Company

Salzgitter AG is the second biggest steelmaker in Germany with an annual capacity of **7.5 million tons of crude steel**. Salzgitter AG **employs 24.500 people**, of which roughly **10.000 work in the steelmaking units**.

The main share of production takes place in the company´s **integrated steel works based in Salzgitter**, Lower Saxony, Germany, operating **three blast furnaces** (including sinter and cokemaking facilities), **power station, basic oxygen meltshop as well as hot and cold rolling mills and finishing lines**. The plant is focused on the production of **high-quality flat carbon steel**. 90% of our finished steel is being sold to **European customers**.

Company website: www.salzgitter-ag.com

SALCOS® – A distinct example of Carbon Direct Avoidance (CDA)

With respect to decarbonization of primary steelmaking, Salzgitter AG plans to take advantage of a **unique feature of ferrous metallurgy**: **Hydrogen** can **replace carbon** in iron ore reduction processes, leading to the final **formation of water (H_2O) rather than CO_2**. Additionally, **process heat** for steelmaking may be **supplied by electrical energy instead by carbon**.

Thus, it is possible to **address the root cause of the problem**, directly **avoiding the formation of CO_2**.

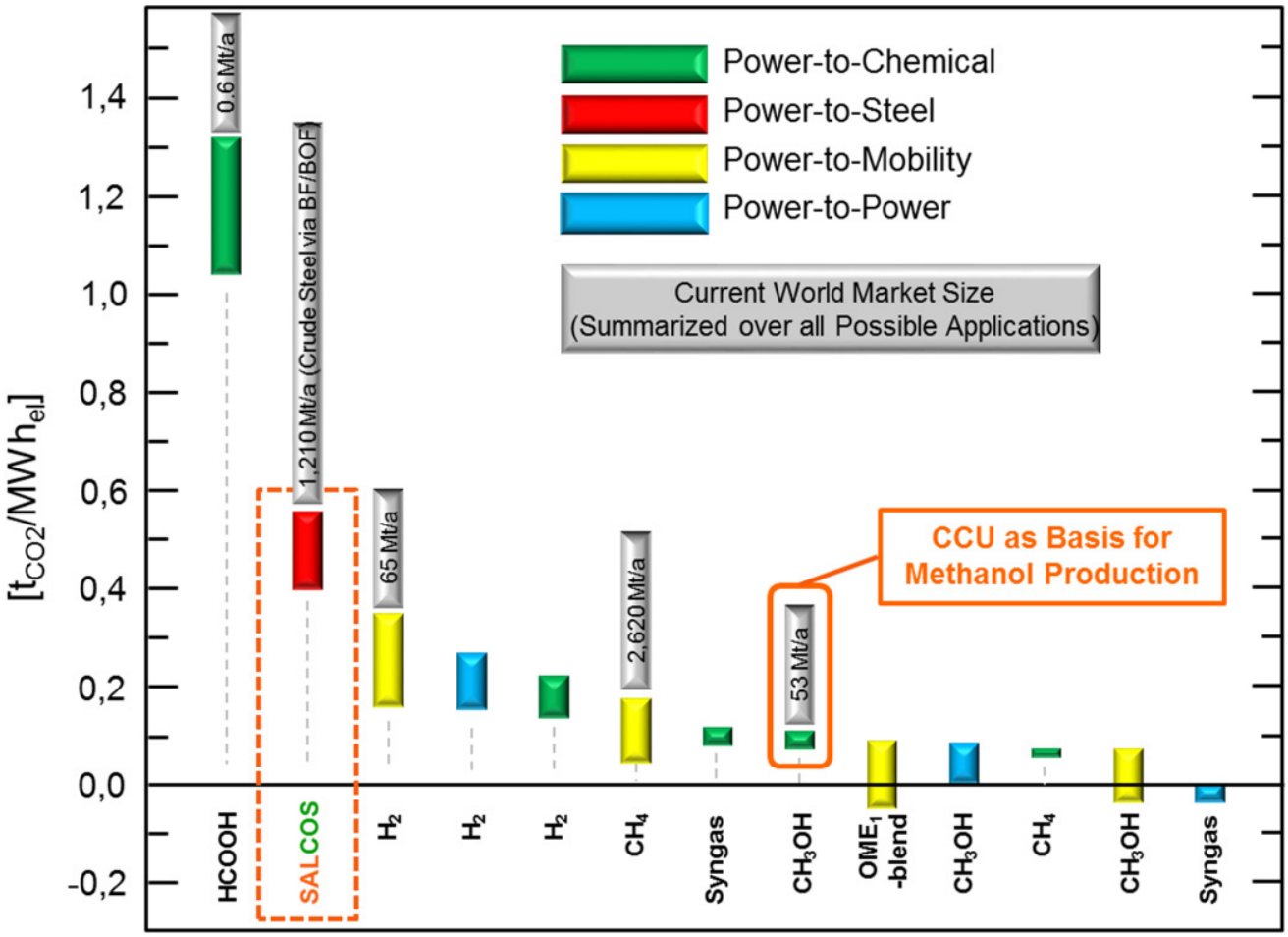
To clearly **distinguish** our new set of ideas **from CO_2 usage (CCU) or disposal (CCS)** concepts, **we coined the term "Carbon Direct Avoidance" (CDA)** in November 2016.
This rather neutral acronym should point out that the introduction of our respective approach is **not limited to Salzgitter AG**, but technically **principally applicable at all integrated steelmaking sites around the world**.

