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An AIChE Technological Community

Common interest: WTE, WTERT, and AIChE

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Center for Energy Initiatives
Director, Technical Entities

WTERT October, 2014

Ref: Castaldi, 2014

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Center for Innovation & Entrepreneuring Excellence
An AIChE Technological Community

institute for sustainability
An AIChE Technological Community

International Society for Water Solutions

Welcome to *Technical Entities of AIChE*

SOCIETY for BIOLOGICAL ENGINEERING
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AIChE
The Global Home of Chemical Engineers

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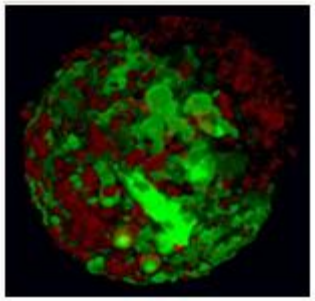
Providing Solutions for Society's Grand Challenges

Energy

Environment & Sustainability

Water



Health & Nutrition

Center for Energy Initiatives

Institute for Sustainability

New **International Society for Water Solutions**

Society for Biological Engineering

New *International Society for Metabolic Engineering*

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(ITAs): Providing Solutions for Industry's Challenges

CCPS

CHO II

CSTP

DIPPR

CCPS & DIERS address process safety

CHO II addresses pharmaceutical development & quality

CSTP & Cosmetics roundtable cover sustainability

DIPPR addresses quality of physical properties measurement

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State of Waste To Energy: Growing Importance for Energy and Source of Renewables

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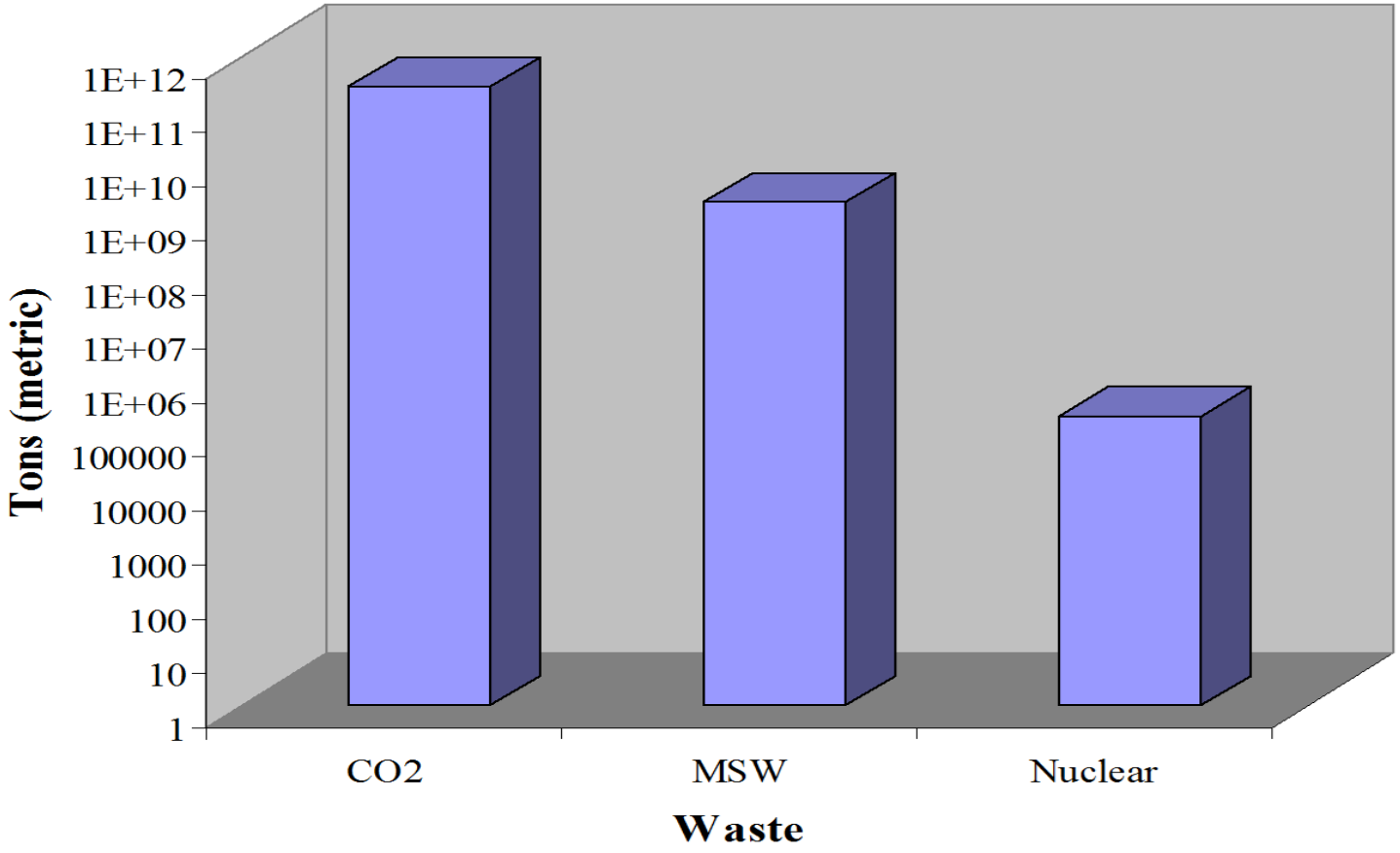
Major Waste Streams



