Analysis of Multi-Pollutant Emissions Inventories for Key Industrial Sectors

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Multi-Pollutant Inventories Are Needed to Support Development of Multi-Pollutant Sector Strategies

- EPA has initiated multi-pollutant analyses to explore the development of multi-pollutant sector-based approaches for managing emissions and air quality.
  - NAS report “Air Quality Management in the United States”, recommends: EPA take an integrated multi-pollutant approach to controlling emissions of pollutants posing the most significant risks

- A “Sector” is a logical grouping of processes, emissions sources, and pollutants in a manner that maximizes environmental benefit while reducing costs and regulatory burden

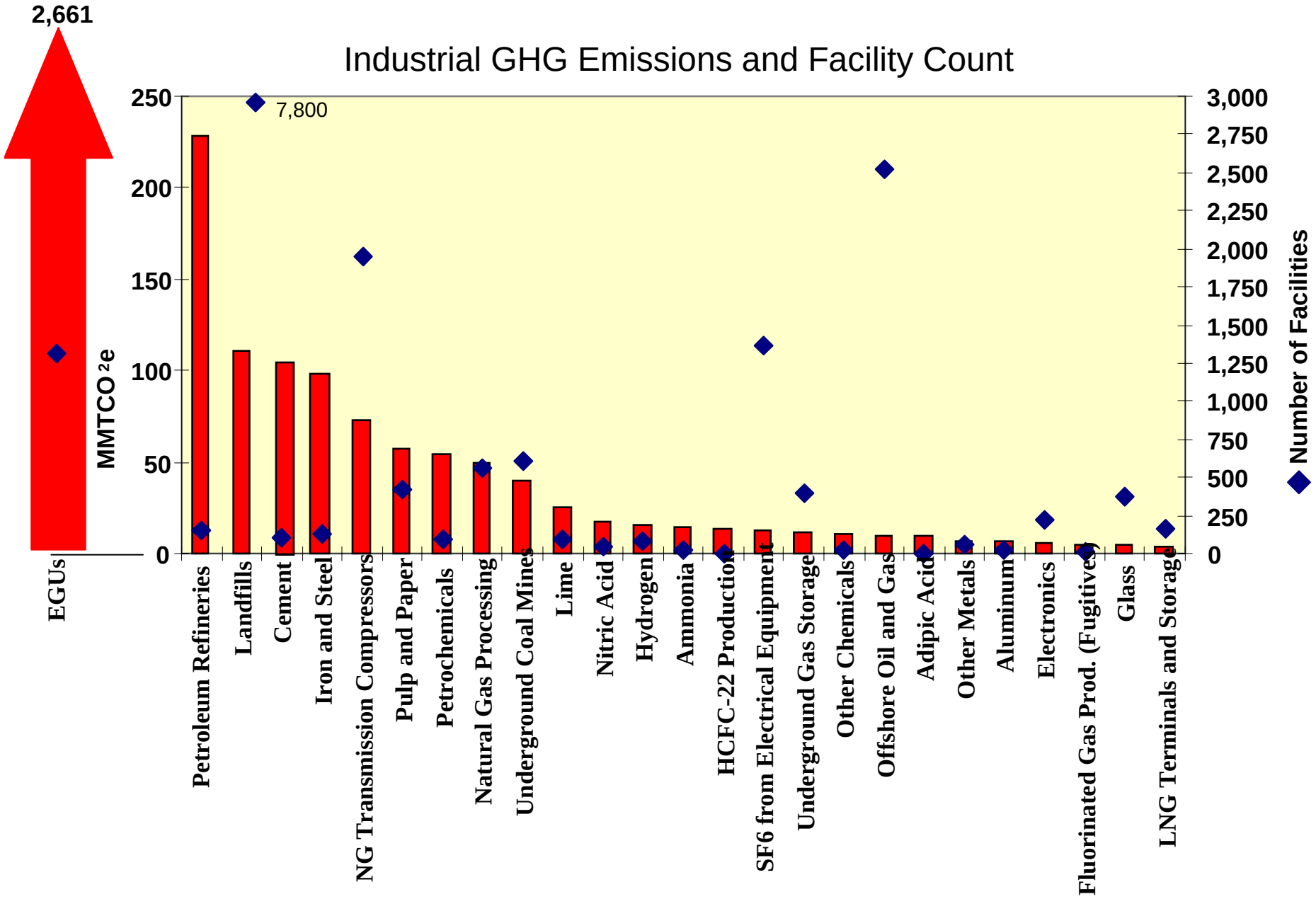
- The Approach:
  - Considers multi-pollutant interactions and emission reduction options
  - Relies on replicable and consistent emissions inventories and numerical metrics
  - Includes measurable environmental improvement

Benefits of Multi-Pollutant Sector Strategies

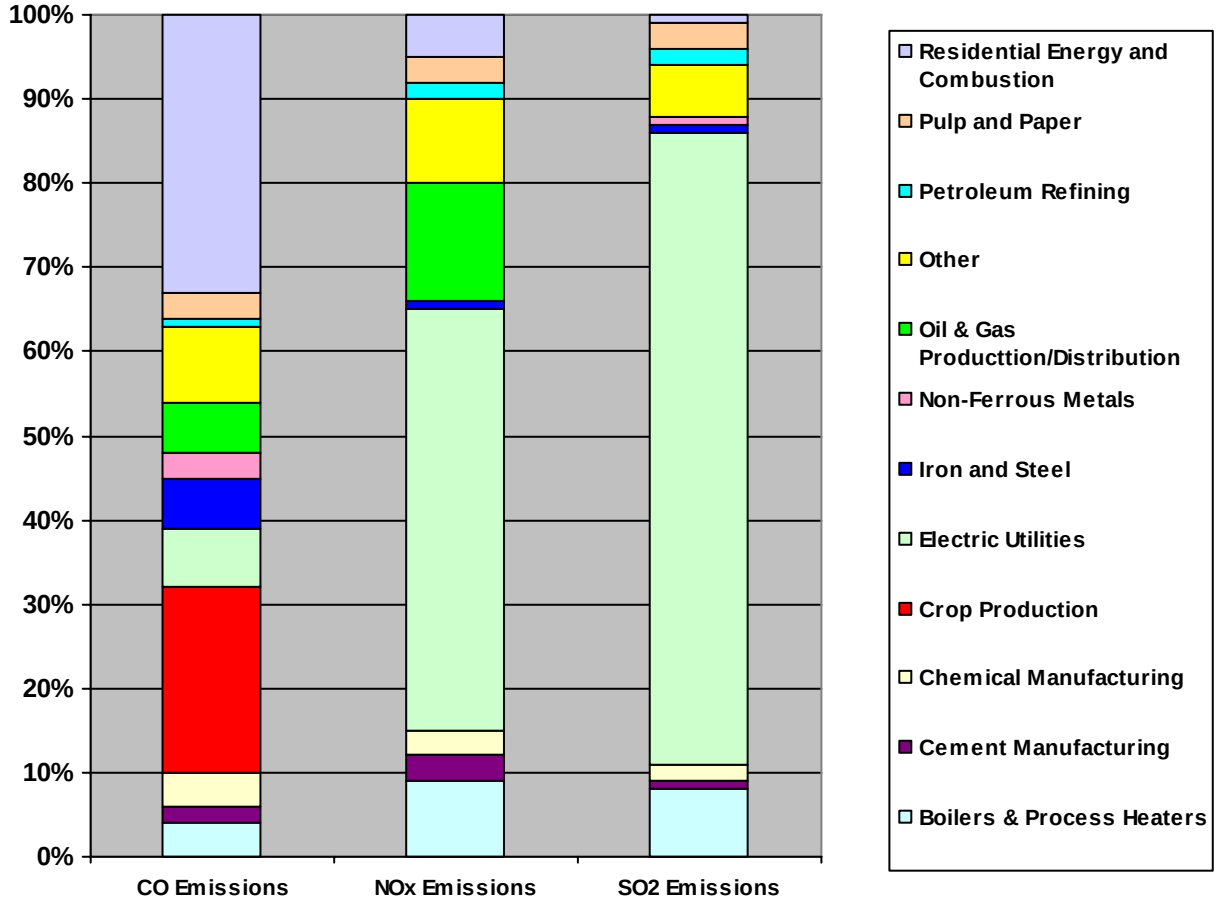
- Benefits to Public
  - Focus on reducing emissions of greatest public health interest
  - Optimization of tax $ spent
  - Ability to address local concerns better
- Benefits to Industry
  - Maximization of capital and operating environmental expenditures
  - Reduction in costs of control or over-control in the wrong areas
  - Avoidance of "stranded" costs associated with piecemeal investment in control equipment for individual pollutants
  - Increased flexibility
  - Consolidated monitoring, recordkeeping and reporting
- Benefits to Regulators
  - Development of better emissions data and compilation tools for characterizing individual sectors
  - Reduction in existing regulatory barriers to improve environmental performance
  - Consolidated requirements to reduce overall administrative burden

Emission Inventory Data Used in This Analysis

- CAPs:
  - Includes CO, NOx, PM10, PM2.5, SO2 and VOC
  - Data source - 2005 NEI v2
- HAPs
  - Includes 382 individual pollutants
  - Data source - 2005 NEI v2
- GHGs:
  - Includes CO2, CH4, and N20
  - Data sources:
    - Electric Utilities - CAMD Acid Rain Program & EGRID databases
    - Iron and Steel Mills, Lime Manufacturing, Petroleum Refineries, and Portland Cement - GHG Reporting Rule
    - Other categories - Inventory of U.S. Greenhouse Gas Emissions and Sinks

