REINHOLD ENVIRONMENTAL Ltd.

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Effectiveness of Mercury Control Strategies: A MATS Report Card

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Disclaimer

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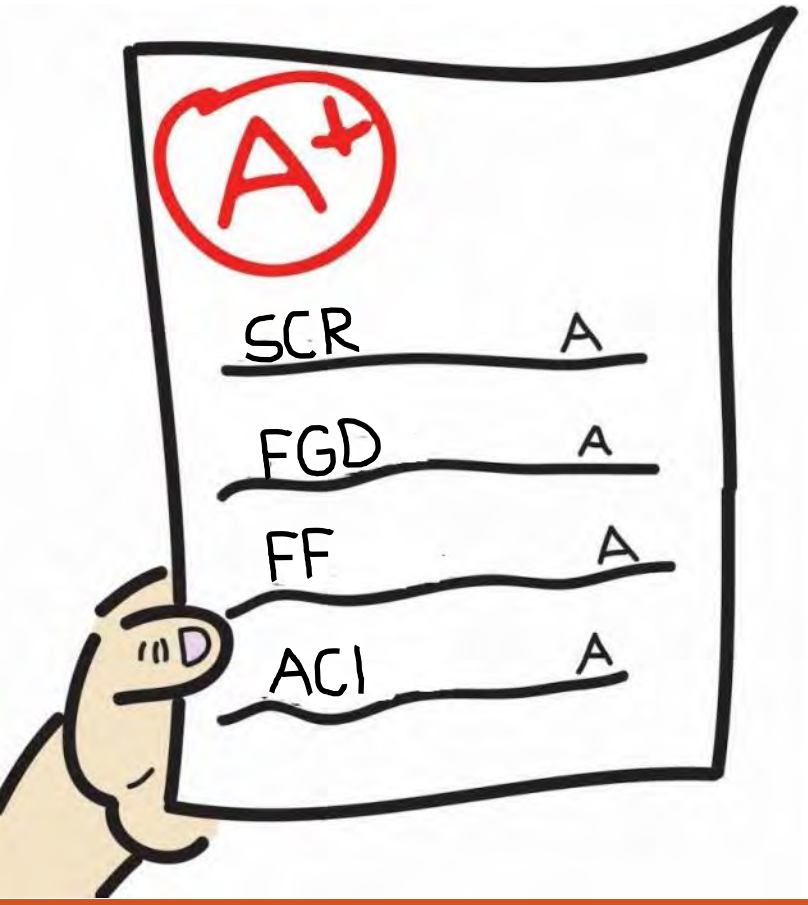

- We're in a MATS world now – how are we doing?
- What's working?
- What's not working?
- Let's check the report card…

Methodology

- Query EPA Air Markets Database* for boilers subject to MATS reporting Hg emissions
- Two time periods: 8/27/16 – 8/31/16 and 12/27/16-12/31/16
- Obtain DAILY AVERAGE Hg emissions (lb/TBtu) and loads (MW) for those days for each boiler (excluding days when load was < 20% MCR)
- Categorize each boiler by APCD type and primary fuel
- APCD abbreviations used:
  - CESP – cold-side ESP
  - HESP – hot-side ESP
  - FF – Fabric filter
  - WFGD – Wet FGD
  - DFGD – Dry or semi-dry FGD
  - SCR – Selective catalytic reduction
  - +Hg – With Hg controls (e.g., ACI, CHI, fixed structures, etc.)
    - *Note that we have no way of knowing if Hg controls are actually being used*

*https://ampd.epa.gov/ampd/

APCD Configurations

- 533 boilers
- 255,906 MW total

Bituminous	121,807 MW
Subbituminous	117,319 MW
Lignite	15,302 MW
Petcoke	1,478 MW

- What determines how well a boiler controls Hg emissions?
  - Fuel
    - Hg content: Lignite > Bituminous > Subbituminous
    - Cl content: Bituminous > Lignite, Subbituminous
  - APCD
    - FF generally better than ESP
    - FGD helps if there's enough halogen
    - DFGD > WFGD
    - SCR helps oxidize Hg on scrubbed units
  - Hg control technology
    - ACI and/or CHI
    - Lower SO_3 in flue gas is better

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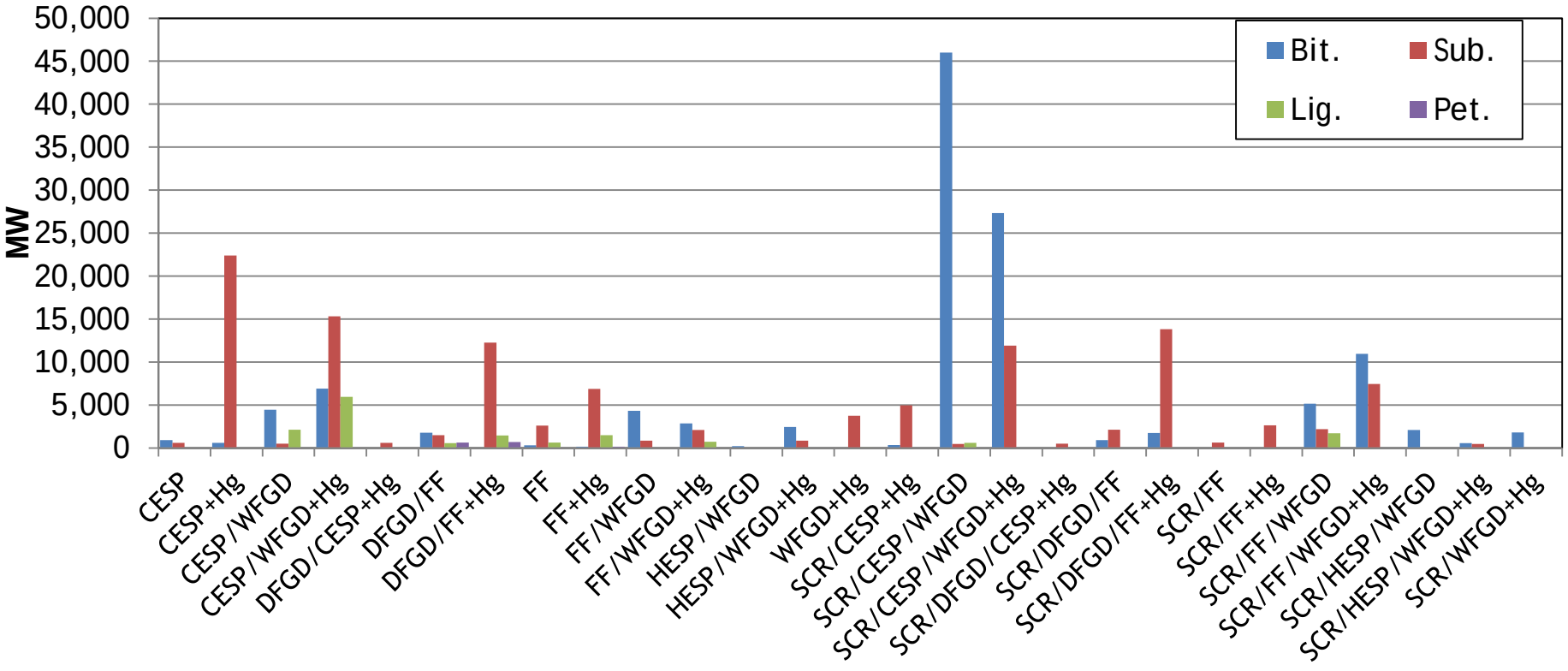


