Trace Element Sampling and Partitioning Modeling to Estimate Wastewater Composition and Treatment Performance at Coal Generators

Principal Investigator: *Meagan S. Mauter, Associate Professor of Civil & Environmental Engineering, Stanford University*
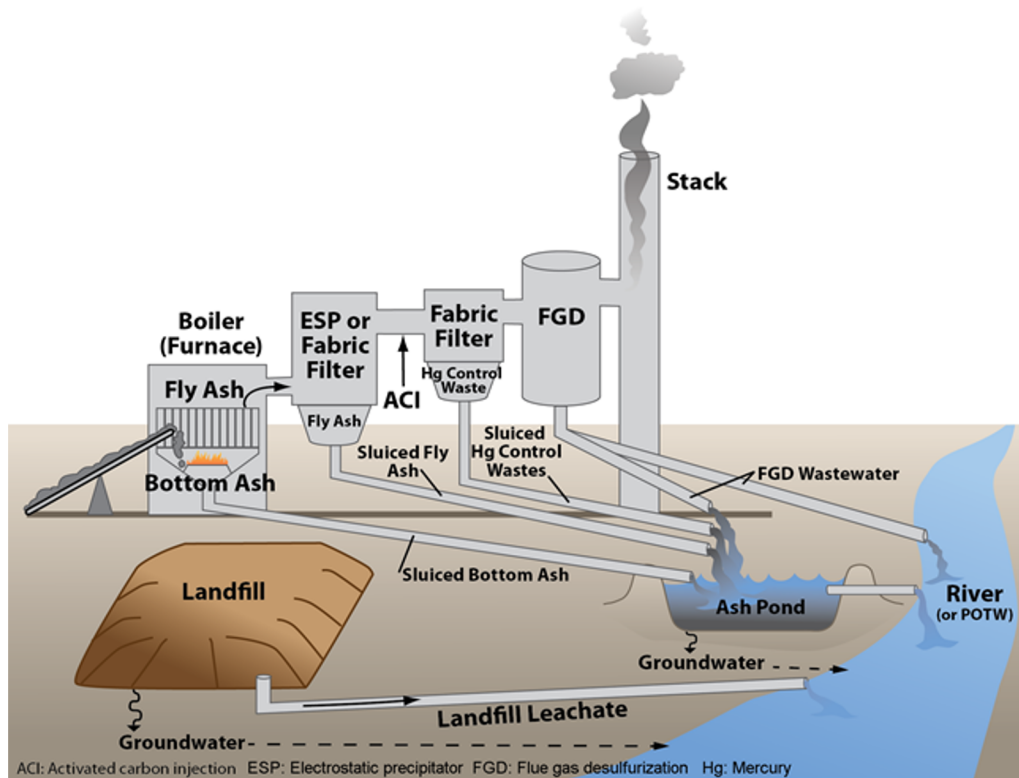
Co-Principal Investigators: *James C. Hower, Research Professor of Earth & Environmental Sciences, University of Kentucky; Heileen Hsu-Kim, Associate Professor of Civil & Environmental Engineering, Duke University*

Senior Personnel: *Daniel B. Gingerich, Assistant Professor of Civil, Environmental & Geodetic Engineering & Integrated Systems Engineering, The Ohio State University*

Doctoral Researcher: *Alison Fritz, PhD Student, Civil & Environmental Engineering, Stanford University*

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Regulatory Drivers and Alignment to Fossil Energy Objectives

Regulatory Drivers- Effluent Limitation Guidelines (2020)
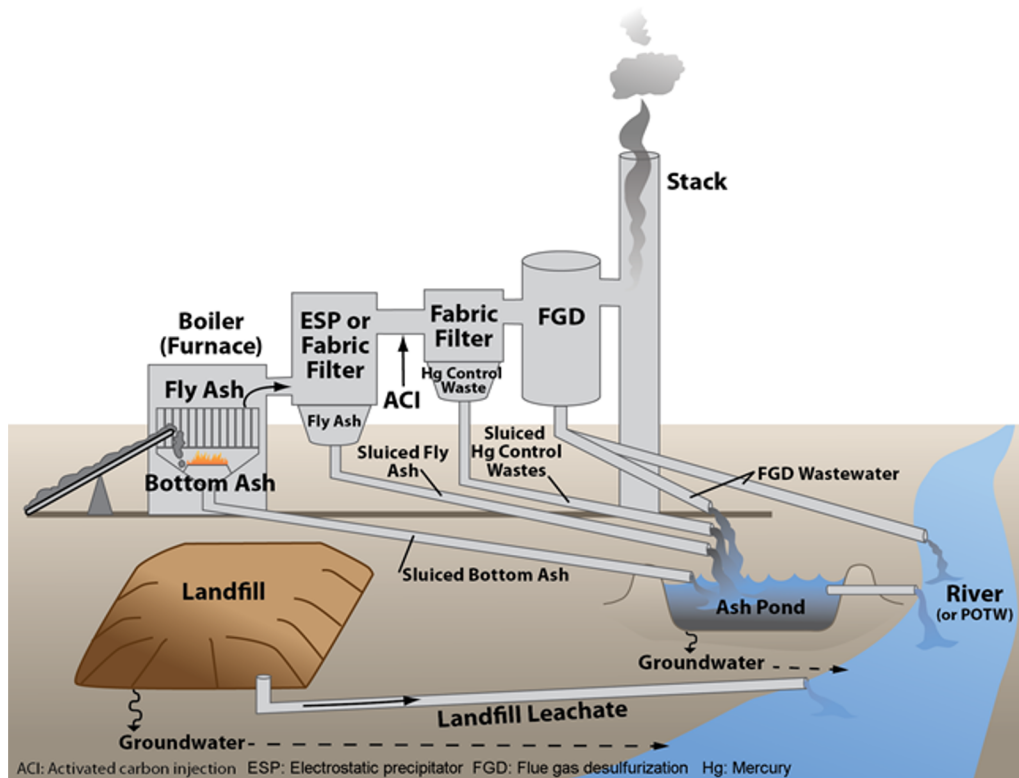
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Regulatory Drivers and Alignment to Fossil Energy Objectives

