RSET
RAJAGIRI SCHOOL OF ENGINEERING & TECHNOLOGY

EE403 Distributed Generation & Smart Grids

Dr. Unnikrishnan P.C.
Professor, EEE

Module II

Distributed energy resources: Introduction - Combined heat and power (CHP) systems - Solar photovoltaic (PV) systems – Wind energy conversion systems (WECS) - Small-scale hydroelectric power generation - Storage devices: Batteries: Lead acid, nickel metal hydrate, and lithium ion batteries , ultra-capacitors, flywheels

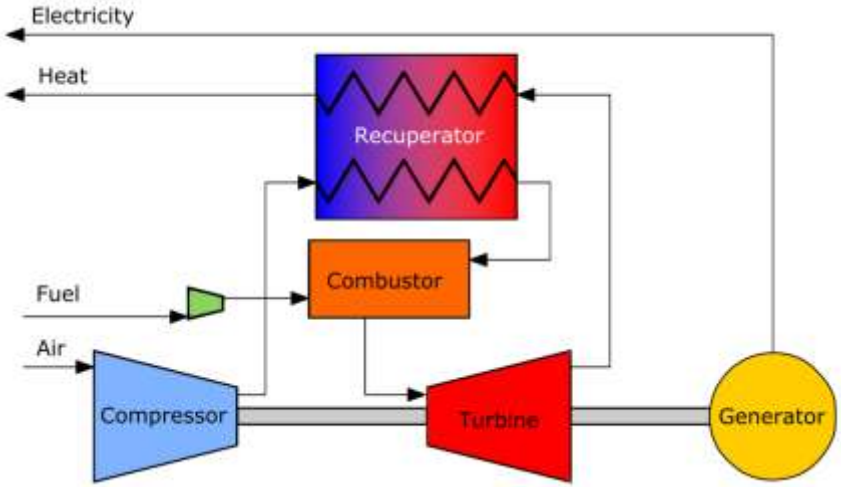
Control of Microgrids: Introduction to Central Controller (CC) and Microsource Controllers (MCs) - Control functions for microsource controller, Active and reactive power control, Voltage control, Storage requirement for fast load tracking, Load sharing through power-frequency control

Micro-CHP Systems

Micro-CHPs are based on the following technologies

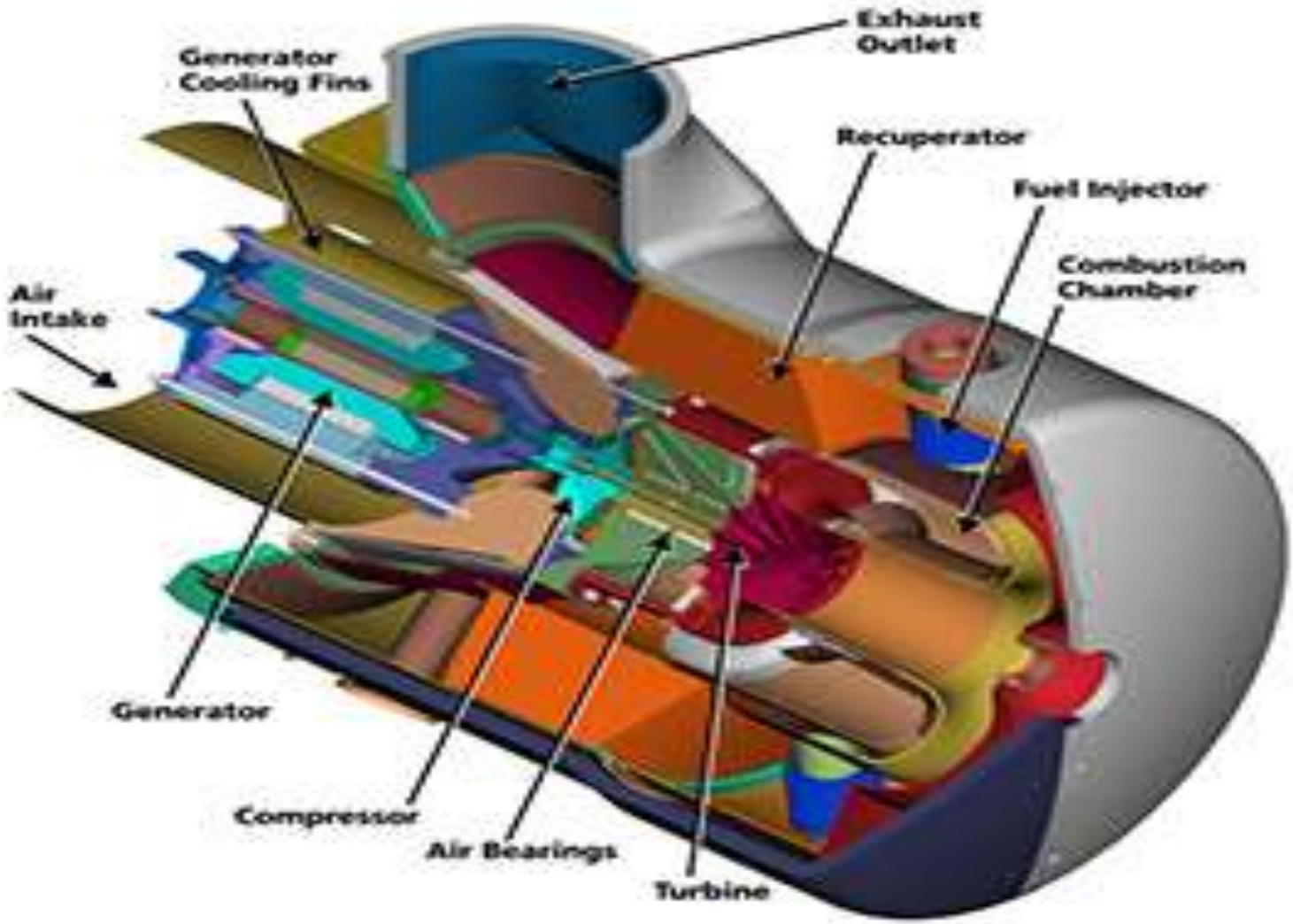
1. Internal Combustion (IC) Engines
2. Stirling Engines
3. **Microturbines**
4. **Fuel Cells**

