

PIONEERING GREEN STEEL PRODUCTION IN OMAN

Hydrogen Rise sets out its vision for a Green Hydrogen economy in Oman

By Olav Carlsen, CEO Hydrogen Rise (Oman) LLC



When Munich-based Hydrogen Rise AG began to focus on Oman in 2018, we did this with a clear vision: To develop a Green Hydrogen Economy in Oman. We strongly believed that green hydrogen would play a leading role in the global energy transition and offer enormous opportunities also to the Sultanate.

We also believed early in the significance that green hydrogen is holding to achieve reach Oman's Vision 2040 goals: The diversification of the national economy and specifically within the energy sector. The

creation of plenty new job opportunities for young people in cutting-edge technology fields. Involving local academics in meaningful global research opportunities. And putting Oman in the path of the right now evolving new trading systems of renewable energy and decarbonized products.

Over the past 4 years we carefully studied the application of green hydrogen for the decarbonization of local industrial processes, especially in hard-to-abate sectors such as steel production, and the saving of natural gas as a result. We saw a longer-term development of considerable new green hydrogen-based export industries. Therefore, in 2019, together with the German University of Technology in Oman ("GUtech") and under the auspices of the Ministry of Energy and Minerals, we organized the first hydrogen symposium in the country and later established our project development company Hydrogen Rise LLC in Oman as a joint venture between the German company and our local partner Oman Educational Services.

It is reassuring to observe today's commitment to the development of a local hydrogen economy by all stakeholders in Oman - in industry, academia and authorities of the highest levels. We see our early vision taking shape. Now the time has come to bring the technology onto the ground and to develop projects that deliver the most relevant immediate goals: a bankable business model to accomplish the goals of the national Oman Vision 2040.

Compared to other previous major technology or industrial changes the worldwide transition towards renewable energy sources and green hydrogen is an



epic exercise. The entire global private and industrial concept of generating and consuming energy needs to transform. No single company, technology, industry or government can solve this challenge alone. It requires a dedicated international and cross-disciplinary team effort to develop projects that overcome that (challenge for all newly developing industries and technologies: early economic feasibility and scaling. Green hydrogen is still expensive when compared to its fossil-based alternatives, grey hydrogen or natural gas. In 10 years from now we will have overcome this early challenge and so the main question remains: “How do we get there?”

Many countries face, in varying degrees, similar challenges developing a large-scale green hydrogen industry: Land availability for the generation of sufficient renewable energy. Water availability and management for the electrolysis process. And the development and management of the energy grid to store and transmit renewable power for a 24-hour operation of the electrolysis process – at least solar power is not available day and night. There are technical solutions for all these challenges – some in currently just in theory, some already applied. Over the coming years, green hydrogen will become without doubt a natural and exclusively market-driven business choice. Economies of scale, further technology advancements in efficiency,

widening regulations for consumption and trading of fossil-based products and overall global consumer demand for decarbonized products will make green hydrogen a trillion-dollar business opportunity. Until then, during the ramp-up phase we find ourselves in, the focus must be on how we design the early green hydrogen projects to address the immediate issue of economic feasibility.

Let us look at one of the several Hydrogen Rise projects for that: Three partners, Hydrogen Rise LLC, Jindal Shadeed Iron & Steel LLC and Sohar Industrial Port Company SAOC recently announced that they are evaluating the greening of the steel production at Jindal’s state-of-the-art steel plant in Sohar. Let me use this green steel project to discuss our green hydrogen vision for Oman in more detail.

Building a bankable business

This is the game changer in the project planning and development process. Fact is that green hydrogen - today – per kg or per mmbtu is (in general still more expensive than the fossil fuel alternatives natural gas or grey hydrogen. The markets for green hydrogen-based products, such as green ammonia, methanol or steel are just evolving, as are the corresponding global government policies and regulations or mandates for trading and consuming fossil-based products. These



*Jindal Shadeed Iron & Steel,
Sohar.*

three factors represent uncertainties for investors. The global steel market is already subject to carbon credit pricing established in many countries. Spot market prices for these required credits upon import into the European Union have recently soared to over €80 per ton of CO₂ and are expected to increase further in the future, some suggest to €200 in the future. When considering export opportunities to markets that are subject to such a stiff carbon taxing at its border, it gives green steel with its higher production cost already today a competitive edge towards a bankable business model.

