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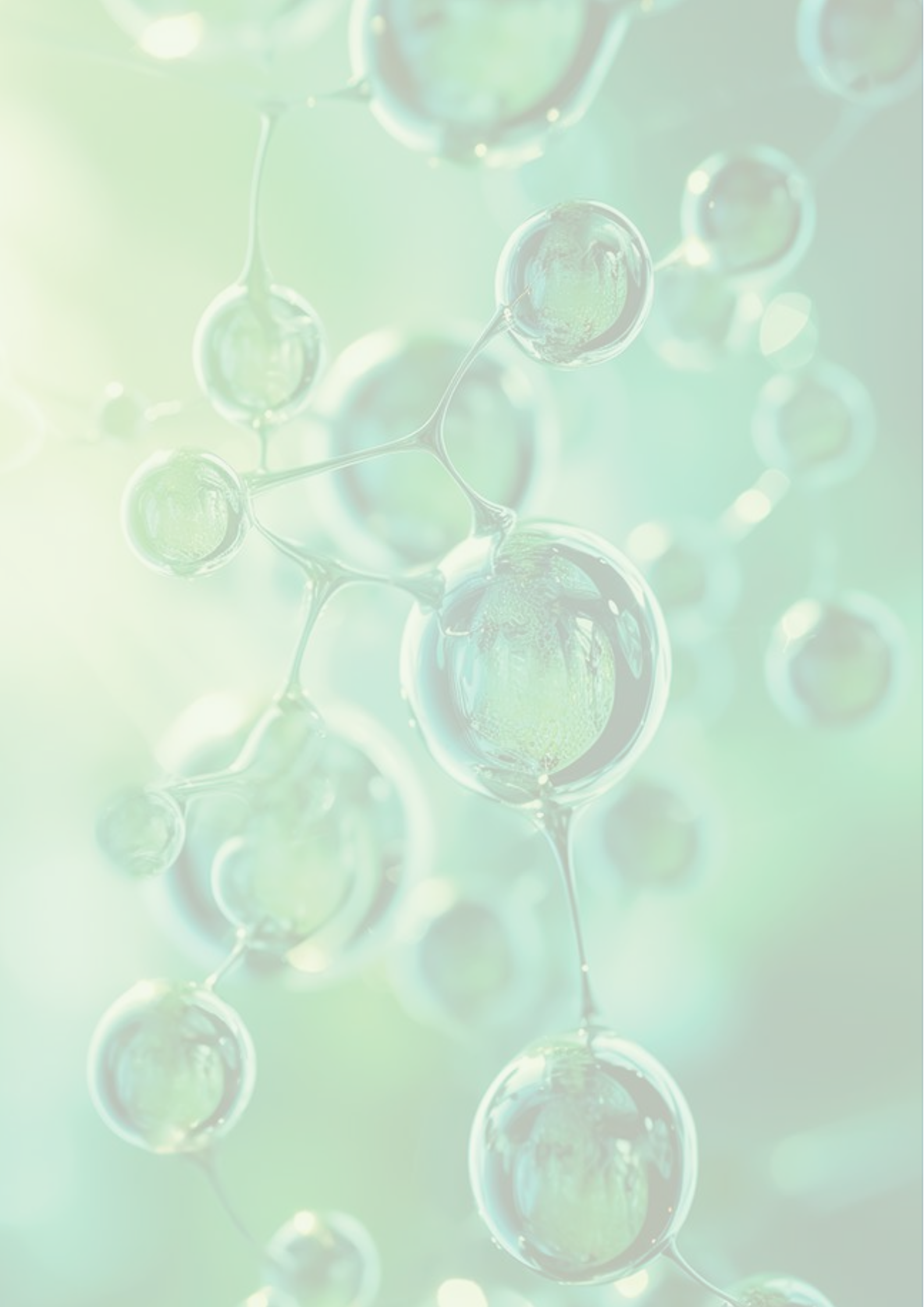
INDIA'S GREEN HYDROGEN REVOLUTION
– An Ambitious Approach

May 2024



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PREFACE

The world faces a pressing challenge: **DECARBONISATION**. To combat climate change, nations around the globe are striving to reduce greenhouse gas emissions and transition towards cleaner energy sources. International conferences like COP 26 (2021) and COP 28 (2023) have played a crucial role in fostering global collaboration on this front.

The booklet includes overview of decarbonisation scenario in India and the policy measures of the Government for supporting the need of the hour, with right mix of decarbonisation pathways and technology levers.

In this context, Green Hydrogen emerges as a game-changer. Produced using renewable energy sources like solar, wind, hydro and biomass, Green Hydrogen offers a clean and sustainable alternative to fossil fuels. However, large-scale production necessitates significant renewable energy capacity.

Recognizing this potential, India launched the National Green Hydrogen Mission in 2023. This ambitious mission aims to establish India as a global hub for Green Hydrogen production, usage, and export. The mission seeks to:

- Drive down production costs through financial incentives for electrolyser manufacturing and Green Hydrogen production.
- Boost domestic demand by mandating minimum Green Hydrogen consumption in specific sectors.
- Facilitate exports by establishing supportive policies and strategic partnerships.

The Government of India already has a strong focus on renewable energy with ambitious targets for capacity expansion. This focus on renewables is crucial for powering Green Hydrogen production and achieving the mission's goals. The economic potential of Green Hydrogen in India is significant and the mission projects creation of millions of jobs, attracting substantial investments, and reducing dependence on fossil fuel imports. This economic development will contribute to India's overall energy security and Aatmanirbhar Bharat (self-reliant India) goals.

Several major Green Hydrogen projects (Pilot and Commercial) are already underway across India, showcasing the country's commitment to its clean energy targets. Few success stories of the projects have been showcased in the booklet. These projects pave the way for a greener future powered by innovation and sustainability.

Financing Green Hydrogen and Renewable Energy projects requires a multi-pronged approach. Traditional methods remain important, but innovative solutions and supportive policies are crucial to unlock the full potential of clean energy investments. Along with the financing options of debt and equity, green financing facilities like Green Bonds & Sovereign Loans can be explored. Collaboration between public and private sectors is key to bridging the financing gaps and accelerating the transition to a sustainable future.

FOREWORD

Ajay Yadav
Joint Secretary
Ministry of New &
Renewable Energy

As we stand at the cusp of a transformative era in energy evolution, the significance of Green Hydrogen cannot be overstated. With great enthusiasm that I introduce this booklet, depicting the brief development of Green Hydrogen in India.

In recent years, the discourse around sustainable energy solutions has shifted towards the imperative of decarbonisation, and Green Hydrogen has emerged as a beacon of hope in this journey. Unlike its grey counterpart, Green Hydrogen production offers a pathway free from harmful emissions, harnessing the power of renewable energy sources such as solar and wind. Through the process of electrolysis or biomass gasification, water is transformed into a clean fuel that holds immense potential across various sectors, from industry to transportation.

India's commitment to this cause is underscored by the National Green Hydrogen Mission, a visionary initiative aiming to produce 5 million tonnes of Green Hydrogen by 2030. This mission not only aligns with our national goals for sustainability but also positions India as a frontrunner in the global green energy landscape.

As we embark on this journey, it is imperative to prioritize quality and safety at every step. The development of robust standards and regulations will ensure that Green Hydrogen maintains its promise as a safe and reliable energy source.

The booklet you hold in your hands is not just a compilation of articles; it is a testament to our collective vision for a greener, more sustainable future. Through insightful analysis and informed perspectives, we aim to provide you with a comprehensive understanding of the development of Green Hydrogen eco system in India.

Moreover, this booklet serves as a platform to highlight the pioneering Green Hydrogen projects already underway in India. These projects stand as testament to our nation's capacity for innovation and our unwavering commitment to a cleaner, brighter tomorrow.

I am confident that this booklet will prove to be a valuable resource for understanding the Indian initiatives for the development of Green Hydrogen in India. By fostering dialogue, sharing knowledge, and promoting collaboration, we can accelerate the adoption of Green Hydrogen and usher in a new era of sustainable development.

In closing, I extend my gratitude to the contributors, who have made this booklet possible. Together, let us strive towards a future powered by clean, renewable energy, where Green Hydrogen takes its rightful place at the forefront of our energy transition.

Warm regards,

FOREWORD

Somesh Kumar
Partner
Ernst & Young-LLP

The world stands at the crossroads of an energy revolution, where sustainability and innovation converge to create a future that is not only green but also economically vibrant. India, with its rich history of leadership in renewable energy, is at the forefront of this transformative journey. It is with great pleasure that I welcome you to this special issue of our booklet, where we explore the National Green Hydrogen Mission of India and the various initiatives that are propelling this mission toward success.

The National Green Hydrogen Mission of India represents a landmark effort to position India as a global leader in the production, use and export of Green Hydrogen (GH2) and its derivatives such as Green Ammonia and Green Methanol. By harnessing the power of renewable energy sources like solar and wind, green hydrogen has the potential to decarbonize industries, reduce reliance on fossil fuels, decrease import and contribute significantly to India's climate goals. This mission embodies the spirit of innovation and sustainable development, with a vision to create a robust green hydrogen economy that benefits industries, communities, and the environment.

The Ministry of New and Renewable Energy (MNRE), under Government of India plays a pivotal role in this endeavour, with various schemes designed to encourage the adoption of green hydrogen technologies. Through strategic incentives, infrastructure development, and policy frameworks, the ministry is laying the groundwork for a vibrant green hydrogen ecosystem. The schemes by MNRE are not just about promoting green hydrogen but also about fostering a culture of sustainability and clean energy that resonates across the nation.

We also delve into the initiatives undertaken by various government bodies and public-private partnerships, highlighting their collaborative efforts to make the green hydrogen mission a reality. From pilot projects that demonstrate the viability of green hydrogen in diverse applications to financing options that support its large-scale deployment, these initiatives showcase the commitment and creativity that drive India's green hydrogen vision forward.

Finally, we feature a selection of pilot projects that are leading the way in green hydrogen innovation. These projects, ranging from industrial applications to transportation and energy storage, demonstrate the versatility and potential of green hydrogen in transforming various sectors. They serve as beacons of progress, showcasing the tangible impact of India's green hydrogen mission.

We hope this booklet inspires you to learn more about the National Green Hydrogen Mission of India and the collective efforts driving its success. As we embark on this journey toward a greener, more sustainable future, let us remember that innovation and collaboration are the keys to unlocking the full potential of green hydrogen. Thank you for joining us, and enjoy the read.

Warm regards,

CONTENTS

ACRONYM

ADB	Asian Development Bank
AEM	Anion Exchange Membrane
BEE	Bureau of Energy Efficiency
BIS	Bureau of Indian Standards
BESS	Battery Energy Storage System
BoP	Balance of Plant
BOS	Balance Of Systems
CCUS	Carbon, Capture, Utilisation and Storage
CEA	Central Electricity Authority
CERC	Central Electricity Regulatory Commission
COP	Conference of Parties
CSP	Concentrated Solar Photovoltaic
DC	Direct Current
DISCOM	Distribution Companies
ECIU	Energy & Climate Intelligence Unit
EG	Empowered Group
EPC	Engineering, Procurement and Construction
ESG	Environmental, Social and Governance
ETS	Emission trading system
EU	European Union
EV	Electric Vehicle
EOUs	Export Oriented Units
FCEV	Fuel Cell Electric Vehicle
GA/GNH3	Green Ammonia
GB	Green Bonds
GCF	Green Climate Fund
GDP	Gross Domestic Product
GHG	Greenhouse Gas emissions
GH2	Green Hydrogen
GoI	Government of India
GW	Gigawatt
IPCC	Intergovernmental Panel on Climate Change
IREDA	Indian Renewable Energy Development Agency
IRENA	International Renewable Energy Agency
ISTS	Inter State Transmission Systems
LCoH	Levelised Cost of Hydrogen

KTPA	Kilo Tonnes per Annum
LiFE	Lifestyle for Environment
MNRE	Ministry of New and Renewable Energy
MoP	Ministry of Power
MoEFCC	Ministry of Environment, Forest and Climate Change
MMTPA	Million Metric Tonnes Per Annum
MTCO2e	Million Tonnes of Carbon Dioxide equivalent
MW	Mega Watt
NDCs	Nationally Determined Contributions
NGHM	National Green Hydrogen Mission
NISE	National Institute of Solar Energy
PEM	Proton Exchange Membrane
PLI	Production linked Incentive
PHS	Pumped Hydro Storage Plant
PV	Photovoltaics
RE	Renewable Energy
REC	Renewable Energy Certificates
RPO	Renewable Purchase Obligation
RCS	Regulations, Codes and Standards
RfS	Request for Selection
RTC	Round The Clock
SECI	Solar Energy Corporation of India
SEZs	Special Economic Zones
SHP	Small Hydro Power
SHIP	Strategic Hydrogen Innovation Partnership
SIGHT	Strategic Intervention for Green Hydrogen Transition
SPV	Special Purpose Vehicles
UAE	United Arab Emirates
UNFCC	United Nations Framework for Climate Change
WB	World Bank
WRI	World Resources Institute

INDIA'S "PANCHAMRIT" TO ACHIEVE NET-ZERO

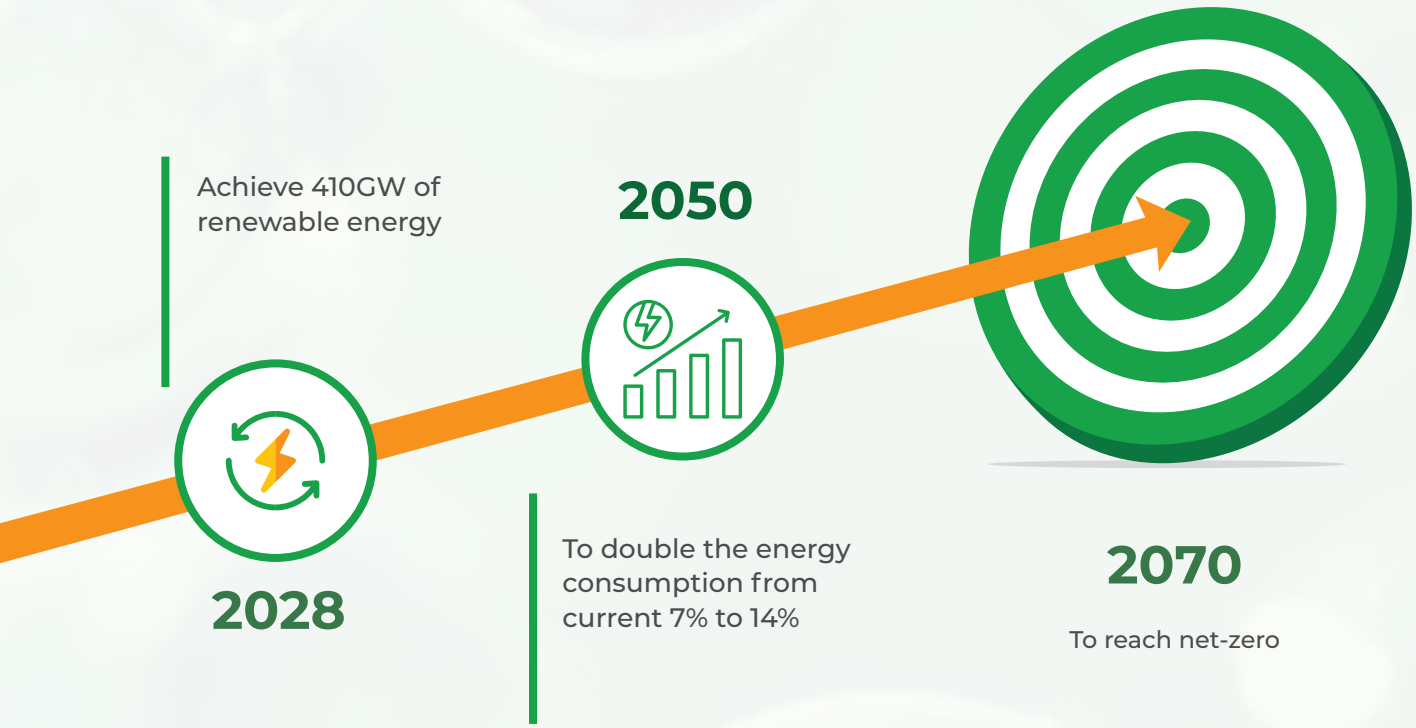
Ranks in top 5 globally to add renewable energy

2023

Crossed the mark of 175GW of renewable energy

Increase the energy mix from existing 42% to 61% by end of the current decade

1. Raising the non-fossil fuel-based energy capacity of the country to 500 GW by 2030.
2. Half of the energy requirements of the country would be met using renewable energy sources by 2030.



Source: MNRE

3. Reduce one billion tons of carbon emission by 2030.
4. The carbon intensity would be reduced to less than 45% by 2030.
5. By 2070, India would become carbon neutral and achieve net zero emissions.

PRIME MINISTER'S SPEECH AT COP-26

'India has delivered Paris commitments in letter and spirit', said Mr. Narendra Modi

Friends,Today I am representing amid you, the land which gave this mantra thousands of years ago-

सम्-गच्छ-ध्वम्, (Let's move together)

सम्-व-दद्वम्, (Let's all interact together)

सम् वो मानसि जानताम्। (Everyone's minds should also be one)

Friends,

When I first came to Paris for the Climate Summit, it was not my intention to add one promise to the many promises already being made in the world. I came with a concern for the humanity. I came as a representative of a culture that gave the message of '**Sarve Bhavantu Sukhinah**', which means "Happiness for All" and so, for me the event in Paris was not a summit, it was a sentiment and a commitment. And India was not making those promises to the world, but 125 crore Indians were making those promises to themselves.

And I am happy that a developing country like India, which is working to lift crores of people out of poverty, and which is working day and night on the Ease of Living for crores of people, today, despite being 17 % of the world's population, whose responsibility has been only 5 percent in emissions, it has left no stone unturned to show that it has fulfilled its obligation.

Today the whole world believes that India is the only big economy which has delivered in letter and spirit on the Paris Commitment. We are making every effort with determination; and we are working hard and showing results.

Friends,

Today, as I come among you, I have brought India's track record. My words are not just words; they are announcements of a bright future for our future generations. Today, India ranks 4th in the world in installed renewable energy capacity. India's non-fossil fuel energy has increased by more than 25% in the last 7 years and now it has reached 40% of our energy mix.

Friends,

Every year more passengers travel by Indian Railways than the population of the world. This huge railway system has set a target of making itself 'Net Zero' by 2030.This initiative alone will lead to a reduction of emissions by 60 million tonnes annually. Similarly, our massive LED bulb campaign is reducing emissions by 40 million tonnes annually. Today, India is working at a faster pace on many such initiatives with a strong will.

Along with this, India has also given institutional solutions to cooperate with the world at the international level. As a revolutionary step in solar power, we initiated the initiative of International Solar Alliance. We have created a coalition for disaster resilient infrastructure for climate adaptation. This is a sensitive and vital initiative to save millions of lives.

Friends,

I would like to draw your attention to one more important topic. Today, the world admits that lifestyle has a big role in climate change. So, I propose before you a One-Word Movement.

This One-Word , in the context of climate, can become the basic foundation of One World. This word is LiFE - Lifestyle For Environment. Today, there is a need for all of us to come together and take LiFE forward as a campaign.

This can become a mass movement of environmental conscious lifestyle. What is needed today is mindful and deliberate utilization, instead of mindless and destructive consumption. These movements together can set goals that can revolutionise many sectors in diverse areas such as Fishing, Agriculture, Wellness, Dietary Choices, Packaging, Housing, Hospitality, Tourism, Clothing, Fashion, Water Management and Energy.

These are subjects where each of us should make conscious choice every day. These choices exercised by billions of people daily around the world, will take the fight against climate change, billions of steps forward every day. And I consider it as a movement on all grounds like on economic grounds, on scientific grounds, on the basis of the experiences of the past century, it meets every criterion. This is the path of self-realization. This is the only way to benefit.

Friends,

In the midst of this global brainstorming on climate change, on behalf of India, I would like to present five nectar elements, 'Panchamrit', to deal with this challenge.

- **First:** India will take its non-fossil energy capacity to 500 GW by 2030.
- **Second:** India will meet 50 percent of its energy requirements from renewable energy by 2030.
- **Third:** India will reduce the total projected carbon emissions by one billion tonnes from now till 2030.
- **Fourth:** By 2030, India will reduce the carbon intensity of its economy by more than 45 percent.
- **Fifth:** by the year 2070, India will achieve the target of Net Zero.

These '**Panchamrits**' will be an unprecedented contribution of India to climate action.

(The above is few lines from the Speech at COP 26 , Glasgow .The original speech was delivered in Hindi. The translation for the same has been taken from PIB.)

CHAPTER

1

EXECUTIVE SUMMARY

COP 26 has given the birth to "Green Hydrogen" for enabling India's journey towards net zero by 2070.

Only a targeted approach towards **Green Hydrogen eco system** can enable India's energy transition, while supporting its growing energy needs. India has set a target to achieve net zero by 2070 at the United Nations Climate Change Conference in Glasgow (COP26), held in 2021.