Regulatory Drivers- Effluent Limitation Guidelines (2020)

DOE FE Objective 1.1 – Develop cost-effective, environmentally responsible transformational technologies that will underpin coal-based facilities of the future

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# Regulatory Drivers and Alignment to Fossil Energy Objectives

Regulatory Drivers- Effluent Limitation Guidelines (2020)

DOE FE Objective 1.1 – Develop cost-effective, environmentally responsible transformational technologies that will underpin coal-based facilities of the future

DOE Water Security Grand Challenges - Reduce water impacts in the power sector

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Statement of purpose

- Trace elements have variable concentration in coal, and behave predictably in air pollution control devices (APCD)
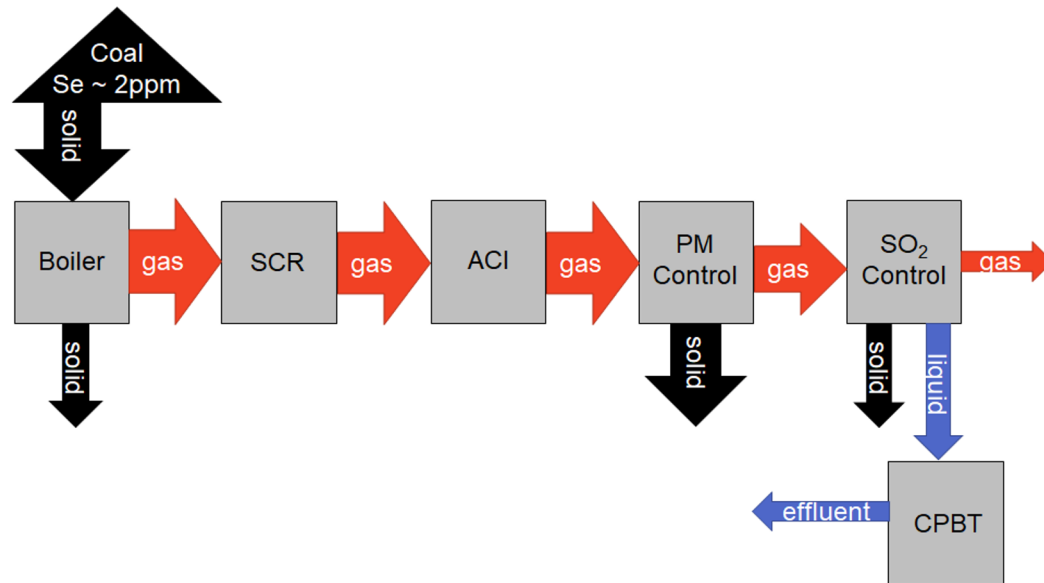
Statement of purpose

- Trace elements have variable concentration in coal, and behave predictably in air pollution control devices (APCD)

