

REINHOLD ENVIRONMENTAL Ltd.



2011 NO_x-Combustion Round Table & Expo Presentation

February 7-8, 2011, in Birmingham, AL / Hosted by Southern Company

All presentations posted on this website are copyrighted by Reinhold Environmental, Ltd (RE). Any unauthorized downloading, attempts to modify or to incorporate into other presentations, link to other websites, or obtain copies for any other uses than the training of attendees to RE's Conferences is expressly prohibited, unless approved in writing by RE or the original presenter. RE does not assume any liability for the accuracy or contents of any materials contained in this library which were presented and/or created by persons who were not employees of RE.



Clean Air Act Utility MACT Review

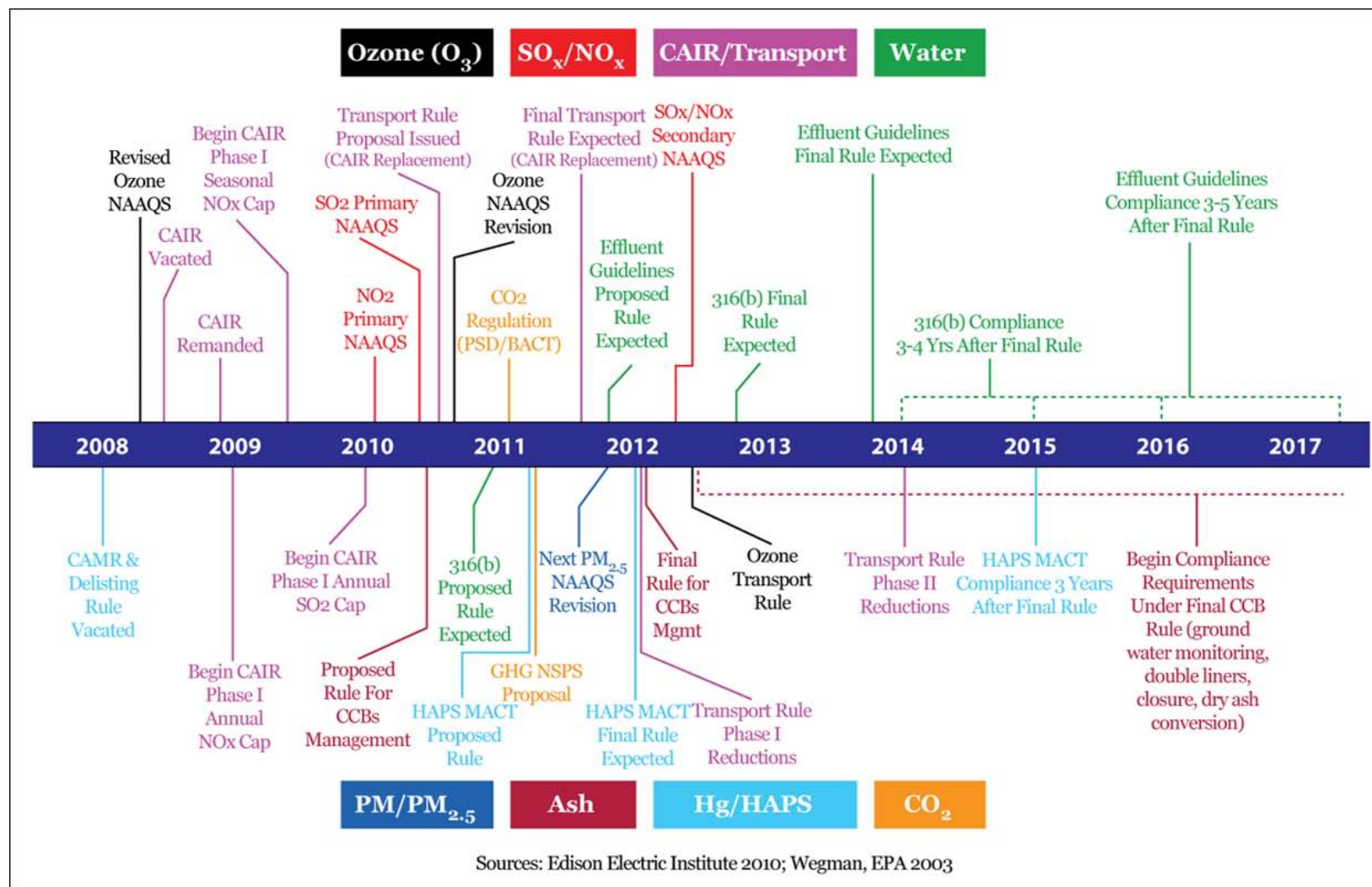
*Brian Higgins
Nalco Mobotec*

*Reinhold Conference
Feb 7, 2011*

Upcoming EPA Regulations

- Focus is on Utility MACT
 - Basis: PC, CISWI, Boiler MACTs (easy, right?)
- Other utility rules
 - CAIR / CATR
 - GHG NSPS (Tailoring Rule)
 - Tailoring Rule
- Other issues
 - NAAQS
 - Regional Haze
 - Non air rules (water)
- Other industries
 - PC-MACT, Boiler MACT

Upcoming Regulations



Clean Air Act (1990 Amendments)

- Title I - **Air Pollution Prevention and Control**
 - **Air Quality and Emission Limitations** (§101-131)
 - **Prevention of Significant Deterioration of Air Quality** (§160-169b)
 - **Plan Requirements for Nonattainment Areas** (§171-193)
- Title II - Emission Standards for Moving Sources
 - Motor Vehicle Emission and Fuel Standards (§201-219)
 - Aircraft Emission Standards (§231-234)
 - Clean Fuel Vehicles (§241-250)
- Title III - General (§301-328)
- Title IV - Acid Deposition Control (§401-416)
- Title V - **Permits** (§501-507)
- Title VI - Stratospheric Ozone Protection (§601-618)

Clean Air Act - Title I

- §109-111
 - NAAQS (Criteria Pollutants)
 - Leads to CAIR / CATR
- §112
 - Air Toxics (Haps)
 - Leads to MACT
- §160 - §169
 - PSD, BACT, Regional Haze
- §171- §193
 - Non-attainment (NAAQS) rules

Clean Air Act - NAAQS

- §109
 - NAAQS (National Ambient Air Quality Standards)
 - CO, Pb, NO₂, PM₁₀, PM_{2.5}, O₃, SO₂
- §110
 - SIP (State Implementation Plan) required to achieve NAAQS
 - if no SIP then FIP
- §111
 - NSPS (New Source Performance Standards)
 - limiting SO₂, PM, and NO_x
 - Compliance Monitoring Program
 - CAIR/CATR
- Court vacated CAIR and CAMR problem with §111
 - Cap-and-trade did not account for transport

Clean Air Act - MACT

- §112
 - NESHAP (National Emissions Standards for HAPs)
 - AIR TOXICS
 - MACT
 - 188 HAPs (Hazardous Air Pollutants)
 - Uses surrogates
 - Technology based *versus* health based
 - Solid wastes are in §129 (and §111)
- Court vacated CAIR and CAMR problems with §112
 - EPA tried two things:
 - to remove utilities from HAPs rules (MACT)
 - to move Hg regulations from §112 to §111

