NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE | Nanyang Environment and Water Research Institute

CO_2 CAPTURE USING WASTE-DERIVED SORBENTS

Abstract:

This project aims to advance the technological readiness level (TRL) of post-combustion CO_2 capture by calcium looping using waste-derived sorbents towards 6-7 through pilot-scale testing, 100 – 500 kg/day scale sorbent production and feasibility study for a 1 t/day demonstration facility. The overarching research objectives are: (i) upgrade and operate a pilot system at NTU's Waste-to-Energy Research Facility (WTERF) for continuous capture at ~100 kg/day CO_2 (TRL5-6) (ii) produce durable, low-cost sorbents from air pollution control (APC) residues and carbide sludge at 100-500 kg/day scale and (iii) design and feasibility study of a CO_2 capture demonstration unit, scaling up from the pilot system to reach a capture capacity of 1 t/day. Our central hypothesis is that incineration ash and carbide sludge can be upcycled at large scale into high-performance Ca-based sorbents, enabling capture at ≤ S$80/t-$CO_2$.

To achieve the target, the project integrates (a) pilot-scale operation at WTERF for data generation, (b) sorbent formulation and production from local waste streams, and (c) design and in silico evaluation a (dual fluidised bed) DFB demo system employing oxy-fired calcination for realistic operation. Potential applications include direct decarbonisation WtE plants, which remain large point sources of emissions even after renewable energy transition. Spent sorbents will be valorised as construction aggregates, or as supplementary cementitious materials (SCMs) displacing ordinary Portland cement to facilitate resource circularity. This solution uniquely addresses two national challenges: decarbonisation and circular use of solid waste.

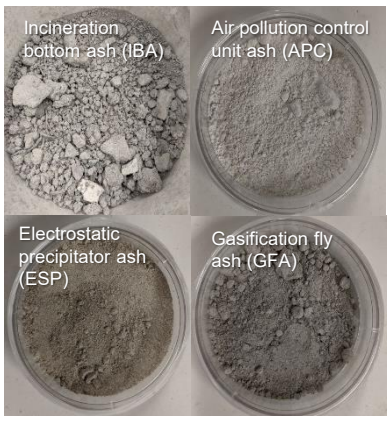
The project requests a budget over 3 years (2026–2029, inclusive of direct cost) to cover manpower, facilities, sorbent production, demo-plant design, pilot-plant upgrading and pilot plant operation. Successful outcomes will pave the way for potentially negative-emissions technology and the first-of-its-kind demonstration of Ca-looping CO_2 capture with ash-derived sorbents at industrially relevant scale, showcasing Singapore's world-leading capability in urban mining and research upgrading.

Project objectives:

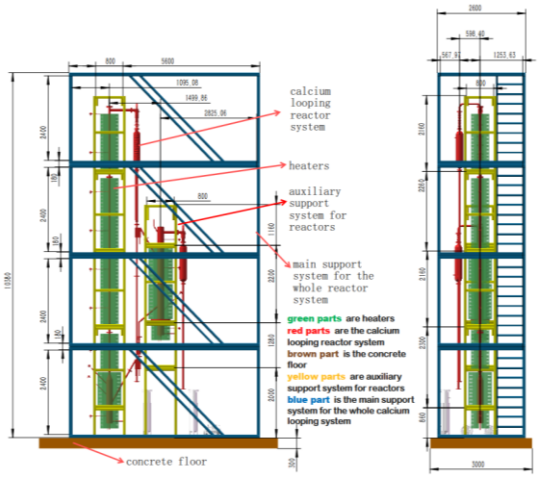
(i) Upgrade and operate a pilot system at NTU's Waste-to-Energy Research Facility (WTERF) for continuous capture at ~100 kg/day CO_2 (TRL5-6)

(ii) Produce durable, low-cost sorbents from air pollution control (APC) residues and carbide sludge at 100-500 kg/day scale

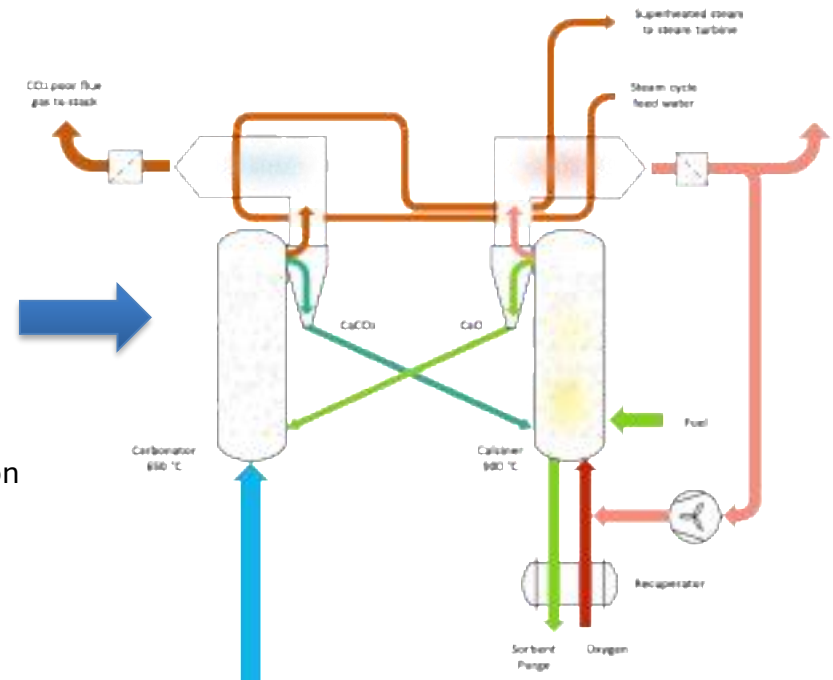
(iii) Design and feasibility study of a CO_2 capture demonstration unit, scaling up from the pilot system to reach a capture capacity of 1 t/day.



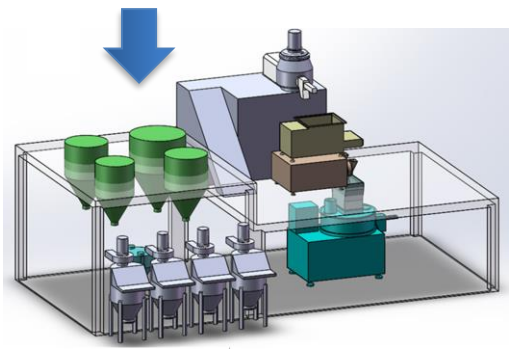
Different types of waste materials



100 kg/day CO_2 capture pilot demonstration



Integration with commercial WtE plants



100-500 kg/day sorbent production system

Ca-based CO_2 sorbents

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