Zero Net Energy: Case Studies of Wastewater Agencies Achieving Energy Self-Sufficiency, Revisited

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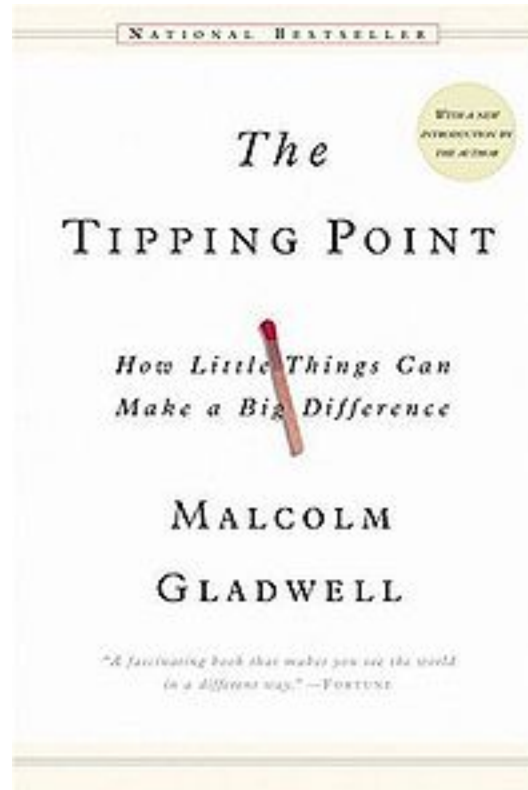
NJWEA 95th Annual Conference
Thursday, May 13, 2010

Are We at the "Tipping Point"?

- Malcolm Gladwell, author of Tipping Point, b. 1987; father a civil engineering professor
- "the moment of critical mass, the threshold, the boiling point."
- Discusses potentially massive implications of small-scale social events.
- Says real change is possible



7 DEADLY SINS

sins virtues features gallery resources tales stuff

S I N S

Click on the sin for a more in-depth review. Related topics are listed below.

Pride is excessive belief in one's own abilities, that interferes with the individual's recognition of the grace of God. It has been called the sin from which all others arise. Pride is also known as Vanity.

Envy is the desire for others' traits, status, abilities, or situation.

Gluttony is an inordinate desire to consume more than that which one requires.

Lust is an inordinate craving for the pleasures of the body.

Anger is manifested in the individual who spurns love and opts instead for fury. It is also known as Wrath.

Greed is the desire for material wealth or gain, ignoring the realm of the spiritual. It is also called Avarice or Covetousness.

Sloth is the avoidance of physical or spiritual work.

PRO PUBLICA

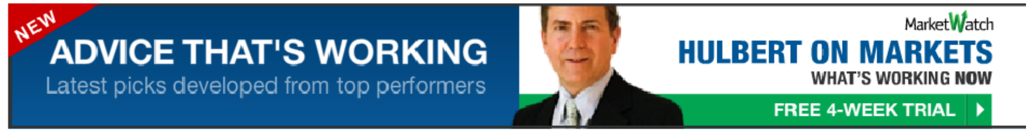
The Magnetar Trade: How One Hedge Fund Helped Keep the Bubble Gc (Single Page)

by Jesse Eisinger and Jake Bernstein, ProPublica - April 9, 2010 1:00 pm EDT

- 360 retweet
- Share 2144
  - 27
- Buzz up! (69)

A hedge fund, Magnetar, helped create arcane mortgage-based instruments, pushed for risky things to go inside them and then bet against the investments. (Ethan Miller/Getty Images)

"But the shale discoveries complicate the issue, making it harder for wind, solar and biomass energy, as well as nuclear, to compete on economic grounds."



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THE WALL STREET JOURNAL.
WSJ.com

MAY 10, 2010

Shale Gas Will Rock the World

Huge discoveries of natural gas promise to shake up the energy markets and geopolitics. And that's just for starters.

By AMY MYERS JAFFE

There's an energy revolution brewing right under our feet.

Over the past decade, a wave of drilling around the world has uncovered giant supplies of natural gas in shale rock. By some estimates, there's 1,000 trillion cubic feet recoverable in North America alone—enough to supply the nation's natural-gas needs for the next 45 years. Europe may have nearly 200 trillion cubic feet of its own.

We've always known the potential of shale; we just didn't have the technology to get to it at a low enough cost. Now new techniques have driven down the price tag—and set the stage for shale gas to become what will be the game-changing resource of the decade.

I have been studying the energy markets for 30 years, and I am convinced that shale gas will revolutionize the industry—and change the world—in the coming decades. It will prevent the rise of any new cartels. It will alter geopolitics. And it will slow the transition to renewable energy.

To understand why, you have to consider that even before the shale discoveries, natural gas was destined to play a big role in our future. As environmental concerns have grown, nations have leaned more heavily on the fuel, which gives off just half the carbon dioxide of coal. But the rise of gas power seemed likely to doom the world's consumers to a repeat of OPEC, with gas producers like Russia, Iran and Venezuela coming together in a cartel and dictating terms to the rest of the world.

The advent of abundant, low-cost gas will throw all that out the window—so long as the recent drilling catastrophe doesn't curtail offshore oil and gas activity and push up the price of oil and eventually other forms of energy. Not only will the shale discoveries prevent a cartel from forming, but the petro-states will lose lots of the muscle they now have in world affairs, as customers over time cut them loose and turn to cheap fuel produced closer to home.

The shale boom also is likely to upend the economics of renewable energy. It may be a lot harder to persuade people to adopt green power that needs heavy subsidies when there's a cheap, plentiful fuel out there that's a lot cleaner than coal, even if gas isn't as politically popular as wind or solar.

Virtues:

- **The Seven Contrary Virtues:** humility, kindness, abstinence, chastity, patience, liberality, diligence
- **The Cardinal Virtues:** prudence, temperance, courage, justice
- **The Theological Virtues:** love, hope, faith
- **The Seven Heavenly Virtues:** faith, hope, charity, fortitude, justice, temperance, prudence

Net Zero Energy – Hope, Faith, Temperance, Fortitude, Prudence?

Multiple Drivers: Facility and Location Specific

- Leadership Goals: The Exciting Vision
- Energy Pricing: High Costs and Subsidies
- New Regulations, Now or Anticipated
- State and Federal Grants for Projects
- Environmental Ideals of Community
  - Greenhouse Gases
  - Carbon Footprint
- Need for Capital Replacement

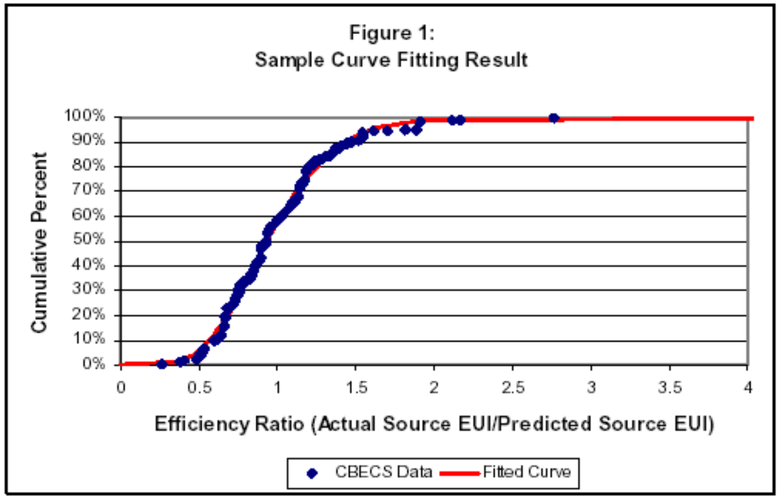
Listening for Virtuous Technologies

- Biosolids Management: Assessment of Innovative Processes (WERF, 1997) review of 110 embryonic, innovative and established technologies. About half have disappeared.
- Criteria for Virtuous Technologies
  - Need no subsidies
  - Need no hype
  - Make sense by the “TBL”
  - Responsible and robust

Much WWT is Fundamentally Screwy

- Toronto Calorimetry Study
  - Wastewater contains10 times the energy required for treatment
- Energy embedded in wastewater
  - Could meet between 2% and 12% of the national electricity demand
- Current WWT process is essentially an exercise in growing bacteria.
  - Food & nutrition, in the form of wastewater,
  - Give them air and oxygen, which consumes energy,
  - End up with a waste sludge which we have to dispose of

Electricity Usage Benchmarks



AwwaRF Index/EPA Energy Star

Wisconsin Focus on Energy

focus on energy

The power is within you.

