Worldwide Pollution Control Association

WPCA/LG&E and KU

Coal-fired APC Environmental Seminar

May 23-24, 2017

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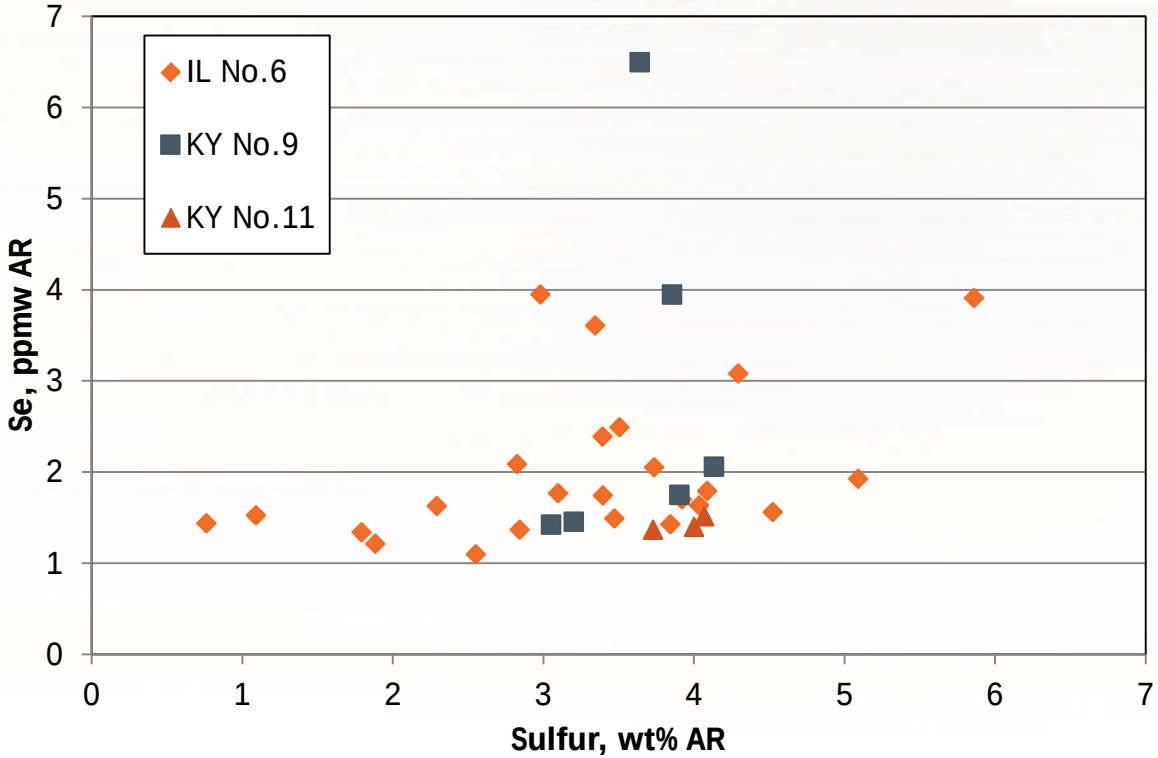
Selenium in US Coals

- Selenium is found in coals in trace concentrations
- USGS has reported concentrations in coal as high as 150 µg/g, but 0.5 to 5 µg/g is a more typical range for US coals
- Selenium is often found in coal either associated with metal sulfide minerals, predominantly pyrite, or as an organically associated element
- Selenium has also been observed to be associated with silicates in some coals
- In low-rank coals, selenium is mostly organically bound, but in bituminous coals the element is split between organic and mineral association

