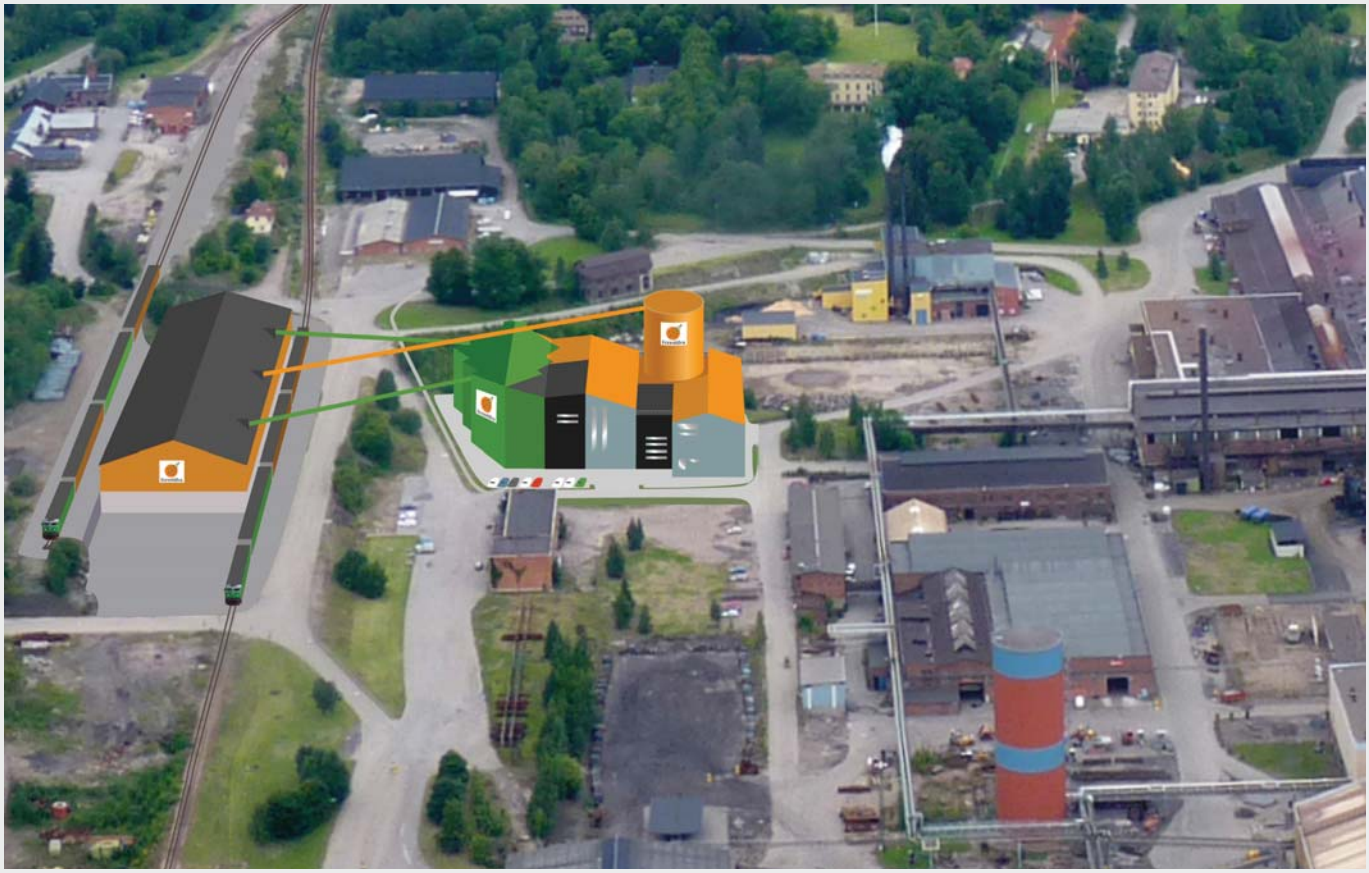


An image of the first FerroSilva plant. Building in a brownfield location has advantages with existing infra structure and services like in Hofors where the closeness to the customer that can take warm DRI directly from the reduction plant is an extra advantage. Layout: Katarina Hamilton.