- This model improves on existing predictions for trace element partitioning at coal-fired power plants (CFPPs) by (1) accounting for plant-level variability and (2) providing validation
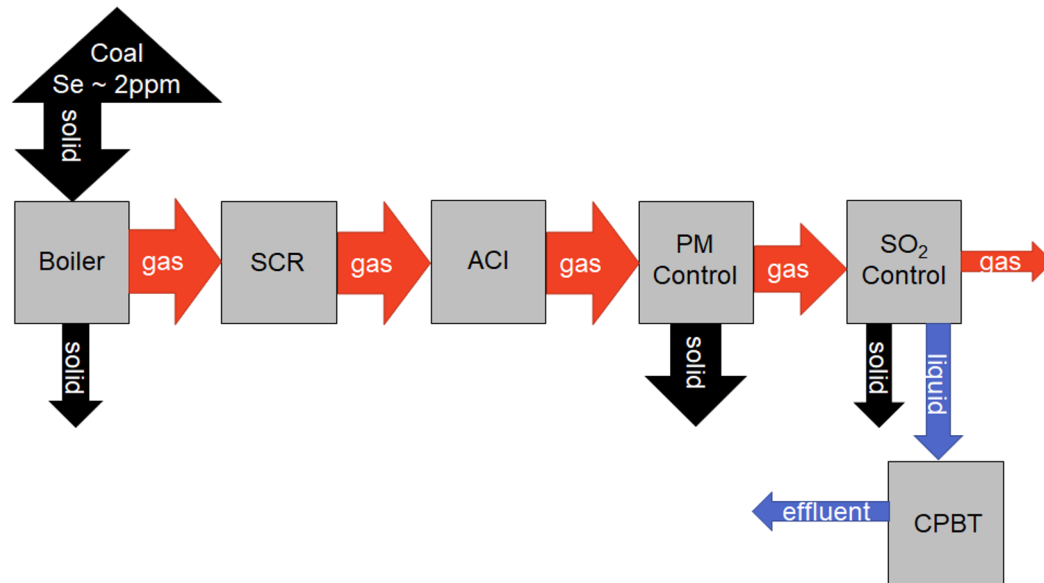
Project objectives

1. Develop a generalizable, open-source COntaminant behavior in Air, Liquid, and Solids (COALS) Controls Model to describe the quantity and partitioning behavior of trace elements **B, As, Se, Pb, Hg, Cl and Br** at US CFPPs

COALS Controls Model

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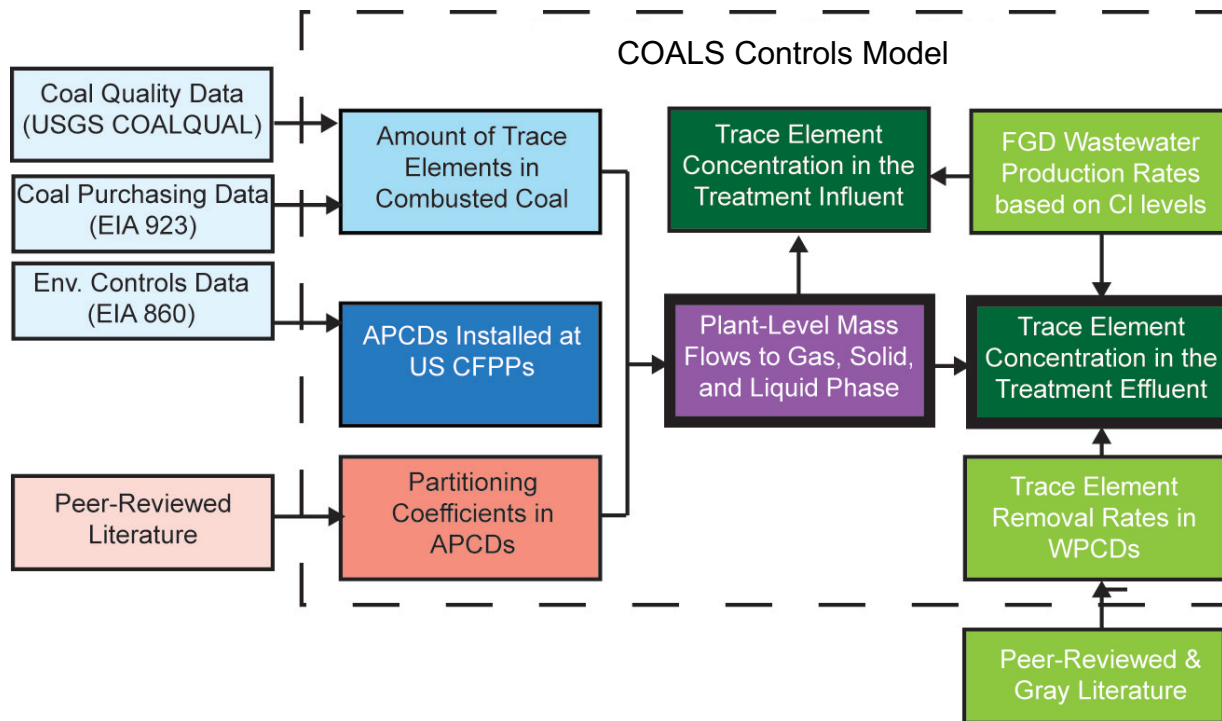
Project objectives

2. Characterize removal performance for trace elements of concern within the best available technologies (BATs) under the Effluent Limitation Guidelines (ELGs) for Flue Gas Desulfurization (FGD) wastewater treatment

