KPIT

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Green Mobility with Bio Hydrogen-

A Sustainable & Viable Solution

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A Global *Technology Partner* To The Automotive Industry For Reimagining Mobility For A Cleaner, Smarter & Safer World

KPIT Technologies

10+
Mn vehicles on road with KPIT software

11,000+
specialists with Automotive & Mobility domain know-how

13 Countries
25 Locations

25+
OEM/Tier-1's count us as strategic partners

75+
platforms, tools & accelerators

Electrifying Transportation

Battery based

- Passenger Cars : Lower weight & short driving distance

Hydrogen based

- Buses/ trucks
- Heavy-Duty & long distance

Hydrogen-based Transportation Options:

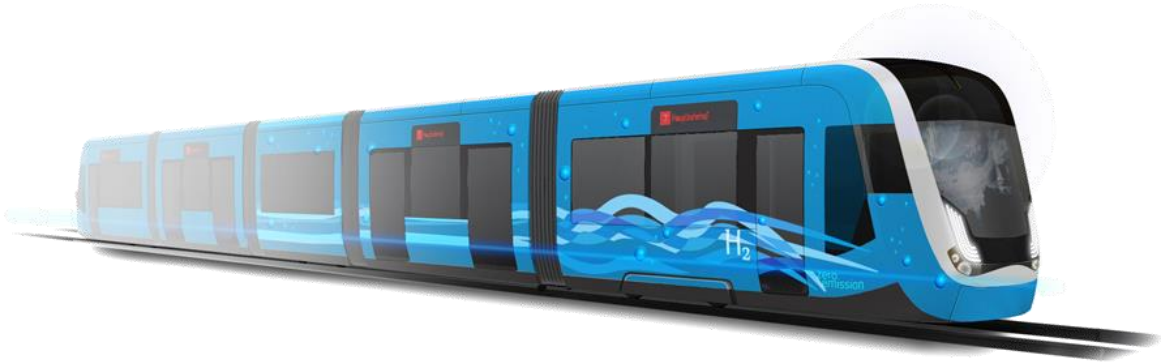
- Fuel Cell Electric Vehicles (FCEVs)
- Hydrogen IC Engine (H2-ICE) Vehicles

There's room for both technologies, each with its own advantages and disadvantages.

FCEVs Best Suited for Long-Distance Mobility

- BEVs not appropriate for long distance transport due to high battery weight and long charging time. Fuel Cell Electric Vehicles (FCEV) can address this constraint.
- Buses/trucks travelling over 350 km/day are best suited for fuel cells. They can become cost competitive with diesel in a short period.
- India has around 2 Mn buses and over 8 Mn trucks and 50% operate over long distances. Most of these can be converted to Fuel Cell.
- Thus 40 Mn tons of diesel can be displaced by 8 Mn tons of green Hydrogen, saving $ 30 Bn of oil imports.

Going Beyond Road Transportation



The Key Issue

Economic Viability Of The Solution

Economic viability depends on the complete value chain of

- Hydrogen Generation
- Storage/Transportation
- Dispensation
- Consumption

This presentation seeks to address the issue of the economic viability of

- Hydrogen Generation
- Storage/Transportation
- Hydrogen consumption

Green Hydrogen Generation

- **Photolysis** - Promising solution but some years away
- **Plasma-based gas separation-** Promising solution but some years away
- **Electrolysis**- Here & now but costly
- **Biomass-based-** High potential

Current cost economics of green hydrogen production via Electrolysis

Details	Electrolyzer System Capex	Electricity Rate	Price of Hydrogen
Current	$ 1000/kW	₹ 3.0/kWh	$ 4 to 6/kg

There is a discussion on bringing the H2 cost to $ 1/kg by 2030.

At the current cost of H2, H2 mobility is not viable without significant subsidy.