WEF Manual

ACE3

ACEEE WATER AND WASTEWATER ENERGY ROADMAP (WWER) 2004

Stakeholder Survey Results

One in a Series of ACEEE White Papers

Prepared by Elizabeth Brown and Neal Elliott

DRAFT: June 4, 2004

Typical Wastewater Electricity Use

Estimates of Electricity Used in Wastewater Treatment

kWh per MG treated (assumes belt filter press, no UV disinfection)

Source: "Energy Conservation in Water and Wastewater Facilities, WEF MOP No. 32, Appendix C)

Type of Treatment	1 MGD	10 MGD	100 MGD
Trickling Filter Plant	1,811	852	673
Activated Sludge Plant	2,236	1,203	1,028
Advanced Wastewater Treatment Plant (no nitrification)	2,596	1,408	1,188
Advanced Wastewater Treatment Plant (with nitrification)	2,951	1,791	1,558

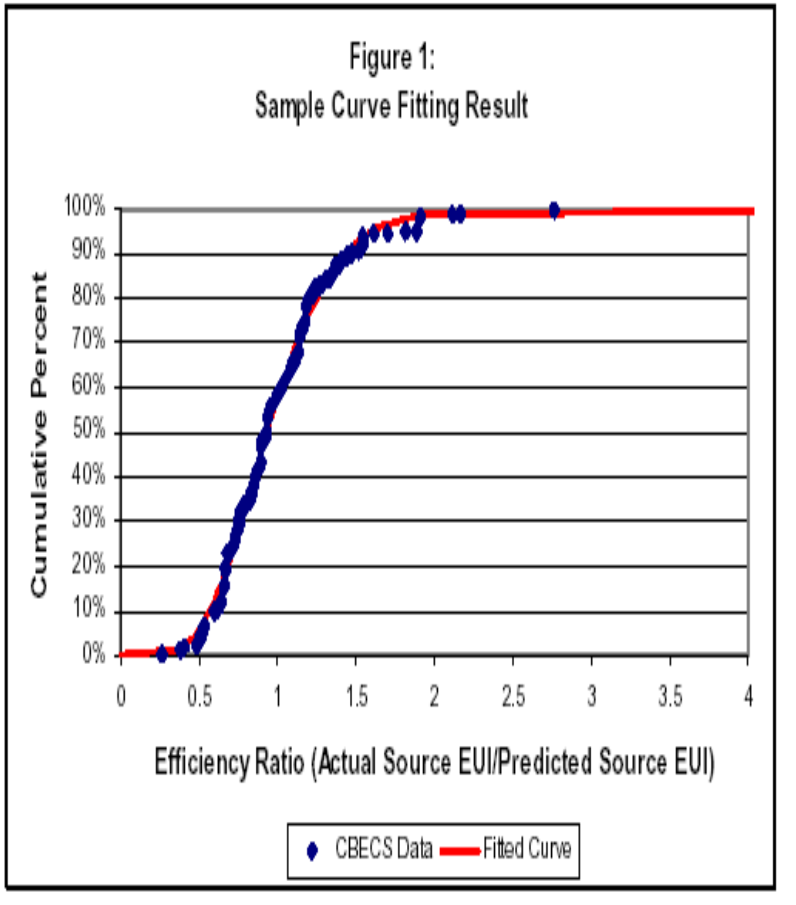
WEF Manual: Electricity Use by Process

(in kWh/MG)from WEF M.O.P No. 32, "Energy Conservation in Water and Wastewater Facilities, Ap C)

	1 MGD	10 MGD	100 MGD
Wastewater Pumping	171	140	118
Screens	2	1	1
Aerated Grit Removal	49	13	12
Primary Clarifiers	15	16	16
Aeration	532	532	532
Biological Nitrification	346	345	340
Return Sludge Pumping	54	51	38
Secondary Clarifiers	15	16	15
Chemical Addition	80	55	42
Filter Feed Pumping	143	82	67
Filtration	137	39	34
Thickening	6	203	131
Digestion	1200	170	155
Dewatering	0	46	25
Chlorination	1	3	3
Lighting and Buildings	200	80	30
Total Process	2951	1792	1559

AwwaRF: Energy Index Development for Benchmarking Water and Wastewater Utilities (Devine et al, 2007, 196pp)

Survey of Literature and utility operations to develop a statistical basis for the EPA Energy Star performance rating for wastewater.



Different Approaches to NZE

- Can Target Net Zero Electricity
  - Distributed electricity production: solar, wind, biomass
- Can Embrace Peak Electricity Reduction
  - Demand Management
- Can Move to Net Zero Energy
  - Electricity balanced with Gas
- Each Approach Can Achieve NZE
  - High energy efficiency - Strass
  - Supplemental biogas production - EBMUD
  - Alternative energy development – ACUA

Energy Payback from Process Improvements: 30 to 50% Reduction

Carns, Global Energy Partners, LLC 2003

Energy Impacts of New Technologies - Energy Savers in Wastewater Treatment

Technology	kWh/MG	kWh / 1,000 m^3
Fine pore diffusers	140	37
Ultra-fine pore diffusers	210	55
DO control systems	50 to 100	13 to 26
Blower control systems	50 to 150	26 to 40
Energy efficient blowers	100 to 150	26 to 40

NZE Thru Efficiencies: Strass, Austria

Strass WWTP: Serves tourist population; 200,000 pe in summer)

Percentage of energy self-sufficiency was steadily improved starting from 49% in 1996 to 108% in 2005, without co-substrates

- Biogas converted to electrical energy by the 340 kW CHP unit at a high average efficiency of 38%.
- Maximum transfer of organics to digesters increased organic loading, decreased SRT and increased gas production
- Intermittent aeration controlled by on-line effluent ammonia
- Energy savings from side-stream treatment using DEMON®-process for deammonification

Strass and Beyond in Austria

"Energy self-sufficiency as a feasible concept for wastewater treatment systems"

B. Wett, K. Buchauer, C. Fimml

22 SEPTEMBER 2007 ***Asian Water***

"operational optimisations, which came up with average energy saving potentials of about 30-50% for existing utilities."

