

WHITE PAPER

Financing Strategies to Achieve GH2 Competitiveness (USD 1/KG)

KNOWLEDGE PARTNER



PUBLICATION PARTNER





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Once again, we thank everyone who contributed to the creation of this White Paper, and we hope that it will be a useful resource for all those interested in the potential of green hydrogen to transform our energy system.

And in the end, a few lines on “Hope”

“Hope we grow, but with lesser emission..

Hope we produce more steel, than the carbon emission..

Hope we manufacture cement, with less carbon combustion..

Hope we make glass, but no pollution..

Hope we energize cars with RE RTC revolution..

Hope we transfer goods with water as emission..

Hope we produce chemicals without the polluting hydrogenation..

Hope we capture more carbon than the oil & gas consumption..

Hope we commit ourselves for “GH2 led” energy transition..

Hope we poll-vault to greener tomorrow by embracing decarbonization... ”

Shardul Kulkarni,

MD & CEO

Deesha Power Solutions

Knowledge Chair – GH2 Conclave

Message from Chairman - GH2 Conclave 2023

In our last white paper message, I had said that Global Sustainability Initiatives will disrupt various Industrial initiatives, and this is the beginning of Industry 5.0. Now 6 months down the line I can see that the Sustainability bug has already bitten many large conglomerates and corporates alike. Companies have started focusing on sustainability from all the angles, be it Business, Operations, or Corporate Social Responsibility. The 3 Ps, People Planet and Profit had never got so much importance as it has been given now and we expect this momentum to continue accelerating.

Today Government of India has committed to Net Zero by 2070. To achieve the same, some of the recent initiatives taken for decarbonization are:

- Renewable energy share jumped from 16.5% in 2014 to 42% in 2023 with installed capacity of 175 GW
- Ethanol Blending Program (EBP) advance targets from current 10% to 20%
- Indian Railways has set a target to making itself Net Zero by 2030
- Boosting production of Compressed Biogas (CBG) as alternative affordable clean fuel
- National Hydrogen Mission (NHM) commitment of USD 2.3 Bn for promoting Green Hydrogen ecosystem.

We all have seen the progress of Renewable Energy penetration in the country wherein after 2014, India has shown to the world new ways of its audacious plans into renewable energy goals, especially Solar Energy Mission. Today, 40% of energy produced in India is renewable and non-fossil fuel based. And by 2030, Our Indian Government has committed for 500 GW of renewable power. I remember in 2010 we used to talk about how unviable solar power is, due to high cost of PV Cells, however, with regulatory support, evolved technology and increase in consumption, prices have dropped significantly from INR 18 Rs. Per KWH to Rs. 2.4 per KWH and it is expected to come down further to INR 1.90 per KWH by 2030.

I believe the recent announcement of National Green Hydrogen Mission and budgeting fund outlay of USD 2.3 Billion till 2030 for promoting GH2 will be a gamechanger for India. This will potentially be the largest opportunity for Energy Security and help India achieve its Net Zero Targets along with Global commitments. The regulatory support GH2 Mission would require is similar to the one given to Solar Mission. I am sure you will enjoy reading this White Paper wherein we have shared our views on Financing Strategies to achieve the set target of USD 1 dollar / Kg.

As we have seen lot of action on the ground, GH2 Conclave has been conceived to deliberate Policy, Financing and Contracting of GH2. With this context and commitment from our Hon. Prime Minister Shri Narendra Modi we believe India will become Global Hub of GH2

Manish Panchal

Chairman - GH2Conclave 2023

Key stakeholders with whom Extensive primary interactions have been undertaken

1. Amplus Solar Pvt Ltd
2. Ankur Scientific Energy Technology Pvt Ltd
3. Avaada Energy Pvt Ltd
4. CAC-H2 Pte Ltd
5. Destiny Energy Pte Ltd
6. Eastern Electrolyzer Pvt Ltd
7. Enel Green Power India Pvt Ltd
8. Enfinity Global
9. HyGenco Green Energy Pvt Ltd
10. Lanxess India Pvt Ltd
11. Leading GH2 Developer
12. Leading Norwegian RE Generator
13. Galaxy FCT
14. GH2 Solar Pvt Ltd
15. Godrej Industries Ltd
16. O2 Power
17. Ocior Energy Pvt Ltd
18. Power Finance Corporation Ltd
19. Rallis India Pvt Ltd
20. Tata Capital Cleantech Ltd
21. Vibrant Energy

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1. Executive Summary

Introduction

- GH₂ is the biggest business disruption of the century
- India needs to harness GH₂ for energy security & democratization of energy access

Global GH₂ Financing Programs and Implications for India

- Cumulative global investment of \$15 Trillion by 2050 will be required to support GH₂ led energy transition involving 5-7x growth in hydrogen consumption over the present level
- EU GH₂ Program is most complex but most generous with incentive upto USD 4/KG of GH₂
- US IRA is not that complex as EU with handsome production tax credits upto USD 3/KG of GH₂
- Japan's GH₂ program is pragmatic and import centric
- Global green hydrogen financing programs offer many valuable learnings for India such as importance of need of simpler supporting policies, need of international collaborations etc

India's GH₂ Funding Opportunity

- India's Hydrogen program envisages creation of 5 MMTPA domestic demand by 2030 with an outlay of 19,700 Cr under various initiatives of NHM. To support NHM related GH₂ infra, one would require investment of USD 200 Billion
- To support India's energy transition and independence led by GH₂, we estimate Equity investments of USD 60 Billion and debt funding of USD 140 Billion would be required in base case scenario of 5 MMTPA
- Industry stalwarts have expressed support for green hydrogen and have called for increased investment and financing to support the growth of the green hydrogen sector

Existing Constraints & Possible Options

- Globally, there are several constraints like capital intensive, lack of established markets that currently exist in the financing of green hydrogen projects
- There are two main constraints viz policy and financial for GH₂ in India with a genuine dearth of bankable GH₂ projects and a lot needs to be done on RE Power/Land/Water by states
- There could be three new financing options for GH₂ viz. carbon financing, GH₂ bonds, GH₂ lines of credit from MDFIs
- Given its pros & cons, each new funding source can be considered as an important brick while building a bridge to GH₂ financing

Voice of Industry Leaders

- Majority of Industry wished for an assistance of atleast USD 0.5 /KG and 60% expects that such assistance may not be given to export led GH₂
- Bankable GH₂ contracts is the principal constraint for GH₂ financing, believed ~80% of the respondents
- Product warranties addressing technology risks would make GH₂ projects more bankable said 60% of the respondents
- According to 50% of industry leaders, Sovereign Green Bonds could be an additional option for funding India's GH₂ projects
- Inability to measure, strip and trade the green component of GH₂ is principal bottle neck; if addressed flood gate of investments in GH₂ could open

Possible Strategies to Accelerate GH₂ Financing

- Five pronged strategy to accelerate GH₂ financing involve conducive policies, investment vehicles, public-private partnerships, awareness and innovation
- Conducive policies involves creating right regulatory framework to monetise green component and appropriate carbon tax provisions
- Creating investment vehicles, such as green hydrogen funds, can help attract equity investment and financing for GH₂
- Government can partner with private sector investors to create GH₂ Bank to meet requirements of debt financing/structured products
- Raising GH₂ awareness could be established through education and outreach initiatives
- Start-up Innovation and Incubation Centers should be increased and supported for focus initiatives like Sustainability and GH₂

Roadmap for GH₂ @ USD 1/KG

- LCoH journey from present \$6/KG to desired level of \$ 1/KG by 2030 is possible through reduction in opex (electricity), capex and financing costs
- India's GH₂ pricing will possibly be driven till 2027, by input cost rationalization and carbon economics/mandates to spur a growth in efficiency till 2030

2. Introduction

2.1 Introduction



India's National Hydrogen Mission is a clarion call to the world about its commitment to Net Zero by 2070

NHM talked about creating GH2 economy of 5 MMTPA with an aggregate investment of USD 100 billion or INR 8 trillion. That calls for a serious deliberation of who will fund this massive requirement.

With this background, Deesha Power Solutions through this Whitepaper is making an attempt to deliberate rare opportunity of GH2 financing opportunity. Among others, this white paper would aim also to ponder upon need of global GH2 financing programs, contours of GH2 financing, possible options and strategies to accelerate GH2 financing, leading to competitive pricing at USD 1/KG.

2.2 GH2 – A Business Disruption

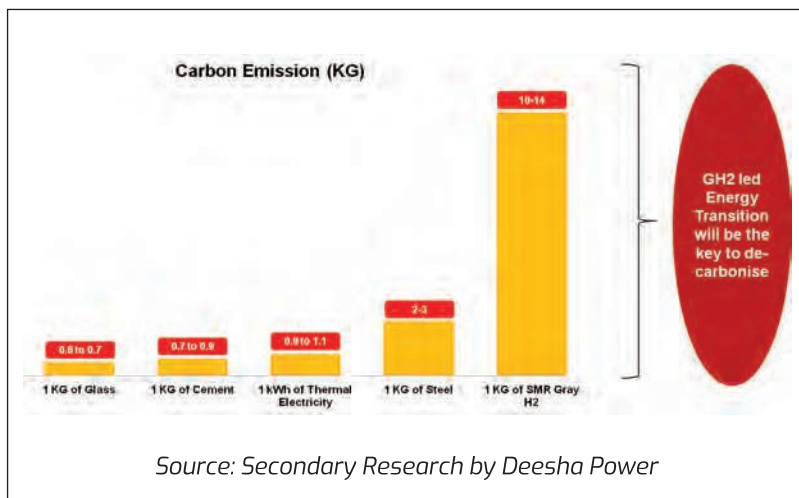
GH2 is the biggest business disruption of the century due to three reasons as mentioned in the adjoining figure:

The beauty of GH2 is that it brings a democratic access to energy "on demand" in a decentralized manner. Plus, being a new entrant, it does not have clutches of oil pricing and hence it is completely decoupled from vagaries of oil pricing (hence inflation) being often witnessed due to whims and fancies of a few oligarchs. Most importantly, GH2 is far less carbon intensive. Hence it is touted as the biggest business disruption of this century.



