Green Fuel Cells

for

World Hydrogen Energy Summit- 2023

Convention Centre-NDCC, Parliament Street, New Delhi, India

16th -17th October, 2023

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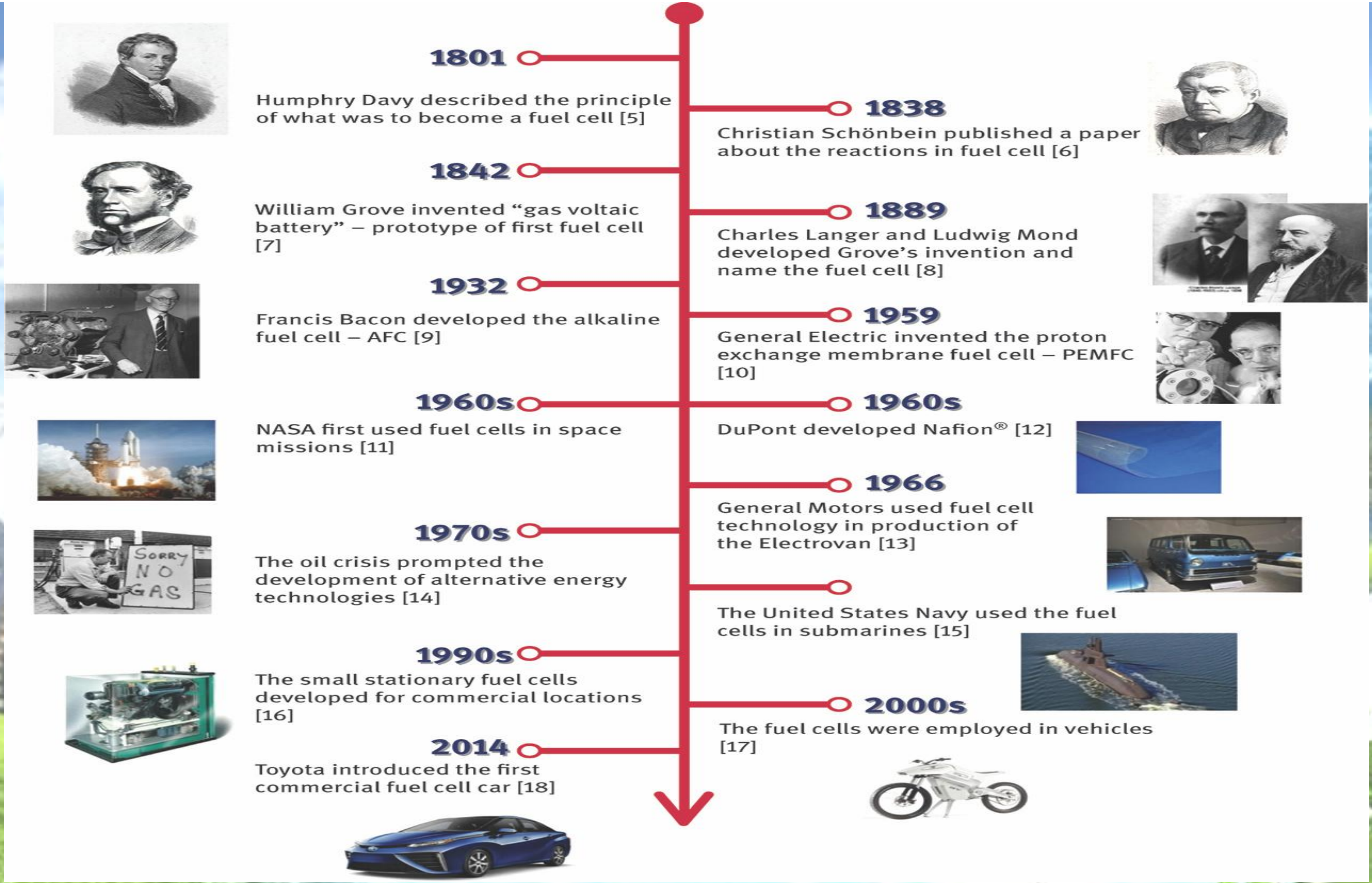
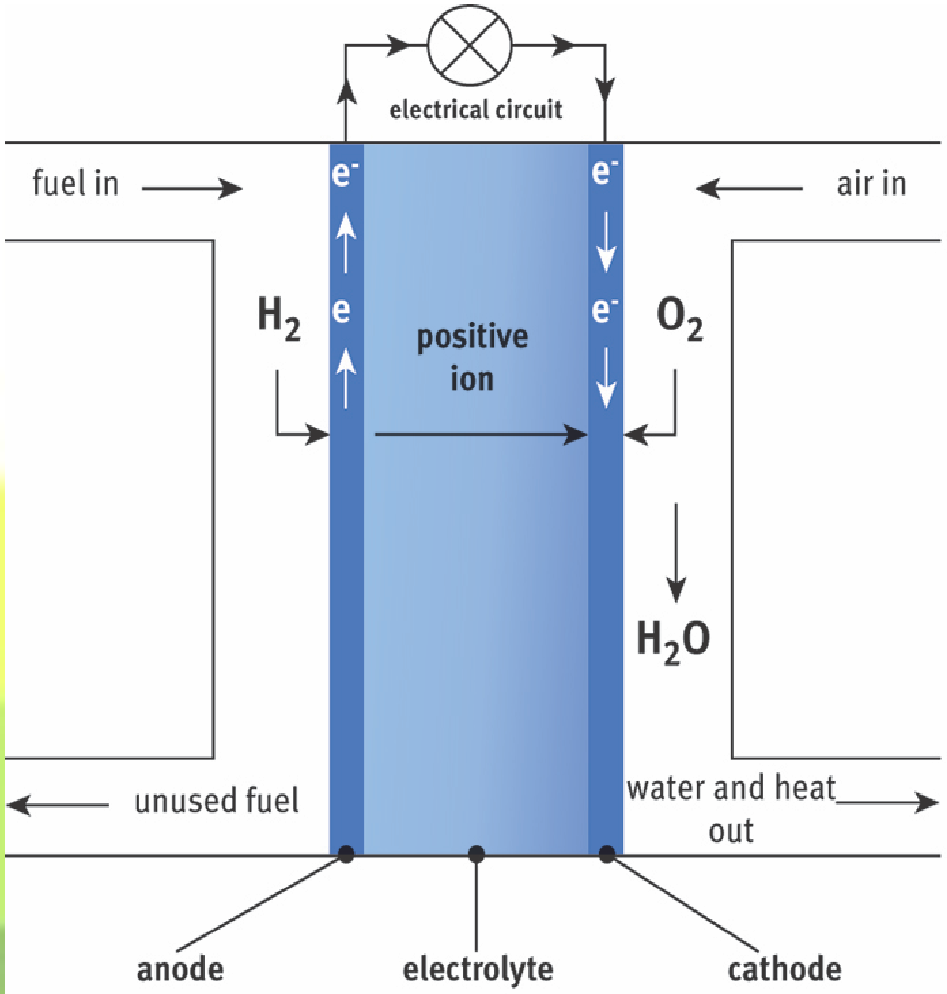
1.0 Historical Development