APCD Configurations

- 533 boilers
- 255,906 MW total
- Configurations of top 90% in each fuel category:

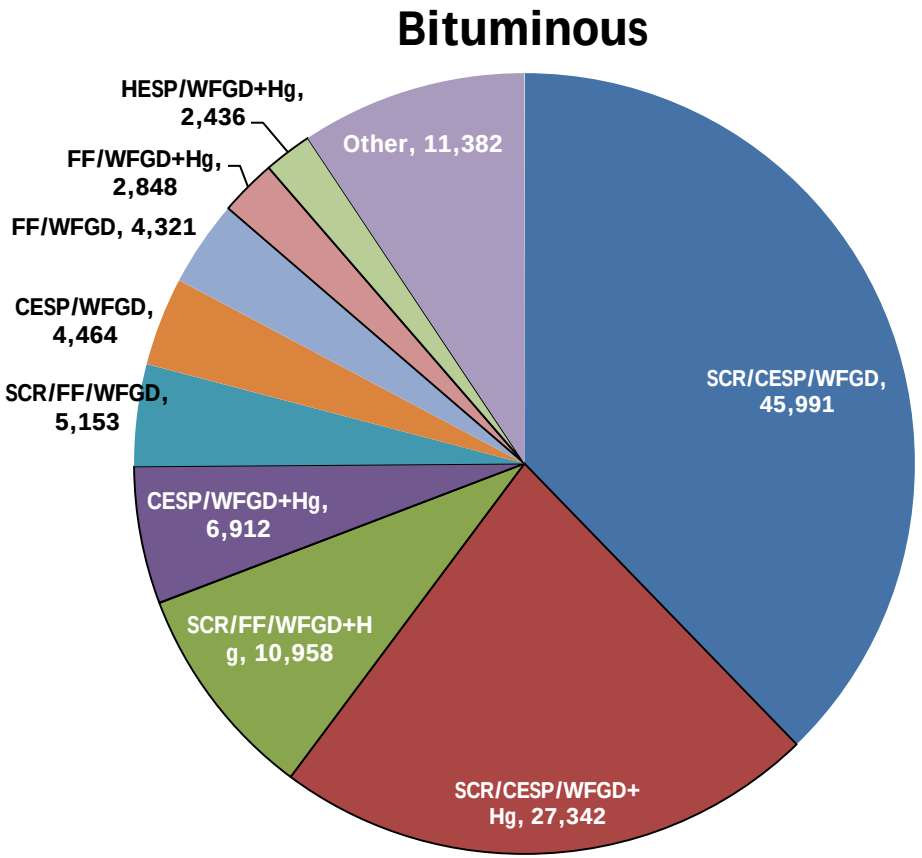
Bituminous Top 90%	MW
SCR/CESP/WFGD	45,991
SCR/CESP/WFGD+Hg	27,342
SCR/FF/WFGD+Hg	10,958
CESP/WFGD+Hg	6,912
SCR/FF/WFGD	5,153
CESP/WFGD	4,464
FF/WFGD	4,321
FF/WFGD+Hg	2,848
HESP/WFGD+Hg	2,436

Subbituminous Top 90%	MW
CESP+Hg	22,384
CESP/WFGD+Hg	15,322
SCR/DFGD/FF+Hg	13,823
DFGD/FF+Hg	12,274
SCR/CESP/WFGD+Hg	11,900
SCR/FF/WFGD+Hg	7,458
FF+Hg	6,865
SCR/CESP+Hg	4,947
WFGD+Hg	3,754
SCR/FF+Hg	2,651
FF	2,616
SCR/FF/WFGD	2,175

Lignite Top 90%	MW
CESP/WFGD+Hg	5,958
CESP/WFGD	2,140
SCR/FF/WFGD	1,720
FF+Hg	1,474
DFGD/FF+Hg	1,447
FF/WFGD+Hg	723

Bituminous APCD Configurations

- Less than half (by MW) have Hg control technology
- Most (80% by MW) bituminous units have SCRs
- Almost all bituminous units have wet FGDs
- Only 22% (by MW) have FFs



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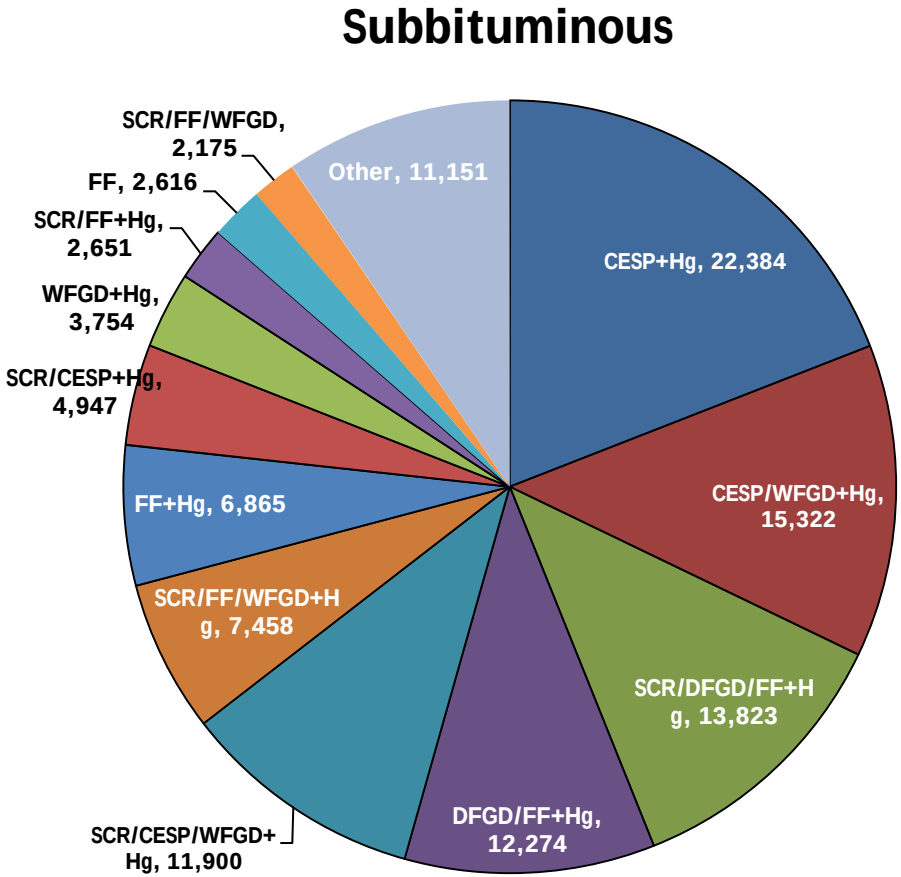
Bituminous Top 90%	MW	Aug Mean Hg	Dec Mean Hg
SCR/CESP/WFGD	45,991	0.54	0.44
SCR/CESP/WFGD+Hg	27,342	0.53	0.50
SCR/FF/WFGD+Hg	10,958	0.47	0.46
CESP/WFGD+Hg	6,912	0.84	0.74
SCR/FF/WFGD	5,153	0.26	0.34
CESP/WFGD	4,464	0.84	0.82
FF/WFGD	4,321	0.17	0.17
FF/WFGD+Hg	2,848	0.24	0.21
HESP/WFGD+Hg	2,436	0.95	0.58

