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The role of waste to energy (WTE) as a renewable, sustainable, clean energy solution in the US: A review of the health impacts of WTE facilities

Marco J. Castaldi

Professor, Chemical Engineering

Director, Earth System Science and Environmental Engineering

Director, Earth Engineering Center | CCNY

Director, WTERT-U.S.A.

City College, City University of New York

Presentation to:

June 23 – 25, 2021

from NYC - online

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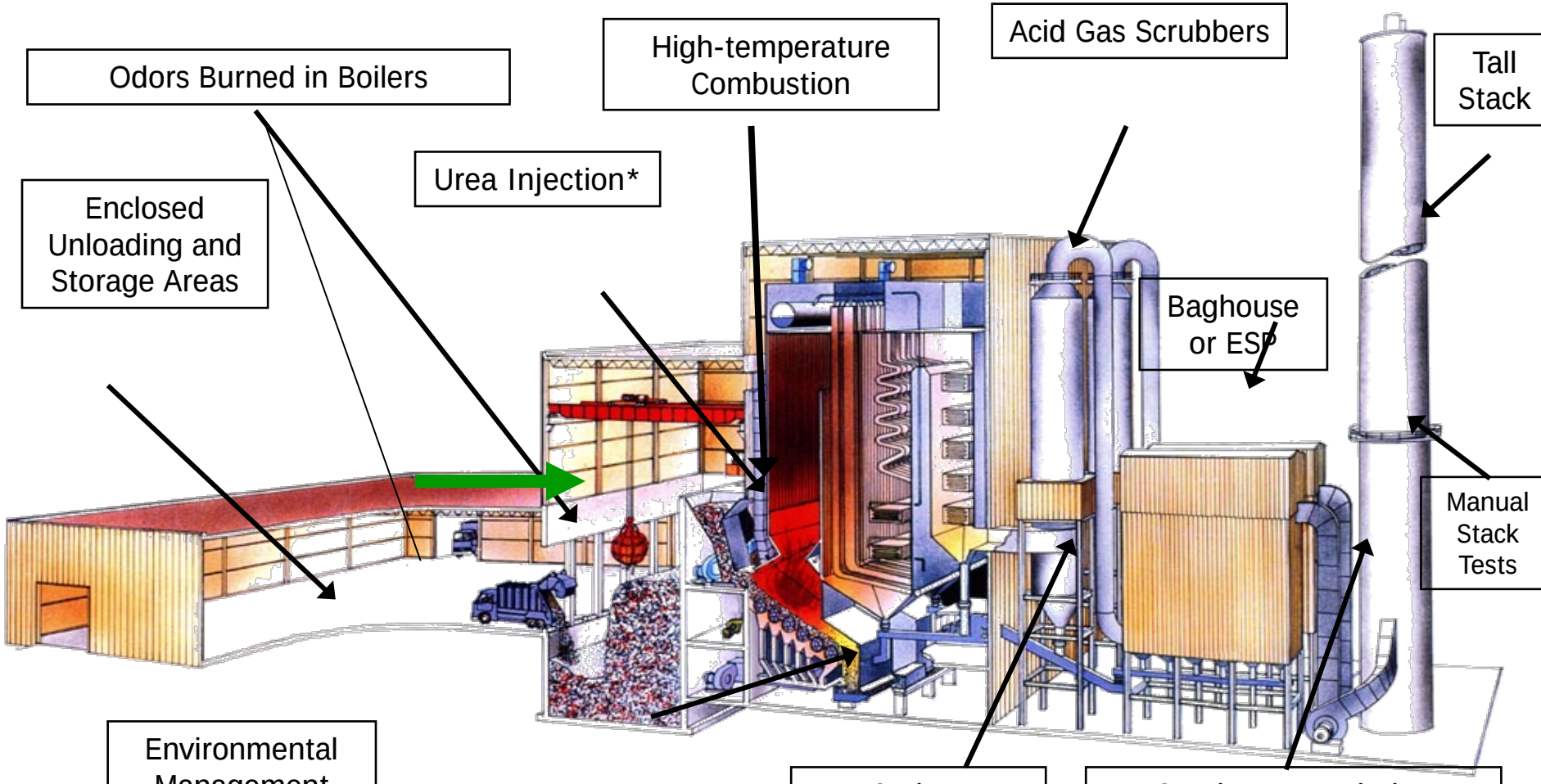
Combustion & Catalysis Laboratory

Introduction

- **Only WTE & landfilling can match MSW generation**
  - Reduction, reuse and recycling need to continue and increase
- **Misinformation about WTE is counterproductive**
  - Main result is more landfilling, not more recycling
- **Decades of reliable, safe operation demonstrate WTE should be increased to avoid landfilling**
  - Global, Country & local data show those with more WTE correlate to less landfilling and more recycling.

Study focused on conventional WTE



** Some Plants*

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New Review Released

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https://ccnyeec.org/wp-content/uploads/2021/05/WTE-REPORT7603.pdf

SCIENTIFIC TRUTH ABOUT WASTE-TO-ENERGY

MARCO J. CASTALDI, PH.D.
Chemical Engineering Department
The City College of New York
City University of New York

PREFACE

Our society's increasing focus on the interrelationship of energy and the environment, including in particular sustainable waste management, has prompted the need for a comprehensive review of generating energy from waste. While there is growing interest in a circular economy that facilitates productive reuse of municipal solid waste (MSW), there is also significant confusion and misinformation regarding sustainably managing MSW using thermal conversion – or "Waste-to-Energy" (WTE). But juxtaposed to that confusion and misinformation are the facts, which show that WTE plays a key role as part of an environmentally sound system that includes full protection of human health and where post-recycled MSW supplies the energy to serve residential, commercial and industrial needs.

That is the context for this study, which provides the most up-to-date information on WTE and the environment, and can serve as a comprehensive resource for policy makers and others interested in learning more about the quantifiable benefits of WTE. The study has been reviewed by the following experts who possess first-hand knowledge and experience with WTE and are recognized internationally for their research and other scientific and engineering contributions. Their review ensures that the information and data presented are accurate and up to date. Any opinions or interpretations are those of the author only.

