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Water & Energy
In Maryland

2010 Water Resources Symposium

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For further information or for permission to use large portions of this material, contact the author directly:

Kevin Selock
Parkway WWTP Superintendent
Washington Suburban Sanitary Commission
kSelock@wsscwater.com

(all contact information current as of Oct. 2010)

Water & Energy in Maryland Symposium

WSSC Feasibility Study For Generating Combined Heat & Power from WSSC's Wastewater Biosolids (Converting a Waste Into a Resource)

Kevin Selock, Parkway WWTP Superintendent

10/28/10

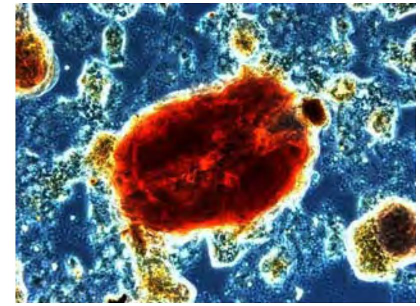
Water/Wastewater as Users of Power

WSSC's has $25M annual power budget; actual power usages identified below for major facilities. (Excludes pump stations, tanks, vaults, depots, admin offices).

	mgd avg day	$/yr (millions)	Electricity kWh/yr	kWh/mg	avg daily MW
Potomac WTP	116.0	9.5	80,525,000	1,902	9.2
Patuxent WTP	49.0	2.4	21,825,000	1,220	2.5
Piscataway WWTP	23.7	2.1	17,270,000	1,996	2.0
Western Branch WWTP	21.0	2.8	23,815,000	3,107	2.7
Parkway WWTP	6.7	0.8	7,880,000	3,222	0.9
Seneca WWTP	16.0	2.1	15,370,000	2,632	1.8
Damascus WWTP	0.9	0.2	2,130,000	6,484	0.2

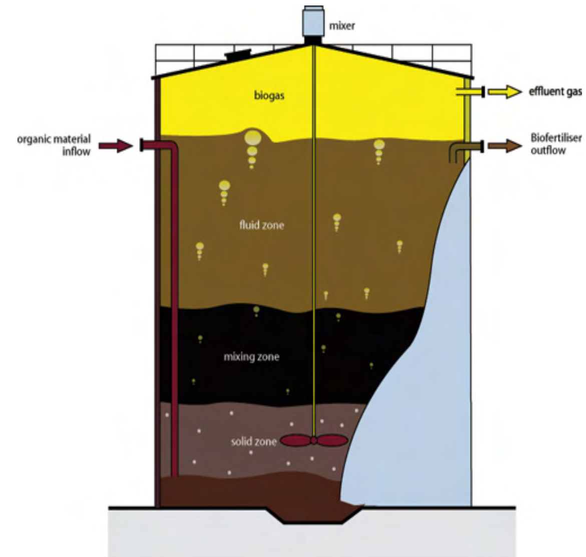
Approx Total = 20 MW daily

Anaerobic Digestion (AD)



What is it?

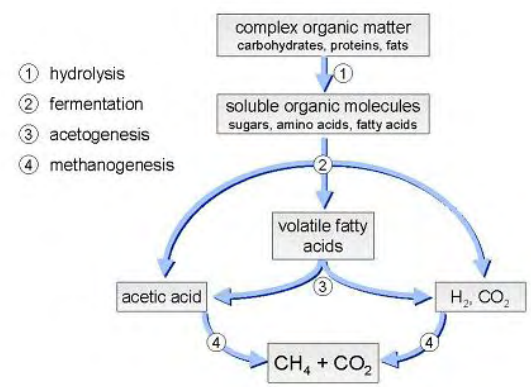
$C_cH_hO_oN_nS_s + yH_2O \text{ --->- } xCH_4 + nNH_3 + sH_2S + (c\text{-}x)\ CO_2$



Benefits?

- Reduction in biosolids (of approx 50-60%).

- Destruction process can convert a waste into a resource through production of CH_4 which can be recovered for combined heat & power (CHP); approx 60% CH_4 and 40% CO_2 with trace other gases.



