Advancing Cleaner Energy

Effectiveness of US Mercury Control Strategies at Coal-Fired Power Plants and Applicability to European Plants

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Approach for Review

- Now that MATS is in place in the US, it's raining mercury data!

  - Plants in the US employ a variety of strategies to reduce mercury air emissions
    - We combine 11 months of US mercury emissions data for all coal-fired power plants reporting emissions
    - Information on the control technologies employed at specific plants can assess the efficacy of different control strategies
  - Subset of US plants with similar configurations to many EU plants selected to examine the potential efficacy of mercury controls when applied to EU plants

Comparing US and EU Regulations

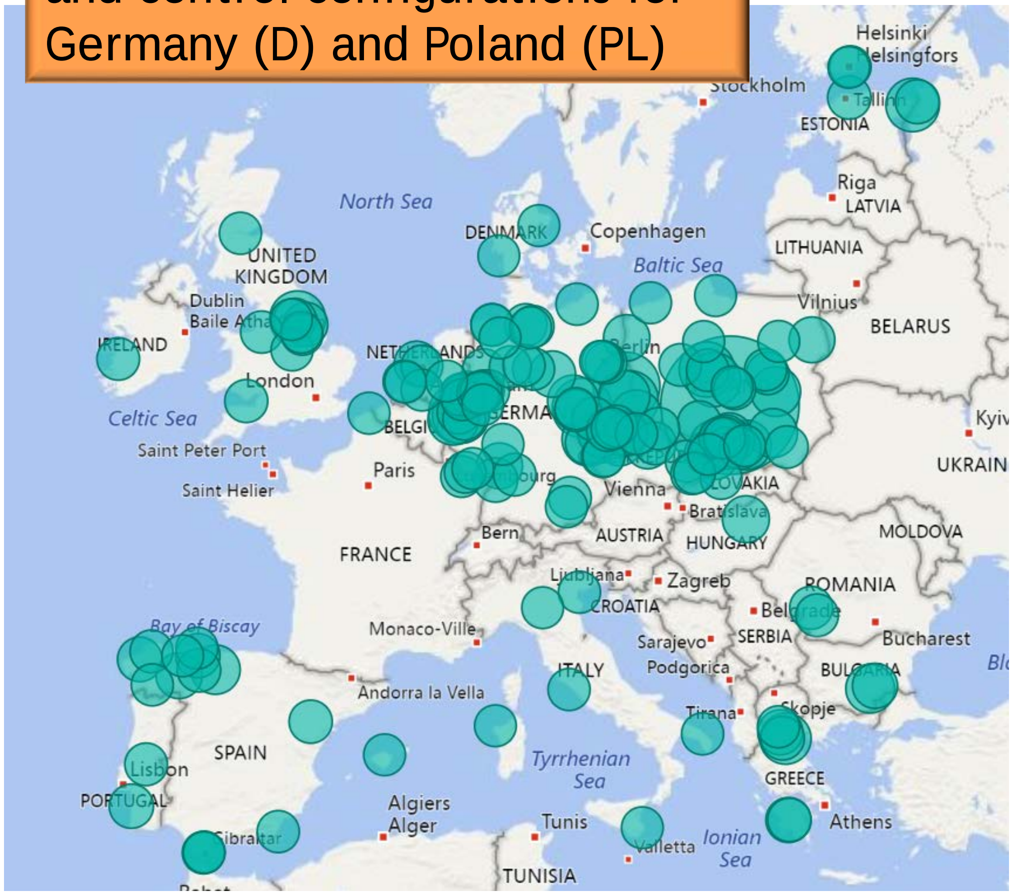
Country and legislation	Emission limit for hard coal, µg/m³	Emission limit for lignite, µg/m³
USA MATS (assumed by BREF) **30-day rolling average**	1.4	4.7
New EU BREF <300 MWth	< 1 - 9 (existing)	< 1 - 10 (existing)
New EU BREF ≥300 MWth	< 1 - 4 (existing)	< 1 - 7 (existing)

Mercury Control Strategies Applied to US Plants

- Co-Benefits: no mercury-specific controls
  - More common on scrubbed plants firing higher halogen coal
- Coal Additives: Increase halogen content in coal → increase fraction of oxidized mercury
  - More common as a stand-alone option on scrubbed plants
- Activated carbon injection: increase particles that can adsorb mercury
  - Common on plants firing low-halogen fuel, often with coal additives
- Can these strategies be applied to German and other EU plants?

