Hydrogen Economy- India's Perspective- MISSION INNOVATION programme

Implementation programme on Research, Development and demonstration of Hydrogen Technology

NATIONAL HYDROGEN ENERGY MISSION

PM Narendra Modi floating the idea of the National Hydrogen Energy Mission at the 3rd Re-Invest Conference, November 2020

ARCI Fu Scoot
300 watts Stack, 1 cu.M hydrogen

3 Wheeler Vehicle- 8 seater
5 kW PEMFC System

Mission Innovation 6th July 2023

Strategies and plans for Hydrogen and infrastructure

National Hydrogen Mission

Objective:

- To make India the global Hub for production, usage and exporter of green hydrogen and its derivatives
- Enable India to assume technology and market leadership in Green Hydrogen
- support development and widespread commercialization of H2 technologies (**GREEN HYDROGEN),**
- Meeting future demand for energy in transportation, industry and other sectors through R & D pilot projects and infrastructure development
- Facilitate policy and regulatory support, and international linkages.

Mission Strategy:

- All concerned ministries, departments and agencies and institutions of central and state government will undertake focused and coordinated steps to ensure successful objectives of mission objectives
- MNRE overall coordination; Ministry of Power - regulations and policies to ensure delivery of RE for green hydrogen production; Ministry of Petroleum and Natural Gas- facilitate uptake of GH_2 in refineries and city gas distribution, development and facilitation of regulations; Ministry of Chemicals and Fertilizers - adoption of GNH_3 based fertilizers; Ministry of Road and Transport - adoption of GH_2 in transport, codes, standards and regulations; Ministry of Steel- adoption of GH2 in steel sector; Ministry of Ports, Shipping and Waterways - establishing India's capabilities for export of $GH_2$and its derivatives; Ministry of Finance -suitable fiscal and financial frameworks; Ministry of commerce - Industry encourage investments, facilitate ease of doing business and implement specific industrial and trade policy for low cost H_2 production and its derivatives; Ministry of Railways - adoption of GH_2; Department of science and technology, DSIR, Department of space, DRDO - goal oriented Research and innovation programme, Ministry of External Affairs will be instrumental in building bilateral and multilateral partnerships for supporting GH_2 ecosystem development in India and abroad

Mission Components

- Demand Creation
- SIGHT Programme
- Pilot Projects
- Green H2 Hubs
- Enabling Policy Framework
- Regulations, Codes and Standards
- Research & Development
- Skill Development
- Public Awareness & Outreach
- International Cooperation

Phased Approach

Phase I (2022-23 to 2025-26)

- Creating demand, enabling adequate supply by increasing electrolyser manufacturing
- Utilisation in refineries, fertilizers and city gas sectors
- Pilot projects for initiating green transition in steel, long haul heavy duty transport and shipping
- Scale up GH_2 production and use, dive down cost

Phase II (2026-27 to 2029-30)

- GH_2 expected to be at par with fossil fuel based alternatives in refineries and fertilizer
- Commercial scale GH_2 based projects in steel, mobility and shipping sectors
- Undertake pilot projects in railways, aviation etc.
- Enhance penetration across al potential sectors to deep decarbonize economy

Outlay

		Mission Components	Amount (₹ Crore)	Amount (₹ Crore)
Outlay recommended till 2029-30	i.	Strategic Interventions for Green Hydrogen Transition (SIGHT)	17,490	18,133
	ii.	Support for low-carbon Steel projects	455	
	iii.	Human Resource Development	35	
	iv.	Public Awareness and Outreach	70	
	v.	Programme Management	83	
Outlay recommended till 2025-26	vi.	Support for Shipping and ports projects	115	1,611
	vii.	Support for Mobility projects	496	
	viii.	GH_2 production technologies, storage, hubs, etc.	400	
	ix.	R&D Projects	400	
	x.	Testing Facilities, Standards & Regulations development	200	
		Total		**19,744**

