Mitigation of Aerosol Emissions from Solvent-based Post-Combustion CO_2 Capture Systems

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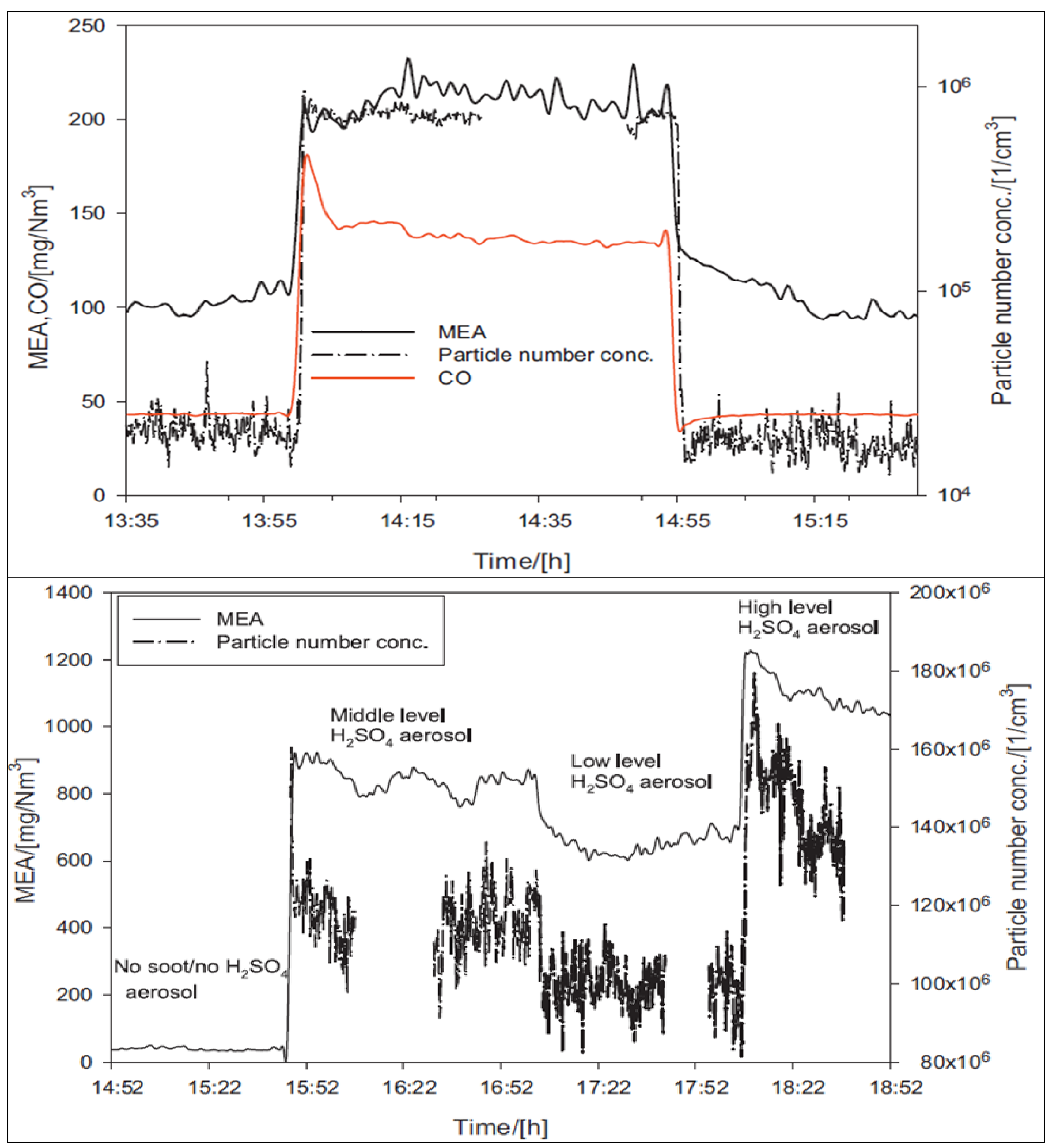
Background – Aerosol Formation

