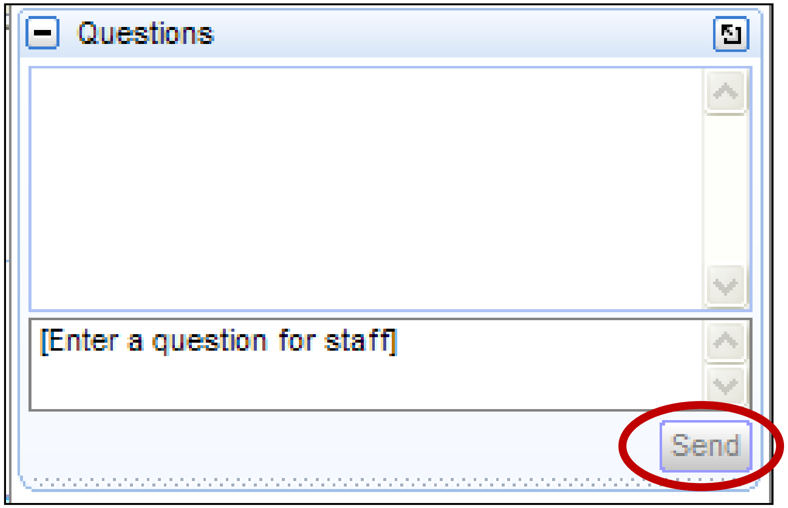
Biogas Recovery in the Wastewater Sector will begin shortly…

All attendees will be in listen-only mode.

A copy of the presentations and a recording of today's meeting will be available to view on the GMI website in the coming weeks: http://globalmethane.org

Please type your questions and comments into the Questions box on your GoTo control panel. Staff will answer questions as time allows.



Global Methane Initiative

Biogas Recovery in the Wastewater Sector

23 November 2015

Agenda

- **Introduction**
  - Chris Godlove, U.S. EPA
- **GMI Administrative Support Group (ASG) Update**
  - Henry Ferland, Director, GMI, U.S. EPA
- **Wastewater as Resources: Water, Energy, and Food Nexus**
  - Dr. Qiang He, University of Tennessee
- **How the Philadelphia Water Department Moved from flaring their methane to a co-generation plant with 5.6 MW power generation**
  - Dr. Metin Duran, Villanova University

Global Methane Initiative

Global Methane Initiative

Wastewater Webinar

Henry Ferland

Director, Administrative Support Group

21 November 2015

Global Methane Initiative

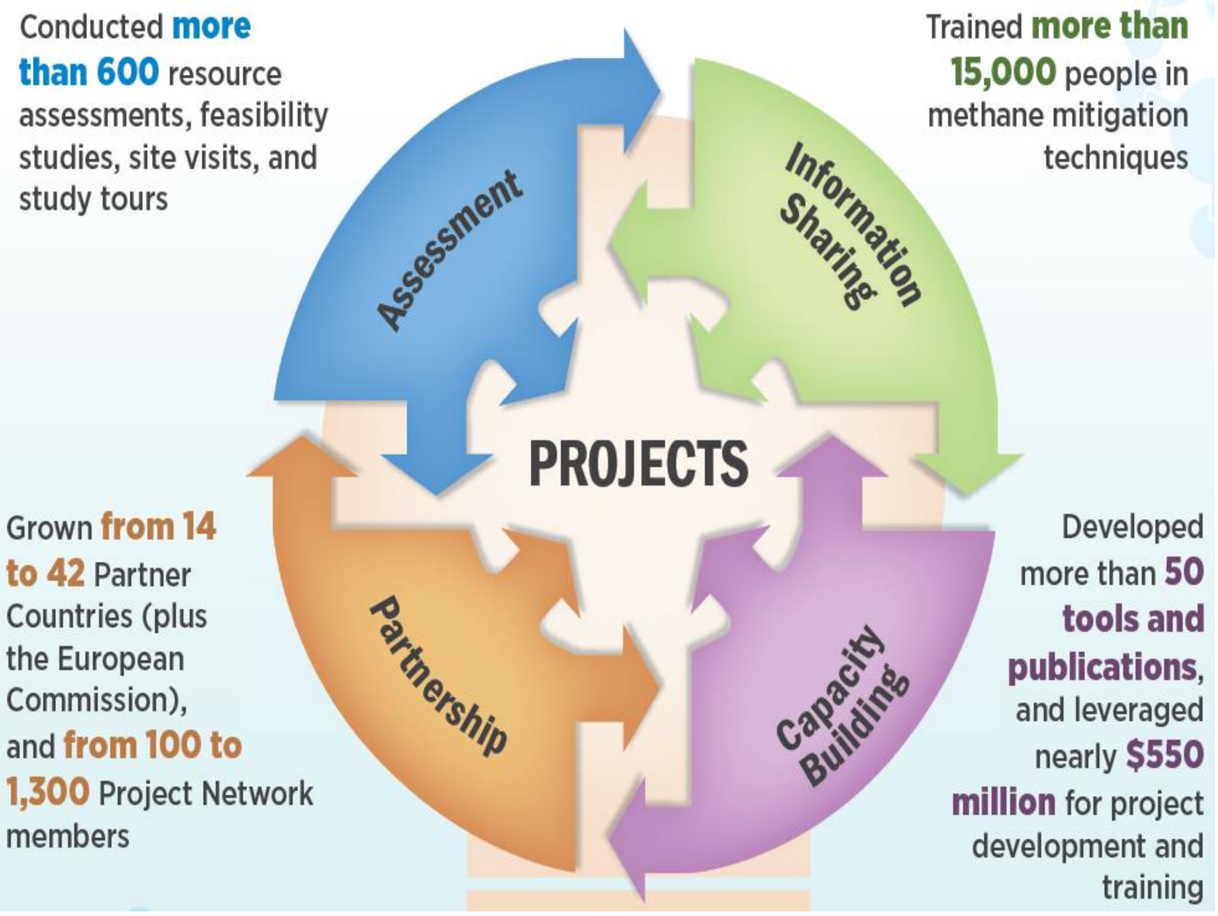
Overview

- Administrative Support Group (ASG) Updates
- Report out from GMI Task Force Recommendations
- 2016 Global Methane Forum

Global Methane Initiative

ASG Update

- Infographic completed
- Video finished
- GMI blog
- Fact Sheets updated



Background

- From Steering Meeting in October 2014
  - Broad agreement to continue GMI
  - Requested new task force to make recommendation for changes to a future GMI.

- Global Methane Forum will be platform to re-charter GMI
    - CCAC is co-hosting the GMF and will hold a CCAC Working Group in Washington DC

Global Methane Initiative

GMI Task Force

- Task Force created and meetings initiated in January 2015
  - Convened monthly to August 2015
  - Member countries include: Argentina, Australia, Brazil, Canada, China Colombia, India, Poland, USA, Mexico, Nigeria

- Task Force developed a list of recommendations for the Steering Committee which were approved this month.

Global Methane Initiative

Recommendations Overview

- Recommendation 1: Mission
- Recommendation 2: Strategic Alliances
- Recommendation 3: Structural changes

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Task Force Recommendation 1: Mission

- Emphasize information sharing (e.g., tools and best management practices, knowledge platforms) and policy development and guidance.
  - Shift from GMI's emphasis on a "project incubator" focused on site-specific project identification and development
- Promote methane abatement through increased strategic alliances with other global efforts.
- Maintain focus across five sectors:
  - Agriculture, Coal Mining, Municipal Solid Waste (MSW), Oil & Gas, and Wastewater.

Task Force Recommendation 2: Strategic Alliances

- Establish and strengthen strategic alliances with other existing international initiatives and organizations
- Strategically partner with CCAC.
  - Becoming a non-state partner
  - Collaborate closely at the sector level (oil and gas, MSW, ag)
  - CCAC has included strategic alliance with GMI in its Implementation Plan for its 5 Year Strategic Plan

- Strategically partner with the United Nations Economic Commission for Europe (UNECE).

- Explore opportunities to continue to collaborate with the World Bank's Climate Change Group.
  - Pilot Auction Facility
  - Global Gas Flaring Reduction Partnership

Global Methane Initiative

Task Force Recommendation 3: Structural Changes

Element	Current	Recommended / future:
Steering Committee	• One Chair	• Two Co-Chairs with 2-year terms. • ASG continues to support Chairs.
Subcommittees	• 5 Subcommittees: Ag, Coal, MSW, O&G, wastewater	• Reduce to 3 Subcommittees by forming a "Biogas" subcommittee (combining Ag, MSW, wastewater)
Funding / Financing	• No independent funding source • No direct access to project financing.	• Potential access to hosting methane activities via CCAC initiatives • Linkage to financial incentives through World Bank Pilot Auction Facility • Explore 3rd party host for trust fund if sufficient interest and commitment from other partners

Global Methane Initiative

Next Steps

- GMI Steering Committee approved recommendations on November 4.

Action items to follow:

  - Revise Terms of Reference
  - Develop Agenda, speakers for Launch event, Recharter Statement
  - GMI applies to be CCAC Non-State Partner

Global Methane Initiative

2016 Global Methane Forum

- Premier showcase for global methane mitigation opportunities
  - Co-sponsored by GMI and CCAC
- 3–day event, as part of full week, adjacent to CCAC working group meeting
- 2 separate high-level (Ministerial) methane-focused plenaries on financing opportunities and policy roundtables
- Technical dialogues focusing on sector challenges, approaches

Global Methane Forum

- Venue: Georgetown University
- Notional schedule:

<table>
<tr><th>Mon 3/28</th><th>Tues 3/29</th><th>Wed 3/30</th><th>Thurs 3/31</th><th>Fri 4/1</th></tr>
<tr><td rowspan="2">Biogas Site Visit</td><td>AM:

Plenary session</td><td>AM:
Plenary session - GMI Strategic Alliance/ New Five Year Pledge</td><td rowspan="2">All day:
CCAC Working Group</td><td rowspan="2">All day:
CCAC Working Group</td></tr>
<tr><td>PM:
GMI Steering committee; technical / policy sessions</td><td>PM:
Technical / policy sessions (GMI sectors jointly with CCAC initiatives)</td></tr>
</table>

2016 Global Methane Forum

- Part of the plenaries, feature an event that announces (Recharter Declaration) the renewed five-year commitment of GMI partners to methane mitigation through GMI and its new strategic alliances
- High-level speakers (to be invited):
  - CCAC Co-Chairs
  - Active CCAC and GMI partners: Canada (TBD), China (TBD)
  - UNECE Executive Secretary
  - World Bank (TBD)
  - CEO - Oil and Gas partner - CCAC Oil & Gas Methane Partnership (TBD)
  - UNEP (CCAC Secretariat)

Global Methane Initiative

Global Methane Forum:

- Next Steps
  - Develop final agenda in coordination with CCAC (ongoing)
  - Outreach at COP Paris
  - Outreach events at embassy(-ies) (Washington DC): January 2016
  - Networking event – country sponsors? Project Network sponsors?
  - Biogas Subcommittee structural planning call with co-chairs (early 2016)

Thank you

Henry Ferland

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Wastewater as Resources:

Water, Energy, and Food Nexus

Qiang He, Chris Cox, & Greg Reed

Dept. of Civil & Environmental Engineering
University of Tennessee, Knoxville

Christian Seal

Ingeniero Civil
Universidad de Santiago de Chile

THE UNIVERSITY of TENNESSEE KNOXVILLE

Wastewater as Resources for Water, Energy, and Food

Water

1. Industry
2. Agriculture
3. Domestic use

Energy

1. Heating
2. Power generation
3. Transportation

Food

1. Nutrients: N & P (also energy)
2. Water
3. Soil amendment

Wastewater as Resources for Water, Energy, and Food

Water
1. Industry
2. Agriculture
3. Domestic use

- Largest irrigated crop wastewater recycle in U.S.
- Produces 76,000 m³/day recycled water
- Irrigates 5,000 hectares
- Through anaerobic biosolids treatment and cogeneration, produces 50% of WWTP's energy needs
- No energy wasted for nitrogen oxidation – all is used as plant fertilizer