Expected Deliverables by 2030

At least
5 MMT GH_2
annual Production

60-100 GW
Electrolyser capacity

600,000
Jobs

125 GW RE Capacity for GH_2 Generation & associated Transmission network

50 MMT CO_2
Annual Emissions Averted

USD 100
Billion
Investment

R&D Framework under the Mission

Public-private partnership framework

Innovation to **enhance affordability, efficiency, safety and reliability** of systems

Strategic International Partnerships

Applied research + Long shot research in breakthrough areas

Innovative **MSMEs and Start-ups** to be encouraged

Identifying and supporting Centers of Excellence

Broad-based: Adequate provision for covering different research areas

Research and Innovation Roadmap

R&D Framework under the Mission

Increase in Funding

Mission Mode Projects

- Short term horizon.
- Focus on end product development in partnership with industry.
- Aggregate and leverage existing capabilities and infrastructure.
  - PPP mode of implementation in time-bound manner
  - TRL 5/6: Academia led-industry support from MNRE
  - TRL 7-9: Industry led-academic support with major investment from industry

Grand Challenge Projects

- Medium term horizon
- Focus on critical technologies to overcome licensing challenges and supply constraints
- Key challenges on efficiencies and costs
  - PPP mode of implementation in time-bound manner
  - TRL 5/6: Academia led-industry
    TRL 7-9: Industry led-academic

Increased failure risks

Blue Sky Projects

- Long term horizon
- Focus on fundamental research(not derivative type)
- Materials, novel processes.
- Develop capabilities of the Indian R&D

R & D activities in India -- Production, Storage & Utilisation

Hydrogen Production

- Alkaline water electrolysis, Polymer exchange membrane electrolysis, thermochemical water splitting (BARC, Mumbai, CECRI,ARCI)
- Thermochemical cycles, I-S and Cu-Cl, demonstrated closed loop cycle (ONGC Energy Centre)
- Hydrogen production from biomass (IISc, IITKh and IITG)
- Photochemical hydrogen generation is still at a nascent stage (IISc. Bangalore, IITM, IITK, C-MET Pune, IITB, CECRI-CSIR)
- Hydrogen from hydrocarbons by sorption enhanced reforming (ICT, Mumbai)
- Methanol reforming to produce 50 kL/h for a 50 kW fuel cell (IICT, Hyderabad)

Hydrogen Storage:

- Compressed hydrogen Type IV tank (IIT Ropar & IIT Kharagpur)
- Solid state storage materials and systems (BHU, IITM, IITB and IITG) for both stationary and vehicular applications
- Motorcycles and three wheelers running on metal hydride (BHU) and on compressed hydrogen (IITD)

Hydrogen Utilisation:

- Fuel Cell based back-up power system for data centres and telecom towers (Intelligent Energy, Reliance)
- Two and three wheelers on hydrogen (BHU & IITD with Mahindra)
- Fuel cells (ARCI, CECRI, IITB, CGCRI ,BHEL,ISRO,NMRL and NCL)
- HCNG blending and use in buses (IOCL)

Mission Innovation - Demonstrations through Three Hydrogen valleys

1. Fully integrated **power generation system** and **energy storage** (clean energy) using **Hydrogen from Chlor- alkali plants**, matching the demand and supply, reduce the transportation and storage issues.

2. Demonstration of **power generation using Renewal Energy** integrated **Hydrogen** Electrolyser and fuel cell system, in regions with water in excess

3. Demonstration of **near coastal areas, using desalination**, VRE, electrolyser, and fuel cells for power generation.

- **H2 valley projects are based on onsite green H2 generation and does not involve transportation issues.**
- **Hydrogen storage system need to be included for the second and third hydrogen valley projects.**

Hydrogen demand could increase 5-fold by 2050, with use in industry being the major driver