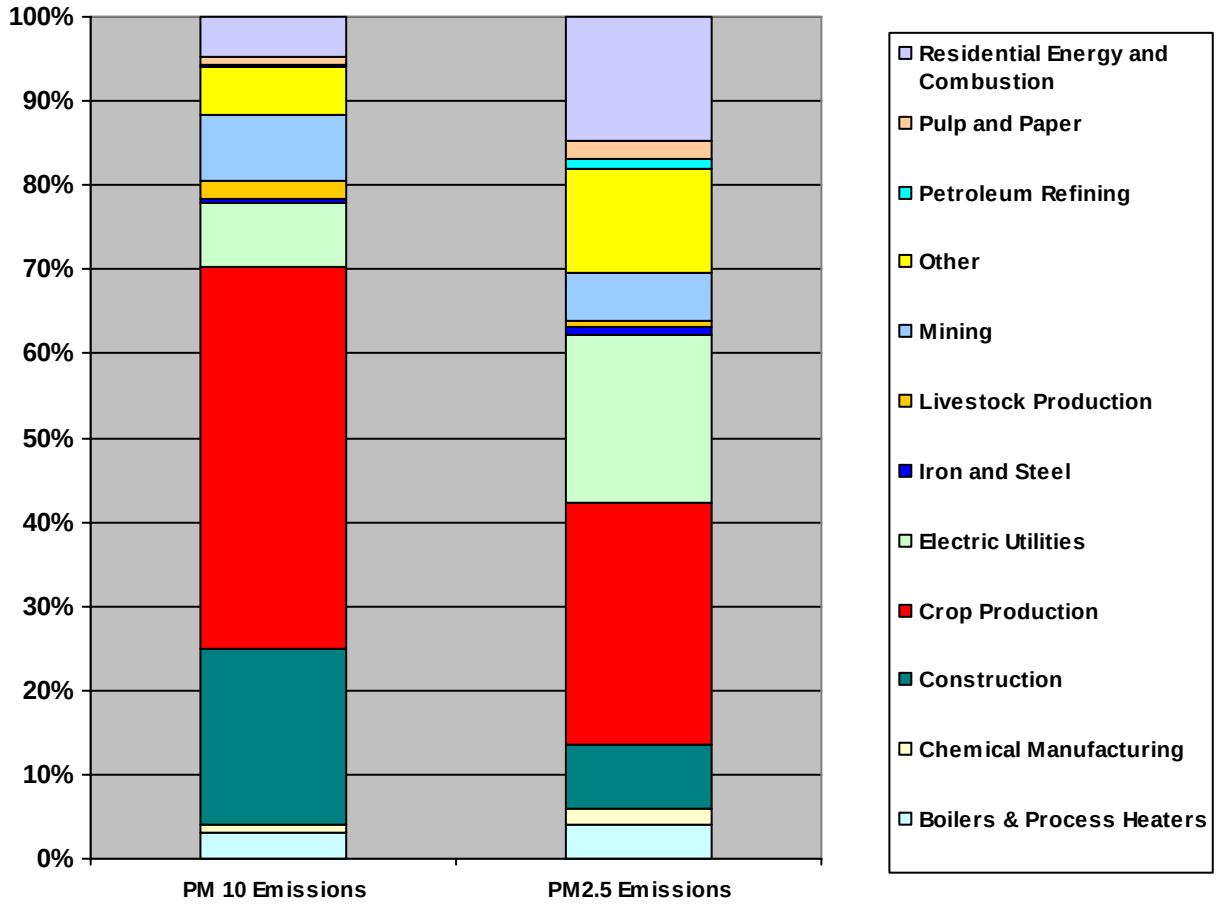

Industrial GHG Emissions and Facility Count
2,661
MMTCO2e
Number of Facilities
250
200
150
100
50
0
3,000
2,750
2,500
2,250
2,000
1,750
1,500
1,250
1,000
750
500
250
0
7,800
EGUs
Petroleum Refineries
Landfills
Cement
Iron and Steel
NG Transmission Compressors
Pulp and Paper
Petrochemicals
Natural Gas Processing
Underground Coal Mines
Lime
Nitric Acid
Hydrogen
Ammonia
HCFC-22 Production
SF6 from Electrical Equipment
Underground Gas Storage
Other Chemicals
Offshore Oil and Gas
Adipic Acid
Other Metals
Aluminum
Electronics
Fluorinated Gas Prod. (Fugitives)
Glass
LNG Terminals and Storage

Stationary Sources of CO, NOx, SO2*



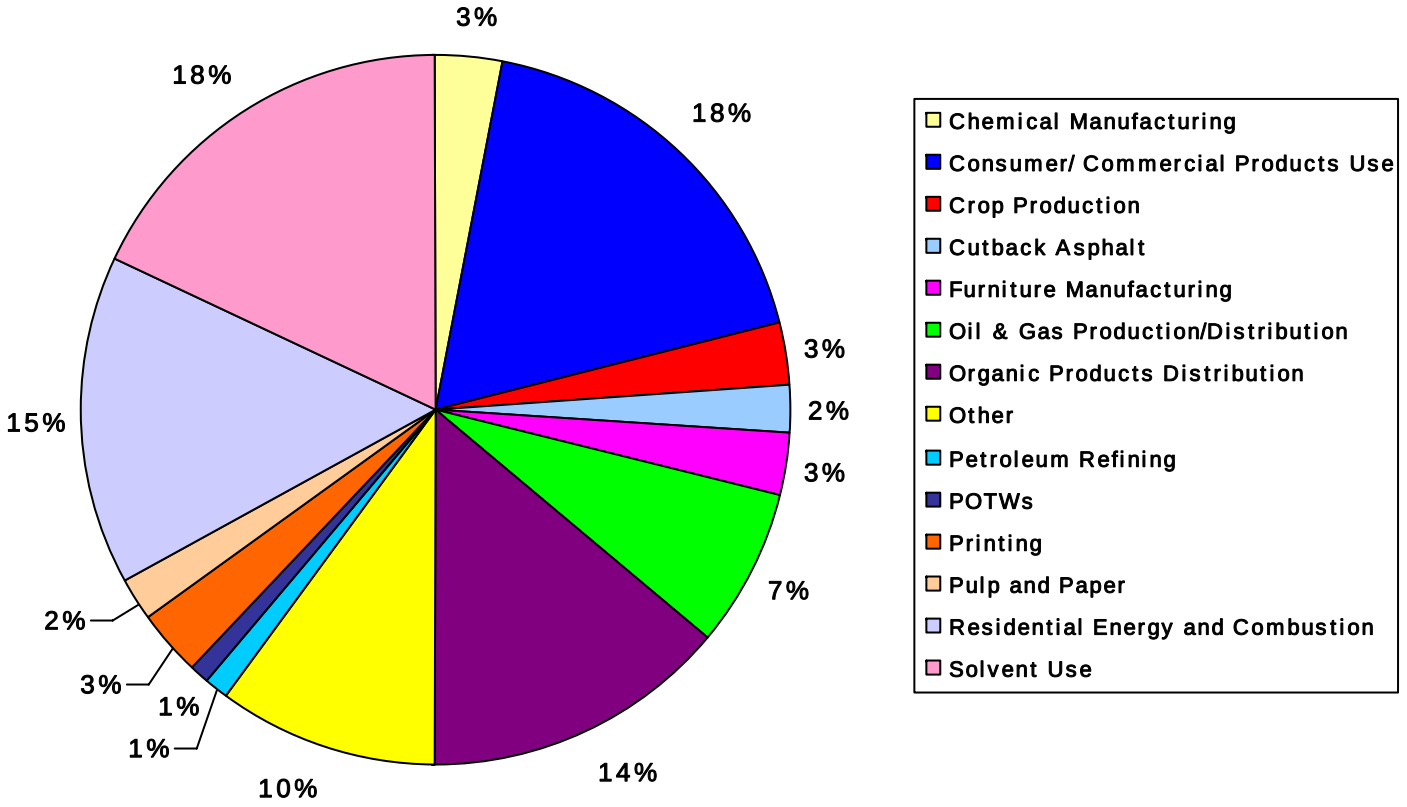
*excludes fires, open burning and road dust.

Stationary Sources of PM*



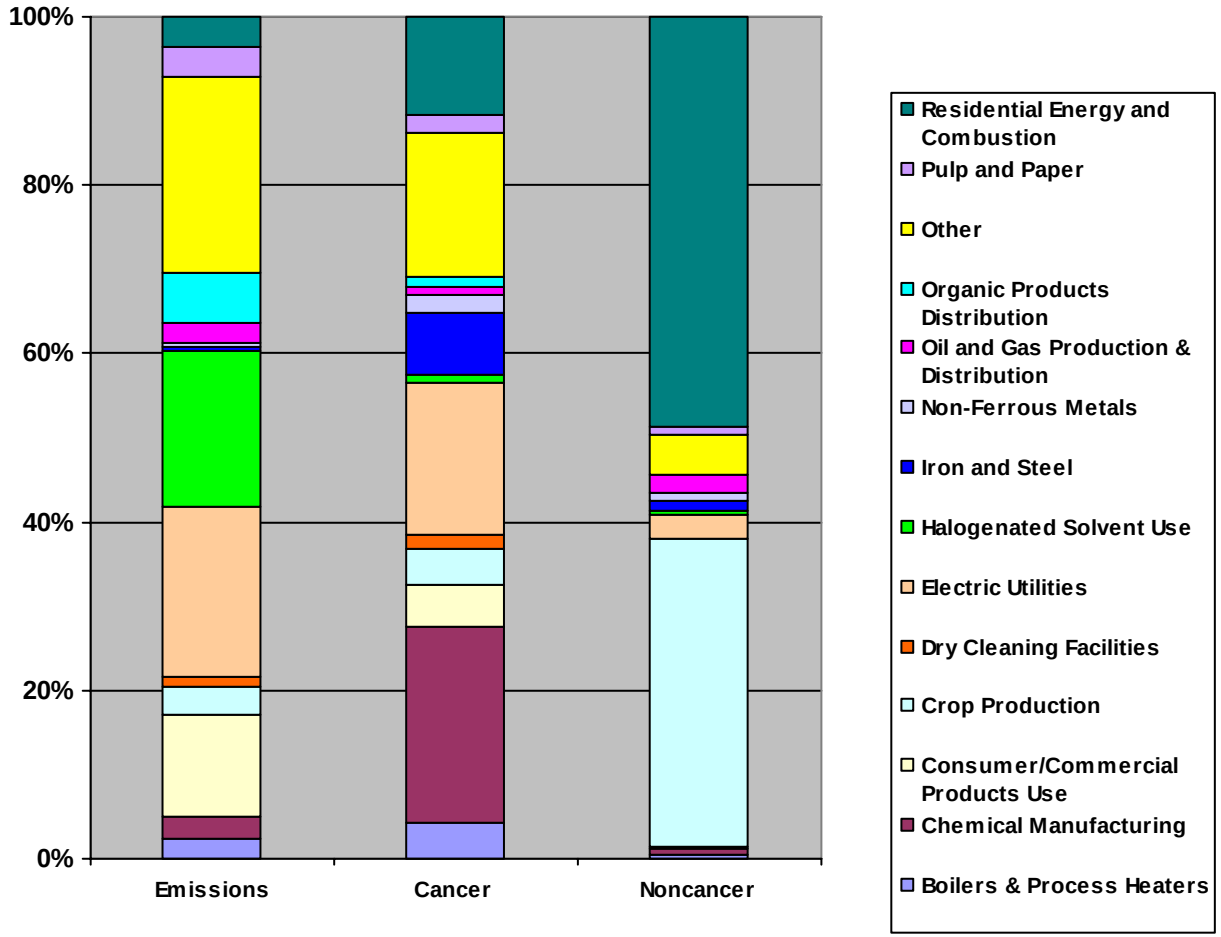
*excludes fires, open burning and road dust.

Stationary Sources of VOC*



*excludes fires, open burning and road dust.

