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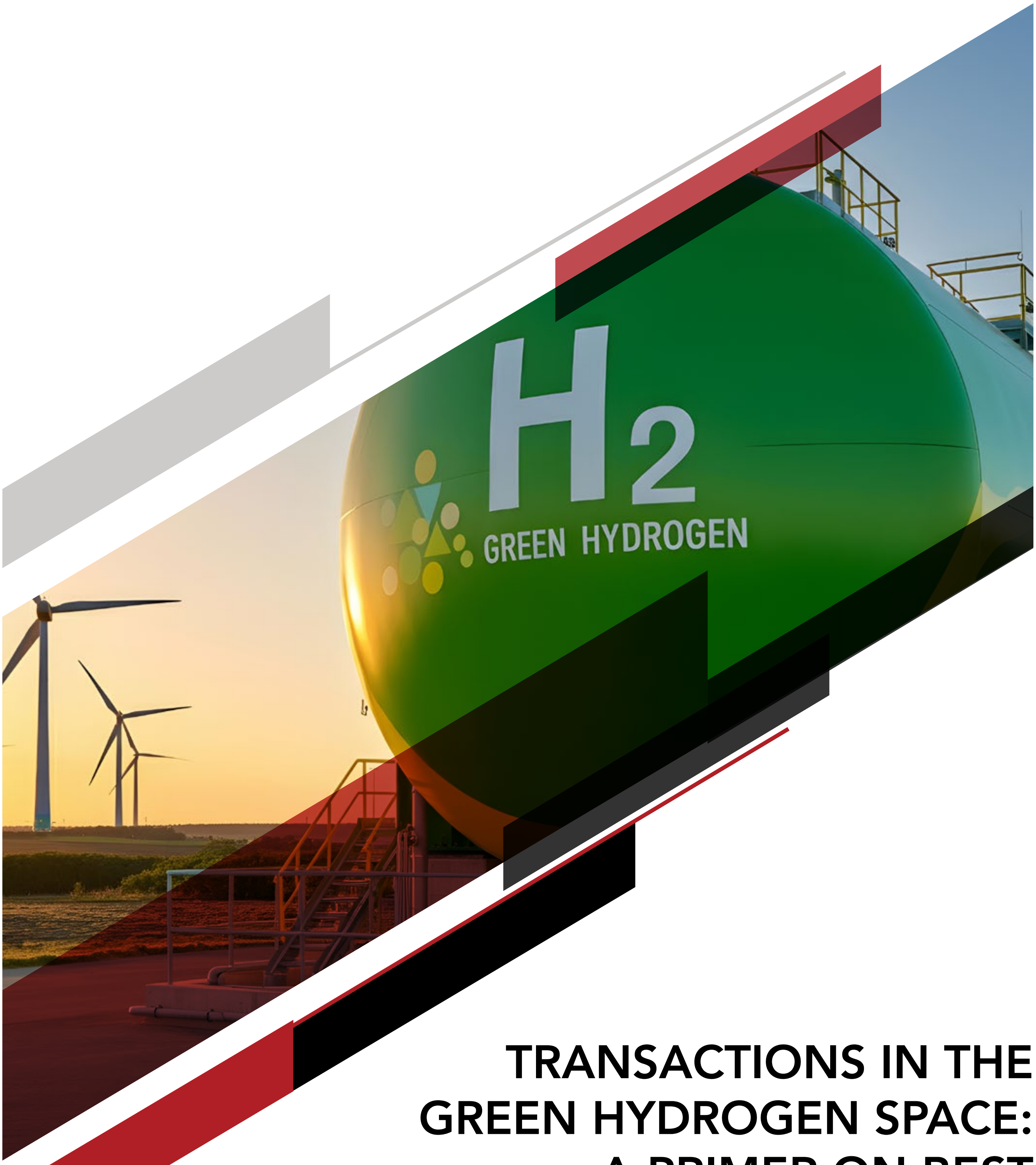

TRANSACTIONS IN THE GREEN HYDROGEN SPACE: A PRIMER ON BEST PRACTICES

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INTRODUCTION

As the world transitions towards more sustainable energy sources, green hydrogen has emerged as a pivotal element in the global clean energy landscape. Transactions in the green hydrogen space are becoming increasingly prevalent, driven by technological advancements, regulatory support, and growing environmental awareness.

India's push towards green hydrogen has been driven through focused policy in the form of the National Green Hydrogen Mission ("**GH Mission**"), which aims to make India a global hub for production, usage and export of green hydrogen and its derivatives. As part of its goals till 2030, India aims to develop green hydrogen production capacity of at least 5 million metric tonnes ("**MMT**") per annum ("**MMTPA**"), with an associated renewable energy capacity addition of 125 gigawatts ("**GW**"). It is expected that this increase in green hydrogen and renewable energy production will abate nearly 50 MMT of annual greenhouse gas emissions, reduce import of fossil fuels of over approximately USD 12 billion, generate over 600,000 jobs and attract investment of over approximately USD 95 billion.[1]

However, with a dynamic environment involving several stakeholders - including the government, hydrogen users and renewable energy producers - it is important to understand the best practices that can guide transactions in the green hydrogen space. Successful transactions require a keen awareness of the unique regulatory framework, financial structures, and technological innovations that underpin this emerging industry.

This primer aims to provide an overview of these best practices, offering insights into the legal and operational considerations essential for success in this burgeoning sector. Understanding these will be crucial in maximizing opportunities and mitigating risks in the green hydrogen market.

1. The currency amounts in this primer are calculated using exchange rates as on September 6, 2024.

1. MARKET OVERVIEW

Currently, India produces approximately 6.5 MMTPA of hydrogen. Most of this demand is currently met by conventional sources of energy thereby making such hydrogen generated to be considered as grey hydrogen or blue hydrogen. This demand is expected to rise to approximately 11-12 MMTPA by 2030, positioning it for a sustainability transition.[2]

As part of the incentive schemes under the GH Mission, India has awarded tenders for setting up of more than 412,000 tonnes of green hydrogen manufacturing and 1.5GW of electrolyser manufacturing capacity already.[3] With Government of India ("**GoI**") schemes currently in force and pending full utilisation of their budgetary allocation, there are opportunities for companies to obtain benefits of subsidised production through financial incentives for electrolyser manufacturing and green hydrogen production. These incentives schemes and measures introduced in the GH Mission are broadly discussed in further detail in section 2.2 below.

1.1. MAJOR PROJECTS, SEGMENTS AND MARKET PLAYERS

The GH Mission has propelled several projects harnessing green hydrogen, across sectors. For example, some of these projects, such as Sembcorp India's Tamil Nadu plant and ACME's Odisha plant are focused on providing green hydrogen primarily for export to Japanese companies. Several green hydrogen projects are also set up with an intent to drive the mobility space such as hydrogen fuel cell locomotives, buses, refuelling stations, etc. Such projects are being set up largely via by public-sector undertakings such as NHPC, NTPC, Indian Railways and Oil India Limited, amongst others. Most projects by private companies domestically, however, are focused towards greenification of existing hydrogen demand, such as glass and steel production, ammonia production and oil refining. Some key private players domestically include ReNew Power, Adani Group, Tata Group, Reliance Group, L&T, JSW Energy, and Essar Group.

1.2. CLUSTERS PRIME FOR GREEN HYDROGEN PRODUCTION

As per the goals under the GH Mission set by GoI, India has an estimated renewable energy potential of around 500GW from commercially exploitable sources such as wind, hydro, and solar power. This potential is due to the country's 7600 km-wide coastline, strong tropical and sub-tropical sunlight throughout the year, and more than 400 rivers in 8 river systems.[4] As such, a large portion of central, western, and southern India along the peninsula is ripe for green hydrogen production.