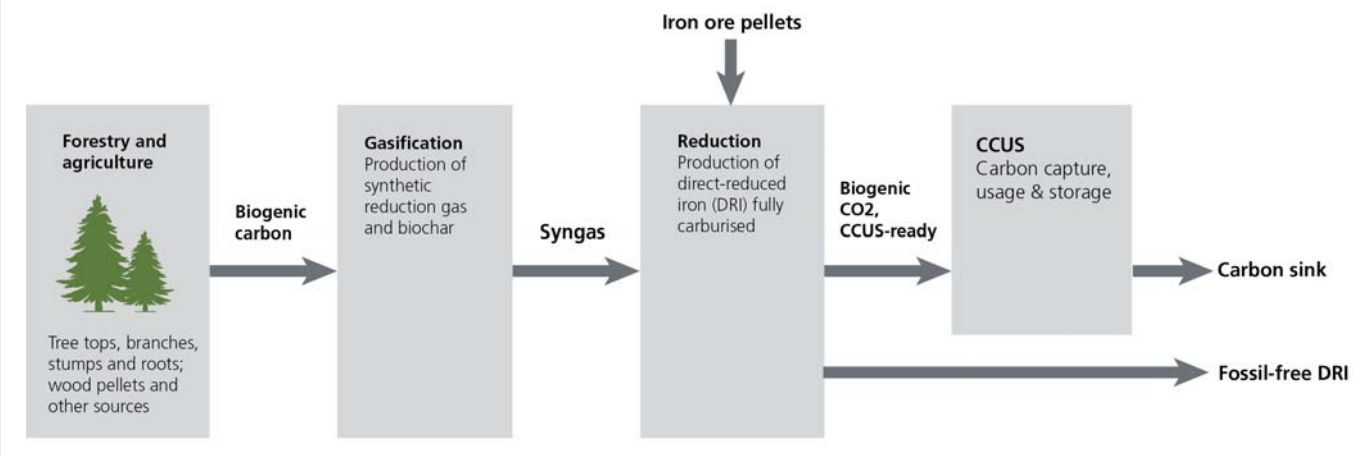
FerroSilva - Creating a new industrial eco-system

A new industrial ecosystem is emerging in the Swedish Bergslagen. Residual products from forestry and agriculture become syngas, which is used to reduce iron ore. The carbon dioxide is captured and becomes products or is stored in the bedrock. But this requires new types of industrial collaboration and well-developed logistics. FerroSilva is now planning its first plant of 50 thousand tonnes per year at the steelmaker Ovako's plant in Hofors.

By Rutger Gyllenram, Peter Samuelsson and Göran Nyström

Going for fossil free iron

The demand for steel with low emissions of greenhouse gases make many steel producers close their blast furnaces and replace them with electric arc furnaces that outside natural gas-rich countries are normally used for scrap. Since the amount of scrap is limited, this transformation must be combined with an increased production of sponge iron, so-called DRI. Today, DRI is mainly manufactured with reformed natural gas as a reducing agent, and by capturing and using or storing the carbon dioxide formed, so-called CCUS, the process can reach low greenhouse gas emission values. Reformed natural



The FerroSilva business model. Residues from forestry and agriculture are gasified to form a syngas used for reduction of iron ore to fully carburized DRI. Biogenic carbon dioxide is captured and further processed to either chemicals or fuels unless it is stored in suitable geologic formations.

gas has a composition of approximately one-third carbon monoxide and two-thirds hydrogen. The DRI produced this way normally has a metallization degree of about 92% and a carbon content of about 2%. The carbon's main role in the DRI is to reduce the last portion of iron oxide to iron in the smelting step. DRI can be used together with scrap and has the advantage that it does not contain tramp elements such as copper.

An alternative to reformed natural gas is to use pure hydrogen as a reducing agent, which gives a DRI without carbon. A number of projects are underway in this area but very little has yet been published in terms of operating results. It is clear, however, that access to large amounts of electricity with low emissions and a well-developed electrolyser technology are requirements.

Possible scrap shortage?

The fact that some blast furnaces have already been scheduled to close down, completely new electric arc furnace plants are planned and that expansion of electricity production and technical development of hydrogen processes can take time creates a concern among today's scrap-based plants that the availability of high-quality scrap will become a limiting factor. This possible shortage is the driving force for three special steel companies, Ovako, Alleima and Uddeholm, to team up with the forestry company Sveaskog and the agricultural company Lantmännen, KTH Royal Institute of Technology, Chalmers University of Technology as well as M3Advice and Kobolde & Partners to form the FerroSilva project. With the goal to investigate the conditions for reducing iron ore with gasified biomass and with part of the funding from the Swedish Energy Agency, a feasibility study was carried out during 2021-2022 with very promising results.