Water

Energy

Food

Monterey Regional Water Pollution Control Agency

Wastewater as Resources for Water, Energy, and Food

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1. Industry
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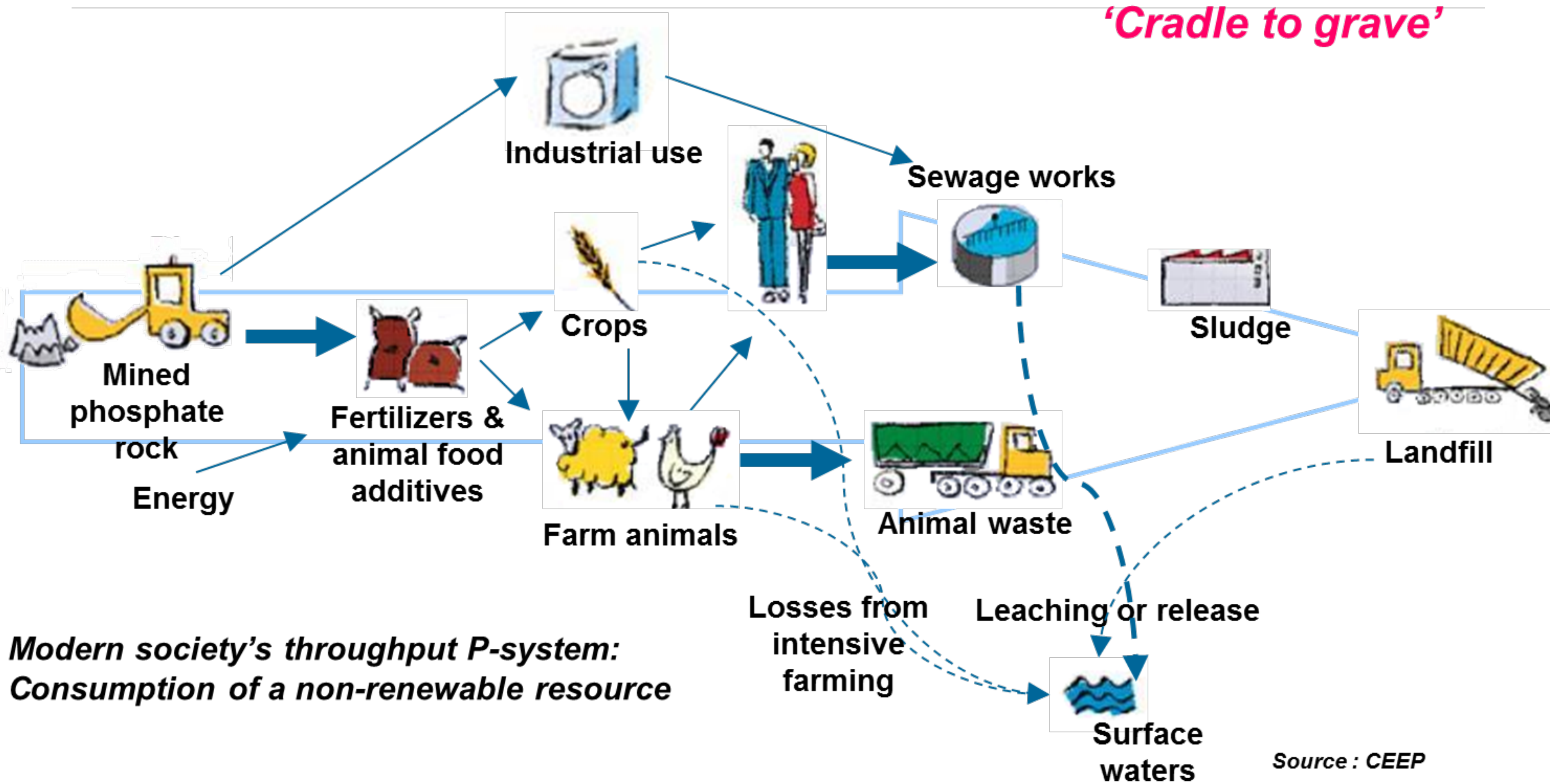
Modern Phosphorus Use



This has consequences

Modern Phosphorus Use: Consequence

Nitrogen or phosphorus are most likely the limiting nutrients.

