Recent Research Results from EEC & CCL



Marco J. Castaldi

Combustion and Catalysis Laboratory at The City College of New York

EEC|CCNY – WTERT|USA

October 3rd, 2024

Combustion & Catalysis Laboratory

Earth Engineering Center
CITY COLLEGE of NEW YORK

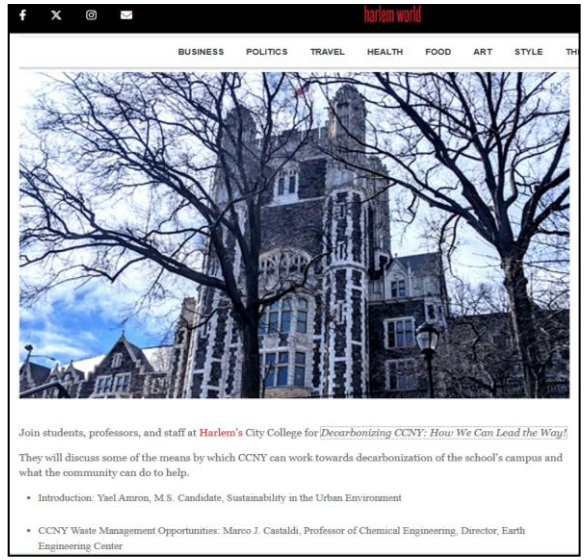
The City College of New York

Recent Dissemination Activities



GHG Impact of Advanced Recycling







Quantitative review of health impacts of WTE, including emissions (GHG & others) and material recovery ability

WTE 101 Lecture - MJC

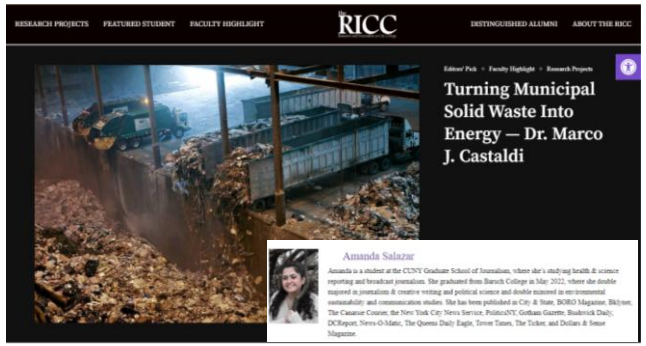




Life cycle and experimental assessment of sustainable thermal processing of waste plastics

SWANA
SOLID WASTE ASSOCIATION OF NORTH AMERICA

Demonstrating Carbon reduction with Advanced recycling



The City College of New York

Combustion & Catalysis Laboratory

Recent Testimony Activities

MARYLAND GENERAL ASSEMBLY

Economic Matters Committee

The City College of New York
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Director, Earth Engineering Center|CCNY
Director, Earth System Science & Environmental Engineering
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Testimony of Prof. Marco J. Castaldi, Ph.D in support of L.D. 399
Director, Earth Engineering Center, City College of New York
Director, Earth System Science & Environmental Eng., City College of New York
Before the Maryland House Economic Matters Committee
February 28, 2023

Senator Lawrence, Representative Ziegler, and distinguished members of the joint committee on Energy, Utilities, and Technology, please accept my testimony in support of LD 399, An Act to Amend the Portfolio Requirements for Class II Resources.

I am a Professor of Chemical Engineering and the Director of the Earth System Science & Environmental Programs at The City College of City University of New York. I have been appointed as a Fulbright Global Fellow for 2017-2019 for the research involved in transforming waste materials, such as municipal solid waste to energy. I have also been appointed by The National Academy of Engineering Frontiers of Engineering Education for the 2012-2013 academic year based on the work related to waste to energy. I am also a Fellow of the American Institute of Chemical Engineers (AIChE) and American Society of Mechanical Engineers (ASME). I have authored two books related to waste conversion technologies and over 100 peer reviewed journal articles related to waste prevention and reduction, waste

THE Examiner NEWS

SCHOOL OF ENGINEERING
DEPARTMENT OF CHEMICAL ENGINEERING

THE CITY COLLEGE
OF
THE CITY UNIVERSITY OF NEW YORK
NEW YORK, NY 10031

February 20, 2024
Re: Response to "Time for W'Chester to Hire Zero Waste Consultant to Meet Emissions Goals"

Dear Editor,

I read the letter "Time for W'chester to Hire Zero Waste Consultant to Meet Emissions Goals," published February 1, 2024. The information provided is contrary to data that I have assembled related to the contributions of waste-to-energy (WTE) facilities to county airsheds. The letter asserts that the incineration of post-recycled trash at WIN Waste Innovations' facility in Peekskill "harms Peekskill residents, and less directly, the whole county." In fact, the facility contributes nominally 35% of the SOx, 27% of NOx and less than 1.7% of PM10, less than 3% of PM2.5, and less than 0.2% VOCs released in the Hudson River Valley. Therefore, Peekskill's WTE emissions — and those of other well-run WTE facilities, are a tiny portion of the emissions picture. In fact, such facilities help reduce health-harming vehicular traffic by eliminating heavy truck trips that would otherwise transport waste to distant landfills.