Recent U.S. AD/CHP Developments – EPA Report

Opportunities for and Benefits of Combined Heat and Power (CHP) at Wastewater Treatment Facilities, EPA, April 2007:

- Typical WWTP processes 100 gpd/person. Can produce approx 1 ft3/day-person biogas, and yield 2.2 W (@30% efficiency). 600 BTU/ft3 biogas. For each 4.5 mgd treated, approximately 100 kW energy can be produced.

- 16,000 U.S. WWTPs & 1,000 >= 5 mgd. EPA assumed if 544 U.S. WWTPs >= 5 mgd w/AD installed CHP, approx 340 MW of electricity could be produced daily.

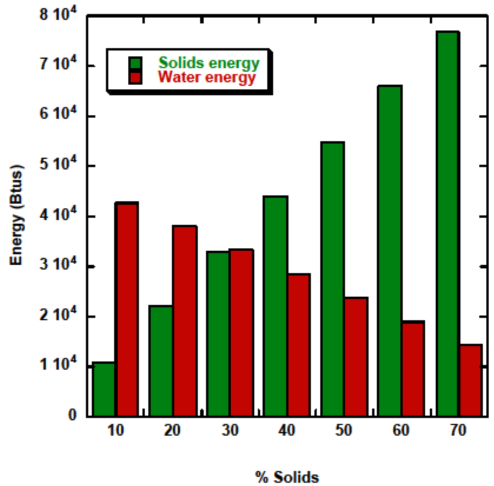
- CHP is strong technical fit for WWTPs, as well as compelling investment (depending upon local electrical prices); under-utilized to date.

- Some examples where used include: Atlanta, Baltimore**, Boston**, Chicago, Dallas, Denver*, Detroit, Honolulu, Los Angeles*, NYC*, Oakland*, Phoenix, San Diego*, San Jose**, Seattle*, Wilmington

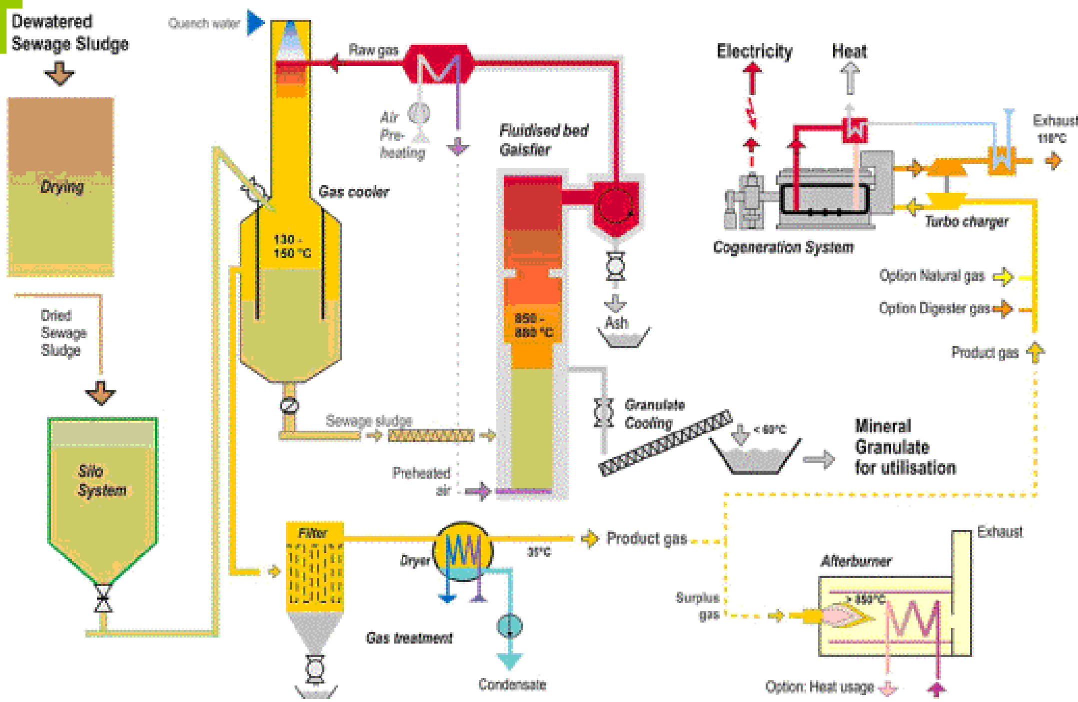
** Signficant history converting biogas to energy. ** Recent addition of CHP systems. All others flare biogas.*

Gasification and/or Combustion

Energy required to dry versus energy of dry solids (Metcalf and Eddy, 100% efficiency)



Example Gasification Process



Sanford FL WWTP, MaxWest gasification system (L); heat then used to dry biosolids used as fuel (R). At present, no excess energy for power production – plans to import additional "dry" solids to augment gasifier.