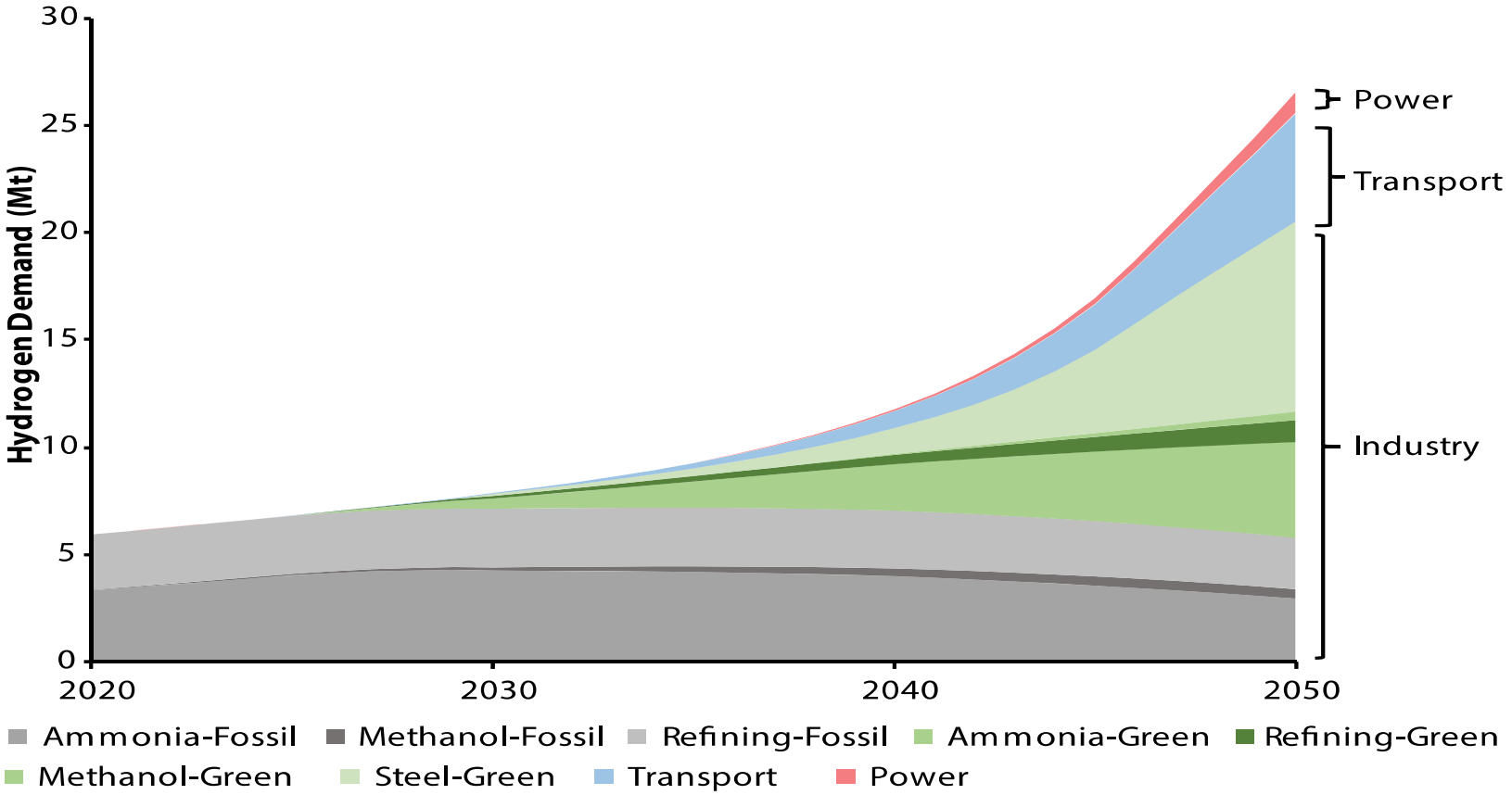


Figure 1: Hydrogen demand projection in the Low-Carbon scenario, 2020-2050

Source: TERI analysis

Three main factors driving a change

- **Continued rapid cost reductions of renewable electricity**
- **Cost reductions and performance improvements of electrolysers, &**
- **Significant action on tackling**