There are only a handful of industrial facilities remaining in the Hudson River Valley, which is why the WIN Waste waste-to-energy (WTE) plant at Peekskill appears high on the list of single-source emitters. The facility is well-run, as evidenced by the fact the plant emits less than the federal EPA and the stricter State of New York standards allow to ensure public and environmental health while protecting even vulnerable populations. In fact, an air quality analysis conducted in strict accordance with New York Department of Environmental

YONKERS TIMES
News in Yonkers and around Westchester

SCHOOL OF ENGINEERING
DEPARTMENT OF CHEMICAL ENGINEERING

THE CITY COLLEGE
OF
THE CITY UNIVERSITY OF NEW YORK
NEW YORK, NY 10031

February 20, 2024
Re: Response to "Environmental Justice for Peekskill"

Dear Editor,

I read the letter "Environmental Justice for Peekskill: At 40, It's Time to Blow Out the Candles on Westchester's Trash Incinerator," published February 4, 2024. The information provided is contrary to data that I have assembled related to the contributions of WTE facilities to county airsheds. The letter implies that a sole industrial facility in the Hudson River Valley is responsible for most of the region's air pollution and negative health outcomes. The specific Wheelabrator (WIN Waste) facility, in fact, contributes nominally 35% of the SOx, 27% of NOx and less than 1.7% of PM10, less than 3% of PM2.5 and less than 0.2% VOCs.

There are only a handful of industrial facilities remaining in the Hudson River Valley, which is why the WIN Waste waste-to-energy (WTE) plant at Peekskill appears high on the list of single-source emitters. The facility is well-run as evidenced by the fact that the plant emits less than the

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News Sports Rockland Westchester Food

SCHOOL OF ENGINEERING
DEPARTMENT OF CHEMICAL ENGINEERING

THE CITY COLLEGE
OF
THE CITY UNIVERSITY OF NEW YORK
NEW YORK, NY 10031

February 19, 2024
Re: Response Waste-to-Energy Is Critical to Zero-Waste Future

Dear Editor,

I read the letter "Westchester can't tolerate its largest polluter — the Peekskill incinerator — any longer," published February 15, 2024. The information provided is contrary to data that I have assembled related to the contributions of WTE facilities to county airsheds. The letter states that a sole industrial facility in the Hudson River Valley is responsible for most of the region's air pollution and negative health outcomes. The specific Wheelabrator facility, in fact, contributes nominally 35% of the SOx, 27% of NOx and less than 1.7% of PM_{10}, less than 3% of $PM_{2.5}$ and less than 0.2% VOCs.

There are only a handful of industrial facilities remaining in the Hudson River Valley, which is why the WIN Waste waste-to-energy (WTE) plant at Peekskill appear high on the list of single-source emitters. The facility is well-run as evidenced by the fact that the plant emits less

The City College of New York

THE BALTIMORE SUN

SCHOOL OF ENGINEERING
DEPARTMENT OF CHEMICAL ENGINEERING

THE CITY COLLEGE
OF
THE CITY UNIVERSITY OF NEW YORK
NEW YORK, NY 10031

January 23, 2023
Re: letter to VEIP article
talkback@baltimoresun.com

Dear Sun Editor,

I read The Sun's recent editorial– *Proposed changes to Maryland's vehicle emissions inspection program. Gov. Moore and the legislature should step in* – with interest. I agree that it may put the burden to pay for it on low-wealth individuals.

Yet, I was particularly struck by the newspaper's incorrect implication that the city's waste-to-energy (WTE) facility poses a health risk to those residing in South Baltimore (or anywhere else). I recently completed an exhaustive scientific review of WTE operations and environmental impacts globally. I am disappointed that The Sun is communicating incorrect information regarding emissions from Bresco and thereby doing a disservice to its readers and the public. That publication, and many others, can be found on our website (CCNYEEC.org) and are free to the public.

Miami Herald

Household trash from NJ can make energy, recover materials, thus benefit the environment. Why do we still bury it?

By Dr. Marco J. Castaldi

New Jersey homeowners, like most in America, bring their garbage cans out to the curb each week,. Once collected and the homeowners put their empty can away, few consider where it all goes after it's collected. Families and businesses are producing more trash every single year – 9 million tons worth in New Jersey alone. We have two choices to manage the amount of garbage: bury it in methane-producing landfills that are among the biggest contributors of greenhouse gases or burn it in a safe and controlled process to create energy and recover materials.

Despite Americans' best efforts to reduce, reuse and recycle, the majority is disposed in landfills. The U.S. Environmental Protection Agency (USEPA) has established the sustainable waste management hierarchy that states after reduction, reuse and recycling effort, the garbage should be processed to recover energy. The science is clear and compelling: waste-to-energy (WTE) facilities should be increasingly relied upon to help fight climate change, enhance recycling, and avoid the permanent environmental impacts associated with landfills.

Every ton of waste processed at a WTE facility, avoids a ton of CO_2 equivalent emissions. Yet, narly 150 million tons of waste are still redirected to landfills in the U.S. every year, a number that could be cut by nearly 90 percent simply by converting it to energy.

In addition to the USEPA, the United Nations has said waste-to-energy is the preferred alternative to landfills. In fact, a United Nations climate report identified landfills as a major contributor to greenhouse

Recent Comment Activities

BACT Reviewed: ESP, Wet Scrubber, Baghouse, SCR & Combustion Controls

Emissions Considered: PM_{10}, $PM_{2.5}$, NO_x, Hg

Emissions Transport Models: AERMOD, TRIM.FaTE, CalPUFF, MIRC



ASME
SETTING THE STANDARD

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March 25, 2024

The Honorable Michael S. Regan
Administrator
United States Environmental Protection Agency
1200 Pennsylvania Avenue, NW
Washington, DC 20460