Selenium in US Coals: Example

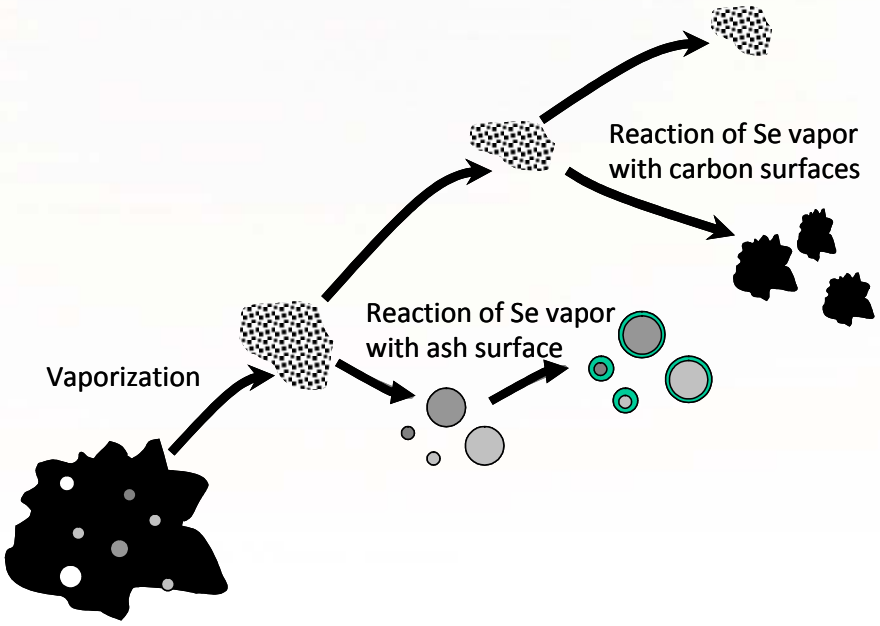
- Data from Illinois State Geological Service (ISGS) for selected coals