Reported Mercury “Releases” from EU plants

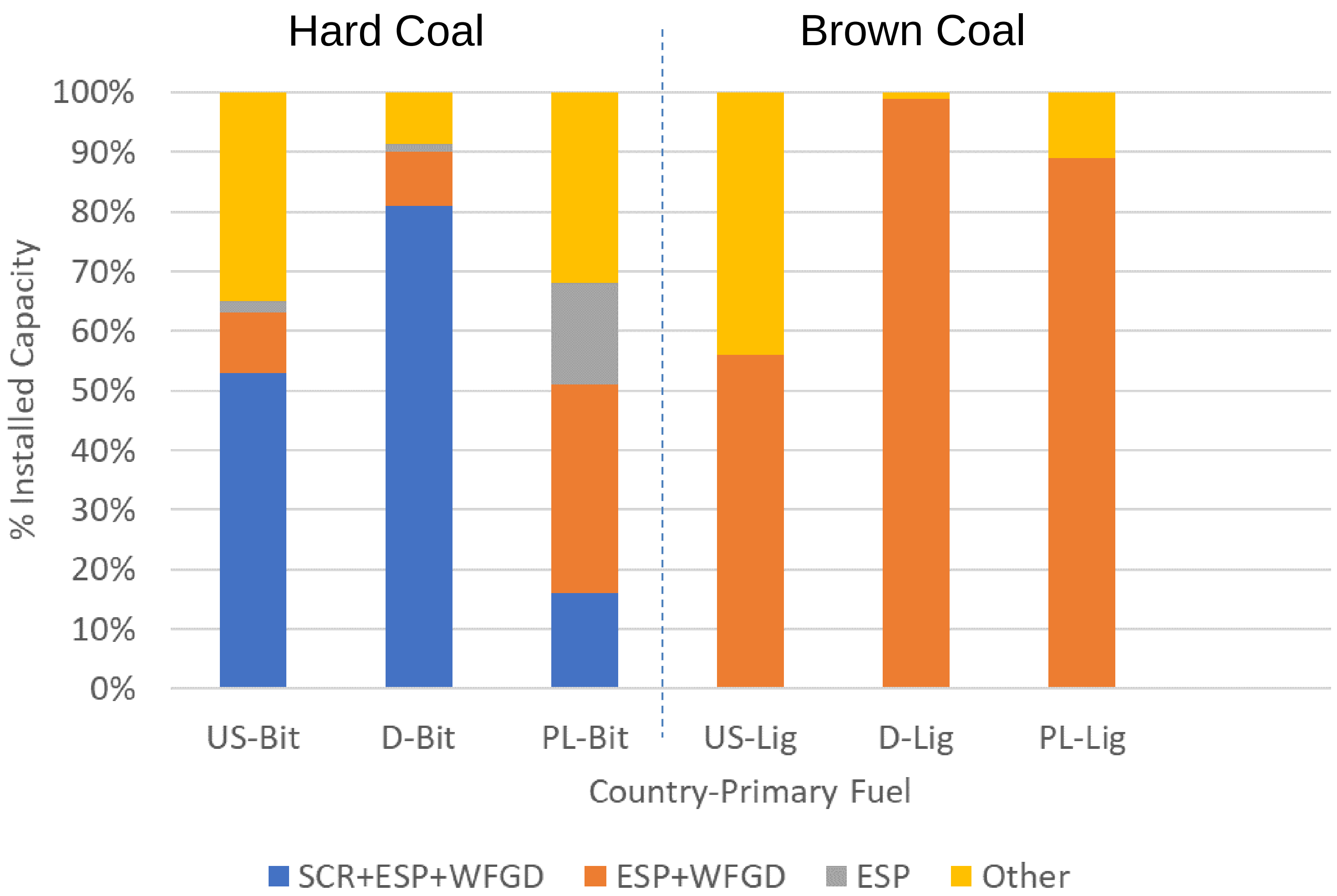
Today we will focus on fuels and control configurations for Germany (D) and Poland (PL)



Country	No. Plants	Hg (kg/yr)	% of Facilities representing 75% of reported releases
PL	35	5850	20%
D	47	5150	19%
CZ	24	1891	33%
ES	15	901	40%
UK	10	729	30%
Others	36	2336	

European Pollutant Release and Transfer Agency, 2016 data
Thermal power stations and other combustion installations, Air relases

Comparison of Installed Controls



US: EPA Air Markets Program data, EU: IIR

Reported Operating Constraints Affecting Mercury Control: Germany

- Hard coal plants:
  - Ash and gypsum are all sold and subject to quality specifications
  - Scrubber effluent is treated and discharged
- Brown coal plants:
  - All gypsum is sold, and therefore subject to specifications for gypsum quality
  - WFGD purge stream is mixed with ash, and then landfilled
    - Possible chemical limitations in landfill permit at mine
    - May restrict use of sorbents or additives

Can Plants Rely on Co-Benefits Alone?