Stationary Sources of HAPs*



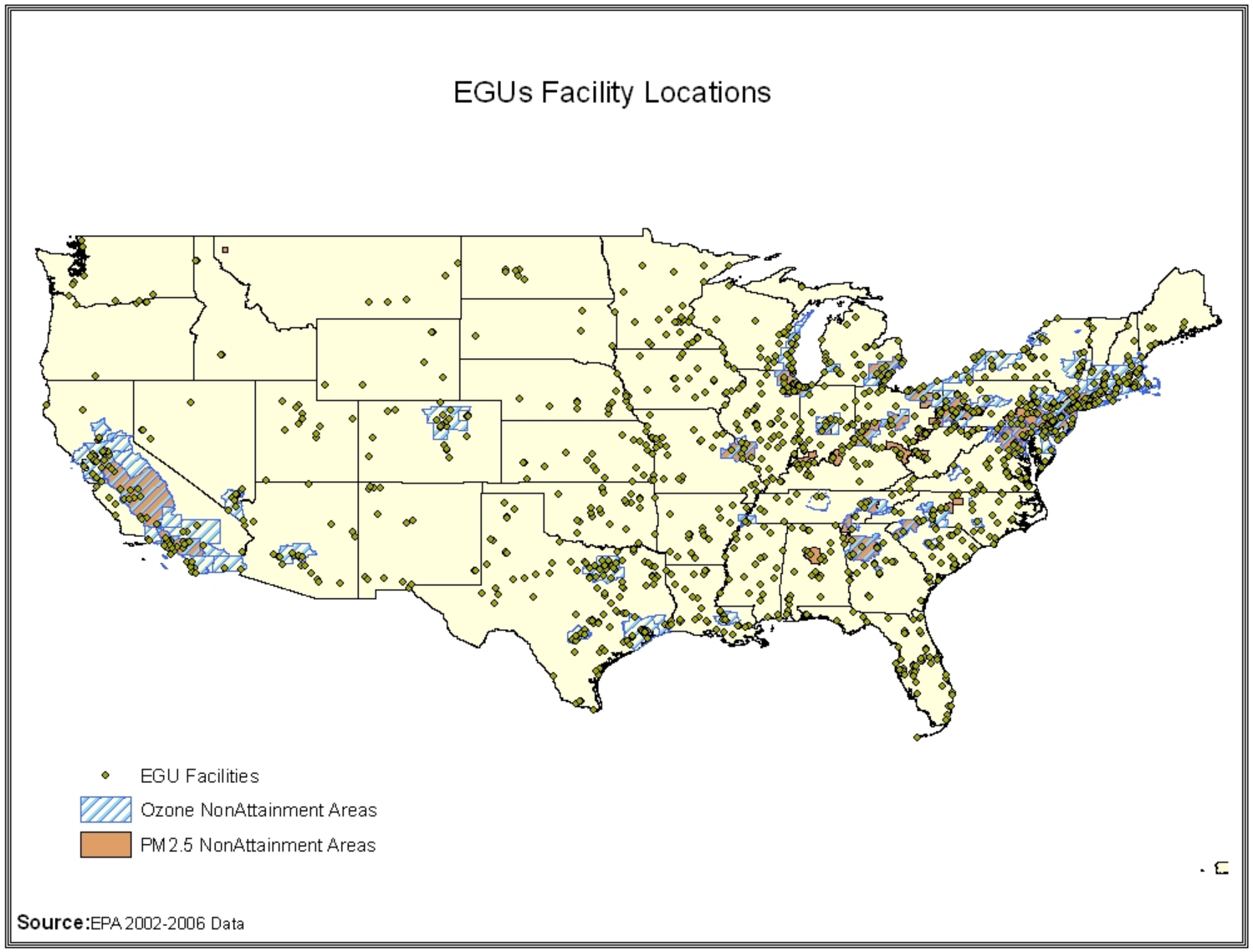
*excludes fires, open burning and road dust

Ranking of Sectors across Pollutant Emissions

Source Category	Rank GHG	Rank CO	Rank NOx	Rank PM10	Rank PM25	Rank SO2	Rank VOC	Rank 188 HAP	Rank Cancer Tox Wt	Rank Non Cancer Tox Wt
Electric Utilities	1	3	1	4	2	1	26	1	1	2
Petroleum Refining	2	12	9	15	11	4	15	30	27	30
Solid Waste Landfills	3	20	20	23	27	35	24	15	19	25
Cement Manufacturing	4	10	7	13	17	8	49	44	33	31
Iron and Steel	5	4	11	14	12	9	38	37	3	4
Oil & Gas Production & Distribution	6	5	3	25	19	12	5	14	20	12
Pulp and Paper	7	7	6	9	8	3	12	5	12	7
Chemical Manufacturing	8	9	8	10	9	6	9	8	8	10
Mining	9	26	15	3	5	26	53	58	42	33
Mineral Processing	10	16	10	11	14	13	51	50	21	27

Correlation Matrix of HAPs & CAPs with GHGs

INDUSTRY	CO	NOx	PM_{10}	$PM_{2.5}$	SO_2	VOC	188 HAPs	CO_2 Equivalent
Electric Utilities	0.23756	0.86216	0.72212	0.69542	0.72468	0.05621	0.68956	1
Petroleum refining	0.26306	0.70512	0.60240	0.64697	0.28890	0.58144	0.55532	1
Portland Cement	0.09715	0.59179	0.28805	0.33109	0.38260	0.18841	0.38206	1
Iron and Steel	0.72917	0.56366	0.64417	0.69255	0.615043	0.63146	0.22380	1
Lime Manufacturing	0.07782	0.28233	-0.02984	-0.05832	0.00668	-0.17158	-0.02134	1

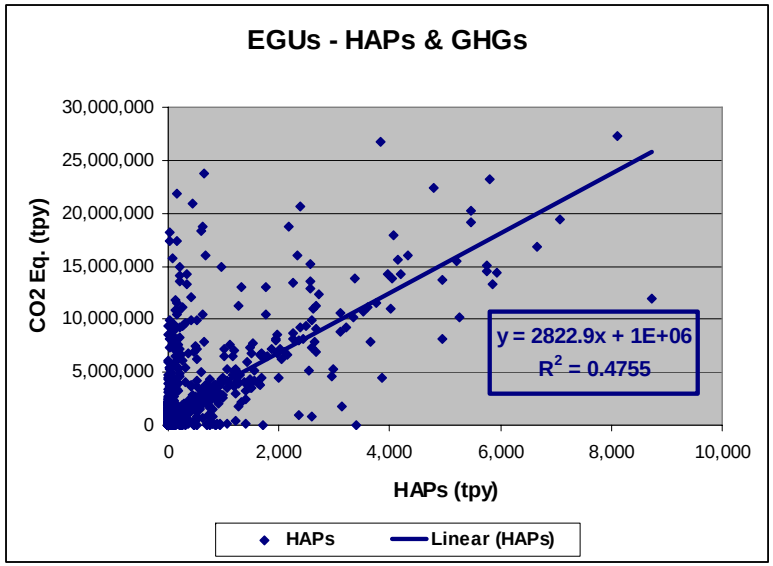

EGUs Facility Locations
EGU Facilities
Ozone NonAttainment Areas
PM2.5 NonAttainment Areas
Source:EPA 2002-2006 Data

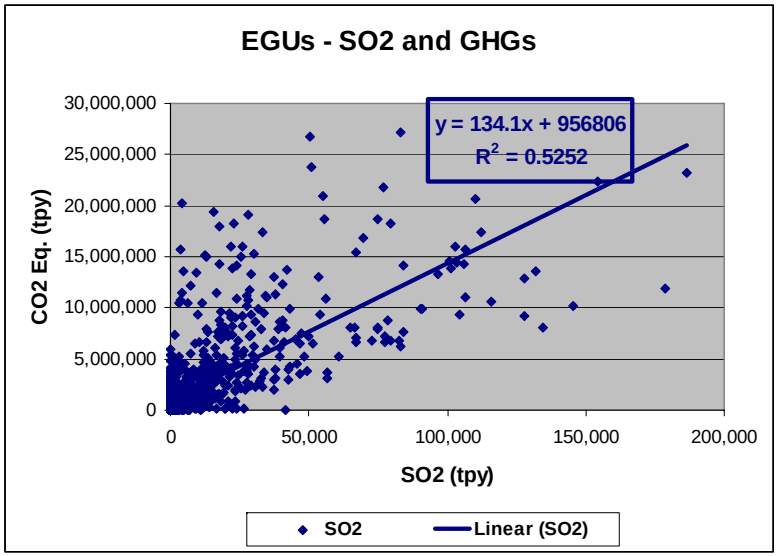
Electric Utility Summary

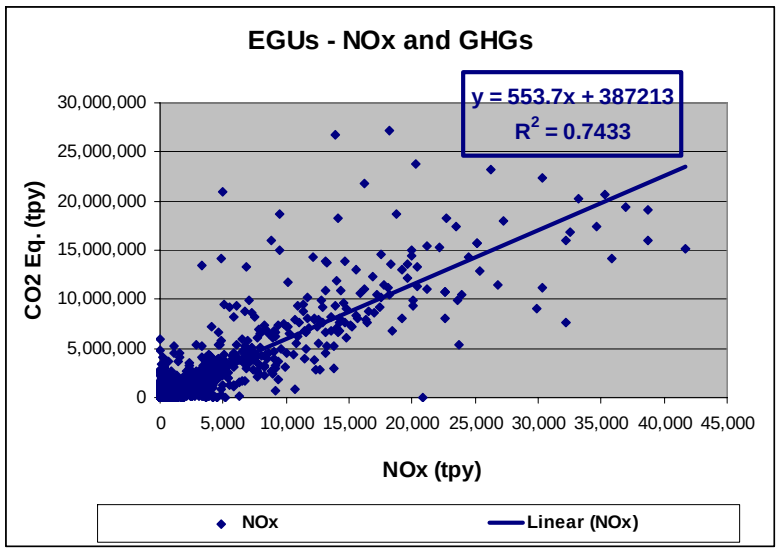
Parameter	Total	GHG	CAPs	HAPs
# Unique Facilities	1440	1380	1328	1194
# U.S. Counties	799	781	769	735
# Tribes	1	1	1	1
# U.S. States	49	49	49	48
# Facilities in Ozone Nonattainment areas (8 hr standard)	524	495	478	405
# Facilities in CO Nonattainment areas	10	10	9	5
# Facilities in $PM_{2.5}$ Nonattainment areas	365	340	332	302
2007 Acid Rain SO_2 Nonattainment areas	11	11	11	9
# HAPs (individual) reported	238			
HAPs with highest Cancer risk	As, Be, Cd, Cr VI, Ni			
HAPs with highest Non-Cancer effect	acrolein, As, HCl, HF, Mn, Ni			
HAPs with highest emissions	acetaldehyde, hexane, HCl, HF, methanol			

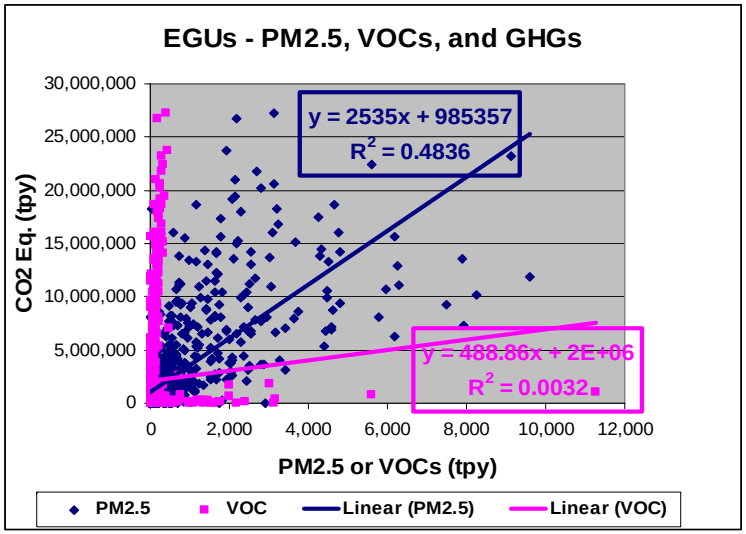
Pollutant	**Total Emissions (tpy)**	**Nonattainment Area Emissions (tpy)**			
		Ozone	**CO**	**SO_2**	**$PM_{2.5}$**
GHG	2661336595	659127331	11896333	17755617	839535123
CO	924223	309179	2107	2839	288389
NH_3	27831	8167	283	166	5390
NO_x	3887315	820199	37096	19719	1226526
PM_{10}	687284	188115	4262	12711	289407
$PM_{2.5}$	556963	157008	3825	11442	242568
SO_2	10722071	2916877	43731	212311	5020729
VOC	127155	35380	277	108	33297
188 HAP	435666	95265	4695	10528	151228