2.3 Emission Intensity of Various Commodities

Green Hydrogen is key for decarbonization of hard to abet sectors such as glass, cement, steel, gray H2 as mentioned in the figure given next page:



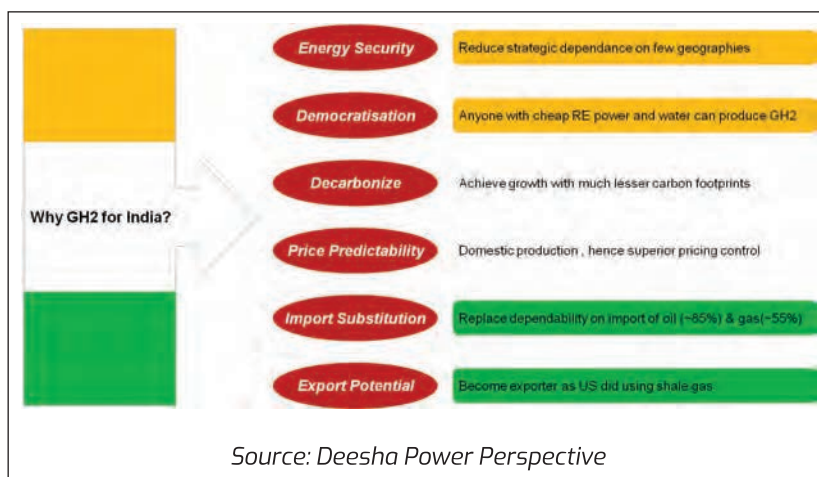
Lets first look at emission intensity of various building blocks for the infrastructure. To produce 1 kg of float glass, we end up emitting 0.6 to 0.7 Kg of CO₂. Cement is a notch higher to 0.7 kg of CO₂/kg of Cement. Thermal electricity is ~1 KG/kWh. We end up making double the CO₂ while making a kg of steel. Gray H₂, which is getting used in refineries/fertilizers/chemical industries, results into emission of 10-14 kg of CO₂. And hence GH₂ led Energy Transition will be the key to global decarbonization.

2.4 Why GH₂ for India?

The accompanying graphic illustrates strategic reasons why India should invest in GH₂:

India related imperatives for GH₂ are explained below:

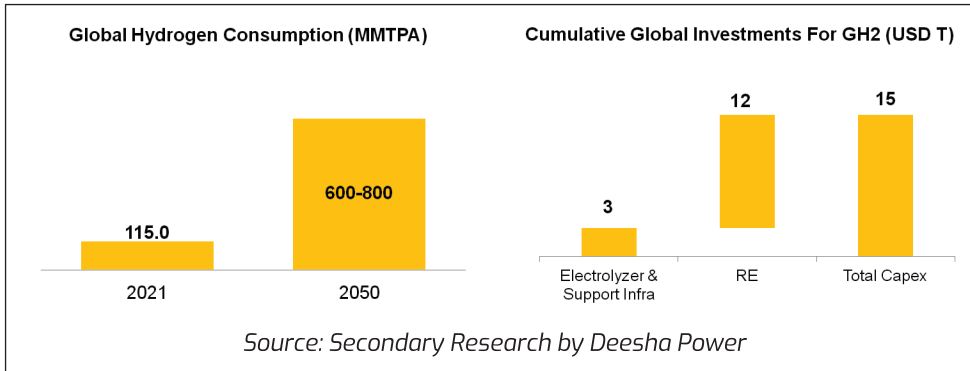
- **Energy & Food Security:** Adventurism by few oil & gas producing countries always pushes India against wall due to its heavy import dependence. This in turn also affects further hydrocarbon value chain leading upto ammonia grossly affecting fertilizers. By adopting indigenous GH₂, we are opting to do away with the security issue once a for all
- **Decarbonization:** Being a responsible, largest democracy, India can not and should not shy away from sustainability related issues. GH₂ could offer significant impetus to Hon PM's vision of net zero economy by 2070
- **Price Predictability & Stability:** Lack of predictability and stability in energy pricing is demotivating for industries and also adds to inflation eating away significant real income of lower strata Indians. Biggest advantage that GH₂ offers is it decouples energy and inflation.
- **Import Substitution:** Locally produced GH₂ and its further value chain will significantly avoid imports of oil, gas, petroleum products, ammonia and urea. This will save precious forex which could be used for infra creation
- **Export Potential:** Using shale gas, US not only met its domestic demand but also became net exporter of energy. GH₂ could be India's shale oil towards the path of exports that too a dominant export hub due cheap (& abundant) availability of RE power and water across Indian states



3. Global GH2 Financing Programs & Implications for India

3.1 Funding requirements for Green Hydrogen

Cumulative global investment of \$15 Trillion by 2050 will be required to support GH2 led energy transition as mentioned in the figure below:



Building a hydrogen economy which accounts for 15 to 20% of total final energy demand, with consumption use increasing 5-7 times from today's 115 Mt, will require very large investments. Total investments in the hydrogen value chain could amount to almost \$15 trillion between now and 2050, peaking in the late 2030s at around \$800

billion per annum. And total investments required in power generation for green hydrogen production could amount to over \$12 trillion over the next 30 years, an average of \$0.4 trillion per annum. Only 15% – reaching a maximum of \$140 billion per annum in the late 2030s – is related to investment in electrolyzers, blue hydrogen production facilities, or hydrogen transport and storage infrastructure

3.2 Net Zero Race

Sixty two countries have adopted Net Zero commitment, mostly by 2050, either through regulatory (18) or policy (44). The same is depicted in a table below:

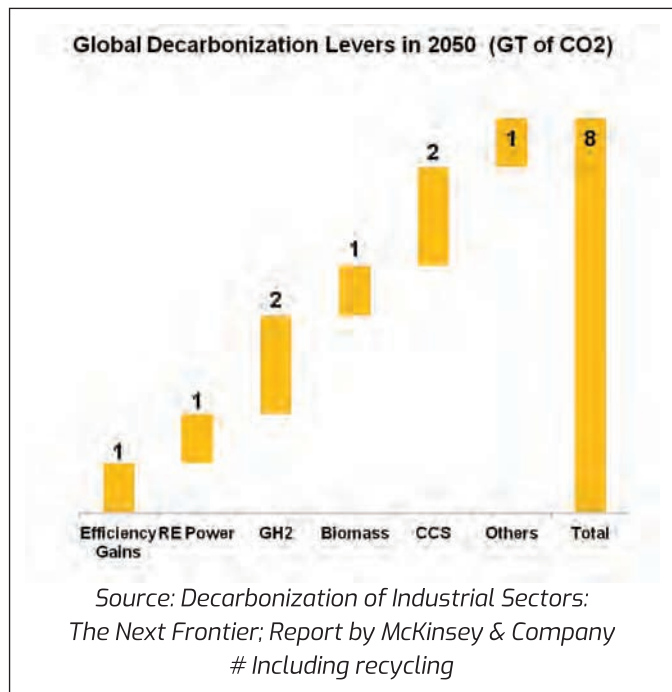
- Good news is 103 countries have agreed / likely to agree to Net Zero by 2050
- 8 countries have agreed / likely to agree to Net Zero by 2060
- Considering its developing status and size of economy USD 3.5 trillion, India has taken a pragmatic target of NetZero by 2070
- However, proactive Net Zero actions have already started in most of the countries including India

Commitment to NZ	2030	2035	2040	2045	2050	2055	2060	2065	2070	Total
In Regulation				2	16					18
In Policy	2	1	2	1	38	1	3	1		49
In Pledge							3		2	5
In Disc.	2				39		1			42
Total	4	1	2	3	93	1	7	1	2	114

Source: Energy & Climate Intelligence Unit

3.3 Global Decarbonisation Levers

There are several decarbonization levers being practiced globally such as efficiency gains, RE power, GH₂, biomass, carbon capture etc. The potential of each of same in overall decarbonization strategy by 2050 is depicted below in a graph:



As seen from the graph, GH₂ is a prominent decarbonization tool with 25% potential. Along with CCUS, GH₂ led derivatives offers ~50% potential especially in four sectors namely Cement, Steel, Ammonia, and Ethylene.

Industrial companies can reduce CO₂ emissions in various ways, with the optimum local mix depending on the availability of biomass, carbon-storage capacity and low-cost zero-carbon electricity and hydrogen, as well as projected changes in production capacity

The optimum mix of decarbonization options depends greatly on local factors. The most important factors is access to low-cost zero-carbon electricity, which India has in abundance

3.4 Global Hydrogen Initiatives & Implications for India

There are several global and region specific green hydrogen initiatives that could have positive repercussions for India. Some of the prominent initiatives are presented below:

These initiatives are aimed at promoting the development and deployment of green hydrogen technology around the world, and could provide opportunities for Indian companies and investors to participate in the global green hydrogen market. Here are a few examples:

- 1) **The Green Hydrogen Catapult:** This is a global initiative aimed at rapidly scaling up the production and use of green hydrogen around

GH₂ Catapult	<ul style="list-style-type: none"> • Global initiative aimed at rapidly scaling up the production and use of green hydrogen around the world • Supported by a consortium of public and private sector organizations, including Acwa Power, ArcelorMittal, Renew, Yara, CWP Renewables etc • Working with an objective to scale up H₂ production capacity 50x, achieve 50% cost reduction, get GH₂ below \$2/KG
EU Clean H₂ Alliance	<ul style="list-style-type: none"> • EU initiative aimed at promoting the development and deployment of clean hydrogen technologies • The initiative brings together public and private sector stakeholders from across Europe to coordinate efforts and share best practices • The European Clean Hydrogen Alliance could provide opportunities for Indian companies to collaborate with European partners on green hydrogen projects and to access European funding for green hydrogen research and development
The GH₂ Council	<ul style="list-style-type: none"> • A global industry group that brings together companies from across the hydrogen value chain, including producers, suppliers, and end-users • The group aims to promote the use of hydrogen as a source of clean energy and to support the development of the global hydrogen market • It has a base of 150+ members including some marquee names such as Adnoc, BP, Bosch, Kawasaki, Cummins, Toyota, Reliance, Adani, Barclays etc

Source: Deesha Power Secondary Research

the world. The initiative is supported by a consortium of public and private sector organizations, including Acwa Power, Arcelor Mittal, Renew, Yara , CWP Renewables etc. The initiative aims to scale up global hydrogen capacity by 50x, achieve 50% cost reduction, get cost of GH₂ below \$2/KG.

Implications for India: The Green Hydrogen Catapult could provide opportunities for Indian companies and investors to participate in the global green hydrogen market by collaborating with international partners and participating in large-scale green hydrogen production projects.

- 2) **The European Clean Hydrogen Alliance:** This is a European Union initiative aimed at promoting the development and deployment of clean hydrogen technologies. The initiative brings together public and private sector stakeholders from across Europe to coordinate efforts and share best practices.

Implications for India: The European Clean Hydrogen Alliance could provide opportunities for Indian companies to collaborate with European partners on green hydrogen projects and to access European funding for green hydrogen research and development.

- 3) **The Hydrogen Council:** This is a global industry group that brings together companies from across the hydrogen value chain, including producers, suppliers, and end-users. The group aims to promote the use of hydrogen as a source of clean energy and to support the development of the global hydrogen market.

