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EEC|CCNY Activities

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City College, City University of New York

Director, WTERT-U.S.A.

Director, Earth Engineering Center|CCNY

Director, Earth Systems Science & Environmental Engineering

Combustion & Catalysis Laboratory

October 4th, 2018

New York City, NY

WTERT
Waste-To-Energy Research and Technology Council

Overview

- Thoughts & Perspective
- Specific examples of some activities
- Acknowledgements

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Perspective on Wastes

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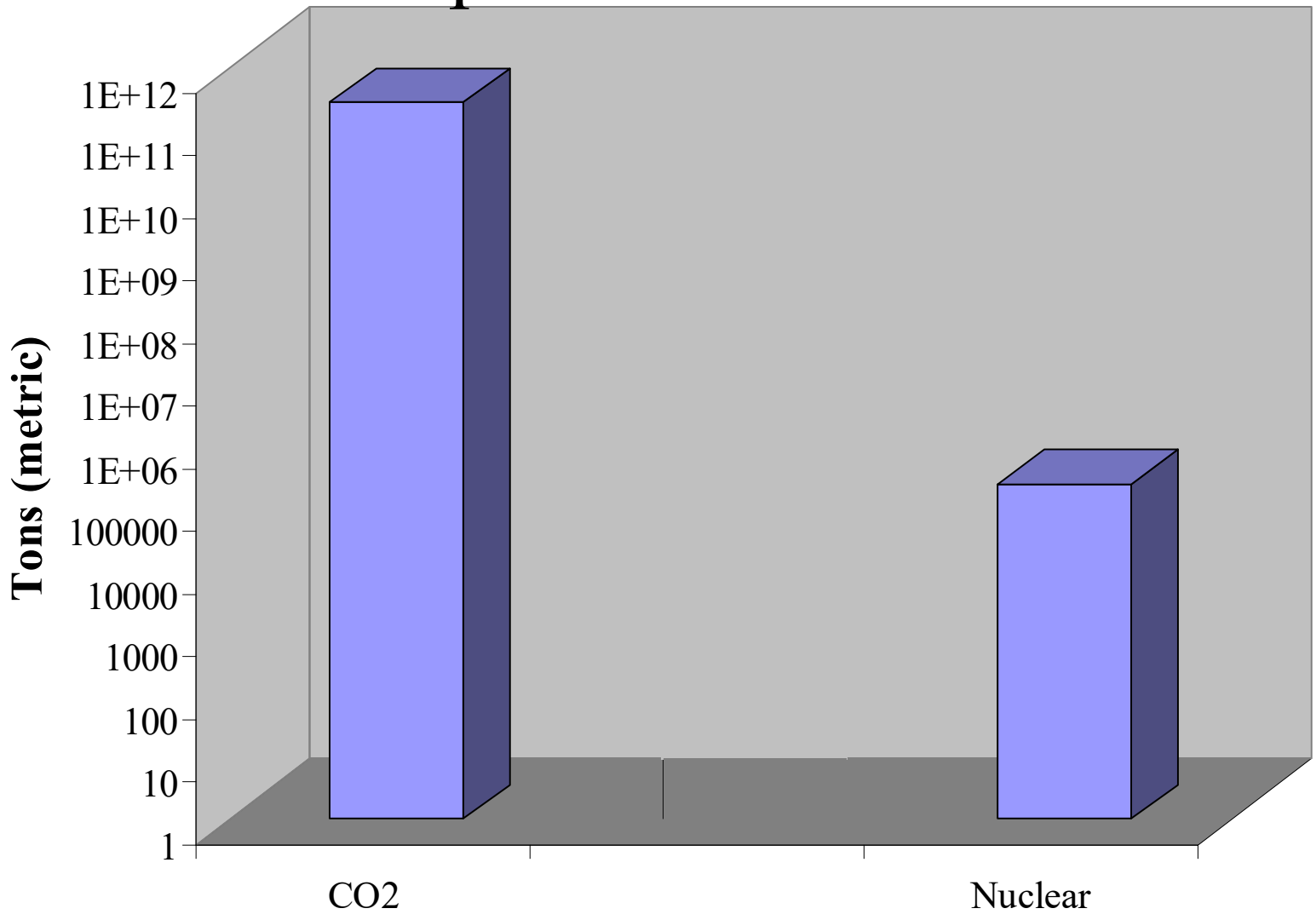

Not Just Energy but also waste and by-products impact the Environment

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What do the percentages say?

18% Without electricity

Source: EIA

11% Without Clean water

Source: UNwater.org

0.0% Without waste

11% Without food

Source: worldhunger.org

Everyone in the world has access to waste

- MSW
- agricultural/biomass
- human excrement

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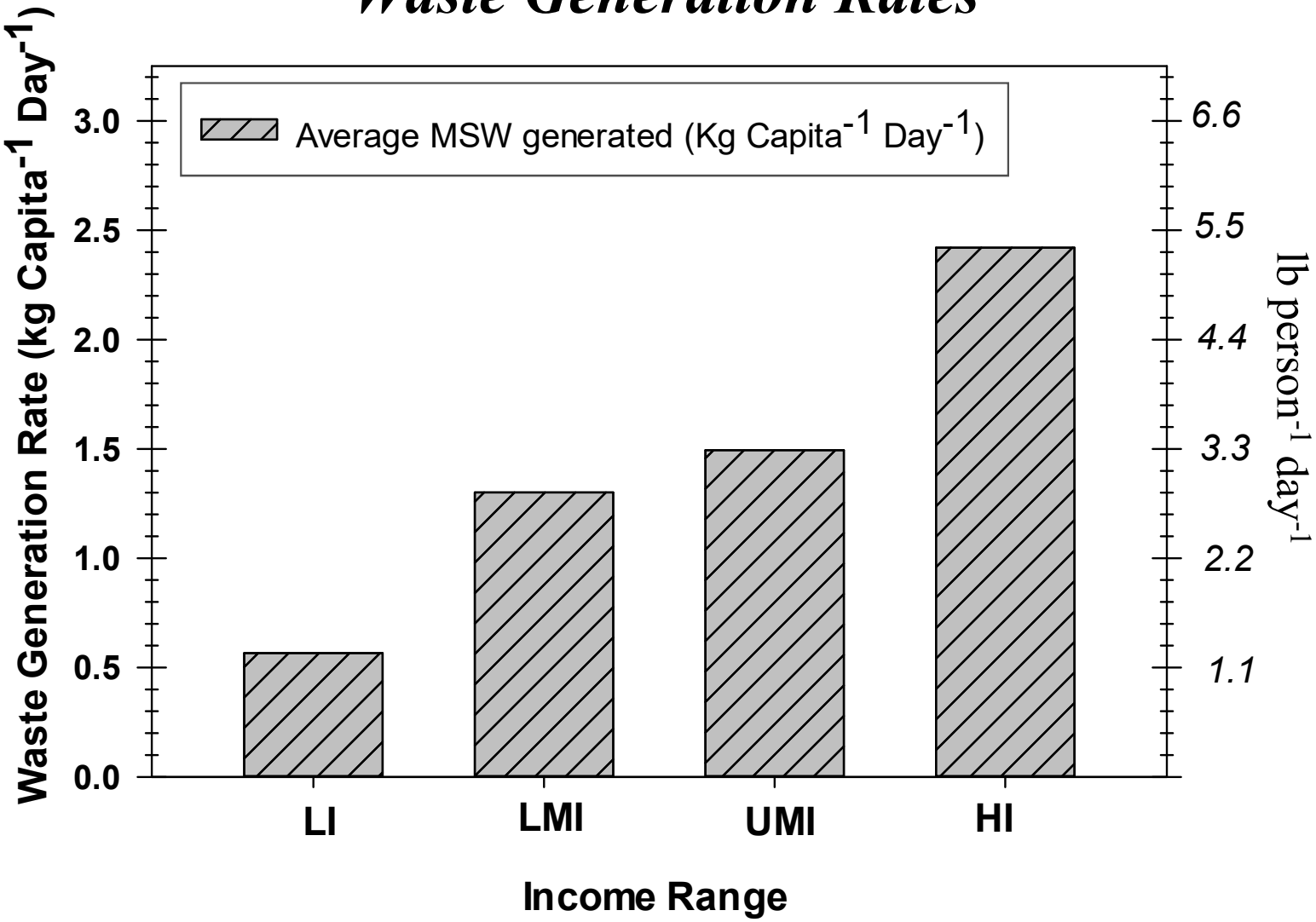
More Perspective, Waste Generation Rates



- *Typical data presentation regarding averages shows higher income regions generate more waste*

