SEMINAR ON GREEN HYDROGEN

Summary Report

22 April 2024

Venue: Seminar Hall-1, 1st Floor, Kamala Devi Complex, India International Centre (IIC), 40, Max Mueller Marg, New Delhi-110003
Time: 11:30 – 17:00 hours IST

Event Webpage: https://isolaralliance.org/ghic/gh_event.html
YouTube: https://youtu.be/NEzecV8AsRo

INAUGURAL SESSION

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Time	**11.30 AM to 12.15 PM**
Welcome by Host	**Mr. Pradeep Chaturvedi, FNAE** *Chairman, INAE Delhi Chapter*
Opening Remarks by President, INAE	**Professor Indranil Manna** *FNAE, President, Indian National Academy of Engineering (INAE)*
Special Address by DG, ISA	**Dr. Ajay Mathur, *FNAE*** *Director-General, International Solar Alliance and Chairman, INAE Forum on Energy*
Inaugural address by Chief Guest	**Mr. Bhupinder Singh Bhalla,** *Secretary, Ministry of New and Renewable Energy, Government of India*
Vote of Thanks	**Lt Col Shobhit Rai (Retd)** *Officiating Executive Director, INAE*

Inaugural Session Recording: https://youtu.be/aIA8_b0Ltlk

Mr. Pradeep Chaturvedi,
FNAE, Chairman,
Indian National Academy of Engineering (INAE) Delhi Chapter

Professor Indranil Manna,
FNAE, President,
Indian National Academy of Engineering (INAE)

Dr. Ajay Mathur,
FNAE, Director-General,
International Solar Alliance and Chairman, INAE Forum on Energy

Mr. Bhupinder Singh Bhalla,
Secretary, Ministry of New and Renewable Energy (MNRE), Government of India

- 2023 was a marquee year with huge number of discussions and interventions in green hydrogen. G20 2023 summit saw an accelerated push for adoption of Green Hydrogen (GH).
- The Indian Government has pledged to invest 8 Lakh Crore by 2030 through Green Hydrogen Mission.
- This mission was launched in 2021 to address challenges related to high capital investment, large infrastructure, transmission, water availability, and associated technology issues.
- Production of GH would require RE capacity addition. It is estimated that additional 100-125 GW RE capacity will be required to meet the 5 MMT GH target by 2030.
- 1.5. GW capacity for electrolysers has been awarded to 8 companies with the target of 3 years to begin manufacturing.
- Incentives should be provided to electrolyzer manufacturers in India to make the country a global hub for GH production.
- Currently, India offers incentives for production of GH. It is also important to have incentives for its utilisation, which is critical to create demand and thereby lower production costs.
- Cost competitiveness is a major concern for GH development. This can be addressed by reducing the electrolyzer cost, by increasing the utilisation as well as using energy from nuclear plants for electrolysis.
- Research and Development will play a crucial role in reducing costs, such as lowering the costs of renewable energy and improving electrolyzer efficiency.
- Emphasis should be placed on reducing carbon emissions and establishing standards for the large-scale use of GH. Recommendations on standards have been sent to certified agencies for review and validation.

SESSION-1

Green Hydrogen - Relevance, Policy, Regulations and Standards

SESSION - I	
Session Title	**Green Hydrogen- Relevance, Policy, Regulations and Standards**
Time	12.15 PM to 1.15 PM
Background & Rationale	Hydrogen has long been recognized as a pathway to deep decarbonization, particularly in hard-to-abate sectors. There is a renewed global interest in this versatile energy resource, with several governments announcing Green Hydrogen policies, strategies, and targets, and global multilateral and private sector organizations increasingly recognizing Hydrogen in their near-to-midterm strategies. This session brings together policymakers and experts to analyze the role of existing policies, regulations, and standards in ensuring the scaling up of green hydrogen deployment in India.
Session objectives	i. Assess policy and regulatory frameworks and incentives that can accelerate green hydrogen ecosystem readiness. ii. Approach for market creation and harmonization of global standards for domestic consumption and export.
Session Chair and Moderator	**Dr Anil Kakodkar, FNAE,** Chancellor, HBNI, Mumbai; Former President, INAE; and Former Chairman of Atomic Energy Commission and Secretary to Government of India, Department of Atomic Energy
Panel Discussion	**Panelists:** • Professor Indranil Manna, FNAE, President, Indian National Academy of Engineering (INAE) • Ms. Gauri Singh, Deputy Director-General, International Renewable Energy Agency (IRENA), Abu Dhabi, UAE • Mr. Jonas Moberg, CEO, Green Hydrogen Organization, Geneva • Mr. Sarbojit Pal, Manager of Partnerships, Clean Energy Ministerial (CEM), Headquarter, Paris
Audience interaction and way forward	Moderated by Session Chair