Implications for India: The Hydrogen Council could provide opportunities for Indian companies to collaborate with international partners on green hydrogen projects and to access funding opportunities for green hydrogen research and development.

Overall, these global green hydrogen financing programs could provide important opportunities for Indian companies and investors to participate in the global green hydrogen market and to contribute to the development of green hydrogen technology around the world.

By participating in these initiatives, India could position itself as a leader in the green hydrogen sector and help to drive the growth and adoption of green hydrogen technology globally.

3.5 Progressive Hydrogen Programs & Learnings for India

Hydrogen programs of three regions namely EU, USA and Japan have been reviewed. Region/country specific strategy, financing and learnings for India are presented below :

3.5.1 EU

EU GH2 Program is most complex but most generous with incentive upto ~USD 4/KG of GH2. The same is presented below:

Initiatives		Financing Strategy	
<ul style="list-style-type: none"> • 10 MMTPA by 2030 • Alignment of GH2 Production & RE generation on hourly basis; adjustments in intermittency over 30-day period • RE power plants should not be older than 3 years -additionality • Concession for above if GH2 production happening in grid with >90% RE content (ex Scandinavia having hydro/wind) • Concession in additionality for low carbon power grids (ex France having nuclear) 	<ul style="list-style-type: none"> ✓ ~\$800 million under first tranche of Innovation fund ✓ Auction based subsidy capped at ~USD 4/KG (if bid at 4.57/KG, consumer bears 0.57/KG) ✓ Applicable for wind/solar based GH2 (not biomass) ✓ Plant to reach full capacity within 3.5 years ✓ Subsidy to be received upon production over 10-year period ✓ Single party assistance capped at 33% of budget and min electrolyzer capacity >5 MW 		
Learnings for India <ul style="list-style-type: none"> ❖ Less complex rules ❖ Net burden on end users of GH2 should be as minimum as possible (< 1 USD/KG) 			
<p><i>Source: Deesha Power Secondary Research</i></p>			

3.5.2 USA

US IRA is not that complex as EU with handsome production tax credits upto USD 3/KG of GH2. The same is presented below:

Initiatives		Financing Strategy	
<ul style="list-style-type: none"> • 10 MMTPA by 2030, 20 MMTPA by 2040 & 50 MMTPA by 2050 • Bring down cost of GH2 to USD 1/KG in 1 decade by 2030 • Waste/biomass based GH2 eligible • Collocated GH2 preferred in early days • Work with impact decarbonization goals viz industries, heavy duty transportation, long duration energy storage • Create regional hubs 	<ul style="list-style-type: none"> ✓ ~\$13 billion as Tax Credits under IRA and \$9.5 billion for regional GH2 hubs under IJJA ✓ GH2 Production tax credit upto ~USD 3/KG of GH2 over 10 year period (Project commissioned in 2023 stands to get highest benefit) ✓ RE Production tax credit upto ~USD 2.6 cents/kWh ✓ Investment tax credit upto 30% of capex ✓ Tax credit linked to carbon intensity of GH2 and social benefits transferred 		
Learnings for India <ul style="list-style-type: none"> ❖ Incentivize production as well as investments in GH2 ❖ Link assistance to carbon intensity of underlying GH2 and social benefits given 			
<p><i>Source: Deesha Power Secondary Research</i></p>			

3.5.3 Japan

Japan's, being first country to introduce it, GH₂ program is pragmatic and import centric. The same is presented below:

Initiatives	Financing Strategy
<ul style="list-style-type: none"> • 3 MMTPA by 2030, 20 MMTPA by 2050 • First country to issue GH₂ Strategy in 2017 • Recognises as GH₂ import country • Carbon neutral by 2050 • Green Growth Strategy: 30% GH₂ blending in NG fired turbines • Aims to bring landed cost of GH₂ to ~\$2.69/KG by 2030 , ~\$1.8 by 2050 • Aims to bring electrolyzer cost to ~\$ 373/KW by 2030 	<ul style="list-style-type: none"> ✓ ~\$14.5 billion as Green Innovation Fund to support carbon neutrality initiatives by organization, funding for R&D, demonstration projects ✓ ~\$2.77 billion for GH₂ Projects <ul style="list-style-type: none"> ✓ Imported : ~\$ 2.24 billion# ✓ Domestic: ~\$ 0.52 billion ✓ Strategic investments in establishing GH₂ supply chains in countries like Brunei, Australia ✓ Separate R&D funding
<div style="display: flex; align-items: center;"> <div style="background-color: #C00000; color: white; padding: 5px; font-weight: bold; margin-right: 10px;">Learnings for India</div> <ul style="list-style-type: none"> ❖ Develop NH₃ ecosystem ❖ Create strategic investments in global GH₂ supply chain </div>	
<p><i>Source: Deesha Power Secondary Research</i></p>	

3.5.4 China

China's GH₂ program features \$ 217 billion for transportation. The same is presented below:

Initiatives	Financing Strategy
<ul style="list-style-type: none"> • 0.1 to 0.2 MMTPA by 2025 • 100 GW of cumulative RE capacity by 2030 • Focus sectors: Transportation, Chemical & Steel • Wish to reduce carbon emission 1-2 MMTPA by 2025 • Aims to bring landed cost of GH₂ to ~\$4/KG by 2025 , ~\$2.4 by 2030 • Aims to focus on PEM electrolyzer technology 	<ul style="list-style-type: none"> ✓ Country level financing program is yet to be announced ✓ Funding of ~\$217 billion R&D support for transportation announced ✓ Subsidies and tax breaks for companies engaged in hydrogen production and transportation ✓ Separate R&D funding for PEM
<div style="display: flex; align-items: center;"> <div style="background-color: #C00000; color: white; padding: 5px; font-weight: bold; margin-right: 10px;">Learnings for India</div> <ul style="list-style-type: none"> ❖ Focus on decarbonization in transportation ❖ Realistic target setting </div>	
<p><i>Source: Deesha Power Secondary Research</i></p>	

3.6 Summary of Learnings

Global green hydrogen financing programs offer many valuable learnings for India as it seeks to develop its own green hydrogen sector.

Some of the key learnings from these programs include:

- 1) **The importance of public-private partnerships:** Global green hydrogen financing programs have shown that collaboration between the public and private sectors is essential for the development of the green hydrogen sector. Governments can provide funding and support for research and development, while private companies can bring expertise and investments to the table.
- 2) **The need for supportive policies:** Green hydrogen financing programs have demonstrated the importance of establishing policies that support renewable energy and green hydrogen production. This can include measures such as tax incentives, subsidies, and regulatory frameworks that encourage investment in green hydrogen projects.
- 3) **The value of international collaboration:** Global green hydrogen financing programs have shown that international collaboration can be a valuable tool for accelerating the development of the green hydrogen sector. By collaborating with international partners, India can access new technologies, funding opportunities, and expertise.
- 4) **The potential for green hydrogen to support economic growth:** Green hydrogen financing programs have demonstrated the potential for green hydrogen to support economic growth, particularly in sectors such as transportation, industry, and energy. By investing in green hydrogen, India can position itself for economic growth and job creation.

Overall, the global green hydrogen financing programs offer many valuable learnings for India as it seeks to develop its own green hydrogen sector. By taking these learnings into account and implementing policies and programs that support green hydrogen development, India can position itself as a leader in the green hydrogen sector and contribute to the growth of the global green hydrogen market.

4. India's GH₂ Funding Opportunity

4.1 Funding Options

India offers several green hydrogen funding opportunities that can help accelerate the development and deployment of green hydrogen technology in the country.

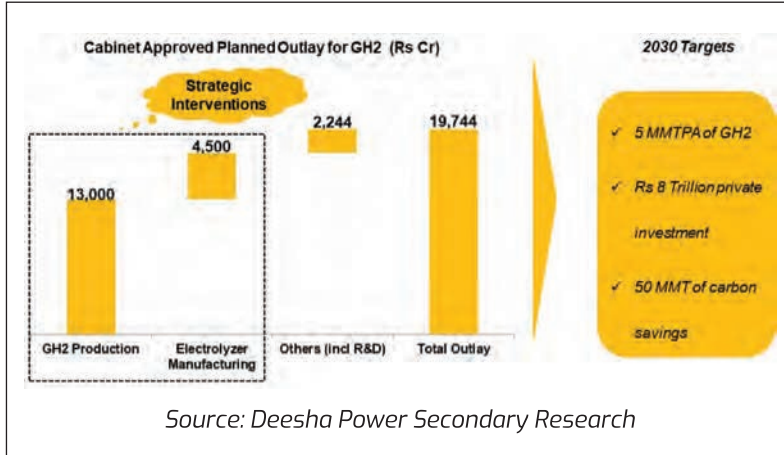
Some of the key funding opportunities include:

- 1) **The National Hydrogen Energy Mission:** This mission was announced in the Union Budget of 2021-22 and aims to create a hydrogen ecosystem in India that can support the growth of green hydrogen as a clean energy source. The mission includes a focus on research and development, demonstration projects, and capacity building, and may provide funding opportunities for companies and organizations working in the green hydrogen sector.
- 2) **The National Clean Energy Fund:** This fund was established by the Indian government to support the development of clean energy technologies, including renewable energy and energy efficiency. The fund is administered by the Ministry of Finance and may provide funding opportunities for companies and organizations working in the green hydrogen sector.
- 3) **The India Innovation Fund:** This is a venture capital fund that invests in innovative technologies and business models in India. The fund may provide funding opportunities for companies and startups working in the green hydrogen sector.
- 4) **The Power System Development Fund:** This fund was established to support the development of power systems in India, including the deployment of renewable energy technologies such as solar and wind power. The fund may provide funding opportunities for companies and organizations working on green hydrogen projects that are integrated with renewable energy sources.

Overall, these funding opportunities can provide valuable support for the development and deployment of green hydrogen technology in India. By leveraging these opportunities, companies and organizations working in the green hydrogen sector can access the resources and expertise needed to accelerate the growth of the sector in India.