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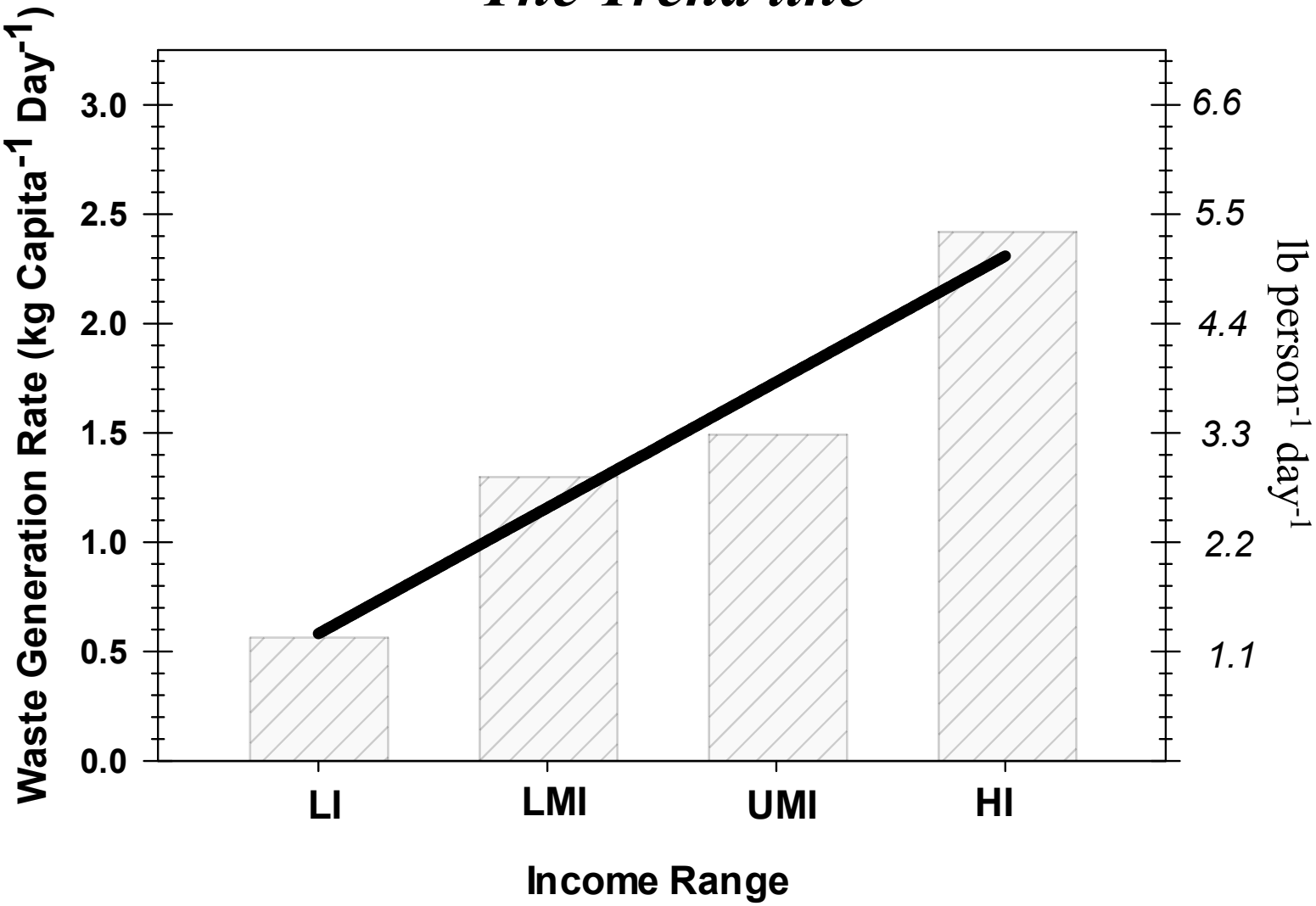
Waste Generation Rates
– The Trend line –



- *Trend line in data does not exactly match average trends*

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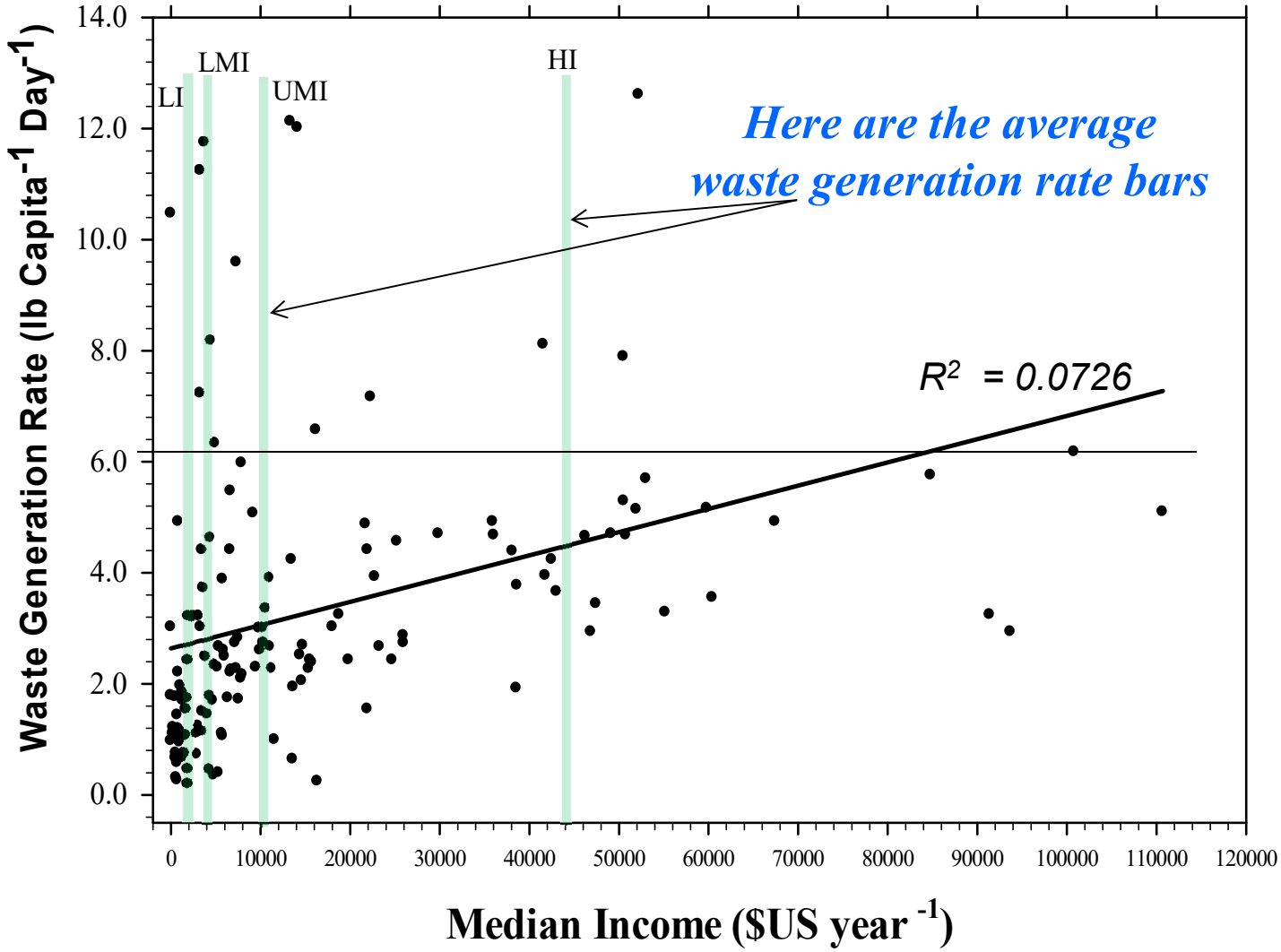
Waste Generation Rates
– Actual Data –



• *No clear correlation with income level when looking at all data*

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Waste Generation Rates
– Actual Data with Statistics –

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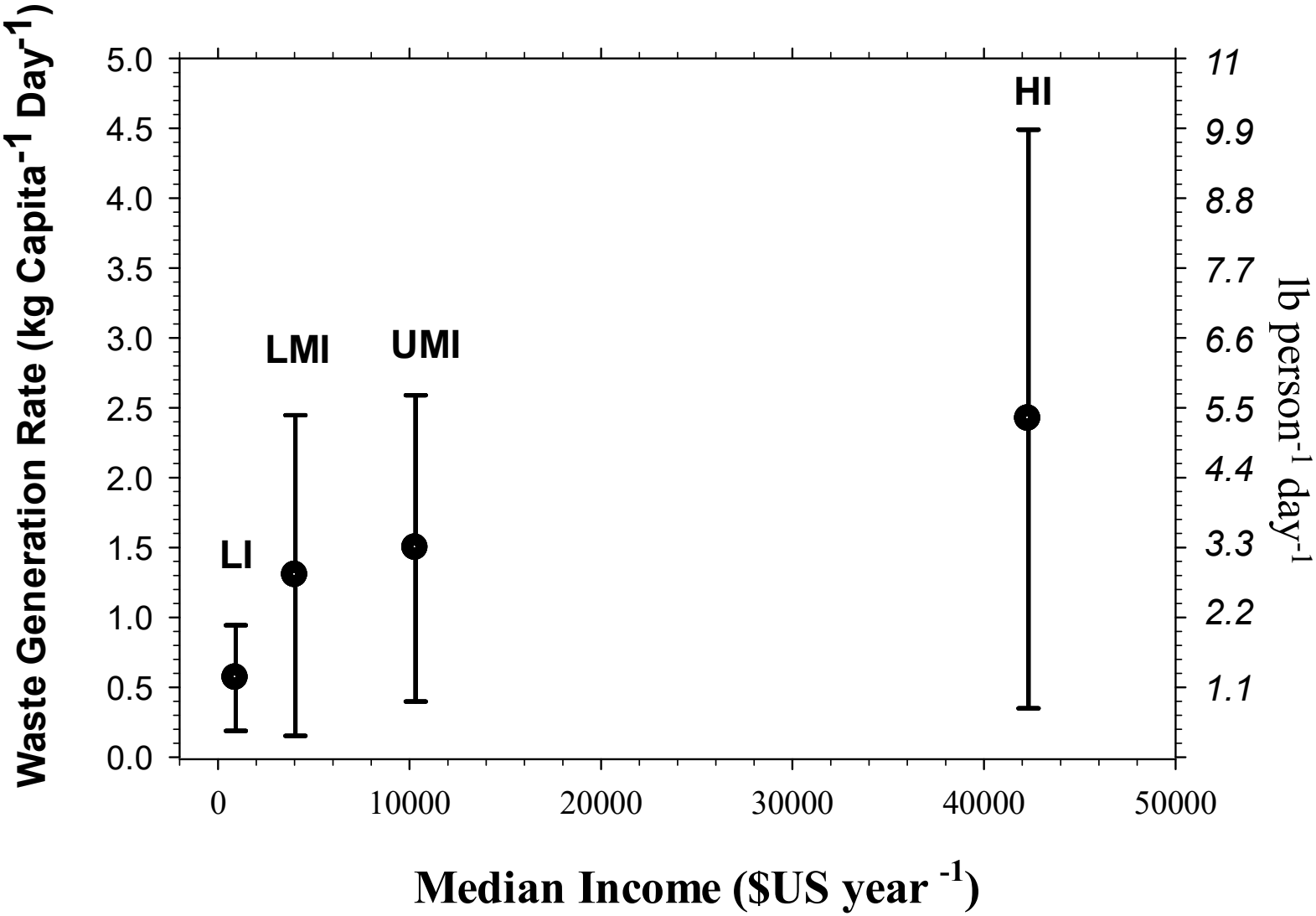

- *Using averages and standard deviation → large overlap*

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Is there a minimum amount of waste?