You don't want to swim in this

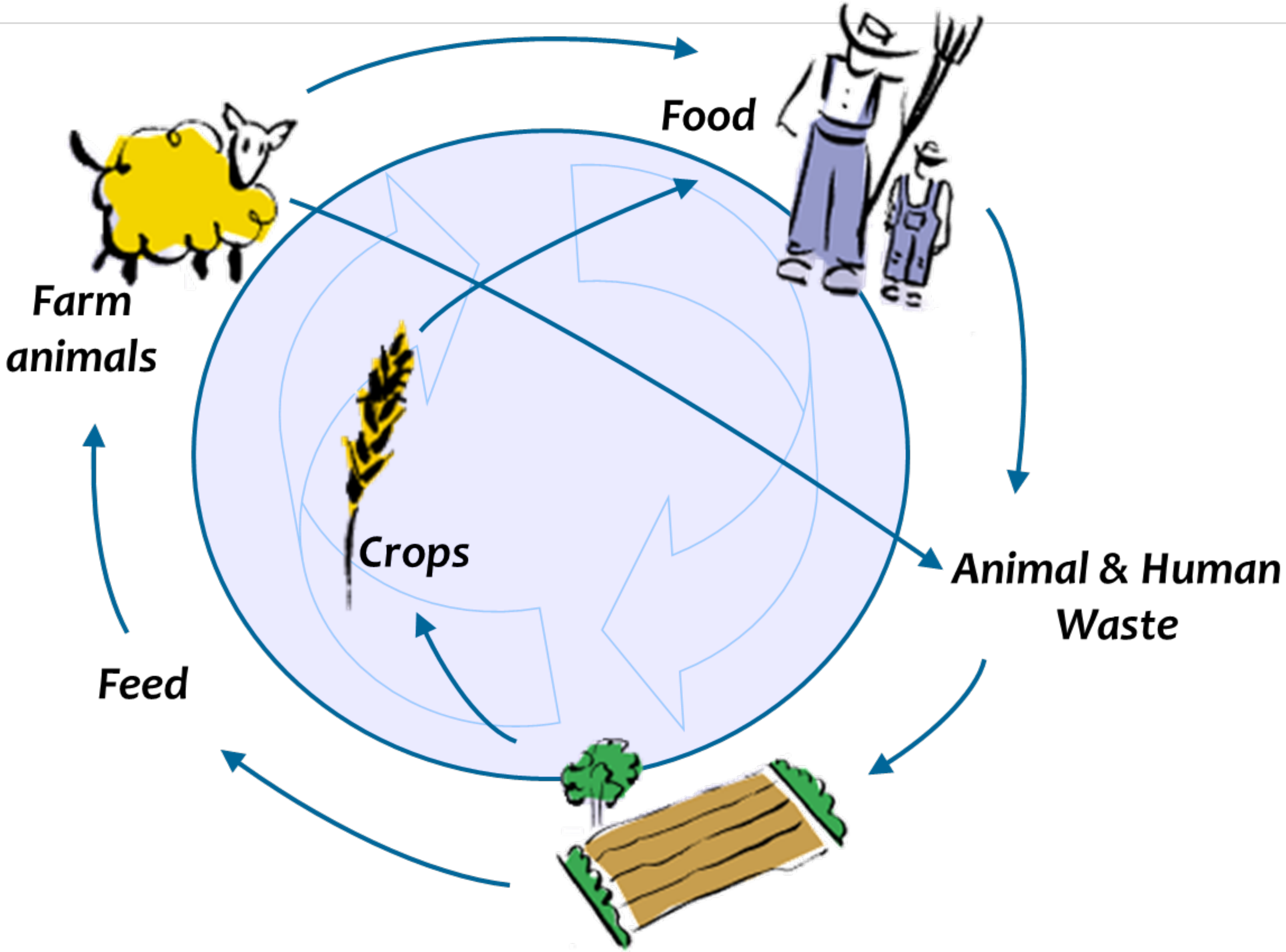
Source: ABC News

Modern Phosphorus Use: Consequence

Olympic nightmare

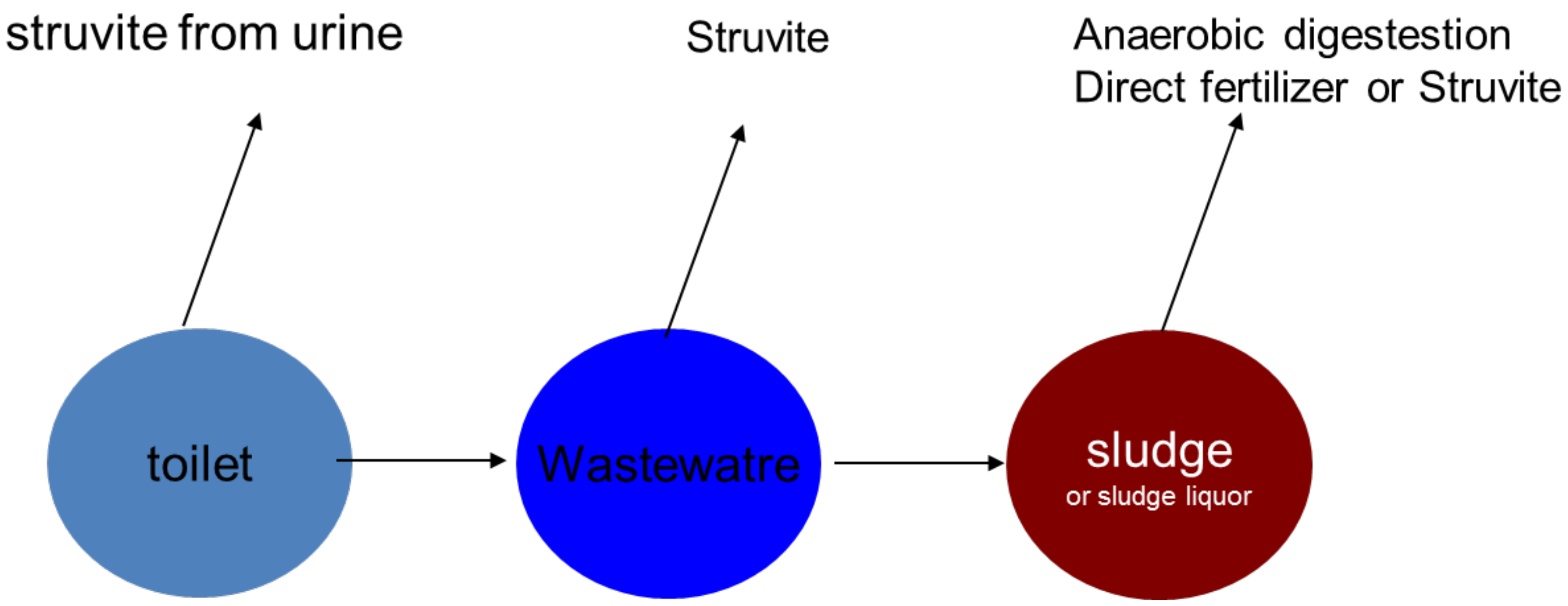
Credit: livejournal.com

Closed Phosphorus Cycle



These practices will have better consequences

Human excretion: 1-2 g/p/d



Wastewater as Resources for Water, Energy, and Food

Water

1. Industry
2. Agriculture
3. Domestic use

Energy : Wastewater treatment ~3% of national electrical load

Solution--Anaerobic conversion to **methane**

1. Heating
2. Power generation
3. Transportation

Food

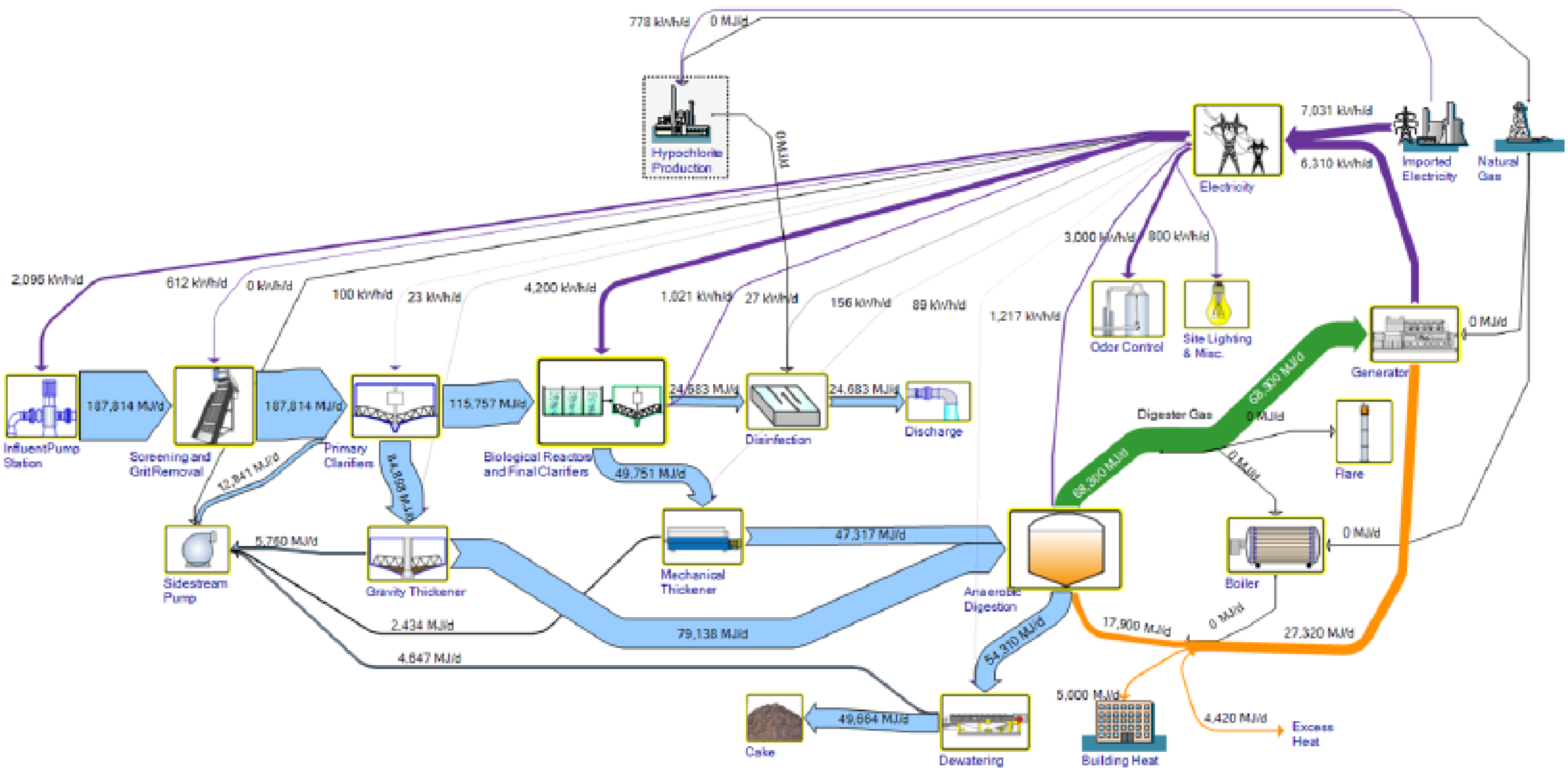
1. Nutrients: N & P
2. Water
3. Soil amendment

Typical Energy Requirement of WWT

	kWh/m^3
Conventional Aerobic Activated Sludge	0.6
Conventional Aerobic with Nitrification	0.8
Aerobic Membrane Bioreactor	1.0
Conventional Aerobic with RO	2.5

WERF, 2012

Typical Energy Balance of Activated Sludge WWTP



WERF, 2012

Best Practices to Improved Energy Balance

1. Anaerobic digestion with combined heat and power (CHP) is the most advantageous approach to energy recovery, reducing energy requirements by up to 35% at WWTPs.

2. Co-digestion of high-strength waste in anaerobic digesters is a valuable approach to achieve energy neutrality.

3. Improving primary treatment and solids capture in thickening and dewatering processes has the most significant total positive impact of all the best practices.

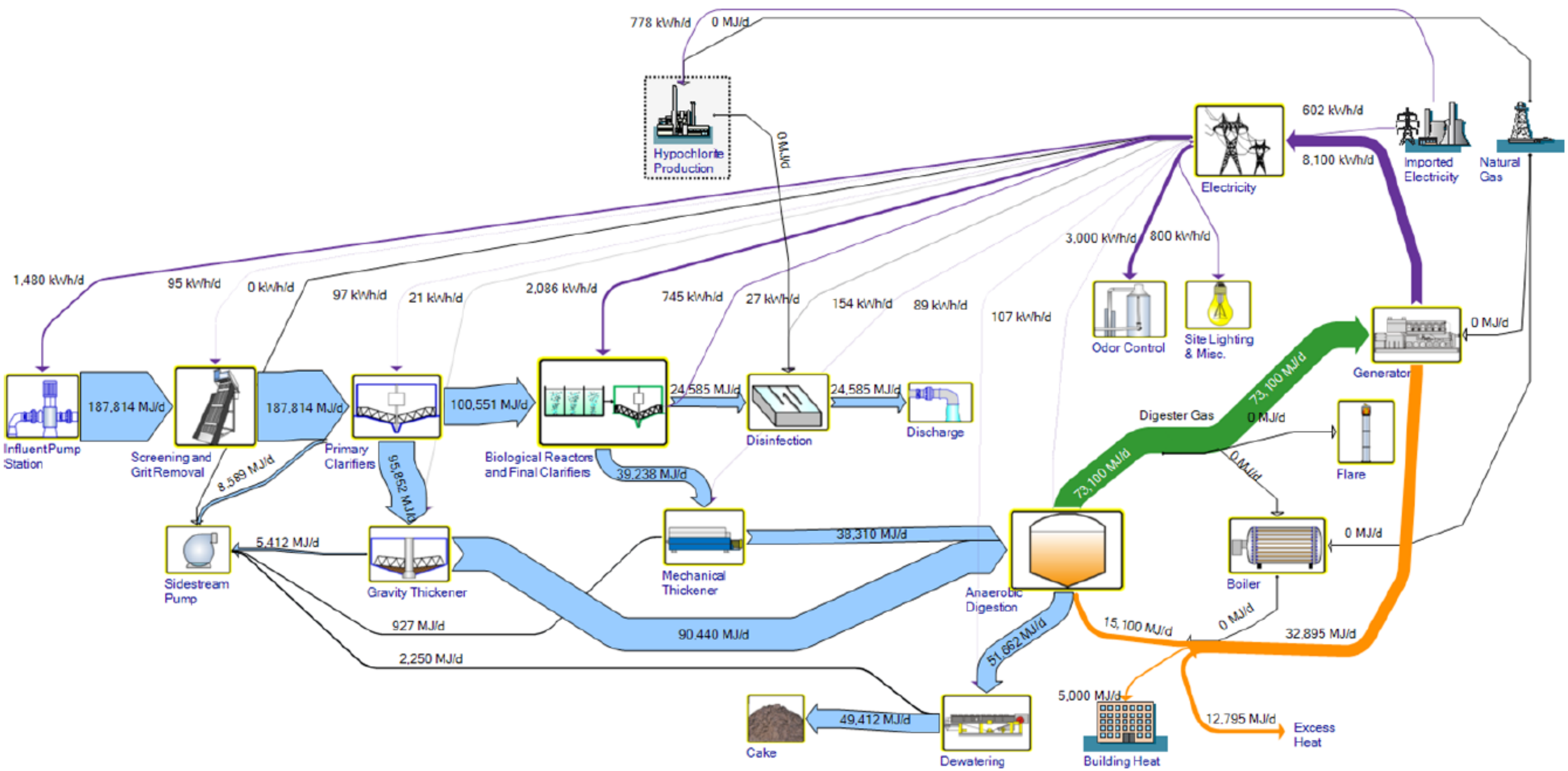
4. Significant savings in aeration blower electricity usage can be achieved by reducing fouling in fine bubble diffusers through improved operation and maintenance procedures.

5. Dewatered biosolids (cake) retains a significant portion of the influent chemical energy.

6. The full combination of best practices can result in approximately 40% lower energy consumption than “typical” performance.

WERF, 2012

Improved Energy Balance of Activated Sludge WWTP



WERF, 2012

Problem: Anaerobic Sludge Digestion

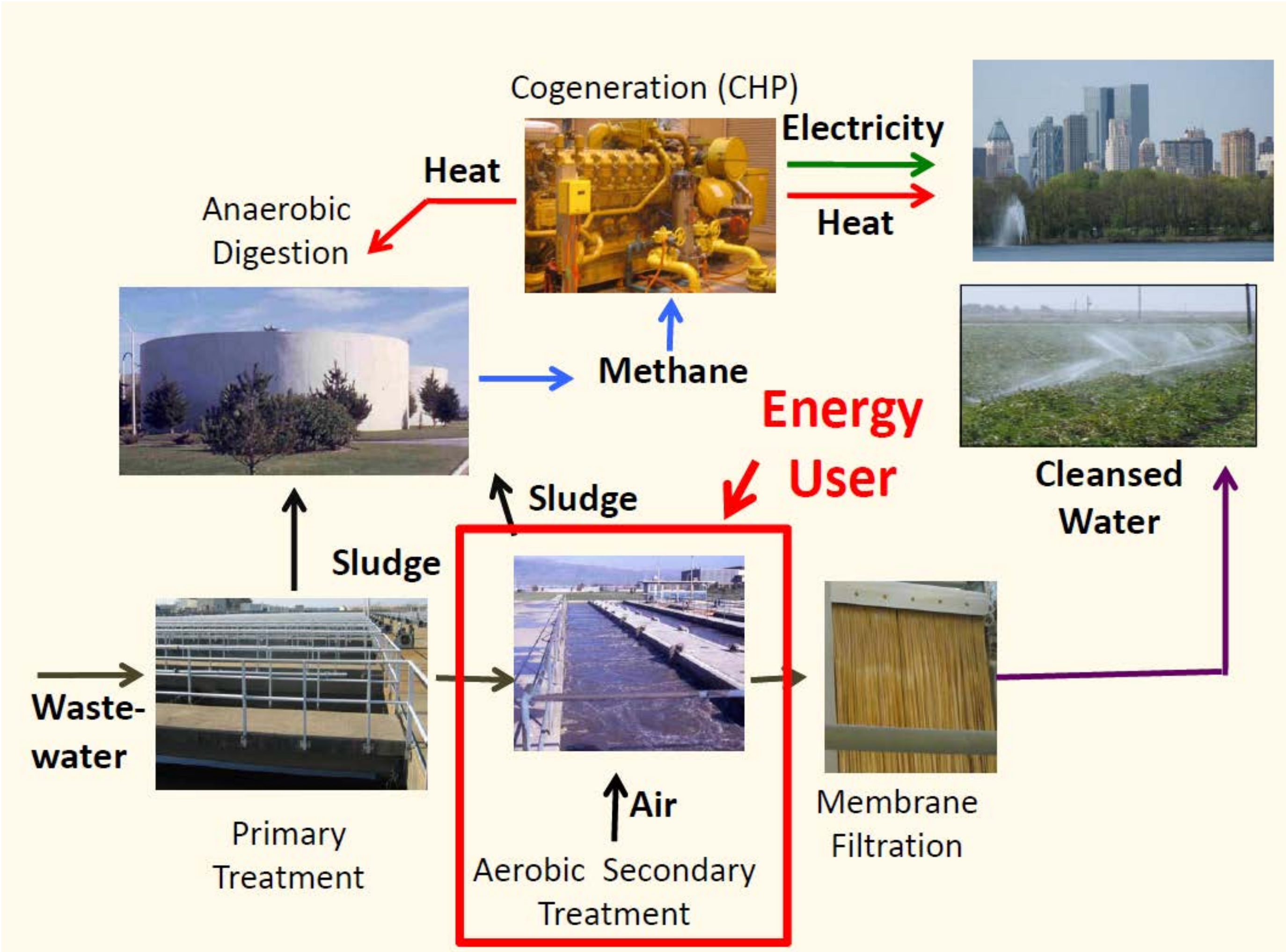
1. Energy in dissolved organics is not recovered by anaerobic sludge digestion.
2. Dissolved organics is removed by aerobic processes that consume energy.