HAPs

Acetaldehyde, Acetamide, Acetonitrile, Acetophenone, 2-Acetylaminofluorene, Acrolein, Acrylamide, Acrylic acid, Acrylonitrile, Allyl chloride, 4-Aminobiphenyl, Aniline, o-Anisidine, Asbestos, Benzene (including benzene from gasoline), Benzidine, Benzotrichloride, Benzyl chloride, Biphenyl, Bis(2-ethylhexyl)phthalate (DEHP), Bis(chloromethyl)ether, Bromoform, 1,3-Butadiene, Calcium cyanamide, Caprolactam(See Modification), Captan, Carbaryl, Carbon disulfide, Carbon tetrachloride, Carbonyl sulfide, Catechol, Chloramben, Chlordane, Chlorine, Chloroacetic acid, 2-Chloroacetophenone, Chlorobenzene, Chlorobenzilate, Chloroform, Chloromethyl methyl ether, Chloroprene, Cresols/Cresylic acid (isomers and mixture), o-Cresol, m-Cresol, p-Cresol, Cumene, 2,4-D, salts and esters, DDE, Diazomethane, Dibenzofurans, 1,2-Dibromo-3-chloropropane, Dibutylphthalate, 1,4-Dichlorobenzene(p), 3,3-Dichlorobenzidine, Dichloroethyl ether (Bis(2-chloroethyl)ether), 1,3-Dichloropropene, Dichlorvos, Diethanolamine, N,N-Diethyl aniline (N,N-Dimethylaniline), Diethyl sulfate, 3,3-Dimethoxybenzidine, Dimethyl aminoazobenzene, 3,3'-Dimethyl benzidine, Dimethyl carbamoyl chloride, Dimethyl formamide, 1,1-Dimethyl hydrazine, Dimethyl phthalate, Dimethyl sulfate, 4,6-Dinitro-o-cresol, and salts, 2,4-Dinitrophenol, 2,4-Dinitrotoluene, 1,4-Dioxane (1,4-Diethyleneoxide), 1,2-Diphenylhydrazine, Epichlorohydrin (1-Chloro-2,3-epoxypropane), 1,2-Epoxybutane, Ethyl acrylate, Ethyl benzene, Ethyl carbamate (Urethane), Ethyl chloride (Chloroethane), Ethylene dibromide (Dibromoethane), Ethylene dichloride (1,2-Dichloroethane), Ethylene glycol, Ethylene imine (Aziridine), Ethylene oxide, Ethylene thiourea, Ethylidene dichloride (1,1-Dichloroethane), Formaldehyde, Heptachlor, Hexachlorobenzene, Hexachlorobutadiene, Hexachlorocyclopentadiene, Hexachloroethane, Hexamethylene-1,6-diisocyanate, Hexamethylphosphoramide, Hexane, Hydrazine, Hydrochloric acid, Hydrogen fluoride (Hydrofluoric acid), Hydrogen sulfide(See Modification), Hydroquinone, Isophorone, Lindane (all isomers), Maleic anhydride, Methanol, Methoxychlor, Methyl bromide (Bromomethane), Methyl chloride (Chloromethane), Methyl chloroform (1,1,1-Trichloroethane), Methyl ethyl ketone (2-Butanone)(See Modification), Methyl hydrazine, Methyl iodide (Iodomethane), Methyl isobutyl ketone (Hexone), Methyl isocyanate, Methyl methacrylate, Methyl tert butyl ether, 4,4-Methylene bis(2-chloroaniline), Methylene chloride (Dichloromethane), Methylene diphenyl diisocyanate (MDI), 4,4'-Methylenedianiline, Naphthalene, Nitrobenzene, 4-Nitrobiphenyl, 4-Nitrophenol, 2-Nitropropane, N-Nitroso-N-methylurea, N-Nitrosodimethylamine, N-Nitrosomorpholine, Parathion, Pentachloronitrobenzene (Quintobenzene), Pentachlorophenol, Phenol, p-Phenylenediamine, Phosgene, Phosphine, Phosphorus, Phthalic anhydride, Polychlorinated biphenyls (Aroclors), 1,3-Propane sultone, beta-Propiolactone, Propionaldehyde, Propoxur (Baygon), Propylene dichloride (1,2-Dichloropropane), Propylene oxide, 1,2-Propylenimine (2-Methyl aziridine), Quinoline, Quinone, Styrene, Styrene oxide, 2,3,7,8-Tetrachlorodibenzo-p-dioxin, 1,1,2,2-Tetrachloroethane, Tetrachloroethylene (Perchloroethylene), Titanium tetrachloride, Toluene, 2,4-Toluene diamine, 2,4-Toluene diisocyanate, o-Toluidine, Toxaphene (chlorinated camphene), 1,2,4-Trichlorobenzene, 1,1,2-Trichloroethane, Trichloroethylene, 2,4,5-Trichlorophenol, 2,4,6-Trichlorophenol, Triethylamine, Trifluralin, 2,2,4-Trimethylpentane, Vinyl acetate, Vinyl bromide, Vinyl chloride, Vinylidene chloride (1,1-Dichloroethylene), Xylenes (isomers and mixture), o-Xylenes, m-Xylenes, p-Xylenes, Antimony Compounds, Arsenic Compounds (inorganic including arsine), Beryllium Compounds, Cadmium Compounds, Chromium Compounds, Cobalt Compounds, Coke Oven Emissions, Cyanide Compounds¹, Glycol ethers², Lead Compounds, Manganese Compounds, Mercury Compounds, Fine mineral fibers³, Nickel Compounds, Polycyclic Organic Matter⁴, Radionuclides (including radon)⁵, Selenium Compounds

<http://www.epa.gov/ttnatw01/orig189.html> (This is the original list, there have been some changes over the years)

Clean Air Act - Other

- §160 - §169
 - Prevention of Significant Deterioration of Air Quality (PSD)
 - You cannot reduce one emission, only to increase another
 - Being in attainment does not mean you can pollute more
 - SO₂, PM, NO₂ (more coming)
 - BACT
 - Regional Haze

- §171- §193
 - Non-attainment (NAAQS) rules

- Operating Permits (Title V)
 - Major sources
 - Extra requirements for non-attainment areas
 - Permitting could create real delays

Two Primary Issues

- NAAQS (National Ambient Air Quality Standards)
 - CO, Pb, NO₂, PM₁₀, PM_{2.5}, O₃, SO₂
 - Driven by non-attainment areas and transport

→ CAIR & CATR

- HAPs (Air Toxics)
 - 188 identified
 - Too many to measure, so surrogates are used
 - Driven by
 - Local emissions and also
 - Local concentrations (“fence line”)

