HYDROGEN INDIA

| Pages: 24 |
| October 2024 |
Pune | Vol I, Issue 4

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EDITORIAL

The three-day International Conference on Green Hydrogen (ICGH-2024), held from September 11-13, 2024, highlighted the strides the sector is making towards our country's ambitious targets. Inaugurated by Shri Pralhad Joshi, Union Minister of New & Renewable Energy; Consumer Affairs, Food & Public Distribution, the event attracted over 8,500 delegates, including 3,000 plus youth and students. It also featured an exhibition showcasing innovations and technological advancements in the Green Hydrogen sector, with a hydrogen-powered bus and hydrogen internal combustion engine (H2ICE)-powered truck receiving much attention.

Addressing the valedictory session, Minister of State, Ministry of New and Renewable Energy (MNRE), Shri Shripad Y. Naik underlined that India has ushered into a new era of energy transition driven by a shared commitment to advancing the Hydrogen Agenda. Prof. Ajay K. Sood, Principal Scientific Adviser to the Government of India, said, "Our commitment to Green Hydrogen is not just about meeting emission targets, which of course is important. It is about seizing a historic opportunity to redefine our energy systems, create new jobs, and secure a cleaner, healthier planet for future generations", he said.

During his address, Secretary, MNRE, Shri Bhupinder S. Bhalla reiterated, "Green Hydrogen is not just a new energy source, it is a pathway towards a future where clean energy is the norm, and industries are decarbonized. Over the past three days, we've seen how collaboration among policymakers, scientists, and industry leaders can drive innovation and push the Green Hydrogen agenda forward. The discussions and breakthroughs will play a critical role in making India a global hub for Green Hydrogen production, usage, and export. The journey ahead will be challenging, but our collective ambition is strong, and the opportunities are vast."

Shri Pankaj Jain, Secretary of the Ministry of Petroleum and Natural Gas (MoPNG), Government of India stressed on the importance of international cooperation and innovative technologies in advancing the Green Hydrogen economy.

Along with other senior government officials, Mr. Ajay Yadav, Joint Secretary, MNRE highlighted that as many as 13 states have policy provisions for supporting the Green Hydrogen ecosystem. He pointed out the Mission would lead to the creation of 600,000 lakh green jobs, and also stressed on the importance of skilling, safety, pilot projects, research & development, and innovation.

The plenary sessions held during the conference highlighted the initiatives and advancements from the US, European Union, Australia, the Netherlands, and Germany, along with the global perspective as presented by International Renewable Energy Agency (IRENA). These sessions underscored the importance of international collaboration and knowledge exchange in accelerating the Green Hydrogen economy.

The 22 breakout sessions delved into the

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HFC-18

The Department of Science and Technology (DST), Ministry of Science and Technology, Government of India, initiated the development of a hydrogen and fuel cell (HFC) technology program in 2018, focusing on creating volumes and infrastructure, demonstrating niche applications, facilitating policy support, and establishing symbiotic international linkages. This has advanced HFC technologies through R&D and validation, aiming to make these technologies competitive in terms of cost and performance, while also reducing institutional and market barriers to commercialization – directly supporting Ministry of New and Renewable Energy's (MNRE) National Green Hydrogen Mission.

A total of 30 proposals under the Research and Technology Stream were approved for funding, with an approximate cost of Rs. 31 crore. These proposals focused on the development of new electrode materials, exchange membranes, and catalysts for hydrogen storage and fuel cell applications.

AHFC

Under HFC-18, DST also supported 11 projects with the cost of Rs. 28 crore under the Advanced HFC Program (AHFC) – the list will appear in the next issue. The objective of this program is to promote and support activities related to the indigenous development of new and existing materials in large quantities, including catalysts, membranes, components for fuel cells, electrolyzers, hydrogen storage materials, materials for Type IV cylinders, and prototypes for the implementation of various HFC applications in the country, which aligns with the R&D roadmap requirements of the National Green Hydrogen Mission and the Make in India initiative.

Indo-Danish Initiative

Under HFC-18, DST recently supported four projects under the Indo-Danish Research and Innovation Cooperation in the area of "Green Fuels, Including Green Hydrogen." These projects focus on green fuels for transport and industry, as well as solutions to convert electricity from renewable energy into products that can reduce emissions in sectors where cost-effective alternatives to fossil energy are not available. The target of the India-Denmark joint program is to enhance value creation through research and innovation for the development of new technologies, solutions, services, and business models.