4.2 NHM Financial Outlay

The National Hydrogen Mission in India is a bold initiative by the Government of India to promote the use of hydrogen as a clean and green source of energy. The mission aims to accelerate research and development activities and create a hydrogen ecosystem in the country. It seeks to make hydrogen a viable and cost-effective fuel for various sectors, including transportation, power generation, and industrial processes. The National



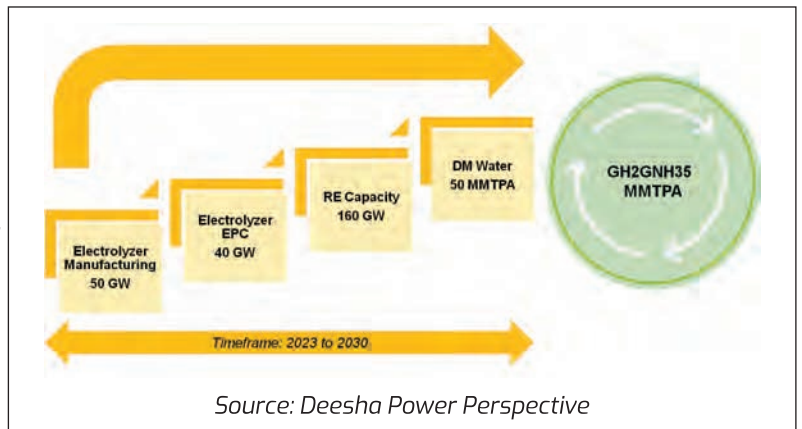
Hydrogen Mission will help India achieve its goal of reducing its carbon footprint and meet its commitments under the Paris Agreement. The graph gives country planned outlay under NHM:

Of the above, majority sum of Rs 17,500 Cr has been earmarked for strategic interventions such as GH₂ production and electrolyzer manufacturing. Govt is in process of making further announcement regarding modalities of distribution among various sectors and stakeholders.

4.3 GH₂ Ecosystem

GH₂ ecosystem required for 5 MMTPA GH₂ production is mentioned below:

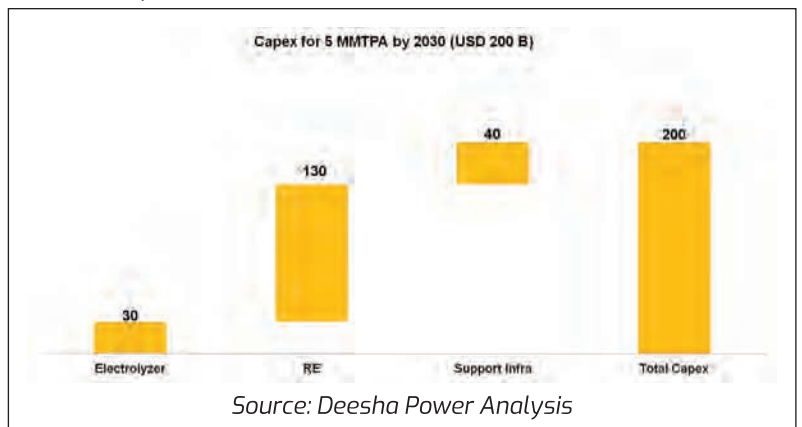
To produce 5 MMTPA of GH₂, one would require operating capacity of 40 GW of electrolyzer. To power these electrolyzers through green energy, one would require RE capacity of 160 GW. This needs to be clubbed with operating DM water capacity of 50 MMTPA. Land requirement is estimated at 0.3 million hectare. One needs to arrange for this infrastructure over next 7-8 years.



4.4 Capital Expenditure for 5 MMTPA GH₂ Ecosystem

NHM implies a capex opportunity USD 200 billion over next 8 years to establish 5 MMTPA GH₂ assets in India as depicted in the graph:

Creating an ecosystem of 5 MMTPA green hydrogen in India would require significant financing of US \$ 200 Billion. Green hydrogen production is currently more expensive than traditional hydrogen production, and as such, it requires substantial investment for scaling up. The financing required would depend on the specific technologies and infrastructure needed to produce



and distribute green hydrogen. Although it appears that a significant upfront investment is needed, but the long-term environmental and economic benefits could justify the cost.

4.5 Equity & Debt Requirements

Equity & debt requirement for GH2 ecosystem is depicted in the graph below:

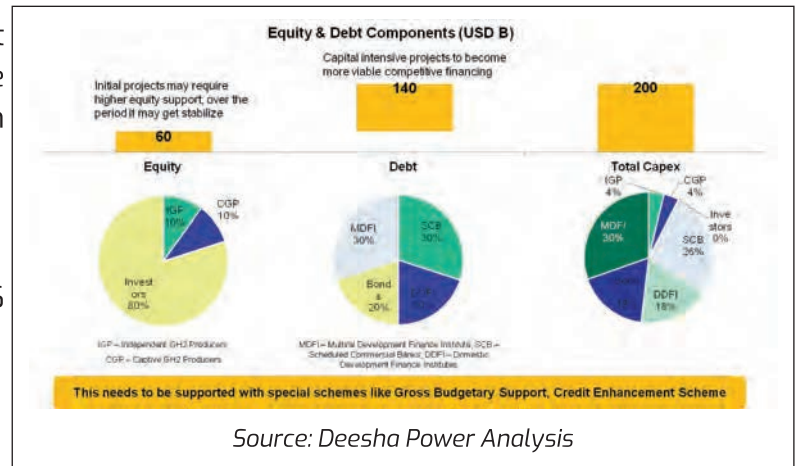
Equity investments of USD 60 Billion and debt funding of USD 140 Billion would be required in base case scenario. Its proposed breakup in subcomponents is presented below:

❖ Equity- \$ 60 Billion

- Independent Green Hydrogen Producers - \$ 6 Billion
- Captive Green Hydrogen Producers- \$ 6 Billion
- Investors- \$48 Billion

❖ Debt- \$ 140 Billion

- Multilateral Development Finance Institutions - \$ 42 Billion
- Scheduled Commercial Banks - \$ 42 Billion
- Domestic Development Finance Institutions - \$ 28 Billion
- Bonds - \$ 28 Billion



Multi-billion funding opportunity for various stakeholders makes India GH2 market as a special case for thriving business opportunities.

4.6 What Industry Stalwarts are Saying about Financing GH2

Industry stalwarts have expressed support for green hydrogen and have called for increased investment and financing to support the growth of the green hydrogen sector.

Here are a few examples:

- 1) **Adani Group Chairman Gautam Adani:** In a recent interview with the Financial Times, Adani said that green hydrogen presents a "huge opportunity" for India and that the country should focus on developing its green hydrogen sector. Adani called for increased investment in green hydrogen and said that government support will be crucial for the development of the sector.
- 2) **Tata Group Chairman N. Chandrasekaran:** In a recent interview with the Economic Times, Chandrasekaran

said that green hydrogen will play a key role in India's energy transition and that the Tata Group is exploring opportunities in the sector. Chandrasekaran called for increased investment in green hydrogen and said that there is a need for supportive policies and regulatory frameworks to support the growth of the sector.

- 3) **Siemens Energy CEO Christian Bruch:** In a recent interview with CNBC, Bruch said that green hydrogen is a "game-changer" in the energy sector and that there is a need for significant investment in the sector to support its growth. Bruch called for a "collaborative effort" between the public and private sectors to accelerate the development and deployment of green hydrogen technology.
- 4) **Mahindra Group Chairman Anand Mahindra:** Mr Anand Mahindra was among more than 70 global members of The Alliance of CEO Climate Leaders, who called on G7 leaders to accelerate credible net-zero and climate commitments, policies and actions. He further opined that we must widen the arc of climate action among the corporations of the world. A marketplace for low carbon technologies and climate funds will create a virtuous cycle. Governments and corporates must work together to achieve this

Overall, industry stalwarts are calling for increased investment and financing to support the growth of the green hydrogen sector. There is a recognition of the potential of green hydrogen to play a key role in the energy transition and to help mitigate the impacts of climate change. It is likely that we will continue to hear more from industry leaders on the importance of financing green hydrogen and supporting the growth of the sector in the coming years.



5. Existing Constraints

5.1 Constraints for GH2 Financing

Globally, there are several constraints that currently exist in the financing of green hydrogen projects. Some of the key constraints include:

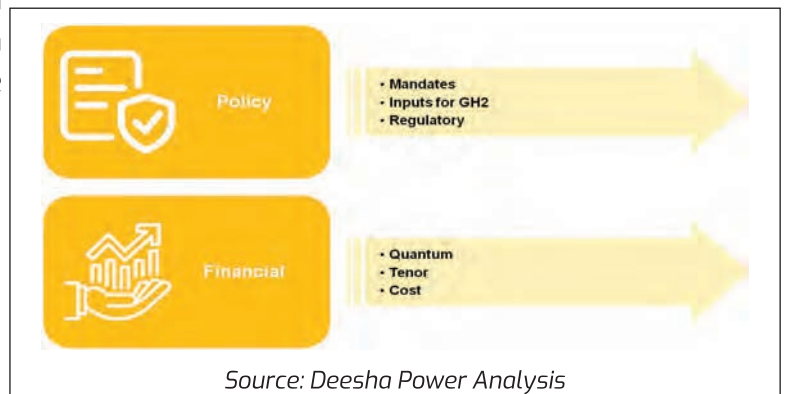
- 1) **High capital costs:** Green hydrogen projects require significant upfront investment, which can make it difficult to secure financing. This is especially true for smaller companies or for projects that are still in the pilot phase.
- 2) **Lack of established markets:** There is currently a limited market for green hydrogen, which can make it difficult to attract financing. This is especially true in countries where there is limited government support for renewable energy and green hydrogen production.
- 3) **Uncertain regulatory environment:** The regulatory environment for green hydrogen production and use is still evolving, which can make it difficult to attract financing. Regulatory uncertainty can create risks for investors and lenders, which can increase the cost of financing for green hydrogen projects.
- 4) **Limited access to financing:** Access to financing can be a challenge for companies and organizations working in the green hydrogen sector, especially those in developing countries or in areas where traditional financing is not readily available.
- 5) **Limited capacity for project development:** There is currently a limited pool of experienced developers in the green hydrogen sector, which can make it difficult to bring projects to fruition.

Overall, these constraints can make it difficult for companies and organizations working in the green hydrogen sector to secure financing. However, as the green hydrogen sector continues to grow and mature, it is likely that these constraints will begin to ease and financing will become more readily available. Governments, multilateral organizations, and private investors can all play a role in supporting the development of the green hydrogen sector and helping to overcome these constraints.

5.2 India Specific Constraints

India specific constraints are presented here:

The same are discussed in subsequent sections.



5.2.1 Mandates

Due to policy related issues, there is genuine dearth of bankable GH₂ projects as mentioned below:

Purpose	Type of GH ₂ Project	Sector	Concerns
Domestic	Top of H ₂ Consumption Pyramid (Mid Sized Projects)	Refinery, Fertilizer etc	Lack of mandates
	Bottom of H ₂ Consumption Pyramid (Small Sized Projects)	Chemical, Pharma etc	Business case for switch to GH ₂ not promising enough
Export	Large Scale GH ₂ /GNH ₃	International Steel/Maritime	Offtake Contracting < 10-15% That to Soft/MoU level




Source: Deesha Power Analysis

Some of the policy constraints for GH₂ Projects is mentioned below:

- Domestic Big GH₂ Projects – In absence of mandates for compulsory GH₂ consumption or targets for energy/carbon intensity reduction, there is no incentive for top of the pyramid hydrogen consumers like refineries/fertilizers to shift to GH₂
- Domestic Small GH₂ Projects – In absence of clarity for specific assistance in Rs/KG of GH₂, business case for switching to GH₂ is not compelling enough
- Export Led GH₂ Project – By design, they would be big. But in absence of standards/definition aligning to international markets, offtake contracting is slow. That too, it is at a soft commitment/MoU level.