States of Andhra Pradesh, Maharashtra, Rajasthan, Uttar Pradesh, and West Bengal have also released dedicated green hydrogen policies for specific promotion of industrial activity surrounding the sector. In comparison, the states of Madhya Pradesh and Odisha have released integrated renewable energy policies that cover green hydrogen as well.

Additionally, under the GH Mission, the Department of Science and Technology has also allocated funds to certain green hydrogen 'valley innovation clusters', particularly in the State of Kerala and the cities of Pune, Bhubaneswar, and Jodhpur. These areas are focused to boost research, innovation, and the capacity of scientific and industrial actors in green hydrogen, showcasing the use of green hydrogen across the entire value chain.

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2. Niti Aayog, Harnessing Green hydrogen Opportunities for Deep Decarbonisation in India, dated June 2022, available at https://www.niti.gov.in/sites/default/files/2022-06/Harnessing_Green_Hydrogen_V21_DIGITAL_29062022.pdf
3. The Hindu Business Line, India awards tenders for 412,000 tonnes green hydrogen production, 1.5 GW electrolyser manufacturing, dated May 16, 2024, available at https://www.thehindubusinessline.com/economy/india-awards-tenders-for-412000-tonnes-green-hydrogen-production-15-gw-electrolyser-manufacturing/article68181467.ece
4. Ministry of Power, 500GW Non-fossil Fuel Target, available at https://powermin.gov.in/en/content/500gw-nonfossil-fuel-target.

2. POLICY FRAMEWORK FOR GREEN HYDROGEN IN INDIA

Recognizing the importance of hydrogen, more specifically green hydrogen, as part of India's broader climate goals and to make India a global hub for the production, use, and export of green hydrogen, India has been consistently and progressively introducing policy reforms aimed at promoting and incentivising production of green hydrogen. As one of the first key policy outcomes, the Ministry of Power, GoI, released the Green Hydrogen Policy in February 2022, outlining several initiatives marking the beginning of the policy change towards developing a conducive environment for production and adoption of green hydrogen. Since then, India has since seen several regulatory changes including the introduction of the GH Mission and green hydrogen standards which have been briefly discussed below.

2.1. POLICY FRAMEWORK

2.1.1. Green Hydrogen Policy

Effectively the first policy regarding green hydrogen in the country, the Green Hydrogen Policy (2022), proposed the introduction of a number of measures to incentivise production of green hydrogen, including (i) waiver of Inter-State Transmission System (ISTS) charges for electricity used for production of hydrogen; (ii) open access sourcing of renewable energy for production; (iii) land allocation in renewable energy parks; and (iv) single window clearance system for clearances required to institute and operate a green hydrogen plant. Several proposals set forth in the Green Hydrogen Policy saw prompt enactment by the GoI with others in the pipeline, according to reports.

The Ministry of Power has granted complete waiver of ISTS charges for green hydrogen and green ammonia for a period of 25 years from the date of commissioning of the projects. Similarly, Electricity (Promoting Renewable Energy Through Green Energy Open Access) Rules, 2022 have been notified facilitating ease of obtaining input power for generation of green hydrogen. Further, to alleviate concerns regarding the obtaining of several central and state licenses and approvals required to operate a green hydrogen plant and to provide operational ease to businesses, the GoI has set up a single window clearance system through the National Single Window Portal[5] and also exempted standalone green hydrogen/ ammonia plants from the requirement of obtaining environmental clearance.[6]

2.1.2. National Green Hydrogen Mission

In January 2023, the GoI introduced the GH Mission with a financial outlay of approximately USD 2.35 billion. At

5. National Single Window System under the National Green Hydrogen Mission, available at https://www.nsws.gov.in/portal/scheme/greenhydrogenpolicy.
6. Ministry of Environment, Forest and Climate Change, Clarification on the applicability of EIA Notification 2006 for manufacturing Green Ammonia / Green Hydrogen - reg., dated July 28, 2023, available at https://environmentclearance.nic.in/writereaddata/OM/654851120$7.%20OM_28_07_2023.pdf.

the core of which is the Strategic Intervention for Green Hydrogen Transition programme with a financial outlay of approximately USD 2.08 billion. The rest of the outlay has been divided as approximately USD 174 million for pilot projects; approximately USD 47 million for R&D and approximately USD 46 million for other components. Non-financial measures outlined in the GH Mission include (i) support for infrastructure development; (ii) establishment enabling policy framework; and (iii) skill development programmes. In March 2024 and July 2024, the Ministry of New and Renewable Energy, GoI ("**MNRE**") introduced scheme guidelines for skill development under the GH Mission and funding of testing facilities, infrastructure, and institutional support of development of a regulatory framework, respectively.

While the GH Mission is primarily focused on generating robust supply generation, it also emphasises demand creation through exports and the introduction of competitive bidding procedures for procurement to facilitate domestic supply generation. Further measures from the GoI on this front are expected to be introduced in the near future.

2.1.3. Foreign collaborations

The GoI has also entered into memorandums of understanding/bilateral agreements with countries such as Germany, USA, Australia, France, UAE and Saudi Arabia to facilitate knowledge and technology sharing and facilitate green hydrogen discussions underway for agreements with countries such as Singapore and South Korea.[7]

2.2. INCENTIVES FRAMEWORK

*2.2.1. Strategic Intervention for Green Hydrogen Transition ("**SIGHT**")*

The SIGHT programme is bifurcated into two separate financial incentive mechanisms focussing on supporting the domestic manufacturing of electrolysers (component 1) and production of green hydrogen (component 2).

Tranche 1 of both component 1 and component 2 attracted substantial interest with component 1 attracting bids of 332.5 megawatt ("**MW**") (from 21 participants) against the proposed capacity of 1500 MW. Successful bidders under component 1 included companies such as John Cockerill Greenko Hydrogen, Jindal India, Reliance Electrolyser Manufacturing and Adani New Industries. Component 2 attracted bids of 551,500 metric tonnes per annum ("**MTPA**") (from 13 participants) against the proposed capacity of 450,000 MTPA with successful bidders including companies such as Reliance Green Hydrogen, ACME Cleantech Solutions and Greenko ZeroC.[8]

After successful tenders of tranche 1 of the SIGHT scheme last year, in July 2024, the MNRE introduced guidelines for the second tranche of component 2. The capacity of tranche 2 has been set at 450,000 MTPA with 40,000 MTPA capacity reserved for biomass-based pathways.

2.2.2. Pilot projects

The GH Mission sought implementation of pilot projects for the replacement of traditional fossil fuels with green hydrogen in sectors such as steel, commercial mobility, shipping etc., to identify operational gaps and measures to modify technology and infrastructure and ascertain the requirement of viability gap funding. In furtherance of the same, the MNRE introduced schemes and guidelines for pilot projects in the shipping sector and steel sector, with a cumulative financial outlay of approximately USD 68 million. The objectives of the schemes include the provision of support for (i) retrofitting of existing ships to run on green hydrogen; (ii) development of bunkering and refuelling facilities on ports for green hydrogen-based fuels, for the shipping sector; (iii) substitution of fossil fuels with green hydrogen in the DRI process; and (iv) use of green hydrogen in blast furnaces, for the steel sector.

In March 2024, the Automotive Research Association of India (the designated scheme implementation agency

7. Ministry of New and Renewable Energy & EY, India's Green Hydrogen Revolution - An Ambitious Approach, dated May 2024, available at https://static.pib.gov.in/WriteReadData/specificdocs/documents/2024/may/doc2024510336301.pdf, p.36.
8. Institute for Energy Economics and Financial Analysis, India's $2.1bn Leap Towards its Green Hydrogen Vision, dated March 2024, available at https://ieefa.org/resources/indias-21bn-leap-towards-its-green-hydrogen-vision.

for green hydrogen pilot projects in automotive sector) floated a request for proposal with the provision of viability gap funding of approximately USD 59 million. The proposal aims to promote development of commercially viable technologies for the utilization of green hydrogen in the commercial transportation sector.

