Mercury Basics: Health Effects, Chemistry, Control Strategies, States and Federal Regulations

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Northeast States for Coordinated Air Use Management (NESCAUM)

Environmental Monitoring, Evaluation, and Protection in New York:

Linking Science and Policy

October 25-26, 2005

Albany, New York

NESCAUM

Overview

- **What does NESCAUM do?**
- **Public health and environmental impacts of mercury: "monetized" benefits of mercury reductions from coal-fired electricity generating units (EGUs)**
- **Fate and transport of atmospheric mercury**
- **Control technologies and strategies for EGUs**
- **Federal and state regulations for EGUs**

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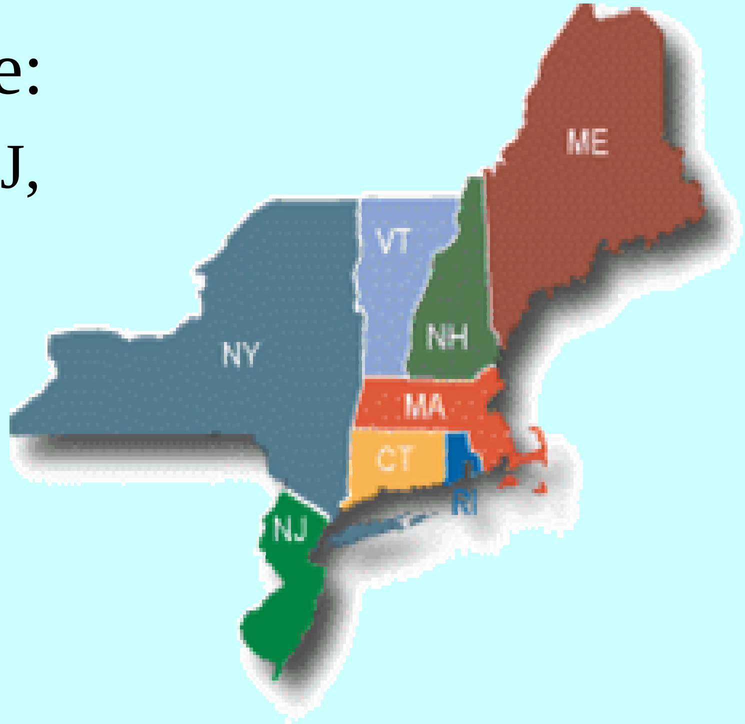
Who we are

- Our Members include:
  - CT, MA, ME, NH, NJ, NY, RI and VT



NESCAUM
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Arthur N. Marin, Executive Director

NESCAUM Report:

Economic Valuation of Human Health Benefits of Controlling Mercury Emissions from U.S. Coal-Fired Power Plants

(Work undertaken by the Harvard Center for Risk Analysis, Dr. James Hammitt and Glenn Rice; and by NESCAUM, Dr. Praveen Amar)

February 2005

www.nescaum.org

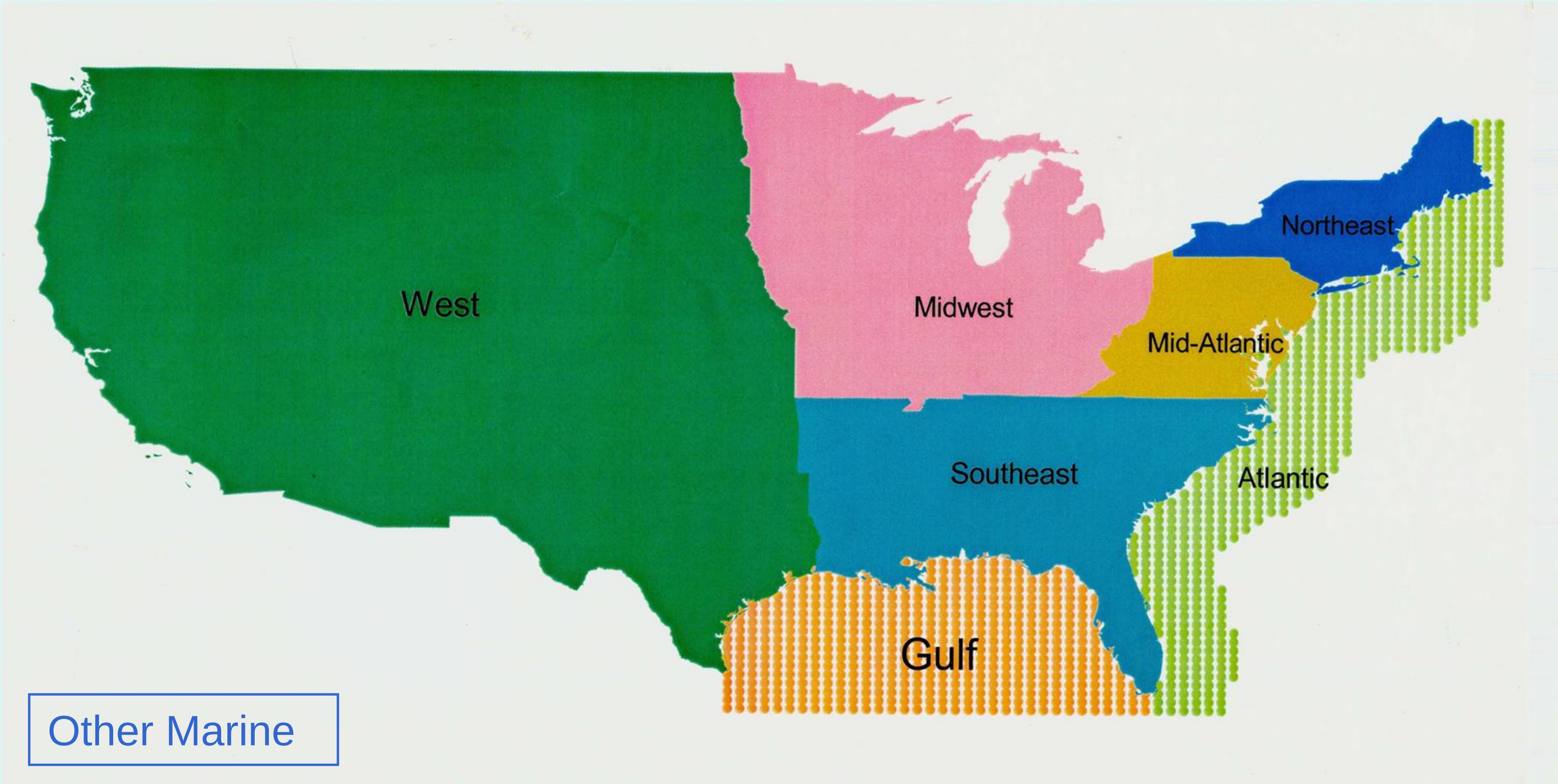
Overview Of NESCAUM REPORT

- The report covers diverse areas of policy-relevant research including:
  - Mercury emissions (including changes from coal plants), atmospheric transport and fate, modeling of Hg deposition
  - Relationship between Hg deposition and methylmercury levels in fish, current and future exposures in humans to mercury in fish
  - Dose response functions, and finally, monetization of benefits

What did this Report Monetize?