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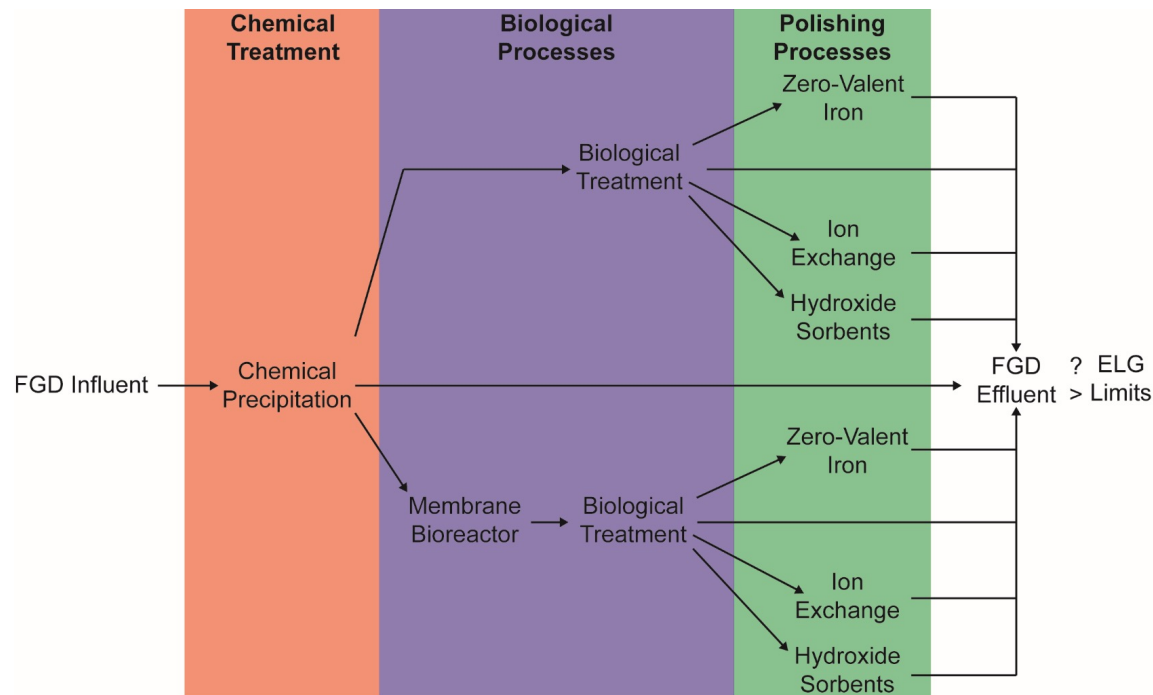
Industry collaboration

- The project uses data collected at LGE-KU partner facilities and includes non-steady state plant operation

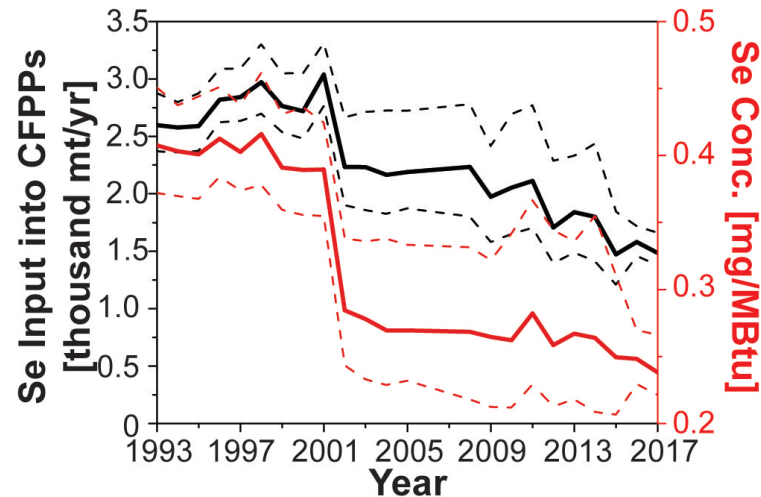- Partner facilities include Trimble County, Ghent, and Mill Creek Generating Stations
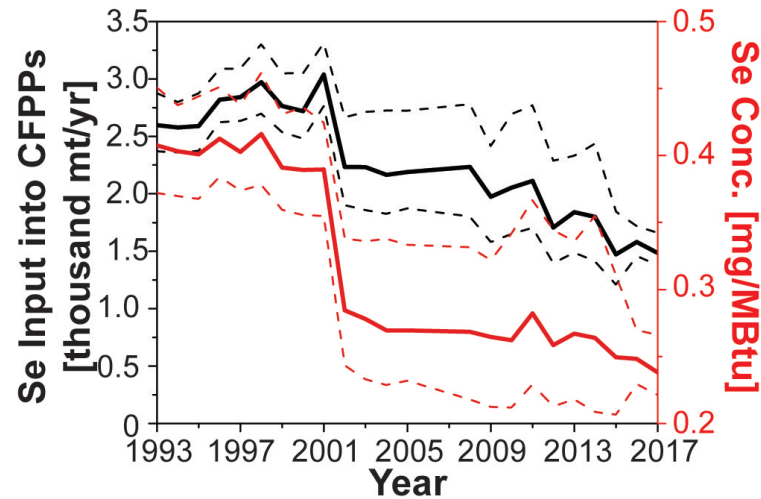