Green Hydrogen is the key to help meet India's energy security needs while reducing emissions in hard-to-abate sectors such as Steel, fertilizers, Refinery, Cement & Mobility, on the path to Net-Zero. Indian government launched the 'National Green Hydrogen Mission' in early 2023.

Today, most of the country's hydrogen supply is grey hydrogen, which is produced using fossil fuels in a process that creates CO2 gas emissions. The **National Green Hydrogen Mission** has set a target to produce 5 MMTPA of Green Hydrogen by 2030.

Fortunately, India has a high potential in terms of renewable energy, which can support its goals for Green Hydrogen growth but needs rapid capacity addition. Government has released multiple of PLI schemes to encourage capacity addition of Renewable Energy in every sectors such as Solar, On Shore Wind, Offshore wind, Biomass, Hydro, & Pumped Storage, along with BESS for storage to provide RTC (Round the Clock) renewable energy requirement for Green Hydrogen sector. Pilot projects schemes have already been launched for use of hydrogen in Steel, Shipping and Mobility sector and several other are in pipeline.

Chapter 2: The Foundation - Renewable Energy

This chapter lays the groundwork by examining the crucial role of Renewable Energy sources in powering the production of Green Hydrogen. It explores the current state of renewable energy deployment, analyses ongoing technological advancements, and discusses the challenges associated with large-scale integration.

Chapter 3: Green Hydrogen - The Clean Energy Carrier

The chapter dives deep into Green Hydrogen, explaining the Green Hydrogen value chain. It covers Green Hydrogen standard, National Green Hydrogen Mission , other initiatives by Ministry of New and Renewable Energy towards achieving the goals of NGHM.

Chapter 4: Enabling Policies and Regulations

Recognizing the importance of supportive policies, this chapter explores the role of government initiatives in fostering the development and adoption of Green Hydrogen. It analyses various policy instruments, including feed-in tariffs, carbon pricing mechanisms, and regulatory frameworks aimed at creating a conducive environment for Green Hydrogen production and utilization.

Chapter 5: Financing Green Hydrogen - Bridging the Gap

Financing Green Hydrogen projects often requires innovative approaches due to their initial capital-intensive nature. This chapter examines various financing options, including public-private partnerships, green bonds, and innovative financial instruments designed to bridge the investment gap and accelerate the growth of the Green Hydrogen sector.

Chapter 6: Pilot Projects - Leading the Way

Showcasing the real-world implementation of Green Hydrogen, this chapter explores ongoing pilot projects across different sectors and geographies, thereby providing valuable insights for future large-scale deployment.

This booklet aims to equip readers with a comprehensive understanding of Green Hydrogen, its potential, and the key factors governing its successful adoption in India. By analysing the various facets of this clean energy carrier, the booklet contributes to the ongoing dialogue on achieving a sustainable and carbon-neutral future.

CHAPTER

2

RENEWABLE ENERGY IN INDIA

2.1 Role

Renewable Energy is the key ingredient that makes hydrogen production truly green, without which hydrogen would still rely on fossil fuels, defeating the purpose of this clean energy alternative.

The standard issued by the Ministry of New and Renewable Energy (MNRE), Government of India outlines the emission thresholds that must be met for hydrogen produced to be classified as 'Green', i.e., from Renewable Sources.

"Green Hydrogen" shall mean hydrogen produced using renewable energy, including, but not limited to, production through electrolysis or conversion of biomass. Renewable energy also includes such electricity generated from renewable sources which is stored in an energy storage system or banked with the grid in accordance with applicable regulations.

Renewable Energy Sources

- **Solar**
- **Wind**
- **Hydro**
- **Pumped Storage**
- **Tidal**
- **Biomass**

2.2 Requirement

To achieve its target of 5 MMT of Green Hydrogen production, India will need 125 GW of Renewable Energy, by 2030. This requirement can be mainly fulfilled through Solar, Wind, and Pumped Storage. India is on spree to enhance the installation of Renewable Energy to 500 GW by 2030, to achieve its goal. Several tenders have been floated for offshore wind and Pumped Storage projects. Solar plants have gained a huge momentum from last 10 years and is on the rising trend, thanks to the initiatives by SECI in accelerating the growth of Solar in India. Even Concentrated Solar Power (CSP) is being thought of to add to the capacity at minimum possible operating cost of generation. Several Pumped Storage projects have been announced by companies like Tata, JSW, Torrent & others in last few months.

2.3 India's Progress in RE

2.3.1 Current Status

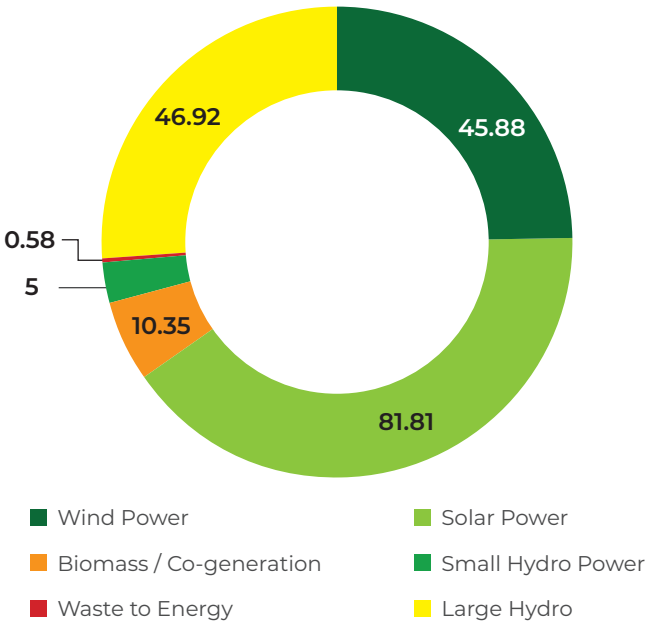
Globally, India stands 4th in Renewable Energy Installed capacity (including Large Hydro), 4th in Wind Power capacity & 5th in Solar Power capacity (as per REN21 Renewables 2022 Global Status Report). The country has set an enhanced target of 500 GW of non-fossil fuel-based energy by 2030, at the COP26. This has been a key pledge under the Panchamrit and is the world's largest expansion plan in Renewable Energy. India's installed non-fossil fuel capacity has increased to 396% in the last 9 years.

INDIA ON THE TOP

- **4th globally for total Renewable Power capacity additions.**
- **4th in Wind Power Capacity and**
- **5th in Solar Power Capacity globally.**
- **India assumed the presidency of the 13th Assembly of the International Renewable Energy Agency (IRENA)**

As of Mar 2024, Renewable Energy sources, including large hydropower, have a combined installed capacity of 190.57 GW. The following is the installed capacity for Renewables:

RE Capacity installed as of March 2024 (GW)



2.3.2 Progress

India saw the highest year-on-year growth in Renewable Energy additions of 9.83% in 2022. The installed Renewable Energy capacity (including large hydro) has increased by around 128% since 2014.

- **Solar**

  The installed solar energy capacity has increased by more than 30 times in the last 9 years and stands at 88 GW as of 31 March 2024. India's solar energy potential is estimated to be 748 GWp as estimated by National Institute of Solar Energy (NISE).

- **Wind**

  A study was conducted by the National Institute of Wind Energy to assess the wind power potential of the country at a height of 150 Meters. The potential now assessed for onshore projects is 1,163 GW. However, the potential sites having high Capacity Utilization Factor (CUF) of 36% and above (which is necessary for financial viability of the project) is 163 GW. India has already utilized sites of total capacity of 42 GW and now a balance 120 GW would be available for new development.

- **Offshore Wind Energy**

  India is blessed with a coastline of about 7600 km (Mainland) surrounded by water on three sides and has good potential for offshore wind energy generation. Initial assessment of offshore wind energy potential within the identified zones has been estimated to be about 70 GW off the coast of Gujarat and Tamil Nadu.

  A revised strategy for development of offshore wind energy projects has been issued in September 2023, indicating a bidding trajectory for installation of 37 GW capacity of Off-shore Wind Energy. Further, Central Transmission Utility has completed the planning of required transmission infrastructure for offshore wind projects for initial 10 GW offshore capacity (5 GW each off Gujarat and Tamil Nadu coasts).

- **National Green Hydrogen Mission**

  The Union Cabinet approved the National Green Hydrogen Mission with a total initial outlay of INR 19,744 Cr, including an outlay of INR 17,490 Cr for the SIGHT programme, INR 1,466 Cr for pilot projects, INR 400 Cr for R&D, and INR 388 Cr towards other Mission components.

Target - 2030

- Reduction of the carbon intensity of the economy by 45% by 2030, over 2005 levels.
- 50% of its energy requirements from renewable energy by 2030.
- 500GW Non-fossil energy capacity by 2030.
- Reduction of total projected carbon emissions by one (01) billion tonnes from 2023 to 2030.
- Five (05) million tonnes of annual production capacity of Green Hydrogen by 2030, supported by 125 GW of renewable energy.
- 50 Solar Parks with an aggregate capacity of 37.49 GW.
- Wind Energy has an offshore target of 30 GW by 2030
- 26.7 GW of Pumped Storage requirement by 2032
- 47.2 GW of BESS requirement by 2032

- **Wind-Solar Hybrid Policy**

  In 2018, National Policy was announced to promote an extensive grid-connected Wind-Solar PV hybrid system for efficiently utilizing transmission infrastructure and land. A way to address the intermittency challenge of one renewable power source is to combine solar and wind, achieving better grid stability. It provides flexibility in a share of wind and solar components in the hybrid project; however, the capacity of one resource must be at least 25% of the rated power capacity of other resources.

  The cost of Solar and Wind Power has significantly declined. Solar, for instance, has become cheaper than coal-based power in most regions. This economic advantage makes renewable energy an attractive choice for power generation companies and consumers alike.

2.4 Government Policies and Initiatives

Ambitious Targets: The Indian government has set ambitious Renewable Energy targets, aiming for a significant portion of the country's energy mix to come from clean sources.

Supportive Schemes: Policy initiatives like the Production Linked Incentive (PLI) Scheme offer financial incentives for manufacturing & promoting domestic production of Renewable Energy equipment . The National Green Hydrogen Mission further strengthens this focus on clean energy solutions.

i. PLI scheme in Solar PV manufacturing with financial outlays of INR 24,000 Cr was introduced under AatmaNirbhar Bharat, along with imposition of Basic Customs Duty of 25% on Solar Cell & 40% on Solar PV Modules w.e.f. 01.04.2022.

ii. Various waivers like Inter State Transmission Charges and other beneficial discom policies for Green Energy transmission were introduced.

Renewable Purchase Obligation (RPO): Government of India has notified the Renewable Purchase Obligation (RPO) targets for designated consumers up to March 2030 under the Energy Conservation Act, 2001

The minimum share of Renewable Energy is set to progressively increase over the years. In 2024-25, 29.91% of the total energy must come from renewable energy sources. This will gradually rise to 43.33% in 2029-30.

Separate RPO for 'Distributed Renewable Energy (DRE)' has been introduced.

The new trajectory represents a significant step towards a greener and more sustainable energy landscape and will help entities in long-term planning.

Year	Wind RPO	HPO	Other RPO	Total RPO
2024-25	3.36%	1.08%	26.37%	29.91%
2025-26	3.36%	1.48%	28.17%	33.01%
2026-27	4.29%	1.80%	29.17%	35.95%
2027-28	5.23%	2.15%	31.43%	38.81%
2028-29	6.61%	2.51%	32.69%	41.36%
2029-30	6.94%	2.82%	33.57%	43.33%

These drivers are expected to continue propelling India's Renewable Energy sector forward. As costs decrease further, technologies become even more efficient, and the government maintains its focus on clean energy goals, India is well-positioned to become a global renewable energy powerhouse.

CHAPTER

3

GREEN HYDROGEN-
THE CLEAN ENERGY CARRIER

Hydrogen is a versatile source of energy that can contribute to decarbonisation of global economy if produced using low-carbon emitting sources. The Government of India is inclining towards Hydrogen as a future fuel and feedstock. The objective of this chapter is to bring insights from global hydrogen ecosystem, their key challenges and recommendations for India.

Hydrogen – the missing link: It has been realized that hydrogen will act as a critical enabler to achieve the global targets to limit the increase in temperature to 1.5-degree Celsius, adapt to adverse impacts of climate change and fostering low greenhouse gas emissions development. In 2020, there was an inescapable excitement around hydrogen. Globally, countries are proposing ambitious targets, pilot projects and huge number of investments towards creating hydrogen ecosystem.

Exhibit 1: Global initiative towards Hydrogen economy

~ US$10.2t
Expected Global Investment until 2050

~ 30 countries
Announced National Hydrogen Mission Plan

~ 250 cities
Targets for 100% Renewable energy

~ US$70b
Government support to transition to hydrogen

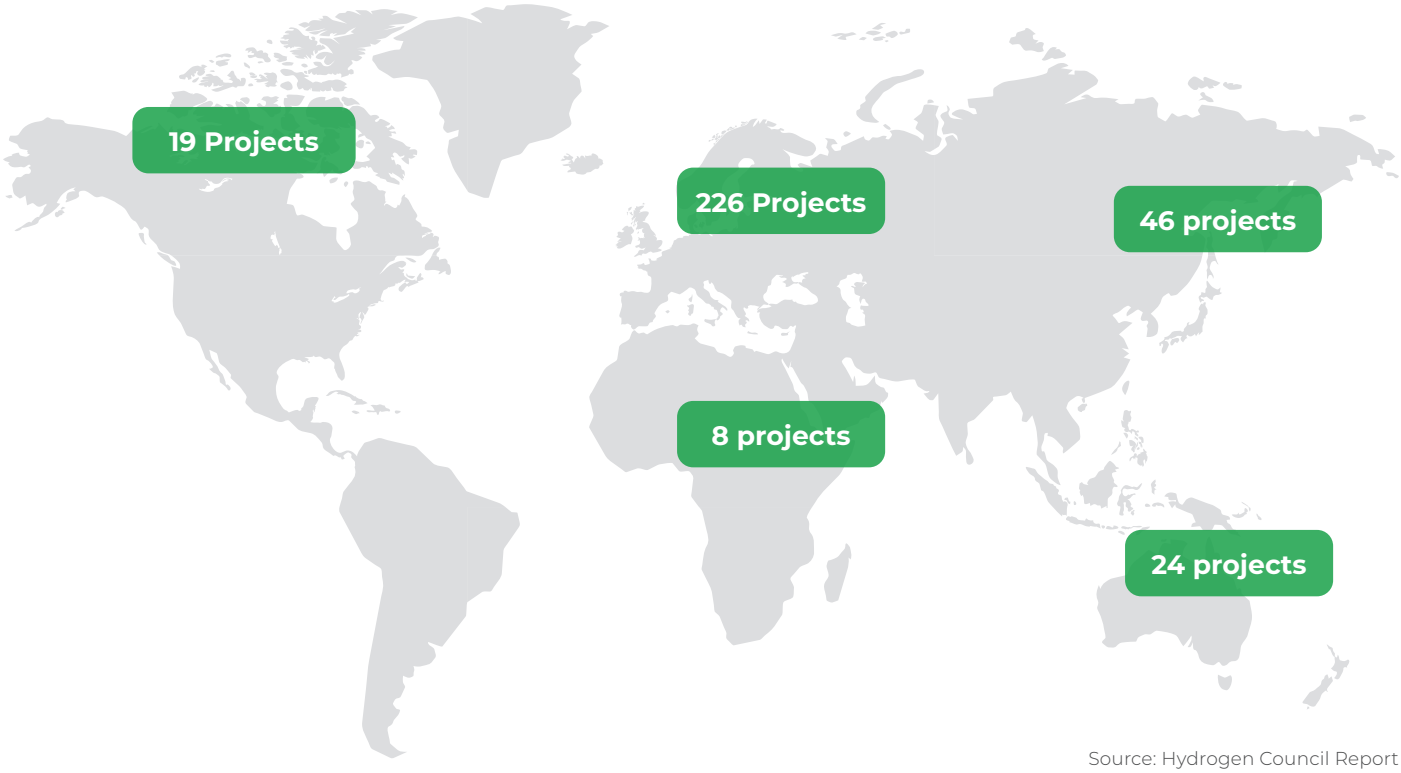
~ 20 countries
Announced sales ban on ICE vehicles before 2035

~ US$2.5t
Expected Global Investment until 2050

~ 114 countries
Countries have or plan to set targets for cutting emission

Source: Hydrogen Council Report

Exhibit 2: Global Hydrogen Projects



Source: Hydrogen Council Report

Growing hydrogen momentum: why now?

Decarbonisation targets: Under the Paris agreement, countries have pledged to reduce national emissions and impact of climate change through "Nationally Determined Contributions (NDCs)" targets. However, to meet such ambitions targets, countries will have to install large number of Renewable Energy systems. It is also essential to find an alternative fuel for applications where direct electrification is not feasible. Hence, hydrogen could be a viable fuel with huge potential to achieve global decarbonisation targets.

A complementary solution to Renewable Energy: Renewable Energy technologies have witnesses tremendous growth both in terms of technical and financial feasibility. It is required to store and utilize excessive energy produced during generation hours. Hydrogen can be the missing piece to complement Renewable Energy systems.

Supporting grid load management via storage solutions: The grid load requirements and better grid resiliency due to increasing Distributed Renewable Energy installations can be managed with Green Hydrogen based energy storage system.

Decarbonisation of hard-to-abate sector: Hydrogen is a potential fuel and feedstock to reduce carbon intensities of sectors such as transportation, industrial and residential applications.

Technological advancement: There is a significant improvement in the efficiency of electrolyser and fuel cells technologies.

Falling technology cost: The cost of hydrogen produced from the electrolysis has fallen by ~ 60% since 2010. Also, the price of Fuel Cell Electric Vehicles (FCEV) has declined by ~ 65% over the past 10 years.

Why is India betting big on hydrogen?

Energy security: The global pandemic has taught the nations to diversify their energy demand as well as their geographical availability. The fluctuations in the oil & gas market have disrupted supply-demand chain and causes variation in the fuel cost. Developing countries like India need to find out an alternative to strengthen its National Energy Security.

Emission targets: India is the third largest global CO2 emitter (~7% of global CO2 emission) well below China & United States. Earlier, it was committed to reduce its emissions intensity by 33-35% under the Paris Agreement which has been revised to 45% by 2030.

Economic dependencies & balance of trade: India is the world's third largest crude oil importer with an import dependency of over 80%. It also imports 54% of natural gas and 24% of coal requirements which largely affects India's financial account balance. India's oil import bill in FY20 and FY19 was approx. US$101.4 billion and US$111.9 billion, respectively.

Energy Subsidies: Along with the high cost of imported fuel, India gives away overall energy subsidies of approx. US$30 bn / year on Oil & Gas, Coal, Transmission & Distribution, Renewable Energy and Electric Vehicles. Some proportion of these subsidies can be diverted for the development of hydrogen ecosystem.

Hence, India can grab this early opportunity to capture entire value chain of hydrogen and look out for global exports

Exhibit 3: Type of Hydrogen

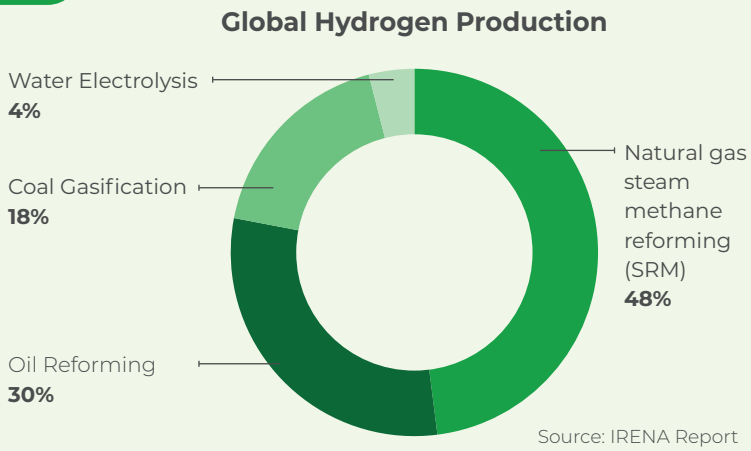
Colour						
Type	Black/Brown Hydrogen	Grey Hydrogen	Blue Hydrogen	Turquise Hydrogen	Pink Hydrogen	Green Hydrogen
Process	Coal Gasification	Methane Reformation	Coal Gasification &Methane Reformation with CCUS	Pyrolysis	Electrolysis	Electrolysis/ Biomass Gasification
Source	Coal	Natural Gas	Fossil Fuel	Methane	Nuclear Energy	Renewable Energy

INSIGHTS

- Hydrogen can be obtained from fossil fuels, biomass, as well as a combination of water & renewables.
- Natural gas is now the most common source of hydrogen generation, accounting for roughly three-quarters of the total dedicated hydrogen production of around 70 million tonnes per year.
- Currently, most of the world's hydrogen is being produced from natural gas and coal. When hydrogen is produced using renewable energy sources, it is termed as Green Hydrogen. Water electrolysis is most matured technology to produce Green Hydrogen.