Microturbines



- Microturbines are small and simple-cycle gas turbines.
- The outputs of the microturbines range typically from around 25 to 300 kW.
- Performance increased using a recuperator (waste heat used to heat incoming gas)
- Microturbines are available as single-shaft or split-shaft units.

Microturbines



Parts of a Microturbine

(1) **Turbine –** High-speed gas turbines.

(2) **Alternator**

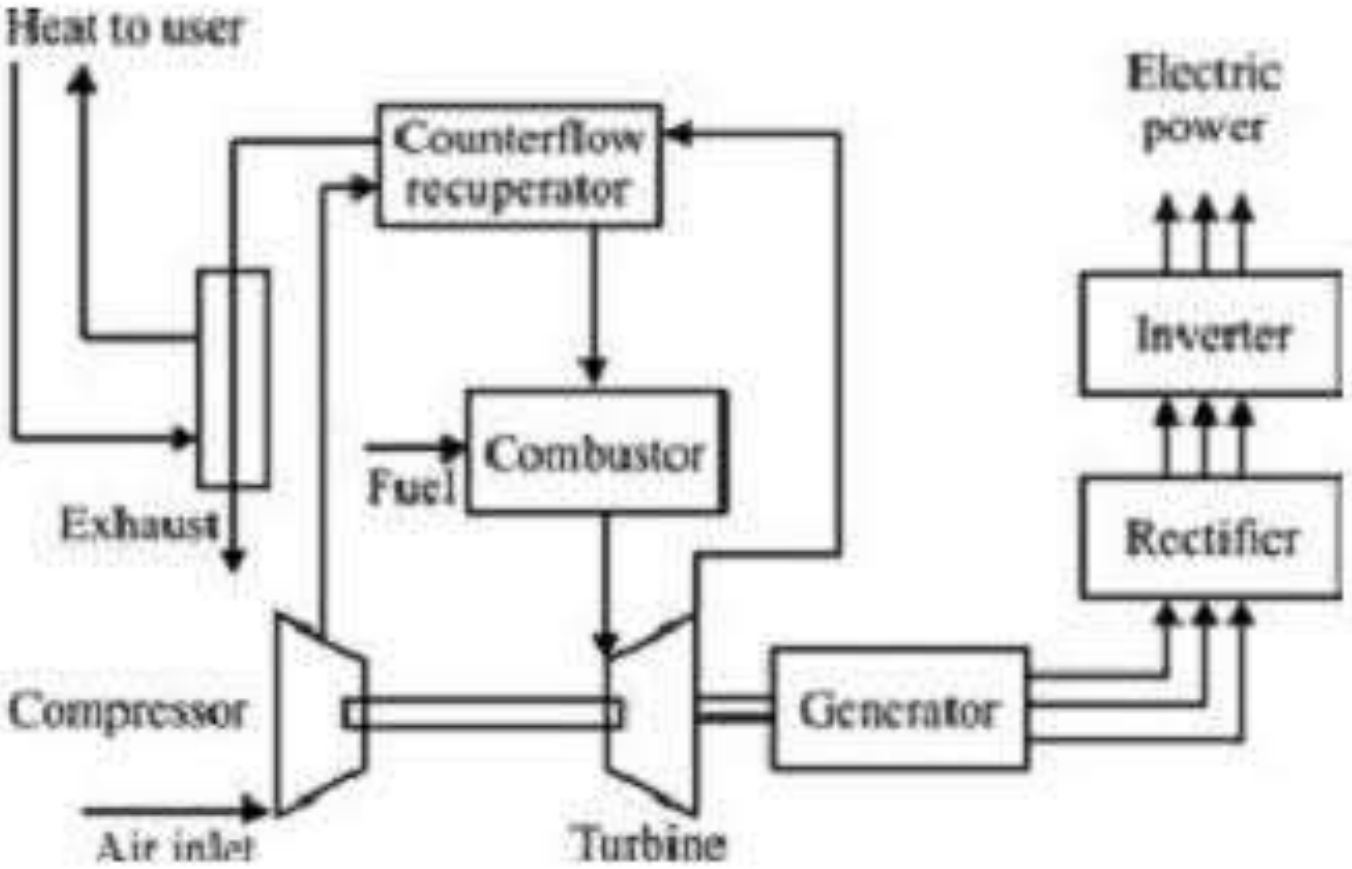
(3) **Power electronics –** In single-shaft machines, the high-frequency (1,500–4,000 Hz) AC voltage generated by the alternator is converted into standard power frequency

(4) **Recuperator –** Recovers the waste heat to improve the energy efficiency of the microturbine.

(5) **Control and communication –** Turbine control mechanism, inverter interface, start-up electronics, instrumentation and signal conditioning, data logging, diagnostics and user control communications.

Single Shaft Microturbines

High-speed (50000 -120000 rpm) alternator with the compressor and turbine mounted on the same shaft