Trimble County Generating Station

Sample collection at Ghent generating station

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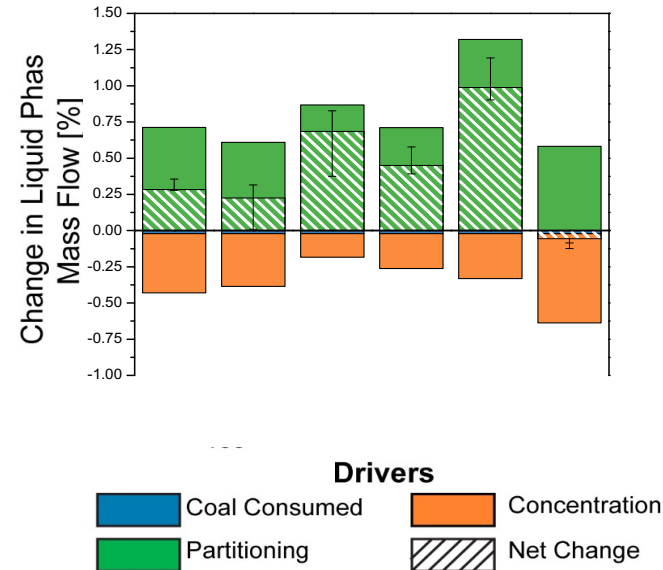# Developed trace element partitioning model in air pollution control devices

Percent change in the mass of
Selenium entering U.S. CFPPs
between 1993 and 2017

D. B. Gingerich, Y. Zhao, M. S. Mauter, Energy Policy. 132, 1206–
1215 (2019).

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Developed trace element partitioning model in air pollution control devices
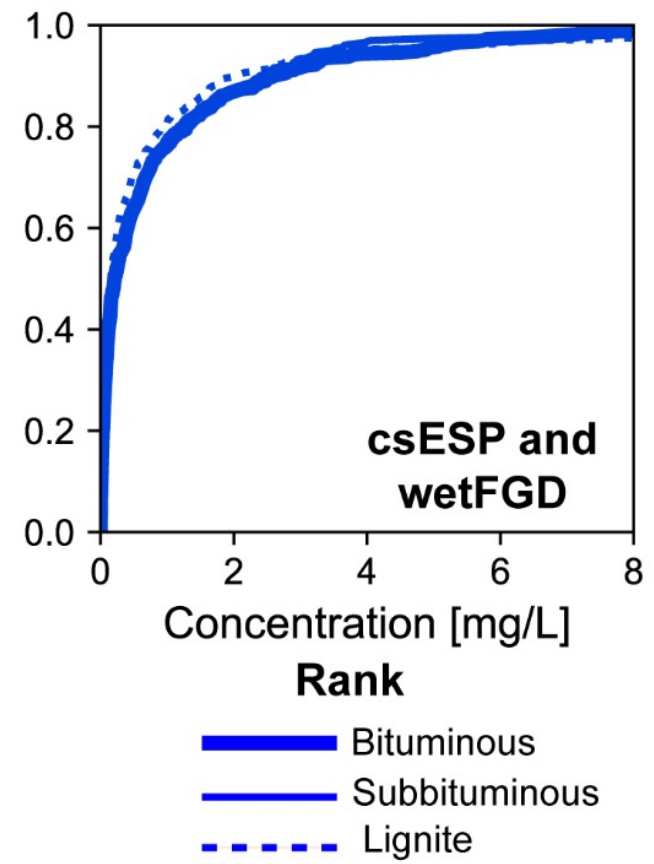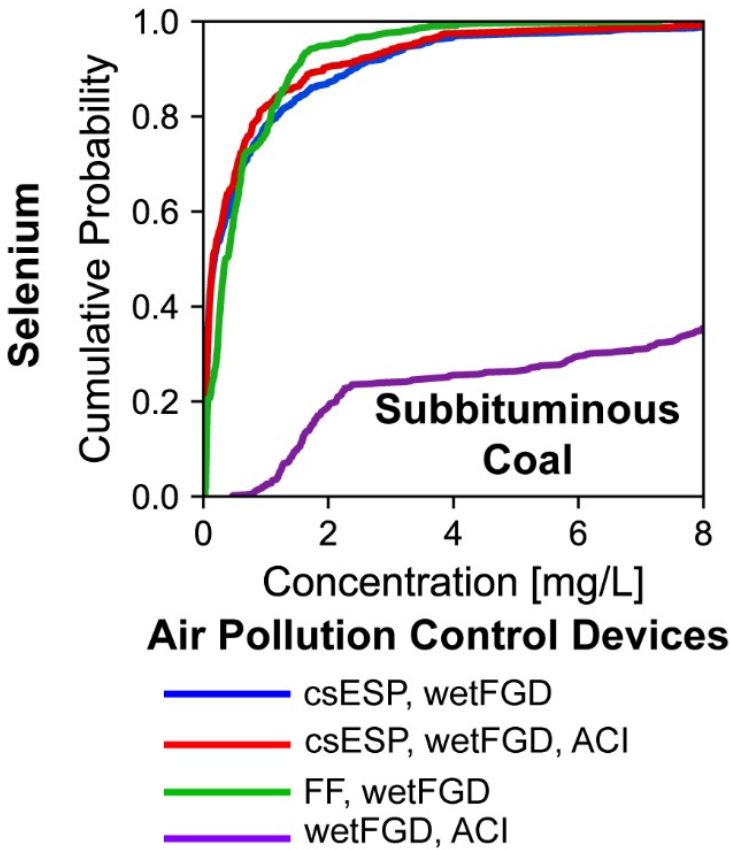

