Waste-to-Energy Emissions in the United States

What EPA Datasets Reveal about Air Quality Impact

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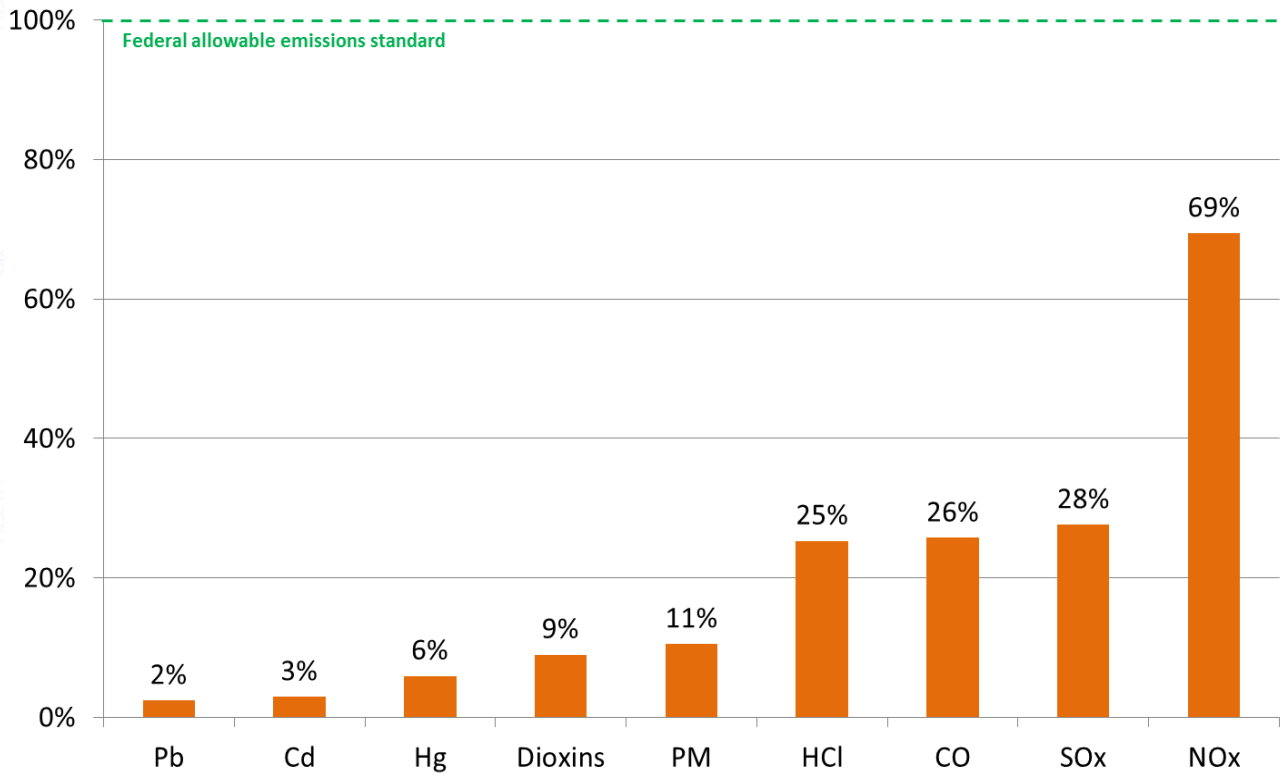
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Motivation:
Understand WtE Contribution to Air Quality from Public Datasets

US WtE Industry Average: Actual vs. Allowable Emissions



Source: Combined data from facility contributions, Earth Engineering Center, CCNY. Note: All concentrations corrected to proper emissions reporting standards (i.e. O_2 %, etc).

- Regulatory environment: stricter standards possible
- Public opinion: disagreement/ misunderstanding of impact of industry
- Technical advice: models are complex, resource intensive and inaccessible to non-experts

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Scope of Study: US WtE Facilities, Emissions Monitored

OPERATIONS: Scale, Geography

- 70 Facilities
- 64 Counties across Continental US and Hawaii
- National Emissions Inventory, 2020
- National Ambient Air Quality Database, 2018-2021
- 7 Criteria Pollutants

EMISSIONS: Criteria Pollutants Screened

- Carbon Monoxide
- Nitrogen Oxides (NOx)
- Volatile Organic Compounds (VOCs)
- Sulfur Dioxide
- PM 2.5, 10
- Lead Compounds

IMPACT: Waste Management, Energy

- Waste management: 26.3 million tons of municipal solid waste (~10% of MSW generated in US/year)
- Electricity production: ~14,000 GWh/year, ~0.4% of US electricity demand (2022)

