Fuel cell systems – A leapfrogging technology for clean transportation/ backup power applications

Virayaa Green Energy Systems Pvt Ltd.
Hyderabad, India
Vamsi krishna
***Email*: vamsi@vgesystems.in**

Outline

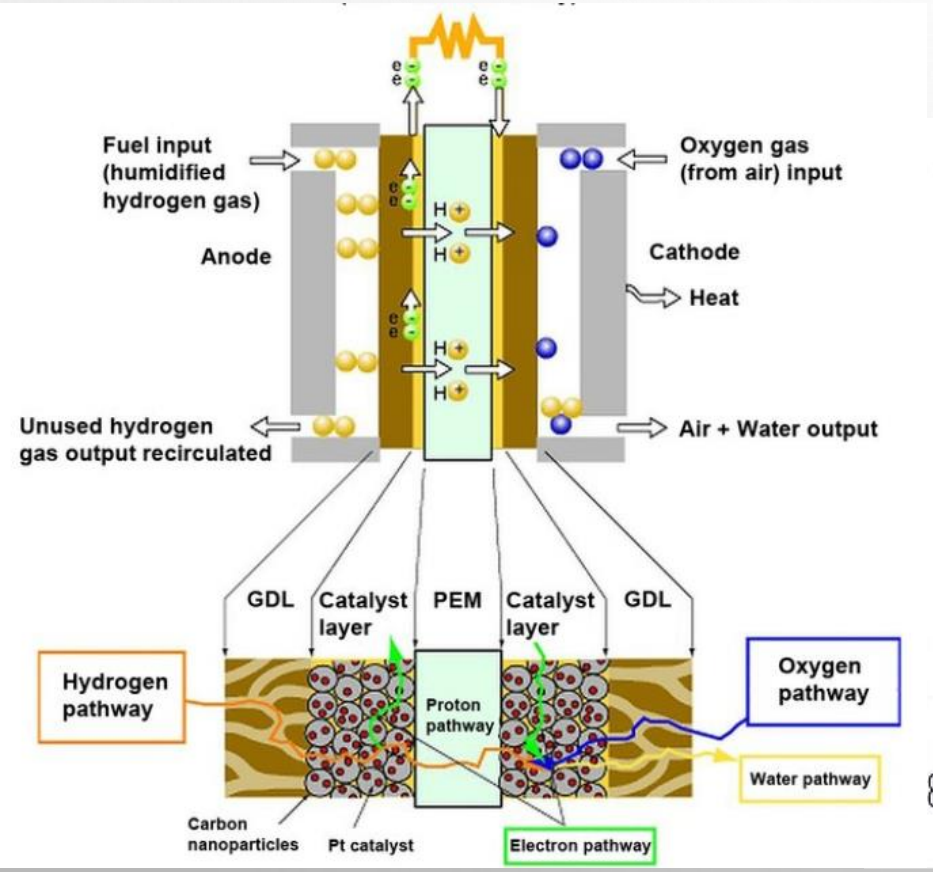
- Conventional Energy conversion systems Vs Fuel cells
- Fuel cell systems - Business opportunities & Application
- What we offer & Uniqueness of VGE systems
- Challenges in commercialization of Fuel cell systems
- Opportunities in Hydrogen & Fuel cell eco system
- Policy support required from Govt of India

