Zero Energy concept :→

It is a concept where cossumption of total energy on annual basis should be equal & less than renewable energy produced.

for example: Zero Energy Building (ZEB)

Zero Energy campus.

Zero Energy port-folio

Zero Energy Community.

These above places | buildings | sites consequently contribute less greenhouse gas to the atmosphere than similar non zero net buildings.

A zero-Energy Building is a building with net zero Energy consumption meaning the total amount of energy used by the building on an annual basis is equal to the amount of renewable energy created on the site.

The goal is that these buildings contribute less overall greenhouse gas to the atmosphere during operations than similar non-ZNE buildings.

Zero Energy building offer a variety of benefits like.

- Reduced energy cost
- Increased comfort for occupants.
- Improved energy security.
- Positive environmental input.

Advantages ZEB

*) Isolation for building owners from future energy - price increases.

*) Increased comfort due to more-uniform interior - temperature.

*) Reduced total cost of ownership due to improved energy efficiency.

*) Reduced total net monthly cost of living.

*) Reduced risk of loss from grid blackouts.

*) Improved reliability.

Disadvantages

*) Initial costs can be higher - effort required to understand apply & qualify for ZEB subsidies.

*) Very few builders hav the skills & experience to build ZEBs.

*) challange to recover higher intial costs

*) ZEB is not free of carbon emissions, glass has a high embodied energy and the production requires a lot of carbon.

*) Building regulations such as height restrictions or fire code may prevent the implementation of wind & solar power.

Benefits of Hydrogen Energy :→

Hydrogen is an oderless and colourless gas. It has the simplest and lightest atom with one proton and one electron and molecular weight of 2.016.

i) Use of hydrogen energy reduces the pollution :

When hydrogen is combined with oxygen in a fuel cell the energy in the form of electricity is produced. This electricity can be used to power the vehicles, as a heat source etc.
The byproducts are only water and heat.
Hence there are no green houses gases are produced by the use of hydrogen fuel cells.

ii) Hydrogen can be produced from domestic resources with non-~~zero~~ greenhouse gas emission. It can be produced either centrally or onsite where it will be used.

iii) Hydrogen can be produced from electrolysis of water where the water is seperated into hydrogen & oxygen. no green house gases.

iv) No noise pollution, no green house gases.

v) Can be installed at require site hence no transmission cost.

vi) Hydrogen ~~fuel cells~~ increases the flexibility to the power grid:→ Hydrogen can store renewable electricity during ~~peak time~~ excess generation and then be used during periods of peak demand. hence ~~this~~ increases the reliability of the power grid.

Hydrogen production technologies

Hydrogen is the 3rd most abundant element on the earth. it doesnot exist in free state; large amounts of combined hydrogen are present in compounds such as water, fossil fuel and biomass. It can be therefore produced through two routes:

i) fossil fuels such as natural gas, coal, methanol etc and biomass are decomposed by thermo-chemical method to obtain hydrogen.
~~The CO is produced in the process~~
This route of hydrogen production causes CO_2 emission.

ii) Hydrogen can also be produced by splitting water into hydrogen and oxygen by using electrical energy obtained from any renewable energy source.
This can be done by using several techniques like.
- thermo-chemical method.
- Electrolysis of water
- Thermolysis of water
- Biophotolysis

Electrolysis of water:→

Electrolysis is the simplest method of hydrogen production.
An electrolysis cell essentially consists of two electrods, commonly flat metal or carbon plates immersed in an aqeous conducting solution called electrolyte. as shown in fig (i)
A DC (direct current) decomposes water into H_2 and O_2 which are released at cathode (-ve electrode) and anode (+ve electrode) respectively.