constituent	typical concentrations[a] (mg/L)	energy (kWh/m^3) maximum potential from organic oxidation[b]	energy (kWh/m^3) required to produce fertilizing elements[c]
organics (COD)			
total	500		
refractory	180		
suspended	80	0.31	
dissolved	100	0.39	
biodegradable	320		
suspended	175	0.67	
dissolved	145	0.56	
nitrogen			
organic	15		0.29
ammonia	25		0.48
phosphorus	8		0.02
water			
totals		1.93	0.79

THE UNIVERSITY of TENNESSEE KNOXVILLE

McCarty et al., ES&T, 2011

Aerobic Treatment for Partial Resource Recovery



McCarty et al., ES&T, 2011

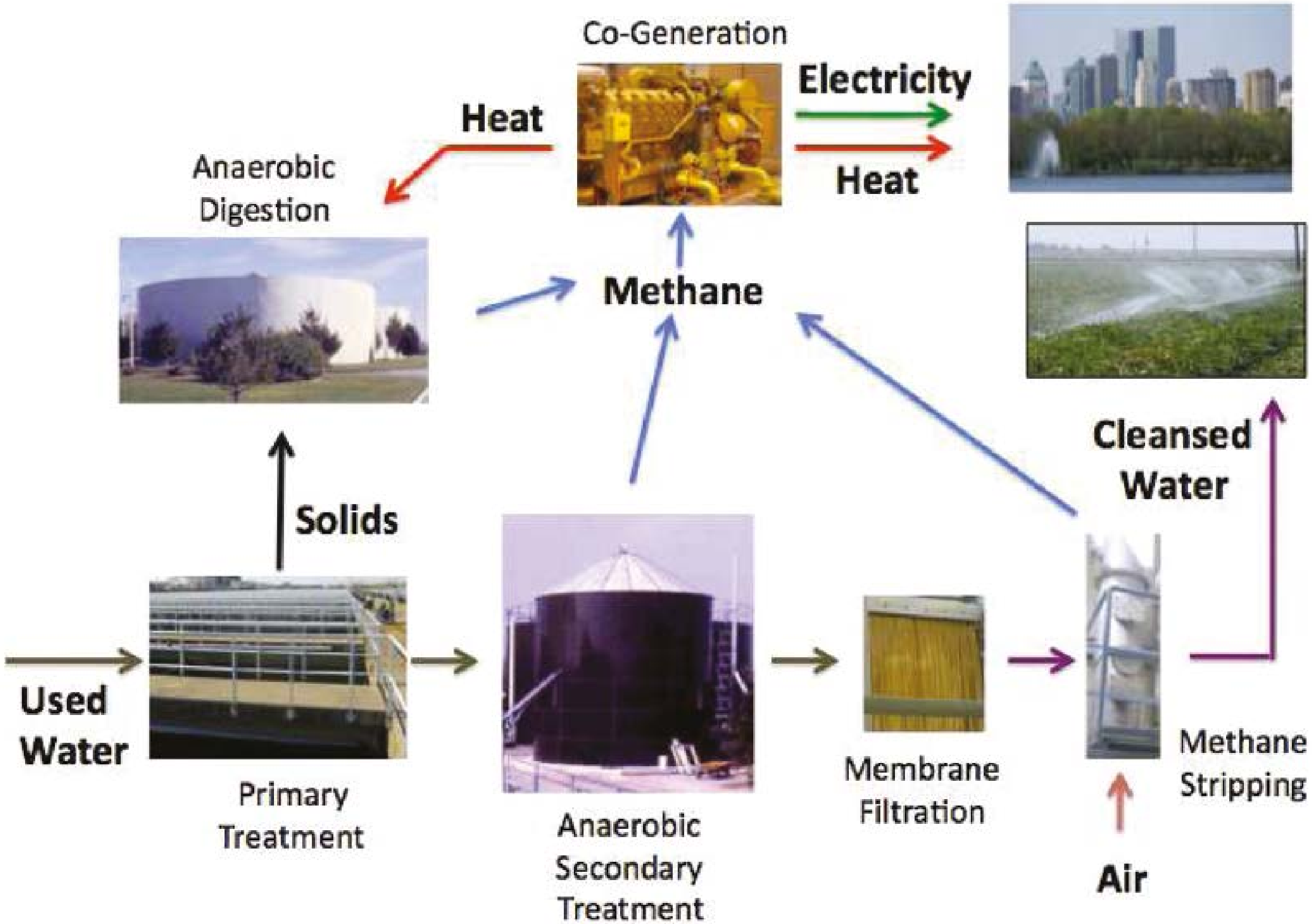
Energy consumed > Recovered by AD

Opportunity: Anaerobic Wastewater Treatment

Achieve energy-positive wastewater treatment by fully capturing all energy in wastewater by 100% anaerobic treatment of wastewater.

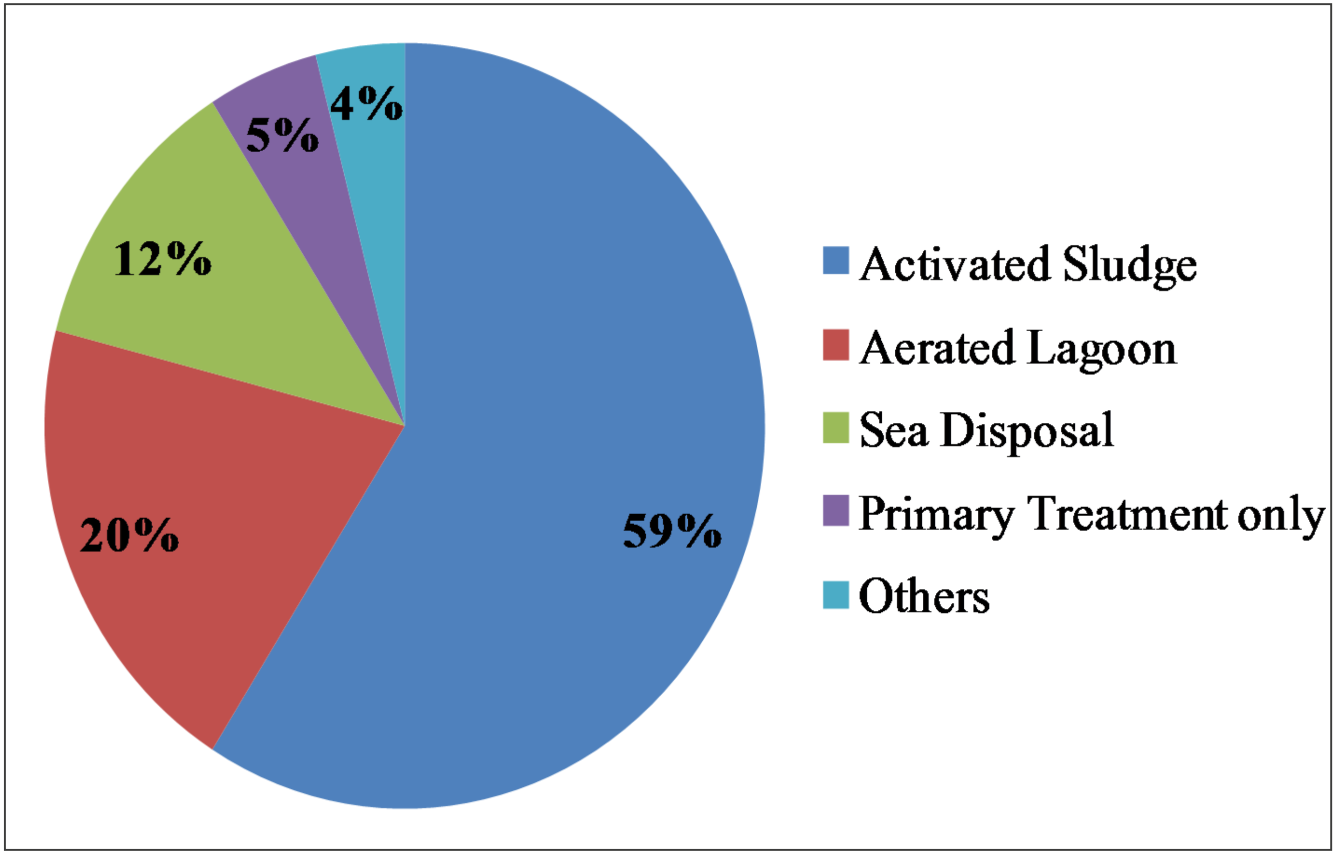
WERF, 2012

Anaerobic Treatment for Complete Resource Recovery



McCarty et al., ES&T, 2011

Methane Resources from Wastewater in Chile



Centralized wastewater treatment systems operated by regional utilities in Chile

Methane Resources from Wastewater in Chile

Regional population coverage of municipal wastewater treatment in Chile

Región	Urban Population	Residential Customers	Residential Customers with Sewer	Population with Sewage Collection	Residential Customers with Sewage Treatment	Population with Sewage Treatment	%Population with Sewage Treatment
Tarapacá (I)	307,096	83,107	79,109	298,664	79,109	298,664	97.3%
Antofagasta (II)	576,303	149,313	148,938	574,813	148,938	574,813	99.7%
Atacama (III)	273,600	81,832	78,522	263,919	78,522	263,919	96.5%
Coquimbo (IV)	607,396	188,308	181,195	586,290	175,444	569,912	93.8%
Valparaiso (V)	1,575,751	542,556	489,663	1,460,970	489,594	1,460,781	92.7%
O'Higgins (VI)	663,524	197,718	168,323	574,325	168,323	574,325	86.6%
Maule (VII)	683,373	212,714	203,404	655,653	200,914	645,288	94.4%
Biobío (VIII)	1,776,626	486,432	452,789	1,655,146	452,789	1,655,146	93.2%
Araucanía (IX)	624,229	185,653	174,931	593,002	174,931	593,002	95.0%
Los Lagos (X)	586,858	160,094	152,191	557,619	152,191	557,619	95.0%
Aysén (XI)	86,588	23,789	22,685	82,704	22,685	82,704	95.5%
Magallanes (XII)	151,958	45,819	45,154	149,751	45,154	149,751	98.5%
De los Ríos (XIV)	250,155	69,849	64,782	231,358	64,782	231,358	92.5%
Arica y Parinacota (XV)	211,091	55,464	55,258	210,307	55,258	210,307	99.6%
Metropolitana (RM)	7,337,395	1,927,545	1,900,777	7,234,510	1,900,327	7,234,412	98.6%
Total	**15,711,942**	**4,410,193**	**4,217,721**	**15,129,029**	**4,208,961**	**15,102,000**	**96.12%**