Waste can be a feedstock

Ref: Castaldi, 2014

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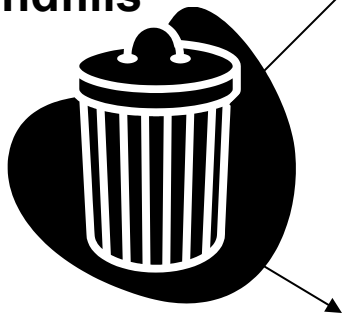
Two Primary Choices for waste management

249 Million tons of trash (MSW) goes to landfills

Landfills

Renewable Energy Generated from Landfills - 5 billion kWh

Up to 100 kilowatt hours of electricity per ton of waste



Waste to Energy

29 Million tons of trash goes to EfW

Renewable energy generated from WTE Facilities - 15 billion kWh

Up to 700 kilowatt hours of electricity per ton of waste

These two options co-exist for the foreseeable future

Ref: Castaldi, 2014

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A Renewable Resource

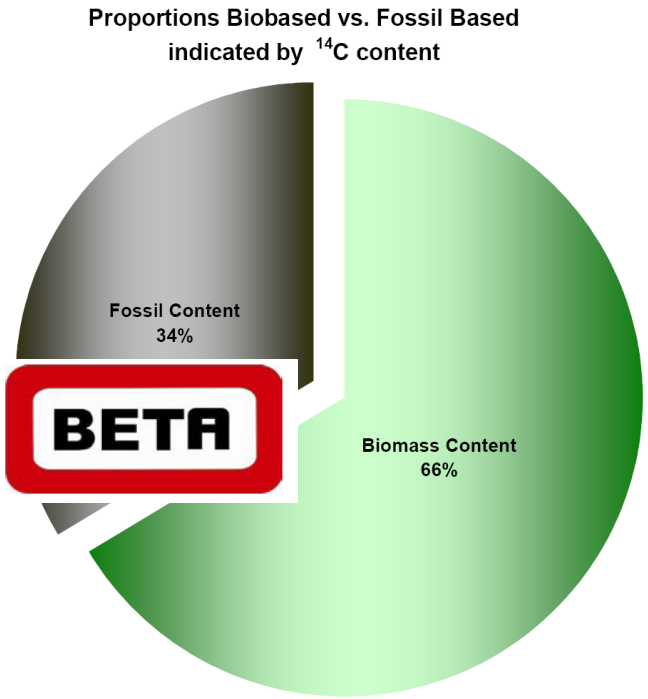