Subbituminous APCD Configurations

- 87% (by MW) have some Hg control
- Less SCRs (40% by MW) and wet FGDs (40% by MW) than on bituminous units



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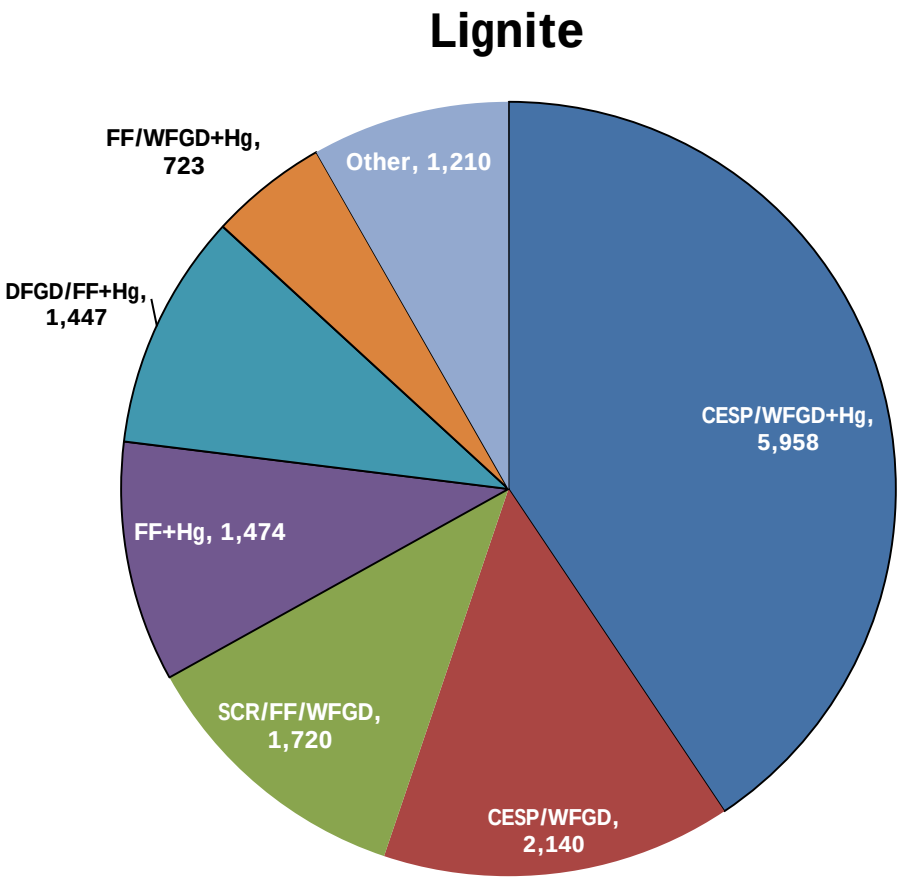
Subbituminous Top 90%	MW	Aug Mean Hg	Dec Mean Hg
CESP+Hg	22,384	0.69	0.61
CESP/WFGD+Hg	15,322	0.83	0.77
SCR/DFGD/FF+Hg	13,823	0.63	0.74
DFGD/FF+Hg	12,274	0.65	0.70
SCR/CESP/WFGD+Hg	11,900	0.56	0.43
SCR/FF/WFGD+Hg	7,458	0.58	0.71
FF+Hg	6,865	0.55	0.52
SCR/CESP+Hg	4,947	0.58	0.46
WFGD+Hg	3,754	0.77	0.76
SCR/FF+Hg	2,651	0.41	0.33
FF	2,616	0.55	0.71
SCR/FF/WFGD	2,175	0.54	0.40

Lignite APCD Configurations

- Most lignite boilers (by MW) have wet FGDs
- Split between ESPs and FFs



Lignite APCD Configurations

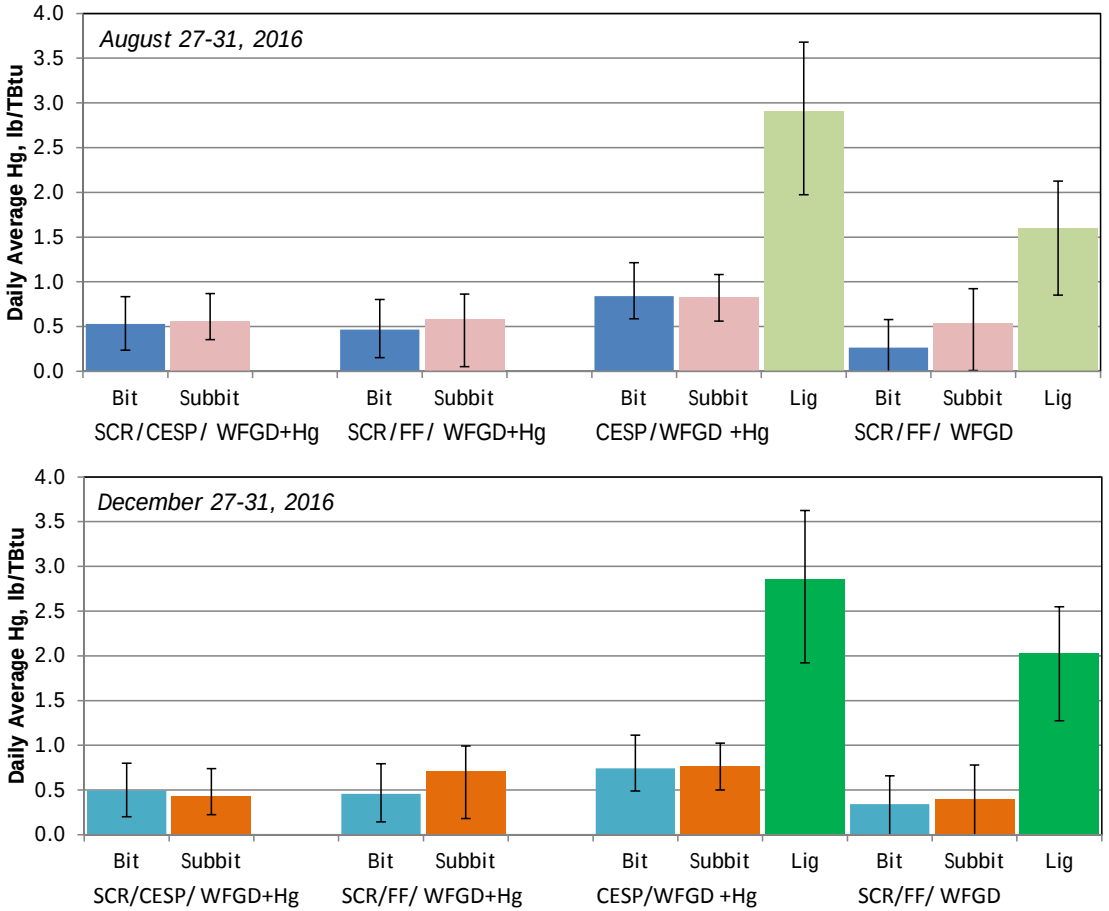
- Most lignite boilers (by MW) have wet FGDs
- Split between ESPs and FFs
- Fewer lignite plants, so we won't spend a lot of time on them, because statistics are poor

Lignite Top 90%	MW	Aug Mean Hg	Dec Mean Hg
CESP/WFGD+Hg	5,958	2.90	2.85
CESP/WFGD	2,140	3.27	4.10
SCR/FF/WFGD	1,720	1.60	2.02
FF+Hg	1,474	1.19	1.38
DFGD/FF+Hg	1,447	2.12	2.83
FF/WFGD+Hg	723	0.84	0.65

What's the Best Coal?

