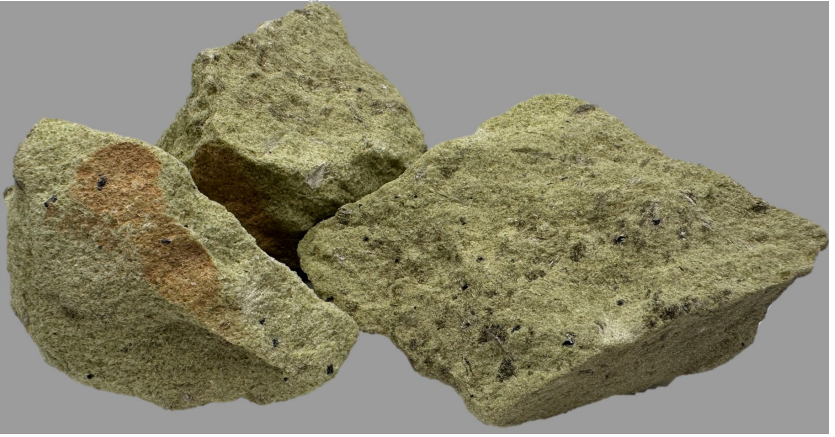
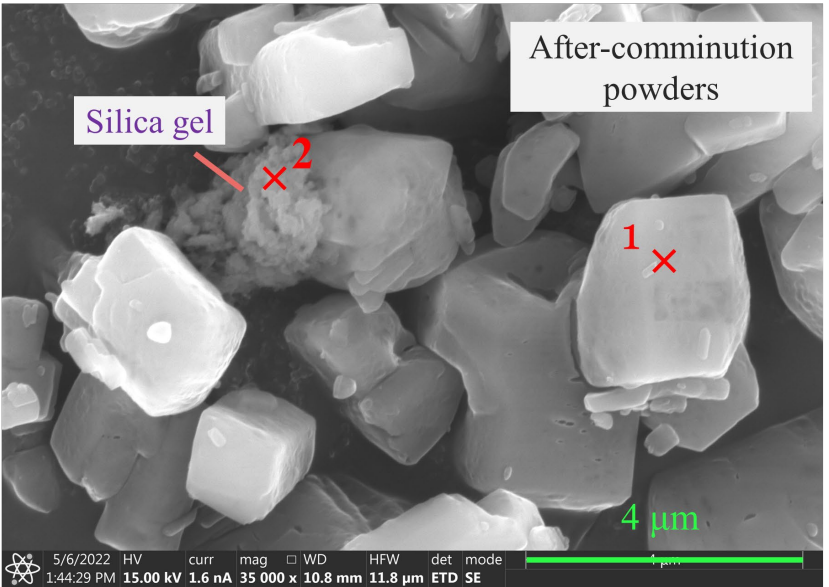






CHEMINUTION

Sustainable Chemical Comminution Technology for Energy Reduction and Enhanced Recovery of Critical Minerals

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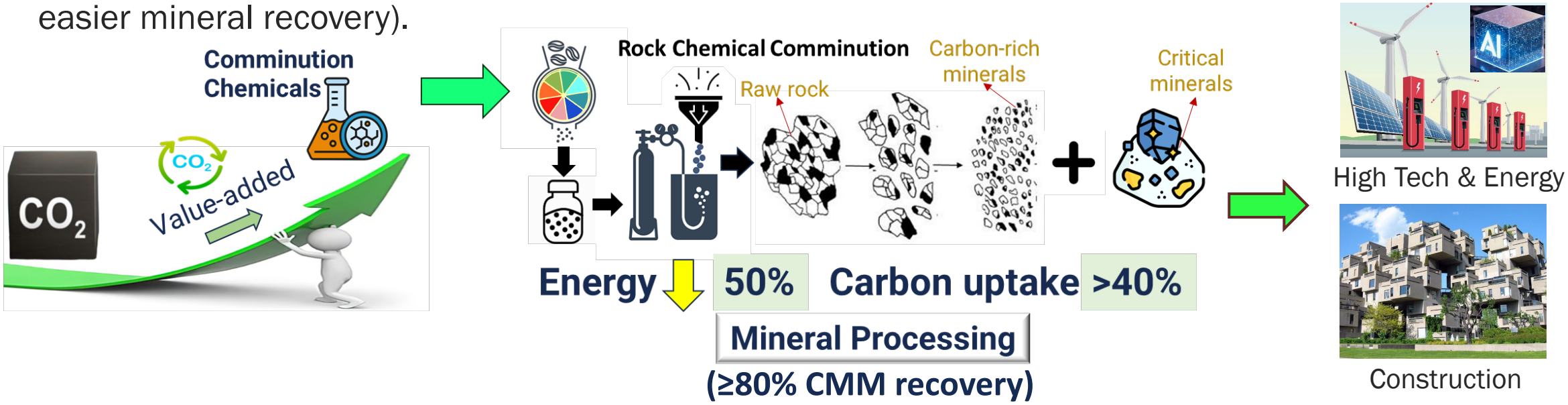
MISSOURI S&T