Co-combustion with Dried Biosolids

- Bituminous coal @ 8,000 - 10,000 Btu/lb vs. dried biosolids @ 6,500 – 7,500 Btu/lb.
- Lehigh Cement's Union Bridge MD, uses dried biosolids (from Baltimore & Boston) to offset up to 20% coal.
- MDE permits Lehigh to combust up to 30,000 tpy biosolids as fuel.

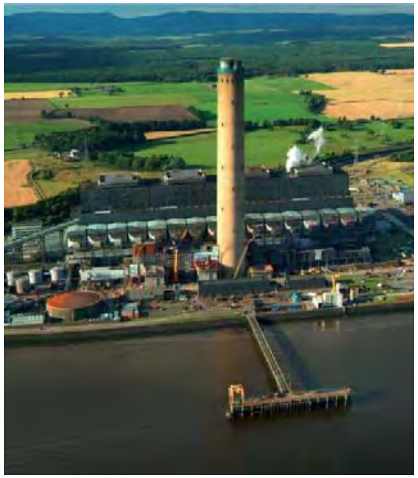
Drying & pelletization

Dried biosolids for use as fertilizer or fuel

Lehigh Cement Plant at Union Bridge

Co-Combustion by Power Plants

- Power plants look to co-combust biomass & diversify feedstocks beyond fossil fuels (ie. consistent w/ RPS goals).
- Power plants ideal in terms of 24/7/365 (like WWTPs), many near population centers like WWTPs, only 35% efficient so huge quantities of waste heat for available drying, … . Potential for regional drying and combustion of biosolids.
- Drawbacks – huge MW capacities, additional investment, risks (such as: odors, new regulations such as EPA's "Emission Standards for Hazardous Air Pollutants for Major or Area Sources", likely public opposition, …).
- 8 million dry metric tonnes biosolids annually in U.S. – potential to produce 1,311 MW/day electricity (35% efficiency), or up to 2,611 MW/day combined heat and power (70% efficiency).



Scottish Power's Longannet Power Station

Germany's Heilbronn Power Station

WSSC WWTP Biosolids - Convert a Waste Into a Resource?

- 5 major plants, rely upon lime stabilization, (except Western Branch WWTP which incinerates biosolids). Lime stabilized biosolids are land applied, primarily throughout VA.
- Evaluate AD/CHP at Piscataway (P.G.) & Seneca (Montgomery) due to economies of scale – approx 400 kW potential at each.
- Evaluate gasification, drying, and/or combustion as alternatives.
- Consider augmenting selected processes w/ biosolids from other WSSC WWTPs.
- WSSC biosolids have energy potential of 619 MMBtu/day, or 2.6 MW/day @ 35% efficiency. (Piscataway & Seneca account for 60% of total.)

Piscataway WWTP

Seneca WWTP

Task 1 – Preliminary Investigations

Balanced Technical Solution

Task I A
Conduct Meetings and Site Investigations & Compile Relevant Data
Project Work Plan

Task I B
Document Existing Treatment Plant Conditions & Planning Assumption
TM 1-B "Basis of Planning"
Workshop #1

Task I C
Step 1: Identify Options for Anaerobic Digestion & Related Technologies
TMs 1-C
Parts 1-5

Step 2: Screen technologies
Workshops 2 & 3

Step 3: Develop and Shortlist Anaerobic Digestion Alternatives
Workshop 4
3 AD/CHP Alternatives for each plant

Task I D
Step 1: Identify Options For Drying Based Alternatives & Related Technologies
TMs 1-D
Part 1-3

