



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

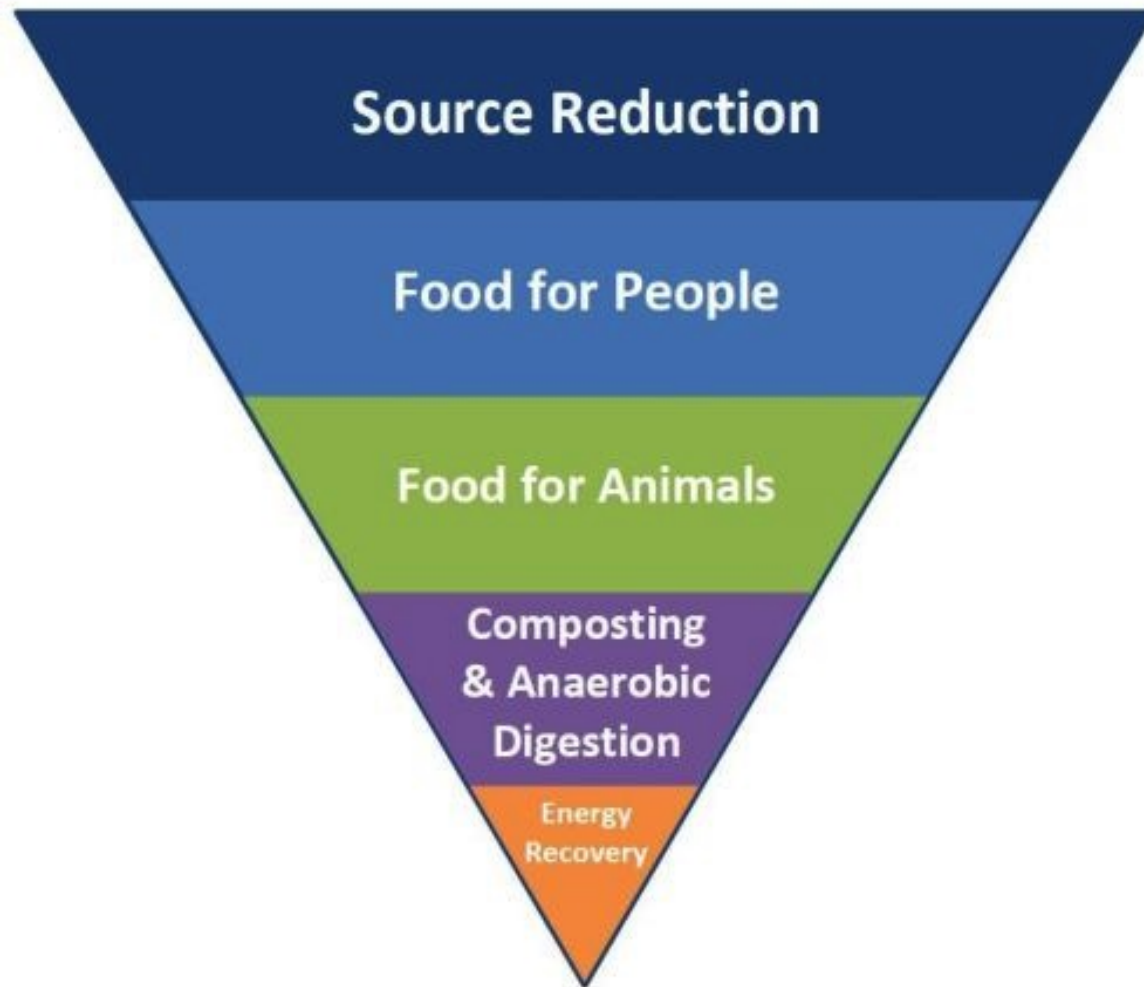
- Some of which goes into some digesters now
- E.g. creameries, breweries, byproducts of cooked products
- Supposedly homogeneous and not loaded with pathogens
- What about FPR as feed? Yes, but not happening yet in Vermont.
 - Limited usefulness in animal diets? Putrescible?

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



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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

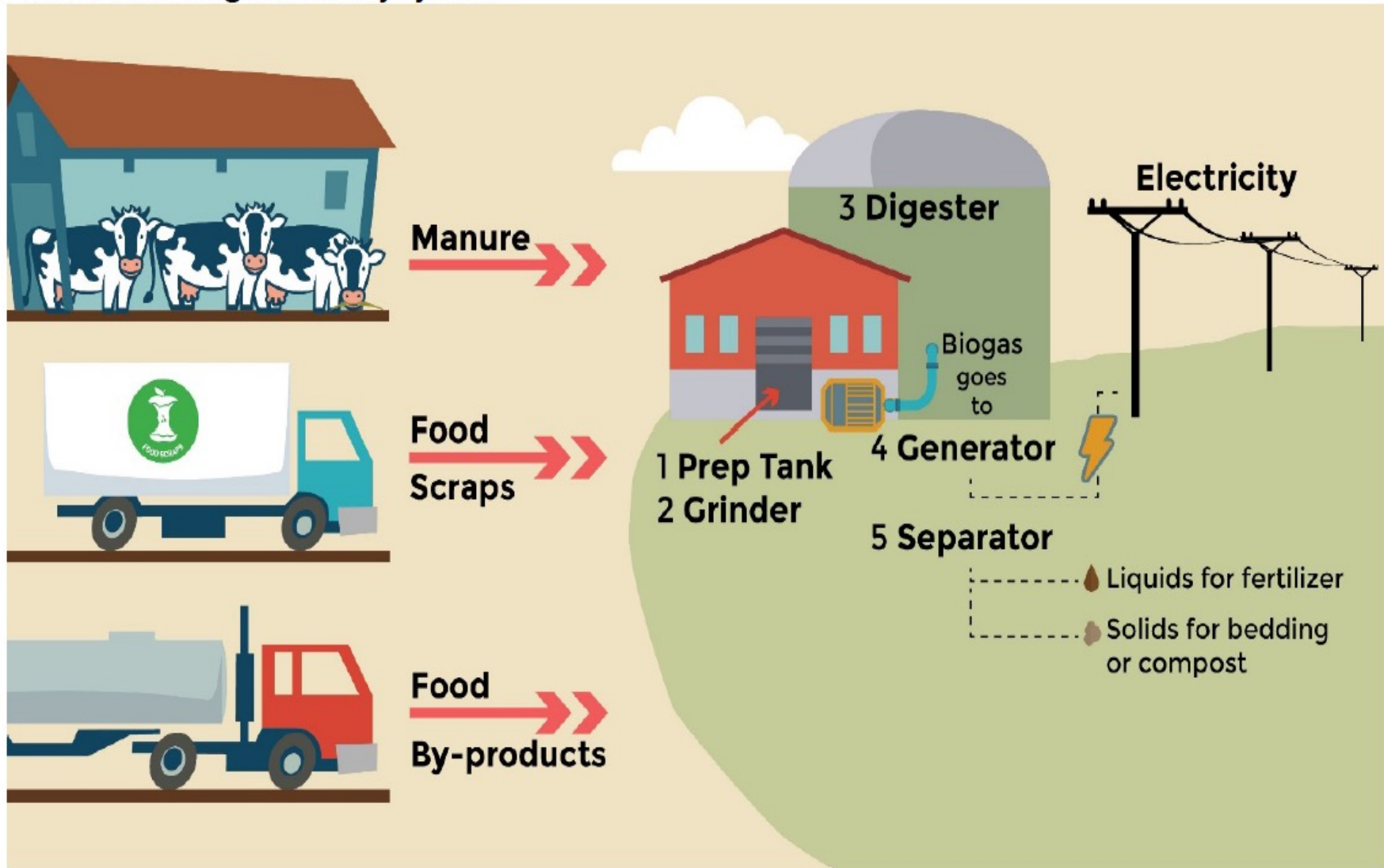
- Glycerin (high-energy byproduct of biodiesel production); hors catégorie.
 - In more than one way!
- Grease-trap waste
 - Handled under rules for sewage or septic waste
- Both to have a clear path to digesters.
 - Draft SW rule