Fuel cell

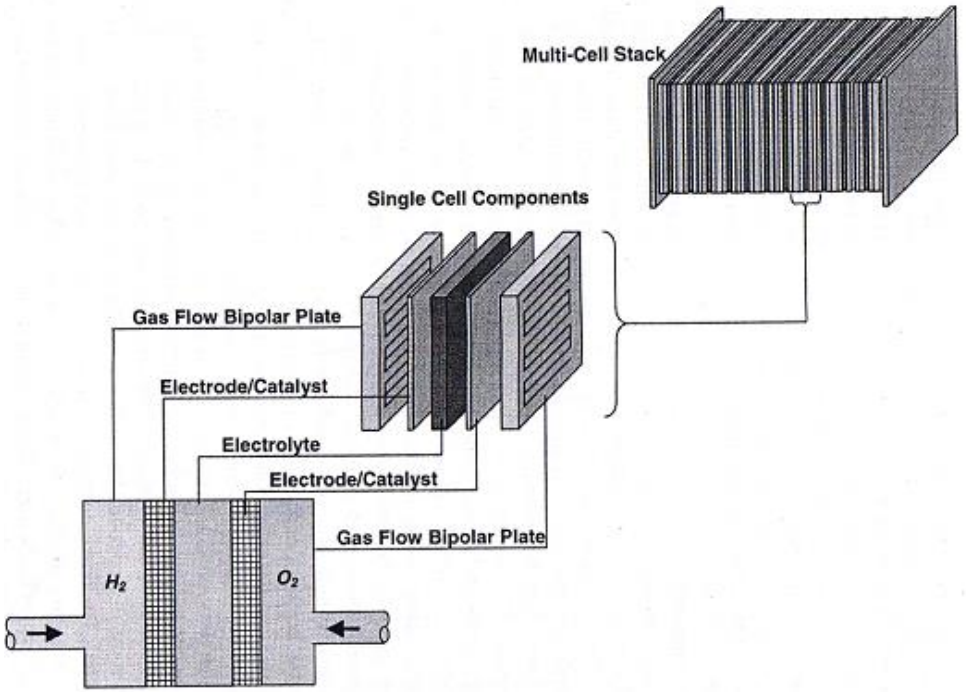
- Fuel cell is an electrochemical device which converts chemical energy to electrical energy for continuous supply of Hydrogen and Oxygen in the form air.
- Any fuel cell consists of three basic components such Anode, Cathode and Electrolyte which is analogues to battery wherein energy is stored in the form of charge within the cell, whereas in fuel cell, the energy (Hydrogen) is stored outside the cell
- Performance of any fuel cell is being characterized by its current – voltage curve which is governed by various operating parameters
  - Reactants Hydrogen & Air stoichiometry ratio
  - Operating temperature of cell/ stack
  - Hydration of the membrane for optimal ionic conduction
- To operate the fuel cell, hydrogen and oxygen in the form of air have to supplied from hydrogen storage vessel and air compressor
- In case of fuel cells, energy (fuel tank) and power (IC engines) are decoupled systems have an advantage of low weight over batteries