→ MACT

www.airnow.gov

Good

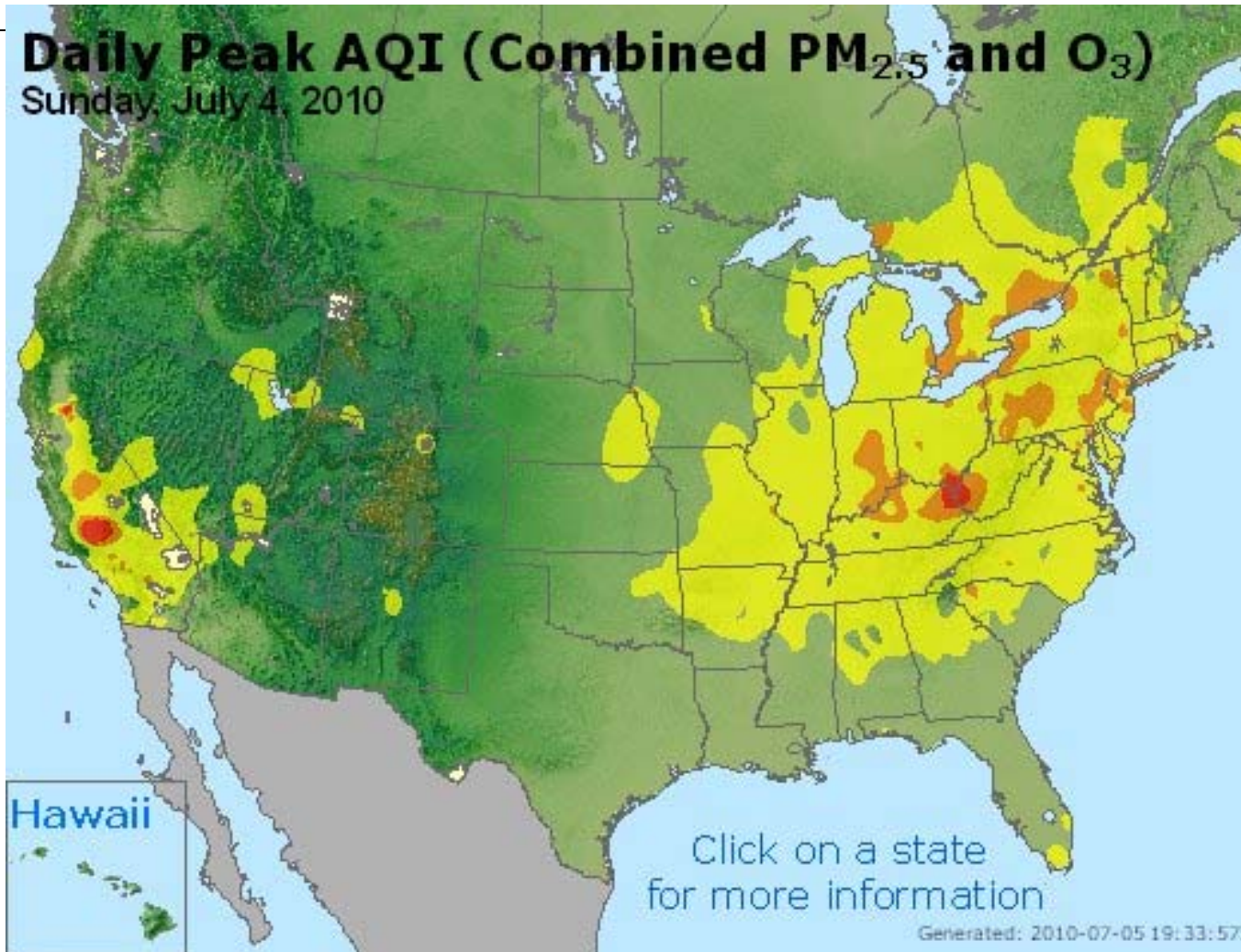
Moderate

USG

Unhealthy

Very Unhealthy

Hazardous



www.airnow.gov

Good

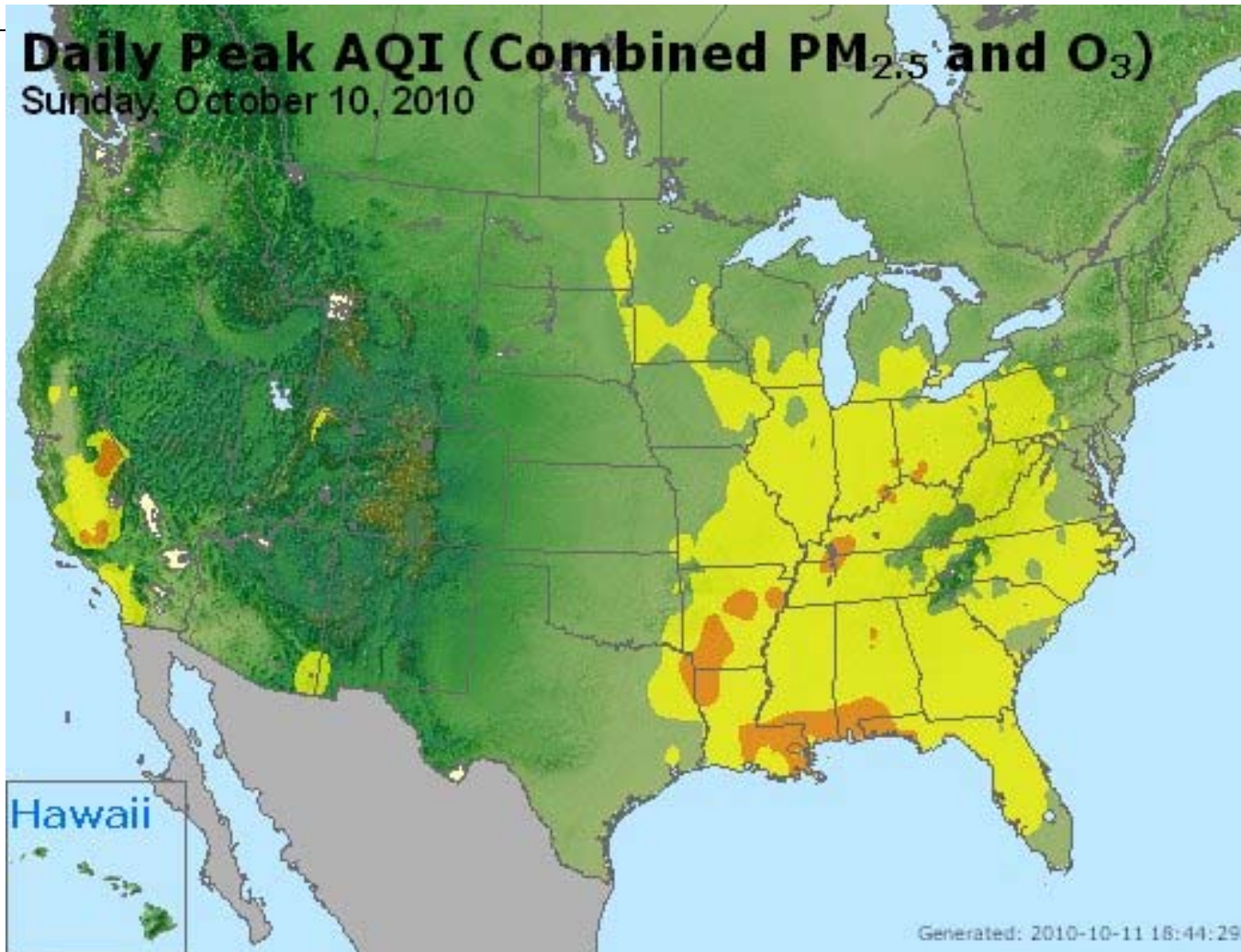
Moderate

USG

Unhealthy

Very Unhealthy

Hazardous



www.airnow.gov

Good

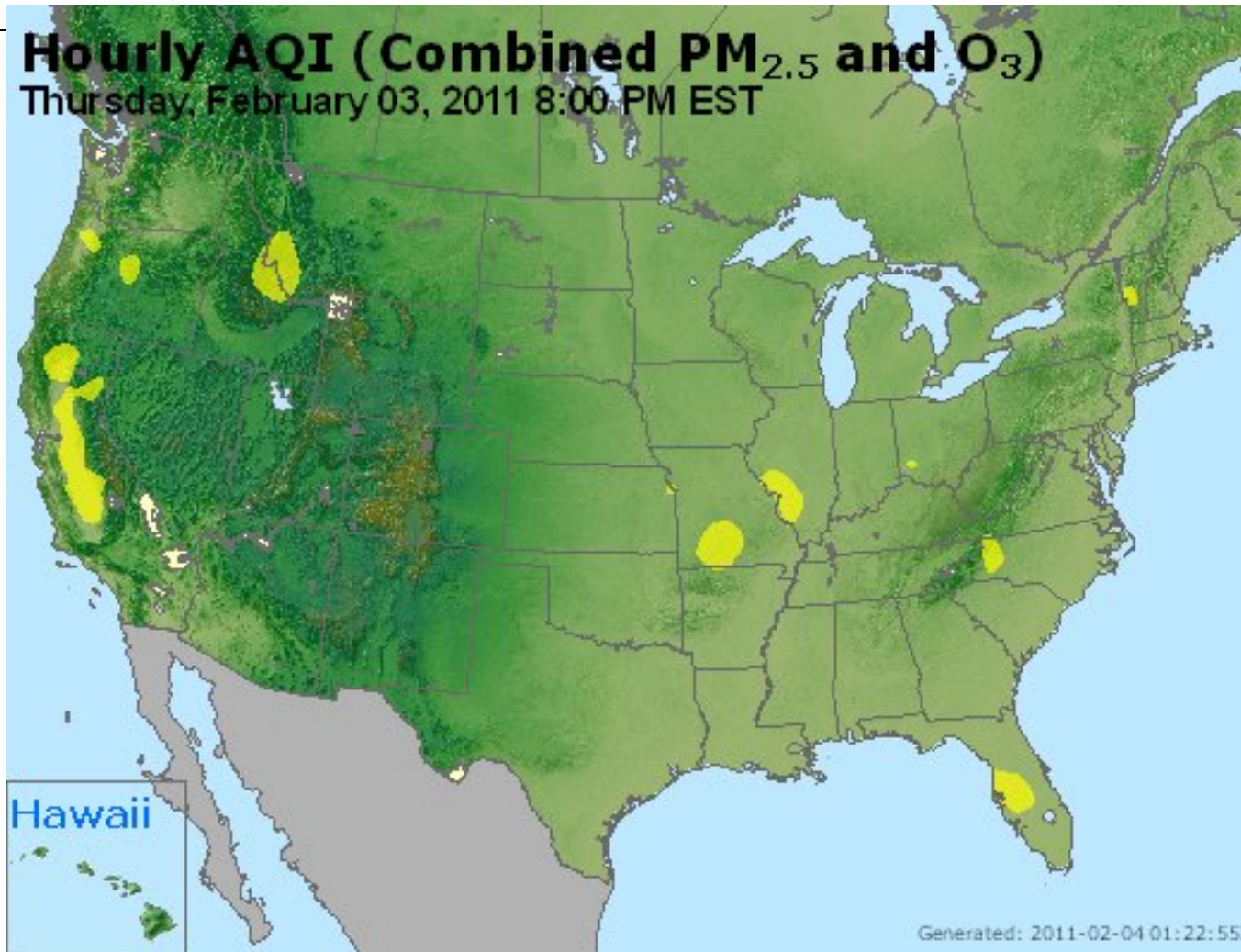
Moderate

USG

Unhealthy

Very Unhealthy

Hazardous



MACT
AIR TOXICS
HAPS - NESHAP
CAA - §112

Prior MACT rules affect Utility MACT

- Portland Cement MACT
- Boiler MACT
- CISWI MACT
- Utility MACT

PC-MACT

- Promulgated fall 2010
- Establishes surrogates
 - PM - surrogate for metals
 - CO - surrogate for organics (non-dioxin)
 - HCl - surrogate for acid gases (and a HAP)
 - Hg - HAP
 - Dioxin/furan - HAP
- PC-MACT establishes the procedure for setting limits
 - Get data (ICR)
 - Establish the top 12% performing (for each surrogate)
 - Set the limit to the average of the top 12% (for each)
 - Make an adjustment to account for data uncertainty

Current Status - Boiler MACT

- Proposed April 2010
- Was to promulgate on December 16, 2010
 - Many comments during comment period
 - EPA asks for more data (follow up ICR)
 - EPA asks for 30 day delay for data analysis
 - Court grants this request
 - EPA asks for 15 month delay for rewrite
 - Courts do not grant this request
 - EPA states that it will promulgate and then immediately ask for reconsideration
- Expectation is that it will promulgate softer than originally proposed

Process

- Same process as PC-MACT
 - ICR
 - 12% determination
 - Data analysis (statistics) flexibility to deal with bad data
 - Big issue with “non-detects”
- Added subcategories
 - Fuel
 - Firing configuration
- Initial ICR was old and insufficient (led to proposed rule)
 - Follow up ICR (I haven't seen the new data)
 - There are a number of independent analyses circulating (CIBO)
- Ok, now let's look at the Boiler MACT rule a little closer

Emissions

- PM
 - lb/MMBtu
 - Initial and annual Method 5 or 17
- CO
 - PPM @ 3% O₂
 - Initial and annual Method 10 or use a CO CEMS
- HCl
 - lb/MMBtu
 - Initial and annual Method 26A (or 26)
 - Method 19 to convert to lb/MMBtu
- Hg
 - lb/MMBtu
 - Initial and annual Method 29 or OHM
- Dioxin/Furans
 - ng/dscm @ 7%O₂ TEQ
 - Initial and annual Method 23
 - TEQ = Toxic Equivalence (weighted sum of component concentrations)

Sources and Fuels

- Area Source
 - < 10 tpy of one or < 25 tpy of all = light regulation (GACT)
- Major Source
 - Not an area source = strict regulation (MACT)

=====

- Coal
 - More than 10% of annual heat input is coal = “coal fired”
- Biomass