1980	FRA	Bernard Hinault
	FRA	Bernard Hinault 2
	NET	Joop Zoetemelk
	FRA	Bernard Hinault 3
	FRA	Bernard Hinault 4
	FRA	Laurent Fignon
1985	FRA	Laurent Fignon 2
	FRA	Bernard Hinault 5
	USA	Greg LeMond
	IRE	Stephen Roche
	SPA	Pedro Delgado
1990	USA	Greg LeMond 2
	USA	Greg LeMond 3
	SPA	Miguel Induráin
	SPA	Miguel Induráin 2
	SPA	Miguel Induráin 3
1995	SPA	Miguel Induráin 4
	SPA	Miguel Induráin 5
	DEN	Bjarne Riis
	GER	Jan Ullrich
	ITA	Marco Pantani
2000		
		Awards stripped
2005		
	SPA	Óscar Pereiro
	SPA	Alberto Contador
	SPA	Carlos Sastre
	SPA	Alberto Contador 2
2010	LUX	Andy Schleck
	AUS	Cadel Evans
	UK	Bradley Wiggins
	UK	Chris Froome
2015	ITA	Vincenzo Nibali
	UK	Chris Froome 2
	UK	Chris Froome 3

Types of digesters

- Why “waste” in title of presentation?
- Akin to WWRF versus WWTP

Exhibit 12-32. Biogas Recovery Systems



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





Organic material is delivered to the digester system

This may include animal manure, food scraps, agricultural residues, or wastewater solids.

Co-products may be returned for livestock, agricultural and gardening uses.



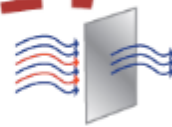
Organic material is broken down in a digester

The digester uses a natural biological process under controlled conditions to break down organic material into products for beneficial use or disposal.

Some biogas can be used to heat the digester.

BIOGAS

DIGESTED MATERIAL



Raw biogas is processed

Typically, water, carbon dioxide and other trace compounds are removed, depending on the end use, leaving mostly methane.



Processed biogas is distributed and used

The gas may be used to produce heat, electricity, vehicle fuel or injected into natural gas pipelines.

SOLIDS

LIQUIDS



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.

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 grease; 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 matter 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.