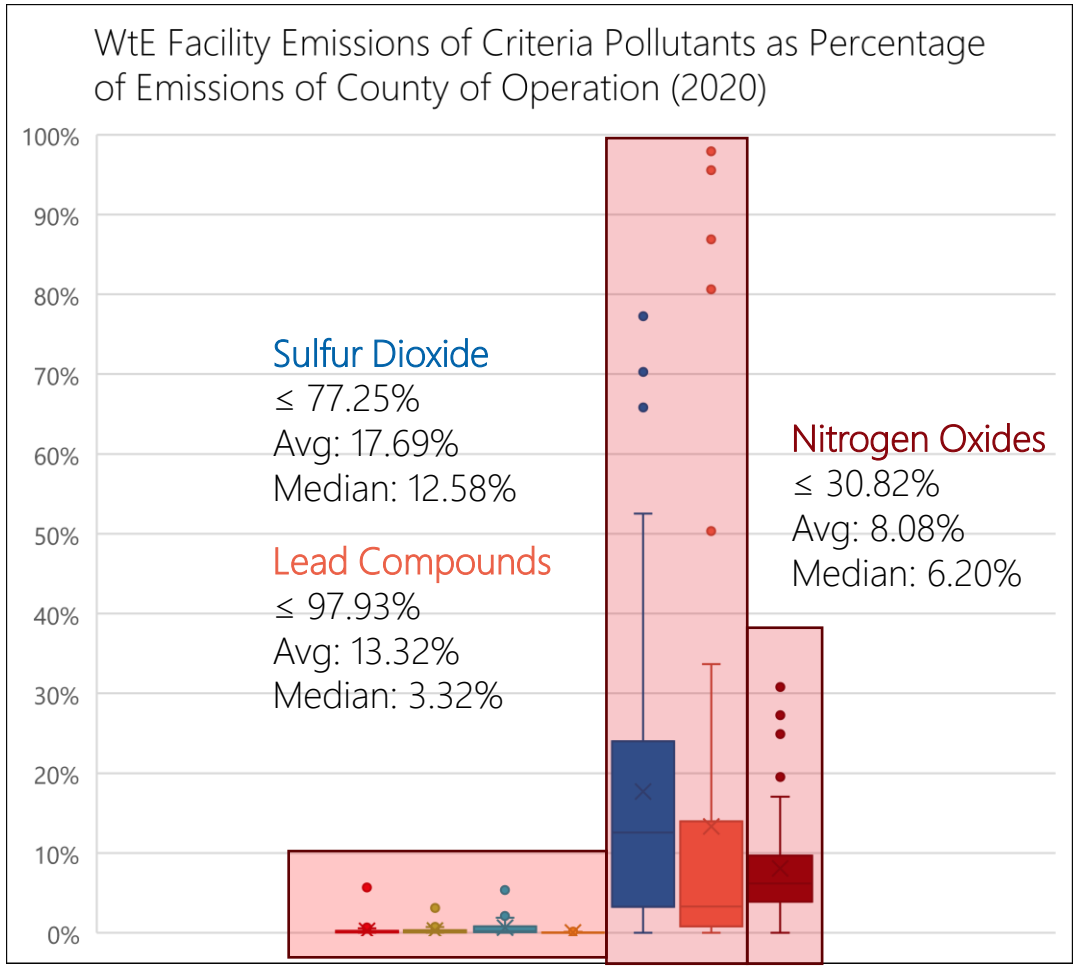
WtE Emissions as Contribution to County Emissions Using National Emissions Inventory (NEI), 2020 Dataset

Carbon Monoxide
≤ 5.69%
Avg: 0.26%
Median: 0.08%

PM 10
≤ 3.13%
Avg: 0.31%
Median: 0.12%

PM 2.5
≤5.36%
Avg: 0.67%
Median: 0.23%

Volatile Organic Compounds
≤ 0.46%
Avg: 0.04%
Median: 0.01%



WtE facilities contribute low percentages of carbon monoxide, particulate matter and VOCs to county totals.

Lead compounds and sulfur dioxide are largely not air quality concerns in counties and areas where WtE facilities operate

Nitrogen oxides are clear emissions focus, as precursor to ground ozone formation

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WtE Facilities and National Ambient Air Quality Standards (NAAQS) Non-Attainment Areas for Ground Ozone