 - If “not coal” and more than 10% of annual heat input is biomass = “biomass fired”
- Liquid
 - More than 10% liquid and less than 10% solid = “liquid fired”
- Gas
 - More than 10% gas and less than 10% liquid/solid = “gas fired”

Firing Configurations

- Coal
 - PC
 - Stoker
 - FB

- Biomass
 - Dutch oven / suspension (PC)
 - Stoker
 - FB
 - Fuel Cell

Proposed Minor (Area) Source Limits

Area (Minor) Source (not a major source)						
Existing/ New	Fuel	Particulate	Hydrogen	Mercury	Carbon	Dioxin/Fur
		Matter (PM)	Chloride	(Hg)	Monoxide	ans (Total
		[lb/MMBtu]	(HCl)	[lb/TBtu]	(CO)	TEQ)
			[lb/MMBtu]		[ppm @7% O2]	[ng/dscm]
Existing	Coal	--	--	3	310	--
Existing	Biomass	--	--	--	160	--
Existing	Oil	--	--	--	1	--
New	Coal	0.03	--	3	310	--
New	Biomass	0.03	--	--	100	--
New	Oil	0.03	--	--	2	--

Proposed Major Source Limits

Major Source (facility > 10 t/yr of a single or > 25 t/yr of 2 or more HAP)							
Existing - New	Fuel	Firing Method	Hydrogen			Carbon	Dioxin -
			Paticulate Matter (PM) [lb/MMBtu]	Chloride (HCl) [lb/MMBtu]	Mercury (Hg) [lb/TBtu]	Monoxide (CO) [ppm @3% O2]	Furans (Total TEQ) [ng/dscm]
Existing	Coal	Stoker	0.02	0.02	3	50	0.003
Existing	Coal	Fluidized Bed	0.02	0.02	3	30	0.002
Existing	Coal	Pulverized	0.02	0.02	3	90	0.004
Existing	Biomass	Stoker	0.02	0.006	0.9	560	0.004
Existing	Biomass	Fluidized Bed	0.02	0.006	0.9	250	0.02
Existing	Biomass	Suspention (DO)	0.02	0.006	0.9	1010	0.03
Existing	Biomass	Fuel Cells	0.02	0.006	0.9	270	0.02
Existing	Liquid		0.004	0.0009	4	1	0.002
Existing	Gas		0.05	0.000003	0.2	1	0.009
New	Coal	Stoker	0.001	0.00006	0.2	7	0.003
New	Coal	Fluidized Bed	0.001	0.00006	2	30	0.00003
New	Coal	Pulverized	0.001	0.00006	2	90	0.002
New	Biomass	Stoker	0.008	0.004	0.2	560	0.00005
New	Biomass	Fluidized Bed	0.008	0.004	0.2	40	0.007
New	Biomass	Suspention (DO)	0.008	0.004	0.2	1010	0.03
New	Biomass	Fuel Cells	0.008	0.004	0.2	270	0.0005
New	Liquid		0.002	0.0004	0.3	1	0.002
New	Gas		0.003	0.000003	0.2	1	0.009

MACT Issues

- Actual compliance dates
 - 3 yrs + 180 days (testing)
 - + 1 (or 2) year delay if requested
 - + Possible presidential delay (2 yrs)
- Final limits likely soften
- Fines
 - Could be significant
 - \$27500/day · 365 days · 5 HAPs = \$50M/yr
- Permitting
 - There will certainly be a process (e.g., Title V)
 - PSD?
 - GHG reporting?
 - Time delay (> 6 months)

EPA Presumed Boiler MACT Solution

- EPA suggests Boiler MACT is:
 - fabric filter
 - carbon injection
 - wet scrubber
 - good combustion practices
- “Wet Scrubber” is a bit unclear
 - WFGD or particulate scrubber?
 - Why have a PM scrubber AND a fabric filter?