We are convinced that **avoidance of CO_2 formation** directly in steelmaking processes is a **more sustainable** - and also **energetically more sensible** - way compared to CCU or CCS, hence closely **reflecting a generally preferred concept in any waste management**.
In fact, seen in **combination of energy efficiency and potential volume of possible CO_2 avoidance**, our approach is the **most favourable compared to any other industrial approach**. The following figure shows various approaches to CO_2 mitigation with respect to their energy efficiency: The higher a bar is arranged for each individual technology, the more CO_2 can be reduced per electrical energy employed. The production of formic acid (HCOOH), for example, via CO_2 from industrial exhaust gases is the only process that offers higher specific energy efficiency compared to SALCOS, but only has a marginal market potential - too small by orders of magnitude to utilize the enormous quantities of CO_2 generated by the steel industry. We are therefore of the opinion that there is **no alternative to CDA in steel industry** if sustainable, significant effects are to be achieved. Additionally, **we do not expect objections** against our proposed solution **from the public**.

With respect to the **realization of CDA in detail**, Salzgitter AG started the project **SALCOS®** (Salzgitter Low CO_2 Steelmaking) in 2015, **investigating the particular preconditions and implications of CDA** for the integrated steelworks of our group.

To **broaden the scientific basis for SALCOS®** and ensure neutral expertise, we joined forces with **Fraunhofer-Gesellschaft (FhG)**, the leading application oriented scientific research organization in Germany.

Beside the aim to lower CO_2 emissions significantly, the paramount prerequisite is the **realization of all planned technical measures at the Salzgitter site**, thus giving a clear statement of maintaining our ties to the traditional production locations of our company, keeping employment in Europe, **avoiding any carbon leakage** to non-ETS countries.



Source: Sternberg und Bardow, Energy Environ. Sci., 2015, 8, 389-400
(SALCOS® and Addition of World Market Size by SZAG)