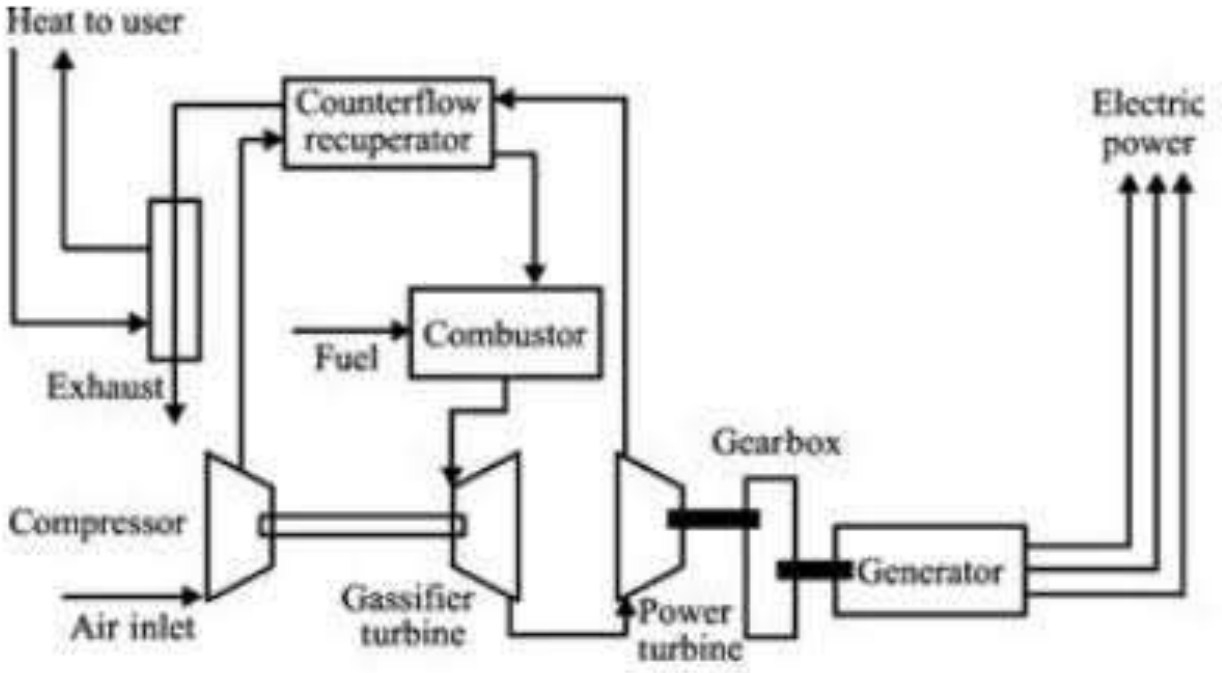


Microturbines

- Most microturbines use permanent magnet synchronous generator (PMSG) or asynchronous generator for power generation.
- High-speed PMSG has disadvantages – such as thermal stress, demagnetisation phenomena, centrifugal forces, rotor losses – because of fringing effects and high cost.
- The disadvantage of coupling induction generators is that though they are cheaper and robust, their speed is load dependent and they cannot be connected to the grid without the use of expensive power converter systems.
