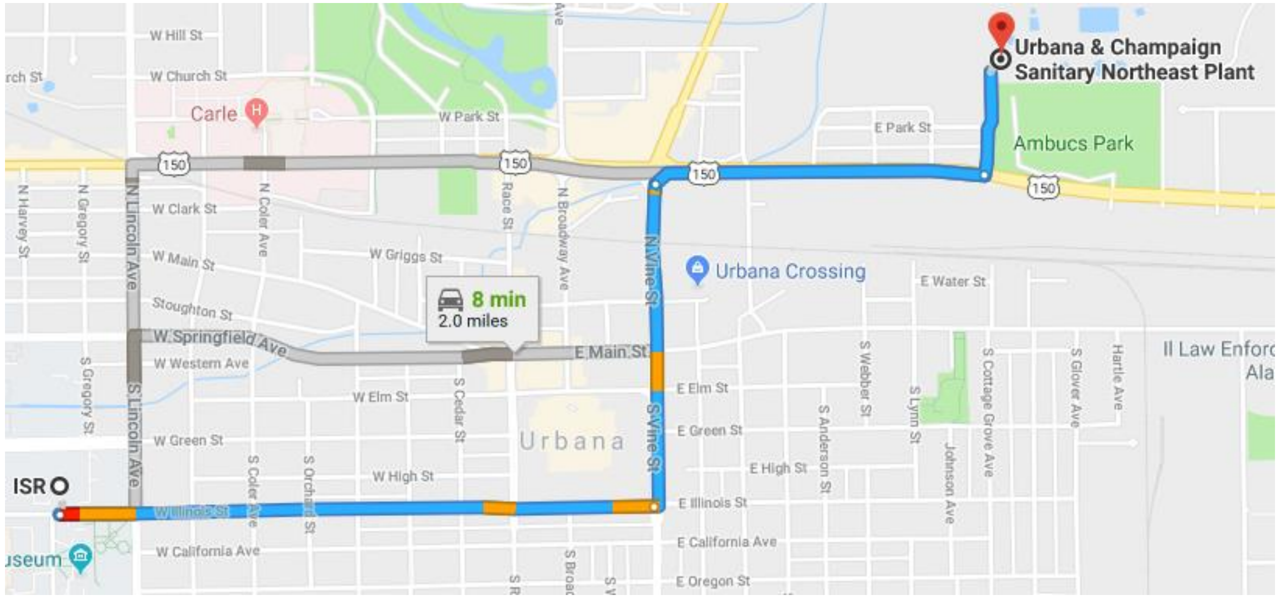
ADDITIONAL VALUE (to UCSD)			
Option	Value	Current	Proposed
1	**Electricity Generation**		
	Electricity Value	$ -	$4,575
	RECs ($1.5/MWh)	$ -	$185
	Heating Value		$870
	Maintenance	$ -	$(2,775)
	Net Annual Value	$ -	**$2,855**
2	**Pipeline-quality Renewable Natural Gas & Credit Sales**		
	RINs Value	$ -	$9,665
	LCFS Credit Value	$ -	$2,190
	Total Credit Sales	$ -	**$7,475**
	RNG Sales	$ -	$1,235
	RNG Upgradation	$ -	$(180)
	RNG O&M Cost	$ -	$(4,150)
	RNG Marketing	$ -	$(2,370)
	Net Annual RNG and Credits value	$ -	**$6,390**



Cost Comparison
$200,000
$180,000
$160,000
$140,000
$120,000
$100,000
$80,000
$60,000
$40,000
$20,000
$0
Current
Slurry
Pulped
Off-site Grinder
Annual Capital Cost (Amortized)
Biomix
Electricity Aerobic Treatment
Maintenance
UCSD Delivered Waste
Hauling
Labor Cost (at UofI + UCSD)
Electricity
Freshwater
Sewer Discharge

Possible Next Step…

- ISR Dining Hall as a Pilot for food waste processing
  - Currently, under construction
  - Possibly, solve the immediate sanitary issue
  - UCSD is willing to accept food waste