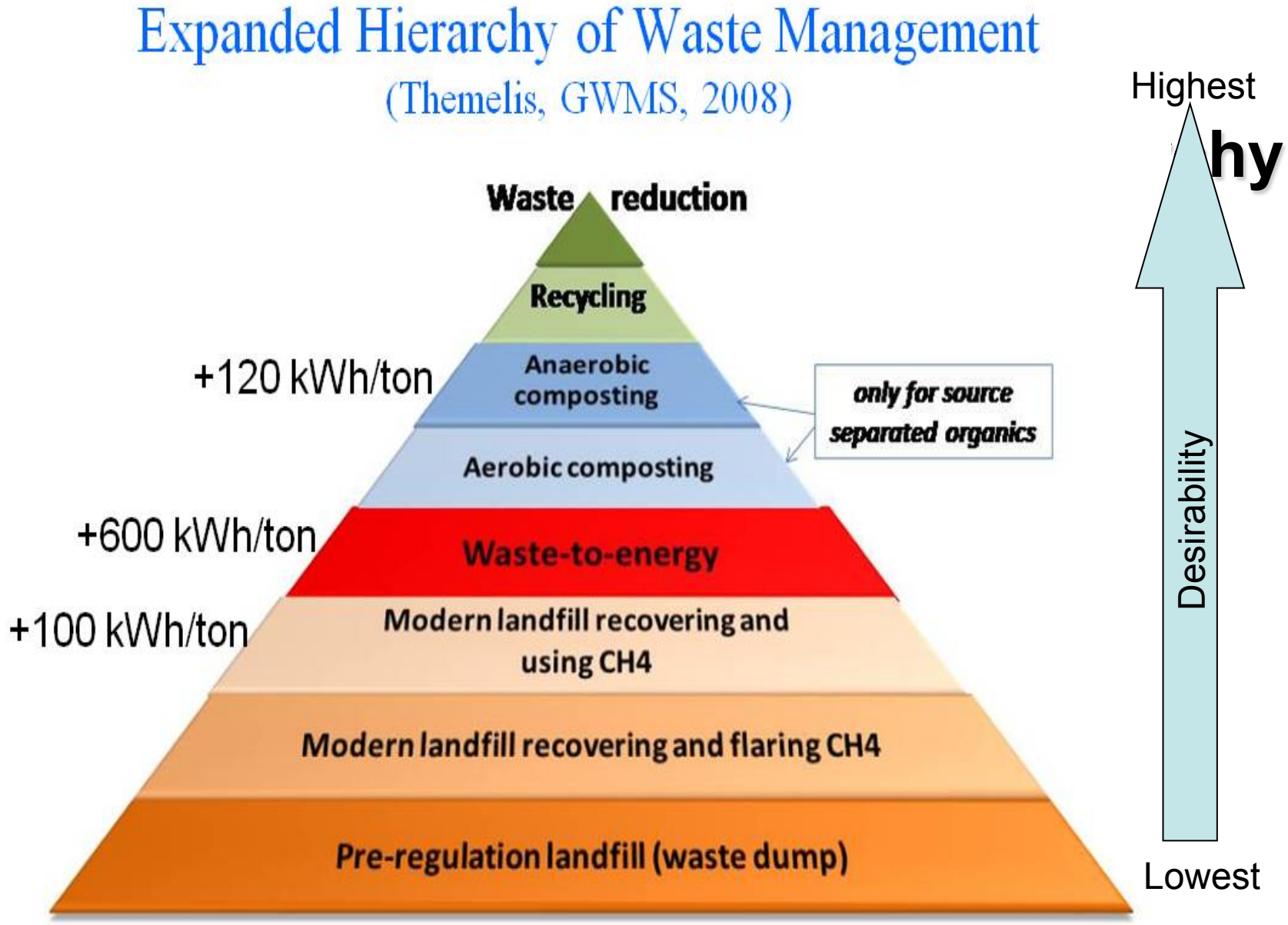
Table 3. Characterization of U.S. MSW by USEPA [7]

Biomass components	%	Petrochemical components	%
Paper/board	36.2	Plastics	11.3
Wood	5.8	Rubber, nylon, other textiles.*	3.7
Yard trimmings	12.1		
Food scraps	11.7		
Textiles (cotton, wool, leather)*	3.7		
Total biomass	69.5%	Total fossil-based	15.0%

**Rubber, leather and textiles category of USEPA 7.4%) were assumed to be divided equally between natural and man-made products*

- ASTM D8666 testing standard using ^{14}C
- Biomass content; 3 WTE flue gas samples
  66%, 68% and 66%
- 10% - 36% reduction of CO_2 emissions compared to landfill

Recommended Methods for Muncipal Solid Waste (MSW)