Exhibit 4: Global hydrogen production

Hydrogen can be produced using different technologies, but sustainable production technologies will create future possibilities of adoption and scale. Today, hydrogen is mainly produced from fossil fuels such as coal & natural gas. However, it can be generated from various feedstocks. The cost of hydrogen, market-competitiveness and market-timeframe is affected by location of production technology and its volume of production



Source: IRENA Report

3.1 Green Hydrogen Value Chain

The specific energy of hydrogen is between 120-140 MJ per kg while that of diesel and gasoline fuel is between 30-45 MJ per kg. Therefore, hydrogen specific energy is around 3X to 4X times higher than gasoline and diesel fuels.

Similarly, specific energy of hydrogen is around 30X to 90X times higher than batteries. Also, diesel and gasoline emit approx. 75-85 g CO2 per MJ of energy produced along with other harmful substances such as nitrogen oxides, hydrocarbons and particulate matter. Whereas hydrogen only emits water as a by-product.

Although Hydrogen is not a new concept as energy carrier, Green Hydrogen has gained momentum for its contribution towards decarbonisation. Green Hydrogen , although a colorless gas, has got its name as green due to the low emission of green house gas , during its production process, including the emission associated with the production of energy it consumes. The **FOUR** pillars of Green Hydrogen Value Chain is depicted as follows:

1 PRODUCTION & TECHNOLOGY

Green Hydrogen refers to hydrogen produced through electrolysis, which splits water molecules (H2O) into hydrogen (H2) and oxygen (O2) using electricity generated from renewable sources like solar, wind, or hydro.

Electrolysis is the heart of the production process, several developments are taking place, through R&D, focussing on efficiency,life and cost of the electrolyser stack.

Popular Technology -
Alkaline electrolyser, PEM, SOEC, AEM

2 STORAGE & TRANSPORTATION

Green Hydrogen's potential as a clean energy carrier, hinges upon efficient storage and transportation solutions

Storage Methods

- Compressed Gas Storage
- Liquefied Hydrogen Storage
- Solid-State Hydrogen Storage (Hydrides)

Transportation Methods

- Pipelines
- Road Transport
- Ships

Challenges

- Energy Efficiency
- Cost Reduction
- Safety Concerns

3 APPLICATIONS

Green Hydrogen boasts a remarkable versatility, making it a potential game-changer across various sectors.

- Fuel Cell Electric Vehicles (FCEVs)
- Aviation and Maritime
- Industry
  - Fertilizer
  - Refinery
  - Steel
  - Transport (Road, Rail)
  - Shipping
  - Power Generation

4 ASSOCIATED ASPECTS

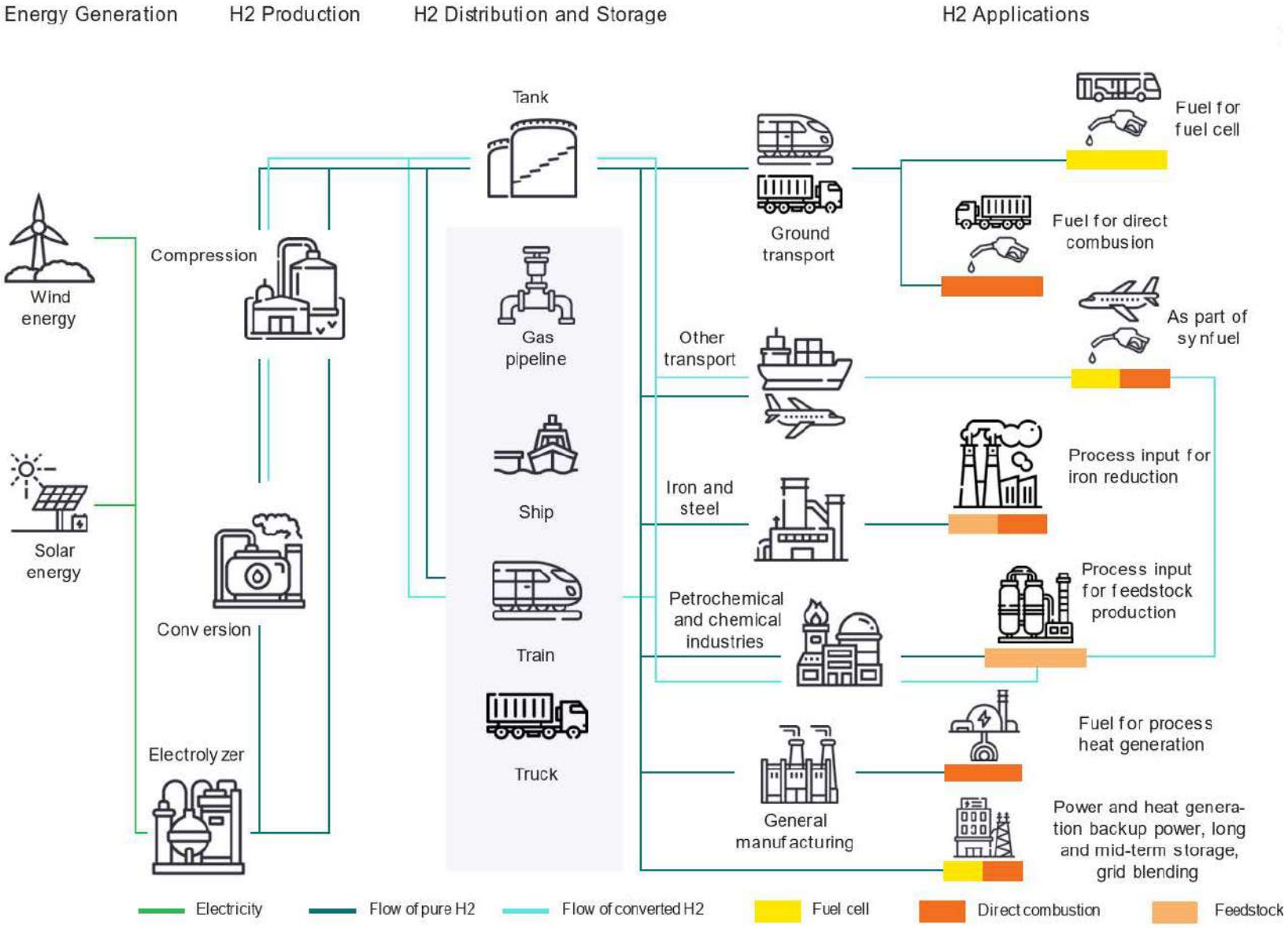
In the overall Green Hydrogen value Chain , the role of Regulations, Codes and Standards is vital for Safety of Equipment and Human Life and to have the product of quality acceptable for end use. Several Aspects includes

- Renewable Energy
- Water Quality
- Standards
  - Safety
  - Equipment Quality
  - Product (GH2) Quality

An overview of hydrogen ecosystem

Looking at hydrogen's low-carbon energy portfolio, it has a potential to decarbonize hard-to-abate sectors such as industry, transport and buildings.

Exhibit 5: Hydrogen ecosystem



3.2 India's Potential as World Leader in Green Hydrogen

Green Hydrogen has enormous potential to decarbonise several industrial sectors like mobility, steel, refinery, petrochemicals, fertilizer, reduce carbon emissions and achieve energy independence. The Green Hydrogen production capacity in India is projected to reach 5 MMTPA, reducing the reliance on import of fossil fuels and curtailing the cumulative imports of fossil fuels worth INR 1 trillion (US$12.03 billion) by 2030.

India has a huge potential to become the world leader in Green Hydrogen. India's target is not only to meet its power demand but to become an exporter of Green Hydrogen in the world.

The factors contributing towards the India's aim to become the world leader are mainly:

1. **Availability of abundant and cheap Renewable Power**
2. **Legislative Support**
3. **Grid Stability**
4. **Coastline and ports**
5. **Engineering, Procurement & Construction capability**

The current renewable installed capacity of India and the vision to establish 500 GW by 2030, in terms of Solar, Wind (both Onshore & offshore), Pumped Hydro Storage, Hydro Power Plants and BESS will support to achieve the National Green Hydrogen Mission of India. India's geographical location near the equator ensures ample sunlight throughout the year (Solar irradiance of 4-7 kWh/m2/day). Vast availability of land particularly in the Thar Desert of Rajasthan and Gujarat, receive very high solar irradiance. Many regions experience long periods of clear skies (clear bright days is around 250-300, with a total of 2300-3200 sunshine hours per year) optimizing solar power generation. Continuously declining costs of solar panels make solar-powered Green Hydrogen increasingly cost-competitive.

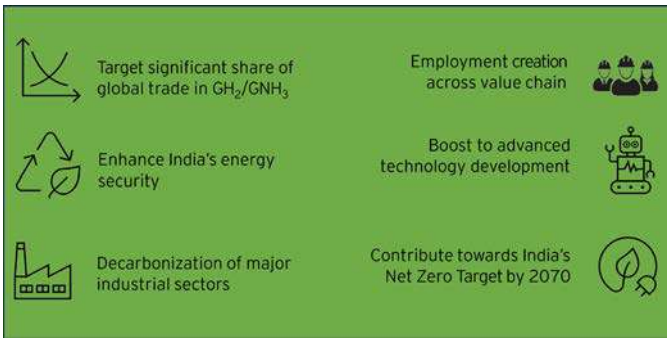
India has a long coastline and various regions with substantial wind resources, providing another avenue for renewable energy to power Green Hydrogen production. Especially southern & western part of India like Tamil Nadu, Karnataka, Gujarat, Maharashtra, Rajasthan experiences significant wind potential due to specific geographical features like wind corridors, where strong and consistent wind speeds prevail, offering ideal locations for wind power generation Continued advancements in wind turbine technology, including larger and more efficient models, can further improve the cost-effectiveness of wind-powered Green Hydrogen production.

India has c (PHS), which acts like a large-scale "water battery", storing excess energy from renewable sources (like solar and wind) during off-peak hours and releasing it back during high demand, contributing towards RTC (Round The Clock) availability of Renewable Energy for Green Hydrogen production. Several Projects have been announced (by companies like Tata, Jindal, Greenko, Torrent, etc) to enhance the capacity of PHS to support the RTC availability of Renewable Energy.

National Electricity Plan 2022 has estimated the need for 18.8GW of PHS by 2032. Along with PHS, BESS is being developed on large scale to enable the availability of renewable energy on RTC basis. On 28th February 2024, Solar Energy Corporation of India Limited (SECI) has commissioned India's largest Battery Energy Storage System (BESS) with an installed capacity of 152.32 MWh and dispatchable capacity of 100 MW AC (155.02 MWp DC) Solar Photovoltaic plant with 40 MW/120 MWh BESS in Rajnandgaon, in the state of Chhattisgarh in India.

Grid Stability is critical for Green Hydrogen generation. India has one of the largest synchronous grids in the world, capable of handling intermittent renewable energy and it has achieved 'One Nation-One Grid-One Frequency'. Electrolyser, the core equipment for Green Hydrogen production, require a consistent and stable power supply to operate efficiently and prevent damage. As Green Hydrogen is produced primarily from renewables, fluctuations in solar and wind generation can disrupt production unless the grid is managed effectively. Due to high base load power along with the renewables, the national grid (the electricity Grid of India) is very stable to serve the developers with the renewable energy, supporting production of Green Hydrogen & its derivatives. The various policies of the Government of India like waiver of Inter State Transmission Charges (ISTS charges), faster connectivity and several favourable electricity policies by individual state governments, banking provisions, etc gives an upper hand towards the availability of cheap renewable power to the developers of the Green Hydrogen value chain.

National Green Hydrogen Mission is a visionary step by Government of India in the energy transition and will help in reducing India's dependency on fossil fuels resources. Mission aims to make India a Global Hub for Production, Utilization and Export of Green Hydrogen and its derivatives. The Mission will help India in decarbonisation towards its goal of Net-Zero and become energy Independent. Several steps have been taken till date in terms of Production linked incentive (PLI) schemes to produce electrolysers (Make in India Initiative) and Green Hydrogen. In January 2024, a total of 8 companies have been awarded the contract for establishment of electrolyser manufacturing (totalling 1500 MW) and 10 companies for production of Green Hydrogen (totalling 412 thousand Metric Tonness). Several schemes for Pilot projects under Shipping, Steel and Mobility has been announced to encourage participation form Industry.



Standards and Regulations have been released and under development to ensure quality and safety of the Green Hydrogen ecosystem. Emerging favourable regulations around production, storage, and use of Green Hydrogen streamline processes and reduce costs for developers

All concerned Ministries, Departments, Agencies, and Institutions of the Central and State Governments has undertaken a focussed and coordinated steps to ensure successful achievement of the Mission objectives. Ministry of New & Renewable Energy (MNRE) is responsible for overall coordination and implementation of the Mission.

India has the advantage of big coastline and availability of water along with several ports to facilitate the export of Green Hydrogen. These regions can support large scale production and/or utilization of Hydrogen has been identified and developed as Green Hydrogen Hubs. In the initial steps, three ports namely Deendayal (Kandla, Gujarat), Paradip (Odisha) and V.O. Chidambaranar (Tuticorin, Tamil Nadu) have been identified for the development of Green Hydrogen Hubs.

India possess a high talent pool of EPC (Engineering, Procurement and Construction) professionals for execution of large-scale Green Hydrogen projects. EPC companies play a crucial role in building infrastructure, driving industrialisation, and creating employment opportunities, contribute to indigenous technology development and innovation to meet India's evolving needs and drives demand for skilled engineers and technicians, promoting technical education and skill development in India.

India boasts a vast pool of skilled engineers, technicians, and project managers experienced in various sectors like energy, infrastructure, and industrial plants. Technical Education in India constitutes towards high skill capacity with numerous engineering colleges and technical institutes, creating a steady flow of skilled manpower into the EPC sector. Many Indian EPC companies have executed large-scale projects worldwide (global experience), gaining experience and expertise in international standards and best practices. Relatively lower labour costs compared to developed economies contribute to the cost-competitiveness of Indian EPC firms.

3.3 National Green Hydrogen Mission of India

India has set its sight on becoming energy independent by 2047 and achieving Net Zero by 2070. To achieve its goal and commitment, Government of India has recognised the critical role of Green Hydrogen. India, with its vast renewable energy resources, also could produce Green Hydrogen for the world. India currently imports over 40% of its primary energy requirements, worth over USD 90 billion every year. Major sectors like mobility and industrial production are significantly dependent on imported fossil fuels. Many major economies have declared Hydrogen strategies as part of the broader climate and clean energy related actions.

The National Green Hydrogen Mission aims to provide a comprehensive action plan for establishing a Green Hydrogen ecosystem and catalysing a systemic response to the opportunities and challenges of this sunrise sector. The Union Cabinet has approved National Green Hydrogen Mission on 4th of January 2023. The initial outlay for the Mission is Rs.19,744 crore, including an outlay of ₹ 17,490 crore for the SIGHT programme, ₹ 1,466 crore for pilot projects (₹ 455 crore up to 2029-30 for low carbon steel projects, ₹ 496 crore up to 2025-26 for mobility pilot projects, ₹ 115 crore up to 2025-26 for shipping pilot projects. ₹ 400 crore up to 2025-26 for Hubs and other projects) ₹ 400 crore for R&D, and ₹ 388 crore towards other Mission components.

MNRE has formulated the scheme guidelines for implementation of the respective components. The Mission will result in the following likely outcomes by 2030:

- Development of Green Hydrogen production capacity of at least 5 MMT (Million Metric Tonne) per annum
- Over Rs. Eight lakh crores in total investments
- Creation of over Six lakh jobs
- Cumulative reduction in fossil fuel imports over Rs. One lakh crore
- Abatement of nearly 50 MMT of annual greenhouse gas emissions

3.3.1 Mission Governance Structure:

An Empowered Group (EG) chaired by the Cabinet Secretary and comprising Secretaries of Government of India and experts from the industry will guide the Mission; an Advisory Group (AG) chaired by the Principal Scientific Advisor (PSA), GoI and comprising experts will advise the EG on scientific and technology matters; and a Mission Secretariat headquartered in MNRE will undertake the programme implementation.

3.3.2 Phased Approach

The mission is proposed to be implemented in a phased manner, focusing initially on deployment of Green Hydrogen in sectors that are already using hydrogen, and evolving an ecosystem for R&D, Regulations and Pilot projects. The later phase of the Mission will build on these foundational activities and undertake Green Hydrogen initiatives in new sectors of the economy. The major thrust areas of each phase are identified below.

A. Phase I (2022-23 TO 2025-26)

The focus of Phase I will be on creating demand while enabling adequate supply by increasing the domestic electrolyser manufacturing capacity. In order to ensure Make in India from the inception stage, a bouquet of incentives aimed at indigenisation of the value chain and increasing Green Hydrogen production and uptake is being developed. Utilisation in the refineries, fertilizers and city gas sectors will also create a sustained demand to support new investments in Green Hydrogen production. The first phase will also lay the foundation for future energy transitions in other hard to-abate sectors by creating the required Research and Development impetus.

In this phase, Pilot projects are being undertaken for initiating green transition in steel production, long-haul heavy-duty mobility and shipping. Parallelly, work will commence on establishing a framework of regulations and standards to facilitate the growth of the sector and enable harmonisation and engagement with international norms.

The scale up of Green Hydrogen production and use, and the proposed measures under the Mission in the first phase, are expected to drive down costs, allowing for greater and wider Green Hydrogen deployment in the next phase.

B. Phase II (2026-27 TO 2029-30)

Green Hydrogen costs are expected to become competitive with fossil-fuel based alternatives in refinery and fertilizer sector by the beginning of the second phase, allowing for accelerated growth in production. Depending upon the evolution of costs and market demand, the potential for taking up commercial scale Green Hydrogen based projects in steel, mobility and shipping sectors will be explored. At the same time, it is proposed to undertake pilot projects in other potential sectors like railways, aviation etc. R&D activities will be scaled up for continuous development of products. The second phase activities would enhance penetration across all potential sectors to drive deep decarbonisation of the economy.

3.3.3 Integrated Mission Strategy

Ministry of New and Renewable Energy (MNRE) will be responsible for overall coordination and implementation of the Mission. The Mission Secretariat, headquartered in MNRE, will formulate schemes and programmes for financial incentives to support production, utilization and export of Green Hydrogen and its derivatives. The Ministry will ensure planned deployment of Renewable Energy and Green Hydrogen capacities, support pilot and R&D projects, undertake capacity building and promote international cooperation efforts. The Ministry will also ensure holistic development of the Green Hydrogen ecosystem in the country through active coordination with various public and private entities responsible for other aspects of the mission. All concerned Ministries, Departments, Agencies and Institutions of the Central

and State Government will undertake focused and coordinated steps to ensure successful achievement of the Mission objectives.

3.3.4 Mission Components

The achievement of Mission objectives requires a comprehensive strategy that coordinates efforts across multiple sectors. The Mission strategy accordingly comprises interventions for:

(i) demand creation by making Green Hydrogen produced in India competitive for exports and through domestic consumption.

(ii) addressing supply side constraints through an incentive framework, and

(iii) building an enabling ecosystem to support scaling and development.

3.3.5 Strategic Interventions For Green Hydrogen Transition (SIGHT)

The Mission strategy include a comprehensive incentive programme to facilitate growth of Green Hydrogen industry value chain in the country. A wide ranging and expansive bouquet of financial incentives and non-financial measures are proposed under the Mission to encourage production of low-cost Green Hydrogen and domestic manufacturing of related equipment and technologies. Depending upon the markets and technology development, specific incentive schemes and programmes will continue to evolve as the Mission progresses.

At the initial stage, two distinct financial incentive mechanisms, targeted at support for domestic manufacturing of electrolysers, and production of Green Hydrogen has been developed. To ensure quality and performance of equipment, the eligibility criteria for participation in competitive bidding for procurement of Green Hydrogen and its derivatives will specify that the project must utilize equipment approved by Government of India as per specified quality and performance criteria.

It is expected that the proposed incentives and interventions under the program will significantly reduce the cost of Green Hydrogen, enabling its uptake in emerging sectors and ensure establishment of a domestic manufacturing ecosystem by de-risking first movers and providing viability support for early innovators in the sector till the production of Green Hydrogen and its derivatives achieves scale and sustainability.

3.3.6 Pilot Projects

For other hard to abate sectors, the Mission proposes pilot projects for replacing fossil fuels and fossil fuel-based feedstocks with Green Hydrogen and its derivatives. This includes sectors like steel, long-range heavy-duty mobility, energy storage and shipping etc. Pilot projects will help identify operational issues and gaps in terms of current technology readiness, regulations, implementation methodologies, infrastructure, and supply chains. These will serve as valuable inputs for future scaling commercial deployment. Their outcomes will also help in understanding technology integration pathways, ascertaining viability gaps and level of government incentives/ policy support required, if any. Accordingly, detailed implementation and performance data will be compiled from pilot projects to serve as inputs for future projects and programmes. Wherever feasible, a competitive selection process could be adopted for implementing pilot projects.

3.3.7 Green Hydrogen Hubs

Given the technical and logistical challenges inherent in transporting Hydrogen over long distances, a cluster-based production and utilisation model would enhance viability of Green Hydrogen projects in the initial years. This would, in turn, enable economies of scale and convergence of key infrastructure requirements in geographically proximate areas.