- Solvent-based scrubbers are leading technology for CO_2 capture from coal-fired power plants
  - Solvents such as MEA, MDEA and PIP are used to strip CO_2 from flue gas
  - Their high volatility results in emission to atmosphere
  - Emissions are due to fine particles (aerosols) too small to be captured by existing counter-measures (water wash and de-misters)
- Aerosol formation occurs primarily from ultra-fine particulate via condensation of alkali and SO_3



Top: MEA Emissions Increase with Increase in Soot levels; Bottom: Emissions increase with increase in H_2SO_4 levels

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Project Objectives and Methodology

- **Objective:**
  - Eliminate formation and improve capture of all aerosol types (particulate, alkali and acid) with >98% efficiency
  - Mitigate *fouling of pre-heater during low load operation cycling*
- **Methodology**
  - Alkali Species – Prevent formation in boiler
  - SO_3 Species & Particulate Species – neutralize in boiler and improve performance of capture devices (ESP)

Phase I Experimental Setup

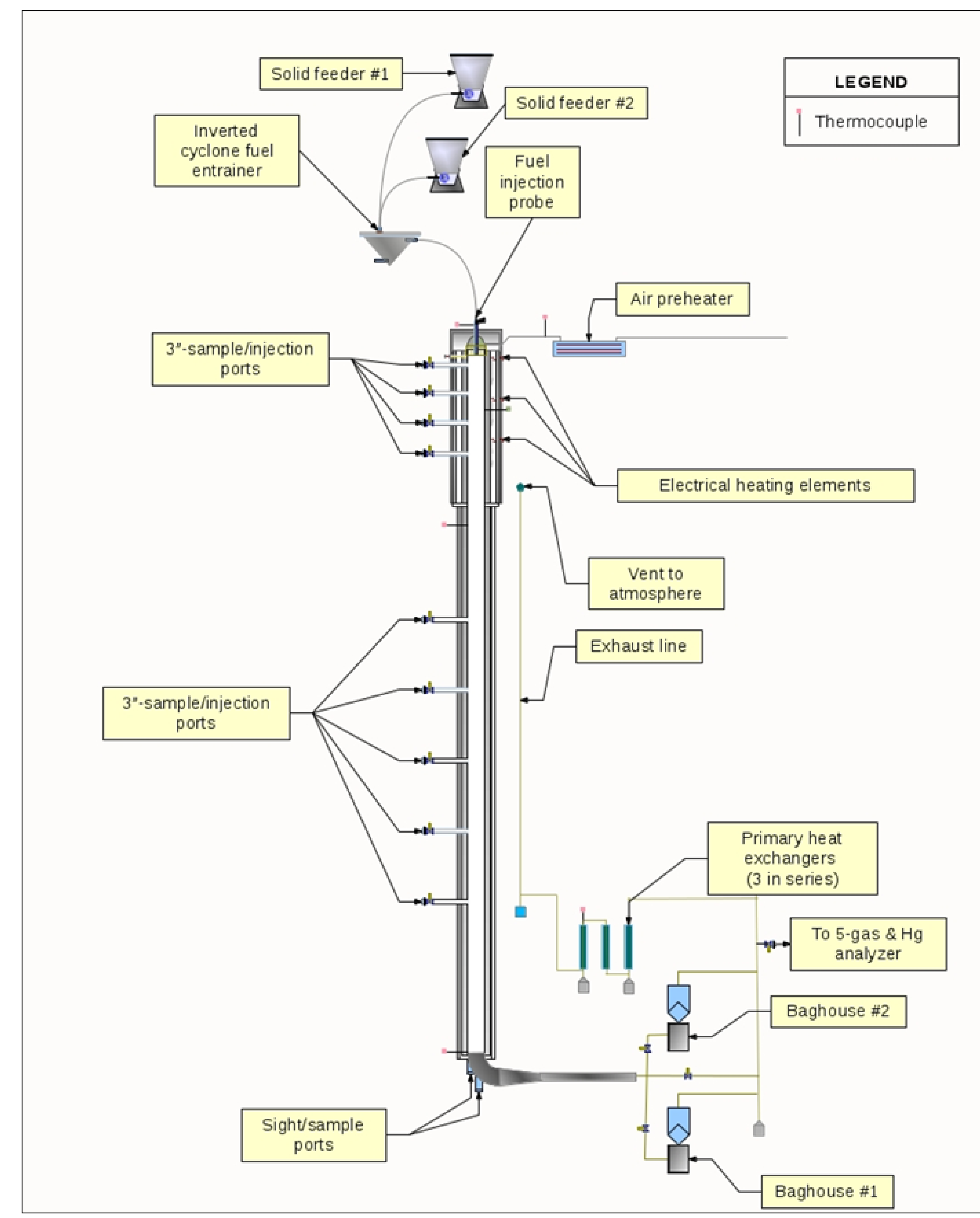
- Alkali-rich coal (0.5% Na) combusted in a 10 kW down-fired combustor
- An alkali sorbent added during coal combustion
- 3 sorbent levels investigated: **Low, mid and high**.
- Fine and Ultra-fine particulate collected using Dekati® Low Pressure Impactor (DLPI) and a EPA Southern Research Institute (SoRI) 5 stage cyclone.