Session-1 Recording: https://youtu.be/tBC9U7wTaaE

Dr Anil Kakodkar,
FNAE; Chancellor, HBNI, Mumbai; Former Chairman of AEC; Secretary to Government of India, Department of Atomic Energy

Professor Indranil Manna,
FNAE, President, Indian National Academy of Engineering (INAE)

Ms. Gauri Singh,
Deputy Director-General, International Renewable Energy Agency (IRENA), United Arab Emirates

Mr. Jonas Moberg,
CEO, Green Hydrogen Organization, Geneva

Mr. Sarbojit Pal,
Manager of Partnerships, Clean Energy Ministerial (CEM), Paris

- Economics and technology transition reduces GH production cost by enabling new technologies to enter the market without barrier.
- For Long term energy security, nuclear energy should be included as a generation source for GH production.
- As per IRENA Energy Outlook, it is estimated that by 2050, about 10-12% of the energy mix will come from hydrogen and of that 90% from GH.
- By 2050, electricity will dominate as the major carrier of energy. However, hard-to-abate sectors can look at effective ways to decarbonise.
- Need to bring down the RE cost and the cost of equipment required, to lower the GH production costs.
- Policy should focus on long term goals and guide technological transition effectively.
- Viability Gap funding is extended to UK hydrogen producers to enhance competitiveness against high carbon sources. A built-in investment mechanism was provided to support and finance GH projects and create a market demand.
- Public sector investment should focus on infrastructure, such as storage, transportation and distribution of GH alongside research and development.
- Develop policies to raise societal awareness and offer incentives to accelerate trainings, research and technology advancement.
- In some markets, it is easier to implement green premium.
- More sector specific mechanisms such as carbon pricing tools will be beneficial, but blanket global carbon pricing (tax) is unlikely to come in near future.
- Need to be technology agnostic to meet collective goals while still balancing domestic priorities.
- Hydrogen has strong potential as an energy source in the long-haul transportation and applications in industries and domestic usage.
- Lot of discussion around biofuels in Clean Energy Ministerial. Future Fuels Accelerator looks at all different kinds of sustainable fuels. Framing of this discussion was initiated during G20 in India.

SESSION-2

Economics of Green Hydrogen
in the Indian context

SESSION - II	
Session Title	**Economics of Green Hydrogen in the Indian context**
Time	2.30 PM to 3.30 PM
Background & Rationale	India has established green hydrogen as a core pillar of its decarbonization and net zero strategy. India's National Green Hydrogen Mission (NGHM) sets out a roadmap for using hydrogen to meet its climate targets and make India a green hydrogen hub. This mission aims to enable India to become a global hub for the production, usage, and export of green hydrogen and its derivatives. This session will delve into the current economic landscape of green hydrogen in India. We will explore factors influencing its cost competitiveness, including renewable energy prices, electrolyzer technology advancements, green hydrogen production and use; and infrastructure development.
Session objectives	i. Analyze existing and emerging business models for off-take of green hydrogen in India. ii. Identify key economic factors and policy instruments that can drive down green hydrogen costs.
Session Chair and Moderator	**Dr. Ajay Mathur, FNAE** Director-General, International Solar Alliance and Chairman, INAE Forum on Energy
Panel Discussion	**Panelists:** ▪ **Dr. Ashish Lele,** Director, National Chemical Laboratory (NCL), Pune, India. ▪ **Dr. Pradeep Tharakan**, Director, Energy Transition, Asian Development Bank ▪ **Mr. Shreyans Jain**, Investment Officer, Upstream Asia, Manufacturing Agribusiness and Services, International Finance Corporation (IFC), India ▪ **Mr. Sturle Harald Pedersen**, Chairman of the Board, Greenstat Norway ▪ **Mr. Mathieu Geze**, Director Asia - HDF Energy, Indonesia
Audience interaction and way forward	Moderated by Session Chair

Session-2 Recording: https://youtu.be/OYVlHE8ADd4

Dr. Ajay Mathur,
FNAE, Director-General, International Solar Alliance and Chairman, INAE Forum on Energy

Dr. Pradeep Tharakan,
Director, Energy Transition, Asian Development Bank

Mr. Shreyans Jain,
Investment Officer, Upstream Asia, Manufacturing Agribusiness and Services, IFC, India

