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GOVERNMENT OF KERALA
सत्यमेव जयते

Green Urban Mobility Partnership

Use of Green Hydrogen in Mobility Sector in India

Presented by: Transport Department, Government of Kerala

February 2022

E mobility Challenges

- I million EV by 2025
- Charging time- LTO by Toshiba
- Weight of batteries
- Range
- Battery disposal and replacement
- Energy storage and Grid balancing
- Differential taxing for service
- Source of power – Environment clearance for Floating solar

Kerala Roadmap for Hydrogen Fuel Cell Public Transport

1. Transport Department, Kerala plans to deploy HFC buses for which strategy roadmap has been prepared with support of SMART-SUT

2. The strategy roadmap:
   - Explores hydrogen production pathways- electrolysis, chlor-alkali, bio-waste
   - Identifies routes for deploying HFC buses and infrastructure requirements
   - Estimates the TCO and GHG emission for various hydrogen sources

3. Transport Department is in the process to issue RFP for deploying 10 buses in Kochi as pilot (feeder to metro system)
   - Rs 10 crore allocated by the state for operating the buses
   - Hydrogen to be sourced from TCC- produced as by-product
   - TCC has issued RFP for preparation of DPR for purification of hydrogen
   - IOCL has proposed to set up green hydrogen units at Kochi and Kannur
   - Approval received from MORTH for pilot between Kochi and Trivandrum

4. Cochin Shipyard Limited is doing a pilot hydrogen fuel cell ferry boat in Kochi

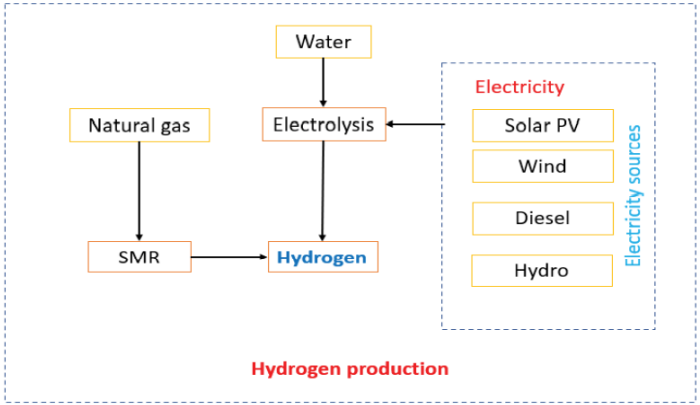
Hydrogen production pathways in Kerala

1. **Grey hydrogen:** Generated by BPCL in Kochi by steam methane reformers. Additional purification required for utilization in mobility sector

2. **Hydrogen from biogenic sources:** Treatment of MSW, agricultural waste, fisheries waste to hydrogen steam reformation/ oxidation/ gasification. Decentralised hydrogen plants of small capacities.

3. **Hydrolysis:** Electrolysis of water using electrolysers. Different sources of green electricity in Kerala:
   - KSEB capacity: Current: 3023 MW, Potential: 9537 GW
   - Power procurement options: onsite generation, captive RE plant, CIAL, green term markets, floating solar

4. **Hydrogen as by-product of chlor-alkali electrolysis:** Hydrogen formed as by-product in the manufacture of chlorine is purified and used.
   Current capacity of TCC: 1.5 tons