Conclusions and Recommendations

- When considering total costs (capital and operating), the proposed Grind2Energy systems are estimated to be ~$5,000/yr more expensive than the current Enviropure systems
  - If the optional IoT feature is added to the Grind2Energy, the relative increases to ~$14,000/yr
- The proposed Grind2Energy total cost is estimated to be ~$17,500 more than the current operating cost for the EnviroPure systems
  - Expected UCSD connection fees for Enviropure (not included in the recommendation) would likely make it more expensive than Grind2Energy under all scenarios
- Potential for extra renewable energy credits of $2,850-$6,500/yr for Grind2Energy systems
- Recommend using Insinkerator Grind2Energy for upcoming ISR project and/or one other location to evaluate experience prior to replacing all existing Enviropure Systems
  - Can likely negotiate with UCSD to delay connection fees until after evaluation of 1st Grind2Energy system
  - Relative cost advantage for Grind2Energy system is greater at the larger dining halls and new installations
  - May be possible to retrofit Enviropure systems to provide similar functions to the Grind2Energy systems
  - Need to check that space for storage tanks and tanker truck access at each dining hall location is adequate

Thank you!

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Supplementary Information

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Food waste to anaerobic digester

- Divert the food waste generated, at consumer level, on-campus from landfills and current food disposal system to existing anaerobic digesters at the Urbana-Champaign Sanitary District (UCSD)
- Who we intend to contact –
  - Dining Services – Thurman Etchison
  - Illini Union – Lori Holmes
  - Café Byte at ECE – Jane Norder
  - Bevier Café – Carter Phillips
  - Law Building Café – Lori Holmes
- Define current procedure for disposing food waste
- Investigate cost analysis for the Campus and UCSD – Current cost and current value

Universities using AD for food waste

Purdue University

University of Wisconsin, Oshkosh

Michigan State University,
East Lansing

Ohio State University, Wooster

University of California, Davis

Processing of food waste

- Current processing method: EnviroPure Aerobic Treatment
- Possible methods for the future:
  - Grinding and dewatering the food waste: Transporting the food waste in a concentrated form
    - Insinkerator Tri-Cycle Pulper Unit
    - Insinkerator Waste Xpress unit
    - Somat Pulpers
  - Grinding the food waste: Transporting the product in a slurry form
    - Insinkerator Grind2Energy
  - No pre-processing: Transporting the food waste in a solid form

Current 1: Cost analysis at ISR for Aerobic Treatment – Conn. Fee + High Sewer Charge

	Low	Medium	High	Who Pays	Comments
Capital Cost	$40,500	$45,000	$49,500	UofI	Avg Unit + Installation cost = $45,000. Data from Thurman. Error = ±10%
Connection Fee	$106,350	$132,930	$199,400		
Annualized Capital cost	$31,525	$33,750	$39,320	UofI	Annual capital cost. Amortized at 3% for 15 years.
Operating Cost					
Biomix	$3,000	$3,300	$3,600	UofI	Proportional amount of Biomix needed at ISR. Error = ±10%
Maintenance	$2,250	$2,500	$2,750	UofI	Data from Thurman. Error = ±10%
Electricity Aerobic Digestion	$310	$620	$1,250	UofI	Estimate based on average WWTP aerobic digestion. Low: -100% (highly optimized), Med: +0%, High: +100% (poorly optimized)
Electricity (pump and grinder)	$120	$135	$150	UofI	EnviroPure uses 0.32kwh/hr. 32 weeks, $0.0782/kwh. Error = ±10%
Freshwater	$145	$160	$175	UofI	60 lbs bucket takes 5 minutes of grinding. 5 gpm freshwater. Error = ±10%
Sewer	$860	$960	$1,050	UofI	60 lbs bucket takes 5 minutes of grinding. 5 gpm freshwater. Error = ±10%
Annual Operating Cost	$6,685	$7,675	$8,975	UofI	Annual Operating Cost
Total Annual Cost	**$38,210**	**$41,425**	**$48,295**	**UofI**	**Annual Operating Cost + Annual Capital Cost**

Note: No valuable co-product generated from Aerobic Digestion of food waste

Current 2: Cost analysis at ISR for Aerobic Treatment – No Conn. Fee + High Sewer Charge