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Global WTE Facilities Today

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Importance in US is growing

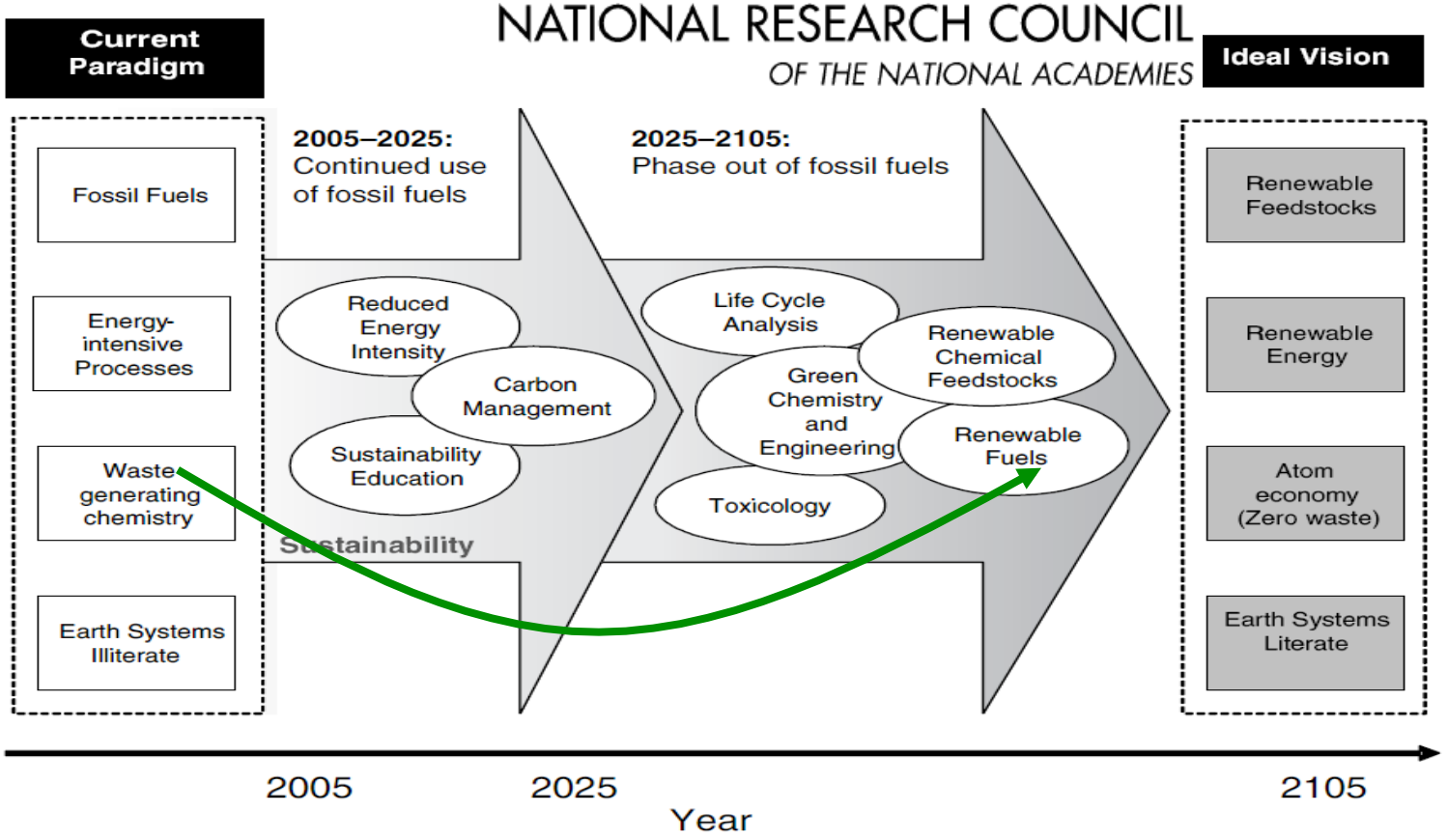

FIGURE ES-1 The Grand Challenges (ovals) for Sustainability (large arrows) that address the transition from current thinking to the ideal vision for the chemical industry over the next 100 years. See text for a more detailed description of figure and the Grand Challenges.

Source: *Committee on Grand Challenges for Sustainability in the Chemical Industry Board on Chemical Sciences and Technology Division on Earth and Life Studies*

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Could a professional society help the Waste Valorization R&D Agenda and Community?

Conferences ★

Workshops for Continuing Ed ★

E-learning for continuing Ed?

Webinars to educate community? ★

Workshops to help set Funding Agendas?

Measuring Impacts?

Standards?

August 26, 2013, 12:14 p.m. ET

Covanta Announces 20-Year Agreement With New York City Department of Sanitation for Sustainable Solid Waste Disposal

Covanta Announces 20-Year Agreement With New York City Department of Sanitation for Sustainable Solid Waste Disposal

Significant Long-Term Contract Will Reduce Greenhouse Gases and Generate Clean Energy-from-Waste

MORRISTOWN, NJ--(Marketwired - Aug 26, 2013) - Covanta (NYSE: CVA), a world leader in sustainable waste management and renewable energy, announced today a new 20-year agreement with New York City Department of Sanitation to transport and sustainably dispose of municipal solid waste ("MSW") delivered to a pair of marine transfer stations located in Queens and Manhattan. Covanta is the largest owner and operator of Energy-from-Waste ("EfW") facilities in North America and plans to utilize capacity at existing facilities to convert the City's MSW into clean energy. It is anticipated New York City will deliver approximately 800,000 tons of MSW per year which reflects the City's continued efforts to reduce waste generation and increase recycling.

"New York City is a leader in addressing climate change which makes us particularly proud that they chose Covanta and our Energy-from-Waste solution to help achieve one of their important sustainability goals," said Anthony Orlando, Covanta president and chief executive

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What is next For Waste Valorization and WTE Community?

Spectrum of Value added Products and Services

- Platform for individuals to present their work (conferences)
- Platform for peer review of projects relevant to industry and academia (Workshops?)
- Ability to network with other experts (Research Coordination Networks)
- Ability to learn (e.g. E-learning?)
- Ability to create new knowledge by sharing with others (committee papers for WTE importance? standards, NSF Workshops for Funding Agendas?)
- Ability to collaborate to create new knowledge and businesses (Academic-Industry Group? Peer review services, Metrics projects)

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WTE is of growing importance

- 2011 world MSW generating ~ 2 billion tons
- ~ 800 thermal WTE plants currently
  - Operating in nearly 40 countries
  - This is 11% vs 70% landfilled
- WTE expected to increase
  - to 283 terawatt hours by 2022 from 221 in 2010
  - Global market for WTE technologies ~$6.2 billion in 2012 and grow to $29.2 billion by 2022.