Prof. Nickolas Themelis – Columbia University

Prof. Ashwani Gupta – University of Maryland

Prof. Frank Roethel – State University of New York, Stony Brook

Mr. Anthony Licata – ASME Fellow, Licata Energy & Environmental Consultants, Inc. (formerly of Babcock Engineering)

Institute of Energy and Resource Management (IERM)

Dr. Helmut Schnurer (Former Deputy Director General at the Ministry for Environment, Germany – 40+ years in Waste Management , German & EU Policies)

Dr. Michael Weltzin (Senior Scientific Advisor to German Green Party on Waste and Climate Policy – 20+ years in Waste Management and Climate)

Rene Moeller Rosendal (Danish Waste Solutions, ISWA Vice Chair Landfilling – 20+ years in Waste Management focus Landfilling)

Dr. Richard Honour (Executive Director The Precautionary Group, Specialist in Environmental Toxicology, Infectious Diseases and Cancer – 50+ years)

Philipp Schmidt-Pathmann, MBA, MIS (Founder and Executive Director, IERM – 20+ years in WTE and Waste Management US and Europe)

Cover Photo: Solid Waste Authority of Palm Beach County (FL) Renewable Energy Facility 2, the newest waste-to-energy facility built in the U.S. which started commercial operations in 2015. https://swa.org/Facilities/Facility/Details/Renewable-Energy-Facility-2-11

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City University of New York

FURTHER READING

- New York State Department of Environmental Conservation, Beyond Waste A Sustainable Materials Management Strategy for New York State, December 2010
- Environmental Research of the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, The Climate Change Mitigation Potential of the Waste Sector: Illustration of the potential for mitigation of greenhouse gas emissions from the waste sector in OECD countries and selected emerging economies; Utilisation of the findings in waste technology transfer, ISSN 1862-4804, 2015
- Waste to Energy Conversion Technology, 1st Edition, Editors: Naomi Klinghoffer and Marco J. Castaldi, Elsevier, ISBN: 9780857090119, 2013
- Energy Recovery from Municipal Solid Waste by Thermal Conversion Technologies 1st Edition, by P. Jayarama Reddy, CRC Press, ISBN-13: 978-1138612112, 2016
- Comparative Evaluation of Life Cycle Assessment Models' Measurement of Greenhouse Gas Emissions from Landfills and Waste-to-Energy Facilities, Prepared for: Local Government Coalition for Renewable Energy, Prepared by: University of Florida, November 2019

ACKNOWLEDGMENTS:

- Photos courtesy of Covanta, Wheelabrator, and Solid Waste Authority of Palm Beach County
- Special thanks to Steve Faber, Byrum & Fisk Communications, for final design and editing. www.byrumfisk.com

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SETTING THE STANDARD
MATERIALS & ENERGY RECOVERY DIVISION

The Materials & Energy Recovery (MER) Division of ASME supports this document and is aligned with the findings.

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Important Findings

The current performance of WTE facilities in the U.S., and globally, shows their emissions are more than 70% below MACT standards, except for NOx, which operates at approximately 35% below emission standards.

Well-designed and well-operated WTE facilities will result in destruction and removal of viruses, enteric bacteria, fungi, human and animal parasites at an efficiency between 99.99 to 99.9999% (Ware, 1980).

US and International reports show human health effects cannot be directly connected to properly operating WTE facilities.

A recent review of 70 published studies concluded that a WTE facility's contribution to the overall daily air pollutant dose to the affected urban populations was negligible.