Stage #	D50% (µm)
13	10
12	6.8
11	4.4
10	2.5
9	1.6
8	1
7	0.65
6	0.4
5	0.26
4	0.17
3	0.108
2	0.06
1	0.03

13 Stage DLPI showing aerodynamic cut-points for each stage

Cyclone Stage	Cut-Points (µm)
1	6.6
2	3.4
3	1.9
4	1.3
5	0.5

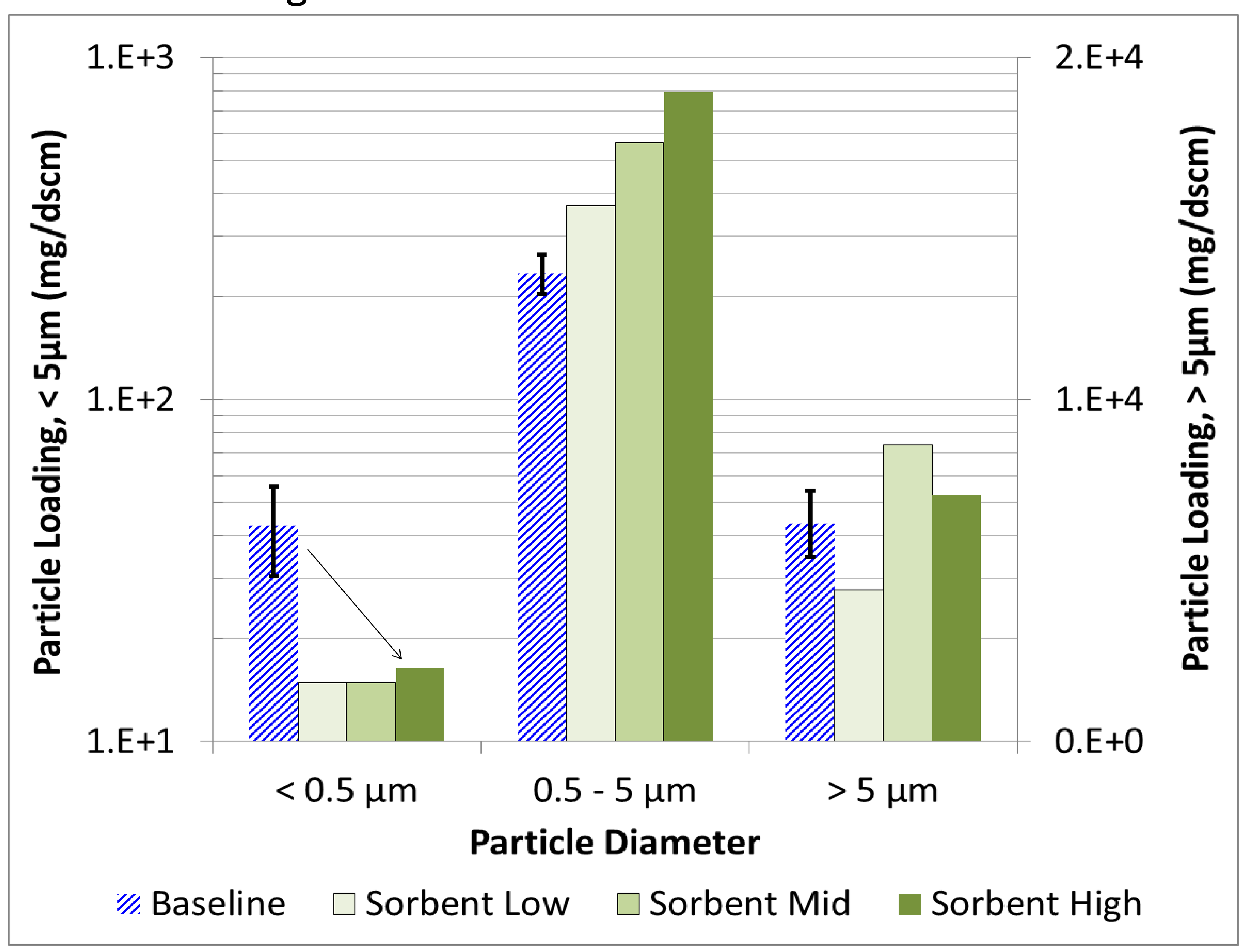
5-Stage SoRI/EPA Cyclone equipped with Back-Up Filter (left) and cut-points (right)