Success Factors from US experience

YES – many US BIT plants do:
35% of US bituminous units
All lignite plants report Hg controls

- Coal and combustion
  - Mercury, halogen, sulfur
- SCR
  - Lower = better: temperature, NH_3, age, gas flow rate, CO, H_2O,SO_2
  - Higher = better: halogen concentration, O_2
  - Other: SCR type, SCR management scheme
- Particulate Controls
  - Hg removed before WFGD: fraction of particulate-phase Hg (carbon in ash, temperature, SO_3, ESP SCA, FF cleaning)
- Scrubber
  - Fraction of oxidized Hg at inlet, ORP, halogens, temperature, pH

Mercury Emissions – US Plants Bituminous Coal, SCR+ESP+WFGD

	CA + PAC	CA	PAC	Co-Benefits	RC
Sample Size (Units)	6	20	10	53	35
Avg. Hg (lb/TBtu)	0.51	0.62	0.31	0.44	0.51
% time hourly Hg avg below 1.2 lb/TBtu	96%	92%	99%	98%	94%
% time hourly Hg avg >10% below 1.2 lb/TBtu	94%	89%	99%	97%	93%
% time hourly Hg avg >20% below 1.2 lb/TBtu	93%	84%	98%	96%	89%
Average Coal Sulfur (%)	2.5	2.4	2.7	2.9	2.6

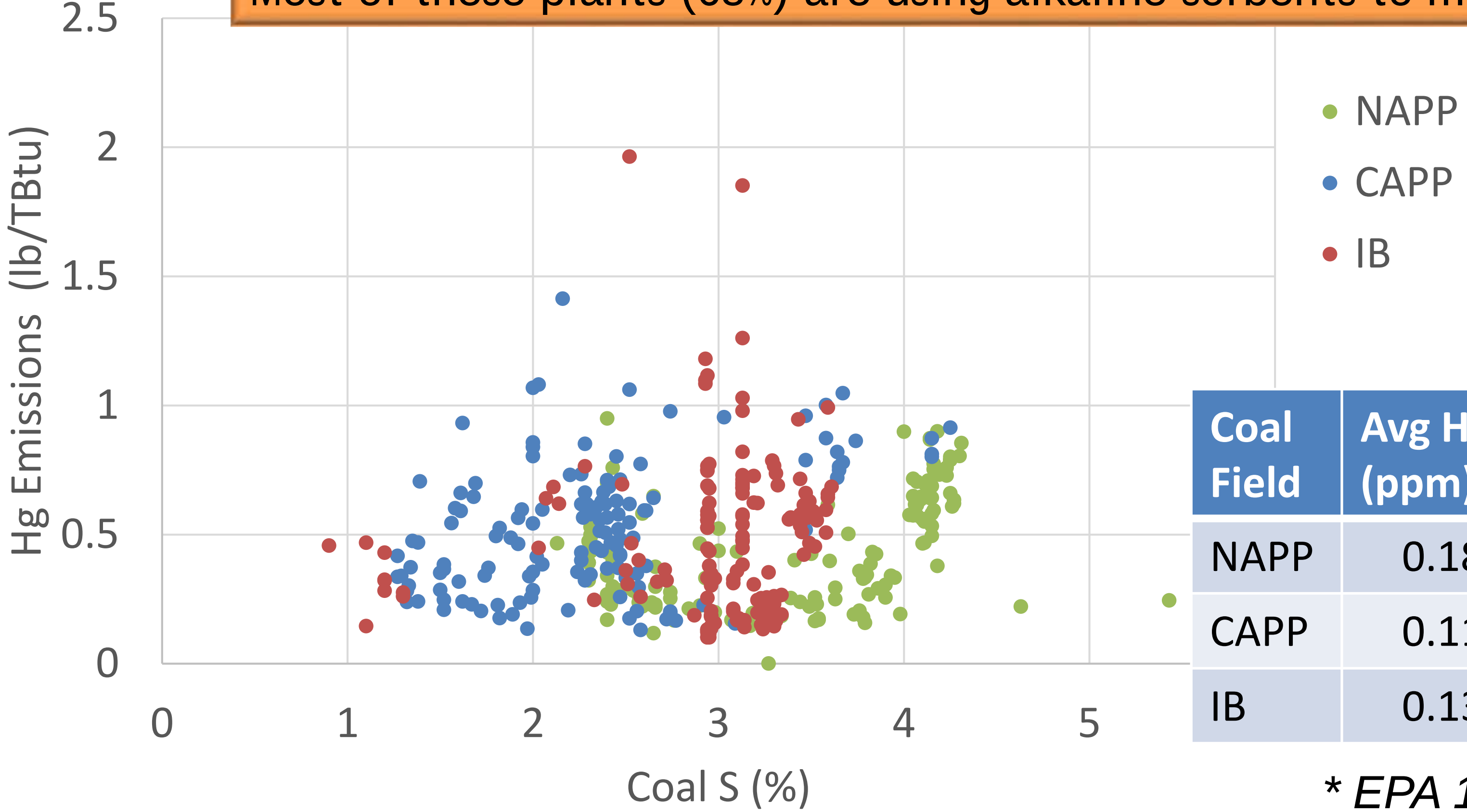
1 lb/TBtu ≈ 1 µg/m^3 at 7% O_2, dry
CA = Coal Halogen Additive
RC = Refined Coal (halogen addition)
PAC = Powdered Activated Carbon
Co-Benefits: No mercury-specific technology is reported