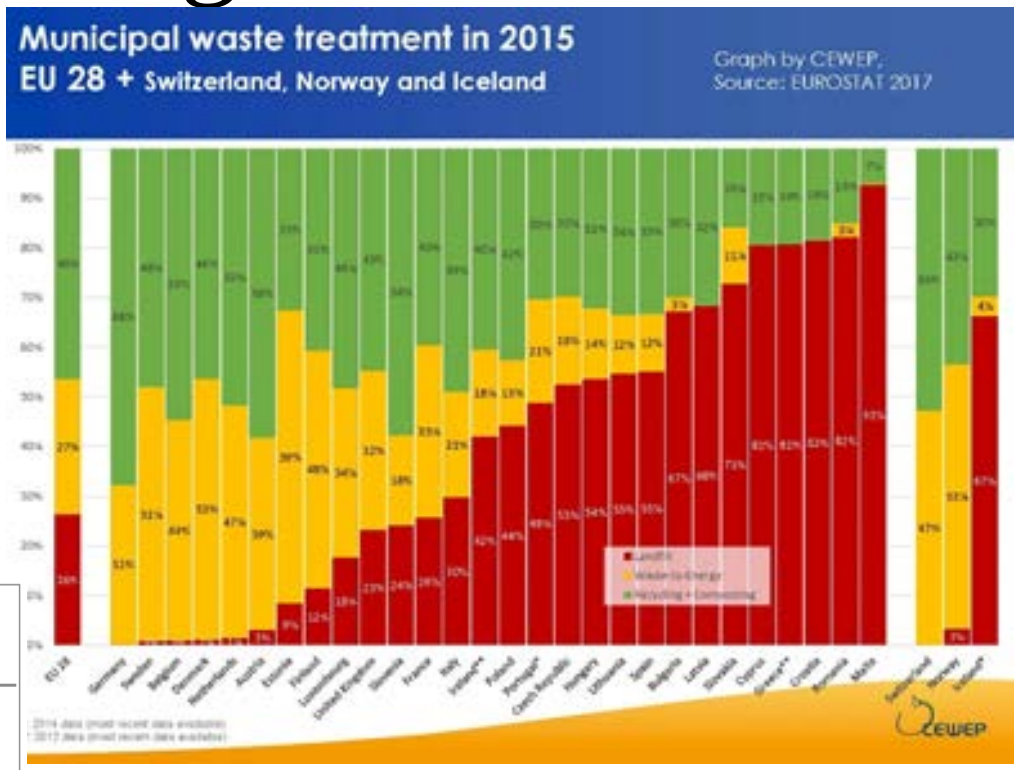
Main Findings

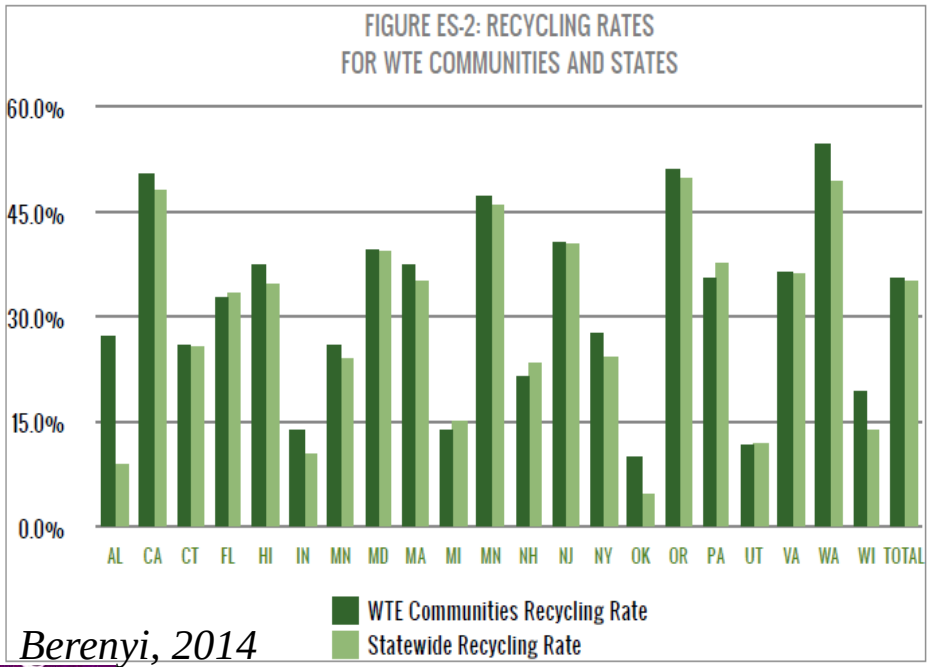
- **Longstanding & well-documented scientific consensus → human health is not adversely impacted by WTE.**
  - National Research Council report → WTE emissions contribute little to environmental concentrations or to health risks.
  - Epidemiological studies suggest there is no association between human health effects and the operation of WTE facilities.
  - A 2019 review → health benefits of modern, properly-managed WTE facilities may outweigh the health risks.
  - A 2003 to 2010 study → "*We found no evidence that exposure to PM_{10} from, or living near to, an [WTE] operating to current EU standards was associated with harm for any of the outcomes investigated. Results should be generalisable to other MWIs [i.e., WTE facilities] operating to similar standards.*"
  - A study from 1996 to 2012 found no evidence that WTE caused an increase in infant mortality when compared to control areas.

WTE-Recycling Correlation

UK's Department for Environment Food & Rural Affair (DEFRA) shows that recycling, and WTE are complementary. *(Sara, 2016).*

Austria:70% recycling , 30% WTE;
Germany: 62% recycling, 38% WTE;
Belgium: 62% recycling, 37% WTE
Korea: 60% recyc/comp, 20% WTE