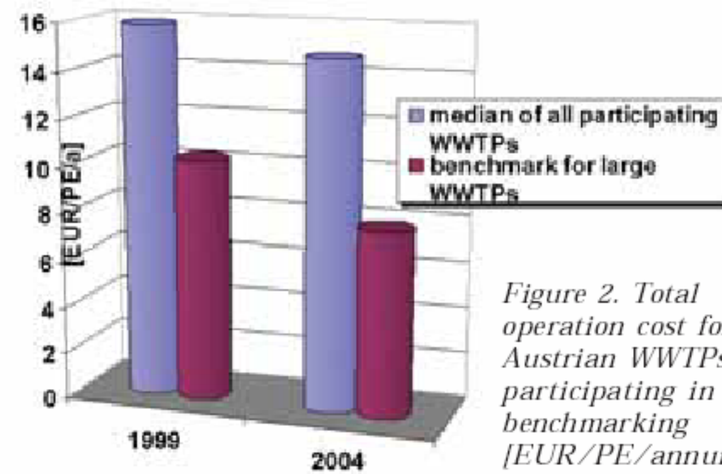


Figure 2. Total operation cost for Austrian WWTPs participating in benchmarking [EUR/PE/annum]

Anaerobic Digestion for Biogas

- Evolving Purpose of Digestion
  - Solids reduction for operational efficiency
  - Pathogen and Odor Control for regulations
  - Biogas production for energy efficiency
- Optimizing Digester Performance
  - From a standard of 38% to 50% to 65%+
  - Measuring performance as gas yield per feed mass (cubic feet of gas per pound of VS feed or milliliter of gas per gram of feed)

Gas Treatment Technology

Pretreatment of Wastewater Sludges
(from Dru Whitlock, et al, CH2M Hill)

- ***Processes and Mechanisms:*** *Sonication, Thermal Hydrolysis, Cambi Thermal Hydrolysis Process, BioThelys Process, Homogenization, Pressure Release*
- ***Mechanical Shearing Methods:*** *ABS-Kady Biolysis Process, Lysate Centrifuge, Pulsed Electric Field*

Oxley Creek Water Reclamation Plant, Brisbane, Australia

- "Evaluation, selection and initial performance of a large scale centralised biosolids facility at Oxley Creek Water Reclamation Plant, Brisbane," K. G. Barr, D. O. Solley, D. J. Starrenburg and R. G. Lewis, Water Science & Technology57.10, 2008
- Thermal hydrolysis of WAS prior to digestion:
  - Twice the VSR,
  - twice the gas production,
  - one-half the digester capacity,
  - twice percent solids from dewatering,
  - yielding 70% reduction in wet volume of biosolids for disposal.

Advanced Anaerobic Digestion
(from Dru Whitlock, et al, CH2M Hill)

Multiple Goals: Pathogens, Odors, Energy, VSD

- ***Conventional High Rate with Recuperative Thickening AD System***
- ***Processes Employing Mesophilic Temperatures***
  - *Mesophilic Acid Hydrolysis—Single Tank AD System*
  - *Mesophilic Acid Hydrolysis—Plug Flow AD System*
- ***Processes Employing Thermophilic Temperatures***
- ***Temperature-Phased AD Systems***

Co-Digestion as Improving Asset Use

(D. Parry, CDM)

Vegetable Oil

Restaurant Grease

Chicken Waste

Excess Anaerobic Digestion and Cogeneration Capacity

Gas Clean-up and Electricity Generation

Lethbridge Wastewater Treatment Plant, Alberta, Canada

Co-Digestion Approaches

(from Dru Whitlock, et al, CH2M Hill)

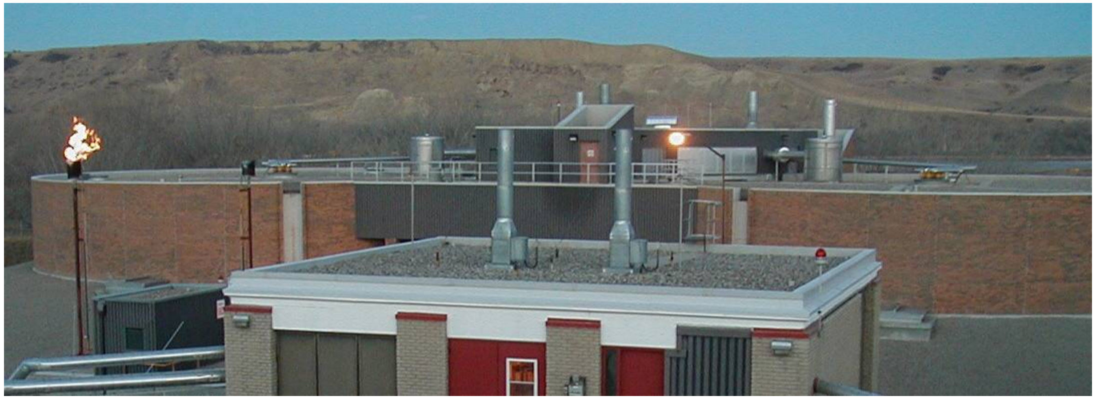
- ***Co-Digestion of Combined Municipal PS + WAS and Expired Produce (EBMUD)***
- ***Codigestion of Combined Municipal PS + WAS and Manure (IEUA)***
- ***Biogas Production from High Solids Content Food and Green Wastes (UC Davis Trial of APS)***

Organic Waste-to-Energy Research

(Several projects with DOD, WERF, Edmonton Centre of Excellence, Recycling Companies and CDM (D. Parry, CDM))

Edmonton, Canada

- **Bench: Waste Characterization**
- **Lab: Acclimation**
- **Pilot: Scale up (Food to Fuel)**
- **Full scale: Demonstration**
  - Organic loading rate & digester performance
  - Waste characterization & biogas production



Municipal Anaerobic Digesters for Codigestion, Energy Recovery, and Greenhouse Gas Reductions

Table 2—Full-scale codigestion test conditions.

Codigestate	Control system data source*	Codigestate feeding method	Type of municipal sludge fed
ADW	Digester operated in parallel with codigester, but fed only municipal sludge	Fed directly to digester	Mixture of primary sludge and TWAS
Food flavorings production waste	Codigestion system during subsequent period when only municipal sludge was fed	Fed directly to digester	Primary sludge
Restaurant waste	Codigestion system during subsequent period when only municipal sludge was fed	Codigestate was passed through a comminutor at the restaurant, trucked to the treatment plant, and fed to the primary clarifier, with primary sludge conveyed through a sludge screen and then to the digester	Primary sludge

* Control systems were operated similarly to codigestion systems, except that only municipal wastewater sludge was fed to the control systems.

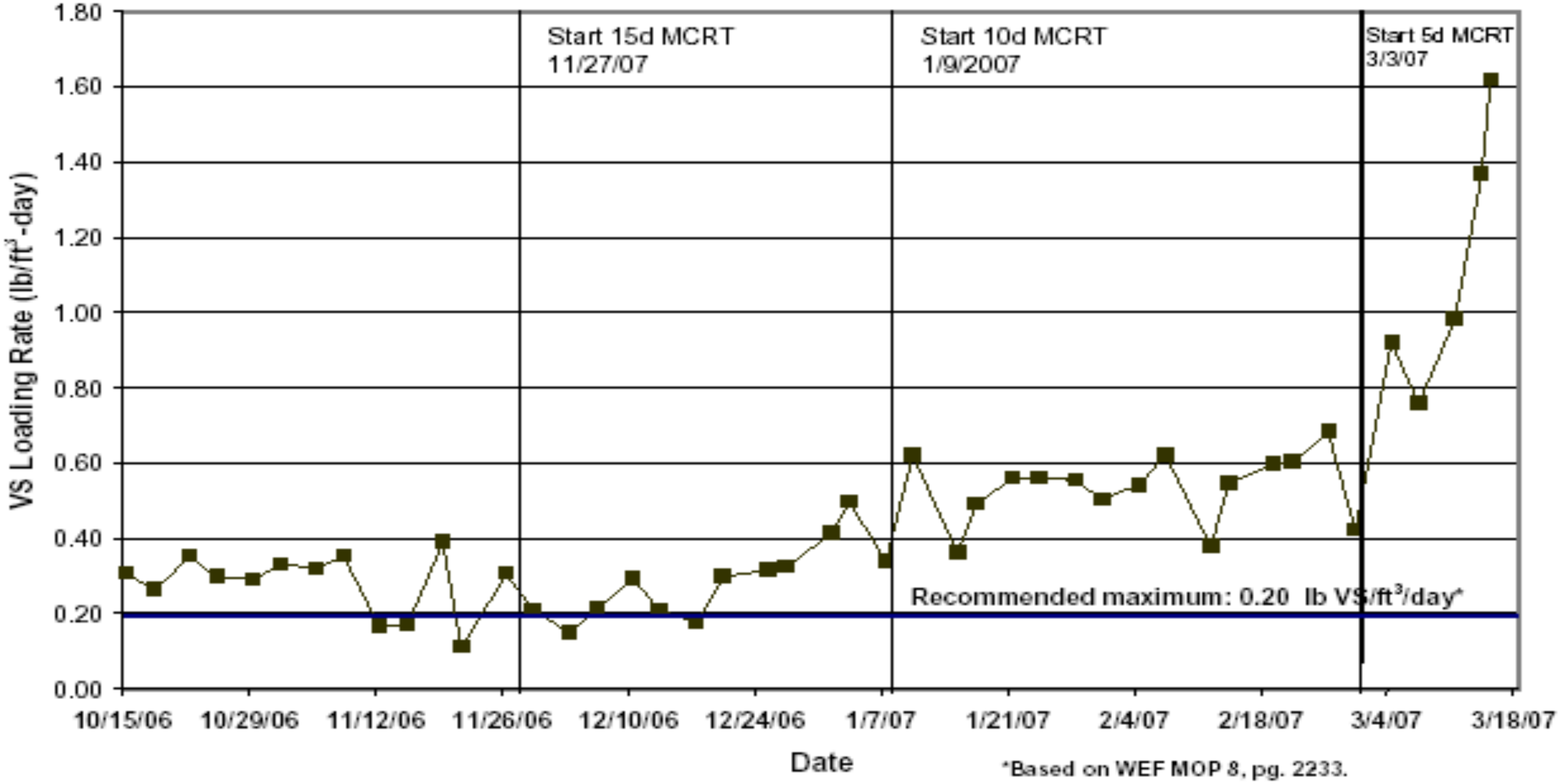
East Bay MUD (Oakland, CA): Leader in Organic Waste Processing