2.0 Basic Principle



Anode reaction: $2\,H_2 \rightarrow 4\,H^+ + 4\,e^-$

Cathode reaction: $O_2 + 4\,H^+ + 4\,e^- \rightarrow 2\,H_2O$

Overall reaction: $2\,H_2 + O_2 \rightarrow 2\,H_2O$

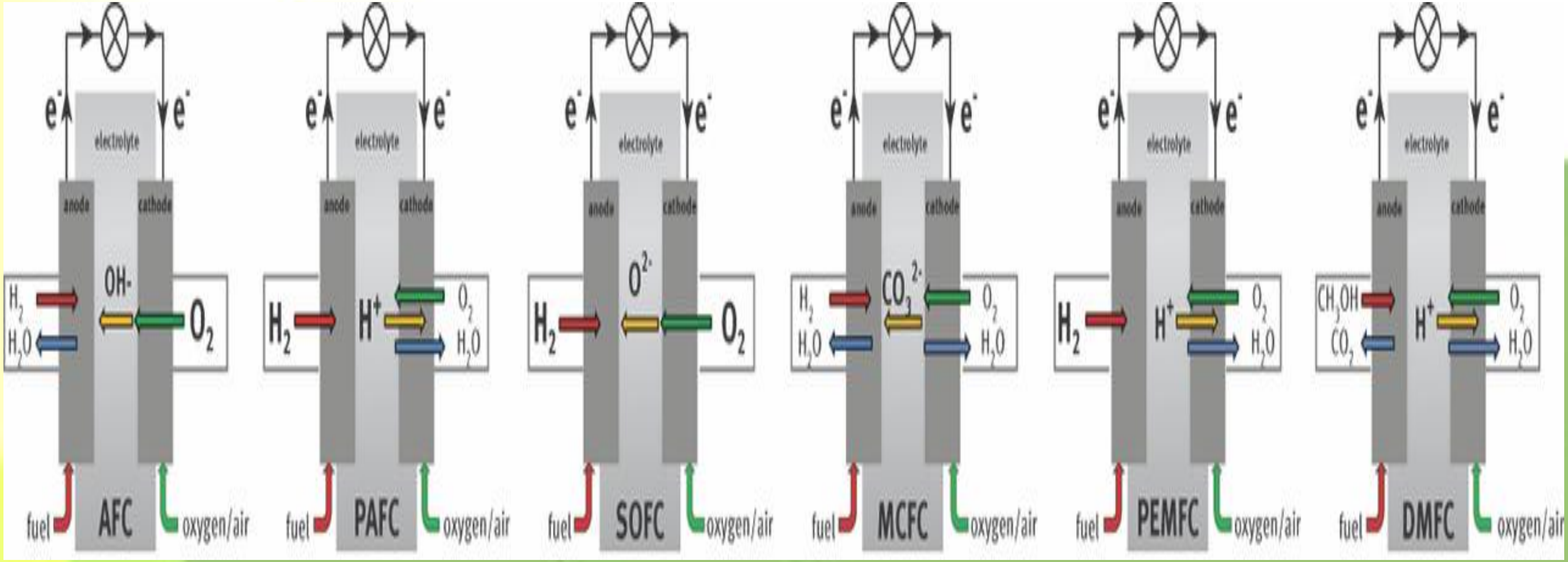
3.0 Fuel Cell

- Device to convert chemical energy directly into electrical energy;
- It comprises of two electrodes, Anode and Cathode separated by electrolyte;
- All fuel cells technologies require hydrogen and oxygen. Hydrogen gas and oxygen gas from the air are continually supplied to anode and cathode, respectively;
- At anode, hydrogen reacts with catalyst, producing positively charged protons (H+) and negatively charged electrons (e-);
- Electrolyte membrane allows only positive ions to pass through from anode to the cathode side and serve as insulator for electrons.

4.0 Types of Fuel Cells

Fuel Cell Type	AFC	PAFC	SOFC	MCFC	PEMFC	DMFC
Common electrolyte	Solution of potassium hydro	Phosphoric acid	Solid ceramic inorganico	Molten potassium or lithium carbonate	Solid polymeric protonex	Solid polymer membrane
Anode reaction	2H2+4OH− →4H2O+4e−	2H2→4H ++4e−	2O2−+2H2 →2H2O+4e−	2H2+2CO32− →2H2O+2CO2+4e−	2H2→4H++2e−	CH3OH+H2O →CO2+6H++6e−
Cathode reaction	O2+2H2O+4e− →4OH−	O2+4H++4e− →2H2O	O2+4e− →2O2−	O2+2CO2+4e− →2CO32−	O2+4H++4e− →2H2O	3O2+12H++12e− →6H2O
Fuel	Pure H_2	Pure H_2	H_2,CO,CH4, other hydro	H2,CO,CH4, other hydro carbons	Pure H2	CH_3OH
Oxidant	O2 in air	O2 in air	O2 in air	O2 in air	O2 in air	O2 in air
Charge carrier	OH−	H+	O2−	CO32−	H+	H+
Operating temperature (°C)	60–200	150–250	600–1000	600–700	50–200	60–200
Capacity (kW)	10–100	50–1000	<1–3000	<1–1000	<1–250	0.001–100
Electrical Efficiency (%)	60	>40	50–60	>50–60	35–45	30–40
Power density (Wm−2)	~1.0	0.8–1.9	0–1.5	1.5–2.6	3.8–6.5	1.0–2.0
Installation cost (US $kW−1)	1800–1900	2100	3000	2000–3000	<1500	1500–1800

5.0 Chemical Reaction and Electron Migration



6.0 Fuel Cell for Mobility

6.1 Mobility

- By utilizing fuel cell technology with pure hydrogen as input, can benefit both, increased mileage and zero emissions;
- Fuel cell technology has the potential to revolutionize the mobility sector;
- Hydrogen based transportation will become reality in India soon;
- With large population of three-wheeler and two-wheeler, significant opportunity to transform, the transportation for people and goods, on a large scale;
- By utilizing a Proton Exchange Membrane, Fuel Cell (PEMFC) with hydrogen, a three-wheeler can achieve a range upto **200 km**, a bus can travel to **600 km**, and a heavy-duty truck can reach nearly, **1,000 km**.

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6.2 Technologies

- Combination of hydrogen fuel cells, advanced batteries and supercapacitors will be key technologies in the upcoming years.

6.3 Present Constraints

- Fuel cell technology has safety risk, especially associated with hydrogen storage;
- Fuel cell technology is expensive.

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6.4 Research and Development

- Low temperature PEMFC stacks;
- PEMFC using metal bipolar plates, fuel cell architecture, power train integration, control strategies and testing processes;
- Initial capital investment and total cost of ownership (TCO) for PEMFC systems are still very high;
- Indigenous technology development is the need of the hour;
- Development of stacks with increased power density and increased durability, which enable number of components and simplify system-level operations;
- Integration of stacks with suitable hydrogen generation system;
- Several companies are working on LTPEM and HTPEM fuel cells.

Thank You