Different Coal Types – Same APCD

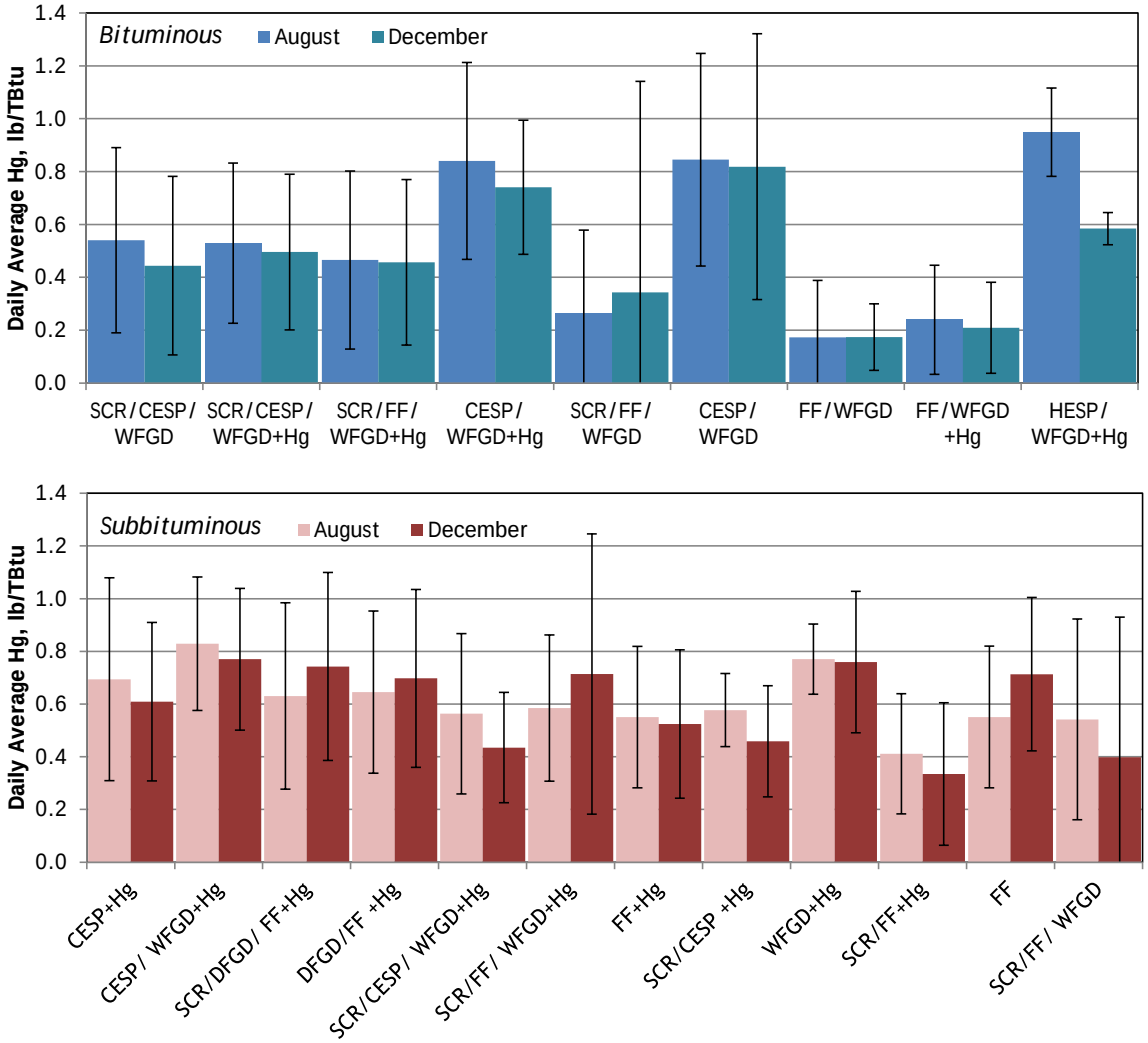
- Where do we expect to see the lowest emissions?



Summer vs. Winter?

Summer vs. Winter

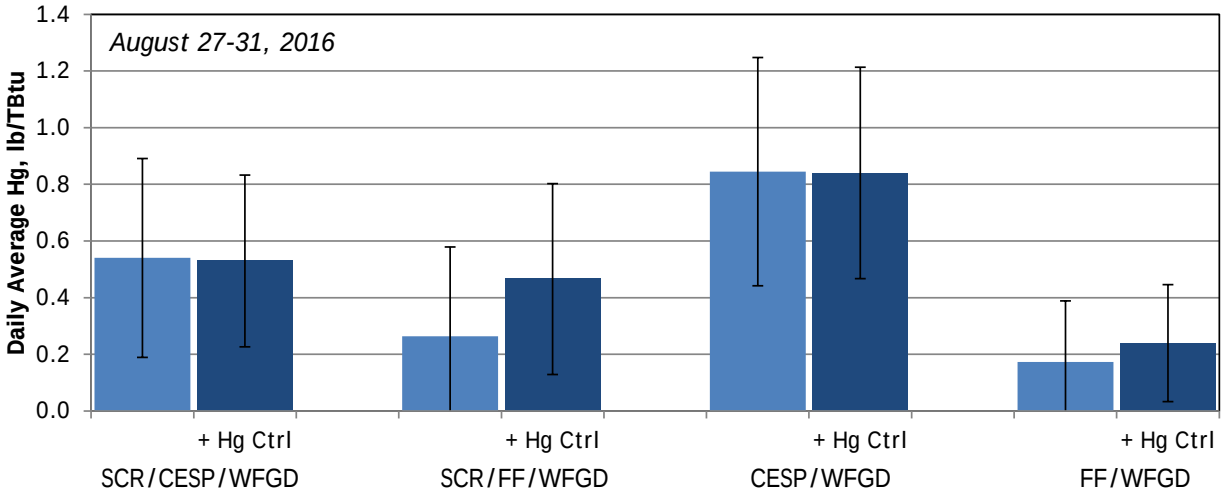
- When do we expect to see the lowest emissions?

