A steely resolve to cutting carbon emissions

Reducing carbon emissions in steel production is crucial in achieving global net zero CO_2 targets. Siemens Energy is collaborating with European steel producer Salzgitter AG to help reduce emissions from its steel production process. But it is a partnership that is also helping Siemens Energy to cut its own Scope 3 emissions. **Junior Isles** explains.

The importance of decarbonising the steel industry cannot be understated. According to a 2021 report by the World Steel Association, steel production accounts for between 7 and 9 per cent of global CO_2 emissions. More recently, in its Tracking Clean Energy Progress 2023 report, the International Energy Agency (IEA) estimates that it accounts for 8 per cent of primary production in 2030 in its NZE (Net Zero Emissions) Scenario. The IEA therefore stresses that innovation is crucial for the commercialisation of new near zero emissions steel production processes.

Fortunately, both the steel industry and major players in the energy sector have not been sitting on their hands. Although the current pipeline of low- and near zero-emission projects in the steel industry falls short of what is required to meet the NZE Scenario, important progress is being made.

Commenting on the size of the problem of CO_2 emissions from steel production, Anand Sengupta, Vice President and Head of Global Sales, Compression at Siemens Energy, said: "In a word, it's as big as 8 per cent of global emissions. The industry has seen a big demand for steel in the last few years. It's a fundamental indicator of economic growth… demand will stay and the problem will grow in size. But today steel production is heavily dependent on coal, which is primarily used for reducing iron ore to so-called pig iron.

"But over the last decade, these emissions have gone up. There has been some improvement in terms of efficiency, i.e. the number of tonnes of CO_2 per tonne(t) of steel. But due to the higher demand, things have really gone south and the overall amount of CO_2 emissions has gone up in a way that now we really need measures to meet the net zero emissions target."

Sengupta: CO_2 emissions have gone up in a way that "now we really need measures" to meet the net zero emissions target

Siemens Energy has secured the contract to deliver and install its advanced centrifugal compressors for compressing hydrogen at Salzgitter. The compressor package features an integrally-geared compressor design, allowing for more efficient compression

"Figures from the Energy Information Administration (EIA) show that producing 1 t of steel produces about 1.9 t of CO_2. And using coal means that CO_2 emissions are not the only problem – methane, nitrous oxides, sulphur dioxide and particulates are also an issue. So this is a very important problem for us to solve."

Siemens Energy has put reducing carbon emissions from industrial processes such as steel production, and indeed its own processes and products, at the heart of its operations. In what is one of the most important projects aimed at cutting CO_2 emissions from steel production, the company has been collaborating with Salzgitter AG on a programme to make steel production more climate-friendly.

Salzgitter AG is one of Europe's leading steel and technology groups. Apart from the carbon used, the company operates its integrated steelworks in Salzgitter, southeast Lower Saxony, Germany, on a virtually energy autonomous basis and closed material loops by reusing residual material and cogenerated products. According to the company, it is "working very close to the limits of what science and technology permits", which puts it "among the world's most efficient producers of steel".

Nevertheless, production in the Salzgitter steelworks generates about 8 million t of CO_2 per year, made unavoidable by processes and by the current status of technical conditions and the facilities available. In order to lower its CO_2 emissions, the company has begun to implement its SALCOS® programme – Salzgitter Low CO_2 Steelmaking.

Although the ambition among steel producers to cut emissions varies from region to region, Sengupta says that, overall, Siemens Energy's customers are "working very hard to define their own individual strategy".

He added: "It depends on the process they are using; how old the steel plant is; and the different local requirements, i.e. whether they are in Europe, US, India or Japan. But most of them want to become climate-neutral by 2045 at the latest."

Sengupta says that the most realistic pathway is to first optimise and electrify. Historically, the most common

blast furnace used by steel producers has been the Basic Oxygen Furnace (BOF). A growing number are shifting towards the electric arc furnace (EAF) to implement a different production route, which is easier to decarbonise. The second part, he says, is "decarbonising operations". This means reducing the carbon in the electricity supply, i.e. using renewables. The third is carbon capture.

"We see some frontrunners – especially in Europe where we are trying to implement, with the government, some concrete actions. Most of the major steel producing countries have targets to reduce emissions by between 15 and 40 per cent by 2030. But the EU has launched a strong push for industries to transition from a high carbon to a low carbon footprint," he said.

"Beyond Europe, the Inflation Reduction Act (IRA) in the US is providing a huge amount of funding [for industries] – around $5.6-5.8 billion – a large part of which will be available to some of the projects in the steel industry."

