



Project Title

Helios Cycle: A Novel Method for Iron Ore Reduction with Zero Direct Emissions and Optimized Resource Utilization.

Industry Partner

Helios Project Ltd

Industry Sector

Iron and Steel

Technology Pathway (Primary)

Alternative materials & more efficient processes

NIM Pillar

Technology Demonstration

Source

NIM Awards 2025

Description

Helios pioneered the Helios Cycle™, a novel iron ore reduction technology that substitutes sodium for carbon to produce Helios Green Iron (HGI™) - a fully metallized iron briquette compatible with EAF and BOF steelmaking. The process emits only oxygen and inert mineral byproducts, achieving zero direct CO₂ emissions, and features a sustainable, cost-effective sodium recycling mechanism in a closed loop, reducing operating costs compared with blast furnaces, and resulting in green iron available at no premium.

Operating at 300–400 °C and consuming less than 4.5 MWh per tonne, the Helios Cycle™ runs in two stages: sodium reduces iron ore to metallic iron, and sodium oxide decomposes back into metallic sodium and oxygen for reuse.

The process requires no beneficiation or pre-treatment beyond crushing. It is indifferent to ore type, grade, and impurities, enabling the cost-effective use of low-grade ores, iron ore tailings, mine residues, and EAF slag. This expands and optimizes the use of resources while reducing upstream emissions and turning mining waste into value.

Given these characteristics, Helios furnaces can be deployed near mining sites for on-site production of green iron briquettes. These can be transported directly to steel manufacturers and fed into EAFs, increasing value creation at the mine, reducing shipping costs, and cutting Scope 3 emissions, while providing steelmakers with a cost-competitive, zero-emission feedstock.

The Helios Cycle™ advances the Mission Innovation Net-Zero Industries goals by combining industrial electrification, alternatives to carbon-based feedstocks, and circular use of ores, slag, and residues, fully aligning with the NIM 2025 priority areas.

Innovations Employed

Conventional routes - BFs and DRI/H₂ - require coke or hydrogen, DR-grade pellets, and continuous operation above 1,000 °C. They demand high capex, heavy infrastructure, and still depend on subsidies or green premiums.

The Helios Cycle™ replaces this with a closed sodium loop that reacts only with Fe in the ore, making energy use proportional to iron content. It achieves >98% metallisation on ores down to 20–25% Fe, tailings, and EAF slag, with >97% sodium recycled and only oxygen emitted (or liquefied).

Operating at 300–400 °C and <4.5 MWh/t, it avoids beneficiation or pelletising. Helios furnaces are modular ~50,000 tpa “plug-and-play” units, halving capex vs DRI and lowering opex vs BFs. They can pause or run in standby with renewables. Near mines,



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they turn waste into high value product, cut logistics and Scope-3 emissions, improve safety vs H₂/CO, raise miner margins, and deliver green iron at no premium.

Helios is redefining ironmaking beyond today's state of the art.

Dimension of Novelty

New in Country

Israel

New on the international market

Innovation Collaboration

In house

Israel

Intellectual Properties

Helios secures the Helios Cycle™ through a layered IP portfolio:

Patents

HLS001 (PCT/IL2022/050754): broad coverage of transition-metal oxide reduction and sodium recycling; US parent granted; national phases filed in AU, EU, EA.

HLS005 (PCT/IL2024/050060): protection of sodium-loop reduction applied specifically to iron ores; positive PCT review.

HLS006 (PCT/IL2024/050062): systems and configuration variants for industrial deployment; positive PCT review.

HLS009 (US Provisional 63/704,573): electrochemical sodium-oxide reduction, incl. β"-alumina and membraneless cells.

Trademarks

Helios Cycle™ Helios Green Iron (HGI™) Trade secrets and know-how. Proprietary designs for sodium handling, reactor safety, separation/purification steps, and integration with mining/steelmaking systems.

IP boundaries in place with suppliers and partners; no IP sharing in collaborations.

Together, this portfolio establishes Helios's clear ownership of the sodium-loop ironmaking pathway, combining formal patents, brand protection, and safeguarded engineering know-how.