Dr. Ashish Lele,
Director, National Chemical Laboratory (NCL), Pune, India

Mr. Sturle Harald Pedersen,
Chairman of Board, Greenstat Ltd, Norway

Mr. Mathieu Geze,
Director Asia, HDF Energy, Indonesia

- The user sector will start adopting GH and its derivatives when they are cost effective.
- Some projects in India, with better integration of solar, wind and hydro, could achieve up to 75% electrolyzer utilization, significantly lowering GH cost.
- Reducing GH production cost to match that of gray hydrogen is key to kickstarting India's hydrogen economy.
- Scaling up electrolyzer technology can reduce the cost of GH, boosting its economic viability.
- Utilizing low cost electrolyzer, combined with hybrid renewable energy generator is expected to reduce GH take off price to $2.50/kg.
- Developing project pipelines and assisting stakeholders in creating industrial corridors or GH hubs can significantly boost the hydrogen economy.
- Developing smaller captive GH plants for C&I sectors show significant potential.
- India's strong push for GH includes PLI scheme that incentivise financiers. Interstate transport charges are waived, which helps making the GH production commercially viable.
- Factors such as the durability and choice of raw materials for electrolyzer offer significant opportunities to reduce the costs and enhance the local supply chain for GH components.
- Developing infrastructure such as pipelines and ports is crucial for expanding the market and cross border trade for GH, thereby reducing the costs and stimulating the economic growth.
- In India strategic sector like pharmaceuticals, agro chemical and specialty chemicals heavily use hydrogen for hydrogenation, consuming 250 kilotons per annum, offers ready market for transitioning to GH.
- Identifying the major consumers like refineries, fertilizer, and steel industries can create an opportunity to make the transition from gray hydrogen to GH.

SESSION-3

Demand creation for
Green Hydrogen in the Indian context

SESSION - III	
Session Title	**Demand creation for Green Hydrogen in the Indian context**
Time	3.45 PM to 4.45 PM
Background & Rationale	The National Green Hydrogen Mission demarcates the sectors and the market development approach. The highest priority is accorded to those sectors where green hydrogen would support the replacement of fossil fuels and fossil fuel-based feedstocks. These include: ▪ replacement of fossil fuel-derived hydrogen with green hydrogen in ammonia production and petroleum refining; ▪ blending of green hydrogen in City Gas Distribution (CGD) systems; ▪ production of steel with green hydrogen. This panel discussion will delve into the current landscape of green hydrogen demand in India, identifying the key challenges and opportunities that exist. By exploring strategies to stimulate demand across different applications, we can promote a thriving green hydrogen ecosystem in India.
Session objectives	i. Understand the emerging demands of green hydrogen in various sectors across India. ii. Examine effective strategies to accelerate green hydrogen demand in India.
Session Chair and Moderator	**Dr. BN Suresh, FNAE,** Chancellor, Indian Institute of Space Science & Technology (IIST) and Honorary Distinguished Professor, ISRO Headquarters and Former President, INAE; Director, VSSC, Trivandrum; and Member, Space Commission
Panel Discussion	**Panelists:** • **Mr. T K Ramachandran**, Secretary, Ministry of Ports, Shipping and Waterways, Government of India • **Dr. Sanak Mishra, FNAE**, Former President, INAE; Member of Governing Board, Steel Research & Technology Mission of India; and Formerly Managing Director of Rourkela Steel Plant and Member of the Board of SAIL, India • **Dr. Bibek Bandyopadhyay**, Senior Adviser, EY India; Former Director Solar Energy Centre; and Former Adviser, MNRE, Government of India. • **Dr. Umish Srivastva**, Executive Director (AE&IOTDD), Indian Oil Corporation Limited (IOCL), India • **Mr. Hiren Mehta,** Chief Commercial Officer, VP Business Development, Green Hydrogen and Ammonia, ACME Cleantech Solutions, India
Audience interaction and way forward	Moderated by Session Chair

Session-3 Recording: https://youtu.be/m7b1FWI_boc

Dr. BN Suresh,
FNAE, Chancellor, IIST and Honorary Distinguished Professor, ISRO Headquarters and Former President, INAE; Director, VSSC, Trivandrum; and Member, Space Commission

Mr. T K Ramachandran,
Secretary, Ports, Shipping and Waterways, Government of India

Dr. Sanak Mishra,
FNAE, Former President, INAE; Member of Governing Board, Steel Research & Technology Mission of India; Formerly Managing Director of Rourkela Steel Plant; & Member of Board of SAIL

Dr Bibek Bandyopadhyay,
Senior Adviser EY India, Former Director Solar Energy Centre & Former Adviser MNRE, Government of India.