He noted, however, that the technology aspect is also important, highlighting some of the new technologies that are being deployed. "Sweden, for example is doing a scrap waste steel project that will help reduce carbon footprint. We are also seeing some hydrogen-based direct reduction of iron (H_2-DRI) that will demonstrate the future of how the industry will move forward."

As part of its SALCOS programme, Salzgitter is replacing its existing blast furnaces with direct reduction plants. The company currently produces pig iron, or crude iron, by using coal in its blast furnaces. This releases CO_2 as a result of the process. In direct reduction, iron ore is reduced with the aid of hydrogen. The hydrogen reacts with the oxygen in the iron ore (iron oxide) directly in the solid state and converts it into sponge iron (almost pure iron).

Instead of CO_2, this technology produces water (H_2O), which in turn is reused in the integrated process. In order to be able to process sponge iron further, the porous material is finally melted down together with steel scrap in an electric arc furnace.

The SALCOS programme is already in the midst of implementation. The financing of stage 1 of the programm has been secured through subsidies of about €1 billion from the Federal Republic of Germany (€700 million) and the State of Lower Saxony (€300 million), as well as through the substantial funds of Salzgitter AG, amounting to well over €1 billion. The total investment volume for the first stage of SALCOS is € 2.2-2.4 billion.

Integrally-geared compressor rotor

The SALCOS programme will be implemented in three stages. The first – consisting of a direct reduction plant, an electric arc furnace and a 100 MW electrolysis plant for hydrogen production – will be completed in 2026. Wind power generation has already been installed along with the electrolyser, which produces hydrogen for use in the electric arc furnace. Phases two and three will entail the increased use of scrap.

Salzgitter is targeting at least a 95 per cent reduction in CO_2 emissions by 2033. The company noted: "By setting ourselves the goal of avoiding CO_2 directly rather than storing it or making it usable at great expense (carbon direct avoidance strategy), our concept is sustainable and sets an example for the industry."

Transformation of the steel production process at the Salzgitter site should be completed by the end of 2033, well ahead of the regulatory requirements.

In May this year Salzgitter reached a major milestone in executing this plan with the order of an 'Energiron ZR Direct Reduction' plant from a consortium of Tenova, Danieli and DSD Steel Group. The consortium will build the DRI plant on the site of Salzgitter Flachstahl GmbH. The unit is the largest sub-plant in the first stage of the SALCOS programme and has a production capacity of more than 2 million t of direct reduced iron per year.

Sengupta commented: "SALCOS has also announced that they will stop using blast furnaces by mid-2030s and replace their coal-based process with a new hydrogen route. That's a massive change. It's a huge change in the plant itself. This transformation is expected to achieve emissions savings of 95 per cent, which is actually 1 per cent of Germany's CO_2 emissions."

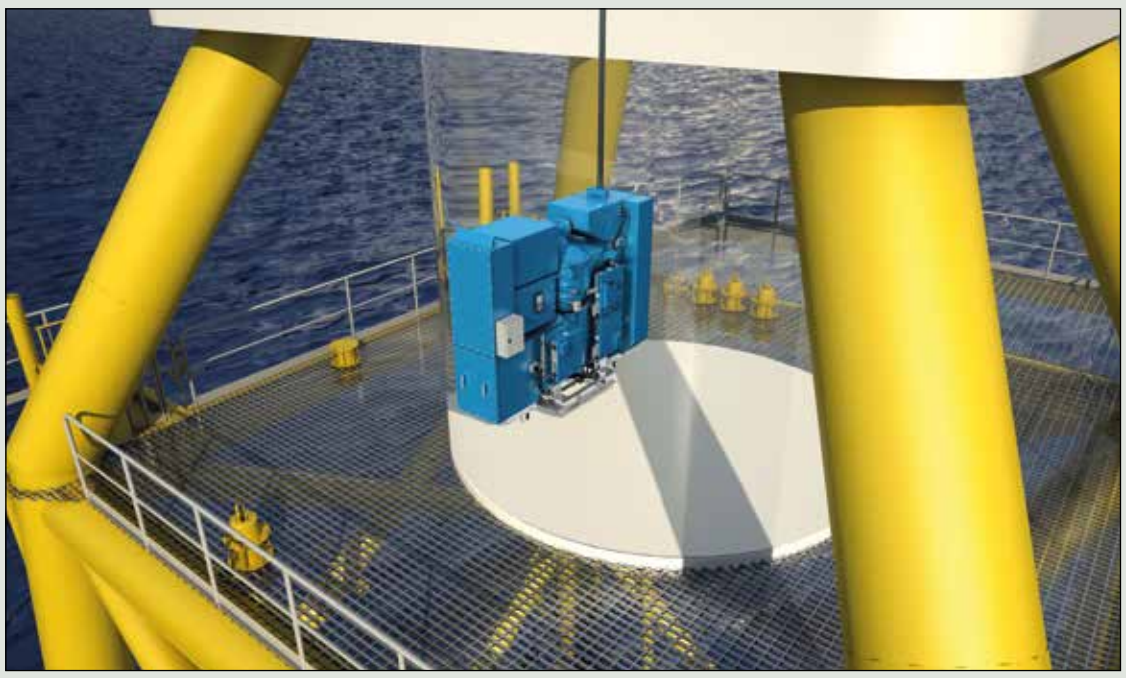
Sengupta noted that blast furnaces sites around the world can also use DRI technology similar to that used by Salzgitter. A key benefit here is that operators can switch from natural gas to hydrogen "on the fly". This would allow them to make the transition from natural gas to hydrogen slowly.