- Monetized two end points:
  - IQ of children born to mothers with high blood-Hg levels
  - Myocardial infarction and premature mortality among adults

8 Regions


West
Midwest
Northeast
Mid-Atlantic
Southeast
Atlantic
Gulf
Other Marine

Spectrum of Health Effect Certainty

	Persistent IQ deficits from fetal exposures above MeHg RfD	Persistent IQ deficits in all children from fetal MeHg exposures	Cardiovascular effects and premature mortality in male consumers of non -fatty freshwater fish with high MeHg levels	Cardiovascular effects and premature mortality in male fish consumers	Cardiovascular effects and premature mortality in all fish consumers
Scenario 1 (26 TPY)	$75M	$194M	$48M	$1.5B	$3.3B
Scenario 2 (18 TPY)	$119M	$288M	$86M	$2.3B	$4.9B

Decreasing Certainty

→

Increasing Benefit

Spectrum of Certainty of Causal Association of Health Effect with Mercury Exposure with Estimated Benefit Overlay in Millions ($M) and Billions ($B) of Dollars (2000$)

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Value of Monetized Benefits for about 70 percent control

- Annual Benefits: 200 to 300 million dollars for IQ gain
- Annual benefits: 3 to 5 Billion dollars for avoided fatal and non fatal heart attacks among adults

Science of Mercury: Emissions, Transport and Deposition: Policy Implications for Cap and Trade Approach for Mercury Control

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Scientific "Scale" of Air Pollution

- Air Pollution is
  - Local (CO, Ozone, PM, mercury)
  - Regional (Ozone, PM, SO_2, NOx, mercury)
  - Global (CFC's, CO_2, mercury)
- Key is to design control strategies that take into account relative contribution from various transport scales

Atmospheric Mercury

- Mercury is present mostly as three "species" in the atmosphere
  - Elemental mercury
    - Hg^0
  - Divalent reactive gaseous mercury
    - $HgCl_2$, $Hg(OH)_2$, HgO, etc.
    - referred to collectively as Hg^{II} or reactive gaseous mercury (RGM)
  - Particulate-bound mercury:
    - Hg^{II} or Hg^0 adsorbed on PM
    - mostly divalent
    - referred to collectively as Hg_p

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Atmospheric Deposition of Mercury

- Hg^0 is not very soluble and has a low dry deposition velocity (<0.1 cm/s)
- Hg^{II} is very soluble and adsorbs readily on surfaces: it is rapidly removed by wet and dry deposition
- Hg_p is mostly in the fine particle range and will remain in the atmosphere for several days in the absence of precipitation

Control Technologies and Strategies: Coal-Fired EGUs: Feasibility and Costs

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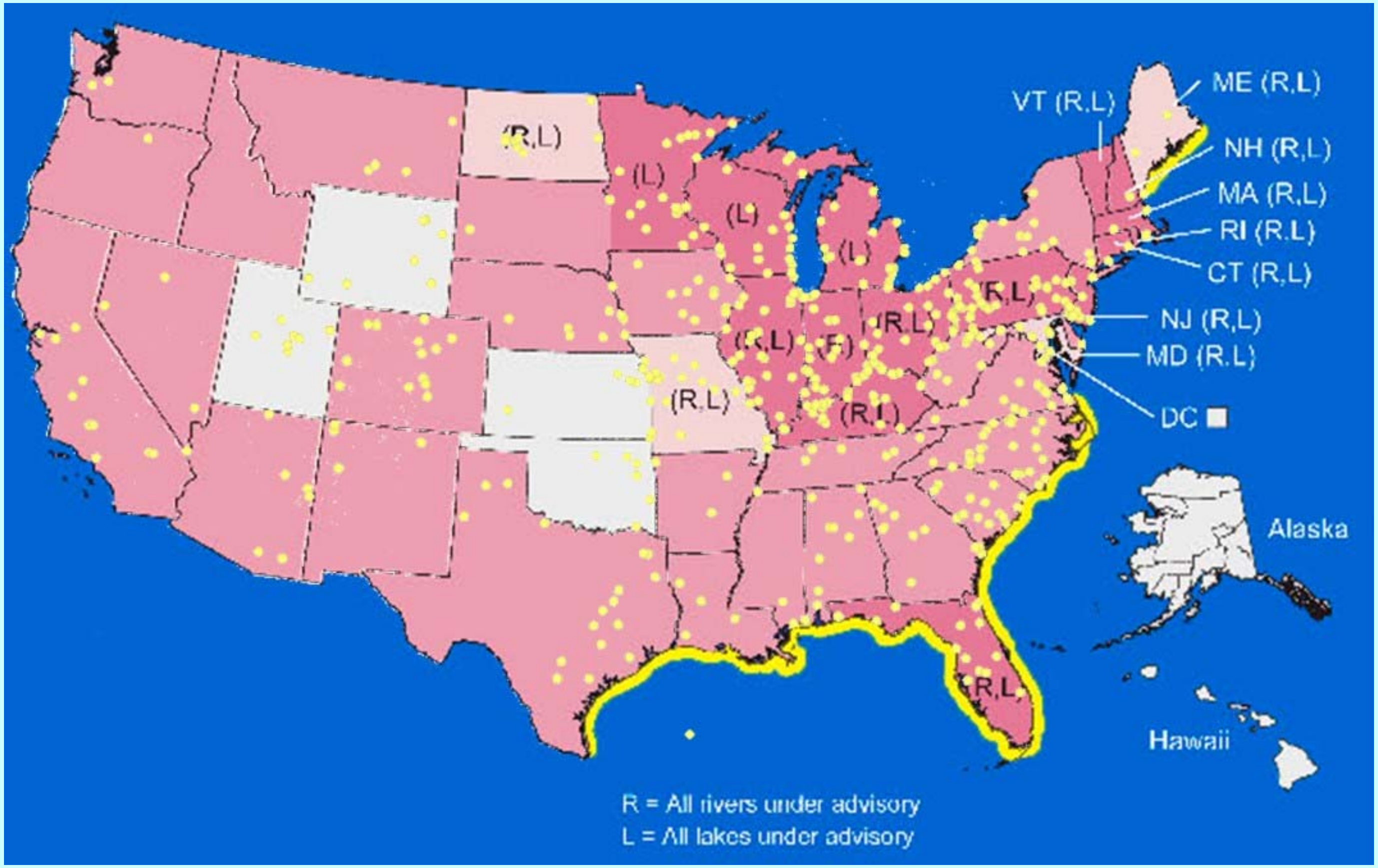
Regulatory Drivers

- **Environmental Regulation and Technology Innovation (NESCAUM's September 2000 Report)**