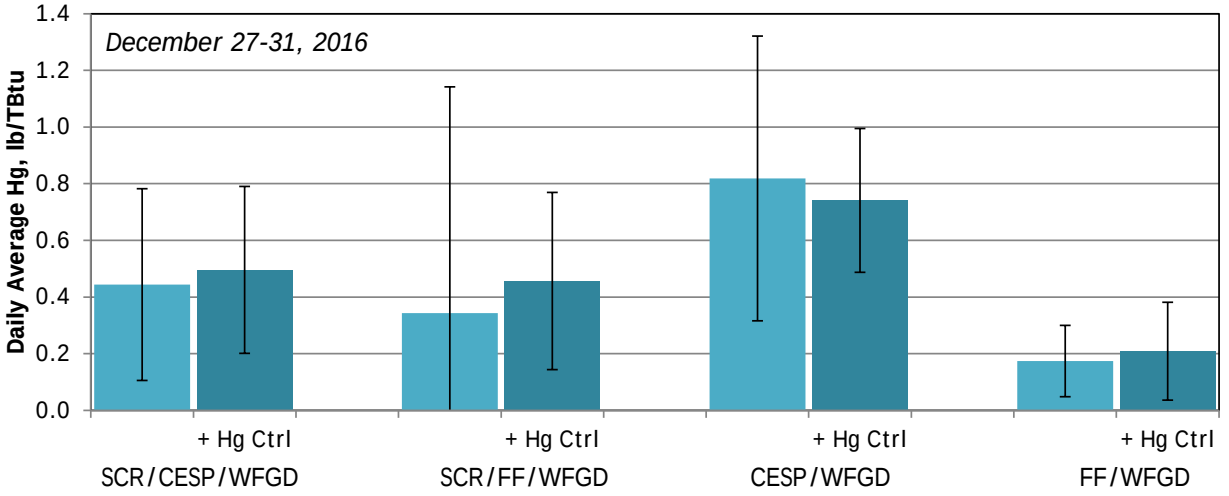


Does Hg Control Help?

Hg Control: Bituminous Units

- Hg control includes:
  - ACI
  - CHI
  - ACI+CHI
  - Other Hg control
- Do we think it will help?





Hg Control: Subbituminous Units

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  - ACI+CHI
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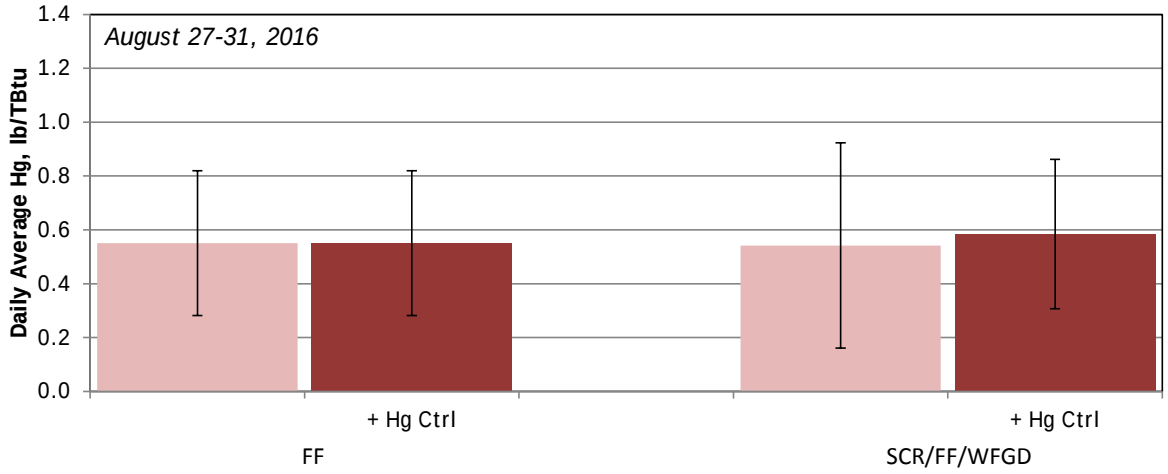
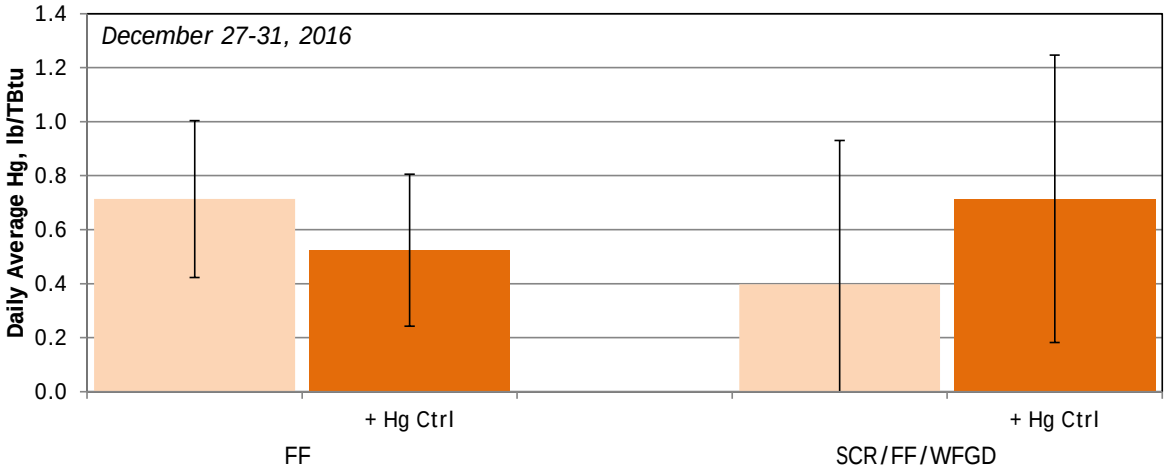
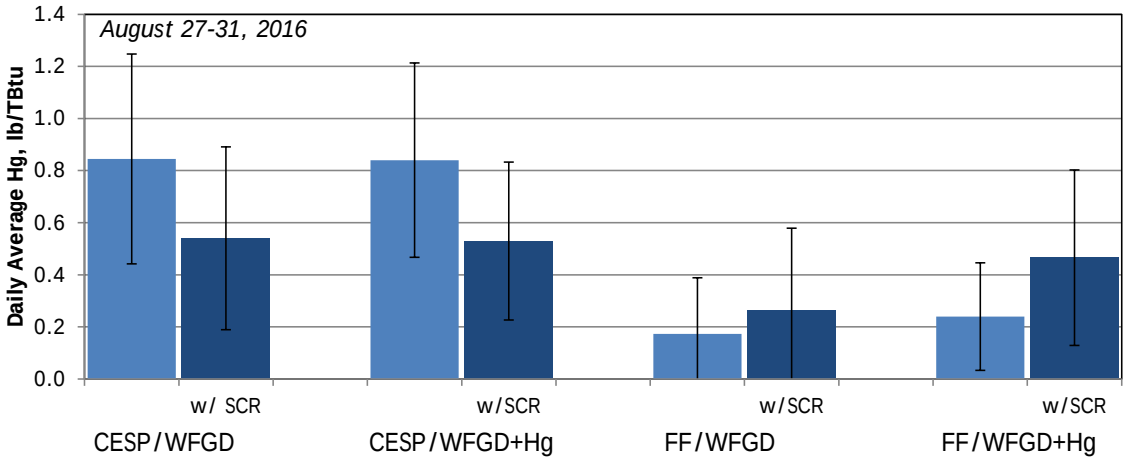