Step 2: Screen technologies
Workshop 5

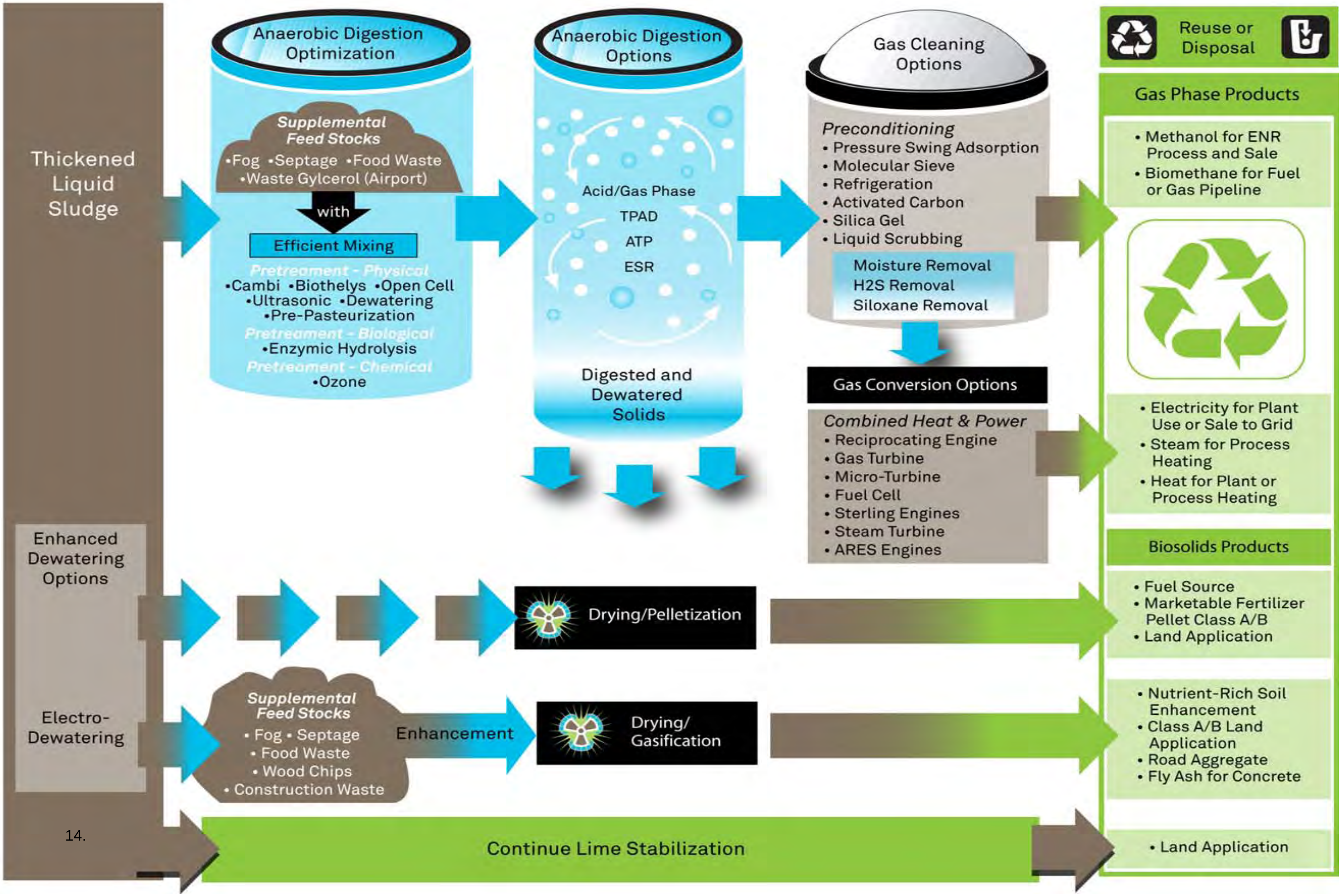
Step 3: Develop and Shortlist Drying Based Alternatives
Workshop 6
2 Biomass Alternatives

Viable Alternatives Shortlist

3 Anaerobic Digestion/ 2 CHP Based Alternatives for each plant

2 Biomass Drying Based Alternatives

Identify & Evaluate Viable Technical Building Blocks



Task II – Development & Selection Of Alternatives

Task I Preliminary Investigations → **Task II Development & Selection of Alternatives** → **Task III Technical Memorandum, Conceptual Design, and Recommendations**