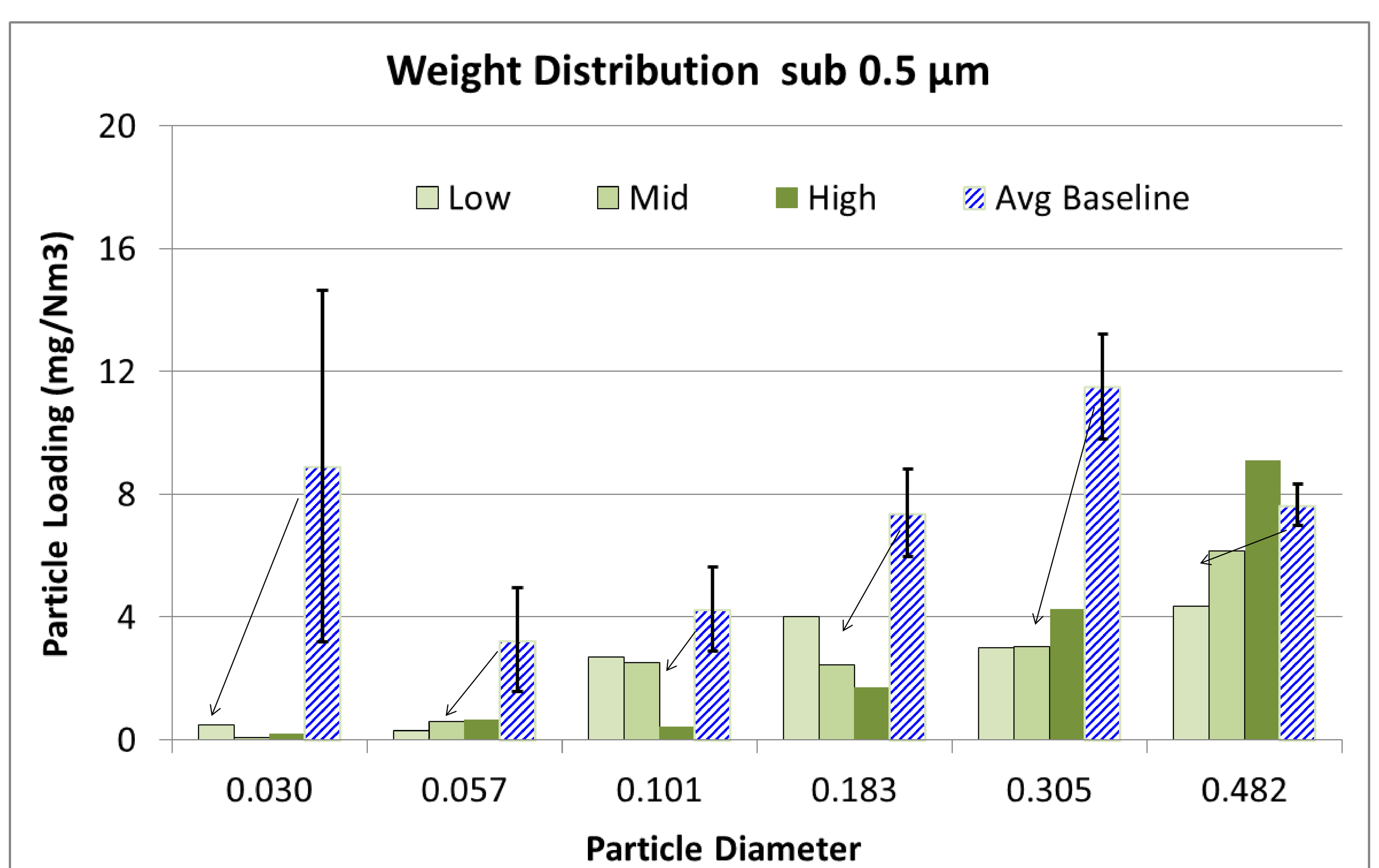
UND's 10 kW Down-Fired Coal Combustor

Results – Phase I

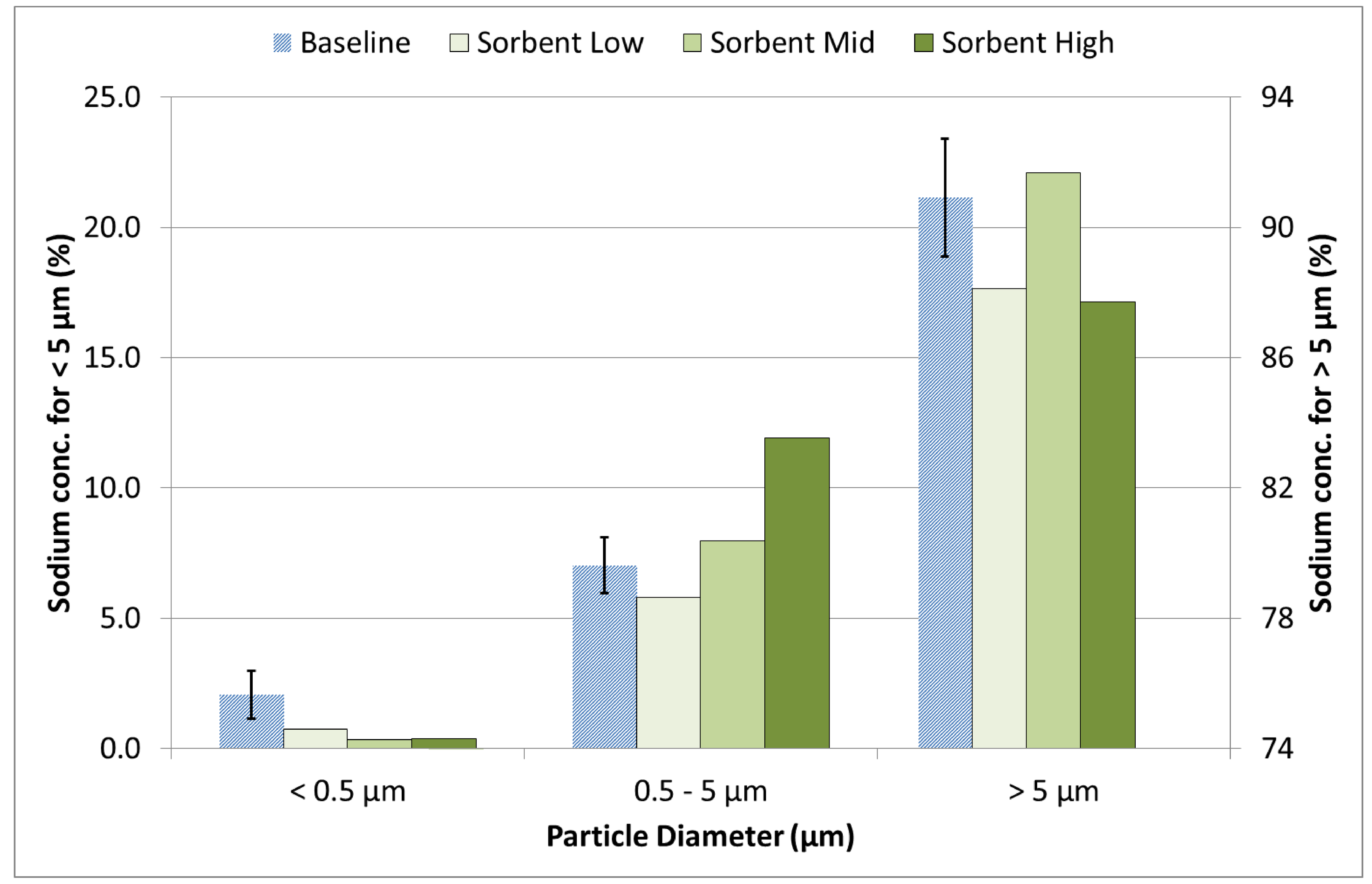
- Three baseline runs were performed. The average particulate size distribution (PSD) was determined.
- Sorbent runs showed a decrease in loading compared to baseline runs for the sub -0.5micron size bin.
- A corresponding increase observed in the larger size bins for the sorbent runs.
- Distribution within sub-0.5 micron bin shows how effective the sorbent is in reducing particulate loading
- Sodium (Na) levels in the ash showed shift to larger (> 1 micron) range; **75% drop in the sub-micron range compared to baseline.**
- Sorbent reducing ultra-fine particulate and concentrating alkali to larger size bins.