Percent change in the mass of Selenium entering U.S. CFPPs between 1993 and 2017

Attributional analysis of changes in the phase of trace elements exiting U.S. CFPPs

11   D. B. Gingerich, Y. Zhao, M. S. Mauter, Energy Policy. 132, 1206–1215 (2019).

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Simulated flue gas desulfurization wastewater composition

csESP = cold side electrostatic precipitator; ACI=Activated Carbon Injection; FGD=Flue Gas Desulfurization

D. B. Gingerich, M. S. Mauter, Environ. Sci. Technol. 54, 3783–3792 (2020).

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Determined probability of treatment costs at the baseline 550 MW NETL coal fired powerplant
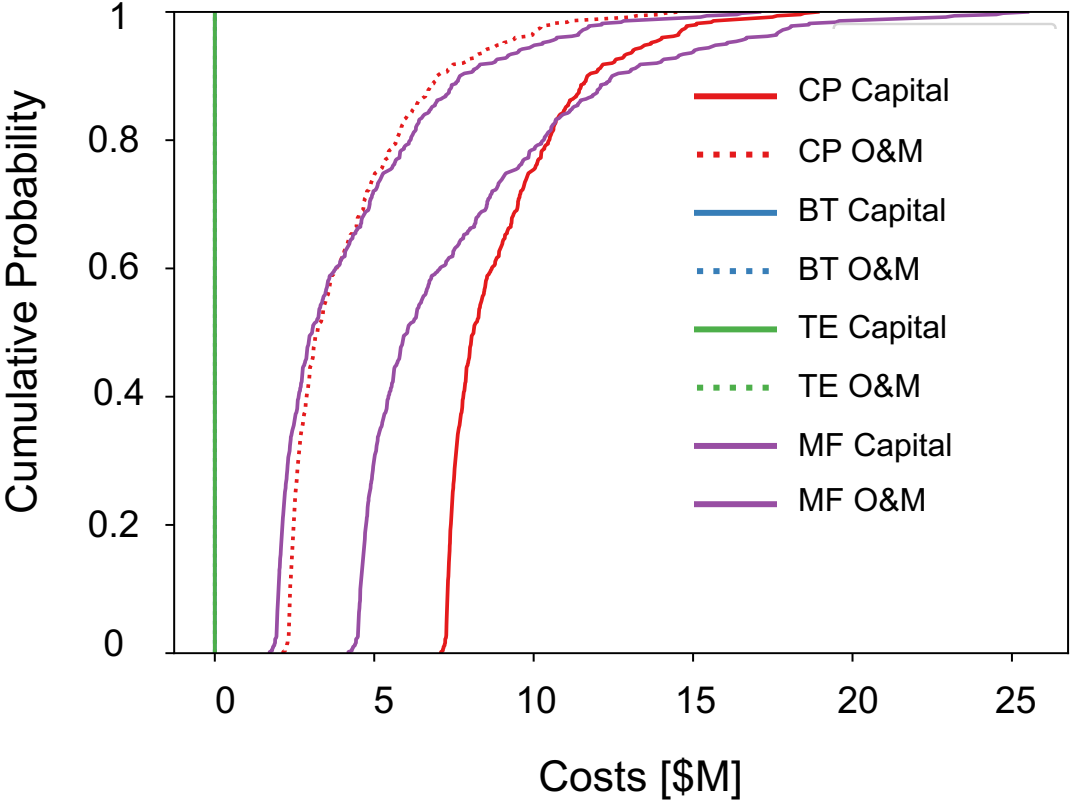
[i = 10%, n = 25 years]