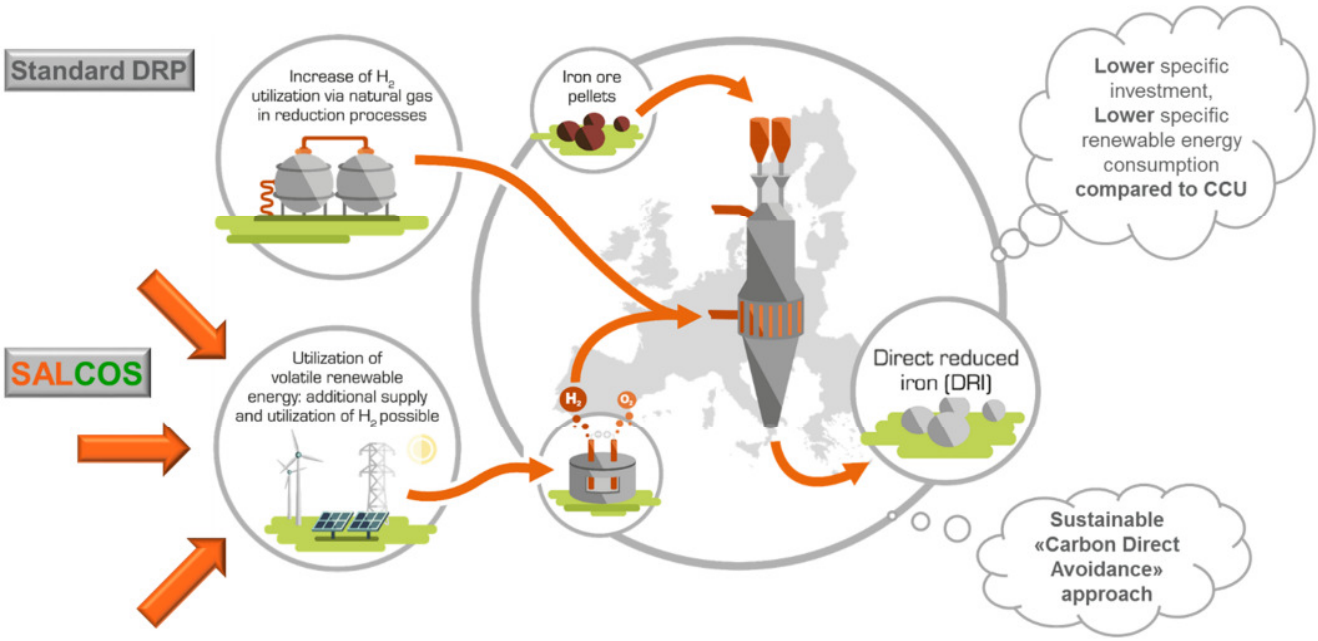
The project is based on a **modular concept**, offering the possibility to be realized in **subsequent steps**, **tailor-made** to address the challenging further development of CO_2 reduction targets in Europe after 2030. Consequently, the **sophisticated, energy efficient process layout of steelmaking at the integrated Salzgitter plant has to be considerably changed**, based on the concept as outlined below.

As a first step, we plan to add a natural gas based **direct reduction process (DRP)** for iron ores to the actual plant layout at the integrated site in Salzgitter. The direct reduced iron **(DRI)** from this plant is to be **fed to the existing blast furnaces** (**stage 1a**). This concept already **reduces the carbon footprint of steel** production **by roughly 10%**, as **natural gas used for reduction has a certain amount of hydrogen content**. Additionally (**stage 1b**), **large amounts of hydrogen may be fed to the process**, replacing the needed natural gas partly. The hydrogen will be produced via **electrolyzers** operated with **power from renewable resources**.

Operating the direct reduction plant on such a **mixed natural gas/hydrogen basis** enhances the **CO_2 reduction further to about 18%**.

The combination of direct reduction with **flexible electrolysis technology** on such a large scale (**biggest electrolysis capacity world-wide**), necessary for taking maximum advantage of the fluctuating availability of **power from renewable resources**, is **highly innovative**.

It has to be underlined that the incorporation of such a **flexible direct reduction plant** to an existing integrated steelworks in full operation **has never been realized before** and thus poses **great challenges** for the production route as a whole, both **process-wise and economically:** As with other concepts currently under preparation for the reduction of CO_2 emissions in the steel industry, the incorporation of **SALCOS® might intermittently lead to virtually unbearable OPEX increase within the given regulatory and economic framework.** As a consequence, these **conditions have firstly to be adapted in order to facilitate the realization of the proposed project**.