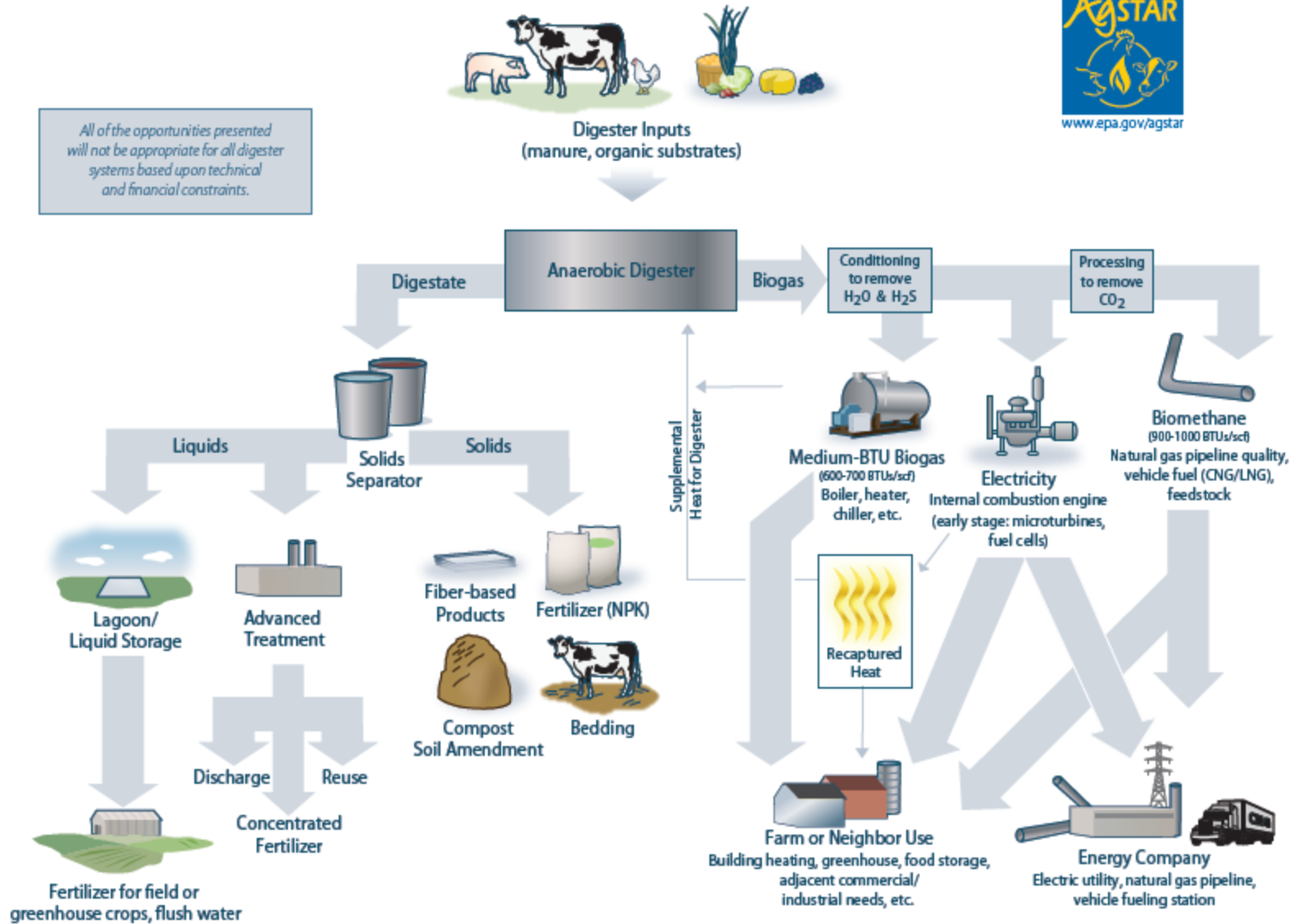
digested material

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.

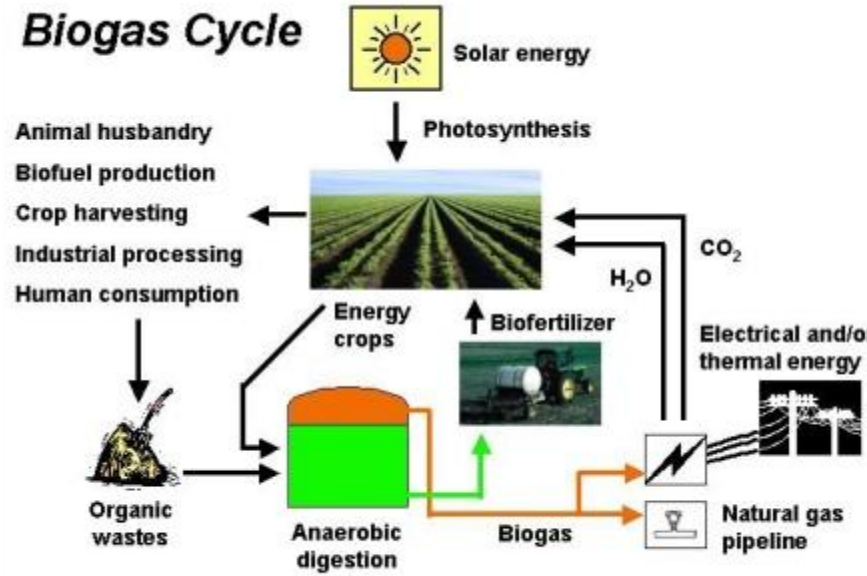
Basic Anaerobic Digester System Flow Diagram



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

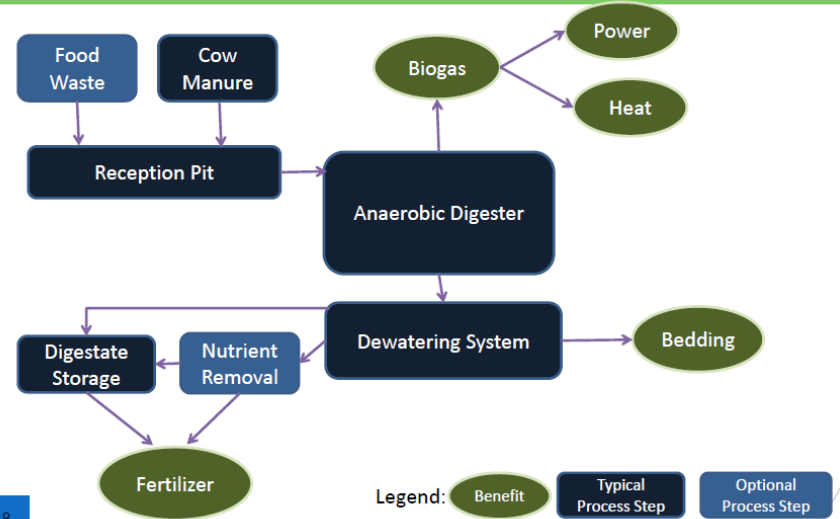


Biogas Cycle

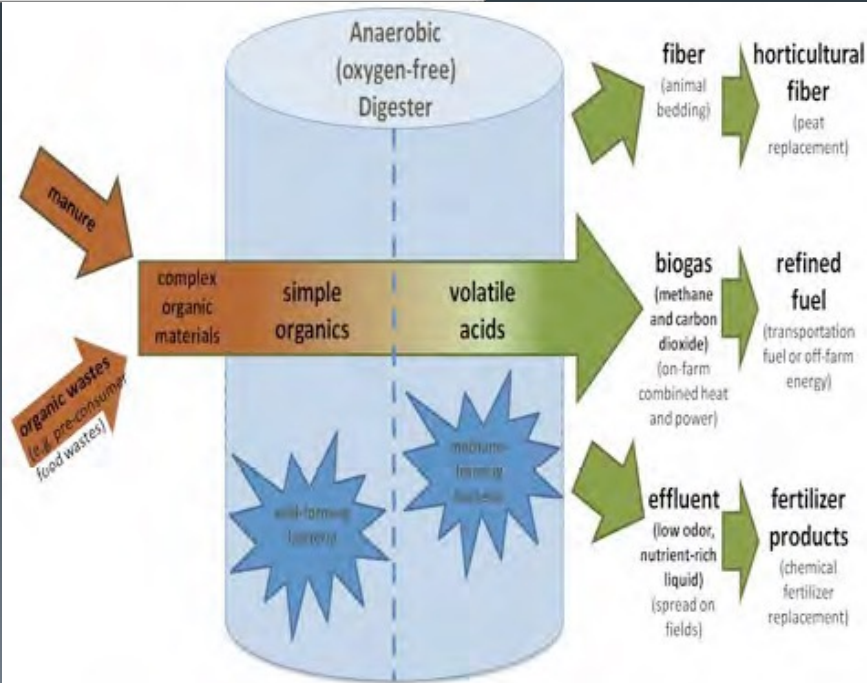


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PROCESS FLOW CHART



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Carte Figurative des pertes successives en hommes de l'Armée Française dans la campagne de Russie 1812-1813.
 Dessinée par M. Minard, Inspecteur Général des Ponts et Chaussées en retraite. Paris, le 20 Novembre 1869.