Task IIA: Prepare Non-Economic Evaluation Background Narratives

Step 1: Evaluate Plant Integration issues

Step 2: Evaluate project Implementation / Execution Options

Step 3: Summarize non-economic benefits and impacts of each alternative

Workshops 7
TM II A

Task II B: Prepare Cost Opinions

Workshops 8
TM II B

Task II C: Select "Best" Anaerobic Digestion Alternative

Workshop 9

Task II D: Select "Best" Drying Based Alternative

Workshop 10

- Economic Analysis
- Plant Integration / Operational Risk
  - ✓ Centrate, rDON, Odor, FOG management
- Non-Economic Analysis
- Address Financial Risk
  - ✓ ESCO, DBO, DBOOF, DBB/Ops contracts

"Best" Alternative

"Best" Anaerobic Digestion / CHP Alternative for each plant

"Best" Biomass Drying Based Alternative

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Task III – Technical Memorandum, Concept Design & Recommendations

Project Work Flow

- **Task I Preliminary Investigations**
- **Task II Development & Selection of Alternatives**
- **Task III Technical Memorandum, Conceptual Design, and Recommendations**

Task IIIA: Draft Technical Memorandum

Workshop 11 & 12

Task III B: Prepare Conceptual Designs

Task III C: Finalize and Distribute Report

Final Report

Summary

- Water & Wastewater treatment is a very energy intensive industry. WSSC facilities average approximately 2,000 – 3,000 kWh/mg treated.
- There are opportunities to recover energy from wastewater biosolids – converting a waste into a resource. (Note: Power recovered is fraction of power required to treat.)
- In most cases, significant investment in new facilities (possibly anaerobic digesters, gas cleaning systems, generators, new facilities to treat recycle streams, …) will be required to recover the energy. (Note: EPA AD/CHP report focused on addition of CHP where digesters were already in-place.)
- WSSC has begun comprehensive feasibility evaluation of AD/CHP, gasification, and/or co-combustion. Scheduled completion is Summer 2011.
- Feasibility will be largely driven by cost of power, RPS goals and incentives, political will, public support, … .

Research Needs

- Emerging Technologies for Biosolids Management, EPA 832-R-06-005, September 2006 – see Chapter 9
- “State of Science Report: Energy and Resource Recovery from Sludge”, Global Water Research Coalition, 2008 – see Chapter 8 (Gaps in Knowledge)
- “BioEnergy Research: The Place Where Water Meets Energy”, WEF Residuals & Biosolids Workshop, May 2009

European Experience Converting Wastes Into Resources

- Gryaab & Henriksdal WWTPs (Sweden) digest biosolids & FOG; biogas is compressed and used to fuel transit buses. WWTP effluent used for district heating.
- Vasteras WWTP (Sweden) co-digests biosolids, source separated organics, & FOG. Semi-annually also supplement with Ley crop silage. NH3 rich centrate stored and land applied on farms in lieu of fertilizers.
- CAMBI AS thermal hydrolysis AD/CHP, one of multiple AD alternatives. Facility in Dublin IRE produces up to 4 MW; 1 WWTP.

from "Discussion Paper: Investigation of Examples of Integrated Resource Management in Sweden", 031-DP-2, CH2M-Hill, May 2008

