Waste Not: Closing the Loop on Organics Wastes

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The Problem with Food Waste

- At the retail and consumer levels, food waste amounts to 1,250 calories per person daily, 61% of what we actually eat!

- The value of wasted food in the U.S. is $160 billion per year – about $500 per person.

- Food waste comprises 21% of total municipal landfill waste.
Environmental impacts of U.S. food waste

31% of cropland

25% of water consumption

21% of landfill volume

2% of energy consumption

Current: Flow-Through Organic Waste System

- Food Waste
- Sewage
- Ash
- Fertilizer
- Animal food

The Future: Closed Loop System

- Food-to-feed
- Food Waste
- Sewage
- Residue
- Ash
- Food-to-feed

The diagram illustrates a closed loop system where food waste, sewage, and other residues are processed and transformed into feed, indicating a circular economy approach.
How could we re-engineer the flow of wastes to move from an flow-through system to a closed loop system?

• Technology
• Economics
• Social and political system
What is the highest and best use of food waste?
Lunds/Byerleys Grocery store

University of Minnesota dining hall waste

Household source-separated organics

Mixed organics waste, transfer station

Some of our favorite organic wastes!
Which food wastes could become feedstocks for animal feed?
Caloric content of two conventional feedstocks and four sources of urban organic wastes.

SSO = source separated organics, from Minneapolis, 83% food waste.

On a caloric basis, urban organic wastes compare well with corn and soybean meal!
Nutrients in three organic wastes, corn and soybean meal.

<table>
<thead>
<tr>
<th>Data are based on dry weight</th>
<th>Super-market</th>
<th>Dining Hall</th>
<th>Transfer Station</th>
<th>Corn</th>
<th>Soybean Meal</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. samples</td>
<td>22</td>
<td>60</td>
<td>27</td>
<td>115</td>
<td>101</td>
</tr>
<tr>
<td>Metabolizable energy, kcal/kg</td>
<td>4,843</td>
<td>4,300</td>
<td>3,301</td>
<td>3,395</td>
<td>3,294</td>
</tr>
<tr>
<td>Crude protein, %</td>
<td>24</td>
<td>16</td>
<td>16</td>
<td>8.2</td>
<td>47.7</td>
</tr>
<tr>
<td>Ether extract, %</td>
<td>34</td>
<td>12</td>
<td>9.7</td>
<td>3.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Neutral detergent fiber, %</td>
<td>16</td>
<td>8</td>
<td>26</td>
<td>9.1</td>
<td>8.2</td>
</tr>
<tr>
<td>Phosphorus, %</td>
<td>0.61</td>
<td>0.26</td>
<td>0.42</td>
<td>0.26</td>
<td>0.71</td>
</tr>
<tr>
<td>Shadow pricing, $/ton</td>
<td>300</td>
<td>240</td>
<td>300</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Shadow pricing of urban organic wastes is $240-300/ton.
Production of biofuels
Fast Microwave Assisted Pyrolysis and Gasification (fMAP and fMAG)

Organic substrate →
gas + liquid fuel + char

Vary heating, distillation

to control product
Examples of products produced by fMAP and fMAG from various organic wastes in the batch studies.

<table>
<thead>
<tr>
<th></th>
<th>Product</th>
<th>U of M Dining Hall</th>
<th>Household SSO</th>
<th>Grocery Store</th>
<th>Transfer station</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>fMAP, % of waste mass</strong></td>
<td>Bio-oil</td>
<td>22.4</td>
<td>23.4</td>
<td>29.6</td>
<td>17.5</td>
</tr>
<tr>
<td></td>
<td>Bio-char</td>
<td>35.8</td>
<td>35.32</td>
<td>43.8</td>
<td>54.8</td>
</tr>
<tr>
<td></td>
<td>Gas</td>
<td>42</td>
<td>41</td>
<td>27</td>
<td>28</td>
</tr>
<tr>
<td><strong>fMAG, % of waste mass</strong></td>
<td>Total gas</td>
<td>61</td>
<td>56</td>
<td>69</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td>H₂</td>
<td>35</td>
<td>27</td>
<td>27</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>CO</td>
<td>17</td>
<td>13</td>
<td>13</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>CH₄</td>
<td>9.7</td>
<td>35</td>
<td>3.5</td>
<td>9.8</td>
</tr>
<tr>
<td></td>
<td>CO</td>
<td>15</td>
<td>25</td>
<td>25</td>
<td>19</td>
</tr>
</tbody>
</table>
Wastes that produce high yields in batch studies move to pilot studies (above) and eventually to full-scale operations. The design at left is for producing biofuels from sewage plant scum.
Industry benchmark study for food wastes (Cascadia 2006).