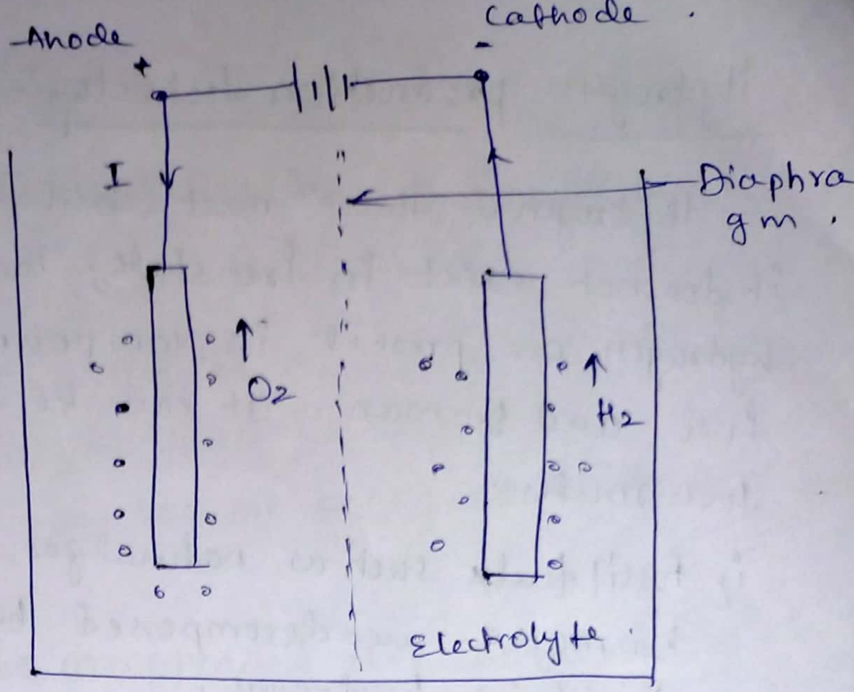

fig (i) Electrolytic cell.

Cathode Reaction

$$2H_2O + 2e^- \longrightarrow H_2 + 2OH^-$$

Anode reaction

$$2OH^- \longrightarrow \tfrac{1}{2}O_2 + 2H_2O + 2e^-$$

Overall reaction

$$\underset{\text{(liquid)}}{2H_2O} \longrightarrow \underset{\text{(gas)}}{2H_2} + \underset{\text{(gas)}}{\cancel{2}O_2}$$

Hydrogen energy storage :→

→ Hydrogen can be stored as a gas or liquid or in a solid chemical compound.

→ In gaseous form it occupies 3.6 times the volume occupied by natural gas and in liquid form it occupies 3.8 time the volume occupied by natural gas. gasoline.

→ The hydrogen can be compressed into containers or underground reservoirs.

→ On large amounts the hydrogen is stored in the underground and on low or moderate scale, hydrogen is frequently stored in a strong steel tank or cylinder.

However at present the most common form of hydrogen storage for the transport industry with hydrogen compressed to approximately 700 bar.

→ Hydrogen can ~~be liquified by pressuring and cooling.~~ also be stored as compact storage in liquid form at low temperature. It takes up low storage volume but requires cryogenic containers as boiling point of hydrogen is 20 K or −253°C.

→ Hydrogen can be stored at high densities in reversible metal hydrides. When required it can be released by heating the hydride and original metal is recovered for further recycling. ~~as follows~~

Charging H_2 + Metal ⟶ hydride + heat (H₂ is stored & heat is released)

Discharging hydride + heat ⟶ H_2 + Metal (heat is stored & H_2 is released)

From the above discussion it is concluded that hydrogen can be stored in the form of gas, liquid and solid.

→ It can be stored in the form of gas by compressing it in a tank but the energy required for compression is a major drawback.

→ It can be stored in the form of liquid but keeping the hydrogen in liquid form is very energy intensive because the boiling point of hydrogen is 20°K.

→ It can be store in the form of solid but the metals & alloys used are more expensive and the process consumes energy.

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Applications of hydrogen energy :→

→ Hydrogen can be used in combustion based power generation such as gas turbine using hydrogen alone or mixed with natural gas. Such applications are proposed for stationary power generation including backup power units.

→ ~~Fuel~~ Hydrogen fuel cells are ideal for ~~residual~~ residential zones. The working is silent with no moving parts and provide reliable power.

Ex:- In Japan the fuel cells are powering thousands of homes.