- **State Rules (strong drivers)**
  - NJ, CT, MA, NH(?), WI and others
- **Consent Decrees**
  - We Energies, Xcel, PSNM, Dynegy

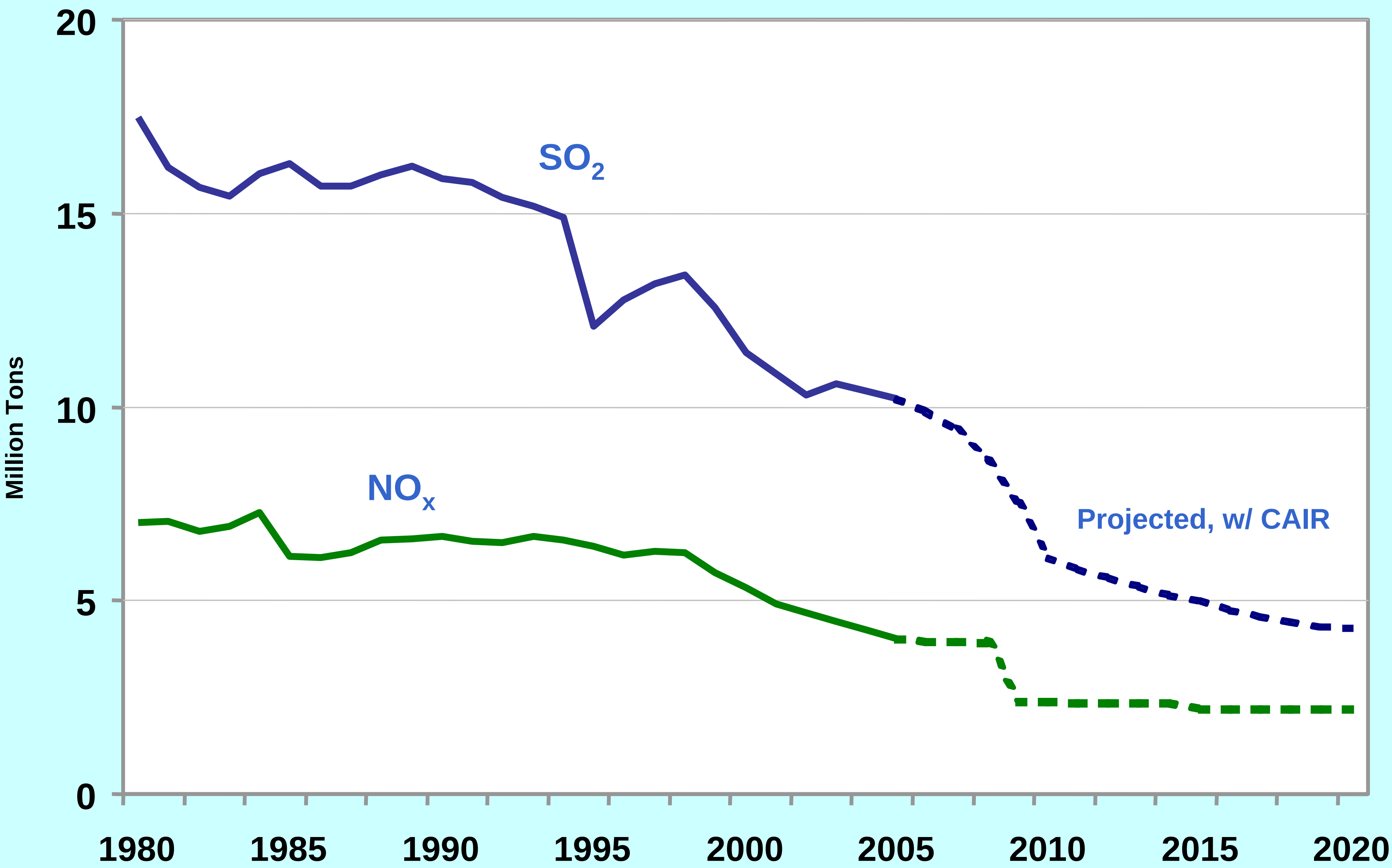
- **EPA's Clean Air Interstate Rule (CAIR), Clean Air Mercury Rule (CAMR): weak drivers for mercury**
  - 2010 Phase I cap of 38 TPY (about 20 percent reduction)
  - 2018 Phase II cap of 15 TPY (70% reduction; not achieved till 2025 and beyond because of trading)
  - States have leeway to adopt EPA's CAMR or propose a more-stringent approach

Coal-Fired Power Plants



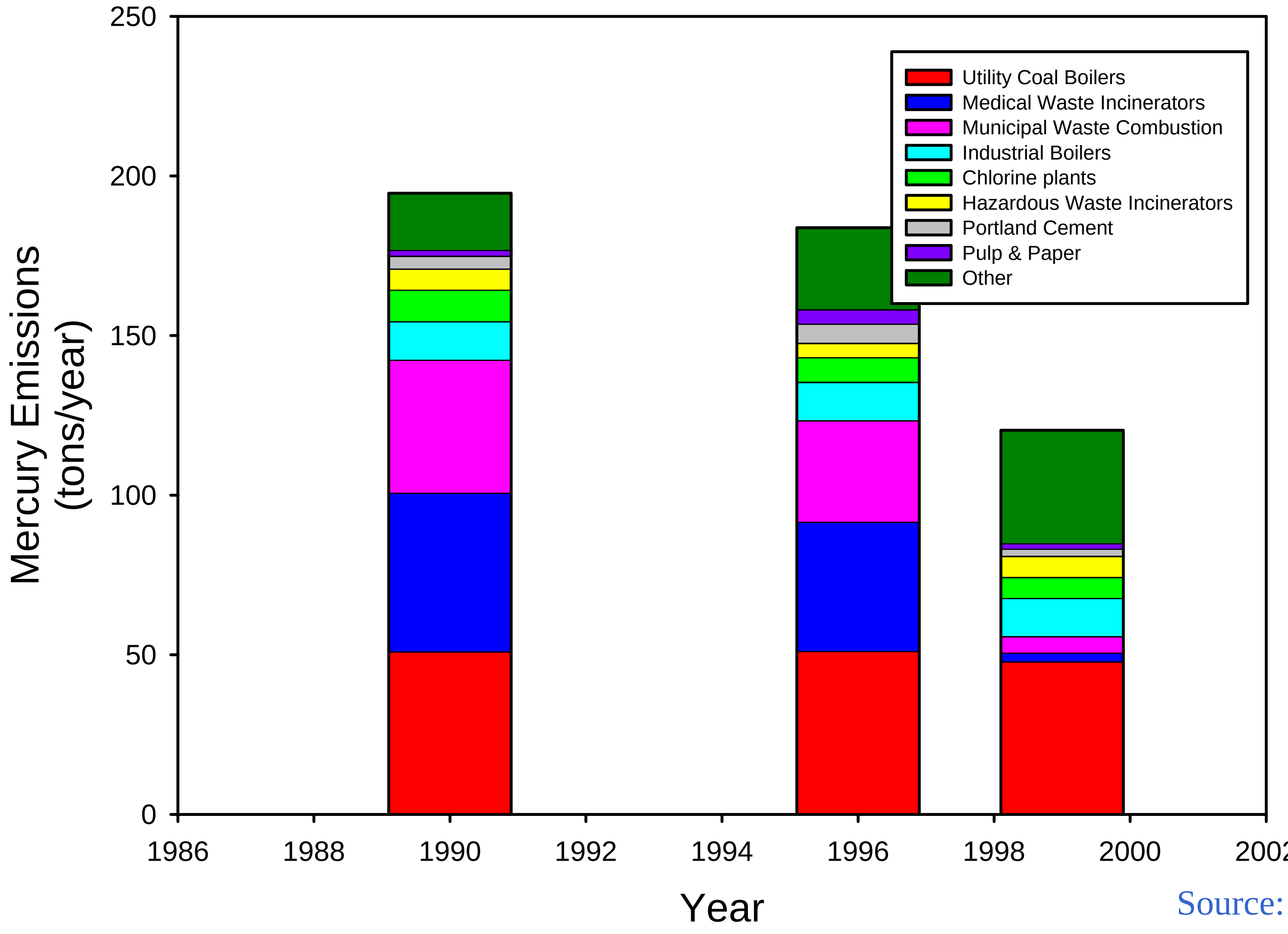
- **There are about 530 power plants with 305 gigawatts of capacity that consists of about 1,300 units, 1,150 of which are >25 megawatt.**
- **Coal plants generate the vast majority of power sector emissions:**
  - **- 100% of Hg**
  - **- 95% of SO_2**
  - **- 90% of NO_X**

