States Programs on Coal-Fired Utility Mercury Controls and Measurements; Status of Utility Mercury Control Technologies

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2009 Mercury Science and Policy Conference, Chicago
November 17-18, 2009

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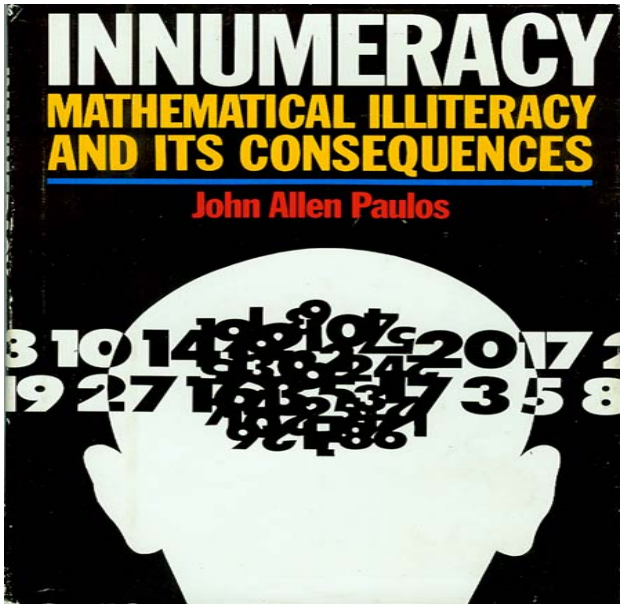

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Overview

- What does NESCAUM do?
- Status of the federal MACT (Maximum Achievable Control Technology) Rule
- Current States mercury regulations and where they may be headed
- Current Status of mercury CEMS for EGUs
- A new EPA-funded NESCAUM Study with Reaction Engineering International (REI), Energy and Environmental Strategies (EES), and Andover Technology Partners (ATP)

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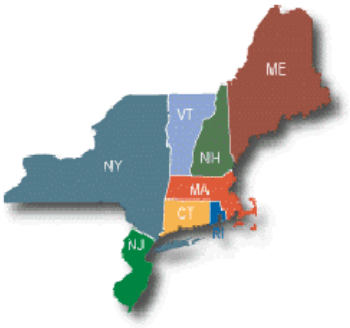
Who we are

- Our Members include:
  - Connecticut
  - Massachusetts
  - Maine
  - New Hampshire
  - New Jersey
  - New York
  - Rhode Island
  - Vermont



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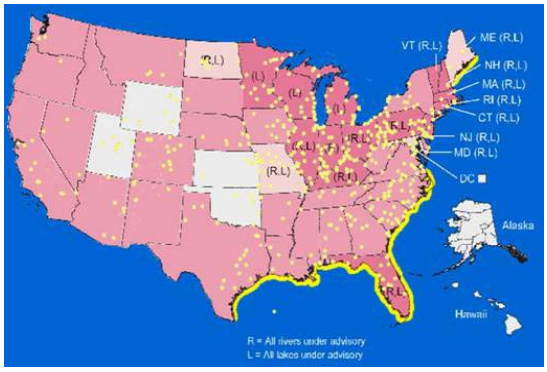
Coal-Fired Power Plants



- There are about 530 power plants with 305 GW of capacity (56% of GWhr). The capacity consists of about 1,300 units, 1,150 of which are >25 megawatt. They burn 1 billion TPY of coal; 40% is PRB coal
- Coal plants generate the vast majority of power sector emissions:
  - 100% of Hg
  - 95% of SO2
  - 90% of NOX

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EPA CAMR/MACT Rule and States Mercury Control Rules

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In 2009: Status of Federal Regulations

- Federal cap-and trade program for mercury vacated by U.S. Appeals Court (D.C. Circuit) – February 2008
- After nine years, it is once again "appropriate and necessary" to regulate mercury emissions from coal-fired power plants under Section 112 of the CAA
- The new EPA Administration is developing MACT standard(s) for Hg and other HAPs (the "twelve-percent solution")
- Section 114 Information Collection Request (ICR): the process has started
- EPA to promulgate final MACT standards for *all HAPs* including mercury by no later than November 16, 2011
- Final federal regulations will affect *all* states, including the ones that already have current state rules in place

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Where are the States?

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In 2009: Where are the States?