Bankability also depends on the right project size. The investments made today in the green hydrogen production and/or renewable energy generation assets lock in a significant part – up to 80% - of the production cost of hydrogen for the long life of these assets. Once locked in by the initial investments, little can be done to benefit from future cost declines. We should see a decline of electrolyser cost per MW capacity of 50% or more over the next years. The Jindal Green Steel project has the potential capacity for a 500 MW green hydrogen generation to decarbonize a significant portion of the production within technical possibilities. The project partners opted for a realizable kick-off size of up to 50 MW. This also better aligns with the still limited global supply of electrolyser capacity today. By scaling the project step-by-step afterwards, it will

benefit from future cost declines and from the learning and technical synergies in the first step. This approach delivers a manageable risk in the ramp-up business model and offers long-term investors perspectives through a reasonable and carefully managed scaling plan. It requires a project plan that integrates a modular technical scaling ability and considers up-front all related logistical scaling challenges.

A project's economic feasibility must be further improved through modeling an optimal use of the production assets: Maximizing the output of kg of hydrogen per \$ investment. The more hours per day an electrolyser is operating, the lower the levelised cost of hydrogen. How can electrolyser investments be used to their maximum production output in a 24h operation when solar power is only available for part of that. A mix of wind and solar power is helpful for this challenge. More importantly innovative renewable power storage solutions are needed to store excess renewable power generated during the day to enable running electrolysers during non-daylight hours. Regular battery solutions do not offer the answer. For the green steel project at Jindal, we will evaluate the replacement of gas-powered grid electricity by use of excess solar power generated during the day in the existing steel production process and subsequently using the same amount of replaced power from the grid for the electrolyser operation during nighttime. This concept is complex and meets many regulatory, grid capacity, industrial and green certification challenges. And it is a valuable concept to be analysed and lobbied for when building competitive business models. Here, government agencies, industry and the green certification agencies have to work hand in hand.

The cost gap between green hydrogen and the fossil fuel-based alternatives will still be a challenge for bankable business models, even though we see the gap closing recently because of the price hike of natural gas especially for fossil fuel importing countries. The nascent green hydrogen industry and business community, especially the financial community is looking for government support incentives to get comfortable with the risk,

especially for the first generation of projects. In Oman, an innovative support mechanism could consider the higher commercial value from an alternative use of natural gas saved by decarbonization projects. Applying the monetary gain from the alternative use as direct project incentive will help de-risking the investment decisions, a possible win-win for all. Many countries have assumed different financial support models to help early adopters to bridge the initial cost gap, but few have the advantage of applying a direct monetary gain from an alternative use of gas to support the energy transition itself, like Oman.

Align the project development with the Oman Vision 2040 goals

The economic diversification of the industry in the Sultanate depends on an efficient long-term use of its today's fossil and future renewable power capacity. This begins with short-term opportunities to decarbonize existing industrial processes, such as steel production. It saves natural gas today to either prolong the availability of national gas reserves or free up natural gas reserves for the above-mentioned alternative use with higher economic value, for example the global LNG spot market. In parallel to this short-term strategy, a longer-term economic diversification process will include large-scale green hydrogen projects adding additional national production capacity of decarbonized products. Because of their much higher investment size and the still existing uncertainty in today's markets their risk profiles of course differ significantly from the short-term options.

We believe that large-scale projects will become the standard in developed hydrogen economies. For the early adoption phase however, Hydrogen Rise focuses on immediate decarbonization opportunities to enable the green hydrogen applications and contribute to the Vision 2040 goals as early as possible. Greening the existing steel production process is such an opportunity. The global steel production is responsible for a significant part – bordering 10% - of the global CO2 emission. Jindal Shadedee with its Direct Reduction Iron plant using natural gas and its Electric Arc



“Our green steel project plan with Jindal Shadedee in Sohar is just the beginning.”

Furnace in Sohar is already way ahead in terms of the CO2 footprint per ton of steel compared to other international coal- or coke-based traditional steel manufacturing plants. Applying green hydrogen to the reduction process of iron ore instead of NG to produce Direct Reduced Iron “DRI” will make Jindal steel ultimately almost carbon-free.

Aligning with the Oman Vision 2040 the green steel project partners prioritized the following project outcome: The immediate saving of natural gas as a result of the replacement with green hydrogen. Securing the local steel industry by increasingly reducing dependence on fossil fuels and by opening an important access to the evolving new global green steel market. Providing an early base for acquiring know-how and building local experience with green hydrogen technologies – not only for the project partners - but also the broader academic base in Oman. If we want to continue to attract energy intensive industries to Oman in the future, access to a stable and sufficient supply



MoU with Hydrogen Rise establishing the Oman Hydrogen Center.

of cost competitive renewable energy, a sufficient green hydrogen production capacity and a high level of local green hydrogen experience and engineering know-how are key. This leads to the third element of our vision:

- Integration of decarbonization projects in global market developments downstream.
- Through the increasing pressure of carbon pricing tariffs at international borders for most products currently being produced mostly with fossil fuels, the burden of decarbonisation is increasingly shifted onto the oil and gas sector and industries in high emission sectors such as steel, cement, ammonia and methanol.