National NO_x and SO_2 Power Plant Emissions: Historic and Projected with CAIR



Source: EPA

Total U.S. Mercury Emissions by Source Category



Source: U.S. EPA

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Native or Baseline Mercury Capture

- **Mercury emissions vary with:**
  - **Coal type and mercury content**
  - **Trace species present in coal/flue gas**
  - **Mercury form in the flue gas**
  - **Unburned carbon (Loss on Ignition, LOI)**
  - **Unit configuration**
  - **Control devices (FF, SCR, FGD, SDA) and operating temperatures**

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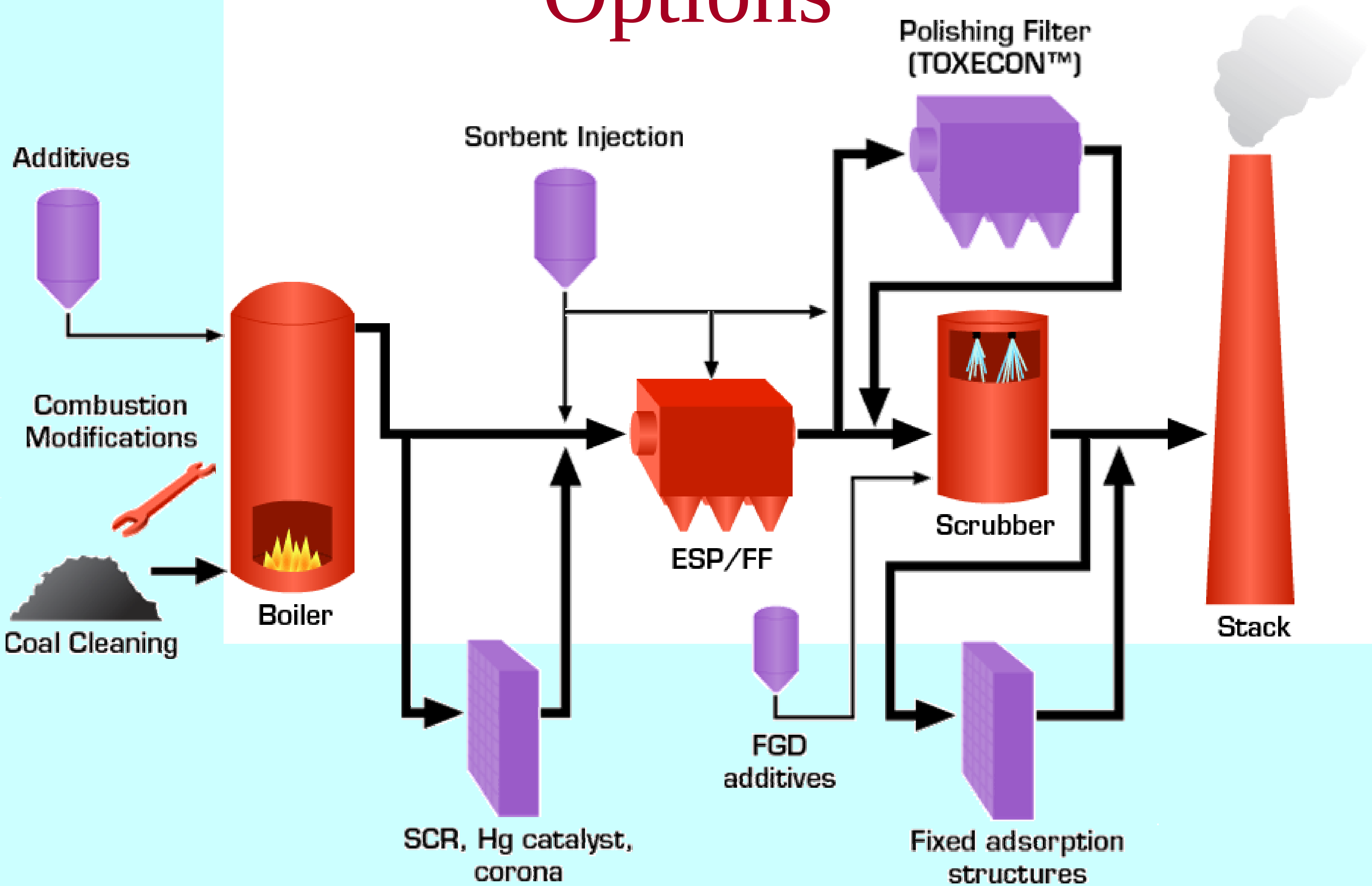
Native Hg Capture with Existing Control Equipment(1999 ICR Data)

Controls	Bituminous	Subbituminous
PM Only		
CS-ESP	46%	16%
HS-ESP	12%	13%
FF	83%	72%
PM Scrubber	14%	0%
Dry FGD		
SDA + ESP		38%
SDA + FF	98%	25%
Wet FGD		
CS-ESP+Wet FGD	81%	35%
HS-ESP+Wet FGD	55%	33%
FF+Wet FGD	96%	

