

HELIOS

THE HELIOS CYCLE - A NOVEL
METHOD TO REDUCE IRON ORES

worldsteel
ASSOCIATION

Breakthrough
Technology Conference

December 2023, Abu Dhabi, UAE

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THE HELIOS STORY

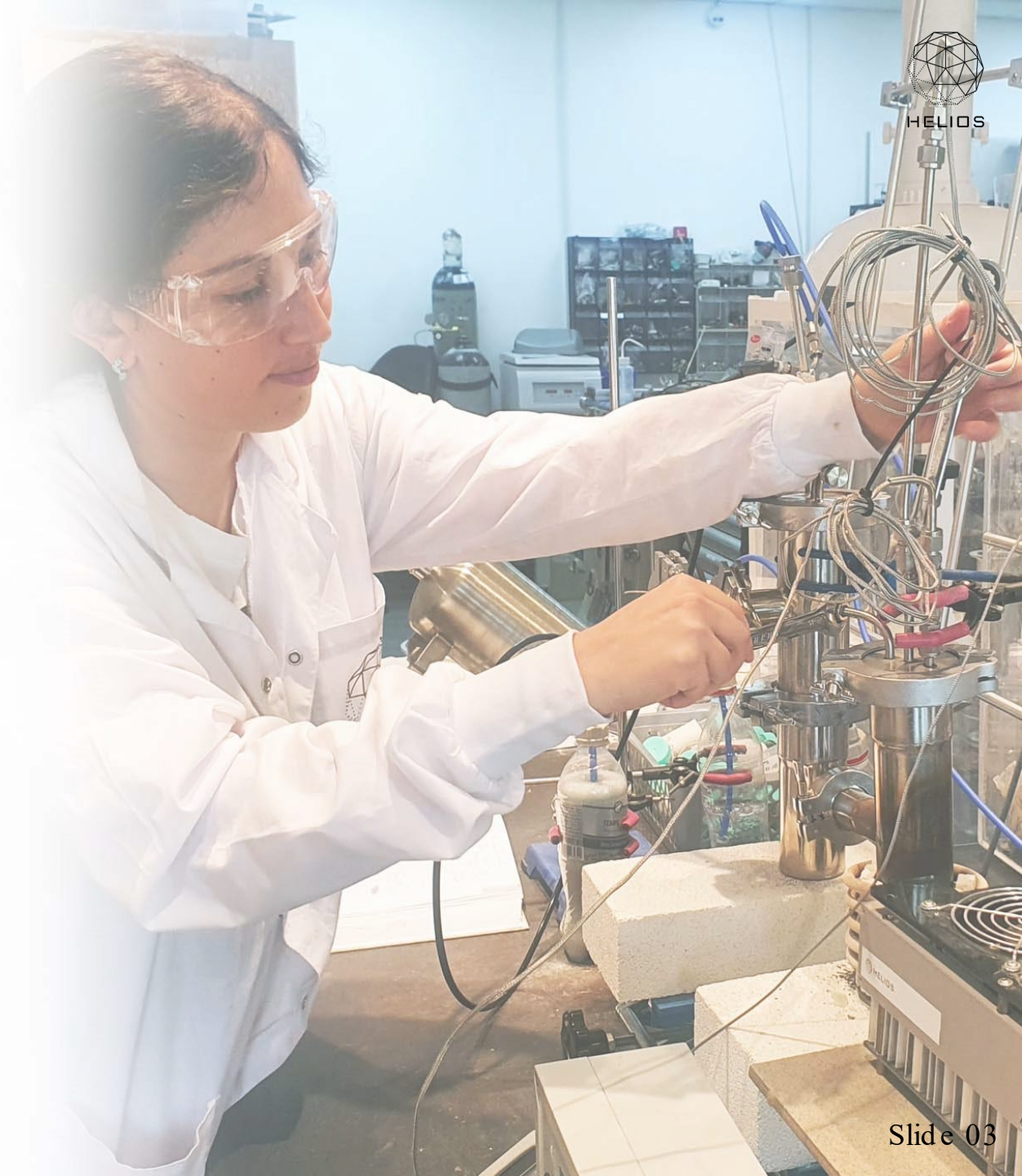
Established in 2018, as a space-tech company. Developing technologies to enable the separation of oxygen from lunar minerals in extreme environments, where zero emissions are not an option but a necessity

Simultaneously Helios developing a novel process to produce iron from iron ore, using only thermal energy while emitting only oxygen