5.2.2 Inputs for GH₂

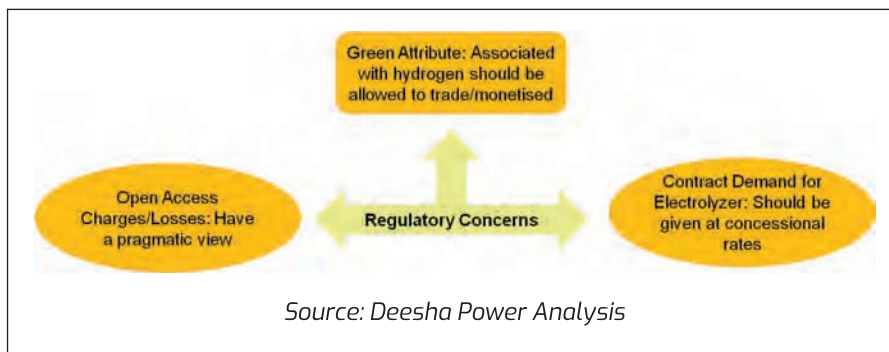
RE power, land and water are the critical inputs for GH₂; These are the state subjects where a lot needs to be done as mentioned below:

 RE Power	<ul style="list-style-type: none"> • State electricity duty is a component in landed power at many states, Plus state STU losses/charges also feature in landed cost of power • Such charges could be removed and access to RE power should not be artificially restricted
 Land	<ul style="list-style-type: none"> • Land near coastal areas is a prime requirement for export led project • Need an uniform approach for its allocation. Plus there may be consistent approach for various SOPs such as waiver of stamp duty/registration charges
 Water	<ul style="list-style-type: none"> • Water allocation policy along with charges could be harmonized across the states • Recycled water could be made available to such projects on priority

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- Water - Water allocation policy along with charges could be harmonized across the states. Recycled water could be made available to such projects on priority

5.2.3 Regulatory

Regulatory constraints are as mentioned below:



- **Open Access Charges/Losses:** Electricity demand from electrolyzer is very very negligible at the moment. New demand is going to get created. Considering this, a fresh pragmatic review of open access charges/losses is desired by SERCs so as to optimise the landed cost of RE power resulting in natural optimisation in production cost of GH₂.
- **Contract Demand:** SERCs could come up with concessional rates connectivity/contract demand charges for electrolyzer (which is likely to get installed near the consumption point/ At present, such charges are adding ~20-25% to the cost of production of GH₂.
- **Green Attribute:** Independent GH₂ Developer/GH₂ investors could be allowed to sell green attribute associated with GH₂ to the concerned parties who has a specific requirement around the same. It would subsidize cost of hydrogen to cost sensitive actual H₂ consumers.

5.2.4 Financial

Financial constraints are as mentioned below:

- **Quantum:** Balance sheet size of SCBs may be small to fund massive finance requirements of GH₂. Plus most of these SCBs have heavy lending to power sector, hence no incentive. Fresh lending perspective is desirable to attract quantum

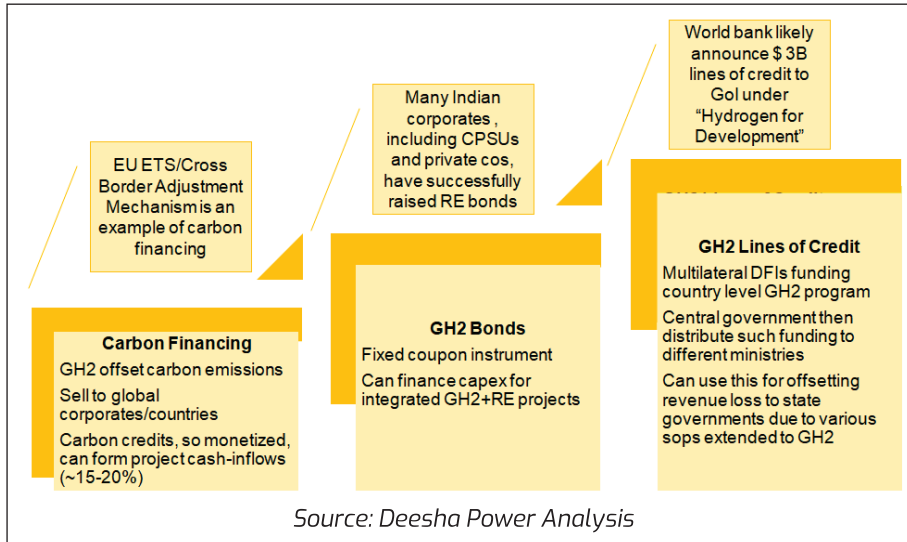
- **Tenor:** The capital intensive nature of GH₂ projects requires raising debt for longer tenor (more than 15 years) which can be supported by life of the Project (around 25 years). Asset Liability Mismatch is an issue likely to be faced, hence options like re-financing may be explored.
- **Cost:** Cost of Rupee funding is high as compared to foreign currency funding. Dollar denominated lending could be explored to cost and currency hedging issues. The credit rating of the GH₂ projects being set up under SPV structure is generally lower than investment criterion of bond investors and there is a need for credit enhancement products



6. Possible new financing options

6.1 New Financing Options

There could be three new financing options for GH2 viz carbon financing, GH2 bonds, GH2 lines of credit from MDFIs as mentioned below:



Pros and cons of each option is presented below:

	Pros	Cons
Carbon Funding	<ul style="list-style-type: none"> • Additional revenue stream • Can incentivize MNCs/Govts for investment • Acts as a glue for investors promoting sustainability 	<ul style="list-style-type: none"> • Complex instrument • Fluctuation in pricing • Risk of fraud if not designed appropriately
Green Bonds	<ul style="list-style-type: none"> • Additional way for investors to support carbon friendly projects • Can fill funding gaps where traditional financing has limitations 	<ul style="list-style-type: none"> • Can be expensive than traditional route • Yield may affect if underlying project fails to deliver anticipated returns
Lines of Credit	<ul style="list-style-type: none"> • Can be crucial source of financing till industry stabilizes • MDFIs can provide their expertise to drive investments 	<ul style="list-style-type: none"> • Can be subject to political and economic volatility • In case of conflict in objectives, process can become complicated

Source: Deesha Power Analysis

Given its pros & cons, each new funding source can be considered as an important brick while building a bridge to GH2 financing.

7. Views of industry leaders

7.1 Structured Questionnaire

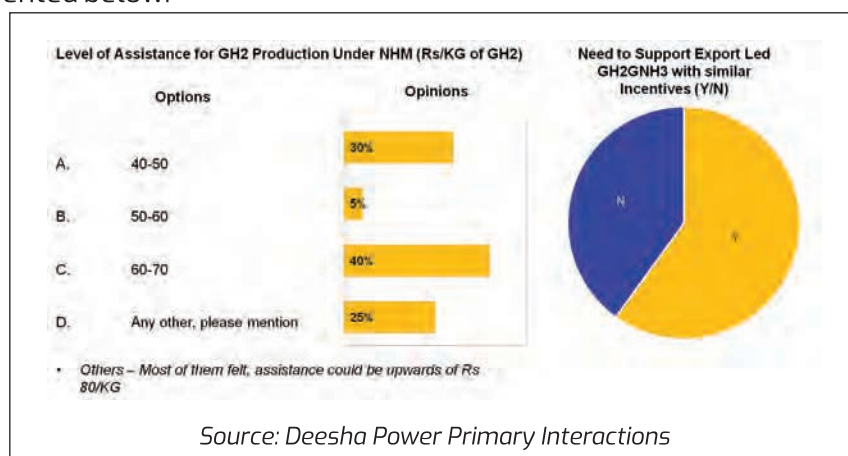
Stakeholder's views were sought through structured questionnaire around following aspects:



White paper team got a fantastic response on the participation from 25 global and Indian organizations, whose names have been mentioned at the beginning of this white paper.

7.2 Level of Assistance under NHM

Industry views are presented below:

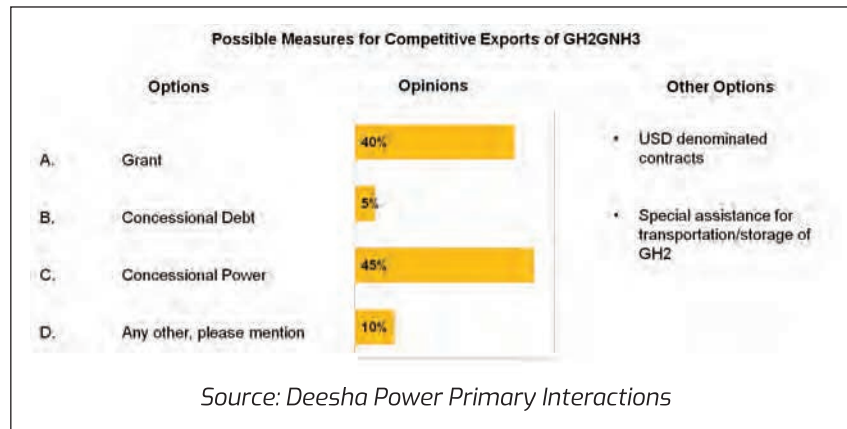


- Others - 80% of C-level executives opined that there is huge disparity between assistance provided under NHM and what has been given under EU/USA GH2 programs

- When further asked, whether same level of Rs/KG assistance may be provided to export led GH2 projects, ~60% opined that it needs to be provided.

7.3 Competitiveness for Export Led GH2

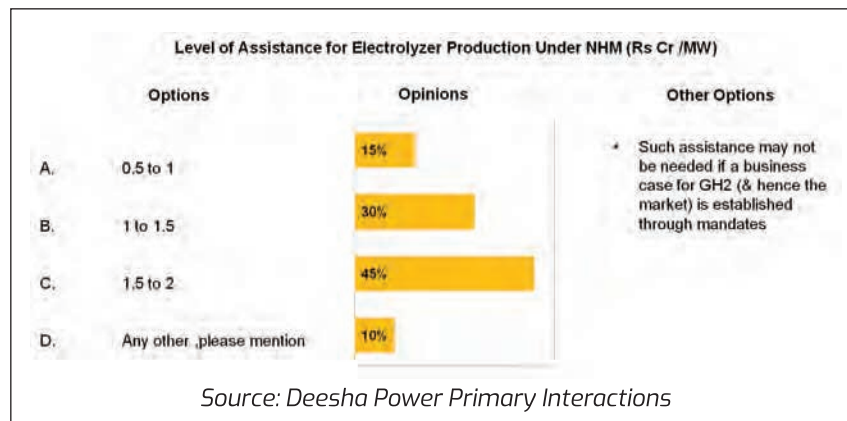
Industry was asked about their opinion in terms of ways to make Indian GH2 exports more competitive. The responses are presented below:



85% of the respondents believed that grant and concessional power would make India's exports more competitive.