June 3, 2025

ARPA-E AWARDEE

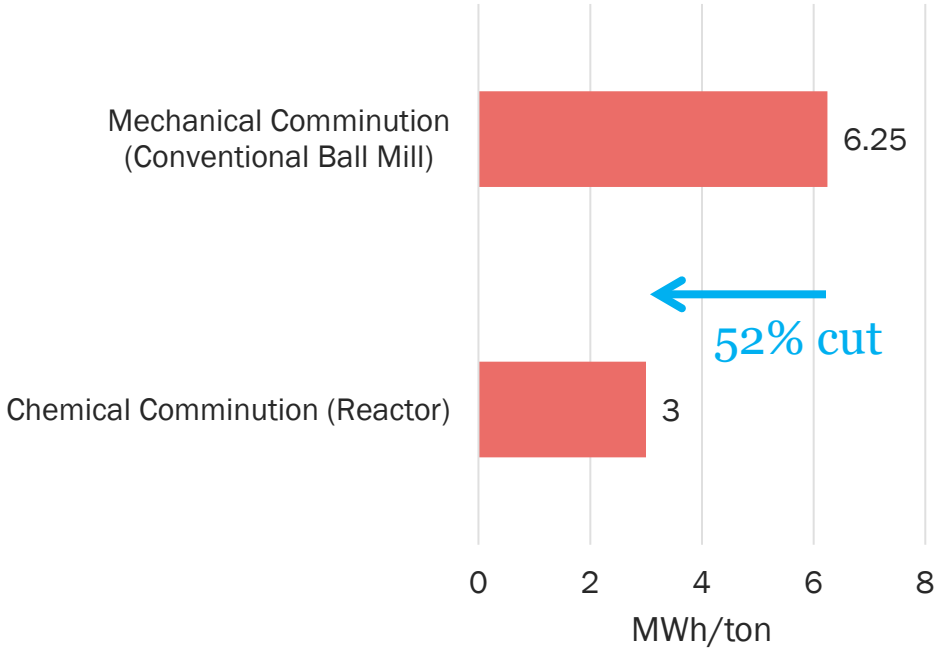
Concept and Goals

- Resilient supply chain necessitates the recovery of critical mineral and materials (CMMs) from unconventional feedstocks. Comminution alone accounts for 56% of the total energy consumption in the mining industry, and this percentage can be higher for unconventional feedstock processing.
- **Chemical comminution technology**, which involves particle size reduction through environmentally-friendly and rapid chemical reactions, is developed to significantly reduce comminution energy (with less mechanical comminution) and enhance the recovery efficiency of critical minerals (with products for easier mineral recovery).