Electric Utility: Correlation of GHG Emissions to CAP and HAP Emissions

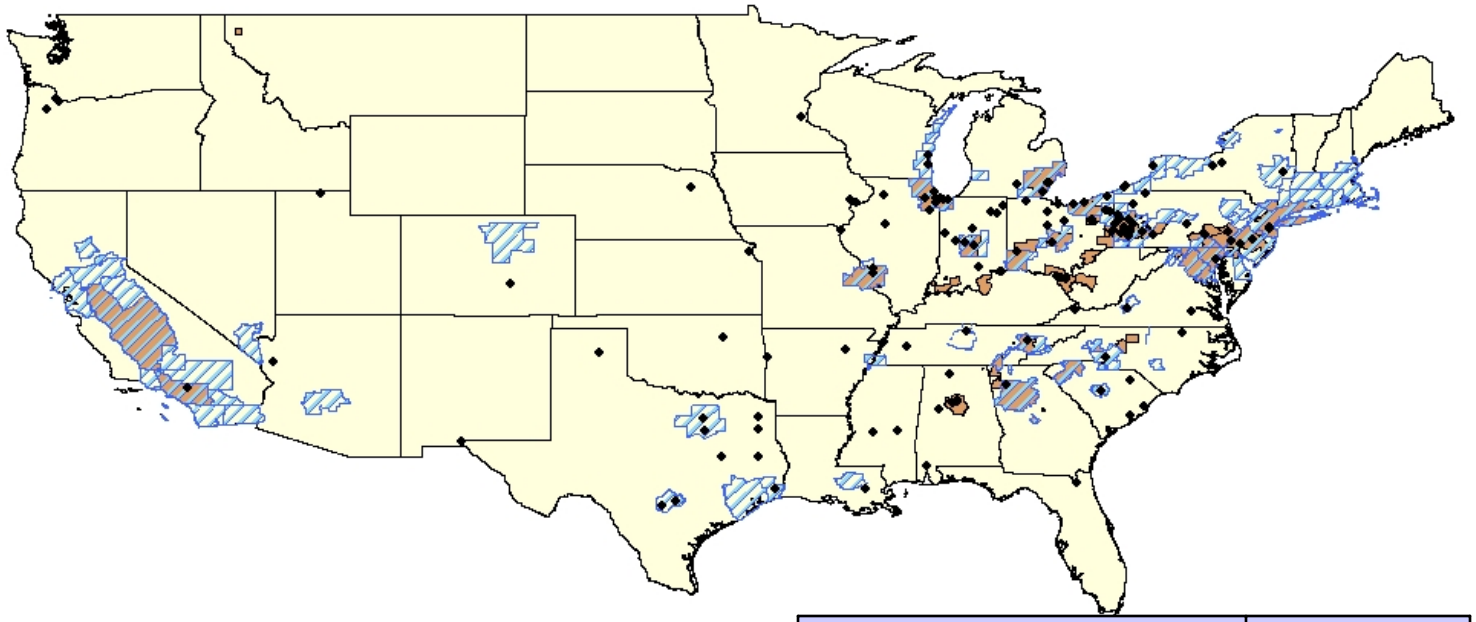








Iron & Steel Facility Locations



Source: EPA 2002-2006 Data

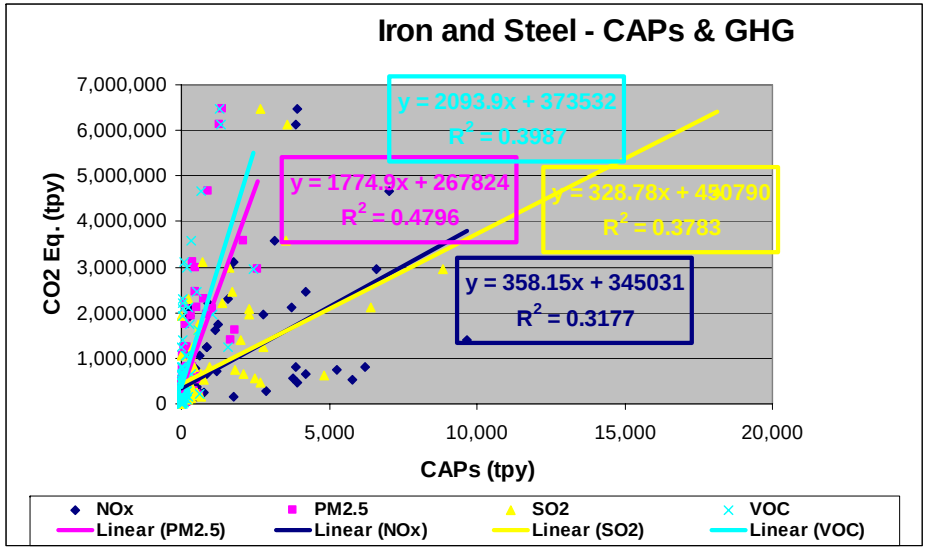
Type of Operations	Number of Facilities
Coke Oven	12
Coke Ovens & Integrated Iron and Steel	6
Integrated Iron and Steel	11
Integrated Iron and Steel &EAF	2
EAF	94
EAF and DRI	2
Taconite	8

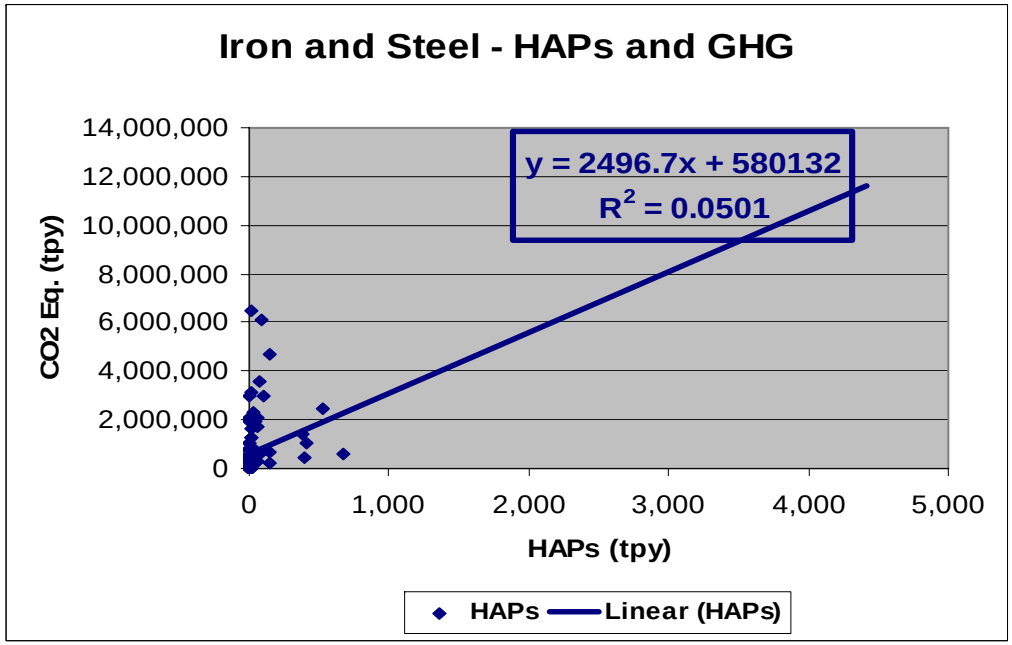
Iron and Steel Summary

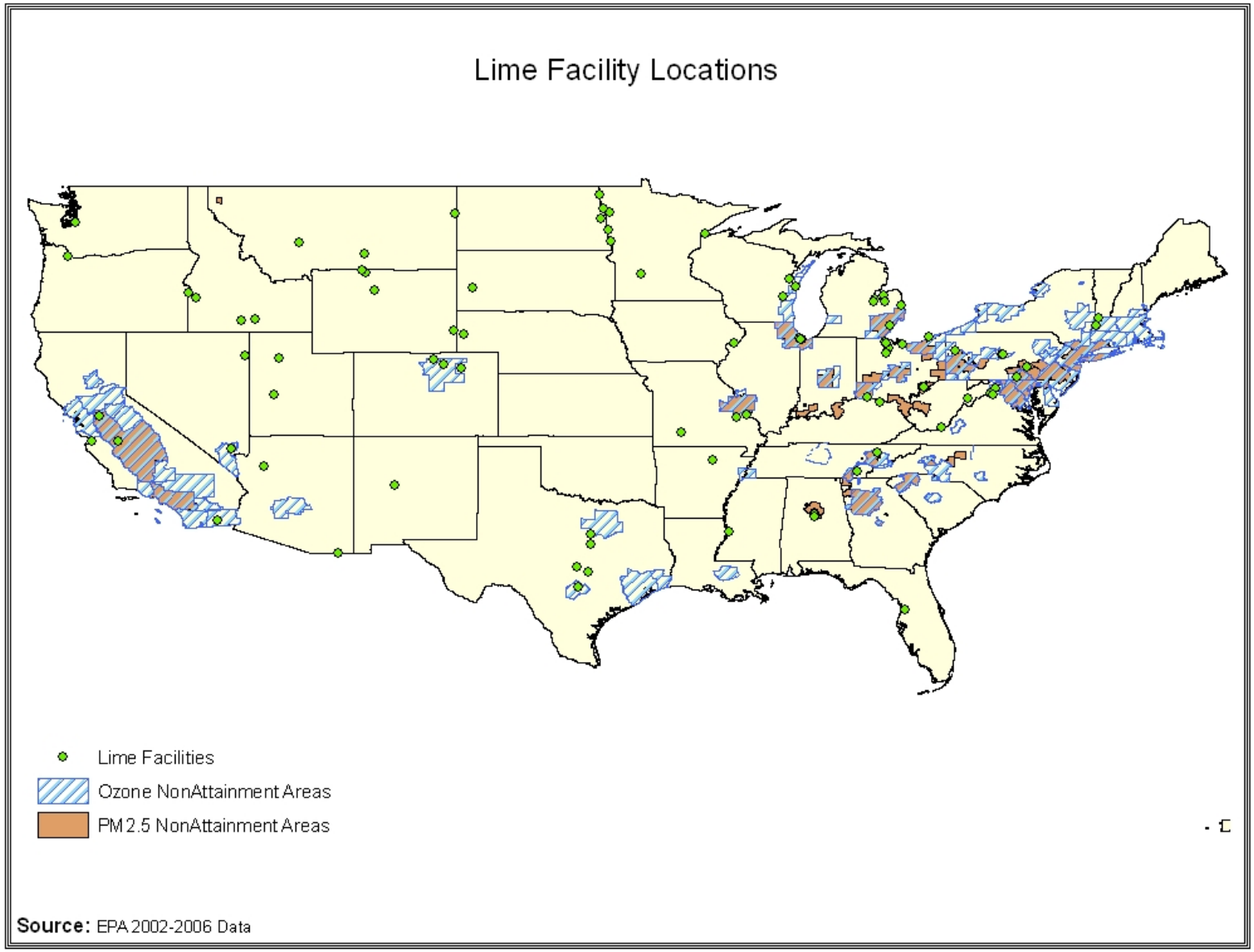
Parameter	Total	GHG	CAPs	HAPs
# Unique Facilities	135	128	119	135
# U.S. Counties	99	97	89	99
# Tribes	0	0	0	0
# U.S. States	32	32	30	32
# Facilities in Ozone Nonattainment areas (8 hr standard)	46	43	43	46
# Facilities in CO Nonattainment areas	0	0	0	0
# Facilities in $PM_{2.5}$ Nonattainment areas	61	56	53	61
2007 Acid Rain SO_2 Nonattainment areas	0	0	0	0
# HAPs individual reported	185			
HAPs with highest Cancer risk	As, Cr VI, coke oven emissions, Ni, POM			
HAPs with highest Non-Cancer risk	acrolein, As, Cl2, Mn, Ni			
HAPs with highest emissions	benzene, coke oven emissions, Cl2, HCl, Mn			

Pollutant	Total Emissions (tpy)	Nonattainment Area Emissions (tpy)			
		Ozone	CO	SO_2	$PM_{2.5}$
GHG	93862647	54075187			65228851
CO	554502	414523			449113
NO_x	111566	49787			52190
PM_{10}	42039	20771			25267
$PM_{2.5}$	27607	14764			18697
SO_2	85551	56220			58348
VOC	17548	9275			11213
188 HAP	4410	1400			2100