2.2.3. Research & development

After recognition of R&D as a critical component of India's green hydrogen commitment, the MNRE introduced the R&D Roadmap for Green Hydrogen Ecosystem in India. The roadmap outlines the current research progress and provides key milestones, identifies research priorities, and presents a vision of research targets in sector. The roadmap recommends research and development actions for each part of the value chain and aims to foster a robust research and development ecosystem to drive the commercialization of green hydrogen. Key proposals under the roadmap include enabling public private partnerships for developing research infrastructure, establishing a specific R&D fund and establishment of centres of excellence. In furtherance of this, the MNRE released a call for proposals for such research projects in March 2024.

2.2.4. Comparison with global incentives

Worldwide, incentives to make green hydrogen competitively priced are offered in a variety of ways, and there does not appear to be any clear standard for optimal encouragement yet, given the nascent field. For example, the United States currently offers a Clean Hydrogen Production Tax Credit of up to $3/kg of hydrogen produced to the supplier, depending upon the carbon intensity of the hydrogen production pathway.[9] A similar tax incentive scheme is also in place in Australia.[10] As another example, Germany is offering grants in aid through a competitive bidding process, in the form of direct grants per kilogram of green hydrogen produced.

On the other hand, countries such as the United Kingdom and Japan are using a multi-pronged approach to incentives. While the UK is offering funding support via an accelerator fund and the UK Infrastructure Bank,[11] Japan is set to put in place a 'contract-for-difference' ("**CfD**") scheme to bridge the price gap between grey and green hydrogen, alongside support in the form of regulatory exemptions. Interestingly, Japan's CfD scheme requires the submission of a business plan from both the supplier and the user of green hydrogen, making the scheme a unique demand-plus-supply incentive mechanism.

As the industry continues to evolve, it appears that the sector's incentives are experimental in nature, involving diverse approaches.

In this light, however, while several initiatives have been introduced by the GoI aimed at addressing supply side constraints and bringing down the cost of production in India, as on date, there is limited development on the provision of demand-side incentives. On the other hand, to boost domestic demand, instead of incentivisation through subsidies or other programmes, the GH Mission contemplates statutory green hydrogen/green ammonia consumption targets which will be imposed on specific industries such as mining, steel, cement, textile, chemicals, etc. However, given the broad nature of the GH Mission objectives, we expect that the range of incentives provided by the GoI will be diversified in the years to come.

2.3. GREEN HYDROGEN STANDARDS IN INDIA

In August 2023, the MNRE issued an office memorandum providing a definition for green hydrogen and specific emission standards which must be met in order for the hydrogen produced to be classified as 'green'. This notification provided that green hydrogen shall mean hydrogen produced using renewable energy including production through use of electrolysis, conversion of biomass, and electricity generated from renewable sources which is stored in an energy storage system or banked with the grid. The well-to-gate emission thresholds, i.e., non-biogenic greenhouse gas emissions from water treatment, gas purification, biomass processing etc., have been set as 2kg of CO_2 per kg of hydrogen produced i.e., $2kgCO_2e/kgH_2$. It has also been

9. U.S. Department of Energy, Financial incentives for hydrogen and fuel cell projects, available at https://www.energy.gov/eere/fuelcells/financial-incentives-hydrogen-and-fuel-cell-projects.
10. Australian Taxation Office, Hydrogen Production and Critical Minerals Tax Incentives, available at https://www.ato.gov.au/about-ato/new-legislation/in-detail/businesses/hydrogen-production-and-critical-minerals-tax-incentives.
11. Department of Energy Security and Net Zero, Government of the United Kingdom, Hydrogen net zero investment roadmap: leading the way to net zero, available at https://www.gov.uk/government/publications/hydrogen-net-zero-investment-roadmap/hydrogen-investment-roadmap-leading-the-way-to-net-zero#innovation-and-incentives.

specified that MNRE will provide a specific methodology for tracking lifecycle emissions for the produced green hydrogen which will include monitoring compliance and on-site inspection.[12] The proposed tracking methodology and compliance to the standards would become critical for project developers under component 2 of the SIGHT scheme to successfully claim incentives, and these also can act as a guarantee of origin for the Offtaker.

This measure has brought India on the same front as countries such as the United States, United Kingdom, Japan, and the EU as one of the first few countries to provide emission thresholds for green hydrogen.

Sr. No.	Country	Carbon emission threshold (in $kgCO_2e/kgH_2$)
1.	**India**	**2**
2.	United States	4[13]
3.	European Union	3.38
4.	United Kingdom	2.4[14]
5.	Japan	3.4

Most countries are yet to implement clear standards for green hydrogen production and there is yet to be a global consensus on what the standard should be. However, emissions tracking remains vital for the sector, at least for private consumption and ESG reporting. In this regard, the Australian government is in the process of developing hydrogen standards and a guarantee of origin scheme (Hydrogen GO Scheme) to ensure accounting for well-to-gate emission tracking of the produced hydrogen. Several other certification programmes have also been introduced by independent organisations such as the GH2 standard which sets a maximum threshold of 1$kgCO_2e/kgH_2$ taken as an average over a twelve-month period.[15]

As India's standards are more stringent or at par with most other jurisdictions, export of green hydrogen from India is unlikely to face any hurdles regarding level of emissions. Readily acceptable low-emission hydrogen alongside geographical advantages makes India a prime destination for green hydrogen export projects. Especially in regions/ countries such as the European Union, Japan, Singapore and South Korea, India may play the role of a key hydrogen hub in the years to come.

12. Ministry of New and Renewable Energy, Green Hydrogen Standard for India, dated August 18, 2023, available at https://static.pib.gov.in/WriteReadData/specificdocs/documents/2023/aug/doc2023819241201.pdf.
13. As per the Clean Hydrogen Production Standard Guidance introduced in the US in June, 2023, clean hydrogen is defined as hydrogen generated with a well to gate carbon intensity not exceeding 4kgCO2e/kgH2 produced which is likely to be achieved by projects with less than 2kgCO2e/kgH2 at the site of production. This is also aligned with the definition of 'qualified green hydrogen' under the Inflation Reduction Act of 2022, which mandates lifecycle greenhouse gas emissions rate no higher than 4kgCO2e/kgH2.
14. The UK Low Carbon Hydrogen Standard sets an emission threshold of 20 grams of carbon dioxide equivalent per megajoule of hydrogen product, which translates to 2.4kg CO2e/kgH2; UK Department for Energy Security & Net Zero, UK Low Carbon Hydrogen Standard, dated December 2023, available at https://assets.publishing.service.gov.uk/media/6584407fed3c3400133bfd47/uk-low-carbon-hydrogen-standard-v3-december-2023.pdf
15. Green Hydrogen Organisation, GH2 Green Hydrogen Standard Fact Sheet, available at https://gh2.org/sites/default/files/2023-03/GH2_Standard_Fact%20Sheet_v2_DIGITAL.pdf

3. KEY NEGOTIATION CONSIDERATIONS IN OFFTAKE CONTRACTS

An offtake contract is a contract under which a third party (the "**Offtaker**") agrees to buy a certain amount of the product/energy produced by a project at an agreed price wherein the product is usually oil, gas, minerals or power. Offtake contracts are necessary for the bankability of the project as they showcase a secure guaranteed buyer and a predictable revenue stream for the energy projects which provides power developers the certainty to make decisions regarding final investment in respect of their production projects. While offtake contracts in sectors such as oil and liquified natural gas ("**LNG**") have stabilised and certain market standards have been developed, the green-hydrogen market is relatively new and is set to achieve rapid development and expansion. This results in offtake contracts in the present state of the green hydrogen sector to be rather flexible.