Fuel cell stack

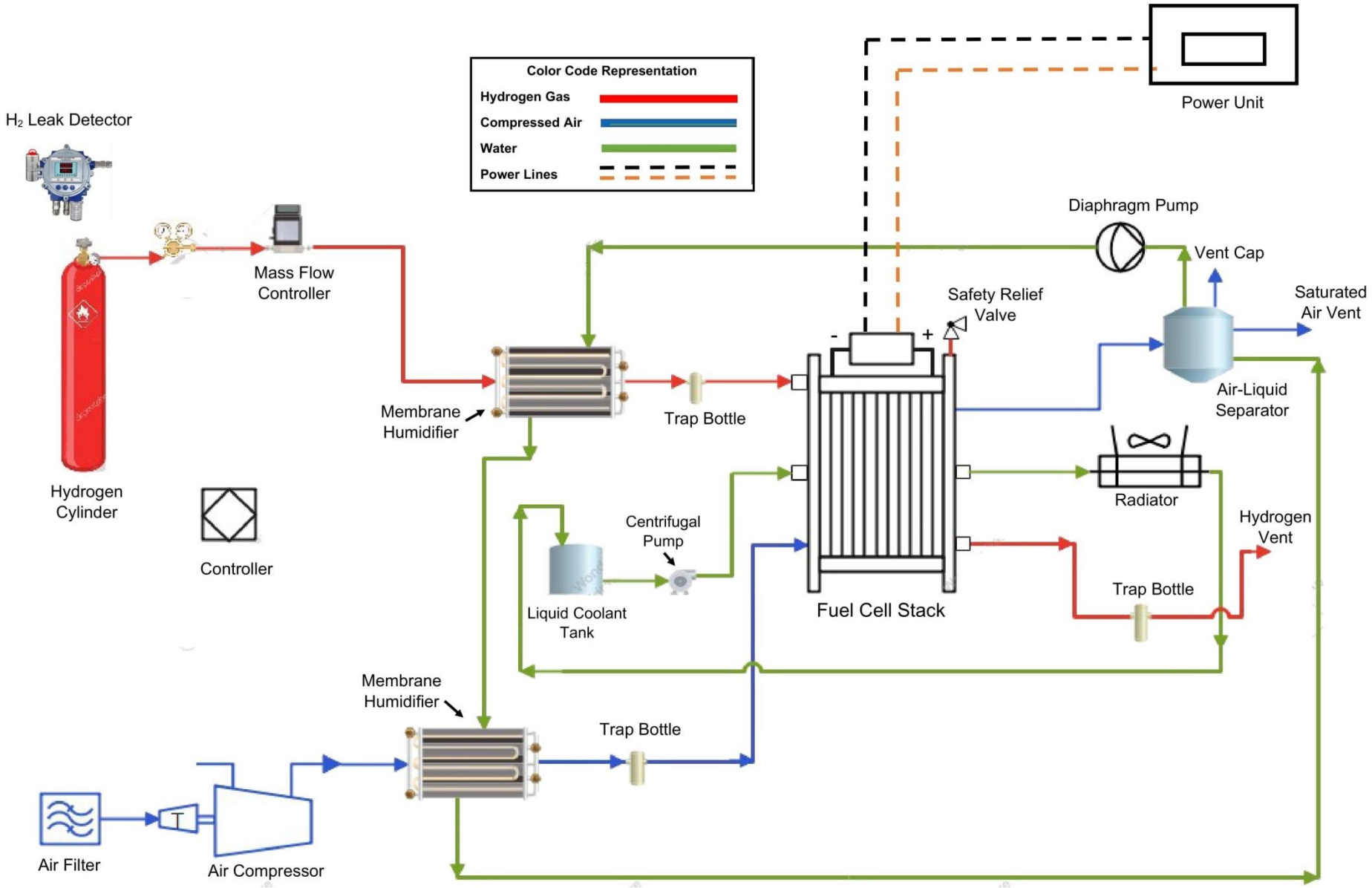
- Temperature and electrolyte membrane hydration are to be maintained at its optimal values to minimize the degradation of cell performance over life time
- Typical operating voltage of PEM fuel cell (single cell) is 1 VDC to 0.6 VDC,(to meet the requirements of higher power and voltages multiple such single cells are connected in series to form a fuel cell stack



Transformation of single cell to stack



Schematic of Fuel cell system

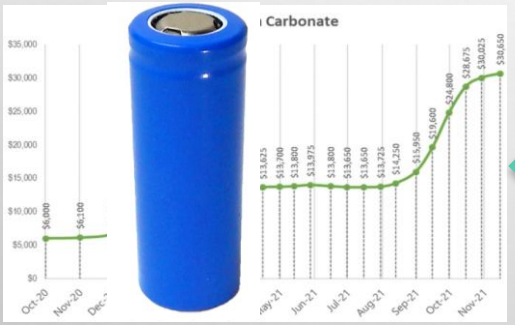


Note: Liquid cooled PEM Fuel cell stack with its BoPs and BMS for offline testing with e-LCV

Conventional Systems – Current Challenges

Raise of oil prices with stringent fuel grade norms and dependence on foreign imports

Low energy efficiency of internal combustion engines (<30%) and its emissions



Price rise of Lithium cells due to rise of EV demand & limited resources of Lithium ores