Iron and Steel: Correlation of GHG Emissions to CAP and HAP Emissions





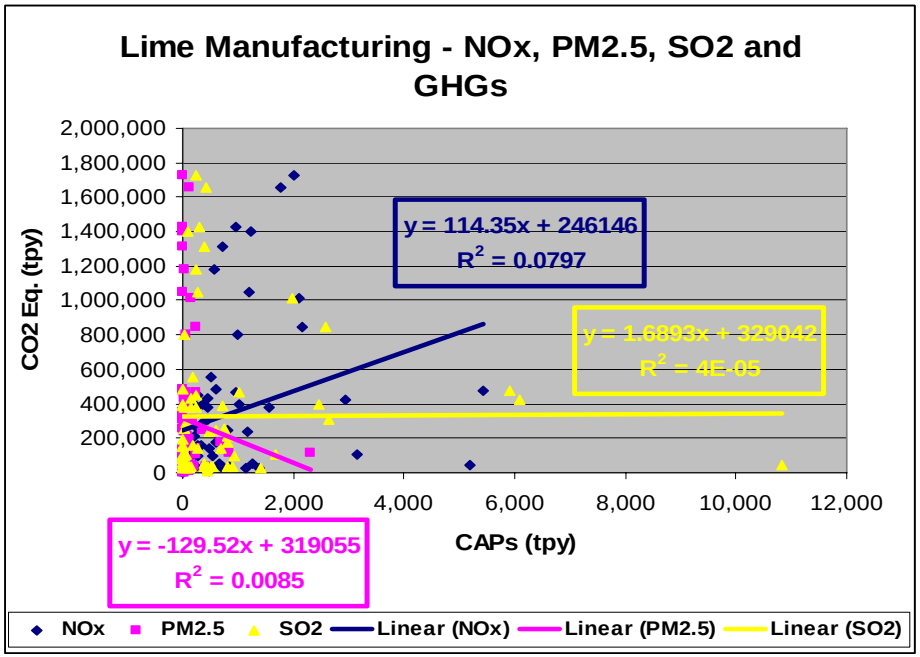

Lime Facility Locations
Lime Facilities
Ozone NonAttainment Areas
PM 2.5 NonAttainment Areas
Source: EPA 2002-2006 Data

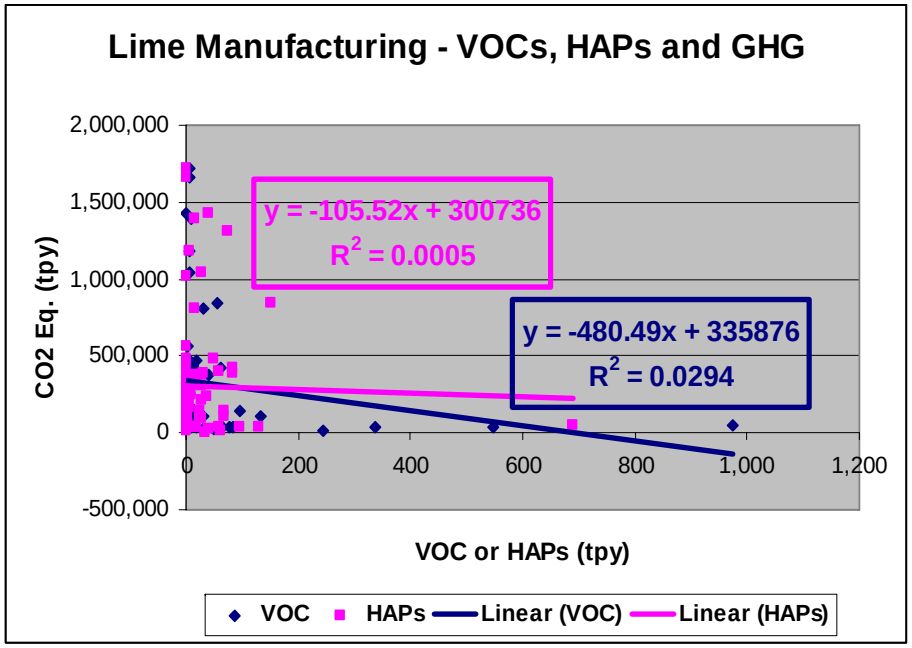
Lime Summary

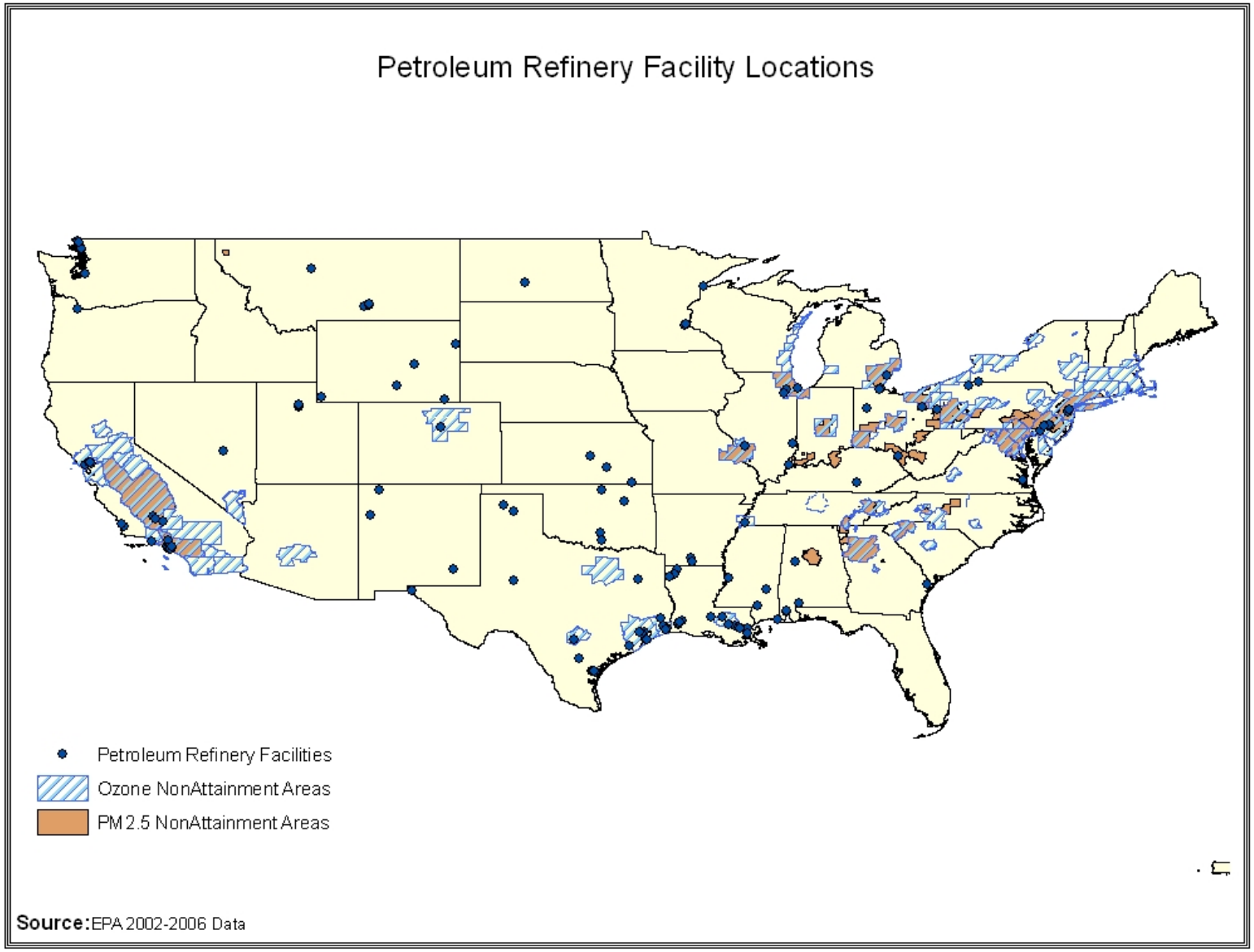
Parameter	Total	GHG	CAPs	HAPs
# Unique Facilities	94	89	78	84
# U.S. Counties	81	77	69	73
# Tribes	0	0	0	0
# U.S. States	34	32	32	32
# Facilities in Ozone Nonattainment areas (8 hr standard)	15	14	15	12
# Facilities in CO Nonattainment areas	1	1	1	1
# Facilities in $PM_{2.5}$ Nonattainment areas	18	16	15	16
2007 Acid Rain SO_2 Nonattainment areas	2	2	2	2
# HAPs individual reported	138			
HAPs with highest Cancer risk	acetaldehyde, As, Cd, Cr VI, Ni			
HAPs with highest Non-Cancer risk	acrolein, As, HCl, Mn, Ni			
HAPs with highest emissions	acetaldehyde, HCl, HF, methanol			

Pollutant	Total Emissions (tpy)	Nonattainment Area Emissions (tpy)			
		Ozone	CO	SO_2	$PM_{2.5}$
GHG	28020714	5179753	417775	116845	8475660
CO	38638	2693	814	227	3041
NO_x	53151	5974	1566	75	10270
PM_{10}	15165	751	233	108	912
$PM_{2.5}$	9013	396	180	64	381
SO_2	51526	2727	228	132	6689
VOC	3125	91	39	7	259
188 HAP	2204	276	13	39	483

Lime: Correlation of GHG Emissions to CAP and HAP Emissions






Petroleum Refinery Facility Locations
Petroleum Refinery Facilities
Ozone NonAttainment Areas
PM 2.5 NonAttainment Areas
Source: EPA 2002-2006 Data