European Experience Converting Wastes Into Resources

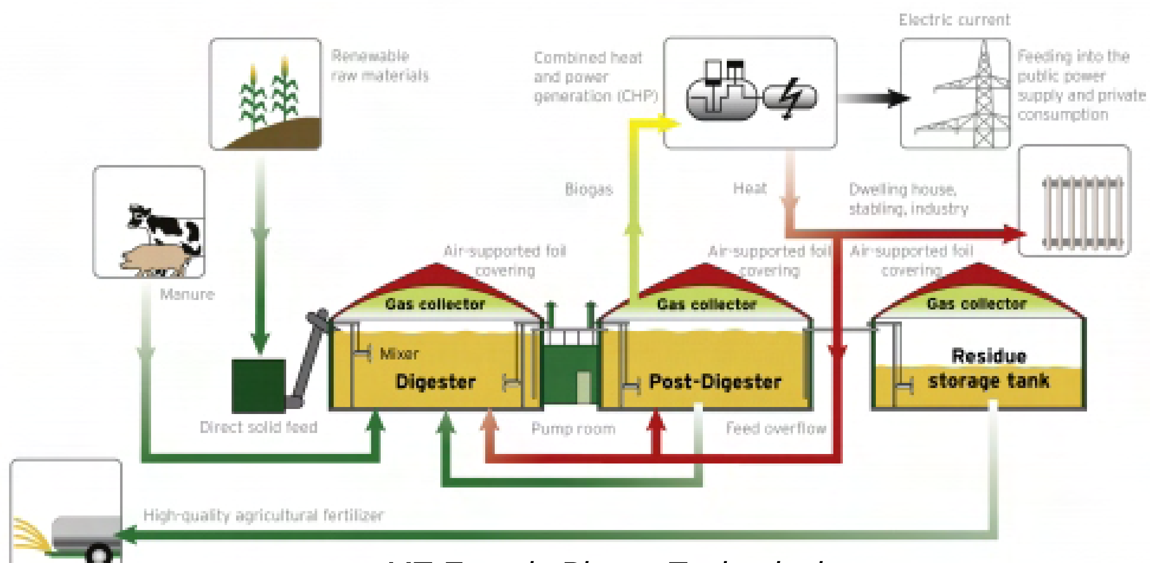
AD/CHP used even at small scales such as farms.

Farmatic, Hashoj, Danemark

Farmatic, Holsworthy England

EU leaders in biogas production (kilotons of oil equivalent), from www.eubia.org/108.0.html

Country	2001	2002	2003	2004	2005	2006
Germany	600	659	685	1291	1594	1923
United Kingdom	904	1076	1151	1473	1600	1696
Italy	153	155	155	203	344	354
Spain	134	168	257	275	317	334
France	196	302	322	359	220	227
The Netherlands	161	149	154	110	119	119
Austria	56	59	64	42	31	118



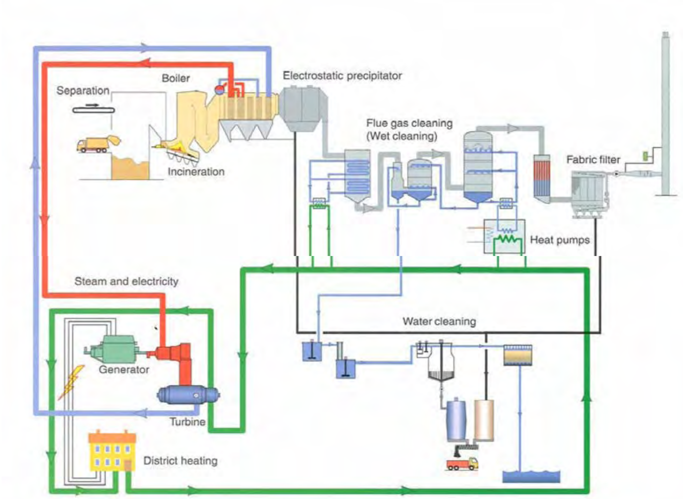
MT-Energie Biogas Technologie

European Experience Converting Wastes Into Resources

- Brugge & Brussels, Belgium + Copenhagen Denmark– ZEROFUEL drying and fluidized bed combustion.
- Germany & Netherlands are recognized as leaders in co-firing wastes (including biosolids) at power, WTE, & cement plants.
- AD/CHP of MSW focusing on segregated vegetable, fruit, garden, and paper waste via CAMBI, Dranco, Haase, Monsal, Passavant … systems.
- Renova MSW WTE facility (Sweden) with district heating loop for CHP.

Keppel Seghers drying & combustion facility in Brugge, Belgium

Monsal MSW digester at Kings Lynn, UK



from "Discussion Paper: Investigation of Examples of Integrated Resource Management in Sweden", 031-DP-2, CH2M-Hill, May 2008

Water/Wastewater as Users of Power and GHG Contributors

- Many factors – topography, influent water quality and quantity, treatment technology (lagoons, aeration basins, … membranes), levels of treatment (primary, secondary, nitrification, nutrient removal such as BNR or ENR, …), size / age / efficiency of facilities & equipment.

