Digesters and Food Waste in Vermont

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Vermont Agency of Agriculture
Outline

- Types of waste
- Types of digesters
- Resulting end uses
Food processing residuals

- Some of which goes into some digesters now
- E.g. creameries, breweries, byproducts of cooked products
- Supposedly homogeneous and not loaded with pathogens
- What about FPR as feed? Yes, but not happening yet in Vermont.
  - Limited usefulness in animal diets? Putrescible?
Source-separated organics

- Solid waste
- Pre-consumer
  - “back of the house” (restaurant kitchen, supermarket, or similar)
- Post-consumer
  - Sometimes mixed with pre-consumer
Another point of reference

Vermont Food Recovery Hierarchy

- Source Reduction
- Food for People
- Food for Animals
- Composting & Anaerobic Digestion
- Energy Recovery
Pathways for SSO

- Many pathways and feedstocks.
- Needing a home might amount to only 40,000 tpy
  - § non-compliance (landfilling)
  - § feeding swine illegally
  - § other animal feeding (chickens!)
  - § processing for digesters
  - § food-waste digesters (with maybe some manure)
  - § expansion of composting infrastructure
Composting pathways and trends

- First big test: Chittenden Solid Waste District and Green Mountain Compost
  - Reaching capacity for SSO within a year or two
  - All options on the table

- Two composters with no solid waste permit
  - Raising chickens in conjunction with composting
  - Best practices in the works... becomes something like a regulator condition under which a farmer operates.
SSOs to WWRF

- Yes, it can be done
- One of three EPA ways of thinking.
  - AgSTAR (Ag methane destruction)
  - Solid waste (food recovery, waste reduction)
  - Water quality (point source)
    - Lessen energy usage
- More later, including from you!
Other wastes that go to digesters

- Glycerin (high-energy byproduct of biodiesel production); hors catégorie.
  - In more than one way!
- Grease-trap waste
  - Handled under rules for sewage or septic waste
- Both to have a clear path to digesters.
  - Draft SW rule
<table>
<thead>
<tr>
<th>Year</th>
<th>Country</th>
<th>Name</th>
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<tbody>
<tr>
<td>1980</td>
<td>FRA</td>
<td>Bernard Hinault 1</td>
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<tr>
<td>1980</td>
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<td>Bernard Hinault 2</td>
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<td>1980</td>
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<td>Bernard Hinault 3</td>
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<td>Bernard Hinault 4</td>
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<tr>
<td>1980</td>
<td>FRA</td>
<td>Bernard Hinault 5</td>
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| 1980 | NET     | Joop Zoetemelk  
| 1985 | FRA     | Bernard Hinault 6 |
| 1985 | FRA     | Bernard Hinault 7 |
| 1985 | FRA     | Laurent Fignon  2 |
| 1985 | FRA     | Bernard Hinault 8 |
| 1985 | USA     | Greg LeMond  
| 1985 | IRE     | Stephen Roche  
| 1990 | SPA     | Pedro Delgado  
| 1990 | USA     | Greg LeMond 2  
| 1990 | USA     | Greg LeMond 3  
| 1990 | SPA     | Miguel Indurain  
| 1990 | SPA     | Miguel Indurain 2 
| 1990 | SPA     | Miguel Indurain 3 
| 1990 | SPA     | Miguel Indurain 4 
| 1990 | SPA     | Miguel Indurain 5 
| 1995 | DEN     | Bjarne Riis  
| 1995 | GER     | Jan Ullrich  
| 1995 | ITA     | Marco Pantani  
| 2000 |        | Awards stripped  
| 2005 | SPA     | Óscar Pereiro  
| 2005 | SPA     | Alberto Contador  
| 2005 | SPA     | Carlos Sastre  
| 2005 | SPA     | Alberto Contador 2 
| 2005 | LUX     | Andy Schleck  
| 2005 | AUS     | Cadel Evans  
| 2005 | UK      | Bradley Wiggins 
| 2005 | UK      | Chris Froome  
| 2010 | ITA     | Vincenzo Nibali 
| 2010 | UK      | Chris Froome 2 
| 2010 | UK      | Chris Froome 3  
| 2015 | UK      | Chris Froome 4  
| 2015 | UK      | Chris Froome 5  