Power Plant Mercury Control Options



Full-Scale Tests of Sorbent Injection Completed: 2001-2004

	Site	Coal	Equipment
1.	Gaston 1 month	Low-S Bit	FF
2.	Pleasant Prairie	PRB	C-ESP
3.	Brayton Point	Low-S Bit	C-ESP
4.	Abbott	High-S Bit	C-ESP/FGD
5.	Salem Harbor	Low-S SA Bit	C-ESP
6.	Stanton 10	ND Lignite	SDA/FF
7.	Laskin	ND Lignite	Wet P Scrbr
8.	Coal Creek	ND Lignite	C-ESP
9.	Gaston 1 year	Low-S Bit	FF
10.	Holcomb	PRB	SDA/FF
11.	Stanton 10	ND Lignite	SDA/FF
12.	Yates 1	Low-S Bit	ESP
13.	Yates 2	Low-S Bit	ESP/FGD
14.	Leland Olds	ND Lignite	C-ESP
15.	Meramec	PRB	C-ESP
16.	Brayton Point	Low-S Bit	C-ESP

(Source: ADA-ES)

Full-Scale Tests of Sorbent Injection Scheduled: 2005-2006

Site	Coal	Equipment
1-6 Commercial Tests	Low-S Bit	ESP
7. Laramie River	PRB	SDA/ESP
8. Conesville	High-S Bit	ESP/FGD
9. DTE Monroe	PRB/Bit	ESP
10. Antelope Valley	ND Lignite	SDA/FF
11. Stanton 1	ND Lignite	C-ESP
12. Council Bluffs 2	PRB	H-ESP
13. Louisa	PRB	H-ESP
14. Independence	PRB	C-ESP
15. Gavin	High-S Bit	C-ESP FGD
16. Presque Isle	PRB	HS-ESP TOXECO

(Source: ADA-ES)

Weekly, Average Mercury

Week Starting	Inlet Mercury ($\mu g/m^3$)	Outlet Mercury ($\mu g/m^3$)	Mercury Removal (%)	Standard Deviation Hg Removal
7/20/03	9.2	0.8	91	6.5
7/27/03	11.8	0.8	93	3.6
8/3/03	18.1	1.6	91	4.5
8/10/03	13.0	1.6	87	10.7
8/17/03	14.9	2.0	86	12.0
8/24/03	13.9	2.9	79	6.3
8/31/03	13.2	1.7	87	5.7
9/7/03	13.1	2.3	82	6.3
9/14/03	16.7	3.8	77	10.6
9/21/03	11.8	1.9	83	7.3
9/28/03	11.3	1.1	90	1.6
10/5/03	15.8	2.1	86	6.3
10/12/03	15.8	3.1	80	8.7
10/19/03	11.6	1.6	86	6.2
10/26/03	15.2	3.5	77	14.6
11/2/03	19.2	2.4	87	6.6
11/9/03	17.6	3.2	82	6.5
11/16/03	14.9	1.9	87	7.1
Overall Average	14.3	2.1	**85.6%**	