By 2030, costs of hydrogen from renewables will fall more than 50% and will start to compete with hydrogen produced from fossil fuels

India's Hydrogen Technology Demonstrations

17-07-2023

Mission Innovation 6th July 2023

" ARCI FuGo "

A platform to test Fuel cells for use in Electric Vehicles ; 1 kW Stack, Hub Motor 1 cuM Hydrogen

ARCI Fu Scoot

300 watts Stack, 1 cu.M hydrogen

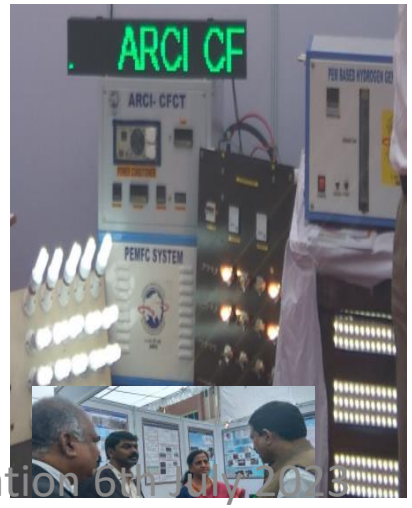
3 Wheeler Vehicle- 8 seater
5 kW PEMFC System

Stack weight : Reduced by 30%

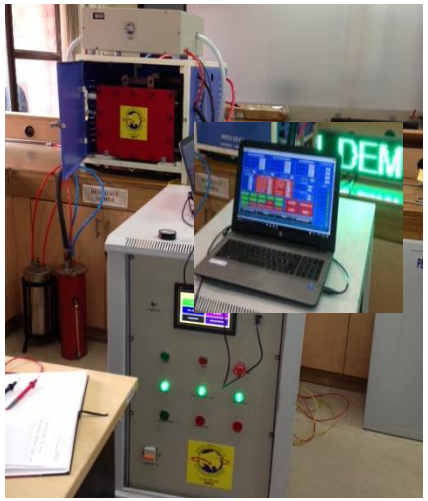
Improved controller.

With 2nd generation stack

3 kW , ARCITECH 2017, 27th Feb 2017, Hyderabad



5 kW @ GAIL, Noida March 15th 2017

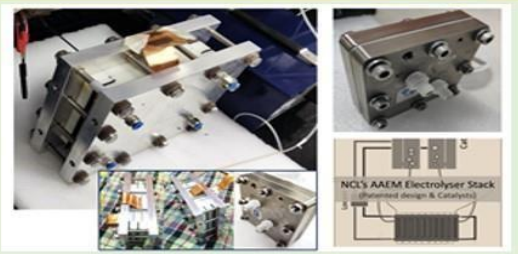


3 kW , ESCI, 10th March 2017, Hyderabad

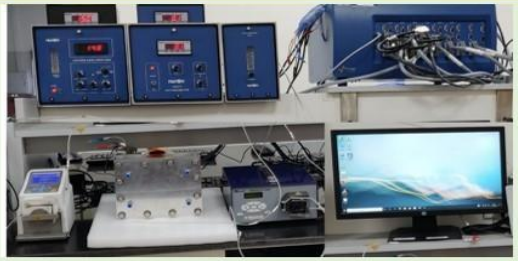
India's Hydrogen Technologies

PEM Water Electrolyser Unit (1 Nm^3/h)

Solar Powered Hydrogen Generator (500 L/h)



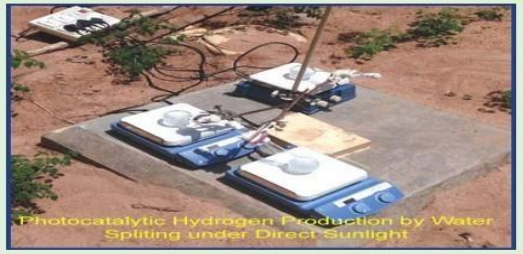
AEM Electrolyser (Non-precious catalysis)



