Technical Education and Analysis for Community Hauling and Anaerobic Digesters (TEACH AD)

TEACH AD Webinar Series - May 31, 2022
Universities go green! A case study from the Michigan State University South Campus Anaerobic Digester
The goal of this program is to help communities and water resource recovery facilities in the Midwest region divert food waste from landfills by providing education and no-cost technical assistance to explore the increased adoption of anaerobic digestion and renewable energy biogas technologies.

- Educational Assistance
- Technical Assistance

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Webinar Speakers

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Associate Professor
Michigan State University
Thanks to our sponsor!
Q&A
Submit your questions to the host using the Q&A box in the upper right-hand corner.

Presentations
A recording of today’s webinar will be posted on the TEACH AD webpage and you will be emailed a link by early next week.

Survey
After the presentation you will receive a brief survey. We appreciate your feedback.

Technical Issues
Contact Sam Rinaldi at: samr@uic.edu or 312-996-2554 for assistance.
Importance of diverting food waste from landfills

• Municipal solid waste (MSW) landfills are the third-largest source of human-related methane emissions in the United States
• By reducing the amount of food waste landfilled, we reduce methane emissions
Importance of diverting food waste from landfills

- One-third of all food produced for human consumption worldwide is lost or wasted
- Source Reduction
- Feed People, Not Landfills
- Industrial Uses
  - Anaerobic digestion
Overview of anaerobic digesters

- Anaerobic digestion is the natural process in which microorganisms break down organic materials in the absence of oxygen.
- Two valuable outputs
  - Biogas
  - Digestate

Sources: U.S. Environmental Protection Agency
### Environmental Impacts of U.S. Food Waste:
What resources go into a year of food loss and waste in the U.S.?

*excluding impacts of waste management, such as landfill methane emissions*

<table>
<thead>
<tr>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greenhouse gas emissions of more than 42 coal-fired power plants</td>
<td>Enough water and energy to supply more than 50 million homes</td>
</tr>
<tr>
<td>The amount of fertilizer used in the U.S. to grow all plant-based foods for U.S. human consumption</td>
<td>An area of agricultural land equal to California and New York</td>
</tr>
</tbody>
</table>

Learn more: [www.epa.gov/land-research/farm-kitchen-environmental-impacts-us-food-waste](https://www.epa.gov/land-research/farm-kitchen-environmental-impacts-us-food-waste)
Michigan State University South Campus
Anaerobic Digester

9 years of life lessons

Dana Kirk, Ph.D., P.E., Louis Faivor, & Fahmi Dwilaksono
Michigan State University
Biosystems and Agricultural Engineering Department
Anaerobic Digestion Research and Education Center
• Size: 5,200 acres

• Student body
  • 51,000 strong
  • All 50 states
  • 138 countries
  • 15% international

• Housing:
  • 28 residence halls
  • 2 apartment complexes
  • 14,000 residences
History of Campus Sustainability

- Recycling (1988)
  - Construction of Recycling Center & Surplus Store (2009)
- Sustainability Plan (2011)
  - Significant recycling efforts, lacked options for organics
  - Campus food waste is approximately 1.80 lb/person/day (3x US average)
- Energy Transition Plan (2012)
  - South Campus Anaerobic Digester first project (2012)
  - 2015 renewable energy target of 15%
  - 2015 30% reduction in GHG emissions
  - 2015 end of the “coal era”
  - 2016 20 MW solar array planned
  - 2021 27MW natural gas power plant
South Campus Anaerobic Digester (SCAD)
• Digester tank
  • 52’ * 26’ plus cover (380,000 gallons)

• Digestate storage tank
  • 101’ * 42’ plus cover (2.1 million gallons)

• CHP system
  • 380 kW electrical production & 400+ kW of thermal energy recovery
  • Electricity supplied to Campus
  • Thermal energy used to sustain the process, heat support building and separator area

• Digestate
  • Separated solids to compost
  • Separated liquid to storage and land application
Anaerobic digester & digestate storage

Biogas storage

Anaerobic digester (380,000 gal, mixed)

Digestate storage (2.1 Mgal)
South Campus Anaerobic Digester Site
Key Sources of Organic Waste on Campus

• University Farms (manure)
  • Dairy, Swine, Beef, Sheep, Poultry, Equine
  • Pavilion