- 1985 Cogeneration installed
- 2000 50% of electricity produced
- 2002 “Trucked Waste Acceptance”
- 2004 Post consumer food waste accepted
- 2007 100% of electricity produced
- 2010 2X biogas production; 2 new 4.5 MW
- Future: vehicle fuels, revenue from RECs

EBMUD: Food Waste Pulp for A.D.

EBMUD Digester Loading Rate

Figure 8 - Anaerobic Digestion of Food Waste Pulp Bench-Scale Study: Volatile Solid (VS) Loading Rate



Wastewater and Organic Waste Treatment Center, (D. Parry, CDM)

Des Moines Wastewater Treatment Plant, Des Moines, IA

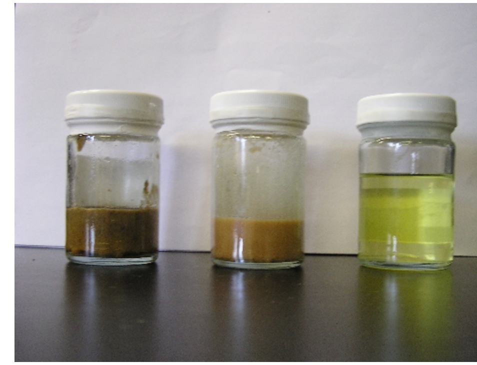
Comprehensive Biogas Treatment and Cogeneration System, (D. Parry, CDM)

Replaced 200 KW Phosphoric Acid Fuel Cell with two 800 kW Internal Combustion Engine-Driven Generators

Columbia Blvd Wastewater Treatment Plant, Portland, Oregon

FOG can be converted to biodiesel or biomethane

(D. Parry, CDM)

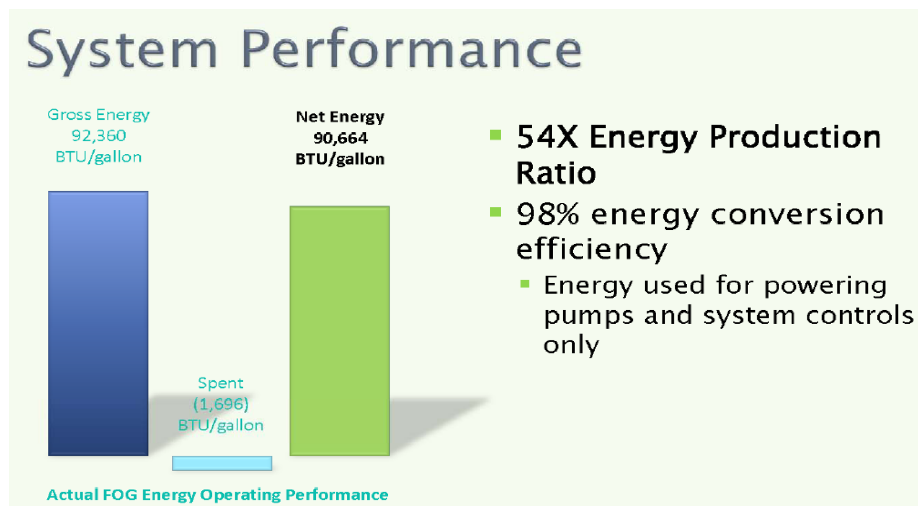


FOG (fats, oils, grease)

Biodiesel

Biomethane

Dick York, the champion of FOG for Anaerobic Digestion



Milbrae (CA) FOG Project

How did we boost bioavailability?

- **Automated Preconditioning**
  - Treatment begins immediately as FOG is off loaded.
  - FOG is combined with actively digesting sludge in a precise ratio.
- **'Bioreactor' Storage**
  - FOG-Sludge Mixture Blended into miscible, stable slurry. NO separation, NO clogs.
  - Chemical composition is changed, surface area maximized.
- **Continuous introduction**

Connects with Recycling Goals: Food Waste Supplementation in Ontario

ORMI's Solution – Best of Class (after 20 years)

- Organic Resource Management Inc.
  prepares food scraps for anaerobic digestion *(Biocycle 2010)*

Full Service Collection and Processing\

ORMI Harvests Feedstock – that is all we do

Potential of Co-digestion (IEA Bioenergy)

>121 codigestion plants in Europe

Legislation on organic waste reduction in landfills in selected European countries

COUNTRY	BANNING YEAR	CRITERIA / REMARKS
EU		Reduction of untreated organic waste to 35% by 2014
Austria	2004	Waste >5% TOC or Upper heating value >6 MJ/kg TS
Denmark	1997	Ban for all wastes that can be incinerated
Finland	2002	All wastes shall be treated prior to landfill
Sweden	2005	All untreated organic wastes
Switzerland	2000	All organic waste
U.K.		Reduction targets for biodegradable wastes based on 1995 levels: Down to 75% by 2010; down to 50% by 2013 and down to 35% by 2020. Since 2001 new landfills must only take pretreated waste

Large scale co-digestion plant, Holsworthy, UK
(Picture courtesy of Rudolf Braun, Austria)

Large Scale Centralised Co-digestion Plant Grindsted, Denmark
(Picture courtesy of Rudolf Braun, Austria)

Large Scale Centralised Co-digestion Plant Lemvik, Denmark (Picture courtesy of Teodorita Al Seadi, Denmark)

Technology Works Internationally: Grevesmuhlen, Germany

"Can a wastewater treatment plant be a powerplant? A case study," N. Schwarzenbeck, E. Bomball and W. Pfeiffer, WS&T, 57.10, 2008.

- Grevesmuhlen, northern Germany (72,000 pe)
- Degradation of sludge solids 20% higher with a dry residue load of 30% grease skimmings added to AD
- Gas increase with no adverse effect on AD, no solids increase from digester
- Power increased to 103 kW from 30 kW.