IP Links

Timetable & Progress

Development commenced in 2021

The Helios Cycle™ was established in 2018, originally focused on space technology to produce oxygen from lunar soil (regolith). In 2021, we discovered its breakthrough application on Earth for ironmaking and other first transition metals.

Financing (Public/ Private)

Public funding

At the start of our journey, we secured several grants from the Israeli Space Agency, the Ministry of Energy, and the Israel Innovation Authority. These grants were awarded for our space technology work.

Finance Links

Project Phase TRL

TRL 4



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Problems to be Solved and Risks to be Managed

Developing the Helios Cycle™ required solving key technical and market risks. On the process side, achieving >98% metallisation on ores as low as 25% Fe and slag demanded proof that sodium reacts only with Fe, separating gangue cleanly. Risks of residual sodium in iron were resolved through controlled separation and washing steps, validated by lab analysis.

The sodium oxide dissociation loop was engineered for >97% sodium recovery without reactor degradation. Safety risks of sodium handling were mitigated through closed-loop design, materials choice, and containment practices.

Engineering risks included scaling from TRL4 lab systems to modular pilot units and ensuring reactor durability under sodium cycling.

Techno-economic and life-cycle analyses (TEA/LCA) confirmed ~30% lower opex, half the capex of DRI, and zero direct CO₂ emissions, supporting both technical feasibility and market acceptance. Market risks—proving EAF compatibility and industry adoption—are addressed through ongoing tests and offtake discussions.

Preliminary or Final Results Achieved

The Helios team, with expertise in mechanical, electrochemistry, and materials science, has run 600+ experiments across 50+ ore types including low-grade magnetite, hematite, tailings, and slag, consistently achieving >98% metallisation. The process operates at 300–400 °C with <4.5 MWh/t energy use, emitting only oxygen and inert residues, while recycling >97% sodium. Controlled separation steps remove residual sodium and gangue, ensuring high-purity iron compatible with downstream steelmaking.

TRL4 validation is complete, with preliminary engineering and lab infrastructure in place for a TRL5 mini-pilot. Independent TEA/LCA confirm ~30% opex savings vs BFs, ~50% lower capex vs DRI, and zero direct CO₂ emissions. Helios Green Iron (HGI™) briquettes have been validated in EAF conditions, proving consistent performance at no green premium. Helios has secured investment to advance the pilot and established robust IP protection around the technology.

CO2 Emissions Reduction Potential - Implementation and Future Market

Helios is advancing to market through pilot and commercial negotiations with US steelmakers and OEMs, linked to offtake agreements, and parallel efforts with HiLT CRC in Australia. As a registered supplier to the First Movers Coalition, Helios contributes to its near-zero steel targets, and as the first startup member of the World Steel Association, it is embedded in global supply chains.

Deployment is based on modular ~50,000 tpa near-mine furnaces, enabling miners to convert non-commercial ores into HGI™ briquettes, raising margins and cutting logistics and Scope 3 emissions. Steelmakers gain a cost-competitive, zero-emission feedstock compatible with EAFs, with no premium required.

The Helios Cycle™ eliminates all Scope 1 emissions, recycles >97% sodium, and uses <4.5 MWh/t. A TRL7 pilot (~1 t/day) is planned for 2026, a first commercial site (~150 t/day) by 2028, and scale to 26 Mt by 2035,—making Helios one of the fastest, most scalable pathways to net-zero steel as a commercial scales, and cost competitive edge to set up new standard.



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Market Positioning

Helios is positioned as a first-mover in sodium-loop ironmaking, directly aligned with global demand for near-zero steel. Current negotiations with US steelmakers and OEMs, supported by a joint TEA, indicate that Helios can be the first solution to meet FMC Level 4 targets (≤ 0.4 t CO₂/t steel). This gives Helios a unique role as an early enabler for buyers committed to near-zero steel. Credibility is reinforced by recognition as a registered FMC supplier, the first startup member of the World Steel Association, and an UpLink Top Innovator. Market traction includes MoUs with two leading producers and active engagement with engineering firms to fabricate modular furnaces. Helios differentiates itself by combining 30% lower opex, ~50% lower capex, and no green premium, ensuring rapid early adoption and a clear competitive edge in the transition to net-zero steel.

Project Location

Israel

Project & Technology Links

www.heliosmatters.com

Technology Links