Key:
- SPA: Spain
- FRA: France
- NET: Netherlands
- USA: United States
- IRE: Ireland
- GER: Germany
- ITA: Italy
- LUX: Luxembourg
- AUS: Australia
- UK: United Kingdom

The first Tour de France winner was Jacques-Édouard Virenque in 1899.
Types of digesters

- Why “waste” in title of presentation?
- Akin to WWRF versus WWTP
Exhibit 12-32. Biogas Recovery Systems

1. Prep Tank
2. Grinder
3. Digester
4. Generator
5. Separator

Manure

Food Scraps

Food By-products

Electricity

Source: Vermont Sustainable Jobs Fund
Basics

- Schematics
- Mass flow and system boundary and Sankey diagram
- Nutrients
  - Nutrient management – manure is not a waste
Overall function

Example Process Flow

Barn → Screw-Press Separator (or other solids removal system) → BioEliminator™ → Biogas

Reuse for flush water → Bedding (for reuse) → Lagoon → Irrigate fields

Genset, Water Heater, Boiler
**Organic material**

Organic materials are the "input" or "feedstock" for a biogas system. Organic materials will digest more readily than some others. Restaurant fats, oils and greases, animal manures, wastewater solids, food scraps, and by-products from food and beverage production are some of the most commonly-digested materials. A single anaerobic digester may be built for a single material or a combination of them.

**The digester**

An anaerobic digester is one or more airtight tanks that can be equipped for mixing and warming organic material. Naturally occurring microorganisms thrive in the zero-oxygen environment and break down (digest) organic material into usable products such as biogas and digested materials. The system will continuously produce biogas and digested material as long as the supply of organic material is continuous and the microorganisms inside the system remain alive.

**Biogas processing**

Biogas is mostly methane, the primary component of natural gas, and carbon dioxide, plus water vapor, and other trace compounds (e.g., siloxanes and hydrogen sulfide). Biogas can replace natural gas in almost any application, but first it must be processed to remove non-methane compounds. The level of processing varies depending on the final application.

**Biogas distribution**

Processed biogas, often called "biomethane" or "renewable natural gas," can be used the same way you use fossil natural gas to produce heat, electricity, or vehicle fuel, or to inject into natural gas pipelines. The decision to choose one use over another is largely driven by local markets. In addition to biogas, digesters produce solid and liquid digested material, containing valuable nutrients (nitrogen, phosphorus, and potassium) and organic carbon. Typically, raw digested material, or "digestate," is processed into a wide variety of products like fertilizer, compost, soil amendments, or animal bedding, depending on the initial feedstock and local markets. These "co-products" can be sold to agricultural, commercial, and residential customers.

**Digested material**

Digested material is processed and distributed. Solids and liquids from the digester may be used to produce marketable products, like fertilizer, compost, soil amendments, or animal bedding.
Basic Anaerobic Digester System Flow Diagram

Digester Inputs
(manure, organic substrates)

Anaerobic Digester

Digester Outputs

Conditioning to remove H₂O & H₂S

Liquefied Biogas

Recaptured Heat

Solids

Solids Separator

Liquids

Lagoon/Liquid Storage

Advanced Treatment

Discharge

Reuse

Fertilizer for field or greenhouse crops, flush water

Biomethane
(500-1000 BTU/sf)
Natural gas pipeline quality, vehicle fuel (CNG/LNG), feedstock

Energy Company
Electric utility, natural gas pipeline, vehicle fueling station

Recapturing Fuel

Farm or Neighbor Use
Building heating, greenhouse, food storage, adjacent commercial/industrial needs, etc.

Biogas

Medium-BTU Biogas
(600-700 BTU/sf)
Boiler, heater, chiller, etc.