Dr. Umish Srivastva,
Executive Director, AE&IOTDD, Indian Oil Corporation Limited

Mr. Hiren Mehta,
Chief Commercial Officer, VP Business Development, Green Hydrogen & Ammonia, ACME Cleantech Solutions, India

GHIC Green Hydrogen Innovation Center | Indian National Academy of Engineering ESTD - 1987 | ISA International Solar Alliance

- The MNRE is seeking international alliances for a carbon credit mechanism to reduce GH cost and scale up demand.
- The NGHM aims for 5 million tons per year of GH and currently annual hydrogen requirement is around 6 million tons.
- The shipping industry is targeting 50% GH usage by 2050, aiming for 2.5 million barrels per day of hydrogen-based fuel.
- The IMAC corridor, connecting India with Singapore and the Middle East, emphasizes fuel bunkering, making hydrogen a crucial component.
- The Harit NAA program proposes converting 1000 vessels into green vessels over the next decade, will envisage an investment of about three lakh crores (USD~36 Billion).
- GH has two key uses : as fuel and industrial applications (e.g., reducing agent in steel industry).
- The steel and iron industry in India contributes 7% of country's carbon dioxide emission, highlighting urgent need for decarbonization.
- In Steelmaking, hydrogen reduces iron oxide, through a process known as DRI. India being one of the largest producer of DRI at 22-23% can effectively use GH.
- The momentum for GH in Indian steel industry is growing, positioning it as major consumer and largest market for GH over next 50 years.
- GH is a game changing technology for sustainable transportation specially in long-haul transport.
- Indian Oil R&D is working to reduce the green hydrogen cost to boost demand by using AEM electrolyser technology to avoid precious metals.
- To produce GH in big volumes, resources have to be readily available in the country. In India, it is estimated that the production cost of GH is likely to come down through alternative generation routes such as Biogas or Biomass.
- Renewable power is available for 16 to 18 hours a day from solar and wind sources. To ensure round the clock power we need battery backups. Given the high cost of batteries, producing & storing hydrogen during the day can provide continuous power when solar & wind are unavailable, thus minimizing the battery need.
- In areas like Andaman and Nicobar Islands, diesel is currently used for power generation. Green ammonia can be viable alternative for power generation.

Key takeaways

SESSION-1:
GREEN HYDROGEN- RELEVANCE, POLICY, REGULATIONS AND STANDARDS

1. The relevance of green hydrogen is evident globally It is estimated that GH could comprise 10-12% of the energy mix by 2050.
2. Policy initiatives mainly aim to reduce cost and incentivize production by providing infrastructure development incentives and funding for research and development program, particularly in the states with strong renewable energy focus.
3. Regulatory framework and standards are crucial for fostering transparency related to Guarantee of Origin (GO) and hence international trade.

SESSION-2:
ECONOMICS OF GREEN HYDROGEN IN THE INDIAN CONTEXT

1. With current Capex and renewable energy prices, incentives from both central and state government in India, the cost of producing GH via electrolysis stands at around $4-5 per kg.
2. Understanding the economic factors like energy pricing, where approximately 70% of Opex comes from renewable sources, is essential to lowering cost associated with GH in India.
3. Factors such as building new supply chains, financial incentives, risk insurance, enabling legislative efforts for pricing, etc., will further drive demand for GH.

SESSION-3:
DEMAND CREATION FOR GREEN HYDROGEN IN THE INDIAN CONTEXT

1. GH is a game changer for hard-to-abate sectors such as – Shipping, Steel, long-distance transportation and fertilisers.
2. To stimulate demand for GH in India, it is crucial to reduce its cost by optimizing solar and wind energy generators along with storage
3. Establishing standards for green hydrogen and ammonia can ensure competitive pricing, fostering widespread adoption.

Way forward

Ecosystem Development: To move ahead, an ecosystem for hydrogen utilization needs to be created, with the required logistics in place. This includes developing clusters of user industries to minimize the demand for extensive pipelines and supporting local production and utilization.

Regulations and Standards: There is a need to establish GH regulations, policies, standards, and certifications in line with international procedures. This regulatory framework will support the overall energy transition, focusing on decarbonizing sectors such as industries, maritime shipping, and transportation.

Financing and Investment: Access to low-cost finance remains a challenge. Efforts to create demand need to be stepped up, supported by technological and infrastructural incentives to make GH usage economical across various sectors.

Demand Creation and Transition: All players in an industry sector should collaboratively drive the demand for GH. Understanding challenges, identifying interlinkages, and promoting regulatory support, bold policies, and private sector participation are critical to ensuring fair and widespread adoption.

Technological Development: Development needs to take place in a technology agnostic manner, focusing on key issues such as reducing the cost of electricity for hydrogen production and creating hydrogen bunkers to refuel ships. Long-term economic and technological dynamics should be considered to facilitate the transition from diesel to hydrogen.

Role of INAE and ISA: INAE will focus on the technology enhancements required for GH development, while ISA will address policy, regulatory and financial aspects in their training programs. This dual focus will ensure comprehensive support for the GH initiative, covering the entire GH valuechain.

THANK YOU!