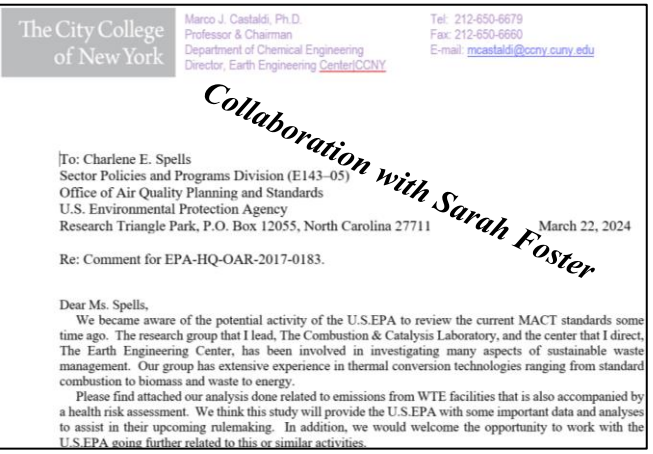
Subject: Response to Docket ID No. EPA-HQ-OAR-2017-0183;

Dear Administrator Regan:

On behalf of the ASME's Material and Energy Recovery (MER) Division and the Research Committee on Energy, Environment, & Waste (RCEEW), We are submitting this response to Docket ID No. EPA-HQ-OAR-2017-0183 on the Standards of Performance for New Stationary Sources and Emission Guidelines for Existing Sources: Large Municipal Waste Combustors Voluntary Remand Response and 5-year Review.

Founded in 1880 as the American Society of Mechanical Engineers, ASME is a not-for-profit professional organization that enables collaboration, knowledge sharing and skill development across

Copies available by registration



The City College of New York

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Professor & Chairman
Department of Chemical Engineering
Director, Earth Engineering CenterICCNY

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E-mail: mcastaldi@ccny.cuny.edu

To: Charlene E. Spells
Sector Policies and Programs Division (E143–05)
Office of Air Quality Planning and Standards
U.S. Environmental Protection Agency
Research Triangle Park, P.O. Box 12055, North Carolina 27711

March 22, 2024

Re: Comment for EPA-HQ-OAR-2017-0183.

Dear Ms. Spells,

We became aware of the potential activity of the U.S.EPA to review the current MACT standards some time ago. The research group that I lead, The Combustion & Catalysis Laboratory, and the center that I direct, The Earth Engineering Center, has been involved in investigating many aspects of sustainable waste management. Our group has extensive experience in thermal conversion technologies ranging from standard combustion to biomass and waste to energy.

Please find attached our analysis done related to emissions from WTE facilities that is also accompanied by a health risk assessment. We think this study will provide the U.S.EPA with some important data and analyses to assist in their upcoming rulemaking. In addition, we would welcome the opportunity to work with the U.S.EPA going further related to this or similar activities.

Collaboration with Sarah Foster

Table 3. PM and NOx removal technologies and removal efficiencies data

	Plant 1[1]		Plant 2[2]		Plant 3[3]		Plant 4[4]	
PM control technology	Fabric Filter Baghouse		Fabric Filter Baghouse		Fabric Filter Baghouse		Fabric Filter Baghouse	
Nominal Removal efficiency (%)	99.50		99.50		99.80		99.50	
NOx control technology	SNCR + Low NOx[(a)]		SNCR		SCR		SNCR + Low NOx[(a)]	
Nominal Removal efficiency[(b)] (%)	70%	75%	40%	50%	80%	90%	70%	75%

Table 2. Emissions data for four WTE plants operating in North America

		Plant 1	Plant 2	Plant 3	Plant 4
MWC Features	**Combustion Technology**	Mass-burn	Refuse derived fuel	Mass-burn	Mass-burn
	Combustion Units	3	2	3	2
	Facility Capacity t/day	1800	3000	3000	480
NOx	**In stack emissions, 24-hr average**	88 ppmv	142.8 ppmv	30 ppmv	94 ppmv
	MACT ruling limit	180 ppmv	230 ppmv	180 ppmv	121 ppmv[(a)]
	% Below EPA limit	48%	38%	83%	22%
PM_{total}	**In stack emissions, annual concentrations**	4.92 mg/dscm	8.05 mg/dscm	3.29 mg/dscm	0.33 mg/dscm
	MACT ruling limit	20 mg/dscm	20 mg/dscm	20 mg/dscm	9 mg/Rm[(a)]
	% Below limit	75%	60%	84%	96%
Year facility began operation		1995	1989	2016	2016

CR values less than 1.0 are not expected to result in adverse health effects

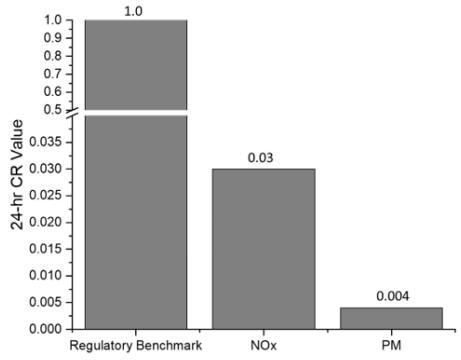


Figure 1. CR values associated with 24-hour average air concentrations are far below the regulatory benchmark for protection of public health