Biomass-Based Green Hydrogen Generation

Pilot Plants with Indigenously Developed Technologies

H2 Generation by Gasification of Biomass

H2 Generation by Microbial Process

Through a well-integrated value chain, H2 cost can be brought down to as low as **$ 2/kg**. In other cases, it can still be less than **$ 3/kg.**

How Much Of Bio-Hydrogen Can Be Generated in India? (1/2)

Sources of bio-mass:

- Agri waste- Rice/Wheat Straw, Soya/Cotton waste- 250 Mn Tons/Annum
- Energy plantation on non- agricultural land

35-40 Tons of Bio-mass per acre every 10 months from energy cane

How Much Of Bio-Hydrogen Can Be Generated in India? (2/2)

How much wasteland is available in India?

- 97 Million hectares
- Government of India's commitment at Bonn convention to greenify 30 Million hectares

10 Million hectares can give us 10 Million tons of Hydrogen every year

- GOI current goal is to generate 5 Million tons of Hydrogen by 2030

High potential to generate green hydrogen at an affordable cost

Decentralized Generation & Decentralized Consumption

Maharashtra

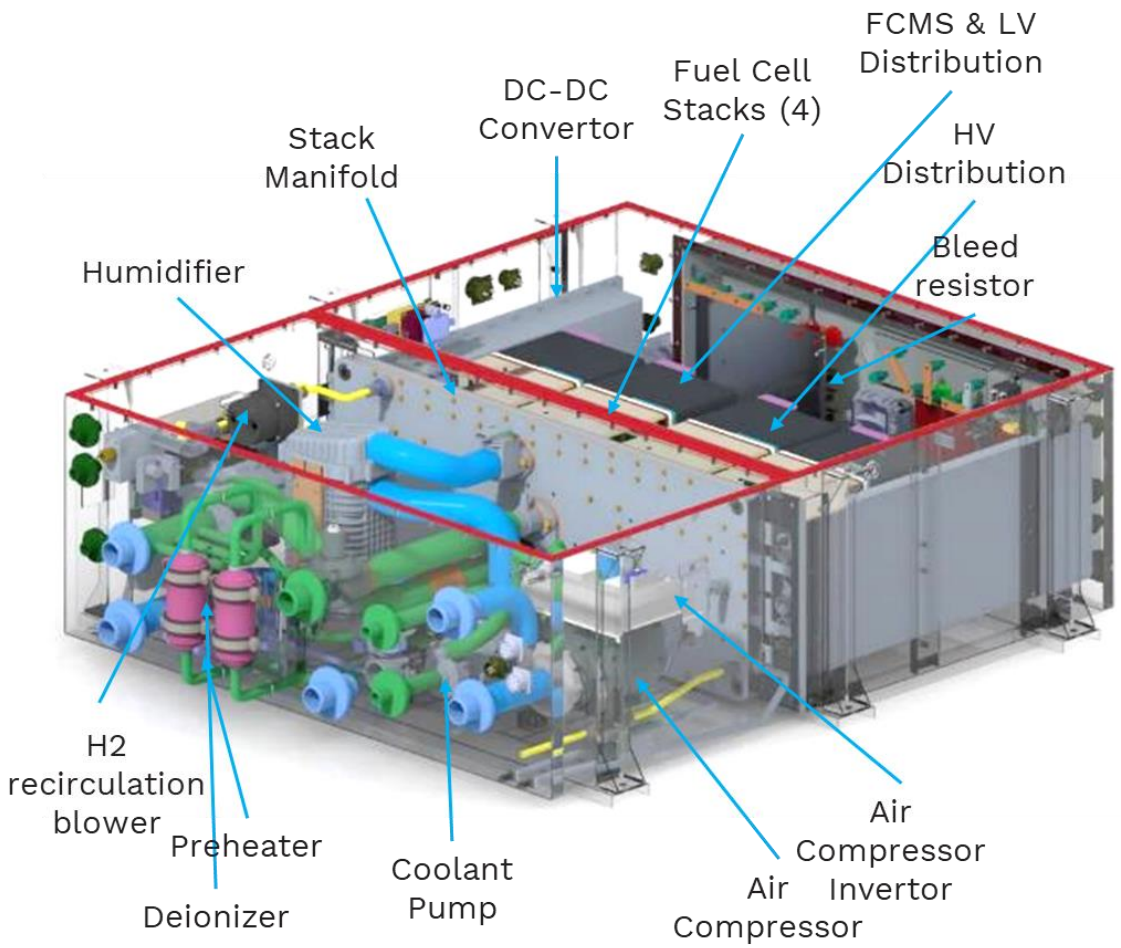
Madhya Pradesh

Gujarat

Bihar

Saving the Transportation Cost

Indigenously Developed Fuel Cell Stack & Engine- KPIT & CSIR Labs (modular up to 120kW)