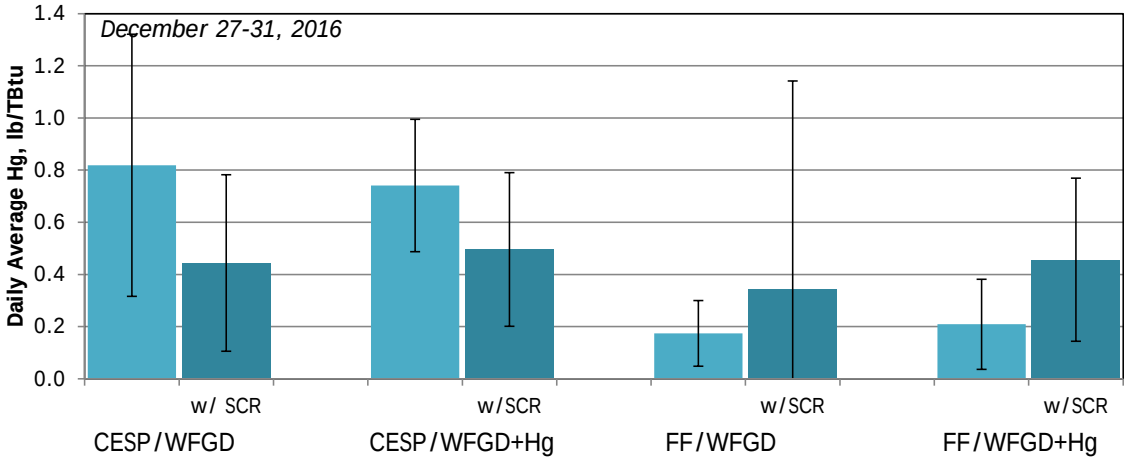


Does an SCR Help?

Does an SCR Help on Bituminous Units?

- Where do we expect to see the lowest emissions?





Does an SCR Help on Subbituminous Units?

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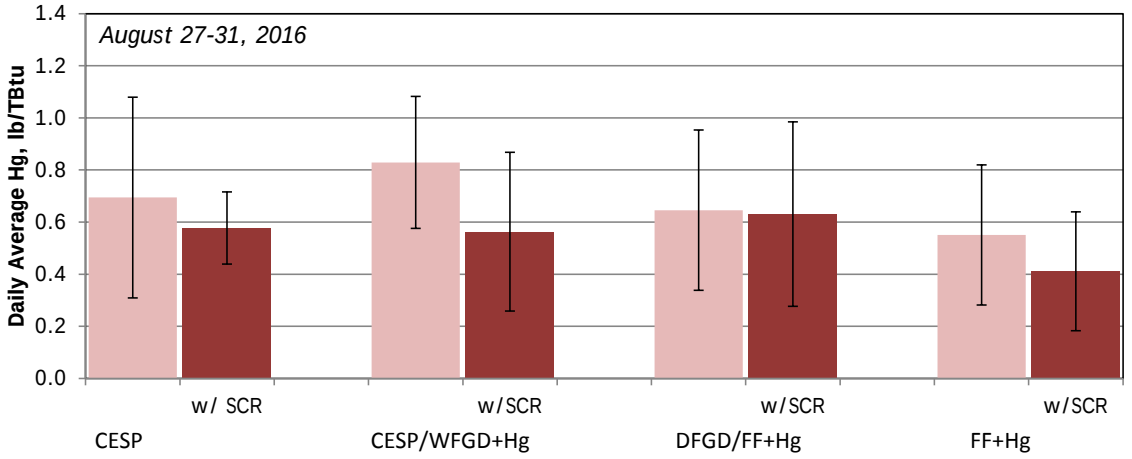
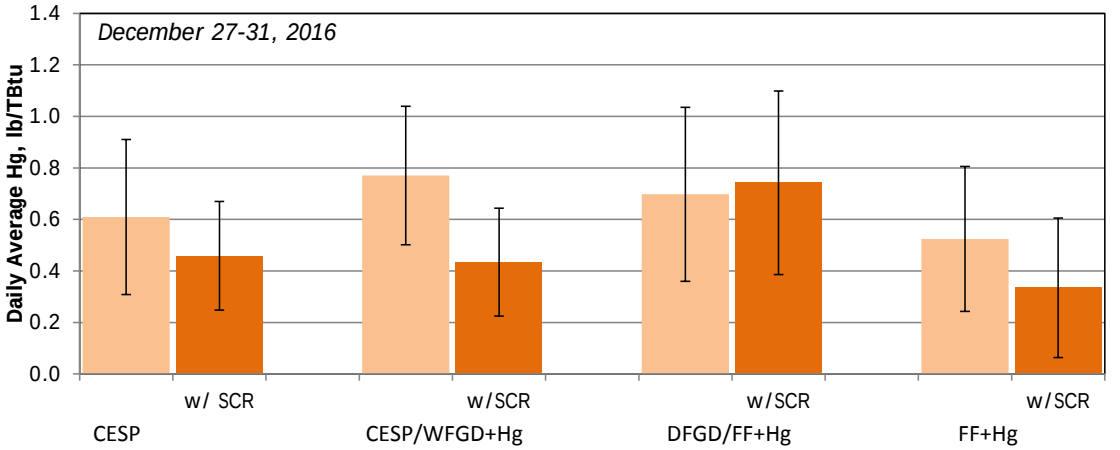
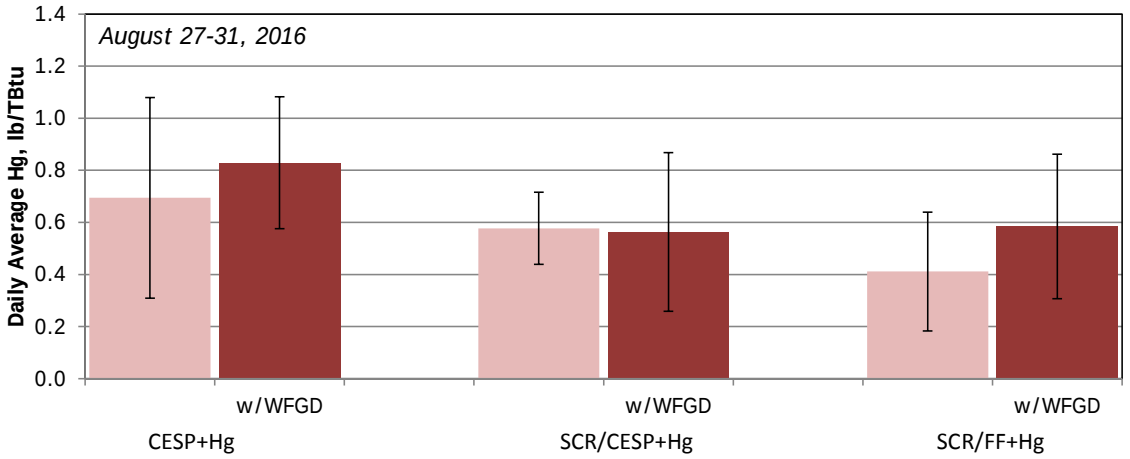
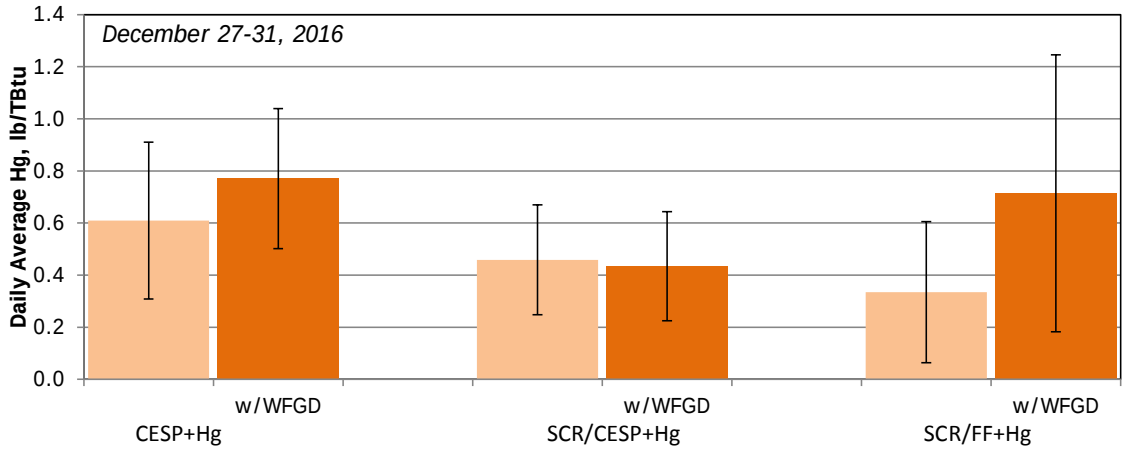




Does a WFGD Help on Subbituminous Units?