	Low	Medium	High	Who Pays	Comments
Capital Cost	$40,500	$45,000	$49,500	UofI	Avg Unit + Installation cost = $45,000. Data from Thurman. Error = ±10%
Connection Fee	$ -	$ -	$ -		
Annualized Capital cost	$3,400	$3,770	$4,145	UofI	Annual capital cost. Amortized at 3% for 15 years.
Operating Cost					
Biomix	$3,000	$3,300	$3,600	UofI	Proportional amount of Biomix needed at ISR. Error = ±10%
Maintenance	$2,250	$2,500	$2,750	UofI	Data from Thurman. Error = ±10%
Electricity Aerobic Digestion	$310	$620	$1,250	UofI	Estimate based on average WWTP aerobic digestion. Low: -100% (highly optimized), Med: +0%, High: +100% (poorly optimized)
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Sewer	$860	$960	$1,050	UofI	60 lbs bucket takes 5 minutes of grinding. 5 gpm freshwater. Error = ±10%
Annual Operating Cost	$6,685	$7,675	$8,975	UofI	Annual Operating Cost
Total Annual Cost	**$10,085**	**$11,445**	**$13,120**	**UofI**	**Annual Operating Cost + Annual Capital Cost**

Note: No valuable co-product generated from Aerobic Digestion of food waste

Proposed: Cost Analysis at ISR for Pulper: Insinkerator Tri-Cycle Unit

	Low	Medium	High	Who Pays	Comments
Capital Cost (Equipment, Collection and construction)	$44,625	$52,870	$61,780	UofI	Unit cost $25k. Construction. Low: Installation = 0.5*Unit cost; Med: Installation = 0.75*Unit cost; High: Installation = Unit cost
Annualized Capital Cost	$3,740	$4,425	$5,175	UofI	Annual capital cost. Amortized at 3% for 15 years.
Operating Cost					
Hauling	$1,920	$2,560	$3,840	UofI	$50/hour for F&S drivers, half a day per week 3 trips per week, 32 weeks. Low: 3hrs, Med: 4 hrs, high: 6 hrs
UCSD Delivered Waste Fee	$415	$460	$510	UofI	$0.09/gal in liquid form is equivalent to $21.53/wet ton. 85% water removal. 32 weeks. Error = ±10%
Maintenance	$2,250	$2,500	$2,750	UofI	Assuming maintenance cost is same as EnviroPure. Data from Thurman. Error = ±10%
Labor Cost @ UCSD (unload)	$575	$640	$700	UofI	$50/hr. 3 trips per week, 1 hour per trip. 32 weeks. Error = ±10%
Electricity	$130	$175	$185	UofI	Data from Insinkerator Sales Rep. Low: 1.5 kWh, Med: 2.0 kWh, High: 2.1 kWh. Runs 5 hrs/day. 32 wks
Freshwater	$85	$95	$105	UofI	Based on number of meals served every week. 32 weeks. 3 gpm fresh water supply. Freshwater charge = $4.18/kgal. Error = ±10%
Sewer	$70	$75	$85	UofI	Based on number of meals served every week. 32 weeks. Sanitary charge = $3.35/kgal. Error = ±10%
Annual Operating Cost	**$5,445**	**$6,505**	**$8,175**	**UofI**	**Annual Operating Cost**
Total Annual Cost	**$9,185**	**$10,930**	**$13,350**	**UofI**	**Annual Operating Cost + Annual Capital Cost**

Proposed: Cost Analysis at ISR for Insinkerator Grind2Energy

	Low	Medium	High	Who Pays	Comments
Capital Cost (Equipment and Collection)	$59,950	$65,950	$71,940	UofI	Starting cost for one unit = $59,950. Includes installation. 6 units. Low= Total, Med= Total * 1.1 (10% more); High= Total * 1.2 (20% more)
Annualized Capital Cost	$5,000	$5,525	$6,025	UofI	Annual capital cost. Amortized at 3% for 15 years.
Operating Cost					
Hauling	$730	$1,100	$1,450	UofI	Based on hauling cost for tanker trucks currently used by UCSD. Assuming 3 gpm water inflow. Low: $20/kgal, Med: $30/kgal, High: $40/kgal
UCSD Delivered Waste	$1,450	$3,250	$4,000	UofI	Low (Kraft): $0.04/gal; Med (Current): $0.09/gal; High: $0.11/gal. 32 wks
Maintenance	$2,250	$2,500	$2,750	UofI	$59.88/hr. Low: 1 day/yr; Medium: 2 days/yr; High: 3 days/yr. Error: ±10%
Electricity	$90	$100	$110	UofI	Emerson Electric Company rep said <$100/year per equipment. Assuming error = ±10%
Freshwater	$32	$64	$96	UofI	Based on number of meals served every week. 32 weeks. Freshwater charge = $4.18/kgal. Error = ±10%
Sewer	$ -	$ -	$ -	UofI	Ground food waste is sent to the septic tank.
IoT fee	$1,548	$1,548	$1,548	UofI	Opt: Internet of Things (IoT) monthly charge $129. (Not Recommended)
Annual Operating Cost	**$4,552**	**$7,014**	**$8,406**	**UofI**	**Annual Operating Cost**
Total Annual Cost	**$9,552**	**$12,539**	**$14,431**	**UofI**	**Annual Operating Cost + Annual Capital Cost**