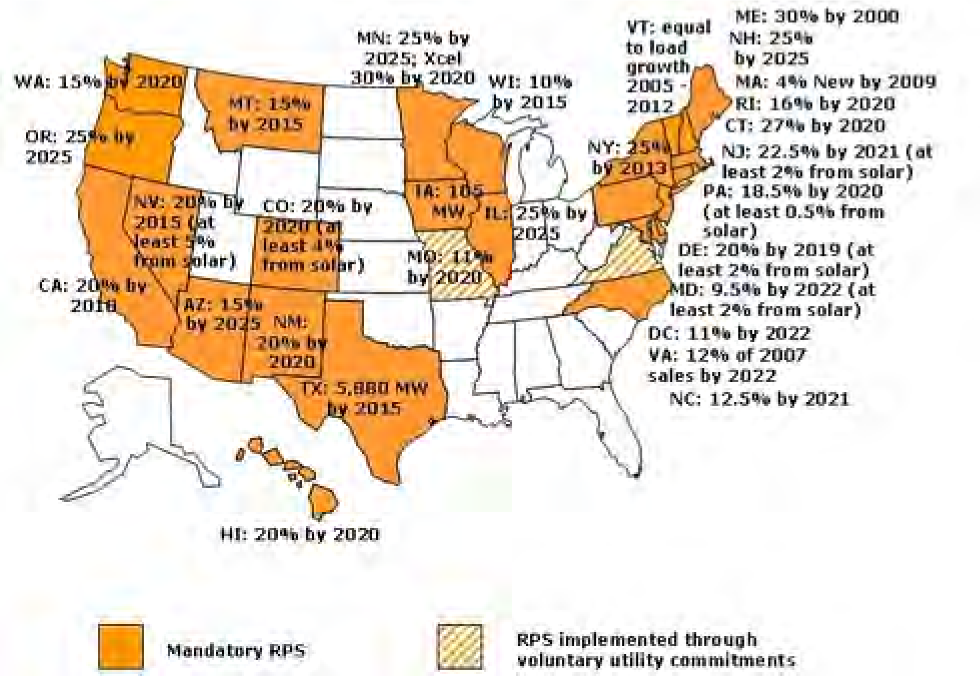
- Majority of power usage is typically associated with pumping and/or aeration, though biosolids handling can also be significant.

- California - 15% of energy used to pump water & wastewater + another 5% to treat – it is the largest energy consumer industry in the state.

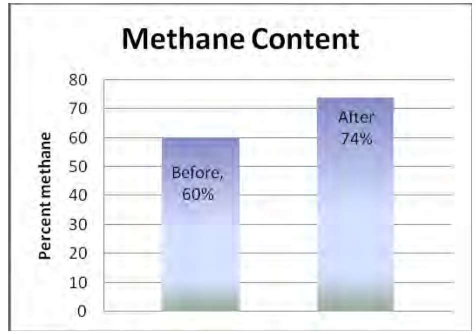
- Inventory of U.S. GHG Emissions & Sinks: 1990-2003 reports 95% of CO_2 (5,500 Tg/year CO_2 Eq.) originates from fossil fuel combustion – of which 40% originates from electricity generators; 7% of CH_4 (35 Tg CO2 Eq) originates from wastewater treatment; 5% of N_2O (15 Tg CO_2 Eq) originates from human sewage.

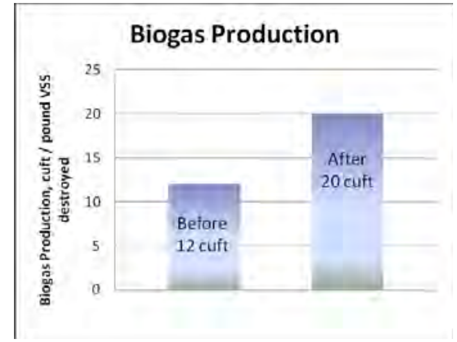
Drivers of Renewed Interest in U.S. AD/CHP

- Increasing cost of power.
- Focus on Green House Gases (GHGs).
- Renewable Portfolio Standards (RPSs).