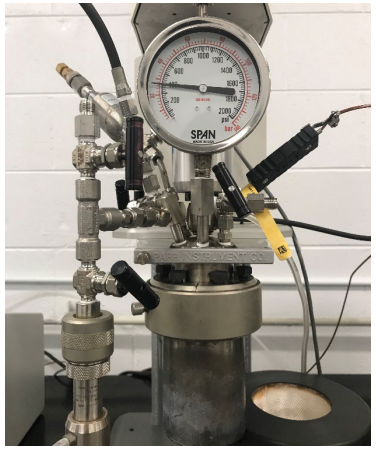


Achievement 1: Lower Comminution Energy by 52%, Carbon Uptake of 92 wt%

Comminution Energy Reduction

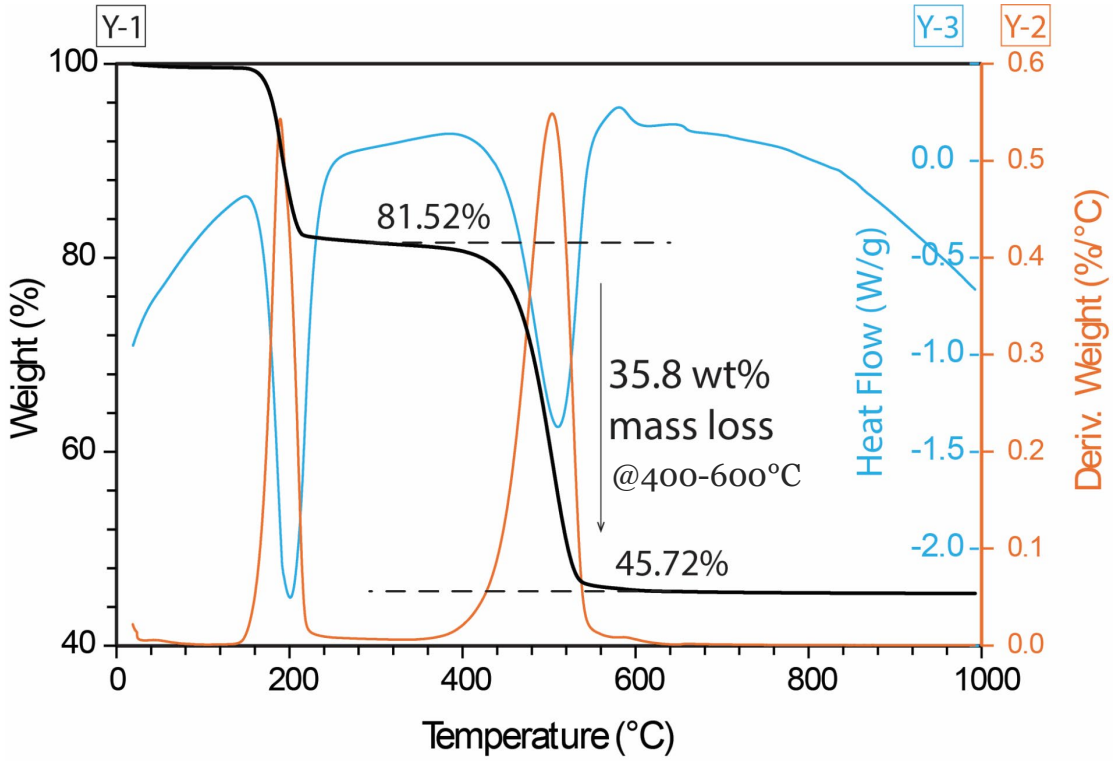






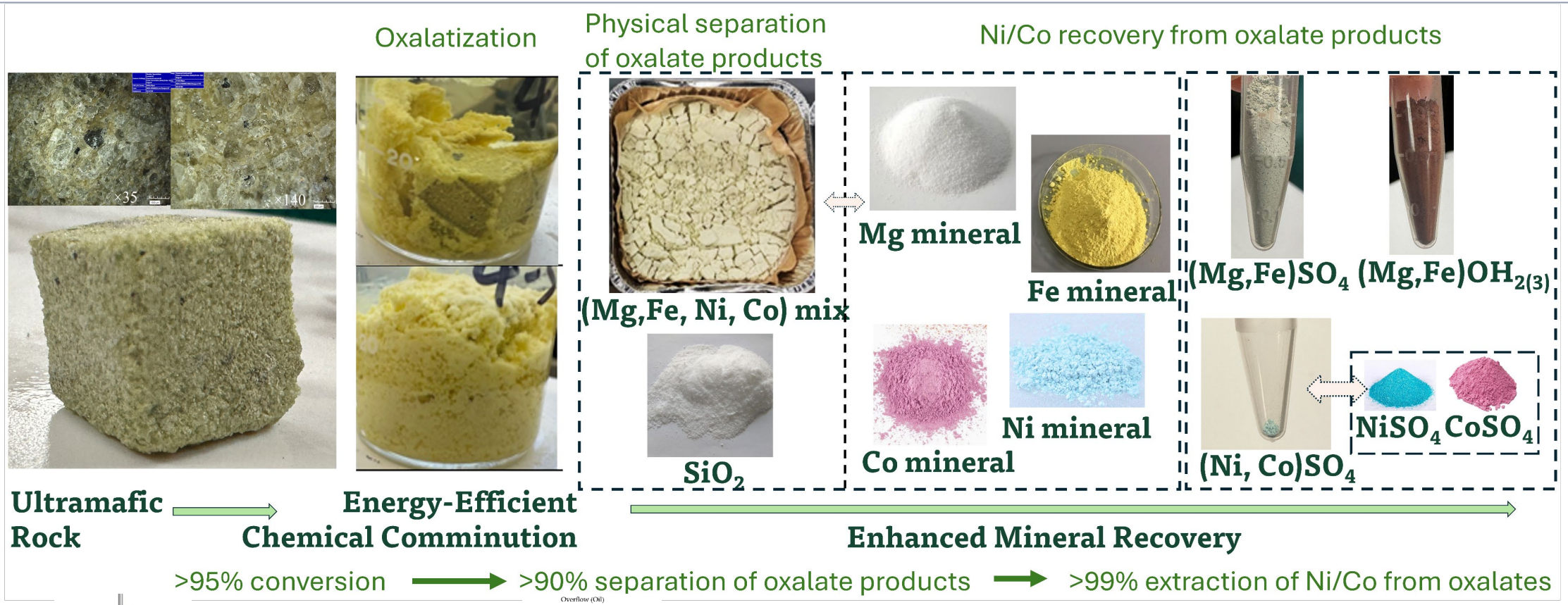
6.25 MWh/ton vs. 3.00 MWh/ton
(Particle Size Reduction from 200 µm to 5 µm)