Les nombres d'hommes présents sont représentés par les largeurs des zones colorées à raison d'un millimètre pour dix mille hommes; ils sont de plus écrits en lettres des zones. Le rouge désigne les hommes qui ont été en Russie, le noir ceux qui en sortent. Les renseignements qui ont servi à tracer la carte ont été puisés dans les ouvrages de M. M. Cbiers, de Fénelon, de Chambray et le journal inédit de Jacob; organisation de l'Armée depuis le 28 Octobre. Pour mieux faire juger à l'œil la diminution de l'armée, j'ai supposé que les corps du Prince Jérôme et du Maréchal Davoust qui avaient été détachés sur Minsk et Mielow en ont rejoint vers Czocha et Wilkoff, avant toujours marché avec l'armée.

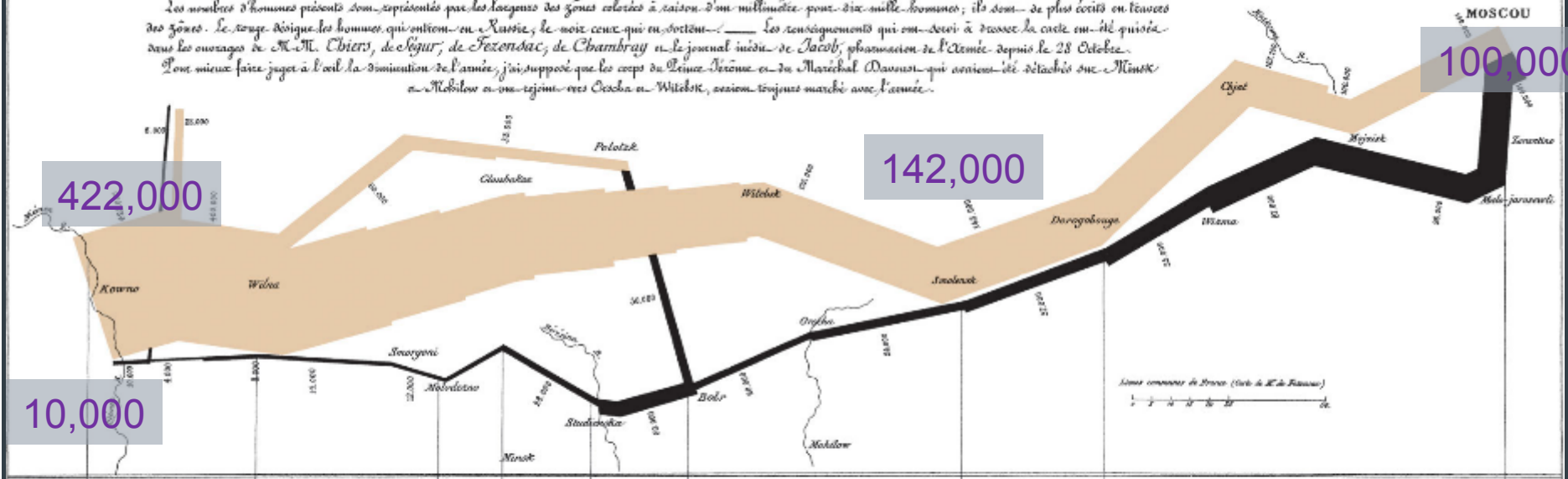
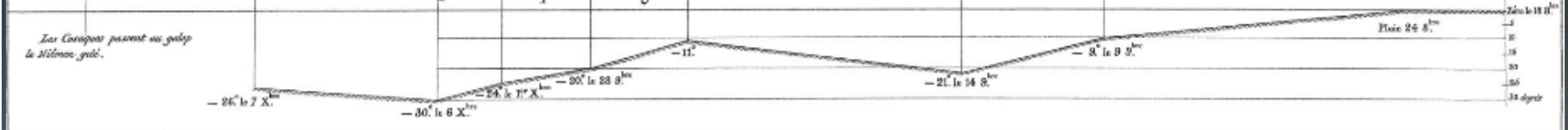


TABLEAU GRAPHIQUE de la température en degrés du thermomètre de Réaumur au dessous de zéro.