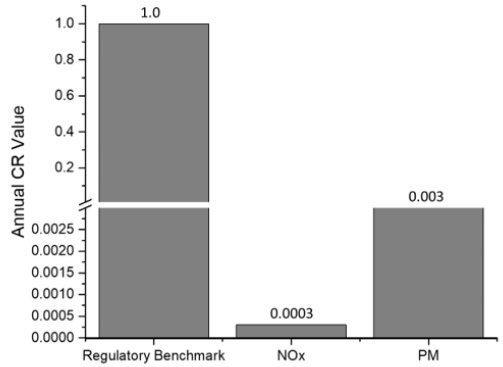


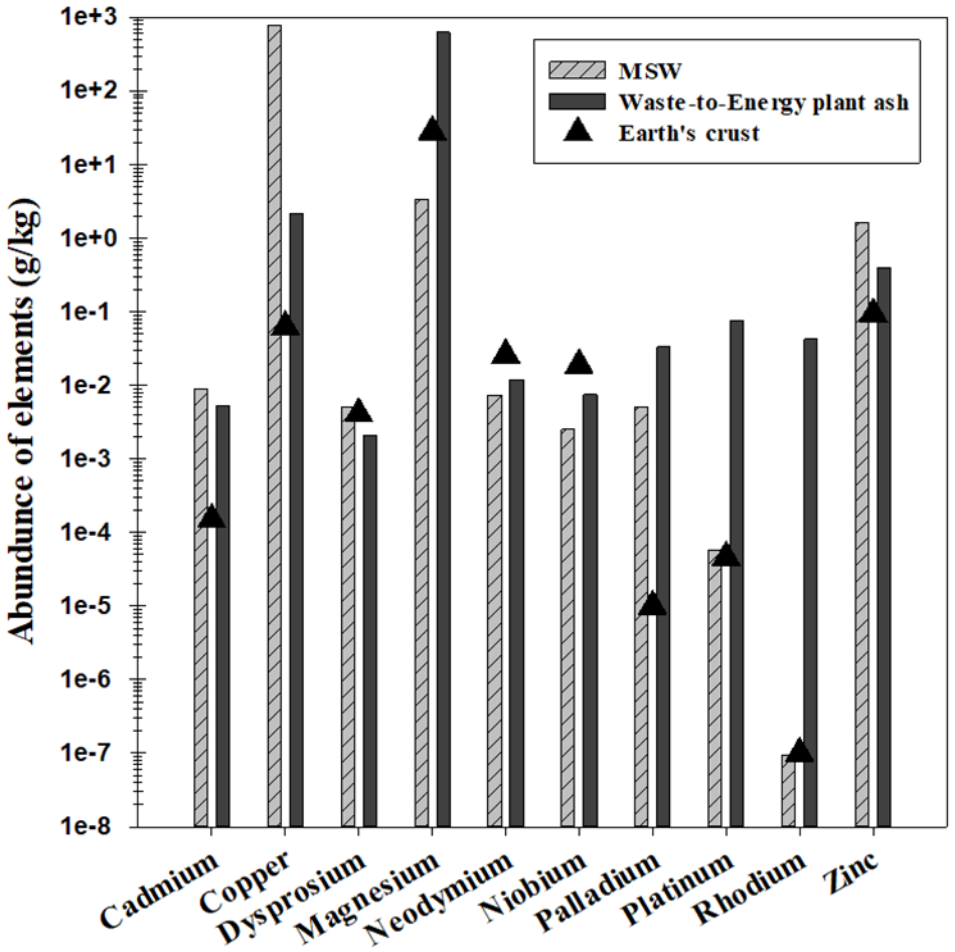
Figure 2. CR values associated with annual concentrations are far below the regulatory benchmark

Main Conclusion: *This analysis evaluated potential impacts associated with applying additional control technologies to WTE plants. It was demonstrated that simply adding on additional APC units to theoretically reduce emissions would not result in lowered emissions.*

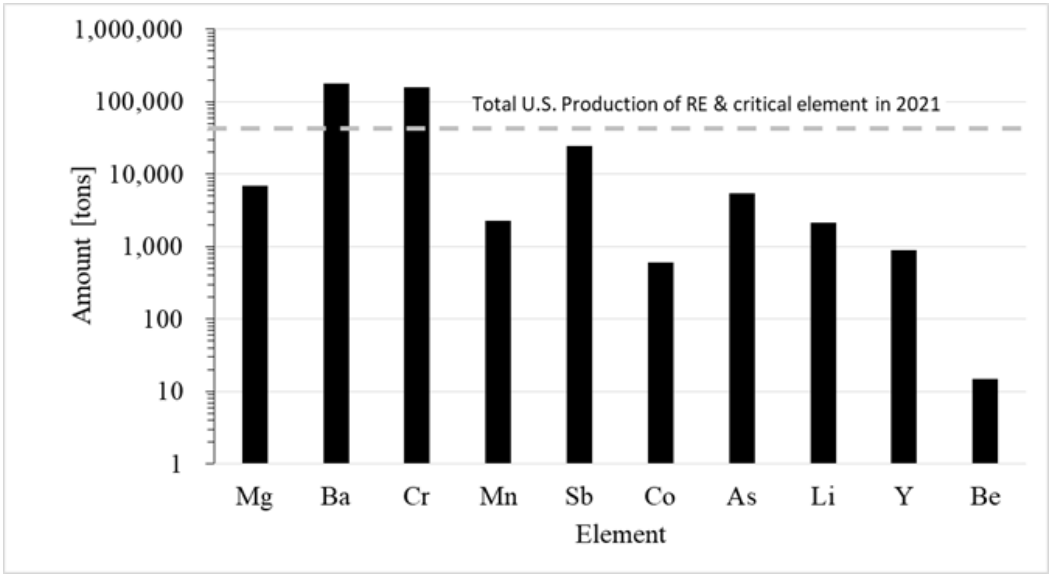
The City College of New York

Experimental Research Efforts: Critical Material Recovery from Ash

Values of Selected Elements in US MSW WTE Ash



Current amount of select elements present in domestic ash



Element	US production tonnes	tonnes import	% imported	% recovery from ash to offset imports
Mg	101	59	-71	
Ba	2764	2550	-8	
Cr	130	490	73	0.23
Mn	0	1117	100	49
Sb	4000	19508	79	63
Co	2700	10000	73	1202
As	0	391	100	7
Li	1900	2500	24	28
Y	0	670	100	76
Be	160	49	-227	