Based on reported emissions data
1 May 2017 – 31 April 2018

Influence of Coal Sulfur on Mercury Emissions

Why don't we see a correlation?

Most of these plants (68%) are using alkaline sorbents to manage SO_3



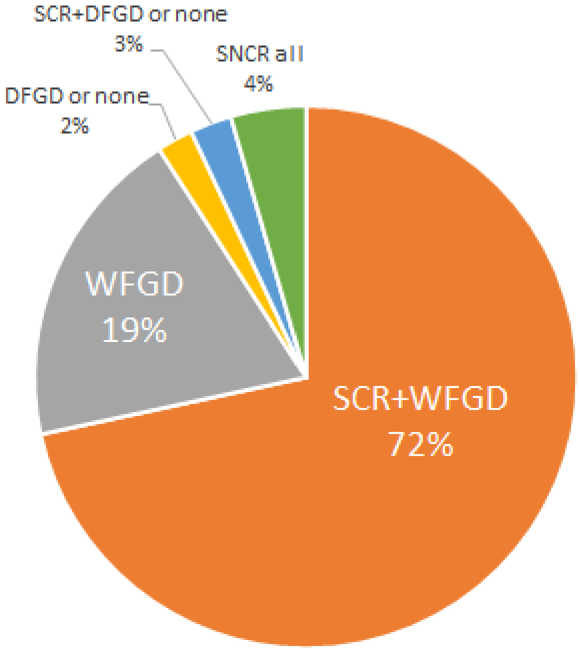
Coal Field	Avg Hg* (ppm)	Avg Cl* (ppm)
NAPP	0.18	700
CAPP	0.11	1000
IB	0.13	950