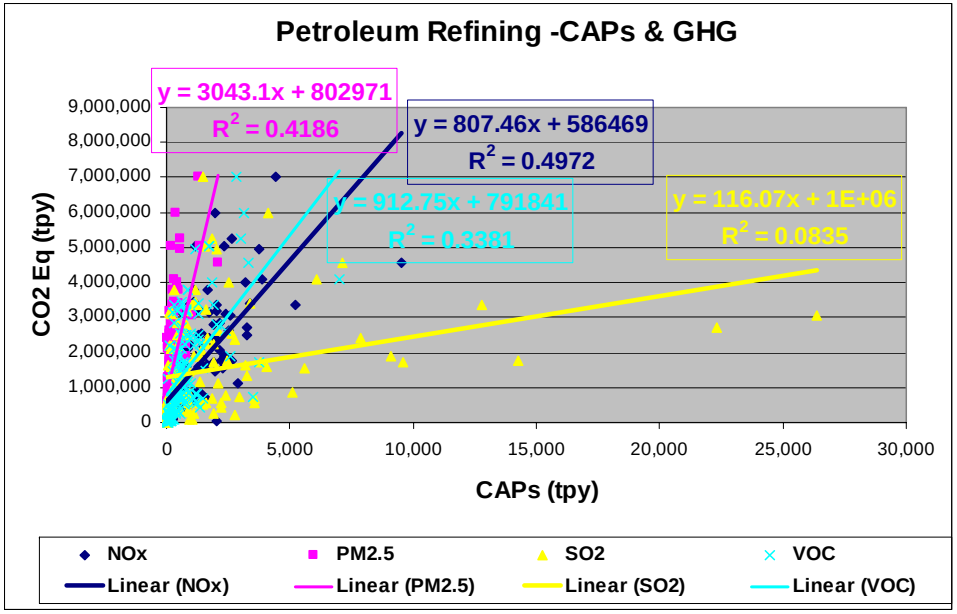
Petroleum Refinery Summary

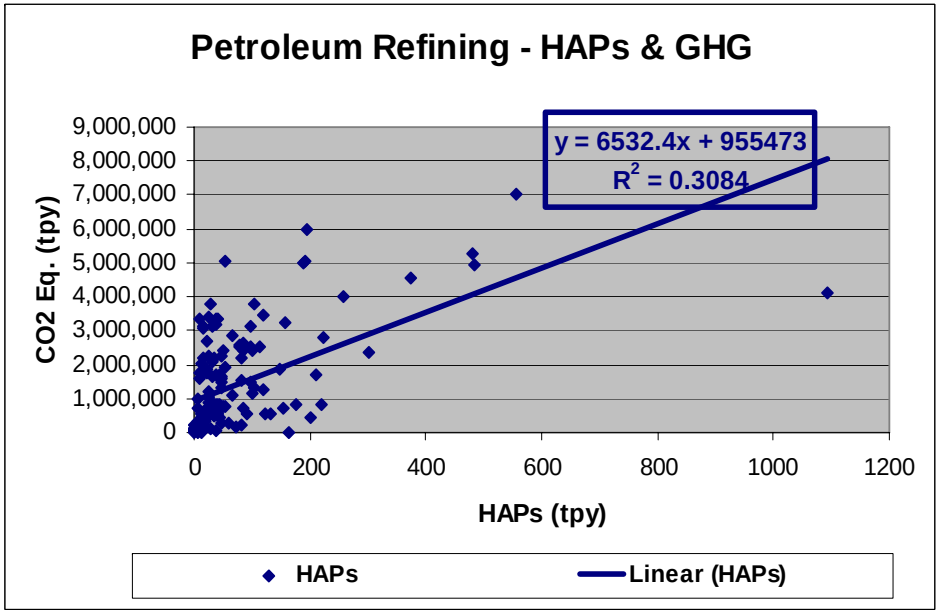
Parameter	Total	GHG	CAPs	HAPs
# Unique Facilities*	152	151	137	151
# U.S. Counties*	99	99	87	98
# Tribes		0	0	0
# U.S. States*	35	35	30	34
# Facilities in Ozone Nonattainment areas (8 hr standard)	53	53	51	53
# Facilities in CO Nonattainment areas	0	0	0	0
# Facilities in $PM_{2.5}$ Nonattainment areas	31	31	31	31
2007 Acid Rain SO_2 Nonattainment areas	5	5	5	5
# HAPs individual reported	149			
HAPs with highest Cancer risk	benzene, POM 1,3-butadiene, Cr VI, naphthalene,			
HAPs with highest Non-Cancer risk	acrolein, 1,3-butadiene, Cl2, Mn, Ni			
HAPs with highest emissions	benzene, hexane, methanol, toluene, xylenes			

Pollutant	Total Emissions (tpy)	Nonattainment Area Emissions (tpy)			
		Ozone	CO	SO_2	$PM_{2.5}$
GHG	233117905	122535731		3624657	55265072
CO	134050	62082		1856	27509
NO_x	149426	67750		1230	38277
PM_{10}	34842	15098		681	6766
$PM_{2.5}$	30566	13886		483	6108
SO_2	242175	121961		9069	96141
VOC	101823	37158		3472	15133
188 HAP	10423	4000		256	1162

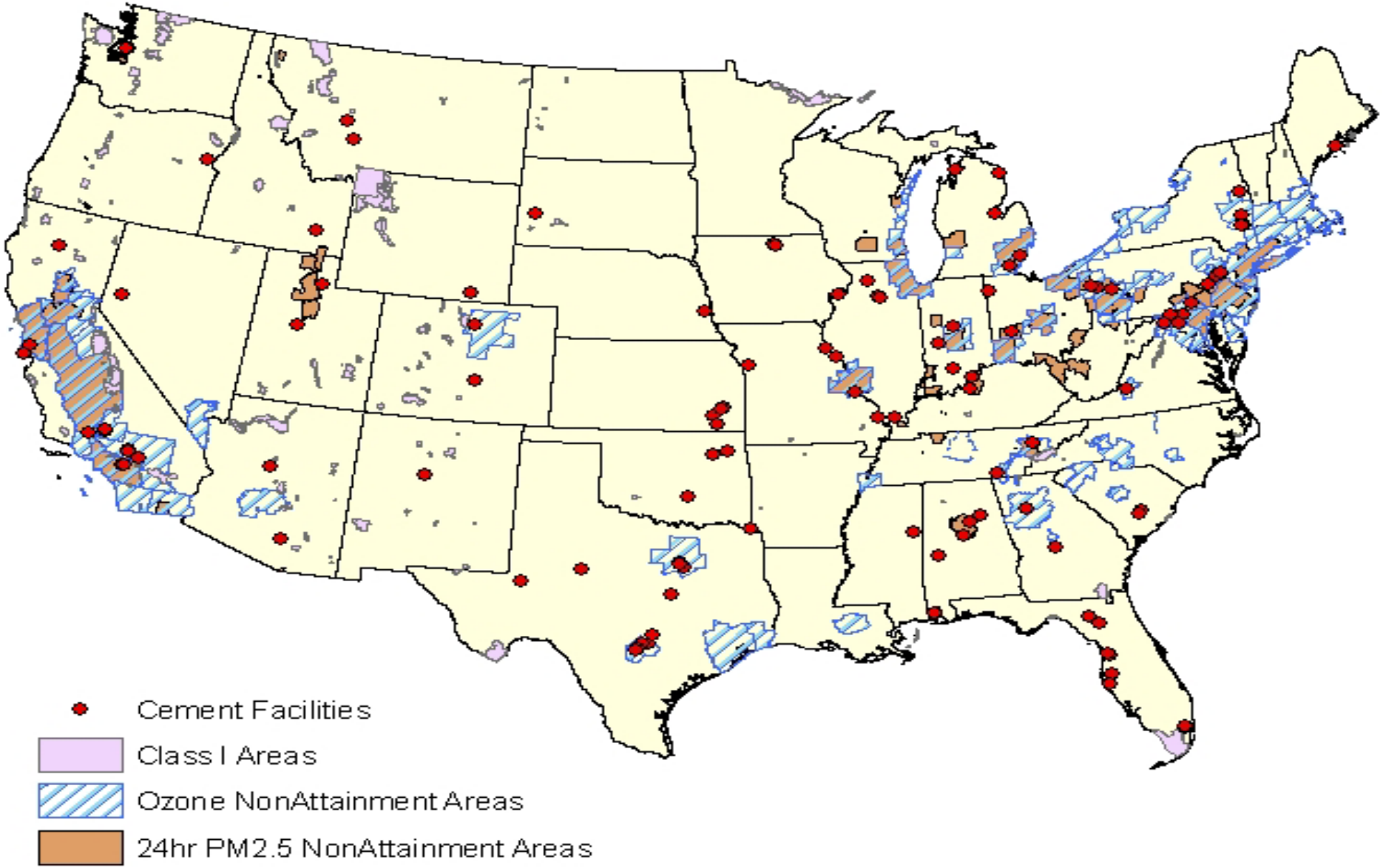
*includes territories

Petroleum Refinery: Correlation of GHG Emissions to CAP and HAP Emissions





Cement Facility Locations



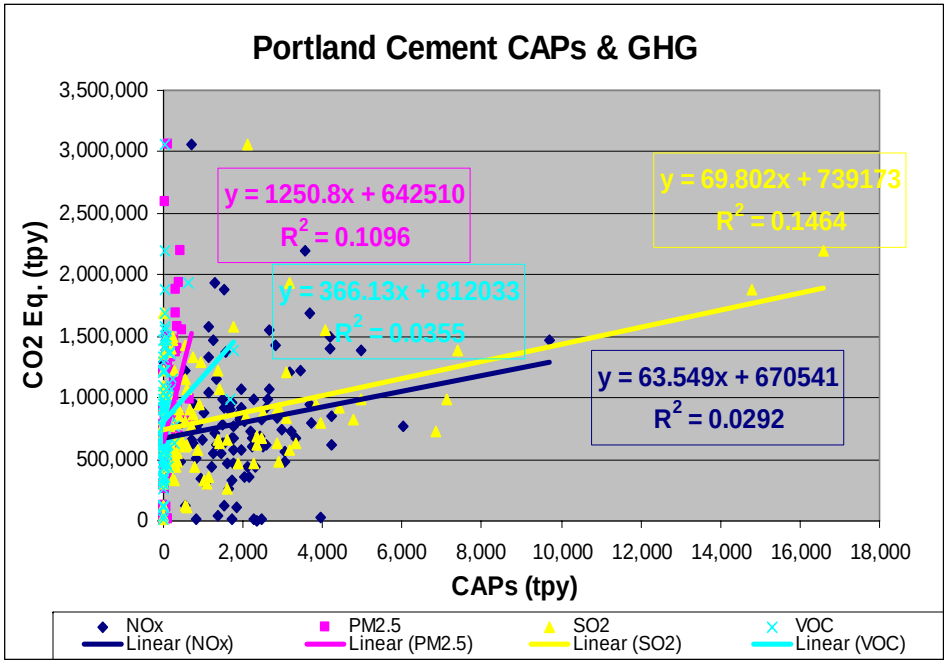
Source: EPA 2002-2006 Data

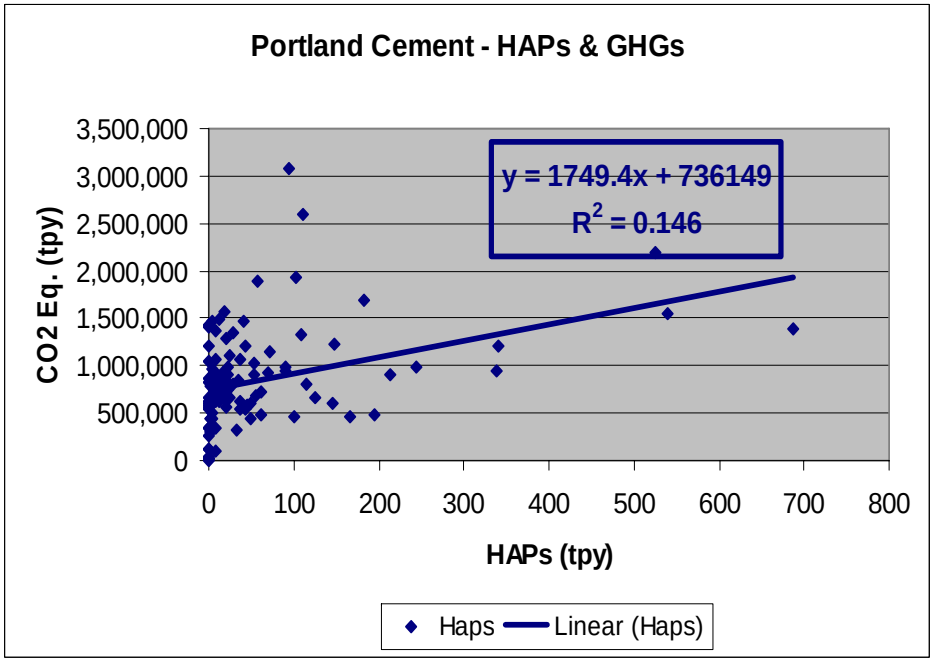
Portland Cement Summary

Parameter	Total	GHG	CAPs	HAPs
# Unique Facilities	113	113	110	110
# U.S. Counties	38	38	36	36
# Tribes	0	0	0	0
# U.S. States	37	37	36	36
# Facilities in Ozone Nonattainment areas (8 hr standard)	24	24	24	24
# Facilities in CO Nonattainment areas	0	0	0	0
# Facilities in $PM_{2.5}$ Nonattainment areas	28	28	28	28
2007 Acid Rain SO_2 Nonattainment areas	0	0	0	0
# HAPs individual reported	194			
HAPs with highest Cancer risk	benzene, Be, Cr VI, POM			
HAPs with highest Non-Cancer risk	acrolein, Cl2, HCl, Mn			
HAPs with highest emissions	benzene, Cl2, formaldehyde, HCl, toluene			