• Campus Living (food waste)
  • Culinary Services serves over 35,000 daily, 150,000+ weekly
  • 9 dining halls have all access from 7AM to 12AM
  • 24 coffee shops/convenience stores/retail foods
  • Hotel & conference centers (2x)

• Grease interceptors (FOG)

• Food processors & manufacturers
## SCAD Manure Feedstocks

<table>
<thead>
<tr>
<th>Year</th>
<th>Dairy G.</th>
<th>Parlor*</th>
<th>Beef</th>
<th>Waste Feed</th>
<th>Poultry</th>
<th>Swine</th>
<th>ANS Other</th>
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</thead>
<tbody>
<tr>
<td>2014</td>
<td>11,463</td>
<td>25,466</td>
<td>6,354</td>
<td>4,069</td>
<td></td>
<td>12,645</td>
<td>179</td>
</tr>
<tr>
<td>2015</td>
<td>12,647</td>
<td>27,034</td>
<td>4,784</td>
<td>1,069</td>
<td></td>
<td>4,537</td>
<td>741</td>
</tr>
<tr>
<td>2016</td>
<td>13,844</td>
<td>21,659</td>
<td>3,914</td>
<td>3,426</td>
<td>568</td>
<td></td>
<td>441</td>
</tr>
<tr>
<td>2017</td>
<td>13,307</td>
<td>20,612</td>
<td>2,394</td>
<td>1,451</td>
<td>1,071</td>
<td>25,682</td>
<td>919</td>
</tr>
<tr>
<td>2018</td>
<td>13,207</td>
<td>23,907</td>
<td>2,878</td>
<td></td>
<td></td>
<td>17,275</td>
<td>688</td>
</tr>
<tr>
<td>2019</td>
<td>13,287</td>
<td>21,993</td>
<td>3,432</td>
<td>1,847</td>
<td>1,935</td>
<td></td>
<td>1,562</td>
</tr>
<tr>
<td>2020</td>
<td>12,678</td>
<td>21,269</td>
<td>3,053</td>
<td>3,159</td>
<td>1,950</td>
<td></td>
<td>3,022</td>
</tr>
<tr>
<td>Average</td>
<td>12,919</td>
<td>23,134</td>
<td>3,830</td>
<td>2,503</td>
<td>1,381</td>
<td>15,035</td>
<td>1,079</td>
</tr>
<tr>
<td>St. Dev</td>
<td>705</td>
<td>2,222</td>
<td>1,255</td>
<td>1,105</td>
<td>589</td>
<td>7,653</td>
<td>888</td>
</tr>
</tbody>
</table>
Pre Consumer Food Waste

Post Consumer Food Waste

Fruit & Vegetable Waste

FOG
Feedstock received in the SCAD food pit

- Filtrate
- SLS Solids
- P.A.
- Pulp
- FOG
- W. Feed
- Other
- Cart Food

Quantity (metric ton/year)

Year

### SCAD Food Waste Feedstocks

<table>
<thead>
<tr>
<th>Year</th>
<th>P.A.</th>
<th>Pulp</th>
<th>FOG</th>
<th>Waste Feed</th>
<th>Other</th>
<th>Cart Food</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>11,547</td>
<td>1,112</td>
<td>18,952</td>
<td>2,017</td>
<td>10,870</td>
<td>2,151</td>
</tr>
<tr>
<td>2015</td>
<td>11,093</td>
<td>1,272</td>
<td>35,270</td>
<td>2,146</td>
<td>2,849</td>
<td>1,845</td>
</tr>
<tr>
<td>2016</td>
<td>11,345</td>
<td>1,317</td>
<td>35,052</td>
<td>1,341</td>
<td>2,417</td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>2,013</td>
<td>32,703</td>
<td></td>
<td>1,067</td>
<td></td>
<td>121</td>
</tr>
<tr>
<td>2018</td>
<td>1,656</td>
<td>31,780</td>
<td>1,620</td>
<td>1,498</td>
<td></td>
<td>117</td>
</tr>
<tr>
<td>2019</td>
<td>2,088</td>
<td>34,277</td>
<td></td>
<td>2,857</td>
<td></td>
<td>92</td>
</tr>
<tr>
<td>2020</td>
<td>1,630</td>
<td>40,428</td>
<td></td>
<td>13,222</td>
<td></td>
<td>67</td>
</tr>
<tr>
<td>Average</td>
<td>11,328</td>
<td>1,584</td>
<td>32,637</td>
<td>1,928</td>
<td>4,815</td>
<td>973</td>
</tr>
<tr>
<td>St. Dev</td>
<td>186</td>
<td>346</td>
<td>6,143</td>
<td>224</td>
<td>4,663</td>
<td>1,020</td>
</tr>
</tbody>
</table>