Range limitation of commercial utility EVs due to predominant weight of batteries

Why Fuel cell systems could be the Solution for Energy Needs

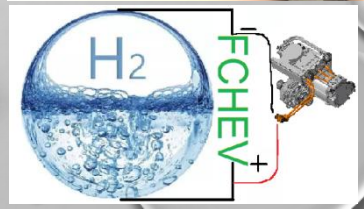
- Availability of Green Hydrogen as clean fuel with increase in capacity addition of renewable energy

- Carbon Neutral Energy Generation using Fuel Cells – water is the only emission

- High gravimetric Energy of Hydrogen compared to any advanced batteries

- Low Total cost of ownership in comparison to conventional technologies

- Fuel cell systems are compatible to integrate with EV powertrain

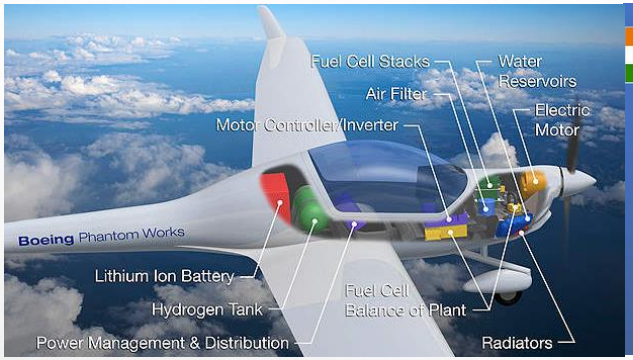


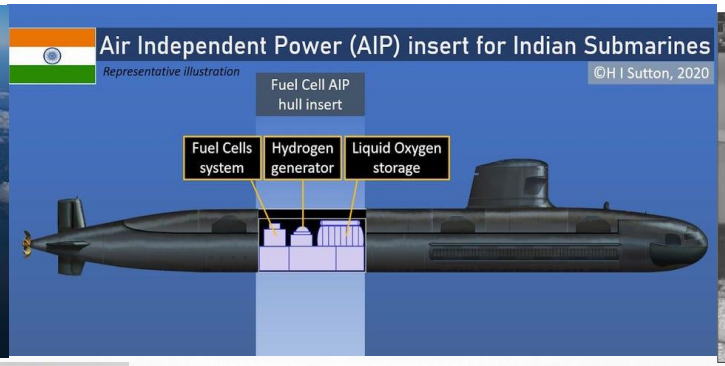
Business opportunities in clean transportation