Electricity
Internal combustion engine (early stage: microturbines, fuel cells)

Processing to remove CO₂

Supplemental Heat for Digester

Fertilizer (NPK)

Compost

Soil Amendment

Bedding

All of the opportunities presented will not be appropriate for all digester systems based upon technical and financial constraints.
Biogas Cycle

Animal husbandry
Biofuel production
Crop harvesting
Industrial processing
Human consumption

Solar energy
Photosynthesis

Code
Biofertilizer
H₂O

Energy crops

Electrical and/or thermal energy

Anaerobic digestion
Biogas
Natural gas pipeline

Crop wastes

PROCESS FLOW CHART

Food Waste
Cow Manure

Biogas

Power
Heat

Reception Pit
Anaerobic Digester

Dewatering System
Bedding

Nutrient Removal
Fertilizer

Digester Storage

Legend: Benefit
Typical Process Step
Optional Process Step

VERMONT
AGRICULTURE, FOOD & MARKETS
Carte Figurative des pertes successives en hommes de l'Armée Française dans la Campagne de Russie 1812 - 1813.

Dessiné par M. Minard, Ingénieur Général des Ponts et Chaussées.

Dessiné le 20 Novembre 1869.

Le nombre d'hommes présents en repartie par les lignes des dates allant à chaque d'un millier plus en moins hommes, il y a eu plus d'hommes à l'arrivée des dates. Le nombre des hommes qui ont fini en Russie, le mois en cours, qui en restèrent. Les représentations qui sont arrivés à travers la carte ont été dépeintes et les couleurs de M. Chret, de Dumas, de Fenelon, de Chambray et le journal inédit de Jacob, annexé à l'Armée depuis le 21 Octobre.

Pour mieux faire jouer à l'esprit l'état de l'armée, j'apportai que les corps du Prince François et du Maréchal Soult, qui avaient été détachés de Minuit à Micol et à son voyage, sous Charles X. Weber, avaient toujours marché avec l'Armée.

TABLEAU GRAPHIQUE de la température en degrés du thermomètre de Réaumur au dessous de zéro.

Les cartes sont poussées au givre et le chiffre e gèle.

-26° le 7 A°
-29° le 10 A°
-30° le 28 A°
-27° le 10 A°
-17° le 9 A°
-19° le 2 A°
-18° le 1 A°
-14° le 11 A°
-10° le 14 A°
-9° le 10 A°
-8° le 6 A°
-6° le 4 A°
-5° le 4 A°
-4° le 4 A°
Vermont energy flows in 2015, with an illustrative path forward to 2025, 2035, and 2050.
Sankey Diagram

Estimated U.S. Energy Use in 2013: ~97.4 Quads

Source: LLNL. 2014. Data is based on DOE/EIA-0035i/2014-03, March, 2014. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports consumption of renewable resources (i.e., hydro, wind, geothermal and solar) for electricity in BTU equivalent values by assuming a typical fossil fuel plant “heat rate.” The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 63% for the residential and commercial sectors 80% for the industrial sector, and 21% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-110527
Make me a Sankey diagram with lb per lb of nutrient mass flow!!
Technologies

- Solid (Bioferm, etc.)
- Liquid
  - 7-9% solids -- non-Newtonian (blood, ketchup)
  - Complete-mix or plug-flow
  - Liquid-fraction-only systems
- Mesophilic (100° F) or
- Thermophilic (135° F)
US EPA AgSTAR

- [https://www.epa.gov/agstar](https://www.epa.gov/agstar)
  - Biogas Recovery in the Agriculture Sector
  - VT a state partner
  - Maintain database of projects
Vermont Snapshot

18 digesters operating
  2nd generation projects, 2005-2013
  17 for electricity
    Valuable byproducts: heat, animal bedding, better agronomic availability
  16 on farms with 700+ cows
    $2-4 million installed cost
  2 on farms with 200-500 cows
  1 on small cheese operation, heat only, post-separated manure.
Non-manure inputs in VT farm digesters

- Low usage of pre-consumer waste ("food processing residuals" – FPR) from beverage and food industry production.
- 8 digesters use 4% of their aggregate digester capacity for FPR.
- 1 – 9% at individual digesters, with one exception
- As a percentage of capacity of the 18 digesters, the FPR is about 2%.
- Exception: Vermont Technical College
  - 13% from off the farm (1/2 brewery, ½ grease-trap waste)
  - Also glycerin
  - Has solid waste permit
  - … and lots of operational issues
Liquid systems