The Mission will accordingly identify and develop regions capable of supporting large scale production and/or utilization of Hydrogen as Green Hydrogen Hubs. Development of trunk infrastructure for such hubs will be supported under the Mission. Projects in the Hubs will be planned in an integrated manner to allow pooling of resources and achievement of scale. It is planned to set up at least two such Green Hydrogen hubs in the initial phase.

3.3.8 Key Enablers

In order to support affordable Green Hydrogen production, coordination across government departments and extension of maximum possible benefits under existing government policies will be required in a whole of government approach. MNRE will liaise and coordinate across multiple departments at the federal and state levels to facilitate a nurturing ecosystem for development of Green Hydrogen projects in the country.

To facilitate delivery of renewable power, various supportive policy provisions will be extended to Green Hydrogen projects. This shall include waiver of Interstate transmission charges for renewable energy used for Green Hydrogen production; facilitating Renewable Energy banking; water availability and time bound grant of Open Access and connectivity.

For this purpose, Government of India will undertake integrated planning and implementation of renewable energy capacities, transmission infrastructure, facilities for suitable banking of power, energy storage, and the associated power system projects.

Enabling Policy Framework

To facilitate delivery of renewable power, various supportive policy provisions will be extended to Green Hydrogen projects. This shall include waiver of Interstate transmission charges for renewable energy used for Green Hydrogen production; facilitating Renewable Energy banking; water availability and time bound grant of Open Access and connectivity.

For this purpose, Government of India will undertake integrated planning and implementation of renewable energy capacities, transmission infrastructure, facilities for suitable banking of power, energy storage, and the associated power system projects.

Infrastructure Development

The National Green Hydrogen Mission, which aims to accelerate the deployment of Green Hydrogen as a clean energy source, will support the development of supply chains that can efficiently transport and distribute hydrogen. This includes the use of pipelines, tankers, intermediate storage facilities, and last leg distribution networks for export as well as domestic consumption.

Regulations and Standards

The Mission will coordinate the various efforts for regulations and standards development in line with the industry requirements for emerging technologies. Work has commenced on establishing a framework of regulations and standards to facilitate growth of the sector and enable harmonization and engagement with international norms.

Research and Development

A public-private partnership framework for R&D (Strategic Hydrogen Innovation Partnership – SHIP) is being facilitated under the Mission. The framework entails creation of a dedicated R&D fund, with contributions from Industry and respective Government Institutions. These institutions will pool resources to build a comprehensive goal-oriented Research and Innovation programme in collaboration with the private sector.

Skill Development

A coordinated skill development programme, that covers requirements in various segments, is being undertaken in coordination with the Ministry of Skill Development & Entrepreneurship.

Other Components

Green Hydrogen is likely to play a critical role in India's energy transition, particularly in decarbonisation of hard to abate sectors. The National Green Hydrogen Mission is a step in this direction. The Mission is expected to

facilitate deployment of Green Hydrogen ecosystem and create opportunities for innovation and investments across the Green Hydrogen value chain, translating into investments, jobs and economic growth. The Government of India interventions will ignite the process and provide required impetus for unlocking the market potential in various sectors through cost reduction and economies of scale.

Full version of Mission document can be downloaded from the link https://mnre.gov.in/national-green-hydrogen-mission/

3.4 Green Hydrogen Standard for India

The Government of India released its Green Hydrogen Standard for India on 19th August 2023. The standard issued by the Ministry of New and Renewable Energy (MNRE), Government of India defines the emission thresholds that producers must meet for hydrogen produced to be classified as 'Green', i.e., from renewable sources. The standard applies to both Hydrogen produced through electrolysis and from biomass-based methods, ensuring a comprehensive framework for sustainable hydrogen production.

The Ministry of New and Renewable Energy (MNRE) established a definition for Green Hydrogen after consulting with various stakeholders. This definition specifies that well-to-gate emissions (i.e., including water treatment, electrolysis, gas purification, drying and compression of hydrogen) must be limited to not more than 2 kilograms of CO2 equivalent per kilogram of Hydrogen (kg CO2 eq/kg H2).

The notification emphasizes that the MNRE will define a specific methodology for tracking, reporting, and verifying Green Hydrogen production throughout its lifecycle. This methodology will include measuring emissions, monitoring compliance, and conducting on-site inspections for both Green Hydrogen and its derivatives, such as Ammonia or Methanol. Bureau of Energy Efficiency (BEE), Ministry of Power has been designated as the Nodal Authority responsible for accreditation of agencies to oversee the monitoring, verification, and certification processes for Green Hydrogen production projects.

3.5 Initiatives and Actions by Ministry of New and Renewable Energy (MNRE)

A. India's Green Hydrogen Push:

Green Hydrogen, produced through the electrolysis of water using Renewable Energy, stands as a pivotal solution for India's energy transition and decarbonisation goals. Recognizing this potential, the Ministry of New and Renewable Energy (MNRE) has undertaken several significant initiatives and actions to establish India as a leader in the Green Hydrogen sector.

B. The National Green Hydrogen Mission

At the forefront of India's Green Hydrogen drive is the National Green Hydrogen Mission. Launched in 2023, this ambitious mission targets the production of 5 million metric tonnes (MMT) of Green Hydrogen annually by 2030.

C. Strategic Interventions for Green Hydrogen Transition (SIGHT)

The SIGHT program, a key component of the Mission, emphasizes Research and Development to accelerate technological advancements in Green Hydrogen production. It supports Pilot projects, large-scale demonstrations, and collaborative research initiatives.

The scheme guidelines for SIGHT Mode 2A (aggregation model for Green Ammonia) and Mode 2B (aggregation model for Green Hydrogen) have been notified on 16th January 2024 and the current development is as below:

i **Electrolyser Manufacturing:** Providing incentives to boost domestic electrolyser manufacturing capacities, reducing reliance on imports.

- **Proposed outlay:** Rs. 4440 crores
- **Scheme Notification:** The Scheme guidelines for Electrolyser manufacturing Tranche-I was notified on 28th June 2023 and Tranche- II was notified on 16th March 2024.
- **Request for Selection (RfS):** Request for Selection (RfS) for the selection of Electrolyser Manufacturers (EM) for Setting up 1.5 GW annual Electrolyser Manufacturing Capacities under SIGHT Scheme Tranche-I was issued on 7th July 2023 and Tranche-II was issued on 16th March 2024
- **Receipt of bid under Tranche-I:** Bids submitted by 21 companies for establishment of an annual electrolyser manufacturing capacity of 3.4 gigawatts (GW).
  - 14 bids pertaining to manufacturing capacity of 2942 MW under Bucket-1
  - 7 bids pertaining to manufacturing capacity of 486 MW under Bucket -2

Award under Tranche-I: The tender for selection of Electrolyser Manufacturers (EM) for setting up manufacturing capacities for Electrolysers in India under SIGHT Scheme (Tranche-I), was awarded on 12th January 2024 to 8 companies for a total capacity of 1,500 MW per annum.

List of awarded Companies for electrolyser manufacturing are as under:

Award for Manufacturing of electrolyser under SIGHT scheme –Bucket 1

S. No.	Name of Bidder	Capacity (MW)	Type of electrolyser
1.	Reliance electrolyser Manufacturing Limited	300	Alkaline
2.	Ohmium Operations Private Limited	137	PEM
3.	John Cockerill Greenko Hydrogen Solutions Private Limited	300	Alkaline
4.	Advait Infratech Limited (consortium with Rajesh Power Service Private Limited)	100	Alkaline
5.	L&T Electrolyser Limited	300	Alkaline
6.	Matrix Gas and Renewables Limited	63	Alkaline
	Total	**1200**	

Award for Manufacturing of electrolyser under SIGHT scheme –Bucket 2

S. No.	Name of Bidder	Capacity (MW)	Type of electrolyser
1.	Homi hydrogen Private Limited	101.5	AMSE/Solid Oxide
2.	Adani New Industries Limited	198.5	Alkaline
	Total	**300**	

ii. **Green Hydrogen Production:** Offering incentives to Green Hydrogen producers, making it competitive with fossil-fuel-derived hydrogen.

- **Proposed outlay:** Rs. 13050 crores
- **Scheme Notification:** The Scheme guidelines for Green Hydrogen production Mode-I have been notified on 28th June 2023
- **Invitation of bid (RfS):** On July 10, 2023, state-owned SECI invited bids for selection of Green Hydrogen producers for setting up production facilities of 4,50,000 tonnes of Green Hydrogen under the SIGHT Scheme (Mode-1-Tranche-I).
- **Receipt of bid:** 14 companies showed interest for incentives for Green Hydrogen production, with a total capacity of 553,730 metric tons per annum. Details are as follows:
  - 13 bids pertain to a production capacity of 551,730 metric tonnes per annum under Bucket I (Technology Agnostic Pathways) and awarded to 9 companies as listed below.
  - One bid pertains to a production capacity of 2,000 metric tonnes per annum under Bucket II (Biomass-based Pathways).
- **Award (Tranche-1:Mode-1):** The tender for selection of Green Hydrogen Producers for setting up production facilities for Green Hydrogen in India under the Strategic Interventions for Green Hydrogen Transition (SIGHT) Scheme (Mode-1-Tranche-I), has been awarded on 9th January 2024 to 10 companies for a total capacity of 4,12,000 tons per annum.

List of awarded Companies for SIGHT Green Hydrogen production are as under:

Bucket-1 (Technology Agnostic Pathways)

S. No.	Name of Bidder	Production Capacity (MT/annum)
1.	UPL Limited	10000
2.	CESC Projects Limited	10500
3.	Reliance Green Hydrogen and Green Chemicals Limited	90000
4.	Welspun New Energy Limited	20000
5.	HHP Two Private Limited	75000
6.	Torrent Power Limited	18000
7.	ACME Cleantech Solutions Private Limited	90000
8.	Greenko ZeroC Private Limited	90000
9.	JSW Neo Energy Limited	6500
	Total	**4,10,000**

Bucket-2 (Biomass Based Pathways)

S. No.	Name of Bidder	Production Capacity (MT/annum)
1.	Bharat Petroleum Corporation Limited	2000
	Total	**2,000**

D. Notification of Scheme Guidelines

To support the mission, MNRE has launched several guidelines for different sectors. This include Pilot projects, Hydrogen hubs, R & D and Skill development. However, Schemes on Regulation, code & standards, testing, certification etc. are under development.

Pilot Projects

- **Shipping Sector**
  1. **Budgetary Outlay**: Rs. 115 Crore till FY 2025-26
  2. Scheme guidelines for implementation of pilot projects for use of Green Hydrogen in the Shipping Sector have been issued on 1st February 2024.

     For details: Please visit https://cdnbbsr.s3waas.gov.in/s3716e1b8c6cd17b771da77391355749f3/uploads/2024/02/20240205992946502.pdf

- **Steel Sector**
  1. **Budgetary Outlay:** Rs. 455 Crore till FY 2029-30
  2. Scheme guidelines for implementation of pilot projects for use of Green Hydrogen in the Shipping Sector have been issued on 2nd February 2024.

     For details: Please visit https://cdnbbsr.s3waas.gov.in/s3716e1b8c6cd17b771da77391355749f3/uploads/2024/02/20240202206454630 5.pdf

- **Transport Sector**
  1. **Budgetary Outlay:** Rs. 496 Crore till FY 2025-26
  2. Scheme Guidelines for implementation of Pilot projects for use of Hydrogen in the Green Transport Sector under the National Green Hydrogen Mission (NGHM) have been issued on 14th February 2024.

3. **Invitation of Proposals (RfP):** A Request for Proposal for Pilot Projects for use of Green Hydrogen in the Transport Sector was issued by The Automotive Research Association of India (ARAI) on 22.02.2024 and 13 companies participated in the bid.

   For details: Please visit https://mnre.gov.in/notice/scheme-guidelines-for-implementation-of-pilot-projects-for-use-of-hydrogen-in-the-transport-sector-under-the-national-green-hydrogen-mission-nghm/

- **Hydrogen Hubs**

1. **Budgetary Outlay:** Rs. 200 Crore till FY 2025-26.
2. The Scheme Guidelines for setting up Hydrogen Hubs in India have been notified on 15th March 2024.

   For details: Please visit: https://cdnbbsr.s3waas.gov.in/s3716e1b8c6cd17b771da77391355749f3/uploads/2024/03/20240316695795641.pdf

- **Research and Development**

1. **Budgetary Outlay**: Rs. 400 Crore till 2025-26
2. The scheme guidelines for the implementation of R&D Scheme have been notified on 15th March 2024.
3. **Call for Proposals (CfP):** A CfP was issued on 15th March 2024 by MNRE under Research and Development Scheme of National Green Hydrogen Mission.

   For details: Please visit: https://cdnbbsr.s3waas.gov.in/s3716e1b8c6cd17b771da77391355749f3/uploads/2024/03/20240316152774043.pdf

- **Skill Development or Human Resource Development**

1. **Budgetary Outlay:** Rs. 35 Crore till 2029-30
2. The scheme guidelines for skilling, up skilling and reskilling have been notified on 16th March 2024.

   For details: Please visit: https://cdnbbsr.s3waas.gov.in/s3716e1b8c6cd17b771da77391355749f3/uploads/2024/03/20240316172141778 7.pdf

E. Stakeholders Consultation

Regular consultation meetings of all stakeholders, including Ministry, Implementation Agencies, Public and Private Industry partners of Hydrogen value Chain held up to discuss opportunity, risks and mitigation strategy in different sectors (like Steel, Shipping, Mobility, Regulations, Codes and Standards, Research & Development , Safety, etc).

F. Infrastructure Development

The MNRE recognizes the importance of establishing a comprehensive infrastructure network for the green hydrogen value chain. Efforts are underway to facilitate the development of pipelines, storage facilities, transportation networks, and dedicated export infrastructure, streamlining the distribution and utilization of Green Hydrogen domestically and internationally.

G. Collaborations and Partnerships

The MNRE fosters international collaborations and partnerships to accelerate knowledge sharing, technology transfer, and joint project development in the Green Hydrogen space. This includes partnerships with leading research institutions, technology providers, bilateral/multilateral cooperation and countries with substantial expertise in the field.

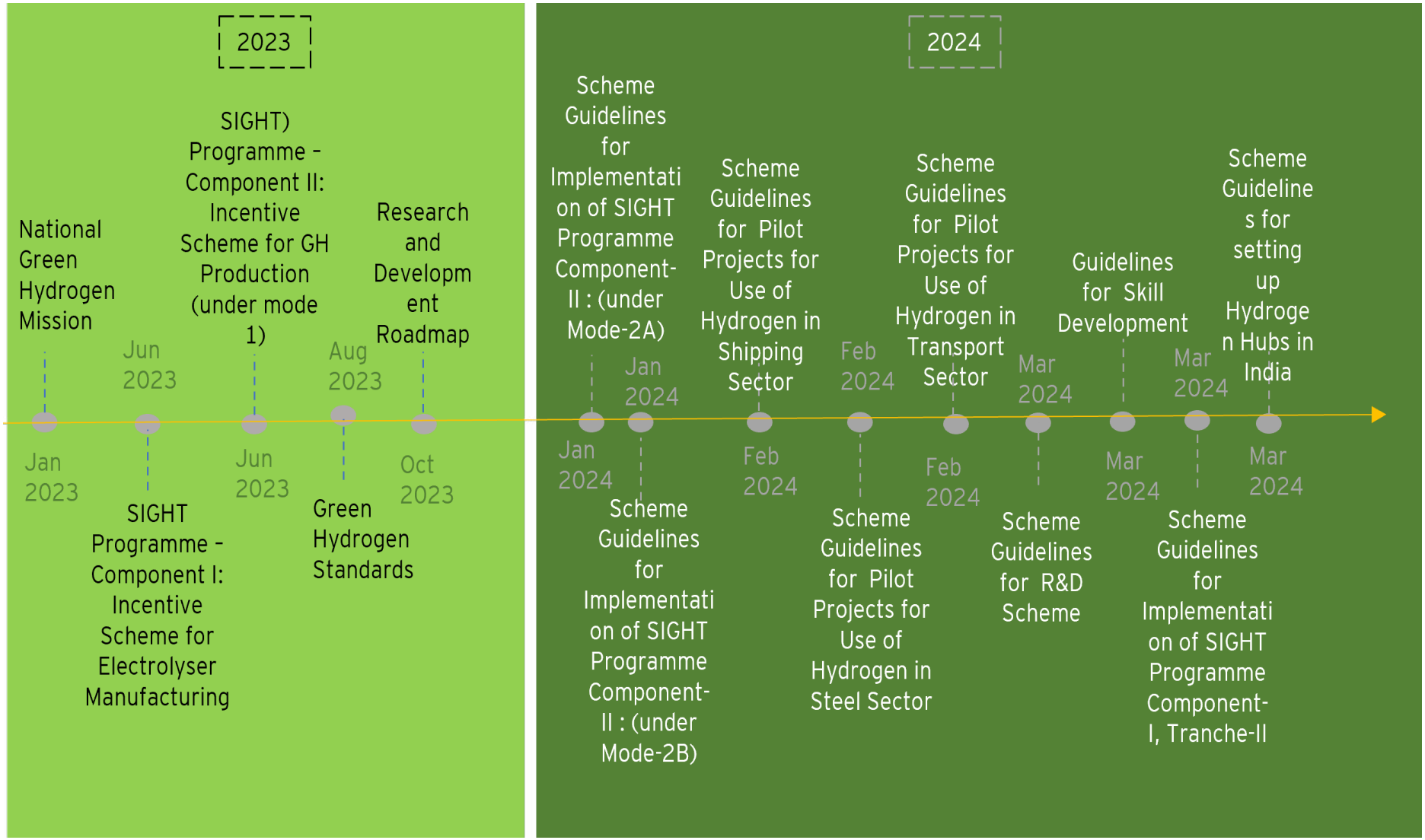
Few are:

1. Indo-German task force
2. Indo-Australian task force
3. MoU with countries like UAE, Saudia Arabia
4. International partnership for Hydrogen and Fuel Cells in the Economy (IPHE)
5. Many more in various stages of discussion

H. The Road Ahead

The **MNRE's** initiatives lay a solid foundation for India to emerge as a major player in the global Green Hydrogen economy. As costs continue to decline and technological advancements materialize, Green Hydrogen will gain wider acceptance across industrial sectors, solidifying India's commitment toward a sustainable and clean energy future.

Exhibit 6: Major Announcements



CHAPTER

4

ENABLING POLICY & REGULATION

Beyond the core mission statement, both central and state governments in India are implementing additional policies to support the National Green Hydrogen Mission (NGHM). The Ministry of Power (MoP), the Government of India (GoI) has notified the Inter-State Transmission Charges (ISTS) waiver policy, the Ministry of Environment, Forests and Climate Change (MoEFCC) has formulated Environment Clearance to produce Green Hydrogen/ Green Ammonia (GH_2/GA) and Green Open Access Rules have been notified by the MoP regarding incentives or exemption of various charges like cross-subsidy surcharge, additional charges, banking provisions, etc. GoI is working on different policies to support the NGHM. Few major policies by the Central Government are discussed further.

4.1 ISTS Charges Waiver

GoI is offering a major boost to Green Hydrogen production by exempting ISTS charges for a period of 25 years from the date of commissioning of the project, for GH_2/GA production units, using Renewable Energy (RE) (commissioned after 8th March 2019), Pumped Storage System or Battery Storage Systems or any hybrid combination of these technologies. The projects commissioned on or before 31st December 2030 shall be eligible for this waiver. The projects after 31st December 2030 will attract graded transmission charges thereafter. The decision effectively extends the applicability of the waiver date from 30th June 2025 to 31st December 2030.

4.2 Environmental Clearance (EC) for GH_2/ GA

MoEFCC has exempted Green Ammonia plants from prior environmental clearances under Environment Impact Assessment notification 2006 released on 28th July 2023. MoEFCC specified that standalone plants producing GH_2/GA by way of electrolysis of water using RE would not require any prior EC.

4.3 Open Access

GoI had notified Electricity (Promoting Renewable Energy through Green Energy Open Access) Rules, 2022 on 6th June 2022, to further accelerate India's ambitious RE programmes, with the objective of ensuring access to affordable, reliable, sustainable, and green energy for all. The salient features and benefits for common consumers from the 'Green Energy Open Access Rules (GOAR)' are as follows:

- Green Open Access is allowed to any consumer and the limit of Open Access transactions 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 green power supply from Discoms. The discoms would be obligated to procure and supply green power to the eligible consumers.
- These rules have streamlined 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 voluntary basis.
- Provide certainty on open access charges to be levied on Green Energy Open Access Consumers, which include transmission charges, wheeling charges, cross subsidy surcharge, standby charges wherever applicable, banking and other charges.
- GoI has capped the cross-subsidy surcharge as well as the removal of an additional surcharge to incentivise consumers to go green.
- There shall be a uniform Renewable Purchase Obligation (RPO) on all obligated entities around a distribution licensee. GH_2/GA has also been included for fulfilment of its RPO.
- Consumers will be given Green Certificates if they consume green power and will also be facilitated.

4.4 Single Window Clearance Portal

Single window portal has been developed for all statutory clearances,& permissions required for ease of business.