More, the “Net Zero Emission” goals lead to global pressure on most international supply chains to decarbonize any aspect of industrial production. An example is the German automotive industry currently requesting from their global steel component suppliers to decarbonize all car component production beginning in 2025 leading to an extensive international search by these suppliers for supply of green steel or green Direct Reduced Iron feedstock. The economics of global steel production will shift from the current combination of cost-efficient access to raw materials, inexpensive fossil fuels and proximity to steel demand to a mix of new vectors including most certainly also the ability to green the DRI or the entire steel

production at the globally most competitive cost. New steel trading production routes will evolve and present an enormous opportunity for Oman: With renewable energy generation costs that are amongst the lowest in the world and geographically well positioned with deep-sea port infrastructure at the highest level to support the future trading routes. This is a good segue into the fourth element of our vision:

Projects require complete value chains from renewable energy to green product off-take

A successful project includes the most efficient management of greening the entire green hydrogen value chain. This again includes the captive generation or wheeling-in of renewable energy, finding the above mentioned cost efficient innovative energy storage or supply solutions for enabling the 24-hour run-time of electrolyzers, managing the most cost effective integration of possibly varying quantities of hydrogen supply into an industrial process, adapt the industrial process, designing the project around the most beneficial logistical requirements for land, transmission of energy and/or transport and storage of hydrogen as well as providing competitive advantages of export logistics for the finished product. While Hydrogen Rise plans to operate a Build-Own-Operate business model, this can only be achieved by partnering with a wide range of hydrogen technology providers, engineering experts, steel experts and researchers as well as logistics partners. Including the Port of Sohar with its own strong focus on a renewable and green hydrogen strategy as a project partner was therefore a logical move by Hydrogen Rise and Jindal. Many of the above-mentioned logistics requirements are best addressed together with an expert partner like Port of Sohar focusing on providing such solutions to all their port tenants.

Our green steel project value chain further extends to involving early potential green steel off-takers, especially in Germany, who contribute to the economic feasibility study and add insight into future demand for green steel, thus helping to de-risk some investment decisions. To avoid surprises late in the

process - as another significant task to de-risk important investment decisions - we involve international green certification agencies and experts early in the project development process because of the complexity in industrial scaling decarbonization processes.

Scouting for and requesting international project funding is another important element of a successful management of a complete hydrogen value chain. In our green steel project case, we applied for a potentially substantial amount from the German National Hydrogen Strategy that will have a game changing impact on the green hydrogen and ultimately green steel production cost.

The complexity of managing all relevant elements of a green hydrogen value chain requires new and disruptive business concepts – more companies like Hydrogen Rise will evolve that focus on filling the gap that individual hydrogen components specialists face when success of a project depends on the successful management of the entire chain. These new project developers and operators will build strong and long-lasting relationships with “best-of-class” component experts and create strong consortia that execute the first successful green hydrogen projects together. For the Jindal project specifically, Hydrogen Rise has built a network of over 40 individual industry, academic and financial experts and companies that “connect the dots” and contribute individually to all project steps which are to follow.

Connecting the project to In-Country-Value

When expecting government support on certain angles of the development of successful green hydrogen projects, questions arise what these projects deliver in return as In-Country-Value. All of our projects consider an integration with local academia and applied research as an opportunity for young engineers to learn. The future Oman hydrogen economy and all possible projects depend on the broad availability of well-trained hydrogen engineers and early projects must serve as a tool to achieve this. It becomes a self-serving prerequisite for a long-term development of a successful pipeline of green hydrogen projects for companies



Dr Bernd Wiemann, Hydrogen Rise CEO, with Dr Hussain Al Salmi of GUtch.

like Hydrogen Rise. Our green steel project partners Jindal Shadeed and Port of Sohar are also recognizing this as an important value of our project. Based on this belief Hydrogen Rise in 2020 participated in the founding of the Oman Hydrogen Centre at GUtch as part of a strategy to develop and then accelerate hydrogen knowledge and experience in the country.

There are many project opportunities in Oman like the green steel project and we have met many stakeholders that share our vision. Cement and associated methanol production, shipping and aviation are a few examples for hard-to-abate sectors that offer significant potential for reasonable ramp-up projects. We are very pleased with the support we have received, especially from the Ministry of Minerals and Energy, the Vision 2040 team and entities like EDO that are adopting an increasingly important role in the development of the green hydrogen future of the country. The latest directives by His Majesty Sultan Haitham bin Tarik directed at the most important green hydrogen topics are a very decisive step towards a successful energy transition. No doubt that it will be achieved as alternatives do not really exist. It will be a global and inter-disciplinary team effort and the success is in managing the complexity of the process with constantly integrating the learnings along the way. I cannot wait to see that future starting with the first opening of a green hydrogen plant in the Sultanate. ■