Regulatory Variables

- Case-by-case MACT
 - North Carolina example
- Health based versus technology based limits
 - HCl at 0.3 ppm or 3.0 ppm?
- Work Practice Standards
 - Dioxin limits or procedures?
- PSD and NSPS
- Fence line measurements/modeling options
- Continuous Impending Legislation!

CISWI MACT

CISWI MACT

- Commercial/Industrial Solid Waste Incinerators
- Issue with definition of solid wastes
 - Could be anything solid?
 - TDF
 - Process residuals
 - Reclaimed biomass
 - Agricultural?
 - Construction?
 - Hurricane refuse?
- Lots of uncertainty regarding the final rule
 - Should promulgate in sequence with Boiler MACT

CISWI MACT - More HAPs

Compound	Incinerators	Energy Recovery Units	Waste Burning Kilns	Burn Off Ovens	Small Remote Incinerators	Units
HCl	29	1.5	1.5	130	150	ppmv
CO	2.2	150	710	80	78	ppmv
Pb	0.0026	0.002	0.0027	0.041	1.4	mg/dscm
Cd	0.0013	0.00041	0.0003	0.045	0.26	mg/dscm
Hg	0.0028	0.00096	0.024	0.014	0.029	mg/dscm
PM, filterable	13	9.2	60	33	240	mg/dscm
D/F	0.031	0.75	2.1	310	1,600	Total ng/dscm
D/F	0.0025	0.059	0.17	25	130	TEQ ng/dscm
NO_x	34	130	1,100	120	210	ppmv
SO₂	2.5	4.1	410	11	44	ppmv
Opacity	1	1	4	2	13	%

UTILITY MACT

Now let's look at Utility data

- Assumedly the same: PM, CO, HCl (or SO₂?), Hg, and D/F
- Heavily weighted to SCR, ACI, and WFGD units
 - There will always be 12% that have one of the above
 - True for most potential subcategories (fuel and firing configuration)
 - MACT on MACT issue (12% of 12%)
- Low CO
 - Hot combustion with SCR down stream to lower LOI and CO
- Low HCl
 - Wet scrubbers
- PM seems to split efficient CS-ESPs and FFs
- Low Hg
 - Due to state regulations, there are many ACI systems
- D/F is still variable

Will they subcategorize by fuel?

- Coal rank
 - Anthracite
 - Eastern Bituminous
 - Distinguish high sulfur (Illinois) and Kentucky coals?
 - PRB and other sub-bituminous
 - Specify the class?
 - Lignite
 - Specify gulf versus northern?
 - Imported coals
 - Columbian? Indonesian (Adaro)? Russian?
- Non-coal and Co-firing?
 - Biomass
 - Oil
 - Natural Gas

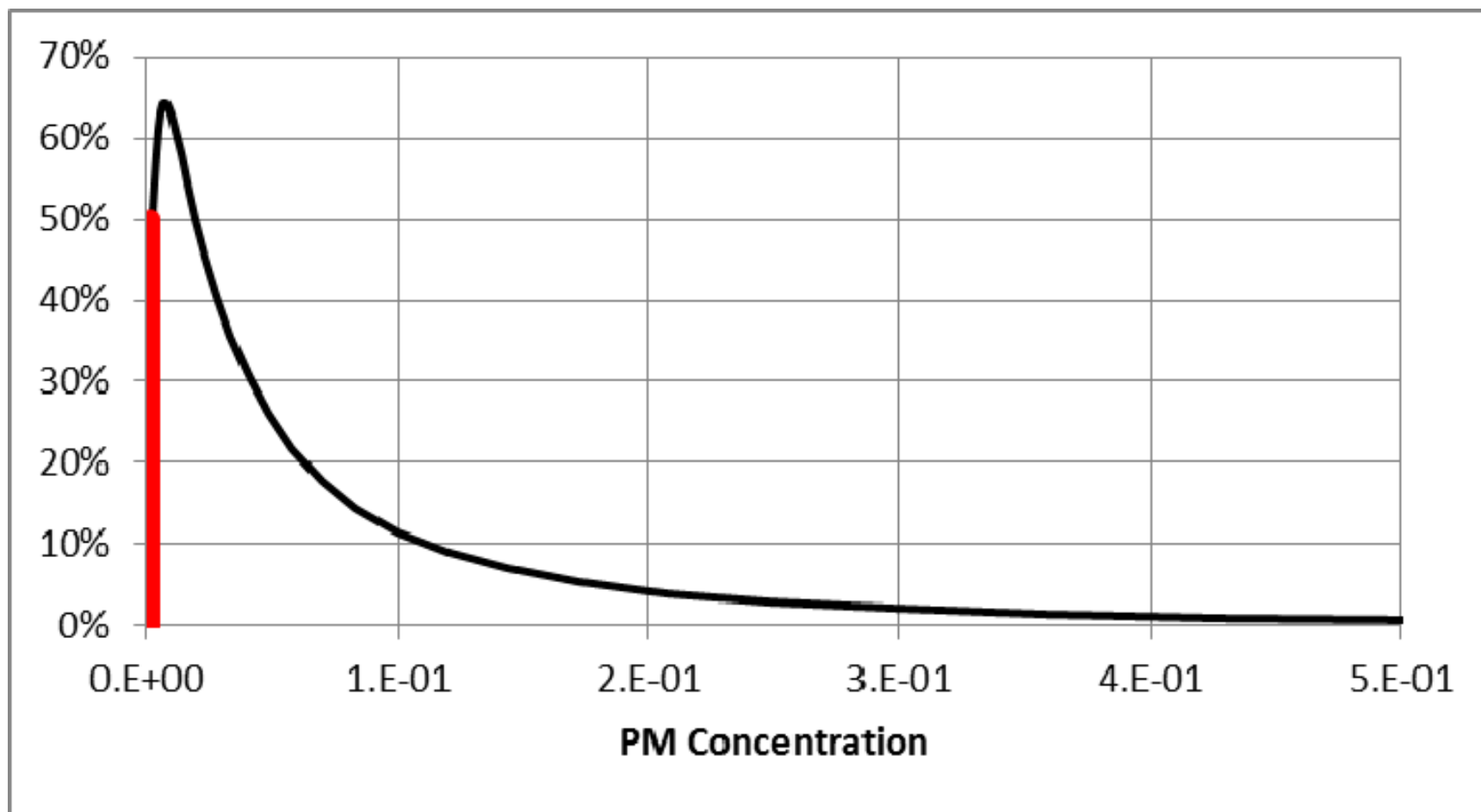
Will they subcategorize by firing arrangement?

- Cyclone boilers
- CFB
- T-fired / wall fired
- Downfired (arch)
- Gasifiers
- Oxycombustion
- Other?