The length of offtake contracts in other sectors can range from 1 year to 20 years depending on the nature of industry, capital requirement for production and nature of demand. However, recent examples of offtake contracts in the green hydrogen sector in India as well as globally, suggest a trend towards longer contracts ranging between 10-20 years with the primary aim of producers being able to forecast revenue and maintain constant demand.

A key factor for potential investors and project developers for development of green hydrogen projects is the security of the offtake contracts. Usually, project developers enter into one or more long-term offtake contracts with financially reliable buyers depending on the form of agreements. Key considerations while negotiating terms of an offtake contract other than the form of agreement can include contract quality management, pricing and accounting for change in regulatory environment.

3.1. FORMS OF OFFTAKE CONTRACTS

The primary forms of offtake contracts seen in more developed sectors such as LNG which are also being seen in the green hydrogen sector are (i) tolling model; and (ii) sale and purchase model. While there are some observable examples of the above models, given the early stage of the green hydrogen market, the utility of each of the models remain untested.

3.1.1. Tolling method

Usually, in tolling contracts, the Offtaker i.e., the buyer of the finished product is the supplier of the input material to the project developer, wherein the project developer processes the input material to the desired output and supplies it to the Offtaker. In sectors such as LNG, the Offtaker is the supplier of the natural gas, and the project developer is tasked with liquifying the natural gas (without assuming title) and transporting it to the Offtaker.

In the green hydrogen sector, a tolling agreement involves the Offtaker supplying electricity to the project developer, which is utilized for electrolysis and potentially, the water required for the production process. A recent example of this structure in the Indian market can be seen in the 20-year offtake contract entered into between Asahi India Glass (Asahi) and INOX Air Products (Inox) for the supply of green hydrogen, wherein Inox is supplying green hydrogen to Asahi's greenfield glass float facility in Rajasthan. As part of the green hydrogen production process, Inox will utilise solar energy supplied by a solar plant established separately in which Asahi will invest.[16]

3.1.2. Sale and purchase

In the sale and purchase model, contrary to the tolling method, the project developer will be required to obtain the input power and other resources required to produce green hydrogen, process it at its facility, and supply the Offtaker with green hydrogen. Input power may be obtained by the project developer through a captive renewable energy plant, from a third party at arm's length through a power purchase agreement or through the open market. However, assurances must be built into the agreement to ensure that renewable energy is procured as input power for production of green hydrogen to ensure it meets the relevant emissions thresholds.

Long term sale and purchase agreements ensure a fixed revenue stream for the project developer while also permitting the project developer to divide and allocate its production capacity across multiple Offtakers. A recent example in the Indian market is the term sheet signed between IHI Corporation and the ACME group for the export of 400,000 tons of green ammonia (a liquid derivative of green hydrogen). This export quantity constitutes approximately 30% of the production capacity of the ACME group plant sold to a pre-determined buyer.[17]

3.2. CONTRACT QUALITY MANAGEMENT

The primary forms of contract management seen in the green hydrogen sector which permit the project developer to forecast future revenue stream are: (i) take-or-pay model; and (ii) take-and-pay model.

3.2.1. Take-or-pay model

Under a take-or-pay model, the parties to the offtake contract agree on a specified quantity of green hydrogen which shall be delivered in a periodic manner. Here, the Offtaker can either take delivery of the entire contract quantity and make the payment for the same to the project developer, or accept a minimum product quantity (as negotiated) and compensate the seller for any amount not taken by the Offtaker. The payment obligation on the Offtaker for the quantity of products not taken may extend to the entire cost of the products or may be limited to a specified amount to safeguard the interest of the seller. The amount of supply not taken by the Offtaker, can, as negotiated amongst the project developer and the Offtaker, usually be adjusted in future deliveries or be sold by the project developer to a third party.

3.2.2. Take-and-pay model

In the take-and-pay model, unlike the take-or-pay model, the Offtaker is under the obligation to accept and pay the project developer for the entire contract quantity, with the project developer having the right to seek damages from the Offtaker on any failure to do so (other than circumstances provided for in the agreement).

While both of the above models provide a reasonable forecast of future revenue and mitigate possible risks, the choice of model may be dependent on the individual project developer depending on production capacity and number of offtake contracts entered into by such project developer. The storage capacity and capabilities of the concerned project, as discussed in section 6.2. below, are also important factors in the determination of the choice of model.

16. Asahi India Glass, Asahi India Glass & INOXAP collaborate for an industry pioneering initiative for off-take of Green Hydrogen at Asahi India's new greenfield float glass plant at Soniyana (Dist. Chittorgarh), Rajasthan, dated May 06, 2024, available at https://www.aisglass.com/wp-content/uploads/2024/05/Press-Release-INOXAP-Asahi-Green-Hydrogen-07-05-2024.pdf
17. IHI and ACME Signed Term Sheet to Supply Green Ammonia from India to Japan, dated January 23, 2024, available at https://www.ihi.co.jp/en/all_news/2023/resources_energy_environment/1200584_3523.html

3.3. PRICING

Unlike other sectors such as oil or LNG, both the Indian and global markets for green hydrogen have yet to develop an index that provides spot pricing. The only example of a green hydrogen pricing index is *'Hydrix'* which was launched by the European Energy Exchange in 2023 to increase price transparency despite the lack of a traded renewable green hydrogen market. However, a year after the launch of the index, it is still in a nascent stage with around 40 companies subscribed to receive data from the index.[18]

Due to the lack of spot pricing, similar to blue hydrogen contracts (hydrogen derived from conventional fossil fuels), pricing for green hydrogen is likely to be computed on the basis of fixed costs plus variable costs plus any profit elements.

Given the anticipated rapid development in the hydrogen market, parties may want to consider incorporating price review clauses into their contracts. These clauses would involve periodic reviews of the price formula or adjustments based on specific triggers indicating changes in circumstances. However, these provisions should be approached with caution, as price reviews are prone to disputes and there may be no objectively determinable spot prices available when the review opportunity arises in early green hydrogen contracts.

3.4. BACK-TO-BACK OBLIGATIONS

As outlined in section 3.1 above, green hydrogen projects can be structured in a manner where input power and other raw materials are either sourced by the project developer through third party suppliers and/or through a captive plant. In these cases, it is crucial for the parties to the offtake contract to allocate risks regarding disruption of the projects' production capabilities due to disruption, in turn, of the supply of input material. The offtake contract needs to take into account agreements entered for procurement of input power/ expected timeline of development of renewable energy plant being set up for input power and other ancillary plants, such as water treatment or desalination plants, to establish the date of first supply.[19]

It must be ensured that the obligations under the offtake contract are 'back-to-back' to the extent possible to appropriately allocate risk to account for disruptions or pass through risks to the relevant supplier. For this, the *force majeure* clause under the offtake contract can either be aligned with the definition provided under the input power procurement agreement to ensure harmony in the production process or exclude input power/ material disruptions completely from the force majeure clause with an appropriate mechanism to pass the risk to the input power/material supplier. Further, in cases where the Offtaker is acting as an intermediary and is required to supply the procured green hydrogen to other entities, aligning *force majeure* provisions under the offtake contract with further supply agreements becomes necessary to protect such Offtaker from risk.

Additionally, while contract quantity management models discussed above in section 3.2. can help safeguard project developers against revenue interruptions from demand disruptions, it is also necessary to build in protections for the project developer for consistent demand disruptions. This can be achieved by provisioning for liquidated damages or establishing mechanisms to pass the risk of halting raw material or energy procurement from the project developer to the Offtaker.