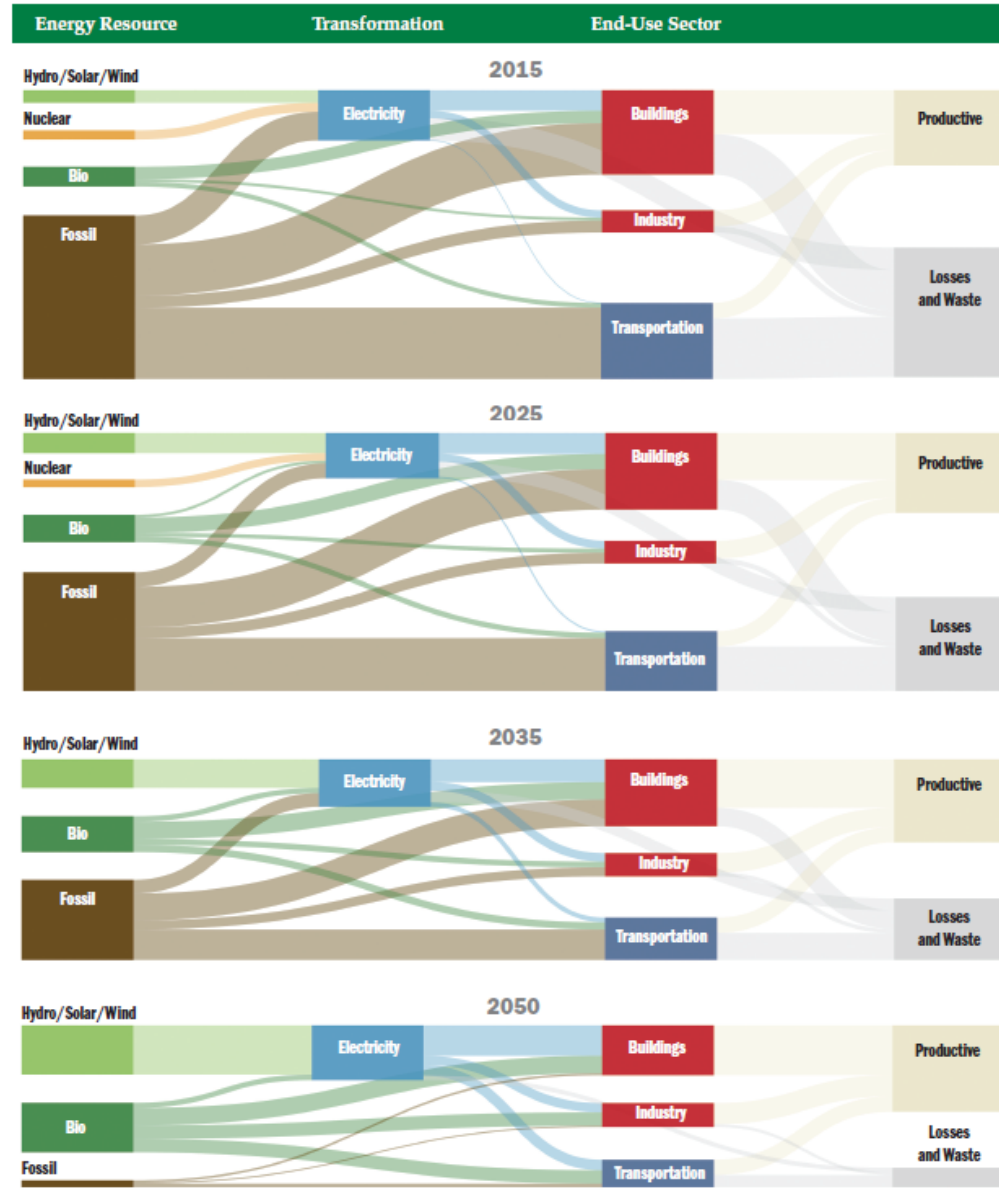
Antiq. par Reynier, à Paris. 57^{me} Mars 51^{me} à Paris.

Antiq. par Reynier et Bourlet.



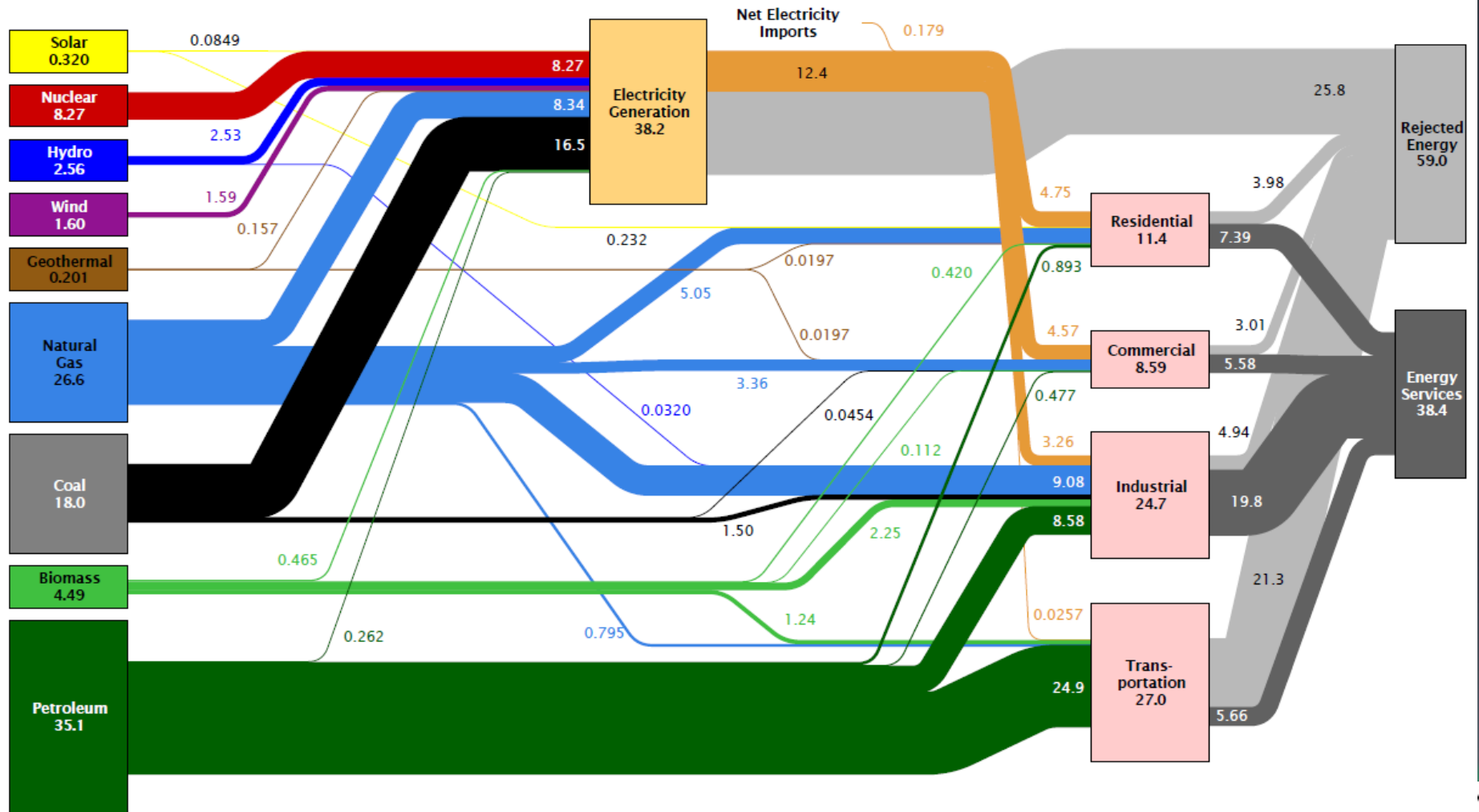
Figure ES-1

Vermont energy flows in 2015, with an illustrative path forward to 2025, 2035, and 2050.