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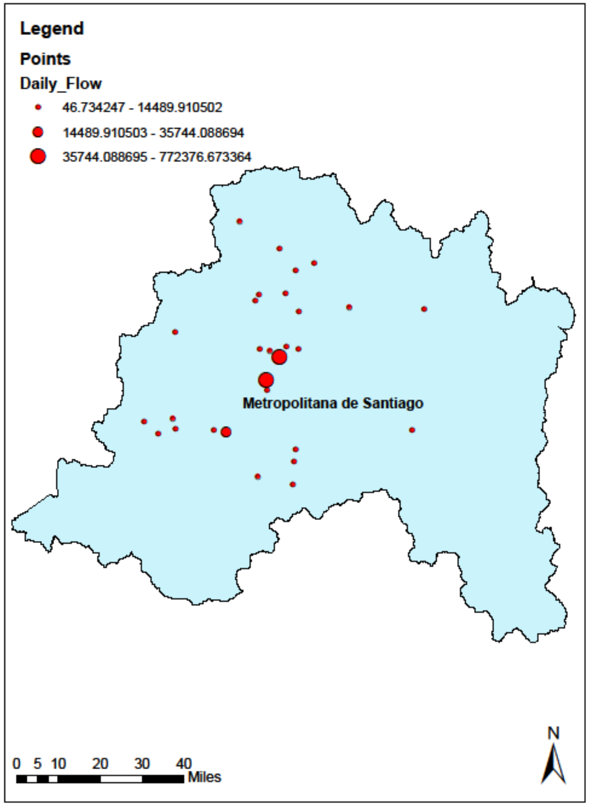
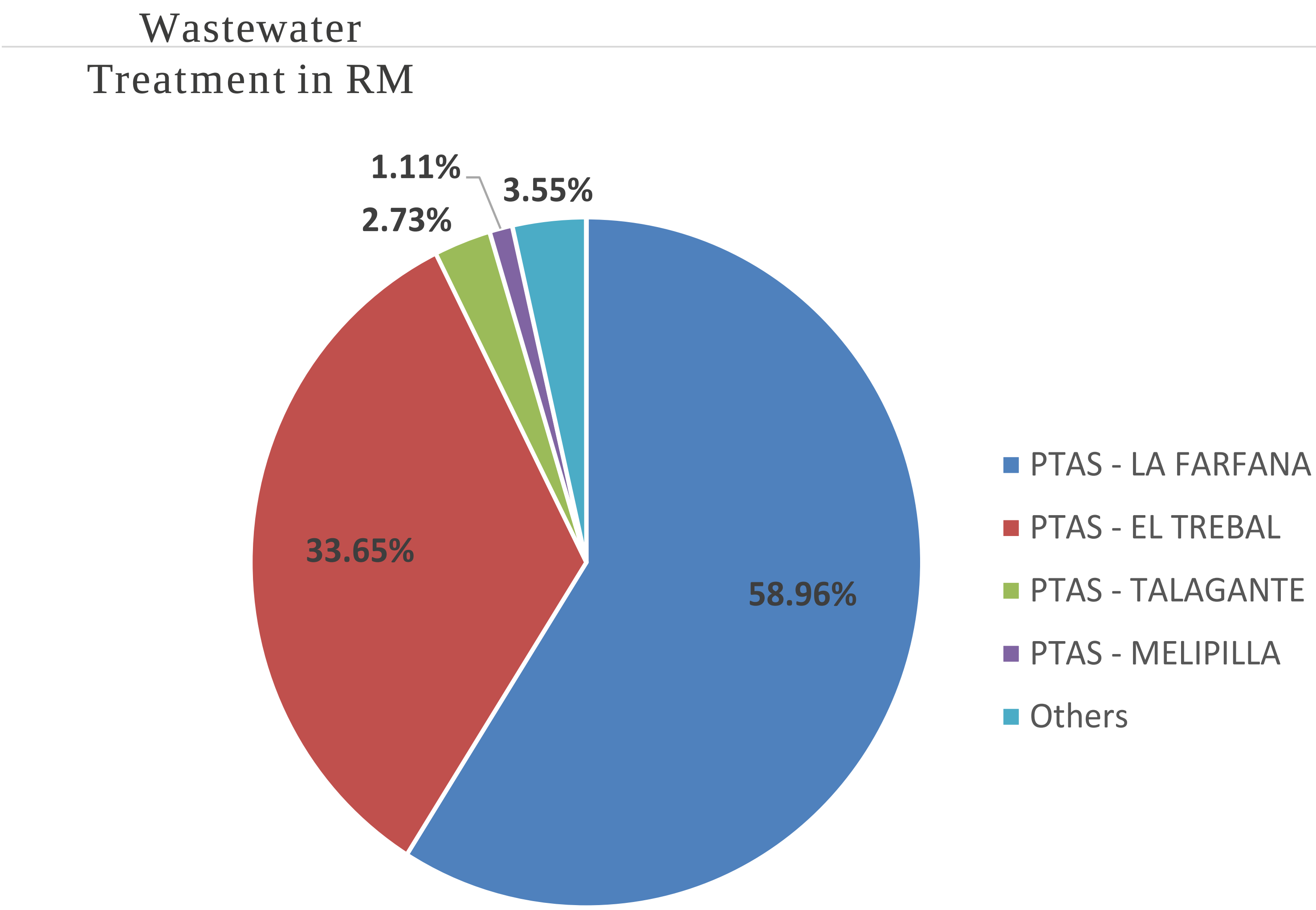
Methane Resources from Wastewater in Chile

Wastewater Treatment in RM

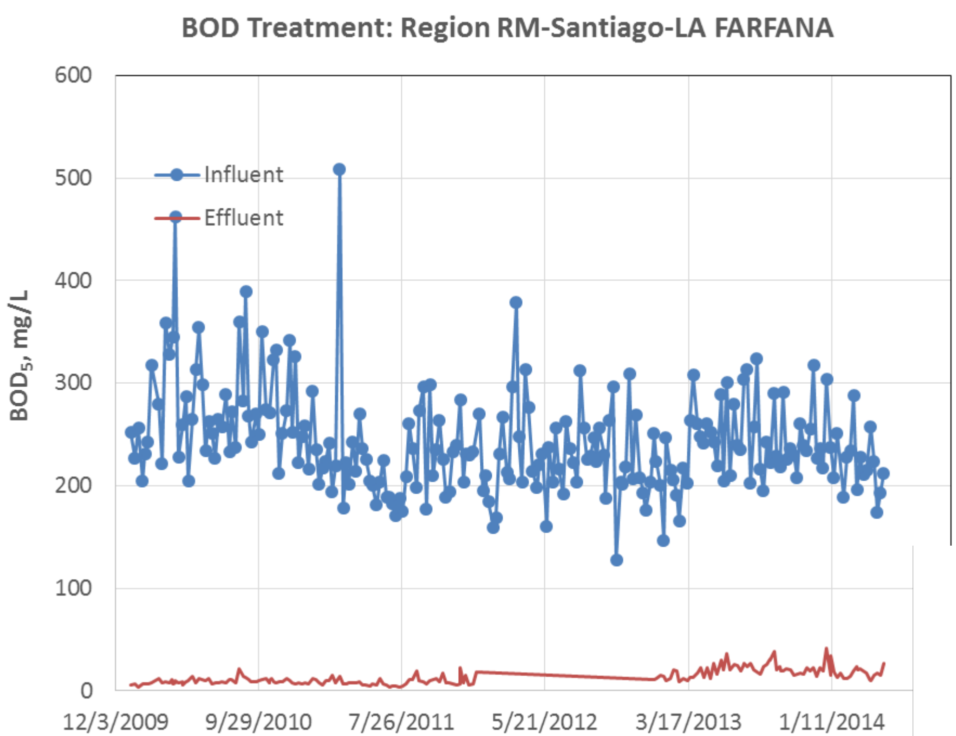


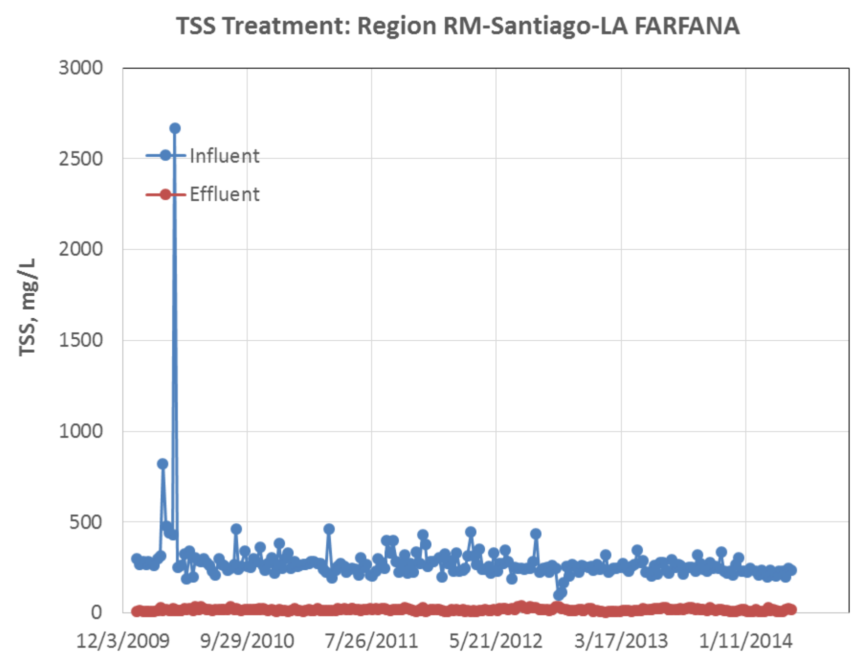
Commune	Utility	Wastewater Treated, m^3/Mo
BUIN	PTAS - BUIN MAIPO	274,601
BUIN	PTAS - ESTACION BUIN	6,371
COLINA	PTAS - SANTA ELENA	8,988
COLINA	PTAS - SANTA LUZ	30,279
CURACAVI	PTAS - CURACAVÍ	95,797
EL MONTE	PTAS - EL MONTE	168,403
LAMPA	PTAS - LARAPINTA	42,593
LAMPA	PTAS - LAS HIGUERAS	65,634
LAMPA	PTAS - SANTO TOMAS	44,760
LAMPA	PTAS - JARDINES DE LA ESTACIÓN	2,713
LO BARNECHEA	PTAS - LOS TRAPENSES	85,757
LO BARNECHEA	PTAS - LA LEONERA	1,422
LO PRADO	PTAS - JARDIN LO PRADO	66,133
MELIPILLA	PTAS - EL PARRONAL	14,360
MELIPILLA	PTAS - MELIPILLA	440,735
MELIPILLA	PTAS - POMAIRE	50,015
MELIPILLA	PTAS - VILLA GALILEA	27,209
PADRE HURTADO	PTAS - EL TREBAL	13,407,037
PADRE HURTADO	PTAS - PUERTAS DE PADRE HURTADO	4,176
PAINE	PTAS - PAINE	211,241
PAINE	PTAS - VALDIVIA DE PAINE	57,362
PUDAHUEL	PTAS - BARRANCAS	76,650
PUDAHUEL	PTAS - IZARRA DE LO AGUIRRE	1,626
PUDAHUEL	PTAS - LOMAS DE LO AGUIRRE	10,611
SAN JOSE DE MAIPO	PTAS - SAN JOSE DE MAIPO	37,090
SANTIAGO	PTAS - LA FARFANA	23,493,124
TALAGANTE	PTAS - TALAGANTE	1,087,216
TILTIL	PTAS - EL MANZANO	8,016
TILTIL	PTAS - TIL TIL	23,099
Total		**39,843,019**

Methane Resources from Wastewater in Chile



Methane Resources from Wastewater in Chile





Methane Potential

Methane Potential = (% collected) × (total BOD_5 produced) × (% anaerobic) × (% anaerobic w/primary) × (1-%BOD removed in prim. treat.)] × (Bo) × (MCFanaerobic) × 1/10^6

Increase in methane production:

(Anaerobic Wastewater Treatment vs Anaerobic Sludge Digestion)

122%

Acknowledgement

U.S. Environmental Protection Agency

Global Methane Initiative

COALICIÓN CLIMA Y AIRE LIMPIO PARA REDUCIR CONTAMINANTES DE VIDA CORTA

How Philadelphia Water Department moved from flaring their methane to a co-generation plant with 5.6 MW power generation

by
Metin Duran (Villanova University) and Paul M. Kohl (Philadelphia Water Department)

Outline

- Introduction and objectives
- PWD's Northeast Water Pollution Control Plant
- Digester optimization work
- Co-digestion studies
- Details of co-generation plant
- Concluding remarks

Introduction and objectives

Philadelphia is 5th largest city in US with approximately 1.5 million people living in greater Philadelphia area

Philadelphia Water Department (PWD) is one of city government arms responsible for water supply and sanitary operations

Sanitary operations include operating three wastewater treatment plants, all performing secondary treatment of wastewater by some form of activated sludge process

Introduction and objectives (Cont.)