Proposed: Cost Analysis at ISR for Off-site Grinder

	Low	Medium	High	Who Pays	Comments
Capital Cost (Equipment, Collection and Construction)	$9,600	$12,260	$15,580	UofI	Construction cost at UCSD. 32 gallon blue recycling bins. Assuming $80 ea.
Annualized Capital Cost	$805	$1,025	$1,300	UofI	Annual capital cost. Amortized at 3% for 15 years.
Operating Cost					
Labor at UofI (Student labor or Ac Hourly)	$2,700	$3,360	$4,480	UofI	Low: $12/hour, Med: $15/hour, High: $20/hour. 2 hrs/day, 32 wks.
Hauling	$1,920	$2,560	$3,840	UofI	$50/hour for F&S drivers, half a day per week 3 trips per week, 32 weeks. Low: 3hrs, Med: 4 hrs, high: 6 hrs
UCSD Delivered Waste	$990	$1,100	$1,200	UofI	$0.09/gal in liquid form is equivalent to $21.53/wet ton. 85% water removal. 32 weeks. Error = ±10%
Labor Cost @ UCSD (unload)	$575	$640	$700	UofI	$50/hr. 3 trips per week, 1 hour per trip. 32 weeks. Error = ±10%
Maintenance	$ -	$ -	$ -	UofI	
Electricity	$ -	$ -	$ -	UofI	
Freshwater	$ -	$ -	$ -	UofI	
Sewer	$ -	$ -	$ -	UofI	
Annual Operating Cost	**$6,185**	**$7,660**	**$10,220**	**UofI**	**Annual Operating Cost**
Total Annual Cost	**$6,990**	**$8,685**	**$11,520**	**UofI**	**Annual Operating Cost + Annual Capital Cost**

Proposed: Pulper - InSinkErator Waste Xpress to grind & de-water food waste

Food waste is collected in buckets

Insinkerator: Addition of water, grind food waste, dewatering unit

Dewatered product collected in blue bin

Blue bin taken to the loading dock

Trucked to UCSD

Pros:

- Low capital cost
- 100 units of food waste in and 60 units of food waste out
- Reduced hauling cost
- Low operating cost

Cons:

- No water recycling
- High freshwater supply required
- Possible odor issue
- High labor cost
- Processed food waste in non-flowable form
- Currently, UCSD cannot accept waste in solid form to feed the Anaerobic Digester
- UCSD and UofI prefer slurry form

Proposed: Cost Analysis at ISR for Pulper: Insinkerator Waste Xpress

	Low	Medium	High	Who Pays	Comments
Capital Cost (Equipment, Collection and construction)	$35,770	$44,500	$53,900	UofI	Unit cost $15k. Construction. Low: Installation = 0.5*Unit cost; Med: Installation = 0.75*Unit cost; High: Installation = Unit cost
Annualized Capital Cost	$3,000	$3,725	$4,515	UofI	Annual capital cost. Amortized at 3% for 15 years.
Operating Cost					
Hauling	$1,920	$2,560	$3,840	UofI	$50/hour for F&S drivers, half a day per week 3 trips per week, 32 weeks. Low: 3hrs, Med: 4 hrs, high: 6 hrs
UCSD Delivered Waste Fee	$820	$910	$1,000	UofI	$0.09/gal in liquid form is equivalent to $21.53/wet ton. 85% water removal. 32 weeks. Error = ±10%
Maintenance	$2,250	$2,500	$2,750	UofI	Assuming maintenance cost is same as EnviroPure. Data from Thurman. Error = ±10%
Labor Cost @ UCSD (unload)	$575	$640	$700	UofI	$50/hr. 3 trips per week, 1 hour per trip. 32 weeks. Error = ±10%
Electricity	$90	$100	$110	UofI	Emerson Electric Company rep said <$100/year. Assuming error = ±10%
Freshwater	$215	$240	$265	UofI	Based on number of meals served every week. 32 weeks. 3 gpm fresh water supply. Freshwater charge = $4.18/kgal. Error = ±10%
Sewer	$175	$190	$210	UofI	Based on number of meals served every week. 32 weeks. Sanitary charge = $3.35/kgal. Error = ±10%
Annual Operating Cost	**$6,045**	**$7,140**	**$8,875**	**UofI**	**Annual Operating Cost**
Total Annual Cost	**$9,045**	**$10,865**	**$13,390**	**UofI**	**Annual Operating Cost + Annual Capital Cost**