Grevesmuhlen, Germany Grevesmuhlen, Germany

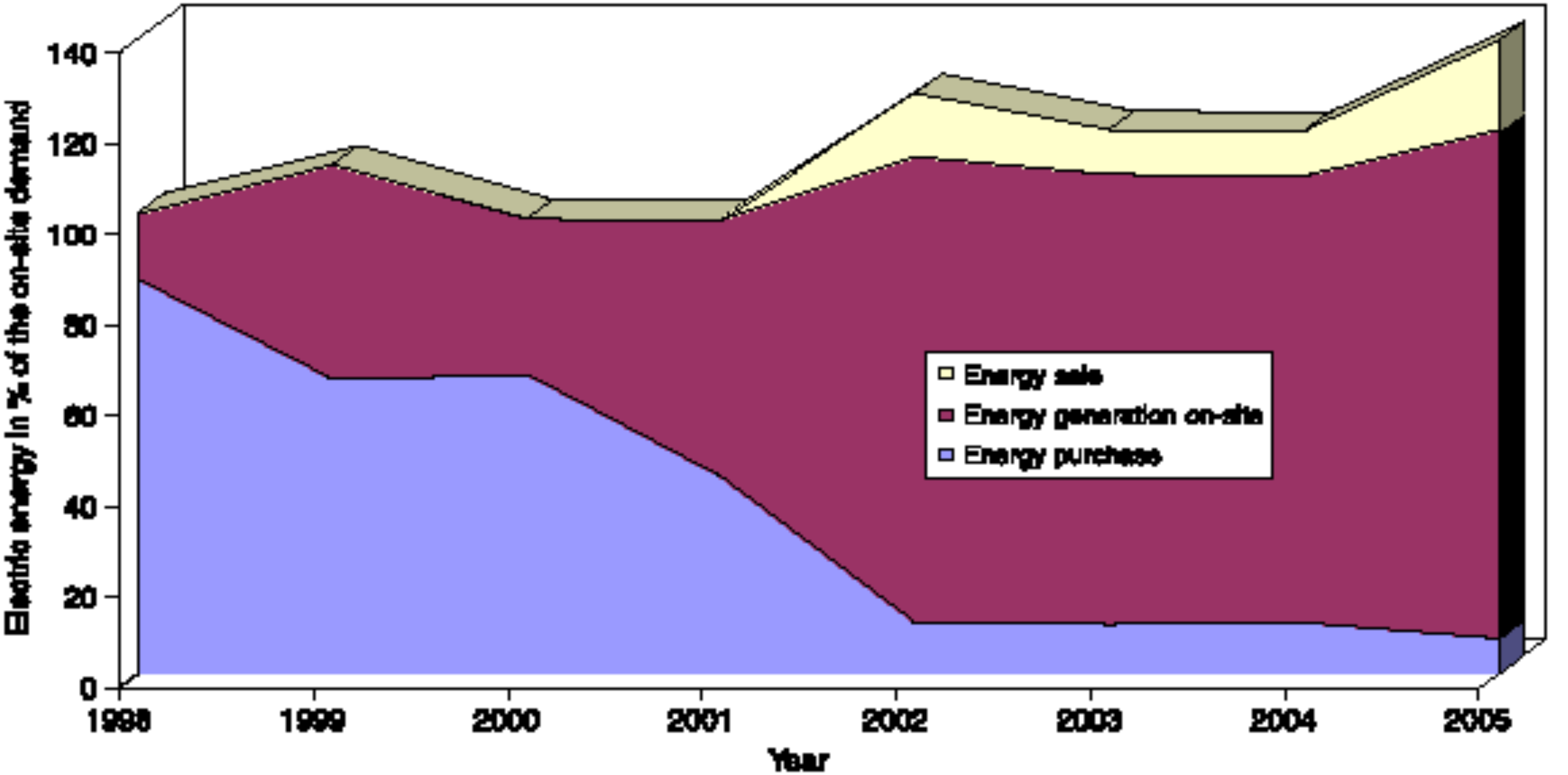


Figure 8 | Development of acquisition, generation and sale of electric energy.

“The optimisation of food waste addition as a co-substrate in anaerobic digestion of sewage sludge,”

Hyun-Woo Kim, Sun-Kee Han and Hang-Sik Shin, *Waste Manag Res,* 2003; 21; 515

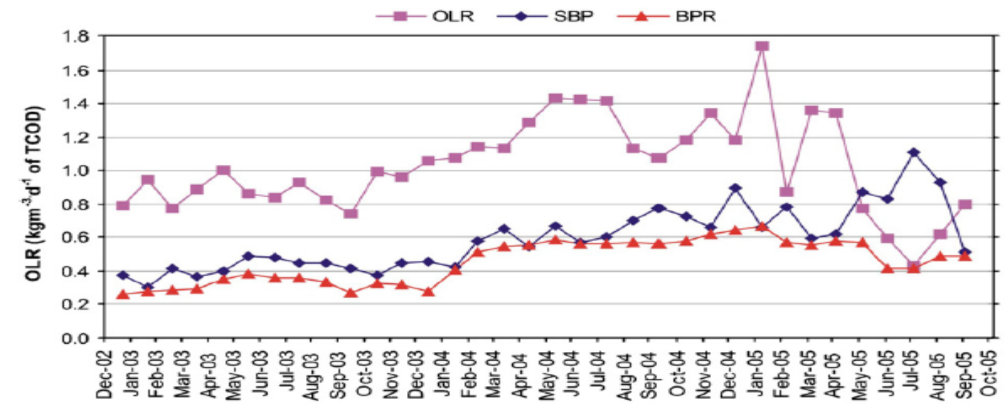
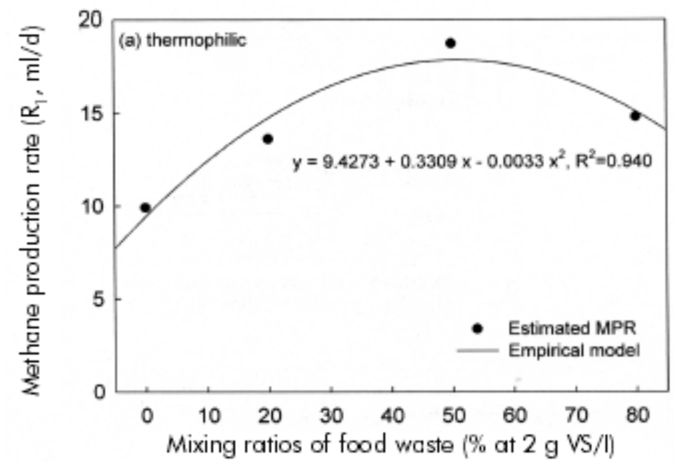


Fig. 3 – OLR and monthly average biogas production.



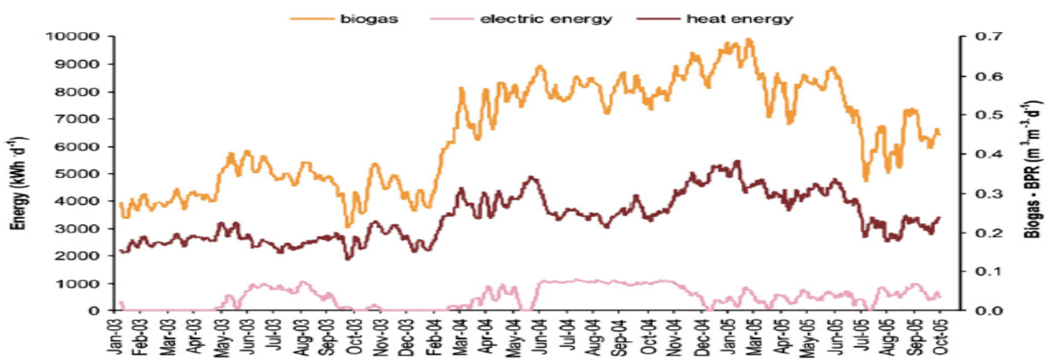


Fig. 4 – Daily biogas production and power output.

Velenje, Slovenia

Municipality of Velenje operates a WWTP of 50,000 population equivalents (PE) with two mesophilic anaerobic digesters of a combined volume of 2000 m3

- Virtually complete degradation of Organic Waste
- no increase in effluent VSS during the experiment
- degradation efficiency increased from 71% to 81%.
- 80% increased biogas quantity.
  - Biogas Production Rate increased from 0.32 to 0.67m3m-3digester d-1.
  - Specific Biogas Production increased from 0.39 to a peak of 0.89m3 kg-1 VSS inserted.
- Electrical energy production increased by 130% and heat energy production increased by 55%.