7.4 Level of Assistance for Manufacturing of Electrolyzer

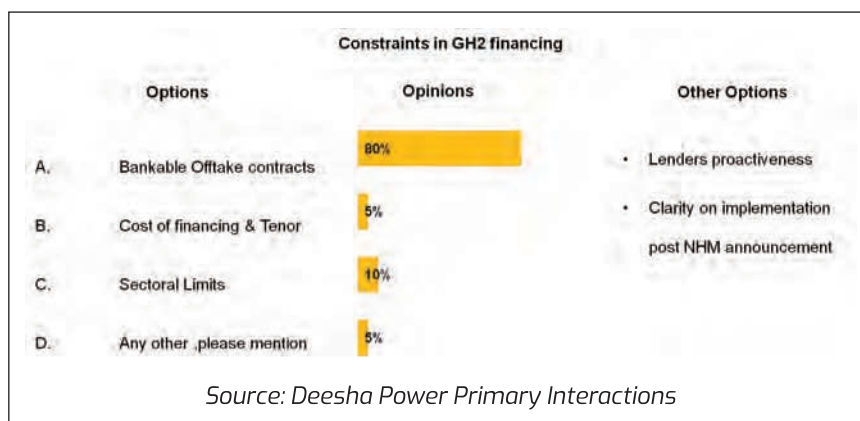
Industry stakeholders were asked about the likely assistance from Gol for electrolyzer manufacturing. The responses are presented below:



While 45% of executives sought assistance in the range of Rs 1.5 to Rs 2 Cr/MW, which is the current difference between the pricing of electrolyzer from China vs pricing for made in India electrolyzer.

7.5 Constraints in GH2 Financing

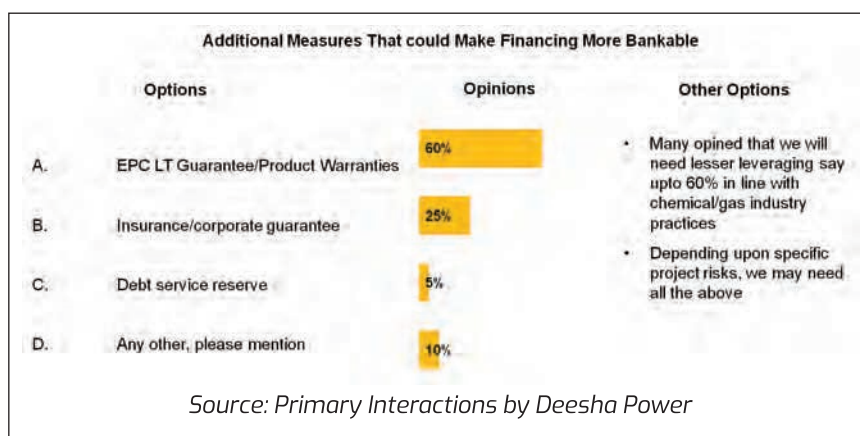
Industry participants were requested to share views on the likely constraints in financing of GH2 projects in India. The response is presented below:



Bankable GH2 contracts is the principal constraint for GH2 financing, believed overwhelming ~80% of the respondents. Sectoral limit could be spoil sport, opined 10% of the respondents.

7.6 Additional Measures for GH2 Bankability

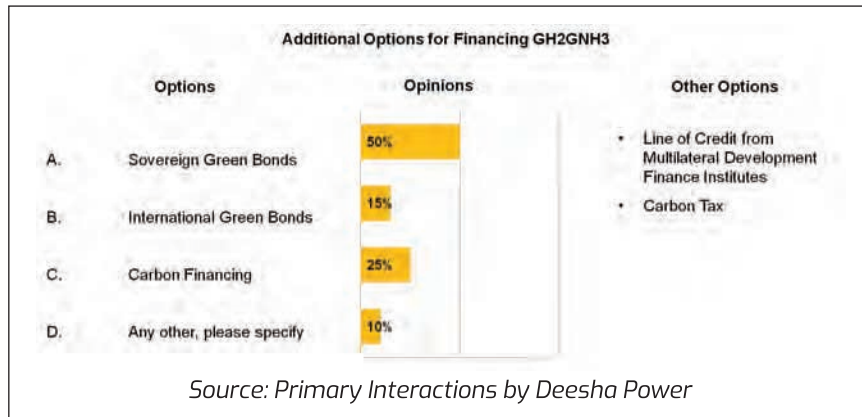
Industry stakeholders were requested to share their views on how GH2 projects could be made more bankable. Their responses is presented below:



It is understandable that the technology risk is biggest risk given precedence of continuous operating data for MW scale projects. This is clearly reflected with 60% of respondents highlighting the same. Some of the interesting suggestions received is lesser leveraging till the confidence is built among the lenders. However, industry feels that the lenders should become more proactive and cooperative to address this risk through mutually agreeable project structuring solutions.

7.7 Additional Financing Options for GH2

Industry stakeholders were asked about their opinion regarding additional financing options for GH2 in India. Feedback from the participants is presented below:



As it is observed from the picture above, Sovereign Green Bonds have emerged as top option. Many also opined that, line of credit from Multilateral Development Finance Institutes along with an introduction of carbon tax could be a great option.

7.8 Constructive Suggestions

Constructive suggestions were sought from the Industry Leaders. Their views are presented below:

MD&CEO, Electrolyzer Manufacturing Company

- Devise GH2 standards as export will be difficult without that
- Please do not put blanket ban on China. It affects supply chain and competitiveness of GH2

CEO, RE Power Developer

- Green tax, a differential of GH2 pricing and gray H2 pricing, on present and future hydrogen consumers could facilitate GH2
- Announce compulsory use of hydrogen in NG blending for power generation

Director, Independent Green Hydrogen Producer

- Inability to measure, strip and trade the green component of GH2 is principal bottle neck; if addressed flood gate of investment in GH2 could open
- Contract demand charges for insitu electrolyzer may be waived for competitive GH2 pricing

Director, Innovative H2 Storage Solution

- "Pay as You Need" instead of "Pay as its cheap" for decarbonisation
- H2 financing ecosystem to involve solid H2 transportation

Source: Primary Interactions by Deesha Power

Please do not put blanket ban on China, said MD of Electrolyzer company. India's supply chain is yet to be matured. Among other, a director of Independent Green Hydrogen Producer opined that currently one can not measure, strip and trade the green component of GH₂ and its the principal bottle neck to attract equity investments; if addressed flood gate of investment in GH₂ could open, self sustaining GH₂ economy will automatically great created with very minimal government assistance, very much an apt statement.

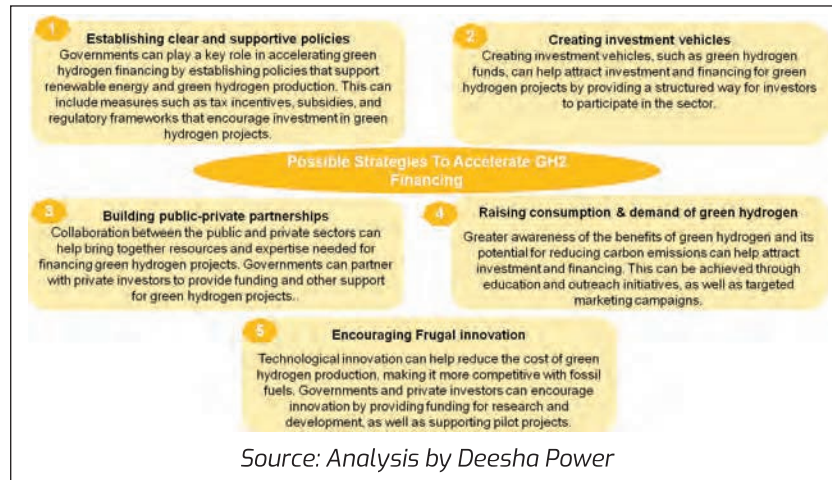
Among other, early GH₂ projects involve insitu electrolyzer near to consumption point by the process industry. Often, process industry is connected to state STU network. The Moment, process industry intsalls electrolyzer, it may have to apply for contract demand enhancement, which has certain costs per KVA/month, which adds to cost of electricity. Therefore, a need to reduce/waive contract demand charges for such electrolyzers, being installed in process industry premises, has been expressed.



8. Strategies to Accelerate GH2 Financing

8.1 Five Pronged Strategy

Five pillars of probable strategy are presented in schematic below:



Each of the strategic element is deliberated in the subsequent paras.

8.2 Clear and Supportive Policies

Examples of strategic measure and India imperative regarding conducive policies is presented below:

8.2.1 Example of A Strategic Measure

- The European Union has established a hydrogen strategy that includes funding for research and development, regulatory measures to support the use of hydrogen, and targets for hydrogen production and use.
- The Chinese government has implemented policies that encourage the use of hydrogen fuel cells in transportation, including subsidies for fuel cell vehicles and the construction of hydrogen refueling stations.

8.2.2 India Imperative

Conducive policies involves creating right regulatory framework to monetise green component and appropriate carbon tax provisions as mentioned below:

- While NHM has been launched, modalities for distributing USD 2.3 billion may be explicitly mentioned
- Standards to ascertain green attribute of GH₂ may be launched
- Framework to monetize this green attribute or carbon savings may be made clear

- In addition to this, carbon tax may be introduced to align domestic industry and restrict polluted imports from Africa

8.3 Investment Vehicles

Examples of strategic measure and India imperative regarding investment vehicles is presented below:

8.3.1 Example of A Strategic Measure

- The Hydrogen One Capital Growth Fund is a private equity fund that invests in companies that are involved in the production, storage, and use of hydrogen.
- The European Investment Bank has established the InnovFin Energy Demonstration Projects program, which provides funding for demonstration projects that explore new technologies and business models in the energy sector, including projects related to hydrogen.