- At least nineteen states have passed laws or regulations requiring emission reductions
- Compliance schedules vary (one-phase; two-phase); 2008 to 2012 to 2014 timeframe
- Some state rules include compliance flexibility if multi pollutant controls applied
- Percentage reductions from 85 to 95 percent
- Emission limits (0.25 to 0.6 to one lb/TBtu input) or output-based limits in lb/GW-hr
- Five states currently require reductions: Connecticut, Delaware, Illinois, Massachusetts, and New Jersey
- No interstate trading allowed; system averaging allowed in some states
- Mercury monitoring requirements in the absence of vacated Part 75 requirements vary widely. Monitoring data hard to obtain

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State Rules Example: Massachusetts

- ❑ **Adopted rule**
- ❑ **85% capture or 0.0075 #/GWh by January 1, 2008**
- ❑ **95% capture or 0.0025 #/GWh by October 1, 2012**
- ❑ **No interstate trading**

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State Rules Example: New Jersey

- Adopted Rule
- 3.00 mg/MWh or 90% control across control device as of December 15, 2007 (one year extension possible)
- Multi-pollutant control option--December 15, 2012;
  - Emission rate limits for SO2, NOx, and PM
  - 50% of MW controlled for mercury by 12/15/2007; 100% by 12/15/2012
  - If necessary, one additional year for optimization of control systems
- No interstate trading

"Scientific" Scales of Air Pollution

- **Air Pollution is a "Mixture" of Scales**
  - **Local** (CO, ozone, SO2, PM, **mercury**); hot spots
  - **Regional** (ozone, PM, NOx, **mercury**, acid deposition, regional haze); warm to hot spots
  - **Global** (CFC's, CO_2, **mercury**, methane, "background" ozone), "not so hot" cool spots
- **Mercury is not just global**

"Scientific" Scales of Air Pollution

- **Key is to design Hg control strategies that take into account relative contributions from various transport scales (local, regional, global)**

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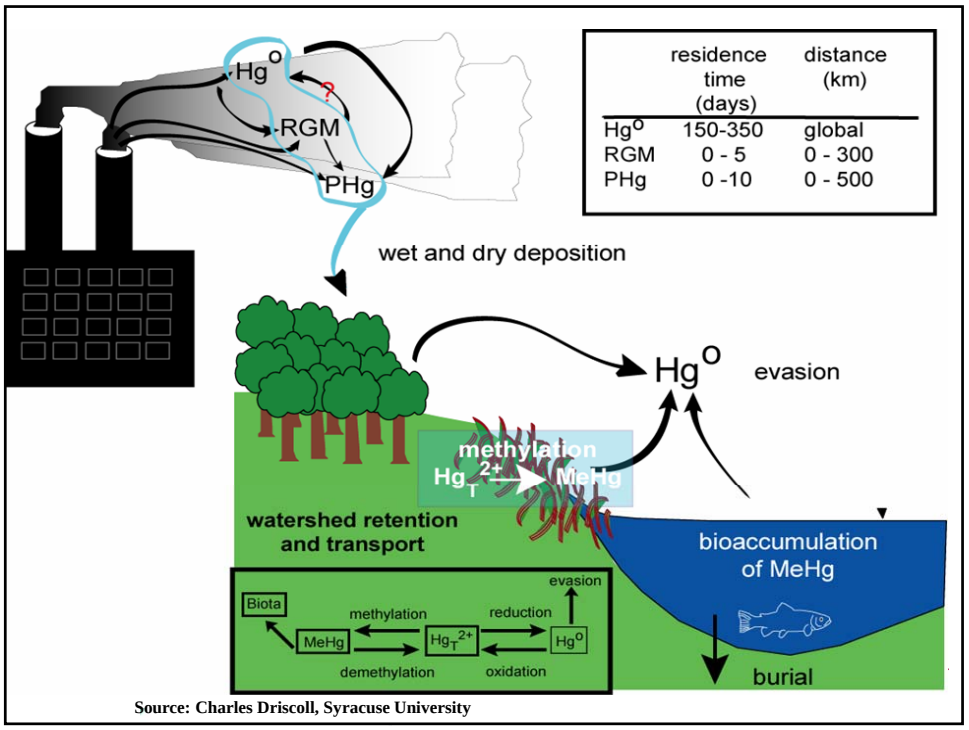

	residence time (days)	distance (km)
Hg^0	150-350	global
RGM	0 - 5	0 - 300
PHg	0 -10	0 - 500

Source: Charles Driscoll, Syracuse University

In Search of 90% and Beyond Capture

- *NESCAUM is currently undertaking an EPA-funded study to assess the status of mercury measurement technologies (Hg CEMS and sorbent traps) and*
- *to assess the status of mercury control technologies, strategies, and costs*
- *What are the technology/strategy options and can they achieve 90% and higher mercury capture?*
- *When high level of controls may not be feasible and why?*
- *Potential approaches*