WTE FACILITIES OPERATING IN OZONE NON-ATTAINMENT AREAS

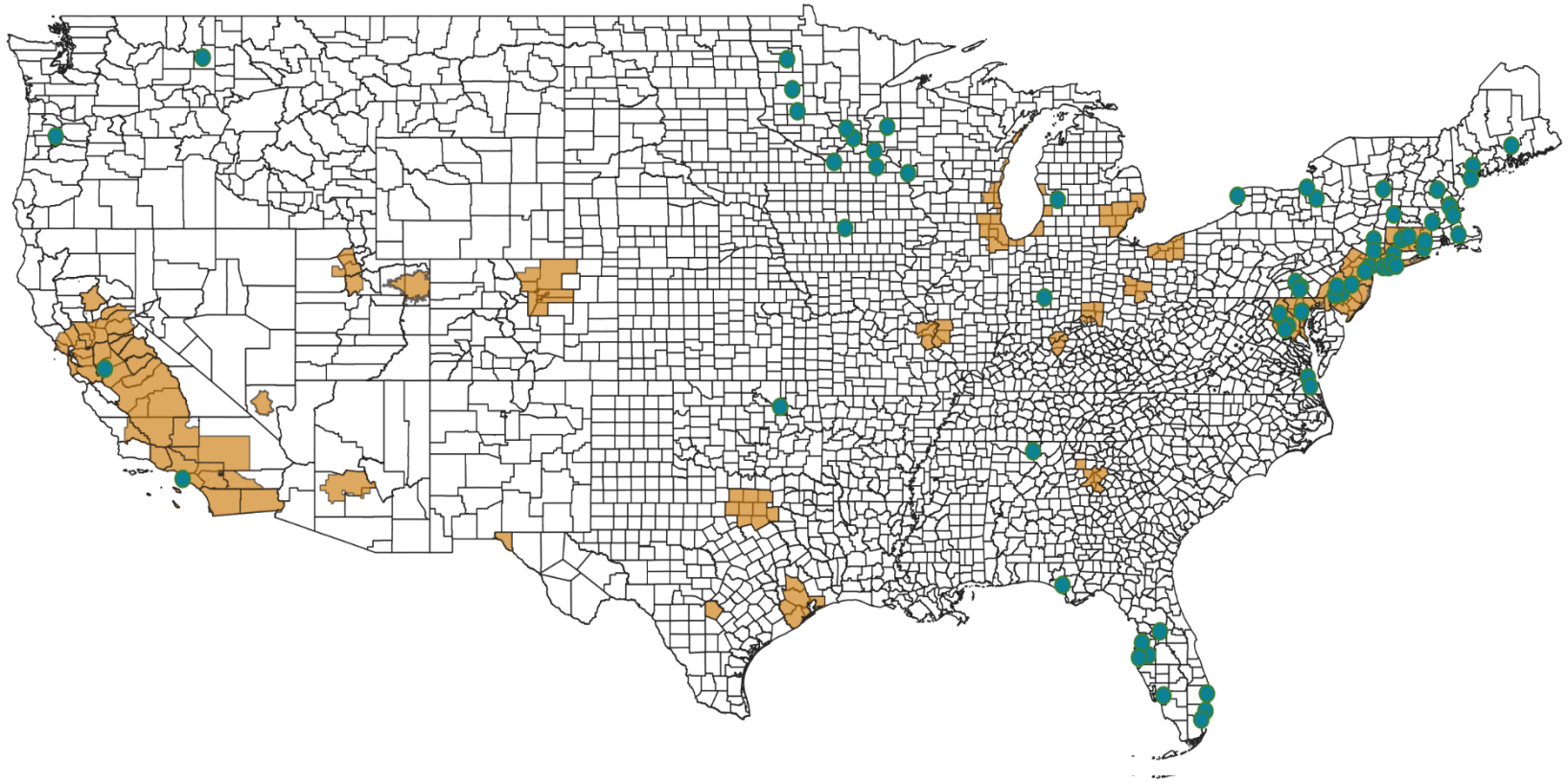
33%

COUNTIES WITH WTE FACILITIES THAT ARE NON-ATTAINMENT FOR OZONE

19

OZONE NON ATTAINMENT COUNTIES WHERE WTE FACILITY CONTRIBUTES MORE THAN 10% OF NOx EMISSIONS

36.8%



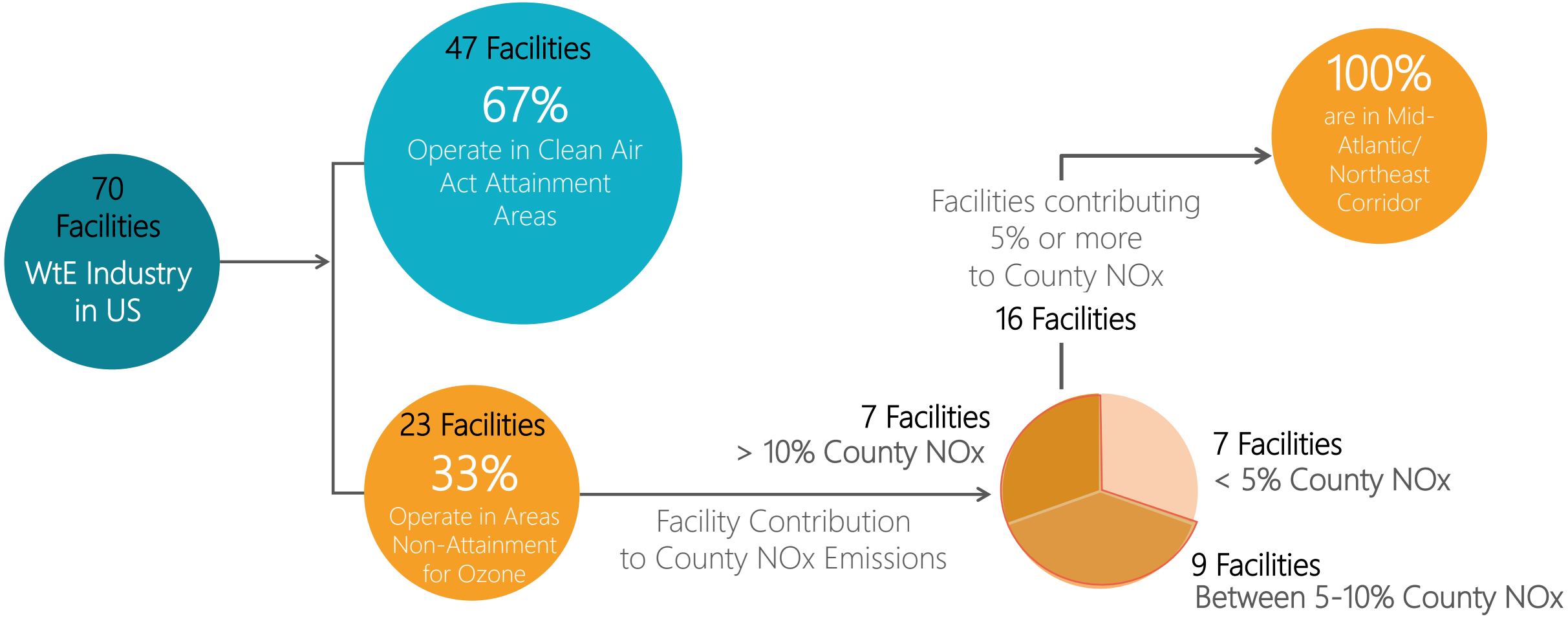
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Non-Attainment Areas for Ground Ozone with WtE Facilities: California and the Mid-Atlantic/Northeast Corridor (NAAQS Data: 2018-2021)