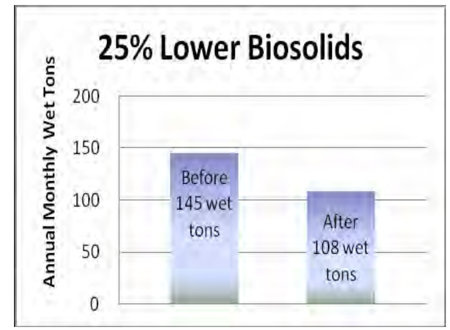


Recent U.S. AD/CHP Developments

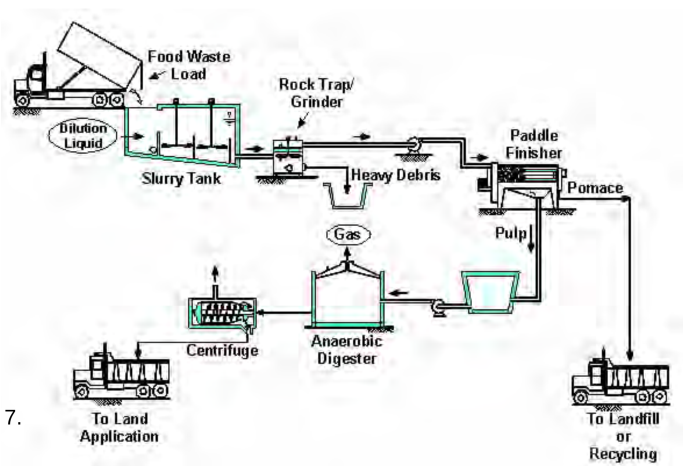


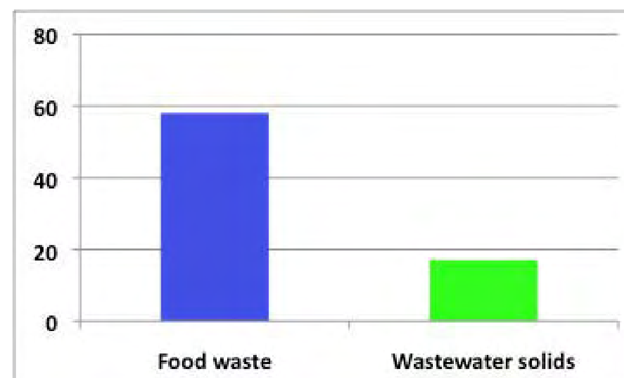


- Millbrae, CA – supplement biosolids AD/CHP with Fats, Oils, & Grease (FOG).



- Oakland, CA (East Bay Municipal District / EBMUD) – supplement biosolids AD/CHP with food waste.

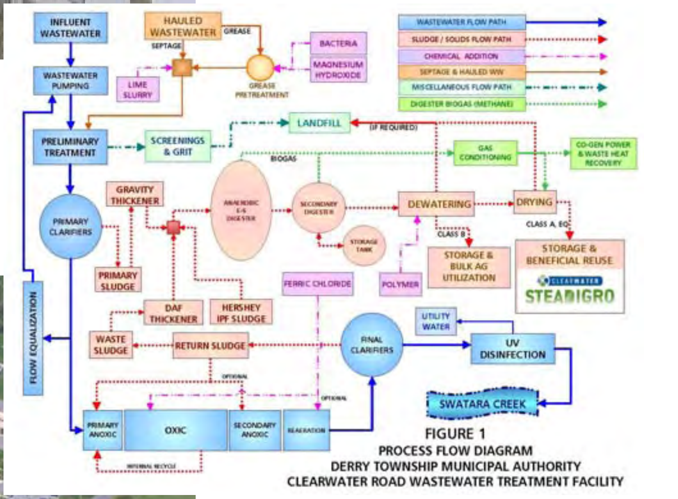




Use of AD/CHP in MD/DC/PA

- Baltimore's Back River WWTP
- Howard County's Little Patuxent WRF
- Washington DC's Blue Plains WWTP
- Hershey PA's Derry Township WWTP

Back River WWTP AD/CHP (Three 1MW Gensets)



Derry Twsp WWTP in Hershey PA (1.5MkWh produced annually)