“Other” Food Waste

- Beverage processing waste
- Packaging material
- Slaughterhouse material
- Tortilla’s
- Greenhouse byproducts
- Research byproducts
- Depackaging slurry
Food (Organic) Waste Planning

- **Challenges**
  - Packaging & contamination
  - Debris
  - Seasonality
  - Cleaning agents
  - Consistency
  - Unloading
  - Water content

- **Pretreatment**
  - Depacking
  - Grinding/maceration
  - Sterilization
  - Other
<table>
<thead>
<tr>
<th>Year</th>
<th>Manure Pit (Metric ton/year)</th>
<th>Food Pit (Metric ton/year)</th>
<th>Total (Metric ton/year)</th>
<th>Food Pit (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>14,763</td>
<td>8,533</td>
<td>23,297</td>
<td>37%</td>
</tr>
<tr>
<td>2015</td>
<td>13,805</td>
<td>12,800</td>
<td>26,605</td>
<td>48%</td>
</tr>
<tr>
<td>2016</td>
<td>11,059</td>
<td>11,726</td>
<td>22,785</td>
<td>51%</td>
</tr>
<tr>
<td>2017</td>
<td>11,109</td>
<td>9,129</td>
<td>20,238</td>
<td>45%</td>
</tr>
<tr>
<td>2018</td>
<td>10,859</td>
<td>8,605</td>
<td>19,464</td>
<td>44%</td>
</tr>
<tr>
<td>2019</td>
<td>11,353</td>
<td>10,539</td>
<td>21,893</td>
<td>48%</td>
</tr>
<tr>
<td>2020</td>
<td>10,332</td>
<td>14,531</td>
<td>24,863</td>
<td>58%</td>
</tr>
<tr>
<td>Average</td>
<td>11,897</td>
<td>10,838</td>
<td>22,735</td>
<td>47%</td>
</tr>
<tr>
<td>St. Dev</td>
<td>1,683</td>
<td>2,294</td>
<td>2,499</td>
<td>7%</td>
</tr>
</tbody>
</table>
Daily OLR

OLR (g VS/L-d)

2018, 2019, 2020
### Sample of Feedstock Characterization

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>TS (mg/L)</th>
<th>VS (mg/L)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parlor Manure</td>
<td>63,844</td>
<td>52,742</td>
<td>7.01</td>
</tr>
<tr>
<td>Beef</td>
<td>462,152</td>
<td>393,620</td>
<td>8.64</td>
</tr>
<tr>
<td>Dairy Gutter</td>
<td>162,268</td>
<td>142,940</td>
<td>8.23</td>
</tr>
<tr>
<td>FOG</td>
<td>120,191</td>
<td>105,384</td>
<td>5.50</td>
</tr>
<tr>
<td>Food Other</td>
<td>219,447</td>
<td>193,795</td>
<td>5.41</td>
</tr>
<tr>
<td>Pineapple</td>
<td>127,389</td>
<td>114,749</td>
<td>3.91</td>
</tr>
<tr>
<td>Pulp</td>
<td>275,459</td>
<td>262,105</td>
<td>4.36</td>
</tr>
</tbody>
</table>
MAN 2842 CHP
(380 kW electricity & 430 kW thermal)
• Electrical energy – 2,400 MW/yr
  • 10-20% of energy produce needed to operate system
• Thermal energy – +3,000 MW/yr
  • <50% of the thermal energy needed to maintain temperature
• Greenhouse gas reduction (carbon credits)
• Landfill & wastewater diversion (>10,000 ton/yr)
• Recycling of carbon and nutrients
## Annual Biogas & Energy Production