NAAQS for Ground Ozone, 8 hr (2015): 0.070 ppm

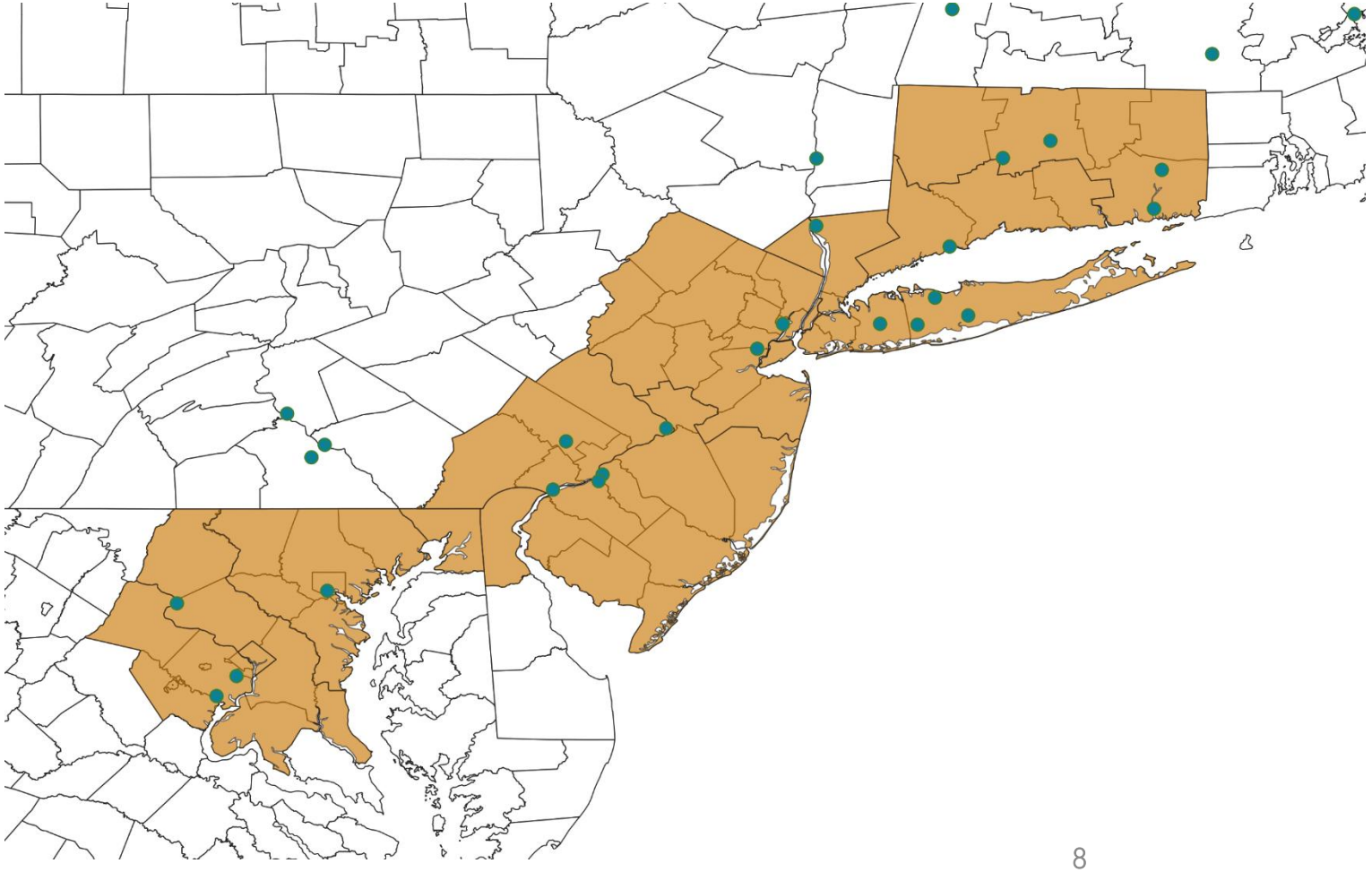
Designation Areas Containing 19 Non-Attainment Counties	Ground Ozone Design Value (8 hr 2015)	Decrease in Design Value Needed to Meet NAAQS
Los Angeles-South Coast Air Basin, CA	0.114	38.6%
Los Angeles-San Bernardino Counties (West Mojave Desert), CA	0.090	22.2%
San Joaquin Valley, CA	0.093	24.7%
New York-Northern New Jersey-Long Island, NY-NJ-CT	0.082	14.6%
Philadelphia-Wilmington-Atlantic City, PA-NJ-MD-DE	0.074	5.4%
Greater Connecticut, CT	0.073	4.1%
Baltimore, MD	0.072	2.8%
Washington, DC-MD-VA	0.071	1.4%