4.5 Policies by States

Few states in India have declared their Green Hydrogen Policy, while others are in the process of its release. Policies of a few state governments are depicted below for an overview of the determination and efforts of state governments towards the development of a Green Hydrogen Ecosystem.

4.5.1 MAHARASHTRA: Maharashtra Harit Hydrogen Policy

The state government of Maharashtra launched its Green Hydrogen Policy, "Maharashtra Harit Hydrogen Policy", in October 2023 with the aim of making the state pioneer in Green Hydrogen generation and utilization. Some of the main features of this policy are provided below:

Objectives:

i. Achieve 500 kilotonnes per year (KTPA) of Green Hydrogen production capacity by 2030.

ii. Promote decarbonization in industries and the energy sector.

iii. Encourage the development and export of Green Hydrogen and its derivatives.

Incentives:

i. Capital cost subsidy of 30% will be given to:
   a. First 3 anchor Green Hydrogen production projects.
   b. First 500 hydrogen-based fuel-cell passenger vehicles in the transport activities of the Maharashtra State Road Transport Corporation (MSRTC) with a maximum cap of ₹60 Lakh per vehicle.
   c. Development of Hydrogen Refuelling Station (HRS) with a maximum cap of ₹4.5 Crore.
   d. Constructing hydrogen transportation through pipeline (max. 10 Km) is limited to ₹2.5 Crore.

ii. 1% interest subsidy on hydrogen transport project.

iii. 100% exemption on stamp duty charges for land conversion.

iv. 60% discount on electricity transmission and wheeling charges for 10 years.

v. Mandatory use of RE for hydrogen production.

vi. Waivers and exemptions on electricity duties and surcharges.

vii. Grant of ₹50/kg for blending Green Hydrogen with CNG/PNG for vehicles (for 5 years).

4.5.2 ODISHA: Odisha Hydrogen Policy

Odisha has an integrated RE policy covering Green Hydrogen and its derivatives for providing incentives.

A. **Industrial Policy Resolution (IPR) 2022:** This policy provides benefits to industries focusing on green energy. Green Hydrogen and Ammonia manufacturing units get:
   i. 100% Exemption from Electricity Duty for 20 years.
   ii. STU, along with cross subsidy charges and additional surcharges, will also be exempted or reimbursed.
   iii. Reimbursement of Power Tariff of Rs. 3 per unit of RE purchased from local Discoms/ GRIDCO for 20 years.
   iv. 30% capital subsidy for plant and machinery.
   v. The land will be provided at 50% of the concessional industrial rate prevailing in that region.
   vi. A 50% incentive will be provided for innovations and R&D activities limited to ₹10 Crore.
   vii. A 100% incentive will be provided for ESI and EPF contributions for 7 years.

B. **Renewable Energy Policy 2022:** This policy encourages RE projects which indirectly benefit Green Hydrogen as
   i. Exemption on Electricity Duty for RE used for 15 years.
   ii. Reduced wheeling charges for consuming RE.
   iii. Exemption from stamp duty and other land-related charges for RE projects.

4.5.3 WEST BENGAL: West Bengal Green Hydrogen Policy

The state government of West Bengal launched its Green Hydrogen Policy, in December 2023. This policy will be in effect for 5 years from the date of notification or until any amendment from State government. Some of the main features of this policy are provided below:

Objectives:

i. Identification of Green Hydrogen demand centres by GIS mapping.

ii. Enabling investment in setting up GH_2/GA production.

iii. Setting up a State Centre of Excellence (SCoE) to support R&D activities for techno-economic

innovation and guide other states in India for the same.

iv. Formulate and execute procurement and trade strategies for acquiring and exchanging GH_2/GA resources.

v. Creation of employment by leveraging GH_2/GA development.

Incentives:

i. 100% exemption in stamp duty and land conversion charges for the policy period.

ii. 100 % waiver of electricity duty charges is provided during the policy period.

iii. Banking of RE power is allowed for 30 days for GH_2/GA production units.

4.5.4 ANDHRA PRADESH: Andhra Pradesh Green Hydrogen and Green Ammonia Policy

The state government of Andhra Pradesh launched its Green Hydrogen and Green Ammonia Policy, in June 2023 with the aim of making Andhra Pradesh the preferred destination for the production and export of GH_2/GA. This policy will be in effect for 5 years from the date of notification or until a new policy is notified. Some of the main features of this policy are provided below:

Objectives:

i. Achieve Green Hydrogen production up to the capacity of 0.5 Million Metric Tonnes Per Annum (MMTPA) or Green Ammonia production up to the capacity of 2.0 MMTPA in the next five years by harnessing the RE potential in the State.

ii. Promote the development of an eco-system for GH_2/GA production.

iii. To attract investments, provide employment and improve the economy of the state.

iv. Creation of 12,000 jobs per MMTPA production of Green Hydrogen in the state.

v. Promote the setting up of Green Hydrogen and Green Ammonia and their related equipment manufacturing facilities in the state.

Incentives:

i. 100% reimbursement of net SGST revenue to the developer from the sale of GH_2/GA within the state.

ii. 100% exemption from Electricity Duty for the power consumed for the production of GH_2/GA from RE plants (with or without storage).

iii. 25% of Intrastate charges shall be reimbursed to the developer with an upper limit of Rs. 10 lakhs/ MW/ year of installed electrolyser capacity.

iv. The cross-subsidy surcharge shall be reimbursed for the energy drawn from RE plants located within the state to produce GH_2/GA.

v. Grid connectivity to the intra-state transmission system at the generation and production end respectively for RE plants established to produce GH_2/GA shall be granted on priority. APTRANSCO/ APDISCOM(s) will dispose of the proposals for the technical feasibility of evacuation within 21 days from the date of receipt of the application.

vi. Land allotment to be allocated on a priority basis at a lease rate of ₹31,000 per acre per year with an escalation of 5% every two years during the project period.

vii. 100% exemption from payment of stamp duty and land use conversion charges.

4.5.5 UTTAR PRADESH: Uttar Pradesh Green Hydrogen Policy

The state government of Uttar Pradesh launched its Green Hydrogen Policy in March 2024. This policy will be valid for 5 years from the date of notification or until any amendment from state government. Some of the main features of this policy are provided below:

Objectives:

i. Target of achieving 1 MMTPA production of Green Hydrogen by 2028.

ii. Creation of 1.20 lakh jobs by 2028.

iii. The capital subsidy of 10% - 30% to be provided depending on the geographical area of investment.

iv. Enabling investment in setting up GH_2/GA production.

v. The establishment of two State Centres of Excellence (SCoEs) is also proposed to lead research, development and techno-economic innovation activities.

Incentives:

i. The first five investments (excluding Meerut division) in Green Hydrogen projects will be provided capital subsidies to the tune of 40% of the total investment amount with a ceiling of ₹225 crore per project per year.

ii. Government/revenue land will be provided on lease at ₹1 per acre per year for government Public Sector Units (PSUs) for setting up Green Hydrogen projects. For investors from the private sector, the lease rate is ₹15,000 per acre per year.

iii. Village/government land will be provided on lease for a period of 30 years. Land purchased or taken on lease for Green Hydrogen projects would be 100% exempt from stamp duty charges.

iv. The Centre for Excellence will receive 100% financial assistance up to ₹50 crore.

v. The policy also allows 100% exemption on electricity duty for the first 10 years of the project or the life of the project, whichever is earlier.

4.5.6 RAJASTHAN: Rajasthan Green Hydrogen Policy

Rajasthan aims to be a pioneer state for the production and export of Green Hydrogen. This policy will be in effect until 31st March 2030 or superseded by another policy. Some of the main features of this policy are provided below:

Objectives:

i. Promote the development of an ecosystem for the production of Green Hydrogen.

ii. Formulate an environment for Industry and Research Institutions for R&D.

iii. The policy has the following targets:

   a. 2000 KTPA of Green Hydrogen production capacity by 2030.

   b. Commission at least one Green Hydrogen valley and at least one Giga factory for electrolyser manufacturing.

   c. Cater to at least 20% of Green Hydrogen exports from India.

   d. Blend up to 10% Green Hydrogen in Natural Gas pipelines for gas produced within Rajasthan by 2030.

Incentives:

i. 50% rebate for 10 years in transmission and distribution charges on installation of first 500 KTPA GH2 established within the state with upper limit fixed at 12,500 MW of RE capacity at the rate of 25 MW per KTPA.

ii. 100% exemption on additional and cross-subsidy surcharges for 10 years on purchasing renewable energy from a third party.

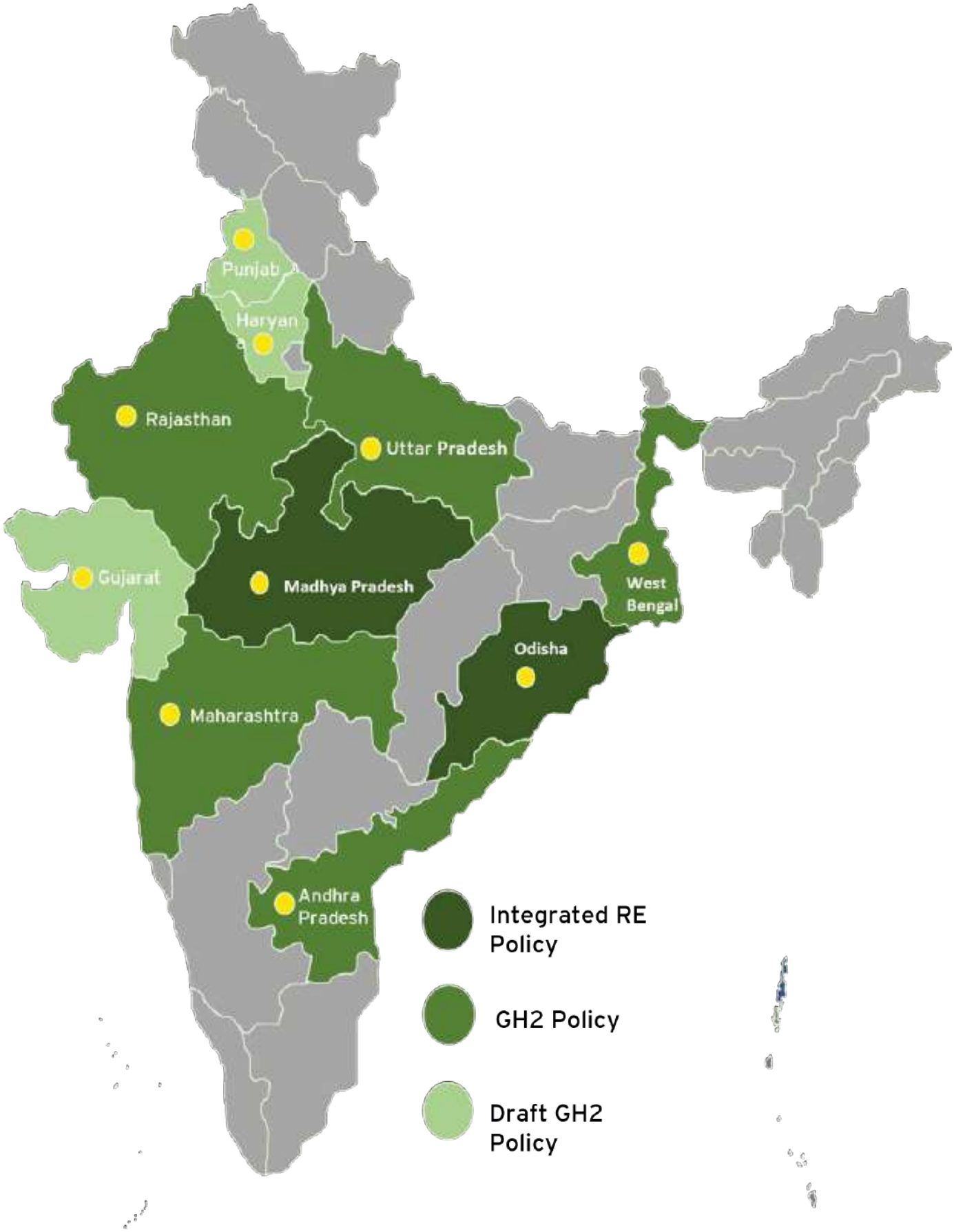
iii. Land allotment for the generation of Green Hydrogen from treated or brackish water will be done on a priority basis.

iv. A subsidy of 30% with an upper limit upto ₹5 Crore for setting up a research centre.

v. There is no prohibition on the capacity of captive power plants or the banking of generated electricity.

vi. 100% waiver on wheeling and transmission charges. Also, the banking charges for power plants will be reimbursed for 7 -10 years.

Exhibit 7: State Policy Indicator



CHAPTER

5

FINANCING OPTIONS IN INDIA

The development of Green Hydrogen in India presents a significant financing opportunity, with the potential to drive economic growth, enhance energy security, and mitigate climate change. Leveraging a diverse array of financing mechanisms and instruments can unlock the full potential of Green Hydrogen and accelerate its deployment across various sectors. Here are some key financing opportunities for the development of Green Hydrogen in India:

5.1 Public Private Partnerships (PPPs)

Establishing PPPs can mobilise private sector capital and expertise to finance Green Hydrogen projects. Governments can provide incentives such as tax breaks, subsidies, and regulatory support to attract private investment in Green Hydrogen infrastructure development.

5.2 Government subsidies and grants

Direct financial support from government agencies can significantly reduce the upfront costs of Green Hydrogen projects, making them more attractive to investors. Subsidies, grants, and incentives for research and development, pilot projects, and commercial-scale deployments can spur innovation and drive down production costs.

5.3 Low-cost financing from multilateral agencies

Partnering with multilateral development banks such as the World Bank, Asian Development Bank (ADB), and the Green Climate Fund (GCF) can provide access to concessional loans and grants for Green Hydrogen initiatives.

5.4 Carbon Financing and Carbon Credit

Monetising carbon credits generated from emissions reductions can provide an additional revenue stream for Green Hydrogen projects. Participating in carbon markets or implementing carbon pricing mechanisms can incentivise investments in low-carbon technologies, including Green Hydrogen production.

5.5 Special Purpose Vehicles (SPVs) and Green Bonds

Establishing Special Purpose Vehicles (SPVs) or issuing Green Bonds (GB) dedicated to financing Green Hydrogen projects can attract capital from institutional investors interested in sustainable investments. Green Bonds offer investors an opportunity to support environmentally friendly projects while generating financial returns.

5.6 Export Credit Agencies (ECAs)

Export Credit Agencies (ECAs) can provide financing and insurance solutions to support export of Green Hydrogen technologies and equipment. By mitigating political and commercial risks associated with international transactions, ECAs can facilitate cross-border investments in Green Hydrogen projects.

5.7 Venture Capital and Private Equity investments

Venture capital firms and private equity investors can provide early-stage funding for startups and innovative companies developing breakthrough technologies in the Green Hydrogen sector. These investments can catalyse innovation, scale up production, and drive down costs.

5.8 Innovative Financing Mechanisms

Exploring innovative financing mechanisms such as carbon finance, crowdfunding, and impact investments can broaden the investor base and attract capital from diverse sources. These mechanisms can align financial returns with environmental and social objectives, fostering sustainable development.

5.9 Role of the Banking Sector and Private Companies in Green Financing in India

Mobilising green finance requires an extensive assessment of current capabilities and assets. This includes factors like available capital, the level of participation from both public and private sectors, and the evolving outlook of financial institutions. The contributions in the financial sector from the public and private institutions in shaping a broader green financing landscape are briefed below:

5.9.1 Banking Sector

The Reserve Bank of India (RBI) has issued Green Bonds to promote green finance within the country along the lines of countries like the United States and China. These bonds are issued and regulated by the Securities and Exchange Board of India (SEBI) specifically for sustainable projects and assets. Green Bonds raised a significant amount of capital, totalling around US$16.3 billion during 2015 and 2020.

In recognition of the booming green energy sector, India's banking sector has strategically positioned itself to capitalise on this growth. They have devised various "green financing" schemes to attract investors. These initiatives have resulted in the rise of loans and credits to support the purchase of green energy products.

Banking institutions act as the lifeline of the green energy ecosystem, channelling financial resources between green energy companies, investors, and consumers. Their involvement is essential for a flourishing green energy market, as they act as the critical bridge that connects all stakeholders.

5.9.2 Private Sector Companies

The private sector is positioned as a game-changer for unlocking a sustainable economy, generating undeniable excitement about the future. However, while renewable energy resources are abundant, their full potential remains hampered by limitations in infrastructure and technology. Recognising the enormous potential of the green energy sector, investors are directing their resources into green industries.

5.10 Latest Developments in Financing

Investors have acknowledged the potential of the green energy sector and are investing in green industries.

5.10.1 World Bank:

To accelerate India's transition to low-carbon energy sources, the World Bank has announced US$1.5 billion in funding in June 2023. The funding will provide assistance in supporting the growth of renewable energy, the development of Green Hydrogen, and the encouragement of climate finance for investments in low-carbon energy.

(https://www.worldbank.org/en/news/press-release/2023/06/29/world-bank-approves-1-5-billion-in-financing-to-support-india-s-low-carbon-transition)

5.10.2 IREDA:

Indian Renewable Energy Development Agency Ltd. (IREDA) has signed a Memorandum of Understanding (MoU) with Indian Overseas Bank (IOB) at IREDA's Business Centre in New Delhi on 16th January 2024, with a view to have collaborative efforts in co-lending and loan syndication for multiple continuums of RE projects across the nation. The partnership aims to rationalise loan syndication and underwriting processes, management of Trust and Retention Account (TRA) for IREDA borrowers, and work towards offering stable interest rates over a 3–4-year period.

(https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1997167)

IREDA and Punjab National Bank (PNB) signed an MoU in February 2024 to provide joint support for co-lending and loan consortiums for the development of RE projects.

(https://pib.gov.in/PressReleaseIframePage.aspx?PRID=2007058#:~:text=The%20agreement%2C%20signed%20at%20IREDA's,support%20for%20renewable%20energy%20projects)

5.10.3 The Asian Development Bank (ADB)

The Asian Development Bank (ADB) approved a US$250 million policy-based loan in November 2023 for India to modernise its power grid and scale up renewable energy projects.(https://www.adb.org/news/adb-support-power-sector-reforms-india)

ReNew Energy Global, an Indian company working in the renewable sector has signed an MoU with the ADB in December 2023 worth an investment of US$5.3 billion for climate resilience projects and decarbonisation. The MoU would support projects undertaken between 2023 and 2028.

(https://investor.renewpower.in/news-releases/news-release-details/renew-signs-mou-asian-development-bank-us-53-billion)

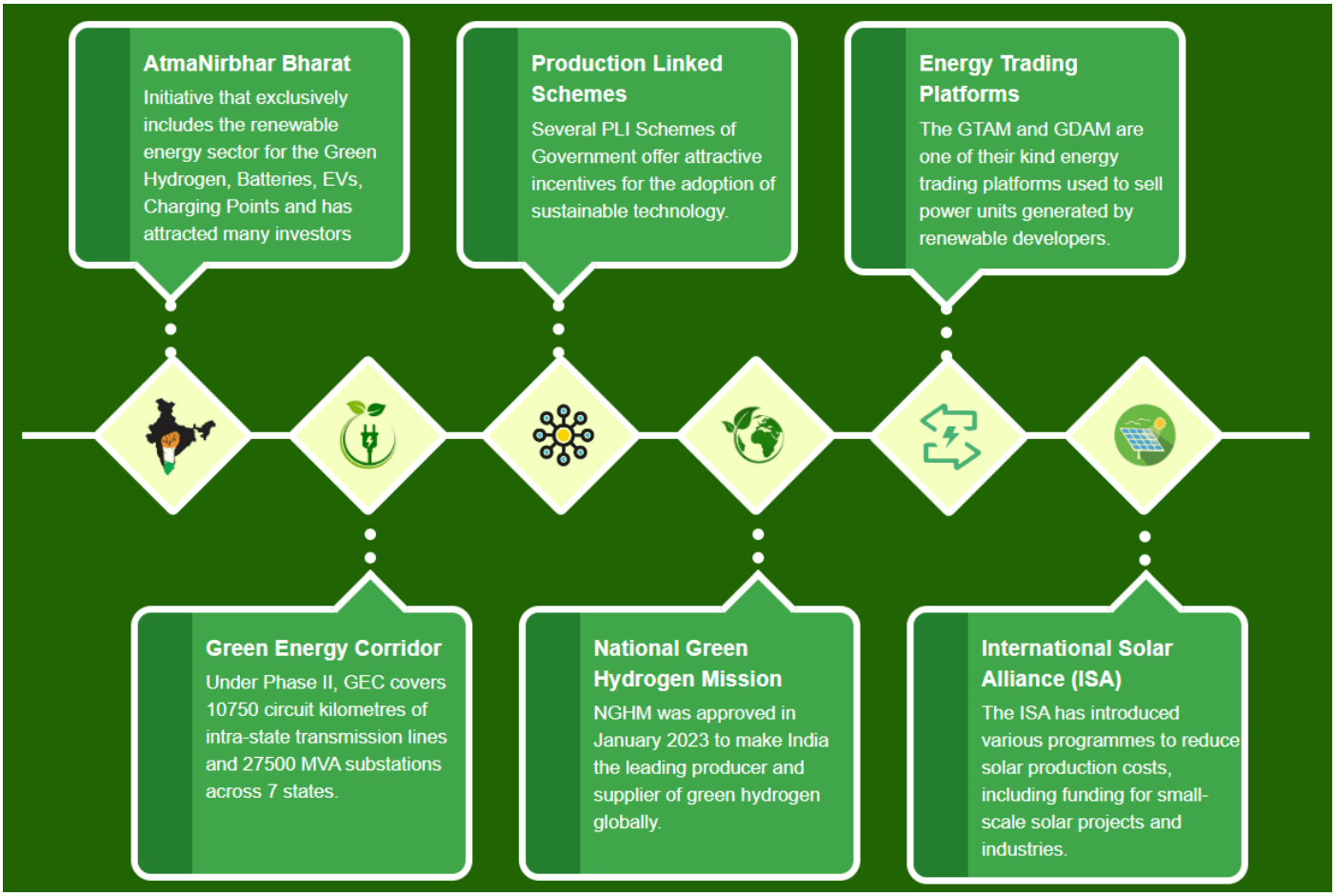
5.10.4 Others

REC Limited under the Ministry of Power along with a leading Non-Banking Financial Company (NBFC) has signed an MOU to formulate funding solutions for RE projects with the National Investment and Infrastructure Fund Limited (NIIFL) in January 2024.