3.5. REGULATORY CONSIDERATIONS

Parties entering offtake contracts also need to take into account, provide for, and allocate risks, for any change in the law, regulation, and government policy, considering the variable and rapidly developing state of the Indian green hydrogen regulatory environment. Calculation of pricing and mechanisms for pricing review will also need to account for present and future availability of benefits availed by the project developer under government production incentive schemes.

Additionally, obligations on the project developer can also be built into the agreement to ensure that the emissions threshold as discussed in section 2.3 above are met. This would be required for classification of the produced hydrogen as 'green'. This would include assurances by the project developer to ensure appropriate source of input power, limited emissions generation during the production process, and other ancillary processes, including warehousing and transportation of produced green hydrogen, to ensure that overall 'well-to-gate' emissions are within the prescribed threshold.

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18. European Energy Exchange, EEX Press Release - EEX HYDRIX anniversary: index established as reference for green hydrogen pricing, dated May 28, 2024, available at https://www.eex.com/en/newsroom/detail?tx_news_pi1%5Baction%5D=detail&tx_news_pi1%5Bcontroller%5D=News&tx_news_pi1%5Bnews%5D=9247&cHash=7ee2e3ff4e4a1e5eccf7f5d7204efc02
19. Norton Rose Fullbright, Negotiating hydrogen contracts, dated February 18, 2021 available at https://www.projectfinance.law/publications/2021/february/negotiating-hydrogen-contracts/

4. STRUCTURING CONSIDERATIONS FOR GREEN HYDROGEN JOINT VENTURES

Companies developing green hydrogen projects are increasingly partnering with others across the value chain through joint ventures. This collaborative approach allows them to share resources, expertise, and benefits, making joint ventures the leading corporate structure in green hydrogen production.

Most commonly, hydrogen producers partner up with renewable energy generators and water suppliers for reliable access to input materials.[20] JV structures are also commonly seen where green hydrogen producers partner with shipping, distribution, and storage providers to offload these tasks and focus on the core hydrogen production business.[21] Apart from these, existing hydrogen consumers looking to greenify their operations may also unite with an existing green hydrogen-renewable energy partnership, creating an all-in-one green hydrogen business for self-consumption. As such, understanding the dynamics of these JVs and structuring them for optimum allocation of risks is imperative.

4.1. FORMS OF JOINT VENTURES

JVs are broadly classified into two categories: incorporated and unincorporated. Incorporated JVs function as special purpose vehicles to carry out the business objectives of the parties to the JV. These may be formed via two means, by either incorporating a new corporate entity into which they may invest, or by developing an existing corporate entity as the JV entity through investment. An incorporated JV is ideal where the parties intend to be bound together in permanence, such as if a hydrogen producer sets up with the intent to be bound to a particular renewable energy source in the area.

Unincorporated JVs are essentially business relationships between parties which are usually based on contracts executed between such parties. When such a business relationship between two or more parties is in furtherance of a common purpose or action for a profitable venture, proceeds of which are to be shared in an agreed ratio, these qualify as JVs. Such JVs are ideal where the parties do not intend to be bound by the formality and permanence of a corporate vehicle. In the case of green hydrogen producers, these may be seen in storage and transportation agreements, where reliability is a crucial factor, but alternative providers exist.

Agreements with Offtakers can take either of the routes depending upon the business plans of the parties. In case the green hydrogen producer intends to supply only one Offtaker for its life-term, an incorporated JV is generally suitable.

20. For example, Jindal Stainless partnered with Hygenco recently for the use of green hydrogen to scale up green steel production; Jindal Stainless, Jindal Stainless to become India's first stainless steel company to install a Green Hydrogen Plant, dated August 10, 2022, available at https://www.jindalstainless.com/press-releases/jindal-stainless-to-become-indias-first-stainless-steel-company-to-install-a-green-hydrogen-plant/.
21. On similar lines, the Adani Group partnered with Kowa Holdings Japan for the sale and marketing of green hydrogen, green ammonia and its derivates in Japan; Adani, Adani Group forms JV for marketing of green hydrogen in Japanese market, dated September 14, 2023, available at https://www.adani.com/en/newsroom/media-release/adani-group-forms-jv-for-marketing-of-green-hydrogen-in-japanese-market.

Broadly, the following factors should be considered whilst determining the appropriate JV route: (i) risk associated with the JV and mitigation of such exposure; (ii) intended management structure and degree of involvement of JV participants; (iii) requirement for capital; (iv) intended exit mechanisms and flexibility of exit; and (v) tax considerations.

Above all, however, synergy and trust between the partners is most important to work towards the success of the project.

4.2. COMPANY LAW CONSIDERATIONS

4.2.1. Related party transactions

As discussed previously, transactions in the green hydrogen space may involve contractual obligations to be undertaken with JV partners, such as in power purchase contracts, tolling relationships, EPC and O&M contracts. In such cases where collaborations are sought with investors, a risk of conflict of interest is created. Conflicts could also arise where one investor has its own local or broader interests that may compete with the interests of the project. For example, when a renewable energy producer provides energy for the green hydrogen project but has other commitments towards the local bodies as well.

Conflict of interest may also arise in the event that one of the JV partners itself is an Offtaker of the green hydrogen, such as in tolling arrangements.

In terms of company law, such contracts will be treated as 'related-party transactions'. Related party transactions require prior approval of the audit committee, board of directors and shareholders (by ordinary resolution). Such transactions are mandatorily required to be disclosed in the board's report, along with justification thereto. However, these compliances are exempt if the transaction is undertaken on an arm's length basis in the ordinary course of business.

In terms of contractual obligations, JV agreements commonly stipulate a higher threshold for shareholder voting on related party transactions, or stipulate for an affirmative vote from each JV partner. In businesses where related party transactions are frequent, such as in tolling arrangements, it is recommended that governance mechanisms and internal policies are put into place to mitigate conflict of interest risks.

4.2.2. Layering restrictions

Companies in the renewable energy space often undertake projects through special purpose vehicles, involving layers of subsidiaries, both horizontally (multiple sister subsidiaries under the same holding company) and vertically (step-down subsidiaries of a holding company), in order to segregate business verticals and diversify risks of different geographical projects.

In this regard, investors must be aware of restrictions prescribed by the Companies (Restriction on Number of Layers) Rules, 2017 ("**Layering Rules**"), notified with an objective to prevent misuse of complex corporate structures. The Layering Rules provide that Indian companies, (other than certain classes of companies such as banking companies) cannot set up structures with more than two layers of subsidiaries. In computation of this restriction, the Layering Rules prescribe that "one layer which consists of one or more wholly owned subsidiary or subsidiaries…" is not taken into account.

This language of 'one layer' has created some ambiguity as to where this one layer should be counted and is currently a grey area in India. While a literal reading of the provision suggests that any one wholly-owned layer would be exempted in such a case, allowing the creation of chains of subsidiaries (consistent with rules of statutory interpretation), a contrary interpretation suggests that only the 'first' layer of the chain would be permissible – keeping in mind the objective of the provision.

Neither of the aforementioned interpretations have been provided any clarification by the Ministry of Corporate Affairs. There also exist ambiguities in terms of whether the layers referred are horizontal or vertical, and whether the top-most Indian entity will be counted as a layer if it is owned by a foreign body corporate.

4.3. FOREIGN EXCHANGE MANAGEMENT CONSIDERATIONS

The Department for Promotion of Industry and Internal Trade ("**DPIIT**") plays a significant role in regulating foreign investment in the country. It formulates and reviews the foreign investment policy of India and determines the sectors in which foreign investment is permitted, prohibited or subject to certain conditions. These conditionalities are provided under the Foreign Exchange Management (Non-Debt Instruments) Rules, 2019 ("**NDI Rules**").