- The use of power electronic interfaces introduces harmonics in the system and reduces the output power quality.

Split-Shaft Microturbines

Split-shaft design uses a power turbine rotating at 3,000 rpm and a conventional generator connected via a gearbox for speed multiplication



Microturbines

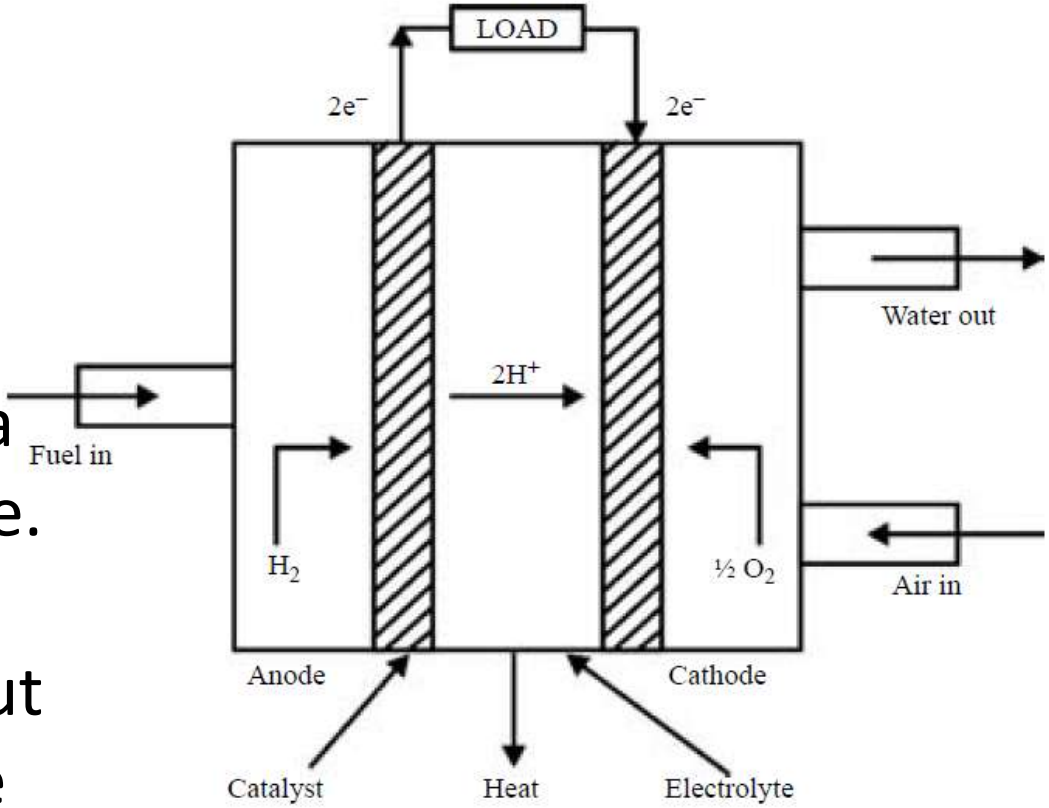
- Advantage of coupling an SG with a split-shaft microturbine is that it eliminates the use of the power converter.
- The generator is connected to the turbine via a gearbox to generate conventional 50/60 Hz power.