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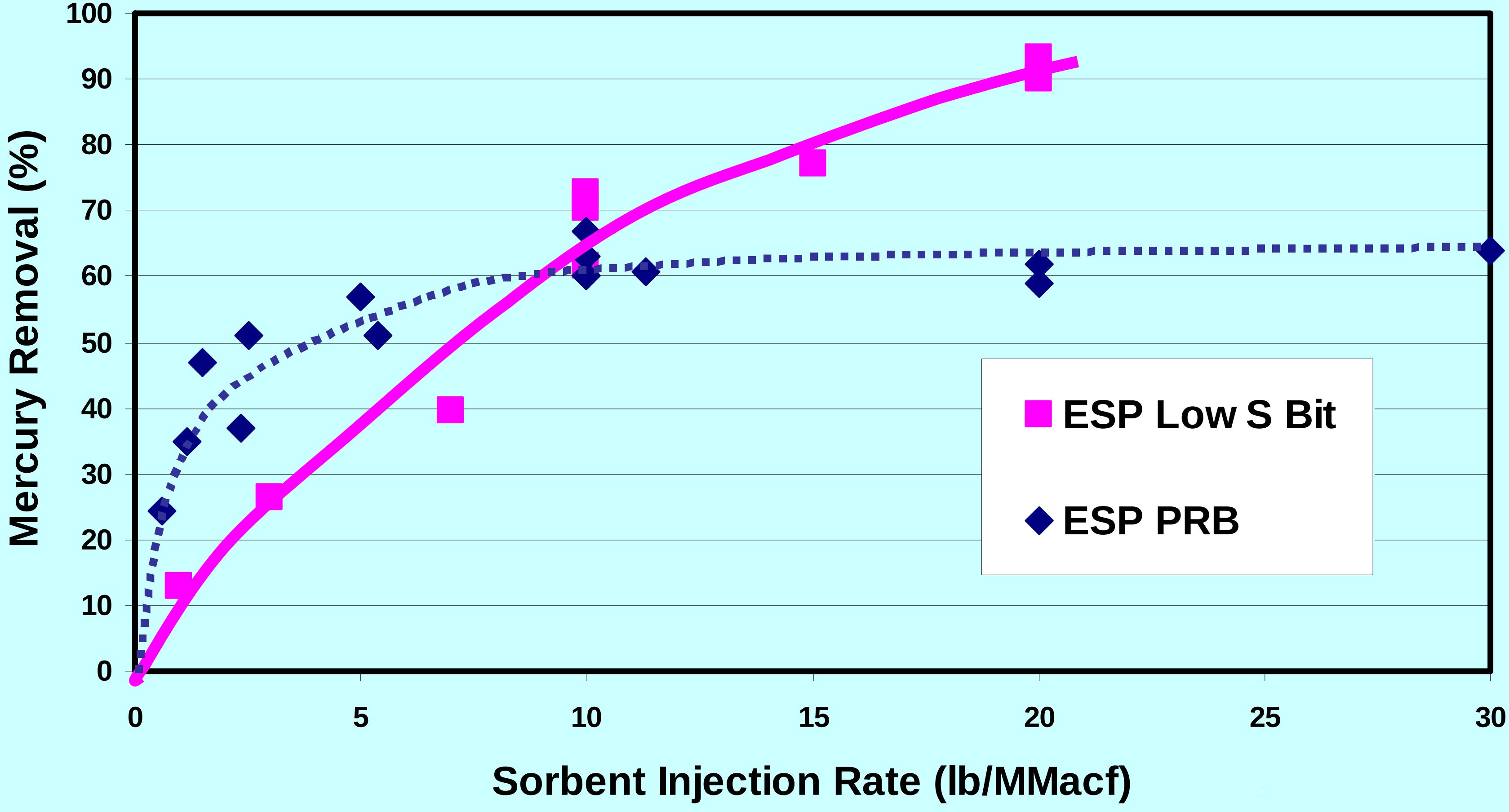
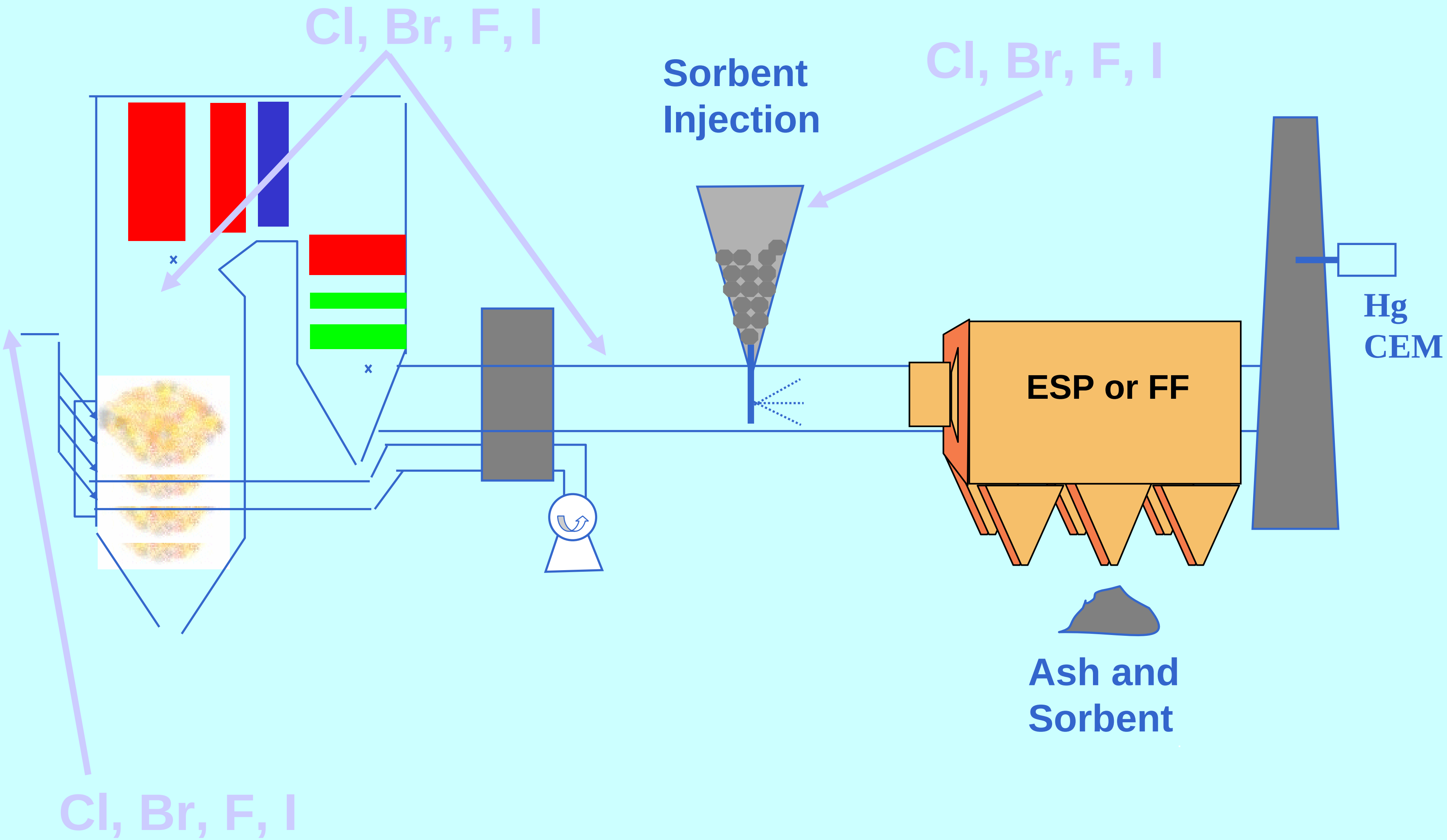
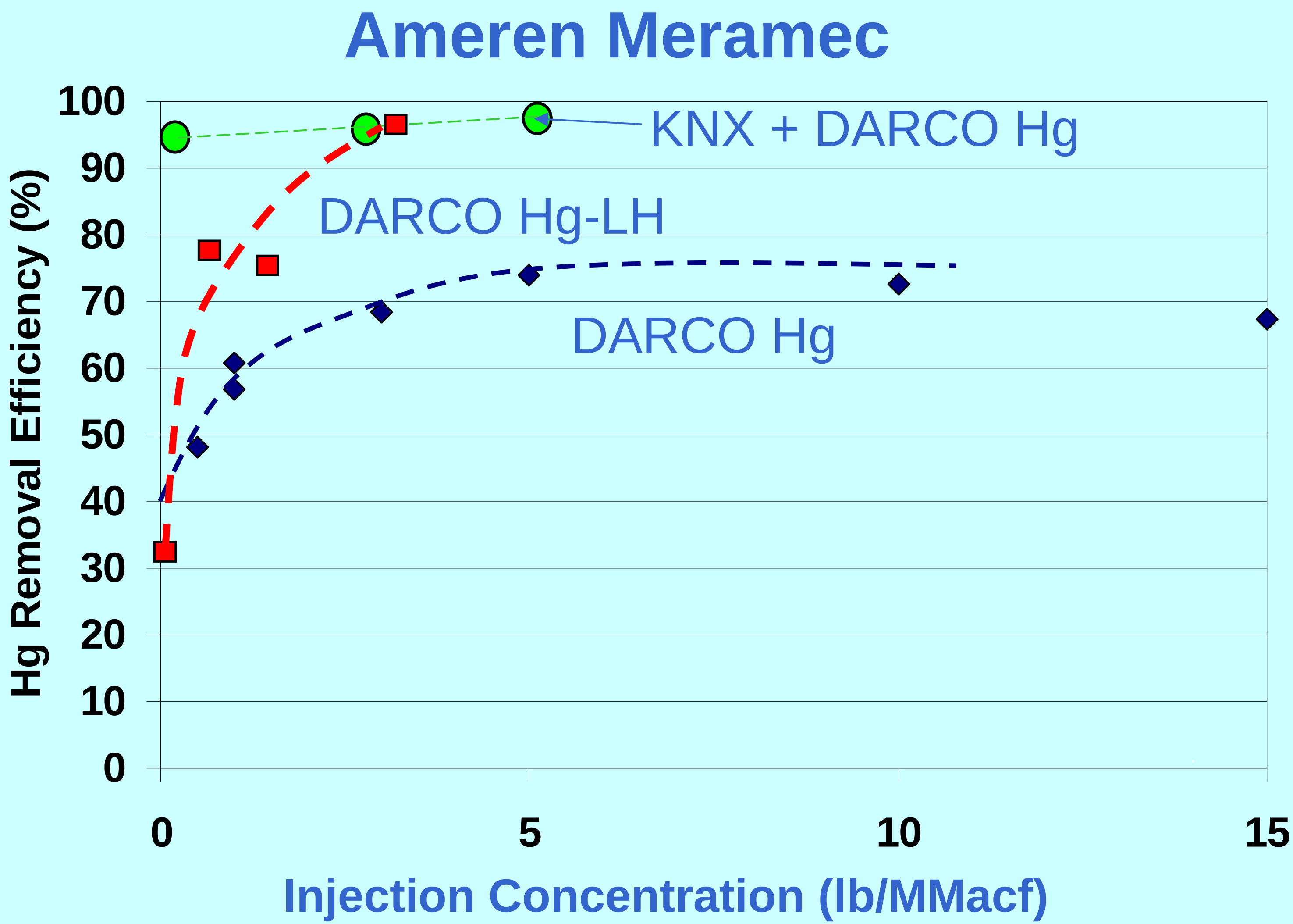
Limited Hg Capture by ACI on Western Coals