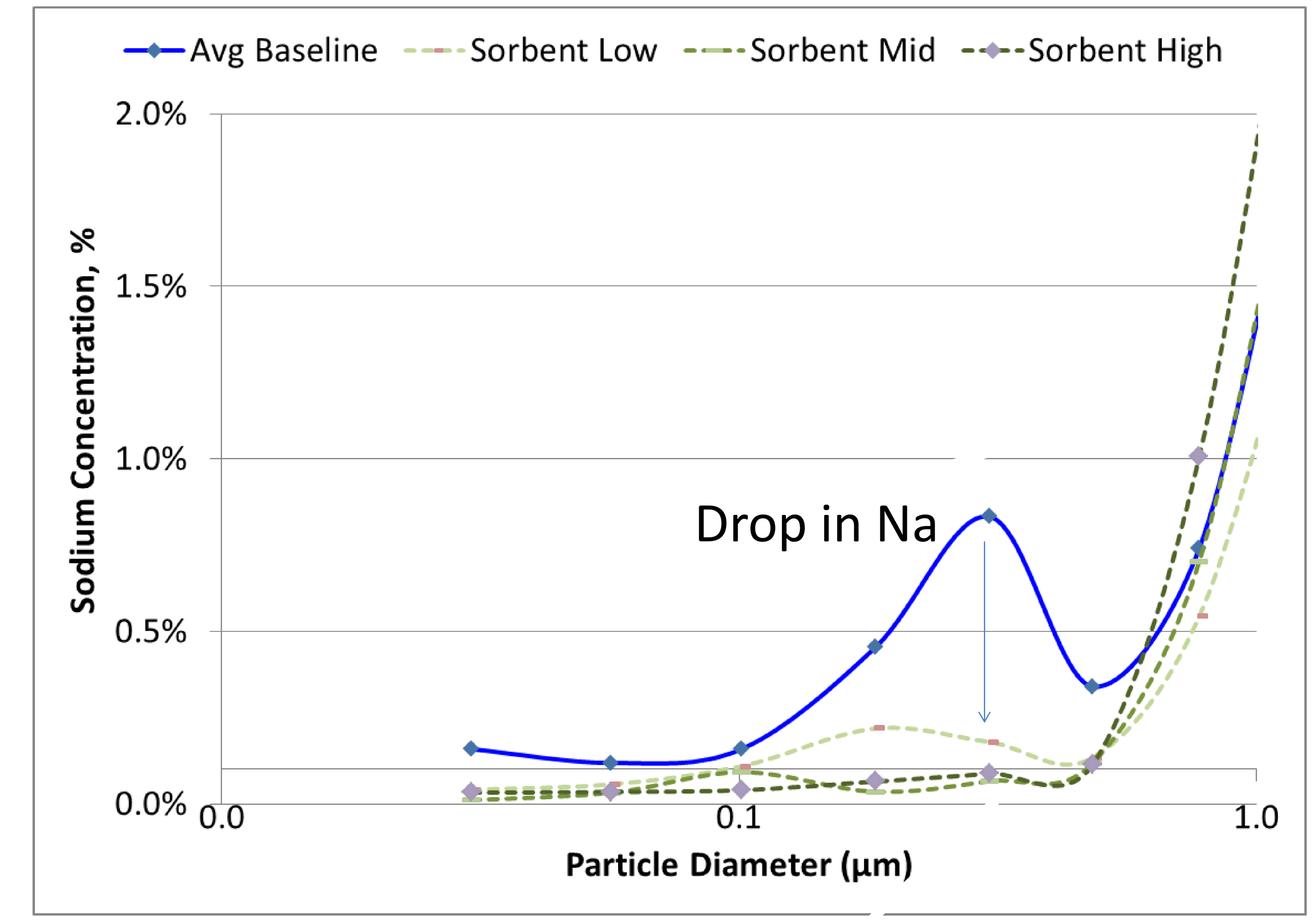
PSD for Baseline and Sorbent Runs collected with DLPI