Indigenously developed fuel cell (FC) engine includes

- Flow field and FC stack design
- Air handling system
- Fuel delivery subsystem
- Thermal management
- Fuel cell engine controls
- Electricals including HV/LV harness and DC/DC converter
- FC engine packaging
- Low parasitic load
- High conversion efficiency
- Wide temperature range operation
- Cell voltage monitoring for diagnostics and State of Health

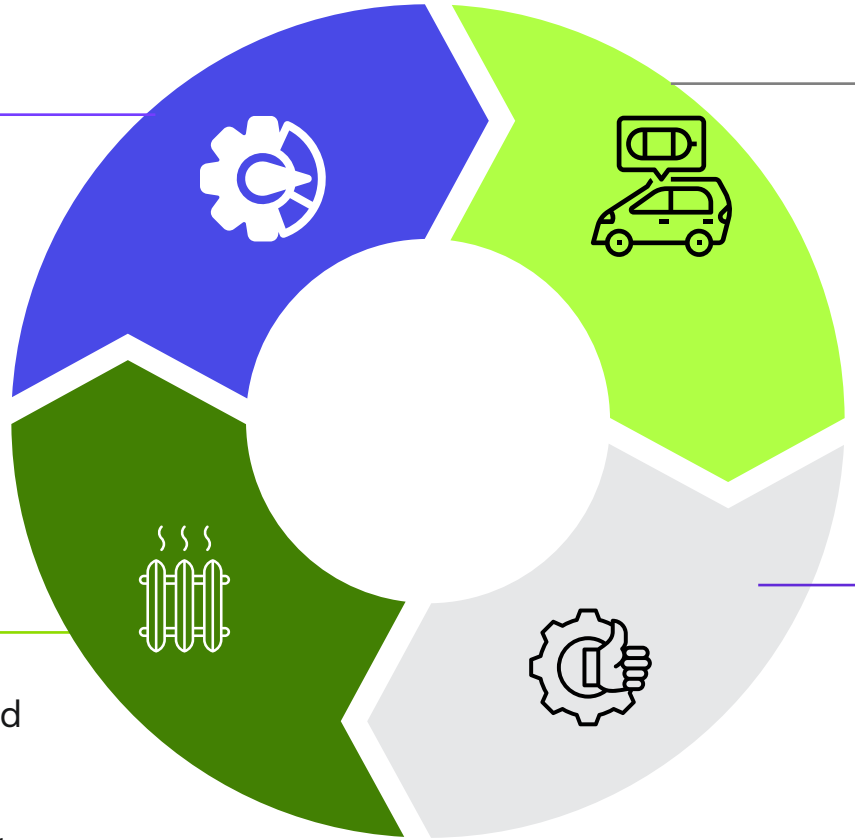
Key Challenges in FCEV Development and Integration

Performance & Efficiency

- Optimizing FC stack and Battery pack capacity
- Meet performance and range
- Operating the FC stack, powertrain and BoP to maximize fuel economy
- Freeze start

Thermal management

- Thermal management for FC Stack and auxiliary components
- Packaging of the thermal management system for a given space claim



Hydrogen Storage & Safety

- Safe handling of high-pressure hydrogen storage
- Design for failure modes

Reliability & lifetime

- Estimating the State of Health (SoH) of the Fuel Cell stack
- Operating the FC stack for longer lifetime

Core Strenghths

Battery & FC Stack sizing

- Sizing of battery pack and FC stack based on drive cycle
- Hybridization strategy
- Sizing for performance, cost, life.