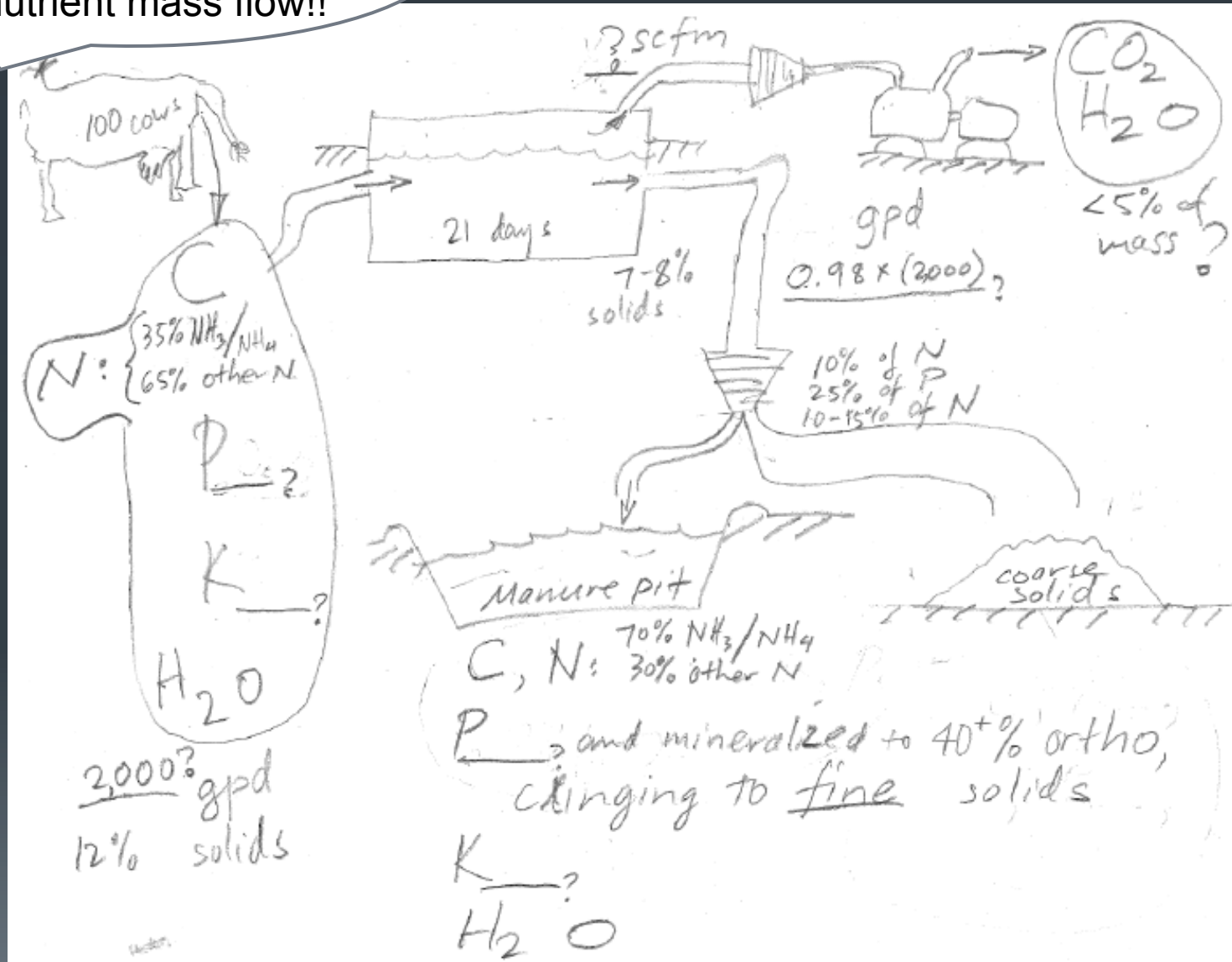
Sankey Diagram

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



Source: LLNL 2014. Data is based on DOE/EIA-0035(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 65% 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-410527

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>
 - Biogas Recovery in the Agriculture Sector
 - VT a state partner
 - Maintain database of projects

Vermont Snapshot

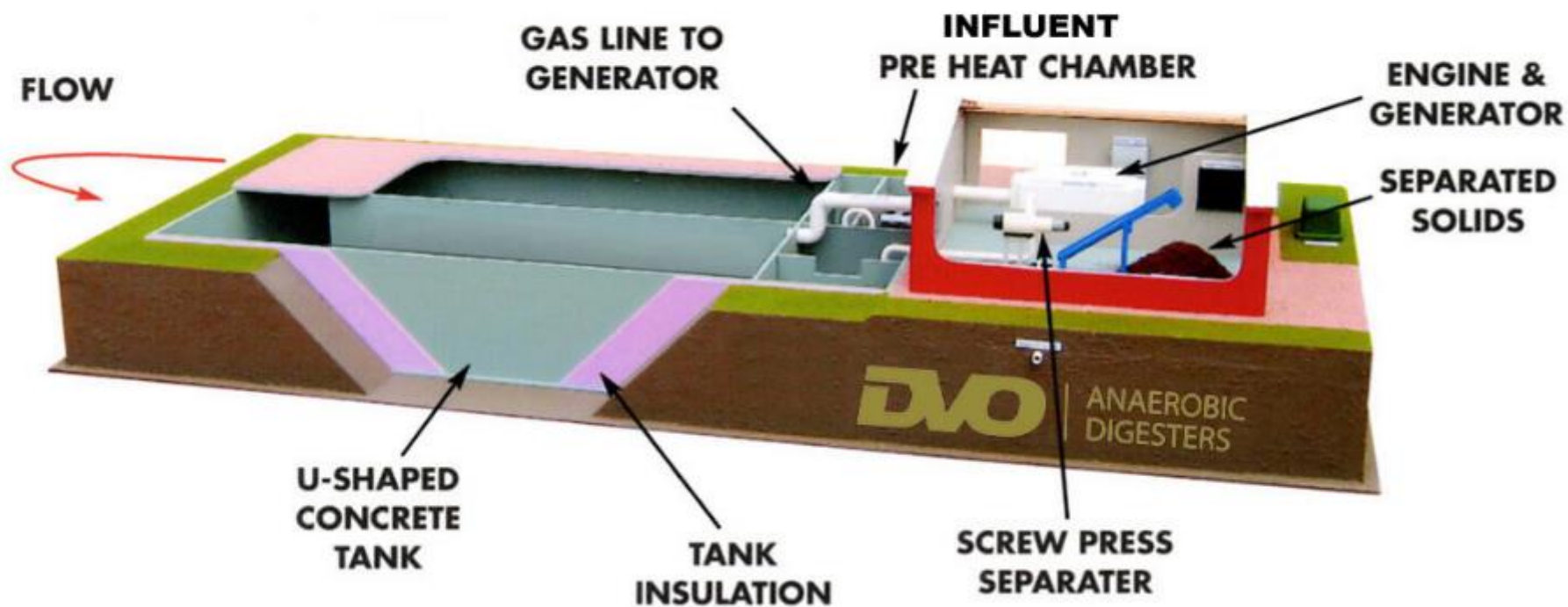
- 18 digesters operating
 - 2nd generation projects, 2005-2013
 - 17 for electricity
 - Valuable byproducts: heat, animal bedding, better agronomic availability
 - 16 on farms with 700+ cows
 - \$2-4 million installed cost
 - 2 on farms with 200-500 cows
 - 1 on small cheese operation, heat only, post-separated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