PSD for Baseline and Sorbent runs for the sub-0.5 micron size bin



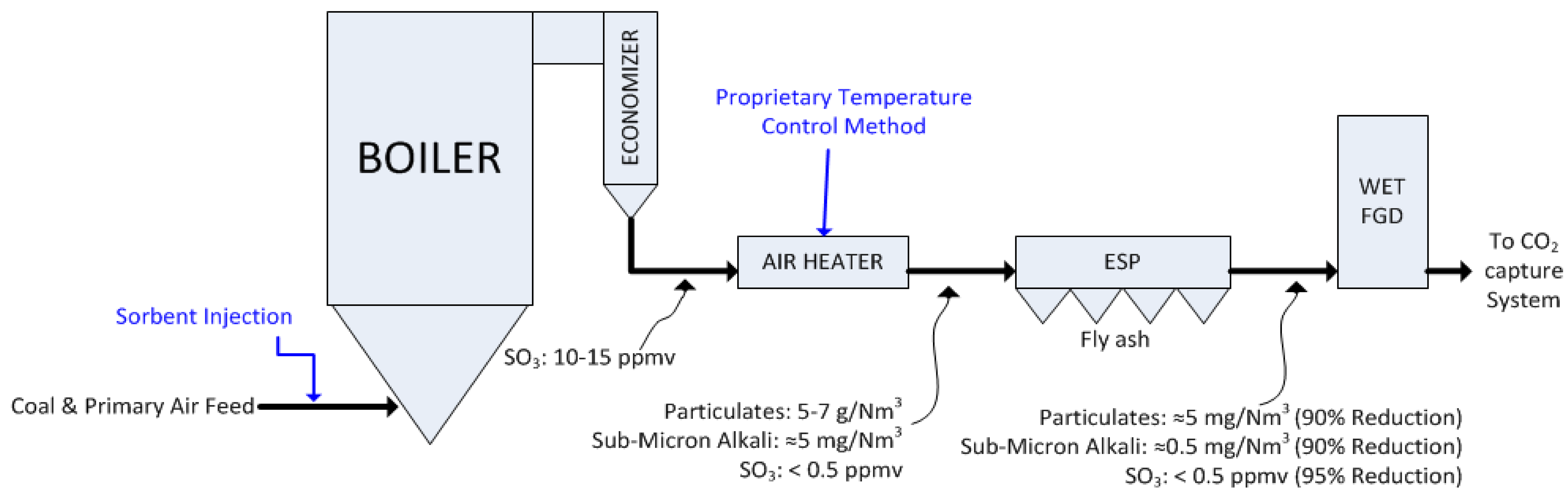
Na concentration in ash collected on different stages of DLPI



Drop in Na levels in the 0.5 micron bin for baseline to additive

Future Work

- Future work will focus on SO_3 and particulate control
- SO_3 is also responsible for aerosol formation and fouling:
  - High SO_3 levels result in acid condensation in air pre-heater
  - Low operating temperatures due to low load cycling also result in acid condensation
  - SO_3 that doesn't condense grows to form aerosols later in the particulate control devices
- Mitigate SO_3: by injecting sorbents to neutralize acidity
- Improve particulate capture operation to improve removal of particulates and neutralized acid
- Perform pilot testing to identify best sorbents for SO_3 capture
- Perform field testing to demonstrate particulate capture, alkali, and SO_3 mitigation



Proposed Control Strategy for Aerosol Mitigation and Fouling due to Low Load Cycling

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