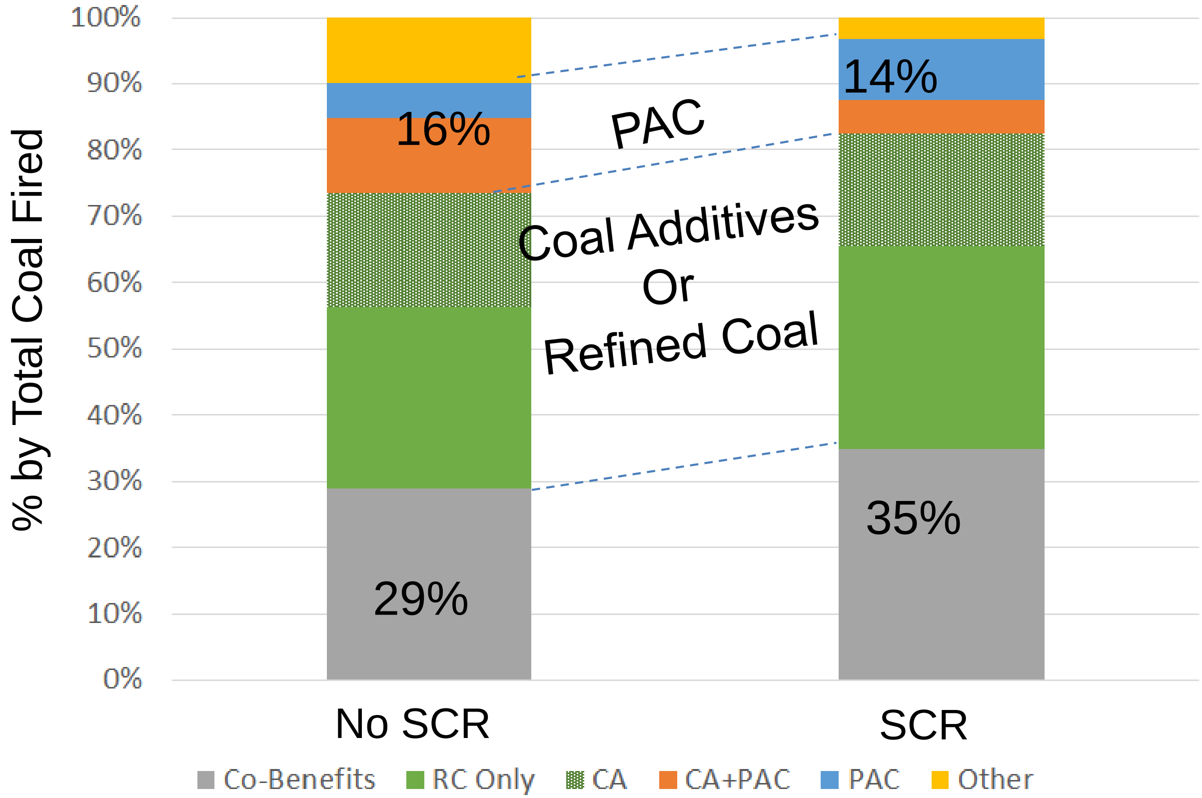
** EPA 1999 ICR*

Bituminous plants, SCR, ESP, WFGD, no specific Hg controls

Reported coal sulfur and Hg emissions 1 May 2017 – 31 April 2018, monthly averages

How Does and SCR Affect Choice of Hg Control Technology





US Bituminous-Fired Units

- Larger fraction of units with SCRs relying on co-benefits alone compared to units without SCRs
- On average, an installed SCR has a minor impact on the fraction of bituminous units with SCRs reporting using PAC to supplement Hg compliance
  - Note that data on the amount of PAC or coal additives is not reported

Outlook for German Lignite Plants

Lignite Region	Mercury Control Needs
Rhein.	Low mercury, low sulfur coal. Moderate to low controls before 2025
Middle Germany	High mercury, high sulfur lignite. Will need additional controls
Lusatia	Low mercury, med. Sulfur coal. Moderate controls needed before 2025

Lignite Characteristics*

REGION	Calorific value	Ash	Sulfur	Mercury	Moisture
	kJ/kg	%	%		%
Lusatia	7,840 - 9,000	4.0 - 12.6	0.3 - 1.1	Low	52-60
Mid. Germany	9,000 - 11,500	6.5 - 8.5	1.2 - 2.1	High	48-55
Rheinland	7,800 - 10,500	1.5- 8.0	0.15 - 0.5	Low	50-60

*http://braunkohle-nein.de/jeffrey.pdf

Mercury Emissions – US Plants
Lignite Coal, No SCR + ESP + WFGD

	Gulf Lignite	ND Lignite	
	CA + PAC	CA + PAC	CA
Sample Size (Units)	5	4	2
Avg. Hg (lb/TBtu)	3.11	2.71	3.80
% time hourly avg below 4 lb/TBtu	80%	93%	89%
% time hourly Hg avg > 10% below 4 lb/Tbtu	80%	93%	89%
% time hourly Hg avg > 20% below 4 lb/Tbtu	73%	79%	11%

4 lb/TBtu ≈ 3.7-4.3 µg/m^3 at 7% O_2, dry
CA = Coal Halogen Additive
PAC = Powdered Activated Carbon

Gulf Lignite: 6 to >30 lb/TBtu Hg
0.5 to 3% Sulfur
North Dakota 6 to 15 lb/TBtu Hg
0.5 to 1.2 % S

Balancing Gypsum Quality and Mercury Re-Emissions

Optimum for Gypsum

- Higher oxidation air rates
  ↓ sulfite
- Low pH
- High blowdown to manage halogen levels

Optimum for Hg Control

- Reduce oxidation air
  < ~ 300 mV[1]
  ↑ sulfite
- Increase pH
- High halogen

1. % Dissolved mercury, and risk of re-emission increases at ORP > 300 mv

Mandi Richardson, AECOM

Summary: Thoughts on Transferring US Experience to EU plants

- Much of the experience is transferable
- Low-end of BREF emission targets (1 μg/m^3, shorter averaging period) will be challenging to achieve consistently
- Not all scrubbed plants in US sell gypsum. Gypsum quality requirements can affect overall results.
  - ORP management and/or re-emission chemicals should be an option for many plants
  - Limiting Hg in gypsum may result in broader use of chemicals and technologies that allow "easy" separation
- Mine permits limiting introduction of added chemicals may require new development (or permit modifications)

THANK YOU!

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Note: Publication on US experience planned for 2018