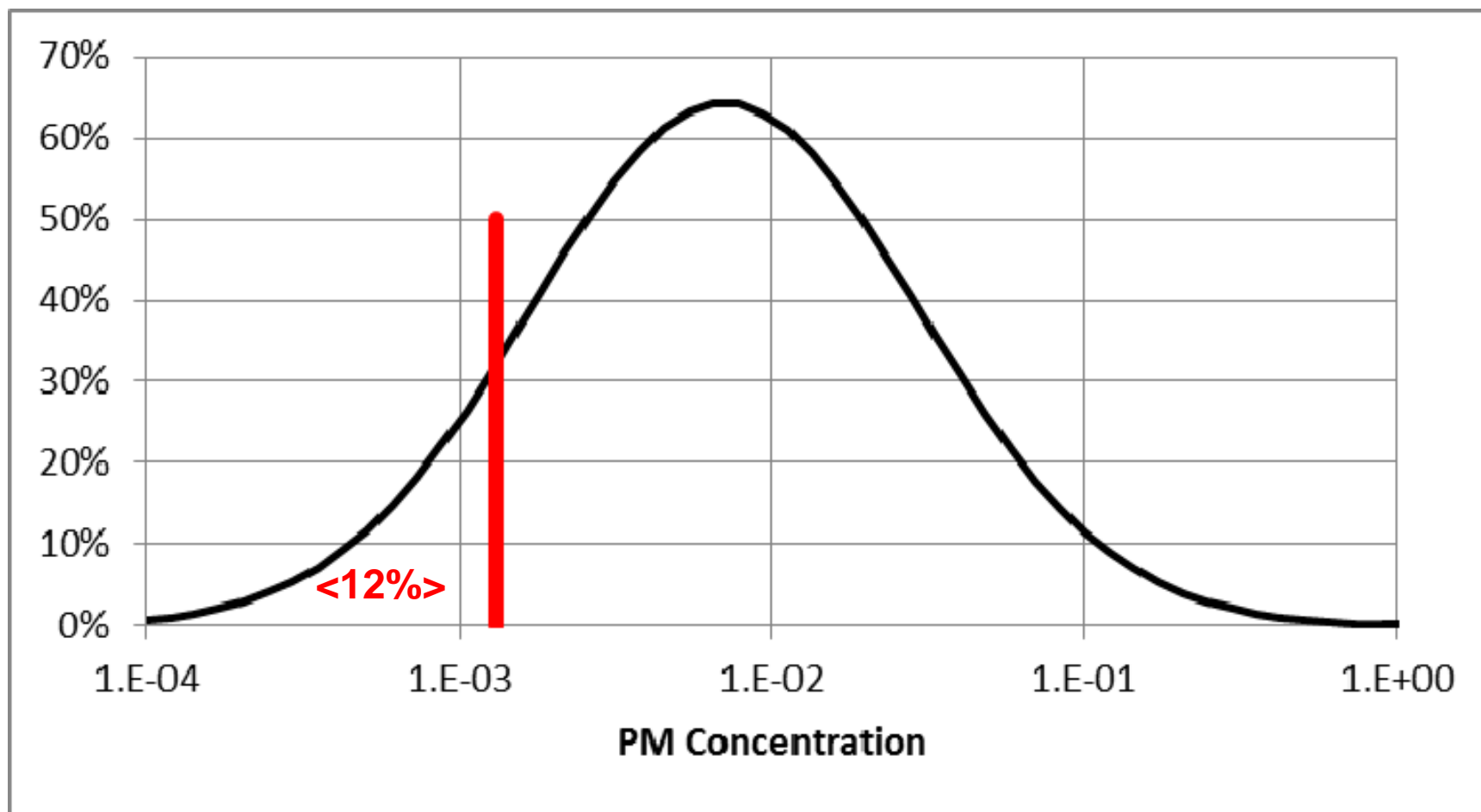
ICR Data Analysis

- Extracted data set
 - <http://www.epa.gov/ttn/atw/utility/utilitypg.html>
 - Not necessarily the final data set the EPA will consider
 - Following analysis for discussion points only
- Look at the obvious pollutants
 - PM, CO, HCl, Hg, D/F
 - Binned data analysis