Example of an advanced rotor hydrogen compressor

"You could initially start with, say 5 per cent hydrogen, and 95 per cent natural gas; or you could have in between 50:50 and switch over from 5:95 to the other way around," said Sengupta. "This is a huge advantage because, without changing the equipment or the process, you can move from point A to point B almost seamlessly."

This is where Siemens Energy compressors play a pivotal role. Sengupta explained: "The process uses natural gas, which has a certain molecular composition, molecular weight, fluid dynamics, etc. But the same process tomorrow has to use a mix or pure hydrogen, which has a different molecular weight and a different kind of fluid dynamics.

"So the compressors need to be flexible and adaptable to handle the wide range of head – the compressor power, the flow that is needed; the pressure ratio that's needed. And the compressors need to be reliable enough to move from a heavy, big molecule, to a lighter, smaller, molecule; so it's really important to understand how the compressors, from a flexibility standpoint, can handle both the gases. Unlike Salzgitter, in



F-gas-free switchgear in an offshore wind turbine: it is important for the wind industry to reduce its carbon footprint through developments such as GIS without SF_6 or other F-gases

F-gas-free switchgear at the Siemens Energy switchgear factory in Berlin

most cases, the operators would like to switch over from existing natural gas to a mix of hydrogen before completely turning over to hydrogen. The flexibility of not having to change the compression system is a huge advantage on continued production and costs."

Apart from hydrogen, compressors are also used in steel plants to handle nitrogen and oxygen.

Sengupta commented: "There are compressors that handle dry oxygen and these are different from the ones that handle hydrogen and natural gas, and different from compressors that handle nitrogen."

For nitrogen compressors, Siemens Energy has extensive experience in the air separation market. These, says Sengupta, are fairly standard technology but need to be extremely reliable. The oxygen compressors are more complicated: you don't want any flammable material inside. And this is where we have the experience, with years of reliable operation; very few manufacturers can do it. For the natural gas/hydrogen compressors, this is where we also have the experience depending on the size."

Siemens Energy has secured the contract to deliver and install its advanced centrifugal compressors for compressing hydrogen at Salzgitter, with an integrally-geared compressor design driving two compression stages to achieve the required pressure ratio. This portfolio of geared compressors driving up to four shafts at individually optimised speeds allows more efficient compression, further reducing the energy consumption of the plant (and resultant CO_2 footprint).

"This lies at the heart of what we do at Siemens Energy. We have a business area that specifically looks at how we reduce the carbon footprint of industrial processes; steel is one of them," said Sengupta.

Siemens Energy is building on its Salzgitter compressor experience, with plans to install an advanced rotor hydrogen compressor at another steel production plant in Sweden. It will meet the steel producer's requirement for a compressor with higher flow rates.

"This will be phenomenal because you won't need to have multiple compressors running in parallel; you can have one large centrifugal compressor, providing all the pressure ratio and the flow rate at the same time," said Sengupta.

"It's something we are very excited about and are talking to multiple customers about it. The future of green steel will need a portfolio where we are not looking at small multiple units but reliable larger units."

The use of fewer units, he says will mean lower costs, higher reliability and reduced footprint. "Each compressor has its own balance-of-plant, so each time you add one more compressor, the average cost per megawatt goes up.

"Also steel producers are converting in a brownfield situation, so there is a space constraint. If you have a large flow there will at some point not be enough room for multiple compressors; so a larger single compressor with a 1+1 configuration would be a huge advantage."

In addition to compressors, Siemens Energy has also secured a contract to build a substation on Salzgitter AG's premises to connect to the 380 kV 'Salzgitter Industrial Line'.