The FerroSilva supply chain

The basic idea can be seen in the figure above, where residual products from forestry and agriculture are collected and gasified into a syngas with the same composition as reformed natural gas. This is then used as reduction gas in a shaft furnace which produces a DRI with the same properties as in production with natural gas. Around 1 ton of carbon dioxide is formed per ton of DRI and this is collected for further transport to a facility that can further process it into methanol to be used as a starting point for other chemical products or as fuel.

The FerroSilva startup team from left Dr Peter Samuelsson, Göran Nyström and Rutger Gyllenram. Peter is driving the work to build FerroSilva's first factory in Hofors, Rutger focuses on issues related to production, raw materials, logistics, environment and research and finally Göran drives marketing and investment matters.

FerroSilva energy use is 300 kWh electricity and 3500 kWh biomass equal to about 1.4 tonnes or 3.7 m3 with a biomass density of 380 kg/m3.

Starting with 50-thousand tonnes DRI per year

The first FerroSilva plant will have a capacity of 50 thousand tonnes of DRI per year and will be located inside Ovako's industrial area at the place where the old blast furnace stood many decades ago. Building on a brown-field site has great advantages as the land is prepared, almost all infrastructure and services are in place and the customer for the produced DRI is only about 100 m away.

The ambitious plan is to start production in the second half of 2026 ramping up to a productivity of 50 thousand tonnes of DRI per year in 2027. The process concept has the advantage of utilizing existing mature technology put together in a new way. Despite a rather small plant size the production is sufficient to provide the copper free raw material necessary to meet the high quality demands on Ovako steel. A preliminary design of the plant is shown in the initial figure. Biomass and pellets are delivered by rail from the raw material suppliers to material bins on the left in the picture and then further transported with conveyor belts to the gasification plant and DR shaft. The product is taken directly by electric truck to the steel mill. The liquid carbon dioxide is planned to be temporarily stored in tanks before being loaded into railway cars for transport to a nearby plant for methanol production or, in case of surplus carbon dioxide, stored in the bedrock.

Building a Bio-DRI Eco-system for the future

Using biomass to generate a reduction gas means that it becomes profitable to use a significantly larger part of the residual material that arises from forestry and agriculture. Unlike the production of district heating, FerroSilva demands a steady stream

In addition to the technical team, FerroSilva is supported by Karin Reuterskiöld, left, from Forever Sustainable in questions regarding sustainable finance and Dr. Elham Yazdkhasti, right, from the Swedish University of Agricultural Sciences/Kobolde who is coordinating FerroSilva's efforts in what we call bio-sustainability.

of biomass throughout the year. Collection of forest by-products for 50 thousand tonnes of DRI uses 0.3% of the residual products that are not collected today and if all of Sweden's iron reduction of 3 million tonnes took place with gasified forest by-products, only 19% of the unused amount of biomass would be consumed. Even if the material is there, the utilization places great demands on the logistics and on the collection taking place in a way that does not damage biological diversity and depletion of soil-bound carbon. How to utilize ash from the FerroSilva plant will be considered.

Likewise, a network of partners to take care of carbon dioxide for usage and storage must be developed. It is still early days in this management but to make methanol from carbon dioxide, large quantities of hydrogen are required, and according to the present plans this will be produced in a brownfield site not far from Hofors in order to produce e-fuels from the FerroSilva biogenic carbon dioxide. But as they say "early days". The FerroSilva team, presented in the figures above, is however now experiencing an intensive period to say the least.

Going for 500 thousand tonnes of DRI

The natural gas-based direct reduction plants being built today normally have a capacity over 2 million tonnes of DRI/year. It took almost 60 years to go from the first facilities of 50-100 thousand tonnes to today's sizes. For hydrogen, there is talk of building facilities of 1-2 million tonnes of DRI after initial pilot trials. In that comparison, 50 thousand tonnes seem extremely limited, but considering that a complete logistic system from the forest to the methanol factory is to be built up, the size feels manageable. Once the new industrial eco-system has been established, a next step of 500 thousand tonnes is planned.

Meeting the goals of the Paris agreement

If the biogenic carbon dioxide captured in the FerroSilva process is used for products or to replace fossil fuels, a so-called carbon dioxide sink is created. These reductions are necessary for us to have a chance of meeting the requirements of the Paris Agreement. It is clear that we have underestimated the amount of forest and agricultural by-products available as the supply is a function of the price to cover the collection. It is therefore the hope of the FerroSilva team that the technology can be used in all countries with certified forestry and agriculture and become an important factor in meeting the climate goals for 2030 and 2050. The important thing is to remember that it is not about a process solution, but about the building of a completely new industrial ecosystem that requires cooperation between different industries and financial actors and with governments raking the arena.