These three plants treat a combined 471 MGD wastewater

1. Southwest Water Pollution Control Plant (SEWPCP)
    - Largest
    - Uses pure oxygen activated sludge

2. Northeast Water Pollution Control Plant (NEWPCP)
    - Second largest

3. Southeast Water Pollution Control Plant
    - Smallest
    - No anaerobic digestion (thickened sludge is transferred to NEWPCP for digestion and processing)

Introduction and objectives (Cont.)

PWD wanted to conduct pilot and bench-scale studies targeted to optimizing performance of anaerobic sludge digestion process at their NEWPCP

Villanova University's Environmental Microbiology and Biotechnology Laboratory (Civil and Environmental Engineering Department) was chosen through a competitive application process to carry out digester optimization work

These studies focused on ways to improve volatile solids destruction and thereby improve methane production and evaluate feasibility of co-digestion of different substrates

Northeast Water Pollution Control Plant

NEWPCP is second largest of three PWD wastewater treatment plant with average discharge flow of 200 MGD (including stormwater from combined sewer system areas)

Conventional activated sludge process including preliminary treatment (screening, grit removal, and primary settling) and secondary treatment (aeration, secondary clarification, and chlorination) is used

Sludge management includes dissolved air flotation thickening of waste activated sludge, anaerobic digestion for stabilization

NEWPCP (Cont.)

NEWPCP has eight “pancake type” anaerobic digesters each with 2 MG capacity

Mesophilic digesters has design SRT/HRT of 18 days and each is cleaned once about every four to five years

Digesters at NEWPCP are mixed by sludge circulation (sludge drawn off from the bottom of digester is mixed with feed sludge after going through a tube heat exchanger and then discharged back to digester five feet below normal liquid level)

NEWPCP (Cont.)

Digested solids are transported to a privately operated facility for , and high speed centrifuge dewatering, drying, pelletisation and subsequent use as fertilizer and fuel

Until 2013, a small fraction of methane generated was used for heating and remaining was flared

Since then all methane generated is used to power a co-generation plant for heat and electricity production

Digester optimization work

1. Effects of operating parameters

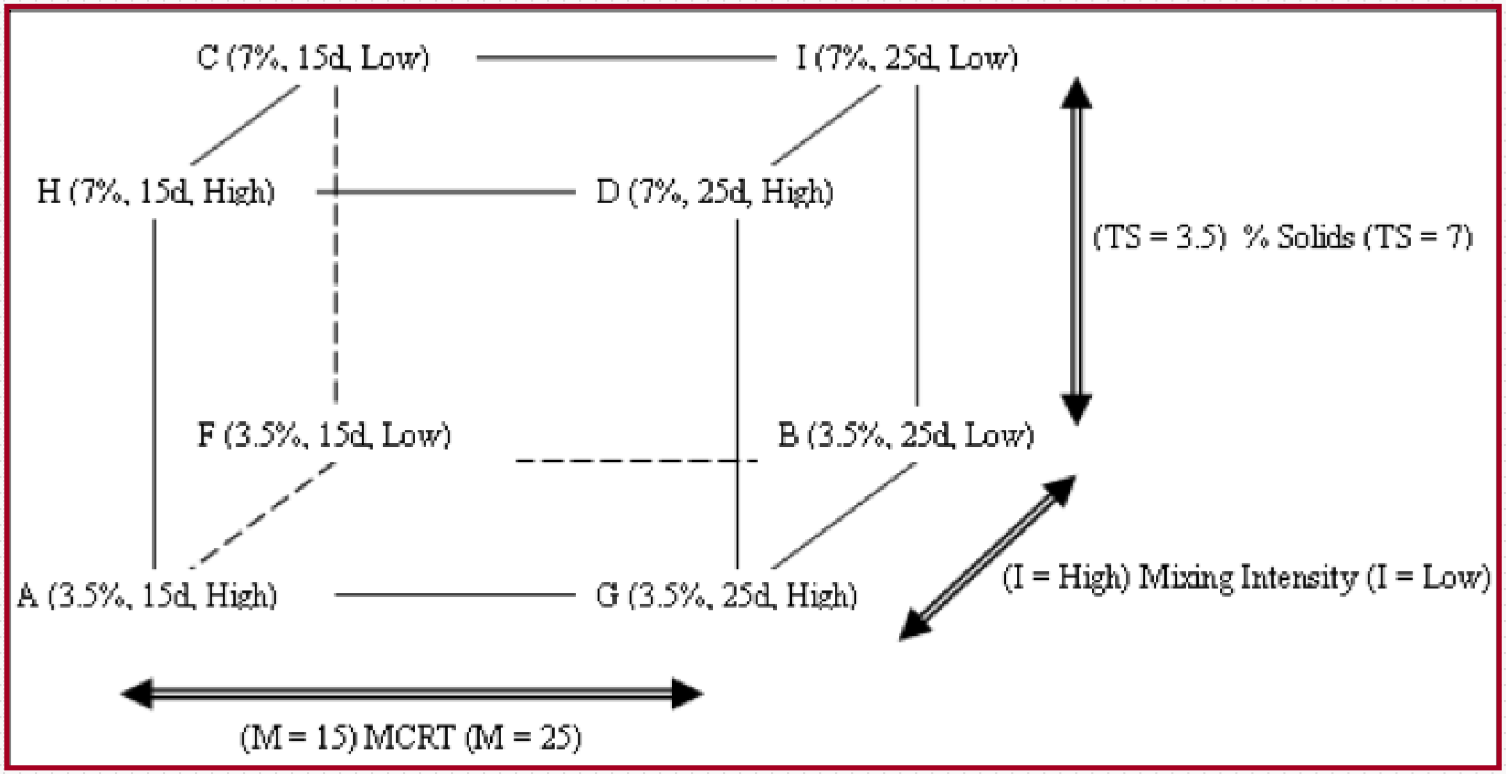
A factorial design approach was used to study effects of three main operating parameters on digestion efficiency: Mixing; Mean cell residence time (MCRT or SRT); and Feed solids (TS) contents

Each variable was tested within typical design and operating ranges:

- Mixing: Low (130 ft*lbf/ft^3*d twice a day for 5 min.) to high (130 for 5 minutes hourly totaling 1580 ft*lbf/ft^3*d)
- MCRT: 15 to 25 days
- Feed TS: 3.5 to 7%

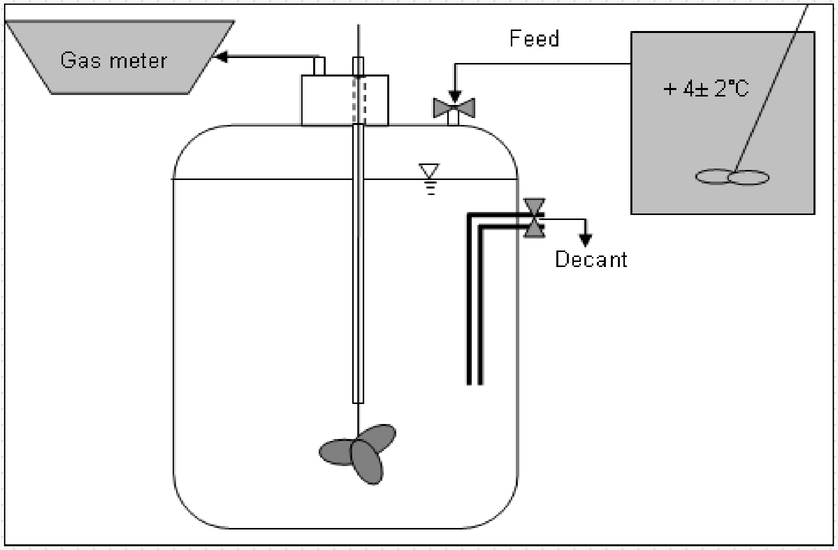
Optimization work: Operating parameters (Cont.)

Factorial design approach was chosen since it requires fewer experiments and gives a quantitative estimate on how these parameters interact



Optimization work: Operating parameters (Cont.)

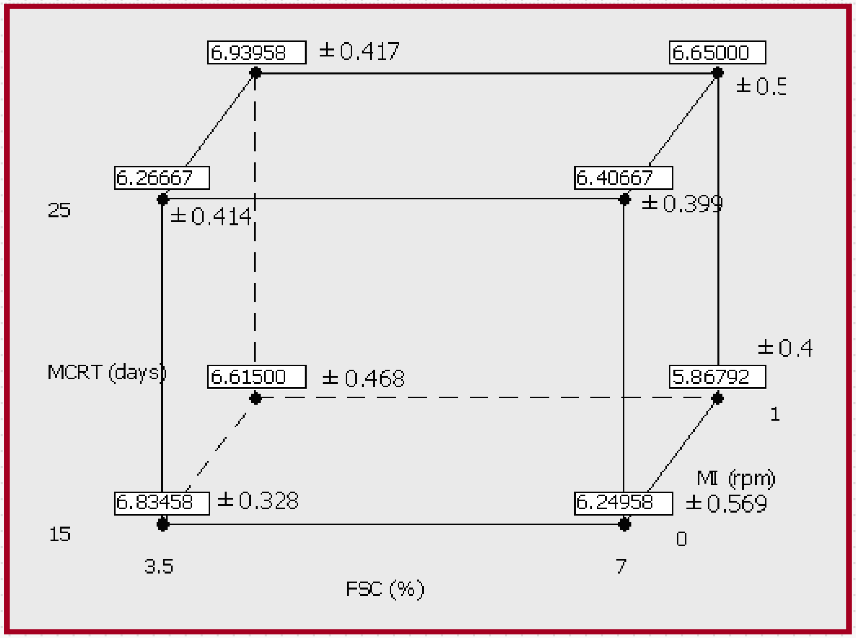
Eight 5-gallong digesters were operated to carry out “factorial design” experiments, four in each phase, due to logistical considerations