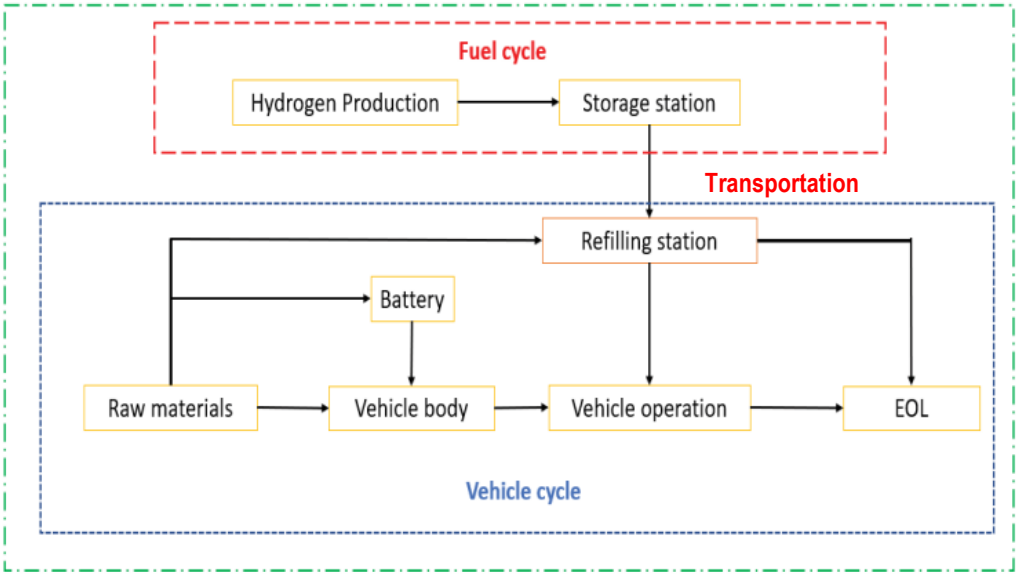


Hydrogen fuel cell buses

Identified routes and hydrogen distribution system

1. 28 routes identified for deploying 70 buses- 50 inter-city, 10 intra-city and 10 feeder routes to metro system.

2. Hub and spoke distribution system proposed:
   - Hydrogen generation facility at Kochi
   - Refuelling stations at Angamaly and Thrissur



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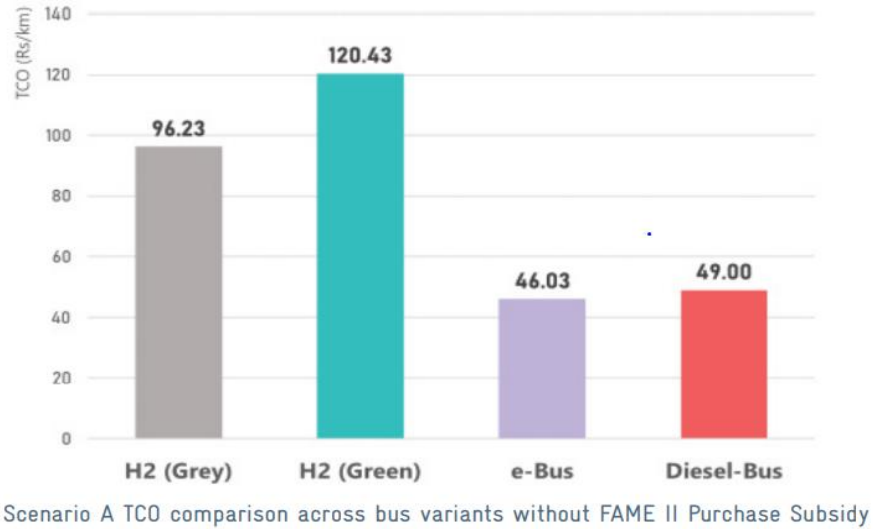
Estimated Total cost of ownership- HFC Bus (inter-city standard bus)