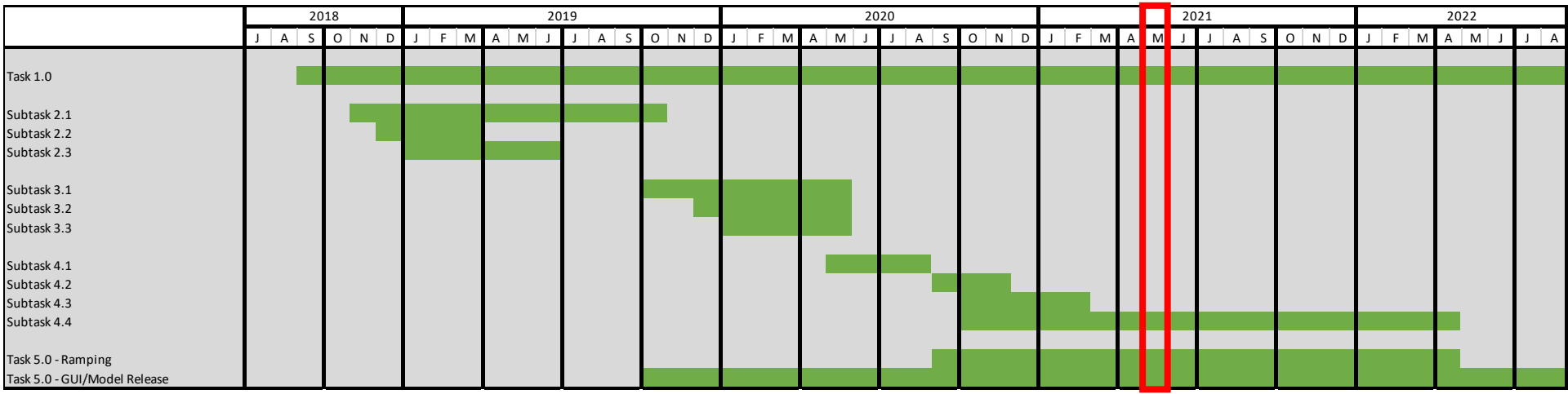CP=Chemical Precipitation; BT=Biological Treatment; TE=Brine Encapsulation; MF=Membrane Filtration
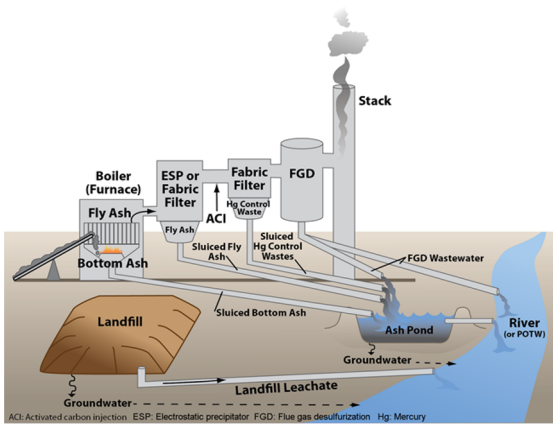
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Next steps for model development

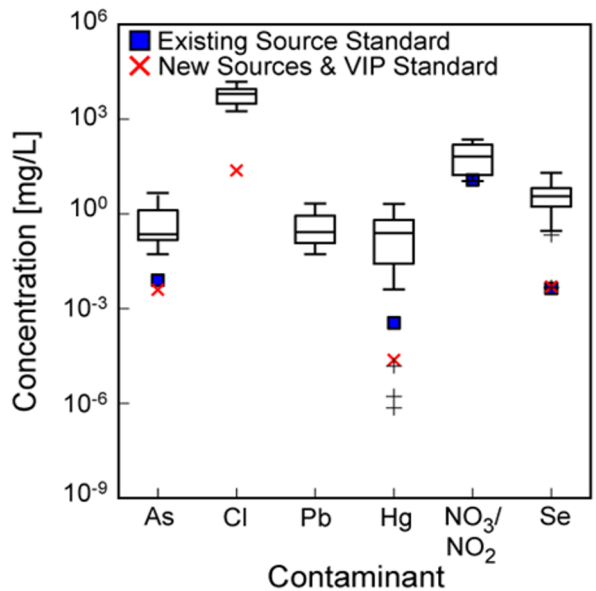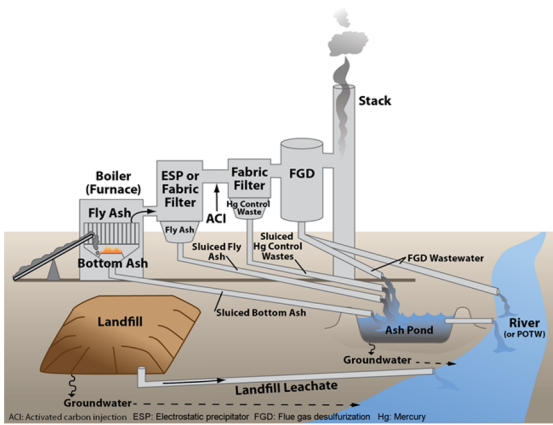Task 4 – Calculate removal of trace elements in FGD wastewater and use linear models to predict removal efficiency

Task 5 - Continue modeling relationship between ramping and APCD/WPCD performance using the data that has been collected at Partner Facilities

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Benefits for discharge management at CFPP