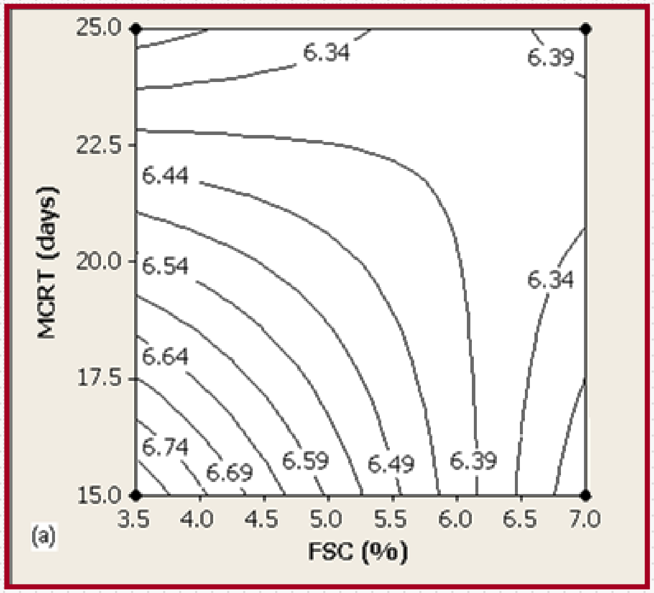


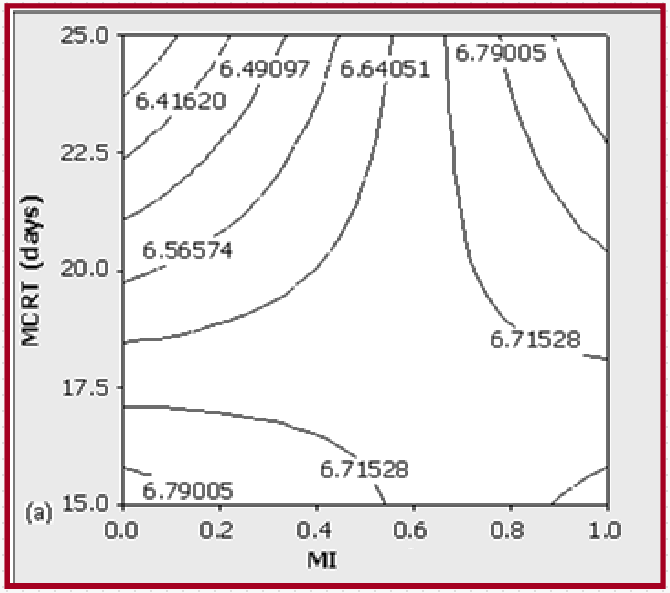
	Digester	Factors (Operating conditions)		
		TS (%)	MCRT (days)	Mixing
Period I	A	**3.5**	**15**	**High**
	B	3.5	25	Low
	C	7	15	Low
	D	7	25	High
Period II	E*	**3.5**	**15**	**High**
	F	3.5	15	Low
	G	3.5	25	High
	H	7	15	High
	I	7	25	Low

Optimization work: Operating parameters (Cont.)

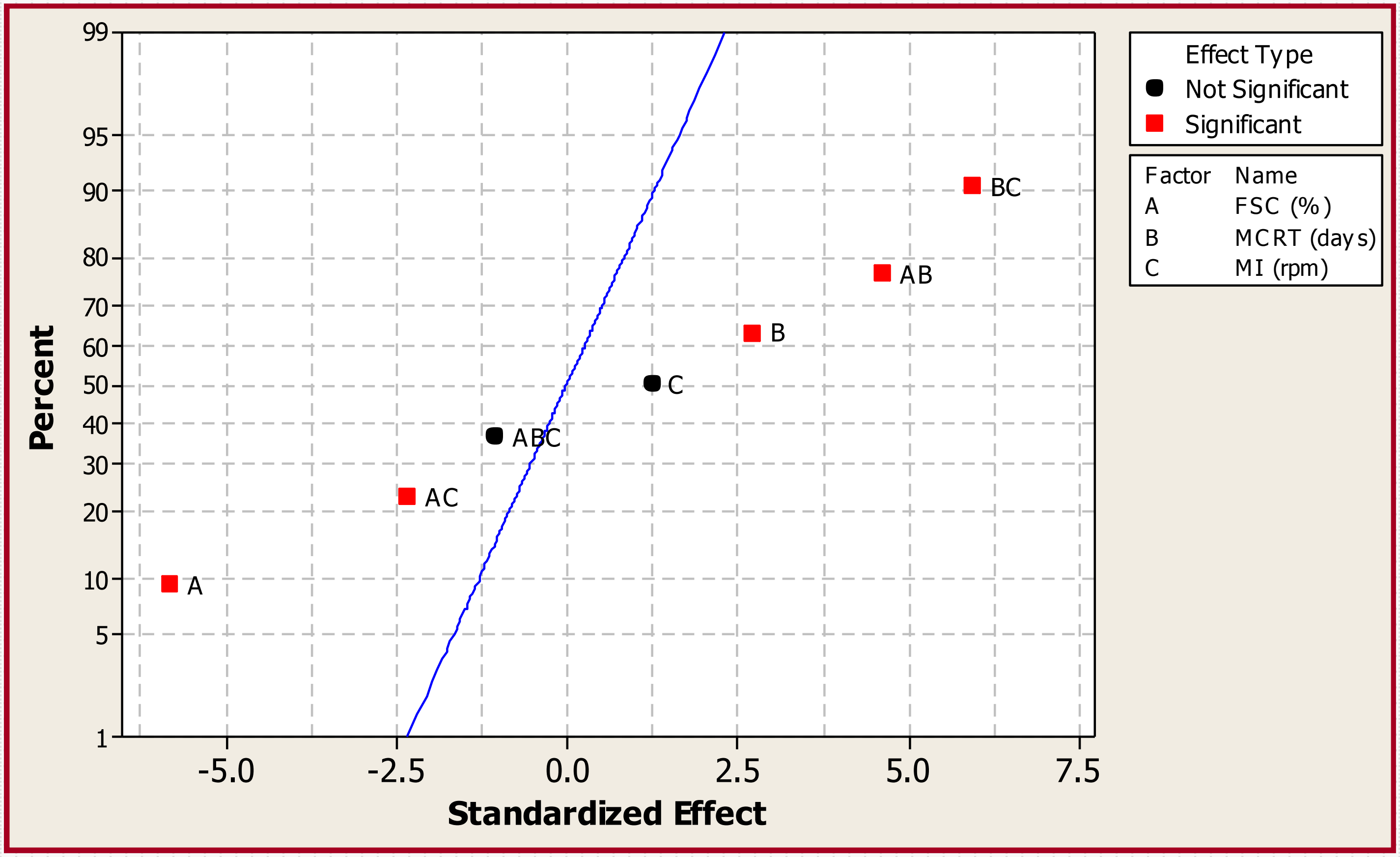
Specific CH_4 production (ft^3 CH_4/lb VS fed) was used as a measure of digestion performance to quantify effects of operating parameters on CH_4 generation







Optimization work: Operating parameters (Cont.)



Specific Methane (ft^3/lb VS fed.day) =

9.35896–0.47786*FSL–0.12929*MCRT–1.7975*MI+0.02071*(FSL*MCRT)

+0.068333*(FSL*MI)+0.11600*(MCRT*MI)-0.00764*(FSL*MCRT*MI)

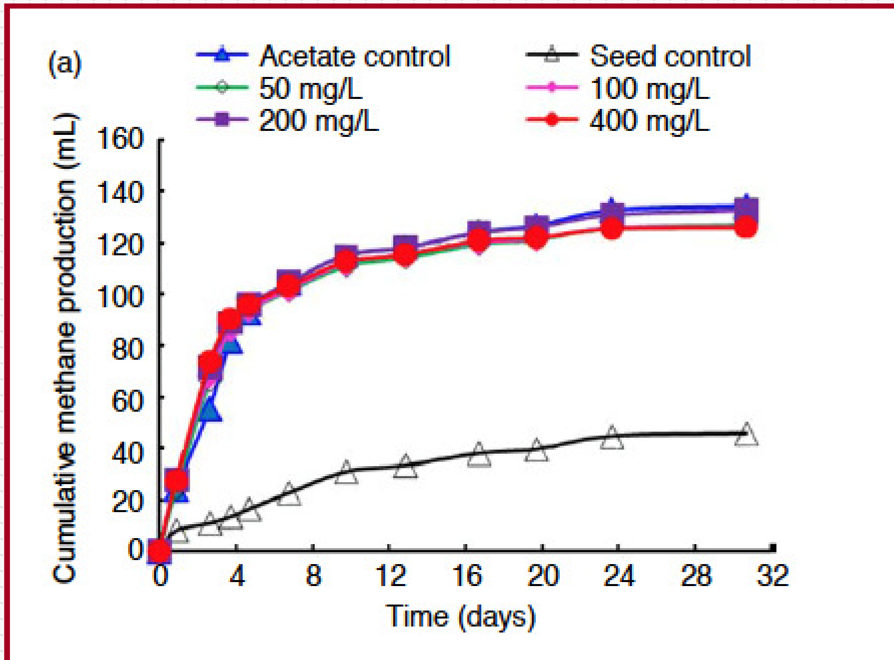
Optimization work (Cont.)

2. Nutrient supplement study

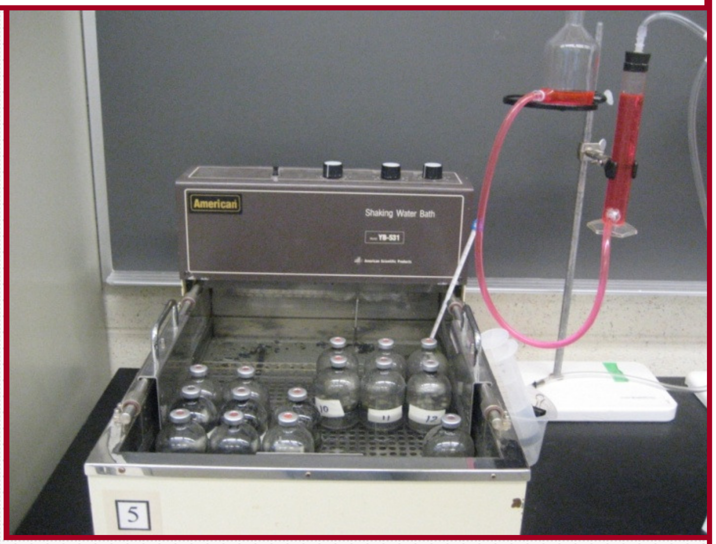
Previous studies showed that full-scale anaerobic digesters could benefit from trace metal and nutrient supplementation, particularly beneficial effects of Fe, Ni, Co addition has been emphasized

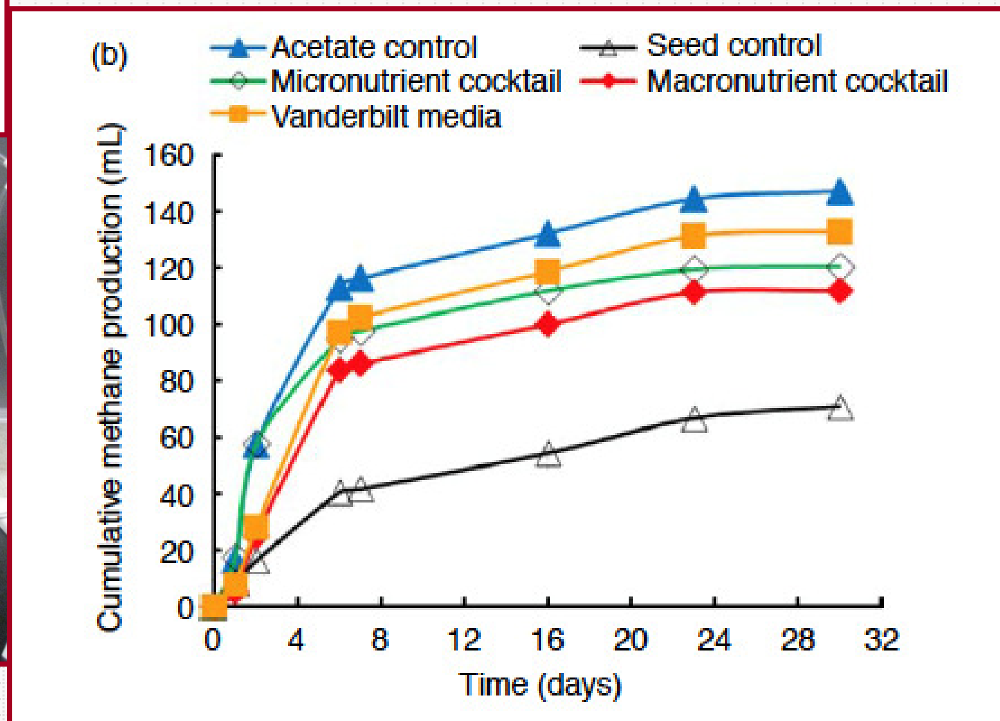
A bench scale biochemical methane potential (BMP) study was conducted to determine if digesters at NEWPCP would benefit from supplement of : 1)Various concentrations of Fe, Ni, Co; 2) A macro nutrient cocktail; 3) A trace metal cocktail; 4) A combination of macro nutrient and trace metal cocktails (Vanderbilt Media)

Optimization work: Nutrient supplementation (Cont.)