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In Search of 90% and Beyond Capture

- *GAO October 2009 report notes, on average, 90 percent reduction with sorbent injection*
- *Fourteen coal-fired plants; twenty-five boilers with commercial deployment*
- *Commercial deployment of sorbent technology is wide spread (Illinois, New Jersey, Massachusetts, Connecticut, Delaware, Michigan, Nevada, Iowa, and Wisconsin)*
- *"Co-benefit" strategies chosen at six plants to meet state requirements (New Jersey, Massachusetts, Connecticut)*
- *GAO notes that "12-percent approach" with new field data results in 96 percent reduction compared to 91 percent reduction based on 1999 ICR data*

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In Search of 90% and Beyond Capture

1. Capture oxidized Hg in SO_2 FGDs (scrubbers)

- Requirements for presence of high levels of oxidized Hg:
  - High native chlorine in coal
  - SCR with moderate chlorine in coal
  - Dedicated Hg oxidation catalysts
  - Oxidation additives to fuel or to boiler (e.g. bromine)

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2. Capture Hg in fly ash in fabric filters

- Requirements for high levels of capture in fabric filter:
  - High level of oxidized Hg (or addition of chlorine)
  - Lower operating temperature for FF
  - Moderate levels of unburned carbon in ash

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In Search of 90% and Beyond Capture

3. Activated Carbon Injection (ACI)

- Requirements for high levels of mercury capture by activated carbons:
  - Cold-side ESP, fabric filter or spray dryer
  - Low concentrations of SO_3 in flue gas
  - Lower temperatures after air preheater

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"Substantial Mercury Reductions Have Been Achieved Using Sorbent Injection Technology...but Some Plants May Require Alternative Strategies to Achieve Comparable Results"

- GAO Report to Congress, October 8, 2009

- Certain configurations have fallen short of 90% reduction in demonstration tests:
  - **High SO_3 in the flue gas interferes with activated carbon injection, either from**
    - High-sulfur bituminous coal with or without SCR
    - Low-sulfur coals with SO_3 injection for flue gas conditioning
  - **Hot-side electrostatic precipitators**
  - **Lignite-fired plants**

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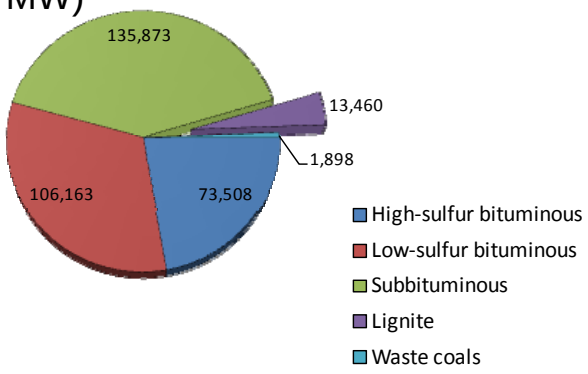
Challenges: Lignites

- Lignite plants represent about 4% of US capacity (in MW)



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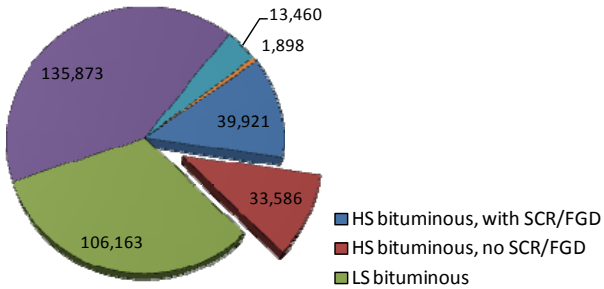
Challenges: Sulfur Trioxide

- High-sulfur bituminous plants without SCR/FGD represent ~10% of US capacity (in MW)



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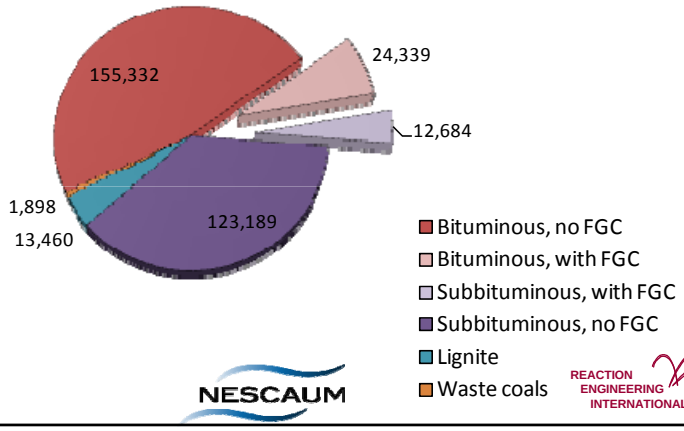
Challenges: Sulfur Trioxide