Source: Pike Research

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Back up

metrics project

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Design Data | Prototype | Materials & Process Tech | Product Manufacturing | Qualification | In Service

Control & Automation

Business Systems

Macro Layer

10s
control loops
Time – days

Focus: 10x Multiple Pass Variability Reduction; Supply Chain Information

Meso Layer

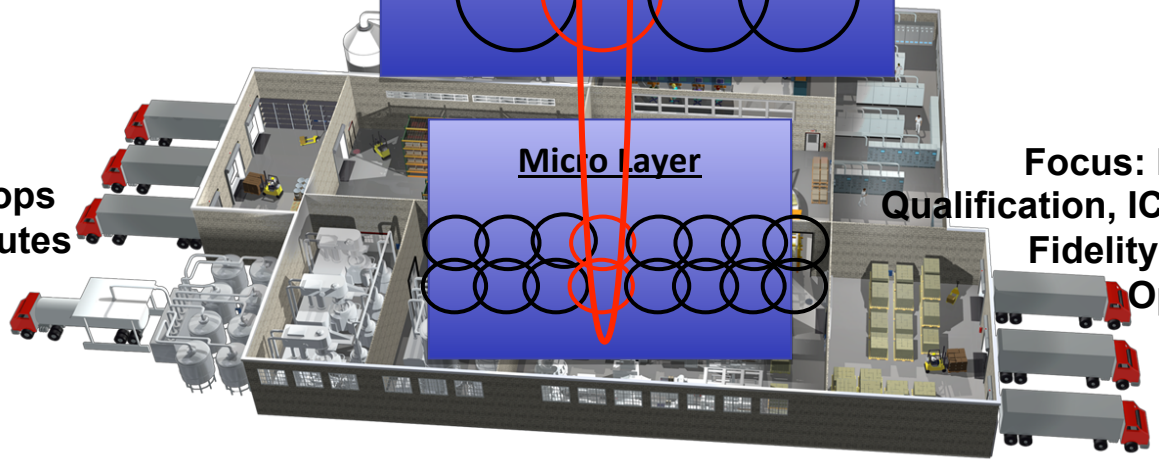
100s
control loops
Time -hours

Focus: 100x Event Variability/Tradeoff Adjustment; Dynamic Performance Mgmt.; Integrated Metrics

Micro Layer

1000s
control loops
Time - minutes

Focus: Insertion, Qualification, ICME, High Fidelity Dynamic Operations



PAN AMERICAN BIOFUELS
AND BIOENERGY SUSTAINABILITY
AN NSF RESEARCH COORDINATION NETWORK

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- About us
- Steering Committee
- Events
- PanAm RCN Conference
  - Organizers
  - Program
  - Registration
  - Sponsorship

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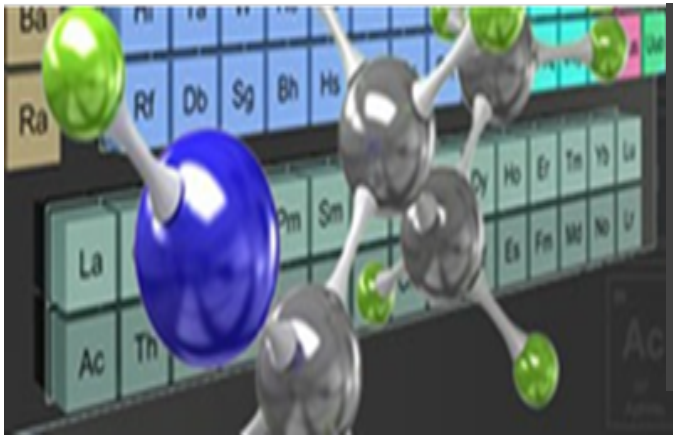
RCN-SEES for Pan American Biofuels and Bioenergy Sustainability

The PanAm RCN will be holding its first Conference on Pan American Biofuels and Bioenergy Sustainability, co-organized by AIChE, IfS and SBE, on July 22-25, 2014 at the Golden Tulip Recife Palace hotel in Recife, Brazil.

The implications of large-scale biofuels and bioenergy production on environmental systems and social conditions are largely unknown. Yet despite this lack of fundamental sustainability knowledge, there currently is a rapid movement toward the development of biofuels and bioenergy production systems that will likely lead to dramatic changes in extant human and natural systems.

These changes may be beneficial or detrimental, and may involve a number of issues such

Outreach Example for IfS and CEI



Separation Science and Technology (SST) as a Convergence Platform for *SusChEM,*

Sustainable Chemistry, Engineering and Materials

Aug 12-13; San Francisco NSF Workshop with ACS

Derrick/Lucy: Implemented

Evan Grant: Proposal

Diane: Support –reimbursements and processing

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Develop and Test Metrics in Prax Air and General Dynamics Test Beds

Metrics – Develop generalized energy performance and productivity metric components focused on the following process technologies: steam reforming (continuous) and discrete (forging and machining).