The scope of the contract covers a 380 kV gas-insulated switchgear (GIS); a 220 kV GIS; substation auxiliary systems; and the entire design engineering. In addition, Siemens Energy will provide four high voltage and medium voltage transformers for the first step of SALCOS.

The substation will be connected via the Bleckenstedt Süd substation of TenneT TSO GmbH to the future 380 kV industrial line that in turn will connect up Salzgitter with the Wahle-Mecklar line. Going forward, this grid connection will allow Salzgitter AG to source the necessary volumes of power from renewable energies.

GIS is in fact another area in which Siemens Energy is already contributing to tackling climate change. The company has launched a range of GIS that has eliminated the use of sulphur hexafluoride (SF_6) – a gas which is used for insulation with a global warming potential 24 300 times that of CO_2.

Siemens Energy has been working on its 'Blue' technology for more than 12 years, initially focusing on lower high-voltage levels, i.e. 72.5 kV. The technology is available for GIS, circuit breakers and instrument transformers all with absolutely zero CO_2 equivalent emissions over the lifetime of the equipment. The technology has been in service around the globe up to 145 kV for several years and is currently being rolled out across Siemens Energy's entire HV switching equipment portfolio up to the highest transmission level of 420 kV.

The company also emphasised that several hundreds of switchgears with Blue technology are already being installed in wind turbines. Big offshore wind farms currently use 72.5 kV, so it developed switchgear especially for wind turbine applications and first installation started in 2017.

Wind power is one of the cornerstones of the green energy transition. With more than 600 GW of new capacity to be installed worldwide in the next five years, it is important for the wind industry to reduce its carbon footprint through developments such as GIS without SF_6 or other F-gases. The work Siemens Energy is doing with Salzgitter also feeds back into this.

In April this year, Siemens Gamesa announced the GreenerTower, a wind turbine tower made of more sustainable steel.

Towers consist of approximately 80 per cent steel plates. The new GreenerTower will ensure a CO_2 reduction of at least 63 per cent in the tower steel plates compared to conventional steel. Siemens Gamesa's new thorough qualification process will verify that only a maximum of 0.7 t of CO_2-equivalent emissions are permitted per tonne of steel, while maintaining the same steel properties and quality.

Salzgitter AG, with its heavy plate mill Ilsenburger Grobblech GmbH, is the first supplier to be qualified, something, which has also been reinforced by third-party certification.

Today, tower production accounts for more than one-third of all wind-turbine-related CO_2 emissions. If all towers installed by the company in one year were exchanged with GreenerTowers, it would be the same as removing more than 466 000 cars from the roads in Europe for a year. This new CO_2-reduced tower will be available as an option for both onshore and offshore wind turbines for projects to be installed from 2024 onward.

The GreenerTower has already closed its first order. RWE and Siemens Gamesa have agreed to introduce 36 GreenerTowers at the 1000 MW Thor offshore wind power project in Denmark. In total, 72 SG 14-236 DD offshore wind turbines are planned to be installed starting in 2026. Sven Utermöhlen, CEO RWE Offshore Wind, said: "Offshore wind already has one of the lowest lifecycle carbon footprints of power generation technologies. At RWE we are fully committed to working towards circularity and net zero emissions. We are already testing the world's first recyclable wind turbine blades by Siemens Gamesa under real-life conditions."

By piloting the GreenerTower at our Thor offshore wind farm, RWE is now looking to take the lead in helping to significantly reduce the carbon footprint of wind turbines.

On average, 1.91 t of CO_2 is emitted during the manufacturing process for every tonne of steel. By setting a threshold of 0.7 t CO_2-equivalent emissions per tonne of steel, Siemens Gamesa says it "significantly" reduces the footprint of the largest component in terms of CO_2-equivalent emissions.

The use of green steel in its wind towers goes a long way to closing the loop in making its wind turbines completely green.

It certainly feeds into Siemens Energy's strategy of cutting emissions from its own operations. "Again, this is at the heart of what we're doing at Siemens Energy and the goals that we've set for ourselves. We look at Scope 1, Scope 2 and Scope 3 emissions. Every time we supply to the steel industry, if it's not green steel it adds to our Scope 3 emissions," said Sengupta. "So we are very actively engaged to reduce Scope 3 emissions, which means we are actively engaged to pursue the HDRI. So it not only helps our customers, it helps us as well. Ten years down the line, this needs to be more the norm rather than the exception."

He concluded: "Technology is important but perhaps even more important is the relationship with our customers. We have been working with Salzgitter to build the solution together, supporting them for the last 5-10 years. It's partnerships that make all of this come to life."

The new GreenerTower will ensure a CO_2 reduction of at least 63 per cent in the tower steel plates compared to conventional steel

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