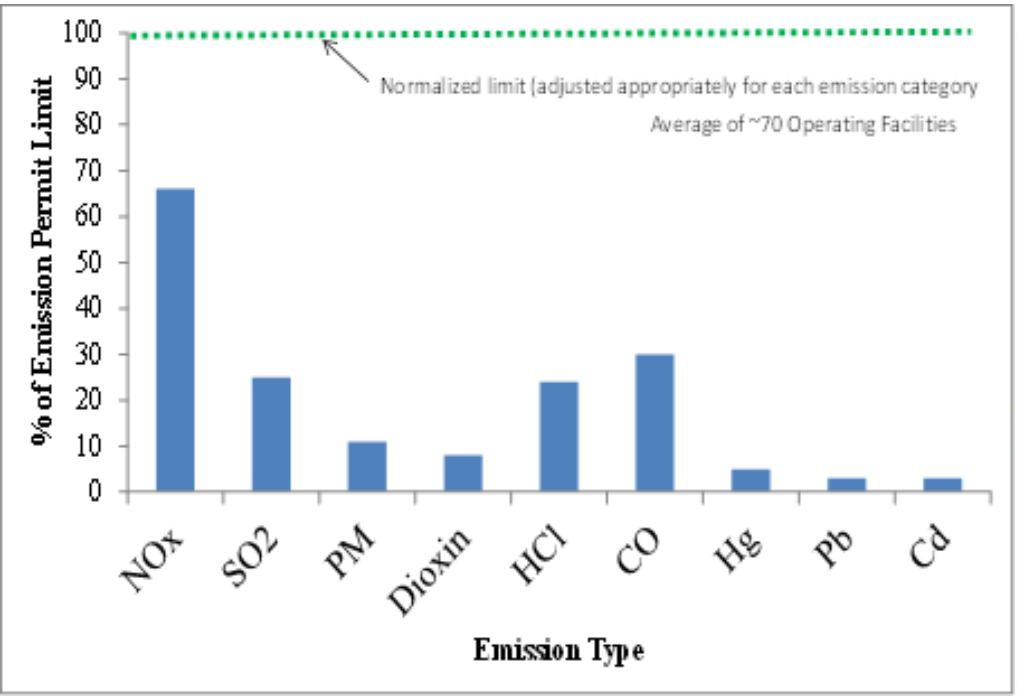
Berenyi, 2014

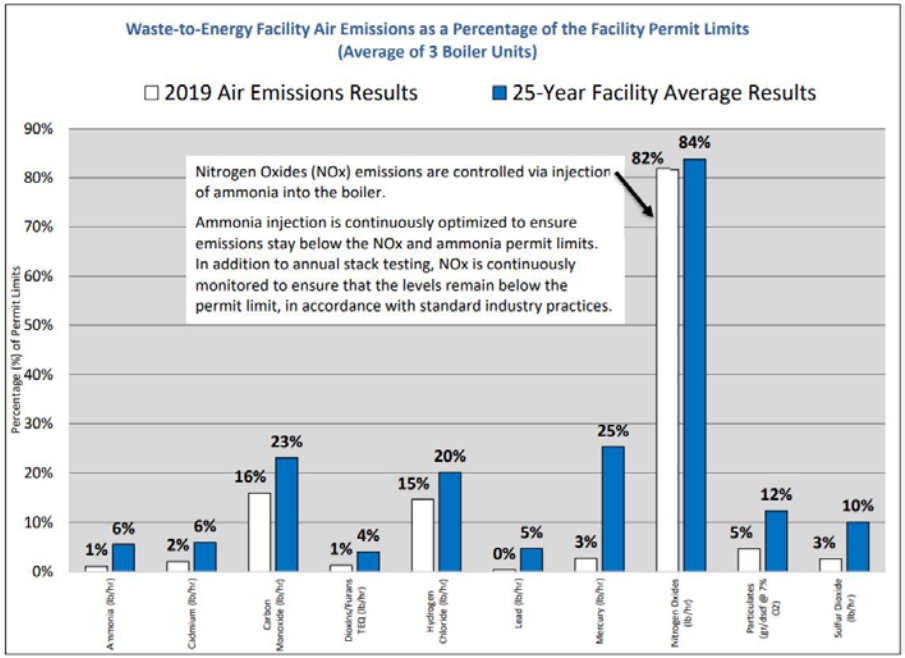
Use of WTE correlates to higher recycling rates

WTE & Health

- **WTE is primarily a sustainable waste management solution**.
  - Disposes MSW, and other wastes, safely through combustion.
  - Extracts value from MSW (power, heat and materials).
  - Flue gas and ash emissions are well regulated.
  - All MSW management has emissions

WTE Emissions are lower than EPA limits





Emissions compared to federal and state limits. ***Left****; results of an average of 70 operating facilities in the U.S.* ***Right****; Average stack emissions for 2019 and 25 years of operation for one facility*

Although well below regulatory limits, emission reduction efforts continue

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Dioxins Reality

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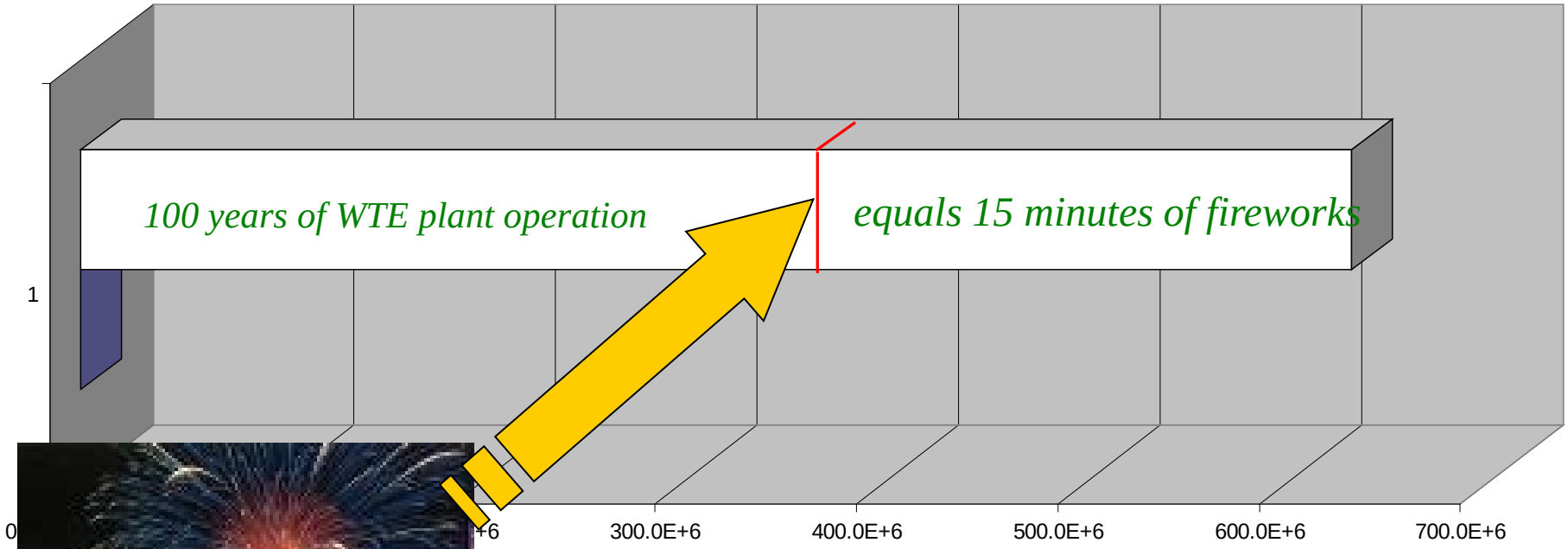

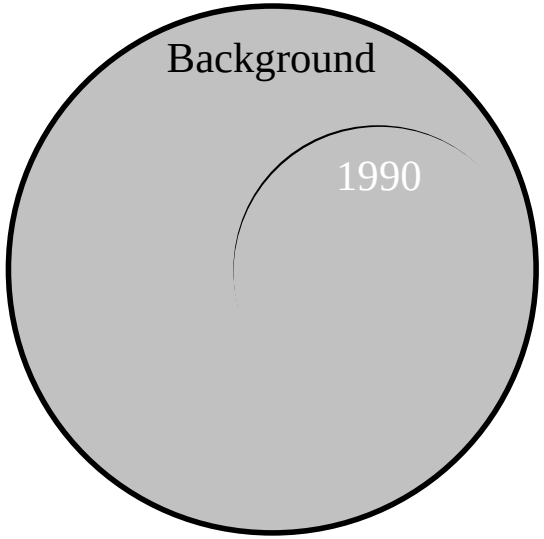

Relative concentrations of dioxins

Dioxins have not been a problem for decades
WTE is a negligible contribution to the environment