6.1: (Yr. 1) Establish an SMLC/practitioner lead to oversee the development of generalized energy performance metrics that also meet the objectives of the Praxair and GD test beds

6.2: (Yrs. 1, 2) Report and establish broader industry acceptance of energy productivity metrics

6.3: (Yr. 3) Demonstrate the SM Platform using a dynamically managed, integrated energy efficiency metric

6.4: (Yr. 3) Use SM Platform to implement energy dashboard beta deployment in Praxair and General Dynamics plants

Spectrum of Value added Products and Services provided by AIChE and ITG's

- Platform for individuals to present their work (conferences)
- Platform for peer review of projects relevant to industry and academia (conferences and workshops)
- Ability to network with other experts (Research Coordination Networks)
- Ability to learn (e.g. attend conferences and continuing education courses workshops)
- Ability to create new knowledge by sharing with others (committee papers, standards)
- Ability to collaborate to create new knowledge and businesses (CHO, books, Sustainability Index, peer review services, Metrics projects)

Extraction of value from wastes is sustainable

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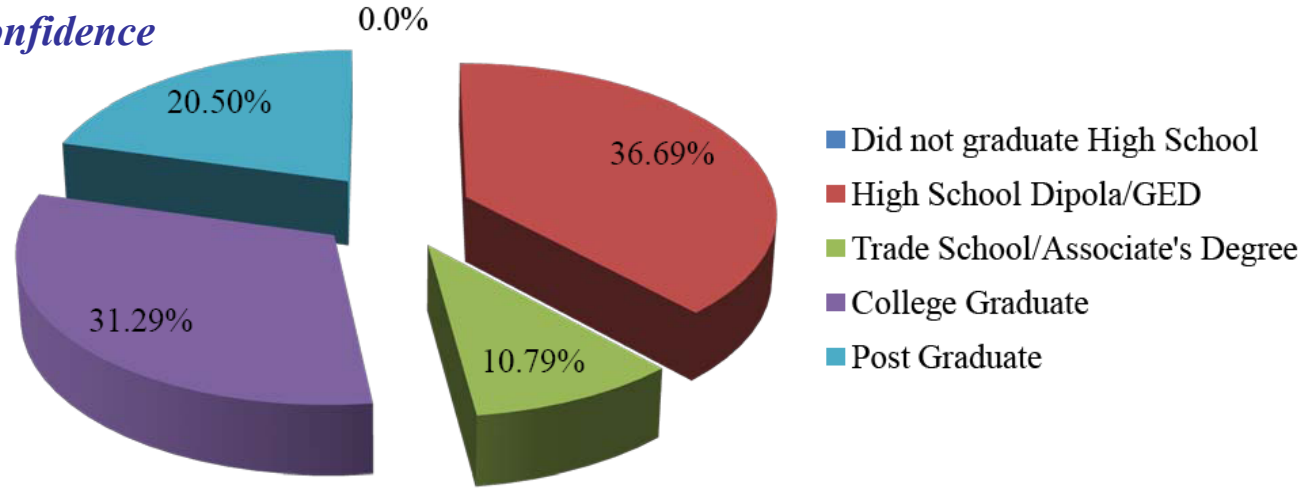
- ***Conserves fossil fuels by generating electricity.*** ***(Energy)***
  - 1 ton of waste combusted = 45 gallons of oil or 0.28 tons of coal
  - Most WTE facilities in U.S. process between 500 and 3,000 tons of waste per day
  - Electricity for 2.8 million homes
- **WTE facilities process 14% of the MSW in the United States.** **(Health)**
  - Trash-disposal needs about than 37 million people
- ***Reduce greenhouse gas emissions.*** ***(Climate, global)***
  - EPA estimates :WTE facilities prevent 33 million metric tons of CO_2 per year avoided
- ***Compatible with recycling****.* ***(Resource Minimization)***
  - Communities served by WTE recycle 35% of their trash, compared to 30% for the general population.
  - Annually removes more than 700,000 tons of ferrous materials
  - ~ 3 million tons of WTE ash reused as landfill cover, roadbed, or building material.

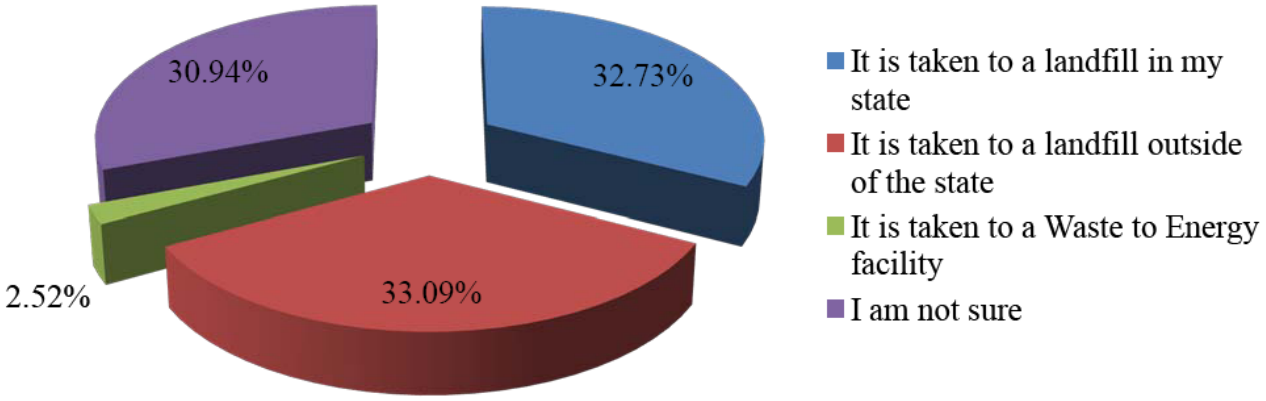
2013 CCNY Survey of NYC residents on WTE

