THE HELIOS CYCLE - A NOVEL METHOD TO REDUCE IRON ORES

Breakthrough Technology Conference

December 2023, Abu Dhabi, UAE
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

Iron ore → Ore reduction → Iron ore

Raw output

Iron, Oxygen, Sodium, Gangue

Rotary kiln

Iron ore → Sodium oxide → Sodium
Iron and Gangue

This is a proprietary document. Copying or transferring this document to a third party without Helios Project Ltd. written consent is prohibited. © All rights reserved to Helios Project Ltd
PROPOSED PROCESS FLOW DIAGRAM

Iron ore → Ore reduction → Sodium Removal → Fe Na2O Gangue → Separator 1 → Fe Na2O Ferrites Gangue → Separator 2 → Fe Gangue

Raw output → Excess Sodium

- Iron
- Oxygen
- Sodium
- Gangue

This is a proprietary document. Copying or transferring this document to a third party without Helios Project Ltd. written consent is prohibited. © All rights reserved to Helios Project Ltd
PROPOSED PROCESS FLOW DIAGRAM

Iron ore → Ore reduction → Sodium Removal → Separator 1 → Post-Treatment → Ferrites Gangue

Separator 1: Fe Na2O Gangue

Separator 2: Fe Na2O Ferrites Gangue

Briquetting: Binders Carbon

EAF: Carbon/additives → Melt → Slag

Not incorporated in Helios process

Iron Briquettes

Helios reduced iron

Helios briquetted iron

This is a proprietary document. Copying or transferring this document to a third party without Helios Project Ltd. written consent is prohibited. © All rights reserved to Helios Project Ltd
PROPOSED REACTION SCHEME

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

**Reduction reaction***

\[
Na + Fe_2O_3 \rightarrow [Fe_3O_4] \rightarrow Fe + Na_2O \rightarrow Na_4FeO_3 + Na
\]

---

SO DIUM 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

\[ \text{Na}_2\text{O} \quad \text{Na}_2\text{O} \text{ begins to evaporate} \quad \text{Na Consolidates on the cold sides quartz tube} \]
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 1 ton/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

2021
✓ Lab PoC
  Tens of grams

2023
✓ Small scale
  1 kg/hour

2025
Pre-orders of
  Helios furnaces

2026
Pilot scale
  1 ton/day

Among our investors:

At One Ventures
AngloAmerican
TechEnergy Ventures
KOMPAS
THANK YOU – STAY UPDATED

CONTACT@PROJECT-HELIOS.SPACE