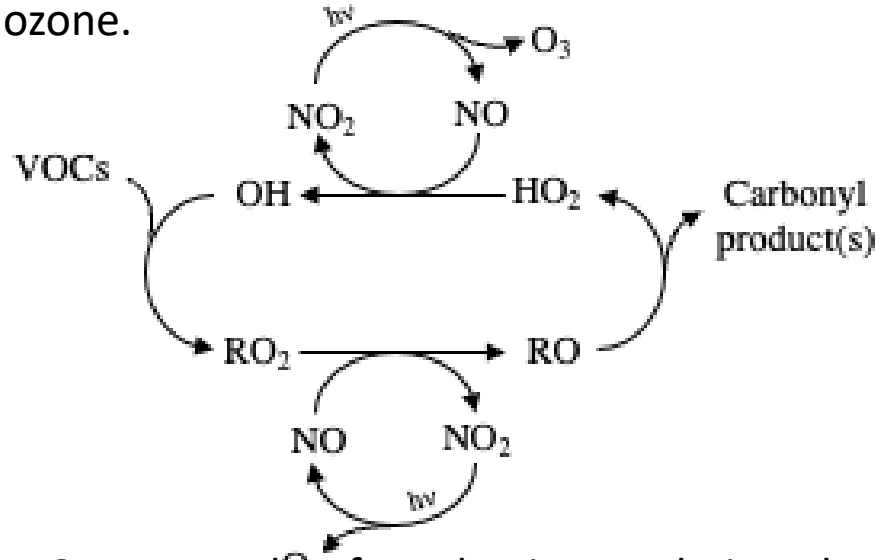
Hopefully interest in critical materials will bring more attention to thermal conversion

The City College of New York

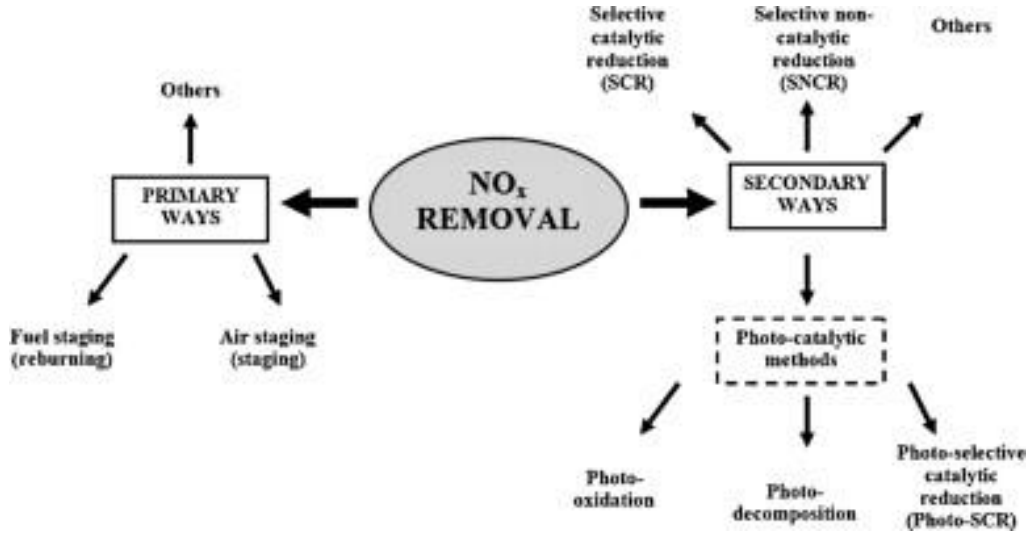
Combustion & Catalysis Laboratory

Experimental Research Efforts: Ash for Harsh Environment APC

NO_x is problematic because its release results in the formation of ozone.



There are a variety of ways to remediate NO_x. Selective Catalytic Reduction (SCR) is the most common.



We've used our NO_x as a catalyst for selective catalytic reduction which led us to propose this mechanism.

$$M^{n+} + NH_3 + O^{2-} \rightarrow M^{(n-1)+} + NH_2(ad) + OH^-$$

Carbon residue in ash

$$C_f + O_2(g) \rightarrow C(O)$$

$$C(O) + NO \rightarrow C(-O - N = O)$$

$$C(-O - N = O) + NH_2(ad) \rightarrow N_2 + H_2O + C_f + O_2$$

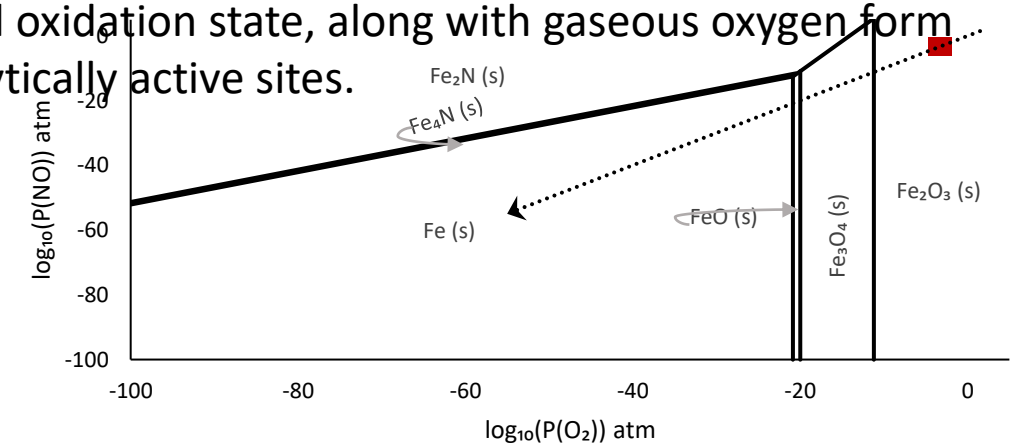
$$M^{(n-1)+} + O_2(g) \rightarrow M^{n+} + O^{2-}$$