THE SOLUTION BY HELIOS

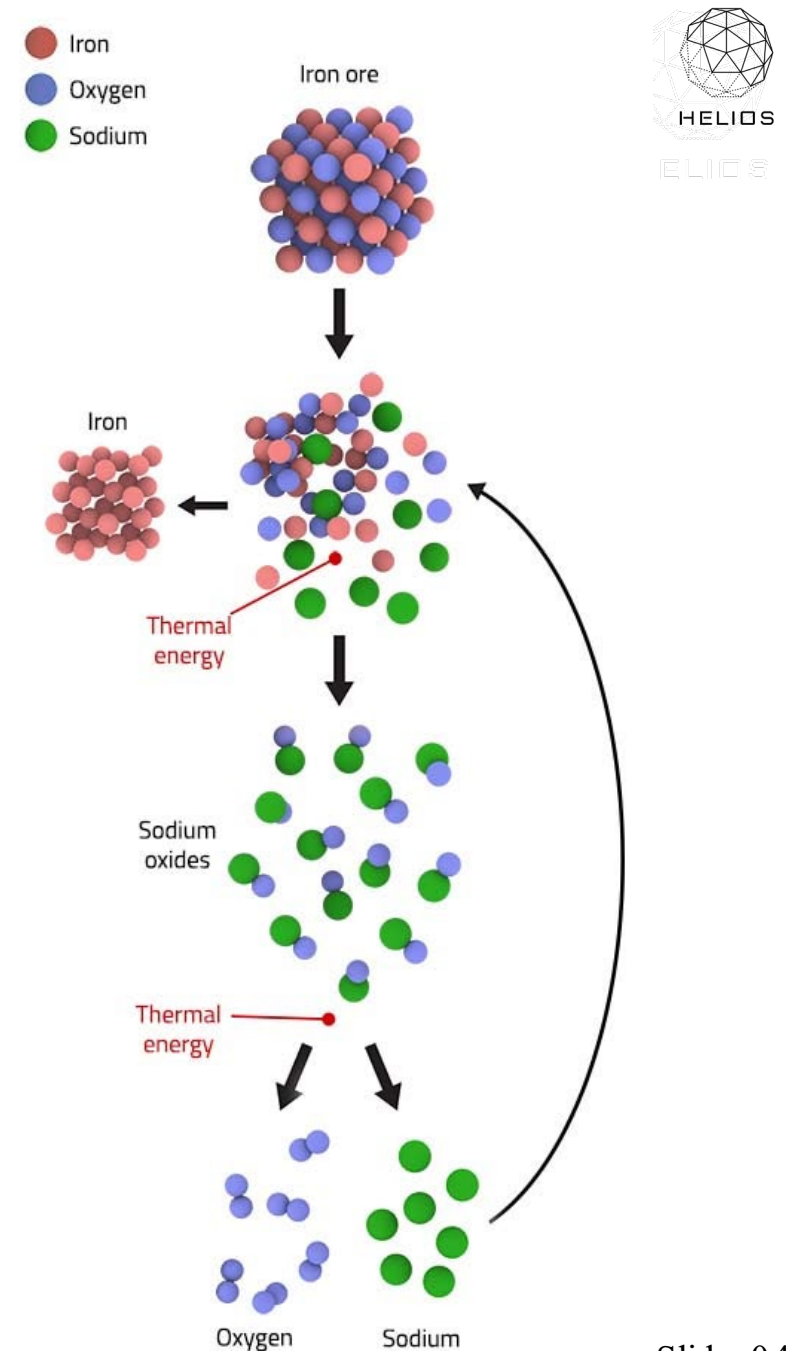
- Zero direct carbon emissions
- Estimated 30% less energy and 30% OPEX reduction compared to traditional production
- No use of coal, natural gas, hydrogen or electrolysis in the reduction process
- Compatible with **low-grade** ores and iron contents minerals
- Geographic flexibility