Microturbines-Features

- Microturbines can supply a customer's **base-load** requirements or can be used for **standby**, **peak shaving** and **cogeneration applications.**
- Smaller size as compared to other DERs.
- Fuel-to-electricity conversion: >80 % if the waste heat recovery is used for CHP applications.
- NOx emissions: Lower than 7 ppm for natural gas types.
- Operational life: service life of at least 45,000 hours.
- Economy of operation: Lower than $500 per kW
- Fuel flexibility – Capable of using alternative fuels.
- Noise level: Reduced level of noise and vibrations
- Installation: Simple

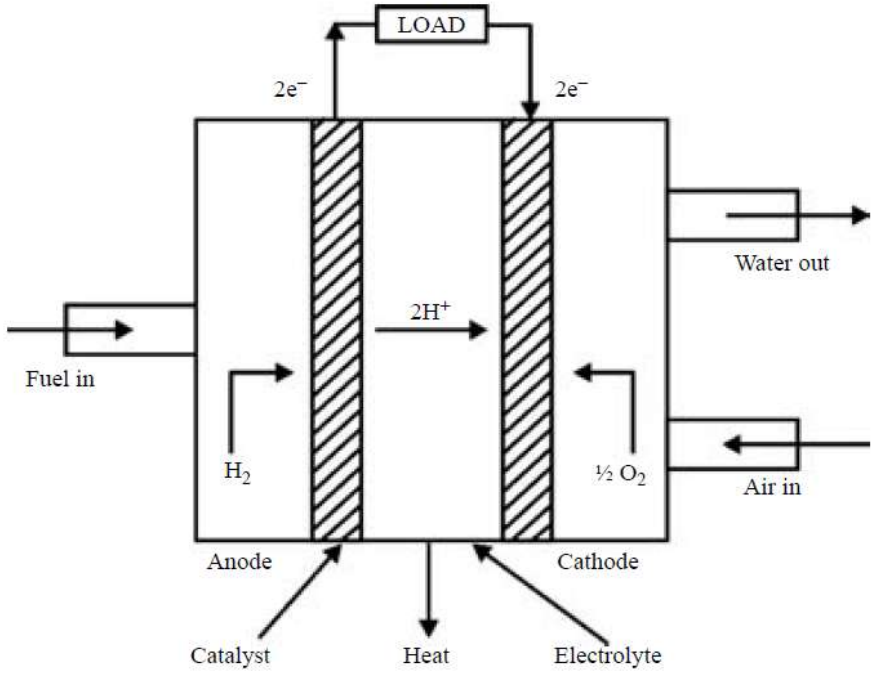
Fuel Cells

- Fuel cell converts chemical energy into electrical energy.
- It consists of two electrodes (an anode and a cathode) and an electrolyte.
- The reactants and products are not stored, but are continuously fed to the cell.



Fuel Cells

- During operation, the hydrogen-rich fuel and oxidant (usually air) are separately supplied to the electrodes.
- Fuel is fed to the anode and oxidant to the cathode.
- Electrochemical oxidation and reduction take place at the electrodes to produce electricity.
- Heat and water are produced as by-products.