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Concentration Ratio Results

Emissions data for four WTE plants operating in North America

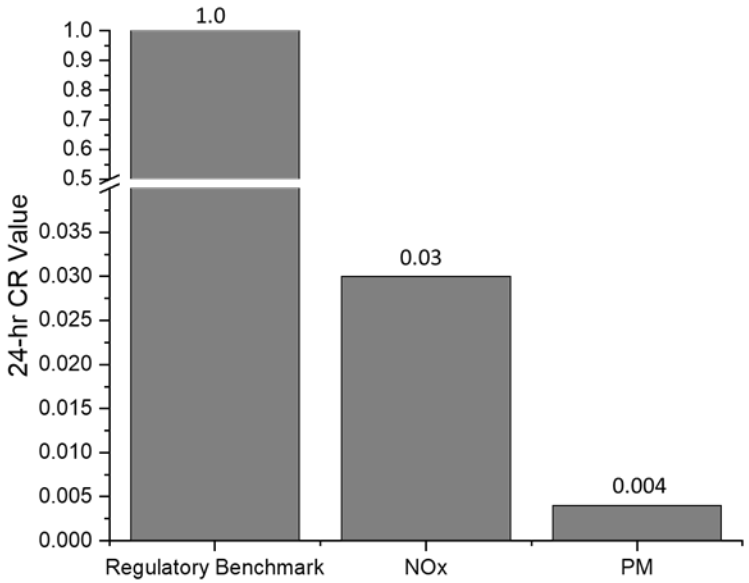
		Plant 1	Plant 2	Plant 3	Plant 4
MWC Features	Combustion Technology	Mass-burn	Refuse derived fuel	Mass-burn	Mass-burn
	Combustion Units	3	2	3	2
	Facility Capacity t/day	1800	3000	3000	480
NOx	In-stack emissions, 24-hr average	88 ppmv	142.8 ppmv	30 ppmv	94 ppmv
	MACT ruling limit	180 ppmv	230 ppmv	180 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

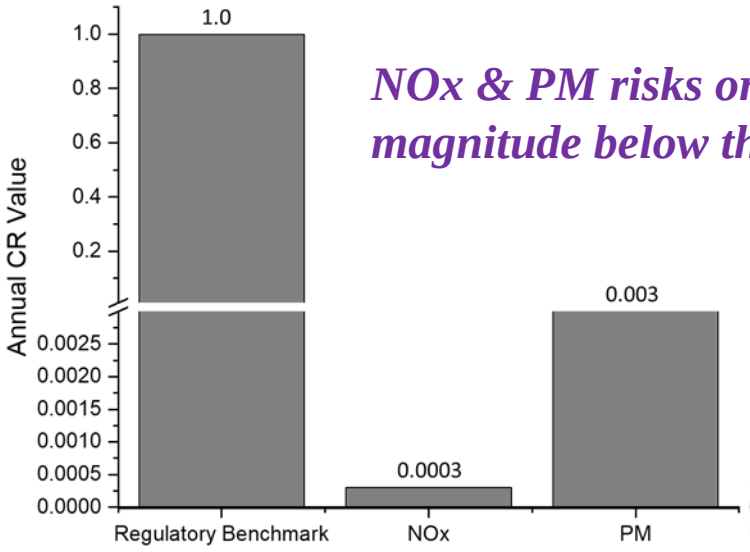
(a) In stack Environmental Compliance Approval Limits in Ontario, Canada

CR = pollutant's modeled ambient air concentration divided by its corresponding health-based benchmark or ambient air quality criteria

Regulatory bodies define CR = 1.0 threshold.

CR > 1.0 → health risk expected
CR < 1.0 → health risk not expected





NOx & PM risks orders of magnitude below threshold

GHGs are reduced with Energy from MSW

CARB's analysis showing specific WTE facilities' ability to reduce GHG emissions((CARB), 2013)

(MTCO2e/Short Ton Waste)

Facility	Waste (TPD)	Non-biogenic MT CO2E Emissions	Energy Credit MT CO2E[1]	Metal Recycled (Tons)	Metal Recycling Credit MT CO2E[2]	Avoided Landfill Methane Emissions MTCO2e[3]	Net MT CO2E per Ton Waste
Covanta Stanislaus	800	79,590	-49,740	5,690	-10,240	-70,080 to -154,760	-0.17 to -0.46
Commerce Refuse to Energy	360	53,760	-26,000	920	-1,660	-31,540 to -69,640	-0.04 to -0.33
Long Beach SERRF	1380	115,790	-81,390	6,500	-11,700	-120,890 to -266,960	-0.19 to -0.48
Total	2,540	249,150	-153,740	13,110	-23,600	-222,500 to -491,360	-0.16 to -0.45

1 Uses 2009-2010 average CA grid emission factor of 668 lb. CO2e per MWh, and assumes facilities produce 85% of rated power capacity per Table 1.
2 Uses a metal recycling credit of 1.8 MT CO2e per short ton of ferrous metal.
3 Estimated avoided landfill methane emission 0.24 to 0.53 MTCO2e/MT

- *Nation-wide use of the WTE technology can become one of the big contributors to America's carbon dioxide reductions, accounting for as much as 325 million tons of CO_2 or 5% of the total U.S. emissions in 2006.*
- *The EPA concluded WTE now produces electricity with less environmental impact than almost any other source(Horinko and Holmstead, 2003).*

UNEP report "District Energy in Cities: Unlocking the Potential of Energy Efficiency and Renewable Energy" states that Paris currently meets 50% of its heating needs by three WTE plant that results in avoidance of 800,000 tons of CO_2 emissions each year.