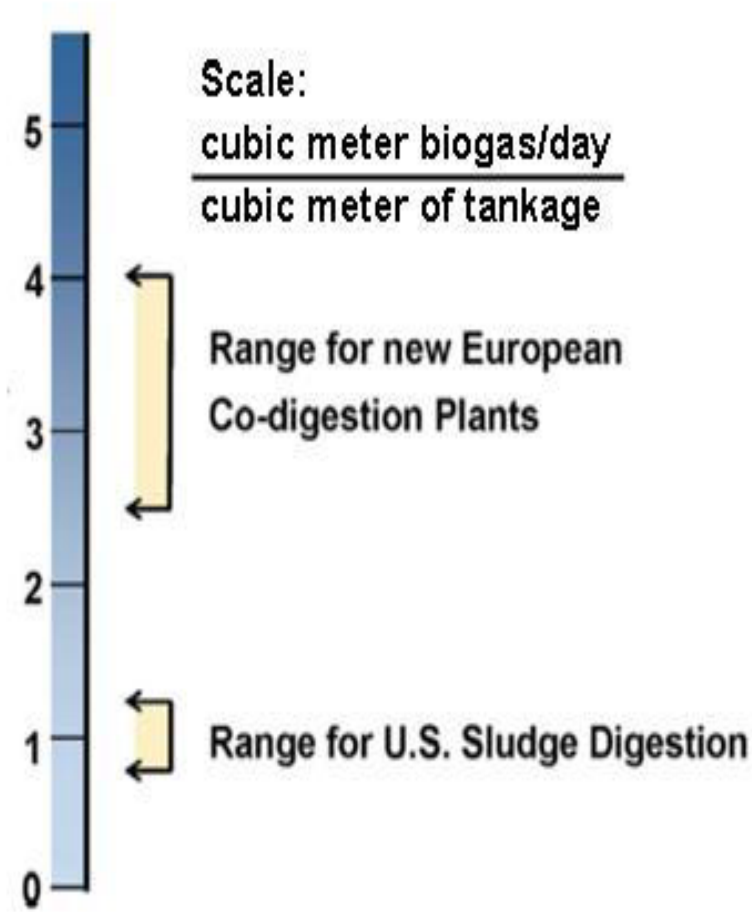
Integrated Sustainable Solutions – Co-digestion of Solid Waste at WWTPs and the BTA Process as a Pretreatment Step

Joerg Blischke, Alan Wong, Kevin Matthews, WEFTEC 2009

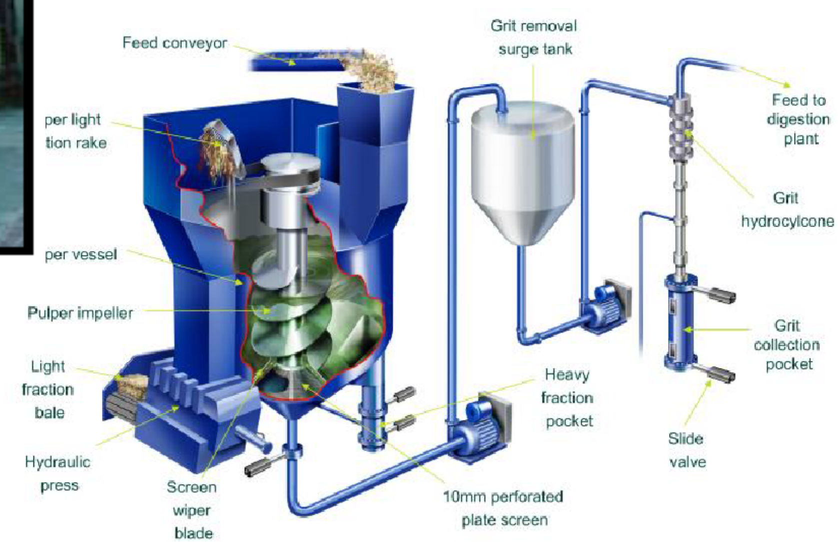
- More than a dozen WWTPs and centralized AD plants use BTA to accept organic feedstock for co-digestion with biosolids
- Typical co-substrate addition rates range between 5 and 20 percent by weight of sludge feed
- Biogas yield raised by 40 to 230 percent

Improving the Usage of Digester Assets: Increasing Organic Loading Rate

- Gas Production Efficiency Comparison (Adapted from Schafer and Lekven, 2008)

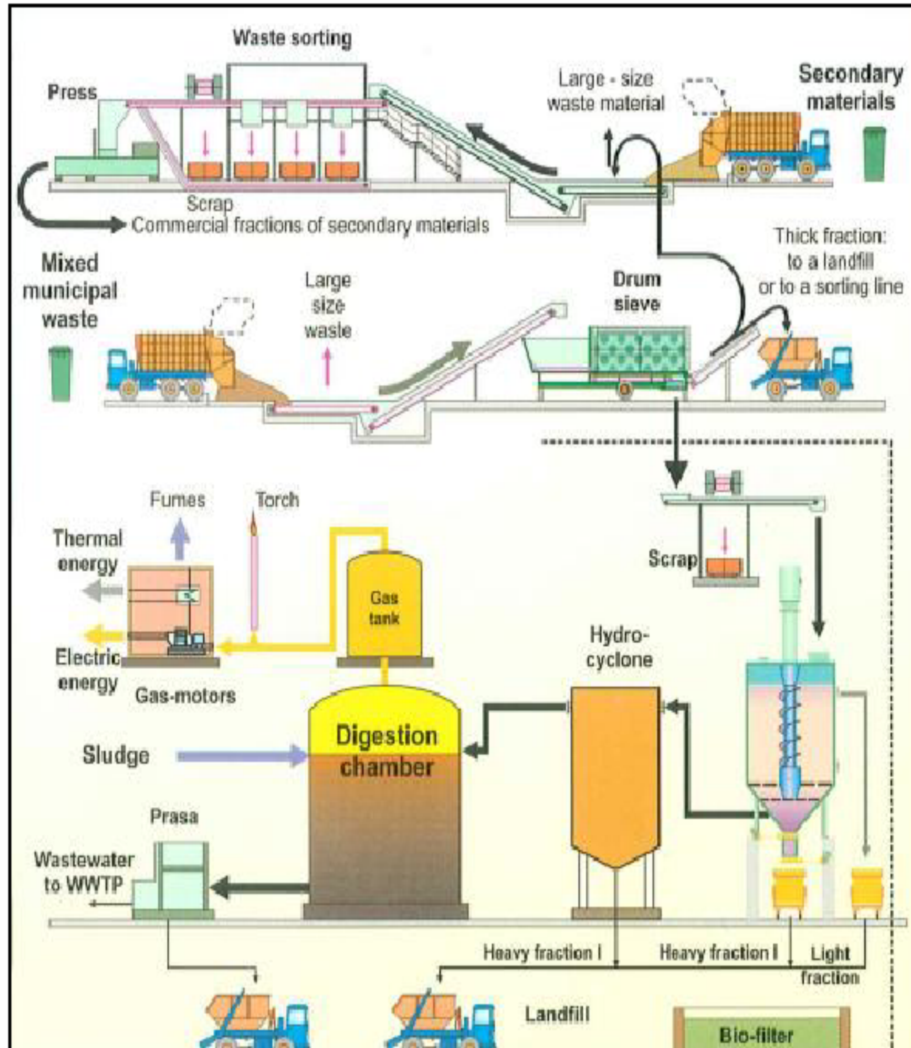


Integrated Sustainable Solutions - The BTA Process – Hydropulper & Grit Removal System



