Supplementary Materials

Low-carbon control of heavy metals in industrial flue gas

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Table 1. Selected quantitative evidence for energy and material demand and environmental burdens along the heavy-metal control and residue-management chain

Study and scale	Reported conditions and quantitative indicator	Assessment boundary and information required for carbon accounting
Xie et al.[1] Plasma conversion and dynamic-wave scrubbing Laboratory	Plasma-only $Hg^0/O_2/N_2$: inlet Hg^0, 100 μg m^{-3}; O_2/N_2 flows, 250/700 mL min^{-1}; frequency, 300 Hz. At 640 J L^{-1} (= 0.178 kWh m^{-3}), Hg^0 conversion was ~63%. Integrated Hg^0 removal: 51.3% without catalyst and up to 96% with catalyst and scrubbing.	The energy benchmark covers the plasma-only discharge. The optimized 96% removal configuration has a different process boundary. Electricity emission factor, power-supply losses, auxiliary power, catalyst/reagent production, pumping, and residue treatment are needed for a numerical carbon estimate.
Li et al.[2] Activated-carbon injection Six MSW incinerators	For 90% overall Hg removal, estimated ACI rates were ~135 mg Nm^{-3} for grate furnaces and ~170 mg Nm^{-3} for circulating fluidized-bed furnaces, versus the original 100 mg Nm^{-3}. Additional demand: ~35 and ~70 mg Nm^{-3}, respectively.	Field-based material demand per gas volume. Carbon accounting additionally requires sorbent production, utilities, and management of metal-bearing solid residues.
Park and Hong[3] Coal-fired power-plant control scenarios Process LCA	For a common annual Hg^0-removal target of 78 kg, aggregated life-cycle impacts were 0.027 kPt for SCR-assisted control and 0.483 kPt for ACI.	The compared routes share the removal target within the source study. kPt is an aggregated environmental-impact score. Carbon-specific reporting requires the climate-change category and its supporting inventory.

Huber et al.[4] MSWI fly ash treatment and disposal Residue LCA	Per 1 Mg of fly ash: ~1400 kg CO_2-equivalent for dedicated thermal treatment; ~550 for cement stabilization; ~260 for thermal co-treatment with combustible hazardous waste. The FLUREC metal-recovery scenario yielded a net impact of approximately −1 kg CO_2-equivalent per Mg of fly ash after substitution credits.	Treatment and disposal of fly ash. The co-treatment result subtracts the reference hazardous-waste disposal burden. Whole-process accounting additionally requires the upstream flue-gas-control inventory and a closed metal balance. The FLUREC scenario credits avoided primary-metal production and reduced quicklime use. Its net result depends on these substitution assumptions and the residue-treatment boundary.

Notes. ACI, activated-carbon injection; SCR, selective catalytic reduction; LCA, life-cycle assessment; SEI, specific energy input. The indicators describe the specified part of the control and residue-management chain; their functional units and boundaries are retained from each study.

Supporting References:

[1] Xie, W.; Zhu, T.; Yuan, B.; Fu, S.; Mao, Z.; Ye, Z.; Zhu, Z.; Zhang, X. Plasma-Catalyzed Combined Dynamic Wave Scrubbing: A Novel Method for Highly Efficient Removal of Multiple Pollutants from Flue Gas at Low Temperatures. *J. Hazard. Mater.* **2024**, *461*, 132518. https://doi.org/10.1016/j.jhazmat.2023.132518.

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