Most food waste at restaurants, stores, and hotels is disposed.
We can now map the distribution of food waste calories from grocery stores and restaurants in relation to potential demand centers.
Evaluation of Collection of Source-Separated Organics In Minneapolis

1. Household survey of Minneapolis SSO participants (350) and non-participants (350). Survey posted at wastenot.umn.edu

2. Policy actor interviews

3. (n = 20)
Household Survey: Results

*Biggest concerns are practical*

### Moderate Concern

- Time
- Smell
- Space
- Unsightly
- Family non-object
- Cleanliness
- Knowledge
- Pests indoors
- Pests outdoors
- Cost
- Little waste
- Work
- Already compost
- Disposal
- No benefit
Waste Management Innovation

Attitudes: Biggest Differences are Specific to Organics Recycling

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Participants</th>
<th>Nonparticipants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost efficient</td>
<td>Green</td>
<td>Red</td>
</tr>
<tr>
<td>Good to do</td>
<td>Green</td>
<td>Red</td>
</tr>
<tr>
<td>Easy to do</td>
<td>Green</td>
<td>Red</td>
</tr>
<tr>
<td>Many barriers</td>
<td>Green</td>
<td>Red</td>
</tr>
<tr>
<td>Know what to do</td>
<td>Green</td>
<td>Red</td>
</tr>
<tr>
<td>Satisfied with city</td>
<td>Green</td>
<td>Red</td>
</tr>
<tr>
<td>Role of government</td>
<td>Green</td>
<td>Red</td>
</tr>
</tbody>
</table>

Strongly Disagree

| Cost efficient                                                               | Green       | Red             |
| Good to do                                                                   | Green       | Red             |
| Easy to do                                                                   | Green       | Red             |
| Many barriers                                                                | Green       | Red             |
| Know what to do                                                              | Green       | Red             |
| Satisfied with city                                                          | Green       | Red             |
| Role of government                                                           | Green       | Red             |
Other differences between participants and non-participants:

**Willingness to Pay**
- Participants willing to pay $2
- Non-participants willing to pay $1.75

**Age**
- Participants are largely middle aged (31-65) with children
- Non-participants older (65+), more even distribution
Similarities between participants and non-participants:

Motivators

Both groups would recycle more given:

- Free indoor bins
- Lower waste collection bill

Information sources

Both groups look to:

- City website
- Mailers
Key findings from policy actor interviews (n = 20)

• Governance innovation and policy reform is necessary to “close the loop” on organic wastes

• Public policy strategies must reflect the important role of the private sector
  • In open systems, public-private collaboration is key
  • In organized systems, government able to play a leading role

• For organics recycling programs to be viable in the long term, public participation must increase
Can biosolids ash serve as a P fertilizer?

Greenhouse experiment: corn and lettuce

Dr. Carl Rosen
Biosolids Recycling in Minnesota

Three-fourths is landfilled directly or as ash (after incineration).

Only about one-fourth is applied to land.
**Is the ash from incinerated biosolids a good source of P for crops?**

Application rate for all pots = 100 lb P$_2$O$_5$/A
Effect of P source on Corn Dry Weight

P source = NS; P rate = **; P rate x P source = NS
Effect of P Source on Corn Tissue P

$P_{source} = **; \ P_{rate} = **; \ P_{rate} \times P_{source} = **$
Phosphorus Uptake by Corn as Affected by P Rate and P Source

P source = **; P rate = **; P rate x P source = *
Economically optimized distribution of biosolids (ash or dried) on farmland based on P.

Spreading biosolids produced by the Metro Region would be economical because of abundant peri-urban cropland.
SUMMARY

➢ There are multiple potential benefits to re-engineering our organic waste system
  • Decrease cost of disposal
  • Generate value from products

➢ Creating knowledge about waste utilization potential (highest and best use) will create value

➢ Modifying waste infrastructure may facilitate broader utilization of organic wastes.

➢ Re-engineering also involves social and political system.
Value of Recycling Food Waste to Minnesotans

For farmers:
- Urban food waste → animal feed
- Urban biosolids → crop fertilizer
Possibly lower (or at least more stable) prices

For cities:
- Avoided landfill costs
- Added value for “highest and best uses” for food wastes

For all:
Lower environmental impacts from our food system.