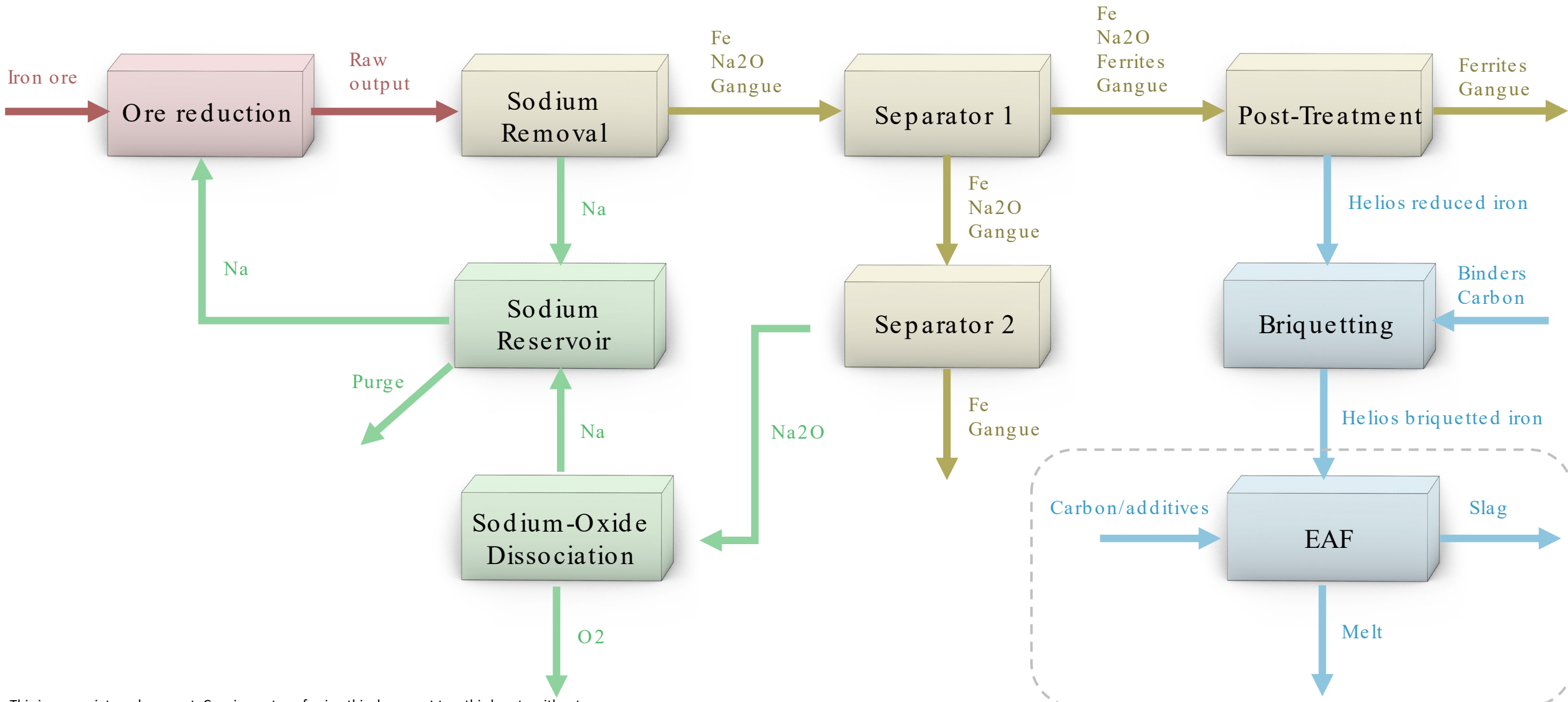
WHAT WE DO - THE HELIOS CYCLE

About Helios cycle:

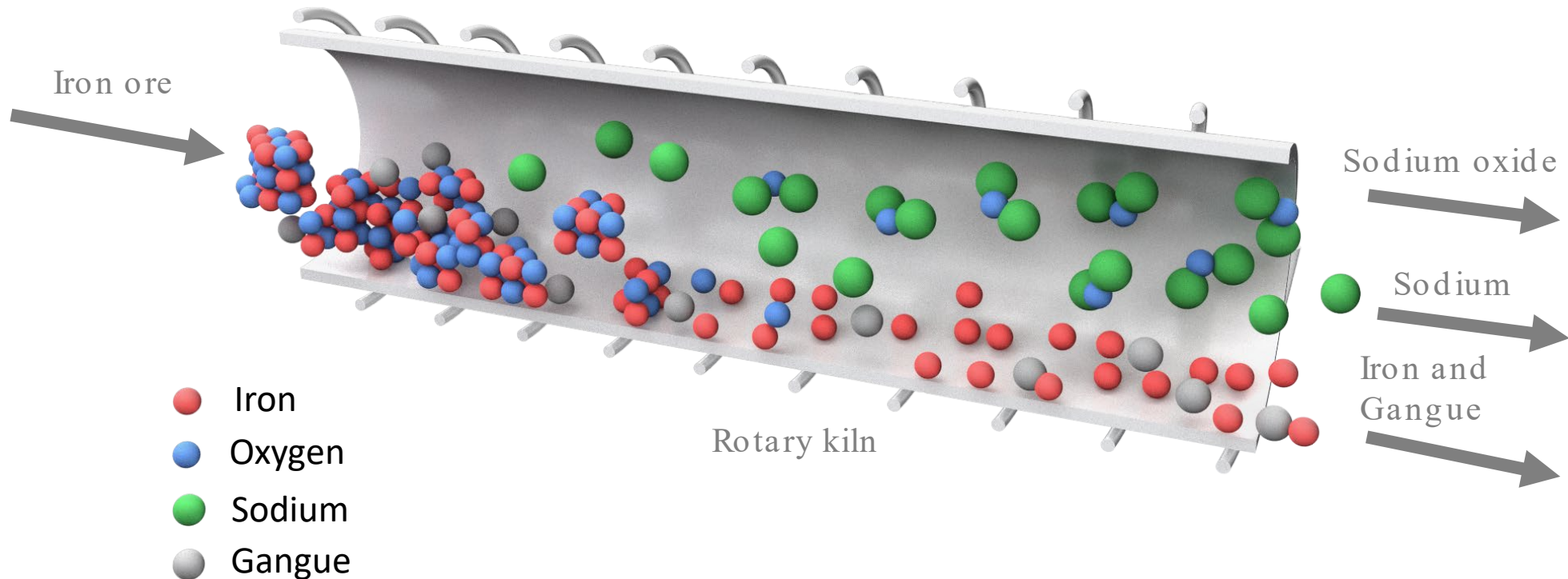
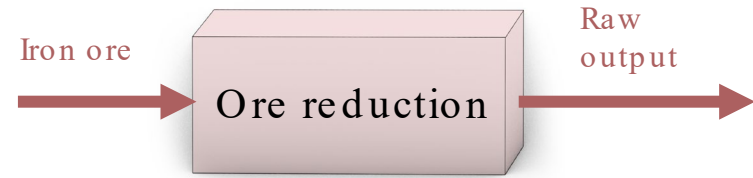
- Using sodium as a reducing agent, to replace coal, natural gas, hydrogen, or electrolysis
- The required input is iron ore and heat, and the output is iron and oxygen
- Iron making between 350°C to 750°C
- Aiming for maximum sodium reuse (turning OPEX into CAPEX)
- Applicable to other transition metals (e.g., copper, nickel, cobalt and more)