→ At work sector fuel cells can be used which produced in stacks large enough to power the large office buildings but occupy the area of couple of parking spaces.

→ Hydrogen is also being proposed for commercial vehicles like bus, trucks, cars, trains etc.

→ Technologies are being developed to use hydrogen in both fuel cells and IC engines. ~~[illegible]~~

Problems associated with hydrogen energy :-

i) Hydrogen storage : It must be stored at extremely low temperature and high ~~pressed~~ pressure.

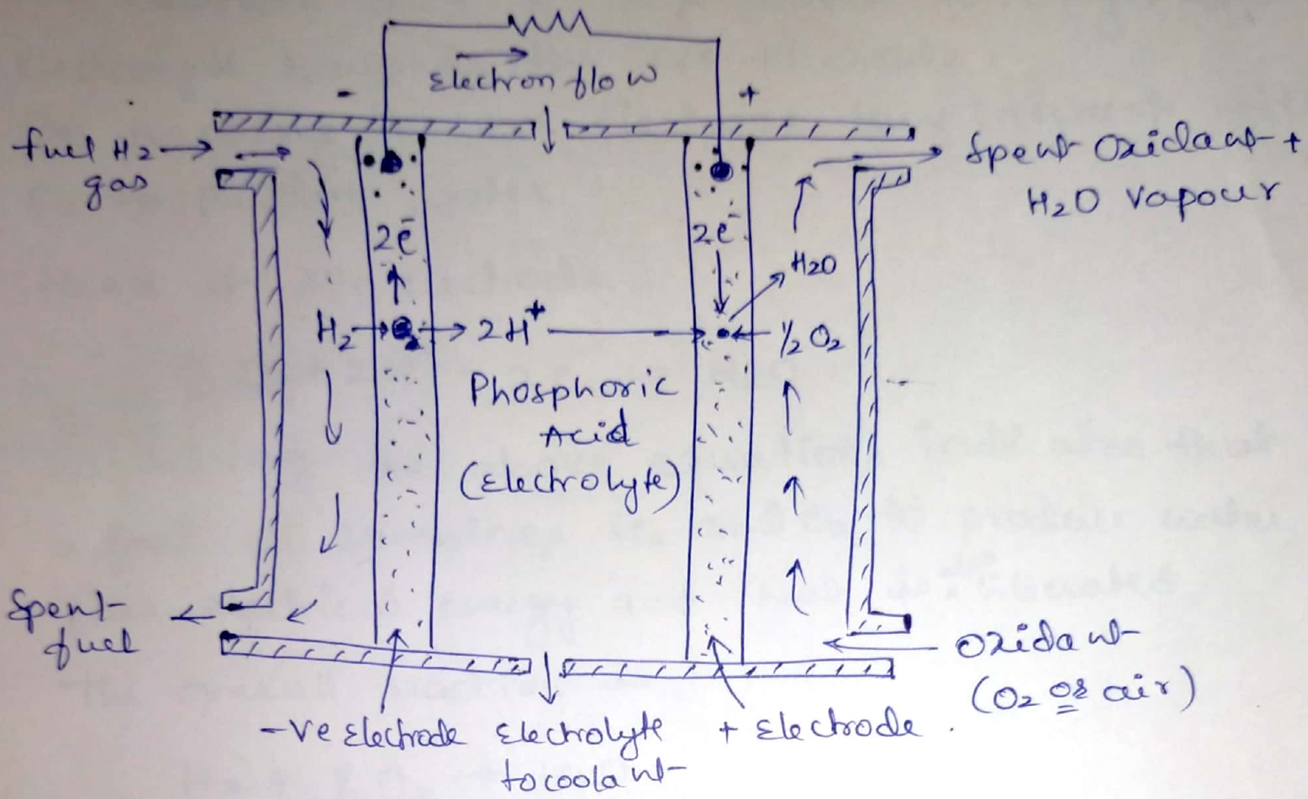
ii) High reactivity of hydrogen : Hydrogen is extreamely reactive. It is combustible and flammable.

iii) Cost and methods of hydrogen fuel production :
Current production of hydrogen takes a lot of energy. By burning the fossil fuels and biomass the hydrogen can be produced but this process emitts CO_2.

iv) Consumer demand : The major companies will not start to produce ~~hydroge~~ hydrogen vehicles until there is consumer demand.

v) Cost of changing the infrastructure :
To accommodate hydrogen equipment and appliances the infrastructure has to modify which increases the cost.