8.3.2 India Imperative

Creating investment vehicles, such as green hydrogen funds, can help attract investment and financing for GH₂ as mentioned below:

- A separate dedicated fund may be carved for GH₂ through pooling the capital from National Clean Energy Fund, India Innovation Fund, Power System Development Fund
- NIIIF may be made the forefront to invest such pooled capital in identified projects with a healthy mix of electrolytic GH₂ and biomass GH₂ technologies

8.4 Partnering with Private Sector To Create Large Pool for GH₂ Bank

Examples of strategic measure and India imperative regarding partnering with private sector is presented below:

8.4.1 Example of A Strategic Measure

- The U.S. Department of Energy has partnered with private companies to fund research and development of hydrogen technology, as well as to promote the deployment of hydrogen fuel cell vehicles.
- The Australian Renewable Energy Agency has partnered with private companies to provide funding for pilot projects that explore the use of green hydrogen in a variety of applications.

8.4.2 India Imperative

Government can partner with private sector investors to create GH₂ Bank as mentioned below:

- PFC, REC, IREDA can pool in 51% capital for a dedicated GH₂ Bank wherein 49% of capital could come from private sector banks to create GH₂ Bank
- IREDA may be made forefront to lend such pooled capital in the identified bankable projects

- Capacity building exercise for the executives going to work for GH2 would be required

8.5 Enhancing Consumption of GH2

Examples of strategic measure and India imperative regarding creating awareness about GH2 is presented below:

8.5.1 Example of A Strategic Measure

- The Hydrogen Council, a global industry group, has launched a marketing campaign to raise awareness of the benefits of hydrogen and promote its use in a variety of applications.
- The California Fuel Cell Partnership has launched a public education program to promote the use of hydrogen fuel cell vehicles and raise awareness of the benefits of hydrogen as a source of energy.

8.5.2 India Imperative

Government can partner with private sector investors to create GH2 Bank as mentioned below:

- Massive awareness, capacity building and training program could be undertaken under leadership of MNRE through select developed country partners like Germany, Norway, Japan
- Energy intensive sectors such as refineries, fertilizers, steel, aluminium, cement, chemical, mobility etc may be targeted

8.6 Promoting Frugal Innovation

Examples of strategic measure and India imperative regarding promoting innovation is presented below:

8.6.1 Example of A Strategic Measure

- The U.S. DoE has provided funding for research and development of hydrogen technology, including projects aimed at reducing the cost of hydrogen production and improving the efficiency of fuel cells
- The European Union has launched the Fuel Cells and Hydrogen Joint Undertaking, a public-private partnership that funds research and development of hydrogen technology and supports the deployment of hydrogen infrastructure

8.6.2 India Imperative

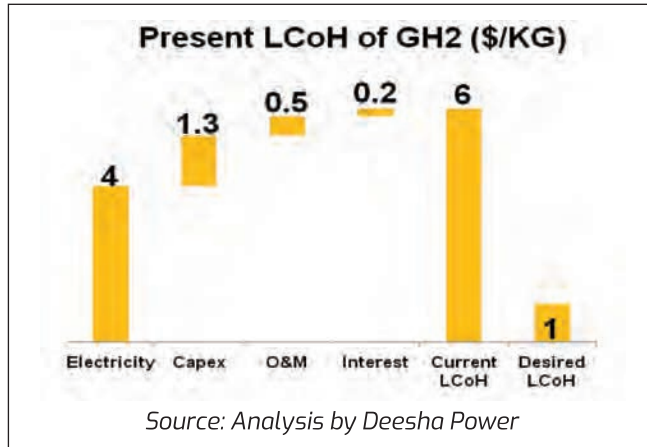
Government can promote innovation through a focused funding to develop technologies and help implement pilots that reduces GH2 costs for consumers as mentioned below:

- India has a vast pool of incubators across reputed education institutes such as IITs, IISc
- Lot of R&D is happening in mobility sector too in addition to industrial sectors
- A separate GH2 cell under aegis of MoRTH comprising of industry experts, in coordination with these incubating centers, may be activated to identify such technologies at early stage and funding support of Rs 50 lacs could be provided

9. Roadmap for GH2 @ USD 1/KG

9.1 Strategy for GH2 @ USD 1/KG

Against popular notion of GH2 pricing between \$ 4-5/KG, basis on the ground understanding where Deesha Power is associated in project evaluation, the present Levelised Cost of Green Hydrogen (LCoH) is ranging between USD 6-7/KG. The breakup is presented below:

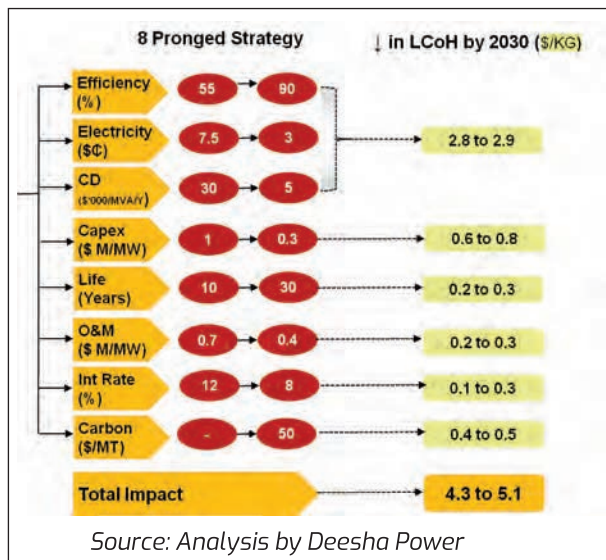


Key realities are mentioned below:

- Efficiency: 55%
- Cost of Electricity: 7.5 \$ cents/kWh
- Contract demand charges: \$ 30,000/MVA/Year
- Capex: \$ 1M/MW
- O&M: \$ 0.7 M/MW
- Interest rate: 12%
- Carbon: none

The market competitive GH2 pricing scenario is envisaged at \$ 1/KG, indicating 84% reduction in present LCOH. Given the fact that solar witnessed downward journey of 85% in its pricing, we believe that such steep reduction to desired LCOH is possible if techno-commercial/regulatory aspects pan out in right direction. Let us see that in subsequent para.

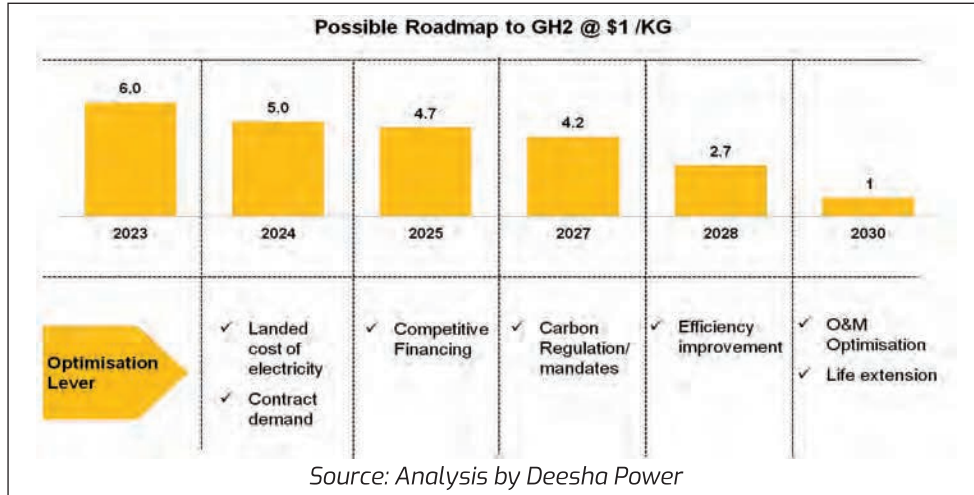
Roadmap to \$1/KG is presented below:



Maximum (~60%) reduction in LCOH is due to reduction in electricity cost on account of efficiency improvement, rationalisation in cost of landed electricity and optimisation in contract demand charges. The next significant reduction is possible to reduction in capex for electrolyzers. Carbon and financing costs too are the influencers after electricity and capex.

9.2 Possible Journey towards USD 1/KG

India's possible journey towards \$ 1/KG is presented alongside:



India's GH₂ pricing will be possibly driven under two phases:

- Till 2027: By input cost rationalization and carbon economics/mandates
- Till 2030: By efficiency improvement, life extension and O&M cost optimisation



10. Annexures

10.1 Advertisements



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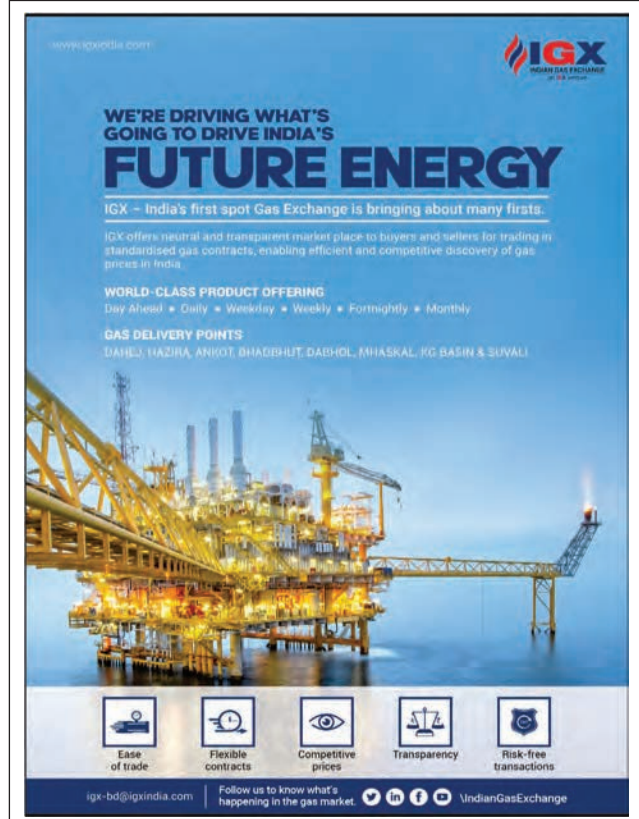
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10.2 Briefs for Policies Related to GH2GNH3

10.2.1 National Hydrogen Mission

NHM propose two phase approach to start decarbonization initiatives across the sectors

NHM PHASED APPROACH

Phases	Phase I: 2022-23 to 2025-26	Phase II: 2026-27 to 2029-30
Target Sectors	<ul style="list-style-type: none"> Refineries Fertilizers City Gas Distribution 	<ul style="list-style-type: none"> Steel Shipping Mobility
Activities	<ul style="list-style-type: none"> DD creation in target sectors Pilot Projects for Phase II target sectors Market mechanisms/R&D to bring cost down 	<ul style="list-style-type: none"> DD creation in target sectors Pilot Projects for railways, aviation etc Deep decarbonization across economy

