The Big Picture: Hydrogen Fuel Cell for Vehicles

Why in News?

Aimed at a significant push for hydrogen vehicles in the country, the Ministry of Road Transport and Highways has notified standards for the safety evaluation of **Hydrogen Fuel Cell-Based Vehicles.**

- This would facilitate the promotion of hydrogen fuel cell-based vehicles in the country.

Key Points

- The notified standards are also at par with the available international standards.
- The prospective manufacturer and suppliers of such vehicles will now have the standards available for their testing.

Hydrogen in Fuel Cell Electric Vehicles (FCEVs)

- In contrast to other electric vehicles, **FCEVs** produce electricity using a fuel cell powered by hydrogen, rather than drawing electricity from only a battery.
- During the vehicle design process, the power of the vehicle is defined by the size of the electric motor(s) that receive electric power from the appropriately sized fuel cell and battery combination.
- Most FCEVs today use the battery for recapturing braking energy, providing extra power during short acceleration events and to smooth out the power delivered from the fuel cell with the option to idle or turn off the fuel cell during low power needs.
- The amount of energy stored onboard is determined by the size of the hydrogen fuel tank.
    - This is different from an all-electric vehicle, where the amount of power and energy available are both closely related to the battery's size.

Fuel Cell

- Fuel cells and batteries convert chemical energy into electrical energy and are very useful forms of galvanic cells.
    - A galvanic or voltaic cell is an electrochemical cell that converts chemical energy into electrical energy through the redox reactions that occur within the cell.
- A **hydrogen** fuel cell is an electrochemical device that converts specifically hydrogen into electrical energy.
- Galvanic cells that are designed to convert the energy of combustion of fuels like hydrogen, methane, methanol, etc. directly into electrical energy are called fuel cells. One of the most successful fuel cells uses the reaction of hydrogen with oxygen to form water.

Production of Hydrogen for HFC

In the context of India there are mainly three effective methods for the production of hydrogen for the hydrogen fuel cell:

- **Natural gas:** Natural gas reforming is an advanced and mature production process that builds upon the existing natural gas pipeline delivery infrastructure. Natural gas contains methane (CH4) that can be used to produce hydrogen with thermal processes, such as steam-methane reformation and partial oxidation.
- **Thermochemical water splitting:** It uses high temperatures—from concentrated solar power or from the waste heat of nuclear power reactions—and chemical reactions to produce hydrogen and oxygen from water.

Thermochemical water splitting

- The process uses high-temperature heat (500°–2,000°C) to drive a series of chemical reactions that produce hydrogen.
- The chemicals used in the process are reused within each cycle, creating a closed loop that consumes only water and produces hydrogen and oxygen.

- **Biomass based production:** Biomass is organic material which includes agriculture crop residues, forest residues, special crops grown specifically for energy use , organic municipal solid waste, and animal wastes. This renewable resource can be used to produce hydrogen, along with other byproducts, by gasification.

Biomass Gasification

- Biomass gasification is a technology pathway that uses a controlled process involving heat, steam, and oxygen to convert biomass to hydrogen and other products, without combustion.
- As growing biomass removes carbon dioxide from the atmosphere, the net carbon emissions of this method can be low, especially if coupled with carbon capture, utilization, and storage in the long term.

Advantage of HFC over Internal Combustion Engine (ICE)

- **Loss of energy in ICE:** In an ICE, the chemical energy of hydrogen is first converted into thermal energy, the heat energy is then converted into mechanical energy which is then converted into electrical energy, too much of energy is lost.
- **Higher efficiency of HFCs:** The conversion of energy takes place at lower temperature, the loss is comparatively much less and the efficiency is higher.
- **Dual purpose:** The fuel cell solves dual purpose as it can run the vehicle and can generate standby power in case of emergencies as well.

Pros and Cons of using Hydrogen Fuel Cells (HFCs) in Vehicles	
Pros	**Cons**
▪ Hydrogen is a clean fuel, no emission of carbon monoxide, hydrocarbons and particulate matter is there.	▪ Estimated cost of a vehicle running on Hydrogen Fuel Cells is $ 50,000 (₹ 36,66,872).
▪ Only water is the residue of HFCs which can be used in the desert areas.	▪ A hydrogen based fuel is highly inflammable, the production, transport and storage of the fuel is a possible challenge.
▪ The biomass based hydrogen production will	▪ The investment required in storing and

lead to the boost in the rural economy.	dispensing of the HFC Vehicle is expectedly very high.
▪ Vehicles running on HFCs are best suited for heavy duty vehicles as electric vehicles are only limited to lighter vehicles.	▪ As the international market of HFC vehicles is very less, the loss and the chances of facing it are very high.

Way Forward

- **India's Commitments:** India has to adhere to its commitment in the **Paris Climate Agreement** and its **Intended Nationally Determined Contribution (INDC) Targets** and ensure that its mobility in the future is with zero emissions.
- **Role of Governments and OEMs:** The governments across the world and the leading **Original Equipment Manufacturer (OEMs)** should step forward to invest in this field as their investment can lower such high cost of production and maintenance of these vehicles drastically.
- **Welcoming the Newer Technologies:** Although electric vehicles solve a large part of the emission problems, HFCVs are the best option in case of the heavy duty vehicles such as trucks and tractors, which is produced in large numbers in India. Hence the technology should be embraced with welcoming hands.
- **Hydrogen Internal Combustion Engine Vehicles:** India is the leading producer of Hydrogen Internal Combustion Engine Vehicles, which could be used as an alternative technology to the high cost Hydrogen Fuel Cell Vehicles.

Hydrogen Internal Combustion Engine Vehicle (HICEV)

- A HICEV is a vehicle powered by a hydrogen-fueled internal combustion engine. Some versions are hydrogen-gasoline hybrids.
- Hydrogen internal combustion engine vehicles are different from hydrogen fuel cell vehicles (which use electrochemical use of hydrogen rather than combustion).
- Instead, the hydrogen internal combustion engine is simply a modified version of the traditional gasoline-powered internal combustion engine.

India's INDC Targets, to be achieved primarily by 2030

- To reduce the emissions intensity of the GDP by about a third.
- A total of 40% of the installed capacity for electricity will be from non-fossil fuel sources.
- India also promised an additional carbon sink (a means to absorb carbon dioxide from the atmosphere) of 2.5 to 3 billion tonnes of carbon dioxide equivalent through additional forest and tree cover by the year 2030

Conclusion

- Currently HFC is still in its infancy stage however we can't depend on conventional fuel for future, hence we should work on alternatives like HFC, electric, solar energy to meet energy requirements for transportation purposes.
- Hydrogen Fuel Cell has a big role to play in mobility and zero emission technology in future.