WTE is a GHG emissions reduction technology

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Non-conventional technology summary

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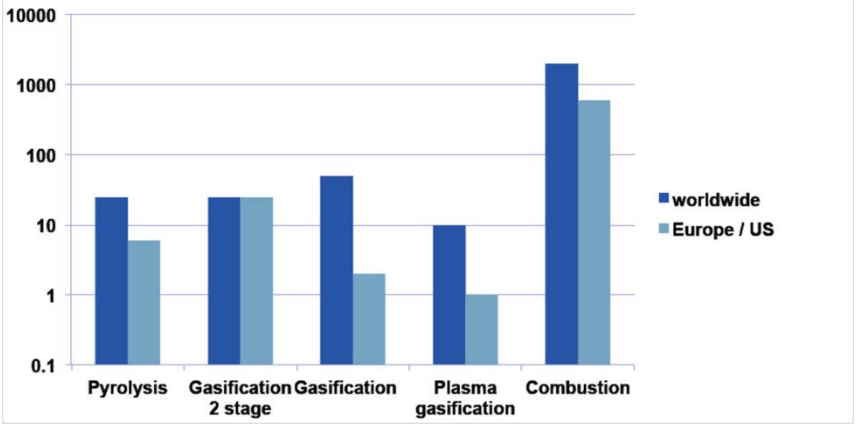
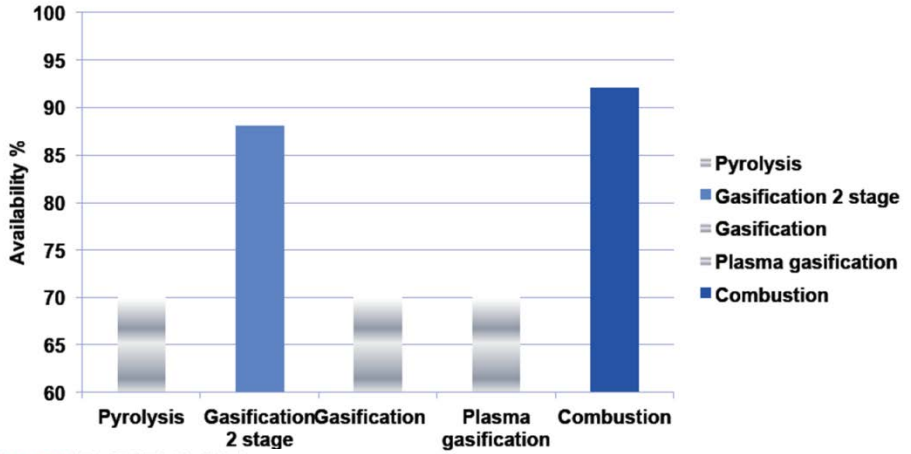
Running installations worldwide

ISWA International Solid Waste Association



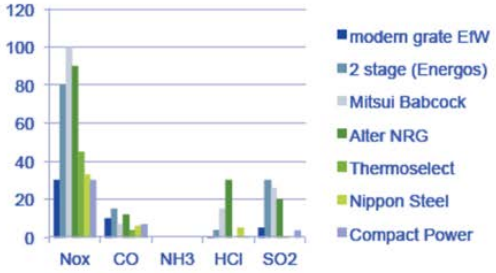
Availability (known or unknown) %

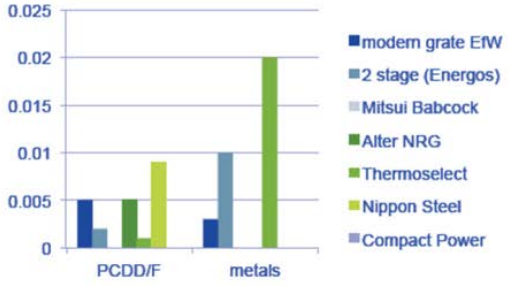
ISWA International Solid Waste Association

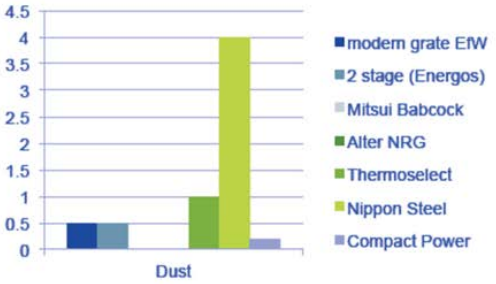


Emission levels ATT's

ISWA International Solid Waste Association







Emissions are similar

Similar concentration levels

Similar pollutant categories

Feedstock dependent

Extensive studies do not exist for these

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Peer-Reviewed Scientific Studies

- 2004 study for Montgomery County, Maryland WTE tested polychlorinated dioxins/furans and selected toxic metals (arsenic, beryllium, cadmium, chromium, lead, mercury, and nickel). Sites ranged from 2.5 to 25 miles away from the facility.
  - No measurable difference compared to pre-operational ambient levels and no expectation of non-carcinogenic health effects as a result of facility emissions (Rao *et al.*, 2004).
  - Health risk assessment found a 1.0×10^{-6} (1/1,000,000) potential carcinogenic health effects (i.e. 99% below acceptable risk).
  - (Ollson, Aslund, *et al.*, 2014; Ollson, Knopper, *et al.*, 2014) found the facility is unlikely to pose undue risk.

- Review of 21 peer-reviewed for Vancouver
  - Modern WTE facility would not pose unacceptable health risks to local residents (Sciences, 2014).

- Biomonitoring studies showed no potential risks to humans or crops in the vicinity of three (3) WTE facilities in The Netherlands (Van Dijk, van Doorn and van Alfen, 2015)

- No correlation to dioxin levels in blood for residents near a Portugal WTE facility (Reis *et al.*, 2007). A similar conclusion related to heavy metals was obtained for a WTE facility built in 2005 in Bilbao, Spain.
  - Blood and urine samples over a two year period from residents 2 to 20 km did not find increased levels of heavy metals for the residents that lived near the plant (Zubero *et al.*, 2010).

- WTE facility in Italy found the excess risk of lung cancer for people living or working nearby the plant is below the WHO target (1×10^{-5}) (Scungio *et al.*, 2016).

- England's Ministry of Public Health determined that it is not able to connect any negative health impacts associated with well-regulated WTE facilities (Freni-Sterrantino *et al.*, 2019; Parkes *et al.*, 2020).

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Peer-Reviewed Scientific Studies

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- 7-year (2003-10) Great Britain WTE study
  - modeled ground-level PM_{10} within 4.5 miles found there was no excess risk for people living in close proximity to WTE facilities (Ghosh *et al.*, 2019). "*We found no evidence that exposure to PM_{10} from, or living near to, an [WTE] operating to current EU standards was associated with harm for any of the outcomes investigated. Results should be generalisable to other MWIs [i.e., WTE facilities] operating to similar standards.*"

- Long-term study from 1996-2012 Great Britain WTE study
  - Interrupted Time Series (ITS) methodology found no evidence of an increase in infant mortality when compared to control areas (Freni-Sterrantino *et al.*, 2019).