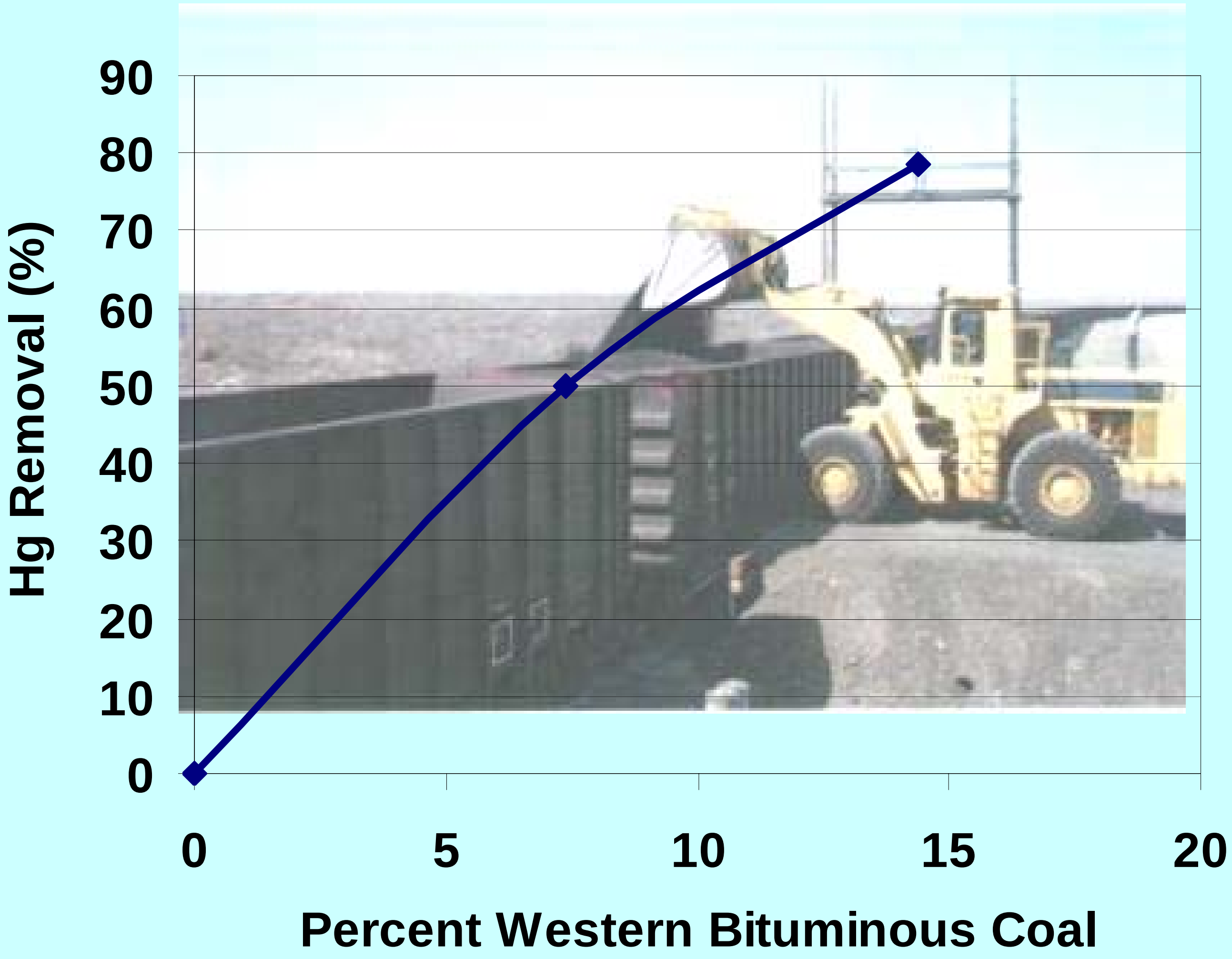
Enhancing Mercury Removal for Western Coals



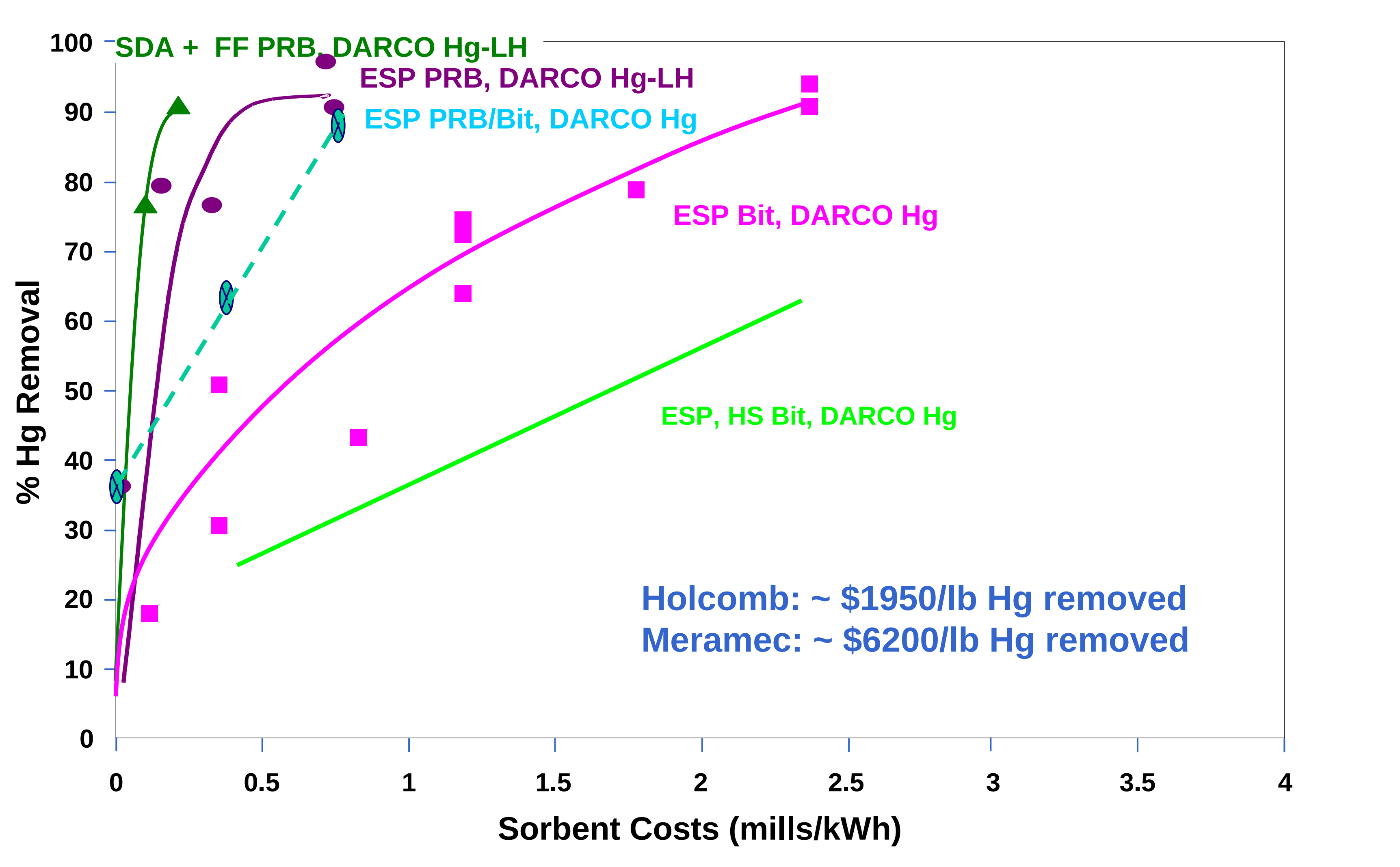
Enhancing Mercury Removal on Units with only an ESP Burning PRB Coal