Source: NHM & Deesha Power Perspective

10.2.2 17th Feb GOI Policy on GH2GNH3

GoI has come out with progressive GH2 GNH3 policy

17th FEB GOI POLICY ON GH2GNH3

- ✓ Green Hydrogen from electrolysis of water/gasification of biomass would be considered under ambit of this policy
- ✓ 25 year waiver in inter-state transmission charges for projects commissioned before 30th June 2025 has been provided
- ✓ Open Access (OA) towards supply of RE power to GH2GNH3 projects be granted in 15 days
- ✓ Banking of Renewable Energy (RE) power earmarked for GH2GNH3 projects allowed for 30 days at an incremental RE power purchase cost over IEX prices
- ✓ RE power park's land to be made available for GH2GNH3 projects
- ✓ Land at ports for generation/storage of GH2GNH3 towards further export/use by shipping industry
- ✓ RE power for GH2GNH3 to help in RPO compliance of obligated entity; excess RE power after such compliance, if any, would be used to offset concerned Discom's Renewable Purchase Obligation (RPO) compliance
- ✓ Special RE power supply rate to such GH2GNH3 projects by Discoms to be determined by appropriate state regulators
- ✓ Ministry of New and Renewable Energy (MNRE) to become single point contact for time bound permits and approvals for GH2GNH3 projects, preferably within 30 days of application
- ✓ MNRE designated entity (most likely Solar Energy Corporation of India) to aggregate demand for GH2GNH3 towards competitive price discovery

10.2.3 Green Open Access Rules

Green Open Access Rules allows entity with threshold load of 100 kW and above to source green power through open access

GREEN OPEN ACCESS RULES

- ✓ These rules are notified for promoting generation, purchase and consumption of green energy including the energy from Waste-to-Energy plants.
- ✓ The Green Open Access is allowed to any consumer and the limit of Open Access Transaction has been reduced from 1 MW to 100 kW for green energy, to enable small consumers also to purchase renewable power through open access.
- ✓ Consumers are entitled to demand supply of Green Power from Discoms. Discoms would be obligated to procure and supply green power to eligible consumers.
- ✓ These Rules will also streamline the overall approval process for granting open access. Time bound processing by bringing uniformity and transparency in the application as well as approval of open access through a national portal has been mandated. Approval for Green Open Access is to be granted in 15 days or else it will be deemed to have been granted.
- ✓ Commercial and Industrial consumers are allowed to purchase green power on voluntarily basis.
- ✓ Provide certainty on open access charges to be levied on Green Energy Open Access Consumers which includes transmission charges, wheeling charges, cross-subsidy surcharge and standby charges. Cap on increasing of cross-subsidy surcharge as well as the removal of additional surcharge, incentivize the consumers to go green.
- ✓ There shall be a uniform Renewable Purchase Obligation (RPO), on all obligated entities in area of a distribution licensees. Green Hydrogen/Green Ammonia has also been included for fulfilment of its RPO.
- ✓ Consumers will be given Green Certificates if they consume green power

10.2.4 Energy Conservation (Amendments) Bill, 2022

The Energy Conservation (Amendment) Bill, 2022 was introduced in Lok Sabha on 03 August 2022

MAIN FEATURES - ENERGY CONSERVATION (AMENDEMENT) ACT, 2022

The Bill seeks to amend the Energy Conservation Act, 2001. The Act promotes energy efficiency and conservation. It provides for the regulation of energy consumption by equipment, appliances, buildings, and industries. Key proposals under the Bill are:

- ✓ mandate use of non-fossil sources, including Green Hydrogen, Green Ammonia, Biomass and Ethanol for energy and feedstock
- ✓ establish Carbon Markets
- ✓ bring large residential buildings within the fold of Energy Conservation regime
- ✓ enhance the scope of Energy Conservation Building Code
- ✓ amend penalty provisions
- ✓ increase members in the Governing Council of Bureau of Energy Efficiency
- ✓ empower the State Electricity Regulatory Commissions to make regulations for smooth discharge of its functions.

10.3 About Deesha Power

10.3.1 GH2GNH3 Consulting Offerings

Deesha Power has two types of consulting offerings for GH2GNH3 sector viz strategy & implementation support



Strategy

- ✓ Net Zero/Sustainability Strategy
- ✓ GH2GNH3 Strategy Work-shop
- ✓ Growth Strategy
- ✓ Market Assessment



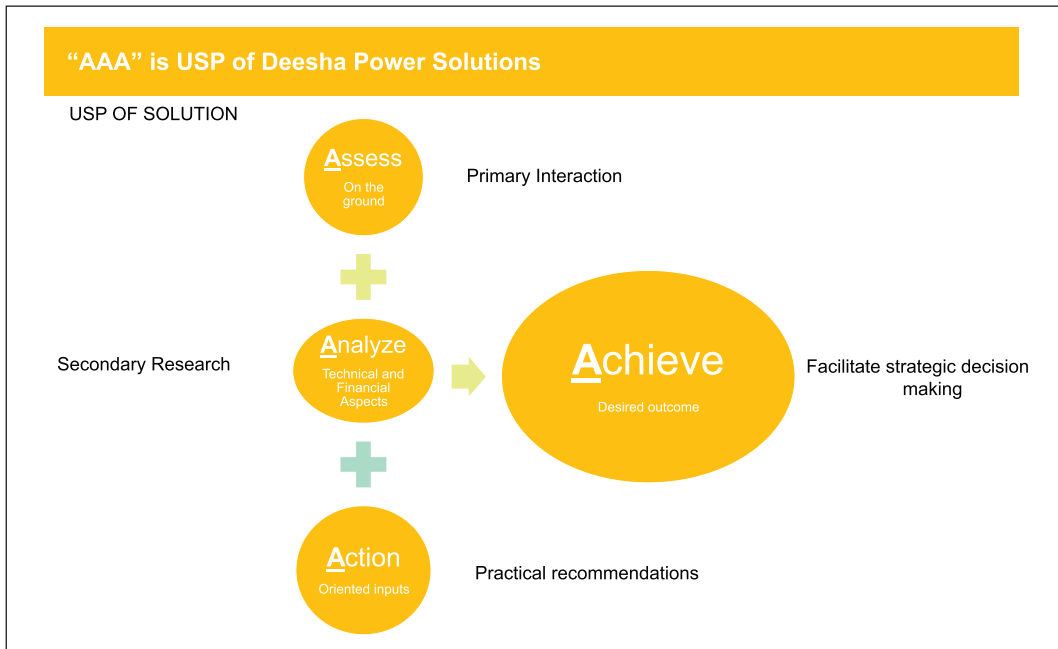
Solutions

- ✓ Sustainability Feasibility & Financial Modeling
- ✓ Implementation Support for Net Zero Transition
- ✓ Opportunity/Partner Identification

10.3.2 Growing Clients List



10.3.3 USP's



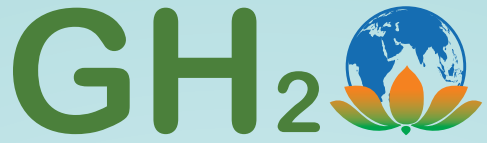
10.4 Abbreviations

A – M		M – Y	
AEM	Anion Exchange Membrane	MoU	Memorandum of Understanding
CAGR	Compounded Annual Growth Rate	MVA	Mega Volt Ampere
CCS	Carbon Capture & Storage	MW	Mega Watt
CGP	Captive GH ₂ Producer	MT	Metric Tonne
DDFI	Domestic Development Finance Institute	NG	Natural Gas
ETS	Emission Trading Scheme	NHM	National Hydrogen Mission
EU	European Union	NZ	Net Zero
FC	Fuel Cell	PEM	Proton Exchange Membrane
GH ₂	Green Hydrogen	PLF	Plant Load Factor
GHG	Green House Gases	PLI	Production Linked Incentive
GHO	Green Hydrogen Organisation	PM	Prime Minister
GNH ₃	Green Ammonia	PV	Photo Voltaic
GT	Giga Ton	RE	Renewable Energy
GW	Giga Watt	RLDC	Regional Load Dispatch Centre
H ₂	Hydrogen	RTC	Round The Clock
IGP	Independent GH ₂ Producer	SCB	Scheduled Commercial Banks
IRA	Inflation Reduction Act	SMR	Steam Methane Reformation
LH ₂	Liquid Hydrogen	SOEC	Solid Oxide Electrolyzer Cell
LOHC	Liquid Organic Hydrogen Carrier	STU	State Transmission Utility
MBPD	Million Barrel Per Day	TW	Tera Watt
MDFI	Multilateral Development Finance Institute	VGf	Viability Gap Funding
MMTPA	Million Metric Tonnes Per Annum	USD B	United States of America Dollars Billions
MoRTH	Ministry of Road Transport & Highways	YoY	Year on Year

10.5 References

- <https://www.india.gov.in/spotlight/national-green-hydrogen-mission#:~:text=The%20National%20Green%20Hydrogen%20Mission,Green%20Hydrogen%20and%20its%20derivatives>
- <https://rmi.org/our-work/china-program/>
- <https://www.iea.org/reports/iron-and-steel>
- <https://eciu.net/netzerotracker>
- <https://www.mckinsey.com/capabilities/sustainability/our-insights/the-net-zero-challenge-accelerating-decarbonization-worldwide>
- www.engineeringtoolbox.com
- <https://spirare.co.in/applications/>
- Statistical Review of World Energy – 2021, bp.com/statsreview
- <https://www.yara.com/corporate-releases/green-ammonia-from-hegra-to-secure-norwegian-competitiveness/>
- <https://ieefa.org/resources/green-ammonia-low-hanging-fruit-indias-green-hydrogen-dream>
- <https://www.bing.com/search?q=AMR+green+hydrogen+market+report&cvid=942b46b0f7ed42a5819f9f6dbf8194d6&aqs=edge..69i57.8375j0j9&FORM=ANAB01&PC=HCTS>
- Green Hydrogen Policy | Government of India | Ministry of Power (powermin.gov.in)
- [Harnessing_Green_Hydrogen_V21_DIGITAL_29062022.pdf](https://www.niti.gov.in/publications/Harnessing_Green_Hydrogen_V21_DIGITAL_29062022.pdf) (niti.gov.in)
- <https://www.india.gov.in/my-government/whos-who/members-parliament>
- <https://www.seaenergy.in/post/the-energy-conservation-act-2001-ec-act-amendment-bill-2022-pdf-download>
- <https://pib.gov.in/PressReleasePage.aspx?PRID=1810907>
- PLI scheme announcement- <https://pib.gov.in/PressReleasePage.aspx?PRID=1776843>
- <https://gh2.org/our-initiatives/gh2-green-hydrogen-standard>
- DNV – Hydrogen forecast to 2050
- GIZ - Status Quo Mapping of Hydrogen Production and Consumption in India
- <https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1842737#:~:text=The%20Green%20Open%20Access%20is,of%20Green%20Power%20from%20Discoms.>





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