# 2024 AIST Sweden Environmental and Decarbonization Study Tour

by Alicia Gauffin

The AIST Environmental Technology Committee (ETC) conducted a Study Tour of environmental and decarbonization facilities in Sweden. The study tour was held 10–14 June 2024. AIST Study Tours provide forums where its members can learn about new and current technologies, discuss safe operating and maintenance practices, address environmental issues, and network globally with industry professionals of all disciplines. The Environmental and Decarbonization Study Tour included technology discussions with individuals of similar interest at Swedish facilities, broadening the collective knowledge of the international environmental community. The technical exchanges featured presentations by the hosting companies and roundtable discussions.

The study tour delegation comprised 17 people from companies including Cleveland-Cliffs Research & Innovation Center, Hyundai Steel Co., Steel Dynamics Inc., Stelco Inc., Tata Steel Netherlands and thyssenkrupp.

The AIST Environmental and Decarbonization Study Tour kick-started with a meeting on Monday, 10 June, at Jernkontoret, Sweden's iron and steel producers' association. Jernkontoret safeguards the Swedish industry's interests by working for the best possible preconditions for operations in Sweden. Jernkontoret is co-owned by the Swedish iron and steel industry. The Study Tour group was welcomed by Helén Axelsson, energy and environment director; Sophie Carler and Cecilia Mattsson, senior advisors environmental issues; and Annika Roos, managing director. Axelsson provided a presentation on Swedish climate policy and the iron and steel industry's net-zero emission target by 2045. Currently 95% of electric power in Sweden is fossil-free. The electricity demand in 2024 was 140 TWh and is expected to rise to 280 TWh in 2035. The International Energy Agenda (IEA) is developing instructions on definitions for international standards for green steel. Malin Baltzar from H2Green Steel then provided a presentation about the installation of the large-scale electrolyzer steel plant in Boden, Sweden. The fully integrated steel mill will be equipped with electrolyzer reactors, a 2.1 Mtpa direct reduced iron (DRI) tower, two electric arc furnaces (EAFs), continuous casters, hot rolling mills, and cold rolling and galvanizing lines. The H2Green Steel plant is planned to start production in 2026 and will have near-net-zero emissions.

The Study Tour continued with a visit to SSAB in Oxelösund. Johnny Sjöström, head of SSAB Special Steels, and Petra Larnesjö, head of external environment and energy, welcomed everyone. Niclas Westin, project manager for SSAB's conversion to fossil-free operations, provided a presentation. SSAB Oxelösund is replacing its blast furnace (BF) with hydrogen-based DRI and green electricity EAF production. The hydrogen DRI pellets will be similar to the BF pellets in use, which will be shipped from SSAB Luleå. The facility plans to use 1.35 million metric tons of DRI and produce 1.2 million metric tons of metallic iron. Around 60% of OPEX in H-DRI is electricity cost. The refractory material used in the EAF to melt H-DRI will be the same as for conventional scrap-fed EAF. The EAF is planned to start up in 2026 and the BF is planned to be shut down in 2027. The facility plans to reduce the number of employees after the DRI-EAF conversion to 200 people from its current workforce of around 2,250 people. Per Enmark and Per Soderstedt then provided a guided tour

of the facility and the attendees got to see the blast furnace, quarto rolling mill, $H_2$ reheat furnaces and additive manufacturing powder center.

The next day, Tuesday, 11 June, the participants visited the GreenIron pilot plant in Kumla. The group was welcomed by Annika Molander, media contact; Jan Boberg, creative product director; and Maciej Kaplan, process engineer. The participants were able to see the GreenIron pilot process in production. The GreenIron process is a low-temperature solid process at 600°C that uses hydrogen gas to reduce various input materials, such as mine tailings, iron ore (lump or pellets), and slags and deposits, and convert them into 98–99% metallization grades. Approximately 5–10% of pellets used in the MIDREX DRI process are broken down into smaller pieces which cannot be used. The GreenIron process can utilize materials that cannot be processed in commercial production routes. The pilot plant in Kumla has a capacity to process 20 kg of raw material, while the full-scale industrial facility in Sandviken can process 5 tons of raw material per batch.


The first visit on the Study Tour was Jernkontoret, Sweden's iron and steel producers' association. Helén Axelsson was presented with a plaque of appreciation.

The participants then visited Outokumpu steel mill in Avesta. The group was greeted by Joakim Rollin, environmental coordinator; Niina Leskinen, senior sustainability engineer; Caroline Soini, energy engineer; and Gunnar Ruist, retiree and former strategic


The delegates visited SSAB Oxelösund. Petra Larnesjö (left) and Niclas Westin (right) were presented with a plaque of appreciation.

The delegates visited GreenIron's pilot facility (pictured above) and its full-scale plant (pictured below). Jan Boberg was presented with a plaque of appreciation for hosting the full-scale plant tour.


environmental developer. Soini provided a presentation on the company's environmental targets and projects associated with decarbonizing their production route. The participants were able to see the production process from melting, casting and further processing. The Outokumpu Avesta mill specializes in thick and wide materials (2-m-wide coil and sheet) and special grades. In addition to finished coil products, Avesta delivers black hot band to sites in Nyby, Sweden, and in Germany, as well as slabs to Degerfors for quarto plate production. Duplex stainless steel was invented at Avesta in 1930. The facility houses a meltshop, hot rolling mill, cold rolling mill and finishing lines, and an R&D center.