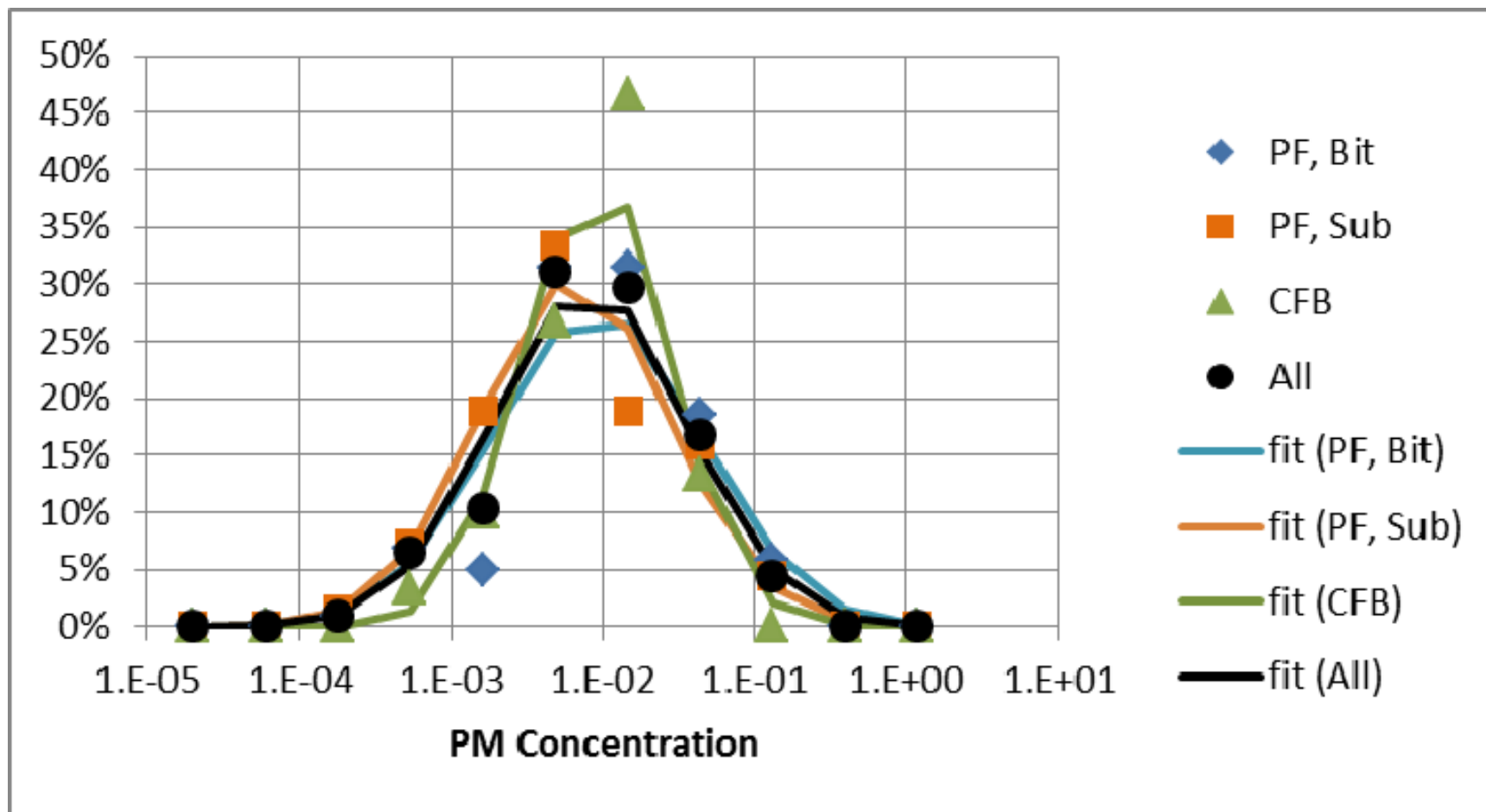
Log Normal Data Distribution



Log Normal on Log Scale



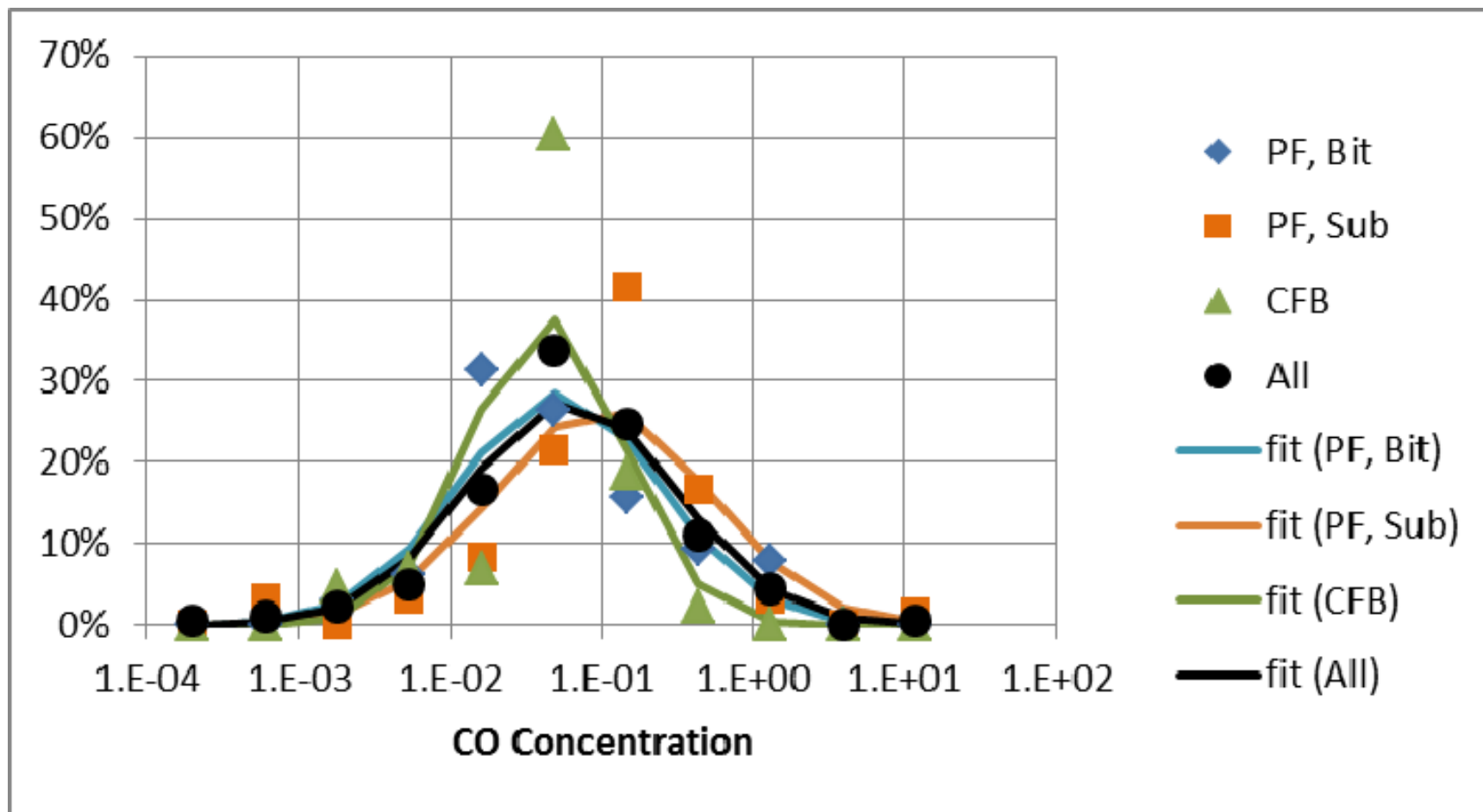
PM - ICR Data Log Scale



PM Cutoffs

- 12%
 - 0.001 lb/MMBtu (~0.002 gr/dscf)
- Mean
 - 0.007 lb/MMBtu (~0.013 gr/dscf)

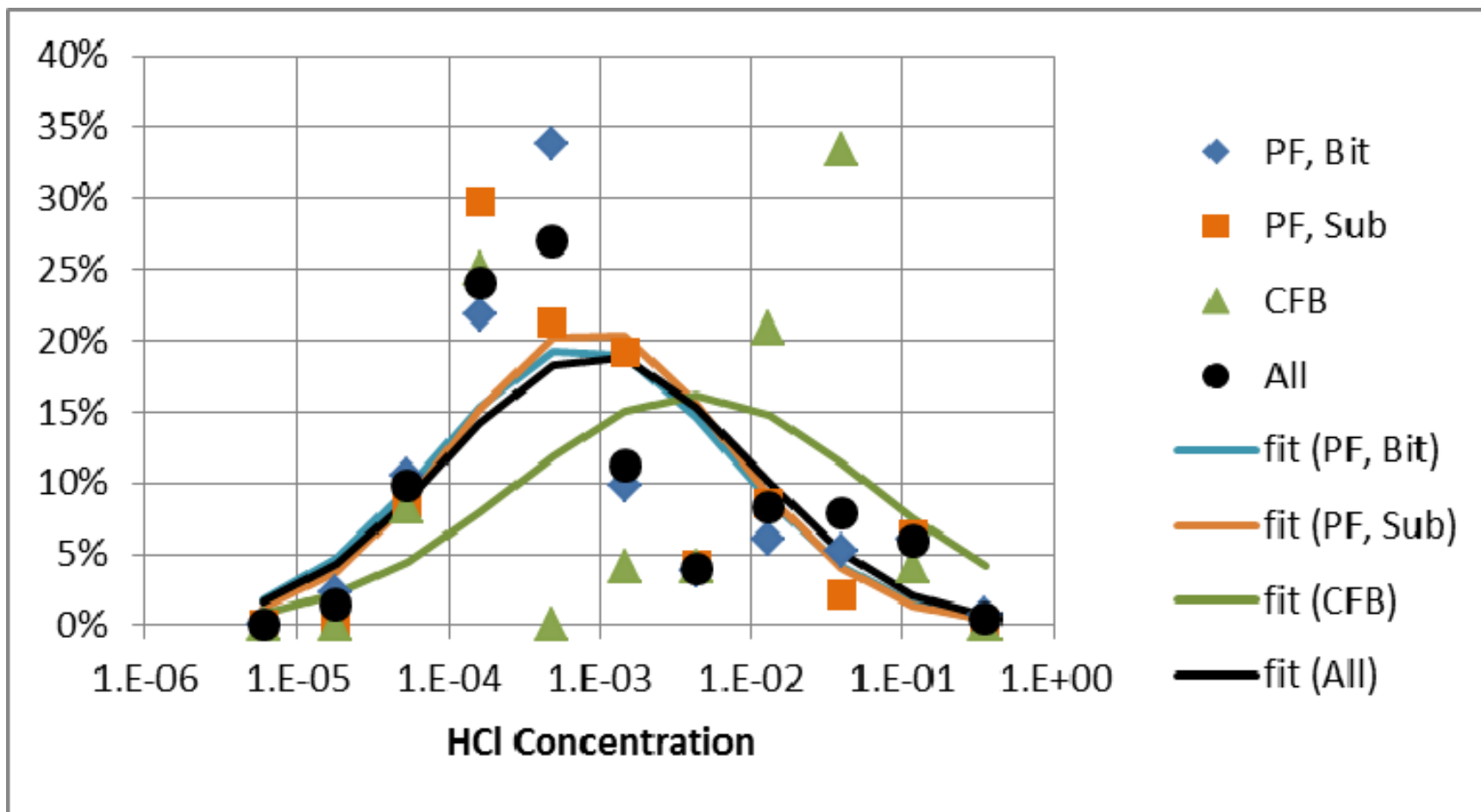
CO - ICR Data Log Scale



CO Cutoffs

- 12%
 - 0.01 lb/MMBtu (~12 ppm)
- Mean
 - 0.05 lb/MMBtu (~60 ppm)