There are no particular restrictions on foreign investment in hydrogen production. However, renewable energy producers may note that investment in atomic energy is completely prohibited for the private sector in India.

Certain specific foreign exchange issues relating to the sector are discussed below:

*4.3.1. Transactions by foreign-owned-and-controlled companies ("**FOCCs**")*

For foreign investors with an existing presence in India, downstream investment (i.e. investments through an entity set up in India) may be a better proposition considering that investments undertaken through Indian subsidiaries attract relatively less compliance. However, certain nuances regarding deferred consideration, pricing and reporting arrangements should be considered in such a scenario. Different views are taken by Authorised Dealer ("**AD**") banks, who are authorised to process and approve such transactions. Market practice currently may be understood in the below manner:

Seller	Buyer	Pricing Guidelines	Reporting
FOCC	Resident	Applicable	Not required[22]
FOCC	Non-resident	Not applicable	FC-TRS
FOCC	FOCC	Not applicable	Not required
Resident	FOCC	Applicable	Form DI
Non-resident	FOCC	Applicable	Form DI + FC-TRS

However, AD banks may take differing views, especially on the permissibility of deferred consideration and with respect to applicability of reporting guidelines in the case of purchase of equity instruments by FOCCs.

4.3.2. Investment company restrictions

As mentioned previously, companies in the renewable energy space often undertake projects through special purpose vehicles, involving layers of subsidiaries in order to segregate business verticals and diversify risks of different geographical projects. As such, many of the holding companies in these structures conduct no activities and have no revenue by themselves. A key consideration while exploring such structures is whether such SPVs may potentially classify as a 'core investment company' or a non-banking finance company – which are subject to additional regulatory supervision.

Core investment companies ("**CIC**") are regulated under the Core Investment Companies (Reserve Bank) Directions, 2016. These companies need to meet the '90-60 test' to qualify as a CIC – i.e., hold not less than 90% of net assets as investment (in shares, bonds, debentures, debt or loans) in group companies, and have equity investments in group companies that constitutes not less than 60% of net assets.[23]

On the other hand, non-banking finance companies ("**NBFCs**"), regulated through the Reserve Bank of India Act, 1935 and various notifications issued by the RBI, are required to pass the '50-50 test', i.e., having financial assets more than 50% of total assets, and generating income from financial assets which is more than 50% of gross income.[24]

As purely holding companies, such SPVs run the risk of being classified as NBFCs and/or CICs. While courts in India have held in varying contexts that the test for such classification of a company would be the real, substantial and systemic activity conducted by such entity, the risk of being classified as a CIC rises if the holding company is engaging in lending and investing to group companies as their main activity. Typically, an auditor undertakes this task of categorisation and reports the same in the annual reports of a company.

In this regard, holding SPVs may also note that as per the NDI Rules, foreign investment in CICs is permitted only under the approval route.

22. While no reporting is required through forms prescribed by the RBI, the Entity Master-FIRMS (EMF) of the target entity should be updated to reflect the revised shareholding pattern on the RBI portal. Typically, this is done through a plain paper filing.
23. Paragraph 2(1)(i) of the Core Investment Companies (Reserve Bank) Directions, 2016.
24. Section 45IA of the Reserve Bank of India Act, 1934 and F.A.Q published by the RBI on NBFCs accessible at https://www.rbi.org.in/commonperson/English/Scripts/FAQs.aspx?Id=1167.

4.4. DUE DILIGENCE CONSIDERATIONS

Prior to committing to investment in a green hydrogen project, investors need to conduct comprehensive due diligence to ensure that the target complies with the necessary regulatory requirements. Infrastructure projects in India should pay higher attention in certain areas such as environmental, land title, labour, anti-corruption, and geographical risks. Some of these due diligence considerations are discussed below:

4.4.1. Title diligence

For upcoming green hydrogen projects, land with clear title and proper access is the most critical aspect in setting up a production facility. It may lead to significant monetary loss if subsequent deficiencies are found in title or approvals which were to be taken prior at the time of acquisition or initiation of construction. Local state and district level laws restrict use or transfer of agricultural land for non-agricultural use and such conversions are typically time-consuming processes. To overcome this, the industrial parks where land is ready for industrial use and title is clear, are a viable alternative. Once land is identified, a title due diligence should be carried out to ensure that the title is clear and the land is free from encumbrances such as mortgages and litigations. Such title diligences typically have a lookback period of 30 years.

While title diligences are typically not part of a due diligence exercise for investments in existing companies, for such capital-intensive investments, it is best practice to undertake the initial spend to avoid any future issues.

4.4.2. Labour and employee-related diligence

Given the numerous labour legislations, most issues are typically found in this section of due diligence exercises. While most offences carry minor penalties, issues in manufacturing lines and infrastructure projects (such as for green hydrogen production) have the tendency to add up and potentially irk employees and trade unions.

Investments into such projects, especially from large conglomerates, have the tendency to face obstacles due to resistance from trade unions within the target entity. It is crucial to determine whether the target entity has an active trade union and to review any existing collective bargaining agreements. Manufacturing facilities typically have unions, which are often affiliated with political parties, enhancing their bargaining power. Certain states in India are also known for their strong trade union culture, where unions have significant influence over businesses and actively negotiate with management to secure better benefits for their members. Identifying these unions, understanding any objections they may have to the investment, and assessing the potential for resolving their grievances is essential.

In this light, on the basis of findings during a diligence exercise, investment agreements should cover disclosure of all existing, as well as threatened claims, irrespective of the forum.

4.4.3. Anti-bribery and anti-corruption (ABAC) risks

Having an infrastructure project in India requires regular contact with government officials throughout the investment chain from setting up to day-to-day compliance. Initial go-ahead may also require lobbying and dealing with advocacy groups and agencies. Thus, infrastructure projects present inherent corruption and bribery risks.

At the time of investment, a strong due diligence exercise and background checks on promoters, as well as contracted third parties and agents is pivotal. Investors may insist for robust internal ABAC policies and frameworks that implements controls to mitigate ABAC risks as a condition precedent to transactions, especially in so far as the target deals with government entities, political organisations and charitable donations.

4.4.4. Cultural and regional due diligence

While outside the purview of a legal due diligence exercise, several cultural and political risks can affect the viability of a green hydrogen project, especially for foreign investors.

Particularly in India, the availability of resources necessary for production of green hydrogen, such as water, green electricity (whether grid reliability or distributor reliability), as well as storage and transportation vendors, can vary significantly within the country and are often dependent upon cultural and political attitudes. Certain states in India have generally been known to be more industry-friendly, such as Tamil Nadu, Andhra Pradesh, and Gujarat, providing reliable market access, necessary for consistent green hydrogen production. As mentioned previously in section 4.4.2., certain states also known to have stronger trade unions and collective bargaining power such as Kerala and West Bengal. On the other hand, some areas of the country are more prone to natural disaster risks, such as those around the coast and riverbeds.

Therefore, a comprehensive risk assessment that includes cultural, political, and environmental factors is essential for the successful planning and execution of a green hydrogen project in India.

4.5. INTELLECTUAL PROPERTY CONSIDERATIONS

In a rapidly evolving field such as that of green hydrogen, intellectual property ("**IP**") considerations are of paramount importance. As a result, JVs should contain strong guardrails for protection of each party's IP.

The obviousness of the use of JV partners' IP may lead to the partners skimping out on entering into an IP licensing or assignment arrangement, and may become a point of contention. Issues generally prop up at the time of further developments in the IP, or at the time of sublicensing to one of the JV partners. This will also necessitate a clear and cogent understanding of who owns the IPs in question. This would extend to IPs that are subject matters of a formal application with the relevant IP office and to unregistered IPs as well. If electrolysers are being produced through licensed IP from a third-party, adequate attention should also be paid to the existing licenses. Thus, it is necessary to discuss the breadth of rights, royalties (if any), further developments, exit options, as well as refer back to existing licenses being used for production, in order to avoid any IP issues.