On Wednesday, 12 June, the participants visited Ovako's steel


The delegates visited Outokumpu. Madhu Ranade (left) presented a plaque of appreciation to Gunnar Ruist (right).

mill in Hofors. The group was welcomed by Fredrik Edin, EHS manager; Ola Törnqvist; and Patrik Undvall. In April 2024, Ovako's mill in Hofors successfully replaced liquefied petroleum gas (LPG) with hydrogen to power their reheat furnaces. The facility is equipped with 20-MW electrolyzer reactors which have the capacity to generate 3,880 $m^3$ of hydrogen per hour. In 2023, Ovako installed electrolyzer reactors at the facility to produce hydrogen gas. In April 2024, their reheat furnaces and rolling mills were 100% run on hydrogen gas. The facility has the possibility to switch from hydrogen to LPG in case the electricity prices become too expensive. So far, there has been no difference in the cost of energy by using hydrogen instead of LPG. Ovako's steel mill in Hofors has a carbon footprint 80% lower than the global average. Ovako is planning to expand the electrolyzer reactor project to their other facility in Smedjebacken, Sweden.

The group then visited the GreenIron facility in Sandviken. The group was greeted by Edward Murray, chief executive officer and cofounder; Ulrika Molander, chief operating officer; Linda Ahl, chief technology officer; and Anette Anderung, site manager. The group visited the construction area of the large-scale GreenIron technology. The start-up of the industrial facility is planned for August 2024. The GreenIron process requires 2,100 kWh/ton hematite, with 400 kWh used toward heating. The full-scale industrial facility will start processing low-grade iron ore pellets from Vale.

On Thursday, 13 June, the participants visited Alleima, formerly named Sandvik Materials Technology. The group was greeted by Haidi Bergqvist, environmental engineer, and Olle Sundqvist, who provided a guided tour of the steel mill. The Alleima facility specializes in advanced materials technology and develops high-value-added products. Alleima produces a variety of products such as seamless stainless tubes, electric heating technology and heating resistance materials, ultrafine wire and components for medical devices, precision strip steel, and coated strip steel for hydrogen applications. Due to the high amounts of alloy elements, Alleima's internal scrap sorting systems and slag recycling processes are extensive. The facility has the goal to reduce $CO_2$ emissions by 50% by 2030. One measure is to change diesel trucks to biofuel. The facility currently produces around 2,200 tons $CO_2$/year.


The delegates visited Ovako Hofors. Fredrik Edin was presented with a plaque of appreciation.

The participants then flew to Luleå, Sweden. Some of the participants visited the Polar Arctic Circle, where the sun, at that time of year, is continuously above the horizon. The Polar Circle is precisely located at the boundary of the zones where the polar night and the polar day occur throughout the solstice day.

The next day, Friday, 14 June, the participants visited SSAB HYBRIT. HYBRIT is a joint venture between SSAB, LKAB

The delegates visited Alleima. Haidi Bergqvist was presented with a plaque of appreciation.


The delegates visited HYBRIT. Ulf Spolander was presented with a plaque of appreciation for hosting the delegates.

and Vattenfall to develop fossil-free steel via hydrogen production and storage, hydrogen DRI and green electricity EAF melting. The group was greeted by Ulf Spolander, general manager HYBRIT Development AB; Helena Sundberg, site and visitor manager; and Johan Risbeck, R&D engineer. The HYBRIT project started in 2020 and has since run 8,000 hours of production with 5,000 tons of hydrogen DRI output. A total of eight campaigns have been completed, two with natural gas and six with hydrogen gas. The refractory material in the HYBRIT process is the same as for DRI. The production facility has a 0.8–1.5 tons/hour capacity. The metallization degree of the iron ore pellets can be up to 97–100% but is normally around 95–99%.

The HYBRIT project has three stages: R&D, pilot and demonstration, and planned commissioning in 2027. HYBRIT is a modified Tenova HYL process. SSAB signed a contract in May 2024 to replace their BF process with a hydrogen DRI-EAF process. The facility aims to reduce $CO_2$ emissions from 1,600 kg $CO_2$/ton crude steel to 25 kg $CO_2$/ton. It takes about 8–9 hours for the commercial pellets from input raw material into outgoing DRI pellets. Due to the HYBRIT and H2Green Steel projects, the electricity demand in Sweden is expected to double by 2035.

The last stop of the tour was at the metals research institute, Swerim. The group was greeted by Pontus Sjoberg, chief executive officer; Daniel Palo, business area manager Pilot & Demo; and Guozhy Ye, principal specialist metallurgy. Swerim conducts industrial research and developments concerning metals from raw materials to finished products. Sjoberg and Ye presented examples of research projects they had recently conducted with the steel industry and provided a guided tour around the facility.


The delegates visited metals research institute Swerim. Pontus Sjoberg was presented with a plaque of appreciation for hosting the delegates.

AIST would like to thank Jernkontoret for their hospitality, and ChemTreat Inc., Paling Transporter Ltd. and Bloom Engineering GmbH for sponsoring the AIST Sweden Environmental and Decarbonization Study Tour.