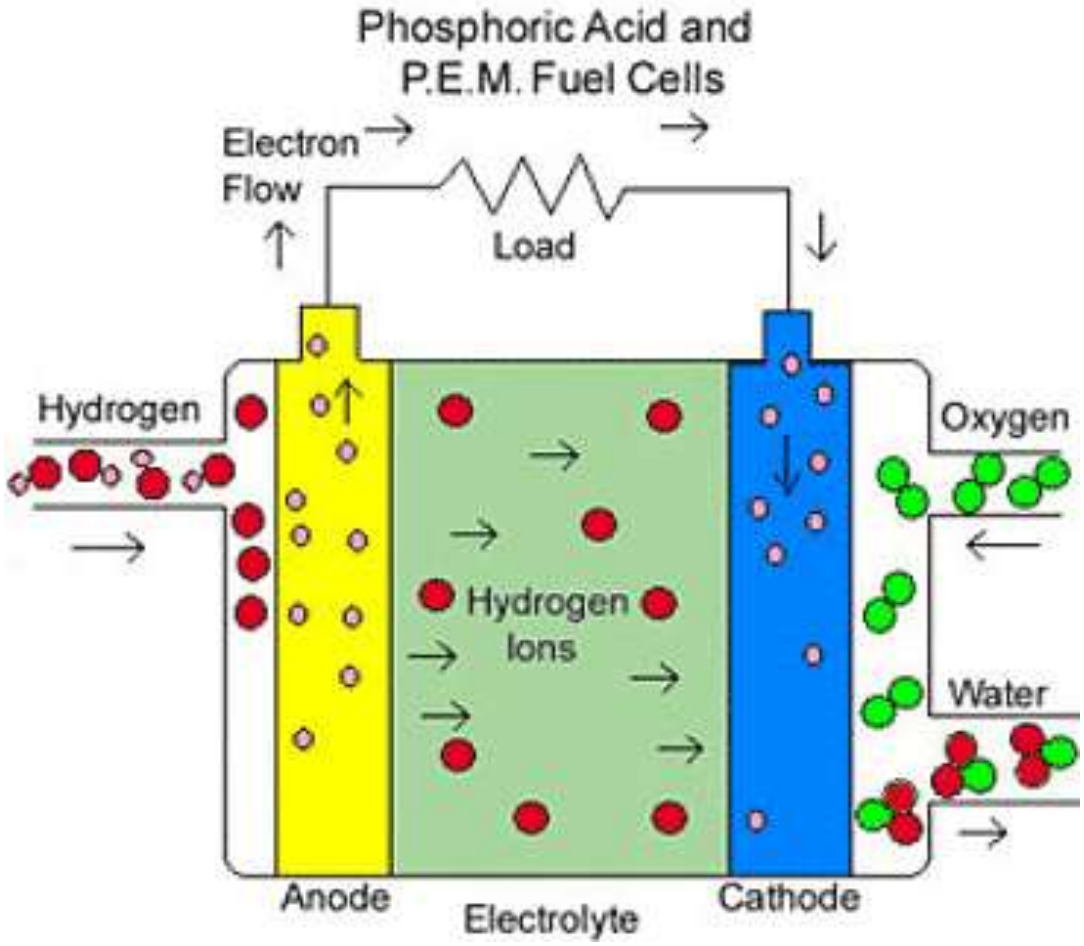


Fuel Cells

- A single fuel cell produces output voltage less than 1 V. Therefore, to produce higher voltages, fuel cells are series connected forming a fuel cell system.