1) Phosphoric Acid fuel Cell (PAFC)



It consists of 2 electrodes of porous material like nickel to collect charges. The electrolyte used is concentrated phosphoric acid filled between the ~~electrolytes~~ electrodes. Pure Hydrogen gas is supplied at -ve electrode and oxygen (Air) is supplied at +ve electrode. The chemical reaction is very slow hence a catalyst is required to accelerate the reaction. So Platinum is used as a catalyst.

During the usage of cell the catalyst gradually loses its activity & is known as poisoning of catalyst due to the impurities.

*) At -ve electrode : hydrogen gas is converted to hydrogen ions (H^+) & equal number of electrones (e^-)

$$\therefore \quad H_2 \rightarrow 2H^+ + 2e^-$$

The electrons flows through the external load to the +ve electrode and H^+ ions flows through the electrolyte towards the +ve electrode.
On reaching the +ve electrode they interact with O_2 to produce water.

Hence at +ve electrode:

$$\frac{1}{2} O_2 + 2H^+ + 2e^- \rightarrow H_2O$$

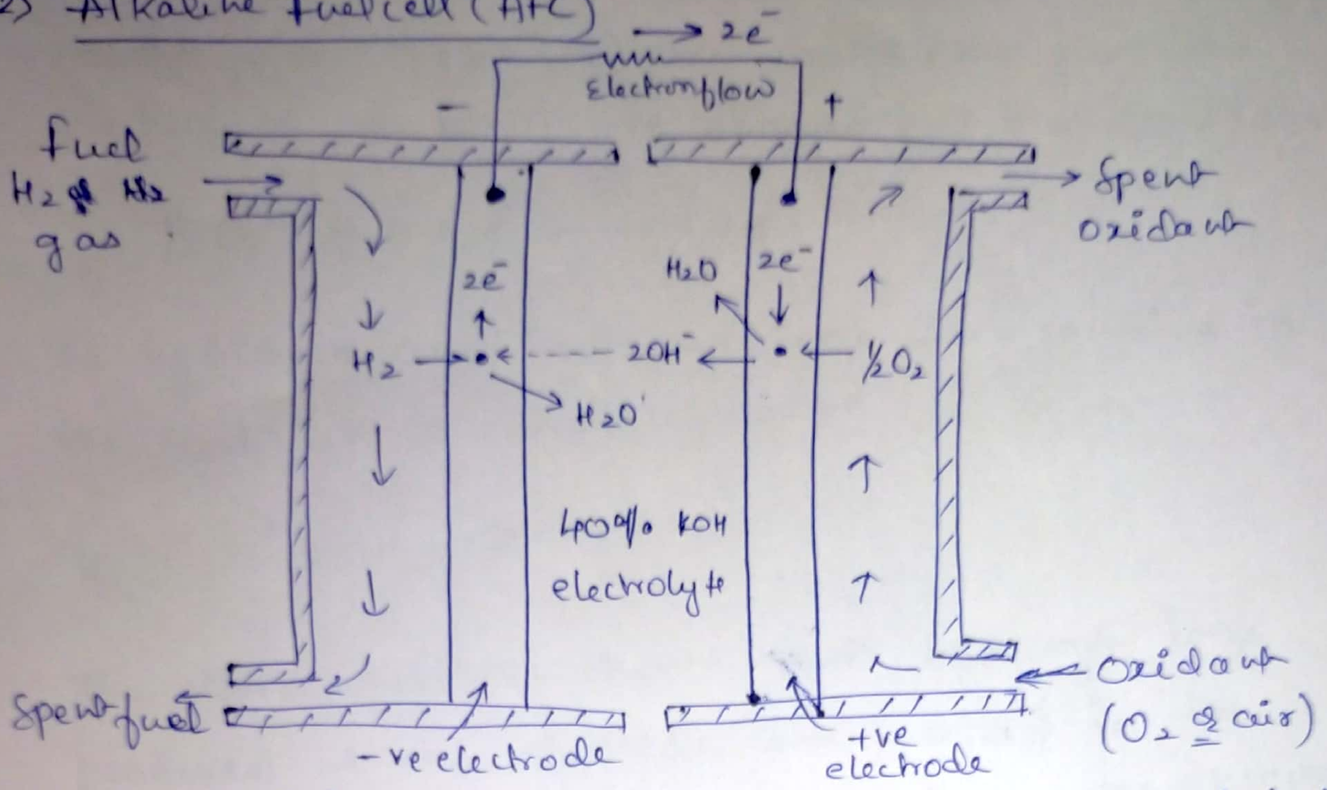
Combining the above equations indicates that a fuel cell combines H_2 and O_2 to produce water plus electrical energy and heat is also liberated.