Proposed: Pulper to grind and dewater the food waste – Somat Pulper

Food waste is collected in buckets

Somat Pulper: Addition of water, Grind food waste, Dewatering unit

Solid dewatered product out directly to the dumpster

Trucked to UCSD

To the Anaerobic Digester at UCSD

Pros

- 100 units of food waste in and 28 units of food waste out
- Water recycled, and less freshwater required
- Reduced hauling cost
- Very low operating cost

Cons

- Very high capital cost
- Labor cost
- Processed food waste in non-flowable form
- Currently, UCSD cannot accept waste in solid form to feed the Anaerobic Digester
- UCSD and UofI prefer slurry form
- Possible odor issues

Proposed: Cost Analysis at ISR for Pulper: Somat Pulper

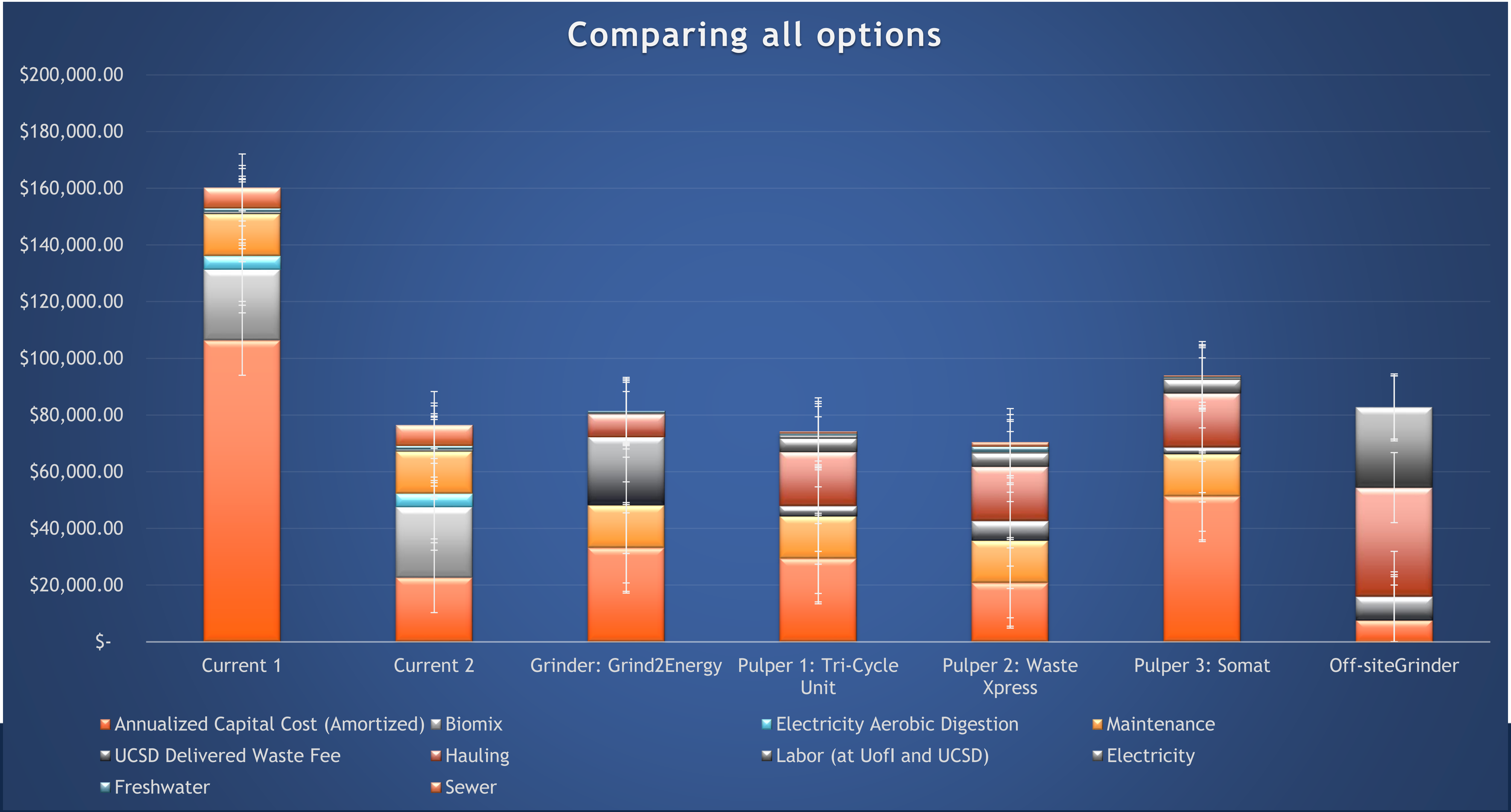
	Low	Medium	High	Who Pays	Comments
Capital Cost (Equipment, Collection and construction)	$82,045	$96,540	$111,700	UofI	Unit cost $50k. Low: Installation = 0.5*Unit cost; Med: Installation = 0.75*Unit cost; High: Installation = Unit cost
Annualized Capital Cost	$6,875	$8,090	$9,360	UofI	Annual capital cost. Amortized at 3% for 15 years.
Operating Cost					
Hauling	$1,920	$2,560	$3,840	UofI	$50/hour for F&S drivers, half a day per week 3 trips per week, 32 weeks. Low: 3hrs, Med: 4 hrs, high: 6 hrs
UCSD Delivered Waste Fee	$275	$300	$335	UofI	$0.09/gal in liquid form is equivalent to $21.53/wet ton. 85% water removal. 32 weeks. Error = ±10%
Maintenance	$2,250	$2,500	$2,750	UofI	Assuming maintenance cost is same as EnviroPure. Data from Thurman. Error = ±10%
Labor Cost @ UCSD (unload)	$575	$640	$700	UofI	$50/hr. 3 trips per week, 1 hour per trip. 32 weeks. Error = ±10%