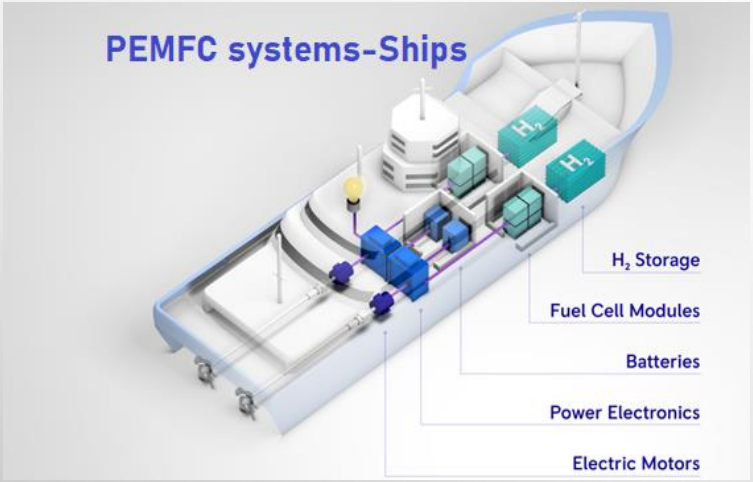
Fuel cell Systems

- 25-40 kW
- 50 – 75 kW
- 100-145 kW
- 150-200 kW
- 250-300 kW
- 7-15 kW

Business Opportunities in Non-transportation

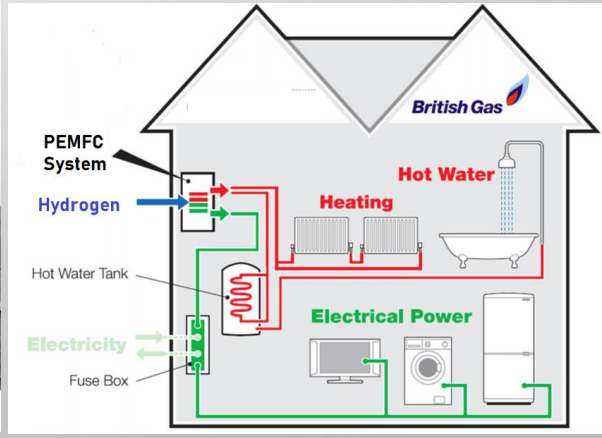






Fuel cell Systems

Electrically charged submarine

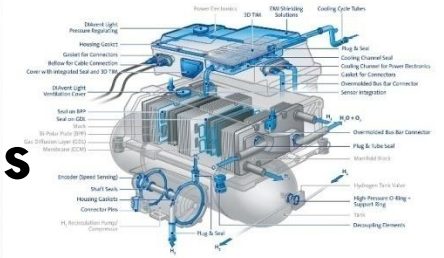


PEM Fuel Cell Systems – Prominent Applications

- Combined Cooling Heating Power (CCHP) ex: Lehladak & others
- off-grid applications – powering Telecom, radar stations, Hill stations
- Microgrid applications in peak power demand
- Transportation systems (Long range public transport vehicles/ commercial vehicles/ Railways)
- Marine applications
- Submarines energy source in place of diesel generators/ batteries
- Replacement of diesel generators at H_2 available places
- Fuel cell drones

Products & Services offered by VGE Systems

Products



- PEM Fuel cell stacks for customized systems
- PEM Fuel cell systems for vehicle integrators
- Hybrid Energy kits for EV distributors
- PEM Fuel cells systems for non-transportation sector

Services

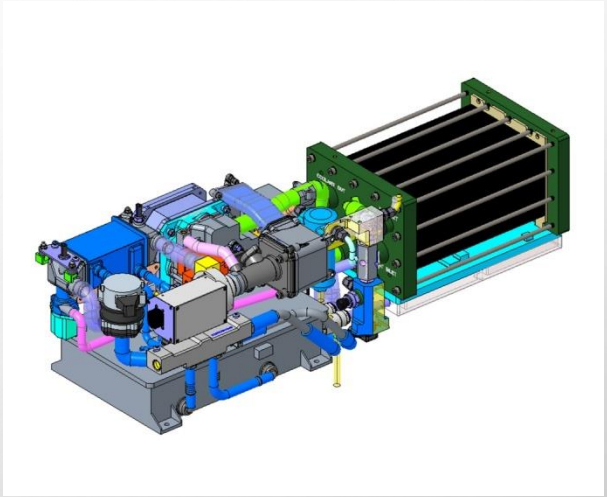
- ✓ Conversion of Evs to FCHEVs
- ✓ Fleet operation of Fuel cell hybrid electric LCV for B to B applications

UNIQUENESS OF STARTUP

- Solution provider from end to end applications for backup power systems and FCHEVs
- System development with key indigenous subsystems
- Rich experience of team in stack & systems developments
- Customized stacks and system development as per user requirements
- Conversion of Electric LCV to Fuel cell Hybrid Electric vehicle
- Complete packaged solution for Fuel cell system + Battery storage + Hydrogen storage