12 shares



The Barstow family (Photo Provided)



By The Republican Business Desk on November 01, 2016 at 2:11 PM. updated November 01, 2016 at 4:57 PM



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

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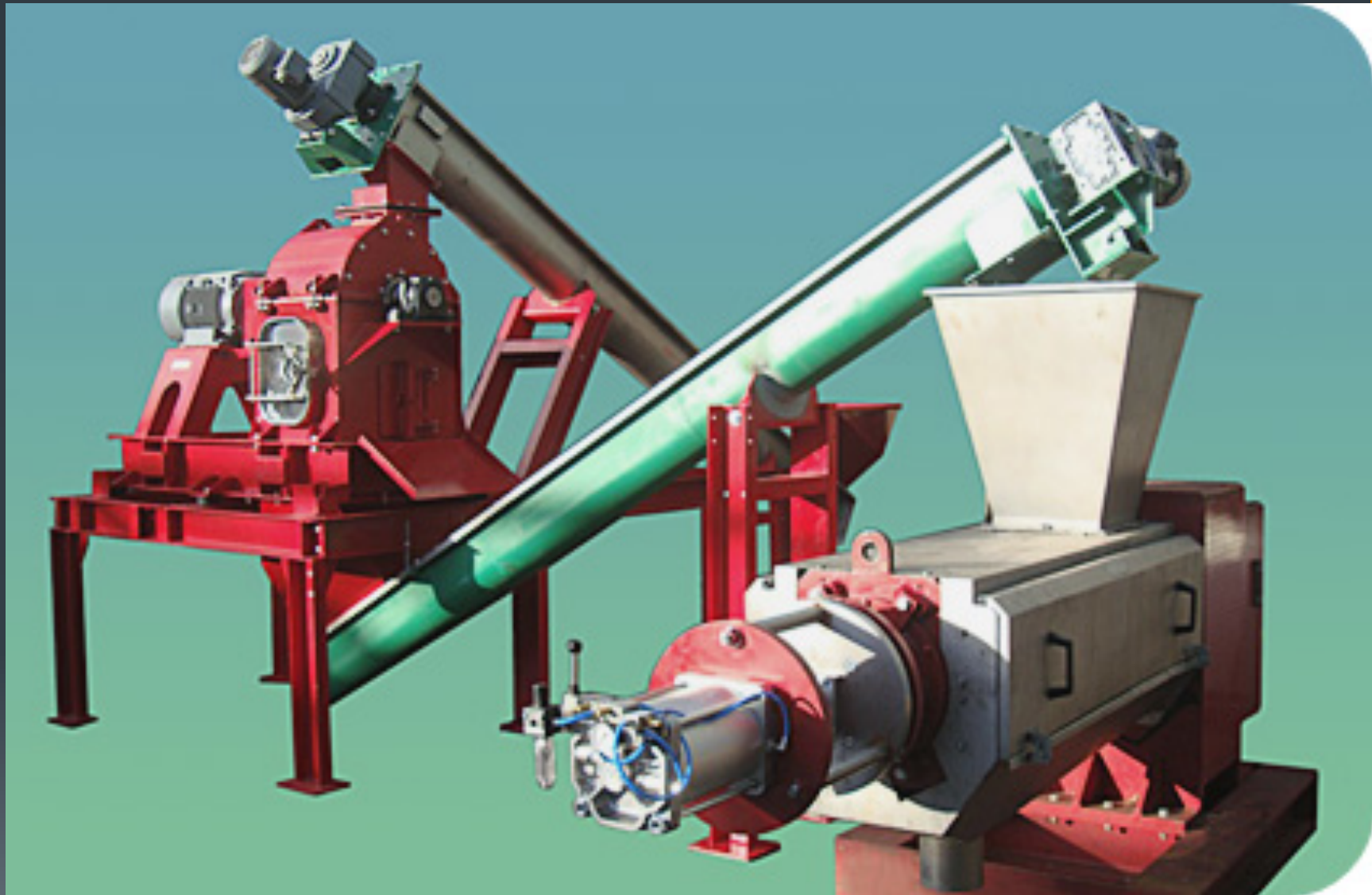
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WRRF digesters

- 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...