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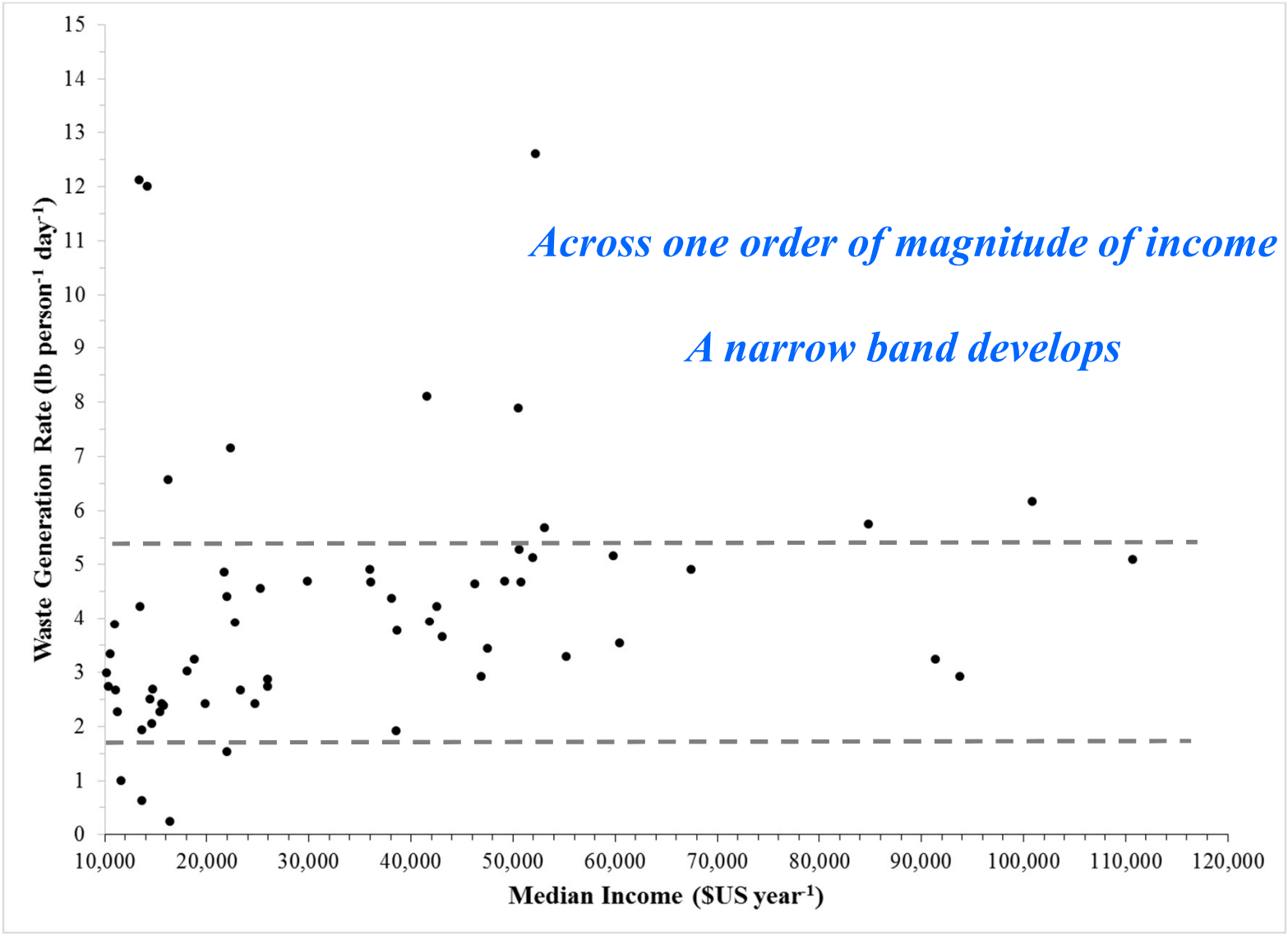

- *\Narrow Band: ~2.5 and 4.0 lb/person/day*

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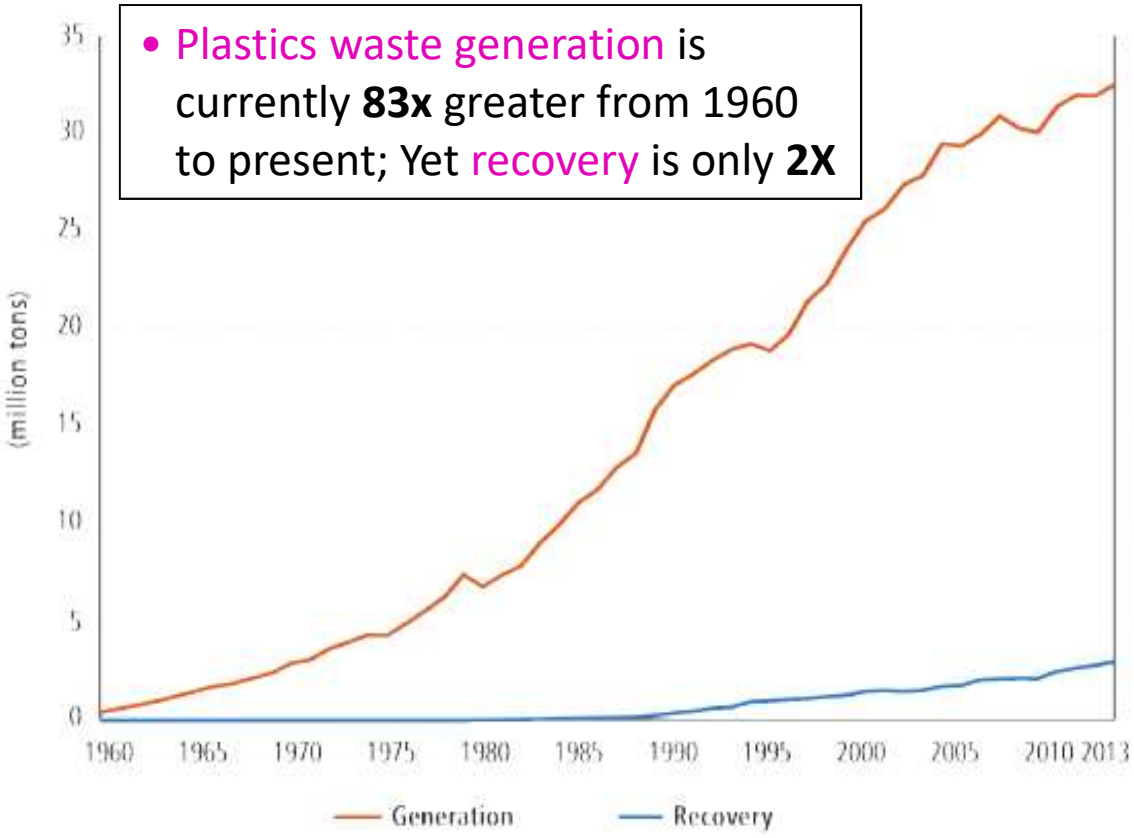
Plastics Waste in the U.S.

- In US, Plastics accounted for approximately 13% of total MSW
- Recyclable plastics are designated as rigid plastics of primarily #1-PET, #2-HDPE, and #5-PP resins
- Non-recyclable plastics are primarily films and multi-layer packaging

Plastics Generation and Recovery in U.S., 1960-2013



Source: US EPA

•Why is this the case? How can this be improved?

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Technical Limits to Recycling

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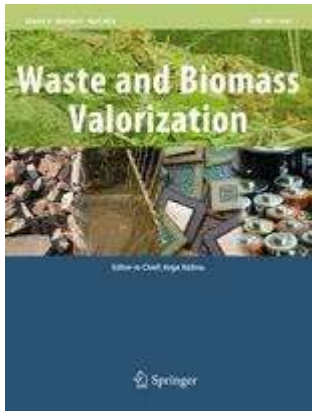
Some areas have great real recovery rates

	Generated (Tons)	waste (Tons)		recycled
Lombardia, Italy (2009)	4403066	538730	12.2	**85**
Lee county, Florida, USA (2012)	1098301	145400	13.2	59
Orange county, Florida, USA (2012)	1881650	306582	16.3	58
Sarasota, USA (2012)	719643	107303	14.9	44



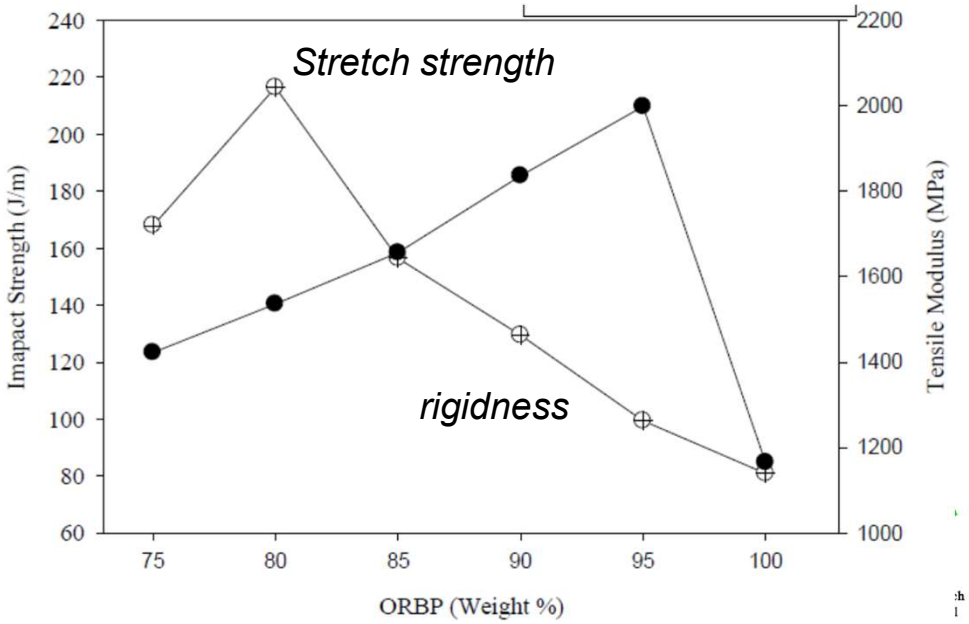
Sharma, D.K., et al. (2017)
https://doi.org/10.1007/s12649-017-0109-5

Having ideal recovery of rates of 85% and 73% for paper and plastic waste streams.