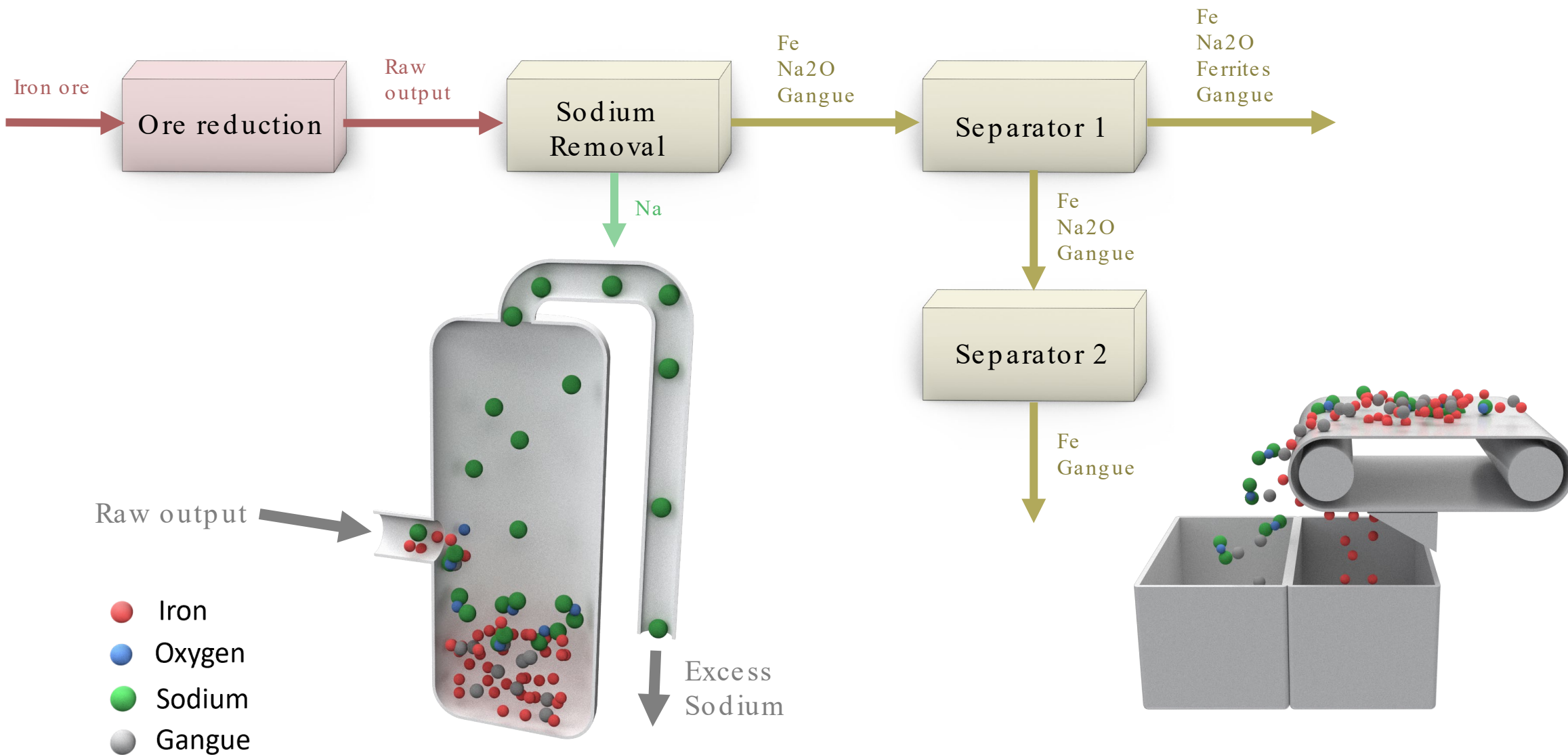
PROPOSED PROCESS FLOW DIAGRAM



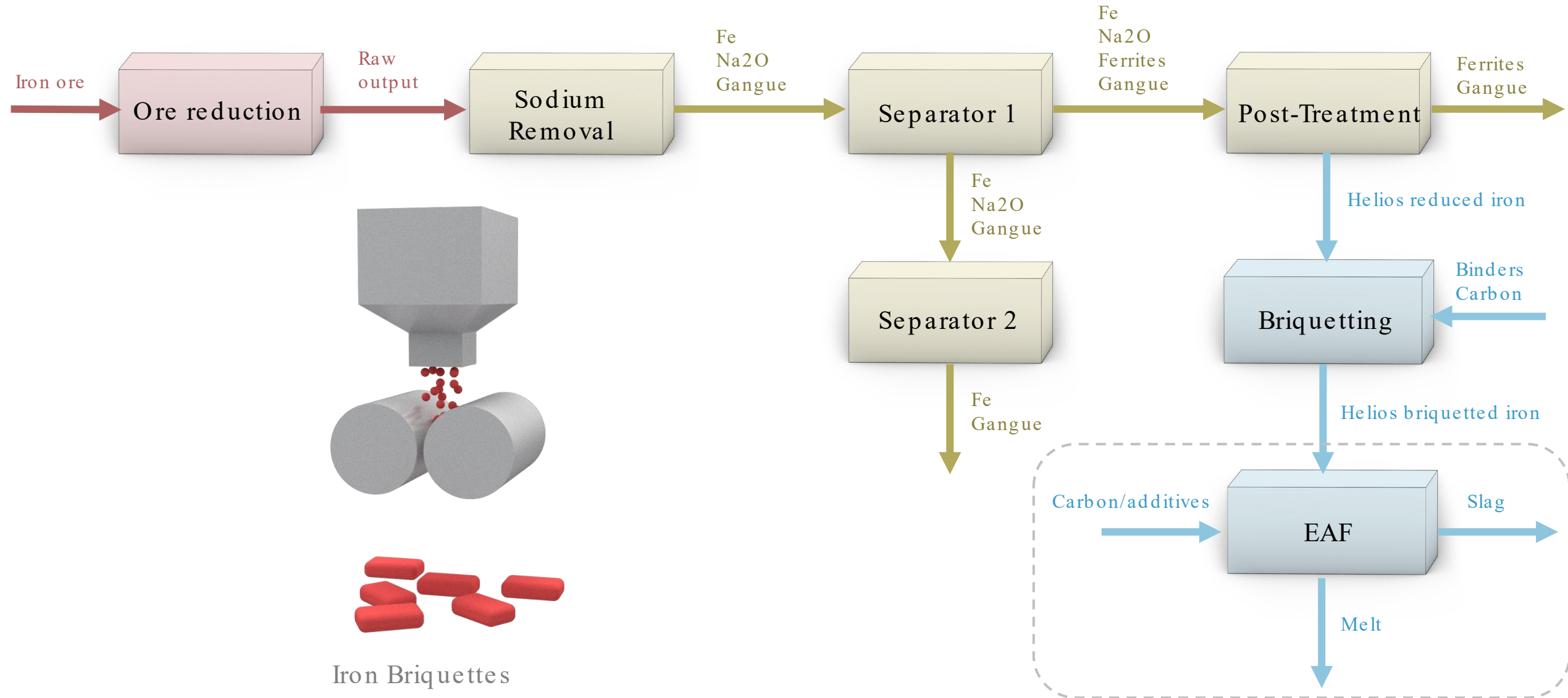
PROPOSED PROCESS FLOW DIAGRAM



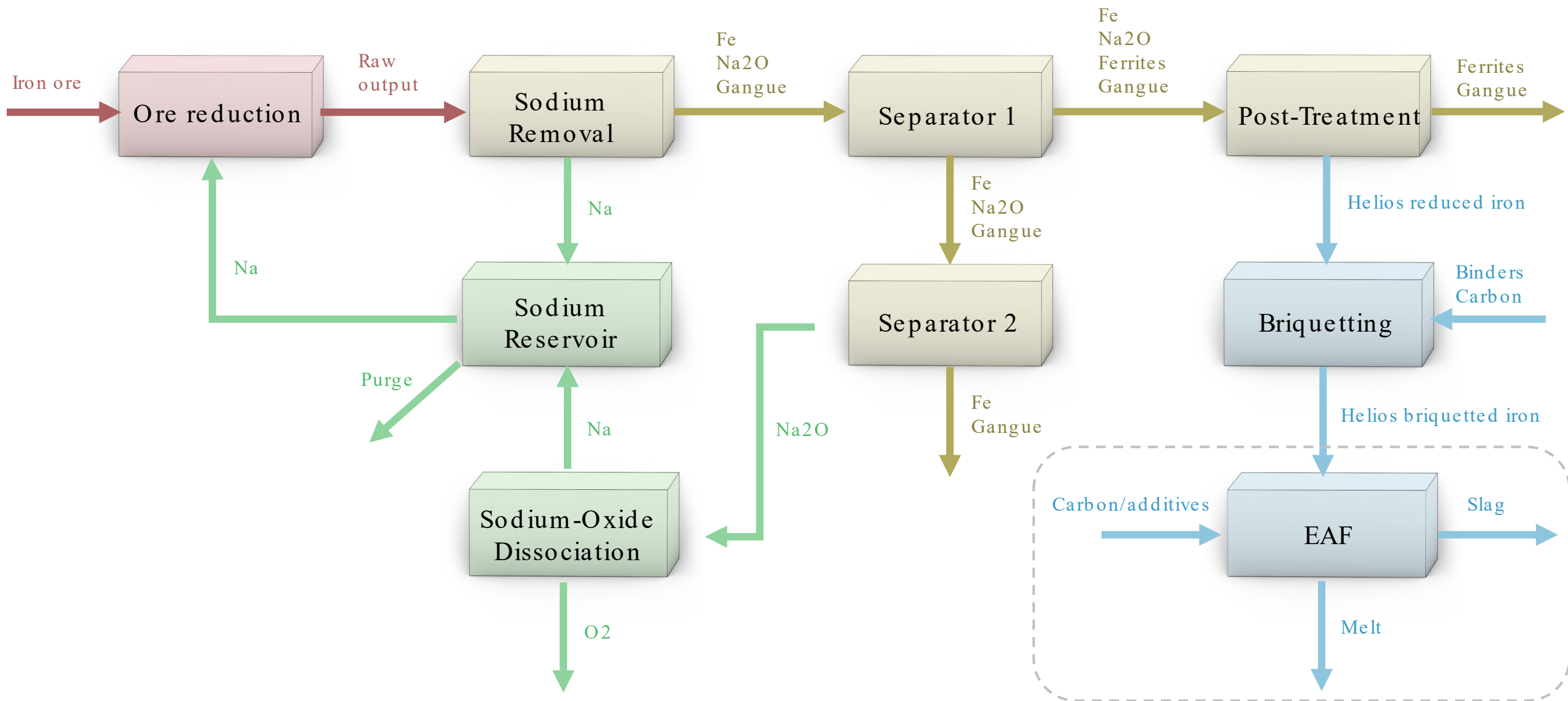
PROPOSED PROCESS FLOW DIAGRAM



PROPOSED PROCESS FLOW DIAGRAM

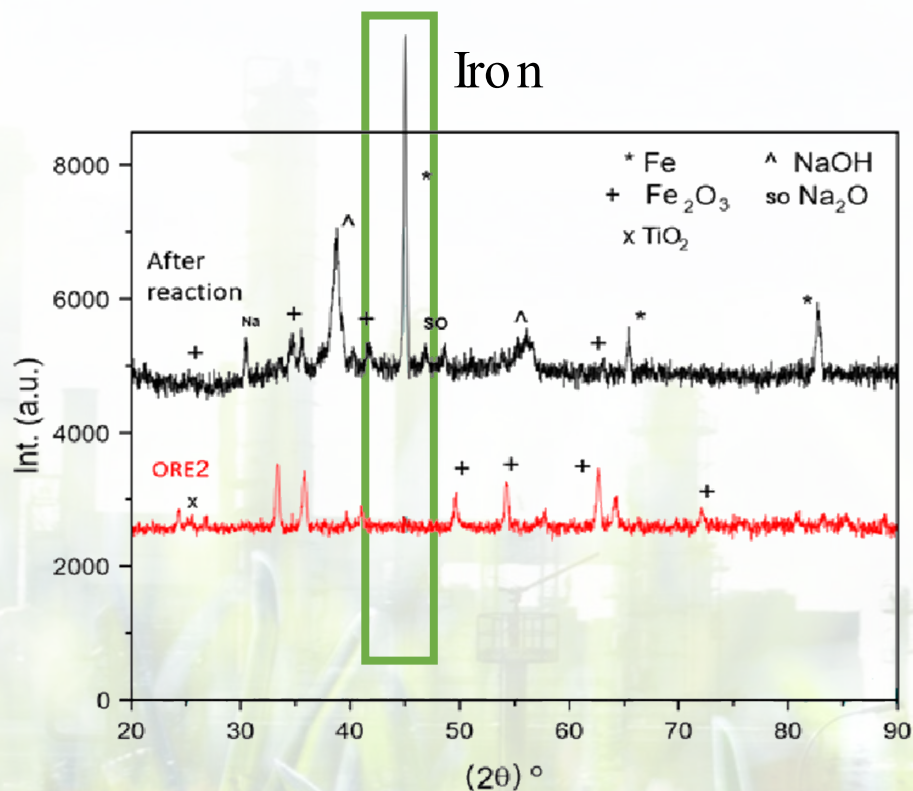