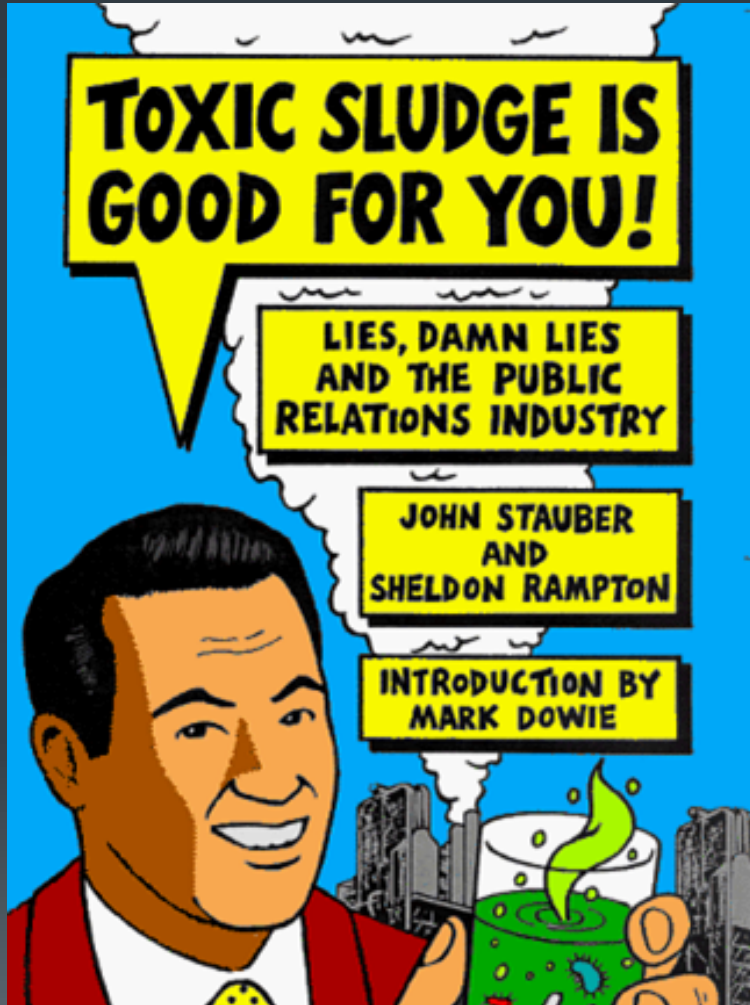
- “...10 wastewater treatment facilities. The responses indicated that, among the 23 digesters at these facilities, only a minority of the digesters are sending the biogas to be burned for energy.”
- “...90 municipally operated wastewater treatment facilities. Thirty are above the permitting threshold 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.”

...the upshot. True??

- “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



2002 -- http://www.prwatch.org/files/pdfs/tsigfy_chap8.pdf



"If you want to know how the world wags, and who's wagging it, here's your answer."—Bill Moyers

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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

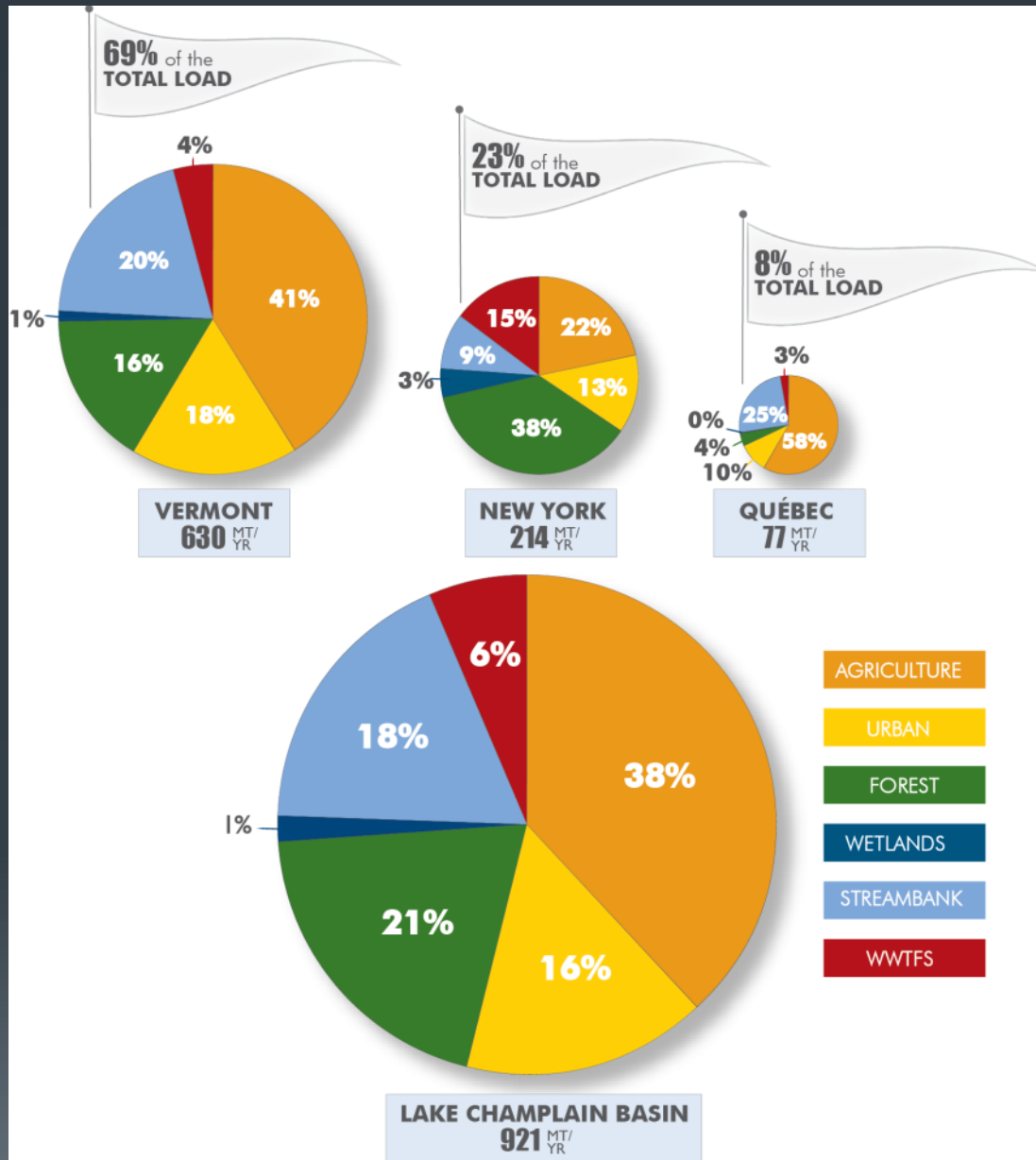
- DAF, centrifuge
- Cost to operate versus savings in purchase of commodity phosphorus
 - ... or cost to solve a complicated compliance problem, versus other solutions?
- Phosphorus trading!!

TMDL



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NOTE: Grass/Shrub was included in the analysis but excluded from this graphic due to the comparatively low percentage of phosphorus.
 DATA SOURCE: Tetra Tech, 2015.

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)