The overall reaction is

$$H_2 + \frac{1}{2} O_2 \rightarrow H_2O.$$

The operating temperature of PAFC is 150°C-200°C.
At atmospheric pressure, it produces an ideal emf of 1.23 V at 25°C which reduces to 1.15 V at 200°C.

2) Alkaline fuel cell (AFC)



It consists of 2 electrodes of porous material like nickel to collect charges. The electrolyte used is 40% KOH (alkaline) between the electrodes.
Pure hydrogen gas is supplied at −ve electrode and oxygen is supplied at +ve electrode. The chemical reaction is very slow hence a catalyst is used to accelerate the reaction & a platinum is generally used as a catalyst.

*) At the −ve electrode hydrogen gas (H_2) is converted into hydrogen ions (H^+) & equal number of electrons (e^-) thus

$$H_2 \rightarrow 2H^+ + 2e^-$$

At this electrode the catalyst enables the hydrogen molecules, H_2 to be absorbed on the electrode surface as hydrogen atoms, which react with hydroxyle ions (OH^-) in the electrolyte to form water.

→ At +ve electrode the electrons (flow through the external load to the +ve electrode) from external load reacts with oxygen (O_2) and water (H_2O) from the electrolyte to form -ve changed hydroxyl (OH^-) ions.

$$\therefore \quad \frac{1}{2} O_2 + H_2O + 2e^- \longrightarrow 2OH^-$$

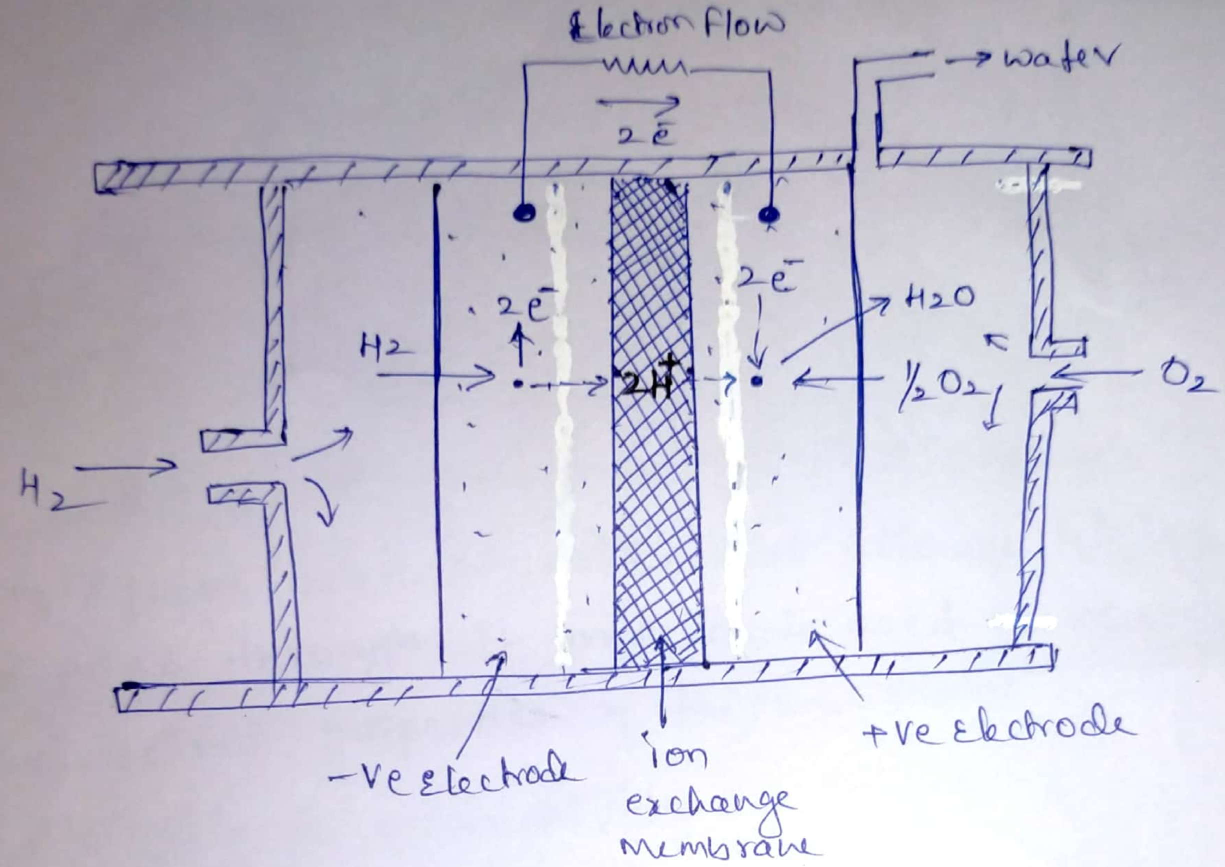
The hydrogen and hydroxyl ions then combine in the electrolyte to produce water

ie; $H^+ + OH^- \rightarrow H_2O$

The above equations shows that hydroxyl ions produced at one electrode and involved in the reaction at the other. Also electrons are absorbed from the oxygen electrode and realesed to the hydrogen electrode. Hence the overall process is the chemical combination of hydrogen and oxygen (gases) to form water.