<table>
<thead>
<tr>
<th>Year</th>
<th>HRT (days)</th>
<th>Temp (°F)</th>
<th>pH</th>
<th>CH4 (%)</th>
<th>H2S (PPM)</th>
<th>CHP Daily total (SCF/d)</th>
<th>Daily Electrical Power Generated (kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>27</td>
<td>103</td>
<td>7.9</td>
<td>63%</td>
<td>360</td>
<td>82,303</td>
<td>4,880</td>
</tr>
<tr>
<td>2015</td>
<td>21</td>
<td>103</td>
<td>7.4</td>
<td>61%</td>
<td>433</td>
<td>106,810</td>
<td>6,431</td>
</tr>
<tr>
<td>2016</td>
<td>23</td>
<td>102</td>
<td>7.5</td>
<td>62%</td>
<td>667</td>
<td>136,744</td>
<td>7,407</td>
</tr>
<tr>
<td>2017</td>
<td>26</td>
<td>102</td>
<td>7.7</td>
<td>65%</td>
<td>421</td>
<td>103,138</td>
<td>6,994</td>
</tr>
<tr>
<td>2018</td>
<td>27</td>
<td>103</td>
<td>8.1</td>
<td>66%</td>
<td>387</td>
<td>125,635</td>
<td>7,342</td>
</tr>
<tr>
<td>2019</td>
<td>26</td>
<td>103</td>
<td>8.0</td>
<td>64%</td>
<td>520</td>
<td>121,743</td>
<td>6,632</td>
</tr>
<tr>
<td>2020</td>
<td>22</td>
<td>98</td>
<td>7.1</td>
<td>66%</td>
<td>652</td>
<td>131,387</td>
<td>7,518</td>
</tr>
<tr>
<td>Average</td>
<td>25</td>
<td>102</td>
<td>7.7</td>
<td>64%</td>
<td>491</td>
<td>115,394</td>
<td>6,743</td>
</tr>
<tr>
<td>St. Dev</td>
<td>2</td>
<td>2</td>
<td>0.3</td>
<td>2%</td>
<td>116</td>
<td>17,630</td>
<td>849</td>
</tr>
</tbody>
</table>
7 Days Average in 2020: Biogas vs OLR

Biogas (m³/kg VS)

OLR (kg VS/1,000 mm³ - d)

OLR / Biogas / 7 day AVG of VS unit

January
February
March
April
May
June
July
August
September
October
November
December

OLR (kg VS/1,000 mm³ - d)

0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

Biogas (m³/kg VS)

0.00
1.00
2.00
3.00
4.00
5.00
6.00
Takeaways from Our Experience

- Plan for feedstock change
  - Seasonality
  - Market driven
  - Competition
- “Clean” feedstock
- Budget for sufficient labor
Questions

Dana Kirk
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517.432.6530
TEACH AD – Educational Assistance

• In person workshops (2)
  • Onsite events
  • Tour of the site
  • April 2022: Kishwaukee Water Reclamation District for
    • Visit [erc.uic.edu/bioenergy/teachad/in-person-workshops/](https://erc.uic.edu/bioenergy/teachad/in-person-workshops/)

• Webinars (10)
  • Will cover different aspects of an anaerobic digestion project
  • Join us again in July for our 6th Webinar
  • Visit [erc.uic.edu/bioenergy/teachad/teach-ad-webinars/](https://erc.uic.edu/bioenergy/teachad/teach-ad-webinars/)

• Project profiles (8)
  • Will highlight successful AD projects
  • First two project profiles covering UW Oshkosh and Urbana Champaign Sanitary District
  • Visit [https://erc.uic.edu/bioenergy/teachad/project-profiles/](https://erc.uic.edu/bioenergy/teachad/project-profiles/)
TEACH AD – Technical Assistance

- Anaerobic Digestion Technical Assessments
  - Tailored technical assistance to each client
  - Initial economic and physical feasibility assessment for (co)digestion of organic wastes
  - Assess opportunity for using U.S. EPA’s Co-Digestion Economic Analysis Tool (CoEAT)
  - Report presentation and follow up with next steps

Visit [erc.uic.edu/bioenergy/teachad/technical-assessments/](http://erc.uic.edu/bioenergy/teachad/technical-assessments/)
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Questions & Answers

Marcello Pibiri  
Senior Research Engineer  
UIC Energy Resources Center

Dana M. Kirk, Ph.D., P.E.  
Associate Professor  
Michigan State University
TEACH AD Webinar Series

Join us again in July for our 6th Webinar!
Thank You

Please fill out our survey.

A recording of today’s webinar will be posted, and you will be emailed a link by early next week.
Thank You