WtE Facilities Contribution to Ground Ozone Non-Attainment



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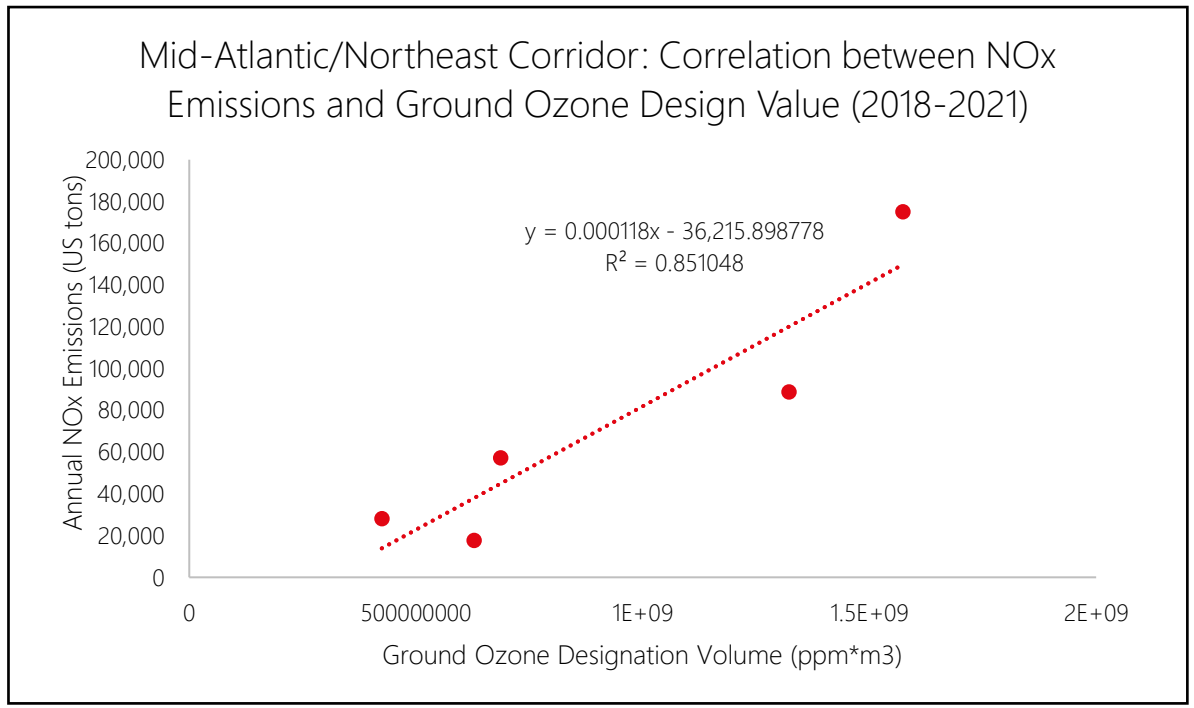
Mid-Atlantic/Northeast Corridor: Connecting Counties to Designation Areas to Use NEI and NAAQS Datasets



- In Mid-Atlantic/Northeast region, designation areas are bounded by county lines.
- Connect county-level emissions data (NOx, VOCs) from NEI to designation area pollutant "design values" in NAAQS reporting.

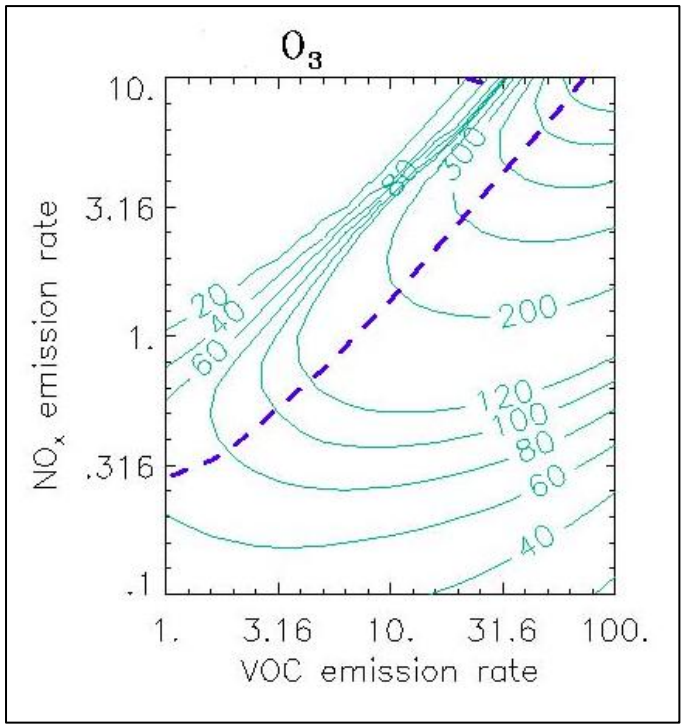
Mid-Atlantic/Northeast Corridor: Correlation Between Ozone-Designation Volume and NOx Emissions

A simplified, linear correlation…



Compare to Observation Based Modelling (UMich): Correlation coefficient 0.000163, R^2=0.87

…of a complex, nonlinear relationship



Ground Ozone Production Isopleths per NOx and VOC Emission Rates. Source: Dr. Sanford Sillman, University of Michigan.

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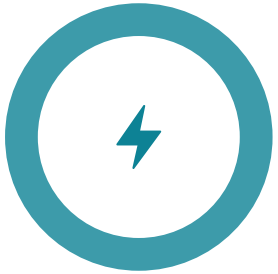
Mid-Atlantic/Northeast Corridor Correlation Predicts Non-Linear Relationship between Ozone and NOx Emissions

Designation Area Name	Ozone Level Decrease Needed to Reach Attainment	NOx Emissions Reduction Needed to Reach Attainment (via correlation)	WtE NOx Emissions Contribution to Designation Area
Greater Connecticut, CT	4.1%	-97.9%	12.9%
New York-Northern New Jersey-Long Island, NY-NJ-CT	14.6%	30.1%	2.9%
Philadelphia-Wilmington-Atlantic City, PA-NJ-MD-DE	5.4%	-25.5%	3.3%
Washington, DC-MD-VA	1.4%	23.7%	4.1%
Baltimore	2.8%	55.5%	3.1%

Preliminary Findings and Future Research



2/3 of the WtE industry in the US operates in areas which are deemed to be in attainment of all clean air standards.



1/3 of the WtE industry in the US operates in areas that are non-attainment for ground ozone pollution. Use of public datasets and a simplified correlation for the Mid-Atlantic/Northeast corridor show that ***even a 100% reduction of NOx from these facilities would not bring the areas they operate in into attainment***.