Leaves 83,846 tons of waste left in this ideal community (~15 %)

This is only plastic and paper

Quality trade-offs with recycling



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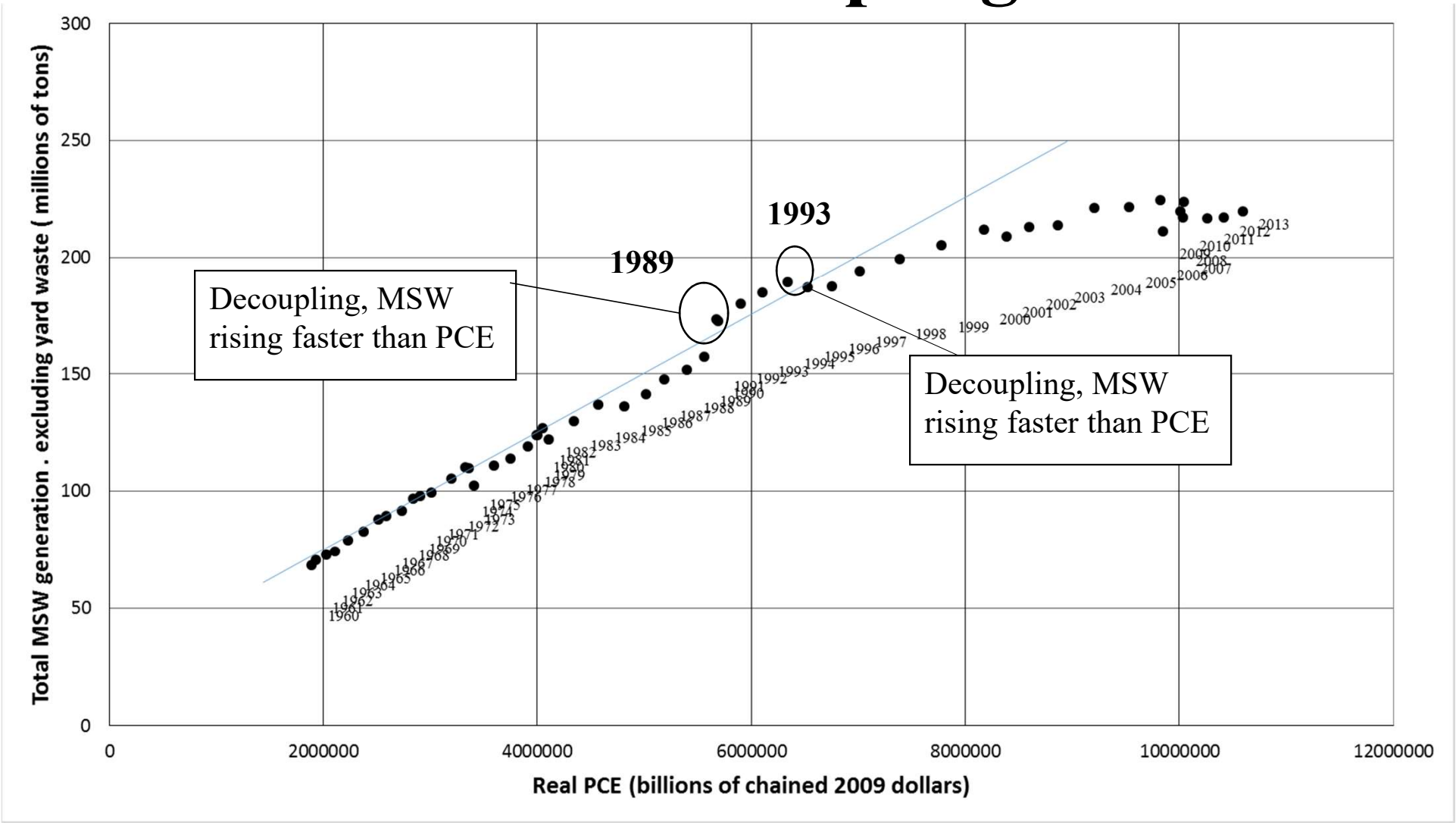
Parity plot shows relative decoupling



Other Process & Techs for NRP

- Reuse of plastics – cannot reach scale to make an impact
- Mechanical Recycling – appears limits are reached (tech & markets)
- Thermal processing & Energy recovery – potential for more
  - E.g. Golden Renewable Energy (GRE) installing 1st commercial unit near Raleigh NC-12 orders of 24 tpd units (Nick Canosa, ncanosa@yahoo.com)
- Chemical Recycling – subject of remainder of presentation
  - Biological based efforts ← interesting; 41 tons of worms per ton of PS
  - POET – Plastic A/D ← 170 tpd (20,000 tons per week) (Nov. 2018)
  - 3-D print applications ← does not scale, tight specs required
  - Farm improvements ← potential, but collection issues
  - ***Solvent/liquid based efforts*** ← new focus, potential
- Uses in construction and road paying – Large potential but undeveloped complicated

Chemical recycling has been around but getting more attention

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Fuel Production from Pyrolysis of Non-Recyclable Plastics

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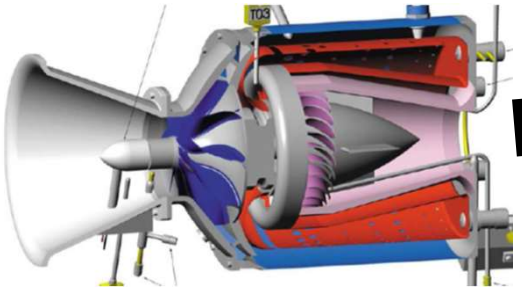
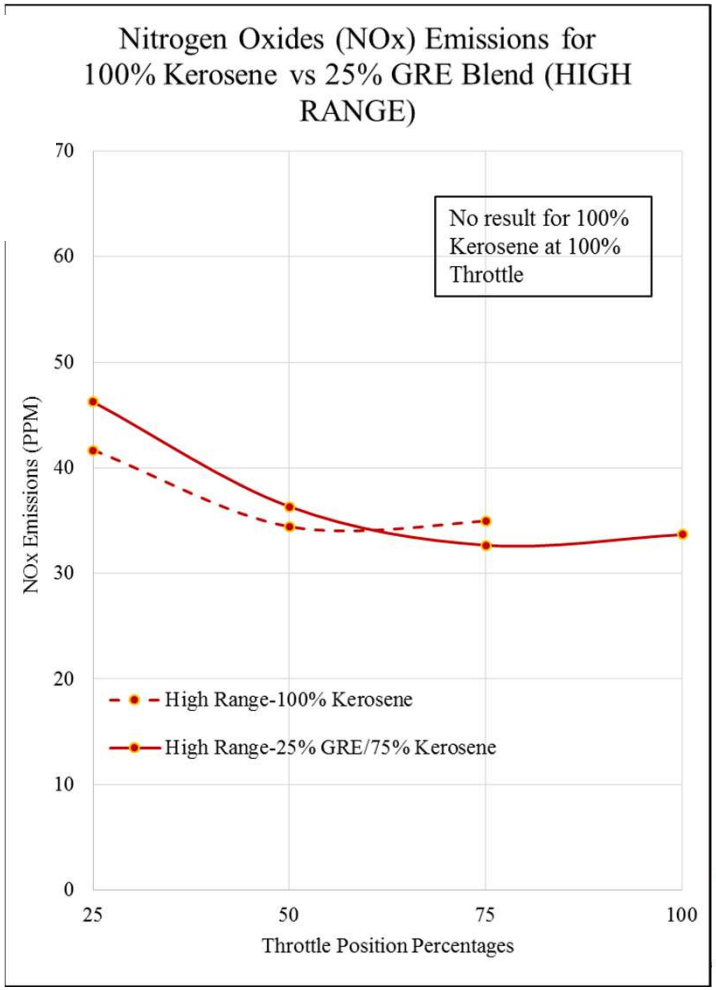
- **Example: Golden Renewable Energy (GRE)** has a continuous process that pyrolyzes non-recyclable plastics (NRP) and produces a fuel product to be sold on the wholesale market

Pyrolysis Produces Fuels



25% fuel from plastic/75% kerosene has similar emissions as high quality fuel

→ added value from end of life plastics



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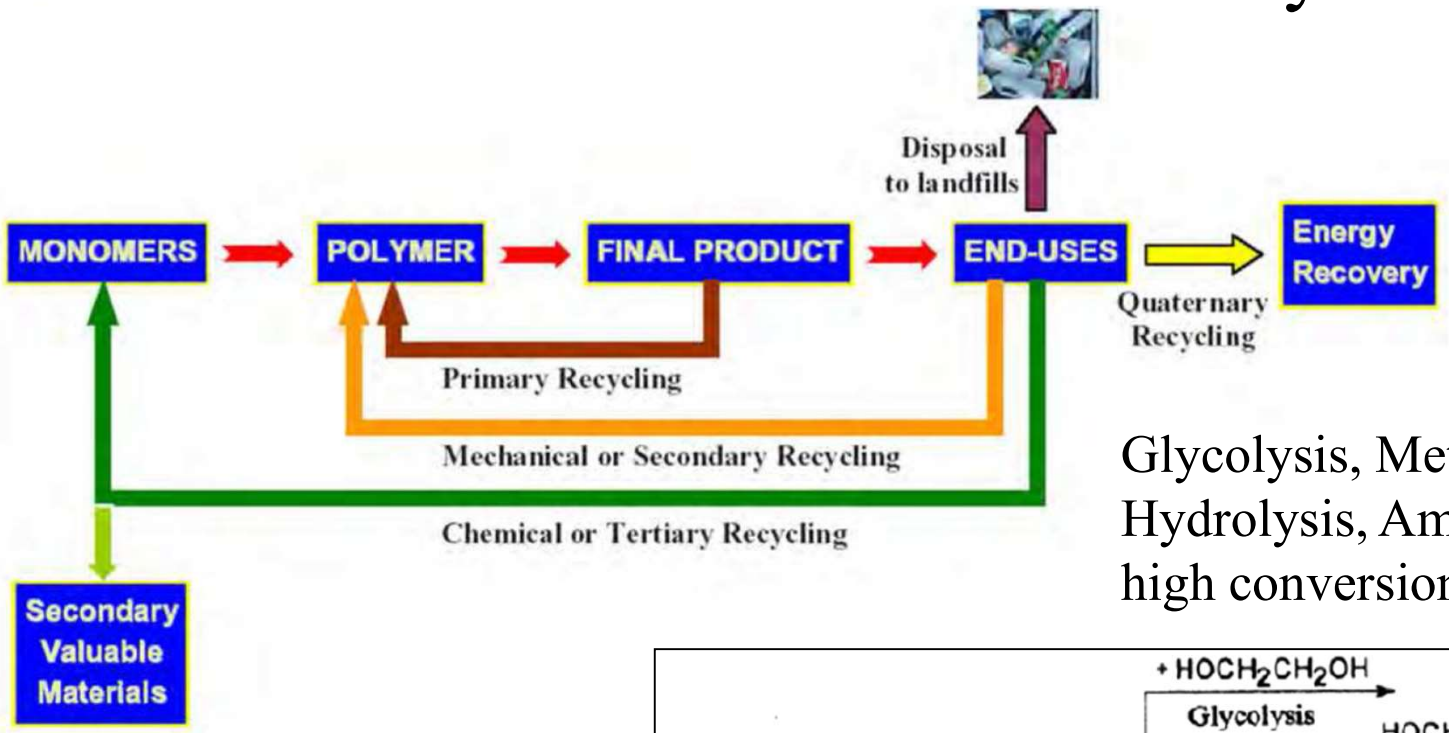
Near-Term: Chemical Recycling of NRP