Scenario A TCO comparison across bus variants without FAME II Purchase Subsidy

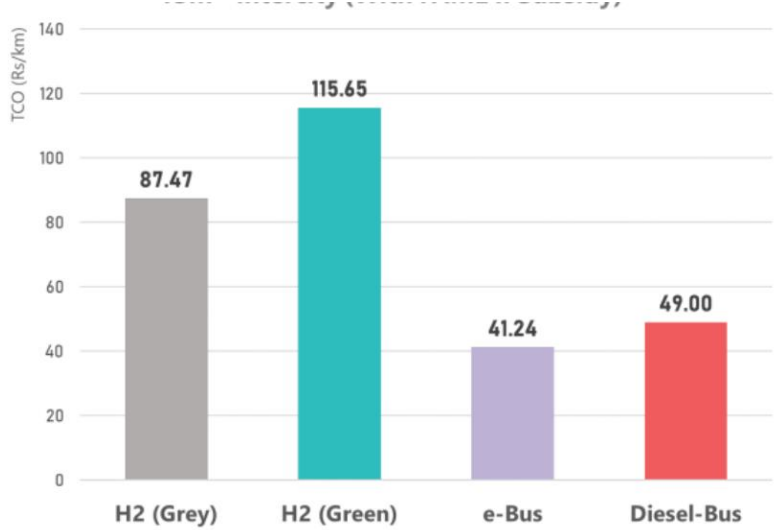


Figure 35- Scenario A – Impact of FAME II subsidies on ZEV variants of e-Bus and HFC

1. Current TCO of H2 bus ~2 times that of e-bus-expected to decrease in coming years.
2. Breakup of TCO: Capex: Opex- 52%: 48%. Ballard Fuel cell prices to drop 70-80 % as volume increases.
3. Central assistance towards developing capital infrastructure for hydrogen generation and distribution system can give a push to H2 mobility.

Estimated Total cost of ownership- HFC Bus (intra-city standard bus)