- Plants with Flue Gas Conditioning represent ~11% of US capacity (in MW)



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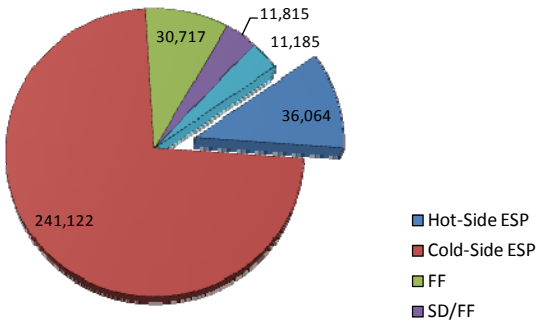
Challenges: Hot-Side ESPs

- Plants with Hot-Side ESPs represent ~11% of US capacity (in MW)



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Meeting the Challenges

Are there near-term technologies to achieve 90%+ on difficult-to-control configurations?

- **High-sulfur bituminous coal without SCR/FGD**
  - Addition of FGD and FGD additives to reduce Hg^0 re-emission
  - Still might not reach 90%, esp. without SCR
- **Low-sulfur coals with SO_3 injection for flue gas conditioning**
  - Install baghouse after ESP; ACI in baghouse
- **Hot-side electrostatic precipitators**
  - Install baghouse after APH; ACI in baghouse
- **Lignite-fired plants**
  - SD/FF with ACI and MerCure technology have demonstrated 90%

- These solutions are more expensive than ACI with ESP

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Recent Cost Data on Sorbent-Based Controls

- Recent published cost estimates for Hg removal
- Variation with level of removal, coal, APCD

APCD	Coal	Hg removal	Sorbent	$/lb Hg removed	Reference
C-ESP	E.Bitum.	70%	B-PAC	$10,300	Nelson et al., 2006 (Lausche)
C-ESP	PRB	70%	B-PAC	$3,700	Nelson et al., 2006 (St. Clair)
C-ESP	PRB	90%	B-PAC	~$10,000	Nelson et al., 2006 (St. Clair)
C-ESP	PRB	90%	DARCO Hg-LH	$6,200	Sjostrom et al., 2006 (Meramec)
SDA/FF	PRB	90%	DARCO Hg-LH	$1,950	Sjostrom et al., 2006 (Holcomb)
SDA/FF	Lignite	70%	DARCO Hg	$8,600	Hill Brandt et al., 2006 (Antelope Valley)

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Where are the States on Mercury CEMS and Sorbent Traps ?

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Electronic Survey Questions to States on Hg CEMS/Sorbent Traps

1. How many Hg CEMs and Sorbent Trap Systems have been PURCHASED by coal-fired EGUs in your state?
2. How many Hg CEMs and Sorbent Trap Systems are currently INSTALLED (not just purchased) at coal-fired EGUs in your State?
3. Who are the vendors of the HG CEMs or Sorbent Trap Systems (for example, ThermoFisher or Terkran Instruments or others)?
4. How many Hg CEMs and Sorbent Trap Systems are currently actually OPERATING and collecting mercury data?
5. For how long have these Hg CEMs and Sorbent Trap Systems been operating? Since 2008? Since 2009?
6. Are the measurement data from Hg CEMs and Sorbent Trap Systems being reported to the state under your permitting programs?
7. Have the EGU sources provided the state with data on "reliability" and "availability" of the Hg CEMs and Sorbent Trap Systems currently in operation?