Electricity	$90	$100	$110	UofI	Assuming same electricity usage as Insinkerator Waste Xpress. Assuming error = ±10%
Freshwater	$60	$65	$70	UofI	Based on number of meals served every week. 32 weeks. 2 gpm fresh water supply. Freshwater charge = $4.18/kgal. Error = ±10%
Sewer	$45	$50	$55	UofI	Based on number of meals served every week. 32 weeks. Sanitary charge = $3.35/kgal. Error = ±10%
Annual Operating Cost	**$5,215**	**$6,215**	**$7,860**	**UofI**	**Annual Operating Cost**
Total Annual Cost	**$12,090**	**$14,305**	**$17,220**	**UofI**	**Annual Operating Cost + Annual Capital Cost**

Proposed: Value Analysis for sending food waste from ISR to the Anaerobic Digesters at UCSD

Option	Value	Low	Medium	High	Who Gets	Comments
1	Electricity Value	$575	$640	$705	UCSD	Based on information provided by UCSD. Error = ±10%
	RECs ($1.5/MWh)	$23	$26	$28	UCSD	Assuming $1.5/MWh electricity generated. Error = ±10%
	Heating Value	$110	$120	$135	UCSD	Based on information provided by UCSD. Error = ±10%
	Maintenance	$(350)	$(390)	$(430)	UCSD (pays)	Maintenance of electricity generators. Error = ±10%
	Net Value	**$358**	**$396**	**$438**	**UCSD**	**Net Value**
2	**Credit Sales**					
	RINs Value	$400	$810	$1,100	UCSD	Low: $1/RIN; Med: $2/RIN; High: $2.75/RIN
	LCFS Credit Value	$90	$185	$275	UCSD	Low: $50/MTCO2e; Med: $100/MT CO2e; High: $150/MT CO2e
	Total Credit Sales	**$580**	**$1,095**	**$1,485**	**UCSD**	
	RNG Sales	$90	$100	$110	UCSD	Natural Gas = $3/MMBTU. Error = ±10%
	RNG Upgradation Proportion	$(14)	$(15)	$(17)	UCSD (pays)	Cost: $1M (EcoEngineer report). Amort=3%, 10 years, Error = ±10%
	RNG Marketing	$(100)	$(200)	$(280)	UCSD (pays)	20% of the Credit Sales. Error = ±10%
	Net RNG and Credits value	**$466**	**$880**	**$1,188**	**UCSD**	