Scheme 1. Polymer Recycling Techniques.

Glycolysis, Methanolysis
Hydrolysis, Aminolysis
high conversion to their monomers

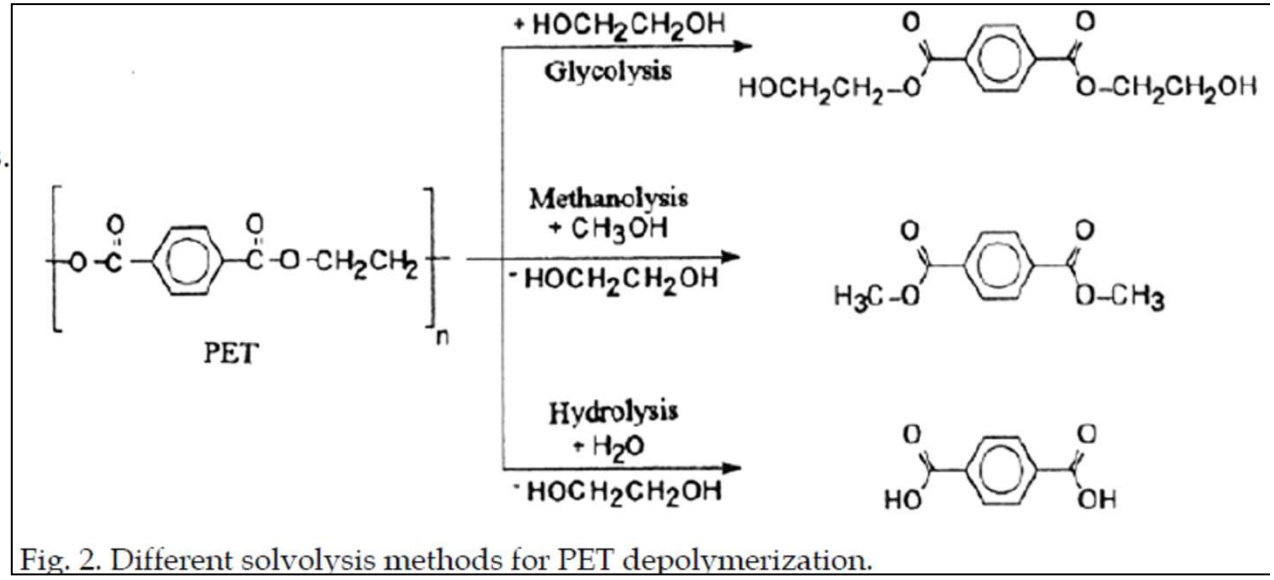


Fig. 2. Different solvolysis methods for PET depolymerization.

Many methods, resin categorized or process categorized

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The Current Solution to NRP

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- ***Primary collection must be improved***
- ***Cement Kiln (ready now but impact ~30% of NRP to LF can be diverted)***
- ***Energy for heat has the potential to use 100% NRP for coal replacement***
  - ***Will require adaptation of current systems (i.e. boilers, etc)***

Possible addition to current solution

Concrete (29 % impact),

demonstrated internationally

*Needs to undergo rigorous testing on a **state by state** basis.*

		NJDOT		PENNDOT	
		asphalt	concrete	asphalt	concrete
Gradation	ASTM C136	901.05.02-2	901.06.02-1	B#1, B #3	Type A
Absorption	ASTM C128	<2.0%	<2.0%		
Soundness	ASTM C88	<5.0%	<5.0%	<5.0%	<5.0%
Clay Lumps	ASTM C142	<5.0%			
Chloride Content	AASHTO T260		<0.06%		
Lightweight Pieces	ASTM C123		<0.25%		
Organic Impurities	ASTM C40		lighter than 11		
Uncompacted Voids	ASTM C1252	<40			
Sand Equivalent	ASTM C2419	<45			
Unit Weight	ASTM C29				

NJ & PA – close but not the same

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Possible "Big Idea"

Asphalt route

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Directly

encapsulating plastic pellets in asphalt. No direct examples related to plastic, but this is being done with car tires in AZ, CA and other countries. At 18% replacement could handle 2.95x the amount of plastics generated currently. Needs to go through vetting process for each state.

		NJDOT		PENNDOT	
		asphalt	concrete	asphalt	concrete
Gradation	ASTM C136	901.05.02-2	901.06.02-1	B#1, B #3	Type A
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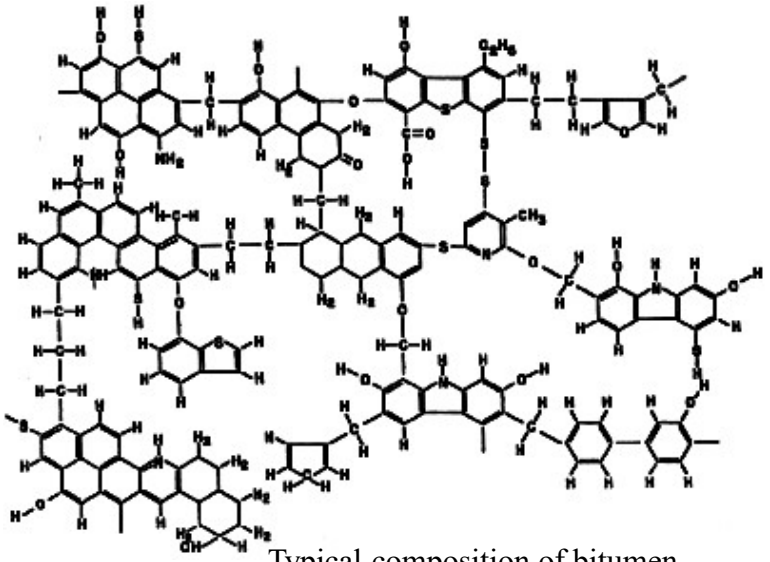
NJ & PA – close but not the same

Indirectly

converting plastic into highly priced bitumen-like substance. Conversion is difficult but some companies are tackling the issue internationally.



Typical composition of bitumen

evizero®
the ecological, transparent binder

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Understanding the State of Food Waste

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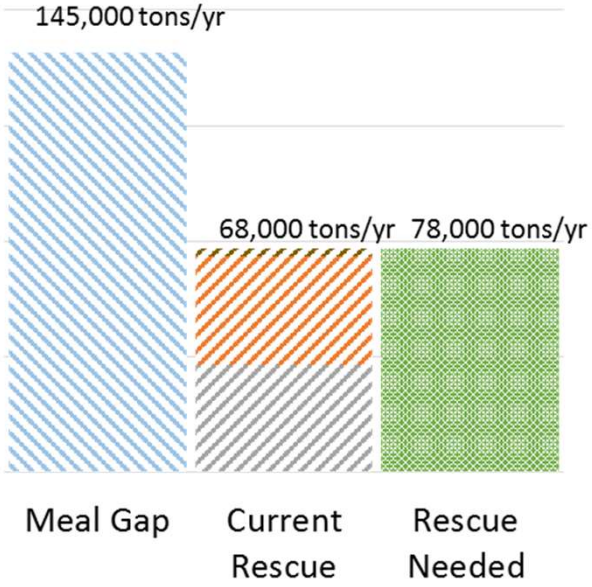
Food Insecurity in NYC*



*Estimations using reported data from Food Bank NYC and City Harvest.