Source: Email from Mary Sullivan Douglas (NACAA) to the NACAA Air Toxics Committee, June 25, 2009

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Information Received from States

		Number Purchased	Number Installed	Number Operating	Technology Vendors	Operating since when?	Data reported to state?	Is "reliability" or "availability" data reported?
AZ	CEMs	10	4	2-3, intermittent	TF (4) Tek (2)	2008 and 2009	NO	NO
	STs	11	6					
CO	CEMs	10[1]	7	7	TF, Tek	2006 (1) 2007 (1) 2008 (5)	YES[2]	YES[3]
	STs	3	3	3	FG ?	2008 (3)		
DE	CEMs	6	6	6	TF (2) Tek (4)	2008	NO	NO
	STs	NA	NA	NA	NA	NA		
Jacksonville, FL	CEMs	4	4	4	NA	2008 (2) 2009 (2)	YES	NA
	STs	NA	NA	NA	NA	NA		
GA	CEMs	21	21	21[4]	TF	2008	NO	Discussions only--no data submitted
	STs	1[5]	NA	NA	NA	NA		

Notes:

[1] 1 of CO's 10 CEMs is installed on an EAF; 3 are planned for reconstructed or modified units and may not yet be purchased.

[2] Reported quarterly beginning 2009.

[3] All required reporting except for NIST Traceability Protocol.

[4] Operating with a reduced QA frequency: system checks monthly or quarterly; RATAs every 2 years

[5] The ST is planned, but may not be purchased yet.

TF = ThermoFisher
Tek = Tekran
FG = Frontier Geosciences
CAE = Clean Air Engineers
NA = No Answer Provided
? = Responder unsure

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Information Received from States

		Number Purchased	Number Installed	Number Operating	Technology Vendors	Operating since when?	Data reported to state?	Is "reliability" or "availability" data reported?
IL[6]	CEMs	~23	~23	?	TF (11) Tek(13)	?	NO	NO
	STs	~3	~3	?	?	?		
MD	CEMs	17	11	11	TF (14) Tek (3)	2008 (3) 2009 (14)	YES	YES
	STs	9	7	7	Apex (2)	2008 (2) 2009 (6)		
MA	CEMs	4	4	4	TF (3) Tek (1)	1/1/08	YES	YES
	STs	3	3	3	CAE (3)	1/1/08		
MI	CEMs	~23	~23	~23	Tek, TECO	2008	NO	NO
	STs	~16	?	?	NA	NA		
MN	CEMs	6	6	6	TF (6)	7/2009	YES	YES
	STs	NA	NA	NA	NA	NA		

Notes:

[6] IL data was drawn from 2009 testimony of several power generation companies on the IL EPA's rulemaking on mercury monitoring at large combustion sources

TF = ThermoFisher
Tek = Tekran
FG = Frontier Geosciences
CAE = Clean Air Engineers
NA = No Answer Provided
? = Responder unsure

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Information Received from States

		Number Purchased	Number Installed	Number Operating	Technology Vendors	Operating since when?	Data reported to state?	Is "reliability" or "availability" data reported?
NC	CEMs	12	3	3	TF	2008	YES[7]	NO
	STs	NA	NA	NA	NA	NA		
NY	CEMs	3	3	3	Tek	2008	YES	YES[8]
	STs	1	1	1	?	2008		
PA	CEMs	~35	All	?	TF (2) Tek (~33)	some 2008 some 2009	NO	NO
	STs	~4	All	?	Apex (All)			
SC	CEMs	10	10	10	TF (8) Tek (2)	2006 (2) 2008 (1) 2009 (4)	YES[9]	YES
	STs	3	3	3	Apex (3)	2009 (2)		
VA	CEMs	12	10	0[10]	TF (6) Tek (6)	2008 (some) 2009 (some)	NO	NO
	STs	NA	NA	NA	NA	NA		

Notes:

[7] Data used to report CY2008 Hg estimates as part of Annual Air Emissions Inventorying required in the air permit.

[8] The NIST Traceability Protocol will be followed when it becomes available. All other RATA procedures are followed.

[9] Data is reported to the state, but not under permitting requirements. It is submitted as part of a MOA between SC and the Utilities.

[10] Some may be operating, but none are operating full-time.

TF = ThermoFisher
Tek = Tekran
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NA = No Answer Provided
? = Responder unsure

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State Summary	
Number of states surveyed	14
Number of cities surveyed	1
States/city collecting Hg data	8
States collecting reliability/availability data	6