Metals in ash

$$OH^- \rightarrow H_2O + O^{2-}$$

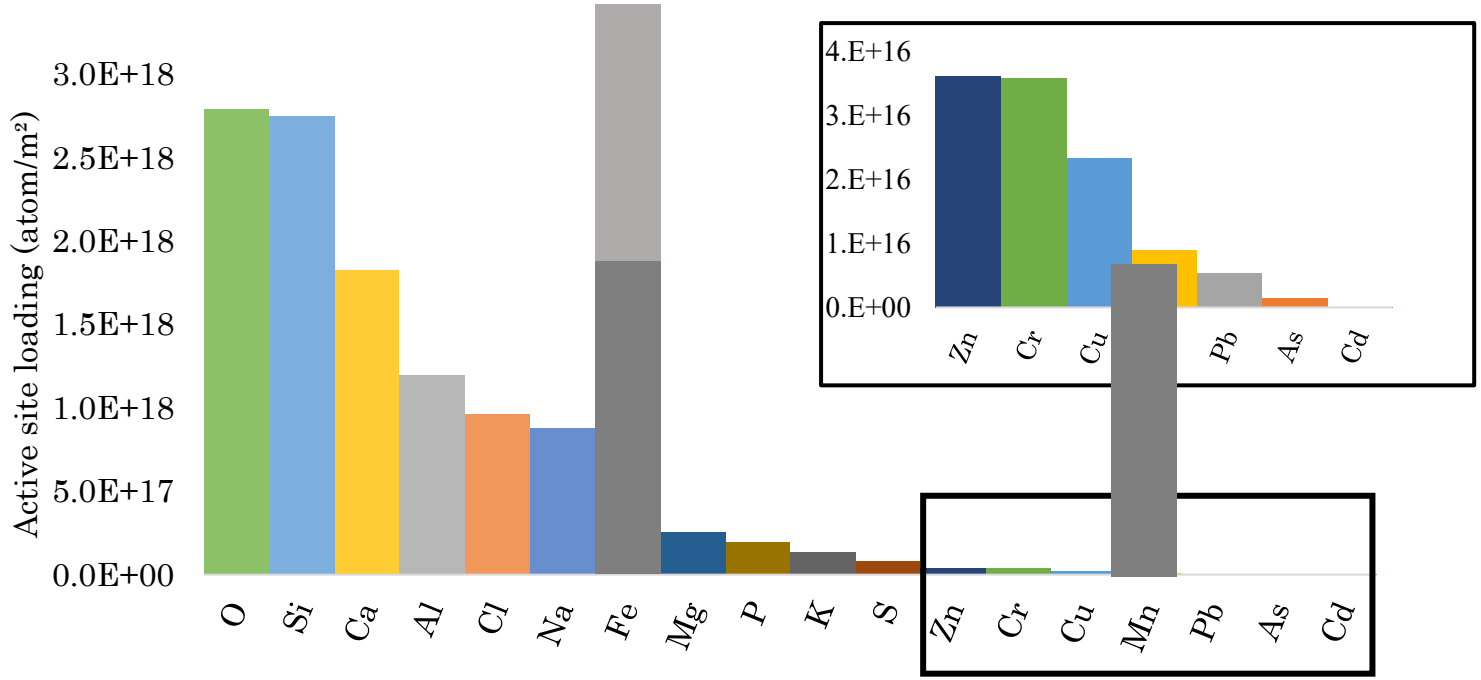
We think this because the oxygen concentration impacts performance, and oxygen concentrations control the form of potential active sites.

Metal oxidation state, along with gaseous oxygen form catalytically active sites.



Experimental Research Efforts: Ash for Harsh Environment APC

	Composition (wt %)	
component	bottom ash, BA	fly ash, FA
SiO_2	37.8	2.47
CaO	20.79	44.5
Al_2O_3	13.4	0.55
Fe_2O_3	7.46	0.32
K_2O	0.85	3.01
Na_2O	5.38	4.39
MgO	2.91	0.57
P_2O_5	3.63	0.26
SO_3	1.01	1.61
ZnO	0.52	2.25
CuO	0.51	0.096
MnO	0.17	0.04
Cr	0.63	0.008
Pb	0.22	0.51
As	0.021	0.062
Hg	ND[a]	ND[a]
Cd	0.0003	0.003
Cl	3.51	35.15



