National Green Hydrogen Mission

R&D Roadmap

5th July 2023

National Green Hydrogen Mission: Deliverables by 2030

At least **5 MMT GH_2** annual Production

60-100 GW Electrolyser capacity

125 GW RE Capacity for GH_2 Generation & associated Transmission network

50 MMT CO_2 Annual Emissions Averted

600,000 Jobs

USD 100 Billion Investment

Green Hydrogen: Technology Challenges

Improve Cost Effectiveness	• Electrolysers, Storage, Transportation, Fuel Cells, Industrial Applications, Advanced Materials
Enhance Efficiency	• RE-Electrolysis, Biomass-based pathways
Achieve Scale	• Moving to GW scale installations
Ensure Safety	• Design for safety, Standards, Regulations
Integrate	• Infrastructure for storage, transport, grid

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 Centres of Excellence

Broad-based: Adequate provision for covering different research areas

Research and Development Roadmap

Formulation of an R&D Roadmap

Drafting committee of technical experts (Industry-Academia)

Review status of national and global R&D → Technology gap analysis → Performance and cost targets → Recommend R&D roadmap

Key Elements of Recommendations		
Identification of High-Impact areas	Blue Sky, Mission Mode, Grand Challenge project themes	Strategies for implementation

Draft Roadmap: Hydrogen Production

- Steep reduction in electrolyser capital and operational expenditure.
- Improve the effectiveness and productivity of operations, with a focus on durability and reliability
- Design and develop large-scale (MW) Electrolyser systems, including Stack and BOP
- Build capacity and keep stock of material and critical components of Electrolyser stacks

Grand Challenge Projects

- AEM electrolyser development
- Power to gas/co-electrolysis with SOEC
- Demonstration of biomass gasification-based
- Compact bio-methane reformers

Mission Mode Projects

- Low PGM catalyst/ electrode development
- AEM electrocatalyst development
- Development of SOEC electrolysers
- Feedstock agnostic biomass gasification technology

Blue Sky Projects

- Sea water electrolysis
- Photo electrochemical water splitting
- Thermochemical water splitting
- Bio-methane pyrolysis

Draft Roadmap: Hydrogen Storage & Transportation

- Create efficient, safe, and affordable hydrogen storage techniques for high-density storage, minimized leakage, and convenient refueling; Indigenous development of Type III and Type IV compressed H_2 tanks.
- Developing test facilities for testing of compressed hydrogen tanks.
- Increase the efficiency and reduce the costs of hydrogen compression and liquefaction technologies.
- To strengthen the pressure and capacity for new builds of 100% hydrogen pipelines while reducing their cost.

Grand Challenge Projects

- Infrastructure development for upscaling technologies
- Reduce boil-off losses in liquid stage storage
- 100% transportation of green hydrogen in pipelines
- Market readiness of type IV and V cylinders developed in India

Mission Mode Projects

- Indigenous manufacturing of materials
- Standards and regulations for H_2 storage
- LOHCs, Reconversion of NH3
- Leakage detection in hydrogen pipelines

Blue Sky Projects

- Novel materials with higher gravimetric capacity
- National testing facility for Type IV cylinders
- Movement of compressed and liquid hydrogen in trains
- Research on Type V cylinders

Draft Roadmap: End Use Applications

- Improving the reliability, endurance, and safety of hydrogen-fuelled jet engines.
- Improving overall system performance for fuel cell systems in terms of power density, reliability and durability.
- Improving technologies for the use of green hydrogen in blast furnaces/ DRI processes
- Designing safe boilers and heat exchangers for using hydrogen/ hydrogen-natural gas mixtures.

Grand Challenge Projects

- Mini hydrogen-powered power plants
- hydrogen-powered locomotives
- Fuel cell-based low Pt light vehicles with onboard H2
- Pilot for green steel and green ammonia

Mission Mode Projects

- PAFC /PEMFC in the range of 100kW to 500kW range
- High temp material/configuration of gas turbines for H_2.
- High efficiency, safe hydrogen high-pressure compressor
- Pilot SOFC stacks for coupling with gasifiers

Blue Sky Projects

- H_2 high-efficiency gas turbine and fuel cell
- Hydrogen-ICE and hydrogen Fuel cell-based light vehicles
- Marine hydrogen-fuel cell-based ships
- End-to-end networking of H2 infrastructure with solar /wind

Next Steps

Draft Roadmap to be put up for public comments

Adoption of Final Roadmap by Government

Call For R&D project proposals

Award of projects

Thank You