- In 2011 study to quantify attributable burden of disease from four (4) WTE facilities near Seoul
  - Combination of air modeling and the fraction associated with the emissions.
  - Projected 30-year operation ≈ 446 ± 59% deaths may occur and could be as low as 126 ± 59%.
  - Calculations were completed **assumed** emissions **equal** to the regulatory limit values.
  - **Actual** emissions were about **10x lower than regulatory limits** and the study did not account for residual risk factors (Kim, Kim and Lee, 2011).

References to above bullets

Rao, R. K. et al. (2004) 12th Annual North American Waste-to-Energy Conference. ASME Digital Collection, pp. 23–40
Ollson, C. A., Aslund, M. L. W., et al. (2014) Science of the total environment. Elsevier, 466, pp. 242–252.
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Van Dijk, C., van Doorn, W. and van Alfen, B. (2015) Chemosphere. Elsevier, 122, pp. 45–51.
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Global, peer-reviewed, scientific studies demonstrate the negligible to undetectable health risks associated with operating WTE facilities

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Plastic & WTE

Total MSW (2017) = 3,121,471 tons

MGP (-15% AD)= 451,053 tons

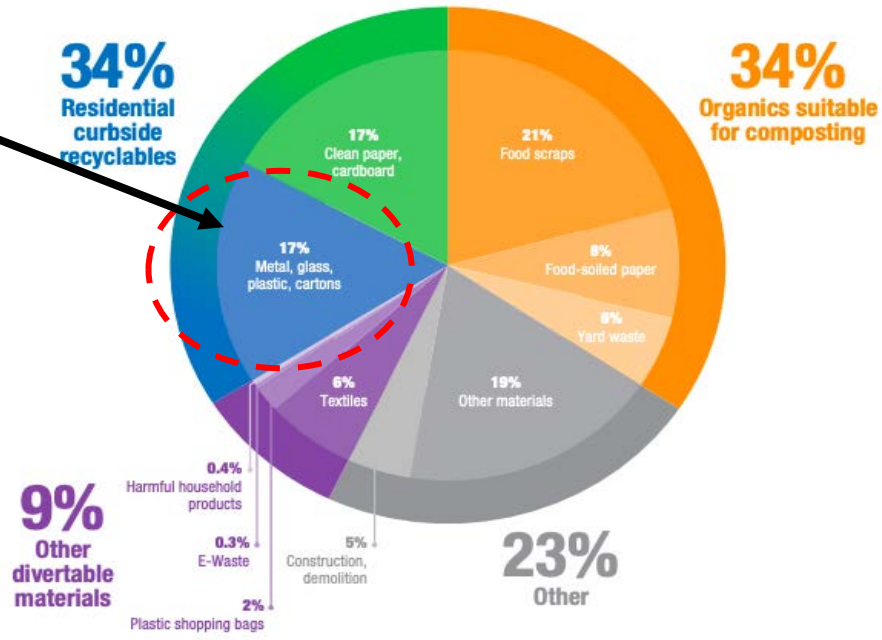
Blue bin plastics collected = 81,679 tons (18%)

Recovered from blue bin = 39,834 tons (48%)

If all recovered plastics are recycled = 8.8%

U.S. EPA states = 9.1%

biocycle states = 7.5%



Only 48% recovered from blue bins due to market opportunities.

Better to send plastics that are not or cannot be recycled (NRP) to WTE facilities instead of landfill

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Plastics in WTE Works

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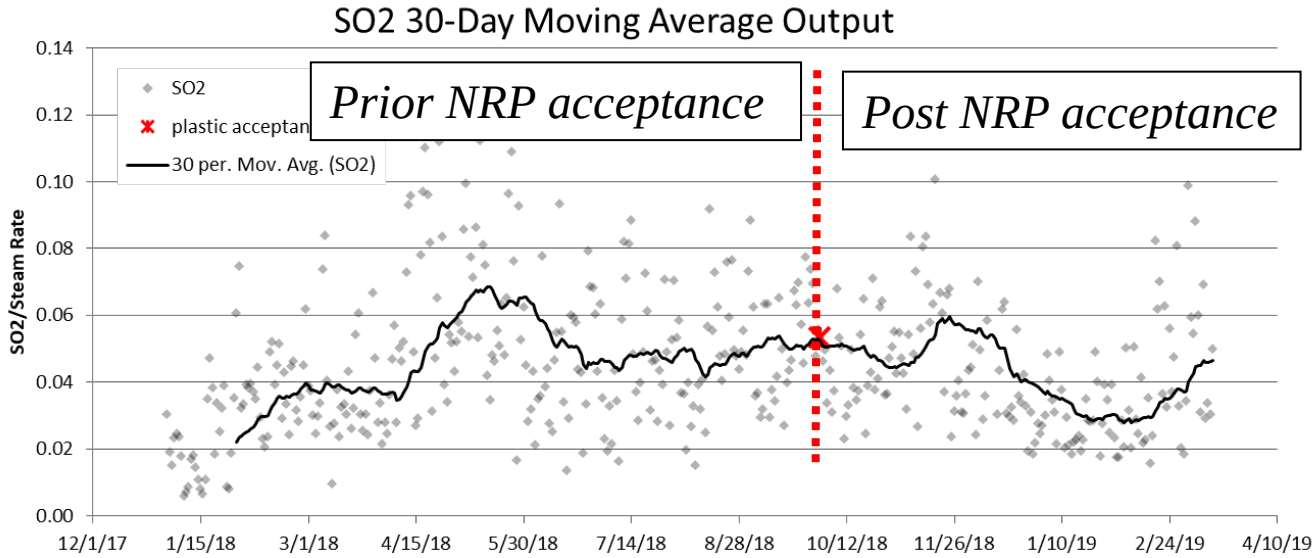