Hg CEM Prevalence	
CEMs Purchased	184
CEMs Installed	170
CEMs Operating	98

ST Prevalence	
STs Purchased	54
STs Installed	30
STs Operating	17

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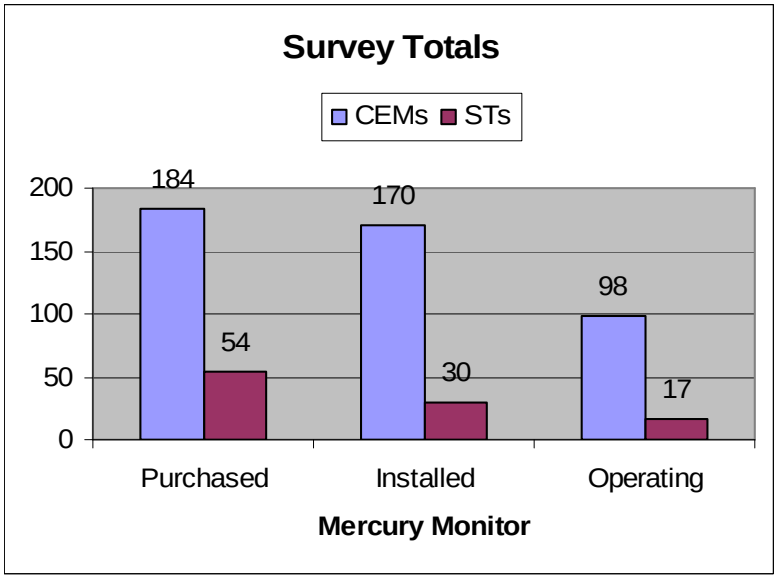

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Availability of Hg CEMS at Dominion Brayton Point Power Plant (Mass)

(CMR 7.29 Compliance Report, February 6, 2009)

Dominion Energy Brayton Point, LLC
2008 Hg CEM Availability

		1	2	3	4	Overall
Unit 1	Operating Hours	1536	2076	2102	2159	7873
	Out of Service Hours	96	223	87	52	458
	Quarter Availability, %	93.7	89.3	95.9	97.6	94.2
	Year to Date Availability, %	93.7	91.17	92.89	94.2	
Unit 2	Operating Hours	2184	2116	1994	2208	8501
	Out of Service Hours	140	123	415	346	1024
	Quarter Availability, %	93.6	94.2	79.2	84.3	88.0
	Year to Date Availability, %	93.6	93.88	89.23	88.0	
Unit 3	Operating Hours	2170	1422	1929	2072	7592.75
	Out of Service Hours	359	253	55	104	771
	Quarter Availability, %	83.5	82.2	97.1	95.0	89.8
	Year to Date Availability, %	83.5	82.96	87.92	89.8	

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Availability of Sorbent Traps for Dominion Salem Harbor Units 1, 2, 3 CMMs (Mass)

	Unit 1	Unit 2	Unit 3
Online Operating Hours	5,922	6,209	3,620
Monitored Hours	5,263	5,587	3,480
Total Operating Hours of Downtime	659	622	140
Availability	89%	90%	96%
Missing data caused by:			
Monitor Not Operated[1]	269	82	0
Monitor Malfunction/Maintenance	12	74	129[3]
Trap QA/QC[3]	360	429	0
Trap Change out	5	17	3
Monitor Calibration	13	12	8

Notes:

1. Early on in the monitoring program the monitor operating parameters (e.g. vacuum, trap flow) were not well enough understood to use as predictive information to change out traps in a timely manner to avoid the monitor shutting down on its own. Automated alerts were not sufficient. The issue has since been resolved.
2. One recurring maintenance issue caused the bulk of this downtime. The issue has since been resolved.
3. Initially the sorbent traps were not able to sample for longer than three days due to a loss of spike recovery. In June of 2008 we worked with the trap vendor to improve the design of the traps which allowed the duration of the run to increase. Subsequently, data loss due to trap QA/QC has been greatly reduced.

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Some Final Observations on Coal-Fired Utility Mercury Controls

- Many (but not all) states in the U.S. are, moving at a faster and a more certain pace than the federal CAMR(as was proposed) or potential Utility MACT Rule, based on the assumption that smart environmental regulations drive technology innovation and implementation
- Hg control technologies for power plants are now commercially available; new technologies are rapidly emerging; 90% and higher control is feasible at most plants

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Some Final Observations continued…

- Small cost savings (if any) of emission trading-based approaches are not worth the forgone benefits to the general public associated with lowered risks of “cooled” hot spots (fish or human exposure)
- Mercury is not just about the averages – hot spots (emissions, deposition, biological (fish), and exposure (people)) need to be considered and have been considered in state regulations

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Some Final Observations continued…

- Many HG CEMS and sorbent trap systems are currently operating in a number of states
- These states have mercury regulations in place
- The Hg CEMS and sorbent trap data are NOT readily available to states under current regulatory regimes
- It appears that mercury stack tests will be used in the interim (one to three years) for state compliance purposes

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