Thermogravimetric Analysis (TGA) of Reaction Products

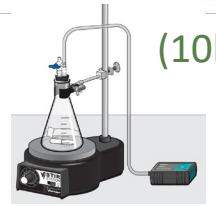


35.8 wt% mass loss = 0.92 ton CO_2/ton feedstock
→ 92 wt% carbon uptake

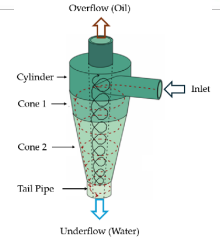
Achievement 2: Overall Ni/Co Recovery Efficiency of 81%



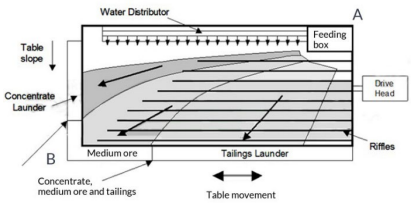
(10kg/hr in avg.)

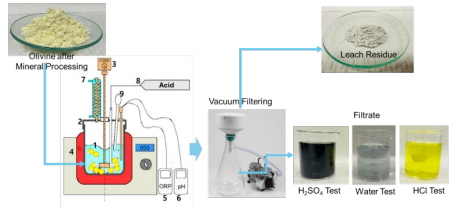


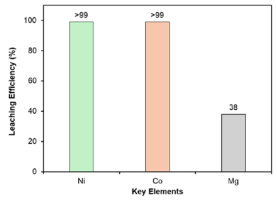












Achievement 3: Upcycle Byproducts into Construction Materials

❑Mine **Wastes** (lean ore, tailings, slag, etc.)

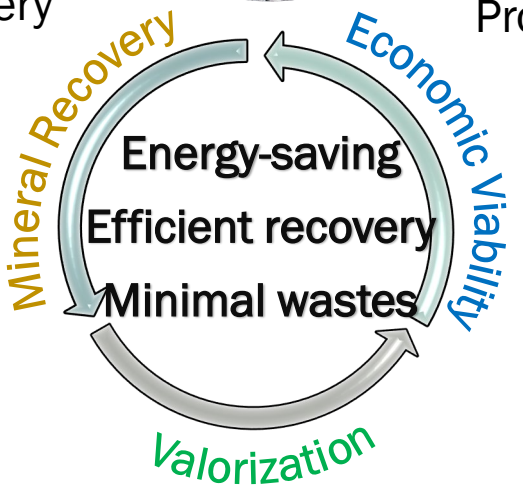


1a. Low-Energy Enhanced Critical Mineral Recovery



1b. Classified **Byproducts** ($MgC_2O_4 \cdot 2H_2O$, SiO_2)