To evaluate emissions impact with greater precision, and to evaluate areas outside of the Mid-Atlantic/Northeast corridor, simulations with advanced software (CMAQ) or observation based modelling is likely necessary.

Feedback and Inquiries Welcome

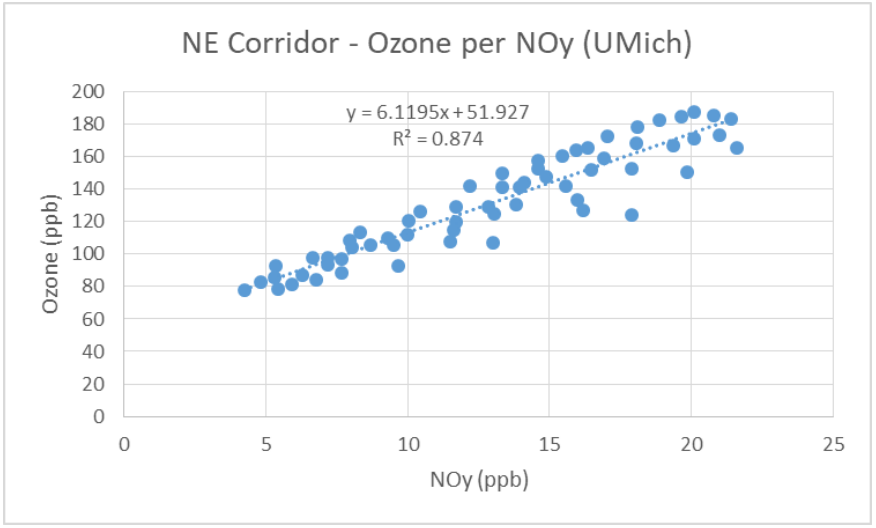
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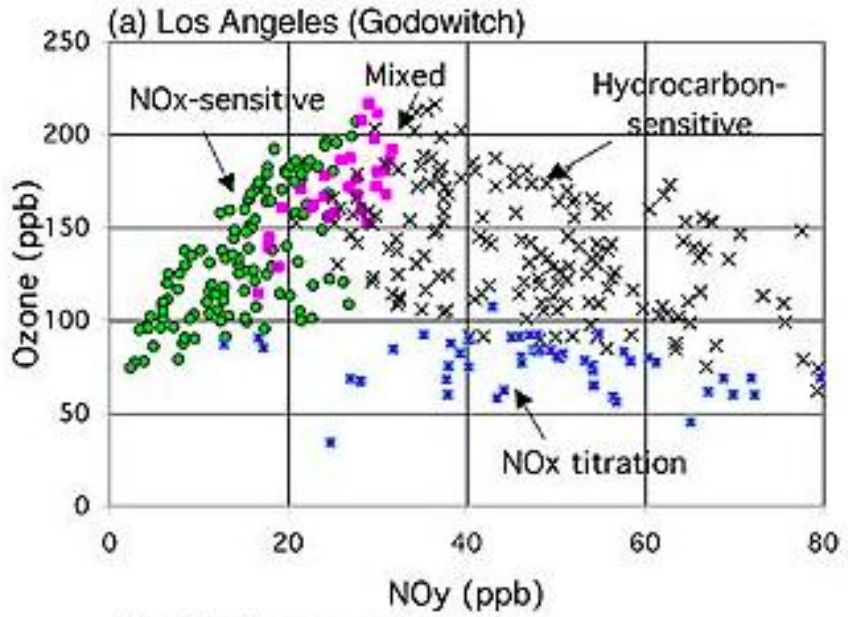


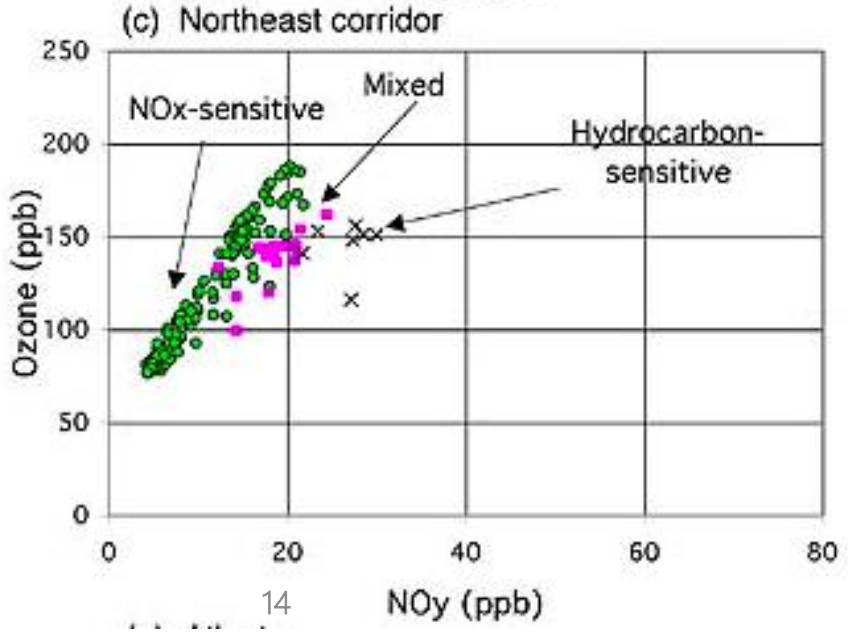
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Supplemental Information Slides