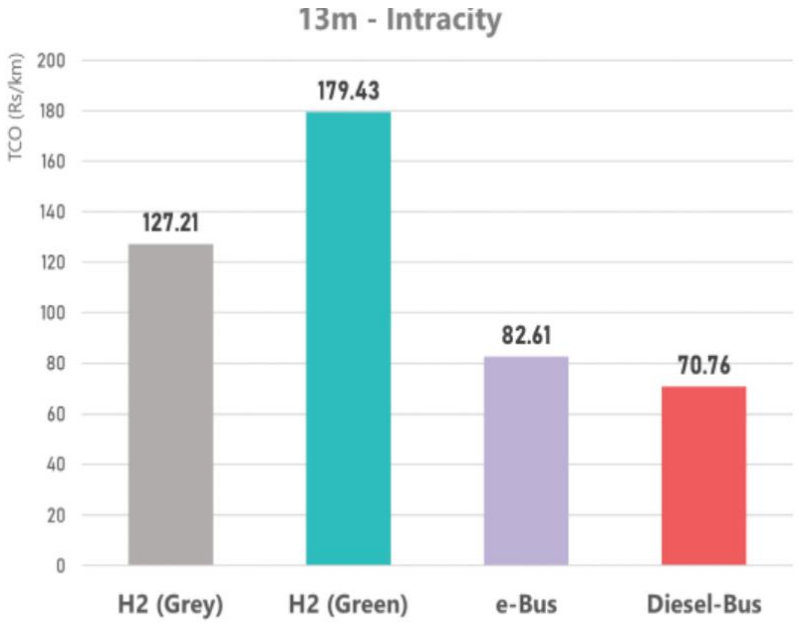


Figure 39- Scenario C – TCO comparison across bus variants

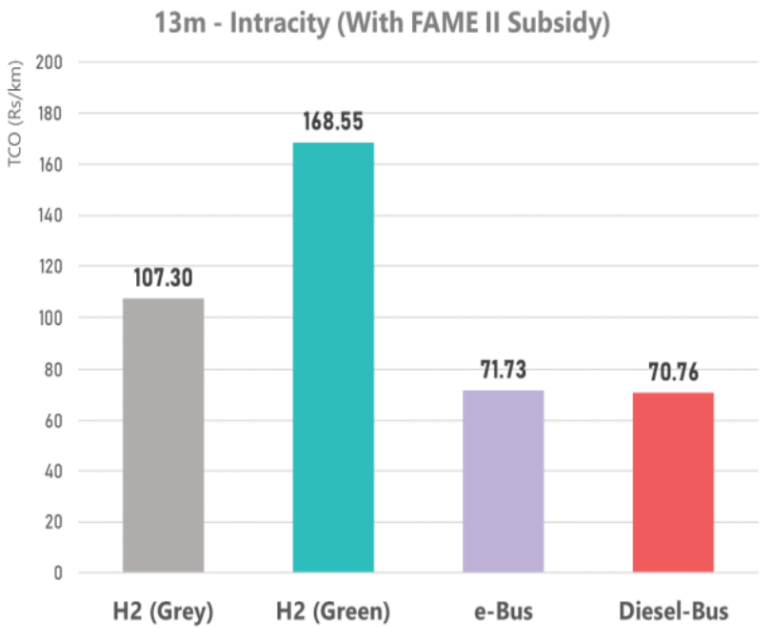
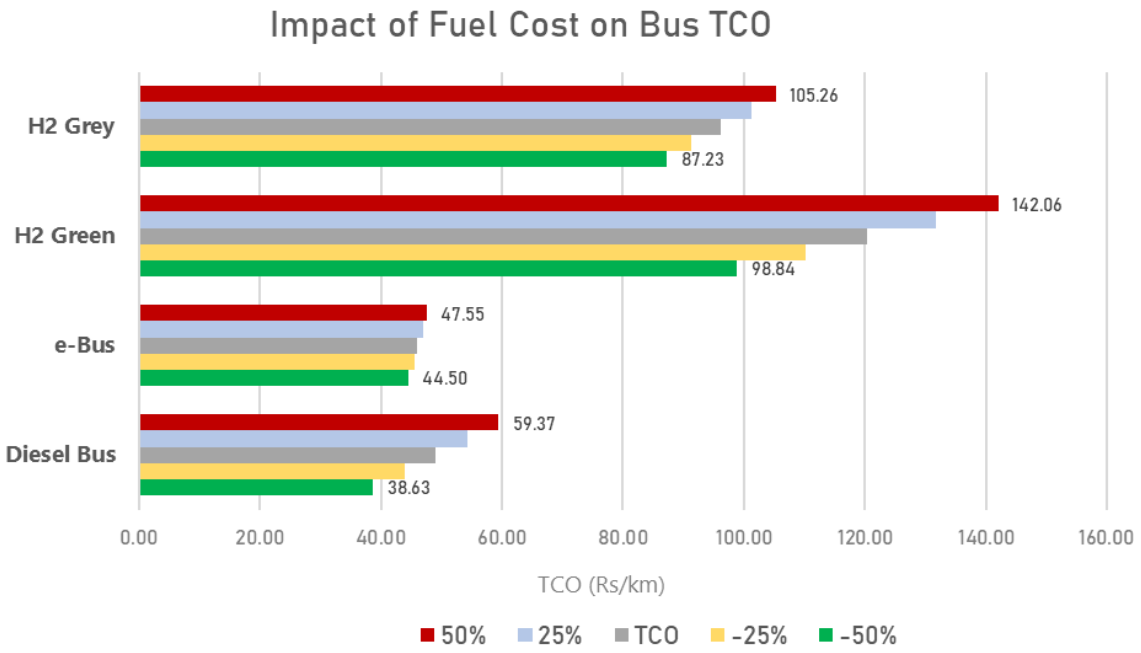


Figure 41- SCENARIO C – FAME II subsidy impact on TCO across bus variants

1. TCO 33% higher than intercity bus because of reduced per day kms travelled

Impact of fuel price on TCO



1. 14% reduction in TCO with 50% decrease in cost of green hydrogen, 7% for grey hydrogen