~400 respondents → 95% confidence level ±5.1error margin

Highest level of education completed

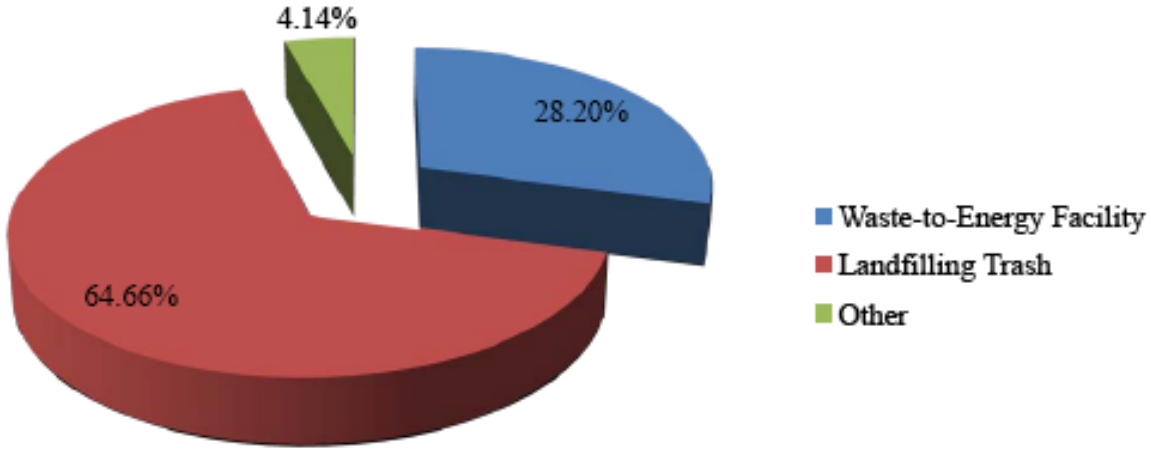


Where do think your trash goes after you throw it away?

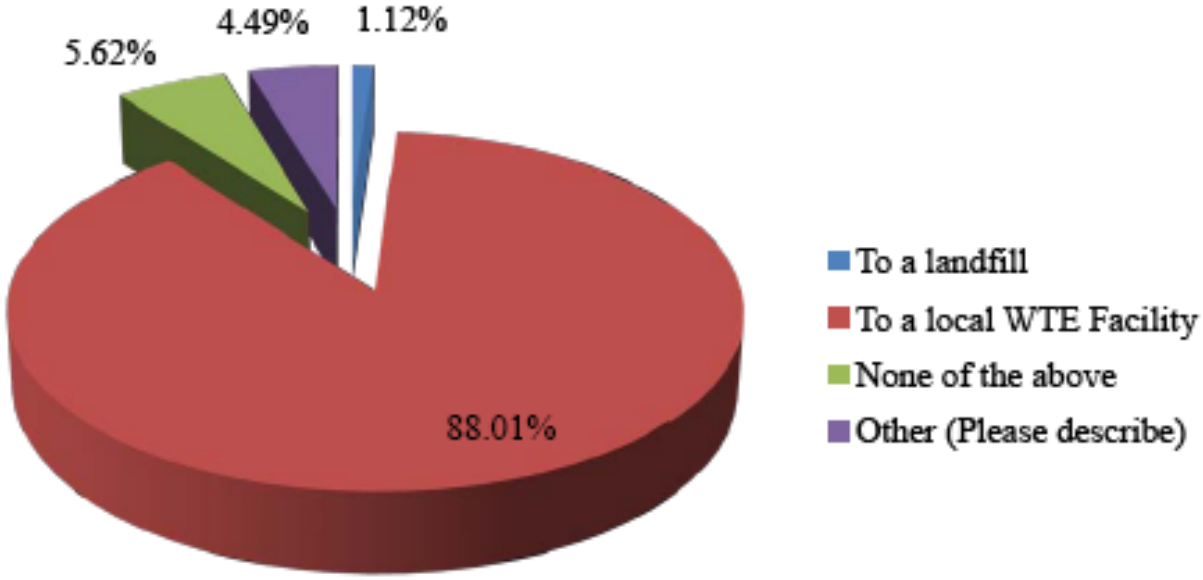


2013 CCNY Survey of NYC residents on WTE

Which option do you think produces more greenhouse gases?