In contrast with the rights to use shareholder / JV Partner's IP, shareholders' / JV Partner's rights to use the JV IP should also be considered. In case of green hydrogen production, shareholders may want to highlight their ESG metrics through such JV, and hence using the JV trademarks becomes imperative. Additionally, where the JV is involved in research and development, it is important to ensure clear understanding that highlights whether such JV developments are permissible to be used by the shareholders.

In the context of research and development-focused joint ventures, four distinct forms of IP assets are commonly discussed: background, foreground, sideground, and postground. With respect to a project, these refer to IP supplied at the start of the project (such as which IP will be supplied, who owns the respective IP, etc.), during the project's tenure produced collectively (providing for further developments, protection of IP and payment obligations for prosecution and maintenance), outside the project but produced during the project's tenure (for example, if software is used for the operation of electrolysers, then whether any software updates will be provided and until when), and after the project ends (including, importantly, the effect of termination of the JV on the ownership of IP and any licensing or assignment rights), respectively. Each of these forms of IP must be thoroughly negotiated and contemplated for between JV partners.

5. DISPUTES IN THE RENEWABLE ENERGY SPACE

The transition in the energy market, driven by the phasing out of fossil fuels, has spurred numerous new greenfield investments and facilitated the integration of renewable energy into existing projects. According to the International Energy Arbitration Survey Report, 2022[25], the number of disputes in the energy sector is expected to rise significantly over the next five years. Similar to conventional energy sources, renewable projects are characterized by their long-term nature, capital intensity and complex nature. Some of the major subject of disputes in the Renewable Energy Space are elaborated below:

5.1. CONTRACTUAL DISPUTES

Contracts play a crucial role in governing renewable energy projects. Disputes may arise concerning project specifications, payment terms, change orders, warranties, and liability for unforeseen events, such as force majeure occurrences. These contractual Disputes can be further divided into three main categories:

5.1.1. Project Contracts

Project contracts include the engineering, procurement and construction (EPC) contracts and operation and management contracts (O&M). These contracts are crucial for renewable energy projects because they help to ensure that the project is completed on time, within budget and to a high standard. EPC contracts can also help reduce risk, save time and provide quality control. Hence, project contracts can lead to disputes in renewable energy sector.

5.1.2. Offshore Contracts

Offshore contracts are comprehensive agreements that govern various dimensions of offshore projects, encompassing oil and gas exploration, renewable energy installations, and maritime construction. These contracts are pivotal for facilitating seamless operations and adeptly managing the complexities inherent to offshore environments. These contracts include PPAs, transportation contracts etc.

5.1.3. Financial Contracts

Renewable energy projects typically demand substantial investment. Whether financed through debt or equity, several challenges commonly emerge. To overcome the financial burden and risk management there are various investors that pool in for renewable energy projects. To protect the interest of the investors, they sign shareholders agreement. But due to the high-risk nature of renewable energy projects, the overall loss due to various reasons like delays in achieving required generation, delay in taking approvals from appropriate authorities etc. can lead to dispute among inventors and other shareholders financing the project.

25. Queen Mary University and Pinsent Masons LLP, Future of Internal Energy Arbitration Survey Report, 2022, dated January 20, 2023, available at https://www.qmul.ac.uk/arbitration/media/arbitration/docs/Future-of-International-Energy-Arbitration-Survey-Report.pdf.

5.2. DISPUTES REGARDING DELAY IN COMMISSIONING OF PROJECTS

Renewable energy projects are frequently situated in remote, expansive areas, which complicates the acquisition of environmental and land use permits compared to other construction ventures. In an era increasingly attuned to environmental concerns, approval processes for renewable projects often undergo substantial public and political scrutiny, which can persist even post-approval. Delays in securing permits are likely to lead to disputes when deadlines and project milestones outlined in contractual agreements are not met. Moreover, the denial or withdrawal of permits could potentially jeopardize the project entirely.

5.3. CHANGE IN LAW

The law continuously evolves to meet the demands of the time, particularly within the energy sector where the term of the contracts are generally for long term. Given their multi-decade duration, energy contracts frequently intersect with government policy changes. These shifts introduce new obligations for parties involved, thereby impacting the terms of agreements and often making energy contracts a breeding ground for disputes. Typically, the revenue generating contracts of the project companies incorporate a change in law clause which provides for compensation to the project developer in case of an increase in costs due to such change in law.

5.4. PAYMENT DISPUTES

Renewable energy projects often encounter cost overruns due to fluctuations in material prices, unforeseen labour expenses, and additional scope requirements. These overruns frequently spark disputes over liability for the increased costs. For instance, significant price hikes in crucial components, such as solar panels or wind turbines, during the project can prompt disagreements over whether the contractor or the client should absorb these additional expenses. Disputes over milestone payments also present a recurring challenge. Renewable energy contracts typically stipulate payments at various stages of project completion. Conflict may arise if there’s disagreement over whether a specific milestone has been achieved in accordance with the contract’s requirements or not.

6. COMMERCIAL CONSIDERATIONS IN GREEN HYDROGEN CONTRACTS

6.1. FINANCING

The commercial terms for a green hydrogen project are contingent upon various factors, including geographical considerations (country risk), project framework, fiscal policies, sponsors' creditworthiness, and Offtake agreements.

Drawing from experiences in other industries and technologies, as well as principles of project financing, certain key debt structuring criteria and financial covenants are anticipated to be applied (with specific levels to be determined):

i. *Debt sizing criteria:* Maximum gearing / leverage ratio (debt to equity) is of 70% debt to 30% equity. *(In case of high-risk projects debt to equity ratio can be 60% debt to 40% equity)*

ii. *Debt service cover ratio ("**DSCR**"):* Calculated as Cash Flow Available for Debt Service (CFADS), which includes revenues minus expenses, adjusted for net working capital changes, minus capital expenditures, and taxes, divided by debt service obligations (principal and interest payments to project lenders).

iii. *Financial covenants:* The borrower will commit to meeting specific financial performance benchmarks. These tests are applied for various purposes, such as distributing profits to equity investors or taking on additional debt and are typically set at different thresholds depending on the intended use.

6.2. STORAGE

Once hydrogen is produced and processed, there's a critical need for its safe distribution and storage. As hydrogen can be stored in either its gaseous or liquid state, there are consequently several Hydrogen storage methods. It's important to note that hydrogen's boiling point is extremely low (-252.9°C). This means that liquid hydrogen requires extremely low temperatures for safe storage or needs to be bonded organically, as seen in solutions like Liquid Organic Hydrogen Carriers (LOHC). On the other hand, gaseous hydrogen, when stored at regular temperatures, necessitates high-pressure solutions for both storage and transport to achieve the same energy density as cryogenic hydrogen.

A significant advantage of hydrogen lies in its ability to be stored over extended periods with minimal losses when in gaseous form. Moreover, a substantial portion of the existing natural gas infrastructure can be repurposed for hydrogen use. Nevertheless, hydrogen does have a lower volumetric energy density at atmospheric pressure compared to other energy carriers, such as natural gas or oil. This poses less of an issue in stationary applications, where large storage tanks with lower pressure are acceptable, as opposed to mobile applications where the size and weight of tanks become significant concerns.

One innovative possibility is the underground storage of hydrogen, typically in large caverns situated within salt domes that may reach depths of up to 1000 meters. These sites are often located in proximity to major hydrogen production facilities and electrolysers.