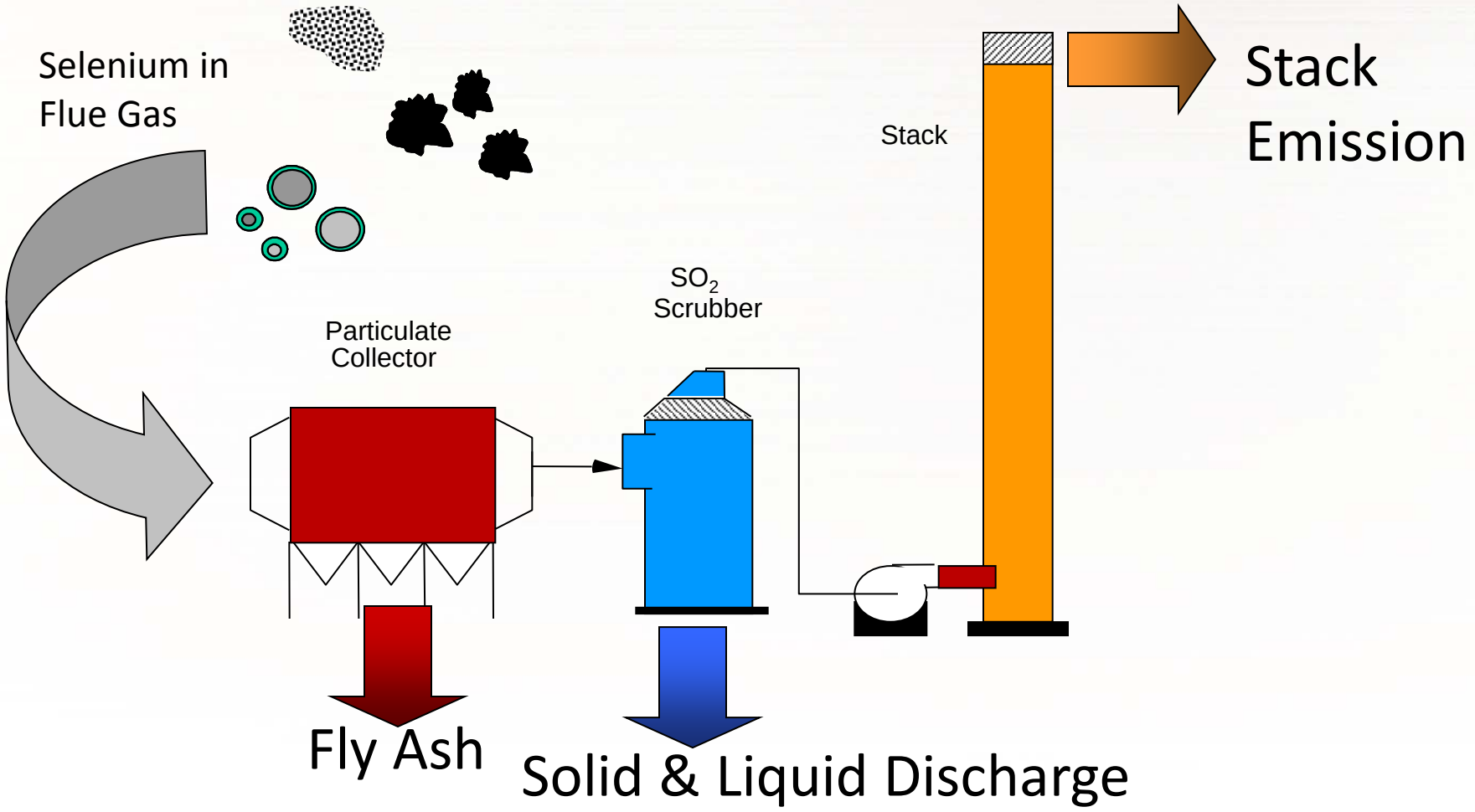
Source: ISGS C499

Behavior of Se in Coal-Fired Boilers

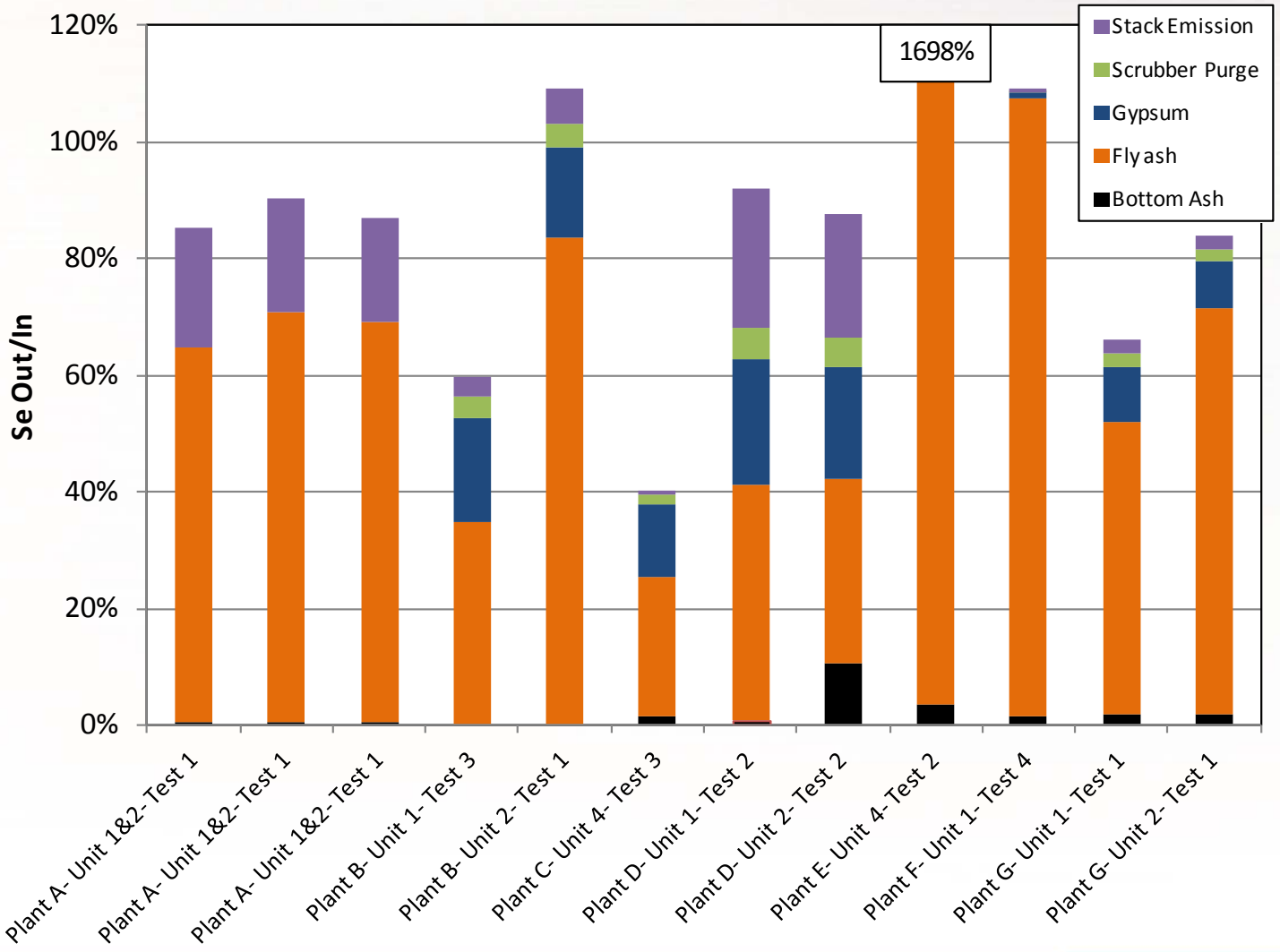
- Selenium mostly vaporized in the combustion zone
- Gas-phase SeO_2 reacts with surface of ash particles as flue gas cools
  - Se reacts with iron and calcium
  - Sulfur interferes with the reactions
- Implications for emissions and control
  - Efficient capture of Se by fly ash in boilers firing subbituminous and lignites
  - Poor capture of Se by fly ash in boilers firing high-sulfur bituminous