ie; $H_2 + \frac{1}{2} O_2 \longrightarrow H_2O$.

3) Polymer Electrolyte Membrane or Proton Exchange Membrane fuel cell.
(PEMFC) or (SPFC)
solid Polymer F.C



The basic components of cell are shown in fig above

→ A thin layer (about 0.076 cm thickness) of the membrane is used to keep the internal resistance of the cell as low as possible → finely devided platinum deposited on each surface of the membrane serves as electrochemical catalyst & current collector.

-ve electrode:

→ Hydrogen enters a closed compartment interacts with -ve electrode and converted into H^+ ions and equal number of electrons (e^-).

$$H_2 \longrightarrow 2H^+ + 2e^-$$

+ve Electrode

→ The H^+ ions are transported to +ve electrode through the membrane and electrons return to +ve electrode through external resistance. At +ve electrode, the ions, electrons and oxygen (O_2) interact to produce water

$$\frac{1}{2} O_2 + 2H^+ + 2e^- \rightarrow H_2O$$

Thus the overall reaction is

$$H_2 + \frac{1}{2} O_2 \rightarrow H_2O .$$

A solid mebrane of organic material (such as polystryrene sulphonic acid) that allows H^+ ions to pass through it and it is used as electrolyte.

The desired properties of the membrane are:

*) High ionic conductivity.

*) Non-permeable to reactant gases ie; H_2 & O_2.

*) low degree of electro-osmosis. (Motion of liquid a/c the membrane)

*) High resistance to dehydration & oxydation.

*) High Mechanical stability.

The main advantage of the solid membrane is it retains only a limited quantity of water and rejects excess water produced in the cell.

The Fuel cell operates at 40 - 60°C.

The ideal emf produced is 1.23V at 25°C.