Project Title	PI Details	Specific Area	Duration	Total Cost (in Rs.)
ZDHYDRO Development of an Integrated Zero Discharge Model for Sewage Sludge to Enhanced Hydrogen Production DST/INT-ETC/IGDF-2022/08	**Prof. M.M. Ghangrekar** Indian Institute of Technology Kharagpur	Hydrogen Production	3 years	9,656,702
PyroGreen – Pyrolysis for Green Fuels and Enabling Future Green Hydrogen DST/INT-ETC/IGDF-2022/09	**Mr. Suhas Dixit** APCHEMI Pvt. Ltd. Navi Mumbai **Dr. Mrutyunjay Suar** CEO, KIIT-Technology Business Incubator (KIIT-TBI), Odisha	Hydrogen Production	3 years	7,437,619
Towards Decarbonization of Cement Industry Model-based Optimization of a Pyrolysis Technology for Flexible Use of Waste Fuels DST/INT-ETC/IGDF-2022/12	**Dr. Varunkumar S.** Indian Institute of Technology Madras	Hydrogen Utilization	3 years	9,387,446
Efficient Cost-saving Grid-friendly (ECoGrif) Power-to-X (PtX) Converter DST/INT-ETC/IGDF-2022/18	**Prof. Krishna Vasudevan** IIT Madras	Hydrogen Production	3 years	15,345,172

Virtual Centers

Under HFC-18, a theme-based initiative was launched to support R&D across the entire spectrum of energy conservation and storage technologies, from early-stage research to technological breakthroughs in materials, systems, and scalable technologies, with the aim of maximizing resource use efficiency. The purpose of this initiative is to support recognized centers of energy materials research, encourage them to collaborate with new research groups working in complementary areas, and link these centers into a coordinated national network. This initiative aims to create a strengthened energy materials research community that covers the full breadth of energy research areas and is strongly linked both nationally and internationally. Under this initiative, two Energy Storage Platforms on Hydrogen are supported by DST, with a total cost of Rs. 18 crore.

DST-IIT Bombay Energy Storage Platform on Hydrogen[1]: DST has

[1] https://www.ese.iitb.ac.in/esphy/

supported the center with a total cost of Rs. 9.83 crore for five years. This platform has been established to conduct research on materials and systems, demonstrate prototypes, develop technology, incubate innovative ideas, facilitate industrial interactions, and promote collaborations, manpower development, and information dissemination in the field of hydrogen. The lead organization is IIT Bombay, with four partnering institutions: IIT Guwahati, IIT Kanpur, IIT Tirupati, and NIT Rourkela. The center aims to become a source of information and a nodal point where individuals and organizations in India working in the area of hydrogen can receive mentorship, materials, or other necessary support.

DST-NFTDC Energy Storage Platform on Hydrogen[2]: DST has supported a total cost of Rs. 8.56 crore to this center, which will be established at the Nonferrous Materials Technology Development Centre, Hyderabad, with a core theme of hydrogen-based materials for energy devices. The focus of this center will be on specific hydrogen-related systems. The network of researchers engaged in this center includes scientists from IISc Bangalore, IIT Madras, IIT Bhubaneswar, and Sri Chitra Thirunal College of Engineering, Thiruvananthapuram.

Some Technologies Developed & Commercialized under DST's HFC-18

PI name	Project	Description	Commercialization
Dr. Somenath Garai Banaras Hindu University, Varanasi	Cutting-Edge Quantum-Technology-Backed Green Hydrogen Production	Developed by: Benares Hindu University (BHU) Quantum-powered green hydrogen production technology with a photocatalyst system for efficient energy generation achieving a production rate of over 1 liter/min per 10 g of quantum photocatalysts.	Technology transfer: Aaparth Engineers Pvt. Ltd. Approved for implementation by Indian Navy Headquarters Foreign technology transfer: Quazer Investment Company, UAE
Prof. P. Muthukumar IIT Guwahati	Metal Hydride-Based Multi-Stage Hydrogen Purification System	Developed by: IIT Guwahati A system with a purification capacity of 6,000 to 10,000 liters per batch, delivering 99.999% purity using low grade thermal inputs in the range of 30-50°C.	Technology transfer: NTPC Financial grant: Rs. 20 lakh
Prof. P. Muthukumar IIT Guwahati	Metal Hydride-Based Multi-Stage Hydrogen Compression System	Developed by: IIT Guwahati & IIT Tirupati A pre-industrial-scale prototype for compressing hydrogen from 1-2 bar to 400-450 bar utilizing a temperature range of 20-95°C.	Technology transfer: NTPC Financial grant: Rs. 38 lakh
Dr. Pratibha Sharma (Lead PI & Institute) IIT Bombay	Metal Hydride-Based Hydrogen Storage System for Two-Wheelers	Developed by: IIT Bombay Developed a hydrogen storage system integrated with a PEM fuel cell, retrofitted on a two-wheeler for a 60-km test drive. Joint project recommended with BPCL and Godrej & Boyce for commercialization.	Technology transfer: Centre for High Technology, MoPNG Financial grant: Rs. 1.92 crore

HFC-2023

HFC-2023 was then launched under DST's Climate, Energy and Sustainable Technology (CEST), Division to identify leading solutions for sustainable hydrogen production, storage, and transportation, and to upgrade them to higher Technology Readiness Levels (TRLs) suitable for industrial-scale implementation and commercialization. The submission deadline was 30 January 2024.