Cost comparison for current and all considered food waste processing systems

	Current 1	Current 2	Grinder: Grind2Energy	Pulper 1: Tri-Cycle Unit	Pulper 2: Waste Xpress	Pulper 3: Somat	Off site Grinder
Cap Cost (Equipment, Bins & Construction)	$1.27M	$270,000	$395,670	$330,940	**$225,300**	**$592,900**	$91,960
Annualized Capital Cost (Amortized)	$106,400	$22,615	$33,150	$27,725	$18,875	$49,665	$7,700
Operating Cost							
Biomix	$25,000	$25,000	$ -	$ -	$ -	$ -	$ -
Electricity Aerobic Digestion	$4,665	$4,665	$ -	$ -	$ -	$ -	$ -
Maintenance	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$ -
UCSD Delivered Waste Fee	$ -	$ -	$24,200	$19,200	$6,820	$2,275	$8,265
Hauling	$ -	$ -	$8,050	$3,475	$19,200	$19,200	$38,400
Labor (at UofI and UCSD)	$ -	$ -	$ -	$4,800	$4,800	$4,800	$28,320
Electricity	$800	$800	$600	$1,050	$600	$600	$ -
Freshwater	$1,200	$1,200	$480	$725	$1,800	$480	$ -
Sewer	$7,200	$7,200	$ -	$580	$1,450	$385	$ -
IoT fee (Not Recommended)	$ -	$ -	$9,300	$ -	**$ -**	**$ -**	$ -
Annual Operating Cost	**$53,865**	**$53,865**	**$48,330**	**$44,830**	$49,670	$42,740	**$74,985**
Total Annual Cost	**$160,265**	**$76,465**	**$81,480**	**$72,555**	**$68,545**	$92,405	**$82,685**


Comparing all options
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Current 1
Current 2
Grinder: Grind2Energy
Pulper 1: Tri-Cycle Unit
Pulper 2: Waste Xpress
Pulper 3: Somat
Off-siteGrinder
Annualized Capital Cost (Amortized)
Biomix
Electricity Aerobic Digestion
Maintenance
UCSD Delivered Waste Fee
Hauling
Labor (at UofI and UCSD)
Electricity
Freshwater
Sewer

Future plan

- Gradually increase the food waste from more dining halls and other university-owned/operated cafeteria and restaurants
- A food waste collection system for all buildings across the campus
- Include a collection point at the new dairy barn (to be constructed in a few years)
- Collection point for manure at the Beef and Sheep Field Research Laboratory
- Have a method to dewater the manure
  - no pipeline from the new dairy barn or the Beef and Sheep laboratory
  - the water content in manure is very high
- Aligned with the Climate Leadership Commitment, the University of Illinois would like to support UCSD in their continued efforts to provide waste-to-energy service throughout the community

Benefits of using AD at UCSD

- UCSD willing to accept food waste
- Existing infrastructure and man-power
- UCSD will be responsible for operation and maintenance
- Digesters are, currently, running at low capacity, especially during the summer break
- UCSD has been supporting university research
- Constructing an anaerobic digester on-campus could take many years and millions of dollars in construction, operation, and maintenance cost

How will it benefit UofI?

- We will be able to reduce our Carbon Footprint
- The University has made a commitment to be carbon neutral no later than 2050
- By utilizing the energy stored in the Food Waste and Manure for power generation, we will have the option to
  - be able to use it as renewable energy/low-carbon/clean energy (Objective 3.3 of the 2015 iCAP), or
  - Contribute to renewable power generation (if we can't claim the RECs or RINs)
- Potential to be converted to Compressed Natural Gas (CNG) in the future
- Show leadership among the peer universities