Improved Mercury Capture with Coal Blending: Holcomb

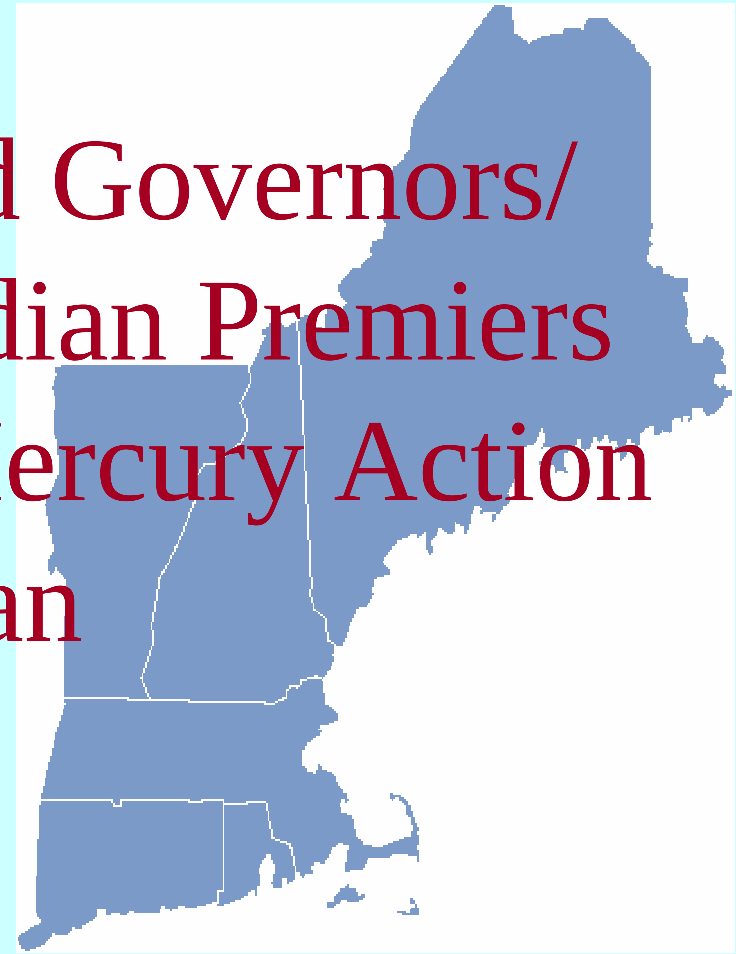


Sorbent Cost Comparison



Regulatory Landscape: State and Federal Mercury Regulations, Rules, Legislation

New England Governors/ Eastern Canadian Premiers (NEG/ECP) Mercury Action Plan



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Mercury Policy Context in the Northeast

- New England Governors/Eastern Canadian Premiers' Regional Mercury Action Plan (1998)
  - 50% reduction by 2003
  - 75% reduction by 2010
  - Virtual elimination of anthropogenic discharges of mercury is long-term goal

Examples of State Activity

State	Program
Connecticut	90% control by 2008 (state law)
Massachusetts	85% reduction in Hg emissions by 2008 and 95% by 2012 (state rule)
Wisconsin	40% reduction in Hg emissions by 2010 and 75% by 2015 (approved plan)
New Jersey	90% reduction in Hg emissions by 2007 (state rule)
North Carolina	55% reduction in Hg emissions by 2013 expected; recommendations for additional reductions (NC Clean Smokestacks Act)
New Hampshire	58% reduction in Hg emissions (cap of 50 lbs/year) 1 year after federal compliance dates; 80% reduction (cap of 24 lbs/year) 4 years later (departmental recommendations to legislature)
New England Governors & Eastern Canadian Premiers	50% reduction in Hg by 2003; 75% reduction by 2010; virtual elimination of anthropogenic discharges long term (Mercury Action Plan)

Smart Regulatory Drivers' Components

1. Long-term averaging (annual)
2. Dual limit: less stringent of:
   - Removal efficiency **or**
   - Emission limit (output based, lb of Hg/MWhr)
3. Flexibility in achieving mercury removal
   - Averaging of units at a site
   - Enhances cost effectiveness

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Some Observations on Policy

- Many states in the U.S. are moving at a faster and a more certain pace than the CAMR, based on the assumption that environmental regulation drives technology innovation and implementation
- Hg Control technologies are now commercially available; new technologies are rapidly emerging; 90% and higher control is feasible
- Cost effectiveness of Hg control is quite comparable to, and more attractive than, the cost effectiveness of SO_2 and NOx controls from power plants (Hg:SO_2:NOx: 0.2 to 1mills/kwhr: 3-5 mills/kwhr: 2-3 mills/kwhr)

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This Session: Science and Policy Issues Related to Mercury in the Environment

- Hg in the atmosphere: Tom Holsen
- Hg modeling: Russ Bullock
- Mercury in Adirondack watersheds: Charley Driscoll
- Mercury in the coastal environment: Bill Fitzgerald
- Ecological impacts/bio indicators and fish: Nina Schoch and Howard Simonin
- Emission reduction strategies and their impacts: Karen Palmer