The primary focus is on prioritizing the upgrade of lab-scale technologies, which are at TRL 3-4, to reach prototypes (TRL 5) and pilot plants (TRL 6) at the earliest possible timescale. The startups with appropriate technologies at the pre-commercialization stage were also eligible to apply for this call.

Identified Areas

The following areas were identified and project proposals invited for:

- Developing completely indigenous technologies pertinent to hydrogen production from water splitting, including but not limited to electrolysis, photo-electrochemical cells, and solar thermochemical systems at the scale mentioned below.
- Cost-effective green hydrogen production technologies belonging to TRL ≥ 4 for wide range adoption and utilization in India to enable resiliency of the power generation while aligning to the existing requirement of domestic industries and transportation sectors. Medium to large capacity electrolyzer (PEM water electrolyzer, alkaline water electrolyzer, solid oxide electrolyzer cell, and other versions of electrolyzers) prototypes capable of producing molecular hydrogen (H_2) at a rate of at least 5.0 liters per minute (5.0 LPM) or 300.0 liters per hour (300.0 LPH). The full balance of plant (BoP), including the components and the electrolyzer, should be indigenously developed.
- Active indigenous prototype models of photochemical units capable of producing H_2 at a rate of at least 22.50 g-H_2/m^2/day under 1.0 sun equivalent of irradiance (1.0 kW/m^2).
- Active indigenous prototype models of photo-electrochemical units capable of producing molecular

[2] https://dst.gov.in/sites/default/files/DST%20-%20NFTDC%20MECSP%20Centre%20Brochure%20v6%2811Feb2019%29%20%281%29.pdf; https://www.nftdc.res.in/mecsp/

hydrogen (H_2) at a rate of at least 5.0 LPM or 300.0 LPH (under 1.0 kW/m^2).

- Industrially viable hydrogen generation approaches from biomass. Showcasing the design of variable converters that can deploy the major variants of biomass available in India. The final prototype models should be capable of processing at least 50.0 kg/h of biomass and producing H_2 at a rate of at least 750 LPM.
- Designing new prototypes of methanol reformers capable of producing H_2 at a rate of at least 5.0 LPM or 300.0 LPH operating at ≥ 60% efficiency. This prototype should also contain appropriate CO_2 capture units to minimize the carbon footprint of the reformer unit.

Hydrogen Storage

Hydrogen storage is critical for enabling the hydrogen value chain. These are the focus areas required for proposals:

- Hydrogen storage system development, including compressed tanks (Type III and Type IV tanks with a capacity of 5 kg of hydrogen storage capacity at 350 or 700 bar resp.). All the development should be indigenous and should include variable components, such as temperature and pressure sensors, and safety vent arrangements.
- Materials-based indigenous hydrogen storage tanks developed to store 5.0 kg of hydrogen at 30.0-35.0 bar with materials synthesized indigenously and using raw materials available in the country. The cost of metal hydrides or material medium used should be Rs. 3000-5000/kg and all developments should be indigenous.
- Prototypes or pilots for material-based hydrogen storage tanks for hydrogen purification, thermal energy storage, heating or cooling applications for mobility applications.
- Conversion of hydrogen to liquid organic hydrogen carrier (LOHC) molecules and the subsequent conversion of LOHC to hydrogen should be established. Energy-efficient and cost-effective hydrogen to appropriate hydrogen-rich organics transformation technology. The LOHC solutions should showcase long-term storage potential along with the possibility of long-distance transportation using the established transport logistics. Here, the new technologies should be capable of converting (i) 300.0 liters of hydrogen per hour to the appropriate organic chemicals, (ii) < 11 kWh/kg-H_2 energy requirement for dehydrogenation from LOHC, and (iii) cyclability of LOHC > 1500 cycles with < 5% loss of H_2 storage capacity.

Other Requirements

Involvement of industries: It is envisaged that the end product of development will be transferred to industries for commercial production. Hence, it is desirable that the industry be associated with the project right from the beginning with defined participation in technical terms.

As far as possible the proposed prototype/device should have sufficient users in the country and there should be adequate demand for the product.

Project duration: The projects should be time-bound normally for the duration of 2-3 years depending upon the prototype/device to be developed.

Funding available: Rs. 5 crore maximum

Status

A total of 196 proposals were received, with 95 evaluated for final selection and recommendation by a DST-constituted Expert Panel Committee (EPC). The EPC-recommended proposals (around 10-15) are currently under consideration and will be announced by October 2024.

HVICs

DST's latest endeavor is the establishment of Hydrogen Valley Innovation Clusters (HVIC), a unique initiative in the country designed to showcase a seamless integration of hydrogen technology across the value chain. Each cluster will be located at distinctive geographical locations of the country and aim to produce up to 2 tons per day, or 500 tons per annum, of green hydrogen, with DST financial assistance of up to Rs. 50 crore per cluster over five years and each cluster will be required to have a post DST financial support sustenance plan. The produced green hydrogen will be utilized in the transport (marine, road), steel, fine chemical sectors, etc. Funding for four upcoming green hydrogen valley projects in India has been approved (*refer Vol 1 Issue 3 of this newsletter for details*).

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