UNIQUENESS OF STARTUP

- TCO demonstration of e-LCV trucks for range of 350 kms+

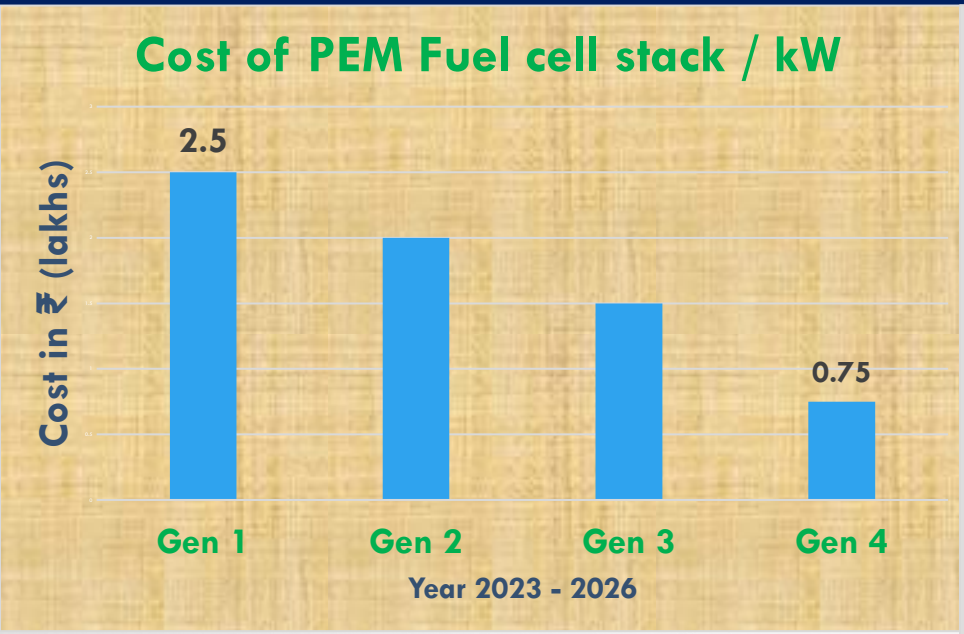


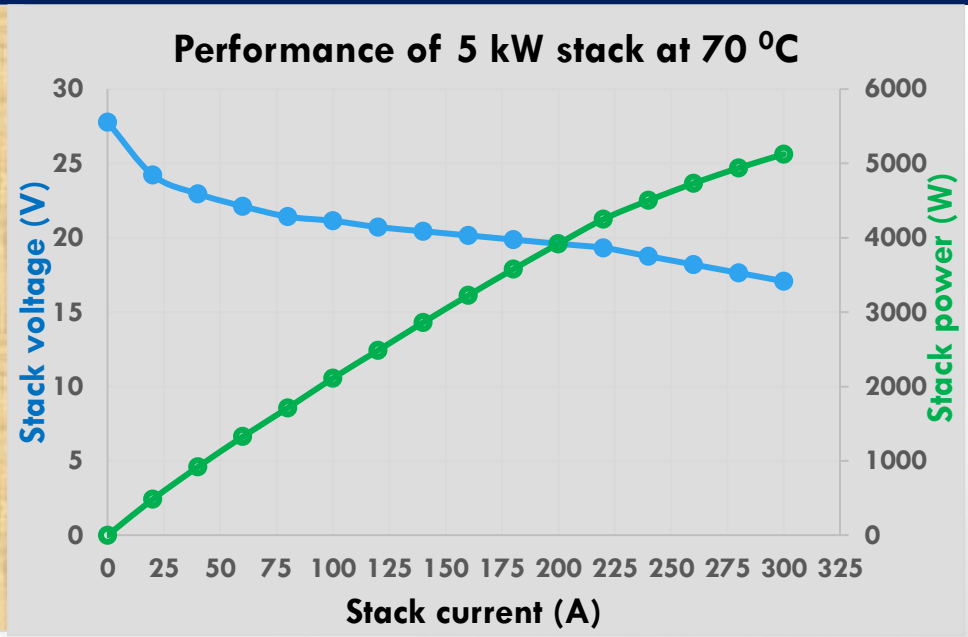
- System development with key indigenous subsystems