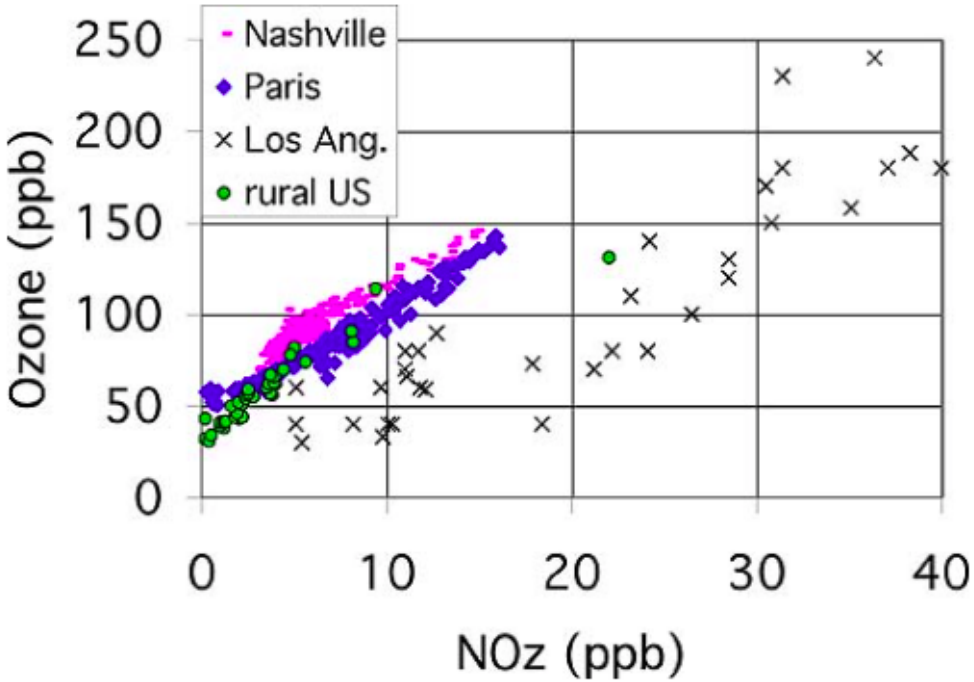
Observation Based Modelling





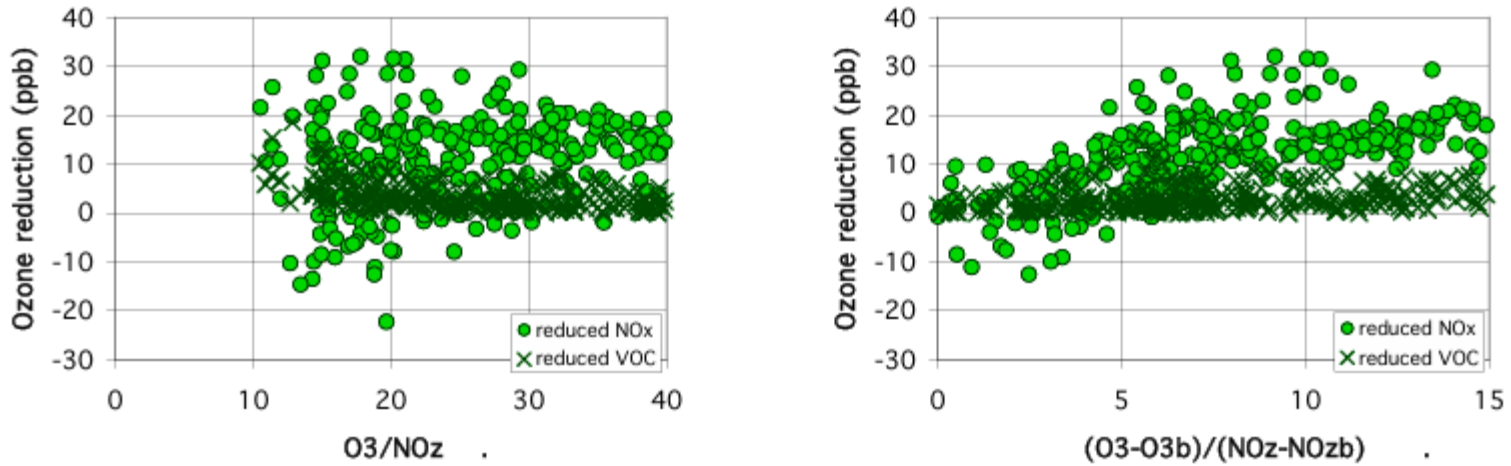


Source: Dr. Sanford Sillman, University of Michigan.



Source: Dr. Sanford Sillman, University of Michigan.

Figure 2.4. Measured correlations between O_3 and NO_z, both in ppb. Measurements are shown from field campaigns in Nashville (pink dashes), Paris (blue diamonds), Los Angeles (X's) and from four rural sites in the eastern U.S. (green circles). From measurements reported by Sillman et al., 1997, 1998, 2002 and Trainer et al., 1993.



Source: Dr. Sanford Sillman, University of Michigan.

Figure 3.1.5. Contrary evidence from Lu and Chang (1998): Predicted reductions in ozone in response to a 50% reduction in emissions of anthropogenic VOC (crosses), and predicted reductions in response to the same percent reduction in emissions of anthropogenic NO_x (green circles), plotted versus model values for indicator ratios. Results are shown for O_3/NO_z and $(O_3-O_{3b})/(NO_z-NO_{zb})$ from the model for San Joaquin reported by Lu and Chang (1998).