- Complete mix very common in Europe
  - Four in Vermont
- US animal-manure market dominated by “modified plug flow”
- Usually all of the 7% solids manure slurry is digested – some systems only use the liquid fraction (Digested Organics, Biobolsa)
VTC digester
SSOs in digesters

- Two pilot projects to process off-farm and deliver pulped waste
- Revenue from waste fees or sale of beneficial products??
  - Waste business model, or resource business model
Large-scale digesters and the waste model

- Very large CAFOs, and/or…
- The waste paradigm
  - Food and beverage manufacturing wastes, with manure
  - Agri-Energy in Maine: one cow per kW instead of five because more than $\frac{1}{2}$ of volume is food waste.
  - AGreen and BGreen in MA – partnership with Casella.
  - “Depackaging”
American Biogas Council

Biogas Project Profile

Real Farm Power
Hadley, Massachusetts 1035

Owners and Developers: Vanguard Renewables, Barstow’s Longview Farm, Agri-Mark/Cabot Creamery Cooperative
Contact: Ann Hoogenboom, 802.496.1359, ahoogenboom@cabotcheese.coop
Date Construction Started: 7/1/2013
Date Tank Started Being Filled: 11/1/2013
Date Project was Fully Operational: 12/31/2013

Project Summary:
Real Farm Power™ is a strategic partnership that has scaled digester technology to medium-size dairy farms, creating heat, valuable soil amendments, farm-generated electricity and providing infrastructure to
American Biogas Council 2016 Agricultural Project of the Year Awarded to Barstow's Longview Farm

HADLEY -- The renewable energy strategic partnership between Barstow's Longview Farm in Hadley, Vanguard Renewables and Eversource was awarded the 2016 American Biogas Council Agricultural Project of the Year, Eversource said Tuesday.

The Farm Powered anaerobic digester at Barstow's combines farm waste and dairy manure digester that will 7,000 MW” of electricity.
WRRF digesters

- Three EPA touch points
  - AgSTAR (Ag methane destruction)
  - Solid waste (food recovery, waste reduction)
  - Water quality (point source)
    - Lessen energy usage

- VT Comprehensive Energy Plan
  - “Brattleboro, Montpelier, Essex Junction, and other municipalities have anaerobic digesters that are part of their municipal waste systems and provide those facilities with heat and power.”
More CEP…

• “…10 wastewater treatment facilities. The responses indicated that, among the 23 digesters at these facilities, only a minority of the digesters are sending the biogas to be burned for energy.”

• “…90 municipally operated wastewater treatment facilities. Thirty are above the permitting threshold of processing one million gallons per day or serving a population of at least 10,000. There are also about 60 private or institutionally operated systems.”
“Good operators, whether they operate a dairy farm or a wastewater treatment facility, are justifiably wary of putting a known and good outcome at risk by adding complexity to their operation. Although the probability of a failure may be low, the consequences can be dire — fish kills, public health problems, and fines.”
End uses

- WWRFs
- Manure digesters
Farm digester end uses

- **In:** 7-10% solids slurry
- **Out #1:** 35% moisture content, peat-moss-like solids
  - 2.0x what is needed as bedding for cows
  - Excess is sold to other farmers or composters
  - Savings in bedding costs and/or revenue can be 30% of overall project revenue
  - Contains about 30% of the phosphorus
- **Out #2:** 1-2% solids manure liquid – to manure pit
- **Out #3:** Potentially... a phosphorus-rich product
Potential of digesters to improve water quality

- DAF, centrifuge
- Cost to operate versus savings in purchase of commodity phosphorus
  - … or cost to solve a complicated compliance problem, versus other solutions?
- Phosphorus trading!!
NOTE: Grass/Shrub was included in the analysis but excluded from this graphic due to the comparatively low percentage of phosphorus.
Suggestions and questions

- Bring ‘em on!
- Plato’s Republic – what is justice?
  “There will be no end to the troubles of states until philosophers become rulers in this world, or until rulers become philosophers.”
Suggestions, mine

- GHG in CA market
- Geotargeting and matchmaking
- Good food waste brokers or “ORFs”
  - Composters/haulers
  - Deliver qualified, tested material to digesters.
- Good solid-waste rules (duck test)