Impact of vehicle cost on TCO

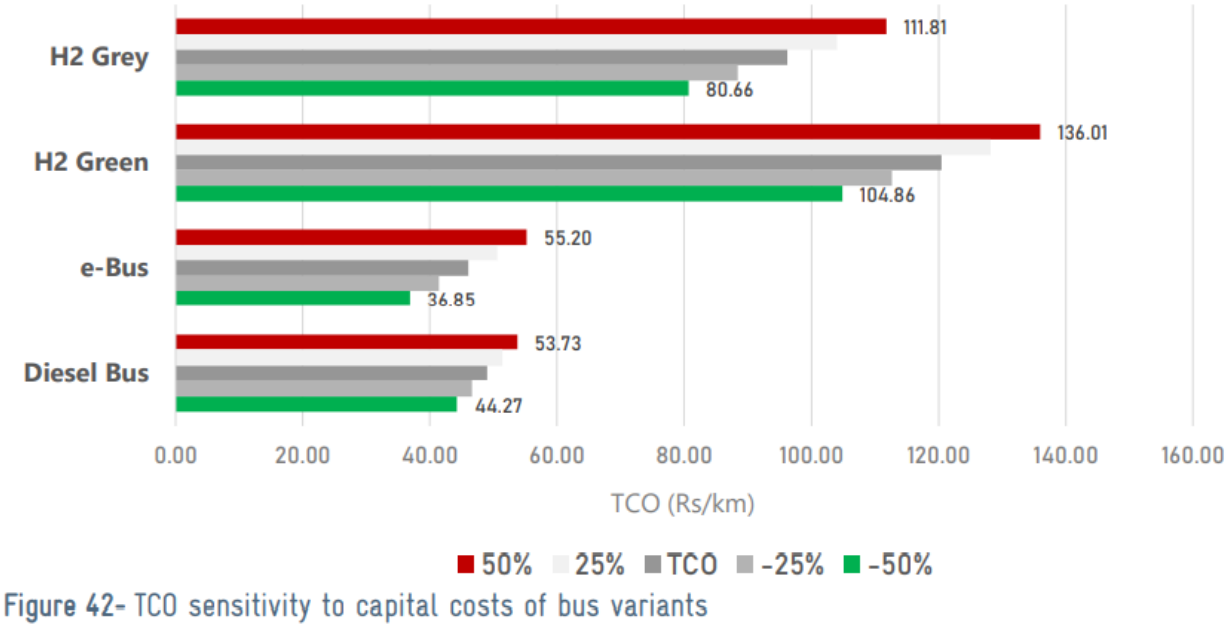
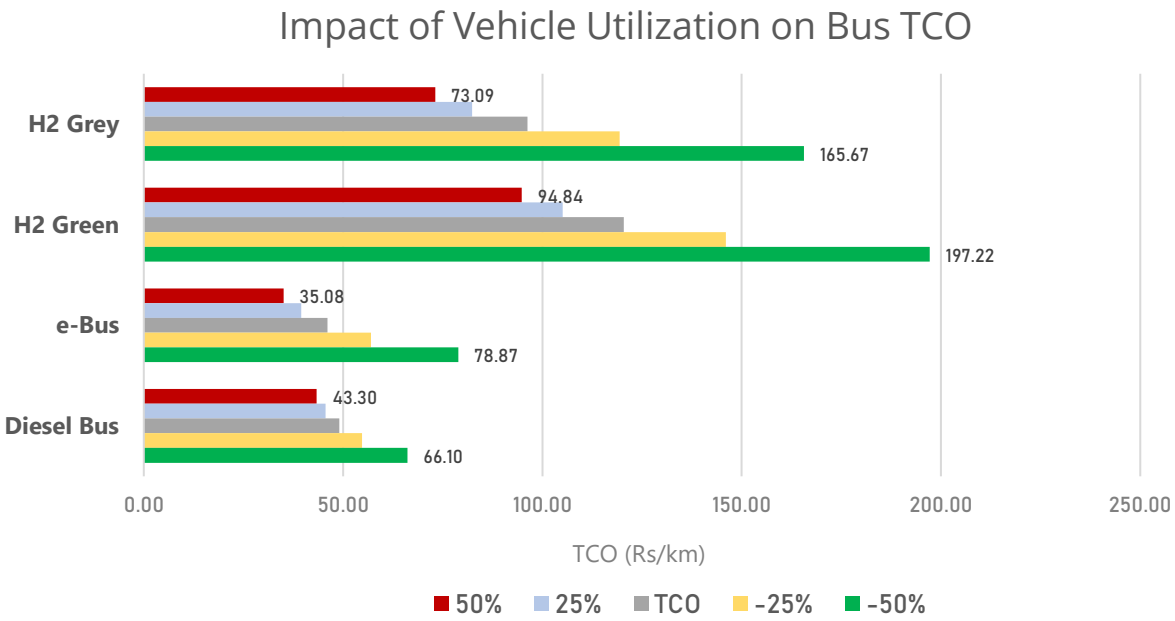


Figure 42- TCO sensitivity to capital costs of bus variants

1. 13% decrease in TCO with 50% decrease in capital cost of HFC buses

Impact of vehicle utilization on TCO



1. 21% decrease in TCO with 50% increase in vehicle utilization, 62% increase in TCO with 50% decrease in vehicle utilization- making it more suitable for long distance routes.