ACME struck a US$7 billion deal with the Karnataka government to develop an integrated Solar-to-Green Hydrogen-to-Green Ammonia facility.

TotalEnergie has partnered with Adani New Industries, pledging a staggering US$50 billion investment for the next decade to produce Green Hydrogen.

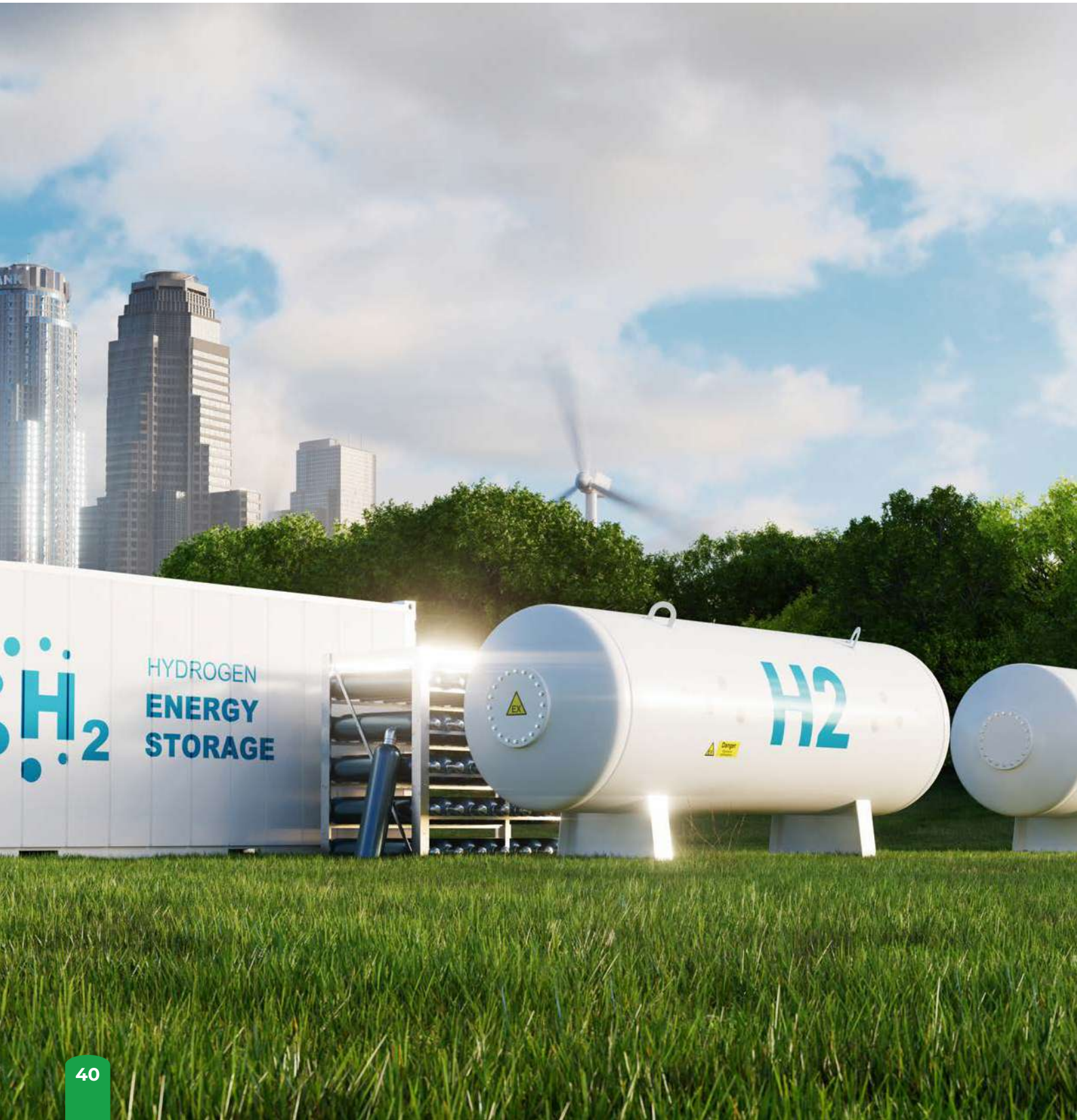
Exhibit 8 : Key Enabler of Financing



CHAPTER

6

MAJOR PROJECTS IN INDIA



Fuelled by ambitious goals for energy independence and decarbonisation, India is emerging as a frontrunner in Green Hydrogen development. The National Green Hydrogen Mission, launched in 2023 with a budget of ₹19,744 crore, is propelling Green Hydrogen projects across various industries like Mobility (Road, Locomotive, & Aviation), Shipping, Steel, Domestic Cooking Gas Blending, Manufacturing of various components (Electrolysers, Cylinders, etc) in Green Hydrogen Value Chain. From recently commissioned Jindal Stainless' pioneering operational plant of Green Hydrogen, in Hisar and SJVN Green Hydrogen pilot project at Jhakri, Himachal Pradesh to upcoming projects by companies like NTPC, NHPC, IOCL, L&T, GAIL, ACME, THDC, Indian Railways, etc., Green Hydrogen production is gaining momentum. Government incentives for both electrolyser manufacturing and GH2 production aim to achieve 5 million metric tonnes of GH2 per annum by 2030. As India strives for a cleaner future, Green Hydrogen projects are lighting the path towards a more sustainable tomorrow.

The major projects are segmented as under:

- Export-oriented Projects
- Green Hydrogen projects in Microgrid
- Green Hydrogen projects in Mobility/Transport sector
- Green Hydrogen projects in Steel sector
- Green Hydrogen projects in Shipping sector

6.1 Export-oriented Agreements:

6.1.1 ACME to supply Green Ammonia to Japan's IHI Corporation

As a part of its export potential, Japan's IHI Corporation has signed an offtake term sheet with ACME (India) for the supply of green ammonia from Odisha (India) to Japan. The term sheet was signed by ACME founder and chairman Manoj Upadhyay and IHI Corporation President and CEO Hiroshi Ide in the presence of Power and New & Renewable Energy Minister Shri R K Singh.

The Green Hydrogen and Ammonia project at Gopalpur (Odisha) is being developed by ACME with a planned capacity of 1.2 million tonnes per annum (MTPA) to be developed in phases with the first production likely by 2027.

The term sheet between IHI and ACME covers the long-term supply arrangement for 0.4MMTPA of Green Ammonia, ammonia for use in a range of applications in power generation and various industrial uses in Japan to reduce overall emissions.

This strategic alignment represents the dedication of both companies to build upon the existing strong relationship between the two countries and contribute to both India's National Green Hydrogen Mission as well as Japan's Net Zero commitment, with a shared vision of sustainability and innovation.

India is well positioned to develop the renewable resources and produce competitive green molecules for export as well as domestic consumption in applications which are otherwise difficult to decarbonise", Ashwani Dudeja (Group President and Director, ACME)

6.1.2 Sembcorp India to export Green Hydrogen to Japan

The Green Hydrogen unit of Singapore's Sembcorp Industries Ltd (SGX:U96) has teamed up with Japan's Sojitz Corp (TYO:2768) and Kyushu Electric Power Co (TYO:9508) to export India-made Green Hydrogen to Japan. The Memorandum of Understanding (MOU) was signed by Sembcorp Green Hydrogen Pte Ltd. Under this initiative, the three companies will explore opportunities to produce green ammonia in India and supply it to the Japanese market. Sembcorp will act as the lead developer of the green ammonia project. Sojitz and Kyushu Electric will leverage their energy trading and supply capabilities to oversee the transport of the green ammonia to Japan and secure local off-takers. The project will support Japan's goal to import three million metric tonnes of green ammonia by 2030, as demand in the Asian nation is seen to reach 30 million metric tonnes by 2050.

6.1.3 NTPC is setting up India's largest Green Hydrogen production facility in Andhra Pradesh : Integrated Green Hydrogen Hub to come up in Atchutapuram Mandal, Visakhapatnam

Power sector PSU and India's largest integrated power company, NTPC Limited has signed a Land Lease Agreement to realise its green energy and Green Hydrogen objectives, thus also contributing to the Government of India's efforts towards energy transition. The agreement, signed on 20th February

2024, between NTPC Green Energy Limited (NGEL) and Andhra Pradesh Industrial Infrastructure Corporation (APIIC), is for the development of an "Integrated Green Hydrogen Hub". The hub will come up on 1,200 acres of land near Pudimadaka village of Atchutapuram Mandal in Visakhapatnam, Andhra Pradesh.

The Pudimadaka Green Hydrogen Hub aims to create a world-class ecosystem for technologies in the new energy paradigm, such as electrolyser and fuel cell manufacturing, related ancillary industries, and start-up, incubation, testing facilities, production and export of Green Hydrogen. The project includes the construction of India's largest Green Hydrogen production facility (1,200 tonnes per day), which will enable further conversion of Green Hydrogen to derivatives such as green ammonia and green methanol, primarily catering to various export markets.

6.1.4 Yara and ACME (India) agreement

Yara, a leading Norwegian crop nutrition company and a global leader in ammonia trade and shipping, and GHC SAOC, a wholly owned subsidiary of Acme Cleantech, a leading renewable energy company in India, signed a firm and binding agreement for supply of ammonia with reduced CO2 emissions from ACME to Yara on a long-term basis. The agreement was signed on 1st March 2024.

6.1.5 JERA partnered with Renew (India)

JERA Co., Inc ("JERA") has concluded an agreement , in April 2024 , with ReNew E-Fuels Private Limited, to jointly develop a green ammonia production project.

6.2 Green Hydrogen Projects for Microgrid

6.2.1 Satluj Jal Vidyut Nigam (SJVN) –Green Hydrogen Fuel Cell-based Microgrid, commissioned

SJVN achieved a milestone by inaugurating India's first multi-purpose green hydrogen pilot project at the company's 1,500 MW Nathpa Jhakri Hydro Power Station (NJHPS) in Jhakri, Himachal Pradesh. The project will generate electricity through its 25-kW fuel cell and produce green hydrogen for other usages at the power station.

6.2.2 NHPC –Green Hydrogen Fuel Cell-based Microgrid

NHPC has awarded the pilot project for the development of Pilot Green Hydrogen fuel cell based Microgrid including Hydrogen production to meet the power requirement of the NHPC guest house at Nimmo Bazgo Power Station (Leh) within NHPC premises. The project has been awarded to a Delhi based EPC Company, Uneecops Technologies, for Engineering, Procurement and Construction (EPC) of a Green Hydrogen-based fuel cell microgrid of capacity 25 KW, at Alchi in the Leh region.

6.3 Green Hydrogen Projects for Mobility

6.3.1 NHPC – Hydrogen-based Mobility Station Project at Kargil

M/s Gensol is developing a 500-kW grid-connected, ground-mounted solar power project that will provide energy to the hydrogen refuelling station, initially to power two buses. The scope of work includes the entire balance of plant EPC encompassing the Green Hydrogen system installation, storage, and dispensing facilities, in addition to the requisite civil and electrical infrastructure for the integrated solar and hydrogen operation in Ladakh. Gensol Engineering Limited is a part of the Gensol group of companies, which offer Engineering, Procurement, and Construction (EPC) services. The Electrolyser capacity is two streams of 30 Nm3/h.

6.3.2 NHPC –Pilot project for Green Hydrogen-based mobility station

The project is under tendering stage. NHPC has invited tenders for the project. Engineering, Procurement, and Construction (EPC) contract for setting up a pilot project for Green Hydrogen-based mobility station at District-Chamba, Himachal Pradesh along with comprehensive O & M of three years. The Green Hydrogen Plant will have a production capacity of 20 kg Green Hydrogen per day.

6.3.3 Indian Railways- Pilot Project for Conversion of Old Diesel Locomotives with Hydrogen Fuel Cells

Indian Railways (IR) has envisaged to run 35 (thirty-five) Hydrogen trains under "Hydrogen for Heritage" at an estimated cost of ₹80 crores per train and ground infrastructure of ₹70 crores per route on various heritage/ hill routes.

Indian Railways has awarded a pilot project for the retrofitment of a Hydrogen Fuel cell on an existing Diesel Electric Multiple Unit (DEMU) rake along with ground infrastructure at a cost of ₹111.83 Crores which is planned to be run on the Jind-Sonipat section of the Northern Railway. The project has been awarded to Medha, as a first step to achieving India Railways' net zero emissions goal. In turn, Medha has contracted GreenH to provide the Engineering, Procurement, and Construction ("EPC") of a Hydrogen production and refuelling station for this important and ground-breaking project.

GreenH will provide the necessary equipment from its newly constructed PEM electrolyser manufacturing plant in Jhajjar District, Haryana. The Hydrogen production and refuelling station is expected to deploy a comprehensive system to both produce Hydrogen and refuel the trains on a daily basis. To achieve the first stage, a 1 MW electrolyser, supplied by GreenH, will operate round the clock with an expected capacity of 420 kg/day of hydrogen. The refuelling infrastructure is expected to integrate 3,000 kg of hydrogen storage, hydrogen compressors, and two hydrogen dispensers with precooler integration, allowing for quick refuelling of the trains, which are adapted to their daily routes. Field trials of the first prototype on Jind –Sonipat section of Northern Railway is expected to commence in 2024.

6.3.4 NTPC- Integrated Hydrogen Refuelling Station at Greater Noida

NTPC is executing an integrated hydrogen refuelling station at its Greater Noida facility. It will also fuel up to five intercity Fuel Cell Electric Vehicle (FCEV) buses, connecting to Indian Heritage stations in Agra and Jaipur

The electrolyser capacity is of 1.6 MW (2x50%) for India's largest Green Hydrogen Fuelling Station being setup in NTPC Renewables Campus in Greater Noida, Uttar Pradesh. The stacks are imported from AHES, South Korea and the complete Balance of Plant (BoP) is being integrated by M/s Jakson. The electrolysers would produce 260kg of hydrogen at 500 bar pressure in 10 hours during the day ;each stack weighs around 20 tonnes.

6.3.5 Oil India Limited- Green Hydrogen generation pilot project in Assam

India's first pure (99.999% pure with solar power) Green Hydrogen Pilot Plant Commissioned in Assam. Oil India Limited (OIL), a Government of India enterprise, has commissioned the country's pure Green Hydrogen pilot plant with an installed capacity of 10 kg per day at its Jorhat Pump Station in Assam in 2022.

The trial run of the country's first hydrogen fuel cell-powered e-bus, a project initiated by Oil India Limited (OIL) under the SNEH (Start-up Nurturing, Enabling & Handholding) scheme, has commenced. The trial run is taking place at the Number 3 Pumping Station of OIL in Charigaon, Jorhat. The project is being carried out in collaboration with the start-up Ohm Clean Tech Private Limited based in Pune. The e-bus is operating on short-distance routes and will gradually make transition to long-distance routes, such as from Jorhat to Kaziranga and Jorhat to Duliajan.

6.3.6 Oil India Limited- Green Hydrogen generation Pilot Project in Himachal Pradesh

Oil India Limited (OIL) has invited bid to establish a 1(one) MW Green Hydrogen project in Himachal Pradesh, featuring a 17 kg/h generation capacity. The project is mandated to be commissioned within 18 months of the issuance of the Letter of Award. The operational unit is expected to run for a minimum of 8,000 hours per year at full capacity.

6.3.7 Indian Oil R&D Centre, Faridabad

IOC's R&D Centre at Faridabad is producing Green Hydrogen for the pilot run. It produces close to 75 kg of hydrogen by splitting water using electricity from

renewable sources. This hydrogen is used to power two buses that runs across the National Capital Region (NCR) for trial runs. Four cylinders with a capacity of 30 kg runs the buses for 350 km. It takes 10-12 minutes for the four tanks to fill.

The future plan is to scale up the number of buses to 15 fuel cell buses powered by Green Hydrogen on the identified routes in Delhi, Haryana, and Uttar Pradesh.

6.3.8 Indian Oil Green Hydrogen Project- Integrated Refuelling Station for Buses in Leh (Ladakh)

NTPC is setting up a Hydrogen Fuelling Station, Solar Plant and providing 05 (five) Nos Fuel Cell buses for operation on intracity routes of Leh. The first of its kind Green Hydrogen Mobility Project at 11,562 ft is co-located with a dedicated solar plant of 1.7 MW for providing renewable power. The fuel cell buses are designed for operation at sub-zero temperature in a rarefied atmosphere, typical to such altitude locations, which is a unique feature of this project

6.3.9 India's First Hydrogen Fuel Cell Ferry: A Technological Marvel

Cochin Shipyard Limited has made a ground-breaking achievement in the country's maritime sector by spearheading the construction of an indigenous hydrogen fuel cell system-based ferry ,developed by KPIT Technologies and the Council of Scientific and Industrial Research Labs. India's pioneering hydrogen fuel cell ferry underscores the nation's commitment to green technology and positions it as a frontrunner in maritime sustainability.

Container Vessel

In March 2024, Cochin Shipyard Limited, India has taken a project for a Netherland-based logistic company, Samskip, for development of zero-emission feeder container vessel powered by Green Hydrogen fuel cells. The vessel specification speaks of 138m in length, 23m in width and deadweight of 8000 tonnes, which can carry 365 numbers high cube 40 ft containers, which is expected to reduce 25000 T of CO2 annually.

6.3.11 Storage: Type IV Cylinder Manufacturing

The Type IV cylinders are made primarily from carbon composite with polymer liner: are lighter by 70% compared to metal cylinders; transport three times more gas than metal cylinders; are completely corrosion-resistant (inert liner); shatterproof/fireproof.

03 Companies have entered the manufacturing of Type IV Cylinders in India

- **Siddha Gas Technik Pvt. Ltd**

  In collaboration with Hexagon Norway, a JV has been formed as Hexagon-SGT Pvt. Ltd., to manufacture Type IV high-pressure cylinders for hydrogen applications.

- **Time Technolplast**

  Time Technoplast (TTL) has announced that it has developed

  Type-IV carbon fibre composite cylinders. Time Technoplast Ltd (Time Tech) is a multinational conglomerate with operations in Bahrain, Egypt, Indonesia, India, Malaysia, U.A.E, Taiwan, Thailand, Vietnam, Saudi Arabia & USA is a leading manufacturer of polymer products

- **Confidence Petroleum**

  Confidence Petroleum Limited announced the launch of its "Type 4 cylinders," which are expected to play a crucial role in the efficient storage and transportation of Green Hydrogen.

Confidence Petroleum Limited, has ventured into the Green Hydrogen market by using its state-of-the-art German technology with innovative designs to optimise storage efficiency and enhance the overall reliability of hydrogen-based solutions. This cylinder is being manufactured by "Silversky Exim Pvt Ltd", a subsidiary of Confidence Futuristic Energetech Ltd.

6.4 Green Hydrogen Project for Steel

6.4.1 Jindal Stainless, Hisar, Haryana

Hygenco India Private Limited has established the Green Hydrogen plant for Jindal Stainless, in Hisar, Haryana, which is projected to lower carbon emissions by about 2,700 metric tonnes per year and some 54,000 metric tonnes of carbon dioxide emissions over the next 20 years. The plant is touted to be the stainless-steel industry's first Green Hydrogen project in India.

The Ministry of New and Renewable Energy (MNRE) has laid out guidelines for pilot projects for use of Green Hydrogen in the steel sector: the use of hydrogen in the direct reduced iron-making process, blend in blast furnaces, and gradually substituting fossil fuels with Green Hydrogen.

6.5 Green Hydrogen Project for the Domestic Sector

6.5.1 NTPC Project, Kawas (Blending of Green Hydrogen with PNG)

State-owned power generator NTPC Ltd. has commissioned the country's first Green Hydrogen blending project. Green Hydrogen blending has been started in the piped natural gas (PNG) network of NTPC Kawas township, Surat. The project is a joint effort between NTPC and Gujarat Gas Limited (GGL).