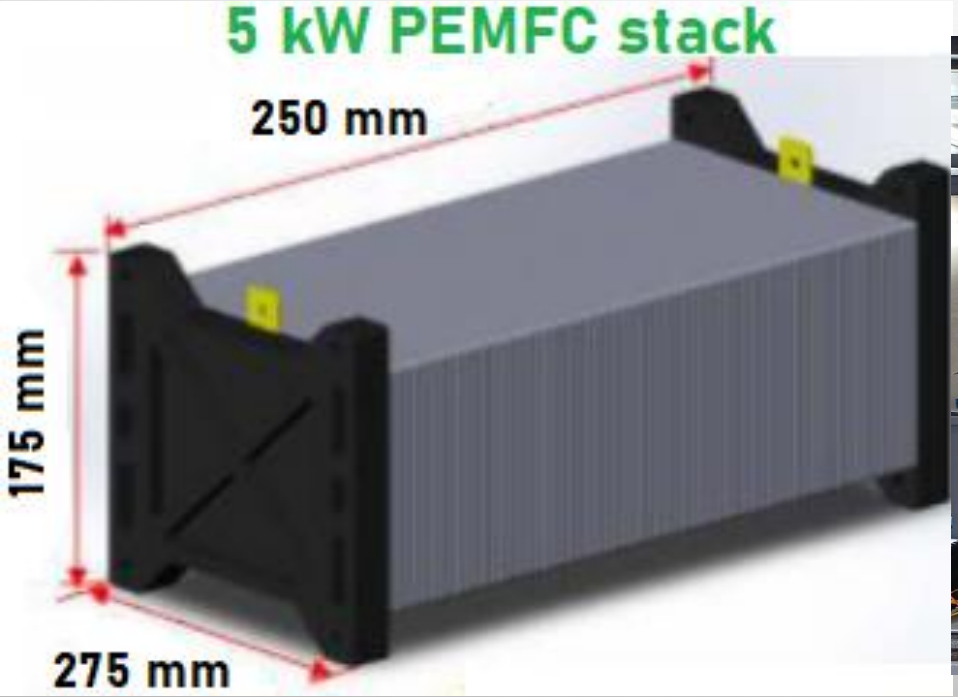
- Rich experience of team in stack & systems developments

- Certified Fuel cell system kits for range extension of existing e-LCVs & to integrate in EVs at city exits