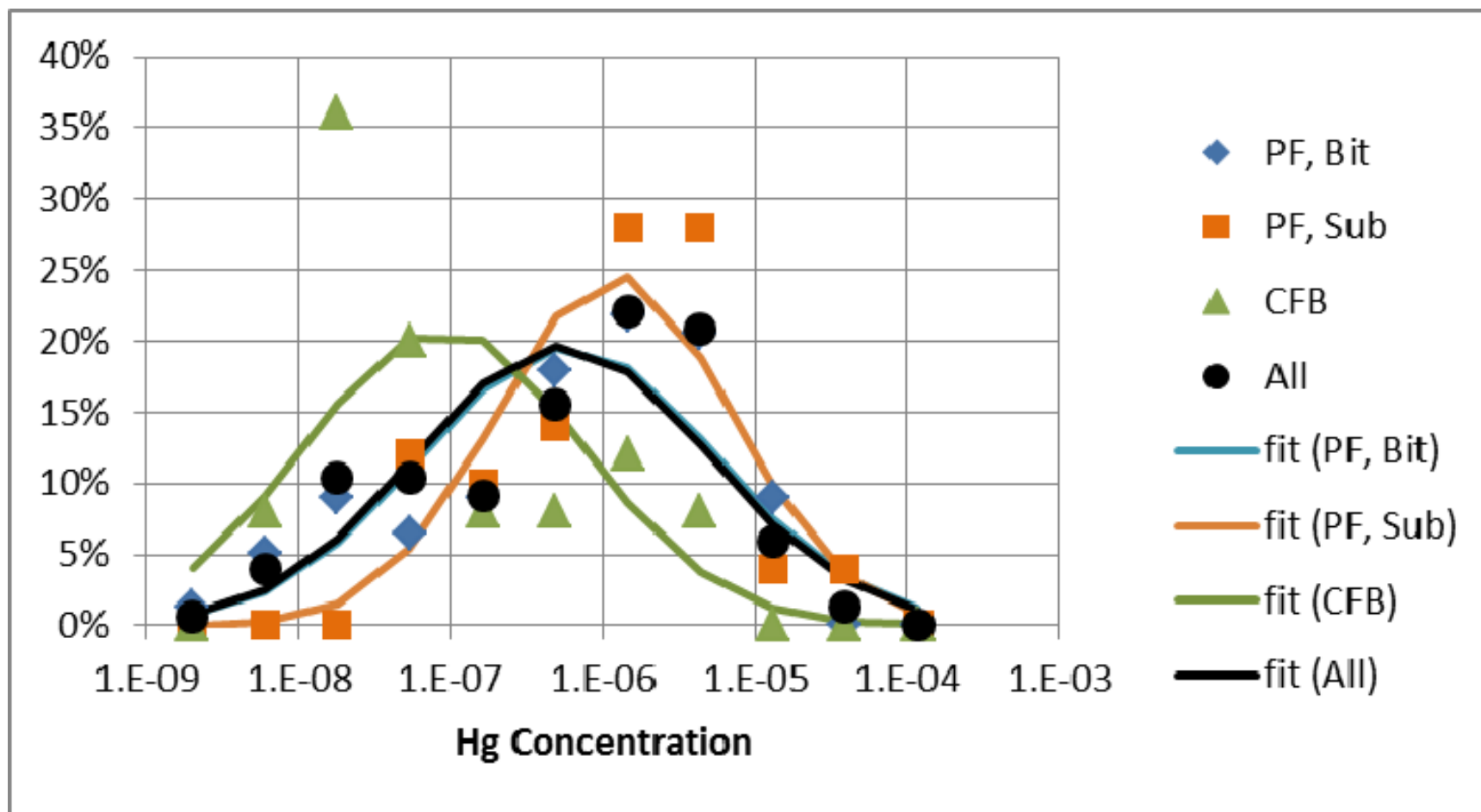
HCl - ICR Data Log Scale



HCl Cutoffs

- 12%
 - 0.00006 lb/MMBtu (~0.06 ppm)
 - Higher for CFB boilers
- Mean
 - 0.0008 lb/MMBtu (~0.8 ppm)

Hg - ICR Data Log Scale



Hg Cutoffs

- 12%
 - 0.04 lb/Tbtu
 - 0.1 lb/Tbtu for sub-bituminous
 - Lower for CFB boilers
- Mean
 - 0.5 lb/Tbtu
 - 1.0 lb/Tbtu for sub-bituminous
 - Lower for CFB boilers

D/F

-
- Not reviewed

UTILITY MACT - SOLUTIONS

Utility MACT Solutions

- Let's finish up by visiting each one in turn:
 - PM
 - CO
 - HCl
 - Hg
 - D/F

PM Solutions

- Fabric Filters (Bag Houses) are the obvious 100% solution
- Many cold side ESPs meet proposed requirements
- Wet ESPs are often discussed by the EPA as having a lot of HAP co-benefit.
 - Expensive and have not seen broad installation
- Tuning marginal ESP units
 - Modification (new TR sets, larger plate separation, more fields)
 - Chemical additives to improve ash resistivity
 - Combustion modifications to reduce LOI and ash carry over
 - Fuel switch (e.g., lower ash fuel)
 - Derate (worse case)
- Beware that other “MACT Solutions” might help or hurt ESP
 - For example, trona injection for HCl capture.

CO Solutions

- Tuning, Tuning, Tuning
- Combustion Modifications
 - Burner modifications
 - Boosted OFA systems
- Fuel distribution (eliminate roping)
- CO catalyst (expensive? unproven with coal?)
- Chemical additives
- Fuel switching or co-firing

HCl Solutions

- Desulphurization systems get HCl as co-benefit
 - Means that very low HCl is required
 - But maybe not due to health based standards
 - The answer to this will drive the solutions

- Ultimate solution: WFGD (then DFGD)

- Duct (or Dry) Sorbent Injection (DSI)
 - Trona
 - Sodium Bicarbonate
 - Hydrate

- Other chemical additives (duct or furnace)
 - Magnesium chemistries
 - Duct injection, furnace injection, or fuel additives

- Fuel switching or blending

- Wet ESPs too

Mercury Solutions

- Halogen Oxidizers
- Activated Carbon Injection
 - Can ruin ash sales and affect ESP
 - Beware high SO₃, which interferes
- Alkali injection
 - Usually as a co-benefit from other technologies
- Proprietary sorbents
 - Many in development
 - Goal is usually to preserve ash sales
- Co-benefit from acid gas reduction
 - Scrubbers (wet or dry) and DSI
 - Need oxidizers
 - Watch out for water regulations

Dioxin / Furans

- Gold standard for MSW incinerators
 - Activated Carbon Injection w/wet ESP
 - Assumed that ACI will work for coal
 - Levels are much lower than MSW
- Possible that “good combustion practices” will result in low D/F
 - D/F primarily is “grown” in the back pass
 - Eliminating precursors, reduces D/F formation
- Catalytic D/F reduction
 - Gore Remedia bags
- Co-benefit from SCR or WFGD?
- Fuel management or switching
 - Low CI or high VM?
- Not a lot of vendors providing guarantees right now
- Testing is very expensive
 - \$3k - \$5k per data point + 1 month turnaround

Other Possible Discussion Topics

- CAIR and CATR
- Possible legislative action
 - Overriding regulations
 - The House is working to cut EPA funding through an appropriations bill
- Tailoring Rule (GHG)
 - PSD permits need GHG reporting starting January 2, 2011
 - This might cause huge delays and court actions
- THE END
- Questions?