The blending project supplies H2- NG (natural gas) to households in the Kawas township at Adityanagar, Surat. The Green Hydrogen in Kawas is produced through the electrolysis of water using power from a 1 MW floating solar project.

The Petroleum and Natural Gas Regulatory Board (PNGRB) has given approval for 5% vol./vol. blending of Green Hydrogen with PNG to start with, and the blending level will be scaled in phases to reach 20%. Green Hydrogen when blended with natural gas reduces carbon emissions while keeping the net heating content the same.

India would not only reduce its hydrocarbon import bill significantly but can also bring forex ashore by being a Green Hydrogen and green chemicals exporter to the world.

6.5.2 Torrent Power Project- Green Hydrogen Blending in City Gas at Gorakhpur

Torrent Power is implementing a Green Hydrogen pilot project for the blending of the Green Hydrogen city gas distribution (CGD) network in Gorakhpur, Uttar Pradesh. Blending with the existing natural gas supply allows for a gradual transition towards a cleaner and more sustainable energy mix. The pilot project based on alkaline electrolyser will blend 2.5 % Green Hydrogen (GH2) into the CGD network.

6.5.3 ATL Gas Blending Project (Green Hydrogen with Natural Gas) in Ahmedabad, Gujarat

Adani Total Gas Ltd (ATGL), co-promoted by Adani Group and Total Energies, has initiated a Green Hydrogen production and blending pilot project, by utilising cutting-edge technologies to blend Green Hydrogen (GH2) with natural gas for over 4,000 residential and commercial customers in Ahmedabad as part of this project. The project aims to gradually increase the percentage of GH2 in the blended gas to up to 8 % or more, subject to regulatory approvals.

Upon successful completion of the pilot, ATGL plans to gradually expand the supply of GH2-blended fuel to larger areas of Ahmedabad and other regions under its license. This phased approach will allow for a controlled and well-monitored rollout of GH2 blending, ensuring optimal performance and safety.

6.5.4 Cooking Stove for Hydrogen Gas Burning

NTPC Energy Technology Research Alliance (NETRA), the R&D wing of NTPC has successfully shown hydrogen cooking with the supply of hydrogen from an existing Green Hydrogen plant at its campus in Greater Noida.

Cooking with hydrogen is different from using traditional fuels like LPG or PNG. Hydrogen burns with a nearly invisible flame, has a higher temperature, and the flame spreads differently. To address these challenges, the researchers designed a special hydrogen burner and modified a cookstove for successful cooking. Notably, the only emission from the hydrogen burner is water vapor, making it a clean-burning alternative fuel.

6.6 Green Hydrogen Project in Aviation Sector

6.6.1 CIAL and BPCL to Set Up the First Green Hydrogen Plant at Cochin Airport

February 2024-The Cochin International Airport Limited (CIAL) has signed a MoU with Bharat Petroleum Corporation Limited (BPCL) to develop the first Green Hydrogen plant in the aviation sector, within the premises of Cochin Airport. This collaborative effort will result in the world's first Green Hydrogen plant and fuelling station located within an airport setting. BPCL has started the bidding process for constructing a Green Hydrogen plant and refuelling station at the CIAL in Kochi, Kerala. The facility will be designed to generate 100 standard cubic meters per hour (Nm3/hr) of Green Hydrogen. The electrolyser system, will ensure a hydrogen generation capacity at 30 bar pressure with a minimum purity level of 99.998%. The system shall be containerised and plug-and-play, and encompass rectifiers, transformers, piping, valves, instruments, analysers, electrical systems, and automation employing a programmable logic controller.

6.7 Electrolyser Manufacturing:

6.7.1 First indigenously manufactured electrolyser, commissioned by L&T electrolysers Ltd, Hazira-Gujarat

On 1st March 2024, Larsen and Toubro commissioned its first indigenously manufactured hydrogen electrolyser at the Green Hydrogen plant in Hazira, Gujarat. The project features a rated power capacity of 1 MW (expandable to 2 MW), and this electrolyser can produce 200 Nm3/h of hydrogen. It is equipped with two stacks and an electrolyser processing unit ML-400 which is indigenously manufactured and assembled, adhering to the latest international standards, and offers exceptional flexibility and thermal stability. The electrolyser is now undergoing rigorous testing to optimise its performance, paving the way for full-fledged manufacturing of electrolysers.

L&T Electrolysers Limited, a newly incorporated entity of L&T, is focused on manufacturing pressurised alkaline electrolysers using the technology from McPhy Energy, France.

The company spearheaded the complete value chain from engineering to manufacturing, in collaboration with Indian vendors and suppliers, thus setting a benchmark for "Make in India" initiatives.

L&T Electrolysers plans to leverage its upcoming giga-scale facility in Hazira to meet the growing demand for Green Hydrogen, maximise product localisation through enhanced local supply chains, and automate for cost-competitiveness.

L&T Electrolysers has been allocated a significant 300 MW/annum capacity under the Incentive Scheme of the National Green Hydrogen Mission, launched by Government of India's Ministry of New and Renewable Energy (MNRE) and implemented by the Solar Energy Corporation of India (SECI).

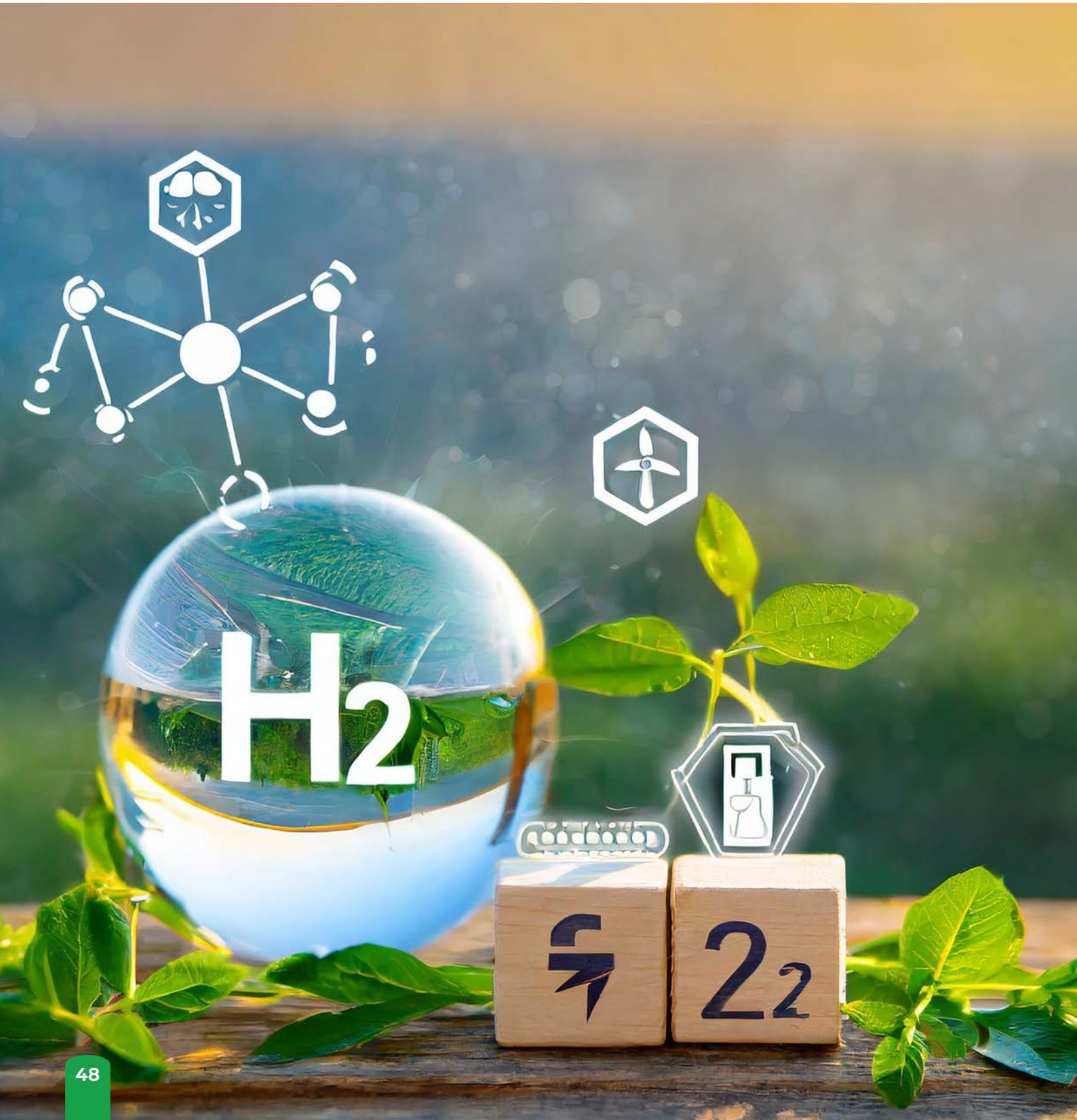
Note: All the projects have not been mentioned here in the booklet. However, there are more than 50 projects, consisting of pilot and commercial production projects, which are in different stages of planning, tendering, implementation and commissioning.

Note

CHAPTER

7

MESSAGE FROM INDUSTRY



Rajat Seksaria
CEO
Adani New Industries Ltd. (ANIL)

Adani New Industries Ltd. (ANIL), the Green Hydrogen platform of Adani Group is a leading player in the nascent Green Hydrogen industry in India. ANIL is dedicated to bolster India's energy security by adopting a fully integrated strategy while developing the Green Hydrogen ecosystem. It is establishing a comprehensive end-to-end supply chain for all key equipment for Green Hydrogen production. With supply chain secured, ANIL plans to commission an integrated Green Hydrogen ecosystem aimed at generating low-cost renewable power and in turn produce globally competitively Green Hydrogen and its derivates at scale.

ANIL intends to set up equivalent to 1 MMTPA of Green Hydrogen production in phases by 2030, with plans for further expansion in future. The strategy is focused on development of an integrated hydrogen ecosystem with three business streams: manufacturing of supply chain products (i.e. solar- polysilicon, ingot, wafer, cell & module, wind turbine generator, electrolysers & ancillary items); Green Hydrogen production and production of downstream derivative products (i.e. Ammonia, Methanol, SAF and others). The equipment manufacturing is the current focus areas i.e. solar panels & ancillaries, wind turbine generators and electrolysers, apart from finalizing engineering works etc. for the Green Hydrogen stream and related components.

ANIL has ventured into solar manufacturing in 2015 and it is today one of the India's largest integrated manufacturer of solar cells and modules with a capacity of 4 GW per annum and intends to expand to 10 GW in the future. ANIL has also developed India's largest wind turbine generator of 5.2 MW capacity (manufacturing capacity 1. 5GW/annum). ANIL has also been awarded 198.5 MW electrolyser manufacturing capacity by SECI under PLI scheme Tranche-I. Adani Green Energy Limited, is already the largest renewable power producer in India with 20,434 MW capacity under operation and construction, and it aims to further expand to 45,000 MW by 2030. With significant experience in these areas, ANIL is well positioned to realize its targets and provide green molecules at globally competitive cost.

Adani Mundra ports' proximity to global supply chain enables export opportunity of Green Hydrogen and derivatives for ANIL and at the same time, integrates it in Indian import supply chain as well. The combined strength of Adani portfolio companies in renewable equipment manufacturing, setting up large scale generation projects, building the grid-infrastructure, and proven project execution capabilities gives it a significant competitive advantage while building the Green Hydrogen ecosystem in India. ANIL is committed to India's National Green Hydrogen mission and decarbonisation goals.

The Group has tied up with multiple technology partners to build a world-class electrolyser manufacturing facility. ANIL targets to have gigawatt-scale electrolyser manufacturing capacity. Additionally, leveraging its supply chain, ANIL has initiate phase 1 project development with the aim of producing 1 MMTPA green ammonia by FY-2028.

Shalin Sheth
Founder and M D
Advait Infratech

Role of Green Hydrogen in Indian and Global Context

The energy sector is undergoing a transformative phase globally, shifting towards more sustainable and eco-friendly sources. Green Hydrogen, produced through the electrolysis of water using renewable energy sources, is emerging as a key player in this transition. Its potential in reducing carbon emissions and fostering energy independence is immense, making it a focal point in climate change mitigation strategies.

Company's Viewpoint on Hydrogen Value Chain

Advait Infratech recognises the hydrogen value chain as a pivotal element in achieving a sustainable energy future. The company views Green Hydrogen not just as an energy carrier but as a linchpin in the global effort to decarbonise various sectors, including transportation, industry, and power generation.

Initiatives towards Development of Hydrogen Eco System

Ongoing Projects

Micro Grid based Green Hydrogen Project: Advait Infratech has embarked on India's pioneer project in this domain, partnering with THDC India Limited, using advanced Fuel Cell technology. This project in Uttarakhand is a testament to the company's commitment to sustainable energy solutions.

Future Plans - 2030/2050

Advait Infratech aims to be at the forefront of green energy solutions, scaling up its hydrogen production capabilities and integrating them with renewable energy projects, targeting significant contributions to India's energy mix by 2030 and beyond.

Export Plans

The company is exploring opportunities to export its expertise and technology, particularly in electrolyser manufacturing, to global markets.

Challenges / Risks and Mitigation Strategy

Challenges and Risks

- **Technology and Cost:** The nascent stage of hydrogen technology poses challenges in terms of cost-effectiveness and large-scale deployment.
- **Infrastructure:** Developing the necessary infrastructure for hydrogen production, storage, and distribution is a significant hurdle.
- **Regulatory Framework:** The absence of a comprehensive regulatory framework for Green Hydrogen can impede growth and investment.

Mitigation Strategy

- **Partnerships:** Collaborating with global leaders, as seen in the MoU with GuoFu, for technical expertise and knowledge transfer.
- **Innovation:** Continual investment in R&D to enhance the efficiency of electrolyser and fuel cell technologies.
- **Advocacy and Policy Engagement:** Working with government bodies to shape policies that support the hydrogen economy.

Advait Infratech's Achievements and Milestones

- **Groundbreaking 300 kW Green Hydrogen Production Plant:** A milestone in India's renewable energy landscape, this project at the THDCIL office in Rishikesh is a significant achievement.
- **Technological Partnerships:** Aligning with globally known OEMs for technology partnerships.
- **Carbon Neutralisation Services:** Offering comprehensive services in carbon consulting and neutrality, aligning with global decarbonisation goals.
- **Fuel Cell and Electrolyser Manufacturing:** The MoU during the Vibrant Gujarat 2024 Summit paves the way for future advancements in this field.

Mr. Vineet Mittal
Chairman
Avaada Group

Embedded in our ethos, 'Avaada' symbolises a commitment to a sustainable future guided by the harmonious principles of Ayurveda through its business verticals, which include Renewable Power Generation, Solar PV Manufacturing, and Green Fuels Avaada Group is contributing significantly towards global decarbonisation. The IPP arm of the group responsible for renewable power generation is one of the fastest-growing platforms in its domain, with over 4.4 GWp of operational capacity across India. It is on a mission to increase its renewable energy generation to 11 GW by 2026 and 30 GW by 2030.

Avaada, through its other business verticals for Solar PV manufacturing and Green Fuels, including Green Hydrogen and its derivatives like Green Ammonia, Green Methanol, Sustainable Aviation Fuel, etc., is leveraging the synergies to build a robust business model with significant competitive advantage.

Viewpoint of Green Hydrogen

Green Hydrogen has diverse applications as fuel and feedstock across sectors like electricity generation, surface transport, marine transport, aviation, and industries like fertilisers, cement, and steel, which are primarily responsible for global GHG emissions. India, with the availability of resources like land, favourable wind and solar radiation intensity, a robust power grid, and a developed eco-system of equipment suppliers and EPC contractors, is well poised to play a significant role in the development of Green Hydrogen globally and is aptly targeting to become global Green Hydrogen hub and become net exporter of energy.

Details of Avaada's plan

Avaada is committed to the transition to clean energy and believes strongly in the potential of Green Hydrogen and its derivatives for global decarbonisation. We are moving aggressively in the space, and the execution of our first Green Ammonia with a capacity of 0.5 MTPA is being undertaken swiftly. We are also in the advanced stages of planning for large-scale projects to produce Green Methanol, SAF, etc.

We plan to cater to the export market and the emerging domestic demand and plan our project accordingly.

Challenges and Risks

The trajectory of renewable energy in India, significantly bolstered by the Renewable Purchase Obligation (RPO), illustrates the profound impact of policy frameworks on accelerating energy transitions. Similarly, for Green Hydrogen to achieve its potential, a robust policy framework akin to a Green Hydrogen Consumption Mandate is imperative. This mandate should extend to mobility and industrial sectors, catalysing the adoption of Green Hydrogen in energy-intensive applications.

A tangible, immediate step towards this transition is the M15 mandate, proposing a 15% blend of green methanol with petrol. This initiative represents a practical, low-hanging fruit that could significantly reduce carbon emissions and foster a domestic market for Green Hydrogen and its derivatives.

By advocating for such mandates, we can emulate the success story of renewable energy in the Green Hydrogen domain. These policy measures will provide a clear direction for the industry, stimulate demand, drive technological advancements, and encourage investment in infrastructure development.

Addressing the challenges of technology maturity, infrastructure build-out, regulatory frameworks, and import infrastructure readiness is crucial. Collaborative efforts across government, industry, and research institutions will be key to overcoming these hurdles, positioning India as a leader in the global hydrogen economy.

Green Hydrogen, the '**Sanjeevani Booti**' of our era, promises to decarbonise the electricity sector, mobility, and industry, pivotal for India's Net Zero ambitions. Avaada Group is committed to leading this green revolution, leveraging Green Hydrogen as the sustainable 'oil' of the future, ensuring a cleaner, greener planet for future generations.

G Krishnakumar
C&MD
BPCL

Transitioning towards CLEANER FUTURE

As the global effort intensifies to decrease greenhouse gas emissions and address the challenges of climate change, the significance of adopting more sustainable energy sources becomes more pronounced. India has emerged as a powerhouse of global economic growth and is witnessing a rising energy demand. With aspirations to diversify the energy mix, achieve energy self-sufficiency, ensure energy security, and meet long-term climate change goals, India is strategically positioning itself for a transformative energy future. In this context, hydrogen has emerged as a promising energy carrier, demonstrating the potential to play a pivotal role in the ongoing energy transition

BPCL's vision for Green Hydrogen revolves around fostering a sustainable and environmentally friendly energy future. Green Hydrogen serves as a key enabler in the energy transition, providing solutions for decarbonising industries, storing renewable energy, fuelling transportation, balancing grids, and promoting international collaboration. Its versatile applications make it a cornerstone in building a sustainable and resilient energy ecosystem for the future.

In alignment with the Indian Government's National Green Hydrogen Mission, initiated by the Honourable Prime Minister, BPCL is at the forefront of pioneering initiatives aimed at promoting the proliferation of Green Hydrogen within India.

BPCL is advancing with a proposed 5 MW Electrolyser Plant in Bina, set to produce 700 tons of Green Hydrogen annually. Under the SIGHT Scheme, our aim is to produce 2000 TPA of Green Hydrogen via biomass pathways, with plans for CBG plants at Kochi and Bina refineries. Collaboration is a key aspect of BPCL's strategy. Our Memorandum of Agreement with Bhabha Atomic Research Centre (BARC) focuses on alkaline electrolyser technology, including a 1 MW demonstration plant. BPCL is expanding infrastructure with a Green Hydrogen Refuelling Station at Kochi Airport, using domestically produced electrolysers providing comprehensive facilities for storage and dispensing. We are also exploring integrating Green Hydrogen into the city gas distribution network, showcasing our commitment to widespread adoption across sectors.

In the pursuit of long-term sustainable solutions, BPCL's R&D efforts are also focused on developing innovative hydrogen storage solutions and indigenous fuel cell systems in collaboration with various academic institutions. Moreover, BPCL is exploring alternatives to replace the use of grey hydrogen in refineries with Green Hydrogen.

Through these concerted efforts, BPCL is actively contributing to the realisation of the National Green Hydrogen Mission, positioning itself as a leader in advancing sustainable and clean energy solutions in India.

The decisive factor in the widespread adoption of hydrogen lies in its cost competitiveness compared to conventional energy sources. The reduction in the cost of hydrogen production, storage, and utilisation will be driven by technological advancements, economies of scale, economic considerations, and supportive policies. As these factors converge, hydrogen is poised to become a more economically viable energy option.

Siddharth R Mayur
Founder & M D
h2e Power Systems Private Limited

24x7 clean, green, reliable & affordable energy to all

A journey that was inspired by bringing energy to h2e's Founders village which was in Darkness on Diwali Day in 2009, has blossomed into India's first homegrown Fuel Cell & Electrolyser company, 'h2e Power Systems Private Limited'. Founded to provide solutions for Agriculture and Rural households, h2e has graduated into a successful mascot of the Startup India initiative Championed by the Honourable Prime Minister, Shri. Narendra Modi ji. h2e is engaged in the entire value chain of the NetZero ecosystem, from manufacturing Electrolysers & Fuel Cells, to developing industry specific solutions and in the downstream producing the Green Hydrogen, Green Ammonia, Green Methanol & SAF molecule.