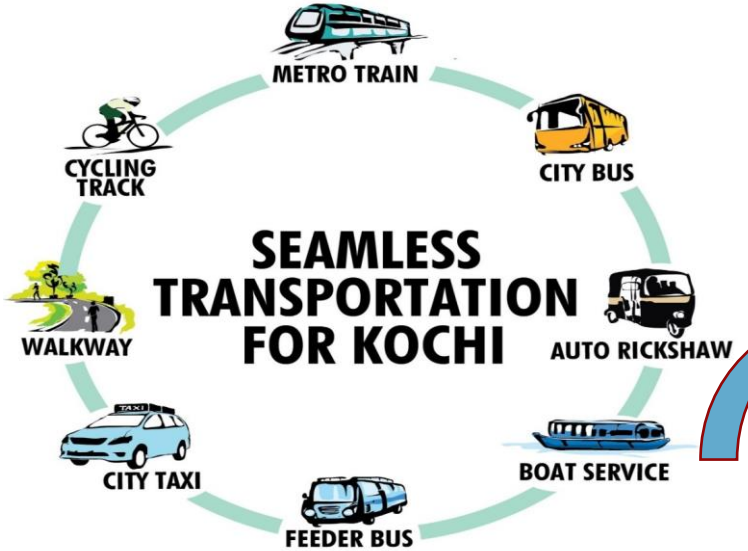
2. Highest sensitivity to vehicle utilization

Issues and challenges in implementation of HFC public transport

1. High hydrogen production cost- average green hydrogen cost is 7-8 $/ kg, which should reduce to ~2$/kg.
2. High cost of transportation and storage- current cost of transportation and dispensing surpasses cost of production
3. Subsidies required for developing hydrogen supply infrastructure systems
4. Inadequate safety standards and regulations for handling hydrogen
5. Need for innovation in technology and components of supply system- low cost and high volume systems to economise infrastructure costs
6. Inadequate availability of safety professionals for safely handling hydrogen

Hydrogen fuel cell for marine application

Kochi Model- Integrated Transport Solution



- Low Impact to Aquatic Ecosystem
- Speed 16 kmph
- 100 Passengers

Approx. 10,300 MT/yr Reduction in CO_2 Emission

Ready to be replicated in other Riverine/Lake Cities

World's Single Largest Fleet of Hybrid Electric Ferries

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Pan Indian possibilities - Fully Electric Water Taxi

Zero-emission and Zero-noise
Battery Capacity - about 120 kWh
24.8 m Length, Speed – 7 Knots
Passengers : 50 ▪ Wheelchairs : 2
Fully Air Conditioned Passenger Space

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Discussions with KMRL for Kochi, IWAI for Varanasi.
Can be replicated in Kolkata, Ayodhya, Guwahati, Patna etc