Stack
Boiler (Furnace)
ESP or Fabric Filter
Fabric Filter
FGD
Hg Control Waste
Fly Ash
ACI
Fly Ash
Sluiced Fly Ash
Sluiced Hg Control Wastes
FGD Wastewater
Bottom Ash
Sluiced Bottom Ash
Landfill
Ash Pond
River (or POTW)
Groundwater
Landfill Leachate
Groundwater
ACI: Activated carbon injection ESP: Electrostatic precipitator FGD: Flue gas desulfurization Hg: Mercury

Enable solid, liquid, and gas discharge management by modeling trace element behavior

D. B. Gingerich, E. Grol, M. S. Mauter, Environ. Sci.: Water Res. Technol. 4, 909–925 (2018).

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Benefits for discharge management at CFPP

Enable solid, liquid, and gas discharge management by modeling trace element behavior

Develop typical FGD wastewater compositions for treatment technology development
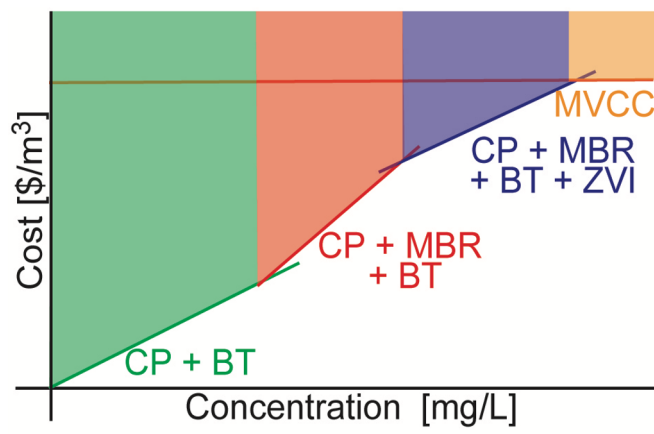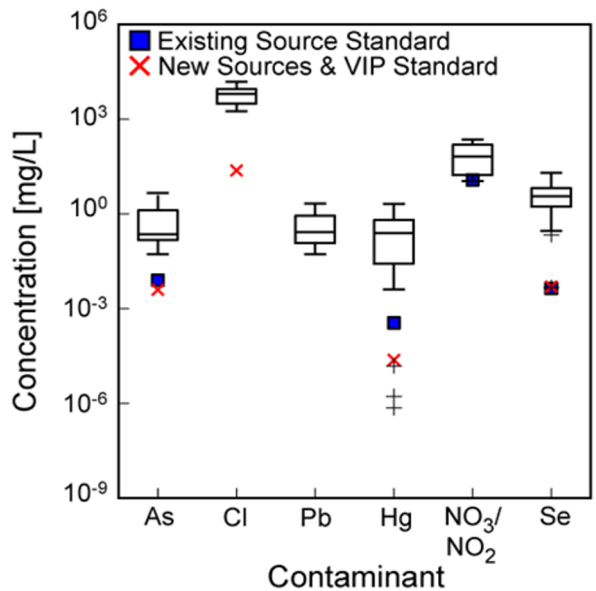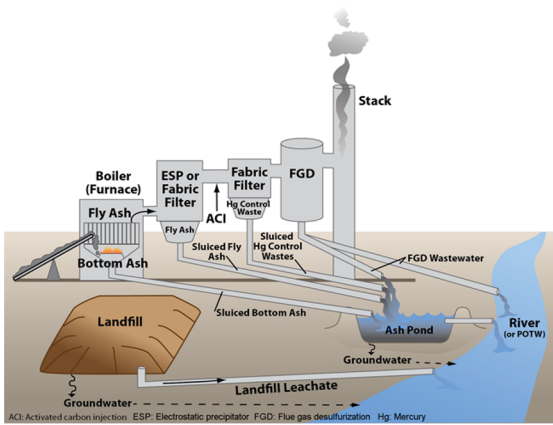
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Benefits for discharge management at CFPP

Enable solid, liquid, and gas discharge management by modeling trace element behavior

Develop typical FGD wastewater compositions for treatment technology development

Identify cost-effective FGD wastewater treatment technology options

D. B. Gingerich, E. Grol, M. S. Mauter, Environ. Sci.: Water Res. Technol. 4, 909–925 (2018).

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Dissemination of results to industry

- 3 manuscripts published in Energy Policy and Environmental Science & Technology

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- Public GitHub project and Open Science Foundation project were created for the COALS Controls Graphical User Interface

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Concluding remarks

- This project has successfully met objectives to predict trace element partitioning at CFPPs and identify FGD wastewater treatment costs

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- The objectives contribute towards DOE FE strategic objectives to improve environmental stewardship of and reduce environmental impacts from coal-based facilities of the future

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Concluding remarks

- This project has successfully met objectives to predict trace element partitioning at CFPPs and identify FGD wastewater treatment costs

- The objectives contribute towards DOE FE strategic objectives to improve environmental stewardship of and reduce environmental impacts from coal-based facilities of the future

- The objectives address water impacts in the power sector highlighted in DOE Water Security Grand Challenges

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Acknowledgement and Disclaimer

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