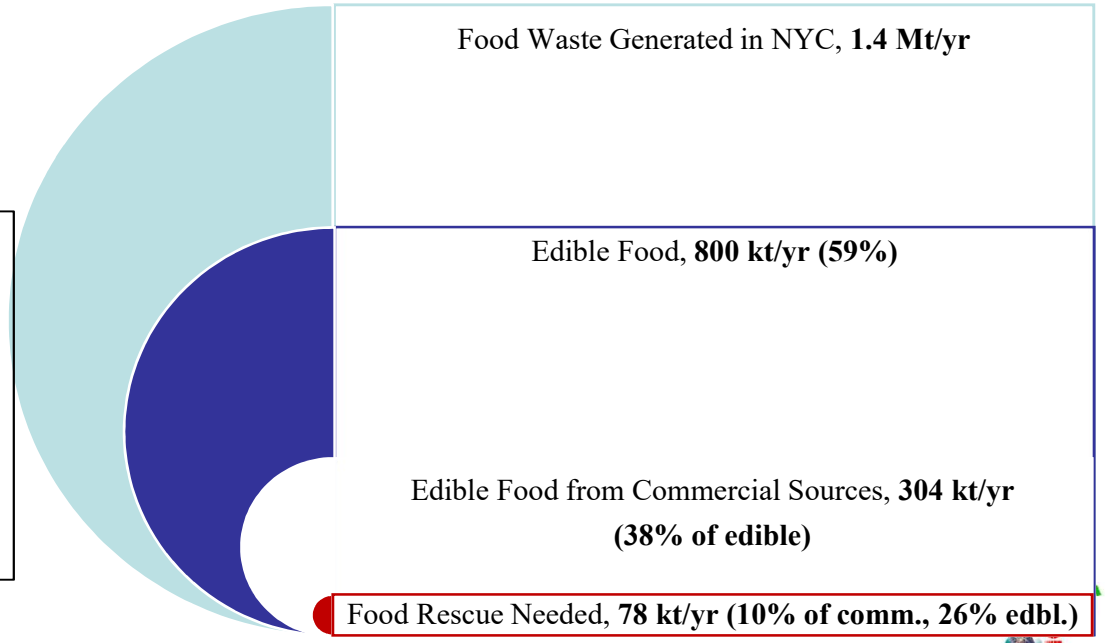
- Current rescue efforts are covering about 50% of NYC's meal gap.
- Hurdles in logistics suggest that future rescue efforts should focus on commercial sources.

New Food Waste Bills on the Menu in NYC

Two new bills targeted at combating food waste are in the works in New York City Council. The first, Int. 1439, sponsored by Councilman Antonio Reynoso, would impose stricter regulations on the process of confiscating food from vendors who violate city law. The second, Int. 1514, sponsored by Councilman Rafael Espinal, would require the city to maintain a web portal to facilitate food donations.

The goal of Int. 1439 is to ensure that confiscated edible food does not end up landfills. The

Food Rescue Potential*



*Estimations using DSNY and Washington state waste characterization reports and NRDC food waste reports.

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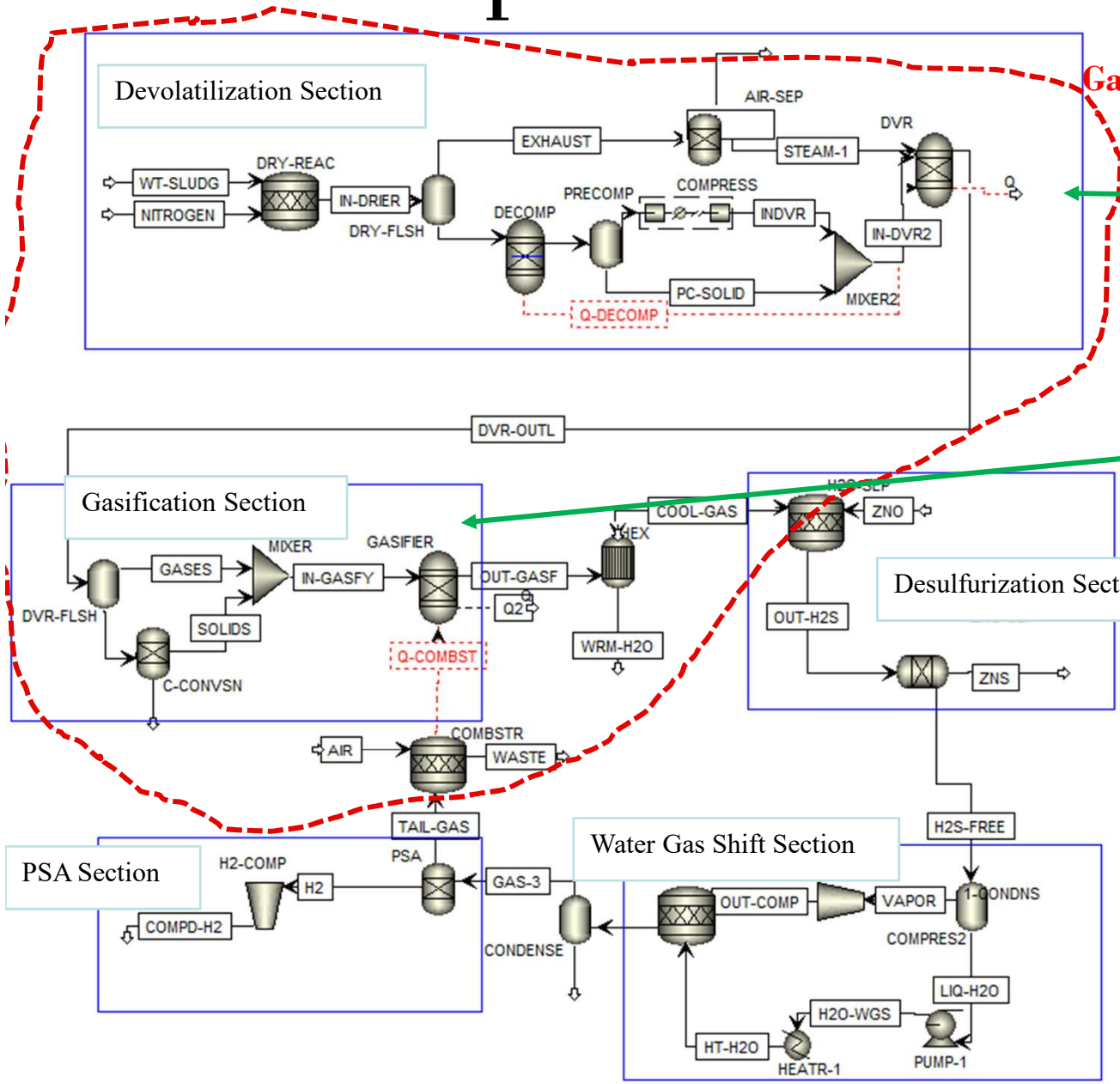
Aspen Simulation Analysis



Gasification Process

- Devolatilization efficiency: 75.23%
- Gasification efficiency: 86.74 %
- Overall Process efficiency: 13 – 42% (wide range → uncertainty in product use)

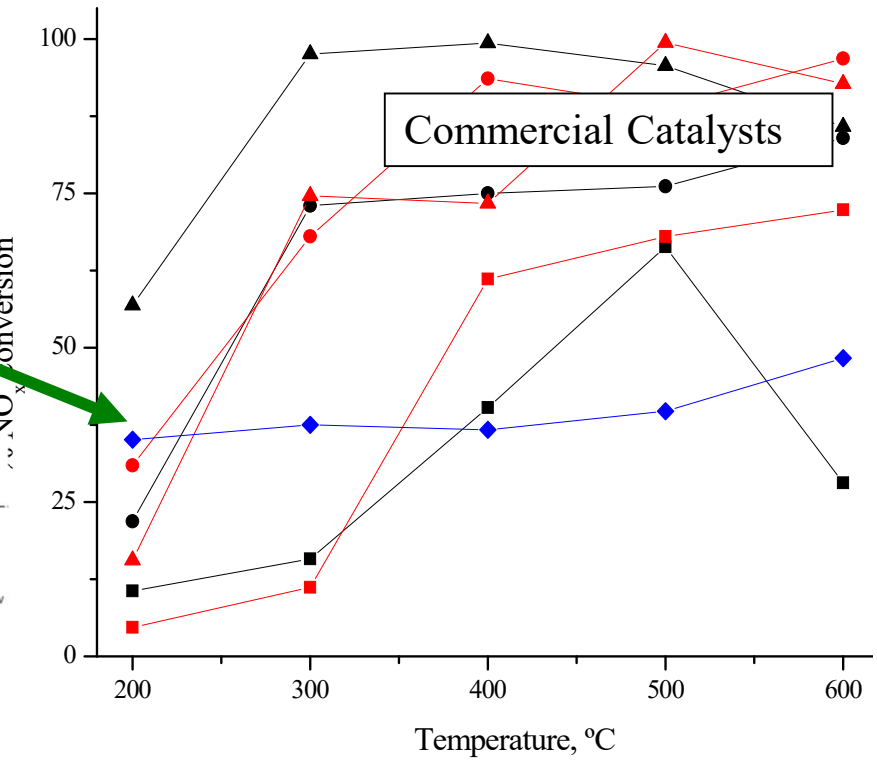
Simulation tool that allows for realistic analysis of different processes

Future Use for Ash

Ash as catalyst: NO_x conversion

WTE Ash

Shows higher performance at low temperatures compared to commercial catalysts



Original Article

WM&R

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1–10
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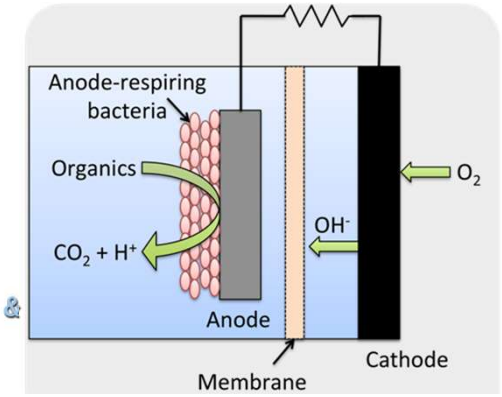
Investigation on electrical surface modification of waste to energy ash for possible use as an electrode material in microbial fuel cells

Megan Webster[1], Hae Yang Lee[1], Kristi Pepa[1], Nathan Winkler[2], Ilona Kretzschmar[1] and Marco Castaldi[1]

Fuel Cell Catalyst



Testing MSW ash for microbial fuel cell anode

Electro/Bio (microbial) ash passivation

Electrical current changes oxidation state of ash → impacts leaching

Color change indicates change in oxidation state → metal extraction / leachability change

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Local (NYC) Issues

What if NYC used more WTE??

- Four facilities @ 3,000tpd on ~15 acres each
- Processing 11,693 tpd total
- Location Possibilities

If Landfilled, over 30 years

34% of Central Park 0.21×10^{-4} acre/ton @ 25 foot depth

125 Union Avenue, Johnstown, NY | Fulton County

125 Union Avenue — Less Detail -

25 acres

Eric Simonds, CCIM , CBRE Albany, Part of the CBRE affiliate network
24.8 acres of land available for sale in the Johnstown Industrial Park

Route 25, Calverton, NY | Suffolk County

42-Acres-Heavy Industrial Land for Sale-Divisible — Less Detail -

42 acres

Scott Roth , Company Not Provided
Town of Riverhead will consider a variety of industrial & commercial uses for this huge property/ gas, electric & water at the road/ ideal for manufacturing, warehousing, trucking, industrial-park,...