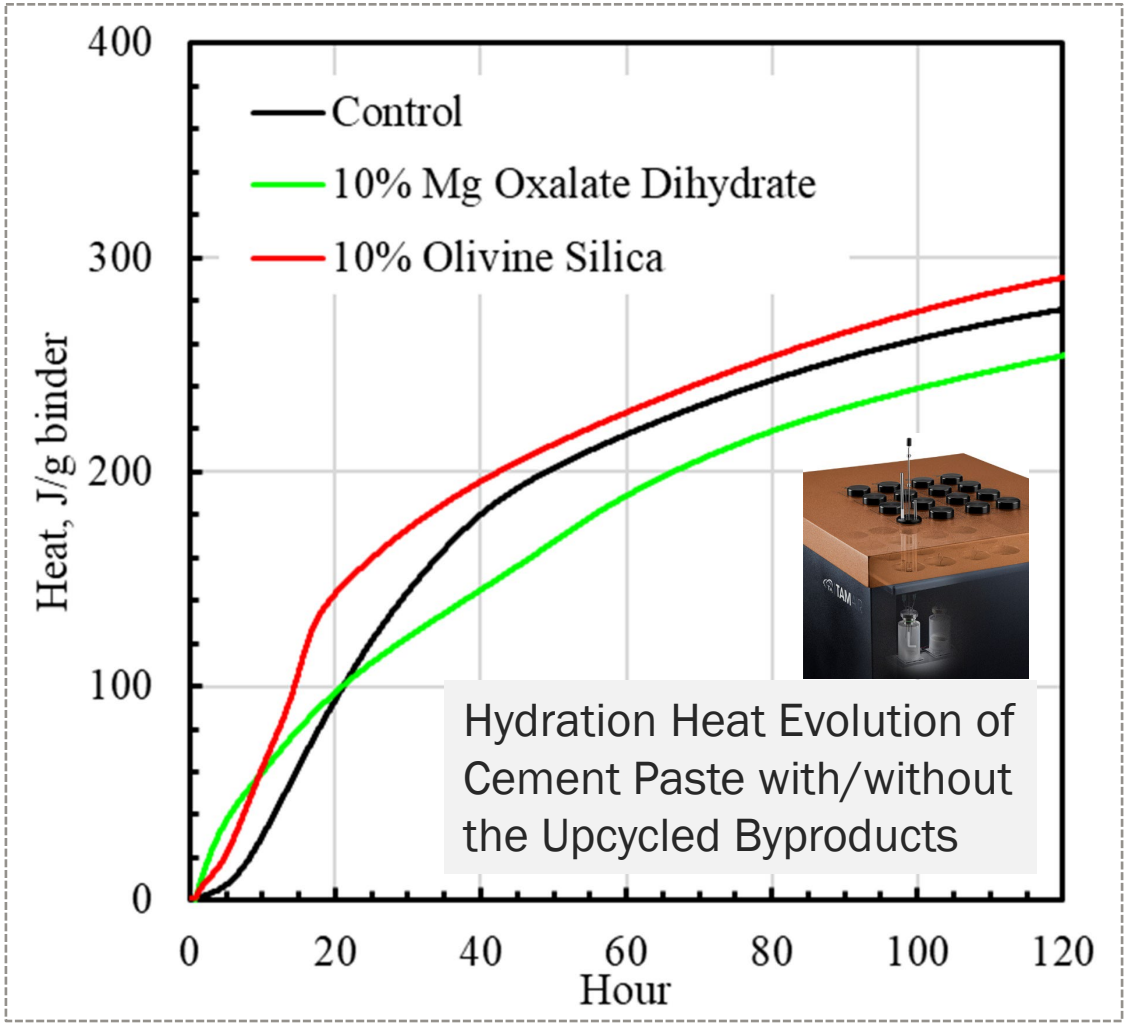
3b. Marketable Products/Routes



3a. TEA (Techno-economic assessment)



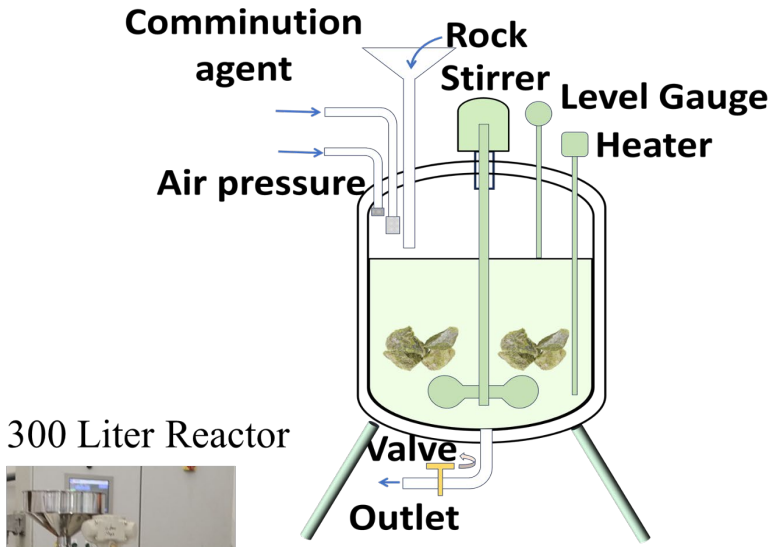
2. Upcycle byproducts into **Construction Materials**



Hydration Heat Evolution of Cement Paste with/without the Upcycled Byproducts

Scaling Up of the Technology

1. Scaling-up demonstration of chemical comminution energy reduction (10^1-10^2 kg)







2. Scaling-up demonstration of improved yield of critical minerals (1 kg/hour)





3. Preliminary numerical simulation for *in situ* application