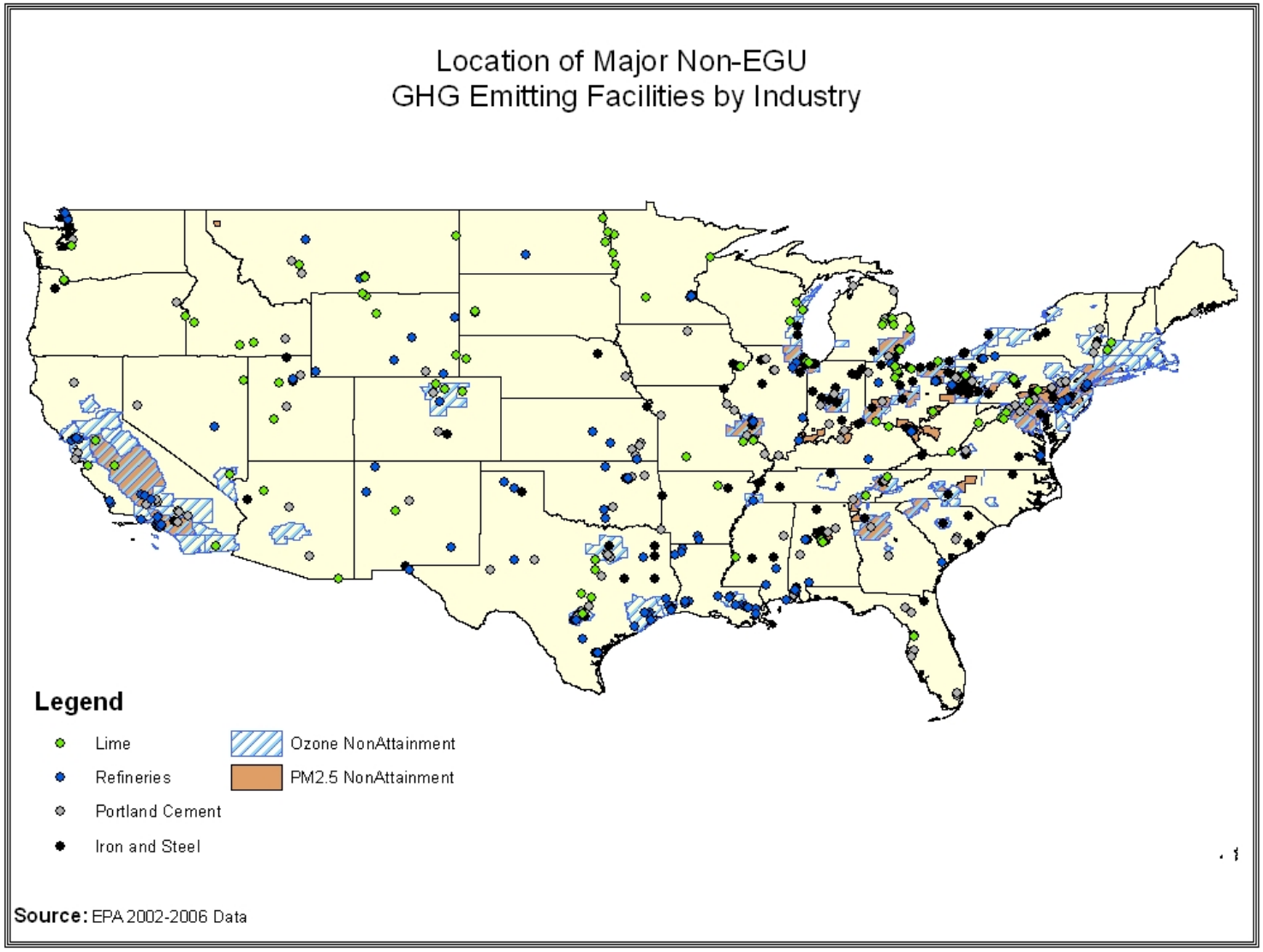
Pollutant	Total Emissions (tpy)	Nonattainment Area Emissions (tpy)			
		Ozone	CO	SO_2	$PM_{2.5}$
GHG	101412500	27337283			26014511
CO	154375	19093			16488
NO_x	217681	51678			52668
PM_{10}	38009	10079			12748
$PM_{2.5}$	16804	4416			5374
SO_2	155917	41955			23623
VOC	8830	2963			2576
188 HAP	6167	1052			911

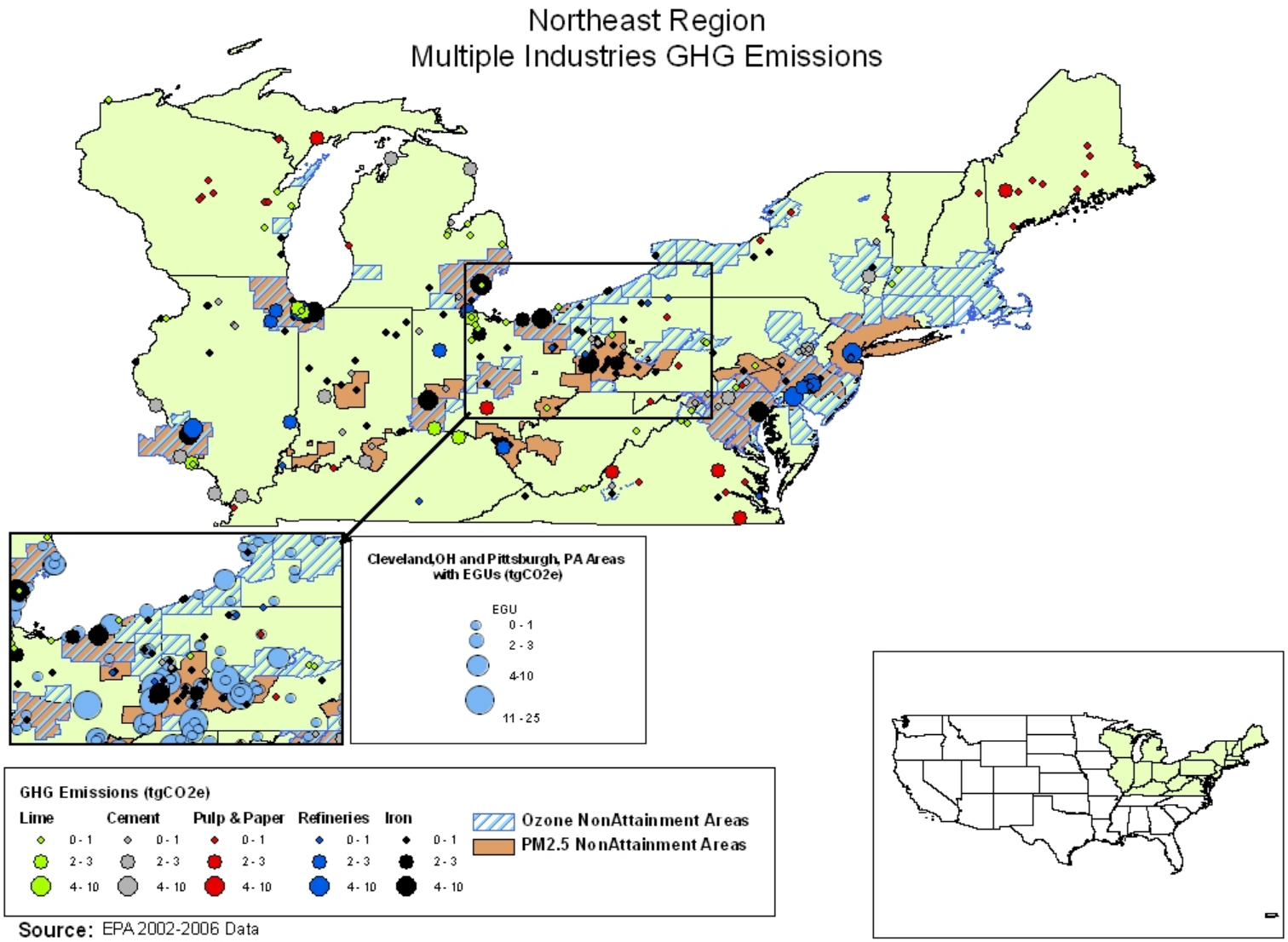
Portland Cement: Correlation of GHG Emissions to CAP and HAP Emissions





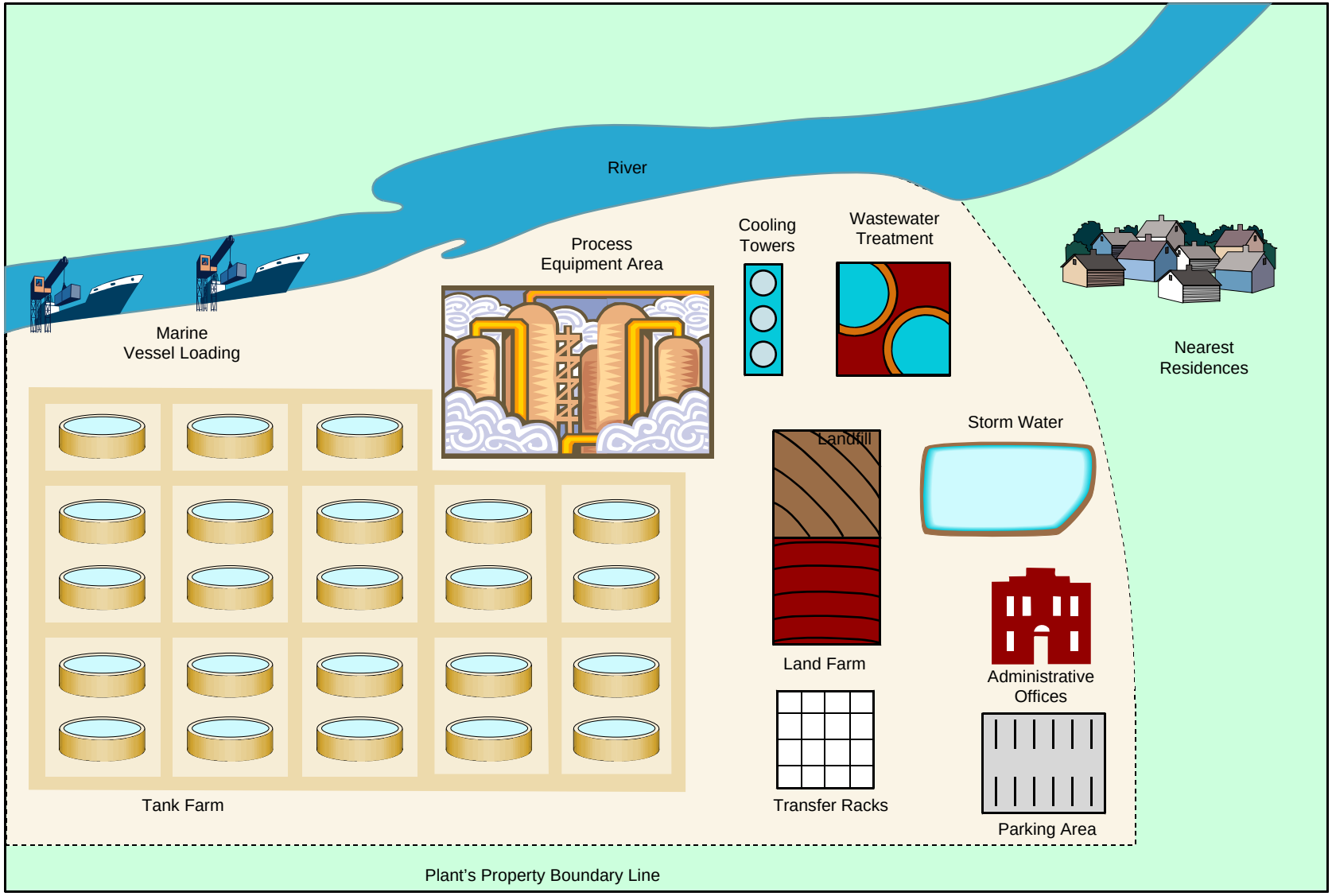
High GHG Emitters Also Contribute to Poor Air Quality