- Where do we expect to see the lowest emissions?





Configurations

- What did we find when we surveyed boilers reporting their MATS emissions?
- 533 boilers and 256 GW
- General observations about configurations:

Bituminous Units

- Less than half (by MW) have Hg control technology
- Most (80% by MW) bituminous units have SCRs
- Almost all bituminous units have wet FGDs
- Only 22% (by MW) have FFs

Subbituminous Units

- 87% (by MW) have some Hg control
- Less SCRs (40% by MW) and wet FGDs (40% by MW) than on bituminous units

What Did We Learn about Fuel Type & Season?

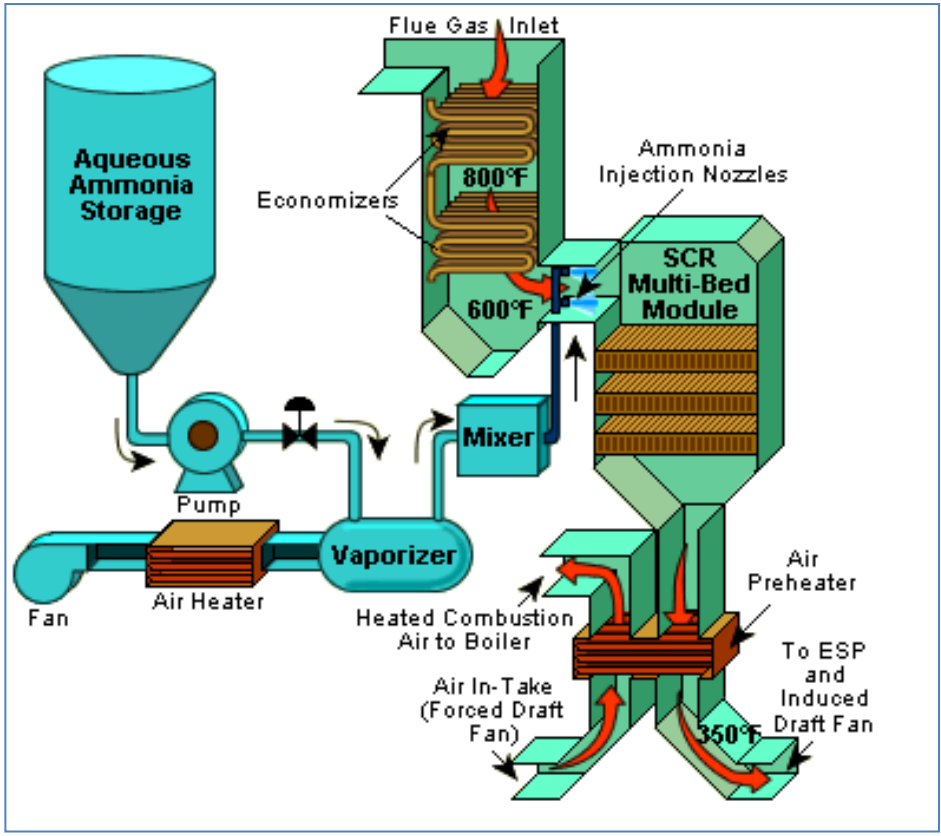
- Bituminous units have average emissions that are equal to or lower than subbituminous units, for a given APCD configuration
- No clear summer vs. winter differences, but a larger data set might be needed to see differences more clearly

What Did We Learn about Hg Control?

- For bituminous units, having Hg control does not result in lower emissions, sometimes higher emissions
- For subbituminous units with FFs, Hg control doesn't have a clear impact on average emissions

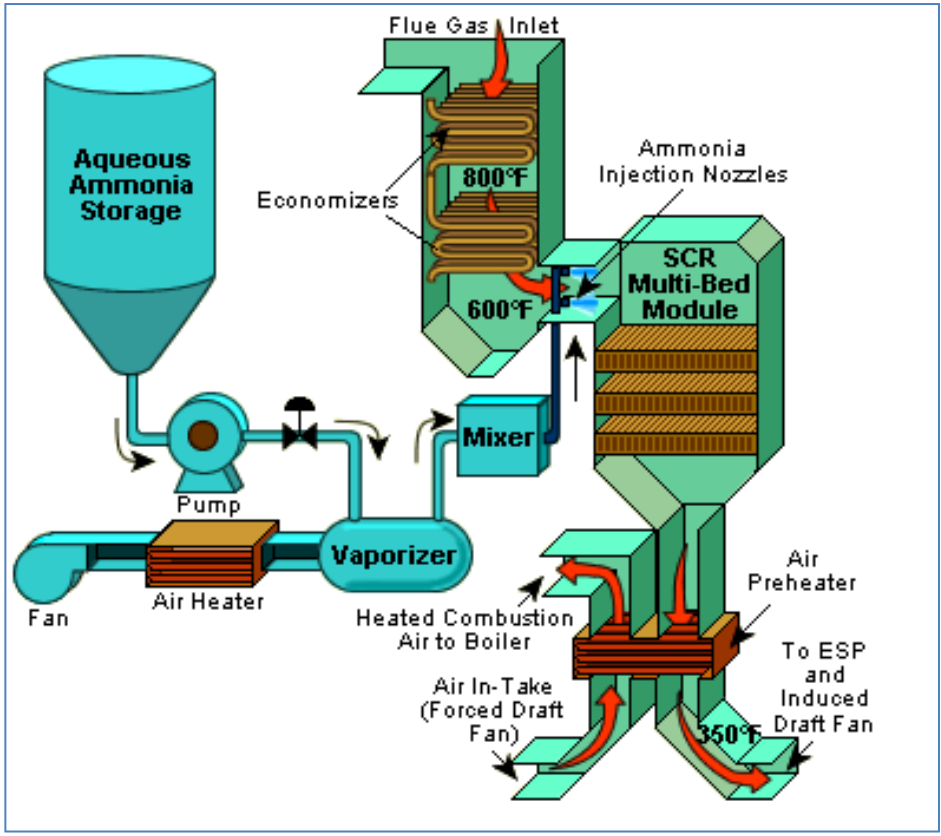
What Did We Learn about SCRs and WFGDs?

- For bituminous units with CESPs, having an SCR results in lower Hg emissions on average
  - However, for units with FFs, having an SCR results in higher average Hg emissions – higher SO_3?