Techno-commercial status of PEM Fuel cell stack



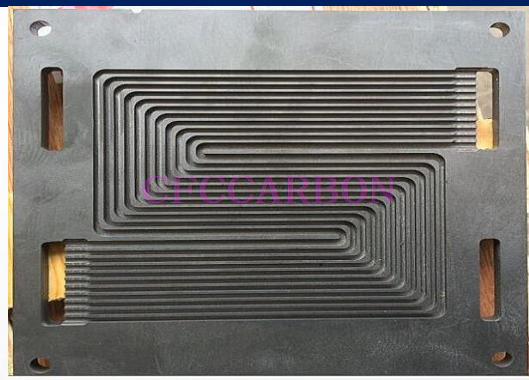


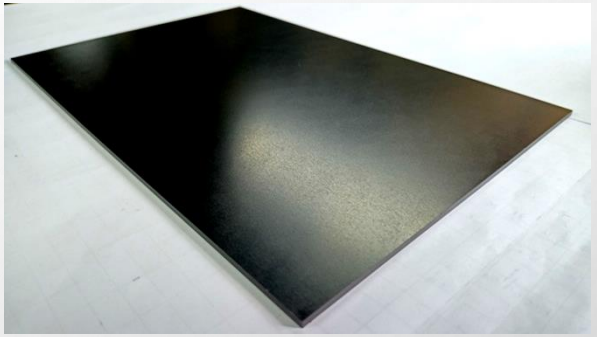


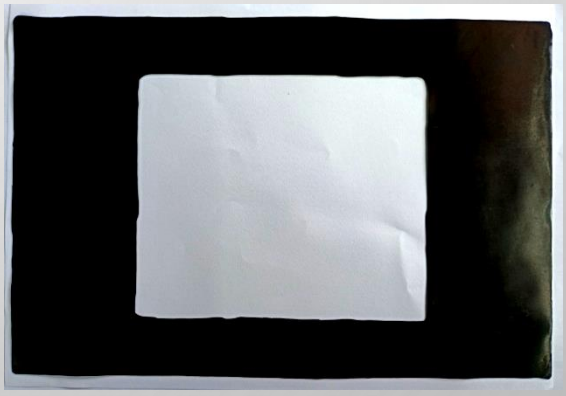
Techno-commercial status of PEM Fuel cell stack

Technical specifications of Composite graphite plates

Property	Parameter value
Density	1.85-1.90 g/cc
Electrical Conductivity	
(In-plane)	178 -180 S/cm
(Thru-plane)	58-60
Flexural Strength	40 MPa
Compressive Strength	55 MPa
Thermal Conductivity	16-18 W/mK
Working temperature	up to 100^0C
Gas permeability	$1X10^{-5}$ cm^3/cm^2 s
Available size	300 mm X 200 mm X 3 mm







Gaskets developed indigenously as per custom specifications

Value addition for society by VGE sytems

- Local employment creation (direct and indirect)
- Additional ancillary units for supply of components
- Existing distribution network of Evs can be extended
- Promotion of green Hydrogen by using existing solar plants/ wind/ Hydro power
- Reduction in City pollution by controlling emissions & Air quality improvement by promoting H_2 generators
- Rural empowerment promoting formers for biomass cultivation for Green Hydrogen via biomass gasification

Commercialization challenges of Fuel cell systems – Key components and subsystems

- Membrane electrode assemblies are still imported – which are similar battery cells price targets are still expensive (Target value: 0.25$/cm^2)
- Current Densities achieved with Indian MEAs < 1A/cm^2 (Target value 1.8 or above)
- Composite graphite plates is the key component having through plane conductivity of maximum achieved value in India is 58 S/cm (Target value 100S/cm or above)
- Current Life of Fuel cell stack : 5000-6000 Hrs (Target Value: 10,000 hrs or above)
- Effective volume of Fuel cell stack is 1.7Lt/kW (Target value: 1Lts/kW or below)
- Cost of Fuel cell stack is ₹2.5L/kW (Taraget value is: ₹60,000/kW or below)
- Fuel cell Air compressors available pressure rating is 0.4-0.5 barg with power consumption 0.2kW/kW of stack (Target value 0.1kW/kW stack or below)
- Fuel cell power converters are still imported & expensive and local power supplies still less efficient to meet the requirement of efficiency 97% or above

Note: Import duty exemption on key components required for 3-5 years

Opportunities in Hydrogen & Fuel cell eco system for Startups

- Fuel cell / Electrolysers stacks which are imported by system integrators
- Fuel cell / Electrolyser systems are being imported by EPC players
- Energy efficient Rectifiers / DC-DC converters for electrolysers and Fuel cells scale varies from kW to MW
- Water purification/ Humidification units for electrolysers and Fuel cells
- Membrane Electrode Assemblies for Fuel cell / Electrolyser stack developers
- Composite metal plates for Fuel cells and electrolysers
- Cost competitive alloy-metals for Hydrogen storage
- Integration of Renewable energy systems with Electrolysers

Policy support from Govt of India

- Establishment of codes and standards for various applications
- Testing and approval agencies for homologation vehicles and certifications for system developers
- exemption in certification charges from agencies Initially for a period of 5 years from now

THANK YOU