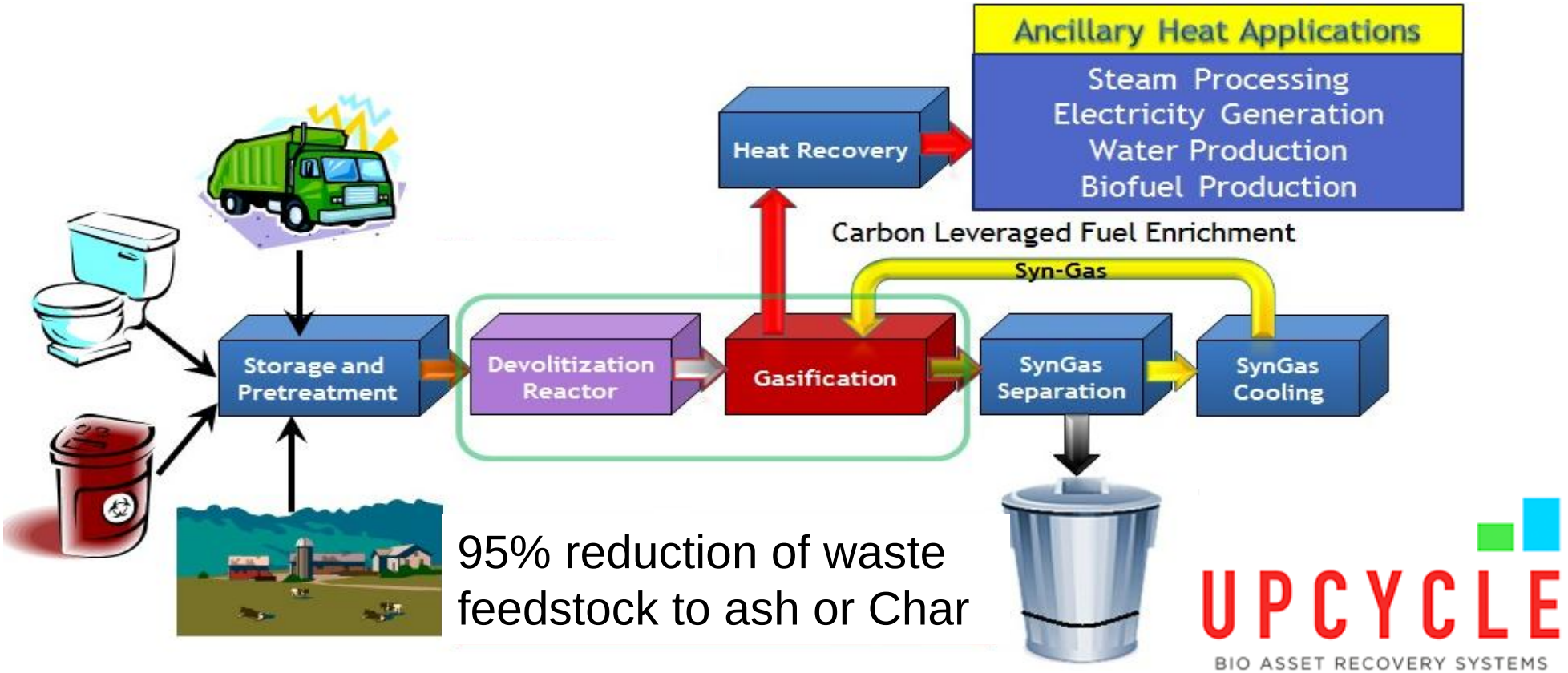
Turnover frequency: 35×10^{-5} s^{-1} [5]

Turnover frequency: 7.6×10^{-5} s^{-1} [6]

K. Park, J. Hyun, S. Maken, S. Jang, and J. Park, "Vitrification of Municipal Solid Waste Incinerator Fly Ash Using Brown's Gas," Energy & Fuels, 2005.
N. Apostolescu, B. Geiger, K. Hizbullah, M.T. Jan, S. Kureti, D. Reichert, F. Schott, and W. Weisweiler, "Selective catalytic reduction of nitrogen oxides by ammonia on iron oxide catalysts," Applied Catalysis B: Environmental, 2006.
G. Qi and R. T. Yang, "Low-temperature selective catalytic reduction of NO with NH3 over iron and manganese oxides supported on titania," Applied Catalysis B: Environmental, 2003.

Municipal solid waste ash's similarities to NO_X reduction catalysts.
Potential use in harsh environments.

Experimental Research Efforts: Thermally Processing Wet Waste



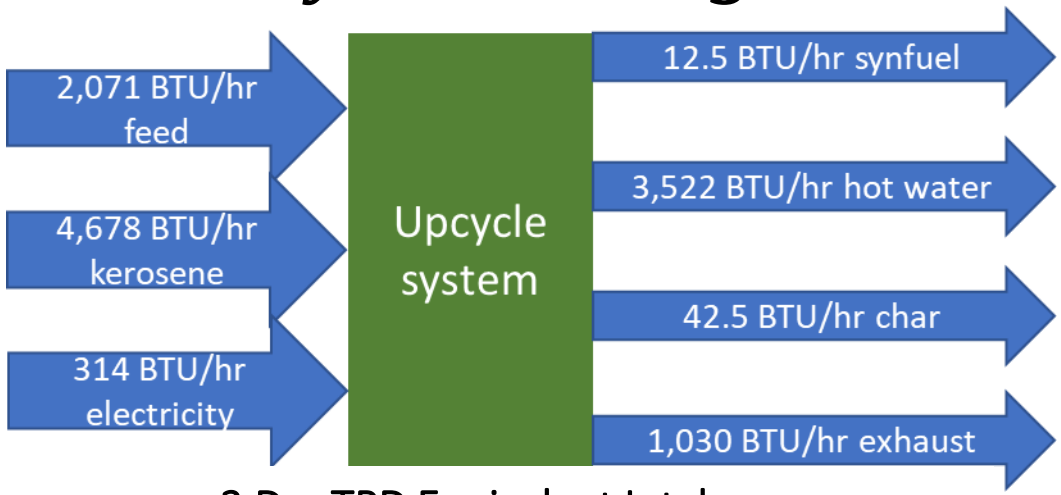
It is possible to process 15 tons of wet waste a day, with low-carbon emissions. A 95% potential asset yield. Water. Energy. Minerals. Small footprint compared to traditional methods.

One Unit processes 15 tons or more of wet waste per day.