Fate of Selenium in APCDs

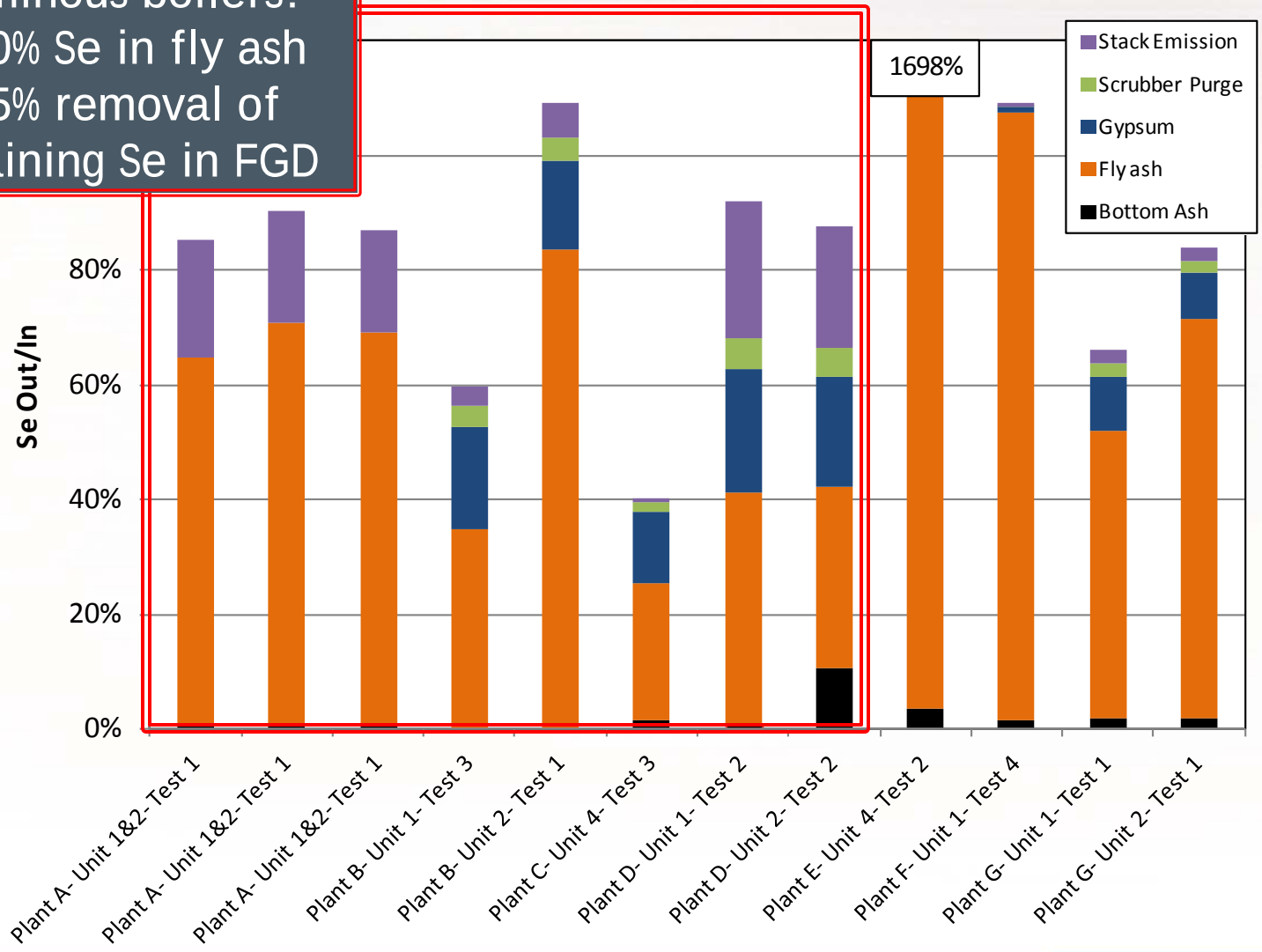


Selenium Mass Balance

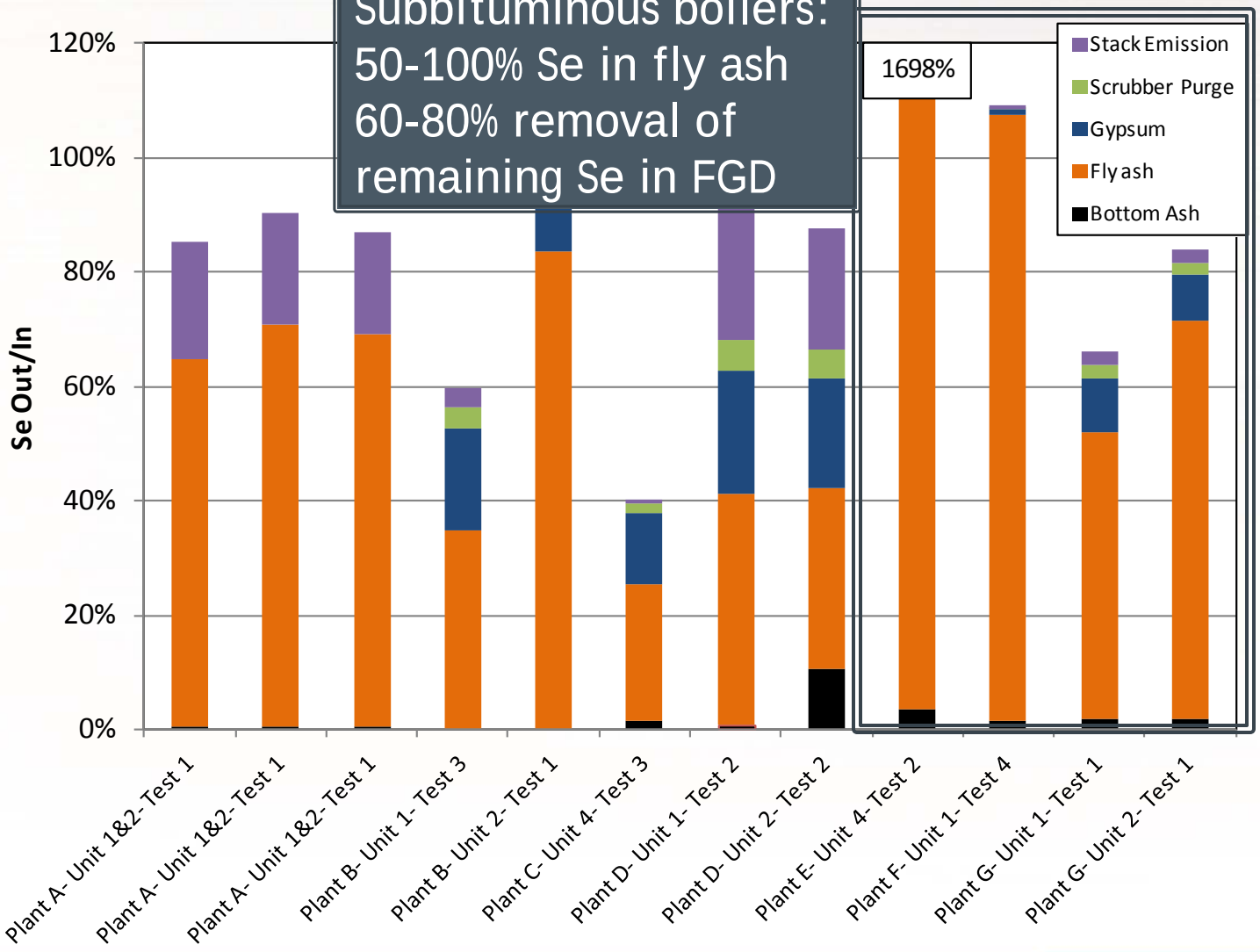


Selenium Mass Balance

Bituminous boilers:
25-80% Se in fly ash
50-95% removal of remaining Se in FGD



Selenium Mass Balance



Se Removal and Distribution in FGD

- Removal of Se across scrubber much lower than removal of SO_2 in most cases

Boiler	SO_2 Removal	Se Removal	Gypsum Se	Blowdown Liquid Se	Blowdown Solids Se	Limestone Se	Make-up Water Se	WESP Effluent Se
	%	%	µg/g	µg/L	µg/g	µg/g	µg/L	µg/L
B-1	97.8%	86.4%	10.1	2059	45.4	<0.57	0.448	--
B-2	95.4%	75.3%	11.4	1690	23.9	<0.57	0.448	--
C	95%[1]	95.6%	1.3	96.5	8.64	<0.62	2.22	36.5
D	92%[1]	53.1%	3.5	1210	294	<0.62	--	--
F	92.6%	57.1%	<0.60	7.81	4.79	<0.57	0.396	--
G-1	92%[1]	82.6%	2.01	942	65.5	1.22	--	--
G-2	92%[1]	78.7%	1.9	861	59.5	1.23	--	--

[1]Estimated

Input, Output, Removal of Se

Se inputs & stack emission in lb/TBtu

Plant	Se input (fuel)	Se input (FGD)*	Se stack emission	Se removal
A-1&2	378.9	--	72.8	81%
B-1	368.5	2.4	12.6	97%
B-2	339.3	1.7	21.7	94%
C	168.5	6.8	1.2	99%
D-1	305.0	7.1		76%
D-2	344.2	7.1	74.6	79%
E	45.7	--	12.7	72%
F	115.7	0.6	0.8	99%
G-1	59.2	2.1	1.5	98%
G-2	46.7	1.5	1.3	97%

bituminous

sub-bituminous

*Limestone and make-up water

- Most Se came from coal – higher input on bituminous units
- Units without scrubbers (A and E): 81% and 72% Se removal
- Scrubbed units: 76% to 99% Se removal

Implications for Emissions and Control

- Unlike most HAP metals, Se can be gaseous (SeO_2) at temperatures in APCDs
- Se can be captured by fly ash, but not always removed with high efficiency by PCDs
  - Low-rank ash more effective at capturing Se than bituminous ash =>
  - FFs more effective than ESPs

Implications for Emissions and Control

- Significant portion of Se can enter FGD in gas-phase
  - Combination of PCD+scrubber removes >85% Se
- Removal of SeO_2 across FGDs less than removal of SO_2 (60%-90%)
- Selenium removed across FGDs could become an issue in wastewater discharge
  - More data needed on distribution within scrubber