PROPOSED PROCESS FLOW DIAGRAM



PROPOSED REACTION SCHEME

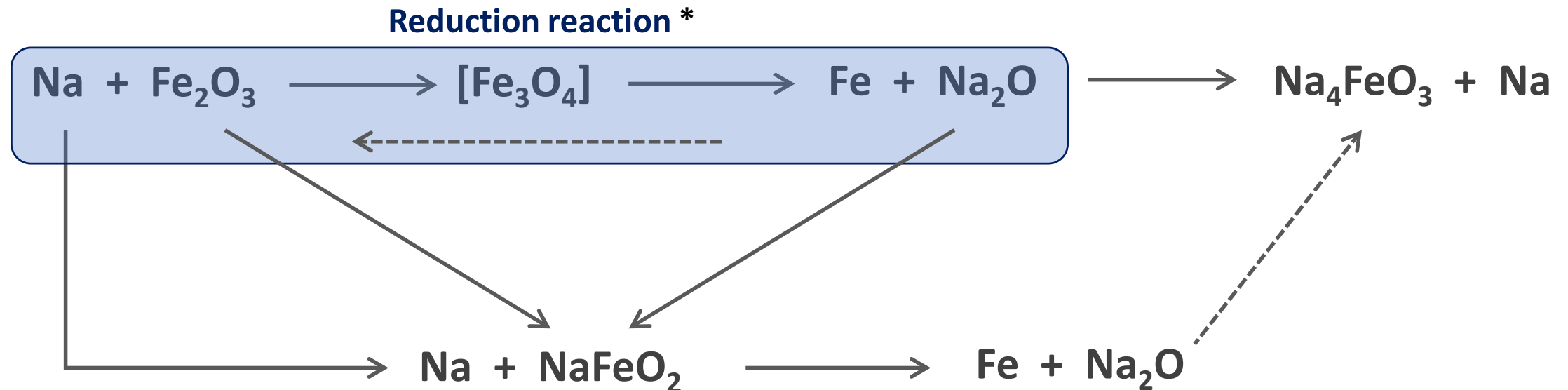
- Iron metallization above 90% achieved reproducibly
- Complete mass balance for iron
- Mechanistic research underway for both reaction steps



Exothermic reaction
Iron ore - sodium

MECHANISTIC UNDERSTANDING OF SODIUM FERRITES

- Sodium ferrites can be diminished by optimizing process conditions (primarily temperature)
- Not all sodium ferrites are created equal, depending on the process step
- Excess sodium is beneficial for increased iron metallization