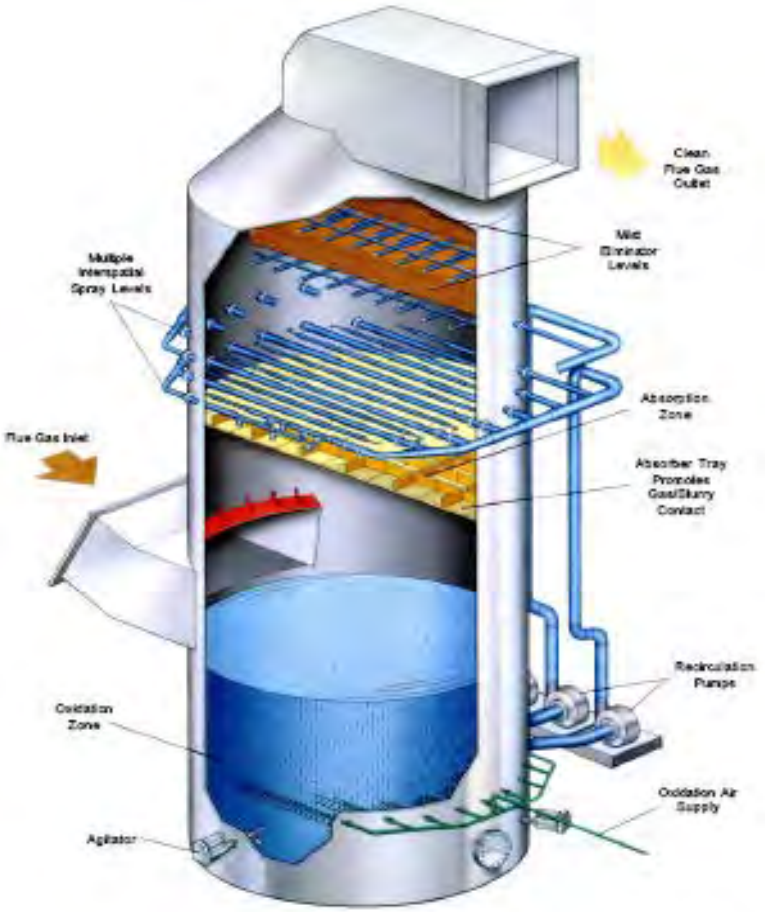
What Did We Learn about SCRs and WFGDs?

- For subbituminous units with CESP or FF, having an SCR results in lower Hg emissions
  - With a dry FGD, however, SCR doesn't seem to make a difference in average Hg emissions

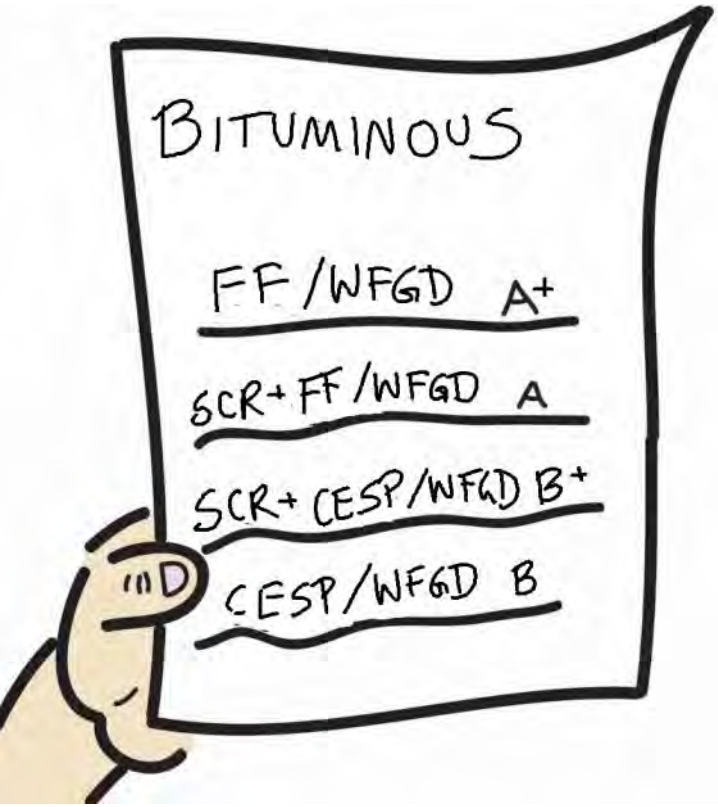


What Did We Learn about SCRs and WFGDs?

- For subbituminous units with CESP or FF, having an SCR results in lower Hg emissions
  - With a dry FGD, however, SCR doesn't seem to make a difference in average Hg emissions
- For subbituminous units with CESP or FF, having a WFGD seems to result in higher average emissions
  - All these units have Hg control – maybe boilers with WFGDs don't run their Hg control as much?

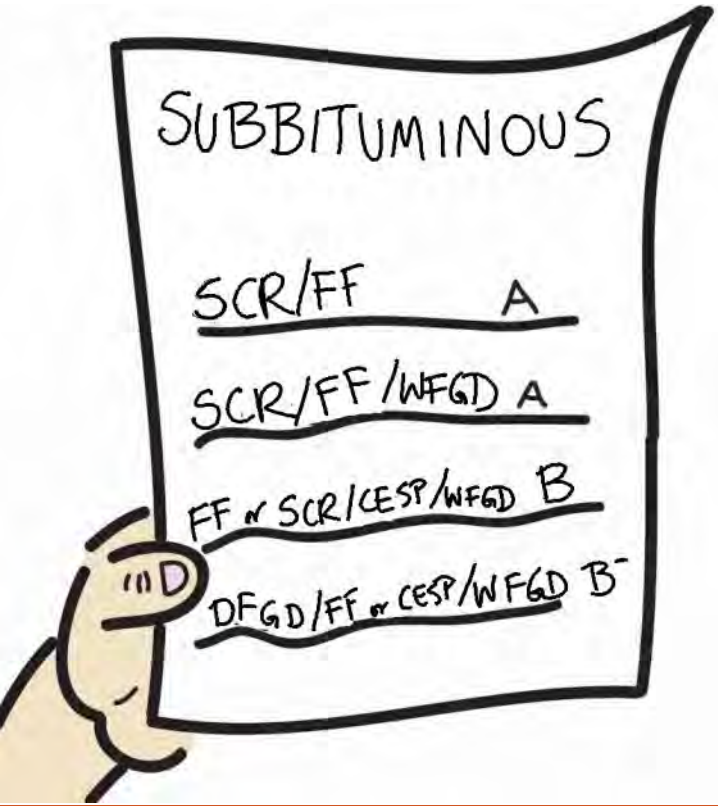


What Worked Best for Bituminous Units?



- Fabric filters give lower Hg emissions than ESP units
- SCRs appear to lower emissions on CESP units, but not on FF units
- Hg control doesn't seem to reduce emissions much – but we can't tell if it is actually on-line

What Worked Best for Subbituminous Units?



- FFs plus SCRs result in lowest emissions
- Adding an SCR generally result in lower Hg emissions
- Adding a WFGD doesn't help lower Hg emissions
- Hg control didn't seem to reduce emissions much – but we can't tell if it was actually on-line

Comments?

Questions?

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