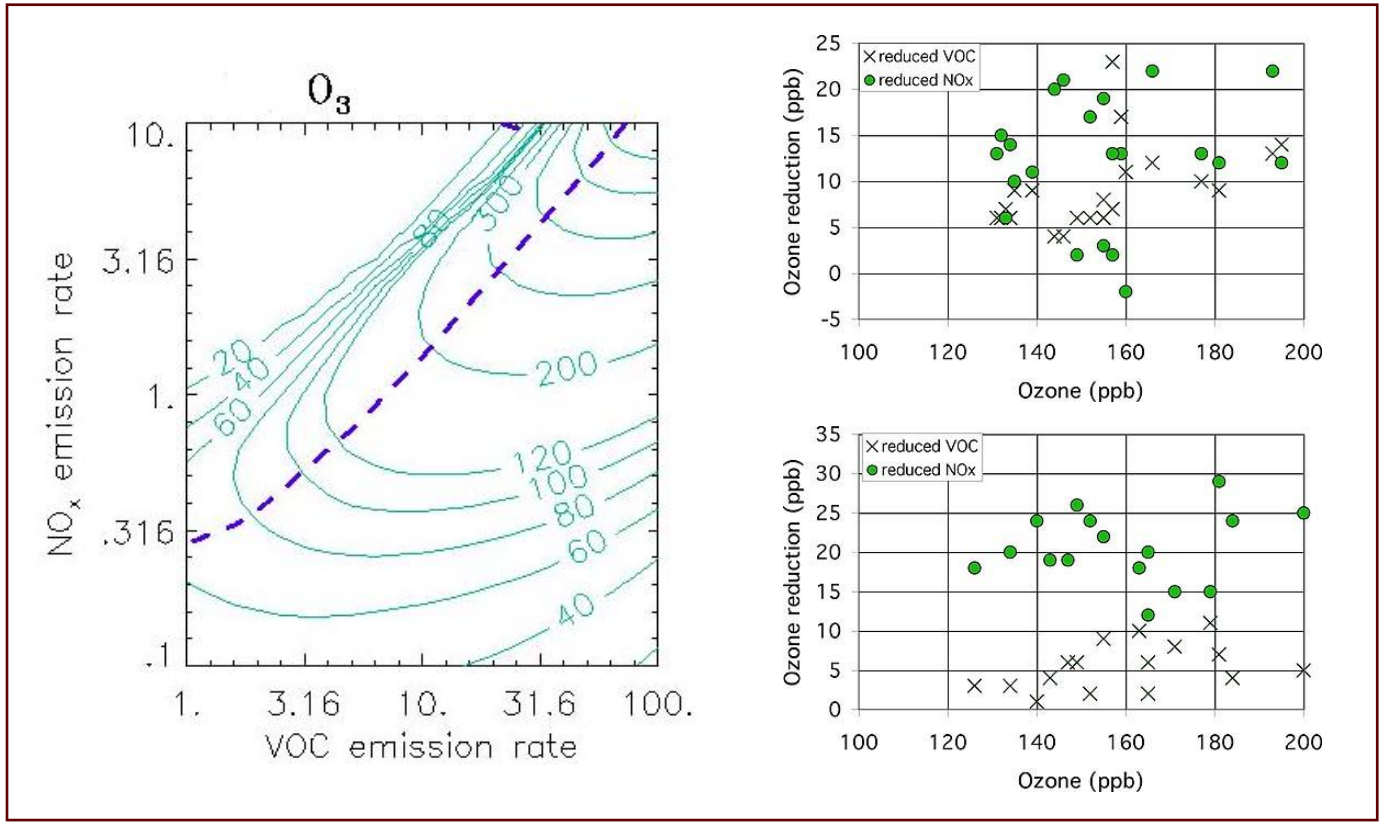
Top 25% WtE Contributors to County NOx Emissions in an Ozone Non-Attainment Area

Facility	State-County	Facility Contribution to County NOx
Onondaga Co Resource Recovery Facility	NY - Onondaga	9.5%
Wheelabrator Westchester LP	NY - Westchester	10.1%
Wheelabrator Bridgeport LP	CT - Fairfield	10.1%
Covanta Essex Company	NJ - Middlesex	10.3%
Covanta Haverhill Incorporated	MA - Essex	11.2%
Pasco County	FL - Pasco	11.4%
Wheelabrator Baltimore, LP	MD - Baltimore	12.2%
Pinellas Co. Board of County Commisioners	FL - Pinellas	12.4%
Mid Maine Waste Action Corp	ME - Androscoggin	14.0%
Covanta Delaware Valley LP/Delaware Valley Res	PA - Delaware	14.3%
Covanta Fairfax Inc	VA - Fairfax	17.0%
Xcel Energy - Key City/Wilmarth	MN - Blue Earth	19.5%
Covanta Niagara LP	NY - Niagara	19.8%
Wheelabrator Hudson Falls	NY - Washington	20.3%
SEMASS Partnership	MA - Plymouth	24.9%
Xcel Energy - Red Wing Generating Plant	MN - Goodhue	27.3%
Wheelabrator Portsmouth Inc, RDF Facility	VA - Portsmouth	28.0%
Covanta Alexandria/Arlington Inc	VA - Alexandria	30.8%

COUNTY LIES WITHIN OZONE NON-ATTAINMENT AREA

Uncertainty in Predicting Emissions Reduction Impact on Ground Ozone Levels

- Correlations – low resolution
- CMAQ
- Other modelling approaches?



Ground Ozone Production Isopleths per NOx and VOC Emission Rates, Ozone-NOx-VOC sensitivity uncertainty plots. Source for both: Dr. Sanford Sillman, University of Michigan.

Supplementary Information: Wind and "The Good Neighbor" Rule