Design and Architecture

- BoP component SOR
- P & ID
- Electrical architecture
- CAN bus topology
- Plant model
- Functional safety

Thermal Management

- FC stack thermal management
- Auxiliary thermal management

Packaging and Layout

- Packaging of Stack, BoP and hydrogen Storage
- Packaging of powertrain components

Control Software

- Vehicle control software
- FC control software
- Startup and shutdown cycles
- Safety and interlocks

Testing & Validation

- Unit testing
- BoP component testing
- Subsystem testing
- Integration testing

Standards & Regulatory compliance

- Standards across various industries, applications and geographies

KPIT Developed Infrastructure & Test Benches

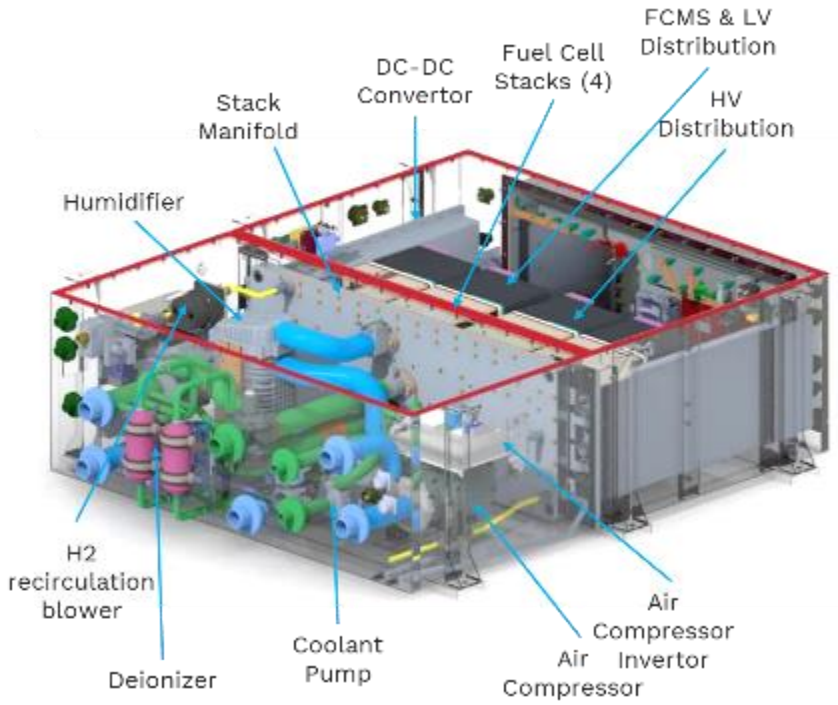
FC stack characterization test Bench

FC Performance & Durability test bench

Motor testing lab

High Voltage lab

Indigenously Developed Fuel Cell Stack & Engine- KPIT & CSIR Labs



Developed Indian ecosystem to supply most components

Lower Cost At Low Volumes

Deploying Fuel Cell Solutions

Demonstrated in 2020

Demonstrated in 2022

Backup System for High Altitude Location- Demonstrated Here

Hydrogen Ship- To be launched this year

Green H2 in Mobility

We believe that with these solutions, the **TCO** (Total Cost of Ownership) for the Hydrogen vehicle should be **comparable with that of a diesel vehicle**

Additional Benefits of Bio-Hydrogen-Based Solutions

Forex Savings

- Transportation sector will potentially demand 8 million tons Hydrogen.
- Potential reduction of 40% in India's fossil fuel imports- $ 30 Bn /Annum.

Employment Generation

- Additional income for farmers consumption of agri residue.
- 500 K jobs (skilled/unskilled) can be generated in setup of H2 generation plants.

Greening Degraded Land

- Contribute to India's commitment to the Bonn challenge.
- Help restore 26 Mn hectares of land by 2030.

CO2 Emissions

- Help meet goal of reduction in CO2 emission of 1Bn ton to 2030.
- Contribute to the target of Net zero emissions by 2070.

Potential of deployment of private capital & reduce the burden on exchequer

Hydrogen
is the Fuel of the Future &
the Future is
Now.

A Call For Action

- Create demonstration projects involving adequate investments

- Launch CATAPULT-like programs to take technologies from TRL 2 to 9


Thank You!