Experimental Research Efforts: Thermally Processing Wet Waste



Prototype @ CCNY,



3 Dry TPD Equivalent Intake
Up to 85% water content
Gasification with water/steam
55% Hot water production
18% Fuel gas production
10% Char production

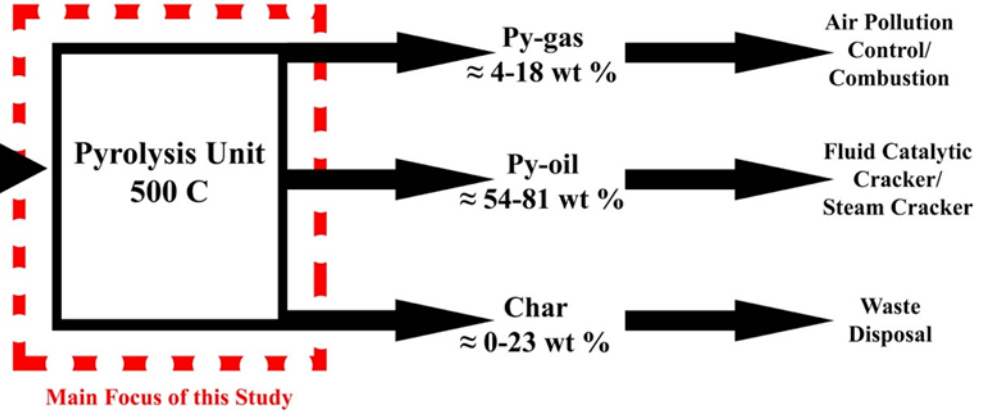
Wet waste statistics in the US

- 1.4 billion tons/yr manure generation
  - 70 – 90% water
- 85 million tons/yr sewage generation
  - Up to 99% water
- 184 million tons/yr organic waste generation
- $50 billion/yr spent on wastewater treatment

The City College of New York
Earth Engineering Center CITY COLLEGE of NEW YORK
UPCYCLE BIO ASSET RECOVERY SYSTEMS
collaboratory science. policy. solutions.
North Carolina Agricultural and Technical State University

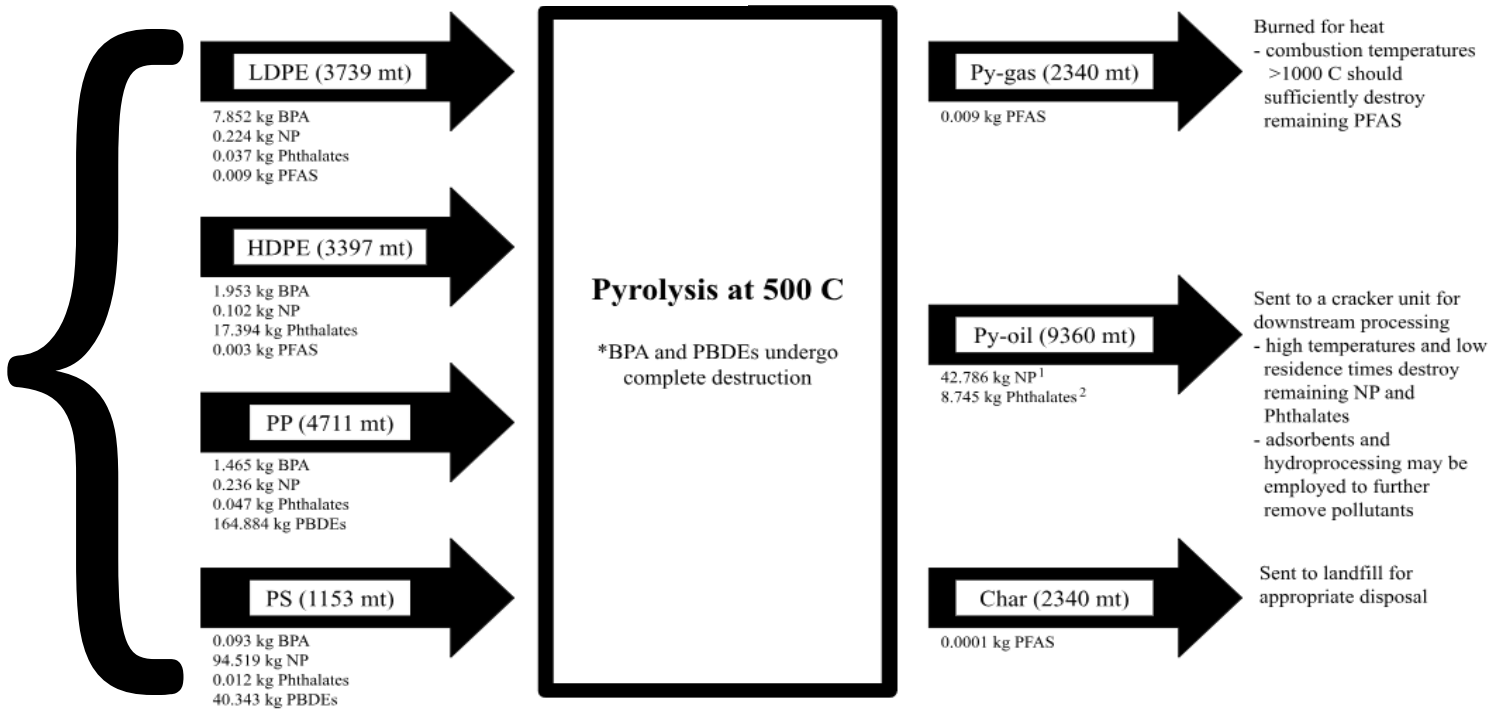
Analytical Research: Thermal Destruction of Problematic Chemicals





American Chemistry Council

Representative example of waste plastic stream from MRF



Processing waste thermally destroys problematic chemicals (e.g. PFAS, BPA, etc)

The City College of New York

Combustion & Catalysis Laboratory

Acknowledgements

- Valentina Rappa
  - Currently at Rheaply doing sustainability and circular economy work
- Anjeza Arapi
- Dr. Michael Lugo
  - CCL Post-Doc. & EEC Resident Research Assoc.
- Erica Razook
  - EEC Resident Research Assoc.
- Sarah Foster
  - EEC Research Assoc.
- Entire CCL & EEC Team
  - Kaitlyn Lawrence, Lauren Creadore, Tricia Marchese, Jahnvi Trivedi, Yegor Nikitin, Camille Richard

The City College of New York

Combustion & Catalysis Laboratory