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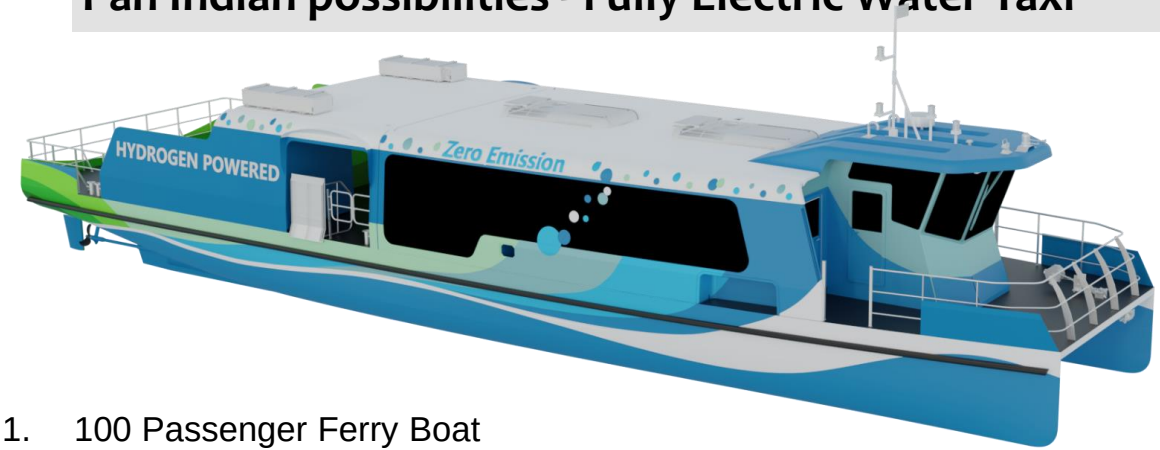
Pan Indian possibilities - Fully Electric Water Taxi



1. 100 Passenger Ferry Boat
2. Fully Indigenised ‘Home Grown Technology’
3. 2 x 25 kWh H2 Fuel Cell, 6 kWh Solar Plant
4. Scheduled Completion : Mar 2023
5. The research committee of MoPSW has granted in-principle approval.

Challenges

- Availability & Cost of Green H_2
- Transportation, Storage & Dispensing of H_2
- Regulation Gap for H_2 fuelled Ships
- Incentivise Marine Applications

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H2 Fuel Cell Vessels

1. It is in line with
    - GoI vision on Green energy and move to cleaner fuels under “Atmanirbhar Bharat” initiatives.
    - India’s vision to reduce GHG emission in line with IMO regulation for marine sector.
2. Will provide impetus for using Hydrogen in marine application as envisaged under the National Hydrogen Mission.
3. Will provide India an early bird advantage on hydrogen fuel cells in marine sector, which can be scaled globally.
4. Will set the context towards zero carbon foot print and create impetus for green initiatives in the marine sector.

Why Kerala?

1. Kerala - With its Inland Waterways can lead the way in Green Marine Transportation
2. Head Start - Implementation of Hybrid Electric Ferry for Urban Mobility Solution under progress in Kochi – 23 Nos Vessels in a go!
3. Substantial impetus already with state gearing for production and supply of Green H2
4. Next series of 52 vessel's for Kochi being contemplated, a part of these could be rolled out with Green H2
5. Kerala's plans to install hydrogen dispensing station at Vyttila mobility hub and introduce a fleet of H2 buses can be dovetailed into kick starting the process in the Marine sector in India.

Opportunities and Strategy for India

Hydrogen opportunities in India

1. India has a high potential for producing renewable energy which can be utilised for hydrogen production and its export.
2. The nascent technology creates a need for R&D, testing and demonstration of pilot projects, showcasing hydrogen supply chain which can be scaled up.
3. Potential hydrogen valleys/ high ways- areas with potential for solar/ wind energy production, upcoming industrial and transportation corridors- Kerala, Tamil Nadu, DMIC, Leh-Ladakh, Assam, Gujarat, National waterway system
4. Opportunities for hydrogen production from biogas in decentralised manner should be explored.
5. Convergence with the Swacch Bharat Mission for hydrogen production through biogas can be explored

302	Bio-Gas/CBG Plants – Functional
47	Bio-Gas/CBG Plants – Construction completed
41	Bio-Gas/CBG Plants – Construction in progress
18,508	Installed Capacity of Bio-Gas (in m^3)
2,11,294	Installed Capacity of Commercial CBG Plant (in kg)
216	Number of districts covered*

Gobardhan launched by Dept. of Drinking Water and Sanitation with concerned Ministries/State Govts./ public and private sector institutions and communities- converting bio-waste to biogas CBG plants being set up by entrepreneurs/ cooperatives- CBG can be used as fuel