488 Hudson River Road Rear, Mechanicville, NY | Saratoga County

Heavy Industrial Lot-45-Ac-Adj. to Rail — Less Detail -

45 acres

Scott Roth , Company Not Provided
Shovel-ready, Industrial Land for Sale or Lease / 45-acre Lot / Zoning coverage allows for construction of 750,000 SF building / well-suited for manufacturing, R&D, defense-contractor, intermodal,...

WTE in 30 yrs

$1.8 - 0.21 \times 10^{-4}$ acres/ton @ 25' depth

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Dissemination/Outreach

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Waste Management 77 (2018) 147–155

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journal homepage: www.elsevier.com/locate/wasman

Role of plastics in decoupling municipal solid waste and economic growth in the U.S.

Demetra A. Tsiamis, Melissa Torres, Marco J. Castaldi *

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ABSTRACT

Analysis of data from the US Environmental Protection Agency (EPA) on municipal solid waste (MSW) generation rates correlated to personal consumption expenditure (PCE) uncovers a decoupling event occurring between 1997 and 2000. A comparison of waste generation rates for each material category

CUNY TV

study with the BEST

Transforming Waste Materials to Energy and Ch
An Update on Sustainable Waste Management

The City College of New York

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Secondary Author: Demetra Tsiamis, Associate Director, Earth Engineering Center|CCNY
Data Analysis Support: Christy Zhang, Chemical Engineering Student, City College, CUNY

As a society we can achieve the cleaner air, water, and soil that we all want. Working toward a more circular economy is in everyone's best interest. But it is only through a pragmatic approach rooted in scientific and engineering realities that we will achieve success. Some organizations are actually rooted, however, in ideology, and this rigidity only serves, ironically, to hinder our progress toward a cleaner environment.

Recently the Global Alliance for Incineration Alternatives (GAIA) released a report "Green Businesses and Cities at Ris
factually incorrect statement
erroneous and quite simply w

WASTEDIVE Home Events Library Jobs Topics

BRIEF

Report: 'Misleading' zero waste goals could send more waste to landfills

DSNY Lunch & Learn Seminar
Waste to Energy:the future of waste disposal?
March 29th, 2018 @ 44 Beaver Street

Office of International Visitors | Bureau of Educational and Cultural Affairs | U.S. Department of Sta

INTERNATIONAL VISITOR LEADERSHIP PROGRAM

SOLID WASTE MANAGEMENT
A Project for Ethiopia

ETHIOPIA – SPEARHEADING
AFRICA'S WASTE MANAGEMENT FUTURE

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Waste Management World May

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EEC|CCNY Professional Seminar Series on Waste Sustainability

- EEC|CCNY's course on waste sustainability **launched in Spring 2018** at **The City College of New York** (CCNY)
- 3-credit course offered to **senior and graduate students at CCNY**
- 21 students enrolled; included **environmental, chemical, and electrical engineers**
- The course consisted of **guest lecturers from around the world** from different sectors to discuss sustainable waste management
- The course also included **weekly site visits to waste management facilities** throughout New York City

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First-Hand Experience: Student Site Visits to Waste Management Facilities in New York City

- As part of the seminar series, students went on **weekly site visits** to **see the waste processes first-hand** that they had learned about in lecture

- The students visited **waste management facilities** throughout **New York City**:
  - **Center for Materials for the Arts** (reuse) in Queens, NY
  - **SIMS Material Recovery Facility** (recycle) in Brooklyn, NY
  - **Earth Matter Compositing Site** on Governor's Island
  - **Newtown Creek Digester Eggs** (anaerobic digestion) in Brooklyn, NY
  - **Covanta Facility** (waste-to-energy) in Essex, New Jersey
  - **Plastics Pyrolysis Pilot Facility** in Yonkers, New York
  - **Wet Waste Gasification Prototype** at CCNY
  - **Fresh Kills Landfill** in Staten Island, New York

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Summary Findings from ~15 years of research

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- A minimum amount of waste must be generated for survival
- A Zero waste solution is not possible without WTE
- Thermal conversion of wastes will increase
  - Compatible with recycling
- Combustion is dominant but gasification & pyrolysis is increasing
  - Gasification provides syngas → may be used in many ways
- Emissions regulations for WTE are the most stringent compared to all other combustion systems
- Novel uses are needed for beneficial utilization of ash & plastics
- Dissemination of accurate information is critical

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Acknowledgements

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The CCL & EEC Team
Colleagues & Competitors
Our Sponsors

Where in the world is CCL?

CCL maintains research collaborations and attends conferences around the world. Click on the map below to see where we've been.

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The main focus is the thermal and catalytic conversion of carbon based material to desired products

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Next Event

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<u>Session 5: 17.00 – 18.00</u> (in GSOE Exhibit Room)

- Poster Session & Cocktail Hour

<u>Gala Dinner: 18.20 – 21.00</u> (in Shepard Hall, Room SH-250)

- ASME Award Program
- ASME MER / Research Committee 50 Year Anniversary Tribute - Tony Licata

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Paris WTE Facility

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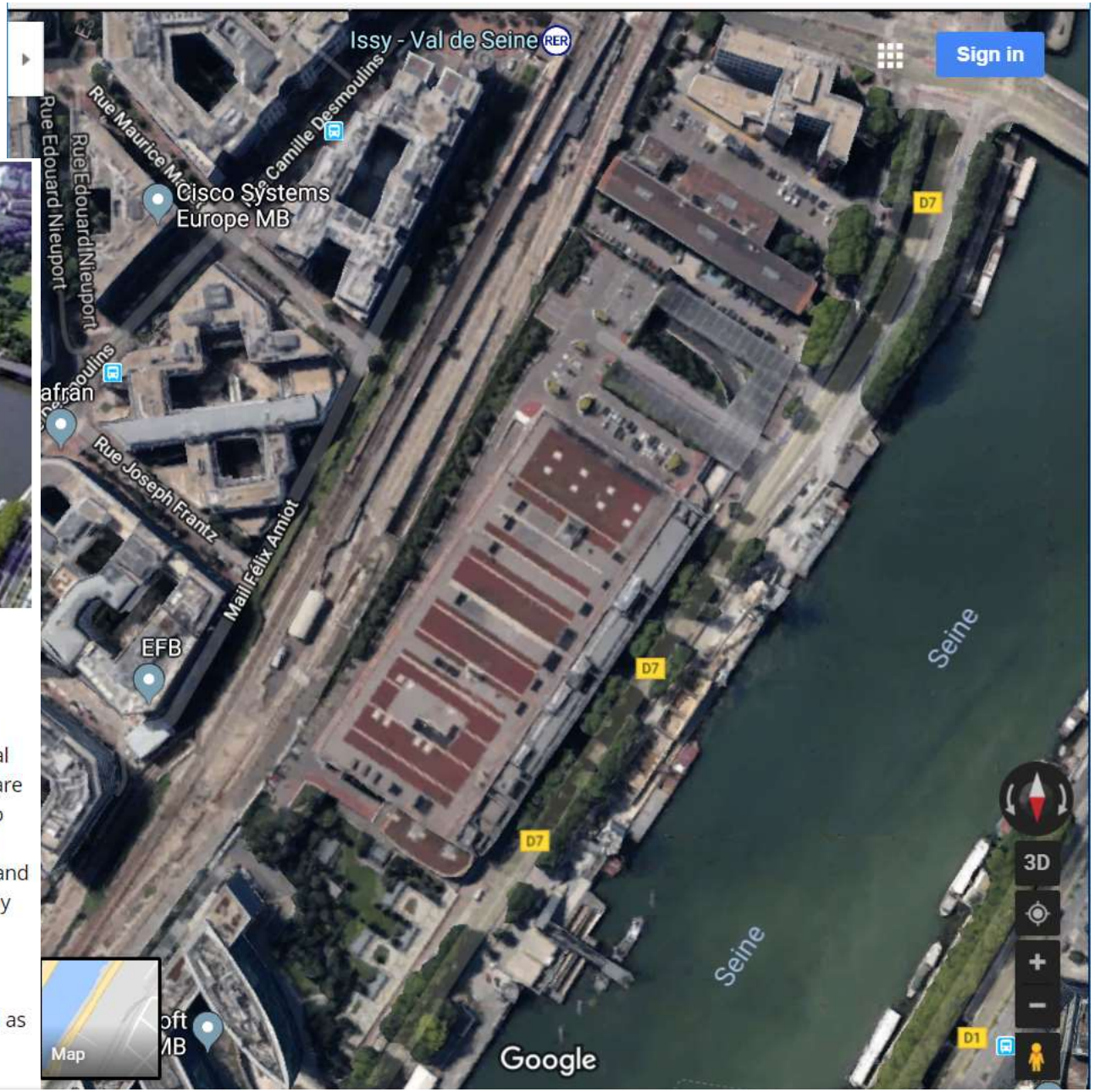
Artist's impression of the plant by the Seine

Click here to enlarge image

SYCTOM, the owner of Isséane, is the organization tasked with the collection, treatment and valorization of municipal solid waste for 5.5 million people in 85 communities that are part of the Paris region. The mandate of SYCTOM is first to reduce the amount of waste being produced and then to treat and valorize the waste it collects, first by recovering and recycling all materials that can be pratically reused, then by thermally treating the residual material left afterward to produce useful energy for the surrounding communities. SYCTOM is also required to carry out its operations while minimizing or eliminating any environmental impact; such as noise, air and water emissions.