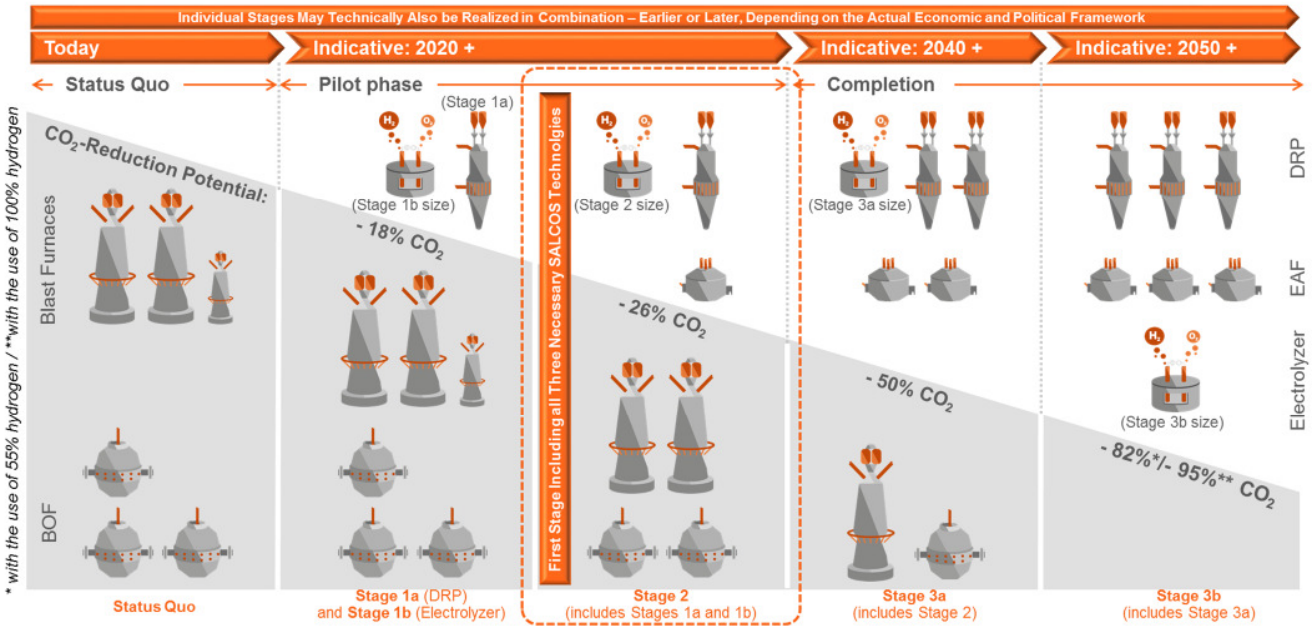


The great strength of SALCOS® is the **further development of existing technology** (here: DRP) to meet the future challenges. This offers the possibility to **go directly for a large-scale pilot plant**, avoiding the necessity of lengthy laboratory scale studies. The reason for this approach is our conviction in the **necessity to act now**, if industry and society really want to **reach the climate targets set for 2050**.

This clearly distinguishes SALCOS® from many other decarbonization projects, targeted for industrial scale realization starting only 2035 or 2040 onwards.

The next step (stage 2) would be the addition of an **electric arc furnace (EAF)** plant to the layout, which is to be fed with the direct reduced iron from the then already existing direct reduction plant. This offers the possibility to shut down one of the three blast furnaces in operation. **The CO_2 reduction in this case will be up to round about 25%.**

Further steps (stages 3a/b) are principally based on the same approach as the steps before, leading to the **complete transformation of steelmaking** from the blast furnace/basic oxygen technology to the direct reduction/electric arc furnace route in the decades to come. **The maximum CO_2 reduction possible by the SALCOS® concept in this ultimate configuration is 95%.**



As described, **SALCOS®** - like all other comparable projects - will **require considerable investments** in new plant equipment. In this context it must be noted, that **new CDA processes** would **not lead to higher efficiency, lower energy costs, better product quality, new steel grades** or any other effect generating a possibility of decreased production costs or increased revenues.
The **sole purpose is sustainably reducing CO_2 emissions** of steelmaking, hence **fulfilling a task for society as a whole**.
Domestic steel industry has to **act locally on CO_2**, but has to **compete on a world scale**.
Therefore, we ask for **significant public funding** with respect to the realization of **SALCOS®**.

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