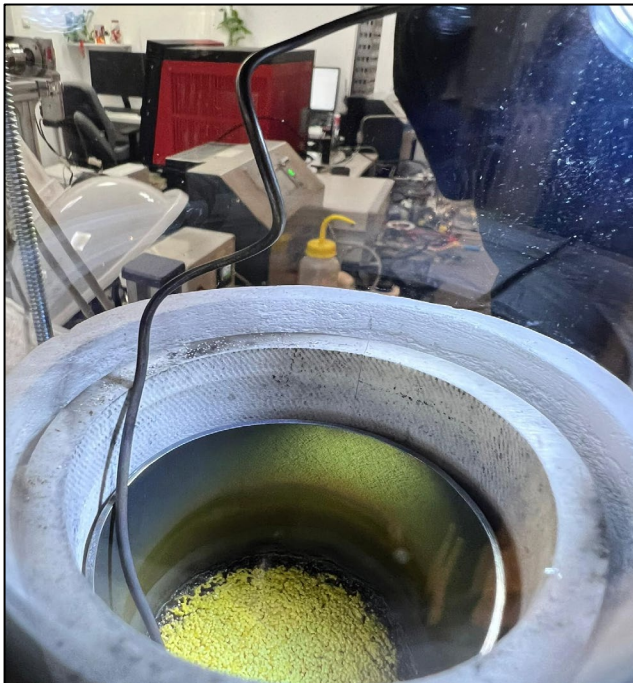


* Addison, C. C. et al. Journal of the Chemical Society, Dalton Transactions 1017-1019 (1972)
 Bhat, N. P. et al. Journal of Nuclear Materials 158, 7-11 (1988).

SODIUM RECLAMATION

- Large differences in the vapor pressure of the decomposition products, and rapid liquefaction of sodium vapor due to its relatively high dew point
- Adjust the equilibrium reaction to remove the oxygen by inert gas flow and vacuum

Na_2O



Na_2O begins to evaporate



Na Consolidates on the cold sides
quartz tube



TECHNOLOGY VALIDATION (TRL5)

- Semi-continuous lab scale system with a capacity of 1 kg/hour reduced iron
- Reactor resembles a rotary kiln with several heat zones, auger system, continuous ore and sodium feeder and control system
- Synchronized technology development at all TRL stages for efficient scale-up and de-risking



R&D FINAL GOAL – TRL7

The end goal is to build an iron ore reducing machine:

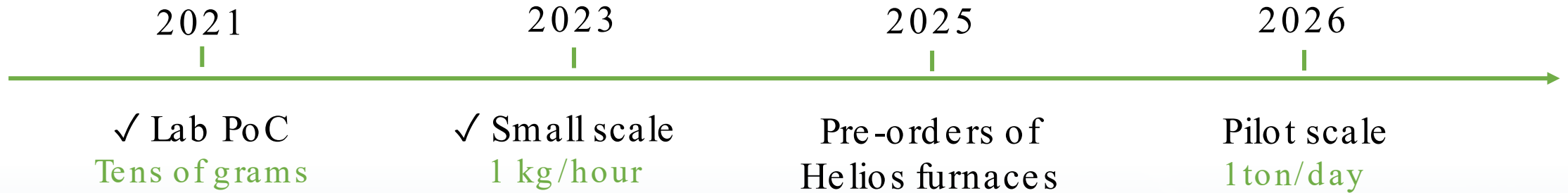
- Production volume of 1ton/day
- Over 92% metallization
- Below 2% sodium in the slag and below 0.2% sodium in the iron
- Between 1.5% to 4% carbon in the iron
- Full sodium reclamation

With the above machine we should be able to:

- Show mass and energy balance
- Show sensitivity analysis on different ore grades
- Perform Techno Economic Analysis/Life Cycle Analysis



BUSINESS ROADMAP



Among our investors:



At
One
Ventures



AngloAmerican

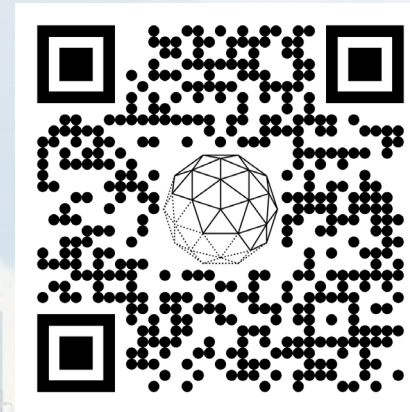
TechEnergy
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KOMPAS



THANK YOU – STAY UPDATED



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