Results suggested that there was no benefit of nutrient supplementation (there was slight inhibition in some cases)





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Co-digestion studies

1. Co-digestion of aircraft deicing fluid (ADF)

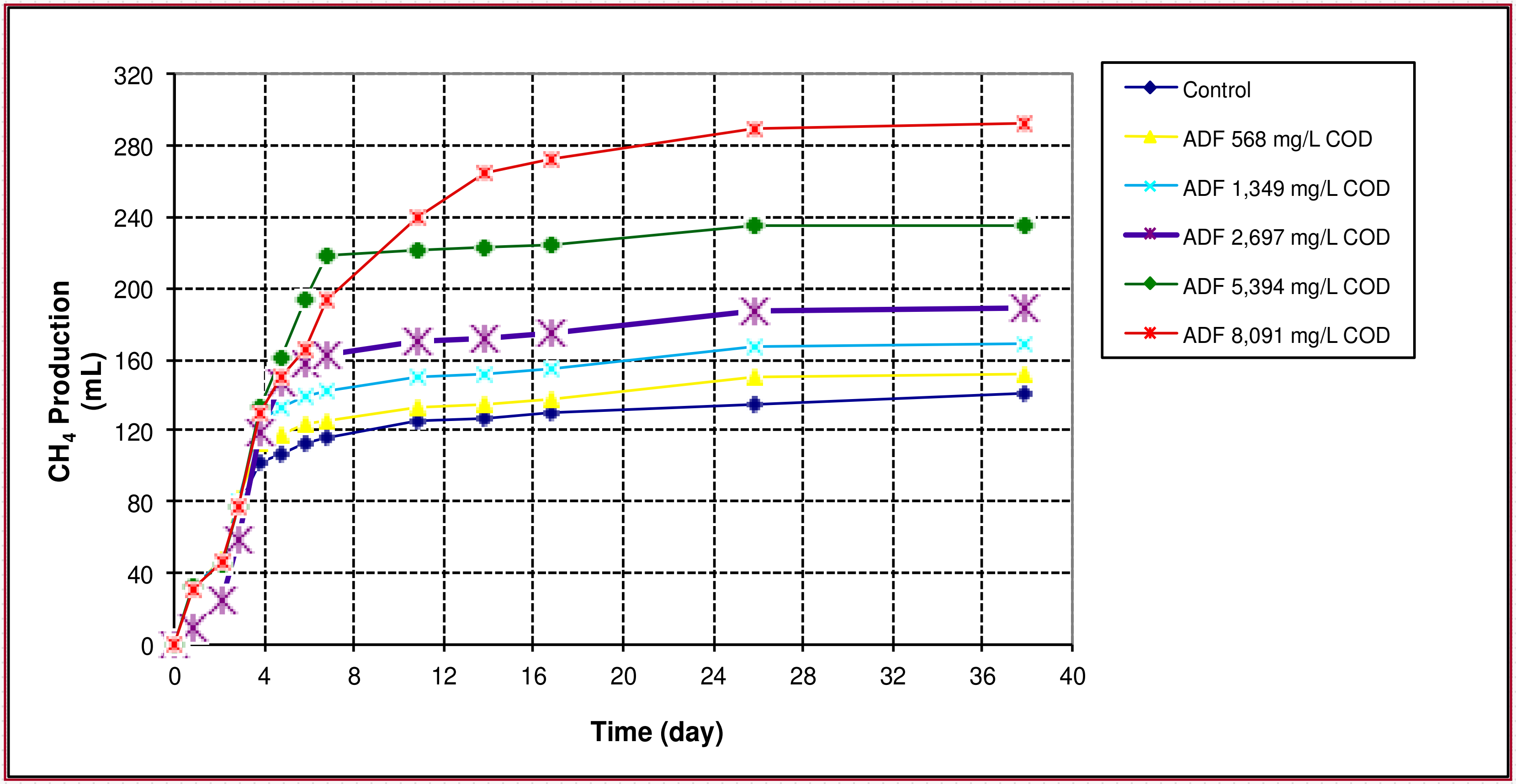
As a potential co-digestion feed-stock, runoff from Philadelphia International Airport (PHL) was studied for its BMP and degradation kinetics

PHL uses propylene glycol-based Type I (88% propylene glycol and 11% water) and Type IV (52.2% propylene glycol and 46.8% water) aircraft deicing fluids (ADF)

Various diluted concentrations of both ADF types were tested

Co-digestion studies: ADF (Cont.)

Results indicated both ADF types have high CH_4 potential and they are easily co-digested in bench-scale anaerobic digesters that simulated the full-scale digesters at NEWPCP



Co-digestion studies (Cont.)

2. Co-digestion of biosolids from a refinery

Waste activated sludge from two different treatment plants of the same refinery process were investigated for their potential toxicity and BMP as potential co-digestion feed-stock

Results suggested that although not inhibitory for co-digestion, biosolids from that particularly refinery had limited CH_4 potential

Co-digestion studies (Cont.)

3. Co-digestion of FOG (scum)

Possible inhibitory effect and BMP potential of clarifier skimmings (fats, oil, and grease, *aka* scum) was investigated when they are co-digested

This particular work was carried out using five-gallon bench-scale digesters

Parameter	Scum sample From primary settlers	From skimmings concentration tank
Total solids (TS), mg/L	287,000 (13,900)	627,000 (1,710)
Volatile solids (VS), % of TS	97 (1.22)	98 (1.69)
Chemical oxygen demand (COD), g/g scum	1.18 (0.084)	1.40 (0.065)

[a]Values in parenthesis represent standard deviations of triplicate samples.

Co-digestion studies: Scum co-digestion (Cont.)

Results indicated scum is a viable co-digestion candidate with high potential (about 0.3 MW power equivalent)

However, due to presence of excessive debris in scum collection tanks, materials handling in feeding scum to digester may pose issues and improving headworks screening process might be necessary

COD loading rate (g COD/(L·d))		CH_4 yield (L CH_4/d)		Specific CH_4 yield (L CH_4/kg COD)	
Scum and feed	Scum only[a]	Scum and feed	Scum only	Scum and feed	Scum only
5.6	1.5	17.4 (1.8)	7.7 (1.4)	238.4 (24.8)	105.1 (18.8)
6.7	2.6	22.6 (3.4)	12.6 (2.8)	257.7 (39.2)	143.5 (32.1)
7.6	3.5	25.9 (3.1)	16.2 (2.9)	262.2 (31.6)	163.9 (29.8)
11.0	7.0	44.1 (5.1)	35.9 (4.4)	308.4 (35.9)	251.3 (30.5)

[a] CH_4 production from 'scum only' was calculated by taking the difference in CH_4 generation from R1 and R2.
[b] Values in parenthesis represent standard deviations of triplicate samples.

Co-generation plant

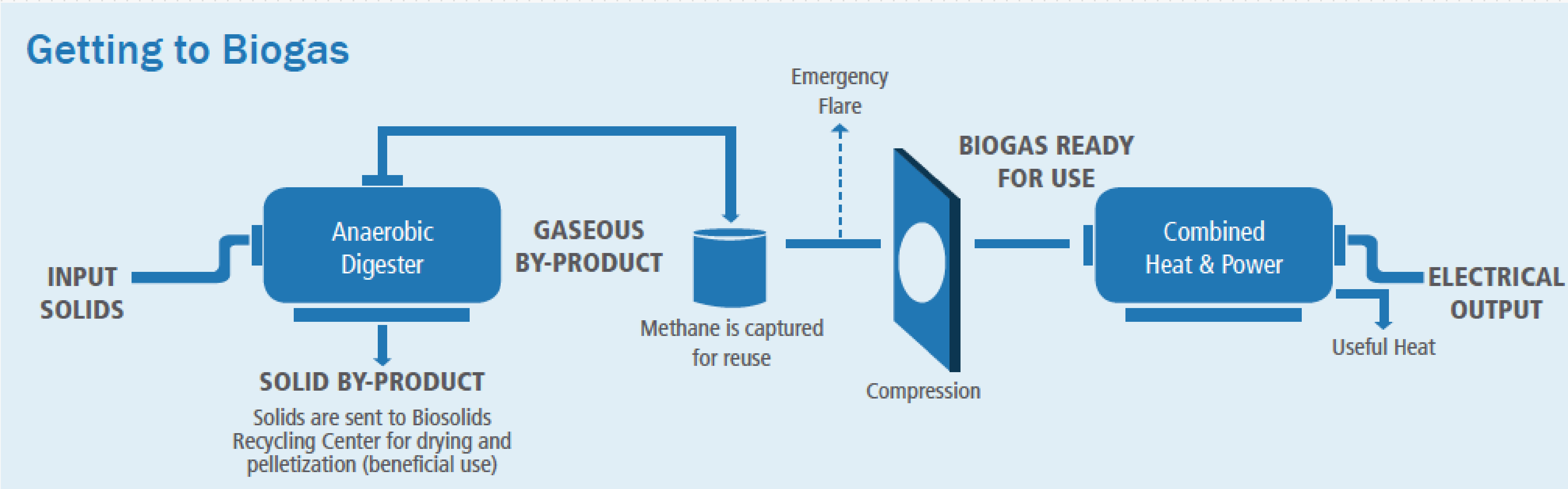
With inclusion of ADF runoff from PHI, PWD were able to generate enough CH_4 to make investing in a co-generation plant economically feasible

On December 23, 2011, PWD finalized its plans to build a co-generation plant at NEWPCP

5.6 MW capacity co-generation plant now runs on CH_4 generated from anaerobic digesters in NEWCP

At full capacity, co-generation plant would meet all process heat needs and eighty-five percent of the electrical requirements for plant operations

Co-generation plant (Cont.)



Important Facts

1. Energy production

- 43 million kWh per year
- Enough energy to power over 4,000 Pennsylvania homes annually. (2010 basis, US Energy Information Administration data)

2. Facility Equipment

- Four 1.4 MW reciprocating engines
- Gas cleaning equipment
- State-of-the-art air pollution control equipment
- Power and heat distribution system

3. Biogas cogeneration is highly efficient

- The generator engines burn the biogas, converting 38% of the energy to electricity and recapturing 44% of the waste heat. This results in a highly efficient capture of over 80% of the available energy.
- In contrast, a coal-fired electrical generation station is about 33 to 35% efficient based on the energy content of its fuel.

Concluding remarks

Anaerobic digester optimization and additional feed stocks for co-digestion could make co-generation plants economically feasible especially for large wastewater treatment plants

CH_4 to energy projects are especially attractive in countries where cost of energy is relatively high

University-industry collaboration is key in conducting bench-scale optimization and co-digestion studies within a limited budget

NEWPCP work could serve as a model for other large-scale facilities around the world