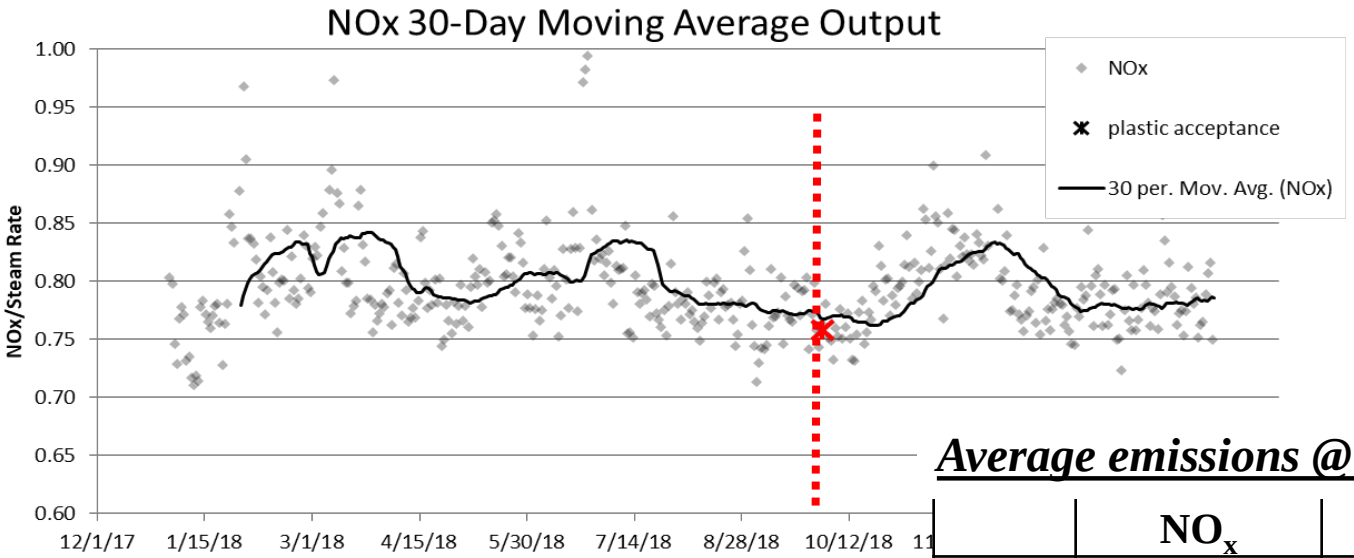

While not ideal, energy recovery from NRP in conventional mass-burn combustion WTE does not impact emissions

Average emissions @ 7% O_2 per klb/day steam

	NO_x	SO_2	HCl
Prior	0.80 ± 0.05	0.05 ± 0.02	0.006 ± 0.004
Post	0.79 ± 0.03	0.04 ± 0.002	0.005 ± 0.005

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Summary

- **Until reduce, reuse & recycle treat all waste – WTE must be used**
  - The best → 85%, leaving nearly 85,000 tons
    - NYC recycles ~50% of plastics that are source separated and recovered – similar throughout U.S.
  - Plastic benefits & export constraints will increase amount in U.S. MSW streams
    - Thank you to China for changing contamination limits → forcing the U.S. to manage waste better

- **Vast scientific, peer-reviewed literature demonstrates negligible to no health risk impact of operating WTE facilities worldwide**
  - Includes asthma, infant mortality, blood-dioxin levels, carcinogenic effects, etc
  - Proximity to WTE does not change findings
  - Performance is constantly improving → cannot rely on outdated studies

- **More health risk impacts from many other sources**
  - Local traffic contributes more to NOx & PM compared to WTE

Peer-reviewed summary of literature to be published early 2021 by Earth Engineering Center|CCNY

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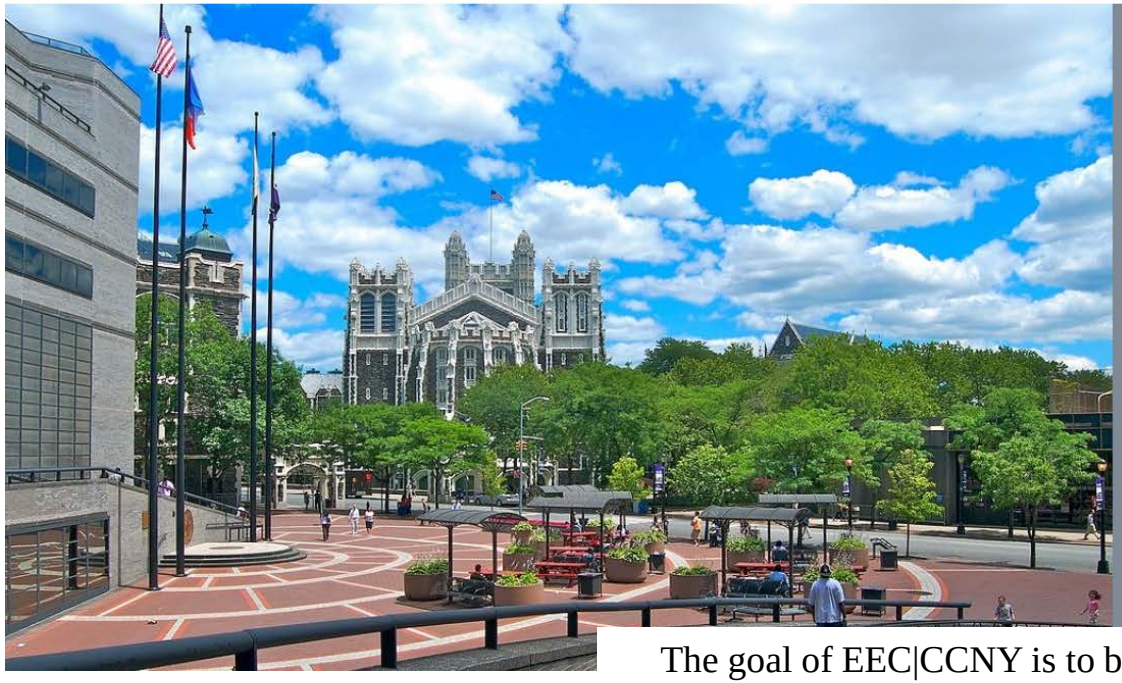

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Engineering of Earth's energy and material resources for responsible utilization and preservation

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Appendix