The company prides itself as a result of the great initiatives & policies undertaken by the Government of India towards MSME companies, especially GreenTech Start-ups. h2e believes that the Hydrogen ecosystem has tremendous potential, not just in the known low hanging fruits, but in unexplored areas like Agriculture, C&I segment, Micro-Grids & Residential units.

h2e to its credit is the first Indian company to have indigenously developed technology that is being commercialized, with a 1GW per annum stack and electrolyser BoP manufacturing plant. h2e's subsidiary homi Hydrogen Private Limited has been amongst the 8 companies that won the PLI for electrolyser manufacturing.

With academic partnerships with Institutes like Fraunhofer Institute in Germany, Saint Andrews College in Scotland, h2e has brought cutting edge technologies from across the world and developed frugal solutions for mass production & implementation on ground. H2e owns 36 patents, another first for an Indian company in the Green Hydrogen industry.

The company has a strong pedigree and is developing itself as a Future ready GreenTech company, Made in India; Made for the world. h2e's Project Pipeline:

h2e's Project Pipeline:

On-Going & Completed Projects	Upcoming Projects	Future Plans 2030-2050	Exports, If Any
Micro-grid development for distributed power generation with NTPC	1,440 TPA Green Hydrogen production plant near Pune	Own 500MW assets to produce 75 KTPA Green Hydrogen & Derivatives	30% of electrolyser sales to come from Exports
Fuel Cell based micro-grid for green EV charging stations with IOCL	Development of CoElectrolysis for production of Syngas & SAF with Solid Oxide Electrolyser	Electrolyser production plant with capacity of 5GW per annum	Currently h2e's Fuel Cell product is under qualification & certification in USA and Korea
India's first Green Hydrogen plant for OIL India	Commissioning of 1GW Electrolyser manufacturing plant for AMSE, SOE & Alkaline technologies	Fuel Cell manufacturing capacity of 2GW per annum	

On-Going & Completed Projects	Upcoming Projects	Future Plans 2030-2050	Exports, If Any
Fuel Cell manufacturing capacity of 2GW per annum	Demonstrator for Smart, Clean & Green Agriculture using Green Hydrogen based CHP micro-grid		
India's First Solid Oxide electrolyser developed			

Challenges and Risk

Challenges & Risks	Mitigation Plan
Well trained manpower on ground	The company has launched a 11-month training program called 'UrjaUdhyami' to train & develop Green Warriors who can help in the last mile implementation of the technologies while generating green jobs in unban and rural areas
Supply Chain (Key Components)	The Company has forged partnerships with major academic institutions in India to develop components of the stack and Bop locally with local components

With a Vision of 'Swadeshi Urja for a Swawalambi Bharat', h2e has adopted the Founders dream of developing a 'Climate Change Vaccine' that will vaccinate the Earth and free humanity from the Climate linked Pandemic that the world is currently su1ering. h2e Power Systems is Founded by First Generation Social Entrepreneur Mr. Siddharth R Mayur & is partnered and supported by Mr. Adar C Poonawalla (CEO, Serum Institute of India

Amit Bansal
CEO
Hygenco Green Energies

Role of Bharat in Shaping Green Hydrogen Sector

Bharat is setting its sights on a clean energy future, driven by the ambitious goals of achieving energy independence by 2047 and net-zero emissions by 2070. Green Hydrogen, with its potential to fulfil India's energy needs and also decarbonise hard- to- abate sectors, is a game-changer in this pursuit. In line with this ambition, National Green Hydrogen Mission aims to produce 5 million metric tonnes of this clean fuel annually. Backed by a ~17,944 crore budget, this initiative reflects India's commitment to becoming a leader in the Green Hydrogen revolution.

India is bound to be one of the biggest beneficiaries in this sector owing to the following reasons

- **Huge existing and growing domestic demand of clean energy**
- **Abundant renewable resources**
- **Supportive government initiatives**
- **Cheap Labour**
- **Robust National Grid – Feature available in very few countries worldwide**

Hygenco: A Pioneer in the Indian Green Hydrogen Landscape

Hygenco, a prime example of Aatmanirbhar Bharat, develops and deploys scaled-up commercially attractive Green Hydrogen and Green Ammonia production assets. We boast several "firsts" in Bharat:

- **India's first fully autonomous Green Hydrogen plant**
- **India's First (and probably world's first) Green Hydrogen plant for the stainless steel sector**
- **India's first commercial Green Hydrogen plant: Supplying Jindal Stainless and reducing their carbon footprint by 54,000 CO2e tonnes over next 20 years**.

Hygenco is making a big bet on India's Green Hydrogen future with a planned capex of US$2.5 billion over next three years. Hygenco brings expertise in developing and operating technically advanced Green Hydrogen Plants and thriving to achieve lowest cost of Green Hydrogen. Our current portfolio includes a pilot plant unit in MP, an operating commercial plant in Haryana, and two more Green Hydrogen plants under construction in Maharashtra.

Furthermore, we are venturing into large-scale projects across various states, specifically targeting industries like refineries, steel, and fertilisers with significant emission challenges. In sync with our Sanskriti of वसुधैव कुटुम्बकम्, Hygenco has undertaken setting up a **1 MTPA Green Ammonia Plant** in Odisha primarily for exports. The key project has received clearance from the High Level Clearance Authority (HLCA), chaired by the Chief Minister's Office, Odisha, and the State Level Single Window Clearance Authority, chaired by Chief Secretary, Odisha

By 2030, Hygenco is aiming to completely revolutionise Green Hydrogen (and its derivatives) sector in Bharat with a targeted investment of more than US$10 billion. Adding steam to the momentum is Hygenco's win in the SECI's Green Hydrogen tender under SIGHT Program. Ryming with Bharat, Hygenco is pioneering efforts to overcome obstacles in the Green Hydrogen sector, driving the transition towards decarbonised industries and a cleaner future.

Challenges in this Journey

Under the leadership of our Honourable Prime Minister Shri Narendra Modi, Bharat aspires to be the world's leader in Green Hydrogen production. To achieve this vision, we need to cross challenges in terms of high dependence on imports and challenges associated with infrastructure for power transmission. Strategies involved to mitigate these challenges include advancements in electrolyser technology, infrastructure push, policy support, and the adoption of digital technologies like AIoT for optimisation.

Sumant Sinha
Chairman and CEO
ReNew

Shifting Gears: Bharat's Rise as a Green Hydrogen Leader

The Hon'ble Prime Minister Narendra Modi has set out a vision of energy independence for India by 2047. Green Hydrogen will be a critical fuel source in this journey, as a clean feedstock to run industrial processes and various modes of transport, including aviation and marine shipping.

The National Green Hydrogen Mission is a commendable initiative by the Government of India's leadership to kick-start the Green Hydrogen sector. At ReNew, we are committed to supporting this initiative of the government. The company already accounts for about 1.9% of India's electricity generation capacity and does so using clean sources like wind and solar power.

We have now ventured into producing Green Hydrogen and its derivatives and aim for an ambitious target of achieving cumulative production capacity of ~1 MTPA by 2030. We are developing several projects in the coastal states of India and expect to start commercial operations of our first project by the year 2027. ReNew has also entered into a strategic partnership with IOCL and L&T, wherein the joint venture will cater to fulfilling the Green Hydrogen requirements of the domestic market.

On the global front, ReNew's JV is one of the two companies from India shortlisted for Germany's Green Hydrogen import tender. ReNew signed a framework agreement with Egypt to set up a Green Hydrogen plant in the Suez Canal Economic Zone.

Drawing from our experience, three areas need particular attention going forward, to accelerate the development of an enabling and internationally competitive Green Hydrogen ecosystem in India.

- **Demand creation:** Project developers and investors need to secure long-term offtake contracts to ensure bankability of the initial set of projects, until the time Green Hydrogen and its derivatives become extensively traded commodities. The government may therefore consider demand creation through mandatory consumption obligations of Green Hydrogen / derivative by industries such as fertilisers, Refineries etc, similar to the Renewable Purchase Obligations (RPO), with a clear roadmap for other sectors.

- **Cost reduction:** The costs of Green Hydrogen need to be halved from the current levels of USD 4-5 per kg, in order to shift consumers of grey hydrogen to Green Hydrogen in India and compete with international suppliers overseas. Two interventions may be helpful to reduce the costs – rationalisation of taxes and duties on the RE power that constitutes for 50-60% of the production cost of Green Hydrogen, and; aggregation of demand and production at cluster level or in-situ at industrial sites, to reduce transportation and conversion costs.

- **Financing support:** Green Hydrogen / Derivatives projects are capital intensive projects and to fulfil the capital requirements of these projects, an economical and competitive financing package will help the industry in competing with the rest of the world. The Government may explore the options of a suitable mechanism to provide competitive financing for Green Hydrogen projects.

To conclude, India is at a crucial juncture in the journey to achieve clean and cost-effective energy independence. We are already well placed, and can go further and faster through investment, innovation, and collaborative efforts, under the overall leadership of the Government of India.

Torrent Power

Torrent Group in Green Hydrogen ..... journey towards sustainable energy solutions

Emerging role of Green Hydrogen in Decarbonisation

Green Hydrogen is an important element of the Energy Transition and is slated to play a critical role globally in achieving decarbonising hard-to-abate sectors like refineries, fertilisers, steel, transportation etc. India's distinct advantage in low-cost renewable energy generation makes Green Hydrogen the most competitive form of hydrogen in the long run. As per a NITI Ayog report, it is estimated that by the year 2030, the price of producing Green Hydrogen will reach USD 1.7 to USD 2.4. This enables India to potentially be one of the most competitive producers of Green Hydrogen in the world. It is estimated that Green Hydrogen's share would grow to 16% in 2030 and 94% by 2050.

Strategic Position of Torrent:

Torrent Group, a global conglomerate with a market cap exceeding $ 14.8 billion and an annual turnover surpassing $ 4.3 billion, is a prominent player in Power sector in India. Renowned for its comprehensive presence in generation, transmission, and distribution, Torrent Power has embarked on the journey of Green Hydrogen to leverage its renewable and projects execution and O&M experience. The company aims to establish itself as a leading end-to-end Green Hydrogen solution provider in the next 3-5 years. The company has strategically positioned itself in the Green Hydrogen value chain, focusing on production of Green Hydrogen and ammonia.

Early Mover Strategies:

Anticipating upcoming opportunities in the Green Hydrogen ecosystem, Torrent's early-mover approach involves meticulous planning, capacity building, technology assessment, supplier tie ups, risk evaluation and active participation in various opportunities. The initial two years provided valuable insight into the challenges and risks associated with the Green Hydrogen ecosystem.

Pilot Project and Innovation:

To gain hands-on experience in GH2 project design and execution, Torrent initiated a GH2 pilot project in 2023 for blending of GH2 in the city gas distribution network of Gorakhpur, UP. The project utilises Alkaline Electrolyser technology and is scheduled for commissioning in next two months. The objective is to understand the dynamic behaviour of the electrolysers and assess the impact of GH2 blending in the downstream system and to gain learning of all techno-commercial aspects.

Future Endeavours:

With a focus on the export as well as the domestic market of green ammonia, Torrent has completed a feasibility study and is soon to start FEED of an integrated GH2/GNH3 plant with a total capacity of 0.45 MTPA of green ammonia in phases. Torrent has got allocation for 18000 tonnes in the PLI scheme of SECI for GH2 production. The company has engaged in constructive discussion with potential off-takers, planning the first phase of commissioning of 100 KTPA GNH3 by the first quarter of 2027. Torrent actively monitors domestic market developments as well, eyeing participation in tenders for end-to-end solutions from RE to GH2 and its derivatives.

Challenges and Way Forward:

Major challenge is the price disparity between grey and Green Hydrogen. To overcome this, mandates, incentives, favourable policies, subsidies, carbon credit mechanisms and standardisation of carbon intensity by concerned Governments are imperative. The absence of infrastructure for storage and transport of Green Hydrogen is another major concern.

Concluding Remark:

Torrent Power is at the forefront of India's Green Hydrogen revolution, committed to sustainable solutions and overcoming challenges through innovation and strategic partnership. The Company's journey unfolds with a clear vision of transforming India's energy landscape and contributing significantly to global sustainability goals.

Jai Shroff
Chairman and Group CEO
UPL Limited

UPL Limited Green Hydrogen based Green Specialty Chemicals Project

UPL group is the leading agrochemical & specialty Chemical company in the world that offers an integrated portfolio of crop protection solutions, specialty chemicals & BioSolutions. UPL is the first agrochemical company included in the esteemed Dow Jones Sustainability World and Emerging Markets Indices (DJSI).

This inclusion is based on UPL's outstanding performance in achieving the highest scores in the agrochemical sector in the S&P Global 2023 Corporate Sustainability Assessment, as announced in November. It has also placed the company as the highest performing agrochemical company globally and in the top 1% of chemical companies worldwide.

In line with UPL strategy to transitioning from fossil raw material-based specialty chemicals manufacturing to green chemicals-based specialty chemicals manufacturing, UPL is planning to set up a renewable power park (Solar, Wind, Hybrid, Battery storage system) & manufacturing projects including Green Hydrogen, green ammonia and green specialty chemical & derivatives in Gujarat state. Through this project, UPL will be decarbonising Specialty Chemicals, contribute to 'Make in India' campaign of Government of India and generate employment and development of ancillary industry.

UPL Ltd is planning to set up 10,000 tonnes per year of Green Hydrogen and derivatives for that it has also been selected as successful bidder under the GoI MNRE's SIGHT Programme (Strategic Interventions for Green Hydrogen Transition) - for Green Hydrogen Production (mode 1 Tranche 1). This project is being planned in Gujarat state. First tranche of this project is already getting pre-commissioned and trailed in March 2024.

Going forward by 2030, UPL LTD is also planning to set up bigger capacities of Gren Hydrogen and derivatives such as Green Ammonia, Green Methanol, Green Speciality chemicals. For this UPL LTD is acquiring bigger land parcels in the state of Gujarat. Currently also 90% of UPL LTD speciality chemicals are being exported. While laying down Green Hydrogen & derivatives project plan, UPL continues to remain export-oriented business model.

Green Hydrogen & derivatives business is having various complexities and challenges since it is a sunrise sector for India. Technologies for electrolyser is still evolving, economic viability is not very clear, renewable power development in country is still not fully matured, off take agreements for Green Hydrogen derivatives are not consistent, regulations and standards are not streamlined internationally. To overcome these challenges, a consortium of industries, Government bodies, Technology companies & institutes must come together to develop a plan and implement it for a sustainable & better future.

Kapil Maheshwari
CEO
Welspun New Energy

As the global pursuit of clean energy transition gathers momentum, Hydrogen is an important lever to achieve carbon neutrality and is expected to contribute to 10-20 % of world's energy mix by 2050. To achieve net zero by 2050, the global demand for Green Hydrogen is projected to reach 528 MTPA, presenting a US$ 0.5-0.7 Tn economic opportunity. In India, the demand for H2 is projected to increase from 6.5 MTPA in 2023 to ~11-12 MTPA by 2030. Under the National Green Hydrogen Mission, the Government of India has set a target to produce 5 MTPA of Green Hydrogen by 2030.

Welspun New Energy Limited, an integral part of Welspun World, is actively involved across the entire Green Hydrogen value chain:

- **Upstream:** Renewable energy production and Green Hydrogen production
- **Midstream:** Welspun Corp (a part of Welspun World) is developing pipeline for safe transportation of Hydrogen.
- **Downstream**: Welspun Corp (a part of Welspun World) is initiating a pilot to use Green Hydrogen for steel production.

We, at Welspun New Energy Limited, aim to develop 2 MTPA of Green Ammonia/ derivatives capacity by 2030 and we have made significant strides towards this goal:

We working with multiple states to set up Green Hydrogen/ derivatives facilities:

- Signed MoU with the Govt. of Gujarat for 1 MPTA Ammonia capacity
- Signed MoU with the Govt. of Maharashtra for 0.55 MTPA Ammonia capacity
- In-principle approval from the Govt. of Odisha to set up 0.7 MTPA Ammonia facility
- We have secured an in-principle approval from Government of Gujarat for ~20,000 acres of land to produce renewable energy for Green Hydrogen production.

We have initiated process to acquire land at Kandla Port (Gujarat) and Paradip Port (Odisha) and have signed MoU with Pipavav Port (Gujarat) to set up Green molecules production facilities.

We have initiated off-taker discussions with multiple end users in Europe, Japan and South Korea for off-take of green derivatives.

Key risks for Hydrogen project developers include long term offtake for the financial viability of projects, uncertainty in electrolyser technology, port infrastructure, certifications related to green derivatives, and indigenous safety standards for handling green derivatives.

Our government has taken multiple initiatives to build the Hydrogen ecosystem in the country including both supply and demand side incentives such as PLI for H2 and electrolyser production, ISTS waiver, Green corridor for renewable energy transfer, development of H2 hubs at ports and incentives to promote demand in Steel, Transportation, and Ammonia. Additionally, multiple state governments have introduced policies to support production including land at a subsidised rate, single window clearance, capex subsidies, subsidised renewable power and many others.

At Welspun New Energy Limited, we are committed to spearheading the Green Energy revolution and positioning India as a prominent exporter of "Green Energy".

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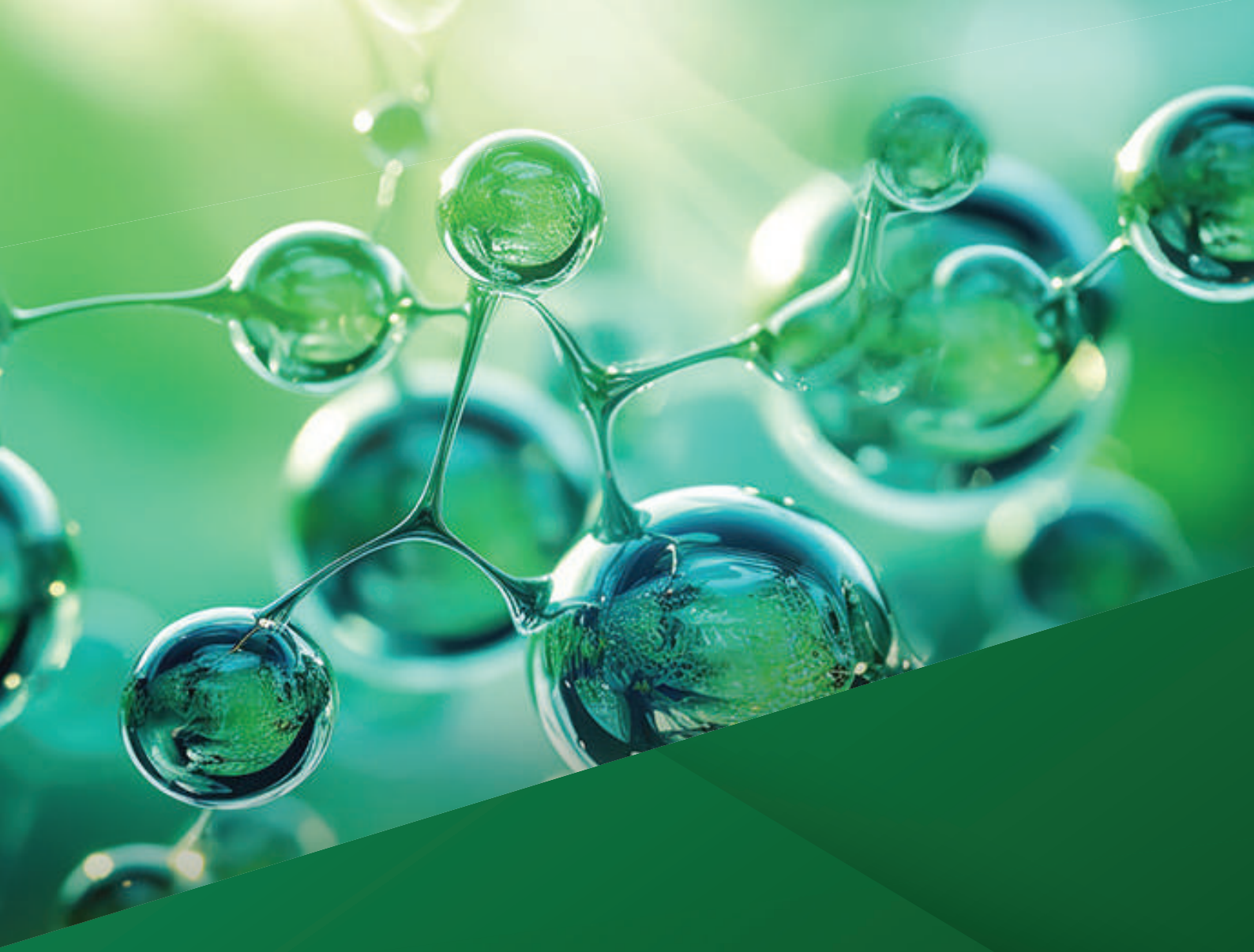

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नवीकरणीय ऊर्जा मंत्रालय
MINISTRY OF
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