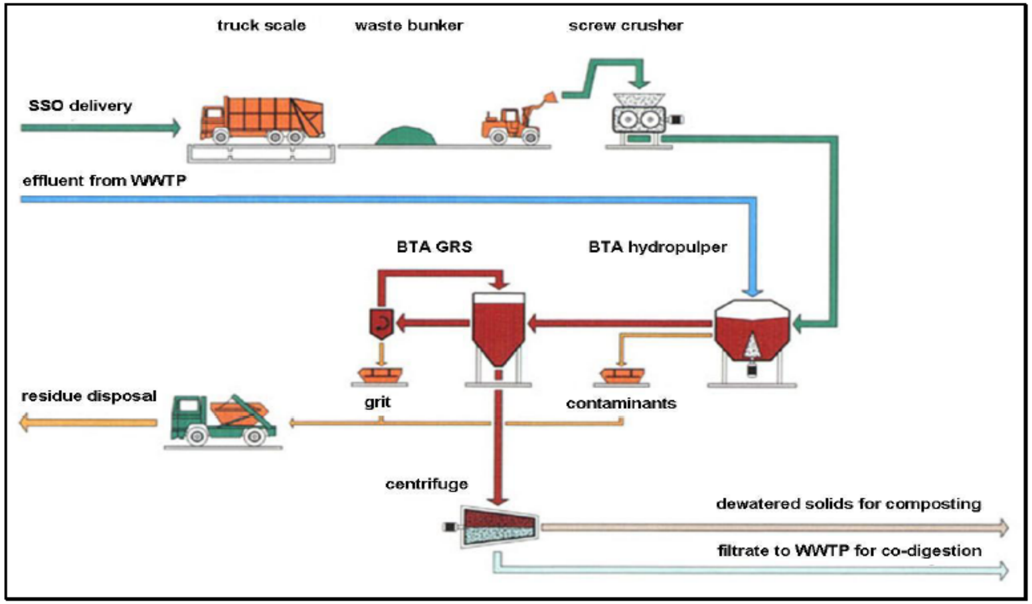
BTA Example: **Pulawy, Poland**

- Start-up: 2001
- Capacity: 22,000 MT/yr
- Waste input: OFMSW (mechanically pre-treated municipal solid waste)
- Process: BTA Pre-treatment prior to co-digestion at WWTP
- The waste treatment facility in Pulawy, Poland is located at the city's landfill site and processes
- 22,000 tons per year of mixed MSW.



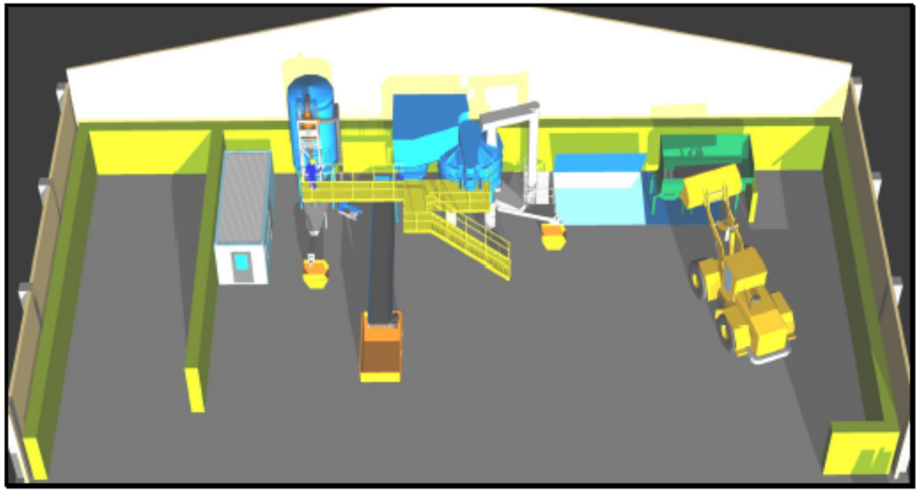
BTA Example: **Baden-Baden, Germany**

- Start-up: 1993
- Capacity: 5,000 MT/yr
- Waste input: Biowaste (residential SSO mixed with some yard waste; commercial SSO (primarily restaurants and cafeterias)
- Process: Waste receiving area; size reduction of the biowaste via screw crusher; BTA pretreatment; solid-liquid separation and co-digestion of filtrate at WWTP



BTA Example: **Leoben, Austria**

- Start-up: Spring 2009
- Capacity: 18,000 MT/yr
- Waste input: Biowaste (residential SSO mixed with some yard waste); commercial SSO (restaurants; grocery stores, dairy sludge); grass clippings
- Process: Waste reception; size reduction of the biowaste via screw crusher; BTA pretreatment prior to co-digestion at WWTP



Kingston (NY) WWTP Dryer by Aslan Environmental Services

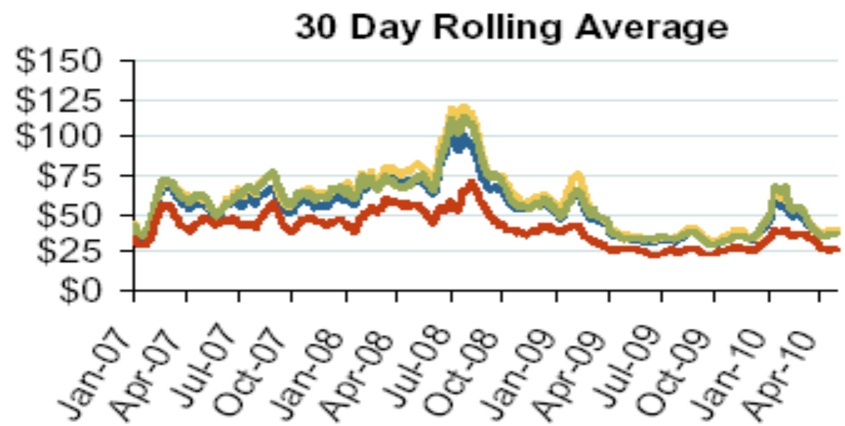
- 6 MGD conventional WWTP
- Until 4 years ago unsuccessful cogen,
- Installed Seeghers Dryers, modified for small scale applications, utilizing digester biogas
- Automatic operations 24-7
- Operational cost $250/dry ton
- Facility DBOO by Aslan; no public financing
- Pellets recycled at no cost to agency

Storing Biogas to Meet Peak Needs

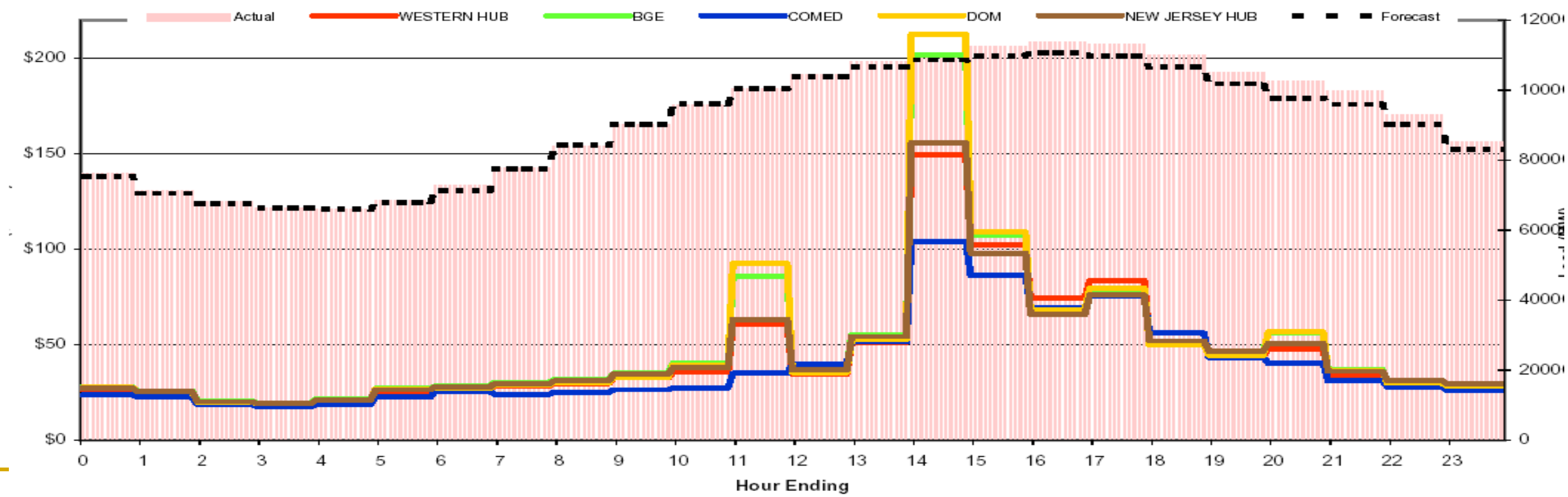
JDV DOUBLE MEMBRANE GAS HOLDER

The ***JDV* Double Membrane Gas Holder** is a proven design to store digester gas with low total cost of ownership. The storage system is easier to install, has lower upfront capital costs and requires lower operating capital when compared to other methods of gas storage.