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Covanta Westbury Facility

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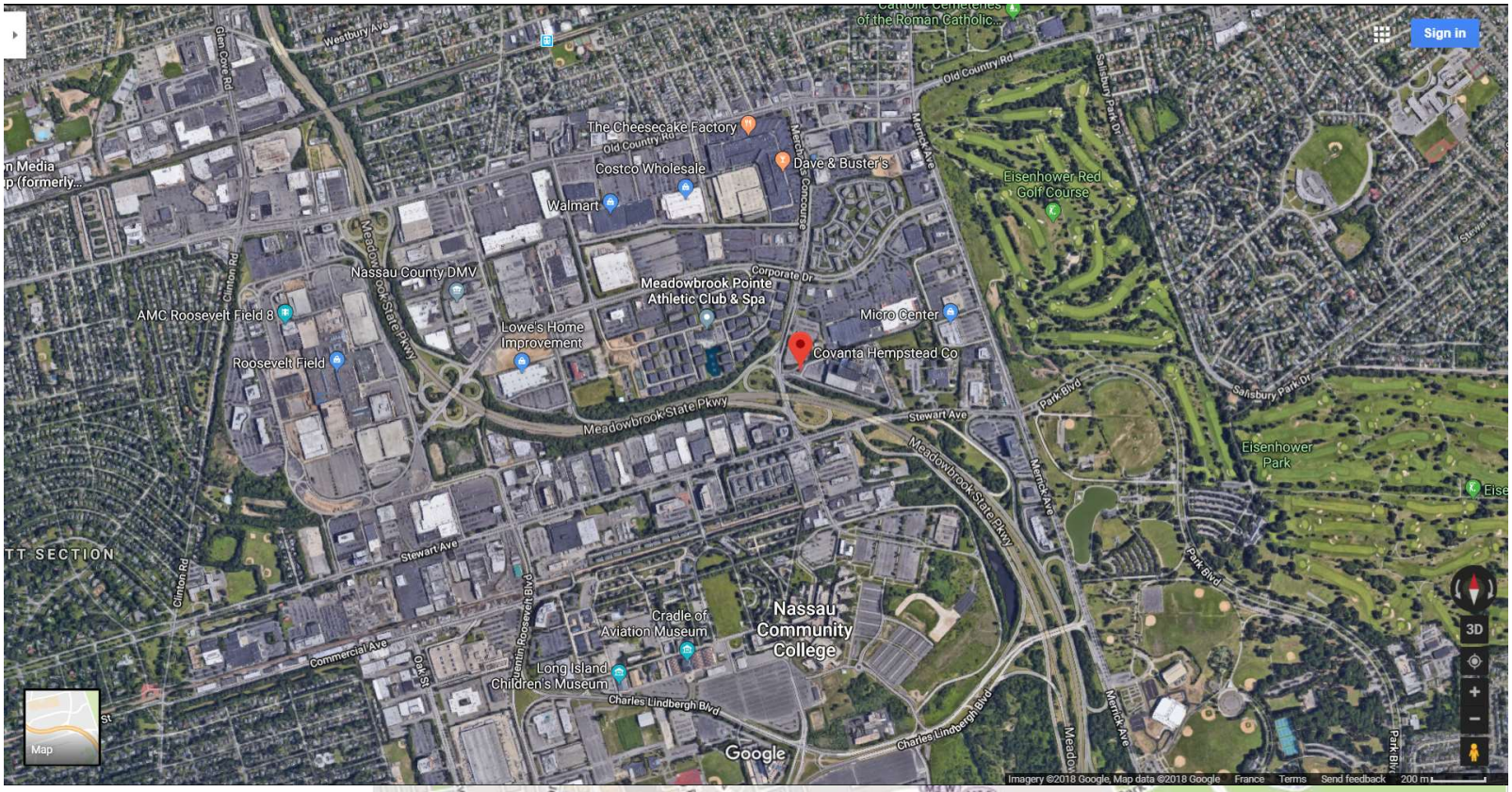
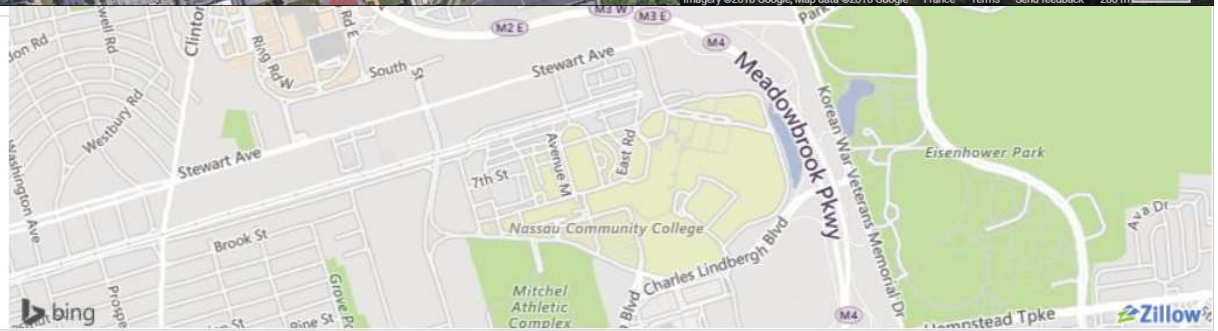


The median home value in Westbury is $493,100. Westbury home values have gone up 8.9% over the past year and Zillow predicts they will rise 3.0% within the next year. The median list price per square foot in Westbury is $295, which is higher than the New York Metro average of $267. The median price of homes currently listed in Westbury is $469,500.

more



Westbury Market Overview

Data through Jan 31, 2018

Zillow Home Value Index | All homes | 1-yr 5-yr Max

IERT
Energy Research
hnology Council

Total MSW Generation in US = 366 Million Tons

Direct Reuse — 0.43 Million Tons

Recycling — 89.1 Million Tons

Well done for metals and glass
~4000 facilities in US
Distinction between recycling and "recovery" – collected for recycling

A/D & Composting — 25.1 Million Tons

Mostly green waste and yard trimmings
~3600 facilities in US
Off-take of residual is uneven

Waste to Energy — 30.2 Million Tons

Landfilling — 221.8 Million Tons

Incineration vs WTE

- Incineration → designed to thermally destroy a waste material
- WTE → designed to produce electricity and useful steam by thermally converting a waste material.
- Incineration is **not** required to produce energy and many actually consume energy to destroy the waste feedstock.
- WTE facility typically produces an average of 650 kWh of electricity per ton of MSW and approximately 600 kWh of steam per ton of MSW that can be used for heating or cooling operations.
- Only similarity between incineration and WTE is that they both combust the waste with air and strive to achieve a well-established performance metric comprised of temperature, time and turbulence, typically referred to as "the 3 T's". $T \geq 850$ °C; $t_{res} \geq 2$ sec & high turbulence.

Earth Engineering Center
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Dioxins Reality

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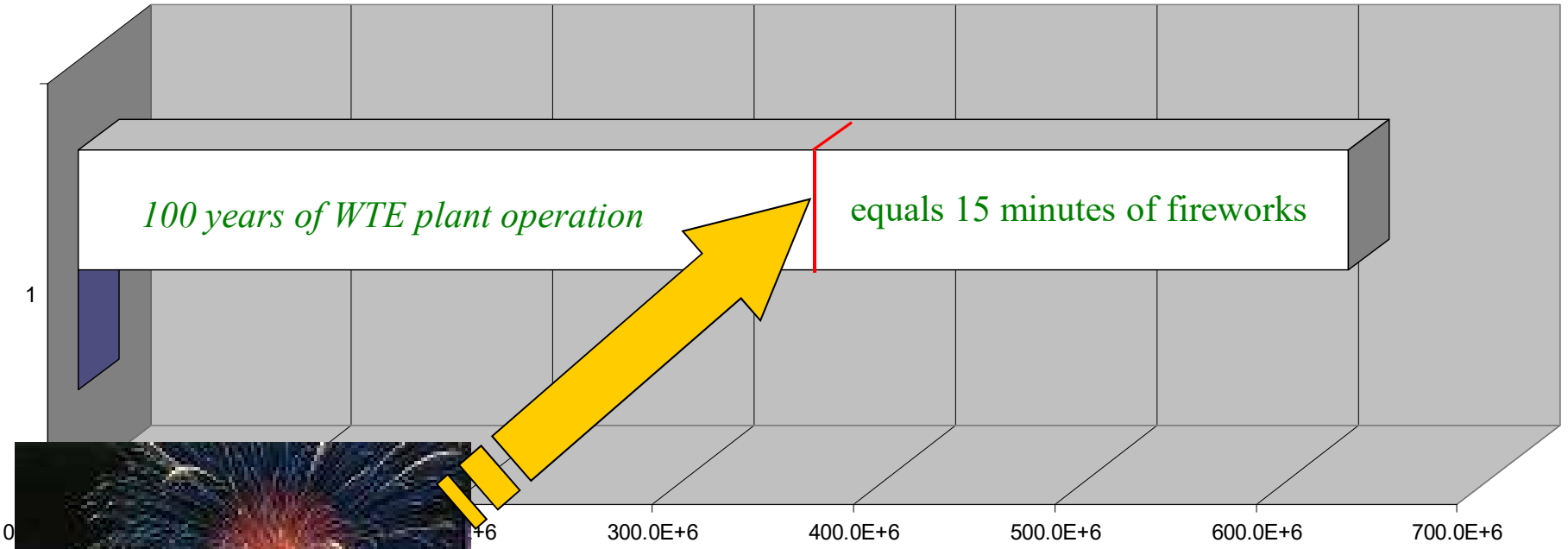

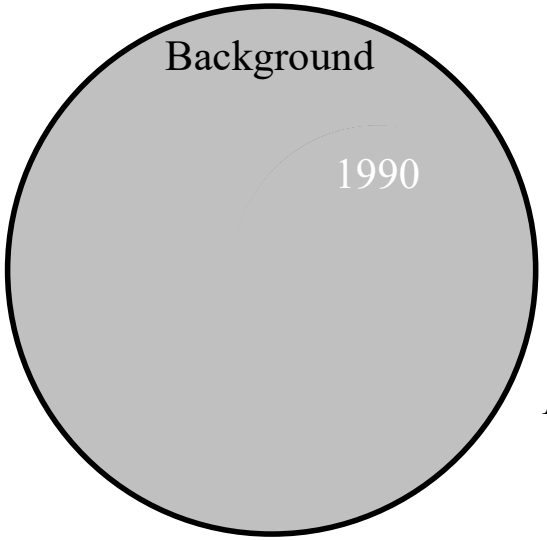

Relative concentrations of dioxins

Combustion & Catalysis Laboratory

WIERT
Waste-To-Energy Research and Technology Council