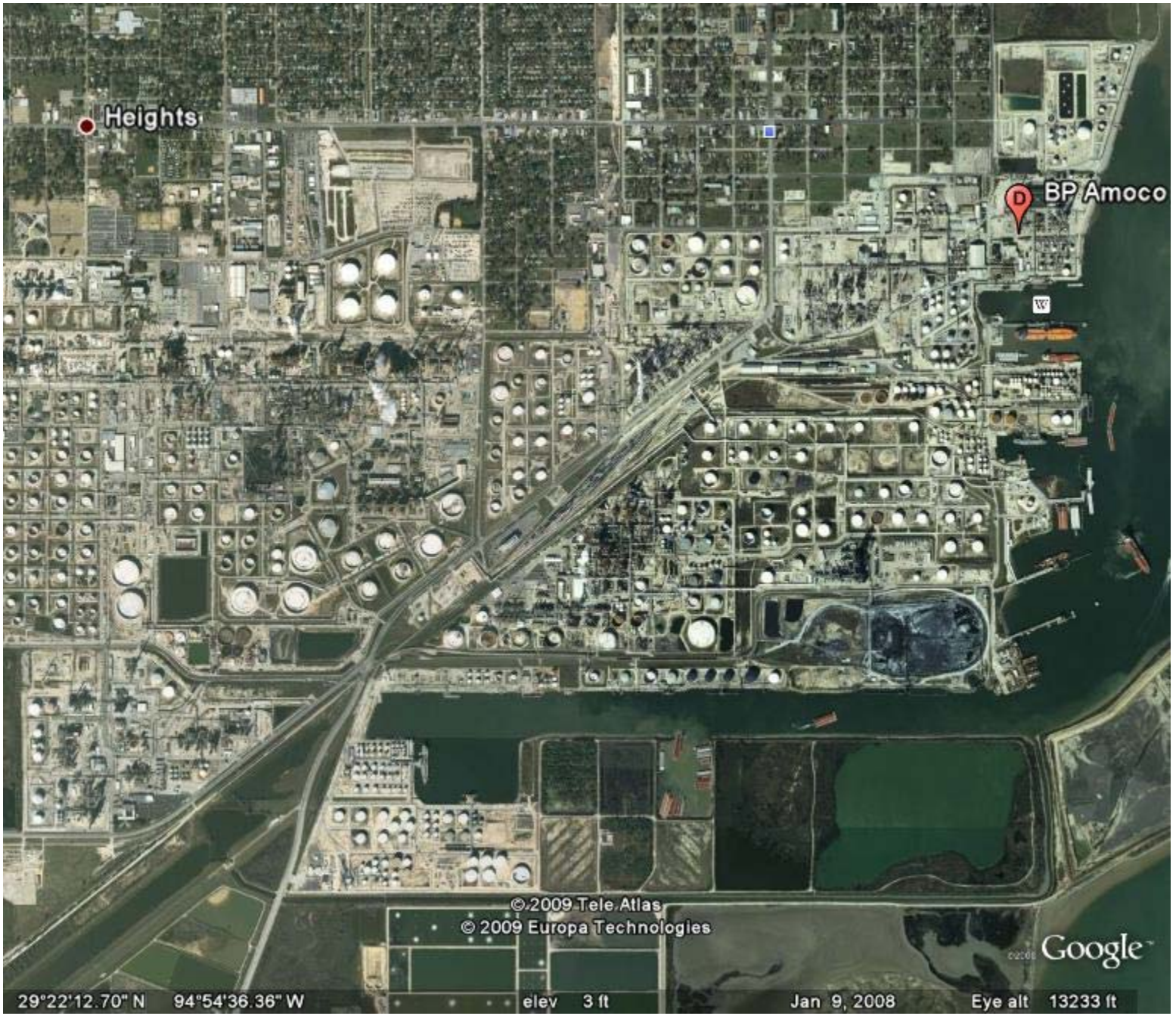



Northeast Region
Multiple Industries GHG Emissions
Cleveland,OH and Pittsburgh, PA Areas with EGUs (tgCO2e)
EGU
0 - 1
2 - 3
4-10
11 - 25
GHG Emissions (tgCO2e)
Lime
Cement
Pulp & Paper
Refineries
Iron
0 - 1
2 - 3
4 - 10
Ozone NonAttainment Areas
PM2.5 NonAttainment Areas
Source: EPA 2002-2006 Data

Example Sector: Refinery

- Large source of industrial emissions
- 152 refineries in all, refining 25% of the world's oil production
- Lots of emission points, some difficult to characterize
- Lots of regs NSPS, NESHAP, ACTs, CTGs)
- Many are located in SIP nonattainment areas


River
Marine
Vessel Loading
Process
Equipment Area
Cooling
Towers
Wastewater
Treatment
Nearest
Residences
Storm Water
Landfill
Land Farm
Administrative
Offices
Tank Farm
Transfer Racks
Parking Area
Plant's Property Boundary Line


Heights
BP Amoco
©2009 Tele Atlas
© 2009 Europa Technologies
Google
29°22'12.70" N 94°54'36.36" W
elev 3 ft
Jan 9, 2008
Eye alt 13233 ft

Petroleum Refineries Regs

Original Date	Rule
1977	Refinery Vacuum Producing Systems, Wastewater Separators, and Process Unit Turnarounds (ACT/CTG)
1977	Storage of Petroleum Liquids in Fixed Roof Tanks (ACT/CTG)
1978	Leaks from Petroleum Refinery Equipment (ACT/CTG)
1978	Petroleum Liquid Storage in External Floating Roof Tanks (ACT/CTG)
1984	Refineries: Equip. Leaks (NSPS)
1988	Refineries: Wastewater (NSPS)
2008	Petroleum Refineries (NSPS)
1984	Benzene Equipment Leaks (NESHAP)
1989	Benzene Storage Vessels (NESHAP)
1990	Benzene Transfer Operations (NESHAP)
1990	Benzene Waste Operations (NESHAP)
1995	Petroleum Refineries I (MACT)
2002	Petroleum Refineries II (MACT)

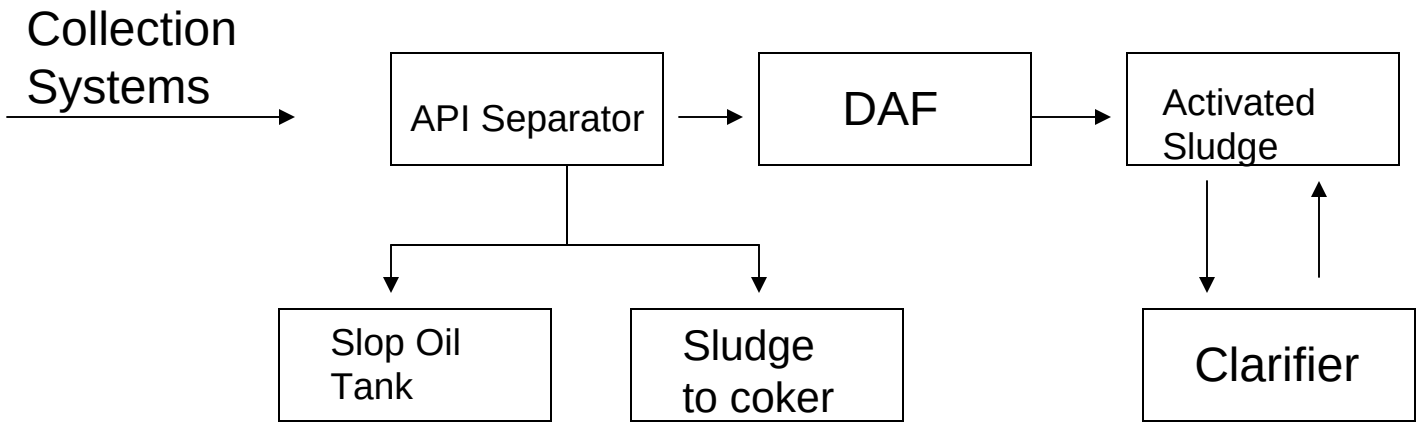
Refinery Fired Source Requirements

Emission Source	CAP	NSPS J CAP	NSPS Ja CAP	NESHAPUUU (MACT) HAP	Other HAP
		1978	2008/2009	2002	
FCCU	PM	<=1.0 lb/1000 lb coke burn + PM for CO boiler	<=0.5 lb/1000 lb coke burn (new) and <=1.0 lb/1000 lb coke burn (M/R)	<=1.0 lb/1000 lb coke burn + PM for CO boiler – or- Ni<= .029 lb/hr –or- Ni<= 0.001 lb/1000 lb coke burn	
	SO2	50 ppmv	25 ppmv		
	NOx	None	80 ppmv		
	CO	500 ppmv	500 ppmv	500 ppmv (suurogate for organic HAP)	
Catalytic Reformer				98% control of TOC; 92/97% control of HCl or to 30/10 ppmv	
Fluid Coker	PM	None	0.5 lb/1000 lb coke burn		
	SO2	None	25 ppmv		
SRP	SO2	250 ppmv for >20 ltpd	250 ppmv for >20 ltpd 99% control < 20 ltpd	250 ppmv for >20 ltpd	
Fuel Gas Combustion	SO2	-20 ppmv (3-hour); 162 ppmv H2S (3-hou avg)	-20 ppmv (3-hour); 162 ppmv H2S (3-hou avg) -60 ppmv H2S long term limit		
Process Heaters	NOx	None	40/60 ppmv for >40 MMBTU/hr	Maybe UUU	MACT for Boilers and Heaters
Boilers	SO2	See Fuel gas combustion above	See fuel gas combustion above	Maybe UUU	MACT for Boilers and Heaters; NSPS Db
Flares	All	None	Flare minimization		Subpart CC

Refinery Non-Fired Source Requirements

Emission Source	Pollutant	NESHAP CC	Other Regs that Apply		
		1995/2009			
Process Vents	VOC/HAP	98% for VOC>33 kg/day (existing); >6.8 kg/day (new)			
Wastewater	Benzene	References Benzene Waste Rule (BWON)	BWON		
	VOC		NSPS QQQ		
Cooling Towers	TOC/HAP	Leak Detection and Repair			
Storage	HAP	Group 1 Tank Controls	NSPS Kb		
	VOC	None	NSPS Kb		
Loading Gasoline Racks	Gasoline	References Subpart R			
Marine Vessels	HAP	References NESHAP Y Group 1 controls for >10/25 TPY terminals			
Equipment Leaks	HAP/VOC	References NSPS VV or NESHAP H for components in HAP service	NSPS GGG	NSPS GGGa (more stringent leak definitions than VV/GGG)	

Wastewater Systems



CONCLUSIONS

- Current GHG, CAP and HAP emission inventories are not sufficient to support development of multi-pollutant sector strategies
- Data providers are strongly encouraged to integrate inventories across all pollutants at the unit/process level and to develop multi-pollutant sector strategies
- Multi-pollutant sector strategies can result in a number of benefits including:
  - Focus on reducing emissions of greatest public health interest
  - Maximization of capital and operating environmental expenditures
  - Reduction in costs of control or over-control in the wrong areas
  - Development of better emissions data and compilation tools for characterizing individual sectors
  - Consolidated monitoring, recordkeeping and reporting