Generating Electricity When Grid Prices Are High



Friday August 14, 2009



Advanced Process Control Technology

Welcome to **BioChem Technology**

BioChem Technology is a process consultation firm founded in 1979 that specializes in the monitoring, optimization and control of wastewater treatment processes. By combining high-level consultation services with a suite of proprietary monitoring technologies, BioChem's experts can show plant owners and operators how to meet increasingly stringent effluent standards, reduce operating costs, and increase the volume of wastewater flow treated—without major capital expenditures.

Leader in Alternative Energy: Atlantic County Utility Authority (ACUA)

ACUA: Wind Farm

- Five 14 foot diameter wind turbine towers. 262 feet high, each 1.5 MW at 14 mph wind.
- Blades are 120 feet long; total height from the ground to the tip of the blade over 380 feet (height of a 35 story building); turn 10 – 20 rpm, tip speed 120 mph.
- Privately owned by Jersey Atlantic Wind, LLC; cost over $12 million, with ACUA contract to purchase at fixed rate for 20 years.

Leader in Total Resource Management: Landis Sewage Authority

New Jersey's "Greenest" Wastewater Plant

- Zero discharge of effluent to surface waters
- Recycling of biosolids to farms and forests
- Anaerobic digester biogas fuels170 kW generator with thermal recovery for digester heating at $1.3 million
- Wind generator installed by LSA
- 4 MW solar panels on 14 acres developed in a "Public/Public/Private partnership"

Lille, Sweden: Digester Biogas to Vehicle Fuel

- 1.1 million people
- Biowaste and biosolids for anaerobic digestion
- 4 million cubic meters of purified biogas
- 150 municipal bus fleet fueled with compressed biogas

END USE SOLUTIONS

FOCUS

Small-Scale Natural Gas Liquefier

Gas Technology Institute (GTI) has developed small-scale natural gas liquefaction systems for use in vehicles, remote gas recovery, bio-gas recovery, and other specialty natural gas markets. This work is presently targeted at 5,000 to 30,000 gallon per day production capability. Linde BOC has licensed this technology and is actively pursuing commercialization on a world-wide basis.

Advances in N Removal with Novel Microbes Affect Energy Use and Production

ENGINEERING

Sewage Treatment with Anammox

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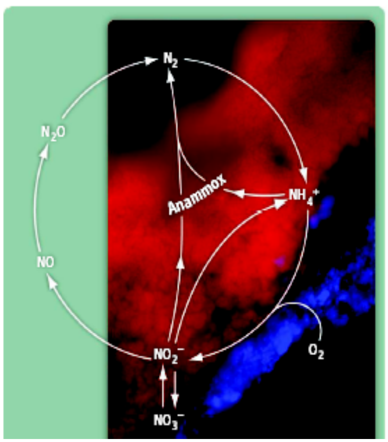
Wastewater treatment including high rat
anammox processes have the potential
to become energy-neutral or even
energy-producing.



The nitrogen cycle including anammox. Molecular nitrogen (N_2) is fixed biologically or industrially to ammonium (NH_4^+), the main fertilizer for plants. When ammonium is released to the environment, it may be oxidized by aerobic, nitrifying bacteria and archaea to nitrite (NO_2^-) and nitrate (NO_3^-), respectively, which plants can use as an additional nitrogen source. Under anaerobic conditions, nitrate and nitrite may be reduced back to ammonium, or to nitrogen gas through denitrification. Nitrite can also be combined with ammonium to give nitrogen gas in the anammox reaction. **(Background)** Outer layer of a compact nitrogen-producing granule for possible use in energy-generating wastewater treatment. The anammox bacteria (red) are on the inside of the granule; the nitrite-producing bacteria (blue) reside in a 40-µm-thick layer on the outside, ensuring that oxygen does not reach the anoxic anammox bacteria. The bacteria have been stained with fluorescent 16*S* rDNA probes.

Proceedings of the 11th World Congress on Anaerobic Digestion (AD11) 23-27 September 2007

Anammox brings WWTP closer to energy autarky due to increased biogas production and reduced aeration energy for N-removal

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Anaerobic Wastewater Innovations for Energy Efficiency

- **Anaerobic Membrane Bioreactors**

  Proposed demonstration plant at the Masdar Ecocity in Abu Dhabi.

- **Microbial Fuel Cells**

  The Israeli company EMEFCY is marketing the MEGAWATTER process which does just this.

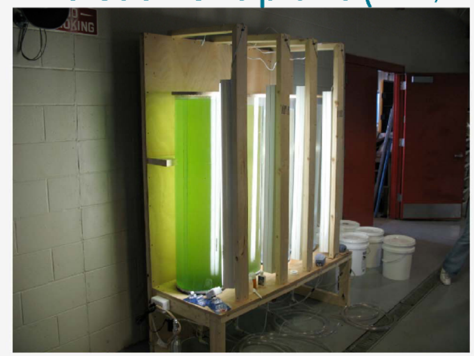
- **Advanced Primary Treatment**

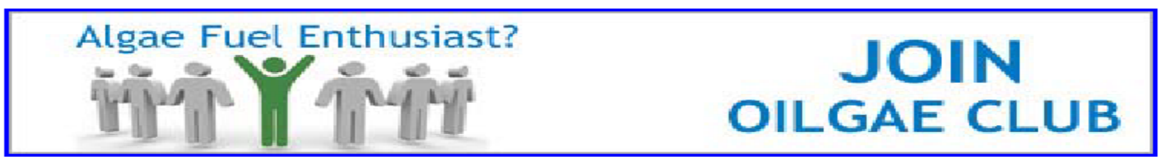
  Micromedia Filtration has a demonstration plant operating in Woodsville, New Hampshire

Passamaquoddy Tribe Algae-to-Oil Using Effluent

- ***KEY POINT-SELF SUFFICIENT!***
- *Carbon Neutral*
- *Waste products, when using Chlorella (42% oil dry-weight)*
  - *Waste gas = oxygen*
  - *"oil cake" is dried chlorella, sold in health food stores for $700/lb*
  - *Fertilizer can be sewage effluent*

Sipayik 100 gal. bio-reactor, sewage treatment plant (250 ml/4 day)





Wastewater Treatment Using Algae - A Comprehensive Guide from Oilgae

Wastewater Remediation - A Critical Problem

Sustainable remediation of wastewater ï¿½ both from municipal from industrial sources ï¿½ is a critical need world over. Many of the current practices used in remediation either rely on expensive and sometimes environment-unfriendly chemicals or in using considerable amounts of energy. Neither of these aspects is sustainable in the long run.

Comprehensive Alternative Energy Production: Biosolids for Biomass

Reading Anthracite's Repplier Mine in Minersville, Pennsylvania

"Pride goeth before destruction, and an haughty spirit before a fall" (Pr 16:18), or

TIPPING POINT: Resource Center for Converting Wastes into Valuable Products and Energy (After D. Parry, CDM)