6.3. TRANSPORTATION

Hydrogen distribution to the point of use can occur either through high-pressure containers or via pipelines. Hydrogen storage and distribution in high-pressure tanks encounters similar challenges as seen in the storage of high-pressure vessels. It can be facilitated using road, rail, or maritime transportation, which offers flexibility and the ability to reach various destinations without requiring extensive new infrastructure.

The transmission of hydrogen via pipelines becomes a viable solution when large quantities of hydrogen must be distributed. Gas pipelines are capable of transporting substantial amounts of energy at a lower cost compared to electricity transmission through overhead power lines. Existing gas pipeline infrastructure in countries like Germany can be adapted for hydrogen transportation with relatively few modifications.

There is a possibility that hydrogen may accelerate the formation of cracks, potentially shortening the pipeline's service life. Other factors like dynamic stress and pre-existing fractures also need to be taken into consideration. An alternative approach to mitigate these risks involves mixing hydrogen with natural gas, thereby reducing the necessary modifications to the pipeline. However, if the hydrogen content exceeds 40%, components such as compressors and turbines may need to be replaced to handle the increased volume flow of hydrogen.

6.4. INPUT POWER: CAPTIVE VS. GRID

One of the ways in which the GoI is promoting hydrogen development projects is by providing incentives relating to the electricity input required for the hydrogen projects. Many states in India have also provided for certain exemptions relating to consumption of green energy by the Hydrogen projects which is eventually resulting in the reduction of the input cost of generation of Hydrogen.

Under the regulatory framework governing the electricity sector, a consumer can set up its own power plant using any source of energy where such energy is for such consumer's, group of consumers', consumption. Such power projects are referred to as captive power projects and consumers can set it up in any part of the country to minimise cost as the government have already provided waiver of ISTS charges on transmission of such electricity where the electricity is used for production of hydrogen.

The government is also facilitating the option of procuring green power from the concerned area's distribution licensee. The green hydrogen production facilities will have the option to procure power from its distribution licensee and will have to pay the green power tariff for such power as determined by the state power regulator.

7. REGULATORY AND SYSTEMIC BARRIERS

7.1. REGULATORY SYSTEMS DEDICATED TO HYDROGEN

Standards related to the green hydrogen value chain are developed or adopted by five entities in India – the Bureau of Indian Standards (BIS), which is the National Standards Body of India, the Oil Industry Safety Directorate (OISD), the Petroleum and Explosives Safety Organization (PESO), the Petroleum and Natural Gas Regulatory Board (PNGRB) and the Ministry of Road Transport and Highways (MoRTH). These entities had issued 53 standards before the launch of the GH Mission. In collaboration with the MNRE, 34 new standards have been issued since the launch of the GH Mission in a short span of 14 months.

Setting up a green hydrogen project requires approvals from the Central Government, State Governments, and local bodies. Out of the total 73 approvals required for green hydrogen projects, State Government entities hold jurisdiction for 43, Central Government entities hold jurisdiction for 23 approvals and seven approvals fall under local government bodies. It is seen that 27 out of the 73 approvals are general and legal approvals, 14 approvals are related to renewable energy use, 13 are related to fire safety, pollution control and labour contain eight approvals and three approvals are for land allocation and use.[26]

7.2. CRITICAL HYDROGEN INFRASTRUCTURE – TRANSMISSION LINES, PIPELINES, PORTS

Hydrogen infrastructure comprises an extensive network of facilities, technologies, and systems dedicated to hydrogen generation, storage, transportation, distribution, and refueling stations. It serves as the foundational framework for a hydrogen-based economy, facilitating the seamless integration of hydrogen as a sustainable energy carrier.

The development of hydrogen infrastructure encounters several significant challenges.

i. Infrastructure must withstand high pressures required for storing and transporting hydrogen, which poses considerable cost and implementation challenges. For instance, hydrogen is compressed to pressures exceeding 700 bar for transportation, necessitating specialized compressors and substantial storage containers.

ii. Cost presents a major hurdle in the advancement of hydrogen infrastructure. Production, storage, and transportation of hydrogen remain costly compared to traditional energy sources. Although hydrogen costs are expected to decrease with technological advancements, the initial investment for developing hydrogen infrastructure can be prohibitive.

26. The elaboration of these standards and approvals is available in the Report published by The Council on Energy, Environment and Water (CEEW) associated with the Ministry of New and Renewable Energy (MNRE), Government of India and the Report is accessible at https://static.pib.gov.in/WriteReadData/specificdocs/documents/2024/may/doc2024510336201.pdf .

iii. Current technologies are not yet fully prepared for large-scale deployment of hydrogen. For example, electrolysers used for producing green hydrogen from renewable sources are not sufficiently efficient or produced at scale to achieve economic viability.

iv. Leakage and durability are critical concerns that require attention. Hydrogen, being highly flammable, can leak from pipelines or storage tanks, posing safety risks and escalating maintenance expenses. Ensuring the robustness and longevity of hydrogen infrastructure is crucial for cost reduction and enhancing safety measures for end-users.

7.3. SOLVING FOR WATER AVAILABILITY – DESALINATION PLANTS, TRANSPORT, DEEP SEA HYDROGENISATION

According to a report by the International Energy Agency ("**IEA**"), the production of green hydrogen requires nine litres of water per kilogram produced. The report highlights concern over freshwater accessibility in water-stressed regions where green hydrogen production is planned. Estimates indicate that using solar energy for electrolysis necessitates a total water consumption of approximately 32 kilograms per kilogram of green hydrogen produced, while wind energy reduces this requirement to 22 kilograms per kilogram. In contrast, producing hydrogen from natural gas (known as grey hydrogen) consumes 22 kilograms of water per kilogram of hydrogen produced, according to the same estimates.

Recognizing water scarcity as a challenge in the production of green hydrogen, MNRE has incorporated strategies in the GH Mission. This includes exploring the use of municipal and industrial wastewater as feasible feedstocks. However, due to water being under state jurisdiction, MNRE encourages states to identify suitable water resources to promote green hydrogen initiatives.

7.4. SUSTAINABLE SOLUTIONS

Balancing hydrogen production with sustainable water use is imperative. Several strategies can mitigate water usage, including:

i. Returning water to the source: Recycling water used in purification and cooling can significantly reduce overall consumption.

ii. Using treated wastewater: Although treated wastewater tends to be more expensive, it represents a viable alternative due to its ability to provide a reliable and sustainable water source. Advanced treatment processes can significantly improve its quality, making it suitable for various uses including production of green hydrogen. This alternative helps to reduce the strain on natural freshwater resources and can contribute to more resilient water management strategies

iii. Desalination: Producing hydrogen with desalinated seawater is another option, though it presents its own environmental and energy challenges.

iv. Infrastructure investments: Developing power lines or water pipelines to connect renewable energy sources with water supplies can help balance regional resource availability.

8. CONCLUSION

In conclusion, the green hydrogen sector presents immense opportunities as the world shifts towards sustainable energy solutions. India's GH Mission is a strategic effort to position the country as a global leader in green hydrogen production, usage, and export. By 2030, India's ambitious goals, such as producing 5 MMT of green hydrogen annually and reducing greenhouse gas emissions by 50 MMT, underline the sector's potential to drive economic growth, create jobs, and reduce reliance on fossil fuels.

Key players, including both public and private entities, are pushing forward with projects across industries such as transportation, steel, and ammonia production. However, success in this emerging market requires thorough understanding of regulatory frameworks, financial structures, and technology. Thorough understanding of the legal nuances is necessary to navigate factors such as government incentives, offtake contracts, and formation of joint ventures. Furthermore, to remain competitive, addressing systemic barriers and ensuring infrastructure development for transmission, storage, and water access are critical. As the market evolves, the green hydrogen sector promises to be a transformative force in achieving global energy sustainability.

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