Given what you know about waste-to-energy and landfilling where would you prefer your trash to go?




The Sustainable Waste Management Ladder
Earth Engineering Center, Columbia University (based on Eurostat 2008 data)
Netherlands
Germany
Sweden
Austria
Denmark
Belgium
Luxembourg
France
Italy
Finland
United Kingdom
Spain
Ireland
Portugal
Slovenia
Hungary
Estonia
Greece
Slovakia
Czech Republic
Poland
Cyprus
Latvia
Lithuania
Malta
Romania
Bulgaria
U.S.A. SOG 2008 data
0
20
40
60
80
100
% Recycled
% Composted
% Landfilled
% to Waste-to-Energy

Representative Emissions for U.S. WTE Operational Facilities

Emissions, mg/Nm3	Average of 10 WTEs	E.U. standard	WTEs as % of E.U. standard
Particulates	3.06	10	31%
SO2	12.2	50	24%
NOx	123	200	61%
HCl	7.88	10	79%
CO	26.3	50	53%
Mercury	0.01	0.05	20%
TOC	0.92	10	9%
Dioxins, ng TEQ/m3	0.02	0.10	21%

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R&D Agenda

- Next generation combustors – higher energy density
  - Low NOx operation
  - Approach 3+ MW m^{-2}
- Liquefaction of wastes (T ~ 300 – 500 ºC)
  - Removal of O_2
- In-situ reduction of corrosive gases
  - Injection of halogen scavengers
- Novel uses of ash – catalytic and property adjustment
- LFGTE Applications and LFG to fuels
  - Casella Energy to implement in DE

Engagements

ESTEE LAUDER

Development of MSW Thermal Treatment 1900 - 2000

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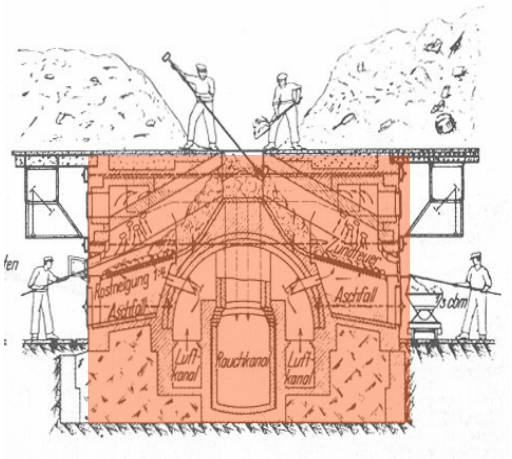

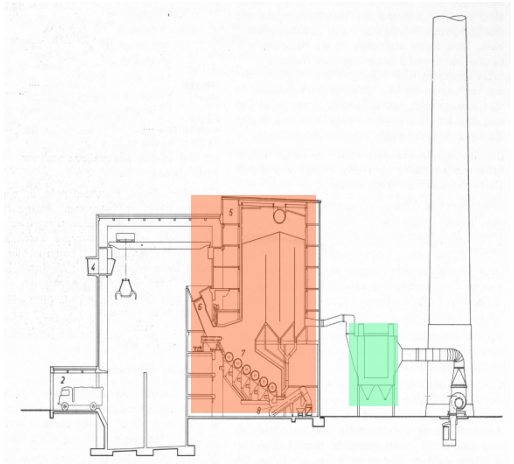

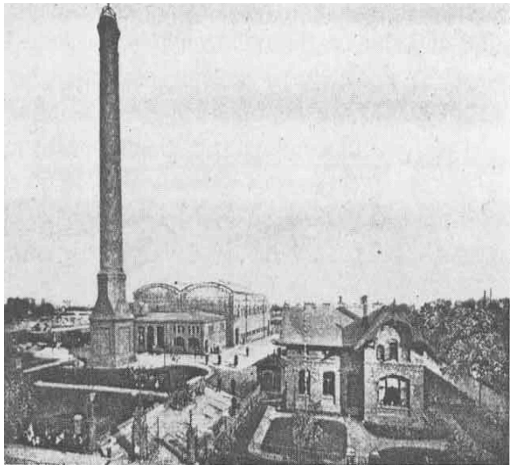

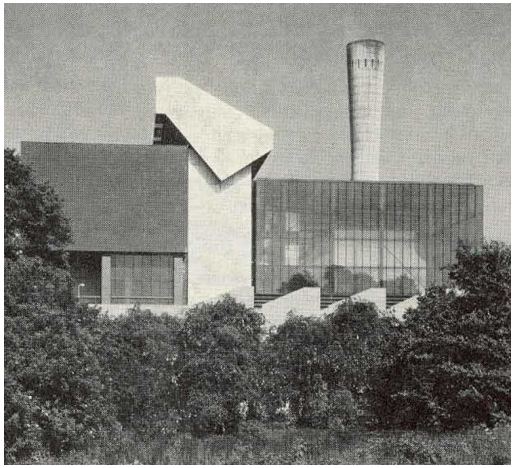

1896 1970