Hydrogen strategy for India

1. Establishing a central coordinating agency
    - Coordination with Ministry of Power, Ministry of Petroleum and Natural gas, State Electricity Boards, MoHUA, Ministry of Jal Shakti, Transport Authorities, Municipal Corporation, State Departments and HFC bus OEMs. Demand aggregation of all refineries/ steel plants/fertiliser plants.
    - Develop infrastructure, model tenders, disbursement of funds from centre to the state, SOPs and standards with discussion and approval of concerned stakeholders.
    - Capacity building for handling hydrogen- generation, refuelling, transportation
    - Identify technology partners for developing infrastructure
2. Development of in-house capacity and technological partnership strategically
    - In-house capacity development for electrolysers
    - Technological partnerships for developing vehicles, conversion of biogas to hydrogen, fuel cells.
3. Identify hydrogen corridors for testing and demonstrating technology chains.

Hydrogen strategy for India

1. Central Assistance towards developing supply chain infrastructure- hydrogen generation and distribution system for pre-identified corridors for identified pilot projects- long distance bus service. Hydrogen liquefaction for refineries / fertiliser plants using free cold energy from LNG
2. Central Assistance under Green Urban Mobility Initiative scheme towards innovative sustainable buses.
    - Procurement of H2 buses on GCC model
    - Subsidy as %age of contract value
    - Option of development and maintenance of refuelling infrastructure under PPP model can be explored
3. Central awards for R&D programs for institutes- electrolysers, biogas to hydrogen, fuel cell, distribution systems, modular scalable building blocks for onsite hydrogen generation integrated with storage and dispensing system. M100 engines to replace diesel engines.
4. Reduction of GST on hydrogen fuel cell vehicles from current 12% to 5% at par with that of electric vehicles
5. Exemption on road tax on hydrogen fuel cell vehicles at par with electric vehicles
6. NHAI / Railways to give ROW for hydrogen pipelines
7. Off shore wind farms and Export potential /Ammonia/ Methanol
8. SAF for aviation and Hydrogen PODs / Trains/ Hyperloops for goods movement

Hydrogen strategy for India

1. Approval from MoEF for installing solar panels on water bodies within the Forest jurisdiction- potential of 9 GW in Kerala itself. Huge potential in Western Ghat areas as well.

2. Public private partnerships and incentives for manufacturing electrolysers, hydrogen fuel cell vehicles

3. Convergence with Ministry of Jal Shakti and MoHUA (Swacch Bharat Mission) on use of solid waste/ agricultural waste, existing biogas plants, STPs for decentralised hydrogen production

4. Extensive consultations with HFC OEMs by the transport authorities to determine the hydrogen tank, fuel cell and battery configurations as per the load requirements a must to minimize costs.

5. Detailed techno-economic studies to be carried out by transport authorities to determine hydrogen pathway, generation and distribution systems, costs and environmental impacts and submitted for availing subsidy

6. Strategic distribution systems to be identified which can result in least cost of hydrogen production- centralised, decentralised, hub and spoke distribution systems may be explored

Hydrogen strategy for India

1. Establishing SOPs, regulations and standards for safe handling of hydrogen and hydrogen vehicles

    - Establishing standards for stationary and mobile applications of hydrogen
    - Regulations/ certification for hydrogen vehicle
    - Framing of SOPs for handling hydrogen safely, transportation of hydrogen
    - Specifications for hydrogen fuel
    - Standards for vehicle fuelling infrastructure
    - Approval for storage and transportation of hydrogen in high pressure systems (above 300 bar, which is currently approved by PESO)
    - Standards for hydrogen PODs/ Hyperloop/ Hydrogen planes

Hydrogen strategy for India

Tenders to be technology agnostic

Tenders to have 15-20 % reservation for Start up

PLI scheme for components

Ammonia to be made mandatory for shipping as IMO approval is there

Mandate 10 % aviation fuel through SAF route by 2030. At least 3 airports to set up SAF plants and OMC should invest

Sugar industry be incentivised to produce SAF or Green methanol

Green tourism

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