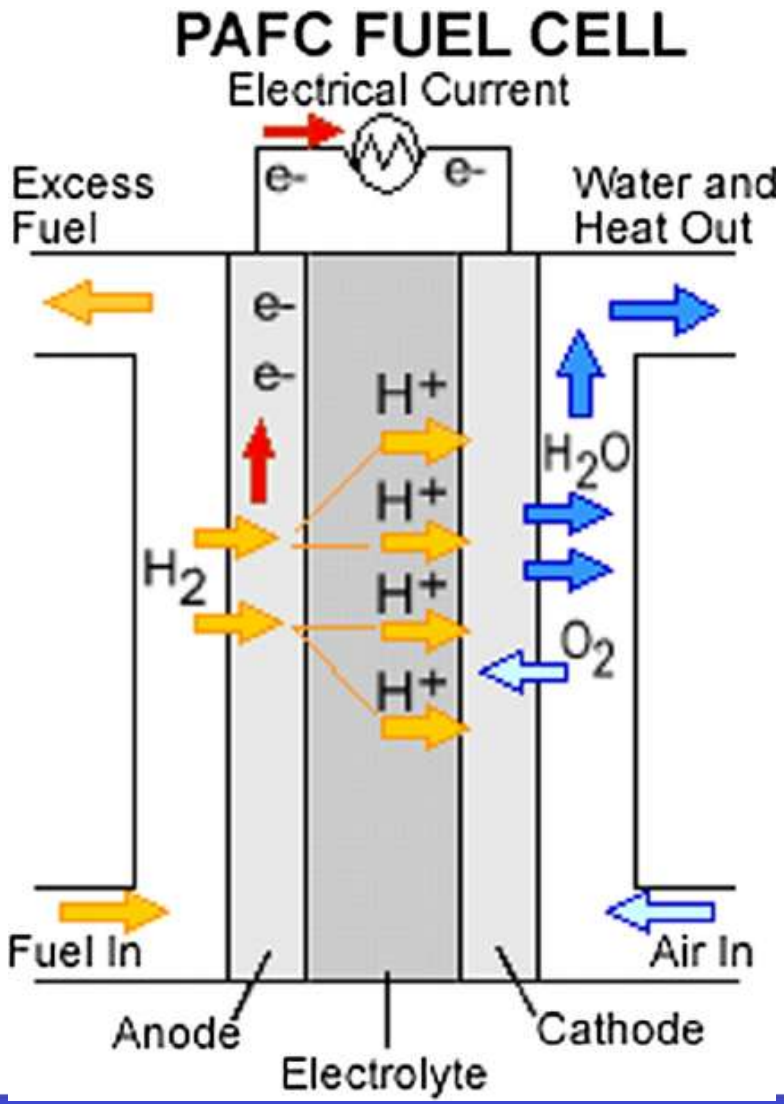
Types of Fuel Cells

(1) Proton exchange membrane fuel cell (PEMFC) operating at 80°C



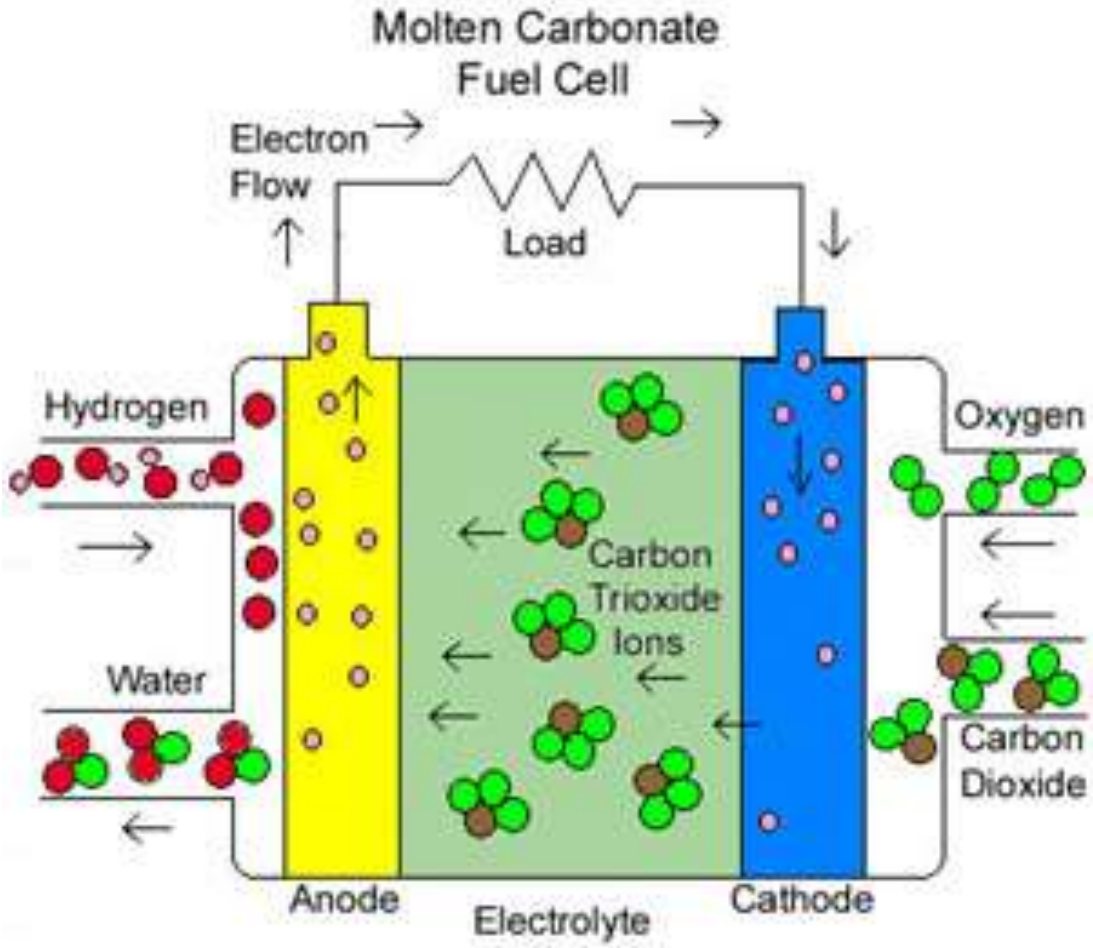
Types of Fuel Cells

(2) Phosphoric acid fuel cell (PAFC) operating at 200 °C



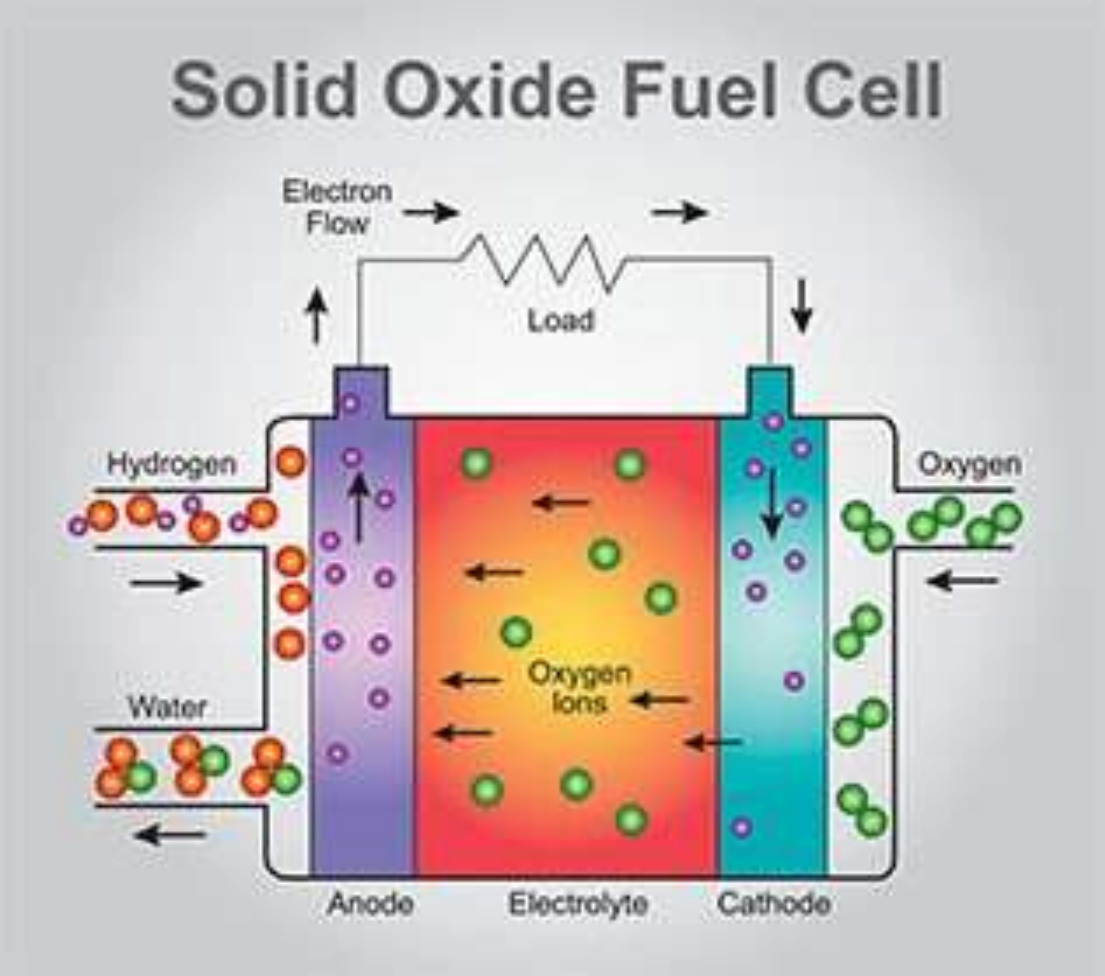
Types of Fuel Cells

(3) Molten carbonate fuel cell (MCFC) operating at 650 °C



Types of Fuel Cells

(4) Solid oxide fuel cell (SOFC) operating at 1,000 °C



ISRO and TATA Motors develop India's First Fuel Cell Bus: Financial Express-13-Mar-2018

The Hydrogen Powered Starbus Fuel Cell bus is a zero-emission mass transport solution and has been developed in partnership with ISRO . Combining hydrogen gas and oxygen, the fuel cell produces electricity to power the electric motor, with water and heat as a byproduct.