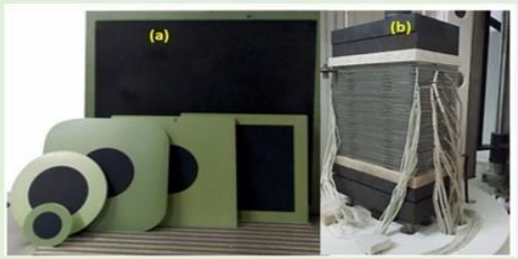
SHADE H_2 Electrolyser (10-1000 cm^2 stack)

Artificial Leaf for Solar to Chemical Conversion

Photoelectrochemical Hydrogen Production

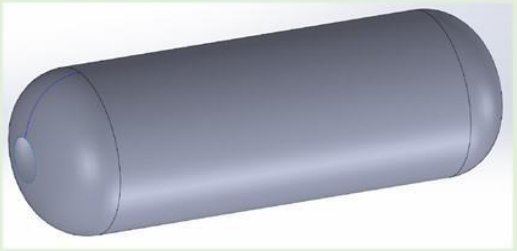


Photocatalytic Hydrogen Production

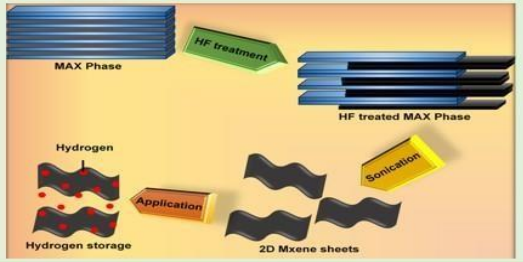


SOFC for High Temp. Steam Electrolyser

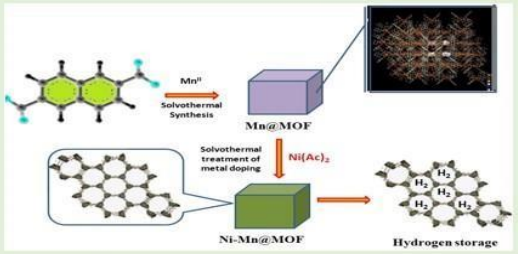
Fluidized Bed Gasification Pilot Plant



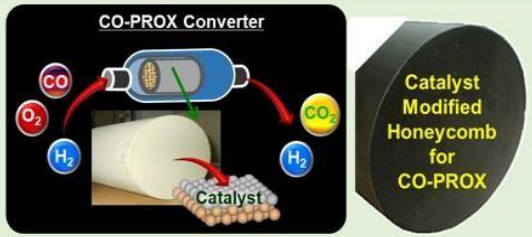
Type IV Hydrogen Storage Tank (CAD Model)



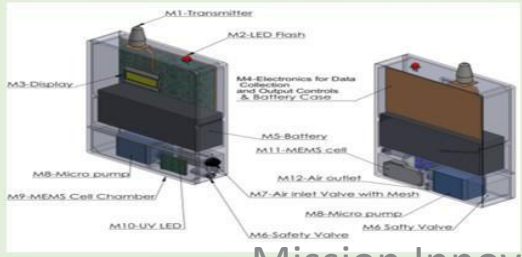
2D MXene based Hydrogen Storage Materials



MOF based Hydrogen Storage Materials

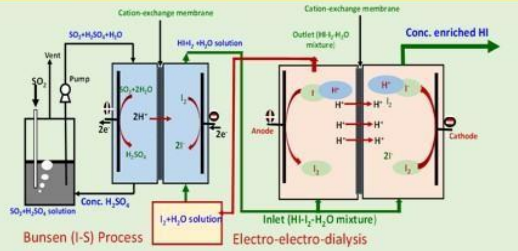


CO-PROX Converter & Catalyst



Hydrogen Detector

I-S Bunsen Cycle



I-S & EED Hybrid Process for HI Production

Conclusions

1.India is developing technologies across entire H2 value chain
2.Focussing on economics, scaleup, performance to realize the H2 potential and to address the issues of climate changes
3. International Collaborations

Thank you